51-D-2

BLACKSTONE RIVER BASIN

WATER QUALITY MANAGEMENT PLAN UPDATE

1984

Prepared by

Dennis R. Dunn
Principal Sanitary Engineer

and

Keith R. Anderson
Assistant Sanitary Engineer

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

DIVISION OF WATER POLLUTION CONTROL

TECHNICAL SERVICES BRANCH

WESTBOROUGH, MASSACHUSETTS

February 1985

PUBLICATION: #14811-91-10-4-87-C.R.
APPROVED BY: State Purchasing Agent

TABLE OF CONTENTS

ITEM	PAGE
List of Tables	2
List of Figures	3
Forward	4
Blackstone River Basin Description	5
I. Water Quality Standards	8
II. Water Quality Conditions and Trends	13
III. Wastewater Discharges	20
IV. Water Quality Model and Wasteload Allocations	28
V. Pollution Abatement Projects	31
Municipal Abatement Programs	33
VI. Non-Point Source Pollutants	44
Control Techniques for Non-Point Source Pollutants	47
VII. Water Supply	52
VIII. Toxic Pollution	57
IX. Future Monitoring Programs	61
References	63
Appendix 1 - Massachusetts Water Quality Standards	65
Appendix 2 - The Assessment of Water Pollution	77
- Water Quality Index	82

LIST OF TABLES

TABLE	TITLE	PAGE
D-1	Population Projections, Blackstone River Basin (CMCRA Area)	7
I-1	Water Quality Classifications, Blackstone River Basin	9
II-1	Water Quality Conditions, Blackstone River Basin	15
II-2	Lakes and Ponds, Blackstone River Basin	17
II-3	Stocked Trout Waters, Blackstone River	19
III-1	Blackstone River Basin, List of Major Wastewater Discharges	22
III-2	Blackstone River Basin, List of Minor Wastewater Discharges	23
III-3	Blackstone River Basin, Cooling Water Discharge	24
III-4	Blackstone River Basin, Discharges Which Have Been Eliminated Since 1975	25
IV-1	Blackstone River Basin, Proposed Effluent Limits	30
VI-1	Solid Waste Disposal Sites	50
VI-2	Impoundments in the Blackstone River Basin	51
A-II-1	Blackstone River 1980 Survey, Location of Sampling Stations	
A-II-2	Blackstone River 1980 Survey, Water Quality Index	87

LIST OF FIGURES

FIGURE	TITLE	PAGE
D-A	Location of Blackstone River Basin	6
I-A	Blackstone River Basin, Water Quality Classification	12
A-II-1	Blackstone River Basin, Location of Sampling Station	86

FOREWORD

Basin water quality management plans are required and written in accordance with the United States Environmental Protection Agency's (U.S. EPA) guidelines for Section 303(e) of the Federal Water Pollution Control Act Amendment of 1977 (P.L. 95-217) and by Massachusetts Clean Water Act of 1966 (Chapters 21 and 685 of the General Laws). The general purpose of such plans is to establish a cost-effective and environmentally sound program of pollution abatement for the waters of the Commonwealth.

Chapter 21 of the Massachusetts General Laws designated the Massachusetts Division of Water Pollution Control as the agency responsible for basin planning in the Commonwealth. In April 1975 the Division published the first of these plans for the Blackstone River Basin. This plan entitled the Blackstone River Basin (Part D) Water Quality Management Plan (Westborough 1975), contained a summary of existing water quality conditions, a statement of water quality goals, and a water pollution abatement strategy to achieve these goals. Since that time, intensive water quality surveys were conducted on the Blackstone River in 1977 and 1980. Wastewater discharge surveys were conducted on the Blackstone River annually from 1976 through 1983. In addition, the Department of Environmental Quality Engineering (DEQE) published a Sediment Control Plan for the Blackstone River in 1981.

As mandated by the Federal Water Pollution Control Act Amendments of 1972, water quality management plans must receive periodic reviews and revisions at least every five years. Due to this mandate, the addition of new data, as previously mentioned, and revisions to the Massachusetts Water Quality Standards in 1978 and 1984, the Blackstone River Basin Water Quality Management Plan must be updated. This report will accomplish this by presenting a summary of existing water quality conditions, point and non-point sources of pollution, a revised abatement strategy, including recommendations for National Permit Discharge Elimination System (NPDES) permit limits, potential im-pacts from the improper disposal of toxic wastes and a future water quality monitoring program.

BLACKSTONE RIVER BASIN DESCRIPTION

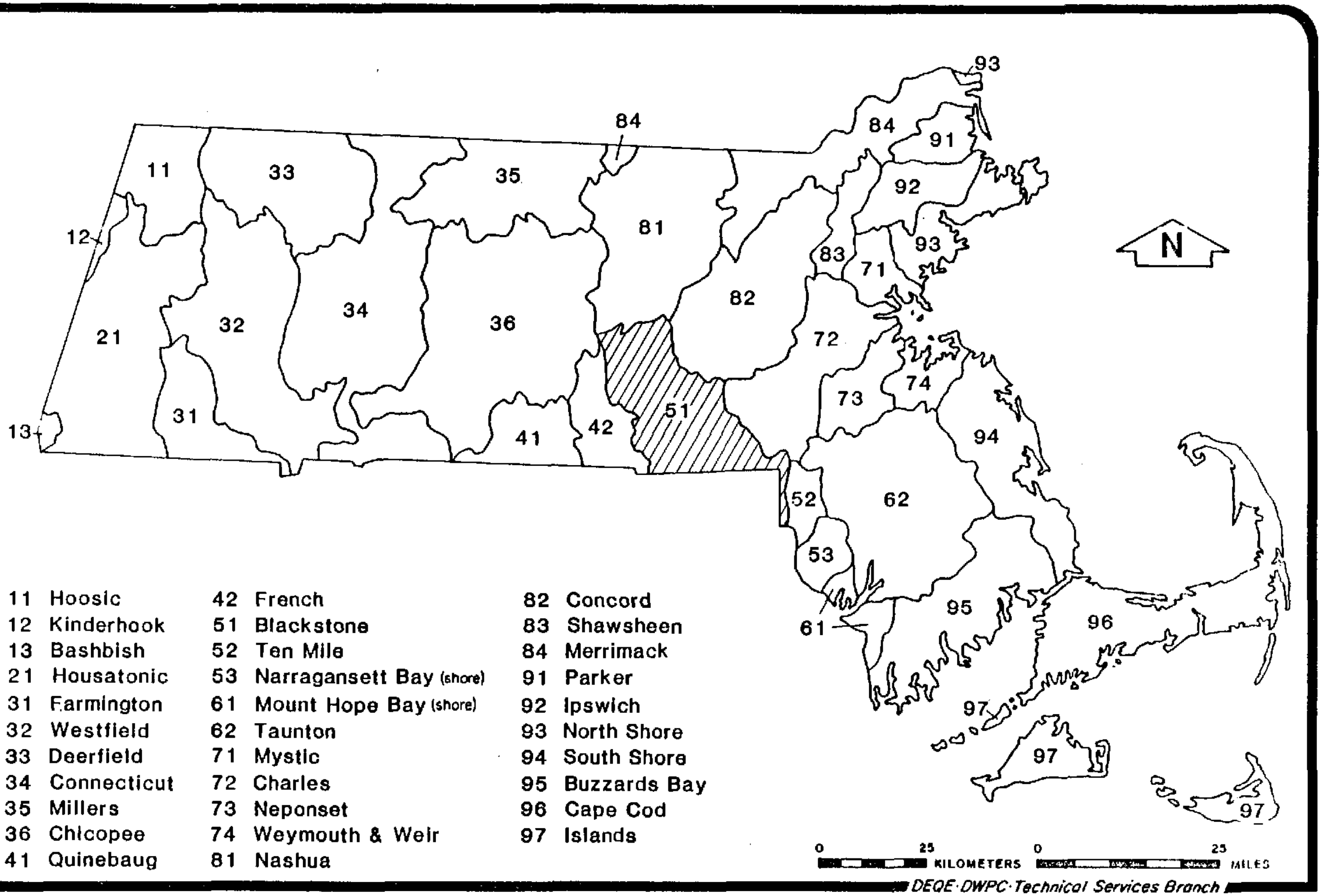
The Blackstone River is formed in the city of Worcester by the confluence of Kettle, Tatnuck, and Mill brooks. Kettle and Tatnuck brooks originate at the outlets of Worcester's reservoirs located in Paxton and Holden, while Mill Brook, an underground stream, drains the northern section of Worcester. The main stem of the Blackstone River flows generally southeasterly through Worcester, Millbury, Sutton, and into Fisherville Pond in Grafton. Below Fisherville Pond the Blackstone River flows southerly through the towns of Northbridge, Uxbridge, Millville, and Blackstone to the Rhode Island state line (refer to Figure I-A).

Major tributaries entering the Blackstone River in Massachusetts are the Quinsigamond, West, and Mumford rivers. The Mill River enters the Blackstone River just below the state line in Rhode Island. Other Massachusetts streams such as Abbott Run, the Peters, the Branch River, and the Ten Mile River join the Blackstone River in Rhode Island.

The total drainage area of the Blackstone River located in Massachusetts is about 373 square miles (see Figure D-A). The area's population in 1980 was 332,800 and is presented in Table D-1.

The United States Army Corps of Engineers operates one flood control dam on the West River. The United States Geological Survey (U.S.G.S.) maintained, until 1978, four flow-gaging stations and one water quality station in the Massachusetts portion of the Blackstone Basin. The gaging station located on the Blackstone River in Northbridge drains an area of 139 square miles and had an average flow from October 1939 to September 1976 of 267 cubic feet per second (cfs). This gage was discontinued in September 1977, and the Kettle Brook gage was discontinued in September 1978. Remaining gages within the Blackstone Basin record flow at the Quinsigamond and West rivers and water quality on the Blackstone River in Millville, Massachusetts.

The Blackstone River was investigated by the U.S. Army Corps of Engineers in 1979 for potential hydroelectric power resources. The study which was entitled, National Hydroelectric Power Resources Study-Preliminary Inventory of Hydropower Resources, Volume 6: Northeast Region, July 1979, identified 6 locations within the Blackstone basin which could have potential for generating electric power. Other potential surface water uses in the Blackstone River Basin include swimming, fishing, and boating in the many lakes and ponds, and fishing, boating combined with aesthetics on the Blackstone River and its tributaries. Uses can be found in greater detail in the report entitled, Recreation and Open Space Opportunities With Water Cleanup, Volume 6: Central Massachusetts, published by the Massachusetts Department of Environmental Quality Engineering (DEQE) in February 1980.



BLACKSTONE RIVER BASIN

Figure D-A

LOCATION OF BLACKSTONE RIVER BASIN

TABLE D-1

POPULATION AND PROJECTIONS

BLACKSTONE RIVER BASIN (CMRPC AREA)

	1970 CENSUS	1973 ESTIMATE	1980 CENSUS	1990 PROJECTION	2020 PROJECTION
Auburn	15,347	15,353	17,900	22,150	26,150
Blackstone	6,566	6,663	7,350	8,500	11,200
Boylston	2,774	3,016	3,300	4,050	6,000
Douglas	2,947	2,997	3,100	3,350	4,750
Grafton	11,659	10,986	13,000	17,100	23,400
Holden	4,292	4,187	4,450	5,000	6,000
Leicester	9,140	9,126	11,300	14,200	18,300
Mendon	2,524	2,676	2,950	3,400	4,650
Millbury	11,987	12,331	12,150	13,600	19,000
Millville	1,764	1,768	1,900	2,200	2,600
Northbridge	11,795	11,792	12,400	13,500	15,600
Paxton	3,731	3,795	4,350	5,500	7,850
Rutland	3,198	3,930	4,300	4,850	7,200
Shrewsbury	19,196	23,822	24,900	26,550	31,950
Sutton	4,950	4,808	5,300	6,000	7,400
Upton	3,484	3,585	4,100	5,250	7,600
Uxbridge	8,253	8,210	8,850	10,100	14,350
West Boylston	6,369	6,630	7,300	8,650	11,800
Worcester	176,572	174,022	169,000	172,500	185,400
TOTAL	318,752	322,555	332,800	364,550	435,800

I. WATER QUALITY STANDARDS

The goals of a basin plan are set by the appropriate water quality standards. Since their establishment in 1967, the Massachusetts Water Quality Standards have undergone major revisions in May 1974 and again in September 1984. These standards were revised once again in 1983 as mandated by Section 303 of the Federal Water Pollution Control Act. The standards consist of water use classifications, as well as general regulations and criteria for the classification of all surface waters including coastal waters in the Commonwealth. A copy of the revised 1984 Massachusetts Water Quality Standards is presented in Appendix 1 of this report.

The 1975 Blackstone River Basin Water Quality Management Plan was based on the revised 1974 standards. At that time, Kettle Brook from the Waite Pond outlet to Curtis Pond outlet, and the entire length of the Middle River had a C classification which was designated for use for the protection and propagation of fish, other aquatic life and wildlife and for secondary contact recreation. When the standards were revised in 1978, the segments were reclassified as B which include primary contact recreation. In addition to these segments, the Blackstone River from the Massachusetts Turnpike to Fisherville Pond in Grafton was upgraded from Class C1 to Class C in the 1978 standards, and to Class B in 1984. Class C1 had anticipated future uses for certain industrial cooling and processing as well as domestic wastewater assimilation. The current water use classifications for the Blackstone River Basin are summarized in Table I-1 and Figure I-A.

TABLE I-1

BLACKSTONE RIVER BASIN

WATER QUALITY CLASSIFICATIONS

BOUNDARY	MILE POINTS	CLASSIFICATION	DESIGNATED USES	OTHER RESTRICTIONS
Kettle Brook				
Source to dam at Reservoir #1	66.0 - 61.0	A	Public Water Supply	MGL., Chp. III
Dam at Reservoir #1 to Waite Pond Outlet	61.0 - 59.3	B	Warm Water Fishery Recreation (P&S)	314 CMR 4.04(2)
Waite Pond to outlet of Curtis Pond	59.3 - 51.3	B	Warm Water Fishery Recreation (P&S)	
Middle River				
Entire length	51.3 - 48.8	B	Warm Water Fishery Recreation (P&S)	
Blackstone River				
Source to outlet of Fisherville Pond	48.8 - 39.7	B	Warm Water Fishery Recreation (P&S)	
Remainder of Massachusetts portion	39.7 - 20.0	B	Warm Water Fishery Recreation (P&S)	
Quinsigamond River				
Entire Length	5.3 - 0.0	B	Warm Water Fishery Recreation (P&S)	
Mumford River				
Source to Douglas STP	14.5 - 9.0	B	Cold Water Fishery (Sn) Recreation (P&S)	314 CMR 4.04(2)
Douglas STP to confluence with Blackstone River	9.0 - 0.0	B	Warm Water Fishery Recreation (P&S)	

TABLE I-1 CONTINUED

BOUNDARY	MILE POINTS	CLASSIFICATION	DESIGNATED USES	OTHER RESTRICTIONS
West River				
Source to Upton STP	--	B	Cold Water Fishery (Sn) Recreation (P&S)	314 CMR 4.04(2)
Upton STP to Blackstone River	8.0 - 0.0	B	Cold Water Fishery (Sn) Recreation (P&S)	
Mill River				
Source to Hopedale Center Dam	--	B	Cold Water Fishery (Sn) Recreation (P&S)	314 CMR 4.04(2)
1000 feet upstream of the State Line	11.0 - 0.0	B	Cold Water Fishery (Sn) Recreation (P&S)	
Beaver Brook				
Entire length	3.0 - 0.0	B	Warm Water Fishery Recreation (P&S)	314 CMR 4.04(2)
Weasel Brook				
Entire length	3.0 - 0.0	B	Warm Water Fishery Recreation (P&S)	314 CMR 4.04(2)
Lynde Brook				
Source to dam at Lynde Brook Reservoir	-	A	Public Water Supply	314 CMR 4.04(2)

TABLE I-1 CONTINUED

BOUNDARY	MILE POINTS	CLASSIFICATION	DESIGNATED USES	OTHER RESTRICTIONS
Tatnuck Brook				
Source to outlet of Holden Reservoir, Holden	-	A	Public Water Supply	MGL., Chp. III
All streams which are public water supply in the Blackstone River Drainage Area which cross the Massachusetts-Rhode Island State Line unless otherwise denoted above	-	A	Public Water Supply	
Other surface waters in the Blackstone River Drainage Area unless otherwise denoted above.	-	B	-	314 CMR 4.04(3)

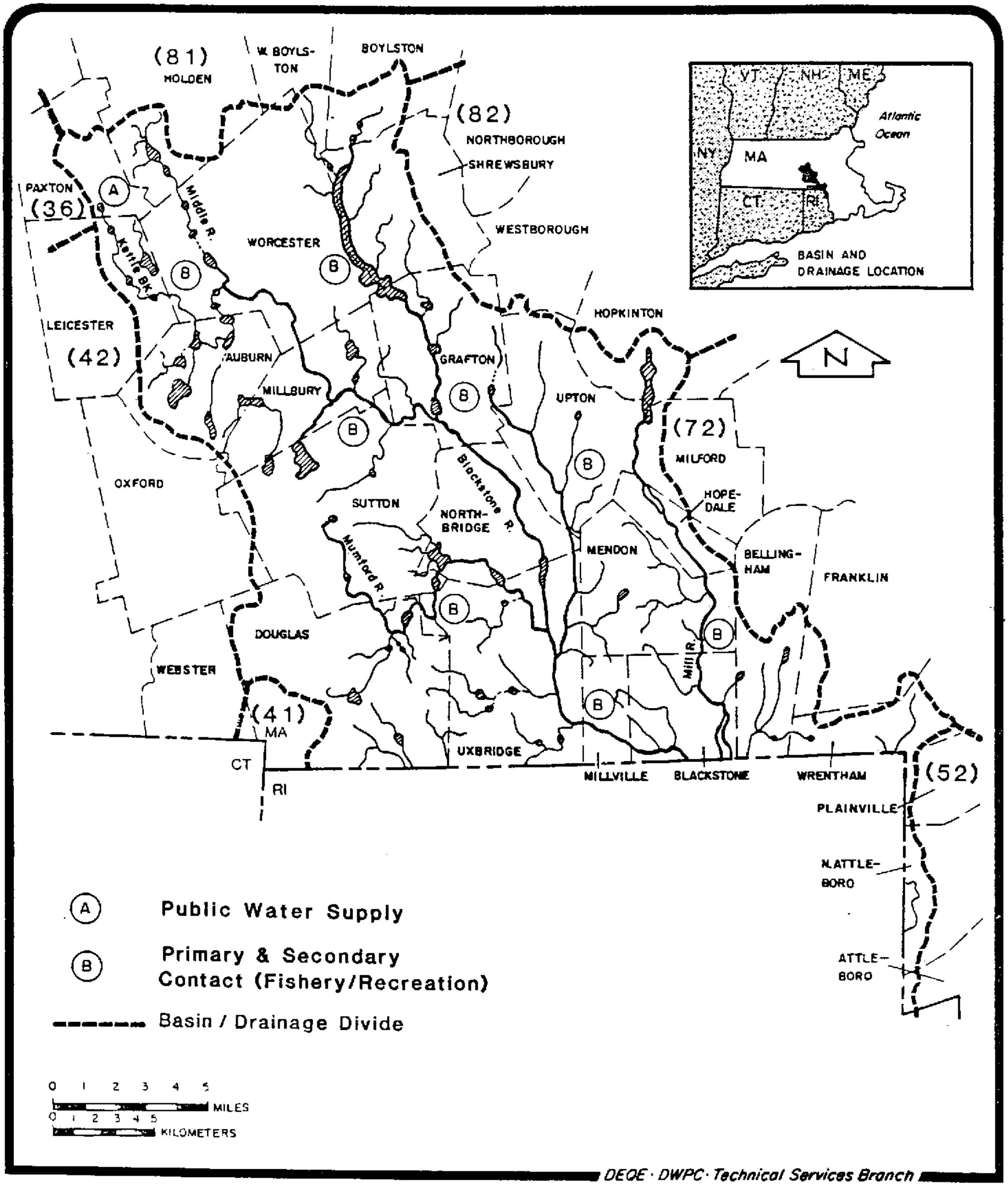


Figure I-A

BLACKSTONE RIVER BASIN

WATER QUALITY CLASSIFICATION

II. WATER QUALITY CONDITIONS AND TRENDS

Existing water quality conditions in the Blackstone River have been published by the Technical Services Branch of the Massachusetts Division of Water Pollution Control. The most recent assessment can be found in the Commonwealth of Massachusetts 1984 Summary of Water Quality report. Published biannually by the Massachusetts Division of Water Pollution Control (MDWPC) to comply with Section 305 (b) of the Clean Water Act Amendments of 1977 (P.L. 95-217). The reports presents a single assessment of the report water quality in the Commonwealth by consolidating the best available information. Water quality problems are rated by comparing existing conditions to the assigned water use classification of that segment. Survey measurements of various water quality parameters are then compared to the numerical limits given in the water quality standards.

