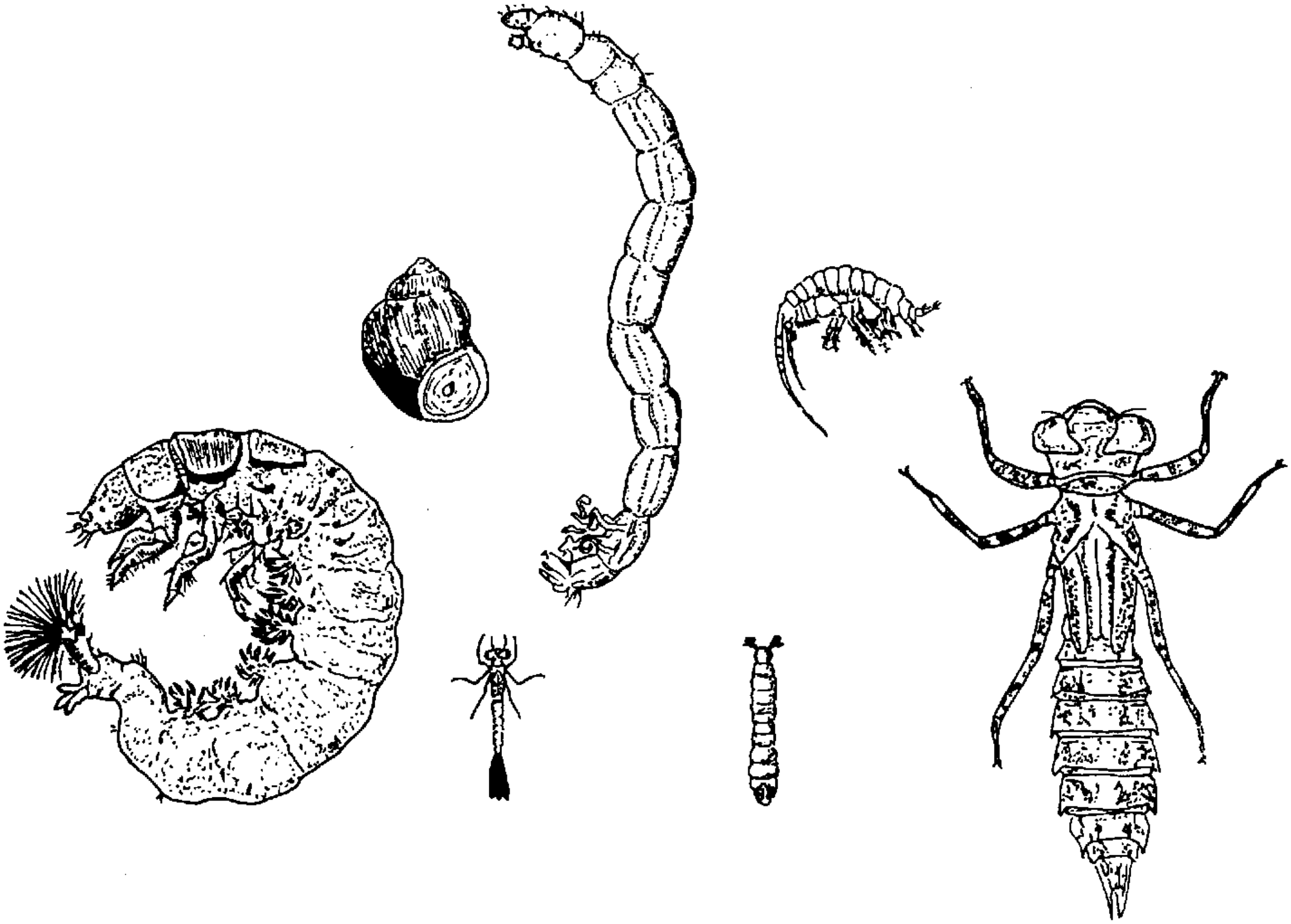
1977
NASHUA RIVER
MACROINVERTEBRATE WATER QUALITY SURVEY



massachusetts department of environmental quality engineering
DIVISION OF WATER POLLUTION CONTROL
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NASHUA RIVER

1977

WATER QUALITY SURVEY

BENTHIC MACROINVERTEBRATE ANALYSIS

BY

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DESCRIPTION OF NASHUA RIVER BASIN

The Nashua River, located in north central Massachusetts and southern New Hampshire (Figure 1), consists of a north branch and a south branch which combine in Lancaster, Massachusetts to form the main stem. The river then flows in a northeasterly direction until it joins the Merrimack River in Nashua, New Hampshire. The river's 530 square mile drainage area lies primarily within Worcester and Middlesex Counties in Massachusetts and includes the 115 square mile watershed of the Metropolitan District Commission's Wachusett Reservoir. However, only twelve million gallons of water per week are released to the south branch from this reservoir. As a result, the Wachusett watershed has only minor importance with respect to the rest of the river basin.

From the headwaters of the north branch in Fitchburg to the confluence with the south branch, a distance of nineteen miles, the river elevation drops 360 feet. The main stem then falls another 110 feet along its remaining 37 mile course to the Merrimack River. The United States Geological Survey maintains a single flow gaging station on the main stem at East Pepperell. The flow at this station over the past forty years averaged 560 cubic feet per second (cfs). Gaging stations are located on the North Nashua River in Leominster and Fitchburg. The average flow at the Leominster gage over the same forty year period was 193 cfs. The new gage at Fitchburg showed an average yearly flow of 141 cfs for 1976.

All or a portion of twenty-six Massachusetts cities and towns lie within the Nashua River Basin. The two largest municipalities are Fitchburg and Leominster with populations of 41,718 and 36,030 respectively (1975). These two cities, located on the north branch, contribute a major portion of the domestic waste load discharged to the river.

The North Nashua River rises in Fitchburg at the confluence of Flag Brook and the outlet of Snows Millpond. The river flows in a southeasterly direction through Fitchburg and Leominster encountering twelve dams before it joins the south branch in Lancaster. Wastewater discharges along the north branch are cooling water, industrial process wastewater, sewage treatment plant effluent and combined sewer overflow.

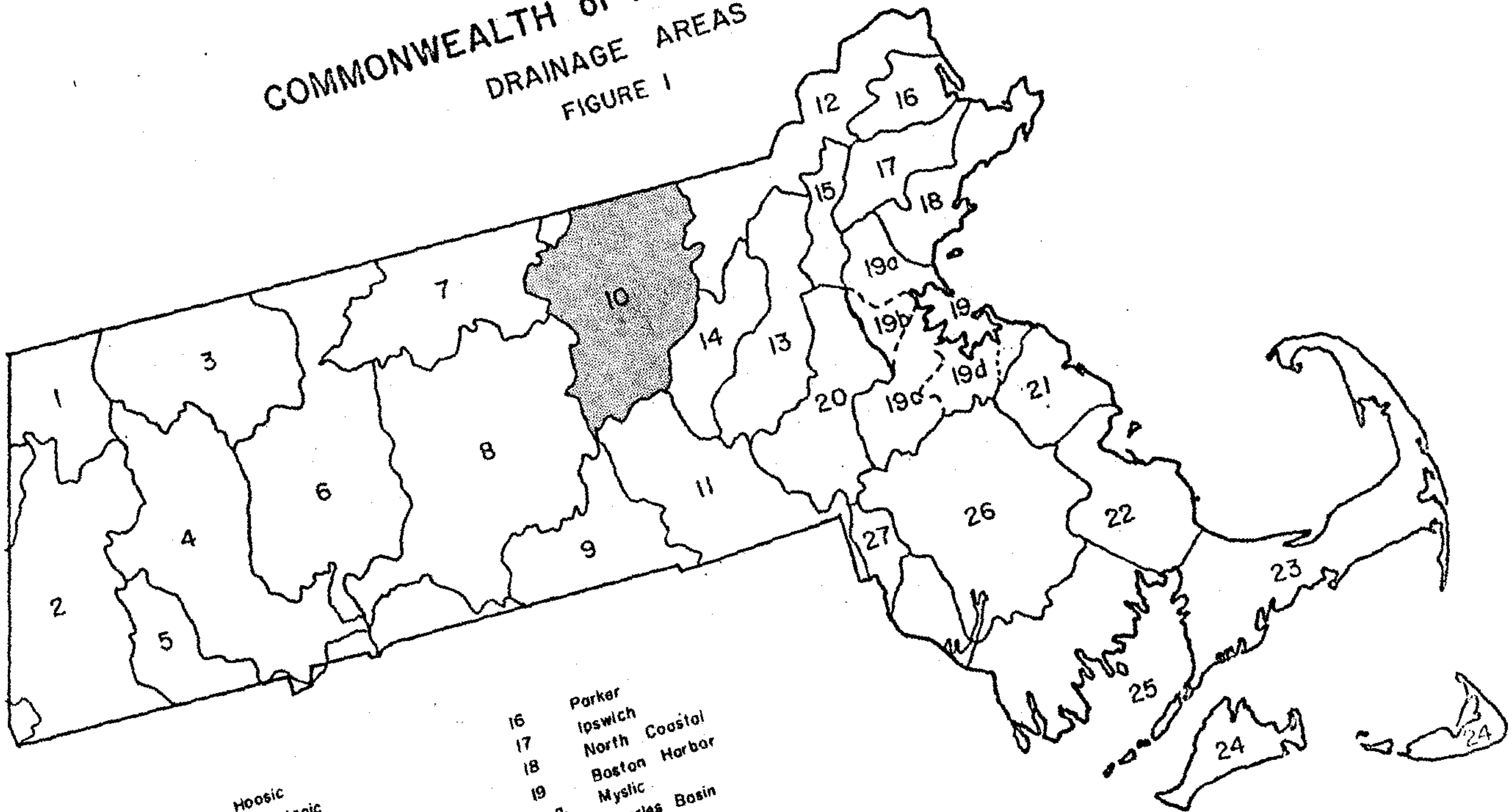
Wachusett Reservoir in Clinton is the source of the South Nashua River. Counterpane Brook is its main tributary. The south branch is polluted by industrial cooling and process wastewater and combined sewer overflow. The major source of pollution is the effluent from the Clinton Sewage Treatment Plant which contributes a large portion of the river's flow at its point of entry.

