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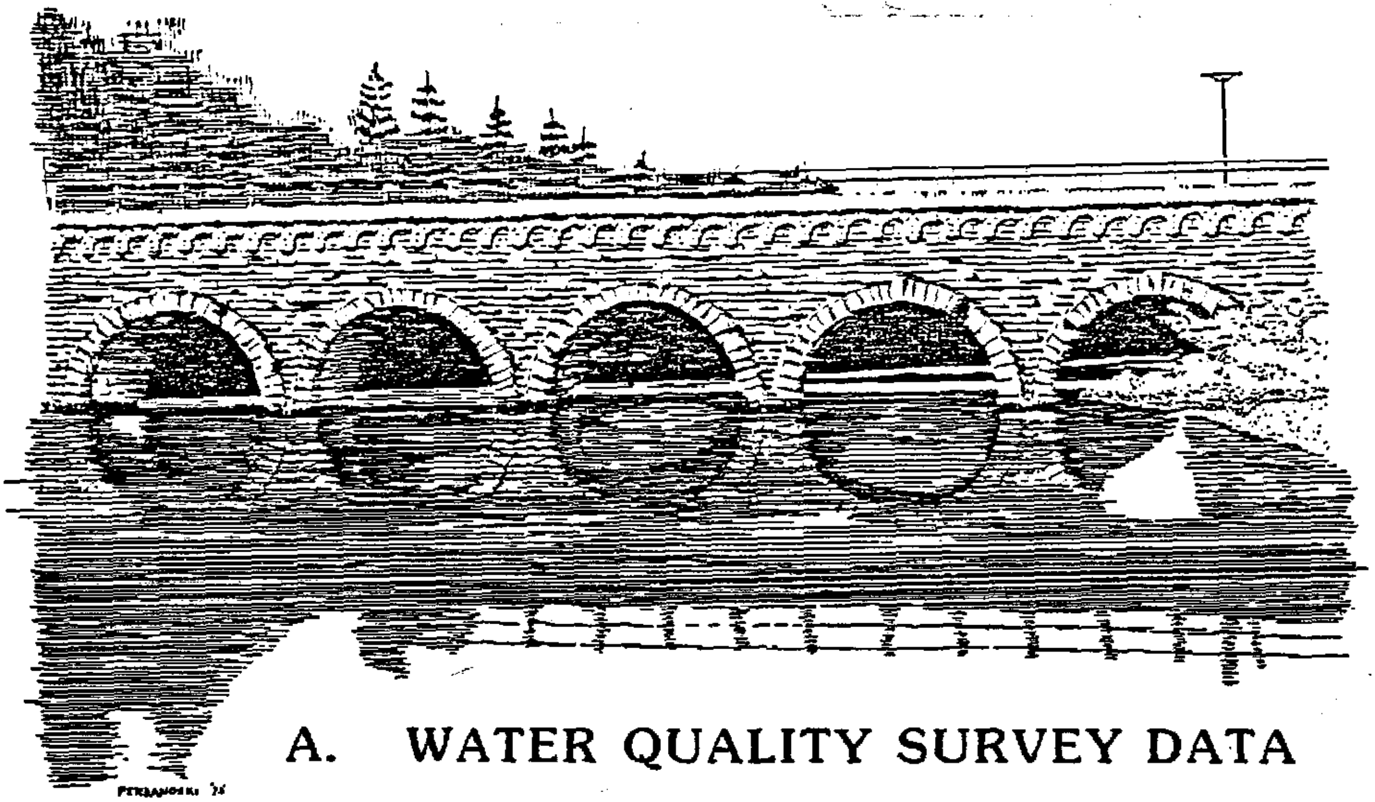
# ASSABET RIVER

# 1986-87



## A. WATER QUALITY SURVEY DATA

## B. WASTEWATER DISCHARGE DATA

## And ANALYSIS

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

KENNETH HAGG, ACTING COMMISSIONER

Division of Water Pollution Control

Thomas C. McMahon, Director

# ASSABET RIVER BASIN

1986-1987

WATER QUALITY DATA
WASTEWATER DISCHARGE DATA
WATER QUALITY ANALYSIS

BY

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# FOREWORD

The Massachusetts Division of Water Pollution Control was established by the Massachusetts Clean Water Act, Chapter 21 of the General Laws as amended by Chapter 685 of the Acts of 1966. Included in the duties and responsibilities of the Division is the periodic examination of the water quality of various coastal waters, rivers, streams and ponds of the Commonwealth, as stated in section 27, paragraph 5 of the Acts. This section further directs the Division to publish the results of such examination together with the standards of water quality established for the various waters. The Technical Services Branch of the Division of Water Pollution Control has, among its responsibilities, the execution of this directive. This report is published under the Authority of the Acts and is among a continuing series of reports issued by the Division presenting water quality data and analyses, water quality management plans, baseline and intensive limnological studies and various special studies.

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## INTRODUCTION

This report is a compilation and analysis of the results of field and laboratory examinations of the Assabet River and its wastewater discharges during the years 1986 and 1987 by the Technical Services Branch (TSB) of the Division of Water Pollution Control (DWPC).

The study had as its goal the preliminary determination of the effects on river water quality from wastewater treatment plant (WWTP) upgradings at four of the river's facilities: the Westborough, Shrewsbury, Hudson, and Maynard WWTP's. Particular attention was focused on the upper Assabet River in the vicinity of the Westborough and Shrewsbury discharges, since the most severe water quality problems on the Assabet River have, in the past, occurred in this vicinity. In addition, intensive surveys of the entire river were conducted twice during 1987 to update the Assabet River data-base as a whole. Finally, wastewater effluent discharge sampling was carried out concurrently with all water quality surveys.

Quality control measures were employed during all surveys. At the central laboratory (the Lawrence Experiment Station), precision, accuracy, and level of detection data is recorded for most parameters. During the surveys themselves, duplicate samples were collected (recognized in the data sets as station numbers having double parameter values listed) and bottles were washed and samples preserved in accordance with EPA methods.

The sampling program consisted of several phases. The upper portion of the river from the headwaters to the Marlborough/Northborough border was grab sampled for chemical and bacteriological parameters approximately monthly from November 1986 to May 1987, and twice per month from June through September 1987. The entire river was sampled intensively July 22-23, 1987 and September 1-2, 1987 at all the stations listed in Table 2. During the intensive surveys, samples were composited each day for chemical analysis by combining equal volumes of water from each run (three runs per day during July, two runs per day during September), before lab testing was done. Bacteria, volatile organic compounds, chlorine residual, temperature, and dissolved oxygen parameters, though, were always grabs. Concurrently, 24-hour composite samples from wastewater discharges were gathered during the times of all river surveys by the Compliance Monitoring Section of the DWPC.

Surficial sediment samples were collected using a Ponar dredge from eight river stations on August 5, 1987. The samples were analyzed for nutrients, metals, PCBs, chlorinated pesticides, and acid and base/neutral extractable organic compounds.

Chemical and bacteriological samples were transported to the Lawrence Experiment Station of the Department of Environmental Quality Engineering (DEQE), where they were analyzed according to procedures set forth in the most current edition of the American Public Health Association's Standard Methods for the Examination of Water and Wastewater. However, dissolved oxygen determinations were made by Technical Services Branch personnel using the Winkler Method. In addition, water temperature, chlorine residual and pH measurements were made at the time of sample collection.

River flow measurements were taken by TSB personnel during the intensive survey weeks at four locations on the Assabet River - Maynard Street, Westborough;

Boundary Street, Marlborough; Cox Street, Hudson; and Route 62 near the industrial complex, Stow. The flow was measured by taking velocity readings with a "pygmy" current meter and integrating over the river area. In addition, river flow measurements during all surveys were collected by the United States Geological Survey (USGS) at the USGS gaging station on the Assabet River in the town of Maynard. It must be noted that the USGS measurements were intended to give an indication of the flow regime of the river during the sampling, although most of the surveys did not extend into Maynard.

ISCO automatic samplers were used to obtain 24-hour composite samples from the six municipal dischargers on the river: the Westborough WWTP, the Shrewsbury WWTP, the Marlborough West WWTP, the Hudson WWTP, the Maynard WWTP, and Concord MCI WWTP. (The Shrewsbury WWTP tied into the Westborough WWTP in the spring of 1987.) A 24-hour composite sample is indicated in this report by bracketing the days over which the sample was taken, e.g., 9/1-2/87.

TABLE 1

1985 ASSABET RIVER BASIN WATER QUALITY CLASSIFICATION*

| BOUNDARY | MILE POINT | CLASSIFICATION | DESIGNATED USES | OTHER RESTRICTIONS |
|---|---|---|---|---|
| Source to Westborough WWTP | 31.8 - 30.4 | B | Aquatic Life<br>Recreation (P&S)** | 314 CMR 4.04(3) |
| Westborough STP to outlet of Boones Pond | 30.4 - 12.4 | B | Aquatic Life<br>Recreation (P&S) | -- |
| Outlet of Boones Pond to confluence with Sudbury River | 12.4 - 0.0 | B | Warm Water Fishery<br>Recreation (P&S) | -- |
| White Pond to its outlet in Stow and those tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |
| Gates Pond to the intake in Berlin and those tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |
| Unnamed brook from its source to Gates Pond, Berlin | -- | A | Public Water Supply | MGL., Ch. 111 |
| Millham Brook Reservoir to its outlet in Marlborough and those tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |
| Lake Williams to its outlet in Marlborough and those tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |
| Cold Harbor Brook Reservoir in Shrewsbury and those tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |

* Massachusetts Water Quality Standards, 1985
** (P & S): Primary and secondary contact recreation

TABLE 1 (CONTINUED)

| BOUNDARY | MILE POINT | CLASSIFICATION | DESIGNATED USES | OTHER RESTRICTIONS |
|---|---|---|---|---|
| Sandra Pond to its outlet in Westborough and those tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |
| Sudbury Reservoir in Westborough, Marlborough, Southborough, Framingham and those tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |
| Nagog Pond to its outlet in Acton and tributaries thereto | -- | A | Public Water Supply | MGL., Ch. 111 |
| Other surface waters of the Assabet River Drainage Area unless otherwise denoted above | -- | B | -- | 314 CMR 4.04(3) |

## PHYSICAL CHARACTERISTICS OF THE ASSABET RIVER

The Assabet River, originating in impounded swamplike land in southwestern Westborough, flows through several highly populated areas including Westborough, Northborough, Hudson, Maynard, and Concord, until it joins with the Sudbury River in Concord to form the Concord River. It currently receives major discharges from four municipal wastewater treatment plants and a state prison treatment plant.

The varying physical characteristics of the Assabet River play a critical role in the chemical and biological activities which occur in the river. The re-occurring presence of dams and the slow moving, swampy impoundments they create are vital factors in the water quality of the Assabet River. Figure 1 shows the drainage basin and the assigned water use classification (see Table 1) of the Assabet River and its tributaries. Figure 2 shows the Assabet profile, with changes in elevation, and location of dams and wastewater treatment plant discharges. In the following description, the mile point from the confluence with the Sudbury River is shown in parentheses.

The Assabet River begins at the outlet of the George H. Nichols Multiple-Purpose Dam in the southwest section of Westborough. 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 swampland. The dam was intended to provide fish and wildlife habitat and low flow augmentation for pollution abatement. Decaying organic matter formed by the insufficient removal of trees and roots when the area was flooded produces inferior water quality within the impoundment. In addition, proper flow regulation is absent. Water which does flow through the dam, however, is aerated, and the resulting water quality in the newly emerging Assabet is good as far as dissolved oxygen and bacteriological parameters are concerned.

After a short, fast flowing stretch, the river begins its characteristic sluggish flow. "Hocomonco Stream" joins the river just above where the first of five wastewater treatment plants discharges into the Assabet - the town of Westborough Wastewater Treatment Plant (WWTP) (30.2). Shortly downstream the Shrewsbury WWTP discharged to the river until the spring of 1987, when its flows were tied in to the Westborough WWTP. The Assabet meanders its way through swamplike lands and flows by a golf course before reaching the next impounded area and dam on Route 20 in Northborough (26.5). Soon, another relatively steep gradient causes the river to ac-celerate through a small industrial complex. Then, taking a 90° turn, the Assabet enters the "headwater" pool of the Allen Road dam impoundment (25.4). After flowing through pasture lands, the basic pattern of the river is repeated - the Marlborough West WWTP (24.1) coincides with the slowing of the river flow. The river flows through swamplands until the dam at Route 85 in Hudson (18.2). Through Hudson center the flow is constricted by industrial developments on both banks. Passing out of Hudson center the pattern is again repeated - the Hudson WWTP 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.

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 pat-tern - flowing into the Powder Mill impoundment and receiving the discharge from the Maynard WWTP (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 receiving its final discharge from the Massachusetts Correctional Institution (MCI) at West Concord (2.4). The river slowly reaches the Sudbury River just north of the center of Concord. The confluence of the Assabet and Sudbury rivers produces one main stream - the Concord River.

TABLE 2

1987 ASSABET RIVER BASIN SURVEYS

LOCATION OF SAMPLING STATIONS

| STATION NUMBER | LOCATION | RIVER MILE |
|---|---|---|
| AS01 | Water Outlet, George H. Nichols Multi-Purpose Dam, Westborough | 31.8 |
| AS02 | Maynard Street, Westborough | 31.0 |
| AS03 (T) | Outlet of Hocomonco Pond, Otis Street, Westborough | 30.5, 0.5 |
| AS04 | Route 9, Westborough | 30.1 |
| AS05 | Route 135, Westborough/Northborough Line | 29.2 |
| AS06 | School Street, Northborough | 28.3 |
| AS07 | Above Dam, Route 20, Northborough | 26.5 |
| AS09 | Boundary Street, Northborough/Marlborough Line | 24.2 |
| AS10 | Robin Hill Road, Marlborough | 23.8 |
| AS11 | Bigelow Road, Berlin | 22.0 |
| AS13 | Chapin Road, Hudson | 19.6 |
| AS14 | Below dam, Route 85, Hudson | 18.2 |
| AS16 | Cox Street, Hudson | 16.2 |
| AS17 | Below dam, Route 62, Stow | 14.4 |
| AS18 | Boon Road, Stow | 12.1 |
| AS19 | Route 62/117, above dam, Maynard | 9.0 |
| AS20 | Routes 27/62 at USGS gage, Maynard | 7.7 |
| AS21 | Above Powdermill dam, Acton | 6.5 |
| AS22 | Route 62, first bridge, Concord | 6.1 |
| AS24 | Route 62, third bridge, Concord | 3.3 |
| AS25 | Routes 2/2A, Concord | 2.6 |
| SU15 | Sudbury River, Nashawtuc Hill Road, Concord | 0.0, -0.5 |
| CO01 | Concord River, Lowell Road, Concord | 0.0, +0.1 |

# DATA ANALYSIS

The Assabet River has had relatively severe water quality problems in the recent past, mostly as a result of wastewater discharges from the six municipal WWTP's lining its banks. Today, the river still only partially meets its Class B Water Quality Classification. Past sampling programs in 1965, 1969, 1974, and 1985 all documented significant dissolved oxygen deficits and excessive fecal coliform bacteria counts. Data from the latest survey in 1987, the subject of this report, shows that the river has improved considerably in these respects. However, significant portions of the river still support dense populations of algae and macrophytes during the summer months. Decay of this excess vegetation in many slow moving parts of the Assabet River can cause local odor problems.

The studies done in 1987 had, as their goal, the preliminary determination of the effects on river water quality from recent WWTP upgradings at four of the river's facilities: the Westborough, Shrewsbury, Hudson, and Maynard WWTP's. Accordingly, the interaction of these discharges with river hydrology and chemistry will be explored in this report. Particular attention was focused on the Upper Assabet River in the vicinity of the Westborough and Shrewsbury WWTP discharges, since the most severe water quality problems on the Assabet have occurred in this vicinity.

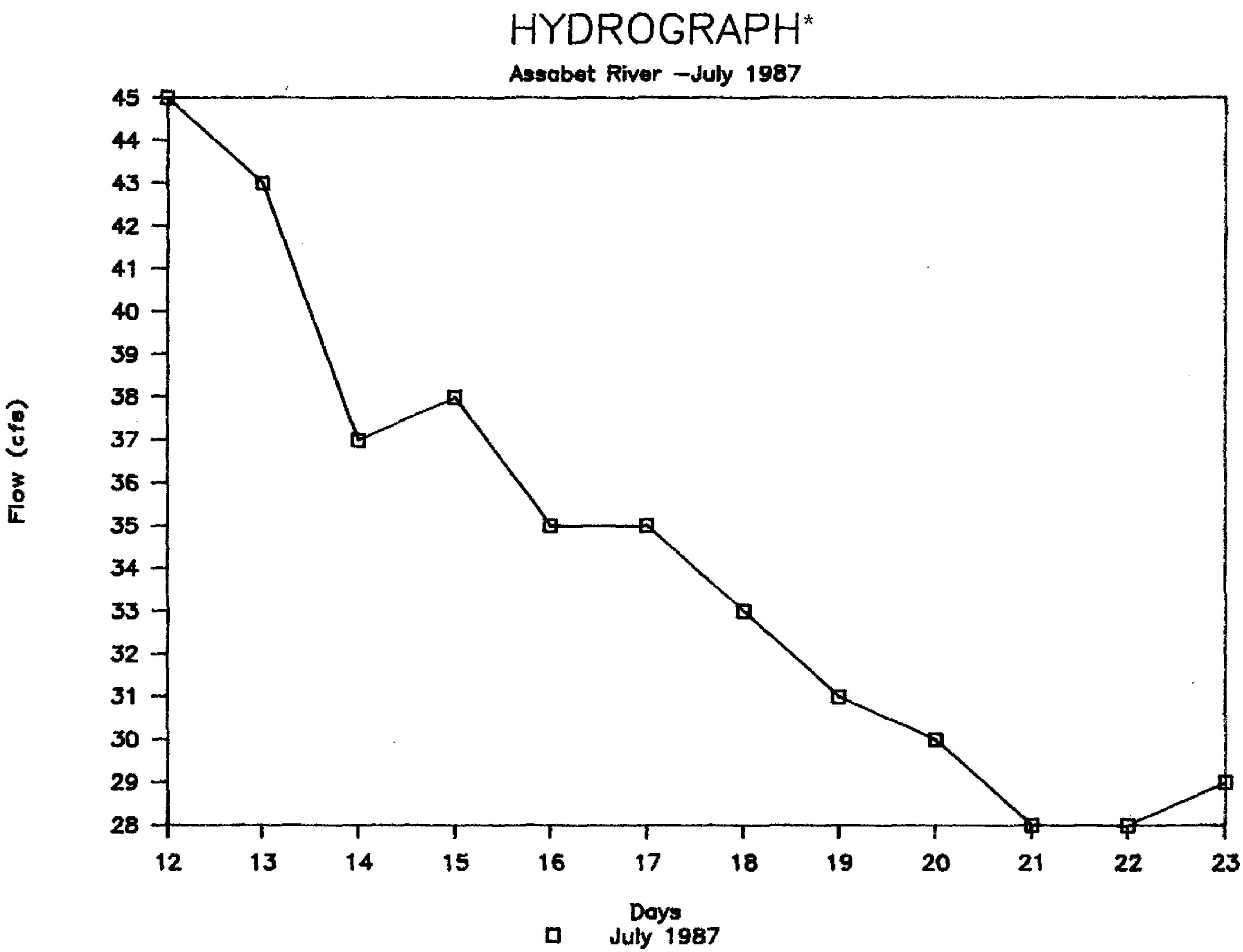
For analytical purposes, this data analysis will be discussed in three sections - wastewater discharges, conventional pollutants in-stream, and toxic pollutants in-stream.

For proper interpretation of water quality data, hydrographs of Assabet River flows as measured at the Maynard U.S.G.S. gage are presented in Figures 4 and 5 for the intensive July and September 1987 surveys. Tables 17 and 43 present flow data for the smaller and past years' surveys. Ideally, river flows should be similar for direct comparison of parameters such as BOD and nutrients across months or years.

The conventional pollutant chemical and biological parameters of principal interest which will be examined as to source and effect are dissolved oxygen, five-day biochemical oxygen demand, ammonia-nitrogen, phosphorus, and fecal coliform bacteria. The water quality problems which occur, and which have occurred over ten years, are exacerbated in the summer, when river flows are at a minimum (yielding minimum dilution), and decay and vegetative growth processes are at a maximum.

The toxic pollutant problems which occur in the Assabet River are more elusive to quantify. However, the data which has been gathered will be discussed according to best professional judgment.

FIGURE 4




* FLOWS FROM U.S.G.S GAGE, MAYNARD

## WASTEWATER DISCHARGES

The wastewater discharges on the Assabet River during 1987 are the six municipal sewage treatment plants, the Westborough, Shrewsbury, Marlborough West, Hudson, and Maynard WWTP's, as well as a plant that serves the Massachusetts Correctional Institute at Concord (see Figure 2). Major upgradings were on-line at four of these facilities for the 1987 surveys: the Westborough-Shrewsbury, Hudson, and Maynard WWTPs. Upgradings at the remaining two are also in the planning stage. Thus, the summer of 1987 was an opportune time to first document the effects of major improvements in effluent quality on Assabet River water quality.

The Compliance Monitoring Section of the Division of Water Pollution Control (DWPC) surveyed all of these WWTPs concurrently with the 1987 river water quality surveys. Laboratory analyses of these discharges appear in Tables 44 to 50. The following section is a brief description of each discharge and its effect on the Assabet River.

### Westborough WWTP

During the late spring of 1987 the new $29 million Westborough Regional WWTP, built to replace both the Shrewsbury and older Westborough WWTPs, and located adjacent to the former Westborough plant, came fully on-line. The Westborough Regional WWTP is the most upstream discharge on the Assabet River, very near the headwaters. It serves the communities of Westborough and Shrewsbury, as well as a small section of Hopkinton. Since the most severe water quality problems on the Assabet River have, in the past, occurred in the Westborough/Northborough vicinity, the new plant was of vital importance to the area.

The facility is an advanced secondary treatment plant with ammonia oxidation capability. It employs a multi-channel oxidation system where wastewater is aerated through three concentric channels to achieve biological treatment. The effluent passes through sand filters before chlorination. Extra oxygen is added to the effluent while it cascades down a channel before release to the Assabet River. The plant was designed to produce a high quality effluent, as evinced by its National Pollutant Discharge Elimination System (NPDES) permit limits of flow: 7.68 MGD; summer daily maximum $BOD_5$, 15 mg/l; dissolved oxygen, 6 mg/l; and ammonia, 1.5 mg/l. However, since coming on-line the plant's flows have been below design limits, and so it has frequently produced effluents of much better quality than its NPDES permit requires. Sludge will be disposed of via composting.