The segments of the basin are listed in Table II-1. Table II-2, presents a summary of the lakes and ponds in the Blackstone River Basin. The following analysis is the most recent assessment of water quality taken from the 1984 305 (b) report which includes all available data collected up to that date.

From the mid 1800's to the late 1960's and early 1970's water quality in the Blackstone River was degraded to the extent that it was unfit for any uses other than power generation and waste disposal. Problems included greatly elevated coliform counts, solids and nutrients, and severely depressed dissolved oxygen concentrations. Sections of the Mumford River and Mill River were similarly degraded.

The late 1970's to the present have shown great strides in pollution abatement. A report published by this Division in 1971 listed 58 NPDES waste discharges to the Blackstone River and its tributaries. This number has been reduced to 16 permitted discharges. Included in this number are four new secondary treatment plants; in Grafton, Uxbridge, Millbury and Worcester.

Despite these improvements many areas of the river are still not meeting the assigned classifications. Problems start shortly downstream from the Waite Pond Dam. Worcester Spinning and Finishing Company operates a treatment facility to handle their textile process wastes. While treatment is good, effluent volumes are high compared to stream flow causing color, D.O., and nutrient problems. These problems are further aggravated by untreated sanitary discharges throughout the Cherry Valley Section of Leicester. Water quality improves and remains at its B classification through Worcester except for stormwater runoff problems (being studied) and problems from the Mill Brook combined sewer. The overflow from Mill Brook is continuous but is scheduled to be tied into the Upper Blackstone Water Pollution Abatement District Wastewater Treatment Facility (UBWPAD-WWTF). Excess stormwater flows will be handled by a stormwater detention and chlorination plant to be on line by 1987.

One of the major problems on the Blackstone River is the sheer volume of the UBWPAD-WWTF discharge. During periods of low flow in summer months, the discharge flow is close to or greater than the river flow. While the UBWPAD plant is producing good secondary effluent or better, the river tends to take on the characteristics of the effluent due to volume. The major impact appears to be deoxygenation caused by nitrification of the large amounts of ammonia-N discharged by the UBWPAD. Other past problem areas have greatly improved. Many of the raw sanitary discharges in South Grafton have been tied into the new Grafton Treatment Facility. Likewise the Uxbridge plant has picked up the discharges in Uxbridge center and the Emile Bernat discharge.

A new area of concern is the toxicity of the sediment below Worcester. Years of waste disposal have created large deposits of sediment from Millbury to Uxbridge. A recent study conducted by the Department of Environmental Quality Engineering (DEQE) (July 1981) found these sediments to be laden with cadmium, chromium, nickel, lead, tin, and zinc. The public health impacts of this condition are not known at present. This situation should, however, preclude any primary contact type of recreation until further investigation is conducted.

For the most part all tributary streams meet their assigned classification. Minor problems on the Mumford River have improved due to the elimination of the discharge from Hayward Schuster which has gone out of business. Problems from Emile Bernat and untreated sanitary discharges in North Uxbridge have been alleviated due to the construction of a new municipal treatment plant in Uxbridge. Water quality problems existed in the Mill River due to the outdated treatment plant in Hopedale. The completion of a new advanced secondary wastewater treatment facility has corrected the problems. Many of the tributaries support a wide variety of uses. The upper reaches of the Blackstone (Tatnuck and Kettle Brooks) are used as the major source of Worcester's water supply. Most of the tributaries support at least warm-water fisheries and many are stocked trout waters (Table II-3). The West River is used extensively for fishing and also has a recreation area (swimming/picnicking). The U.S. Army Corps of Engineers maintains a dam on this river for the purpose of flood control. The lower portion of the Mill River (Harris Pond) is used as an emergency water supply for the city of Woonsocket, Rhode Island.

In addition to the segment by segment analysis presented, A Water Quality Index (WQI) analysis was conducted. Designed by the National Sanitation Foundation (NSF) as a means of communicating water quality trends to the general public in a simple, non-technical manner, the WQI incorporates nine water quality parameters into a single numerical value on a scale from zero (poorest quality) to one hundred. Water quality data from both 1977 and 1980 were subjected to this analysis. The results of these analyses are included with a detailed description of the Water Quality Index in Appendix 2 of this report.

TABLE II-1

BLACKSTONE RIVER BASIN

SEGMENT DESCRIPTION	RIVER MILE	WATER USE CLASSIFICATION	S.V.*	DATA BASE YEAR(S)	WATER QUALITY PROBLEM(S)	SOURCE(S) OF PROBLEMS	ABATEMENT NEEDS TO MEET CLASSIFICATION
Blackstone River from Waite Pond, Leicester to Curtis Pond, Worcester	59.3-51.3	B	yes	1977 1980	Color Solids Coliform Nutrients	Worcester Spinning and Finishing. Cherry Valley sewer discharge.	Sewer this area to the UBWPAD-WWTP Leicester WWTP.
Curtis Pond to American Steel Dam, Worcester	51.3-48.8	B	yes	1977 1980	Solids Coliform	Urban runoff.	Stormwater detention and chlorination project underway.
American Steel Dam to Fisherville Dam, Grafton	48.8-39.8	B	yes	1977 1980	D.O. Solids Coliform Nutrients	Mill Brook. UBWPAD-WWTF. Millbury STP	Combined sewer separation in Worcester. Upgrade UBWPAD to AST. Correct industrial user problems in Worcester and Millbury (minor).
Fisherville Dam to Rice City Pond, Uxbridge	39.8-31.1	B	yes	1977 1980	D.O. Nutrients Algae	UBWPAD-WWTF. Nitrification	Upgrade UBWPAD-WWTP to AST.
Rice City Pond to Water Quality Monitor, Millville	31.1-23.7	B	no	1977 1980	--	--	--
Water Quality Monitor to state line, Blackstone-Woonsocket,RI	23.7-20.0	B	yes	1977 1980	Coliform Nutrients	Sanitary discharges in Blackstone.	Sewering of Blackstone to Woonsocket underway.

* Standards Violations

TABLE II-1 (CONTINUED)

SEGMENT DESCRIPTION	RIVER MILE	WATER USE CLASSI-FICATION	S.V*	DATA BASE YEAR(S)	WATER QUALITY PROBLEM(S)	SOURCE(S) OF PROBLEMS	ABATEMENT NEEDS TO MEET CLASSIFICATION
Quinsigamond River, entire length	5.3-0.0	B	no	1977 1980	--	--	--
Mumford River, entire length	14.5-0.0	B	no	1977 1980 1982	--	--	--
West River, entire length	8.8-0.0	B	no	1977 1980	--	--	--
Mill River, entire length	11.0-0.0	B	yes	1977	Coliform D.O. Solids Nutrients	Hopedale STP.	Upgrade to AWT.
Mill Brook, entire length	3.0-0.0	B	yes	1977 1980	D.O. Solids Coliform pH Nutrients	Combined sewers.	Separate combined sewers.
Tatnuck/Beaver Brooks, entire length	3.0-0.0	B	yes	1977 1980	D.O. Solids Coliform pH Nutrients	Combined sewers.	Separate combined sewers.

* Standards Violations

Total miles assessed (Blackstone River) - 39.3
Total miles meeting standards (Blackstone River) - 7.4
Total miles assessed (tributaries) - 45.6
Total miles assessed (tributaries) - 28.6

TABLE II-2

BLACKSTONE RIVER BASIN

LAKES AND PONDS

INVENTORY

Number of lakes and ponds	183
Surface area of lakes and ponds (in acres)	6,993
Number of lakes and ponds greater than 10 acres	107
Surface area of lakes and ponds greater than 10 acres	6,615
Number of officially recognized Great Ponds	8
Surface area of officially recognized Great Ponds (in acres)	2,060

INTENSIVE SURVEY(S)

LAKE	LOCATION	SURVEY PERIOD	REPORT PUBLICATION DATE
Dorothy Pond	Millbury	1981-1982	July 1983
Flint Pond (North & South)	Grafton/Shrewsbury	1979-1981	October 1982
Indian Lake	Worcester	1975-1976	December 1978
Lake Quinsigamond	Worcester/Shrewsbury	1979-1981	October 1982

CLASSIFICATION

LAKE	LOCATION	STRATIFICATION	SEVERITY POINTS
Bell Pond	Worcester	U	6
Brierly Pond	Millbury	U	9
Coes Reservoir	Worcester	U	10
Cook Pond	Worcester	U	9

TABLE II-2 (CONTINUED)

LAKE	LOCATION	STRATIFICATION	SEVERITY POINTS
Crystal Lake	Douglas	U	8
Dark Brook Reservoir	Auburn	U	10
Dorothy Pond	Millbury	U	9
Eddy Pond	Auburn	U	8
Flint Pond (North & South)	Grafton/Shrewsbury	U	9
Green Hill Pond	Worcester	U	7
Indian Lake	Worcester	S	9
Jordan Pond	Shrewsbury	U	11
Lackey Pond	Uxbridge/Northbridge	U	12
Manchaug Pond	Douglas/Sutton	S	3
Nipmuc Pond	Mendon	S	6
Patch Pond	Worcester	U	8
Pondville Pond	Auburn/Millbury	U	11
Lake Quinsigamond	Worcester/Shrewsbury	S	11
Ramshorn Pond	Millbury/Sutton	S	3
Salisbury Pond	Worcester	U	10
Singletary Pond	Worcester	S	10
Stoneville Reservoir	Auburn	U	5
Waite Pond	Leicester	U	5
Wallum Lake	Douglas/Burrillville R.I.	S	2

TABLE II-3

BLACKSTONE RIVER BASIN

STOCKED TROUT WATERS*

STREAMS	TOWN/CITY
Big Bummitt Brook	Shrewsbury
Center Brook	Upton
Centerville Brook	Douglas
Cronin Brook	Grafton
Dean Brook	Upton
Emerson Brook	Uxbridge
Fox Stream	Blackstone
Ironstone Brook	Uxbridge
Mill River	Mendon, Blackstone
Miscoe Brook	Grafton
Muddy Brook	Mendon
Mumford River	Sutton, Douglas
Peters River	Bellingham
Warren Brook	Upton
West River	Grafton, Upton, Uxbridge
Whitins Reservoir Brook	Douglas
(Unnamed Mass. Classification System)	

LAKES, PONDS	TOWN/CITY
Coes Reservoir	Worcester
Lake Quinsigamond	Worcester, Shrewsbury
Singletary Lake	Millbury, Sutton
Wallum Pond	Douglas

*Source: Massachusetts Division of Fisheries and Wildlife, "Stocked Trout Waters of Massachusetts."

III. WASTEWATER DISCHARGES

Wastewater discharges in the Blackstone River Basin are governed by permits which are joint Federal (United States Environmental Protection Agency) and State (Massachusetts Division of Water Pollution Control) issued. This program, known as the National Pollutant Discharge Elimination System (NPDES) establishes levels of effluent quality to be maintained at existing treatment facilities and sets forth implementation schedules for discharges which contribute to violations of water quality standards. Discharge permits comprise the vehicle for implementation of water quality management plans. Whereas the basin plan is essentially a strategy document, each permit sets a formal implementation schedule for abatement action. Coordination of basin planning and permit issuance is, therefore, vital in order to assure effective abatement of pollution in each basin, as well as statewide.

Tables III-1 and III-2 provide a list of "major" and "minor" wastewater discharges in the Blackstone River Basin. The criteria for a "major" discharge in this report are flows greater than 50,000 gallons per day (GPD) and/or contain potentially harmful pollutants, such as heavy metals. Effluents not meeting these criteria are considered "minor" discharges. One exception to the rule are those discharges which contain only cooling water and are not influenced by industrial or domestic process wastewater. These discharges are listed in Table III-3. Table III-4 presents all of the discharges in the Blackstone River Basin which have been eliminated since the implementation of the 1975 Water Quality Management Plan. Of particular note is that 33 out of 47 discharges which have been eliminated were due to the construction of the Upper Blackstone facility in Millbury.

In the past, the U.S. EPA has allowed discharges with acceptable performance and permit compliance records to continue releasing wastewater under the old permit until a new permit is issued. In the Blackstone River Basin, the majority of discharge permits have expired. These permits are presently awaiting renewal by the U.S. EPA. The U.S. EPA, however, is trying to expedite the permit renewal process and has recently established a Consolidated Permits Program. This program requires that all dischargers holding expired permits file for renewal according to the new format.

Each permit contains two sections: effluent limitations and schedules for corrective actions. The effluent limitation formally establishes performance criteria for treatment facilities. Some limitations are currently under review and may be modified when the permit is officially renewed. Implementation schedules are included if existing levels of treatment are not adequate to meet in-stream water quality goals or when no treatment is being provided. In cases where an upgraded treatment facility is needed to maintain water quality standards, the effluent limitations portion of the permit requires that present performance levels be maintained while corrective action is undertaken.

The Massachusetts Division of Water Pollution Control samples all major wastewater discharges at least once a year and during each intensive water quality survey. These data are analyzed and checked for compliance with their NPDES permit and then published by the Technical Services Branch of the Division. Recent survey results can be found in the following reports: The Blackstone River, Part B-Wastewater Discharge Data (1973, 1976, 1979-80, and 1982).