The main stem flows sluggishly from Lancaster to the Massachusetts border. It encounters a dam in Ayer and another one in East Pepperell. Behind the dam in East Pepperell is a large impoundment known as Pepperell Pond. Pollution on the main stem of the Nashua River results from industrial process effluent, raw sewage, and treated domestic wastewaters. However, the pollution to which the main stem is subjected is minor in comparison to that of the north branch. Land along this stretch of the river is largely undeveloped. Therefore, ignoring the water quality, the river basin is very scenic. The Squannacook River, the southern most of the main stem's two major tributaries, receives effluent from two paper mills along the last five miles of its course. The Nissitissit River is one of the cleaner rivers in the state.

COMMONWEALTH of MASSACHUSETTS

DRAINAGE AREAS

FIGURE I



1 Hoosic
2 Housatonic
3 Deerfield
4 Westfield
5 Farmington
6 Connecticut
7 Millers
8 Chicopee
9 French & Quinebaug
10 Nashua
11 Blackstone
12 Merrimack
13 Concord & Sudbury
14 Assabet
15 Shawsheen
16 Parker
17 Ipswich
18 North Coastal
19 Boston Harbor
a. Mystic
b. Charles Basin
c. Neponset
d. Weymouth
20 Charles
21 North
22 South Coastal
23 Cape Cod
24 Islands
25 Buzzards Bay
26 Taunton
27 Ten Mile

INTRODUCTION TO BENTHIC MACROINVERTEBRATE SAMPLING

In 1973, the Division initiated an extensive program of benthic macroinvertebrate sampling with the objectives of: 1) determining the suitability of aquatic environments for supporting healthy and diverse indigenous communities; 2) providing accurate taxonomic baseline data on benthic organisms for future comparative water quality evaluations; 3) providing data useful in the detection of the presence of hazardous or toxic substances in the aquatic environment, and 4) establishing reliable and consistant methods of sampling and identifying benthic organisms and formulating statistical methods of data analysis to define the water quality responses of benthic macroinvertebrate communities.

The study of benthic organisms offers several advantages over a purely physico-chemical water quality sampling program. These benthic communities being for the most part sedentary and incapable of moving great distances by self-locomotion, are a useful tool for detecting environmental perturbations resulting from introduced contaminants. Because they exhibit a relatively long life span, their characteristics are a function of the past and present, including reaction to infrequently discharged wastes such as toxic substances. Such contaminants could cause macroinvertebrate populations that are sensitive to stress to reduce their numbers or biomass which, in turn, could reduce the number of taxa or organisms. Detecting contaminants by periodic chemical sampling would be difficult in this case.

Another advantage of studying benthic organisms is that they exhibit a relatively long-term retention of contaminants like pesticides, heavy metals, PCB's, and radioactive materials. Such contaminants may be so infrequently discharged that it becomes difficult to find them in detectable concentrations. Chemical analysis of selected macroinvertebrate fauna could show the presence of these contaminants.

Biological water quality can be expressed both quantitatively and qualitatively. Each has its own requirements, advantages, and limitations. The quantitative approach is essentially an estimation of the numbers or biomass of the various components of the macroinvertebrate community per unit area in all or a portion of the available habitats in the ecosystem being studied (artificial habitats included), and provides information on species composition, species richness, and distribution of individuals among the species.

A quantitative benthic study requires the use of a sampling device that takes a standard unit area or volume of habitat and that a measure of precision of the estimates be obtained, i.e., replicate sampling in each habitat. This technique provides a measure of productivity, enables the investigator to measure precision of estimates and attach probability statements, thus providing objective comparisons, and also enables the data of different investigators to be compared.

Unfortunately, no sampling device is at present adequate in taking reliable samples in all habitats. Only selected portions of the environment may be sampled. In addition, the sampling precision is often so low that an indeterminate number of replicates is needed, causing a drain on available time limits and resources.

The qualitative approach offers an estimate of the richness of species and leads to the determination of the presence or absence of organisms per habitat. In this case, a knowledge of the available habitat types and suitable collecting techniques is needed in order to reach a high level of expertise.

This mode of sampling gives the collector a wide latitude in collecting techniques and leaves all habitats relatively unrestricted for sampling. The processing of qualitative samples is also considerably shorter than that involved in quantitative samples requiring actual counts.

This data also has its limitations. The skills of the investigators will differ, so comparison of data is difficult. The drift of organisms into a sample area may bias the data and render comparison still less useful, and no standing crop or productivity data can be generated from qualitative data.

There are several other variables to be considered in benthic macroinvertebrate sampling that affect both quantitative and qualitative data. The first is the wide seasonal variations that aquatic macroinvertebrates exhibit. This drastically alters the species present, distribution, abundance, and comparison of data taken during different seasons. At some seasons of the year various life stages of benthic organisms shift from aquatic to terrestrial forms.

Second, are the effects of the abiotic components of the environment such as substrate type, current velocity, and depth. The effects of the physical habitat can often cause differences in benthic communities that are unrelated to those of introduced contaminants. This renders comparisons of unlike habitats with unequal sampling effort useless and misleading.

In the analysis of data, quantitative and qualitative techniques differ greatly. Data from quantitative samples may be used to obtain the total standing crop of individuals or biomass, or both, per unit volume or unit area and to obtain numbers or biomass, or both, of individual taxa per unit area or volume. The data presentation may follow a simple tabular form, pictoral line and bar graphs, or histograms. Diversity indices can measure the environmental quality and the induced stresses on the community structure of benthic macroinvertebrates. These indices basically contain the two components of species richness and distribution of individuals among the species. Also, data of a quantitative nature may follow other statistical techniques like a multivariate analysis or ordination techniques to determine benthic response to water quality.

In qualitative data evaluation the analysis can follow either an indicator organism scheme or a reference station method. In the first method, individual taxa are classified on the basis of their tolerance or intolerance to various levels of contaminants. In the latter method, a comparison of benthic fauna in "clean water" is made with that of a fauna inhabiting an area of stress. This method can show gross to moderate organic contamination on macroinvertebrate populations, but to detect finer changes a quantitative analysis must be conducted. It is possible to show qualitative data on the presence or absence of tolerant and intolerant taxa and richness of species by employing line and bar graphs, pie diagrams, histograms, or pictoral diagrams.

Organism tolerance to organic wastes can be evaluated by using the following classification scheme from EPA's biological methods manual (Weber 1973):

Tolerant (T): Organisms frequently associated with gross organic contamination and are generally capable of thriving under practically anaerobic conditions.

Facultative (F): Organisms having a wide range of tolerance and frequently associated with moderate levels of organic contamination.

Intolerant or Sensitive (I): Organisms that are not found associated with even moderate levels of organic contaminants and are generally not tolerant of even moderate reductions of dissolved oxygen.

METHODOLOGY

The methods employed by the Division in conducting benthic macroinvertebrate sampling have been based upon the literature, field experience, and available resources, i.e., manpower and equipment. A typical sampling routine can best be explained as follows:

Quantitative Sampling

1. With the use of the most efficient piece of sampling gear (Ekman, Ponar, Petersen, Surber), depending on the conditions of depth, flow, and substrate, one set of four hauls is taken. The hauls follow a random transect whereby both banks and two quarter points are sampled.

2. The substrate obtained is evaluated by particle size according to the methods given in Weber (1973) and recorded on a percent basis. It is then placed into a basin and mixed thoroughly. In cases where the sample consists of a heavily organic or sand-silt type substrate, one-quarter of the sample is usually retained after mixing. The remaining material is then qualitatively examined and discarded. This subsampling is necessary because of the time involved in sorting a large quantity of substrate.

3. The sample portion is then passed through a standard U.S. No. 30 brass sieve (0.595 mm openings). The remainder is placed into one-quart (1.06 liter) plastic containers and is returned alive to the laboratory for analysis.