The initial effect on the Assabet River of replacing the older Westborough and Shrewsbury WWTP's with the new advanced secondary Westborough Regional WWTP has been remarkable. Within a few months, and under worst case stream dilution (i.e., extreme summer low stream flows), the dissolved oxygen in the Assabet increased to the Class B water quality standard, and other parameters such as fecal coliform bacteria and solids decreased quickly and drastically. Thus, due to the improvement in effluent quality, the Assabet River seems well on its way to recovery as far as many important measurements of pollution are concerned.

### Shrewsbury WWTP

The Shrewsbury WWTP tied its flows into the new Westborough Regional WWTP in early June 1987. (For further information, refer to the Westborough WWTP section.) Prior to this, the Shrewsbury plant was performing very poorly. NPDES permit violations were noted in $BOD_5$, flow suspended solids, and fecal coliform bacteria.

Marlborough West WWTP

About six miles downstream from the Westborough WWTP, the Marlborough West WWTP discharges about 1.9 MGD into the Assabet River. The industrial input to the plant explains the high nickel concentration in the effluent during the monitoring of the plant during both 1985 and 1987. Planning is well underway for upgrading the plant to accomodate increased flows and to provide ammonia oxidation. Expected completion is in 1989. High nutrients and accompanying excessive algae populations probably will continue, though, downstream of the upgraded facility.

Hudson WWTP

At river mile point 16.0, effluent from the newly upgraded Hudson WWTP, with a design flow of 2.63 MGD, enters the Assabet River. The upgraded plant is advanced secondary and includes ammonia oxidation and post aeration. Sludge has been disposed of on-site, but plans are underway to use a new location.

Improvements in water quality, especially dissolved oxygen, have occurred downstream, but further monitoring will be necessary to confirm that these are permanent improvements and a result of the Hudson WWTP upgrade. However, due to excessive nutrients, many of the slow moving parts of the river from here on support superabundant algae populations.

Maynard WWTP

Effluent from the newly upgraded Maynard WWTP, with a design flow of 1.43 MGD, enters the Assabet River at mile point 6.8. The plant has remained secondary, but now includes an innovative technology - rotating biological contactors, followed by post aeration. The plant performed very well during monitoring in 1987. However, high nutrients and consequent excessive algae populations are expected to continue in the river in the vicinity of the discharge.

Concord MCI WWTP

The Concord Correctional Institute WWTP (mile point 2.4) is a small discharge to the Assabet River with a design capacity of 0.162 MGD and an average flow which is usually substantially higher. In addition, the prison has plans to expand by several hundred beds; thus, a WWTP upgrade will be needed.

The MA Division of Capital Planning has approved a study to evaluate short and long term upgrading alternatives for the facility. Short term priorities are to bring down the sludge inventory and improve the final sand filtration process. The latter should bring some immediate improvement in effluent quality. Long term, a new sludge handling system is needed; composting is being considered.

Although the discharge frequently violates its NPDES permit limits, its impact on the Assabet River is low, since the ratio of WWTP flow to river flow in Concord is small.

## CONVENTIONAL POLLUTANTS

The "conventional pollutants" of concern for the Assabet River are fecal coliform bacteria, biochemical oxygen demand, solids, and the various nutrient parameters in the form of dissolved nitrogen and phosphorus compounds. These parameters are considered "conventional" (as opposed to "toxic") in that they have, until the last several years, received most of the attention of water quality planners. For analytic purposes, the river will be divided into two segments - upper and lower.

### Upper Assabet River

The upper segment, where extensive water quality data were collected in 1987, extends from the Assabet headwaters in Westborough, to Boundary Street, Marlborough. The actual data is compiled in the "Upper Assabet Water Quality Data" section starting on Page 32. Surveys were conducted in this area once per month through June 1987, whereupon they were conducted twice per month through September, 1987.

Water quality problems in this segment were due primarily to the Westborough and Shrewsbury WWTP discharges and were the most severe in the Assabet River. However, rapid improvements in water quality began to occur with the opening of the new Westborough Regional WWTP.

Prior to the opening of the new Westborough Regional WWTP, though, the upper Assabet River had been the focus of considerable public controversy and odor complaints over several years. The most severe odor problems along the river, in Northborough, were caused by sewage inputs high in BOD. These created very low dissolved oxygen conditions, i.e., anaerobic in-stream conditions, and anaerobically decaying organic sediments in and bordering the river. In order to respond to the public anxiety, the Technical Services Branch (TSB) instituted a project to study the odor problem in-depth and recommend possible short term. solutions.

The final report on the Upper Assabet River odor problem and possible short term solutions was published by TSB, Westborough, in December, 1986.[1] It outlined the issues and technical complexities involved in physical alteration of stream conditions, i.e., dredging, liming the river banks, in-stream aeration, and hydrogen peroxide addition. In addition, it presented water quality predictions from mathematical stream modeling of dissolved oxygen for various possible scenarios. The conclusion of the study was that the short term solutions were very expensive and experimental in nature.

The mathematical modeling predicted greatly improved river conditions once the new Westborough WWTP came on line. Thus, the short term "remedial" measures were judged unnecessary.

[1] Internal Memo. Nora Hanley. "Assabet River - Mathematical Modeling and Odor Reduction Options." DEQE-DWPC-TSB, December 1986.

These suppositions were proven correct once the new Westborough WWTP was operational. As a matter of fact, dissolved oxygen levels in the river were even higher and rose more quickly than predicted. The projected (via mathematical modeling) and actual oxygen levels in-stream are presented graphically in Figure 6. Odor problems due to low dissolved oxygen along the Assabet River were minimal to non-existent during the summer of 1987, as predicted.

Examining the upper Assabet River survey data more closely, we also see that $BOD_5$ values have greatly decreased during September 1987 as compared to 1985 and even 1979 values. This is depicted graphically in Figure 7 for river miles 32 through 24. The steep decrease is directly attributable to improved wastewater treatment at the new Westborough facility. In turn, this sharp $BOD_5$ decrease has lead directly to the sharp dissolved oxygen increase described above.

Also of note are the improved fecal coliform bacteria levels in the upper Assabet River as pictured in Figure 9. Steep declines in bacteria densities have occurred since 1985, so that presently the levels are within the Class B water quality standard of 200 organisms/100 ml. Again, these declines are directly attributable to the new Westborough WWTP, where an improved chlorination system and reduced solids loadings in the effluent have allowed for improved disinfection.

Lastly however, as pictured in Figure 10, phosphorus levels in-stream in the upper Assabet (river miles 32 to 24) have not declined. This is reasonable in that the new Westborough WWTP does not have phosphorus removal capabilities; so, phosphorus loading to the upper Assabet is approximately the same as in previous years (but will increase with increased flows). In addition, phosphorus can settle in sediments and later be resuspended and recycled, as opposed to remaining dissolved and being flushed from the upper Assabet. The phosphorus levels in the upper river are very high, and are capable of fostering nuisance algae and weed growth in slow moving sections of the river.

Lower Assabet River

The lower Assabet River, from AS10 through the confluence with the Sudbury River, is beset with similar problems to those described on the upper Assabet but in less severe form. These problems range from occasional dissolved oxygen and fecal coliform standard violations to high nutrient levels. The entire Assabet River was intensively surveyed during the weeks of July 22 and September 1, 1987.

Dissolved oxygen during these times was, at some places, below the 5 mg/l standard for a Class B river, as can be seen in Figure 8. Generally, the reasons for this, as before, are due to the nature of the Assabet, a river which flows slowly through swampy areas with little aeration, as well as to WWTP's effluents and in-place sediments creating an oxygen demand. Since the 1985 water quality survey, dissolved oxygen has increased in the river downstream of the newly upgraded Hudson WWTP, located around river mile 16, as shown in Figure 8. In addition, $BOD_5$ values in-stream, as seen in Figure 7, have dropped throughout the Assabet River since 1985. These are positive signs and may be indications of the effect of improved treatment at the newly upgraded Hudson and Maynard WWTP's.

Nutrients, including ammonia, nitrates, and phosphorus, now present in river sediment, and ultimately of treatment plant origin, continue to be present at very high levels in this river segment, as well as in the upper river segment. This leads to prolific aquatic weed and algae growth in slow moving parts of the river. As a matter of fact, as shown in Figure 10, phosphorus levels in the upper Assabet have actually increased with time. This is reasonable in that none of the upstream WWTP's have phosphorus removal capabilities; so, phosphorus loading to the river is approximately the same as in previous years, and may increase with increased WWTP flows. The fact that phosphorus seems to have increased in-stream since 1979 may point to phosphorus recycling from the sediments. Much of the consequent algae growth is abundant enough, such as near AS14, AS19, and AS21, so as to potentially cause odor problems during the summer as the plants die and decay.

FIGURE 6

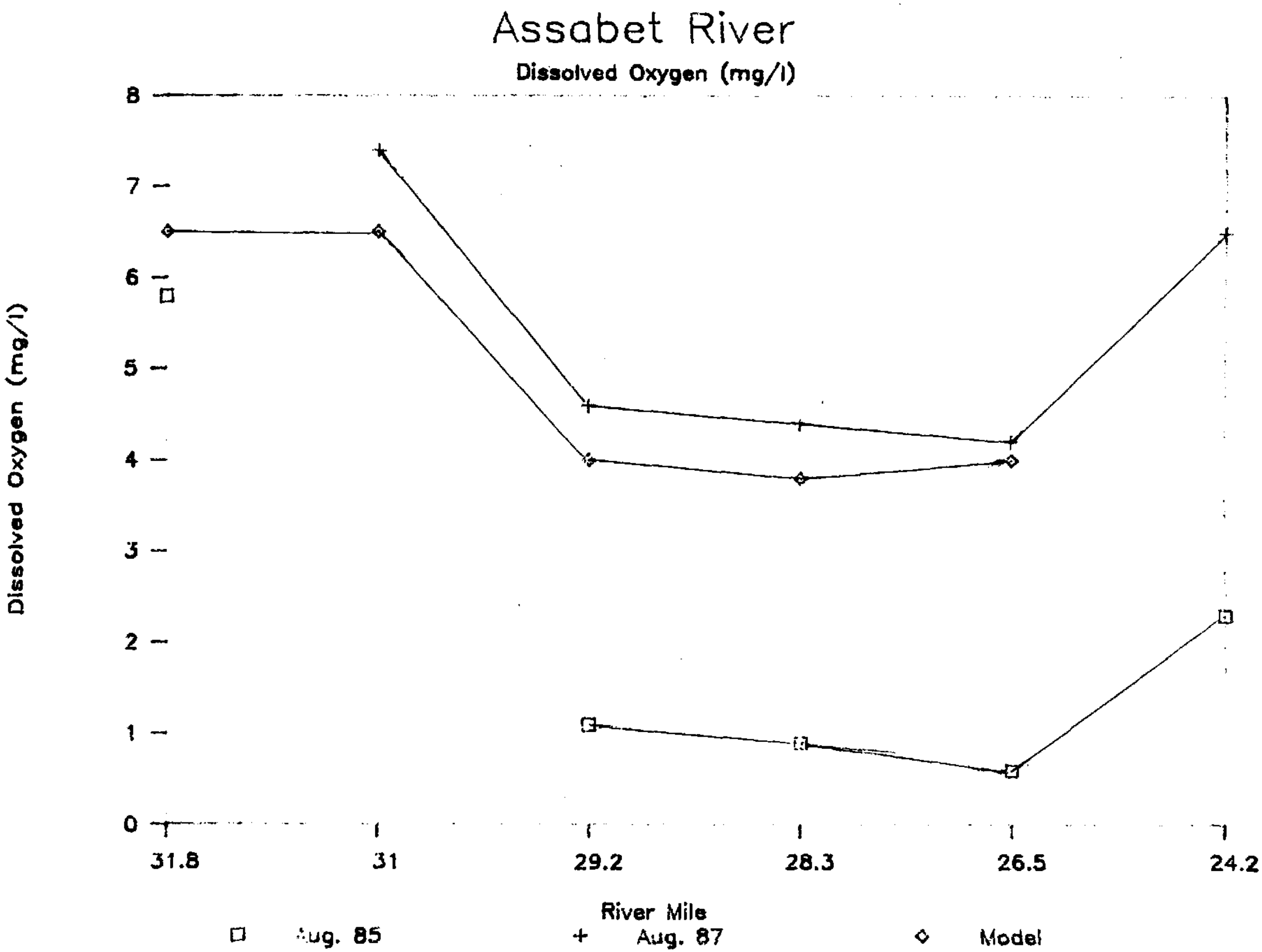
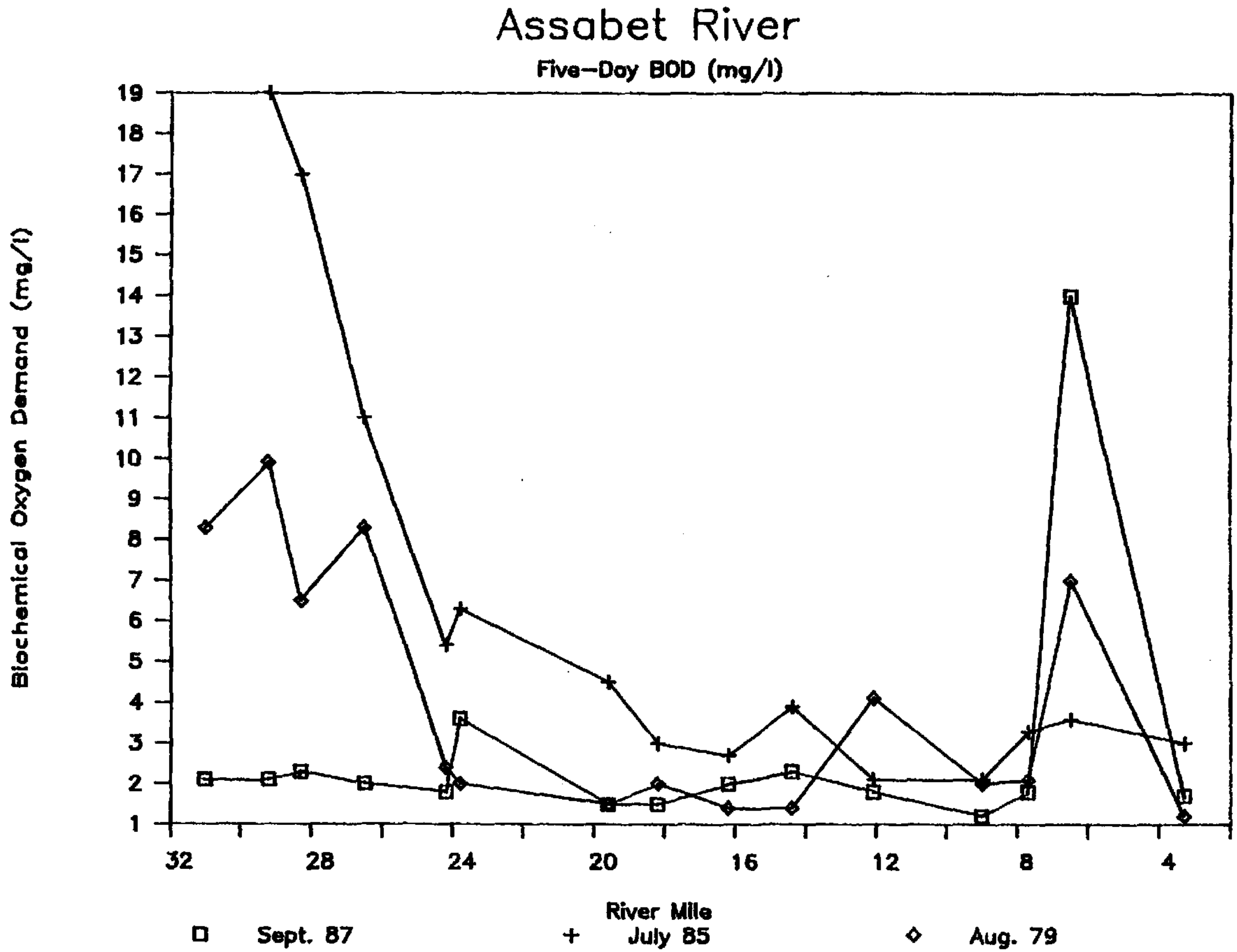
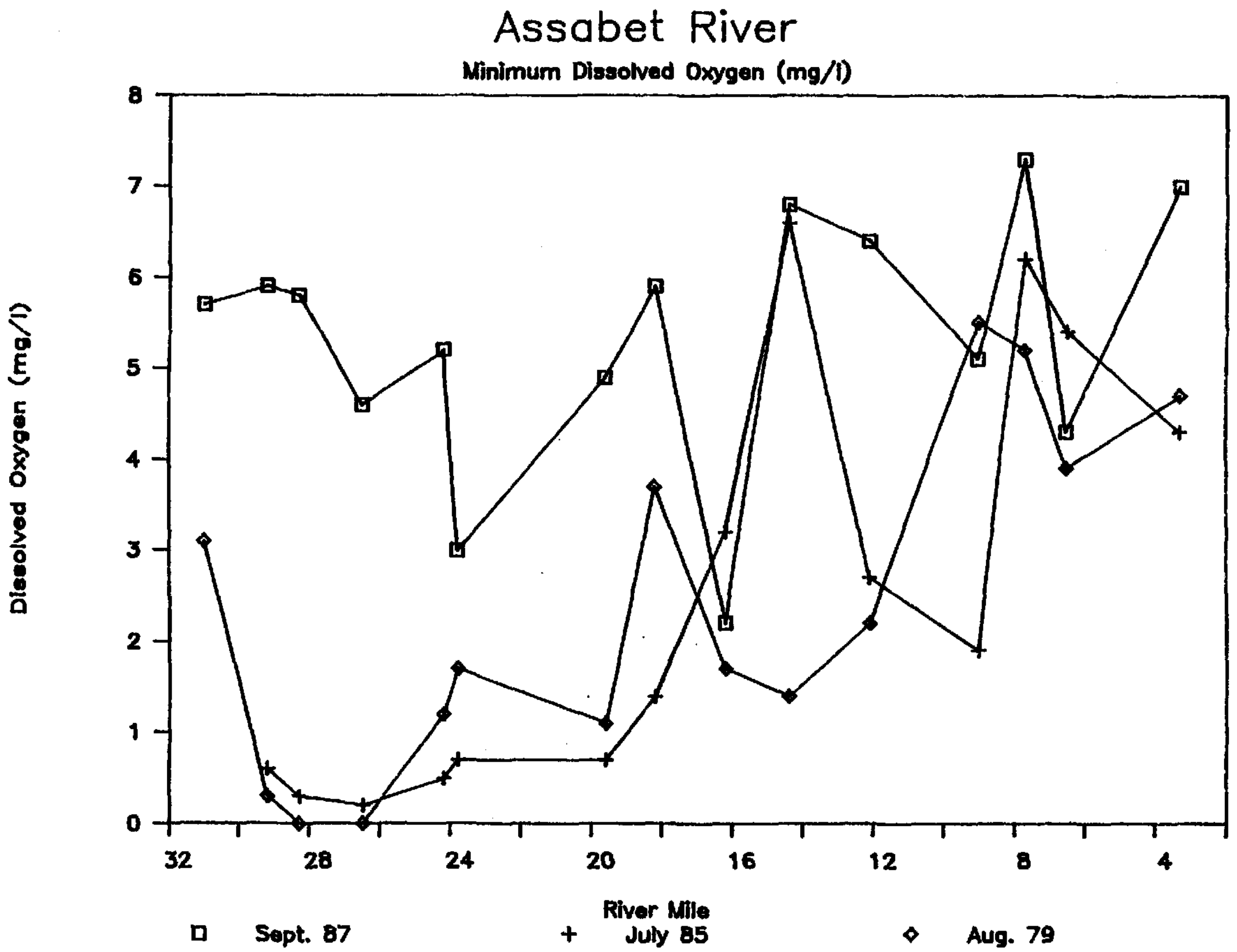

Assabet River
Dissolved Oxygen (mg/l)
Dissolved Oxygen (mg/l)
8
7
6
5
4
3
2
1
0
31.8
31
29.2
28.3
26.5
24.2
River Mile
Aug. 85
Aug. 87
Model

FIGURE 7



Assabet River
Five-Day BOD (mg/l)
Biochemical Oxygen Demand (mg/l)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
32
28
24
20
16
12
8
4
River Mile
Sept. 87
July 85
Aug. 79

FIGURE 8



Assabet River
Minimum Dissolved Oxygen (mg/l)
Dissolved Oxygen (mg/l)
0
1
2
3
4
5
6
7
8
32
28
24
20
16
12
8
4
River Mile
Sept. 87
July 85
Aug. 79