TABLE III-1

BLACKSTONE RIVER BASIN

LIST OF MAJOR WASTEWATER DISCHARGES

SOURCE	NATURE OF DISCHARGE	RECEIVING WATER	NPDES PERMIT NUMBER	EXPIRATION DATE
1) Grafton WWTP, Grafton	Treated municipal wastewater	Blackstone River	MA0101311	8/3/89
2) Johnson Steel & Wire, Inc., Worcester	Treated metal plating process wastewater	Blackstone River	MA0000868	6/30/81[2]
3) Millbury WWTP, Millbury	Treated municipal wastewater	Blackstone River	MA0100650	4/26/89
4) New England Plating, Inc., Worcester	Treated metal plating process wastewater	Mill Brook	MA0005088	7/1/80[2]
5) Northbridge WWTP, Northbridge	Treated municipal wastewater	Blackstone River	MA0100722	6/15/87
6) Upper Blackstone Water Pollution Abatement District, Millbury	Treated municipal wastewater	Blackstone River	MA0102369	1/1/82[1]
7) Upton WWTP, Upton	Treated municipal wastewater	West River	MA0100196	10/31/82
8) Uxbridge WWTP, Uxbridge	Treated municipal wastewater	Blackstone River	MA0102440	8/15/84[3]
9) Worcester Spinning and Finishing, Inc., Leicester	Process wastewater from dyeing operations	Kettle Brook	MA0004171	10/1/79 [3]
10) Wyman Gordon Co., Inc., Millbury	Neutralization tank effluent	Bonny Brook	MA0001121	6/30/80[3]
11) Wyman Gordon Co., Inc., North Grafton	Treated process wastewater from ferrous and non-ferrous forging operations	Quinsigamond River	MA0004341	9/29/88
12) Wyman Gordon Co., Inc., Worcester	Treated process wastewater	Blackstone River	MA0001112	6/24/80[3]

[1] Draft permit requiring advanced wastewater treatment is being finalized
[2] Status unknown
[3] Renewal application submitted

TABLE III-2

BLACKSTONE RIVER BASIN

LIST OF MINOR WASTEWATER DISCHARGES

SOURCE	NATURE OF DISCHARGE	RECEIVING WATER	NPDES PERMIT NUMBER	EXPIRATION DATE
1) E. Douglas WWTP, East Douglas	Treated municipal wastewater	Mumford River	MA010195	3/1/84[3]
2) Hopedale WWTP	Treated municipal wastewater	Mill River	MA0102202	4/14/87
3) Massachusetts Electric Co.,Inc.,Worcester	Cooling waters	Middle River	MA0001741	Permit application submitted
4) Nazareth Home for Boys, Leicester	Treated domestic wastewater	Kettle Brook	MAD025585	4/28/82[3]
5) Reed & Prince, Inc., Worcester	Eliminated	Middle River	MA0022861	--
6) Scavone Concrete, Auburn	Washwater from stone rinsing operation	Leesville Pond	MA0021008	7/1/80[3]
7) Standard Lock Washer & Manufacturing Co., Inc.		Swamp on site	MAD024741	Permit application submitted
8) W & S Laundry, Blackstone	Washwater from laundry	Blackstone	MA0002291	--
9) Worcester DPW, Worcester	Stormwater drains 003-028	Mill Brook	MA00100463	1/19/82[4]

[3] Application for permit renewal has been submitted
[4] Combined sewer overflows will be eliminated upon completion of the sewer separation/storm water treatment facility abatement project

TABLE III-3

BLACKSTONE RIVER BASIN

COOLING WATER DISCHARGES

SOURCE	RECEIVING WATER	NPDES PERMIT NUMBER	EXPIRATION[1] DATE
1) Cincinnati Milacron-Heald Corp., Worcester	Weasel Brook	MA0000566	6/1/79
2) Cumberland Engineering, Inc., Attleboro	Blackstone River	MA0000311	12/28/81[2]
3) Dooley's Cleaners, Auburn	Tributary to Leesville Pond	MA0024911	12/18/81[2]
4) Inmont Corporation, Auburn	Pondville Pond	MA0025691	10/1/79
5) Manchaug Corporation, Manchaug	Mumford River	MA0023540	6/24/80
6) Norton Company, Worcester	Weasel Brook	MA0000817	7/29/80
7) Polyfoam, Inc., Northbridge	Blackstone River	MA0026565	5/5/83
8) Prest-Wheel, Dualite Division, Grafton	Blackstone River	MA0002682	6/1/79
9) Rexnord, Inc., Auburn	Leesville Pond	MA0004618	2/13/81

1 Application for permit renewal has been submitted
2 Status unknown

TABLE III-4

BLACKSTONE RIVER BASIN

DISCHARGES WHICH HAVE BEEN ELIMINATED SINCE 1975

NPDES PERMIT NUMBER	DISCHARGE	REASON FOR ELIMINATION
1) MA0024160	A.A. Brunell Electric Plating Corp., Worcester	Connection to UBWPAD
2) MA0024813	Advance Plating Corp., Worcester	Connection to UBWPAD
3) MA0024520	Astra Pharmaceutical Products, Worcester	Connection to UBWPAD
4) MA0001899	Blackstone Potato Chip, Blackstone	Connection to Woonsocket WWTP
5) Not known	Blackstone Wool Scouring, Worcester	Connection to UBWPAD
6) MA0024244	Commonwealth Gas Co., Worcester	Connection to UBWPAD
7) MA0024252	Commonwealth Gas Co., Worcester	Connection to UBWPAD
8) MA0022373	Coppus Engineering Corp., Worcester	Connection to UBWPAD
9) MA0024805	Edward P. Garrepy, Inc., Worcester	Connection to UBWPAD
10) MA0000639	Elfskin Corp., Leicester	Out of Business
11) MA0000019	Emil Bernat & Sons, Inc., Uxbridge	Connection to Uxbridge WWTP
12) MA0000949	G.F. Wright Steel & Wire Co., Worcester	Connection to UBWPAD
13) MA0024767	G & R Screw Machine Products, Inc., Worcester	Connection to UBWPAD
14) MA 0022136	Hard Chrome Division, Inc., Worcester	Connection to UBWPAD

TABLE III-4 (CONTINUED)

NPDES PERMIT NUMBER	DISCHARGE	REASON FOR ELIMINATION
15) MA0001538	Hayward Schuster Woolen Mills, Inc., E. Douglas, Mumford	Out of Business
16) MA0023523	Holbrook Drop Forge Co., Worcester	Connection to UBWPAD
17) MA0022977	Independent Plating Co., Worcester	Connection to UBWPAD
18) MA0020851	JSB Yarns, Uxbridge	Connection to Uxbridge WWTP
19) MA0024449	Killeen Machine Tool Co., Inc., Worcester	Connection to UBWPAD
20) MA0090191	Massachusetts ANG-Worcester	Connection to UBWPAD
21) Not known	National Standard, Worcester	Connection to UBWPAD
22) MA0000892	New England High Carbon Wire, Millbury	Out of Business
23) MA0022926	New Method Plating Co., Worcester	Connection to UBWPAD
24) MA0020958	Parker Metal Goods, Worcester	Connection to UBWPAD
25) MA0023400	Paul Revere Corp., Worcester	Connection to UBWPAD
26) MA0024791	Photo Panels of New England, Worcester	Connection to UBWPAD
27) MA0022292	Presmet Corp., Worcester	Connection to UBWPAD
28) MA0005169	Rockwell International-Draper Division, Hopedale	Out of Business

TABLE III-4 (CONTINUED)

NPDES PERMIT NUMBER	DISCHARGE	REASON FOR ELIMINATION
29) MA0005690	Snider Brothers, Inc., Sutton	Out of Business
30) MA0001210	Stanley Woolen Co., Uxbridge	Connection to Uxbridge WWTP
31) MA0024783	Swanstrum Galvanizing, Inc. Worcester	Connection to UBWPAD
32) MA0022888	Table Talk, Inc., Worcester	Connection to UBWPAD
33) Not known	Thompson Wire, Inc., Worcester	Connection to UBWPAD
34) MA0004162	U.S. Steel Inc., Worcester	Out of Business
35) MA0090107	U.S. Naval & Marine Corp., Worcester	Connection to UBWPAD
36) MA 0024431	Valve Components Inc., Worcester	Connection to UBWPAD
37) MA0022071	Vertipile Inc., Worcester	Out of Business
38) Not known	Washburn Co., Worcester	Connection to UBWPAD
39) MA0026158	Western Pork Packers, Inc., Worcester	Connection to UBWPAD
40) MA0001252	Whitin Machine Works, Northbridge	Change of Location
41) MA0024651	Worcester Foundry Co., Worcester	Connection to UBWPAD
42) MA0025305	Wright Machine Corp., Worcester	Connection to UBWPAD
43) MA0022870	Worcester Pressed Steel, Worcester	Connection to UBWPAD
44) MA0024538	Worcester Taper Pin Corp., Worcester	Connection to UBWPAD
45) MA0025259	Worcester Wire Company	Connection to UBWPAD

IV. WATER QUALITY MODEL AND WASTELOAD ALLOCATIONS

In June 1971, a water quality model was developed by Quirk, Lawler, and Matusky (QLM) for the Massachusetts Division of Water Pollution Control (MDWPC). This model entitled STREAM 1 was used to develop waste load allocations for point source discharges to streams throughout the Commonwealth. Although the projected effluent loadings provided an initial approach toward the attainment of a sound pollution abatement program, the STREAM 1 model did not consider many important stream dynamics. The model was then refined several times to include the following variables; nitrification rates, sludge (bottom) oxygen-uptake rates, photosynthesis and respiration rates, organic loadings from runoff, temperature simulation, and coliform bacteria die-off rates. This new model entitled, STREAM 7B, is now the basis for determining point source waste load allocations to streams in the Commonwealth.

The most recent waste load allocation developed using the STREAM 7B model was for the Upper Blackstone Water Pollution Abatement District which discharges approximately 30 million gallons per day of wastewater to the Blackstone River at the Worcester/Millbury town line. The model was developed by personnel of the MDWPC and was calibrated using October 1980 data and verified using August and June 1980 data. Projections were then made to the 7-day, 10-year low flow (7Q-10) which is the basis for design loadings in Massachusetts. This is the lowest flow that can be expected to occur seven consecutive days during a ten year period based on past flow data.

As previously noted, there are five municipal wastewater treatment facilities presently in operation which discharge directly to the Blackstone River in Massachusetts. These facilities are the Upper Blackstone Water Pollution Abatement District in Worcester, Millbury WWTP, Grafton WWTP, Northbridge WWTP, and Uxbridge WWTP. These facilities at these design flows contribute approximately 66 million gallons per day (MGD) to the Blackstone River of which 56.0 (MGD) or 85% of this flow will be from the Upper Blackstone plant. When projecting to the Q7-10 condition and design flows at the Upper Blackstone plant it is estimated that this facility will comprise 92% of the total flow in the Blackstone River immediately downstream of the discharge. Due to this fact it is obvious that the discharge from the Upper Blackstone Water Pollution Abatement District is the most critical in terms of water quality impact municipal discharge in the basin.

Past water quality data revealed that the most critical area in terms of oxygen depletion in the Blackstone River is from Sutton Street in Northbridge to the outlet of Rice City Pond in Uxbridge with the greatest sag occurring in Rice City Pond. This depletion has been identified through modeling efforts as being primarily due to the nitrification of the effluent from the Upper Blackstone facility and in part to diurnal fluctuations caused by algal photosynthesis and respiration. Modeling efforts have shown that if nitrification was carried out at the Upper Blackstone facility prior to discharge to the Blackstone River, the projected dissolved oxygen concentrations would meet water quality standards with the exception of periodic nightime violations due to algal respiration. Elimination of the nighttime violations can only be accomplished by reducing nutrient levels (nitrogen and phosphorus) which accelerate eutrophication. Both of these nutrients can be drastically reduced through measures at the Upper Blackstone facility. Nitrogen will be reduced as previously noted, however, the reduction of phosphorus may not be cost effective at this time. Although point source inputs of phosphorus are sufficiently high to produce nuisance aquatic conditions, such conditions do not appear present outside of diurnal fluctuations. Inhibiting effects of toxic substances such as heavy metals in the sediment may be one explanation. Further study such as algal assays are recommended before a decision can be made. It should also be noted that additional model runs were made varying the degrees of treatment at all the municipal plants on the Blackstone River. Results showed that due to the magnitude of the Upper Blackstone discharge, additional treatment at Millbury, Grafton, Northbridge and Uxbridge is not warranted and should remain at their current NPDES treatment levels.

Table IV-1 presents the effluent limitations of the previously mentioned wastewater treatment facilities. Effluent limitations for industrial discharges containing heavy metals, or other potentially toxic contaminants have not been developed by the MDWPC. In the past, these limits have been based on the best practical treatment needed to achieve the guidelines for in-stream water quality which appear in the EPA Quality Criteria for Water (U.S. EPA, 1976 also known as the "Red Book"). More recently, the U.S. EPA has developed updated criteria known as the "White Book" for assessing instream water quality. These guidelines are being reviewed and may be used as a basis for writing NPDES permits in the future.

TABLE IV-1

BLACKSTONE RIVER BASIN

PROPOSED EFFLUENT LIMITS*

(Limits in mg/l unless otherwise noted)

DISCHARGE	FLOW (MGD)	BOD5	SUSPENDED SOLIDS	AMMONIA NITROGEN	DISSOLVED OXYGEN	PHOSPHORUS**
Millbury	0.94	30	30	--	--	--
Northbridge	1.8	30[1]	30[1]	--	--	--
		10[2]	10[2]	--	--	--
Grafton	3.88	30	30	--	--	--
Uxbridge	2.5	30	30	--	--	--
UBWPAD	56.0	30[3]	30[3]	--	$\geq$6.0	--
		10[4]	15[4]	2.0[4]	$\geq$6.0	--

* only those facilities on the main stem for which modeling has been conducted. Wasteload allocations for other facilities will be conducted on a case by case basis.

** to be assessed

1 Seasonal limits October 1 to April 30
2 AWT not required, if UBWPAD achieves required removals
3 November 1 to May 14
4 May 15 to October 31

V. POLLUTION ABATEMENT PROJECTS

The 1975 Blackstone River Water Quality Management Plan outlined both municipal and industrial abatement projects currently underway within the basin of which most were in the planning stages. Since that time additional water quality surveys have been conducted in 1977 and 1980 and the water quality standards were revised in 1978 and 1984. This coupled with the elimination of numer-ous discharges either by municipal tie-ins or plant closings, has necessi-tated a re-evaluation of the 1975 recommendations.

This section presents a town-by-town summary of completed abatement projects and remaining areas which need to be addressed relating to water quality problems in the Blackstone River Basin due to point source discharges.

Wastewater Treatment Technology

Before discussing specific pollution abatement projects that have been completed or presently underway in the Blackstone River Basin, it may be helpful to briefly summarize conventional treatment practices that are currently used for both sanitary and industrial wastewaters. A detailed account of the history, design and development of wastewater treatment plant technology of all of the various unit processes that are in use today is beyond the scope of this report. For more information consult current text books on sanitary and environmental engineering such as Wastewater Engineering: Treatment, Disposal, Reuse, Metcalf and Eddy, Inc. 1979.

Prior to disposal to surface or groundwater, wastewaters are subjected to various forms of treatment to prevent them from severely degrading the quality of the receiving water. Often treatment plant techniques serve to hasten settling or decomposition processes that would occur naturally at a much slower rate and at the expense of a river or stream's water quality.

Treatment practices fall into three general categories. Primary treatment involves the removal of solid matter which either floats to the surface of the wastewater or settles out due to gravity. This is usually accomplished by an initial screening or sieving of the influent, followed by slowly passing the wastewater through large sedimentation tanks or clarifiers. The slow flow of the wastewater allows suspended solids to gradually settle to the bottom of the tank. A well designed efficiently operated primary treatment system should remove fifty to sixty percent of the suspended solids and twenty-five to forty percent of the biochemical oxygen demand from a wastewater.

Secondary treatment or biological waste treatment involves the preparation of a suitable habitat for a community of microorganisms that will slowly decompose the organic matter contained in the wastewater. The fundamental principal underlying this treatment is to provide a medium that accelerates the decomposition of organic matter that would naturally occur more slowly in a receiving stream. A population of microorganisms utilizes the wastewater as a food supply and slowly decomposes the organic matter. Since this digestion process utilizes oxygen, untreated wastewaters being discharged to a receiving stream exert a biochemical oxygen demand (BOD) strong enough to deplete the dissolved oxygen concentration causing adverse effects on the fish populations. The two most common types of secondary treatment processes are trickling filters and activated sludge. A trickling filter is a chamber containing rocks or other coarse materials which acts as a substrate for the microorganisms. The wastewater, after primary clarification, is sprayed over the substrate. The microbes slowly remove the organic matter as wastewater passes through the trickling filter. An activated sludge system involves mixing wastewater with a sludge containing a dense population of bacteria. Agitation and aeration of the mixture causes the microorganisms to clump together and feed on organic matter in the wastewater. Final clarification separates treated wastewater from the biological sludge. These treatment processes followed by secondary clarification can remove up to eighty-five percent of the biochemical oxygen demand (BOD) and suspended solids from a wastewater.

The effluent from a secondary treatment facility may still contain nutrient concentrations too high to be discharged to a receiving stream without further treatment. The processes for further nutrient removal fall within the category of advanced or tertiary wastewater treatment. In order to prevent the introduction of excessive amounts of algal and plant nutrients to a receiving stream it is often necessary to remove nitrogen and phosphorus from the effluent. Numerous methods are available for nitrogen conversion and removal. Most of these procedures involve either a chemical treatment such as ammonia stripping or ion exchange, or a biological process using specialized populations or microorganisms known as nitrifiers. Phosphorus removal is achieved through the addition of coagulating chemicals to a wastewater which, when slowly stirred, converts dissolved phosphorus to an insoluble form which settles to the bottom of the tank. This process is known as coagulation and flocculation.

After each type of wastewater treatment method the sanitary wastewater is subjected to a disinfection process, usually chlorination, before it is discharged to the receiving stream, to kill pathogenic organisms. The wastewater is treated with chlorine in a contact chamber. The chlorine first combines with any ammonia present forming a group of compounds called chloramines. The remaining chlorine through hydrolysis produces hypochlorous acid (HOCL), this compound kills the bacteria and other pathogens that might cause a threat to public health. The chloramines and other chlorine residuals have been shown to be toxic and aquatic organisms at high concentrations. In recent years this toxicity has caused concerns about the use of chlorine for wastewater disinfection. Alternative means of disinfection are presently being investigated, such as ozonation and ultraviolet light.

The concentrations and types of constituents present in industrial wastewaters are extremely variable from industry to industry. The characteristics of industrial wastewater depend largely on how much water is utilized. Some industries use water as part of their manufacturing process while others use water for washing or rinsing manufactured products. Other industries use water for cooling processes. As a result of the variable nature of industrial wastewaters, complex treatment techniques have been developed that are often unique to one or a few industrial classes. Many of the treatment processes are applicable to a number of industries. These include techniques for reducing wastewater volume, neutralizing acid or alkaline wastes, removing suspended solids and sludge handling.

Specialized techniques for the removal of dissolved solids, heavy metals, volatile hydrocarbons, oil and grease, and complex process wastes have been developed and are in use at industrial treatment facilities. Paper manufacturers and food processing industries produce a waste that is biodegradable and therefore amenable to the types of biological treatment used at municipal facilities. In urban and suburban areas the biodegradable industrial wastewaters can be transported by the sewerage system to the municipal treatment facilities for treatment. In other cases, industries must pretreat their wastewater to remove constituents that may disrupt the biological processes used at the municipal treatment plant prior to disposal to the sewerage system.

For detailed information on industrial wastewater treatment the reader is recommended to consult Industrial Water Pollution; Origins, Characteristics, and Treatment, Nemerow, 1978. This text presents a complete overview of the theory and application of numerous treatment techniques and strategies, as well as specific information on the approaches to handle industrial wastewater.

Municipal Abatement Projects

An assessment of municipal wastewater treatment and collection facilities needs was included in the 1975 Blackstone River Basin Water Quality Management Plan prepared by the MDWPC. Since that time many of the communities have initiated pollution abatement programs that were recommended in the 1975 Report. The emphasis to date in the Blackstone River Basin has been on the design and construction of conveyance systems and wastewater treatment plants in municipalities that exhibit thickly settled population centers and/or soil characteristics that are unsuitable for the use of individual on-site subsurface sewage disposal systems.

The U.S. Environmental Protection Agency and the Massachusetts Division of Water Pollution Control administer a Construction Grants Program whereby federal and state funds are made available to cities and towns to be used toward the design and construction of publicly-owned wastewater treatment works (POTW's). In the past, federal and state allotments generally amounted to 75 and 15 percent, respectively, of the costs of treatment works construction to be supplemented with a municipal share of 10 percent. Beginning October 1, 1984, the federal portion of project funding will be reduced to 55 percent. The remaining cost deficiencies will be made up by increased state and local shares. Certain projects may be eligible for "innovative or alternative" funding which may receive additional federal financial aid.