4. In the laboratory the sample is placed into 16-1/2" (42 cm) x 10-1/8" (26 cm) x 2-3/8" (6 cm) white enamel pans and the benthic organisms manually picked and separated to order. The specimens are stored in 70% ethyl alcohol.

5. Later identification is made by the use of a 10x - 210x Bausch and Lomb Stereozoom microscope and, if necessary, a bright-field or phase-contrast compound microscope.

6. Identifications and counts are made to the genus level in most cases and to species if available resources permit. The use of pertinent keys, reference materials and fixing and mounting techniques are employed to attain accurate identifications. In some cases,

specimens are sent to experts for identification and verification.

7. The data analysis includes a taxonomic listing by tolerance classification and bar graphs of the number of taxa by station and tolerance classification. An estimate of diversity ($\bar{d}$) and trophic condition is also given.

Qualitative Sampling

1. All habitat types are sampled at each station by the use of a dredge, dip net, or by hand.

2. Most benthic organisms collected are placed into 95% ethyl alcohol at streamside and kept separated by habitat. Notes on relative abundance and condition are also recorded. Those organisms requiring special fixing techniques to aid in identification are returned alive.

3. Once in the laboratory, any fixing or mounting is accomplished and the specimens identified in the same manner as the quantitative samples.

4. After identification, the specimens are added to the taxonomic list in a presence or absence format and bar graphed in the same manner as the quantitative samples.

BENTHIC MACROINVERTEBRATE ANALYSIS

OF THE NASHUA RIVER BASIN

Introduction

During the month of August 1977, the Division conducted an extensive survey of the benthic macroinvertebrate communities of the Nashua River Basin. A total of sixteen sampling stations were selected - twelve on the Nashua River, one on the Whitman River, and three on the Nissitissit River. Five of these stations were sampled quantitatively. The remainder followed a qualitative analysis. A description of the sampling methods appears in the methodology section (p.8).

The physical characteristics are described in Table 1. Most of the stations are of a similar water depth, flow, and substrate. A typical Nashua River sampling location consisted of a riffled stretch 20 - 30 feet (6 - 9 meters) wide and one foot (0.3 meters) in depth. A substrate of rubble-gravel-sand was the most frequently encountered type. Many of the bottoms were covered with layers of what appeared to be *Sphaerotilus* sp., more commonly known as "sewage fungus".

The banks at many of the stations consisted of decomposed paper sludge which took on the appearance of mica-like sand. Since this substrate is easily eroded it formed bars and spits in areas of deposition.

Several benthic macroinvertebrate studies have been conducted on the Nashua River and its tributaries in Massachusetts. In June and July 1965, a study was conducted on the Nashua River as part of the Merrimack River Project (FWPCA 1966). This study found over sixty miles of the North Nashua, Nashua, and South Nashua grossly polluted based on an overall biological assessment. Even pollution tolerant organisms were not found in abundance.

In 1973, Camp, Dresser, and McKee, Inc. (1975) sampled 25 stations at 11 locations on the Nashua River. This study found an apparent absence of benthic organisms in the Fitchburg area, a more diverse benthic community in the Clinton area, and below Clinton a basically oligochaete inhabited river bottom. Many of these sampling locations were situated in impounded areas.

The Whitman River, a tributary of the North Nashua, was sampled in June 1964 by Oldaker (1966). He found the river at Route 2A in Westminster to support nineteen different kinds of benthic organisms. Twelve kinds were classified as sensitive, six as intermediate, and one as tolerant. The density was calculated at $285/ft^2$ ($3047/m^2$).

TABLE 1

NASHUA RIVER BENTHIC MACROINVERTEBRATE STUDY

PHYSICAL CHARACTERISTICS BY STATION

STATION	RIVER MILE/KILOMETER	DESCRIPTION	*SUBSTRATE TYPE	SAMPLE DEPTH (ft/m)
NN03	55.5/88.8	Outlet Crocker Burbank Mill #9 Dam, Fitchburg	Boulder(50%)-Rubble(30%)-Gravel(10%)-Muck(10%)	~1/ 0.3
NN08	50.8/81.3	Bemis Road Bridge, Fitchburg	Boulder(50%)-Rubble(30%)-Gravel(10%)-Muck(10%)	~1/ 0.3
NN10	47.3/75.7	Rt. 13 Bridge, Fitchburg	Boulder(20%)-Rubble(60%)-Gravel(10%)-Sand(10%)	1/0.3
NN11	45.8/73.3	Mechanic Street Bridge, Fitchburg	Rubble(10%)-Gravel(30%)-Sand(50%)-Silt(10%)	~1/ 0.3
NN12	43.8/70.1	Below U.S.G.S. Gage, Leominster	Boulder(50%)-Rubble(30%)-Gravel(10%)-Sand(5%)-Silt(5%)	1/0.3
NN14	36.9/59.0	Main Street Bridge, Lancaster	Rubble(20%)-Sand(80%)	1-2/0.3-0.6
NS17	36.5, 1.6/58.4, 2.6	Upstream of Clinton STP, Clinton	Rubble(20%)-Gravel(70%)-Sand(10%)	0.5/0.15
NS18	36.5, 1.1/58.4, 1.8	Mill Street Bridge, Lancaster	Rubble(10%)-Gravel(50%)-Sand(20%)-Silt(10%)-Detritus(10%)	2/0.6
NS19	36.5, 0.3/58.4, 0.5	Bolton Road Bridge, Lancaster	Boulder(10%)-Rubble(50%)-Gravel(20%)-Sand(20%)	~ 1/ 0.3

TABLE 1 (CONTINUED)

STATION	RIVER MILE/KILOMETER	DESCRIPTION	*SUBSTRATE TYPE	SAMPLE DEPTH (ft/m)
NM21	31.0/49.6	Tank Bridge, Harvard-Lancaster	Rubble(10%)-Gravel(70%)-Sand(15%)-Muck(5%)	6/1.8
NM25	23.1/37.0	Rt. 2A Bridge, Shirley-Ayer	Rubble(5%)-Gravel(20%)-Sand(25%)-Silt(50%)	3/0.9
NM30	9.6/15.4	Rt. 111 Bridge, Hollis, N.H.	Bedrock(20%)-Boulder(50%)-Rubble(15%)-Gravel(5%)-Sand(5%)-Silt(5%)	1/0.3
		WHITMAN RIVER		
NT34	56.1, 1.3/89.8, 2.1	Westminster Street Bridge, Rt. 2A, Westminster	Rubble(30%)-Gravel(50%)-Sand(20%)	~1/ 0.3
		NISSITISSIT RIVER		
NT66	13.1, 4.8/21.0, 7.7	Pepperell Road Bridge, Hollis, N.H.	Boulder(10%)-Rubble(60%)-Gravel(10%)-Sand(20%)	2/0.6
NT67	13.1, 2.6/21.0, 4.2	Prescott Street Bridge, Pepperell	Boulder(10%)-Rubble(70%)-Gravel(15%)-Sand(5%)	~1/ 0.3
NT68	13.1, 0.8/21.0, 1.3	Rt. 111 Bridge, Pepperell	Bedrock(50%)-Boulder(10%)-Rubble(20%)-Gravel(15%)-Sand-Silt(5%)	1/0.3

*Classified according to EPA methods manual (Weber 1973)

Normandeau Associates, Inc. (1971, 1974) and MDWPC (1976) conducted studies in the Merrimack River Basin and the Leominster Public Health Office made some incidental observations on benthic organisms in Monoosnoc Brook (NEIWPCC 1971).

Analysis of Benthic Communities by Station

Since this benthic macroinvertebrate study on the Nashua Basin is the first conducted on an extensive basis, a description of the benthic macroinvertebrate condition at each station will be presented. By examining the tables and figures and the Parts A and B (MDWPC 1978) trends in the benthic response to the present water quality are noticeable. Because this is mostly a qualitative reconnaissance approach, no concrete conclusions should be drawn from the data. However, this study will serve as a valuable baseline for comparison with future Nashua benthic macroinvertebrate studies.

The following is a description of the benthic community at each station and the general water quality response. For the station locations refer to Table 1 and Figure 2.

Station NN03 was located on the north branch about 100 yards (90m) below the Crocker Burbank Mill #9 dam. This area was subject to the discharge of the Fitchburg Westerly Wastewater Treatment Plant situated about 0.6 miles (1 km) upstream. The benthic community was made up mostly of chironomids (Appendix 1). The physical effects of a slime covered bottom selected against the clinging forms usually associated with "clean water" communities (Figure 3). This, in addition to a maximum BOD_5 of 25 mg/l (Figure 4) and a minimum dissolved oxygen of 0.1 mg/l (Figure 5), created a condition that favored organisms that can tolerate high levels of organic pollutants. The occurrence of Polypedilum and Chironomus indicated a stress of this type. Moderate numbers of Cricotopus, a genus often considered intolerant, were present probably because they favor the rapid current velocities encountered. With a decrease in the load from the Westerly plant and elimination of additional stress from Flag Brook, a more diverse benthic community could exist.