FIGURE 9

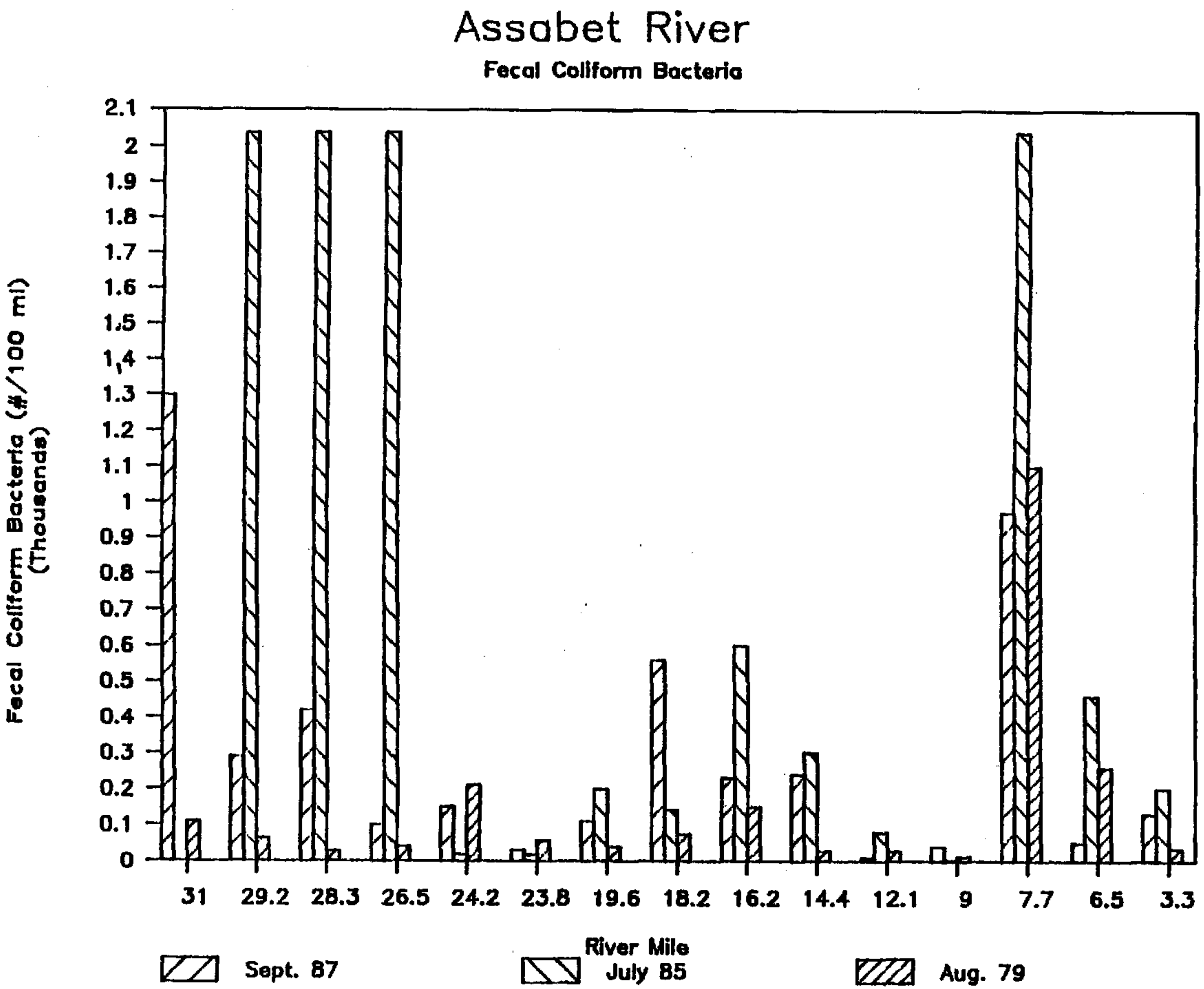
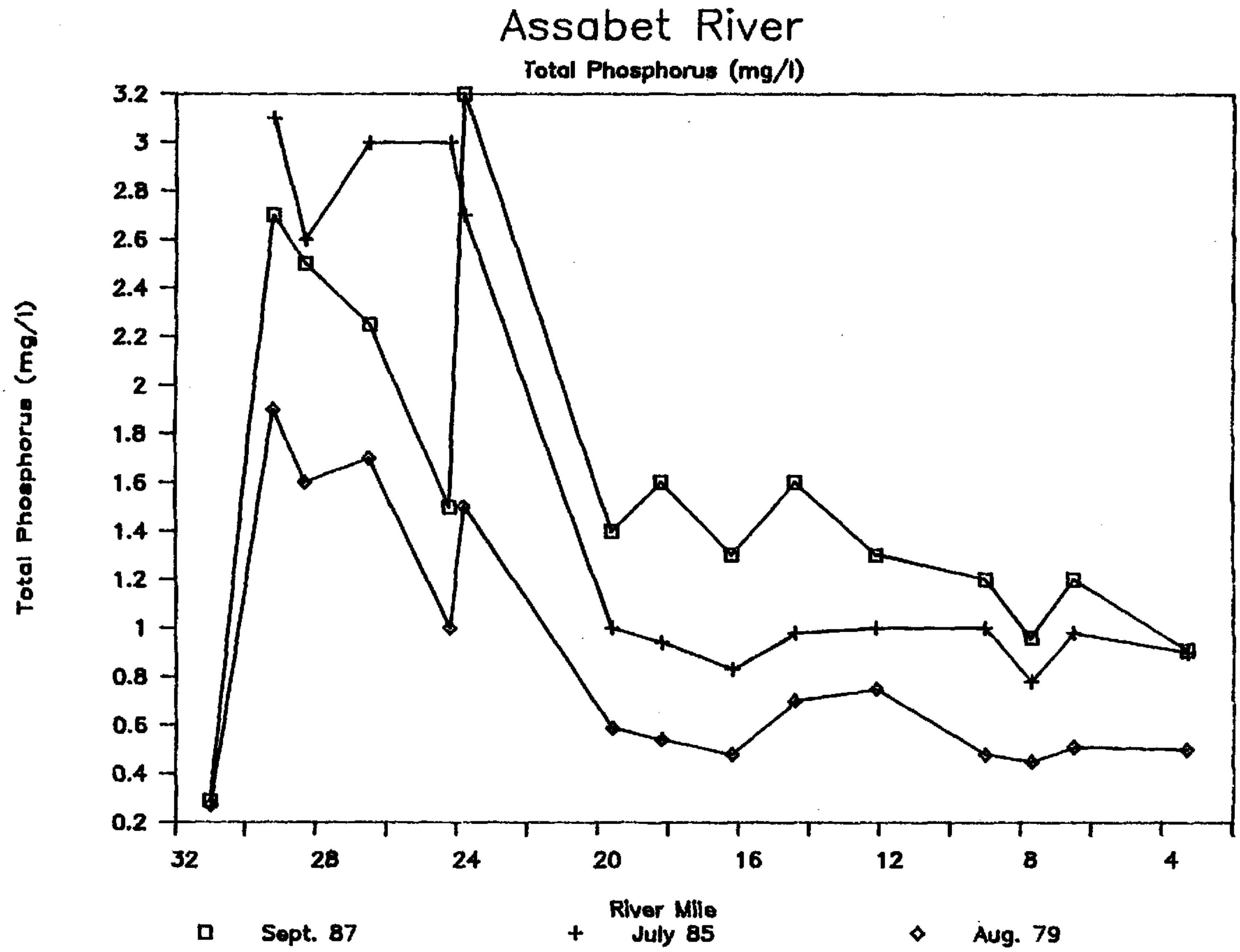

Assabet River
Fecal Coliform Bacteria
Fecal Coliform Bacteria (#/100 ml)
(Thousands)
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
31
29.2
28.3
26.5
24.2
23.8
19.6
18.2
16.2
14.4
12.1
9
7.7
6.5
3.3
River Mile
Sept. 87
July 85
Aug. 79

FIGURE 10


Assabet River
Total Phosphorus (mg/l)
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
Total Phosphorus (mg/l)
32
28
24
20
16
12
8
4
River Mile
Sept. 87
July 85
Aug. 79

## TOXIC POLLUTANTS

The term "toxic pollutants" encompasses a wide range of literally thousands of substances ranging from metals to synthetic organic compounds. Surveys conducted during 1987 were designed to obtain baseline data on the prevalence of toxic substances in the sediments and water column of the Assabet River, and to provide preliminary toxicity testing.

Heavy metals were tested at selected times in the river water column (see Tables 16, 37 and 38), and in the sediment (see Table 41).

The US EPA recommends that water column metals be evaluated applying total recoverable metals to their water quality criteria in the absence of standard methods for acid-soluble metals analyses. Using total recoverable metals as a standard would tend to be, if anything, over-protective of aquatic life. The toxicity of most metals tested for in these surveys is highly dependent on hardness. The equation used to evaluate each metal is given in Appendix A using an average hardness of 50 mg/l as $CaCO_3$. The resulting criteria for the Assabet River are given in Appendix B.

Copper, lead, and mercury concentrations in the water column at some stations exceeded the criteria for four-day average concentrations. Mercury and lead appeared mainly in the lower river. In addition, the four-day average criteria for nickel was exceeded at Station AS10, below the Marlborough West WWTP. Only copper at some stations exceeded the one-hour average criterion.

The laboratory levels of detection for cadmium and mercury, though, are higher than US EPA in-stream criteria; thus, it cannot be predicted from these data the extent to which these metals could, theoretically, pose problems in-stream at many places on the Assabet River.

In general, metals levels from the Assabet WWTP effluents seemed typical for similar plants throughout the state. Copper was found at fairly high levels in all effluents. The probable source of the WWTP copper is the drinking water used by municipalities, where copper piping is typically used. Finally, nickel was found in high concentrations in the Marlborough West WWTP effluent, which caused fairly high in-stream nickel concentrations both in 1987 and 1985.

As for levels of metals in sediments, since no "standards" exist by which to judge sediment quality for toxics, we will instead compare Assabet sediment metals concentrations to standards applied to sludge for land application which are listed in Appendix C. On this basis, the Assabet sediments generally have metals levels below even Class I (least contaminated) sludges, with some exceptions. Lead, at South Street in Hudson, and nickel at AS21 in Acton exceeded Class I limits.

Testing for the multiplicity of synthetic organic compounds was limited to those we might reasonably expect to be present in a given media. For example, PCBs would most likely be detected only in the sediments, and not in the water column, and so they were tested for only in the sediment.

Table 39 lists the synthetic organic compounds found in the Assabet River water column in 1987. In general, the concentrations of these substances were very low, but many of them have no EPA in-stream water quality criteria for comparison. Station AS03T, which had a number of organics present, is located in a small tributary coming from Hocomonco Pond in Westborough, a Superfund Site contaminated chiefly with creosote. Halomethanes such as chloroform and bromodichloromethane are likely to be products of the chlorination disinfection processes at WWTP's. They have a low vapor pressure, and so should not be persistent in the water column in high levels. The presence of isocyanatobenzene at several stations is unexplained.

Table 42 lists synthetic organic compounds found in the Assabet River sediments in 1987. Again, levels of the sediment synthetic organics was generally low. The South Street extension, Hudson sampling station, though, had considerable concentrations of many polynuclear aromatic hydrocarbons (PAHs). The river bottom near this point appeared to be covered in discarded shoe leather. At AS21 in Acton, many of these substances are also found, but in lower levels. PCBs were detected at several stations, but at relatively low levels.

A limited amount of toxicity testing via Microtox™ (see Page 94 for a discussion of Microtox) was conducted on three dechlorinated Assabet WWTP effluents and on river station samples as listed in Table 40. Results downstream of the Marlborough West WWTP (AS10) indicate some in-stream toxic effects as a result of the treatment plant. Further toxicity testing at the WWTP and AS10 is warranted. Toxicity testing will be required in the newly drafted NPDES permit for Marlborough West. No other problems with toxicity were detected in-stream or at the WWTP's with the Microtox tests.

Overall, the potential for toxic effects exists at some places in the Assabet, but actual effects are unknown, and possibly still masked by years of more conventionally recognized pollution problems such as low dissolved oxygen. For example, resident fish populations in areas of the Assabet may be low due to many years of inadequate oxygen in-stream. The effects of toxic substances in Assabet River sediments is, as yet, unknown. However, the PAH concentrations in the sediments found near the South Street extension in Hudson appear particularly high. As the body of knowledge and guidance by agencies such DEQE and US EPA increases concerning toxic substances in the environment, further evaluation of the Assabet will be possible.

UPPER ASSABET RIVER

WATER QUALITY SAMPLING DATA

TABLE 3

1987 UPPER ASSABET RIVER SURVEY

Time (hr/min) - TEMPERATURE (°F) - DISSOLVED OXYGEN (mg/l)

| STATION NUMBER | | 1986 | 1987 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 11/11 | 2/18 | 3/17 | 4/16 | 5/13 | 6/10 | 6/24 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1 | 9/2 | 9/23 |
| AS01 | * | 935 | 945 | 1000 | 1014 | 950 | 934 | 926 | 957 | 1018 | -- | -- | -- | -- | 0922 |
| | ** | 40 | 37 | 36 | 46 | 56 | 67 | 70 | 77 | 82 | -- | -- | -- | -- | 59 |
| | *** | 11.0 | 9.4 | 9.7 | 10.4 | 9.1 | 7.5 | 6.7 | 6.4 | 7.3 | † | † | -- | -- | 8.7 |
| AS02 | | -- | -- | -- | -- | -- | -- | 942 | 1012 | 957 | 900 | 920 | 0445 | 0450 | 0933 |
| | | -- | -- | -- | -- | -- | -- | 57 | 68 | 68 | 67 | 68 | 64 | 59 | 57 |
| | | -- | -- | -- | -- | -- | -- | 8.2 | 8.2 | 7.0 | 8.2 | 7.4 | 5.7 | 7.6 | 9.6 |
| AS04 | | 950 | 1009 | 1017 | 1036 | 1001 | 943 | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 40 | 35 | 36 | 45 | 56 | 64 | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 10.1 | 8.6 | 10.7 | 9.6 | 7.9 | 6.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| AS05 | | 1010 | 1028 | 1051 | 1040 | 1016 | 956 | 1005 | 1023 | 1048 | 910 | 937 | 0510 | 0510 | 0945 |
| | | 40 | 35 | 36 | 45 | 54 | 63 | 62 | 68 | 75 | 73 | 68 | 66 | 64 | 57 |
| | | 9.1 | 9.8 | 9.8 | 8.3 | 6.2 | 4.8 | 4.8 | 3.2 | 5.3 | 5.5 | 4.6 | 5.9 | 6.0 | 8.3 |
| AS06 | | 1025 | 1047 | 1115 | 1051 | 1027 | 1010 | 1026 | 1035 | 1104 | 923 | 950 | 0520 | 0520 | 0956 |
| | | 41 | 33 | 36 | 45 | 54 | 62 | 61 | 68 | 69 | 67 | 68 | 66 | 64 | 59 |
| | | 9.2 | 9.3 | 10.3 | 7.4 | 5.9 | 3.6 | 2.8 | 2.8 | 8.0 | 5.4 | 4.4 | 6.0 | 5.9 | 7.8 |

* Time
** Temperature
*** Dissolved Oxygen
† No river flow

TABLE 3 (CONTINUED)

| STATION NUMBER | 1986 11/11 | 1987 2/18 | 3/17 | 4/16 | 5/13 | 6/10 | 6/24 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1 | 9/2 | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AS07A | 1035 | † | 1200 | 1110 | 1039 | 1021 | 1046 | 1048 | 1117 | 933 | 1000 | 0545 | 0540 | 1005 |
| | 42 | -- | 37 | 44 | 55 | 65 | 60 | 70 | 74 | 76 | 72 | 66 | 64 | 59 |
| | 7.0 | -- | 8.5 | 6.3 | 3.9 | 2.0 | 1.8 | 2.2 | 2.7 | 4.1 | 4.2 | 4.8 | 4.6 | 7.3 |
| AS07B | 1145 | 1106 | 1200 | 1120 | 1039 | 1035 | 1055 | -- | 1120 | 933 | 1006 | 0545 | 0540 | 1013 |
| | 42 | 34 | 37 | 44 | 55 | 64 | 60 | -- | 74 | 72 | 72 | 66 | 66 | 59 |
| | 8.5 | 9.6 | 10.9 | 8.9 | 7.7 | 6.1 | 6.3 | -- | 7.8 | 7.2 | 6.5 | 7.1 | 6.9 | 9.3 |
| AS09 | 1100 | 1115 | 1209 | 1133 | 1100 | 1051 | 1105 | 1110 | 1133 | 948 | 1017 | 0620 | 0550 | 1022 |
| | 40 | 33 | 36 | 45 | 55 | 66 | 62 | 70 | 72 | 74 | 72 | 64 | 64 | 59 |
| | 9.0 | 10.5 | 11.5 | 8.1 | 7.8 | 6.4 | 7.7 | 8.8 | 8.8 | 7.6 | 6.5 | 5.5 | 5.2 | 8.4 |
| AS10 | 1115 | 1123 | 1215 | 1116 | 1110 | 1058 | 1116 | 1122 | 1150 | 1000 | 1025 | 0630 | 0555 | 1033 |
| | 40 | 34 | 36 | 46 | 55 | 65 | 62 | 72 | 76 | 69 | 72 | 66 | 66 | 59 |
| | 9.0 | 10.0 | 11.1 | 7.4 | 7.7 | 5.0 | 5.6 | 3.3 | 3.6 | 3.5 | 2.4 | 3.0 | 3.3 | 6.5 |

† Not accessible due to snow and ice

TABLE 4

1987 UPPER ASSABET RIVER SURVEY

FIVE-DAY BIOCHEMICAL OXYGEN DEMAND DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/7* | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1** | 9/2** | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 1.2 | 4.2 | 2.7 | 3.0 | 3.0 | 6.9 | 6.0 | 5.7 | -- | -- | -- | 4.2 |
| AS02 | -- | -- | -- | -- | -- | 6.6 | 3.6 | 2.1 | 3.3 | 2.4 | 1.8 | 2.1 |
| AS04 | 3.3 | 6.0 | -- | 4.2 | 7.8 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 23 | 14 | 3.0 | 8.7 | 9.6 | 6.3 | 3.6 | 2.7 | 3.0 | 2.1 | 2.1 | 1.2 |
| AS06 | 10 | 9.9 | -- | *** | 6.9 | 6.4 | 3.3 | 2.7 | 3.3 | 2.4 | 1.8 | 1.5 |
| AS07 | 15 | 9.0 | 2.1 | 3.6 | 5.4 | 6.3 | 3.3 | 2.7 | 0.9 | 2.4 | 1.5 | 2.7 |
| AS09 | 5.1 | 6.0 | -- | 2.4 | 3.9 | 4.8 | 1.8 | 1.2 | 1.5 | 1.8 | 1.8 | 1.2 |
| AS10 | 3.6 | 6.0 | 2.7 | 2.4 | 1.2 | 9.0 | 4.2 | 4.2 | 6.2 | 3.9 | 3.3 | 1.8 |

* Sampled after very heavy rains and flooding conditions

** Composite sample

*** Broken bottle

TABLE 5

1987 UPPER ASSABET RIVER SURVEY

pH DATA (Standard Units)

| STATION NUMBER | 2/18 | 3/17 | 4/7* | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1** | 9/2** | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 6.5 | -- | 6.2 | 6.9 | -- | 7.1 | 7.0 | 7.2 | -- | -- | -- | 6.9 |
| AS02 | -- | -- | -- | -- | -- | 7.7 | 7.5 | 7.5 | 7.6 | 7.6 | 7.4 | 7.4 |
| AS04 | 7.0 | -- | -- | 6.8 | 3.4 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 7.3 | -- | 5.8 | 6.8 | -- | 7.2 | 7.0 | 6.9 | 7.3 | 7.1 | 7.1 | 7.4 |
| AS06 | 6.8 | -- | -- | *** | -- | 7.0 | 7.0 | 6.9 | 7.1 | 7.1 | 7.0 | 7.4 |
| AS07 | 6.9 | -- | 5.9 | 6.7 | -- | 7.0 | 6.9 | 6.9 | 7.0 | 7.2 | 6.9 | 7.4 |
| AS09 | 6.9 | -- | -- | 6.6 | -- | 7.2 | 7.1 | 7.0 | 7.1 | 7.3 | 7.1 | 7.3 |
| AS10 | 6.8 | -- | 5.9 | 6.6 | -- | 7.0 | 6.9 | 6.9 | 6.9 | 7.1 | 7.0 | 7.3 |

* Sampled after very heavy rains and flooding conditions

** Composite sample

*** Broken bottle

TABLE 6

1987 UPPER ASSABET RIVER SURVEY

TOTAL ALKALINITY DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/7* | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1** | 9/2** | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 15 | 16 | 9.0 | 11 | 10 | 30 | 32 | 17 | -- | -- | -- | 19 |
| AS02 | -- | -- | -- | -- | -- | 46 | 47 | 49 | 32 | 34 | 34 | 20 |
| AS04 | 46 | 26 | -- | 13 | 27 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 50 | 30 | 8.0 | 18 | -- | 41 | 42 | 28 | 43 | 24 | 29 | 26 |
| AS06 | 39 | 26 | -- | *** | 29 | 41 | 47 | 28 | 46 | 27 | 27 | 28 |
| AS07 | 48 | 28 | 9.0 | 18 | 32 | 37 | 47 | 26 | 39 | 29 | 26 | 29 |
| AS09 | 35 | 23 | -- | 15 | 26 | 31 | 32 | 26 | 34 | 25 | 26 | 20 |
| AS10 | 37 | 21 | 8.0 | 15 | 27 | 42 | 44 | 37 | 39 | 36 | 31 | 25 |

* Sampled after very heavy rains and flooding conditions
** Composite sample
*** Broken bottle

TABLE 7

1987 UPPER ASSABET RIVER SURVEY

TOTAL HARDNESS DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1* | 9/2* | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 24 | 32 | 18 | 75 | 39 | 35 | 24 | -- | -- | -- | 17 |
| AS02 | -- | -- | -- | -- | 53 | 47 | 62 | 37 | 37 | 39 | 16 |
| AS04 | 29 | 29 | 19 | 31 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 49 | 23 | 24 | 39 | 67 | 62 | 58 | 62 | 49 | 49 | 29 |
| AS06 | 52 | 31 | 23 | 34 | 67 | 57 | 54 | 64 | 49 | 39 | -- |
| AS07 | 48 | 15 | 23 | 34 | 64 | 57 | 68 | 62 | 48 | 49 | 25 |
| AS09 | 42 | 14 | 20 | 34 | 57 | 57 | 56 | 61 | 44 | 45 | 24 |
| AS10 | 37 | 16 | 25 | 39 | 56 | 51 | 63 | 57 | 44 | 43 | 24 |

* Composite sample

TABLE 8

1987 UPPER ASSABET RIVER SURVEY

SUSPENDED SOLIDS DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/7* | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1** | 9/2** | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 0.5 | 2.5 | 0.0 | 6.0 | 6.0 | 8.0 | 20 | 12 | -- | -- | -- | 8.5 |
| AS02 | -- | -- | -- | -- | -- | 4.0 | 3.5 | 6.0 | 0.0 | 5.0 | 2.0 | 9.0 |
| AS04 | 8.5 | 6.5 | -- | 5.0 | 7.0 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 27 | 25 | 0.0 | 12.0 | 21.0 | 3.5 | 2.5 | 2.5 | 2.5 | 3.0 | 3.5 | 2.5 |
| AS06 | 20 | 11 | -- | *** | 7.0 | 3.0 | 2.0 | 2.5 | 1.5 | 5.0 | 2.0 | 3.5 |
| AS07 | 11 | 5.0 | 0.0 | 6.0 | 14.0 | 1.0 | 2.0 | 1.5 | 0.0 | 2.5 | 0.0 | 1.5 |
| AS09 | 3.0 | 5.0 | -- | 6.0 | 21.0 | 1.5 | 0.5 | 1.5 | 0.5 | 2.5 | 0.5 | 3.5 |
| AS10 | 4.5 | 5.0 | 0.0 | 6.0 | 19.0 | 2.0 | 2.5 | 2.5 | 9.0 | 2.5 | 1.5 | 4.5 |