The procedure through which a city or town follows when planning and constructing sewers and treatment works consists of three major phases or steps. Step I involves the development of an engineering report or facility plan which assesses the existing sewage handling practices of a municipality, determines the existing and future wastewater management needs, and makes specific recommendations for meeting those needs. The recommendations may include the construction of sewerage systems and treatment facilities, or in other instances, rehabilitation and maintenance programs for existing systems of sewage disposal. The communities for which structural alternatives are recommended during facilities planning then apply for Step II funding which is used for the design work required to proceed with the recommended pollution abatement program. Following a review of the plans and specifications for sewerage works, a Step III grant may be awarded for the actual installation of interceptors and/or construction of treatment facilties.

As each step of the construction grants process is completed, engineering reports are subjected to careful review by the U.S. EPA and the MDWPC to ensure that they meet the requirements set forth in the Construction Grants Program guidelines and regulations. Water quality reviews are also undertaken throughout the grants process to assure that the funding of the POTW's will produce the maximum return in water quality improvement. A municipality is not eligible to move forward to the next step of the construction grants process until the requirements of the preceeding step are satisfactorily met.

The remainder of this section will present community or regional level summaries of water pollution abatement that have been undertaken or are proposed for the municipalities within the Blackstone River Basin.

Auburn

Auburn is a member of the Upper Blackstone Water Pollution Abatement District (UBWPAD). The Kettle Brook watershed lies within the town's boundaries. A majority of the wastes generated in Auburn are conveyed to the UBWPAD treatment facility in Millbury on Route 20. The Construction Grants Section of the Division of Water Pollution control approved the funding for two sewer expansion projects that have eliminated a majority of the on-site disposal systems in the most populated areas of the town. The monies spent on these pollution abatement projects are summarized below.

Date	Step*	Total	Federal	State	Town
6/30/76	3	5,517,900	4,138,425	827,685	551,790
3/25/77	3	4,670,200	3,502,650	700,530	467,020
Sub-Total		10,188,100	7,641,075	1,528,215	1,018,810

Bellingham

The town has experienced rapid residential and industrial growth in recent years. The southern portion of the town drains to the Peters River. The northern portion lies in the Charles River Basin. A facilities plan was completed in 1981 to investigate sewering the southern portion to the Woonsocket, Rhode Island Treatment Facility and the northern portion to the Charles River Pollution Control Facility in Medway. The implementation of the pollution abatement project is presently under consideration by the town and a hired consultant. The septage generated in the town could be disposed of at the Woonsocket Treatment Facilities. The monies spent on the facilities plan are summarized below.

Date	Step	Total	Federal	State	Town
8/27/81	1	231,815	173,861	34,772	23,181

Blackstone

The town is located on the border of Massachusetts and Rhode Island. Blackstone center and the southern portion of the town are the most densely populated areas. These areas are sewered to the Woonsocket Wastewater Treatment Facility. The sewer extension project has eliminated a major pollution source to the Peters River and has improved the water quality. The cost of the sewer expansion project is summarized below.

Date	Step	Total	Federal	State	Town
9/22/77	3	2,109,900	1,582,425	316,485	210,990

*Construction Grants Steps
1 - Facilities Planning
2 - Design of Abatement Project
3 - Construction of Abatement Project
CS - Connector Sewers or Lateral Sewer Construction Project

Boylston

The majority of the land area of the town lies in the Wachusett Reservoir watershed of the Nashua River Basin. The southwest corner of the town borders West Boylston, Shrewsbury, and Worcester. This segment drains to the Blackstone River Basin. No significant waste disposal problems exist at the present time in this area. However, a sewer expansion project to tie into the Upper Blackstone Treatment Facility should be investigated if the area experiences an increase in residential or industrial growth. No monies have been allocated for pollution abatement projects.

West Boylston

The land area of the town drains to the Wachusett Reservoir. The southern portion of the town borders the Greendale section of Worcester which drains to the Blackstone River Watershed. Subsurface disposal systems in this area have the potential of causing water quality problems if not functioning properly. The town should possibly investigate becoming a member of the Upper Blackstone Water Pollution Abatement District or consider the rehabilitation and re-evaluation of the subsurface disposal system. A facilities plan could be completed to evaluate the pollution abatement alternatives. At the present time no Construction Grant monies have been spent in the town.

Douglas

The town lies in the watershed of the Mumford River. It supports a 0.18 MGD activated sludge wastewater treatment facility. The collection system was expanded in 1981 to include the area along Route 16 to Douglas Center. A facilities plan should be completed to investigate the sewering of the Manchaug area of Sutton to the Douglas facility. This area has on-site disposal systems that have the potential of impacting water quality in the river. If the town experiences a period of rapid industrial or residential expansion, the present treatment would be required to be upgraded. The expansion would provide the provision for advanced wastewater treatment. The elimination of industrial/domestic wastewater discharges from Haywood Schuster Woolen Company and the tie-in of other significant discharges to the Douglas Wastewater Treatment Facility has improved water quality of the Mumford River in recent years. The Wallum area of Douglas has subsurface disposal systems that could cause future water quality problems. The sewage generated in this area could be conveyed to the wastewater treatment facility in Burrville, R.I. The following monies were spent on the expansion of the collection system.

Date	Step	Total	Federal	State	Town
6/22/82	CS	560,000	-	280,000	280,000

Grafton

The land area lies in the Quinsigamond River watershed, a tributary to the Blackstone River. The town supports a 1.0 MGD activated sludge treatment facility with the availability of phosphorus removal. The construction of this facility eliminated water quality problems from failing subsurface disposal systems in the watershed. A study of Lake Ripple is recommended to assess the severe weed and algae problems. The nutrient loading caused by on-site septic systems has been addressed, other sources such as urban runoff may still exist. A pollution abatement project would allow recreational activities to resume on the impoundment. The following monies have been spent on sewer system expansion projects and construction of the sewage treatment plant.

Date	Step	Total	Federal	State	Town
9/8/82	CS	3,424,000	-	1,712,000	1,712,000
11/21/79	2	467,147	350,360	70,072	46,715
8/13/76	3	11,446,600	8,584,950	1,716,990	1,144,660
5/16/74	2	675,749	506,812	101,362	67,575
Subtotal		16,013,496	9,442,122	3,600,424	2,970,950

Holden

The financial district and surrounding areas are sewered via MDC/Upper Blackstone Agreement to the Upper Black-stone Wastewater Treatment Facility. The subsurface disposal system located in the watershed of the Holden Reservoirs should be monitored periodically to ensure the protection of the public water supply for Worcester and surrounding communities. A facilities plan was completed in 1971 which investigated the sewer expansion projects to the Upper Blackstone Treatment Facility, of the areas adjacent the reservoirs. The town is presently experiencing failing on-site septic systems and is currently contemplating the allotment to study the problems. The monies spent on the facilities plan are as follows.

Date	Step	Total	Federal	State	Town
1/6/77	1	39,060	29,295	5,895	3,906

Hopedale

The land area of the town drains to the Mill River. It has a municipal sewage collection system which serves a majority of the town. The sewage is conveyed to a newly constructed 1.1 MGD advanced secondary wastewater treatment facility.

The Route 140 South Main Street area is not sewered to this facility, the septage generated in this area is transported to the adjacent Milford Wastewater Treatment Facility, in the Charles River Basin. The monies spent on the sewer expansion and the upgrading of the wastewater treatment plant are summarized below.

Date	Step	Total	Federal	State	Town
10/9/81	CS	2,000,000	-	1,000,000	1,000,000
9/30/81	3	7,968,300	5,916,225	1,195,245	796,830
8/23/78	2	576,625	432,469	86,494	57,663
Subtotal		10,544,925	6,408,694	2,281,739	1,854,493

Leicester

The town is divided into three sewer districts, Leicester Center, and Rochdale, which are located in the French River Basin, and the Cherry Valley Sewer District, which is adjacent to Kettle Brook in the Blackstone River Basin. The 1979 208 Area Wide Management Plan and the 1975 Blackstone Management plan recommends sewering the Cherry Valley Sewer District to the Upper Blackstone Water Pollution Abatement District. This abatement action should be considered a high priority. A facilities plan should be completed to investi-gate sewer expansion of the Upper Blackstone collection system to this area. Kettle Brook has experienced color problems and algal blooms during periods of low flow. No Construction Grants monies have been awarded to the town for pollution abatement projects in this portion of the town.

Mendon

The land area of the town lies in the West River and Mill River watersheds. Its land use is mainly agricultural and has no municipal sewage collection system. If a sewer system becomes necessary in the future, the center of town and the area along Route 16 should be considered high priority areas. These areas could be tied into the Uxbridge Wastewater Treatment Facility. The implementation of a septic tank maintenance program is suggested to avoid any potential water quality problems from failing subsurface disposal systems. Agricultural runoff has the potential of impacting water quality in this area if proper fertilizing, pesticide, and manure handling procedures are not followed. No Construction Grant money has been awarded to the town for pollution abatement projects.

Millbury

The town operates a 2.0 MGD trickling filter wastewater treatment plant that discharges to the Blackstone River. The water quality in this segment of the Blackstone River is influenced somewhat by the effluent from the Upper Blackstone

Wastewater Treatment Facility. Completion of the Stormwater Treatment and Sewer Separation Project in Worcester will eliminate the impact of combined sewer overflows and improve water quality. Construction of the Millbury Wastewater Treatment Facility included an extensive sewage collection system that eliminated a majority of the failing on-site septic systems causing water quality problems. A facilities plan is recommended to investigate the sewering of the Singletary Pond and Dorothy Pond areas to Millbury WWTP and the northern edge of the town along Route 20 to the Upper Blackstone Wastewater Treatment Plant. The monies that have been awarded by Construction Grants for pollution abatement projects are summarized below.

Date	Step	Total	Federal	State	Town
4/11/80	CS	3,288,000	-	1,644,000	1,644,000
1/28/77	2	96,220	72,165	14,433	9,622
6/12/76	3	156,300	117,225	23,445	15,630
Subtotal		3,540,520	189,390	1,681,878	1,669,252

Millville

The town is located on the border of Massachusetts and Rhode Island in the Blackstone River Watershed. There is no municipal sewer system in the town, only a network of subsurface disposal systems. The water quality in this segment of the river is meeting its B classification (1980 Blackstone River Basin, Part A). The elimination of the wastewater discharge from the Stanley Woolen Company has improved the water quality conditions. At the present time no money has been spent on pollution abatement projects for the town. A facilities plan is recommended to investigate sewering the Center of Millville to the Uxbridge Wastewater Treatment Plant or the Wastewater Treatment Facility in Woonsocket, Rhode Island.

Northbridge

The land area of the town lies in the Blackstone River watershed. A majority of the industries and residences are sewered to a 1.8 MGD trickling filter wastewater treatment facility. Thus, eliminating a significant portion of the water quality problems that had existed in the area. A facilities plan has been completed that investigated infiltration and inflow problems which exist in older sections of the collection system. When the recommended abatement project is completed, reduction of flow to the treatment facility will allow the expansion of the lateral sewer to the Benson and Rockdale sections of town. A summary of the Construction Grants money spent on abatement projects is listed below.

Date	Step	Total	Federal	State	Town
10/6/82	CS	232,000	-	116,000	116,000
5/8/81	1	89,593	67,195	13,493	8,959
3/1/78	3	1,377,900	1,033,425	206,685	137,790
3/11/76	1	42,600	31,950	6,390	4,260
Subtotal		1,742,093	1,132,570	342,514	267,009

Paxton

The land area of the town lies in the watershed of the Kettle Brook Reservoir system in the Blackstone Drainage Basin. The sys-tem of reservoirs serves as the source of public water supply for Worcester and neighboring communities. Water quality problems exist from failing on-site septic systems. These have the potential of impacting the public water supply. Therefore, the town should complete a facilities plan investigating sewering the areas adjacent to the Reservoir system to the Upper Blackstone Wastewater Treatment Facility in Millbury. No Construction Grants money has been awarded to the town for pollution abatement projects.

Shrewsbury

A majority of the residents and commercial industries of town are served by a municipal sewage collection system that conveys wastewater to a 1.75 MGD secondary sewage treatment plant. The effluent from the treatment facility is discharged to the Assabet River. The Edgemere section of Shrewsbury borders the City of Worcester and the town of Grafton along the southeast corner of Lake Quinsigamond. The Lake serves as the headwaters of the Quinsigamond River, a tributary of the Blackstone River. This portion of the town has experienced water quality problems from malfunctioning subsurface disposal systems. A facilities plan is recommended to investigate sewering the Edgemere section to the Upper Blackstone Wastewater Treatment Plant. No money has been spent on pollution abatement projects for the portion of the town within the Blackstone River Basin.

Sutton

The town of Sutton is a rural community with no municipal treatment facility. The wastewater generated by the residents is treated by a network of subsurface disposal systems. Should sewering become necessary due to future growth the town should investigate the capability of the Douglas or Millbury Sewage Treatment Plant to process the wastewater. Sutton Center and the Singletary Pond areas have experienced water quality problems and should be considered a priority area for a pollution abatement project. A facilities plan was completed in 1981 to investigate sewering the Manchaug Village area to the Douglas Sewage Treatment Plant. This portion of Sutton has the potential of causing water quality problems in the Mumford River. Construction Grants monies that have been spent in the town on pollution abatement projects are summarized below.

Date	Step	Total	Federal	State	Town
7/20/81	1	49,900	37,425	7,485	4,990
8/11/76	3	1,369,271	1,026,953	205,391	136,927
Subtotal		1,419,171	1,064,378	212,876	141,917

Upton

The town of Upton lies in the watershed of the West River. The town supports a 0.15 MGD treatment facility providing secondary treatment through an extended aeration process. The facility processes waste generated in the Upton Center and the western portion of the town. Expansion of the treatment facility to provide phosphorus and nitrogen removal should be investigated. This abatement project would protect water quality in the West Hill Dam impoundment which is presently used for swimming and other recreational activities. Monies spent on pollution abatement projects are summarized below.

Date	Step	Total	Federal	State	Town
12/15/76	3	497,700	373,275	74,665	49,770
10/26/76	3	1,462,400	1,096,800	219,360	146,240
Subtotal		1,960,100	1,470,075	294,015	196,010

Uxbridge

The town lies in the Mumford and Blackstone River watersheds. The town supports a 2.5 MGD activated sludge wastewater treatment facility. Collection systems convey wastes generated in the North Uxbridge and Uxbridge Center sections of town which previously had waste outfalls to the Mumford River. Construction of the treatment facility and sewer expansion projects has improved water quality conditions in this portion of the river. However, if the town experiences industrial or residential growth, future sewer expansion projects should be considered to prevent water quality problems. Presently, the treatment facility has the capacity to accept wastes generated in Mendon to eliminate the on-site disposal systems along Route 16. The monies spent on pollution abatement projects are summarized below.

Date	Step	Total	Federal	State	Town
7/3/75	3	486,000	364,500	72,900	48,600
1/21/77	3	10,287,000	7,715,250	1,543,050	1,028,700
Subtotal		10,773,000	8,079,750	1,615,950	1,077,300

Worcester

The City of Worcester is the second largest commercial district in the Commonwealth of Massachusetts. Industrial and municipal wastes have historically caused water quality problems in the Blackstone River. The construction of the Upper Blackstone Water Pollution Abatement District (UBWPAD) Wastewater Treatment Facility located on Route 20 in Millbury was a major pollution abatement project. The facility has the capacity to treat 56 million gallons per day of wastewater. A majority of the industries which previously discharged to the river are now tied into the UBWPAD sewer network with pretreatment. A complete list of these industries is included in Section III. Wastewater Discharges. Due to economic factors and increased technology, many of the industries have gone out of business which previously discharged wastewater to the river. A complex sewer network which conveys the wastewater is comprised of combined sewer systems, that collect both stormwater and waste-water, and sanitary sewers which convey only domestic wastewater. The city is presently involved in an extensive pollution abatement project which involves the rehabilitation of the sewer network. The project will include, a stormwater treatment facility and separation of the stormwater and domestic sewers which is scheduled to be completed in early 1987. Historically, during a storm event the capacity of the sewer network would be exceeded, to prevent a "blow out", i.e., exceeding the capacity of the treatment plant. The excess flow would be released to Mill Brook, through combined sewer regulators. The Stormwater Treatment Facility located off Quinsigamond Ave. will have the capacity to treat 108 million gallons of wastewater. The treatment facility will be operated by a computerized control system that will monitor the flow rate in the collection network. The excess flow that cannot be transported to the treatment plant will be diverted to the stormwater treatment facility that will remove the solids and chlorinate the effluent before it is discharged to the Blackstone River. The development of a successful pretreatment program, elimination of wastewater discharges, and completion of the sewer separation project will cause further improvement in water quality of the river. The monies that have been spent on pollution abatement projects in the city are summarized below.

Date	Step	Total	Federal	State	City
4/8/83	3	8,799,024	6,599,268	1,319,854	879,902
4/22/81	3	6,796,609	5,097,457	1,019,491	679,661
5/8/81	3	6,248,100	4,686,075	937,215	624,810
4/30/81	3	12,587,400	9,940,550	1,888,110	1,258,740
1/11/80	3	5,841,200	4,380,900	876,180	584,120
1/11/80	3	5,043,465	3,782,599	756,520	504,347
6/26/79	3	1,237,041	927,781	185,556	123,704
3/9/79	3	294,976	221,232	44,246	29,498
9/18/78	2	334,151	250,613	50,123	33,415
7/29/77	2	1,671,948	1,253,961	250,792	167,195
6/29/77	2	576,403	432,302	86,460	57,640
8/26/76	1	300,000	225,000	54,000	30,000
Subtotal		49,730,317	37,297,738	7,459,547	4,973,032

The following are the totals of the monies spent on water pollution abatement projects for the entire Blackstone River Drainge Basin.

	Total	Federal	State	City/Town
Total	109,197,023	74,769,767	19,705,953	14,721,302

VI. NON-POINT SOURCE POLLUTANTS

In addition to point source pollutants from municipal and industrial wastewaters, non-point source pollutants also contribute to water quality problems in the Blackstone River Basin. In many cases the effects of non-point source pollutants have been masked by the magnitude of point sources. The continued implementation of point source abatement projects will possibly result in the emergence of non-point source pollutant problem areas in the basin.