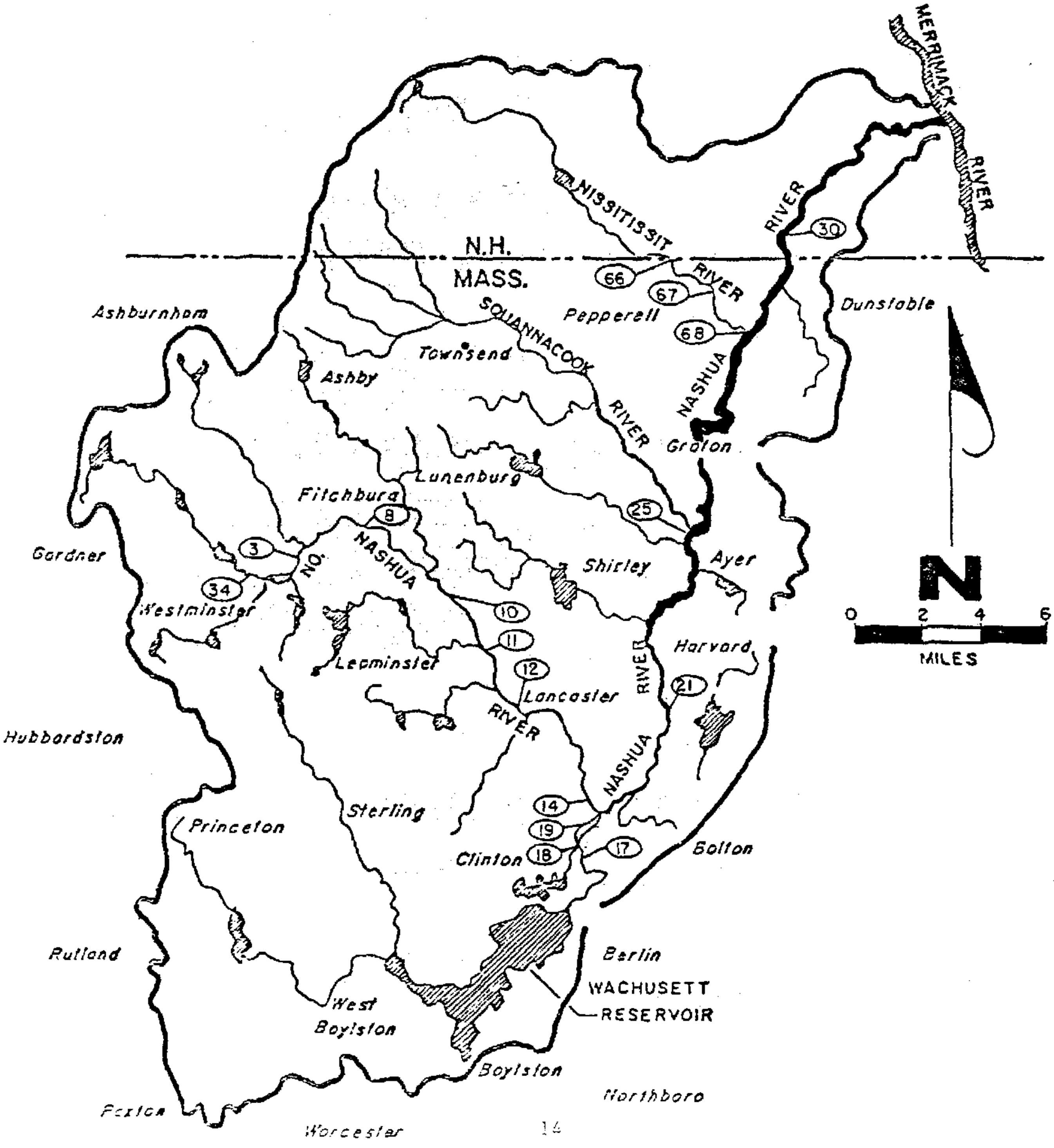
Station NN08 was in a riffled stretch about 20 - 30 feet (6 - 9 meters) wide. The steep banks consisted of decomposed paper sludge and the bottom was coated with what appeared to be muck and paper waste. Although the levels of BOD_5 and DO greatly improved over NN03 the benthic organisms exhibited only a slightly less stressed condition rather than a "recovery zone". The significance of the species change within the genus Chironomus and the addition of a species of Cricotopus is not known. An abundance of physid snails and oligochaetes still indicated a pollutional stress. The presence of early instar baetid mayflies and two early instar caddisflies may indicate an improvement in the water quality only now taking place or may just be chance occurrences.

Station NN10 was located 0.8 miles (1.3 km) below the Fitchburg Easterly Wastewater Treatment Plant. Conditions here indicated a recovery zone