* Sampled after very heavy rains and flooding conditions
** Composite sample
*** Broken bottle

TABLE 9

1987 UPPER ASSABET RIVER SURVEY

TOTAL SOLIDS DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/7* | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1** | 9/2** | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 100 | 160 | 84 | 100 | 92 | 94 | 120 | 94 | -- | -- | -- | 100 |
| AS02 | -- | -- | -- | -- | -- | 130 | 150 | 150 | 110 | 140 | 170 | 110 |
| AS04 | 180 | 200 | -- | 150 | 140 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 280 | 230 | 90 | 140 | 240 | 330 | 330 | 270 | 330 | 320 | 340 | 190 |
| AS06 | 220 | 230 | -- | *** | 160 | 310 | 330 | 290 | 350 | 270 | 300 | 200 |
| AS07 | 240 | 200 | 98 | 160 | 160 | 280 | 310 | 290 | 300 | 270 | 290 | 210 |
| AS09 | 180 | 200 | -- | 140 | 160 | 210 | 250 | 240 | 270 | 220 | 230 | 190 |
| AS10 | 200 | 210 | 100 | 140 | 170 | 230 | 270 | 260 | 290 | 250 | 280 | 200 |

* Sampled after very heavy rains and flooding conditions
** Composite sample
*** Broken bottle

TABLE 10

1987 UPPER ASSABET RIVER SURVEY

TOTAL KJELDAHL-NITROGEN DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1* | 9/2* | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 1.2 | 0.65 | 1.4 | 0.79 | 0.89 | 1.3 | 1.9 | -- | -- | -- | 1.1 |
| AS02 | -- | -- | -- | -- | 0.55 | 0.93 | 1.4 | 0.80 | 1.3 | 1.5 | 0.94 |
| AS04 | 4.2 | 1.7 | 1.4 | 2.5 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 4.4 | 3.2 | 1.9 | 3.8 | 2.0 | 2.2 | 1.9 | 0.82 | 1.1 | 1.7 | 0.80 |
| AS06 | 2.6 | 1.9 | 1.8 | 1.9 | 2.1 | 2.4 | 2.0 | 0.90 | 1.1 | 1.4 | 0.90 |
| AS07 | 4.0 | 1.5 | 1.0 | 2.2 | 1.8 | 2.2 | 2.0 | 1.0 | 0.80 | 1.0 | 0.78 |
| AS09 | 2.7 | 1.1 | 0.62 | 1.9 | 1.8 | 1.0 | 1.2 | 0.59 | 0.72 | 0.90 | 0.64 |
| AS10 | 3.6 | 1.4 | 0.68 | 2.8 | 2.4 | 2.3 | 2.4 | 1.4 | 2.9 | 2.2 | 1.4 |

* Composite sample

TABLE 11

1987 UPPER ASSABET RIVER SURVEY

AMMONIA-NITROGEN DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1* | 9/2* | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 0.21 | 0.15 | 0.06 | 0.09 | 0.06 | 0.06 | 0.02 | -- | -- | -- | 0.10 |
| AS02 | -- | -- | -- | -- | 0.55 | 0.05 | 0.1 | <0.02 | 0.05 | 0.02 | 0.05 |
| AS04 | 4.1 | 1.0 | 0.17 | 2.1 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 3.8 | 1.4 | 0.45 | 2.3 | 0.57 | 0.42 | 0.20 | 0.15 | 0.10 | 0.10 | 0.07 |
| AS06 | 2.5 | 1.0 | 0.38 | 1.3 | 2.1 | 0.68 | 0.30 | 0.23 | 0.15 | 0.14 | 0.11 |
| AS07 | 3.7 | 0.85 | 0.41 | 1.7 | 1.8 | 0.89 | 0.32 | 0.30 | 0.13 | 0.13 | 0.11 |
| AS09 | 2.5 | 0.58 | 0.20 | 1.0 | 1.8 | 0.06 | 0.04 | 0.02 | 0.04 | 0.03 | 0.06 |
| AS10 | 3.1 | 0.80 | 0.21 | 1.2 | 1.6 | 0.10 | 1.4 | 0.52 | 1.4 | 1.2 | 0.53 |

* Composite sample

TABLE 12

1987 UPPER ASSABET RIVER SURVEY

NITRATE-NITROGEN DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1* | 9/2* | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 0.5 | 0.7 | 0.7 | 0.8 | 0.2 | 0.1 | 0.1 | -- | -- | -- | 0.1 |
| AS02 | -- | -- | -- | -- | 0.8 | 0.8 | 1.0 | <0.1 | 0.5 | 0.5 | 0.2 |
| AS04 | 0.4 | 0.7 | 0.6 | 0.3 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 0.6 | 0.9 | 0.7 | 0.4 | 0.8 | 10.0 | 9.2 | 2.3 | 11 | 9.6 | 1.4 |
| AS06 | 0.8 | 0.8 | 0.7 | 0.5 | 1.0 | 8.1 | 10 | 2.5 | 8.4 | 7.8 | 1.5 |
| AS07 | 0.7 | 0.9 | 0.8 | 0.5 | 1.2 | 8.4 | 11 | 2.2 | 7.2 | 7.3 | 2.1 |
| AS09 | 0.7 | 0.8 | 0.6 | 0.7 | 1.2 | 6.9 | 6.4 | 1.8 | 4.1 | 4.9 | 1.6 |
| AS10 | 0.9 | 0.8 | 0.6 | 0.7 | 5.4 | 2.8 | 4.0 | 1.5 | 3.4 | 3.7 | 1.5 |

* Composite sample

TABLE 13

1987 UPPER ASSABET RIVER SURVEY

TOTAL PHOSPHORUS DATA (mg/1)

| STATION NUMBER | 2/18 | 3/17 | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1* | 9/2* | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | 0.05 | 0.04 | 0.08 | 0.06 | 0.05 | 0.08 | 0.28 | -- | -- | -- | 0.08 |
| AS02 | -- | -- | -- | -- | 0.04 | 0.07 | 0.26 | 0.04 | 0.50 | 0.07 | 0.09 |
| AS04 | 0.43 | 0.22 | 0.13 | 0.54 | -- | -- | -- | -- | -- | -- | -- |
| AS05 | 2.0 | 0.80 | 0.27 | 0.75 | 3.8 | 3.3 | 2.3 | 3.5 | 3.3 | 2.1 | 0.57 |
| AS06 | 2.5 | 0.58 | 0.30 | 0.44 | 3.8 | 3.2 | 2.6 | 4.6 | 3.1 | 1.9 | 0.79 |
| AS07 | 3.0 | 0.49 | 0.32 | 3.04 | 3.0 | 3.2 | 2.5 | 3.4 | 2.9 | 1.6 | 0.80 |
| AS09 | 0.83 | 0.36 | 0.22 | 0.44 | 1.0 | 2.0 | 1.8 | 2.5 | 1.5 | 1.5 | 0.50 |
| AS10 | 1.5 | 0.34 | 0.25 | 2.29 | 2.2 | 2.7 | 2.8 | 2.1 | 4.4 | 2.0 | 0.58 |

* Composite sample

TABLE 14

1987 UPPER ASSABET RIVER SURVEY

CHLORIDE DATA (mg/l)

| STATION NUMBER | 2/18 | 3/17 | 5/13 | 7/22 | 7/23 | 9/1* | 9/2* | 9/23 |
|---|---|---|---|---|---|---|---|---|
| AS01 | 22 | 28 | 20 | 25 | 25 | -- | -- | 21 |
| AS02 | -- | -- | -- | 35 | 34 | 30 | 30 | 23 |
| AS04 | 44 | 39 | 33 | -- | -- | -- | -- | -- |
| AS05 | 85 | 50 | 50 | 97 | 87 | 75 | 84 | 46 |
| AS06 | 62 | 50 | 40 | 89 | 87 | 69 | 75 | 46 |
| AS07 | 67 | 47 | 39 | 75 | 86 | 65 | 70 | 50 |
| AS09 | 50 | 44 | 36 | 64 | 67 | 58 | 60 | 40 |
| AS10 | 60 | 50 | 41 | 71 | 74 | 68 | 71 | 43 |

* Composite sample

TABLE 15

1987 UPPER ASSABET RIVER SURVEY

FECAL COLIFORM BACTERIA DATA (organisms/100 ml)

| STATION NUMBER | 2/18 | 3/17 | 4/8 | 4/16 | 5/13 | 7/22 | 7/23 | 8/5 | 8/20 | 9/1 | 9/2 | 9/23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AS01 | <5 | <5 | -- | <5 | <5 | <5 | <5 | -- | -- | -- | -- | <10 |
| AS02 | -- | -- | -- | -- | -- | 440 | 580 | 900 | 16 | 1300 | * | 120 |
| AS04 | <5 | 20 | -- | <5 | <5 | -- | -- | -- | -- | -- | * | -- |
| AS05 | 1,200 | 10,000 | 2,600 | 1,600 | 10,000 | 180 | 280 | 300 | 440 | 360 | 240 | 190 |
| AS06 | 160 | 5,600 | -- | 450 | 6,000 | 260 | 120 | 420 | 600 | 320 | 400 | 130 |
| AS07 | 1,900 | 2,800 | 1,600 | 30 | 6,000 | 200 | 440 | 340 | 80 | -- | 100 | 140 |
| AS09 | 200 | 1,800 | -- | 300 | 2,000 | 40 | 120 | 160 | 120 | 160 | 140 | 1,000 |
| AS10 | <5 | 500 | 440 | 1,200 | <20 | <5 | 1,200 | <5 | 100 | 5 | 200 | 10 |

* Broken bottle

TABLE 16

1987 UPPER ASSABET RIVER SURVEY

TOTAL METALS DATA (mg/l)

| STATION NUMBER | Al | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| 2-18-87 | | | | | | | | | | |
| AS05 | 0.24 | 0.02 | <0.03 | <0.02 | 0.60 | <0.0002 | 0.14 | <0.03 | <0.05 | 0.10 |
| AS07 | 0.19 | <0.02 | <0.03 | <0.02 | 0.52 | <0.0002 | 0.13 | <0.03 | <0.05 | 0.08 |
| 6-24-87 | | | | | | | | | | |
| AS02 | <0.10 | 0.01 | <0.02 | <0.02 | 0.59 | - | - | <0.03 | <0.05 | 0.18 |
| AS05 | <0.10 | <0.01 | <0.02 | <0.02 | 0.61 | - | - | <0.03 | <0.05 | 0.07 |
| AS06 | <0.10 | <0.01 | <0.02 | <0.02 | 0.56 | - | - | <0.03 | <0.05 | 0.09 |
| AS07 | <0.10 | <0.01 | <0.02 | <0.02 | 0.59 | - | - | <0.03 | <0.05 | 0.07 |
| AS09 | <0.10 | <0.01 | <0.02 | <0.02 | 0.77 | - | - | <0.03 | <0.05 | 0.04 |
| AS10 | <0.10 | <0.01 | <0.02 | <0.02 | 0.60 | - | - | 0.07 | <0.05 | 0.05 |
| 7-22-87 | | | | | | | | | | |
| AS02 | <0.10 | <0.001 | <0.002 | <0.002 | 0.40 | 0.0006 | 0.12 | <0.015 | <0.002 | 0.007 |
| AS05 | 0.10 | <0.001 | <0.002 | 0.03 | 0.22 | 0.0007 | 0.10 | <0.015 | <0.002 | 0.06 |
| AS06 | 0.12 | <0.001 | <0.002 | 0.02 | 0.19 | 0.0005 | 0.07 | <0.015 | <0.002 | 0.05 |
| AS07 | <0.10 | <0.001 | 0.003 | 0.02 | 0.18 | 0.0003 | 0.21 | <0.015 | <0.002 | 0.05 |
| AS09 | <0.10 | <0.001 | <0.002 | 0.006 | 0.30 | <0.0002 | 0.02 | 0.015 | <0.002 | 0.006 |
| AS10 | <0.10 | <0.001 | <0.002 | 0.007 | 0.31 | <0.0002 | 0.08 | 0.015 | <0.002 | 0.03 |
| 9-1-87 | | | | | | | | | | |
| AS02 | 0.38 | 0.001 | 0.004 | 0.004 | 0.84 | <0.0002 | 0.25 | 0.014 | 0.006 | 0.02 |
| AS05 | 0.17 | 0.006 | 0.006 | 0.032 | 0.20 | <0.0002 | 0.05 | 0.007 | 0.008 | 0.03 |
| AS06 | 0.13 | 0.003 | 0.007 | 0.028 | 0.28 | <0.0002 | 0.11 | 0.012 | 0.01 | 0.04 |
| AS07 | 0.14 | 0.022 | 0.007 | 0.021 | 0.20 | <0.0002 | 0.04 | 0.007 | 0.007 | 0.11 |
| AS09 | <0.10 | <0.001 | 0.005 | 0.007 | 0.22 | <0.0002 | 0.04 | 0.006 | 0.006 | 0.02 |
| AS10 | <0.10 | <0.001 | 0.009 | 0.009 | 0.27 | <0.0002 | 0.04 | 0.13 | 0.006 | 0.02 |

UPPER ASSABET RIVER BASIN

FLOW DATA

TABLE 17

1987 UPPER ASSABET RIVER SURVEY

U.S.G.S. Gage at Maynard

Flow Data

| DATE | DISCHARGE (cfs) |
|---|---|
| 2/18/87 | 123 |
| 3/17/87 | 306 |
| 4/16/87 | 667 |
| 5/13/87 | 239 |
| 6/10/87 | 83 |
| 6/24/87 | 70 |
| 7/22/87 | 28 |
| 7/23/87 | 28 |
| 8/5/87 | 31 |
| 8/20/87 | 18 |
| 9/1/87 | 43 |
| 9/2/87 | 26 |
| 9/23/87 | 151 |
| 11/11/86 | 131 |
| 7/17/85 | 41 |
| 8/8/79 | 34 |
| 8/9/79 | 27 |

1. 1987 figures are provisional measurements made by U.S.G.S. at their automated gaging station.

# ASSABET RIVER

# WATER QUALITY SAMPLING DATA

TABLE 18

1987 ASSABET RIVER SURVEY

COMPOSITE VS. GRAB SAMPLE COMPARISON
(units of mg/l unless otherwise noted)

| DATE | STATION | COMPOSITE/GRAB | COMPOSITE/GRAB | COMPOSITE/GRAB |
|---|---|---|---|---|
| | | $BOD_5$ | pH (St. units) | ALKALINITY |
| 7/22/87 | AS09 | 6.6/4.8 | 7.2/7.3 | 31/30 |
| | AS10 | 9.0/14 | 7.0/7.2 | 42/44 |
| | AS11 | 4.8/6.0 | 7.0/7.0 | 30/28 |
| | AS13 | 6.0/5.1 | 7.1/7.1 | 31/31 |
| | AS14 | 5.4/6.0 | 7.3/7.5 | 35/32 |
| | | HARDNESS | SUSP. SOLIDS | TOTAL SOLIDS |
| 7/22/87 | AS09 | 79/55 | 1.5/2.0 | 230/210 |
| | AS10 | 56/59 | 2.0/3.5 | 230/240 |
| | AS11 | 44/44 | 1.0/1.0 | 220/210 |
| | AS13 | 46/44 | 1.5/1.5 | 220/210 |
| | AS14 | 59/54 | 2.0/4.5 | 210/210 |
| | | TKN | $NH_3$-N | T. PHOSPHORUS |
| 7/22/87 | AS09 | 0.95/1.1 | 0.95/1.0 | 1.8/1.8 |
| | AS10 | 2.4/2.2 | 1.6/1.8 | 2.2/2.0 |
| | AS11 | 1.4/0.72 | 0.28/0.04 | 1.7/1.6 |
| | AS13 | 1.2/1.6 | 0.10/0.09 | 0.94/1.3 |
| | AS14 | 0.90/1.1 | 0.21/0.10 | 0.80/0.78 |
| | | $BOD_5$ | pH (St. units) | ALKALINITY |
| 7/23/87 | AS17 | 3.0/2.4 | 7.0/7.0 | 30/30 |
| | AS18 | 2.7/2.7 | 7.1/7.1 | 34/30 |
| | AS19 | 3.0/3.0 | 7.2/7.2 | 33/34 |
| | AS20 | 2.4/3.6 | 7.2/7.2 | 31/33 |
| | | HARDNESS | SUSP. SOLIDS | TOTAL SOLIDS |
| 7/23/87 | AS17 | 51/59 | 1.0/0.5 | 260/250 |
| | AS18 | 50/52 | 9.0/1.5 | 220/230 |
| | AS19 | 49/52 | 3.5/2.0 | 200/210 |
| | AS20 | 44/47 | 4.5/1.0 | 180/190 |
| | | TKN | $NH_3$-N | T. PHOSPHORUS |
| 7/23/87 | AS17 | 0.80/1.2 | 0.06/0.13 | 1.0/1.0 |
| | AS18 | 0.80/0.69 | 0.09/0.05 | 1.0/0.97 |
| | AS19 | 0.79/0.64 | 0.05/0.02 | 0.73/0.71 |
| | AS20 | 0.99/0.69 | 0.04/0.07 | 0.62/0.56 |

TABLE 19

1987 ASSABET RIVER SURVEY

Time (hr/min) - TEMPERATURE (°F) - DISSOLVED OXYGEN (mg/l)

| STATION NUMBER | | JULY 22 RUN 1 | JULY 22 RUN 2 | JULY 22 RUN 3 | JULY 23 RUN 4 | JULY 23 RUN 5 | JULY 23 RUN 6 |
|---|---|---|---|---|---|---|---|
| AS02 | * | 0400 | 1012 | 1934 | 0415 | 957 | 1949 |
| | ** | 64 | 68 | 73 | 65 | 68 | 77 |
| | *** | 7.5 | 8.2 | 7.1 | 6.6 | 7.0 | 6.9 |
| AS05 | | 0415 | 1023 | 1946 | 0430 | 1048 | 1959 |
| | | 75 | 68 | 75 | 66 | 75 | 79 |
| | | 3.7 | 3.2 | 5.8 | 3.9 | 5.3 | 5.9 |
| AS06 | | 0430 | 1035 | 2000 | 0445 | 1104 | 2008 |
| | | 68 | 68 | 76 | 68 | 69 | 76 |
| | | 3.0 | 2.8 | 3.8 | 3.4 | 8.0 | 3.6 |
| AS07A† | | 0445 | 1048 | 2011 | 0450 | 1117 | 2017 |
| | | 70 | 70 | 75 | 70 | 74 | 75 |
| | | 2.3 | 2.2 | 2.7 | 2.5 | 2.7 | 2.5 |
| AS07B† | | 0445 | - | 2011 | 0450 | 1122 | 2021 |
| | | 70 | - | 75 | 75 | 74 | 75 |
| | | 6.4 | - | 5.9 | 6.5 | 7.8 | 5.6 |
| AS09 | | 0500 | 1110 | 2029 | 0500 | 1133 | 2027 |
| | | 66/66 | 70 | 75 | 67/67 | 72 | 76 |
| | | 3.6/3.6 | 8.8 | 8.0 | 3.7/3.5 | 8.8 | 8.1 |
| AS10 | | 0505 | 1122 | 2043 | 0510 | 1150 | 2037 |
| | | 67 | 72 | 74 | 68 | 76 | 74 |
| | | 2.9 | 3.3 | 4.7 | 2.8 | 3.6 | 4.6 |
| AS11 | | 0520 | 1135 | 2100 | 0520 | 1205 | 2048 |
| | | 67 | 71 | 73 | 68 | 76 | 75 |
| | | 0.9 | 4.8 | 4.9 | 1.0 | 4.6 | 5.0 |
| AS13 | | 0530 | 1150 | 2115 | 0530 | 1217 | 2100 |
| | | 68 | 71 | 73 | 65 | 77 | 75 |
| | | 1.7 | 4.2 | 6.1 | 2.2 | 4.0 | 6.0 |
| AS14 | | 0540 | 1159 | 2130 | 0535 | 1228 | 2109 |
| | | 68 | 72 | 74 | 68 | 79 | 78 |
| | | 4.3 | 5.4 | 8.2 | 5.4 | 6.1 | 8.3 |

* Time
** Temperature
*** Dissolved Oxygen
† "A" indicates above dam, "B" indicates below dam

TABLE 19 (Continued)

| STATION NUMBER | JULY 22 RUN 1 | RUN 2 | RUN 3 | JULY 23 RUN 4 | RUN 5 | RUN 6 |
|---|---|---|---|---|---|---|
| AS16 | 0555 | 1233 | 2150 | 0545 | 1242 | 2120 |
| | 74 | 74 | 73 | 70 | 79 | 76 |
| | 5.2 | 8.3 | 8.6 | 4.3 | 7.4 | 8.9 |
| AS17 | 0605 | 1249 | 2150 | 0555 | 1307 | 2131 |
| | 69 | 72 | 72 | 70 | 81 | 74 |
| | 6.5 | 8.9 | 5.6 | 6.3 | 7.8 | 5.2 |
| AS18 | 0615 | 1259 | 2213 | 0600 | 1318 | 2143 |
| | 70 | 73 | 73 | 71 | 82 | 75 |
| | 5.3 | 7.7 | 6.8 | 6.1 | 7.8 | 7.1 |
| AS19 | 0630 | 1317 | 2234 | 0615 | 1334 | 2200 |
| | 70 | 79 | 73 | 70 | 82 | 76 |
| | 6.5 | 6.8 | 8.2 | 6.7 | 6.7 | 7.4 |
| AS20 | 0700 | 1332 | - | 0645 | 1349 | 2226 |
| | 68 | 73 | - | 72 | 78 | 75 |
| | 7.0 | 8.8 | - | 6.5 | 8.7 | 6.3 |
| AS21 | 0710 | 1350 | 2315 | 0650 | 1401 | 2241 |
| | 70 | 73 | 74 | 72 | 83 | 77 |
| | 7.1 | 7.9 | 8.6 | 7.9 | 8.8 | 8.8 |
| AS22 | 0715 | 1400 | 2326 | 0700 | 1410 | 2247 |
| | 70 | 75 | 71 | 70 | 76 | 73 |
| | 6.6 | 6.7 | 5.4 | 6.6 | 6.7 | 5.3 |
| AS24 | 0730 | 1415 | 2336 | 0705 | 1421 | 2255 |
| | 66 | 72 | 71 | 68 | 76 | 74 |
| | 4.6 | 9.6 | 5.3 | 5.3 | 9.4 | 5.3 |
| AS25 | 0740 | 1426 | 2355 | 0715 | 1435 | 2311 |
| | 67 | 79 | 71 | 68 | 79 | 76 |
| | 5.1 | 10.1 | 5.8 | 5.9 | - | 6.8 |
| SU15 | 0800 | 1440 | 0006 | 0725 | 1453 | 2323 |
| | 70 | 79 | 75 | 73 | 82 | 77 |
| | 7.2 | 8.4 | 8.4 | 7.2 | 8.4 | 8.2 |
| CO01 | 0750 | 1450 | 0018 | 0730 | 1502 | 2335 |
| | 71 | 81 | 73 | 72 | 79 | 75 |
| | 7.1 | 8.3 | 7.5 | 6.7 | 7.9 | 7.6 |