The ability to identify sources of non-point pollutants is difficult due to the variability of time and space in which they occur within a watershed. Most non-point source pollution cannot be alleviated by traditional control techniques of sewers and treatment plants. Non-point source control measures in the Blackstone Basin have been studied under the Section 208 Area Wide Management Plan prepared by the Central Massachusetts Regional Planning Commission (CMRPC) in August 1979. A general description of the types and control techniques of non-point source pollution throughout the Blackstone River Basin are presented in the following pages.

Urban Runoff

Urban runoff conveys dirt, dust, leaves, animal waste and other materials from impervious surfaces on which these materials accumulate during dry weather. A storm event washes over the urban areas and the "pollutants" enter a waterway through storm drains or by overland runoff. Stormwater runoff contains contaminants such as chlorides, silt, oil and grease, coliform bacteria, and organic matter. The impact of urban runoff on water quality depends on the duration and quantity of a storm event, storm intervals, and street cleaning schedules. The following communities have been identified in the 1979 208 CMRPC Area Wide Management Plan as having water qual-ity problems resulting from urban runoff: Auburn, Grafton, Holden, Hope-dale, Leicester, Millbury, Northbridge, Uxbridge and Worcester.

The City of Worcester is presently involved in a water pollution abatement project that will collect and treat stormwater. This project should eliminate a significant portion of the non-point source pollution entering the Blackstone River. The stormwater treatment facility will be located off Quinsigamond Avenue and will have the capacity to treat 180 million gallons of stormwater. The treatment will consist of settling to remove solids and chlorination to kill bacteria before discharging the effluent to Mill Brook which discharges to the headwaters of the Blackstone River.

Agricultural Runoff

Agricultural activity is minor in the Blackstone River Basin. What agriculture exists occurs in the southeast portion of the basin in the towns of Mendon, Uxbridge, and Blackstone. Agricultural runoff from farms contains four categories of non-point source pollutants. The first nurtients, especially nitrogen and phosphorus, became available from livestock wastes and fertilizers. The second, pesticides and herbicides used in insect control, contain a variety of toxic substances. A third category of pollutants is bacterial contamination which results from livestock or livestock waste storage areas. Finally, soil erosion induced by over grazing, livestock activity along a fragile shoreline and poor cultivation techniques used by farmers can increase the amount of suspended solids entering a waterway.

Soil Erosion and Sedimentation

In general soil erosion results from the natural forces of water and wind moving across a landscape. Erosion creates a source of sediment that can effect water quality in two ways. One by increasing the level of nutrients within a stream which promotes algal growth causing large dinural flucculations in dissolved oxygen. The second involves increased organic matter or silt covering the natural stream bed inhibiting benthic organisms.

In the Blackstone River Basin, gravel and earth removal operations located in the communities of Grafton, Northbridge and Uxbridge can disrupt vegetation and steep slopes which can increase the potential of erosion and sedimentation problems.

It should be noted that streambank activity can promote water quality problems. An activity unique for the Blackstone River Basin is the number of used/abandoned junk car lots along the river banks of the Blackstone River. This activity promotes increased concentrations of oil and grease and other contaminants, such as heavy metal within the river system.

Subsurface Disposal Systems

In non-sewered areas of the basin individual septic systems are used for the disposal of domestic waste. If a septic system is neglected or located in inadequate soil that does not percolate the water properly the system will fail. The nitrates and bacteria associated with failing septic systems can contaminate ground and surface water. The CMRPC Area Wide Management Plan (1979) and the 1975 Blackstone Management Plan identified areas of the basin where failing septic systems are causing water quality problems. Sewer expansion projects have been completed or are presently proposed for communities that have new or expanded municipal wastewater treatment facilities. The objective of the projects is to eliminate a majority of the failing on-site septic systems. The remaining on-site disposal systems will be located in areas without a treatment facility or in remote areas not easily sewered. A proper regulating and monitoring program for a septic system, conducted by the local Board of Health will help prevent the systems from deteriorating and causing future water quality problems.

Solid Waste Disposal

Sanitary landfills are used for the disposal of solid wastes, industrial waste, and domestic sludge. The leachate from the landfills can cause surface and ground water contamination if not properly sited and operated. Leachate may contain high concentrations of heavy metals, nutrients, organic matter, toxic compounds, and coliform bacteria. A summary of the status, in active or non-active (closed), and location of the sanitary landfills in the Blackstone River Basin are presented in Table VI-1.

Impoundments

Dams and the impoundments they create are not considered "sources of pollution", however, the hydraulic changes that incur can have several adverse impacts on water quality. The velocity of the river is greatly reduced by the dams. The flow conditions favor the growth of plantonic algae if sufficient nutrients exist. Wastewater treatment plants which discharge to the Blackstone River supply these nutrients and therefore create a favorable media for algal growth. Another adverse effect is the increase in sedimentation behind the dam. Past and pres-ent discharges of industrial and municipal wastes has resulted in the accumulation of contaminated sediments, containing heavy metals, organic matter and low solubility toxic substances. These pollutants have the potential of impacting water quality of the water columns. The in-place sediment of the Blackstone River has been identified as a source of non-point source pollution based on the heavy metal content found at several impoundments in a study undertaken by the Central Massachusetts Regional Planning Commission. A report titled A Sediment Control Plan for the Blackstone River was prepared by DEQE, Office of Planning and Manage-ment suggested possible abatement projects for this problem. A list of the dams and impoundments located in the Blackstone River Basin are presented in Table VI-2.

Wetlands

Wetlands are defined as those areas where the ground is saturated with water from the water table. These areas are often subject to occasional flooding during heavy storm events. Wetlands are characterized by swamps, marshes, bogs, and wet meadows.

The Blackstone River Basin contains a total of 10,758 acres of wetlands. The communities with the largest wetland areas are summarized below:

Community	Major Wetland Area	Wetland Size (acres)
Grafton	Hovey Pond Swamp Cider Mill Swamp	144 238
Mendon	Mill River Wetland	168
Uxbridge	West River Wetland	150
Northbridge, Uxbridge	Rice City Pond Wetland	105
Hopedale	Hopedale Pond Wetland	138

Water quality can be adversely impacted by wetlands. The decomposition of aquatic plants and algae can cause a depletion of the dissolved oxygen concentration and the release of nutrient (phosphorus and nitrogen) which promote unwanted algal activity downstream from a wetland area.

Control Techniques for Non-Point Pollutants

Runoff

The recommended measures for the control of pollution from urban runoff include: improving maintenance programs, i.e., street sweeping and catch-basin cleaning conducted by the state and local highway departments, installing monitoring wells for groundwater to detect any possible contamination from the percolation of runoff, also reducing the amount of de-icing chemicals, road salt, that are applied by state and local highway departments.

Subsurface Sewage Disposal

Subsurface sewage disposal is controlled by Title V of the Massachusetts Environmental Code, revised July 1977. The regulations describe the design and the installation of environmentally acceptable on-site disposal systems. The most important measure for the control of pollution from septic systems is the adoption of a septic system maintenance program. A maintenance program is coordinated by individual communities. The program should require that all subsurface disposal systems be pumped out once a year according to Mass. Title 5. The excess organic matter is removed to prevent a system from failing and contaminating surface and ground waters.

Landfills

Before the pollutants contained in leachate can be controlled, a monitoring program must be conducted to determine the type, concentration and the fate of contaminants generated at both active and abandoned sites. The primary control measure for pollution caused by leachate is to reduce leachate production by sealing the non-active landfills with an impermeable cover. Active sites can be sealed by grading a cover material that promotes the establishment of a dense cover of vegetation that protects nearby watersheds. Groundwater observation wells could be installed to insure the protection of aquifers used for public and private water supplies.

Many communities within the Blackstone River Basin are rapidly using up the expansion space at the current landfill sites. As a result a Regional Resource Recovery Facility was proposed in the CMRPC 1979 Area Wide Management Plan. This facility would reduce the quantity of solid waste that must be disposed of at a landfill site. Operation of the facility will include processing and separating the solid waste to produce a dry solid fuel. The remaining ferrous, non-ferrous scrap and glass must be disposed of. The dry solid fuel would be burned to recover the heating value or energy in BTU's (British Thermal Units) of the waste. The heat energy is then converted to electricity.

Impoundments

The pollution abatement technologies for impoundments are essentially 1) dredging the sediment, 2) breeching the dam, 3) a combination of 1 and 2, and 4) the no action alternative. Until such time that a cost effective asbatement program can be developed, the no action alternative is the most realistic plan for the sediment of the Blackstone River. The Sedi-ment Control Plan for the Blackstone River includes other possible control measures for the in-place sediment. The report concluded that the sediment contains heavy metals and toxic organics that classify the sediment as a hazardous waste. At the present time, there are no approved hazardous waste disposal sites within the Commonwealth of Massachusetts. Therefore, the sediment must be transported to an approved site in another state or left in place. For this reason, dredging the impoundments is not a cost effective alternative.

Soil Erosion and Sedimentation

Control measures for erosion and sedimentation include land use and flood plain zoning. Land use and zoning can prohibit the construction in areas that have the potential of impacting water quality if disrupted. The Soil Conservation Service regulates construction on imbankments that have a 15 percent slope or greater. Flood plain zoning can reduce the occurrence of practices which lead to the generation of non-point source pollutants. Several towns within the basin are considering the adoption of flood plain zoning ordinances in order to quality for federal flood insurance. Such zoning is recommended due to the economic and environmental benefits. Riverbank cleanup projects can further protect water quality throughout the drainage basin.

TABLE VI-1

SOLID WASTE DISPOSAL SITES

TOWN/CITY	LOCATION	STATUS (Active or Inactive)	SPECIAL DESIGNATION
Auburn	Rockdale St.	Active	Municipal
Bellingham	Maple St.	Active	Municipal
Blackstone	Chestnut St.	Active	Municipal
	Farm St.	Inactive	
Boylston[1]	Mill Hill Rd.	Active	Municipal
	Old South Rd.	Inactive	-
Douglas	Riddle St.	Active	Municipal
Grafton	Millbury St.	Active	Municipal
	Hudson Rd.	Inactive	
Hopedale	Rt. 140	Active	Private
Holden[2]	River St.	Active	Municipal
Leicester	Manville St.	Active	Municipal
Mendon	Bellingham Rd.	Inactive	Private
Millville	Rt. 122	Inactive	-
Millbury	Riverlin St.	Active	Municipal
Northbridge	Quaker Rd.	Active	Municipal
Paxton	Davis Hill Rd.	Inactive	-
Shrewsbury	Rt. 20	Active	Municipal
	East of North Quinsigamond Ave.	Inactive	-
Sutton	Old Stone Hill	Active	Municipal
	Putnam Hill	Inactive	-
Upton	Warren St.	Inactive	-
Uxbridge[1]	Hazel St.	Active	Municipal
Worcester[2]	Greenwood St.	Active	Municipal
	Granite St.	Inactive	"

[1] Groundwater monitoring
[2] Both groundwater and leachate collection

TABLE VI-2

IMPOUNDMENTS IN THE BLACKSTONE RIVER BASIN

TOWN/CITY	IMPOUNDMENT	WATERSHED
Worcester	American Steel Dam	Blackstone
Sutton	Fisherville Dam	Blackstone
	Farnumsville Dam	Blackstone
Northbridge	Old Rockdale Dam	Blackstone
	Riverdale Dam	Blackstone
Uxbridge	Rice City Dam	Blackstone
Hopedale	Mill St. Dam	Mill River
Douglas	Lackey Dam	Mumford River

VII. WATER SUPPLY

The sources of water supply are divided into two major classifications: groundwater and surface water. The groundwater supplies include: bored, driven, and dug wells, rock and sand earth springs, and infiltration galleries. The surface supplies include: lakes, reservoirs, streams, ponds, and rivers. The protection of these water supplies and insuring the distribution of high quality drinking water are the tasks of the Department of Environmental Quality Engineering, Division of Water Supply (DWS). The DWS is committed to the development of a groundwater protection program to guard against the degradation public of water supplies[1] for this and future generations. The DWS also oversees the routine sampling and analysis of public water supplies to ensure the quality conforms to the United States Public Health Service Drinking Water Standards. The Commonwealth of Massachusetts Drinking Water Regulations are governed by 310 CMR 22.00 under the provisions of Massachusetts General Laws.

The monitoring program developed for public water supply and distribution systems is dependent on the portion of the population of the community tied into the water supply network. The monitoring data is analyzed and stored at DEQE's Central Regional Office in Worcester for the towns in the Blackstone River Basin.

The major communities within the Blackstone River Basin, discussed in this section, used an average of 35.8 MGD for water supply in 1980. These communities utilize surface and groundwater as a source of water supply. Surface waters provide approximately 60 percent of the water supply within the Blackstone River Basin, of which the city of Worcester is the largest user. Rural communities surrounding Worcester use groundwater as the primary source of water supply.

Inter basin transfer provides over 50 percent of the water supply requirements for the Blackstone River Basin. The Nashua and Charles River Basins transferred an average of 17.47 and 0.89 MGD respectively to the basin water supply network in 1980.

Auburn

Auburn is a large residential and partial manufacturing suburb of Worcester. The community is served by three water distribution agencies. The Auburn Water District has six groundwater wells with a safe yield[2] of 2.5 MGD (Million Gallons per Day). Three wells are located off Church Street, one well near Auburn High School off Southbridge Street, and two wells near Kettle Brook and Dark Brook also off Walsh Avenue. The Woodland Water

---

[1]Definition - Public Water Supply - DEQE defines a public water supply when it has 15 service connections or serves at least 25 people a minimum of 60 days per year.

[2]Definition - The safe yield for a particular water source is the approximate amount of water in million gallons per day (MGD) which can be supplied through an extended dry period. The safe yield figures reflect the best judgement of the respective town superintendent or manager of the water supply system.

District and Elm Hill Water District obtain their water from the Worcester Water Department. The Holden and Kettle Brook reservoirs serve as the major source of public water supply for Worcester. The water from these sources is chlorinated to kill any pathogenic organisms prior to entering the distribution system.

Blackstone

The town is located in the southeast corner of the drainage basin on the Massachusetts and Rhode Island border. The Blackstone River flows through the southwest corner of the town into Woonsocket, Rhode Island. The Blackstone Water Department which serves the town has three groundwater wells with a safe yield of 0.56 MGD. Two of these wells are located at the corner of Summers and Park streets. The third well is located off of Elm Street. The groundwater is treated with hexametaphosphates to protect the distribution system from corrosion and is chlorinated for disinfection prior to entering the distribution system.

Bellingham

Bellingham is a rural community located in the southeast corner of the Blackstone drainage basin within the Peters River watershed. The town is surveyed by the Bellingham Water Department which operates two wells on the Upper Peters River and two wells on the Lower Peters River. These wells have a combined safe yield of 1.11 MGD. Approximately 55 percent, or 0.86 MGD of the water used by the Bellingham Water Department is supplied from sources within the Charles River Basin.

Douglas

Douglas which is largely rural in nature encompasses an area of 36.9 square miles. The Douglas Water District has one well field consisting of 13 wells located off West Street in the Riddle Brook watershed. The safe yield of these wells is 0.5 MGD and serves the northern section of the town. The water supply is treated with soda ash for corrosion control prior to entering the distribution system.

Grafton

Grafton is located in the generally urban area surrounding Worcester. The town is a manufacturing, trade, and residential community. Two water distribution agencies serve the town's residences. The South Grafton Water District consists of two groundwater wells located off Ferry Street and Providence Road. These wells have a safe yield of 0.55 MGD. The second water agency is the Massachusetts American Water Works Company which has four groundwater wells, two of which are located south of Hayes Pond and the remaining wells are located off Millbury Street. The safe yield of the four wells is 2.0 MGD. The American Water Works Company chlorinates the groundwater for disinfection, as a matter of company policy, prior to entering the distribution system.

Holden

The southeast portion of Holden drains to the Blackstone River Basin. The Worcester Water Department owns water rights to Holden Reservoirs one and two. The total safe yield is 8.84 MGD which includes Kettle Brook Reservoirs No. 1 and 2, Lynde Brook Reservoir located in Leicester and Kettle Brook Reservoirs No. 3 and 4 located in Paxton. These water supply sources serve the industrial and residential communities of Worcester.

Hopedale

The town of Hopedale is an industrial community with a small land area of 5.1 square miles. The Hopedale Water Department has two groundwater wells and two interconnections with Milford Water Supply that serve the town's residences. The wellfield is located northeast of Spindleville Pond off Green Street and has a safe yield of 0.42 MGD. The Milford Water Supply District (MWSD) serves the Water Street and South Main Street area of Hopedale. The Milford areas surface water supply is injected into a groundwater well which has a safe yield of 0.10 MGD. The water supplied by MWSD for Hopedale is treated with sodium hydroxide to adjust the acidity for corrosion control and is chlorinated for disinfection prior to its injection into the groundwater aquifer.

Mendon

The residential community of Mendon obtains its water supply from the Milford Water Company from sources in the Charles River Basin.

Millbury

Millbury is located on the southern city line of Worcester. The town is composed of mostly industrial and residential suburban areas which have a land area of 15.8 square miles. Millbury is served by three water supply agencies: the Massachusetts Water Works Company, the Oakwood Heights Water District, and the Maple Hillside Water District. The Oakwood Heights and Maple Hillside Water Districts purchase water from the Massachusetts Water Works Company which has four groundwater wells that have a safe yield of 3.11 MGD. One well is located off Millbury Avenue, another off Dorothy Pond, the remaining two wells are located off North Main Street. The Massachusetts Water Works Company treats the groundwater with hexametaphosphates for corrosion control, sodium hydroxide to adjust the acidity, and adds chlorine for disinfection

Millville

Millville is primarily a residential community for the large manufacturing center of Woonsocket, Rhode Island. The town has no central or public water supply network.

Northbridge

Northbridge is a manufacturing town with a land area of 17.3 square miles. The Whitinsville Water Company owns two wellfields that have a safe yield of 1.35 MGD and one emergency well with a safe yield of 0.38 MGD. The wellfields are recharged by a system of open reservoirs including Carpenter Reservoir, Meadow Pond and Reservoirs No. 4, 5, and 6 located in Sutton. The Northbridge Water Department purchases all water from the Whitinsville Water Company which treats the groundwater with hexametaphos-phates for corrosion control and adds chlorine for disinfection prior to entering the distribution system.