LOCATION OF MACROINVERTEBRATE

SAMPLING STATIONS

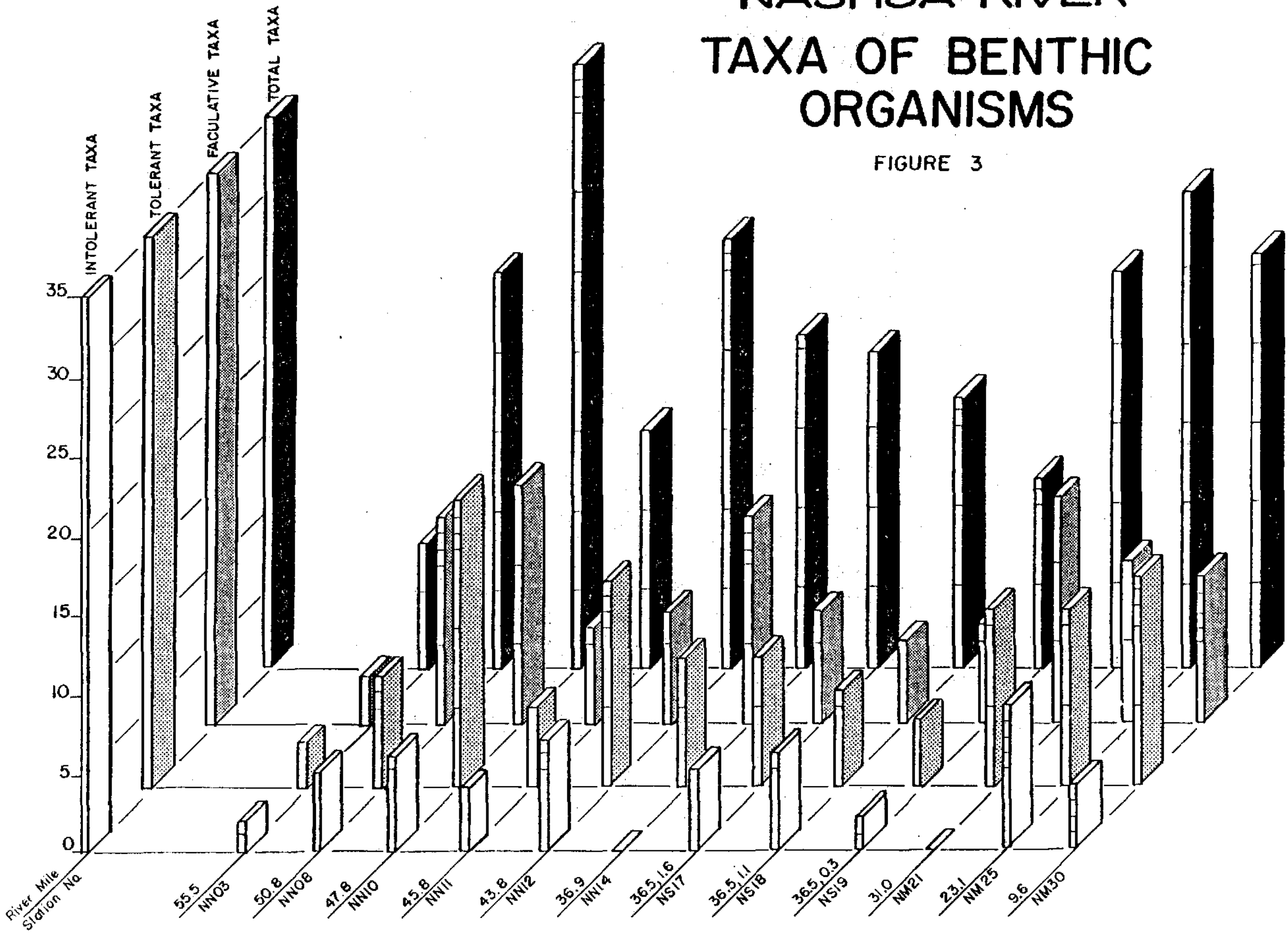
FIGURE 2

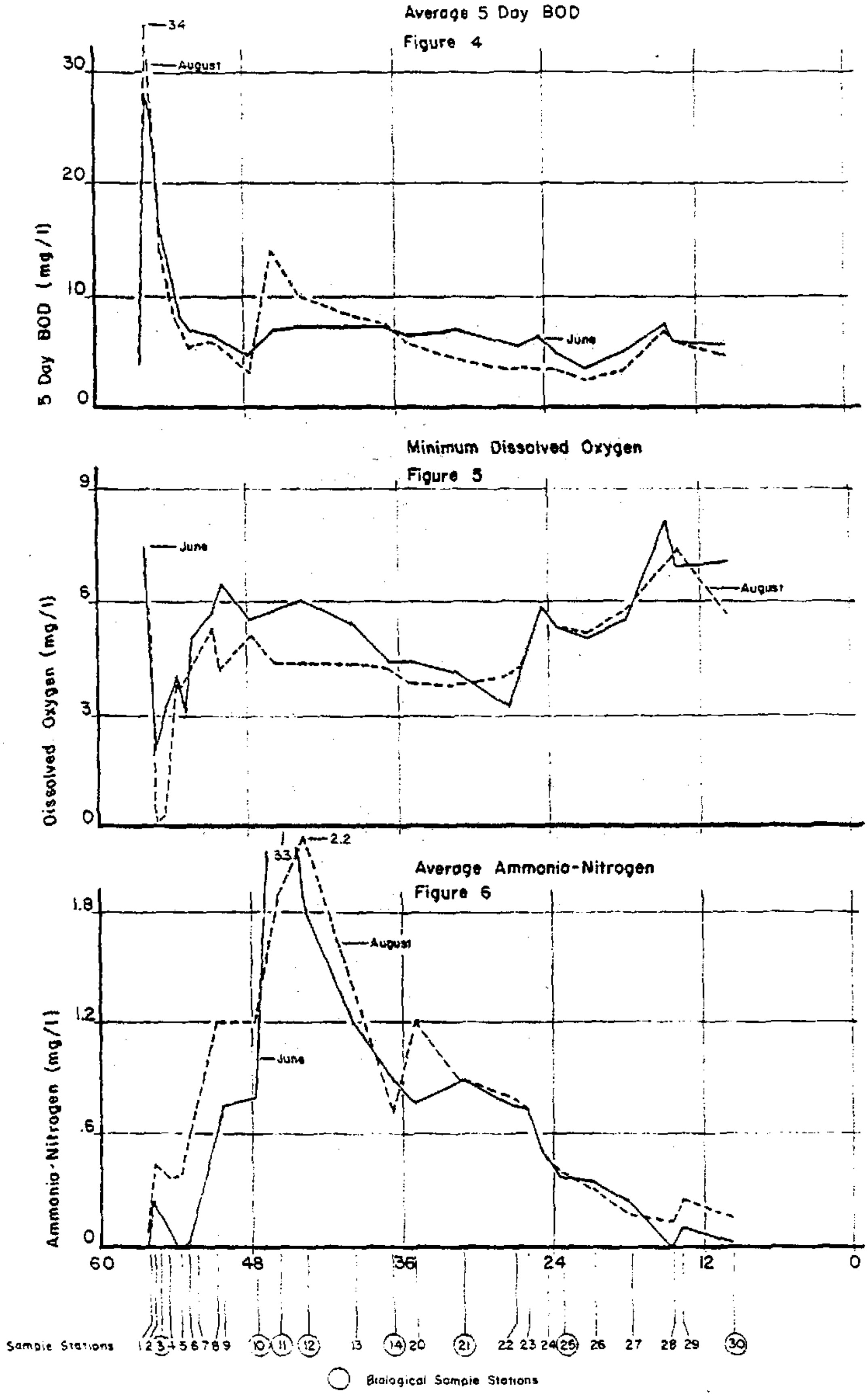


NASHUA RIVER

TAXA OF BENTHIC ORGANISMS

FIGURE 3





Average 5 Day BOD
Figure 4
5 Day BOD (mg/l)
30
20
10
0
34
August
June
Minimum Dissolved Oxygen
Figure 5
Dissolved Oxygen (mg/l)
9
6
3
0
June
August
Average Ammonia-Nitrogen
Figure 6
Ammonia-Nitrogen (mg/l)
1.8
1.2
.6
0
3.3
2.2
August
June
60
48
36
24
12
0
Sample Stations
1 2 3 4 5 6 7 8 9 10 11 12 13 14 20 21 22 23 24 25 26 27 28 29 30
Biological Sample Stations

with low BOD_5 and a DO in excess of 5 mg/l. The substrate lacked the slime coating experienced at the previous stations and was mostly clean except for occasional patches of green filamentous algae. The addition of the intolerant midge Micropsectra, the increase in the abundance of the genus Cardiocladius, the disappearance of Chironomus, and the reduction in the numbers of most of the midge genera indicated a positive change in water quality. The occurrence of the caddisfly Hydropsyche, and change in the oligochaetes from tubificids to naidids also enforced the premise of improved water quality. The Easterly plant appeared to exert no noticeable adverse impact on the benthic organisms. In fact, conditions encountered would suggest the possibility of a community more diverse than the 38 taxa collected.

Station NN11 was located about 0.8 miles (1.3 km) downstream of the Leominster Wastewater Treatment Plant. The water at this station was greyish in color with a septic odor. The bottom was slime covered. These conditions were reflected by the benthic organisms in that the number of taxa plunged from 38 at NN10 to 15. Although the midge fauna remained largely unchanged, the recurrence of large numbers of Cricotopus may indicate a significant response to water quality since they were also present at NN03 and NN08, both stressed areas. The lack of caddisflies, hemipterans, and beetles and their replacement by tubificids and leeches, indicates a stress of an organic nature likely caused by the Leominster plant. The increase in BOD_5 from 3.3 mg/l above the plant to 15 mg/l below and the increased ammonia level (3.6 mg/l) linked with a pH of 7.6 (Figure 6 and Table 2) further implicates the plant as the source of stress.

Station NN12 showed some improvement toward a facultative condition. The number of taxa increased from 15 at NN11 to 27, the bulk of the change being the increase in naidid worms. The chironomid fauna changed little. The occurrence of hydropsychid caddisflies provided the only real indicator of improvement over NN11. As an interesting note, a crayfish was collected entirely covered with a fungal growth. The BOD_5 and ammonia levels remained high at 11 mg/l and 2.8 mg/l, respectively.

At NN14 no riffled stretch was present. The slow current velocity and sand substrate limited the chironomid fauna in both numbers and types. The occurrence of Cheumatopsyche was interesting, since they do not usually favor a slow moving current and sandy bottom. Because of the differences in flow and substrate conditions between NN14 and the upstream stations, no direct comparisons should be made. Only this station and NM21 yielded no intolerant organisms.

Station NS17 was located on the south branch immediately above the discharge of the Clinton Wastewater Treatment Plant. This stretch was narrow and shallow with a rapid flow. The bottom was clean with a few scattered clumps of green filamentous algae. The midge fauna was quite similar to that of the north branch. Non-chironomids were made up mostly of hydropsychids,odonates, beetles, and snails. During 1973, Camp, Dresser, and

TABLE 2

1977 NASHUA RIVER BASIN SURVEY

pH (Standard Units)

STATION	6/21/77	6/23/77	8/16/77	8/18/77
		<u>Nashua River - North Branch</u>		
NN03	6.4	6.5	6.7	6.6
NN08	6.7	---	6.9	6.9
NN10	6.8	6.9	7.5	6.9
NN11	6.9	7.1	7.6	6.9
NN12	7.0	6.9	7.2	6.9
NN14	7.0	6.9	7.1	6.9
		<u>Nashua River - South Branch</u>		
NS17	6.8	6.9	6.9	6.6
NS18	7.1	7.2	7.0	5.8
NS19	7.1	7.0	7.5	6.7
		<u>Nashua River - Mainstem</u>		
NM21	6.8	6.6	7.3	6.9
NM25	6.7	7.0	7.4	7.1
NM30	6.6	6.9	7.3	7.3
		<u>Whitman River</u>		
	6/28/77	6/30/77	8/23/77	8/25/77
NT34	6.4	6.1	6.6	6.1
		<u>Nissitissit River</u>		
NT66	6.5	6.4	7.2	6.2
NT67	6.8	6.6	6.5	4.5
NT68	6.8	6.8	6.9	6.4

McKee, Inc. (1975) sampled very near this station. Of the nine types they collected, three were found by the Division. Since the 1973 study lacked a description of the methods employed and the taxonomic sources were not the same, it is difficult to do a valid community comparison. The differences in the number of taxa (9 vs. 20) could be due to improved stream conditions over the last four years, but could also be due to unlike methods and taxonomy.

Station NS18 was located about 0.5 miles (0.8 km) downstream of the Clinton plant in a stretch that esthetically displayed an organic pollution problem. The water was greyish in color, of a septic odor, and contained recognizable solids. Seven types of midges were collected, four of them thought to be intolerant. Their presence cannot be explained; however, their numbers were very low. The other organisms collected consisted mostly of oligochaetes and leeches. Occurrences of an early instar mayfly and a caddisfly larva were probably due to drift. The conditions of BOD_5 and ammonia worsened from those encountered above the plant.

Conditions at NS19 were very similar to those at NS18. The water was still of a greyish color and septic odor. The midge fauna changed little except for the loss of Brillia and Psectrocladius elatus. This shift was not thought to be significant since their occurrence at NS18 was considered rare. The other organisms were still largely made up of oligochaetes and leeches.

