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Preface

IIASA's Water Resources Project deals with the issue of managing degraded river basins in Central and Eastern European countries going through significant political, economic, and social changes. These changes create rather specific conditions for environmental management and the question is to what extent Western experiences can be utilized. The present paper addresses this issue by analyzing the history of water quality management of the Blackstone River in Massachusetts, U.S.A.

A WATER-QUALITY HISTORY OF THE BLACKSTONE RIVER, MASSACHUSETTS, USA: IMPLICATIONS FOR CENTRAL AND EASTERN EUROPEAN RIVERS

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ABSTRACT

The Blackstone River is a relatively small river that drains the area around Worcester, Massachusetts, one of first industrialized cities in the United States. Until the 1970's, the river was highly polluted by industrial and municipal wastewaters—not unlike the current situation in degraded rivers in areas of Central and Eastern Europe (CEE). Today, the Blackstone enjoys considerably improved water quality as the result of two historical processes: continuing investment and improvement in municipal wastewater treatment in response to increasingly stringent U.S. federal water-quality laws, and the control or elimination of industrial discharges. A key factor in the river's restoration was the early development of and continued adherence to a comprehensive basin water-quality plan. A similar planning process is recommended for CEE countries. Nonetheless, achieving acceptable water quality in the Blackstone was a slow process, requiring decades of intensive improvement in wastewater treatment. A similarly slow process can be anticipated in the CEE countries unless cost-effective interim improvements in wastewater treatment are sought.

KEYWORDS

Water quality; history; management; legislation; economics; dissolved oxygen; wastewater treatment; industrial wastes

OBJECTIVE OF STUDY

This examination of the Blackstone River grew out of an ongoing project at the International Institute for Applied Systems Analysis entitled Water Quality Management of Degraded River Basins in Central and Eastern Europe. The Degraded River Basins Project is focusing on those rivers in the CEE counties that have been excessively polluted by municipal and industrial wastes. The project is directed towards finding innovative strategies for improving water quality within the context of the social, political, and economic transition of Central and Eastern Europe The goal is to identify engineering, economic, institutional, and legal approaches that will improve the water quality of these rivers within the means of the transition economies of the CEE countries. This examination of the Blackstone River arose from the observation that the relatively good water quality in most United States and Western European rivers came about in only the last several decades, and that these rivers were in many cases as polluted as the currently degraded rivers in the CEE countries. The aim is to understand the water-quality history of selected U.S. rivers and see if there are successes to be emulated and failures to be avoided along the way to improved water quality.

The Blackstone River is an ideal river for such study. A relatively small river draining a populous area, the river was severely degraded by the late 1800's. Industrial pollution was a particular problem, and an important factor in selecting the Blackstone River as a case study. This paper reports on some preliminary findings in our examination of the Blackstone River's water-quality history. We recount the settlement and early industrialization of the river basin, the resulting deterioration of the river's water quality, the legislative and economic changes that led to improved water quality, and the cost to improve water quality. We close with observations on the lessons from the Blackstone River that may be useful in restoring degraded rivers in Central and Eastern Europe.

As context for the following historical notes, we summarize the current situation of wastewater treatment in Central and Eastern Europe based on the recent review and analysis by Somlyódy (1993). Somlyódy's report examines the situation in Poland, the Czech Republic, the Slovak Republic, Hungary, and Bulgaria. Currently less than half of the wastewater collected in these countries receives secondary treatment. Many treatment plants are overloaded, some by more than 100%. As a result, treatment efficiencies are low; in those plants that provide secondary treatment the BOD removal efficiency is 70%. Although the former regimes planned significant improvements, resources were lacking and more than 1000 treatment plants in the five countries are only partially constructed. Many receiving waters are contaminated by high BOD, fecal coliform, and toxics levels and low dissolved oxygen. All countries monitor stream water quality and classify streams, but many kilometers of stream fall in the lowest quality classes. Some small tributaries receive the wastewater from relatively large towns and effectively act as sewage canals. There is popular support in the CEE for substantial water-quality improvements and strong environmental laws and regulations are being passed as the countries recreate their economies and institutions. There is, however, great uncertainty as to the availability and sources of funding.