Shrewsbury

Shrewsbury is a suburban residential community with many small diversified industries and wholesale retail trade businesses. The Shrewsbury Water Department has seven groundwater wells with a safe yield of 4.00 MGD. Three of the wells are located near Lamberts Pit referred to earlier in the section, in the town of Sutton. There is no treatment of the public water supply prior to entering the distribution system.

Sutton

Sutton is a residential community bordered by the towns of Douglas, Oxford, Millbury, Grafton, and Northbridge. The town is served by two water districts. The Wilkinsonville Water District operates a well located off Hatchery Road which serves the northeast section adjacent to Grafton. The well has a safe yield of 0.28 MGD. The Manchaug Water District serves the southern section of Sutton adjacent to Douglas. The district operates a well field located south of Tuckers Pond off Putnam Hill Road which has a safe yield of 0.45 MGD. The Whitinsville Water Company which supplies water to Northbridge operates an extensive reservoir and well system. The water supply system has a safe yield of 0.82 MGD.

Upton

Upton is a small manufacturing and residential town with a land area of 21.7 square miles. The town is served by the Upton Water Department which has a single well and a wellfield which combine for a safe yield of 0.69 MGD. These wells serve Upton Center and West Upton and are located off Glen Cove adjacent to the Grafton and Upton railroad tracks. There is no treatment of the public water supply in Upton.

Uxbridge

Uxbridge is a manufacturing town that has a land area of 29.3 square miles. The Uxbridge Water Department serves the northeast and northcentral sections of the town. The water sources consist of 3 groundwater wells located off Blackstone Street which have a safe yield of 2.1 MGD. The Uxbridge Water Department treats the water with hexametaphosphates for corrosion control and chlorine for disinfection prior to entering the distribution system.

Worcester

The city of Worcester is located in the central portion of Massachusetts at the northern section of the Blackstone River drainage basin. The city has a land area of approximately 38.5 square miles and forms the nucleus of the second largest metropolitan area in the state. The water supply system is the largest within th Blackstone River Basin. Worcester is the industrial and commercial center of Central Massachusetts. The Bureau of Water, a subdivision of the Worcester Department of Public Works serves as the water supply agency. The city's water supply network consists of groundwater and surface waters which have a safe yield of 28.0 MGD. These surface waters include the Kettle Brook Reservoirs No. 1 thru 4, Lynde Brook Reservoir, Holden Reservoirs No. 1 and 2, Kendall Reservoir, Pine Hill Reservoir, and Quinapoxet Reservoir. Worcester has a contract with the Metropolitan District Commission (MDC) for an additional 10.0 MGD which is used as a back up. In addition to the water supplies within the drainage basin the city of Worcester receives water by inter-basin transfer from the Nashua River Basin. The groundwater supply consists of wells located adjacent to Lake Quinsigamond which serve as recharge for the water supply. The Worcester water supply network also serves water districts in the surrounding communities. The Water Bureau uses chlorine for disinfection of the surface water supply prior to entering the complex distribution network.

VIII. TOXIC POLLUTION

For many years now, hazardous wastes and other chemicals have been improperly disposed of and have contaminated groundwater and surface waters nationwide. The disposal of these pollutants has become a major problem due to our highly industrialized society. Only recently have the potential public hazards and severity of this problem been brought to the attention of the public.

Not all chemicals can be labeled as toxic, so it is very important to distinguish which are, and which are not. To accomplish this task the U.S. Environmental Protection Agency (EPA) has put more emphasis on the analysis of toxic substances which are known, or thought to have a detrimental impact upon the environment and/or pose potential public health hazards. Some of these toxic pollutants include polychlorinated biphenyls (PCB's), selected heavy metals and pesticides, phenols, cyanides, and volatile organic compounds such as benzene and toluene.

In 1976, the United States Congress enacted the Resource Conservation and Recovery Act (RCRA) to "promote protection of health and the environment and to conserve valuable resources" by significantly changing the ways in which solid and hazardous wastes are handled. RCRA requires the United States Environmental Protection Agency (U.S. EPA) to regulate hazardous waste from "cradle to grave" by developing a list of specific standards that must be met by those who produce, handle, transport, store, treat, and dispose of hazardous wastes. The U.S. EPA's regulations which went into effect November 19, 1980, established a minimum nationwide framework for hazardous waste management. States may build upon and expand these requirements to suit their individual needs.

The RCRA encourages states to take over the hazardous waste management program if they develop regulations and programs minimally equivalent to and consistent with those of the U.S. EPA. States must apply to EPA to have their programs approved. The Massachusetts Department of Environmental Quality Engineering's Division of Solid and Hazardous Waste applied for and was granted Phase I interim authorization from the U.S. EPA on February 25, 1981. The Commonwealth had two years to come into full compliance with the RCRA program. At any point during that time, the Division may have applied for final authorization.

Massachusetts began regulating hazardous waste in 1973, well before many other states or the federal government. However, these laws and regulations were not specific and detailed enough to prevent problems from occurring. In November 1979, the Massachusetts legislature enacted the Hazardous Waste Management Act (Chapter 21C of the General Laws), which updated the state's hazardous waste management program so that it became consistent with RCRA's. The Act requires the Department of Environmental Quality Engirerering (DEQE) to establish a Division of Hazardous Waste to develop more comprehensive hazardous waste regulations and a strong licensing and enforcment program. It requires the Department to license collectors, haulers, processors, and disposers of hazardous waste, as well as to regulate hazardous wastes at the site of generation. In addition, all of these parties must comply with a "manifest" system which tracks the movement of wastes from their point of generation, through each step in their transportation, to their ultimate destination, an approved treatment, storage, or disposal facility.

To further insure safe management of hazardous waste in the Commonwealth, the Act requires the DEQE to involve interested and affected persons in all aspects of the program and to publish a list of sites in Massachusetts where hazardous wastes are known to be deposited. The Division of Solid and Hazardous Waste first accomplished this task in November 1980 with a publication entitled, Management for Site Investigations: The Preliminary Site Assessment. This report listed both confirmed hazardous waste sites (Part A) and sites requiring further investigation (Part B). An aditional report entitled, Management for Site Investigations, 1981 update was then published in 1981 to inform the general public of the Division's on-going assessments.

The Massachusetts Division of Water Pollution Control (MDWPC) is also currently involved in developing a program to evaluate the severity of toxic pollution problems in the Commonwealth. Involvement over the next two years is expected to be at the research and demonstration (R&D) level. The Division is presently joint funding programs with the United States Geological Survey (Water Resources Division), the University of Massachusetts (Department of Civil Engineering), the Massachusetts Institute of Technology, and private consultants, involving solute transport, PCB's in the Housatonic River and New Bedford Harbor, landfill leachate, acid rain, and bioassays for acute toxicity assessment.

As previously noted, the Massachusetts Department of Environmental Quality Engineering is responsible for developing a statewide program for investigating toxic pollution problems and monitoring clean-up operations. In addition, a program must be developed to control the manufacture, use and disposal of hazardous substances to prevent future environmental contamination. This will require mutual cooperation between the MDWPC, the Division of Solid and Hazardous Waste, and other state and federal agencies.

A town by town assessment of the Hazardous Waste Site investigations conducted in the Blackstone River Basin is presented in this section. These sites are confirmed by the Department of Environmental Quality Engineering, Division of Solid and Hazardous Waste, Central Regional Office, Worcester, and sites that are presently under investigation by the Division of Hazardous Waste. These sites include unlined surface lagoons that have been or are presently being used as a means of wastewater treatment which may contain hazardous materials. The site investigation is only one part of a successful four part hazardous waste management program, the other three elements of the program include regulation development, enforcement, and facility securing.

Northbridge

AFT Davidson Co., Inc.
Main Street
Whitinsville

In January 1981 an investigation by DEQE revealed that an impoundment used for fly ash disposal had been paved over for a parking lot. The Division of Solid and Hazardous Waste classified this site as under evaluation. The fly ash may contain heavy metals that could be leached from the soil into the groundwater.

North Grafton

Wyman Gordon
224 Worcester Road
North Grafton

Wyman Gordon was inspected by DEQE on March 29, 1979. The site has unlined lagoons for treatment of industrial process water. Because the treatment lagoons are unlined the metals entraped in the soil have the potential of causing water quality problems in the area. The Division of Hazardous Waste considers this a site under evaluation. Wyman Gordon is presently pursuing an alternative wastewater treatment process to eliminate the use of the surface lagoons. If the lagoons are not secured, they still might cause water quality problems.

Leicester

Fourier Lagoon
Formally: Liquid Waste Specialities, Inc.
off Stafford Street

In February 1976 an investigation of the site revealed that an industrial waste storage lagoon was breached causing soil, groundwater, and surface water contamination with oil and industrial solvents. DEQE has ordered a clean up operation program be implemented to secure the site. The Division of Solid and Hazardous Waste will continue to oversee the owner's action to secure the site by removing the hazardous materials.

Worcester

City of Worcester Municipal Sludge Beds
Route 20 and Greenwood Street

A site investigation conducted by DEQE on September 9, 1980 revealed that the site was used for the disposal of municipal sludge and chemical wastes. Leachate from this area has the potential of causing water quality problems in the nearby surface waters and groundwater aquifer.

Eastern Chemical Specialties
241 Southbridge Street

The property owned by Eastern Chemical was used for the bulk storage of organic compounds in containers both above and below the ground. The containers were abandoned by the chemical handler, causing soil and groundwater contamination. The first phase of the clean-up process has been completed. Contractors for DEQE have removed a total of 35,500 gallons of semisolid drummed waste and approximately 480 tons of contaminated soil. These have been shipped to secure hazardous waste landfills in Ohio and New York. The Division of Solid and Hazardous Waste considers the site to no longer present any danger to public health and safety. The final step in the clean-up operation involves refilling the land with clean gravel.

Owen Illinois
68 Ludlow Street

An investigation of the site revealed that sludge containing heavy metals was deposited in an on-site landfill. The leachate from this site has the potential of impacting ground and surface waters. The Divisions of Hazardous Waste classified the site as: under investigation.[1]

---

1 Definition - Situe Under Evaluation - DEQE is evaluating the site to determine if hazardous wastes are present and if background or field analysis information is sufficient to make a confirmation of hazardous waste site.

References:

"Confirmed Hazardous Waste Sites Which Are Under Investigation or at Various Stages of Enforcement and Remedial Action," DEQE, Division of Hazardous Waste, March 1984.

Management for Site Investigation 1981 Update, The Commonwealth of Massachusetts, DEQE, Division of Hazardous Waste, 1981.

IX. FUTURE MONITORING PROGRAMS

Water quality monitoring that has been conducted in the Blackstone River Basin by MDWPC prior to 1982 is summarized in a document entitled Summary of Water Quality 1982 which was prepared by MDWPC. The most recent water quality data for the basin was collected by MDWPC personnel and appears in the Blackstone River Water Quality Data 1980 Report (Westborough 1980). In order to evaluate on-going pollution abatement activities and effects of the implementation of past and current water quality management recommendations, future water quality is essential. Monitoring data will also be essential to determine the impacts of phosphorous and/or nitrogen removal at advanced wastewater treatment facilities. In addition, non-point sources of pollution as well as the effects toxics tied up in the sediment must also be addressed. It is anticipated that the following proposals will prove to comprise an acceptable water quality monitoring program for the Blackstone River Basin in the future.

1. Intensive Water Quality Surveys. Three intensive water quality surveys were conducted on the Blackstone River Basin in June, August, and October 1980. These surveys were designed to gather data required to evaluate a wasteload allocation for the Upper Blackstone Water Pollution Abatement District. The data was used to calibrate and verify the Stream 7B stream simulation model. The recommendations concluded in the Upper Blackstone Water Pollution Abatement District Wasteload Allocation-1983, MDWPC, Technical Services Branch, are presently under consideration and review by the EPA. After the implementation of the additional treatment required for the UBWPAD and the completion of the Storm-water Treatment Facility and Sewer Separation pollution abatement projects, additional surveys will then be conducted to assess the effectiveness of these projects and also to help pinpoint remain-ing water quality problems.

2. Compliance Monitoring. Wastewater Discharges in the Blackstone River Basin will continue to be sampled periodically to assure compliance with the limitations set forth in their NPDES permits. Major wastewater discharges will be sampled during each water quality survey to provide inputs for simulation modeling and other related projects. Operation and maintenance (O & M) inspections will be increased at both municipal and industrial sources to provide technical assistance for correcting problems as soon as possible. The creation of the Technical Assistance Program within the Division of Water Pollution Control will provide training for treatment plant operators and maintenance assistance to hopefully increase the performance of the municipal wastewater treatment facilities.

3. Biological Monitoring Program (Biomonitoring). Biological sampling in the streams of the Blackstone River Basin has consisted of chlorophyll a analysis and phytoplankton identification and

quantification, as well as macroinvertebrate sampling. The U.S. EPA has developed new effluent guidelines for toxic pollutants known as the "White Book Criteria". The new criteria were developed by using bioassay techniques to assess the acute and chronic toxicity levels of the toxicants to biological organisms. Field surveys that will be conducted will include toxicity assessments and habitat evaluations for classification and use attainability bility analysis. The information gathered from the monitoring program will be used in the development of toxic criteria for the Toxic Control Program being developed by the Technical Services Branch.

4. Non-Point Source Sampling. A significant portion of non-point source pollution in the Blackstone River Basin is due mostly to urban runoff from Worcester and Auburn. The majority of the pollutant loading is attributed to wastewater discharges. The urban runoff problem is difficult to quantify and effectively remedy. Therefore, point sources of pollution must be controlled prior to the commencement of non-point assessment. It should be noted that even though non-point sampling will be given a low priority, surveys will be conducted as site-specific problems arise.

5. Groundwater Monitoring Program. The Massachusetts Department of Environmental Quality Engineering established in 1983 the Massachusetts Groundwater Quality Standards and Groundwater Discharge Permit Program (314 CMR 6.00 and 5.00). The establishment of a Groundwater Protection Program requires the expansion of the existing program to encompass all aspects of groundwater protection and management. The Groundwater Management Program includes such programs as landfill management, leaking underground storage tanks, underground injection control, and aquifer recharge area protection.

6. Water Quality Management Clean Lakes (Limnology) Program. The 1981 legislative session established the Massachusetts Clean Lakes and Great Ponds Program under the provisions of Chapter 628 of the Acts of 1981. This is a high priority and high visibility program which authorizes 3 million dollars statewide for lake restoration or preservation projects. The objective of this program is to maintain the lakes and ponds for public recreation and enjoyment.

7. Special Studies. Periodically, additional water quality and/or hydrological data will be required from the Blackstone River Basin. Studies such as algal assays and bioassays may be needed to evaluate the trophic status of the impoundments downstream from municipal wastewater sources. Supplemental data may also be needed for the evaluation of NPDES permit limitations, wasteload allocations, and impacts of non-point sources of of pollution. These studies will be subject to MDWPC priorities and personnel constraints, but it is hoped that the MDWPC will be able to respond to the needs of the DEQE, as well as other state and federal agencies.

REFERENCES

Alonzo B. Reed, Incorporated under contract by Central Massachusetts Regional Planning Commission and Metropolitan District Commission, Central Massachusetts Comprehensive Water Supply Study. Worcester, Massachusetts.

Camp Dresser and McKee, Wastewater Facilities Plan Update Inflow/Infiltration Analysis for the Town of Northbridge, Massachusetts, September 1983. Boston, Massachusetts.

Central Massachusetts Regional Planning Commission. August 1979. Areawide Water Quality Management Plan. Worcester, Masachusetts.

Dunn, R. Dennis, Upper Blackstone Water Pollution Abatement District Wasteload Allocation-1983, Department of Environmental Quality Engineering, Division of Water Pollution Control, Technical Services Branch. Westborough, Massachusetts. (Unpublished Draft)

Gately, F. Robert P.E. and Schafer, A. Lawrence P.E., Computer Operated Combined Sewer Overflow Treatment Facility at Worcester, Massachusetts, Paper delivered at New England Water Pollution Control Federation Conference, Sheraton-Boston, January 23, 1984.

Massachusetts Division of Hazardous Waste. 1980. Management for Site Investigations: The Preliminary Site Assessment Parts A and B. Boston, Massachusetts.

____________, 1981. Management for Site Investigations Update.

____________, March 1984. Confirmed Hazardous Waste Sites Which Are Under Investigation or at Various Stages of Enforcement and Remedial Action. Boston, Massachusetts.

Massachusetts Division of Water Pollution Control, 1977. Blackstone River Water Quality Data, Part A, May 1978. Westborough, Massachusetts.

____________, 1980. Blackstone River Water Quality Data, Part A, October 1981. Westborough, Massachusetts.

____________, 1979-1980. Part B Wastewater Discharge Data, August 1981. Westborough, Massachusetts.

____________, 1973. Blackstone River, Part C, Water Quality Analysis, September 1974, Westborough, Massachusetts.

Massachusetts Division of Water Pollution Control and Department of Environmental Quality Engineering, 1982. Commonwealth of Massachusetts 1982 Summary of Water Quality. Westborough, Massachusetts.

REFERENCES (CONTINUED)

Massachusetts Water Resources Commission-Division of Water Pollution Control. 1978. Massachusetts Water Quality Standards. Boston, Massachusetts.

McGinn, Joseph, M. 1981. A Sediment control Plan for the Blackstone River Department of Environmental Quality Engineering, Office of Planning and Program Management, July 1981. Boston, Massachusetts.

U.S. EPA. 1979. Technical Justification for NPDES Effluent Limitation for Municipalities on Low Flow Streams. U.S. EPA. Region V.

___________, 1976. Guidelines for State and Areawide Water Quality Management Program Development, Chapter 5, Water Quality Standards. Washington, D.C.

The City of Worcester Department of Public Works. 1982. Present Status of the Construction Funding for Sewerage System Improvements. July 1982. Worcester, Massachusetts.

APPENDIX 1

Commonwealth of Massachusetts

Water Resources Commission

Division of Water Pollution Control

MASSACHUSETTS SURFACE WATER QUALITY STANDARDS

4.01: GENERAL PROVISIONS

(1) Title. These regulations shall be known as the "Massachusetts Surface Water Quality Standards."

(2) Organization of Standards. These standards comprise five units: General Provisions (314 CMR 4.01), Application of Standards (314 CMR 4.02), Water Quality Criteria (314 CMR 4.03), Antidegradation Provisions (314 CMR 4.04), and Basin Classification and Maps (314 CMR 4.05).