TABLE 20

1987 ASSABET RIVER SURVEY

Time (hr/min) - TEMPERATURE (°F) - DISSOLVED OXYGEN (mg/l)

| STATION NUMBER | | SEPTEMBER 1 RUN 1 | SEPTEMBER 1 RUN 2 | SEPTEMBER 2 RUN 3 | SEPTEMBER 2 RUN 4 |
|---|---|---|---|---|---|
| AS02 | * | 0445 | 1500 | 0450 | 1510 |
| | ** | 64 | 66 | 59 | 68 |
| | *** | 5.7 | 9.0 | 7.6 | 9.0 |
| AS05 | | 0510 | 1510 | 0510 | 1520 |
| | | 66 | 72 | 64 | 72 |
| | | 5.9 | 8.1 | 6.0 | 8.0 |
| AS06 | | 0520 | 1525 | 0520 | 1530 |
| | | 66/66 | 68/68 | 64/64 | 68 |
| | | 6.0/6.1 | 7.0/6.9 | 5.9/5.5 | 7.1 |
| AS07A | | 0545 | 1535 | 0540 | 1542 |
| | | 66 | 68 | 64 | 68 |
| | | 4.8 | 7.2 | 4.6 | 7.1 |
| AS07B | | 0545 | - | 0540 | 1542 |
| | | 66 | - | 66 | 68 |
| | | 7.1 | - | 6.9 | 8.3 |
| AS09 | | 0620 | 1545 | 0550 | 1559 |
| | | 64 | 68 | 64 | 68 |
| | | 5.5 | 9.5 | 5.2 | 9.3 |
| AS10 | | 0630 | 1550 | 0555 | 1610 |
| | | 66 | 66 | 66 | 66 |
| | | 3.0 | 5.5 | 3.3 | 5.5 |
| AS11 | | 0645 | 1600 | 0610 | 1620 |
| | | 64 | 66 | 66 | 66 |
| | | 1.9 | 7.5 | 2.0 | 7.3 |
| AS13 | | 0700 | 1610 | 0620 | 1631 |
| | | 64 | 66 | 66 | 66 |
| | | 5.1 | 4.9 | 5.0 | 5.1 |
| AS14 | | 0710 | 1620 | 0630 | 1642 |
| | | 64 | 68 | 66 | 68 |
| | | 5.9 | 6.8 | 7.0 | 6.9 |

* Time
** Temperature
*** Dissolved Oxygen

TABLE 20 (Continued)

| STATION NUMBER | | SEPTEMBER 1 RUN 1 | RUN 2 | SEPTEMBER 2 RUN 3 | RUN 4 |
|---|---|---|---|---|---|
| AS16 | * | 0755 | 1630 | 0725 | 1652 |
| | ** | 66 | 66 | 66 | 66 |
| | *** | 2.2 | 8.9 | 2.6 | 8.6 |
| AS17 | | 0805 | 1640 | 0735 | 1700 |
| | | 66 | 68 | 68 | 68 |
| | | 6.8 | 7.7 | 6.8 | 7.6 |
| AS18 | | 0815 | 1655 | 0745 | 1711 |
| | | 66 | 68 | 68 | 68 |
| | | 6.9 | 9.5 | 6.4 | 9.3 |
| AS19 | | 0830 | 1710 | 0800 | 1725 |
| | | 66 | 66 | 68 | 68 |
| | | 5.1 | 6.8 | 6.2 | 6.9 |
| AS20 | | 0850 | 1740 | 0820 | 1745 |
| | | 66/66 | 68/68 | 64/64 | 68 |
| | | 7.4/7.5 | 8.0/8.2 | 7.1/7.5 | 8.0 |
| AS21 | | 0900 | 1750 | 0830 | 1759 |
| | | 66 | 68 | 66 | 67 |
| | | 6.8 | 7.7 | 4.3 | 7.1 |
| AS22 | | 0910 | 1800 | 0840 | 1815 |
| | | 66 | 66 | 68 | 68 |
| | | 7.1 | 7.0 | 7.8 | 7.2 |
| AS24 | | 0920 | 1810 | 0855 | 1825 |
| | | 66 | 68 | 64 | 66 |
| | | 5.8 | 9.4 | 5.9 | 9.0 |
| AS25 | | 0930 | 1820 | 0905 | 1845 |
| | | 66 | 68 | 64 | 66 |
| | | 6.2 | 10.0 | 6.9 | 9.1 |
| SU15 | | 0955 | 1835 | 0920 | 1855 |
| | | 66 | 68 | 68 | 67 |
| | | 7.6 | 8.9 | 5.5 | 8.0 |
| CO01 | | 1005 | 1845 | 0930 | 1900 |
| | | 66 | 66 | 66 | 66 |
| | | 6.3 | 8.9 | 7.3 | 8.7 |

* Time
** Temperature
*** Dissolved Oxygen

TABLE 21

1987 ASSABET RIVER SURVEY

FIVE-DAY BIOCHEMICAL OXYGEN DEMAND DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 6.6 | 3.6 | 5.1 | 2.4 | 1.8 | 2.1 |
| AS05 | 6.3 | 3.6 | 5.0 | 2.1 | 2.1 | 2.1 |
| AS06 | 6.4 | 3.3 | 4.9 | 2.4/2.1 | 1.8/2.7 | 2.3 |
| AS07 | 6.3 | 3.3 | 4.8 | 2.4 | 1.5 | 2.0 |
| AS09 | 4.5/6.6 | 1.8/2.4 | 3.8 | 1.8 | 1.8 | 1.8 |
| AS10 | 9.0 | 4.2 | 6.6 | 3.9 | 3.3 | 3.6 |
| AS11 | 4.8 | 1.5 | 3.2 | 1.5 | 1.2 | 1.4 |
| AS13 | 6.0 | - | - | 1.5 | 1.5 | 1.5 |
| AS14 | 5.4 | - | - | 2.1 | 0.9 | 1.5 |
| AS16 | 5.4 | - | - | 1.5 | 2.4 | 2.0 |
| AS17 | 6.0 | 3.0 | 4.5 | 2.7 | 1.8 | 2.3 |
| AS18 | 4.8 | 2.7 | 3.8 | 2.7 | 0.9 | 1.8 |
| AS19 | 7.8 | 3.0 | 5.4 | 1.2 | 1.2 | 1.2 |
| AS20 | 9.3/5.1 | 2.4/6.0 | 5.7 | 1.8/1.2 | 2.4/1.8 | 1.8 |
| AS21 | 5.7 | 4.2 | 5.0 | 11 | 17 | 14 |
| AS22 | 6.3 | 3.3 | 4.8 | 4.5 | 3.3 | 3.9 |
| AS24 | 4.5 | 3.0 | 3.8 | 1.8 | 1.5 | 1.7 |
| AS25 | 4.8 | 3.0 | 3.9 | 1.8 | 2.1 | 2.0 |
| SU15 | 6.6 | 5.1 | 5.9 | 2.7 | 4.5 | 3.6 |
| CO01 | 4.5 | 3.6 | 4.1 | 3.6 | 2.1 | 2.9 |

TABLE 22

1987 ASSABET RIVER SURVEY

pH DATA - FIELD MEASUREMENTS[1]
(Standard Log. Units)

| STATION NUMBER | JULY 22 RUN 1 | RUN 2 | RUN 3 | JULY 23 RUN 4 | RUN 5 | RUN 6 |
|---|---|---|---|---|---|---|
| AS02 | 6.8 | 7.3 | 6.5 | 6.9 | 7.4 | 6.8 |
| AS05 | 6.5 | 6.8 | 6.4 | 6.3 | 7.0 | 6.9 |
| AS06 | 6.4 | 6.8 | 6.5 | 6.5 | 7.0 | 6.9 |
| AS07 | 6.4 | 6.7 | 6.4 | 7.0 | 7.0 | 6.9 |
| AS09 | 6.6/6.6 | 7.8 | 7.0 | 6.8 | 7.6 | 7.5 |
| AS10 | 8.7 | 6.8 | - | 6.6 | 7.0 | 7.1 |
| AS11 | 6.7 | 6.8 | 6.7 | 6.5 | 9.5 | 7.0 |
| AS13 | 6.7 | 6.7 | 6.8 | 6.4 | (2) | 7.0 |
| AS14 | 6.5 | 7.2 | 7.2 | 6.4 | (2) | 7.5 |
| AS16 | 6.7 | 7.9 | 7.2 | 6.6 | (2) | 7.5 |
| AS17 | 6.8 | 7.4 | 7.1 | 6.6 | (2) | 7.3 |
| AS18 | 6.9 | 7.3 | 7.1 | 6.7 | (2) | 6.9 |
| AS19 | 6.8 | 7.2 | 7.2 | 6.6 | (2) | 7.1 |
| AS20 | 6.9/6.9 | 8.1 | 7.3 | 6.4 | (2) | 7.3 |
| AS21 | 7.0 | 7.4 | 7.5 | 6.8 | (2) | 7.6 |
| AS22 | 7.1 | 7.0 | 7.7 | 6.7 | (2) | 7.1 |
| AS24 | 7.1 | 7.6 | 7.3 | 6.9 | (2) | 7.2 |
| AS25 | 6.5 | 7.9 | 7.2 | 6.6 | (2) | 7.3 |
| SU15 | 7.0 | 7.9 | 7.5 | 6.8 | (2) | 7.5 |
| CO01 | 6.5 | 7.6 | 7.0 | 6.7 | (2) | 7.4 |

(1) Grab samples - measured in field
(2) Meter malfunction

TABLE 23

1987 ASSABET RIVER SURVEY

pH DATA - FIELD MEASUREMENTS[1]
(Standard Log. Units)

| STATION NUMBER | SEPTEMBER 1 RUN 1 | RUN 2 | SEPTEMBER 2 RUN 3 |
|---|---|---|---|
| AS02 | 7.1 | 6.7 | 6.5 |
| AS05 | 6.9 | 6.4 | 6.6 |
| AS06 | 6.7/6.8 | 6.6/6.6 | 6.6 |
| AS07 | 6.8 | 6.9 | 6.8 |
| AS09 | 6.8 | 7.1 | 6.7 |
| AS10 | 6.6 | 7.0 | 6.7 |
| AS11 | 6.5 | 7.0 | 6.6 |
| AS13 | 6.6 | 7.0 | 6.7 |
| AS14 | 6.7 | 6.9 | 6.8 |
| AS16 | 6.6 | 7.0 | 6.8 |
| AS17 | 6.7 | 7.0 | 6.5 |
| AS18 | 6.9 | 7.2 | 6.7 |
| AS19 | 6.7 | 7.3 | 6.8 |
| AS20 | 6.8/6.8 | 7.3/7.3 | 7.1 |
| AS21 | 6.9 | 7.3 | 7.0 |
| AS22 | 6.8 | 7.3 | 6.9 |
| AS24 | 6.9 | 7.4 | 6.9 |
| AS25 | 7.0 | 7.5 | 6.8 |
| SU15 | 7.1 | 7.4 | 6.9 |
| CO01 | 7.0 | 7.4 | 6.9 |

1 Grab samples - measured in field

TABLE 24

1987 ASSABET RIVER SURVEY

pH DATA - LABORATORY MEASUREMENTS[1]
(Standard Log. Units)

| STATION NUMBER | 7/22 | 7/23 | 9/1 | 9/2 |
|---|---|---|---|---|
| AS02 | 7.7 | 7.5 | 7.6 | 7.4 |
| AS05 | 7.2 | 7.0 | 7.1 | 7.1 |
| AS06 | 7.0 | 7.0 | 7.1/7.1 | 7.0/7.1 |
| AS07 | 7.0 | 6.9 | 7.2 | 6.9 |
| AS09 | 7.2/7.2 | 7.1/7.1 | 7.3 | 7.1 |
| AS10 | 7.0 | 6.9 | 7.1 | 7.0 |
| AS11 | 4.8 | 6.9 | 7.1 | 7.5 |
| AS13 | 7.1 | - | 7.0 | 7.5 |
| AS14 | 7.3 | - | 7.2 | 7.3 |
| AS16 | 7.4 | - | 7.4 | 7.5 |
| AS17 | 7.4 | 7.0 | 7.3 | 7.5 |
| AS18 | 7.4 | 7.1 | 7.5 | 7.4 |
| AS19 | 7.4 | 7.2 | 7.6 | 7.4 |
| AS20 | 7.6/7.6 | 7.2/7.2 | 7.6/7.6 | 7.5/7.4 |
| AS21 | 7.5 | 7.5 | 7.4 | 7.0 |
| AS22 | 7.3 | 7.3 | 7.4 | 7.3 |
| AS24 | 7.3 | 7.3 | 7.5 | 7.4 |
| AS25 | 7.3 | 7.4 | 7.6 | 7.4 |
| SU15 | 7.3 | 7.5 | 7.4 | 7.1 |
| CO01 | 7.4 | 7.4 | 7.4 | 7.2 |

1 Composite samples - measured at central lab.

TABLE 25

1987 ASSABET RIVER SURVEY

TOTAL ALKALINITY DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 46 | 47 | 47 | 34 | 34 | 34 |
| AS05 | 41 | 42 | 42 | 24 | 29 | 27 |
| AS06 | 41 | 47 | 44 | 27/27 | 27/27 | 27 |
| AS07 | 37 | 47 | 42 | 29 | 26 | 28 |
| AS09 | 31/31 | 32/31 | 31 | 25 | 26 | 26 |
| AS10 | 42 | 44 | 43 | 36 | 31 | 34 |
| AS11 | 30 | 33 | 32 | 29 | 31 | 30 |
| AS13 | 31 | - | - | 24 | 31 | 28 |
| AS14 | 35 | - | - | 32 | 26 | 29 |
| AS16 | 36 | - | - | 32 | 25 | 29 |
| AS17 | 34 | 30 | 32 | 38 | 36 | 37 |
| AS18 | 36 | 34 | 35 | 36 | 46 | 41 |
| AS19 | 33 | 33 | 33 | 40 | 40 | 40 |
| AS20 | 32/32 | 31/31 | 32 | 40/39 | 39/40 | 40 |
| AS21 | 33 | 32 | 33 | 36 | 40 | 38 |
| AS22 | 31 | 31 | 31 | 38 | 38 | 38 |
| AS24 | 31 | 31 | 31 | 35 | 35 | 35 |
| AS25 | 31 | 31 | 31 | 34 | 35 | 35 |
| SU15 | 33 | 31 | 32 | 26 | 26 | 26 |
| CO01 | 31 | 30 | 31 | 33 | 28 | 31 |

TABLE 26

1987 ASSABET RIVER SURVEY

SUSPENDED SOLIDS DATA (mg/1)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 4.0 | 3.5 | 3.8 | 5.0 | 2.0 | 3.5 |
| AS05 | 3.5 | 2.5 | 3.0 | 3.0 | 3.5 | 3.3 |
| AS06 | 3.0 | 2.0 | 2.4 | 5.0/5.5 | 2.0/1.0 | 3.4 |
| AS07 | 1.0 | 2.0 | 1.5 | 2.5 | 0.0 | 1.3 |
| AS09 | 1.5/1.5 | 0.5/0.5 | 1.0 | 2.5 | 0.5 | 1.2 |
| AS10 | 2.0 | 2.5 | 2.3 | 2.5 | 1.5 | 2.0 |
| AS11 | 1.0 | 1.5 | 1.3 | 0.5 | 0.0 | 0.3 |
| AS13 | 1.5 | - | - | 2.5 | 0.0 | 1.3 |
| AS14 | 2.0 | - | - | 2.0 | 1.0 | 1.5 |
| AS16 | 0.5 | - | - | 3.0 | 1.5 | 2.3 |
| AS17 | 1.0 | 1.0 | 1.0 | 7.0 | 0.5 | 3.8 |
| AS18 | 1.5 | 9.0 | 5.3 | 14 | 0.0 | 7.0 |
| AS19 | 5.0 | 3.5 | 4.3 | 2.5 | 0.0 | 1.3 |
| AS20 | 1.5/20 | 4.5/5.0 | 3.3 | 2.5/2.5 | 1.0/1.0 | 1.4 |
| AS21 | 3.0 | 12 | 7.5 | 11 | 56 | 33.5 |
| AS22 | 2.5 | 2.5 | 2.5 | 6.0 | 1.0 | 3.5 |
| AS24 | 1.0 | 0.0 | 0.5 | 2.5 | 2.0 | 2.3 |
| AS25 | 2.0 | 0.0 | 1.0 | 4.0 | 2.5 | 3.3 |
| SU15 | 6.5 | 7.5 | 7.0 | 11 | 14 | 12.5 |
| CO01 | 7.0 | 2.5 | 4.8 | 8.5 | 7.0 | 7.8 |

TABLE 27

1987 ASSABET RIVER SURVEY

TOTAL SOLIDS DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 130 | 150 | 140 | 140 | 170 | 155 |
| AS05 | 330 | 330 | 330 | 320 | 340 | 330 |
| AS06 | 310 | 330 | 320 | 270/270 | 300/290 | 283 |
| AS07 | 280 | 310 | 295 | 270 | 290 | 280 |
| AS09 | 210/230 | 250/250 | 235 | 220 | 230 | 225 |
| AS10 | 230 | 270 | 250 | 250 | 280 | 265 |
| AS11 | 220 | 240 | 230 | 230 | 250 | 240 |
| AS13 | 220 | - | - | 220 | 230 | 225 |
| AS14 | 210 | - | - | 250 | 230 | 240 |
| AS16 | 230 | - | - | 260 | 240 | 250 |
| AS17 | 240 | 260 | 250 | 300 | 310 | 305 |
| AS18 | 210 | 220 | 215 | 360 | 280 | 320 |
| AS19 | 210 | 200 | 205 | 280 | 270 | 275 |
| AS20 | 140/150 | 180/180 | 163 | 260/260 | 260/260 | 260 |
| AS21 | 150 | 170 | 160 | 260 | 280 | 270 |
| AS22 | 150 | 170 | 160 | 260 | 230 | 245 |
| AS24 | 170 | 170 | 170 | 260 | 230 | 245 |
| AS25 | 160 | 170 | 165 | 260 | 230 | 245 |
| SU15 | 160 | 170 | 165 | 190 | 150 | 170 |
| CO01 | 160 | 170 | 165 | 210 | 170 | 190 |

TABLE 28

1987 ASSABET RIVER SURVEY

TOTAL HARDNESS DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 53 | 47 | 50 | 37 | 39 | 38 |
| AS05 | 67 | 62 | 65 | 49 | 40 | 45 |
| AS06 | 67 | 57 | 62 | 49/50 | 39/49 | 47 |
| AS07 | 64 | 57 | 61 | 48 | 49 | 49 |
| AS09 | 57/79 | 57/52 | 61 | 44 | 45 | 45 |
| AS10 | 56 | 51 | 54 | 44 | 43 | 44 |
| AS11 | 44 | 51 | 48 | 44 | 45 | 45 |
| AS13 | 46 | - | - | 44 | 45 | 45 |
| AS14 | 59 | - | - | 47 | 48 | 48 |
| AS16 | 54 | - | - | 47 | 50 | 49 |
| AS17 | 58 | 51 | 55 | 40 | 53 | 47 |
| AS18 | 50 | 50 | 50 | 39 | 55 | 47 |
| AS19 | 56 | 49 | 53 | 37 | 49 | 43 |
| AS20 | 42/39 | 44/47 | 43 | 46/46 | 49/52 | 48 |
| AS21 | 42 | 41 | 42 | 47 | 53 | 50 |
| AS22 | 42 | 41 | 42 | 49 | 47 | 48 |
| AS24 | 49 | 44 | 47 | 44 | 47 | 46 |
| AS25 | 42 | 44 | 43 | 49 | 47 | 48 |
| SU15 | 43 | 44 | 44 | 39 | 36 | 38 |
| CO01 | 45 | 44 | 45 | 47 | 38 | 43 |

TABLE 29

1987 ASSABET RIVER SURVEY

TOTAL KJELDAHL-NITROGEN DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 0.55 | 0.93 | 0.74 | 1.3 | 1.5 | 1.4 |
| AS05 | 2.0 | 2.2 | 2.1 | 1.1 | 1.7 | 1.4 |
| AS06 | 2.1 | 2.4 | 2.25 | 1.1/1.3 | 1.4/1.4 | 1.3 |
| AS07 | 1.8 | 2.2 | 2.0 | 0.80 | 1.0 | 0.90 |
| AS09 | 1.8/0.95 | 1.0/1.1 | 1.2 | 0.72 | 0.90 | 0.81 |
| AS10 | 2.4 | 2.3 | 2.4 | 2.9 | 2.2 | 2.55 |
| AS11 | 1.4 | 1.3 | 1.4 | 1.9 | 2.1 | 2.0 |
| AS13 | 1.2 | - | - | 0.70 | 1.6 | 1.15 |
| AS14 | 0.90 | - | - | 2.2 | 1.6 | 1.9 |
| AS16 | 0.93 | - | - | 1.5 | 1.5 | 1.5 |
| AS17 | 0.77 | 0.80 | 0.79 | 1.4 | 1.4 | 1.4 |
| AS18 | 0.70 | 0.80 | 0.75 | 0.94 | 1.6 | 1.27 |
| AS19 | 0.81 | 0.79 | 0.80 | 0.57 | 1.1 | 0.84 |
| AS20 | 1.4/0.96 | 0.99/0.95 | 1.08 | 0.60/2.0 | 2.0/1.3 | 1.48 |
| AS21 | 1.6 | 1.2 | 1.4 | 2.0 | 3.2 | 2.6 |
| AS22 | 1.3 | 1.2 | 1.3 | 1.2 | 1.5 | 1.35 |
| AS24 | 0.99 | 0.77 | 0.88 | 0.64 | 1.1 | 0.87 |
| AS25 | 1.0 | 0.67 | 0.84 | 1.1 | 1.3 | 1.2 |
| SU15 | 0.60 | 0.57 | 0.59 | 0.46 | 0.70 | 0.58 |
| CO01 | 0.72 | 0.72 | 0.72 | 0.62 | 0.58 | 0.60 |