There are many parallels between the current situation in the CEE countries and the historical situation of the Blackstone River Valley. Water quality in the Blackstone River was as poor and wastewater treatment as inadequate as in the CEE countries. Water-quality laws, which were once weak and poorly enforced, were strengthened in the 1970's and led to real progress in water quality. Nonetheless, funding was uncertain in local communities hard hit by an economic transition that saw most manufacturing jobs leave the area for less expensive labor sources in the southeast United States.

EARLY HISTORY

This history is assembled from information from BRVNHCC (1989), Emel *et al.* (1992), Lewis and Brubaker (1991), McLaughlin (1978), Tennant *et al.* (1975), Tree (1993), and Wilkie and Tager (1991).

The Blackstone River comprises some 966 square kilometers (373 square miles) in Massachusetts and 272 square kilometers (105 square miles) in Rhode Island in the northeastern United States (Figure 1). Land within the river valley was first settled by European settlers in 1635 when William Blackstone settled in Rhode Island. After two failed settlements in the late 1600's, a permanent settlement took hold in what is now Worcester, Massachusetts near the head of the river in 1713. By the time of the United States War of Independence in 1776, there were about 1500 people living in Worcester and the valley was a rural farming area.

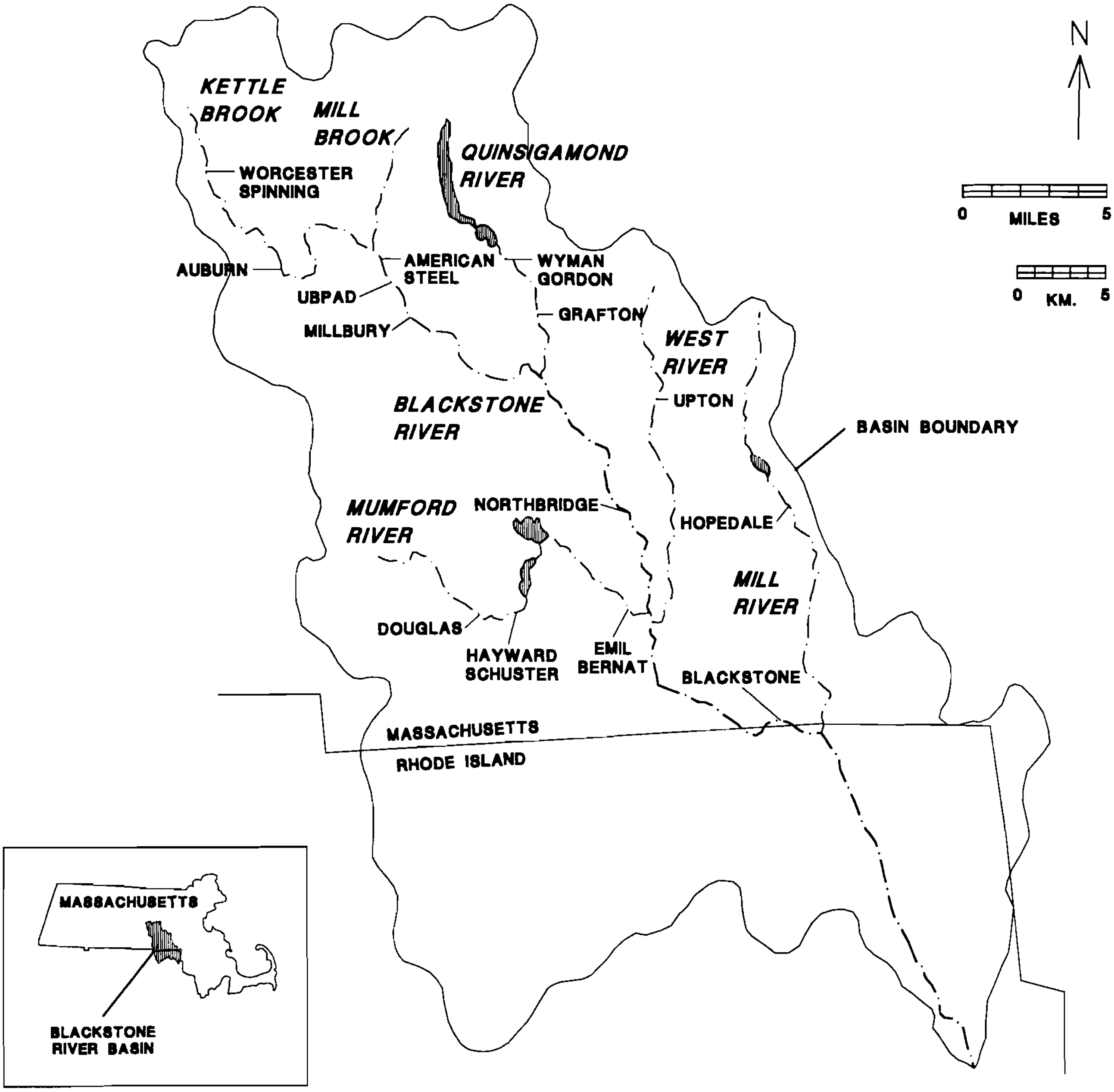

Figure 1. Map of the Blackstone River basin in Massachusetts showing wastewater discharges

The War of Independence brought political independence from Britain, but economic dependence continued. As a colony, the United States was not allowed to develop manufacturing capability and Britain sought to continue the former colony's dependence on British manufactured goods. British law prohibited the export of manufacturing machinery and the emigration of skilled mechanics. However, Samuel Slater, who worked for seven years in the water-powered cotton-spinning factories in Derbyshire, England, evaded these prohibitions and came to the U.S. with the plans for the Arkwright spinning machine committed to memory. In 1790 he joined with Moses Brown, who had twice attempted and failed to start cotton manufacturing operations with home-grown technology, and the two constructed the first successful cotton-spinning factory in the states, beginning operations in December 1790 in a mill on the Blackstone River in Pawtucket, Rhode Island.