Station NM21 was located on the main stem Nashua at a deep, slow-moving stretch. Cricotopus, which occurred at all the riffled stations, disappeared and was replaced by Procladius and Dicrotendipes in small numbers. Hemipterans, odonates, beetles, isopods, amphipods, worms, and leeches were also present. During the 1973 Camp, Dresser, and McKee, Inc. (1975) study, 14 different taxa were collected consisting mostly of leeches and worms. The Division collected 25 taxa of a more diverse nature. Again, differences in methods and taxonomy may explain this difference rather than water quality improvement. The organisms collected at this site were representative of this habitat type. As at NN14 no intolerant types were found.

NM25 was the only station sampled on the Nashua using quantitative methods because it is an EPA water quality station monitored on a monthly basis. This stretch, 1.1 miles (1.8 km) below the Ayer Wastewater Treatment Plant and above the Ayer Ice House Dam, was mostly slow-moving and about three feet (0.9m) in depth. The bottom was silt-covered. The chironomid fauna was composed of 12 total taxa, including several facultative-intolerant types not collected at any of the previous stations. Rheotanytarsus was one of the new genera collected in large numbers. The rest of the community consisted of mostly tubificid worms (5000 $+/m^2$). The 1973 CDM study found this area to support six taxa: two leeches, two worms, a midge, and a sow bug. The Division found 30 taxa. The numbers of organisms by tolerance, diversity index, and trophic index are given in Table 3.

In a riffled area downstream, Cheumatopsyche was collected along with a baetid mayfly, physid snails, and sphaeriid clams.

TABLE 3

QUANTITATIVE SAMPLING DATA ON MACROINVERTEBRATES
REPORTED AS NUMBERS BY TOLERANCE
TYPE, DIVERSITY, AND TROPHIC CONDITION

STATION	NM25	NT34	NT66	NT67	NT68
Total No. of Organisms	576	1216	115	982	452
No. of Intolerant	2	711	73	803	353
No. of Facultative	19	503	32	160	78
No. of Tolerant	555	2	10	19	21
Diversity (Shannon-Weaver)[1]	1.06	3.96	4.92	3.60	4.77
Trophic Condition Index[2]	1.96	0.42	0.45	0.20	0.26

1 $\bar{d} = \frac{C}{N}(N \log_{10} N - \Sigma n_i \log_{10} n_i)$ where,

C = 3.32 (converts base 10 log to base 2 {bits})

N = total number of individuals

n_i = total number of individuals in the i th species

2 $\text{Trophic Condition} = \frac{\Sigma N_1 + 2\,\Sigma N_2}{\Sigma N_0 + \Sigma N_1 + \Sigma N_2}$ where,

N_0 = # intolerant organisms

N_1 = # facultative organisms

N_2 = # tolerant organisms

0 = maximum oligotrophy

2.00 = maximum eutrophy

Station NM30 was the last sampled. This was a wide, fast-moving stretch with many large boulders and rapids. Even though the area appeared capable of supporting a diverse community, the midge fauna exhibited a condition of stress with the major component consisting of the tolerant genus *Glyptotendipes*. Some hydropsychid caddisflies, considered intolerant, were present; however, the bulk of the community consisted of facultative and tolerant sowbugs, beetles, worms, and snails. The reason for such a low diversity under the existing conditions may be the silty bottom which extended even into the riffled areas.

NASHUA RIVER TRIBUTARIES

Two Nashua tributaries were sampled for quantitative, "clean water" data - the Whitman River and the Nissitissit River. The quantitative data is given in Table 3. For the chemical water quality consult the Nashua River Part A (MDWPC 1978).

Station NT34 on the Whitman River was chosen for two reasons: 1) it is an EPA monitoring station under the NWQSS program and; 2) previous data exists on the benthic community. As part of the Merrimack River Study the Whitman River was sampled in June 1964 (Oldaker 1966). At this time he found 19 taxa that suggested a "clean water" condition. The Division's 1977 study also found the Whitman in good condition supporting 63 taxa, of which 60% were intolerant (Figure 7). Fifteen types of midges were collected many of which are restricted to unpolluted conditions (Appendix 2). Most noteworthy was the genus Pseudodiamesa which occurred in moderate numbers. Many genera of mayflies, caddisflies, and beetles considered intolerant were collected. Only three genera - Stenelmis sp., Rhyacophila sp., and Stenonema sp. were common to the studies. The reasons for these differences may be due to the state-of-the-art taxonomy, particularly in the stoneflies, caddisflies, and dipterans and not necessarily to water quality changes.

The Nissitissit River was sampled at three locations in order to provide "clean water" comparative stations for the eastern half of the State. The first station, NT66, was located in New Hampshire in a more pooled than riffled stretch. This probably accounts for the slightly lower diversity encountered (63 taxa) in comparison with the other two stations. The midge fauna was diverse with Ablabesmyia, Psectrocladius and Rheotanytarsus indicating the presence of unpolluted conditions. The occurrence of diverse mayfly, caddisfly, odonate, and beetle populations also indicated favorable water quality. The silty bottom at this location may exclude some clinging forms.

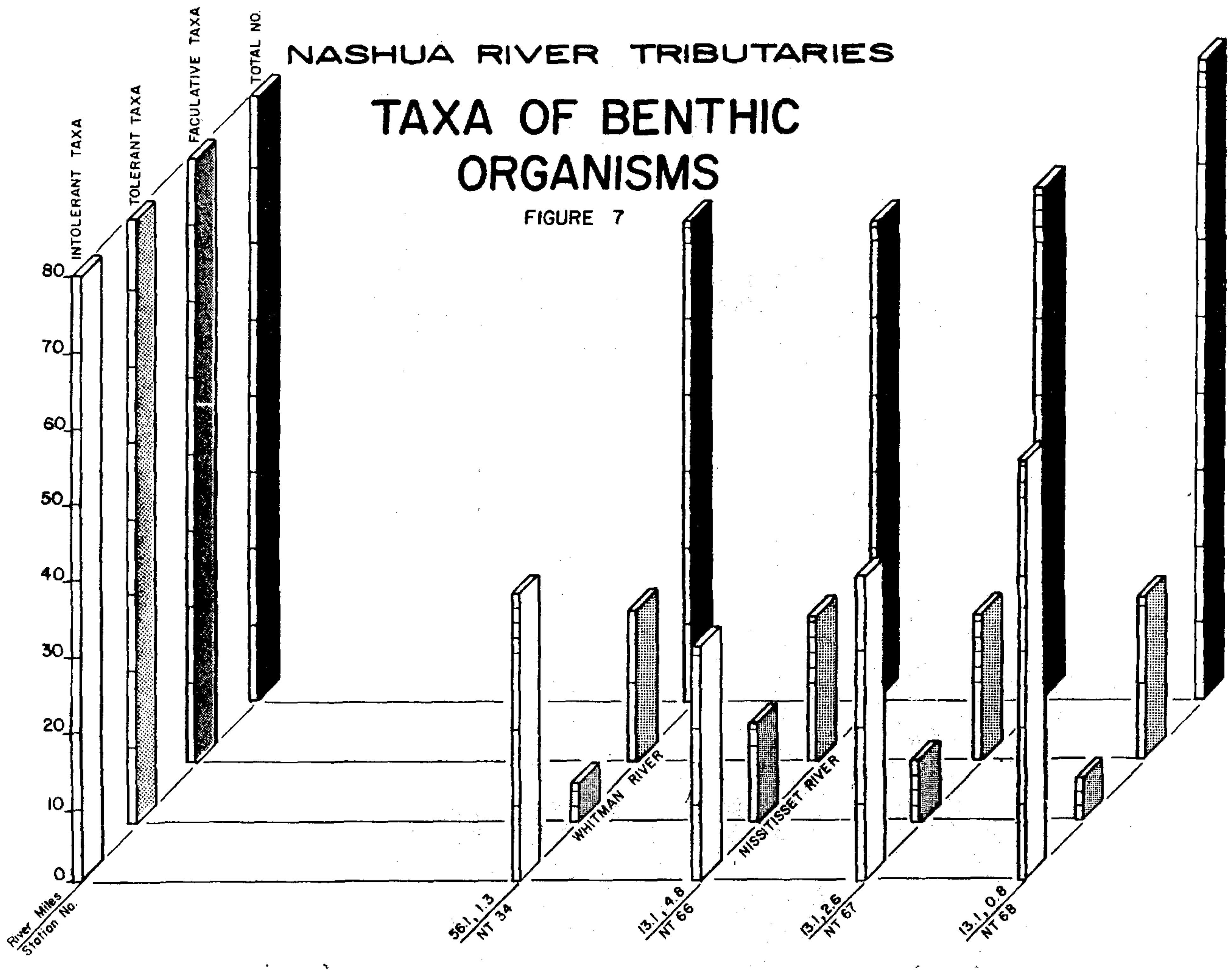
Station NT67 was located 2.2 miles (3.5 km) downstream in a swift moving, well vegetated area. The bottom was mostly shale with a silt covering. A total of 67 taxa were collected. The midge fauna changed by the addition of five new taxa, four of which are considered intolerant. The chironomid abundance may have increased as a response to the favorable habitat. Very high numbers of caddisflies were encountered along with diverse populations of mayflies, beetles, and snails. Over 60% of the community was of a pollution intolerant classification.