TABLE 30

1987 ASSABET RIVER SURVEY

AMMONIA-NITROGEN DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 0.55 | 0.05 | 0.30 | 0.05 | 0.02 | 0.04 |
| AS05 | 0.57 | 0.42 | 0.50 | 0.10 | 0.10 | 0.10 |
| AS06 | 0.85 | 0.68 | 0.77 | 0.15/0.16 | 0.14/0.14 | 0.15 |
| AS07 | 1.0 | 0.89 | 0.95 | 0.13 | 0.13 | 0.13 |
| AS09 | 1.0/0.95 | 0.06/0.11 | 0.53 | 0.04 | 0.03 | 0.04 |
| AS10 | 1.6 | 0.10 | 0.85 | 1.4 | 1.2 | 1.3 |
| AS11 | 0.28 | 0.06 | 0.17 | 0.54 | 0.59 | 0.57 |
| AS13 | 0.10 | - | - | 0.06 | 0.24 | 0.15 |
| AS14 | 0.21 | - | - | 0.38 | 0.24 | 0.32 |
| AS16 | 0.05 | - | - | 0.35 | 0.14 | 0.25 |
| AS17 | 0.03 | 0.06 | 0.05 | 0.40 | 0.15 | 0.28 |
| AS18 | 0.04 | 0.09 | 0.07 | 0.22 | 0.19 | 0.21 |
| AS19 | 0.08 | 0.05 | 0.07 | 0.09 | 0.11 | 0.10 |
| AS20 | 0.62/0.04 | 0.04/0.07 | 0.19 | 0.11/0.12 | 0.10/0.06 | 0.10 |
| AS21 | 0.35 | 0.37 | 0.36 | 0.51 | 0.26 | 0.39 |
| AS22 | 0.21 | 0.26 | 0.24 | 0.43 | 0.26 | 0.34 |
| AS24 | 0.12 | 0.17 | 0.15 | 0.10 | 0.02 | 0.06 |
| AS25 | 0.10 | 0.15 | 0.13 | 0.31 | 0.03 | 0.17 |
| SU15 | 0.07 | 0.07 | 0.07 | 0.02 | <0.02 | <0.02 |
| CO01 | 0.10 | 0.09 | 0.10 | 0.06 | 0.02 | 0.04 |

TABLE 31

1987 ASSABET RIVER SURVEY

NITRATE-NITROGEN DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 0.8 | 0.8 | 0.8 | 0.5 | 0.5 | 0.5 |
| AS05 | 0.8 | 10 | 5.4 | 11 | 9.6 | 10.3 |
| AS06 | 1.0 | 8.1 | 4.6 | 8.4/8.6 | 7.8/7.8 | 8.2 |
| AS07 | 1.2 | 8.4 | 4.8 | 7.2 | 7.3 | 7.3 |
| AS09 | 1.2/0.9 | 6.9/3.8 | 3.2 | 4.1 | 4.9 | 4.5 |
| AS10 | 5.4 | 2.8 | 4.1 | 3.4 | 3.7 | 3.6 |
| AS11 | 6.2 | 1.7 | 4.0 | 3.3 | 3.7 | 3.5 |
| AS13 | 4.6 | - | - | 3.3 | 3.1 | 3.2 |
| AS14 | 2.4 | - | - | 4.5 | 3.3 | 3.9 |
| AS16 | 1.6 | - | - | 4.5 | 4.7 | 4.6 |
| AS17 | 2.0 | 3.0 | 2.5 | 5.0 | 5.2 | 5.1 |
| AS18 | 1.4 | 1.4 | 1.4 | 4.2 | 4.1 | 4.2 |
| AS19 | 0.5 | 0.8 | 0.7 | 1.6 | 3.7 | 2.7 |
| AS20 | 0.7/0.5 | 0.5/0.5 | - | 1.1/0.9 | 1.1/1.0 | 1.0 |
| AS21 | 0.6 | 0.6 | 0.6 | 1.0 | 0.9 | 1.0 |
| AS22 | 0.8 | 0.8 | 0.8 | 0.18 | 1.0 | 0.6 |
| AS24 | 1.1 | 1.0 | 1.1 | 1.5 | 1.6 | 1.6 |
| AS25 | 0.8 | 1.0 | 0.9 | 1.5 | 1.4 | 1.4 |
| SU15 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CO01 | 0.5 | 0.6 | 0.6 | 0.6 | 0.4 | 0.5 |

TABLE 32

1987 ASSABET RIVER SURVEY

TOTAL PHOSPHORUS DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS02 | 0.04 | 0.07 | 0.06 | 0.50 | 0.07 | 0.29 |
| AS05 | 3.8 | 3.3 | 3.55 | 3.3 | 2.1 | 2.7 |
| AS06 | 3.8 | 3.2 | 3.5 | 3.1/3.1 | 1.9/1.9 | 2.5 |
| AS07 | 3.0 | 3.2 | 3.1 | 2.9 | 1.6 | 2.25 |
| AS09 | 1.0/1.8 | 2.0/2.2 | 1.75 | 1.5 | 1.5 | 1.5 |
| AS10 | 2.2 | 2.7 | 2.45 | 4.4 | 2.0 | 3.2 |
| AS11 | 1.7 | 1.9 | 1.8 | 3.1 | 2.3 | 2.7 |
| AS13 | 0.94 | - | - | 1.0 | 1.8 | 1.4 |
| AS14 | 0.80 | - | - | 2.0 | 1.2 | 1.6 |
| AS16 | 0.67 | - | - | 1.4 | 1.2 | 1.3 |
| AS17 | 1.0 | 1.0 | 1.0 | 1.6 | 1.6 | 1.6 |
| AS18 | 0.93 | 1.0 | 0.97 | 1.3 | 1.3 | 1.3 |
| AS19 | 0.74 | 0.73 | 0.74 | 1.2 | 1.2 | 1.2 |
| AS20 | 0.52/0.53 | 0.62/0.67 | 0.59 | 0.99/0.76 | 1.0/1.1 | 0.96 |
| AS21 | 0.70 | 0.75 | 0.73 | 1.0 | 1.3 | 1.2 |
| AS22 | 0.73 | 0.72 | 0.73 | 0.84 | 1.0 | 0.92 |
| AS24 | 0.59 | 0.56 | 0.58 | 0.91 | 0.90 | 0.91 |
| AS25 | 0.52 | 0.53 | 0.53 | 0.96 | 0.85 | 0.91 |
| SU15 | 0.08 | 0.90 | 0.09 | 0.16 | 0.14 | 0.15 |
| CO01 | 0.30 | 0.32 | 0.31 | 0.44 | 0.21 | 0.33 |

TABLE 33

1987 ASSABET RIVER SURVEY

CHLORIDE DATA (mg/l)

| STATION NUMBER | 7/22 | 7/23 | MEAN | 9/1 | 9/2 | MEAN |
|---|---|---|---|---|---|---|
| AS01 | - | - | - | - | - | - |
| AS02 | 35 | 34 | 35 | 30 | 30 | 30 |
| AS05 | 97 | 87 | 92 | 75 | 84 | 80 |
| AS06 | 89 | 87 | 88 | 69/67 | 75/75 | 72 |
| AS07 | 75 | 86 | 81 | 65 | 70 | 68 |
| AS09 | 64/63 | 67/67 | 65 | 58 | 60 | 59 |
| AS10 | 71 | 74 | 73 | 68 | 71 | 70 |
| AS11 | 68 | 70 | 69 | 64 | 68 | 66 |
| AS13 | 72 | - | - | 60 | 65 | 63 |
| AS14 | 72 | - | - | 68 | 63 | 66 |
| AS16 | 69 | - | - | 70 | 73 | 72 |
| AS17 | 84 | 87 | 86 | 91 | 87 | 89 |
| AS18 | 71 | 75 | 73 | 83 | 82 | 83 |
| AS19 | 69 | 69 | 69 | 88 | 85 | 87 |
| AS20 | 58/58 | 62/62 | 60 | 77/77 | 80/84 | 80 |
| AS21 | 57 | 58 | 58 | 72 | 72 | 72 |
| AS22 | 57 | 57 | 57 | 72 | 72 | 72 |
| AS24 | 55 | 55 | 55 | 68 | 69 | 69 |
| AS25 | 53 | 55 | 54 | 67 | 71 | 69 |
| SU15 | 53 | 53 | 53 | 55 | 49 | 52 |
| CO01 | 53 | 53 | 53 | 57 | 54 | 56 |

TABLE 34

1987 ASSABET RIVER SURVEYS

FECAL COLIFORM BACTERIA DATA
(Organisms/100ml)

| STATION | JULY 22 | | JULY 23 | | |
|---|---|---|---|---|---|
| NUMBER | RUN 1 | RUN 2 | RUN 3 | RUN 4 | GEOMETRIC MEAN |
| AS02 | 440 | 280 | 580 | 560 | 450 |
| AS05 | 180 | 560 | 280 | 160 | 260 |
| AS06 | 260 | 160 | 120 | 160 | 170 |
| AS07 | 200 | 140 | 440 | 80 | 180 |
| AS09 | 40/60 | 60/20 | 120/140 | <5/20 | 40 |
| AS10 | <5 | <5 | 1200 | 20 | 30 |
| AS11 | 660 | <5 | 140 | 200 | 100 |
| AS13 | 100 | 80 | 100 | 20 | 60 |
| AS14 | 100 | 180 | 740 | 2400 | 420 |
| AS16 | 600 | 600 | 520 | 600 | 580 |
| AS17 | 140 | <5 | 60 | 60 | 40 |
| AS18 | <5 | 20 | <5 | <5 | <7 |
| AS19 | <5 | <5 | <5 | <5 | <5 |
| AS20 | 700/880 | 940/1000 | 800/1400 | 960/740 | 910 |
| AS21 | 80 | 60 | 60 | 40 | 60 |
| AS22 | 200 | 160 | 400 | 300 | 250 |
| AS24 | 180 | 100 | 200 | 40 | 110 |
| AS25 | 200 | 20 | 540 | 20 | 80 |
| SU15 | 40 | 60 | 80 | 20 | 40 |
| CO01 | 260 | 40 | 260 | 40 | 100 |

TABLE 35

1987 ASSABET RIVER SURVEYS

FECAL COLIFORM BACTERIA DATA
(Organisms/100ml)

| STATION NUMBER | SEPTEMBER 1 | SEPTEMBER 2 | GEOMETRIC MEAN |
|---|---|---|---|
| AS02 | 1300 | * | 1300 |
| AS05 | 360 | 240 | 290 |
| AS06 | 320/600 | 400/420 | 420 |
| AS07 | * | 100 | 100 |
| AS09 | 160 | 140 | 150 |
| AS10 | 5 | 200 | 30 |
| AS11 | 60 | 80 | 70 |
| AS13 | 80 | 160 | 110 |
| AS14 | 400 | 780 | 560 |
| AS16 | 260 | 200 | 230 |
| AS17 | 160 | 360 | 240 |
| AS18 | <5 | 20 | <10 |
| AS19 | 80 | 20 | 40 |
| AS20 | 900/800 | 1100/1000 | 970 |
| AS21 | 120 | 20 | 50 |
| AS22 | 300 | 100 | 170 |
| AS24 | 440 | 40 | 130 |
| AS25 | 260 | 120 | 180 |
| SU15 | 440 | 130 | 240 |
| CO01 | 460 | 60 | 170 |

*Sample broken

TABLE 36

1987 ASSABET RIVER SURVEY

Algae: Results of Microscopic Examinations

7/22/87

| | AS01 | AS07 | AS14 | AS17 | AS21 |
|---|---|---|---|---|---|
| ALGAE TYPE (natural units/ml) | | | | | |
| Diatoms | | | | | |
| Centric | 0 | 0 | 65 | 0 | 110 |
| Pennate | 569 | 11 | 0 | 76 | 88 |
| Blue-Green | | | | | |
| Coccoid | 1139 | 0 | 0 | 0 | 0 |
| Filamentous | 2102 | 0 | 0 | 0 | 66 |
| Green | | | | | |
| Coccoid | 1270 | 33 | 0 | 11 | 503.7 |
| Desmids | 0 | 0 | 11 | 0 | 87.6 |
| Filamentous | 0 | 0 | 0 | 0 | 0 |
| Flagellates | | | | | |
| Green | 350 | 22 | 11 | 0 | 22 |
| Other | 88 | 11 | 0 | 0 | 22 |
| Total Live Algae | 5518 | 77 | 87 | 87 | 921 |
| Chlorophyll a ($mg/m^3$) | 10.64 | .792 | 1.056 | .42 | 4.48 |

TABLE 37

1987 ASSABET RIVER SURVEY

TOTAL METALS DATA (mg/l)

7/22/87

| STATION NUMBER | Al | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| AS02 | <0.10 | <0.001 | <0.002 | <0.002 | 0.40 | 0.0006 | 0.12 | <0.015 | <0.002 | 0.007 |
| AS05 | 0.10 | <0.001 | <0.002 | 0.03 | 0.22 | 0.0007 | 0.10 | <0.015 | <0.002 | 0.06 |
| AS06 | 0.12 | <0.001 | 0.003 | 0.02 | 0.19 | 0.0005 | 0.07 | <0.015 | <0.002 | 0.05 |
| AS07 | <0.10 | <0.001 | 0.003 | 0.02 | 0.18 | 0.0003 | 0.21 | <0.015 | <0.002 | 0.05 |
| AS09 | <0.10/ <0.10 | <0.001/ <0.001 | <0.002/ <0.002 | 0.006/ 0.13 | 0.30/ 0.28 | <0.0002 <0.0002 | 0.02/ 0.04 | <0.015 0.015 | <0.002 <0.002 | 0.006/ 0.006 |
| AS10 | <0.10 | <0.001 | 0.002 | 0.007 | 0.31 | <0.0002 | 0.08 | 0.015 | <0.002 | 0.03 |
| AS11 | <0.10 | <0.001 | 0.002 | 0.007 | 0.20 | 0.0002 | 0.04 | 0.05 | <0.002 | 0.04 |
| AS13 | <0.10 | <0.001 | <0.002 | 0.011 | 0.18 | <0.0002 | 0.07 | 0.044 | <0.002 | 0.03 |
| AS14 | <0.10 | <0.001 | <0.002 | 0.006 | 0.20 | <0.0002 | 0.06 | 0.017 | 0.003 | 0.008 |
| AS16 | <0.10 | <0.001 | <0.002 | 0.009 | 0.19 | <0.0002 | 0.034 | <0.015 | <0.002 | 0.02 |
| AS17 | <0.10 | <0.001 | <0.002 | 0.006 | 0.15 | <0.0002 | 0.026 | 0.029 | <0.002 | 0.02 |
| AS18 | <0.10 | <0.001 | <0.002 | <0.002 | 0.24 | <0.0002 | 0.10 | <0.02 | 0.003 | 0.02 |
| AS19 | <0.10 | <0.001 | <0.002 | 0.007 | 0.24 | 0.0028 | 0.05 | <0.02 | <0.002 | 0.03 |
| AS20 | <0.10/ <0.10 | <0.001/ <0.001 | <0.002/ <0.002 | 0.003/ 0.006 | 0.30/ 0.30 | 0.0004/ 0.0002 | 0.03/ 0.03 | <0.02/ <0.02 | 0.003/ 0.002 | 0.005/ 0.02 |
| AS21 | <0.10 | <0.001 | <0.002 | 0.016 | 0.49 | 0.0019 | 0.05 | 0.035 | 0.007 | 0.05 |
| AS22 | <0.10 | <0.001 | <0.002 | 0.005 | 0.50 | 0.0008 | 0.04 | <0.02 | 0.003 | 0.02 |
| AS24 | <0.10 | <0.001 | <0.002 | 0.011 | 0.39 | 0.0006 | 0.036 | <0.02 | 0.004 | 0.02 |
| AS25 | <0.10 | <0.001 | <0.002 | 0.006 | 0.38 | 0.0007 | 0.02 | <0.02 | 0.005 | 0.02 |
| SU15 | <0.10 | <0.001 | <0.002 | 0.004 | 0.48 | 0.0006 | 0.22 | <0.02 | 0.003 | 0.007 |
| CO01 | <0.10 | <0.001 | <0.002 | 0.016 | 0.42 | 0.0009 | 0.11 | <0.02 | 0.005 | 0.015 |

TABLE 38

1987 ASSABET RIVER SURVEY

TOTAL METALS DATA (mg/l)

9/1/87

| STATION NUMBER | Al | Cd | Cr | Cu | Fe | Hg | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| AS02 | 0.38 | 0.001 | 0.004 | 0.004 | 0.84 | <0.0002 | 0.25 | 0.014 | 0.006 | 0.02 |
| AS05 | 0.17 | 0.006 | 0.006 | 0.032 | 0.20 | <0.0002 | 0.05 | 0.007 | 0.008 | 0.03 |
| AS06 | 0.13/<br>0.12 | 0.003/<br><0.001 | 0.007/<br>0.007 | 0.028/<br>0.027 | 0.28/<br>0.28 | <0.0002<br><0.0002 | 0.11/<br>0.10 | 0.012/<br>0.008 | 0.01/<br>0.01 | 0.04/<br>0.04 |
| AS07 | 0.14 | 0.022 | 0.007 | 0.021 | 0.20 | <0.0002 | 0.04 | 0.007 | 0.007 | 0.11 |
| AS09 | <0.10 | <0.001 | 0.005 | 0.007 | 0.22 | <0.0002 | 0.04 | 0.006 | 0.006 | 0.02 |
| AS10 | <0.10 | <0.001 | 0.009 | 0.009 | 0.27 | <0.0002 | 0.04 | 0.13 | 0.006 | 0.02 |
| AS11 | <0.10 | <0.001 | 0.005 | 0.01 | 0.14 | <0.0002 | 0.06 | 0.12 | 0.005 | 0.03 |
| AS13 | <0.10 | <0.001 | 0.004 | <0.004 | 0.16 | <0.0002 | 0.09 | 0.07 | 0.004 | 0.03 |
| AS14 | <0.10 | <0.001 | 0.005 | <0.004 | 0.25 | <0.0002 | 0.07 | 0.12 | 0.019 | 0.03 |
| AS16 | <0.10 | <0.001 | 0.008 | <0.004 | 0.08 | <0.0002 | 0.03 | 0.05 | 0.008 | 0.02 |
| AS17 | <0.10 | <0.001 | 0.006 | <0.004 | 0.33 | <0.0002 | 0.13 | 0.05 | 0.009 | 0.03 |
| AS18 | <0.10 | <0.001 | 0.004 | <0.004 | 0.10 | <0.0002 | 0.03 | 0.04 | 0.014 | 0.03 |
| AS19 | <0.10 | <0.001 | 0.005 | <0.004 | 0.10 | 0.0008 | 0.04 | 0.023 | 0.022 | 0.03 |
| AS20 | <0.10<br><0.10 | <0.001<br><0.001 | 0.003/<br>0.005 | <0.004/<br><0.004 | 0.29/<br>0.25 | 0.0004/<br>0.0005 | 0.05/<br>0.06 | 0.021/<br>0.018 | 0.011/<br>0.006 | 0.02/<br>0.02 |
| AS21 | <0.10 | <0.001 | 0.004 | <0.004 | 0.82 | 0.0006 | 0.20 | 0.017 | 0.014 | 0.02 |
| AS22 | <0.10 | <0.001 | 0.004 | <0.004 | 0.36 | 0.0003 | 0.05 | 0.015 | 0.010 | 0.03 |
| AS24 | <0.10 | <0.001 | 0.002 | <0.004 | 0.17 | 0.0003 | 0.04 | 0.009 | 0.012 | 0.02 |
| AS25 | <0.10 | <0.001 | 0.003 | 0.01 | 0.24 | 0.0003 | 0.04 | 0.014 | 0.012 | 0.02 |
| SU15 | <0.10 | <0.001 | 0.003 | 0.004 | 0.32 | 0.0002 | 0.17 | 0.011 | 0.013 | 0.02 |
| CO01 | <0.10 | <0.001 | 0.002 | 0.005 | 0.30 | 0.0004 | 0.17 | 0.011 | 0.007 | 0.02 |

TABLE 39

1987 ASSABET RIVER SURVEY

SYNTHETIC ORGANIC COMPOUNDS (ug/l)
WATER COLUMN

| STATION NUMBER | COMPOUND | QUANTITY (ug/l) |
|---|---|---|
| | 2/18/87 | |
| AS04 | Acid extractables | ND* |
| AS06 | Phenol | 17 |
| | 7/8/87 | |
| AS05 | Chloroform | 1.2 |
| | Bromodichloromethane | 1.0 |
| AS06 | Chloroform | 1.5 |
| | Bromodichloromethane | 1.0 |
| | 7/24/87 | |
| AS03T | Acenapthene | <10 |
| | Fluorene | 3.6 |
| | Trichlorotrifluoroethane | 7.9 |
| | 1,1,1-Trichloroethane | 14 |
| | Trichloroethylene | <1.0 |
| | Tetrachloroethylene | 5.2 |
| | Toluene | 1.1 |
| | Acetone | 62 |
| AS05 | Isocyanatobenzene | ** |
| | Chloroform | 10 |
| | Bromodichloromethane | 4.9 |
| | Dibromochloromethane | 1.8 |
| AS06 | Base/Neutral Extractables | ND |
| | Chloroform | 7.3 |
| | Bromodichloromethane | 3.3 |
| | Dibromochloromethane | 1.4 |
| AS10 | Isocyanatobenzene | ** |
| | 1,1,1-trichloroethane | 4.5 |
| AS17 | Isocyanatobenzene | ** |
| | Volatile Organics | ND |
| AS22 | Isocyanatobenzene | ** |
| | Volatile Organics | ND |

* None detected.

** No standard available for quantitation. The mass spectrum was compared to a mass spectral database for identification.