The fast-flowing Blackstone River proved fertile ground for the new technology. The river has a quite consistent fall of 133 meters in its 74 kilometers (438 feet in its 46 miles); it is seldom frozen in winter and never dry. Soon there were over 100 mills in the area and mill dams harnessed the river's power along its entire length. By 1814 water-powered cotton and wool mills occupied virtually all dam sites along the river; by 1830 there was an average of two dams every 3 kilometers along the river (one dam per mile).

With the early mills came the first conflicts over water quality. The Slater Mill ended forever the anadromous fish run on the Blackstone. Before long, there were conflicts between mill owners and fisherman over pollution of the river, but the state legislatures favored the development of industry and refused the fisherman's requests for laws governing mills and their damage. Even the mills were complaining of the river's quality, which was too dirty to be used for washing cloth.

Among the earliest mills was the Worcester Cotton Manufactury in Worcester on Mill Brook, a small headwater tributary of the Blackstone. However, manufacturing in Worcester and the upper Blackstone valley was hampered by the lack of good transportation for the shipping of finished goods. This problem gave rise to proposals to construct a canal along the Blackstone River to connect Worcester to Rhode Island and the sea with inexpensive water transportation. Construction commenced in 1826 and the canal opened in 1828. Mill Brook, the small tributary of the Blackstone through central Worcester, was channelized through the southern half of the city. The Blackstone Canal was initially highly successful, and led to the doubling of Worcester's population between 1825 and 1835. Soon, however, the lack of reliably adequate flow and other problems became apparent. In 1835, the Boston & Worcester Railroad provided a more reliable alternative to the canal; by 1848 canal operations had ceased.

Worcester flourished despite the problems of the canal. In 1835 Ichabod Washburn invented a machine to draw wire and opened the Washburn Wire Company, soon employing 3,000 people to manufacture barbed wire for fencing in the American west. In 1837, William Crompton invented a new loom for weaving patterns and opened a mill that became the Crompton and Knowles Company. Other factories opened: all were on the Blackstone River or its headwater tributaries, especially Mill Brook through the center of Worcester. Meanwhile, population grew as Irish immigrants were brought to the city to construct the canal and later to work in the new factories. The new immigrants settled largely in a low-lying part of town along Mill Brook that had been recently drained when the new canal was constructed.