Station NT68 had the most diverse benthic community sampled in the Nashua Basin with a total of 82 taxa. The chironomid fauna was essentially the same as that encountered at NT67 except for the loss of the genus Eukiefferiella. Again, very diverse populations of mayflies, caddisflies, beetles, and shellfish were collected. During the summer of 1973, the Division

NASHUA RIVER TRIBUTARIES

TAXA OF BENTHIC ORGANISMS

FIGURE 7



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collected macroinvertebrates from this site and identified 21 taxa. Since this study was not conducted on the same level of intensity it should not be directly compared to the 1977 study. However, it does show that the conditions at this station have not worsened during the past four years.

SUMMARY

The Nashua River no longer exhibits the grossly polluted conditions found during the 1965 FWPCA study and presently supports more diverse benthic communities than encountered during CDM's 1973 survey. As was stated before, there are considerable differences in the methodologies and taxonomy between the studies, however, it is apparent that the Nashua's ability to support diverse benthic communities is on the increase.

Although the water quality is improving steadily, the effects of the substrate on the organisms continue. Until the bottom is purged of slime growths and sludge the likelihood of recolonization by "clean water" organisms remains in doubt. Even the natural processes of flushing and decay will require time.

Fortunately no high metals levels or other toxins tested for were encountered during the survey. Unfortunately, high concentrations of BOD and ammonia and low concentrations of dissolved oxygen were found. In these areas with high levels of organic pollutants depressed benthic communities existed. Once these pollution sources are discovered and eliminated, the river stands a good chance of recovery from the standpoint of benthic macroinvertebrate community structure. When this occurs higher levels of the food chain such as fish will also benefit, promoting more desirable water uses.

The two tributaties sampled supported very diverse intolerant communities and appear to be free of pollutional stresses. The Nissitissit River is one of the most diverse "clean water" streams sampled by the Division to date.

TABLE OF APPENDICES

Appendix 1 - Number and Kinds of Benthic Macroinvertebrates by Pollution Tolerance - Nashua River 1977

Appendix 2 - Number and Kinds of Benthic Macroinvertebrates by Pollution Tolerance - Nashua River Tributaries 1977

Appendix 3 - List of Biological References

APPENDIX 1

NUMBER AND KINDS OF BENTHIC MACROINVERTEBRATES BY POLLUTION TOLERANCE

NASHUA RIVER

1977

ORGANISMS	Pollution Tolerance	NN03	NN08	NN10	NN11	NN12	NN14	NS17	NS18	NS19	NM21	NM25	NM30
		NASHUA RIVER											
PLATYHELMINTHES													
Turbellaria (flatworms)													
Planaria sp.	F											*	
NEMATODA (nematodes)	F			*								1	*
ANNELIDA													
Oligochaeta (aquatic earthworms)													
Cambarincola macrodonta	T					*	*					5	
Naididae sp.	F			*	*	*			*	*			*
Dero sp.	F			*		*							
Nais sp.	F			*	*	*			*		*		
Nais communis	F			*		*							*
Pristina sp.	F			*		*							*
Lumbriculidae sp.	T									*			
Tubificidae spp.	T			*						*		1	
Limnodrilus sp.	T		*										
Limnodrilus hoffmeisteri	T		*						*	*		25	
Limnodrilus udekemianus	T		*									5	
Tubifex ignotus	T		*										
Immature without capilliform setae	T		*	*	*	*			*	*	*	485	*
Immature with capilliform setae	T	*	*		*	*			*			30	
Hirudinea (leeches)													
Helobdella elongata	T				*								
Helobdella stagnalis	T					*	*			*	*		

APPENDIX 1 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	NN03	NN08	NN10	NN11	NN12	NN14	NS17	NS18	NS19	NM21	NM25	NM30
		NASHUA RIVER											
Erpobdellidae sp.	T		*		*	*	*		*		*		*
Dina sp.	F								*				
Erpobdella sp.	T			*									
Erpobdella punctata	T				*	*							*
Erpobdella triannulata	T			*									
ARTHROPODA													
Crustacea													
Isopoda (sow bugs)													
Asellus sp.	F											*	
Asellus communis	F					*	*				*		*
Amphipoda (scuds)													
Hyalella azteca	F										*		
Crangonyx obliquus-richmondensis Complex	F												*
Decapoda (crayfish)													
Orconectes sp.	F						*				*	*	
Orconectes limosus	F					*							
Insecta													
Collembola (springtails)													
Podura aquatica	F												*
Ephemeroptera (mayflies)													
Baetidae sp.	I		*										
Baetis spp.	I											*	
Heptageniidae sp.	I								*				
Odonata (dragonflies and damselflies)													
Aeschna umbrosa	F							*					
Coenagrionidae sp.	F			*			*	*			*		
Enallagma hageni-ebrium Group	F			*									

ORGANISMS (continued)	Pollution Tolerance	NN03	NN08	NN10	NN11	NN12	NN14	NS17	NS18	NS19	NM21	NM25	NM30
		NASHUA RIVER											
Ischnura sp.	F										*		
Ischnura posita	F			*									
Ischnura verticalis	F		*	*			*						
Hemiptera (true bugs)													
Corixidae sp.	T		*										
Hesperocorixa sp.	T		*										
Trichocorixa sp.	T			*									
Notonecta sp.	T			*			*				*		
Belostoma sp.	T			*			*				*		
Ranatra sp.	T			*									
Gerris sp.	T						*				*		
Rheumatobates sp.	T						*					*	
Rheumatobates rileyi	T										*		
Microvelia sp.	T										*		
Mesovelia mulsanti	T										*		
Coleoptera (beetles)													
Haliplus sp.	T			*				*					
Peltodytes edentulus	T			*									
Bidessus sp.	T						*				*		
Colymbates/Rhantus sp.	T		*										
Laccophilus sp.	T		*	*			*	*					
Dineutus sp.	F										*		
Anacaena sp.	T							*					
Berosus sp.	T			*	*						*		*
Berosus striatus	T			*									
Enochrus sp.	T												*
Helocombus bifidus	T												*
Tropisternus sp.	T			*				*			*		
Stenelmis sp.	I												*

APPENDIX 1 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	NN03	NN08	NN10	NN11	NN12	NN14	NS17	NS18	NS19	NM21	NM25	NM30
		NASHUA RIVER											
Neuroptera (dobsonflies & alderflies)													
Sialis sp.	F							*					
Chauloides sp.	I					*							
Nigronia sp.	I							*					
Trichoptera (caddisflies)													
Rhyacophilidae sp.	I		*										
Hydropsychidae sp.	I		*										
Cheumatopsyche sp.	F	*		*		*	*	*				1	*
Hydropsyche spp.	I			*		*		*	*				*
Hydropsyche betteni	I			*									
Agraylea sp.	I											*	
Diptera (true flies)													
Tipula sp.	I							*					*
Chaoborus sp.	F												
Culex pipiens	T	*											
Ceratopogonidae sp.	F		*										
Chironomidae (midges)													
Conchapelopia/*Arctopelopia* sp.	F		*	*	*	*	*	*	*	*	*	*	
Procladius sp.	F										*	10	
Chironominae sp.	F			*									
Chironomus sp.	T						*	*			*	3	
Chironomus riparius	T		*										
Chironomus tentans	T	*											
Cryptochironomus sp.	T						*					1	
Dicrotendipes sp.	F										*	*	
Glyptotendipes sp.	T												*
Harnischia sp.	I											1	

APPENDIX 1 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	NN03	NN08	NN10	NN11	NN12	NN14	NS17	NS18	NS19	NM21	NM25	NM30
		NASHUA RIVER											
Polypedilum spp.	F	*	*	*	*	*		*	*	*	*	*	
Polypedilum fallax	F	*		*	*	*	*	*	*	*			
Polypedilum scalaenum	F					*	*						
Micropsectra sp.	I			*									
Rheotanytarsus sp.	F											7	*
Brillia sp.	I				*								
Brillia flavifrons	I								*				
Cardiocladius sp.	I	*	*	*	*	*		*	*	*			*
Cricotopus spp.	I	*	*	*	*	*		*	*	*		*	
Orthocladius sp.	I			*		*						*	
Psectrocladius sp.	I				*				*			*	
Psectrocladius elatus	I					*							
Thienemanniella sp.	I											*	
Simuliidae sp.	I					*							*
Simulium sp.	F		*	*									
Hemerodromia sp.	F			*									
Arachnida													
Acari "Hydracarina" (water mites)	I											*	
MOLLUSCA													
Gastropoda (snails)													
Physa sp.	T		*	*		*	*	*	*	*	*	*	*
Lymnaea sp.	F		*										*
Gyraulus sp.	F		*					*					
Helisoma sp.	T						*	*		*			*
Ferrissia sp.	F			*		*							*
Amnicola sp.	I											1	

APPENDIX 1 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	NN03	NN08	NN10	NN11	NN12	NN14	NS17	NS18	NS19	NM21	NM25	NM30
		NASHUA RIVER											
Pelecypoda (bivalves)													
Pisidium sp.	F											*	
Sphaerium partumeium	F							*					
Sphaerium securis	F												*

*Denotes the occurrence of organisms. Numbers indicate organisms collected in the quantitative samples.