TABLE 40

1987 ASSABET RIVER SURVEY

ACUTE TOXICITY VIA MICROTOX™

30-MINUTE TIME PERIOD*

| STATION | DATE | $EC_{10}$ (%)** | $EC_{20}$ (%) | $EC_{50}$ (%) |
|---|---|---|---|---|
| Westborough WWTP Effluent | 7/22-23/87 | 12.9 | 22.8 | 77.0 |
| Marlborough W. WWTP Effluent | 7/22-23/87 | *** | *** | *** |
| Maynard WWTP Effluent | 7/22-23/87 | 29.0 | 81.0 | >100 |
| AS05 | 7/23/87 | *** | *** | *** |
| AS10 | 7/23/87 | 29.0 | 70.0 | >100 |
| AS21 | 7/23/87 | *** | *** | *** |
| AS10 | 8/5/87 | 37.0 | 75 | >100 |
| AS09 | 9/1/87 | 67.0 | >100 | >100 |
| AS10 | 9/1/87 | 17.0 | 70.0 | >100 |
| Marlborough W. WWTP Effluent | 9/1-2/87 | 13.0 | 23.5 | 82.0 |

* More extensive data (i.e., 5 and 15-minute toxicity) on file at DWPC, Westborough

** Reported as percent volume of sample.

*** Spurious results - negative gamma values.

TABLE 41

1987 ASSABET RIVER SURVEY

SEDIMENT METALS DATA (mg/kg dry weight)

8-5-87

| STATION NUMBER | Al | B | Cd | Cr | Cu | Hg | Mo | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| AS0I | 4,300 | 10 | <0.20 | 5.8 | 7.4 | 0.032 | <0.5 | 6.2 | 8.9 | 16 |
| AS04 | 3,000 | 11 | 0.90 | 11 | 150 | 0.57 | <0.5 | 9.3 | 90 | 130 |
| AS05 (Right Bank) | 4,600 | 10 | 0.90 | 14 | 150 | 0.60 | <0.5 | 11 | 83 | 130 |
| AS05 (Left Bank) | 5,500 | 12 | 1.5 | 31 | 270 | 1.34 | 0.8 | 13 | 81 | 200 |
| AS07 | 6,900 | 17 | 1.1 | 27 | 160 | 0.42 | 0.9 | 13 | 190 | 380 |
| AS10 | 6,400 | 17 | 0.50 | 38 | 72 | 0.50 | <0.5 | 32 | 97 | 69 |
| South St., Ext., Hudson | 7,500 | 17 | 0.80 | 160 | 280 | 2.5 | <0.5 | 19 | 510 | 330 |
| AS17 | 13,000 | 18 | 0.20 | 16 | 24 | 0.30 | <0.5 | 7.8 | 66 | 69 |
| AS21 | 6,600 | 20 | 1.0 | 80 | 140 | 0.40 | 1.3 | 200 | 100 | 120 |

TABLE 42

1987 ASSABET RIVER SURVEY

SYNTHETIC ORGANIC COMPOUNDS

SEDIMENT

8/5/87

| STATION NUMBER | COMPOUND | QUANTITY (ug/g) |
|---|---|---|
| AS01 | Caryphyllene | * |
| | Nonadecane (small peak) | * |
| | Acid Extractables | ND** |
| | PCB 1242 | ND |
| | PCB 1260 | <0.17 |
| | Pesticides | *** |
| AS04 | Acid Extractables | ND |
| | Base/Neutral Extractables | ND |
| | PCB 1242 | <0.16 |
| | PCB 1260 | <0.17 |
| | Pesticides | *** |
| AS05 (Left bank) | Acid Extractables | ND |
| | Base/Neutral Extractables | ND |
| | PCB 1242 | ND |
| | PCB 1260 | 0.21 |
| | Pesticides | *** |
| AS05 (Right bank) | Acid Extractables | ND |
| | Ethylhexanol (large peak) | * |
| | Nonanol | * |
| | Methylcyclodecane | * |
| | PCB 1242 | <0.16 |
| | PCB 1260 | 0.30 |
| | Pesticides | *** |
| AS07 | Acid Extractables | ND |
| | Base/Neutral Extractables | ND |
| | PCB 1242 | <0.16 |
| | PCB 1260 | <0.17 |
| | Pesticides | *** |

* No standard available for quantitation. The mass spectrum was compared to a mass spectral database for identification.

** None detected.

*** Unable to determine due to the presence of PCB's.

TABLE 42 (Continued)

8/5/87

| STATION NUMBER | COMPOUND | QUANTITY (ug/g) |
|---|---|---|
| AS10 | Acid Extractables | ND** |
| | Base/Neutral Extractables | ND |
| | PCB 1260 | 0.22 |
| | Pesticides | *** |
| South St. ext., Hudson | Naphthalene | 1.8 |
| | Acenapthylene | 0.86 |
| | Acenapthene | 1.1 |
| | Fluorene | 1.7 |
| | Phenanthrene | 41 |
| | Anthracene | 4.6 |
| | Fluoranthene | 80 |
| | Pyrene | 70 |
| | Chrysene | 27 |
| | Benzo-a-anthracene | 44 |
| | Benzo-(k)-fluoranthene | 35 |
| | Benzo-a-pyrene | 34 |
| | Benzo-(ghi)-perylene | 26 |
| | Methylnaphthalene | * |
| | Dimethylnaphthalene (small peak) | * |
| | Methylphenanthrene (small peak) | * |
| | Methylpyrene (small peak) | * |
| | Cresol (small peak) | * |
| | Hexanol (small peak) | * |
| | PCB's | ND |
| | Pesticides | ND |
| AS21 | Acenapthylene | 0.83 |
| | Fluorene | 1.1 |
| | Phenanthrene | 8.1 |
| | Fluorianthene | 18 |
| | Pyrene | 15 |
| | Chrysene | 10 |
| | Benzo-a-anthracene | 17 |
| | Benzo-(k)-fluoranthene | 9.3 |
| | Dimethylnaphthalene (small peak) | * |
| | Acid Extractables | ND |
| | PCB 1260 | 0.26 |
| | Pesticides | *** |

* No standard available for quantitation. The mass spectrum was compared to a mass spectral database for identification.

** None detected.

*** Unable to determine due to the presence of PCB's.

ASSABET RIVER BASIN

FLOW DATA

TABLE 43

1987 ASSABET RIVER SURVEY

Flow Data (cfs)

| STATION | DATE | FLOW |
|---|---|---|
| AS02[1] | 7/22/87 | 0.1 |
| | 7/23/87 | 0.06 |
| | 9/2/87 | 0.1 |
| AS10[1] | 7/22/87 | 9.27 |
| | 9/2/87 | 14.1 |
| AS16[1] | 7/22/87 | 17.2 |
| AS17[1] | 7/23/87 | 10.9 |
| | 9/2/87 | 23.9 |
| AS20[2] | 7/22/87 | 28 |
| | 7/23/87 | 28 |
| | 9/1/87 | 43 |
| | 9/2/87 | 26 |
| | 7/17/85 | 41 |
| | 8/8/79 | 34 |
| | 8/9/79 | 27 |

1. Measurements made by TSB personnel using Pygmy meter.

2. Provisional measurements taken by U.S.G.S. at automated gaging station.

# ASSABET RIVER BASIN

# WASTEWATER DISCHARGE DATA

TABLE 44

WESTBOROUGH WASTEWATER TREATMENT PLANT*

Results of Laboratory Analyses

(Samples are 24-hour Composite and Units mg/l unless otherwise noted)

| PARAMETER | 3/16-17/87 | 4/15-16/87 | 5/12-13/87 |
|---|---|---|---|
| | EFFLUENT | | |
| $BOD_5$ | 14 | 75 | 27 |
| pH (Standard units)** | 7.2 | 6.65 | - |
| Total Alkalinity | 90 | 90 | 20 |
| Suspended Solids | 10 | 32 | 29 |
| Settleable Solids (ml/l) | <0.05 | <0.05 | 10 |
| Total Solids | 360 | 400 | 350 |
| Total Kjeldahl Nitrogen | 7.5 | 14 | 23 |
| Ammonia-Nitrogen | 7.0 | 12 | 15 |
| Nitrate-Nitrogen | 0.3 | 0.2 | 0.1 |
| Total Phosphorus | 0.88 | 4.5 | 4.0 |
| Chlorine Residual** | - | 1.5 | 1.2 |
| Fecal Coliform Bacteria (organisms/100 ml)** | - | - | 430 |
| Chloride | 94 | 118 | 88 |
| Flow (MGD) | 1.94 | 2.5 | 1.91 |
| Temperature (°C)** | 6 | 10 | 13 |
| Aluminum | - | - | 0.14 |
| Cadmium | - | - | <0.02 |
| Chromium | - | - | <0.02 |
| Copper | - | - | 0.11 |
| Iron | - | - | 0.20 |
| Manganese | - | - | 0.05 |
| Nickel | - | - | <0.03 |
| Lead | - | - | <0.05 |
| Zinc | - | - | <0.02 |
| Silver | - | - | <0.02 |

* Samples taken prior to Shrewsbury WWTP tie-in.
**Grab Sample

TABLE 45

WESTBOROUGH WASTEWATER TREATMENT PLANT*

Results of Laboratory Analyses

(Samples are 24-hour Composite and Units mg/l unless otherwise noted)

| PARAMETER | 6/9-10/87 | 7/7-8/87 | 7/21-22/87 | 7/22-23/87 | 8/19-20/87 | |
|---|---|---|---|---|---|---|
| | EFFLUENT | | | | INFLUENT | EFFLUENT |
| BOD$_5$ | 19 | 1.8 | 13 | 4.4 | 170 | 3.3 |
| pH (Standard units)** | 6.55 | 6.45 | 6.55 | 6.2 | - | - |
| Total Alkalinity | 46 | 31 | 40 | 43 | 156 | 52 |
| Suspended Solids | 0.0 | 3.4 | 9.5 | 5.5 | 49 | 2.5 |
| Settleable Solids (ml/l) | 0.05 | <0.05 | <0.05 | <0.05 | 4.0 | <0.05 |
| Total Solids | 390 | 440 | 440 | 440 | 560 | 450 |
| Hardness | - | 57 | - | - | - | 44 |
| Total Kjeldahl-Nitrogen | 7.0 | 4.6 | 5.6 | 3.9 | 25 | 2.0 |
| Ammonia-Nitrogen | 2.5 | 0.17 | 0.13 | 0.13 | 0.5 | 0.11 |
| Nitrate-Nitrogen | 14 | 17 | 17 | 24 | <0.1 | 5.0 |
| Total Phosphorus | 5.2 | 4.5 | 5.6 | 5.5 | 5.5 | 4.8 |
| Chlorine Residual** | 0.09 | 0.9 | 0.5 | 0.7 | - | 0.5 |
| Fecal Coliform Bacteria** (organisms/100 ml) | 9,300 | <5 | <10 | <10 | - | 5 |
| Chloride | 86 | 85 | 300 | 100 | 80 | 80 |
| Flow (MGD) | 3.46 | 3.214 | 3.11 | 2.72 | - | 2.72 |
| Temperature (°C)** | - | 20 | 21 | 20 | - | 22 |
| Aluminum | - | 0.20 | <0.10 | <0.10 | 0.59 | <0.10 |
| Cadmium | - | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Chromium | - | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Copper | - | 0.08 | 0.08 | 0.05 | 0.42 | 0.03 |
| Iron | - | 0.05 | 0.14 | 0.10 | 0.72 | 0.07 |
| Manganese | - | 0.04 | <0.02 | <0.02 | 0.19 | 0.02 |
| Nickel | - | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Lead | - | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Zinc | - | 0.05 | 0.09 | 0.06 | 0.11 | 0.03 |
| Silver | - | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Methylene Chloride (ug/l)** | 2.6 | - | ND | ND | - | - |
| Chloroform (ug/l)** | ND | - | ND | 16 | - | - |
| Bromodichloromethane (ug/l)** | ND | - | ND | 7.1 | - | - |
| Dibromochloromethane (ug/l) | ND | - | ND | 2.9 | - | - |

*Samples taken after Shrewsbury WWTP tie-in to Westborough WWTP.
**Grab Sample

TABLE 45 (Continued)

| PARAMETER | 9/1-2/87 INFLUENT | 9/1-2/87 EFFLUENT | 9/2-3/87 INFLUENT | 9/2-3/87 EFFLUENT | 9/22-23/87 INFLUENT | 9/22-23/87 EFFLUENT |
|---|---|---|---|---|---|---|
| $BOD_5$ | - | - | 260 | 4.5 | 590 | 9.6 |
| pH (Standard units)* | - | 6.4 | - | 6.3 | - | - |
| Total Alkalinity | 162 | 33 | 175 | 43 | 150 | 54 |
| Suspended Solids | 47 | 3.0 | 180 | 3.5 | 490 | 4.0 |
| Settleable Solids (ml/l) | 4.0 | <0.05 | 12 | <0.05 | 34 | <0.05 |
| Total Solids | 580 | 450 | 700 | 450 | 1,450 | 380 |
| Hardness | 94 | 88 | - | - | - | - |
| Total Kjeldahl-Nitrogen | 50 | 2.5 | 50 | 8.8 | 45 | 2.8 |
| Ammonia-Nitrogen | 19 | 0.06 | 22 | 0.12 | 17 | 0.03 |
| Nitrate-Nitrogen | 0.1 | 16 | 0.2 | 15 | 0.1 | 7.4 |
| Total Phosphorus | 14 | 5.3 | 14 | 5.5 | 19 | 3.3 |
| Chlorine Residual* | - | 1.8 | - | 1.5 | - | - |
| Fecal Coliform Bacteria* (organisms/100 ml) | - | <5 | - | <20 | - | <5 |
| Chloride | 96 | 104 | 100 | 100 | 100 | 86 |
| Flow (MGD) | - | 3.14 | - | 3.07 | - | 3.64 |
| Aluminum | 0.45 | 0.17 | 0.95 | 0.50 | - | - |
| Cadmium | <0.02 | <0.02 | <0.02 | <0.02 | - | - |
| Chromium | <0.02 | <0.02 | <0.02 | <0.02 | - | - |
| Copper | 0.36 | 0.08 | 0.57 | 0.09 | - | - |
| Iron | 0.84 | 0.08 | 1.2 | 0.08 | - | - |
| Manganese | 0.11 | 0.05 | 0.18 | <0.02 | - | - |
| Nickel | <0.03 | <0.03 | <0.03 | <0.03 | - | - |
| Lead | <0.05 | <0.05 | <0.05 | <0.05 | - | - |
| Zinc | 0.07 | 0.05 | 0.17 | 0.12 | - | - |
| Silver | <0.02 | <0.02 | <0.02 | <0.02 | - | - |

*Grab Sample

TABLE 46

SHREWSBURY WASTEWATER TREATMENT PLANT

Results of Laboratory Analyses

(Samples are 24-hour Composite and Units mg/l unless otherwise noted)

| PARAMETER | EFFLUENT 2/18/87 | 3/16-17/87 | 4/15-16/87 | 5/12-13/87 |
|---|---|---|---|---|
| $BOD_5$ | 250 | 65 | 87 | 138 |
| pH (Standard units)* | - | 6.55 | 6.55 | 7.1 |
| Total Alkalinity | 198 | 105 | 95 | 130 |
| Suspended Solids | 122 | 12 | 88 | 62 |
| Settleable Solids (ml/l) | 2.0 | 1.8 | 0.7 | 1.5 |
| Total Solids | 800 | 200 | 390 | 420 |
| Hardness | - | - | - | - |
| Total Kjeldahl-Nitrogen | 28 | 18 | 14 | 18 |
| Ammonia-Nitrogen | 18 | 12 | 7.9 | 16 |
| Nitrate-Nitrogen | 0.2 | 0.4 | 0.6 | 1.1 |
| Total Phosphorus | 9.6 | 4.9 | 3.5 | 4.5 |
| Chlorine Residual* | - | - | 0.075 | 0.10 |
| Fecal Coliform Bacteria (organisms/100 ml)* | - | - | - | 2,400,000 |
| Chloride | - | 108 | 89 | 84 |
| Flow (MGD) | 1.66 | 2.37 | 3.56 | 2.29 |
| Temperature (°C)* | - | 8 | 9 | 9 |
| Aluminum | - | - | - | 0.18 |
| Cadmium | - | - | - | <0.02 |
| Chromium | - | - | - | <0.02 |
| Copper | - | - | - | 0.22 |
| Iron | - | - | - | 0.55 |
| Manganese | - | - | - | 0.09 |
| Nickel | - | - | - | <0.03 |
| Lead | - | - | - | <0.05 |
| Zinc | - | - | - | 0.05 |
| Silver | - | - | - | <0.02 |

*Grab Sample

TABLE 47

MARLBOROUGH WEST WASTEWATER TREATMENT PLANT

Results of Laboratory Analyses

(Samples are 24-hour Composite and Units mg/l unless otherwise noted)

| PARAMETER | 7/21-22/87 INFLUENT | 7/21-22/87 EFFLUENT | 7/22-23/87 INFLUENT | 7/22-23/87 EFFLUENT | 9/1-2/87 EFFLUENT | 9/2-3/87 EFFLUENT |
|---|---|---|---|---|---|---|
| $BOD_5$ | 460 | 20 | 320 | 26 | 14 | 7.8 |
| pH (Standard units)* | - | 6.9 | - | 7.0 | 7.0 | 6.95 |
| Total Alkalinity | 131 | 154 | 89 | 174 | 205 | 173 |
| Suspended Solids | 120 | 6.5 | 180 | 23 | 22 | 11 |
| Settleable Solids (ml/l) | - | <0.05 | 14 | <0.05 | <0.05 | <0.05 |
| Total Solids | 620 | 460 | 600 | 480 | 710 | 580 |
| Hardness | - | - | - | - | 50 | - |
| Total Kjeldahl-Nitrogen | 39 | 17 | 51 | 21 | 24 | 26 |
| Ammonia-Nitrogen | 26 | 17 | 18 | 19 | 22 | 15 |
| Nitrate-Nitrogen | 0.5 | <0.1 | 0.6 | 0.1 | 0.1 | <0.1 |
| Total Phosphorus | 12 | 12 | 12 | 7.0 | 25 | 9.2 |
| Chlorine Residual* | - | >2.0 | - | - | 0.1 | 0.1 |
| Fecal Coliform Bacteria* (organisms/100 ml) | - | <10 | - | <10 | 500 | 100 |
| Chloride | 70 | 83 | 80 | 95 | 100 | 108 |
| Flow (MGD) | - | 1.45 | - | 1.69 | 1.4 | 1.44 |
| Temperature (°C)* | - | 20 | - | 20 | 19 | 19 |
| Aluminum | 1.6 | <0.10 | 0.95 | <0.10 | 0.14 | 0.23 |
| Cadmium | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Chromium | 0.12 | 0.11 | 0.04 | <0.02 | 0.03 | <0.02 |
| Copper | 0.42 | 0.04 | 0.44 | 0.04 | 0.04 | <0.02 |
| Iron | 4.6 | 0.83 | 3.8 | 0.58 | 0.53 | 0.43 |
| Manganese | 0.18 | 0.16 | 0.15 | 0.17 | 0.10 | 0.13 |
| Nickel | 0.95 | 0.43 | 1.7 | 0.57 | 0.86 | 0.88 |
| Lead | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Zinc | 0.31 | 0.16 | 0.31 | 0.10 | 0.16 | 0.20 |
| Silver | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Tetrahydrofuran (ug/l)* | - | 41 | - | 100 | - | - |
| Chloroform (ug/l)* | - | 1.7 | - | 1.8 | - | - |
| 1,1,1-Trichloroethane (ug/l)* | - | 13 | - | 15 | - | - |
| Toluene(ug/l)* | - | ND | - | <1.0 | - | - |

*Grab Sample

TABLE 48

HUDSON WASTEWATER TREATMENT PLANT

Results of Laboratory Analyses

(Samples are 24-hour Composite and Units mg/l unless otherwise noted)

| PARAMETER | 7/21-22/87 INFLUENT | 7/21-22/87 EFFLUENT | 7/22-23/87 INFLUENT | 7/22-23/87 EFFLUENT | 9/1-2/87 EFFLUENT | 9/2-3/87 EFFLUENT |
|---|---|---|---|---|---|---|
| $BOD_5$ | 130 | 30 | 170 | 19 | 11 | 32 |
| pH (Standard units)* | - | 6.65 | - | 6.4 | 6.5 | 6.55 |
| Total Alkalinity | 97 | 56 | 100 | 42 | 83 | 53 |
| Suspended Solids | 84 | 8.0 | 100 | 14 | 8.5 | 12 |
| Settleable Solids (ml/l) | - | <0.05 | 7.0 | <0.05 | <0.05 | <0.05 |
| Total Solids | 750 | 610 | 700 | 590 | 740 | >10 |
| Hardness | - | - | - | - | 153 | - |
| Total Kjeldahl-Nitrogen | 28 | 15 | 48 | 15 | 3.0 | 10 |
| Ammonia-Nitrogen | 26 | 10 | 21 | 9.0 | 0.09 | 1.4 |
| Nitrate-Nitrogen | 0.6 | 1.9 | <0.1 | 7.8 | 16 | 18 |
| Total Phosphorus | 6.2 | 5.2 | 8.8 | 5.2 | 5.7 | 6.8 |
| Chlorine Residual* | - | 0.5 | - | - | 1.5 | 1.2 |
| Fecal Coliform Bacteria* (organisms/100 ml) | - | <5 | - | 10 | <10 | <20 |
| Chloride | 230 | 200 | 240 | 200 | 200 | 176 |
| Flow (MGD) | - | 2.04 | - | 1.91 | 2.09 | 2.1 |
| Temperature (°C)* | - | 21 | - | 20 | 19 | 19 |
| Aluminum | 0.37 | <0.10 | 0.30 | <0.10 | <0.10 | 0.38 |
| Cadmium | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Chromium | 0.24 | 0.06 | <0.02 | <0.02 | <0.02 | <0.02 |
| Copper | 0.25 | 0.15 | 0.28 | 0.07 | 0.06 | 0.10 |
| Iron | 2.1 | 0.33 | 1.1 | 0.22 | 0.10 | 0.09 |
| Manganese | 0.08 | 0.08 | 0.09 | 0.10 | 0.03 | 0.09 |
| Nickel | 0.07 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Lead | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Zinc | 0.21 | 0.05 | 0.18 | 0.05 | 0.02 | 0.09 |
| Silver | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Chloroform (ug/l)* | - | 1.5 | - | 1.0 | - | - |
| Tetrahydrofuran (ug/l)* | - | ND | - | 3.2 | - | - |