(3) Authority. The Massachusetts Surface Water Quality Standards are adopted by the Division pursuant to the provisions of M.G.L. c.21, §27.

(4) Purpose. The Massachusetts Act charges the Division with the duty and responsibility to enhance the quality and value of the water resources of the Commonwealth and directs the Division to take all action necessary or appropriate to secure to the Commonwealth the benefits of the Federal Act. The objective of the Federal Act is the restoration and maintenance of the chemical, physical and biological integrity of the Nation's waters. To achieve the foregoing requirements the Division has adopted these standards which designate the uses for which the various waters of the Commonwealth shall be enhanced, maintained and protected; which prescribe the water quality criteria required to sustain the designated uses; and which contain regulations necessary to achieve the designated uses and maintain existing water quality including, where appropriate, the prohibition of discharges.

(5) Definitions. As used in these standards, the following words have the following meanings:

Artificial conditions - Those conditions resulting from human alteration of the chemical, physical or biological integrity of waters.

Beneficial use - Any use not impairing the most sensitive use designated in the classification tables contained in 314 CMR 4.05; except that in no case shall the assimilation or transport of pollutants be deemed a beneficial use.

Cold water fishery - Waters whose quality is capable of sustaining a year-round population of cold water trout (salmonidae).

Division - The Massachusetts Division of Water Pollution Control, as established by General Laws c.21, §26.

Discharge - Any addition of any pollutant to the waters of the Commonwealth.

EPA - The United States Environmental Protection Agency.

Federal Act - The Federal Water Pollution Control Act, as amended, 33 U.S.C. §§1251, et seq.

Massachusetts Act - The Massachusetts Clean Waters Act, as amended, General Laws, c.21, §§26-53, inclusive.

Pollutant - Any element or property of sewage, agricultural, industrial or commercial waste, runoff, leachate, heated effluent, or other matter, in whatever form and whether originating at a point or major nonpoint source, which is or may be discharged, drained or otherwise introduced into any sewerage system, treatment works or waters of the Commonwealth.

Primary contact recreation - Any recreation or other water use, such as swimming and water skiing, in which there is prolonged and intimate contact with the water sufficient to constitute a health hazard.

Seasonal cold water fishery - Waters whose quality is capable of sustaining only an extremely limited cold water population on a year-round basis, with cold water fish in these streams provided largely by stocking.

Secondary contact recreation - Any recreation or other water use in which contact with the water is either incidental or accidental, such as fishing, boating and limited contact incident to shoreline activities.

Segment - A finite portion of a water body established by the Division for the purpose of classification.

Warm water fishery - Waters whose quality is not capable of sustaining a year-round cold water or seasonal cold water fishery.

Waters of the Commonwealth - All waters within the jurisdiction of the Commonwealth, including, without limitation, rivers, streams, lakes, ponds, springs, impoundments, estuaries and coastal waters, but not including groundwaters.

(6) Severability. If any provision of these standards is held invalid, the remainder of these standards shall not be affected thereby.

(7) Repealer. The "Rules and Regulations for the Establishment of Minimum Water Quality Standards and for the Protection of the Quality and Value of Water Resources" filed with the Secretary of the Commonwealth on May 2, 1974 and the "River Basin Classifications" filed with the Secretary of the Commonwealth on July 21, 1967 are hereby repealed, except that all permits, orders, determinations or other actions of the Division, based upon such standards and river basin classifications, and any court actions seeking to enforce such standards, permits, orders and determinations shall remain in full force and effect until modified, amended, revoked or reissued by the Division and/or the courts of the Commonwealth, as appropriate.

(8) Effective Date. These standards shall become effective upon publication by the Secretary of the Commonwealth pursuant to the provisions of M.G.L. c.30A, §6.

4.02: APPLICATION OF STANDARDS

(1) Establishment of Effluent Limitations. In regulating discharges of pollutants to waters of the Commonwealth, the Division will limit or prohibit such discharges to insure that the water quality standards of the receiving waters will be maintained or attained. The determination by the Division of the applicable level of treatment for an individual discharger will be made in the establishment of effluent limitations in the individual discharge permits in accordance with 314 CMR 3.10(3), (4), (5) and (6). In establishing water quality based effluent limitations, the Division must consider natural background conditions, existing discharges, must protect existing downstream uses, and must not interfere with the maintenance and attainment of beneficial uses in downstream waters. Toward this end, the Division may provide a reasonable margin of safety to account for any lack of knowledge concerning the relationship between the pollutants being discharged and their impact on the quality of the receiving waters.

(2) Mixing Zones. In applying these standards, the Division may recognize, where appropriate, a limited mixing zone or zone of initial dilution on a case-by-case basis. The location, size and shape of these zones shall provide for the maximum protection of aquatic resources. At a minimum, mixing zones must:

a) Meet the criteria for aesthetics;

b) Be limited to an area or volume that will minimize interference with the designated uses or established community of aquatic life in the segment:

c) Allow an appropriate zone of passage for migrating fish and other organisms; and

d) Not result in substances accumulating in sediments, aquatic life or food chains to exceed known or predicted safe exposure levels for the health of humans or aquatic life.

(3) Hydrologic Conditions. The Division will determine the most severe hydrologic condition at which water quality standards must be met. In classifying the inland waters of the Commonwealth and in applying these standards to such waters, the critical low flow condition at and above which these standards must be met is the average minimum consecutive seven-day flow to be expected once in ten years, unless otherwise stated by the Division in these standards. In artificially regulated waters, the critical low flow will be established by the Division through agreement with the Federal, state or private interest controlling the flow. The minimum flow established in such agreement will become the critical low flow under this section for those waters covered by the agreement.

(4) Procedures for Sampling and Analysis. For the purpose of collecting, preserving and analyzing samples in connection with these water quality standards, the fourteenth edition of Standard Methods of the Examination of Water and Wastewater published by the American Public Health Association, or Methods for Chemical Analysis of Water and Wastes published by the U.S. Environmental Protection Agency should be used. Where a method is not given in these publications, the latest procedures of the American Society for Testing Materials (ASTM) shall be used, or any other equivalent method approved by the Director.

4.03: MINIMUM WATER QUALITY CRITERIA AND ASSOCIATED USES

(1) Description of Contents. This part sets forth the Classes to be used by the Division in classifying the waters of the Commonwealth according to the uses for which the waters shall be enhanced, maintained and protected. For each class, the most sensitive beneficial uses are identified and minimum criteria for water quality in the water column are established. In interpreting and applying the minimum criteria in 310 CMR 4.03(4), the Division shall consider EPA guidance established in accordance with Section 304(b) of the Federal Act as it applies to local conditions including, but not limited to:

a) The characteristics of the biological community;

b) Temperature, weather, flow, and physical and chemical characteristics; and

c) Synergistic and antagonistic effects of combinations of pollutants.

(2) Coordination with Federal Criteria. The Division will use the EPA publication entitled Quality Criteria for Water, EPA-440/9-76-023 as guidance in establishing case-by-case discharge limits for pollutants not specifically listed in these standards but included under the heading "Other Constituents" in 310 CMR 4.03(4), for identifying bioassay application factors and for interpretations of narrative criteria. Where the minimum criteria specifically listed by the Division in this part differ from those contained in the federal criteria, the provisions of the specifically listed criteria in these standards shall apply.

(3) Classes and Designated Uses. The waters of the Commonwealth will be assigned to one of the classes listed below. Each class is defined by the most sensitive, and therefore governing, uses which it is intended to protect. The classes are:

Classes for Inland Waters

Class A - Waters assigned to this class are designated for use as a source of public water supply.

Class B - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; and for primary and secondary contact recreation.

Class C - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; and for secondary contact recreation.

Classes for Coastal and Marine Waters

Class SA - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation; and for shellfish harvesting without depuration in approved areas.

Class SB - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation; and for shellfish harvesting with depuration (Restricted Shellfish Areas).

Class SC - Waters assigned to this class are designated for the protection and propagation of fish, other aquatic life and wildlife; and for secondary contact recreation.

(4) Minimum Criteria. The following minimum criteria are adopted and shall be applicable to all waters of the Commonwealth.

A. These minimum criteria are applicable to all waters of the Commonwealth, unless criteria specified for individual classes are more stringent.

	Parameter	Criteria
1.	Aesthetics	All waters shall be free from pollutants in concentrations or combinations that: a) Settle to form objectionable deposits; b) Float as debris, scum or other matter to form nuisances; c) Produce objectionable odor, color, taste or turbidity; or d) Result in the dominance of nuisance species.
2.	Radioactive Substances	Shall not exceed the recommended limits of the United States Environmental Protection Agency's National Drinking Water Regulations.
3.	Tainting Substances	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
4.	Color, Turbidity, Total Suspended Solids	Shall not be in concentrations or combinations that would exceed the recommended limits on the most sensitive receiving water use.

5.	Oil and Grease	The water surface shall be free from floating oils, grease and petrochemicals and any concentrations or combinations in the water column or sediments that are aesthetically objectionable or deleterious to the biota are prohibited. For oil and grease of petroleum origin the maximum allowable discharge concentration is 15 mg/l.
6.	Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.
7.	Other Constituents	Waters shall be free from pollutants in concentrations or combinations that: a) Exceed the recommended limits on the most sensitive receiving water use; b) Injure, are toxic to, or produce adverse physiological or behavioral responses in humans or aquatic life; or c) Exceed site-specific safe exposure levels determined by bioassay using sensitive resident species.

B. Inland Waters - the following additional minimum criteria are applicable to inland water classifications.

For Class A waters:

	Parameter	Criteria
1.	Dissolved Oxygen	Shall be a minimum of 5.0 mg/l in warm water fisheries and a minimum of 6.0 mg/l in cold water fisheries.
2.	Temperature	Shall not exceed 83°F (28.3°C) in warm water fisheries or 68°F (20°C) in cold water fisheries nor shall the rise resulting from artificial origin exceed 4.0°F (2.2°C).
3.	pH	As naturally occurs.
4.	Total Coliform Bacteria	Shall not exceed a log mean for a set of samples of 50 per 100 ml during any monthly sampling period.
5.	Turbidity	None other than of natural origin.
6.	Total Dissolved Solids	Shall not exceed 500 mg/l.

7.	Chlorides	Shall not exceed 250 mg/l.
8.	Sulfates	Shall not exceed 250 mg/l.
9.	Nitrate	Shall not exceed 10 mg/l as nitrogen.

For Class B waters:

	Parameter	Criteria
1.	Dissolved Oxygen	Shall be a minimum of 5.0 mg/l in warm water fisheries and a minimum of 6.0 mg/l in cold water fisheries.
2.	Temperature	Shall not exceed 83°F (28.3°C) in warm water fisheries or 68°F (20°C) in cold water fisheries, nor shall the rise resulting from artificial origin exceed 4.0°F (2.2°C).
3.	pH	Shall be in the range of 6.5-8.0 standard units and not more than 0.2 units outside of the naturally occurring range.
4.	Fecal Coliform Bacteria	Shall not exceed a log mean for a set of samples of 200 per 100 ml, nor shall more than 10% of the total samples exceed 400 per 100 ml during any monthly sampling period, except as provided in 310 CMR 4.02(1).

For Class C waters:

	Parameter	Criteria
1.	Dissolved Oxygen	Shall be a minimum of 5.0 mg/l in warm water fisheries and a minimum of 6.0 mg/l in cold water fisheries.
2.	Temperature	Shall not exceed 83°F (28.3°C) in warm water fisheries or 68°F (20°C) in cold water fisheries, nor shall the rise resulting from artificial origin exceed 4.0°F (2.2°C).
3.	pH	Shall be in the range of 6.5-9.0 standard units and not more than 0.2 units outside of the naturally occurring range.
4.	Fecal Coliform Bacteria	Shall not exceed a log mean for a set of samples of 1000 per 100 ml, nor shall more than 10% of the total samples exceed 2500 per 100 ml during any monthly sampling period, except as provided in 310 CMR 4.02(1).

C. Coastal and Marine Waters - the following additional minimum criteria are applicable to coastal and marine waters.

For Class SA waters:

	Parameter	Criteria
1.	Dissolved Oxygen	Shall be a minimum of 85 percent of saturation at water temperatures above 77°F (25°C) and shall be a minimum of 6.0 mg/l at water temperatures of 77°F (25°C) and below.
2.	Temperature Increase	None except where the increase will not exceed the recommended limits on the most sensitive water use.
3.	pH	Shall be in the range of 6.5-8.5 standard units and not more than 0.2 units outside of the naturally occurring range.
4.	Total Coliform Bacteria	Shall not exceed a median value of 70 MPN per 100 ml and not more than 10% of the samples shall exceed 230 MPN per 100 ml in any monthly sampling period.

For Class SB waters:

	Parameter	Criteria
1.	Dissolved Oxygen	Shall be a minimum of 85 percent of saturation at water temperatures above 77°F (25°C) and shall be minimum of 6.0 mg/l at water temperatures of 77°F (25°C) and below.
2.	Temperature Increase	None except where the increase will not exceed the recommended limits on the most sensitive water use.
3.	pH	Shall be in the range of 6.5-8.5 and not more than 0.2 units outside of the naturally occurring range.
4.	Total Coliform Bacteria	Shall not exceed a median value of 700 MPN per 100 ml and not more than 20% of the samples shall exceed 1000 MPN per 100 ml during any monthly sampling period, except as provided in 310 CMR 4.02(1).

For Class SC waters:

	Parameter	Criteria
1.	Dissolved Oxygen	Shall be a minimum of 85 percent of saturation at water temperatures above 77°F (25°C) and shall be a minimum of 6.0 mg/l at water temperatures of 77°F (25°C) and below.
2.	Temperature Increase	None except where the increase will not exceed the recommended limits on the most sensitive water use.
3.	pH	Shall be in the range of 6.5-8.5 standard units and not more than 0.2 units outside the naturally occurring range.
4.	Fecal Coliform Bacteria	Shall not exceed a log mean for a set of samples of 1000 MPN per 100 ml, nor shall more than 10% of the total samples exceed 2500 MPN per 100 ml during any monthly sampling period, except as provided in 310 CMR 4.02(1).

4.04: ANTIDEGRADATION PROVISIONS

(1) Protection of Existing Uses. In all cases, from and after the date these regulations become effective, the quality of the waters of the Commonwealth shall be maintained and protected to sustain existing beneficial uses.

(2) Protection of High Quality Waters. From and after the date these regulations become effective, waters designated by the Division in 310 CMR 4.05(5) whose quality is or becomes consistantly higher than that quality necessary to sustain the national goal uses shall be maintained at that higher level of quality unless limited degradation is authorized by the Division. Limited degradation may be allowed by the Division as a variance from this regulation as provided in 310 CMR 4.04(6).

(3) Protection of Low Flow Waters. Certain waters will be designated by the Division in Regulation 5.5 of these standards for protection under this section due to their inability to accept pollutant discharges. New or increased discharges of pollutants to waters so designated are prohibited unless a variance is granted by the Division as provided in 314 CMR 4.04(6).

(4) National Resource Waters. Waters which constitute an outstanding national resource as determined by their outstanding recreational, ecological and/or aesthetic values shall be preserved. These waters shall be designated for preservation by the Division in 310 CMR

5.05(5) of these standards. Waters so designated may not be degraded and are not subject to a variance procedure. New discharges of pollutants to such waters are prohibited. Existing discharges shall be eliminated unless the discharger is able to demonstrate that:

a) Alternative means of disposal are not reasonably available or feasible; and

b) The discharge will not affect the quality of the water as a national resource.

(5) Control of Eutrophication. The discharge of nutrients, primarily phosphorus or nitrogen, to waters of the Commonwealth will be limited or prohibited by the Division as necessary to prevent excessive eutrophication of such waters. There shall be no new or increased discharges of nutrients into lakes and ponds, or tributaries thereto. Existing discharges containing nutrients which encourage eutrophication or growth of weeds or algae shall be treated. Activities which may result in nonpoint discharges of nutrients shall be conducted in accordance with the best management practices reasonably determined by the Division to be necessary to preclude or minimize such discharges of nutrients.

(6) Variances. A variance to authorize a discharge in water designated for protection under 310 CMR 4.04(2) may be allowed by the Division where the applicant demonstrates that:

(a) The proposed degradation will not result in water quality less than specified for the class; and

(b) The adverse economic and social impacts specifically resulting from imposition of controls more stringent than secondary treatment to maintain the higher water quality are substantial and widespread in comparison to other economic factors and are not warranted by a comparison of the economic, social and other benefits to the public resulting from maintenance of the higher quality water. In making such evaluation, the Division will apply, where appropriate, guidance documents published by EPA.

In addition to the above, the applicant for a variance to authorize a discharge into waters designated for protection under 310 CMR 4.04(3) must demonstrate that:

(c) Alternative means of disposal are not reasonably available or feasible.

In any proceeding where such variance is at issue, the Division shall circulate a public notice in accordance with the procedures set forth in M.G.L. c.30A, §3. Said notice shall state that a variance is under consideration by the Division, and indicate the Director's tentative determination relative thereto. To the extent feasible, the variance proceeding shall be conducted as part of any pending discharge permit proceedings pursuant to M.G.L. c.21, §43. In any variance procedure, the burden of proof relative to justifying the variance shall be on the part requesting the variance. Any variance granted pursuant to this regulation shall not extend beyond the expiration date of the permit.

4.05: BASIN CLASSIFICATIONS AND MAPS

(1) Description of Contents. This part sets forth the procedures and guidelines the Division must follow in classifying the waters of the Commonwealth, and the classifications themselves. The procedural rules for classifying are contained in 310 CMR 4.05(2) through 4.05(4). 310 CMR 405(5) contains maps and tabulations identifying the assignment by the Division of each segment to one of the classes set forth in 310 CMR 4.03 of these Standards, the designation of uses and associated criteria for that segment and the imposition of special limitations in 310 CMR 4.04(2) through 4.04(4) to that segment.

(2) Designation of Uses. In determining the appropriate classification for a particular water, the Division must fulfill its statutory mandate as set forth in 310 CMR 4.01(4) of these standards. Wherever attainable, the Division shall designate the national goal uses of protection and propagation of fish, shellfish, aquatic life and wildlife and recreation in and on the waters in classifying the waters of the Commonwealth. In determining whether the national goal uses are attainable for a given water, the Division has considered limitations imposed by natural conditions, irreversible artificial conditions and the availability of feasible technological treatment methods and designated the optimum number of beneficial uses attainable in the circumstances.