At first, the growing city continued to depend upon on-site privies for disposal of sanitary wastes and the river for disposal of industrial wastes. The sanitary waste situation became intolerable and in 1867 the Massachusetts legislature authorized Worcester to construct sewers emptying into Mill Brook and the Blackstone River. Forty-four sewers discharged about 11,000 cubic meters per day of raw waste to Mill Brook. The former Blackstone Canal had become, for all purposes, an open sewer. By 1870 the downstream community of Millbury was complaining of the odor from the Blackstone River, whose condition continued to worsen as Worcester expanded its sewer system in the 1880's. In the meanwhile, conditions also worsened in the Irish settlement in Worcester along the banks of Mill Brook. There is a report of a resident who attempted suicide in 1878 by jumping into Mill Brook. In the absence of systematic water-pollution control laws, appeals for Worcester to treat its effluent were brought, at first unsuccessfully, to the state legislature and civil court. However, in 1886, a law was passed by the Massachusetts state legislature requiring Worcester to institute wastewater treatment within four years.

By 1891, Worcester's first wastewater treatment system was in operation using chemical precipitation. The plant did little however to improve downstream conditions. Other improvements followed. In 1894, Mill Brook was completely enclosed although storm flows still caused the system to overflow. In 1917, the Worcester treatment system became the second secondary treatment plant in Massachusetts by constructing Imhoff tanks and sand filters. By 1925, the sand filters were no longer adequate and were replaced by fixed nozzle trickling filters and final settling tanks were added. In 1948, rotary trickling filters replaced the former design and more settling tanks were added. At the same time, smaller communities downstream of Worcester began treating wastewater. First the town of Northbridge, and then mill owners in West Upton, South Grafton, and Hopedale, installed septic tanks and sand filters for domestic sanitary wastes.