*Grab Sample

TABLE 49

MAYNARD WASTEWATER TREATMENT PLANT

Results of Laboratory Analyses

(Samples are 24-hour Composite and Units mg/l unless otherwise noted)

| PARAMETER | 7/21-22/87 INFLUENT | 7/21-22/87 EFFLUENT | 7/22-23/87 INFLUENT | 7/22-23/87 EFFLUENT | 9/1-2/87 EFFLUENT | 9/2-3/87 EFFLUENT |
|---|---|---|---|---|---|---|
| $BOD_5$ | 240 | 40 | 190 | 36 | 21 | 27 |
| pH (Standard units)* | - | 6.9 | - | 7.0 | 7.0 | 6.85 |
| Total Alkalinity | 127 | 100 | 144 | 102 | 124 | 127 |
| Suspended Solids | 74 | 8.0 | 92 | 14 | 8.0 | 12 |
| Settleable Solids (ml/l) | <0.05 | <0.05 | 8.0 | <0.05 | <0.05 | 1.1 |
| Total Solids | 420 | 300 | 380 | 300 | 310 | 330 |
| Total Kjeldahl-Nitrogen | 43 | 20 | 45 | 26 | 22 | 35 |
| Ammonia-Nitrogen | 0.36 | 1.9 | 31 | 18 | 22 | 25 |
| Nitrate-Nitrogen | 0.5 | 8.8 | 0.2 | 1.9 | 3.6 | 3.6 |
| Total Phosphorus | 13 | 6.3 | 11 | 7.9 | 4.4 | 7.1 |
| Chlorine Residual* | - | 1.0 | - | - | 2.3 | 2.1 |
| Fecal Coliform Bacteria* *(organisms/100 ml)* | - | 10 | - | <10 | 10 | <20 |
| Chloride | 30 | 40 | 46 | 45 | 49 | 48 |
| Flow (MGD) | - | 1.1 | - | 1.36 | 1.34 | 1.2 |
| Temperature (°C)* | - | 20 | - | 20 | 22 | 20 |
| Aluminum | 0.66 | <0.10 | 0.41 | <0.10 | <0.10 | 0.13 |
| Cadmium | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Chromium | 0.06 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Copper | 0.49 | 0.12 | 0.34 | 0.06 | 0.05 | 0.17 |
| Iron | 2.7 | 0.30 | 2.0 | 0.38 | 0.26 | 0.36 |
| Manganese | 0.16 | 0.19 | 0.14 | 0.10 | 0.07 | 0.10 |
| Nickel | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Lead | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Zinc | 0.21 | 0.05 | 0.12 | 0.05 | 0.02 | 0.10 |
| Silver | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Chloroform (ug/l)* | - | 1.2 | - | 1.0 | - | - |
| Toluene (ug/l)* | - | 1.7 | - | 1.8 | - | - |

*Grab Sample

TABLE 50

CONCORD MCI WASTEWATER TREATMENT PLANT

Results of Laboratory Analyses

(Samples are 24-hour Composite and Units mg/l unless otherwise noted)

| PARAMETER | 9/1-2/87 EFFLUENT | 9/2-3/87 |
|---|---|---|
| $BOD_5$ | 11 | 110 |
| pH (Standard units)* | 6.0 | - |
| Total Alkalinity | 83 | 69 |
| Suspended Solids | 8.5 | 300 |
| Settleable Solids (ml/l) | <0.05 | 61 |
| Total Solids | 740 | 600 |
| Total Kjeldahl-Nitrogen | 3.0 | 33 |
| Ammonia-Nitrogen | 0.09 | 2.2 |
| Nitrate-Nitrogen | 16 | 0.5 |
| Total Phosphorus | 5.7 | 10 |
| Chlorine Residual* | >3.5 | ** |
| Fecal Coliform Bacteria* (organisms/100 ml) | 91 | 2,300 |
| Chloride | 200 | 48 |
| Flow (MGD) | 0.188 | 0.188 |
| Temperature (°C)* | 25 | 25 |
| Aluminum | 0.60 | - |
| Cadmium | <0.02 | - |
| Chromium | <0.02 | - |
| Copper | 0.03 | - |
| Iron | 0.60 | - |
| Manganese | 0.02 | - |
| Nickel | <0.03 | - |
| Lead | <0.05 | - |
| Zinc | 0.11 | - |
| Silver | <0.02 | - |
| Chloroform (ug/l)* | 20 | - |
| Bromodichloromethane (ug/l)* | 2.9 | - |
| Toluene (ug/l)* | 1.9 | - |
| Chlorobenzene (ug/l)* | 7.0 | - |

*Grab Sample
** Sample not taken due to high turbidity

## THE ASSESSMENT OF WATER POLLUTION

A workable definition of the term "water pollution" is difficult to formulate simply because pollution problems are extremely variable and site-specific. The word "pollute" literally means to "render impure"; however, a more acceptable definition of pollution must take factors into account such as the chemical, physical, and biological characteristics of natural water, the intended use of a receiving water, and an understanding of the nature and fate of a given pollutant after its introduction into a body of water. Regardless of how we choose to define it, water pollution involves the addition of certain characteristics to a water body which may render that water unfit for its intended utilization. Some of the more common forms of water pollution include: oxygen demanding organic wastes and sewage derivatives; man-made organic compounds such as pesticides, some industrial wastes, and inorganic toxic compounds; infectious disease producing agents; nutrients and sediments from land runoff; radioactive substances; oil and grease; and thermal discharges. In some instances, the combined effects of two or more contaminants are further enhanced by their interaction. In short, whether discharged from residences, institutions, or industries, each form of pollution has a characteristic effect on the water into which it is introduced. The receiving water may become unsightly, malodorous, and/or a hazard to public health, and consequently its uses may be severely limited.

Methods used for the assessment of water quality generally fall into three main categories: chemical, physical, and biological. Chemical analyses may include the determination of pH and alkalinity in addition to the concentrations of various ions, metals, and dissolved gases such as oxygen, carbon dioxide and hydrogen sulfide. Physical parameters often measured are temperature, color, turbidity, and flow characteristics. Biological methods may be categorized as either field surveys which are an attempt to ascertain the numbers and kinds of aquatic organisms associated with various water qualities, or laboratory studies in which bioassays are conducted to determine the levels of toxicity of different chemical parameters for a given test organism.

The parameters listed above are measured in most water quality surveys conducted by the Massachusetts Division of Water Pollution Control. The Biological Section conducts macroinvertebrate surveys on selected rivers and streams throughout the Commonwealth as well as certain bioassays. In addition, microscopic examinations are conducted during most surveys to determine the abundance and kinds of algae and other microorganisms present in the water. Finally, bacterial samples are obtained and analyzed during each water quality survey.

Two types of samples are collected for chemical analysis. A grab sample is an instantaneous sample collected to indicate water quality conditions at a particular time. Composite samples are collected over a period of time at specific intervals. This method gives a better indication of the overall water quality situation during the sampling period.

## Oxygen Relationships

The dissolved oxygen (D.O.) in water refers to the uncombined oxygen held in solution and thereby made available to aquatic organisms for respiration. Sources of dissolved oxygen include atmospheric aeration and the direct addition of oxygen as the byproduct of chemical reduction reactions and algal photosynthesis. Whereas respiratory processes of aquatic organisms consume oxygen throughout the day and night, photosynthetic release of oxygen is restricted to the daylight hours. As a result, productive waters exhibit a characteristic diurnal variation in dissolved oxygen concentration. The solubility of oxygen ($O_2$) in water is primarily a function of water temperature and the atmospheric partial pressure of oxygen. Saturation levels at standard pressure (760 mm Hg) range from 14.6 mg/l $O_2$ at 0°C to 6.6 mg/l $O_2$ at 40°C.

Organic matter is introduced to a river or stream either as the result of natural phenomena, such as the deposition of leaves and other plant materials in autumn, or by the discharge of pollutants resulting from human related activities. Regardless of its origin, organic matter is gradually decomposed by bacteria which utilize the available dissolved oxygen in the water. Therefore, the ability of a stream segment to assimilate these organic materials, that is, its waste assimilative capacity, is dependent upon the amount of dissolved oxygen present in the water. In many instances, the assimilation of large amounts of organic wastes severely depletes the oxygen concentration in the water body rendering it unsuitable for the existence of aquatic organisms such as invertebrates and fish.

The biochemical oxygen demand (BOD) is a measure of the amount of oxygen required by bacteria to decompose a given amount of organic matter. This decomposition process occurs in two distinct steps each governed by a specific kind of bacteria. During the first step, or carbonaceous stage, carbon compounds are stabilized with a concurrent release of carbon dioxide. The second stage, nitrification, begins approximately seven days later and is the process by which nitrogenous substances are broken down to ammonia and ultimately to nitrate. The total combined oxygen demands of both stages is the ultimate BOD which may be exerted over a period of thirty days or more. Through recurrent use, the five day BOD ($BOD_5$) has been accepted as the standard test used in water quality analysis. While the $BOD_5$ of untreated sewage normally ranges from 150 to 300 mg/l, the $BOD_5$ of an unpolluted water rarely exceeds 2 mg/l.

Some types of organic wastes are not readily broken down by bacteria but can be decomposed by chemical processes. The chemical oxygen demand (COD) refers to the amount of oxygen required for the dichromate oxidation of a given amount of organic matter. Since some organic matter in any waste is not biodegradable, the COD is usually greater than the BOD.

## Nutrients

Nutrients are substances that are essential to the growth or reproduction of organisms. In aquatic habitats algae and macrophytes rely on dissolved nitrogen and phosphorus compounds as nutrients and, as such, these substances are not harmful at low concentrations. Wastewater discharges often contain large amounts of carbon, nitrogen, and phosphorus containing compounds. Excessive nutrient loading of a water body increases plant production. As a result of this increased productivity, rapidly multiplying algal populations or "blooms" occur which may severely limit the potential use of the water. In many instances a high oxygen demand is exerted by the decomposing algae resulting from a sudden dieback.

Nitrogen compounds exist in water in a variety of forms. They may occur as cellular components, particulate matter, soluble organic substances or inorganic ions. These different forms and their interrelated chemical reactions are collectively known as the nitrogen cycle. Organic nitrogen in the form of protein, amino acid, or urea occurs in water containing organic wastes. Oxidation and reduction of these nitrogenous compounds are closely linked to the metabolic activity of many kinds of microorganisms. As described above, nitrification is tied to bacterial action, and is carried out by a fixed sequence of reactions through which ammonia, nitrite, and ultimately nitrate are produced. Therefore, the progress of decomposition of organic nitrogen can be determined by assessing the relative amounts of these compounds. Ammonia ($NH_3$) results from the initial decomposition of organic nitrogen and is always present in untreated sewage. It can also be formed by the reduction of nitrite. Ammonia exerts a high oxygen demand and is toxic to many aquatic organisms. Oxidation of ammonia yields nitrite ($NO_2^-$) which is quickly converted to nitrate ($NO_3^-$), the end product of the decomposition of nitrogenous matter. Nitrate is the form of nitrogen that is directly available to algae and other aquatic plants as a nutrient.

Phosphorus is present in water bodies in dissolved, colloidal, or particulate states and originates primarily from agricultural runoff and wastewaters containing detergents. It may exist as orthophosphate, polyphosphate, or in organic compounds. Although phosphorus occurs in natural waters in smaller amounts than nitrogen, it is an essential plant nutrient.

## Coliform Bacteria

Fecal coliform bacteria are found in the intestinal tract of warm-blooded animals. Although not a serious health hazard by themselves, their presence in water is a good indication that sewage and associated pathogenic microorganisms may be present. Since coliforms can be detected by relatively simple test procedures they are used to indicate the extent of bacterial pollution from sewage and combined sewer overflows. Tests are usually conducted to determine the number of fecal and total coliforms present in water or wastewater. The number of total coliforms includes those of fecal origin and from non-fecal sources such as soil, grain, or decaying vegetation. In areas where urban runoff is a problem, total coliform levels can be very high, whereas fecal coliform levels may remain minimal as long as sewage is not present in the water. Often municipal wastes are disinfected at a treatment plant to kill bacteria before they are discharged to a receiving water.

## pH and Alkalinity

The pH of water is a measure of its hydrogen ion ($H^+$) concentration on an inverse logarithmic scale which ranges from 0 to 14. pH values of less than 7 indicate higher $H^+$ content and therefore acidic solutions whereas pH values above 7 denote alkaline solutions. The pH of pure water at 25°C is 7.00; however, natural waters exhibit a wide range of pH values depending upon their chemical and biological characteristics. Unpolluted river water usually has a pH between 6.5 and 8.5. In productive segments, a diurnal fluctuation in pH may occur as photosynthetic organisms take up dissolved carbon dioxide during the daylight hours. Drastic changes in pH occur when industrial effluents containing strong acids or alkali are discharged to a water body. These pH shifts are sometimes toxic to aquatic organisms. Alkalinity is defined as the capacity of water to neutralize acid. This property is attributed to the presence of several different solute species. These are primarily carbonates and bicarbonates but also hydroxides, borates, silicates, and phosphates. Alkalinity is expressed in milligrams per liter of equivalent calcium carbonate.

## Solids

Suspended solids refers to the particulate matter that either floats on the surface of, or is in suspension in, water or wastewater, and is removable by laboratory filtering techniques. That matter remaining in the water after filtering is referred to as dissolved solids. Suspended solids in a stream may settle out in sluggishly flowing segments causing sediments to build up on the substrate. This siltation can be particularly harmful to fish eggs and larvae by hindering their mechanisms for obtaining oxygen from the water. Suspended solids analysis provides a reliable measure of the efficiency of wastewater treatment facilities. Primary treatment should remove about 50 percent of the suspended solids from an influent while 90 percent removal should result from secondary treatment. The test for total solids measures all suspended and dissolved solids in water. They are measured by evaporating the water from a sample of known volume and weighing the residue. This residue can then be ignited in a furnace to determine the organic portion. Turbidity is a measure of the clarity of a water sample and is related to solids content. The laboratory test is based on the scattering and absorption of light by the sample and the results are expressed in Nephelometric Turbidity Units (NTU).

## Color

The color of natural water is primarily due to the leaching of organic debris and is empirically determined by comparing the sample with known concentrations of colored solution. It is then expressed in standard units of color. Severe color problems resulting from a pollution discharge are described qualitatively rather than numerically. Although color may not be harmful to aquatic life, it may render the water unacceptable for drinking purposes and for some types of industrial use.

## Other Parameters

Depending upon specific river conditions, a water quality survey may include additional analyses such as those for oil and grease, heavy metal, or toxic organic compound content. Grease in a wastewater consists of a mixture of fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and certain other nonfatty substances.

Heavy metals and certain organic compounds are toxic to aquatic organisms when present in sufficient quantities. They may also have an adverse effect on sewage and industrial wastewater treatment systems. Metals that are often monitored are cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc.

# MICROTOX TEST RESULTS

## Test Description

Microtox is the trade name for a particular short-term acute toxicity test. The Westborough Technical Services Branch currently uses the test as a toxics screening tool in addition to its other, more traditional methods of analysis.

The Microtox test uses freeze-dried luminescent bacteria as its indicator organisms. When re-hydrated, these bacteria give off light. To test a water sample for toxicity using Microtox, an analyst prepares a series of dilutions of the sample and adds re-hydrated bacteria to these. The light intensity of each sample dilution is measured over a 30-minute period and compared with that of a control (bacteria only). It is assumed that changes in light intensity are due to toxicant interference with the biochemical reaction that produces light. Toxicity is then measured as the percent decrease in light intensity of each of the sample dilutions compared with that of the control.

## Data Interpretations

The most commonly used result from these tests is the 30-minute $EC_{50}$. This is defined as the sample Concentration causing a 50% reduction in the measured Effect (light production) over a 30-minute time period. The relationship of the $EC_{50}$ to toxicity is an inverse one: i.e., the lower the $EC_{50}$, the greater the toxicity of the sample.

Samples not toxic enough to produce a full 50% decrease in light over the time allotted for the test may still be toxic enough to produce a response in the test. The $EC_{20}$ and $EC_{10}$ (sample concentrations causing a 20% and 10% reduction in light intensity) are reported in order to give the regulator an idea of incipient toxicity - sample dilutions which induce a small, but measurable, response in the test.

## ANALYTICAL METHODS USED AT LAWRENCE EXPERIMENT STATION

| PARAMETER | METHOD | REPORTED AS |
|---|---|---|
| BOD | 5-day oxygen depletion at 20°C | mg/l BOD |
| Dissolved Oxygen | Azide modification of Winkler method. 0.0375 N sodium thiosulfate titrant, 300 ml sample | mg/l D.O. |
| pH | Electrometric, glass indicator, silver chloride reference | pH Standard Logarithmic Units |
| Turbidity | Nephelometric. Hach Turbidimeter. Model 2100A | Nephelometric Turbidity Units |
| Total Alkalinity | 0.02 N sulfuric acid potentiometric titration to pH 4.5, Orion Model 701, digital pH meter | mg/l $CaCO_3$ |
| Suspended Solids | Filtration through standard glass fiber filter paper. Residue dried at 103-105°C. Gravimetric | mg/l S.S. |
| Total Solids | Evaporation to dryness at 103-105°C. Gravimetric | mg/l T.S. |
| Settleable Solids | Gravimetric settling using an Imhoff cone | ml/l sett. solids |
| Total Kjeldahl-Nitrogen | Acid digestion using Technical BD-40 Block Digester. Colorimetric analysis (reaction of ammonia, sodium salicylate, sodium nitroprusside, and sodium hypochlorite in buffered alkaline medium) using Technicon Auto Analyzer II | mg/l TKN |
| Ammonia-Nitrogen | Phenate method, automated. Colorimetric analysis using Technicon Auto Analyzer II | mg/l $NH_3$-N |
| Nitrate-Nitrogen | Hydrazine reduction method, automated. Colorimetric analysis using Technicon Auto Analyzer II | mg/l $NO_3$-N |

ANALYTICAL METHODS (CONTINUED)

| PARAMETER | METHOD | REPORTED AS |
|---|---|---|
| Total Phosphate | Acid digestion using Technicon BD-40 Block Digester. Ascorbic acid reduction colorimetric method using Technicon Auto Analyzer II | mg/l P |
| Total Coliform | Membrane filter technique | Total coliforms/100 ml |
| Fecal Coliform | Membrane filter technique | Fecal coliforms/100 ml |
| COD | Dichromate reflux | mg/l COD |
| Conductivity | Wheatstone Bridge type meter. Yellow Springs Instrument conductivity bridge, Model 31 | umhos/cm |
| Color | Visual comparison of sample with known concentrations of colored solutions | Color Units |
| Chloride | Argentometric (titration with silver nitrate) | mg/l Cl |
| Silica | Colorimetric analysis (silico-molybdate reduction in acidic solution to "heteropoly blue" by aminonaphtholsulfonic acid) Technicon Auto Analyzer I | mg/l $SiO_2$ |
| Cadmium, copper, chromium, iron, lead, magnesium, manganese, nickel, zinc, hardness (Ca+Mg) | Atomic Absorption Spectrophotometry. Air-acetylene flame. Perkin-Elmer Model 403 | mg/l |
| Aluminum, Tin | Atomic Absorption Spectrophotometry. Nitrous oxide-acetylene flame. Perkin-Elmer Model 403 | mg/l |
| Hexavalent Chromium | Colorimetric using diphenylcarbazide. Klett-Summerson photoelectric colorimeter | mg/l $Cr^{+6}$ |
| Phenols | 4-amino anti-pyrine colorimetric method | mg/l |

APPENDIX A

U.S. EPA PROPOSED FRESHWATER CRITERIA FOR SELECTED HEAVY METALS DESIGNATED TO PROTECT AQUATIC LIFE[1]

| | 4-DAY AVERAGE | | ONE-HOUR AVERAGE | |
|---|---|---|---|---|
| METAL | a[2] | b[2] | a[2] | b[2] |
| Cadmium | 0.7852 | -3.49 | 1.128 | -3.828 |
| Chromium III | 0.8190 | 1.561 | 0.8190 | 3.688 |
| Copper | 0.8545 | -1.465 | 0.9422 | -1.464 |
| Lead | 1.273 | -4.705 | 1.273 | -1.460 |
| Mercury | (0.012 ug/l) | | (2.4 ug/l) | |

| | 24-HOUR AVERAGE | | AT ANY TIME NOT TO EXCEED | |
|---|---|---|---|---|
| | a[2] | b[2] | a[2] | b[2] |
| Nickel | 0.76 | 1.06 | 0.76 | 4.02 |
| Zinc | (47 ug/l) | | 0.83 | 1.95 |

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[1] EPA "Quality Criteria for Water 1986," EPA 440/5-86-001, May, 1986.

[2] For input into: exp (a [ln (hardness in mg/l)] + b)

APPENDIX B

U.S. EPA PROPOSED FRESHWATER CRITERIA FOR SELECTED

HEAVY METALS ADJUSTED FOR ASSABET RIVER HARDNESS
(50 mg/l as $CaCo_3$)

| METAL | 4-DAY AVERAGE (mg/l) | ONE-HOUR AVERAGE (mg/l) |
|---|---|---|
| Cadmium | 0.0007 | 0.0018 |
| Chromium III | 0.117 | 0.984 |
| Copper | 0.0065 | 0.0092 |
| Lead | 0.0013 | 0.0338 |
| Mercury | 0.00001 | 0.0024 |
| | 24-HOUR AVERAGE (mg/l) | AT ANY TIME NOT TO EXCEED (mg/l) |
| Nickel | 0.056 | 1.09 |
| Zinc | 0.047 | 0.181 |

APPENDIX C

CLASSIFICATION OF SLUDGE FOR LAND APPLICATION

310 CMR 32.00

| PARAMETER | ALLOWABLE CONCENTRATIONS (mg/kg) CLASS I | CLASS II | CLASS III |
|---|---|---|---|
| Cadmium | 2 | 2-25 | <25 |
| Lead | <300 | 300-1000 | <1000 |
| Nickel | <200 | -- | <200 |
| Zinc | <2500 | -- | <2500 |
| Copper | <1000 | -- | <1000 |
| Chromium (Total) | <1000 | -- | <1000 |
| Mercury | <10 | -- | <10 |
| Molybdenum | <10 | -- | <10 |
| Boron (water soluble) | <300 | -- | <300 |
| PCBs in Class I sludge which is a commercial fertilizer | <2 | 2-10 | <10 |
| PCBs in Class I sludge which is a commercial soil conditioner | <1 | 1-10 | <10 |