I = Intolerant
F = Facultative
T = Tolerant

APPENDIX 2

NUMBER AND KINDS OF BENTHIC MACROINVERTEBRATES BY POLLUTION TOLERANCE

NASHUA RIVER TRIBUTARIES

1977

ORGANISMS	Pollution Tolerance	WHITMAN RIVER	NISSITISSIT RIVER		
		NT34	NT66	NT67	NT68
PLATYHELMINTHES					
Turbellaria (flatworms)					
Planaria sp.	F	2			*
NEMATODA (nematodes)	F	3			1
ANNELIDA					
Oligochaeta (aquatic earthworms)	T				*
Naididae sp.	F	*			
Pristina sp.	F	*			
Stylaria fossularis	F		2		1
Lumbriculidae sp.	T		3	13	
Lumbriculus sp.	T				19
Tubificidae spp.	T			1	
Immature without capilliform setae	T			1	
Hirudinea (leeches)					
Placobdella parasitica	F		*		
Mooreobdella sp.	T		*		
ARTHROPODA					
Crustacea					
Isopoda (sow bugs)					
Asellus communis	F				*

APPENDIX 2 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	WHITMAN RIVER NT34	NISSITISSIT RIVER NT66	NISSITISSIT RIVER NT67	NISSITISSIT RIVER NT68
Amphipoda (scuds)					
Hyalella azteca	F				*
Crangonyx obliquus-richmondensis Complex	F				*
Insecta					
Collembola (springtails)					
Podura aquatica	F		*		
Ephemeroptera (mayflies)					
Siphlonuridae sp.	I				2
Isonychia sp.	I			71	10
Baetidae sp.	I	6	2	9	6
Baetis spp.	I	8		1	8
Heptageniidae sp.	I	5	5	23	42
Epeorus (*Iron*) sp.	I			18	3
Heptagenia sp.	I	1			6
Heptagenia pulla	I				*
Heptagenia maculipennis	I				*
Stenonema sp.	I	26			1
Stenonema rubrum	I	*	*		1
Leptophlebiidae sp.	I	1			
Ephemerella sp.	I	1		2	4
Ephemerella deficiens	I				1
Ephemerella serratoides	I				6
Caenis sp.	F			*	
Tricorythodes sp.	F				21
Odonata (dragonflies and damselflies)					
Basiaeschna janata	F		*		
Boyeria venosa	F		3		

APPENDIX 2 CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	WHITMAN RIVER	NISSITISSIT RIVER		
		NT34	NT66	NT67	NT68
Gomphidae sp.	F	1			
Lanthus sp.	F		1	*	
Ophiogomphus sp.	F			4	1
Macromia sp.	F		*	*	
Libellulidae sp.	F	1		*	1
Calopteryx maculatum	I		1	*	*
Coenagrionidae sp.	F		*	*	
Argia violacea	I		2	*	1
Enallagma sp.	F		*	*	*
Plecoptera (stoneflies)					
Nemouridae sp.	I				1
Leuctra sp.	I	61			
Acroneuria sp.	I		1	6	11
Acroneuria abnormis	I	2			
Acroneuria ruralis	I	*			
Perlesta placida	I				*
Hemiptera (true bugs)					
Sigara sp.	T		*		
Notonecta sp.	T		*		
Gerris sp.	T	*	*	*	
Metrobates sp.	T	*	1		1
Microvelia sp.	T	2		1	
Rhagovelia sp.	T	*		1	*
Coleoptera (beetles)					
Haliplus sp.	T		*		
Peltodytes sp.	T		*		

APPENDIX 2 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	WHITMAN RIVER	NISSITISSIT RIVER		
		NT34	NT66	NT67	NT68
Hygrotus/Hydroporus sp.	T		1		
Dineutus sp.	F	*		3	
Hydrobius sp.	T	*			
Hydraena sp.	T		*		
Anchytarsus sp.	I	2			
Ectopria sp.	I				*
Psephenus sp.	I			1	2
Elmidae sp.	I				*
Dubiraphia sp.	F	1			
Optioservus sp.	F		1	3	1
Oulimnius sp.	I	22		1	
Promoresia tardella	I		9		3
Stenelmis sp.	I	44		2	10
Stenelmis crenata Group	I		1	1	2
Neuroptera (dobsonflies & alderflies)					
Sialis sp.	F	4			4
Corydalis cornutus	I				1
Nigronia sp.	I	5	2	3	1
Trichoptera (caddisflies)					
Agapetus sp.	I		1		
Rhyacophila sp.	I	2			1
Rhyacophila fuscula	I	*	*		
Chimarra sp.	I			9	9
Chimarra aterrima	I	2		65	44
Chimarra obscura	I			19	32
Dolophilus sp.	I		1		
Polycentropus sp.	I			*	2
Phylocentropus sp.	I		5		
Hydropsychidae sp.	I	50	1	29	7

APPENDIX 2 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	WHITMAN RIVER	NISSITISSIT RIVER		
		NT34	NT66	NT67	NT68
Cheumatopsyche sp.	F	8	12	102	17
Hydropsyche spp.	I	57		246	25
Hydropsyche betteni	I	4			
Macronemum sp.	I			235	63
Macronemum zebratum	I				*
Hydroptilidae sp.	I		1		3
Agraylea sp.	I				5
Hydroptila sp.	I		1		
Oxyethira sp.	I		*	*	
Limnephilidae sp.	I			2	
Neophylax sp.	I		4	*	
Pycnopsyche sp.	I			*	
Leptoceridae sp.	I				1
Ceraclea sp.	I		1		
Nectopsyche sp.	I			*	1
Oecetis sp.	F	3	1		2
Lepidostoma sp.	I			3	*
Brachycentrus sp.	I		5	9	5
Micrasema sp.	I		1		
Lepidoptera (butterflies and moths)					
Paragyractis sp.	F		*		
Diptera (true flies)					
Antocha sp.	I	1	2		3
Dicranota sp.	I	7			
Eriocera spinosa	I	5			
Anopheles sp.	I			1	
Ceratopogonidae sp.	F	10	1		
Chironomidae (midges)					
Tanypodinae sp.	F			*	

APPENDIX 2 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	WHITMAN RIVER	NISSITISSIT RIVER		
		NT34	NT66	NT67	NT68
Ablabesmyia sp.	I		7	*	
Conchapelopia/Arctopelopia sp.	F	6	2	1	
Labrundinia sp.	I		1		*
Endochironomus sp.	F	2			
Microtendipes sp.	I	12			
Microtendipes tarsalis	I			3	10
Phaenopsectra sp.	I				3
Polypedilum spp.	F	30	1	17	8
Xenochironomus xenolabis	I		1		
Micropsectra sp.	I	170			
Rheotanytarsus sp.	F	360	7	25	18
Pseudodiamesa sp.	I	55			
Zavrelia sp.	I	20			
Brillia sp.	I				*
Cardiocladius sp.	I				*
Corynoneura sp.	I	2		2	2
Cricotopus spp.	I	2	3	*	*
Eukiefferiella spp.	I	2		13	
Eukiefferiella sp. 1/*similis*	I	11			
Heterotrissocladius sp.	I	1			
Psectrocladius sp.	I		6	4	
Psectrocladius elatus	I		*		*
Thienemanniella sp.	I			*	
Trichocladius spp.3	I	*		16	3
Trichocladius sp.	I	53			
Simuliidae sp.	I	65			
Simulium sp.	F	42		1	

APPENDIX 2 (CONTINUED)

ORGANISMS (continued)	Pollution Tolerance	WHITMAN RIVER NT34	NISSITISSIT RIVER NT66	NT67	NT68
Simulium venustum	F	4			
Empididae sp.	F	1			
Hemerodromia sp.	F	24			
Arachnida					
Acari "Hydracarina" (water mites)	I	5	2	5	5
MOLLUSCA					
Gastropoda (snails)					
Physa sp.	T		*	1	*
Lymnaea sp.	F		*		
Gyraulus sp.	F		1		*
Helisoma sp.	T		5	1	1
Ferrissia sp.	F			*	
Campeloma sp.	F				*
Amnicola sp.	I		3	2	6
Amnicola limosa	I		4	2	1
Pelecypoda (bivalves)					
Anodonta sp.	F				*
Elliptio complanata	F		*		*
Sphaerium sp.	F			*	
Sphaerium partumeium	F	2		2	3
Sphaerium securis	F			2	

*Denotes the occurrence of organisms. Numbers indicate organisms collected in the quantitative samples.

I = Intolerant
F = Facultative
T = Tolerant

APPENDIX 3

LIST OF BIOLOGICAL REFERENCES

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