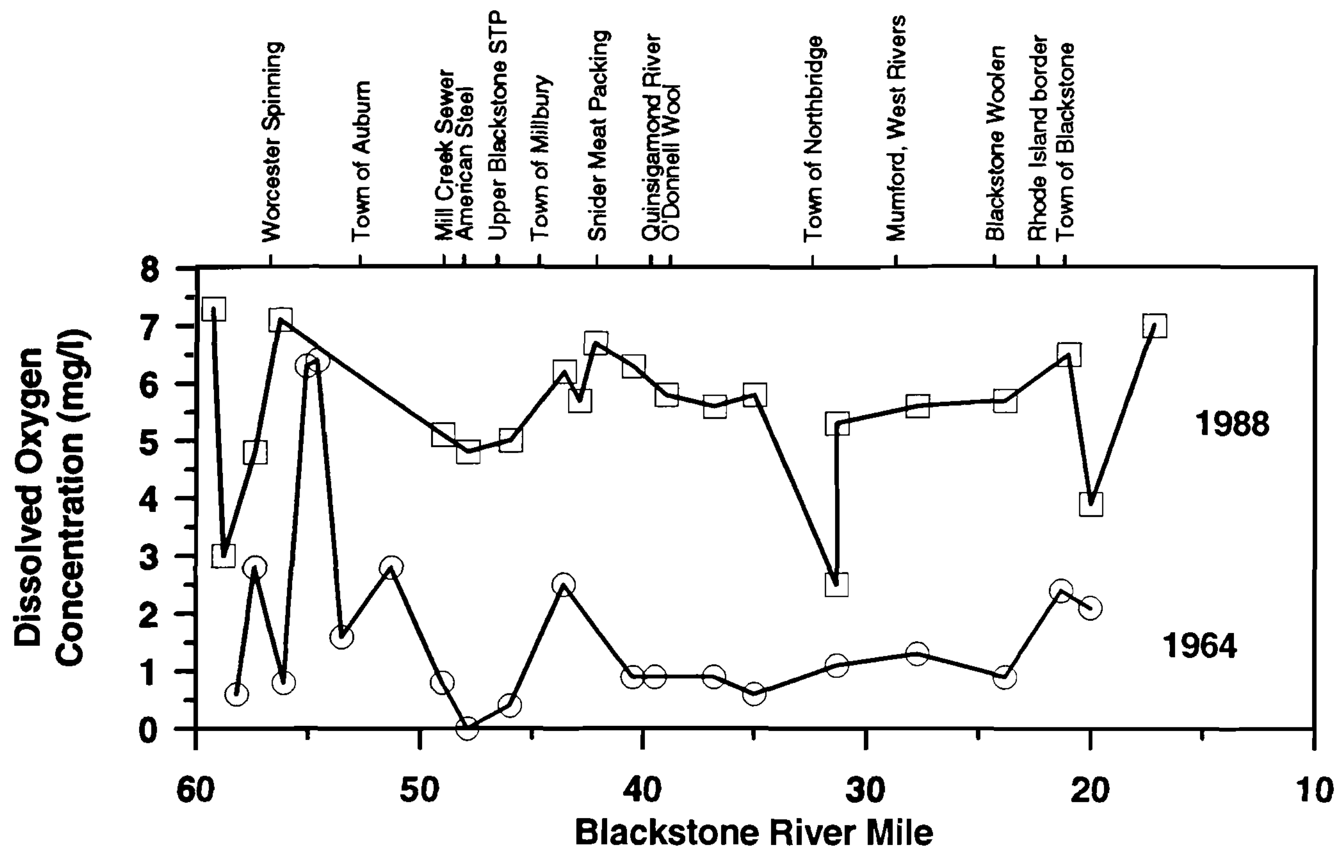

Figure 2. Blackstone River dissolved oxygen profiles, 1964 and 1988
(data from Cooperman *et al.*, 1971 and O'Shea, 1991)

Despite these improvements in wastewater treatment, the condition of the Blackstone River remained deplorable. In 1937, the Massachusetts State Planning Board described the Blackstone as an "industrial river," whose industrial uses were more important than cleaning up its pollution. In 1940, Worcester reached its peak population, 195,000, the only U.S. city of its size not on the ocean or a major waterway. Total wastewater flow from the city was about 125,000 cubic meters per day (33 million gallons per day [mgd]) and comprised virtually all of the upper Blackstone River's low flow. The wastewater included a large volume of industrial wastes, virtually entirely untreated, in addition to the city's sanitary wastes. These industrial operations provided the most enduring legacy of pollution in the river—heavy metals including chromium and mercury from textile dyes and other metals from the wire manufacturing, metal plating, and machining operations. An indication of the condition of the river is seen in Figure 2 in the profile of minimum dissolved oxygen concentrations observed during a river survey in June 1964. The peak concentration of 5-day Biochemical Oxygen Demand during the same survey was 63 mg/l in the station below Worcester; numerous stations reported coliform bacteria counts above one million per 100 ml, and chromium concentrations were as high as 0.12 mg/l. A benthic macroinvertebrate survey found only annelids and worms in those river sediments supporting benthic life. Volatile solids concentrations as high as 55% indicated the presence of extensive sludge deposits on the river bed.

Worsening economic conditions in the Blackstone River Valley diminished the chances for raising monies for water-quality improvement projects. Mills began to falter in the early 1900's, and losses accelerated during the 1930's depression. Many mills closed as owners sought cheaper labor and closer proximity to raw materials in the southeastern U.S. Between 1919 and 1929, 94,000 jobs were lost in textiles in Massachusetts and 154,000 in manufacturing. The Massachusetts Textile Commission reported 90 plant closings from 1929 to 1948. Whereas in 1880 only about 6% of the nation's cotton was manufactured in the south, by 1923 half was made there.

WATER QUALITY IMPROVEMENTS

The 1970's marked the beginning of real progress in improving the water quality of Blackstone River. Some impetus came from the Massachusetts Clean Waters Act of 1966, but the greatest force was Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972. Prior federal laws made water quality a site-specific determination depended upon waste load allocations to compute the assimilative capacity of a river and set allowable wastewater discharges. This case-by-case water-quality-based approach proved administratively unworkable, and PL92-500 replaced it with an effluent-based approach. The effluent approach required minimum levels of wastewater treatment that achieved best available technology (BAT) even if not required to raise the condition of the receiving water to water-quality standards. Moreover, for those rivers in which BAT was insufficient to meet water-quality standards, a greater level of treatment was required by the law. For municipal wastewaters, BAT was secondary treatment, usually by the activated sludge process. The new law also instituted a system under which all discharges of wastewater were required to obtain permits. Finally, the law provided for generous cost-sharing by the federal government with communities upgrading their municipal treatment works. In 1977, the federal Clean Water Act further strengthened water-quality regulations, including new provisions for control of toxic substances in wastewaters.