(3) Other Applicable Standards. Waters classified by the Division in 314 CMR 4.05 may be subject to additional restrictions pursuant to federal or Massachusetts statutes and regulations. Where such additional restrictions are known they are noted in the classifications in 314 CMR 4.05 Where these restrictions impose requirements more stringent than required under the Massachusetts or Federal Acts, e.g. public health restrictions relative to water supplies, such restrictions shall be considered and applied by the Division in classifying the waters to the extent authorized in the Massachusetts Act.

(4) Fisheries Designations. For inland waters certain specific criteria become applicable on the basis of their designation as a particular type of fishery. Therefore, inland segments are designated as cold water fisheries, seasonal cold water fisheries, warm water fisheries or for aquatic life. In seasonal cold water fisheries the criteria for cold water fisheries apply during the period of September 15 through June 30 annually, and criteria for warm water fisheries apply at other times.

Where the Division determines that natural or irreversible conditions prevent the attainment of water quality capable of supporting a warm water fishery, a use designation of aquatic life has been made. In each segment so designated in 314 CMR 4.05(5), the criteria for a warm water fishery apply for constituents except those affected by the natural or irreversible condition, which constituents shall be governed by the most sensitive resident species as determined by the Director in consultation with the Massachusetts Division of Fisheries and Wildlife.

(5) Classifications. For the purpose of applying the Massachusetts Water Quality Standards, the waters of the Commonwealth are hereby classified as shown in the following tables which are a part of these regulations. Columns 1 and 2 of the tables describes the segment. Column 3 identifies the applicable classification of the segment. Column 4 identifies the use or uses for which the segment is designated; (P&S) means primary and secondary contact recreation, (Sn) means seasonal fishery, (O) means open shellfishing, (R) means restricted shellfishing. Column 5 identifies the applicable provisions of 310 CMR 4.04 and 310 CMR 4.05(3).

Segments and their classifications are shown on maps for general orientation. In case of inconsistancy between the tables and the maps, the data contained in the table shall control.

APPENDIX 2

IV. 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. Although no bioassay studies are done by the Division, the Biological Section conducts macroinvertebrate surveys on selected rivers and streams throughout the Commonwealth. 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 or heavy metal 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 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.

Water Quality Index

There has long been a need for an objective method of measuring "water quality". However, the term is difficult to define and often subject to differences in interpretation. The development of a water quality index has provided an objective means of evaluating water quality and documenting changes which occur over time, establishing management priorities, and reporting water quality to the general public.

The Modified National Sanitation Foundation's Water Quality Index (WQI) is a general measure of pollution based on nine parameters: dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, nitrate-nitrogen, phosphate, ammonia-nitrogen, turbidity and total solids. Each parameter, as well as the index itself, is represented on a 100 point decreasing scale: higher values indicating better water quality. Evaluating each parameter on the same scale as the index itself provides a means of highlighting those parameters which contribute to the degradation of water quality. Those parameters evaluated less than 70 on the scale have an adverse effect on water quality, values below 50 having a significant effect. The scale used for the index itself may be evaluated as follows:

100-90 - Excellent
70-90 - Good
50-70 - Fair
25-50 - Poor
<25 - Very Poor

The index provides an "instant analysis" of water quality. However, it must be kept in mind that the index is limited in that it does not reflect the presence of toxic materials, aesthetic qualities and other parameters which may be detrimental to the intended water use. As such it is meant only to complement the water quality analysis.

The Water Quality Analysis (Part C) section of this series of reports presents a detailed interpretation of the water quality data, using the water quality index in the evaluation.

WATER QUALITY INDEX

Designed by the National Sanitation Foundation (NSF) as a means of communicating water quality trends to the general public in a simple, non-technical manner, the Water Quality Index (WQI) incorporates nine water quality parameters into a single numerical value on a scale from zero (poorest quality) to one hundred. To develop this index, a panel of over 100 government, academic, and private water quality experts participated in an opinion poll which asked them to rank a number of physical, chemical, and microbiological parameters according to their relative significance in the assessment of water quality. The nine most significant parameters were then assigned a weight (W_i) based on their comparative importance. In addition, each individual parameter was represented graphically on a 100 point scale; higher values indicating better water quality. These water quality curves are used to assign a quality sub-index (q_i) for each measurement. Thus, each raw data value is assigned a quality sub-index (Q_i) and a certain weight (W_i). With these values the Water Quality Index is calculated, using the following multiplicative equation:

$$WQI = \prod_{i=1}^{n} q_i^{W_i}$$

where WQI = Water Quality Index
- qi = quality index of the i th parameter
- W = unit weight of the i th parameter
- n = number of parameters

The Technical Services Branch of the Division of Water Pollution Control (DWPC) has developed modifications of the WQI which can be applied to the rivers and streams of Massachusetts. The equation given above is utilized; however, some changes have been made in the input parameters as well as the assigned weights (W_i). First, water temperature deviation was eliminated, ammonia-nitrogen was added, and total phosphorus was substituted for phosphate. In addition, turbidity is expressed in nephelometric turbidity units (NTU) rather than Jackson turbidity units (JTU) and the water quality scale (Q_i) for fecal coliforms was adjusted to reflect the water quality standards of the Division more closely. The modification for fecal coliforms was necessitated by the fact that this parameter carried too much weight in the calculation of the WQI. The curve does, however, remain within the 95 percent confidence limits originally established by NSF for this parameter.

The second modification involved the assigned weights (W_i) of each parameter. Due to the lack of data for turbidity and/or total solids in most of the data collected prior to 1977, all nine parameters had to be assigned new weights. All nine parameters used in the DWPC modified indices and their unit weights are presented in the following table.

Parameter	Expressed As:	W ALL	W w/o Turbidity	W w/o Turbidity & Total Solids
Dissolved oxygen	Percent Saturation	0.17	0.18	0.20
Fecal Coliform	Number per 100 ml	0.16	0.17	0.18
pH	Standard Units	0.11	0.12	0.13
BOD	mg/l	0.11	0.12	0.13
Nitrate-Nitrogen	mg/l as NO -N	0.10	0.11	0.12
Ammonia-Nitrogen	mg/l as NH -N	0.10	0.11	0.12
Total Phosphorus	mg/l as P	0.10	0.11	0.12
Turbidity	NTU	0.08	0.00	0.00
Total Solids	mg/l	0.07	0.08	0.00
	W =	1.00	1.00	1.00

In order to apply the WQI to the results of the 1980 Blackstone River Surveys, water quality data were averaged over the sampling periods as follows: average weekly (three days) water temperatures and dissolved oxygen data were used to calculate an average percent saturation value. For the remaining parameters, data from the two chemical sampling dates were averaged to yield a single value for each parameter at each sampling location. The Blackstone October 1980 survey, on the other hand, consisted of one 24-hour survey. Grab samples were collected every four hours and composited to obtain a single sample for each station and, therefore, data from these surveys were input directly for the WQI.

After calculating the index, water quality was evaluated according to the following general scheme:

WQI RANGE	WATER QUALITY
90-100	Excellent
70-90	Good
50-70	Fair
25-50	Poor
0-25	Very Poor

The tables on the following pages present the results of the WQI analyses performed on MDWPC water quality data from the 1980 intensive surveys.

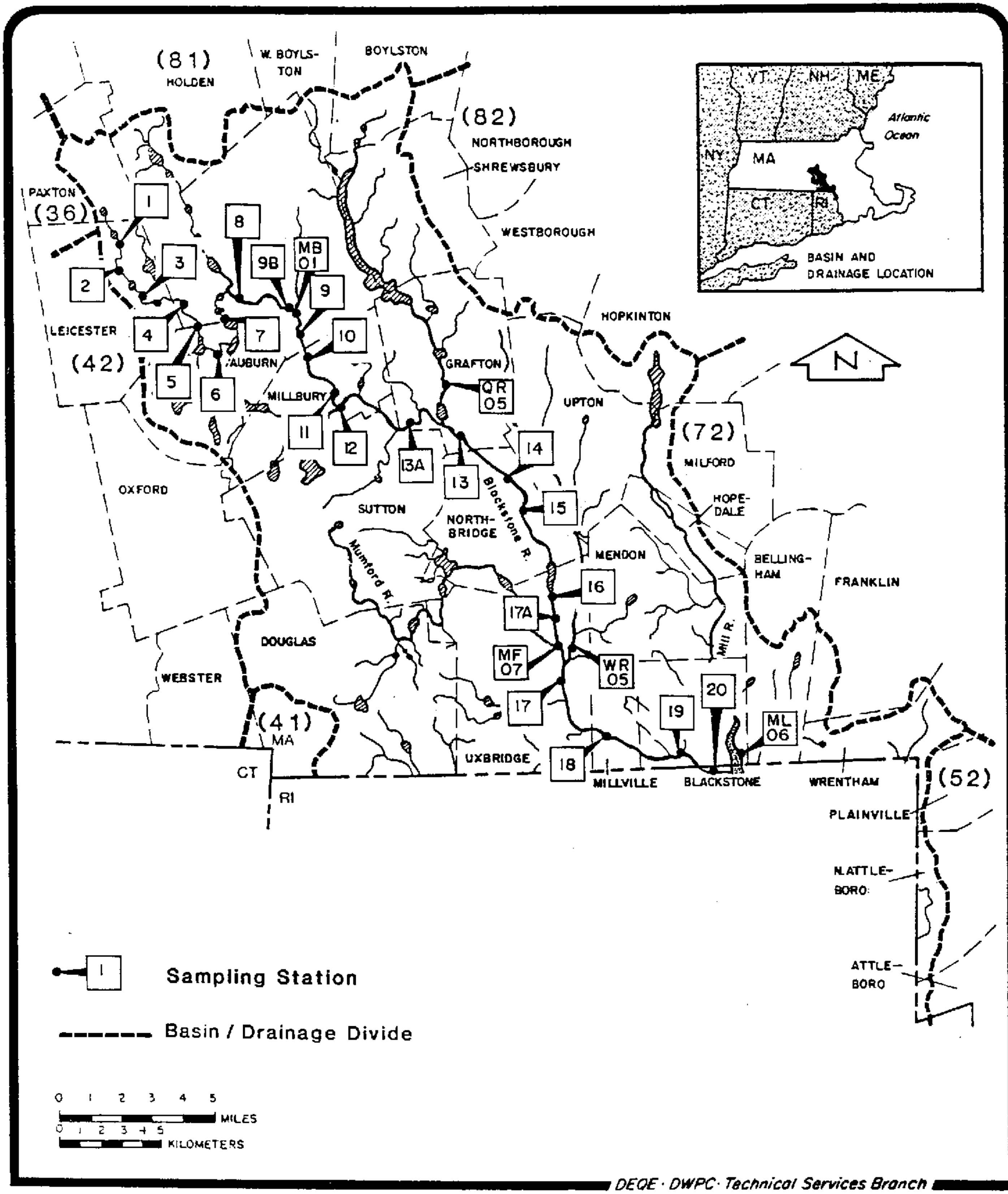
The WQI was designed to give an instant general indication of water quality. Its limitations include the lack of consideration of such factors as toxic waste degradation and aesthetic qualities. Despite these limitations, the WQI is a useful tool with which to supplement the traditional water quality analysis.

TABLE A-II-1

BLACKSTONE RIVER 1980 SURVEY

LOCATION OF SAMPLING STATIONS

STATION NUMBER		RIVER MILE
BS01	Waite Pond Outlet, Chapel St., Leicester	59.3
BS02	Auburn St., Leicester	58.2
BS03	Bridge below Elfskin Corp., Leicester	57.4
BS04	Bridge on James St., Worcester	55.9
BS05	Stoneville Pond Outlet, Oxford St., Worcester	55.0
BS06	Sword St., Auburn	53.5
BS07	Leesville Pond Outlet, Oxford St., Worcester	52.7
BS08	Bridge on Webster St., Worcester	51.3
BS09B	Above Dam off Millbury St., Worcester	48.9
BS09	Bridge on Millbury St., Worcester	47.9
BS10	Bridge on McCracken Rd., Millbury	46.0
BS11	Bridge on Riverlin St., Millbury	43.6
BS12	Above Singing Dam, Sutton	42.2
BS13A	Bridge on Pleasant St. Canal, Grafton	40.6
BS13	Bridge on 122A, at Fisherville Dam, Grafton	39.7
BS14	Bridge on Sutton St., Northbridge	36.8
BS15	Riverdale St., Northbridge	35.0
BS16	Rice City Pond Outlet, Hartford Ave., Uxbridge	31.3
BS17A	Route 16 Bridge, Uxbridge	30.0
BS17	Route 122 Bridge, Uxbridge	27.9
BS18	At Water Quality Monitor off Route 122, Millville	23.7
BS19	Howard St., Blackstone	21.0
BS20	Singleton St., Woonsocket, R.I.	20.0



BLACKSTONE RIVER BASIN

Figure A-II-1

LOCATION OF SAMPLING STATIONS

TABLE A-11-2

BLACKSTONE RIVER SURVEY

WATER QUALITY INDEX

June 1980

STATION	RIVER MILE	PARAMETER VIOLATED	QUALITY RATING	WQI
BS01	59.3	BOD*	47	85.1
BS02	58.2	Fec*, P*, TS	25,31,57	63.4
BS03	57.4	FEC*, BOD, P*, NH_3*, TS	27,62,47,49,64	60.7
BS04	55.9	FEC*	46	77.5
BS05	55.0	BOD, NH_3	69,54	80.6
BS06	53.5	NH_3	64	85.0
BS07	52.7	NH_3	56	83.8
BS08	51.3	FEC*, NH_3	48,57	76.1
BS09B	48.9	FEC*, NH_3	48,57	75.7
BS09	47.9	FEC*, BOD*, NH_3*, TS	32,45,27,69	59.0
BS10	46.0	BOD, P*, NH_3**,TS	64,43,12,63	64.1
BS11	43.6	Fec, BOD, P*, NH_3**, TS	56,67,49,13,65	61.7
BS12	42.2	BOD, P*, NH_3**, TS	56,30,12,69	60.5
BS13A	40.6	Fec, BOD, P*, NH_3**, TS	67,51,47,12,67	61.0
BS13	39.7	Fec, BOD, NH_3**	57,51,13	64.8
BS14	36.8	Fec, BOD, P, NH_3**	61,50,53,16	62.2
BS15	35.0	Fec, BOD*, P, NH_3**	61,40,53,19	61.0
BS16	31.3	BOD*, P, NH_3**	49,60,20	65.6
BS17A	30.0	BOD*, P, NH_3*, TS	39,66,31,69	65.9
BS17	27.9	Fec, BOD*, NH_3*	63,43,35	68.2
BS18	23.7	BOD, NH_3*	53,45	73.7
BS19	21.0	BOD, NH_3	60,54	79.4
BS20	20.0	Fec, BOD, NH_3	65,65,55	79.3

* Quality rating falls below 50

** Quality rating falls below 25

TABLE A-11-2 (CONTINUED)
BLACKSTONE RIVER SURVEY
WATER QUALITY INDEX
August 1980

STATION	RIVER MILE	PARAMETER VIOLATED	QUALITY RATING	WQI
BS01	59.3	BOD	57	83.1
BS02	58.2	Fec**, P*, TS*	24,35,38	61.5
BS03	57.4	Fec*, BOD*, P*, TURB, TS, DO*	50,30,41,68,54,27	51.7
BS04	55.9	Fec**, TS	19,69	66.6
BS05	55.0	P	50	81.0
BS06	53.5	DO**	15	65.0
BS07	52.7	BOD	67	85.7
BS08	51.3	Fec**	21	69.2
BS09B	48.9	Fec*	27	69.1
BS09	47.9	Fec**, BOD*, P, DO*	2,46,62,28	35.0
BS10	46.0	BOD, NO_3, P*, NH_3**, DO	58,69,42,24,59	62.2
BS11	43.6	Fec*, BOD, P*, NH_3**, TS	32,65,45,25,69	56.7
BS12	42.2	Fec*, BOD, P*, NH_3**, DO	48,61,43,25,65	58.0
BS13A	40.6	Fec*, BOD, P*, NH_3*	45,62,44,31	62.6
BS13	39.7	Fec, BOD, P*, NH_3*	54,69,47,41	68.2
BS14	36.8	BOD, P*	62,46	71.6
BS15	35.0	Fec, BOD, P*, NH_3	54,63,46,63	69.2
BS16	31.3	Fec*, P*, NH_3, DO	28,46,66,64	60.9
BS17A	30.0	P*	48	74.6
BS17	27.9	Fec, P	63,65	78.1
BS18	23.7	P	68	79.9
BS19	21.0			82.5
BS20	20.0	Fec	65	83.3

* Quality rating falls below 50
** Quality rating falls below 25

TABLE A-11-2 (CONTINUED)
BLACKSTONE RIVER SURVEY
WATER QUALITY INDEX
October 1980

STATION	RIVER MILE	PARAMETER VIOLATED	QUALITY RATING	WQI
BS08	51.3	Fec**, BOD, NH_3	20,60,54	64.2
BS09B	48.9	Fec*, BOD, NH_3*, TS	26,52,46,67	63.9
BS09	47.9	Fec**, BOD**, P*, NH_3*, TS**, DO	18,9,49,31,20,63	39.8
BS10	46.0	BOD*, P*, NH_3**, TS, DO	46,34,8,54,67	54.5
BS11	43.6	Fec, BOD, P*, NH_3**, TS	69,50,39,10,65	59.0
BS12	42.2	BOD*, P*, NH_3**, TS	47,38,10,65	58.9
BS13A	40.6	Fec, BOD, P*, NH_3**, TS	68,50,39,11,65	58.0
BS13	39.7	Fec, BOD*, P*, NH_3**, TS	52,49,40,13,67	58.1
BS14	36.8	Fec, BOD, P*, NH_3**, TS	62,54,41,14,69	59.8
BS15	35.0	BOD, P*, NH_3**, TS	55,43,16,69	61.6
BS16	31.3	BOD, P*, NH_3**, DO	67,48,23,63	64.2
BS17A	30.0	BOD, P*, NH_3**	57,46,22	64.0
BS17	27.9	BOD, P, NH_3*	62,58,33	70.5
BS18	23.7	BOD, P, NH_3*	62,65,47	75.6

* Quality rating falls below 50
** Quality rating falls below 25