By 1973, the new laws were beginning to have effect in the Blackstone River valley although not yet necessarily on the river. The town of Millbury immediately downstream of Worcester had constructed a new treatment plant and several industrial discharges had ceased. Nonetheless, a 1973 study by the Massachusetts Division of Water Pollution Control (MDWPC) reported that "the effects of Worcester mask contributions downstream" and that "the plant effluent [from Millbury] appears to be cleaner than the receiving stream" (Tennant *et al.*, 1975). The Worcester treatment plant was reported to be hydraulically overloaded and achieving only 50% BOD removal, in part due to the interference from unmonitored industrial discharges. The Blackstone River at the first station below Worcester was reported to be characterized by coliform counts comparable to raw sewage; the water was described as having a "raw sewage gray color" as far downstream as the Rhode Island border. Sludgeworm was found to comprise 98% of the benthic macroinvertebrate population and there were extensive sludge deposits in the river. The report states that "the major use of the Blackstone River is for conveyance of wastes from adjacent communities and industries" and that the river was unfit for recreation.

Despite the still desperate condition of the river, planning for water-quality improvements was underway under the aegis of the 1972 Water Pollution Control Act. A preliminary plan for water-quality in the Blackstone River was prepared by the U.S. EPA in 1973 and called for wastewater treatment improvements in virtually all of the 46 dischargers to the Blackstone River and its tributaries (U.S. EPA, 1973). Industrial dischargers were being pursued under court orders to install wastewater treatment and most were applying for discharge permits under the newly instituted National Pollution Discharge Elimination System (NPDES). The proposed level of treatment was modest compared to later plans: municipal wastewater was to receive secondary treatment of various types depending upon the scale of the operation. No cost estimates were made, but the relative economics of regionalized treatment for the upper Blackstone area were considered.

It was not until 1975 that the state of Massachusetts issued a final Water Quality Management Plan for the Blackstone River. The plan set stream water-quality goals, a schedule for pollution abatement projects, and effluent limitations for individual dischargers. Most of the Blackstone River mainstem below Worcester was assigned to water-quality Class C, able to support fish and wildlife, secondary contact recreation (boating), and industrial water supply. The plan called for the river to meet this classification by the 1977 deadline of the federal Water Pollution Control Act; future improvement to Class B (supporting swimming) was set for 1983. Meeting the Class C standard required maintaining dissolved oxygen levels of 5 mg/l or better for at least 16 hours per day and of at least 3 mg/l at all times.

The 1975 plan set ambitious goals for wastewater treatment determined by stream water-quality modeling of waste load allocation. New secondary treatment facilities were planned for the downstream communities of Grafton and Uxbridge, and advanced waste treatment plants for the upper Blackstone area, and the towns of Douglas, Millbury, Sutton, Northbridge, Hopedale, and Upton. The town of Blackstone was to be sewered to a new treatment plant in Woonsocket, Rhode Island. The upper Blackstone area, which included Worcester and neighboring towns, was organized under the Upper Blackstone Pollution Abatement District (UBPAD). A 180,000 cubic meter per day (47 mgd) waste treatment facility was under construction along with numerous sewer projects within the district. The plan also addressed industrial dischargers, calling for most to connect to the new municipal sewage treatment plants, typically after on-site pretreatment. Several industrial operations were called on to construct separate industrial treatment plants.

COSTS OF IMPROVED WATER QUALITY

The 1975 Water Quality Management Plan included projections of the costs for the municipal projects (MDWPC, 1975). As of the time of the plan $25.6 million had been expended of which $19.5 million was for the UBPAD treatment plant. Forecasted costs were $133 million including $14 million for additional treatment plants, $89 million for new sewers and rehabilitation of existing sewers, and $30 million to address combined sewer overflows in Worcester. The improvements were the responsibility of local municipalities, but they were provided 75% of the costs by the federal government and another 15% by the state government. Nonetheless, the remaining 10% proved a high cost for small towns in economic decline and a number balked at authorizing pollution control funds. The town of Blackstone, for example, was fined for contempt of court when the town at first voted down authorization for a bond issue to fund a treatment plant (U.S. EPA, 1973).

A 1984 update of the Water Quality Management Plan (Dunn and Anderson, 1985) provides totals of the funds eventually spent, although the figures do not appear to include the $25.6 million spent prior to 1975. The total cost through 1983 is given as $109.2 million, of which the U.S. federal government provided $74.8 million, the state of Massachusetts $19.7 million, and cities and towns, $14.7 million. There remained yet additional spending for combined sewers in Worcester: a stormwater treatment facility was eventually completed in 1987 to provide primary treatment and chlorination of stormwater overflows.

The 1975 estimate of $133 million proved to be a reasonably accurate forecast of the $110 million-plus that was spent through 1984. However, there were significant differences between the facilities planned in 1975 and those eventually built. The originally planned design flow for the UBPAD plant was 180,000 cubic meters per day (47 mgd); the final plant capacity was 212,000 cubic meters per day (56 mgd). Advanced waste treatment (nutrient removal) was planned at several of the proposed treatment plants. As of 1984, the only AWT facility was the Grafton plant at which phosphorus removal was described as "available." Nitrification was added to the UBPAD plant in 1988 in order to meet the stream dissolved oxygen standard of 5 mg/l. As of 1993, the Massachusetts Division of Water Pollution Control is continuing to examine the need for advanced waste treatment at smaller plants within the basin.

Costs incurred by private companies for industrial waste treatment are not available. As of 1984, four industries continued to discharge directly to the Blackstone or its tributaries and all were required to construct treatment facilities. Many other industrial discharges to the rivers were eliminated in the 1970's and early 1980's by connecting industries to the UBPAD plant. Of the 47 discharges eliminated between 1975 and 1984, 33 were due to connections to UBPAD (Dunn and Anderson, 1985). These industries generally constructed pretreatment facilities as a part of the process of connecting to the municipal sewer. Eliminated discharges reported in the 1984 plan update also included several large and longtime manufacturers which had gone out of business. While the cost of wastewater treatment may have been a factor in these closings, other costs and changes in the business climate were the primary cause.

PRESENT SITUATION

Figure 2 illustrates the vast improvement in water quality in the Blackstone River. The 1988 survey found a peak BOD5 concentration of 7.8 mg/l in the Blackstone River (versus 63 mg/l in the 1964 survey) and fecal coliform levels that were typically a few hundred colonies per 100 milliliters (versus a few million in 1964). Nonetheless, problems remain. Dissolved oxygen still failed to meet the stream standard of 5 mg/l at some stations and fecal coliform counts numbered in the thousands at a few upstream stations. Mill Brook continues to be polluted, possibly by illegal discharges to its underground reaches. The peak BOD5 was 17 mg/l in Mill Brook and the peak coliform count was 90,000/100 ml. Concentrations of metals continue to be high, both in the river water (Lewis and Brubaker, 1991) and particularly in the sediments (McGinn, 1981). Measurements in 1980 found average concentrations of arsenic, cadmium, chromium, copper, lead, nickel, and zinc in impoundment sediments to fall within the most contaminated category defined under the Massachusetts dredged materials regulations. Measures recommended in a 1981 Sediment Control Plan for the Blackstone River entailed an estimated $35.6 million to address sediments contaminated by metals (McGinn, 1981).

Despite the continuing problems of the Blackstone River, the river has come a long way toward meeting the uses set in the 1975 Water Quality Management Plan. The river is popular for canoeing (although guides warn against extensive contact with the river water) and the river's water-quality classification has been upgraded from Class C to Class B over its entire length in Massachusetts. Public interest in the Blackstone River and its history has been heightened by the river's improved water quality as well as by the establishment of the Blackstone River Valley National Heritage Corridor. The National Corridor was created to preserve historic sites within the valley and encourage public visitation (BRVNHCC, 1989).

IMPLICATIONS FOR PRESENT-DAY CENTRAL AND EASTERN EUROPE

The goal in examining the water-quality history of the Blackstone River was to relearn lessons that might be useful today in Central and Eastern Europe. This closing section of the paper summarizes the implications of the Blackstone's history. We also draw upon a recent study by Somlyódy (1993) which makes recommendations for cost-effectively developing wastewater treatment in the CEE countries.

A number of factors combined to achieve significant improvements in the water quality of the Blackstone River. Greatest was the force of the 1972 and 1977 U.S. federal water-quality laws, which created strict requirements to treat wastewater and meet stream water-quality standards, but which also provided most of the funding needed to meet those requirements. The federal laws further created several planning processes, of which this paper has focused on the water-quality management plan. The 1975 Water Quality Management Plan appears as a critical document in this review. It was based on good science, employing water-quality models to calculate the waste loads that individual dischargers could release to the river and still allow water-quality standards to be met during periods of low river flow. The plan forecasted costs, needed treatment levels, resulting stream water quality, and implementation schedules with fair accuracy. Particularly with respect to wastewater treatment needs, the plan was quite detailed, specifying what was required of individual dischargers to address specific problems in the receiving waters. The development of a strong, basin-specific Water Quality Management Plan in 1975 appears to have set priorities and goals for work over the ensuing 15 years.

Time also was a major factor in the restoration of the Blackstone River. It was fully one-hundred years from the recognition of severe pollution in the river to the time when plans were made in earnest to correct the problem. It was another 15 to 20 years before those plans resulted in real improvement in water quality and the complete restoration of the river has yet to happen.

Money was clearly a factor in improving the Blackstone River. Expenditures for pollution abatement cannot be tallied with accuracy, but appear to have approached $150 million in actual dollars. Of this, roughly 30% was for treatment plant construction, 50% for sewers, and 20% for combined-sewer overflow control. In present value, the total cost is at least $200 million. Based on the basin's population of 332,800 in 1980 (Dunn and Anderson, 1985), the total per capita expenditure is around $600 in present dollars. Of this, perhaps $180 per capita was required for treatment plant construction.

The estimated expenditure of $180 per capita for wastewater treatment plant construction compares reasonably with the $230 estimate by Somlyódy (1993) of the per capita investment needed in the CEE countries for treatment plant construction. Somlyódy's estimate is more because it is based on meeting European Economic Community water-quality standards which require advanced waste treatment. Nonetheless, he also provides estimates of more cost-effective alternatives. For example, if only secondary treatment were required, Somlyódy estimates that costs would be roughly halved—substantially less than was expended in the Blackstone River basin.

Finally, enforcement of the strict water-quality laws was also critical. The historical documents show that cities, towns, and industries were reluctant to allocate funds to pollution control and often did so only when forced by court actions and the threat or realization of large fines.

The legal framework for water-quality control was not a particularly important factor in the Blackstone River because of the nature of wastewater discharges to the river. Previously in this paper, the differences between the effluent-based and the water-quality-based approaches to water-quality legislation are discussed. These differences are largely moot for the Blackstone because a single large headwater discharge dominates the water quality in the river. Because this discharge is so significant, effluent-based limitations fell below the threshold needed to meet stream water-quality standards and a water-quality based approach was required. Thus, the conditions of the river demanded more advanced treatment than the floor set by the effluent-based standards. Nevertheless, the experience in the Blackstone points out the workability of using water-quality-based approach for a specific basin.

Planning at the river-basin level is a key recommendation by Somlyódy (1993) to achieve cost-effective investment in wastewater treatment. He recommends setting water-quality-based standards for each river basin and allowing tradeoffs in the level of technology required at individual treatment plants within the basin so long as the desired river water quality can be achieved. The success of the basin plan for the Blackstone River shows that Somlyódy's recommendation is workable. His recommendation requires greater latitude in the initial plan construction than was available in the Blackstone River planning process. But, this should not create any implementation problems so long as there is the means to carry out and enforce the resulting plan.

The history of water-quality restoration in the Blackstone River holds clear implications for Central and Eastern Europe today. The strongest recommendation is to develop, follow, and enforce clear and carefully constructed water-quality plans developed on a river-basin level. Such plans are likely to predict unpalatably high expenditures and long implementation schedules—but which, if estimated with care, are likely to be fairly accurate. Thus, the realization of these plans will require the simultaneous establishment of clear funding mechanisms and equally clear enforcement measures and penalties.

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