

BENEFITS DERIVED
FROM
WATER QUALITY MANAGEMENT PLANNING

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ABSTRACT

The requirement of water quality management planning for eligibility for federal construction grant funds has added a new dimension to water pollution control. Effective planning can provide for significant cost savings in the construction of wastewater treatment facilities. Additional benefits such as improved operation and treatment efficiencies result from optimizing the pollution control facilities. The rationale behind these planning requirements is discussed and examples of the benefits are presented.

WATER QUALITY MANAGEMENT PLANNING

Water quality management planning is a recent innovation in the area of water pollution control. This planning effort has been initiated for several reasons. Camp, Dresser and McKee conducted a study of the Federal Construction Grants Program at the request of the Office of Management and Budget of the federal government. This study indicated that the construction grants money was not being invested in a cost-effective manner. Some of the monies were being used for construction of treatment facilities that yielded a very minor improvement in water quality. The use of this money for improved treatment of more severe discharges would have had a marked improvement on the water quality. There did not appear to be any organized approach to the expenditure of these funds to achieve maximum improvement of water quality.

As more emphasis has been placed on water quality problems, the need for planning has become more apparent to all involved. The State of New York undertook an extensive planning effort beginning in the mid 60's. Their experience has reinforced the need for more comprehensive analysis of the problem and the development of an organized approach for eliminating the sources of water pollution that have the most severe effect on the receiving waters. These experiences, plus the intuition of many people involved in the water pollution control program, have led to the conclusion that some type of orderly planning is necessary.

The Federal EPA has incorporated planning into their construction grants program. The rules and regulations relating to grants for water pollution control (Federal Register, 1970) specifically require the development of basin and metropolitan/regional water quality management plans in order for specific projects to be eligible for federal construction grants. These rules and regulations were instituted in July of 1970. Recognizing that many states and/or regions did not have adequate plans, a procedure for the development and use of interim plans was provided. However, by July 1, 1974 the final basin and metropolitan/regional plans must be developed and certified if continued support from construction grants program is to be expected.

Not only is this planning required for meeting federal guidelines, but it is also necessary for the orderly development of the State of Illinois water quality control program. Judicious use of the state's water resources require consideration of the capacity of streams to assimilate wastes while maintaining water quality compatible with water uses. This objective will be achieved only by a thorough analysis of the stream's capacity for waste assimilation under the constraints imposed by the water quality standards and the complete inventory of the existing as well as projected waste loads. The assimilative capacity of the stream will dictate the degree of wastewater treatment or other controls that will be required for the present as well as future conditions. This type of planning is currently not available. Most of the water resources planning that has been conducted has been oriented toward the water uses but not the maintenance of water quality at the current level required by the recently adopted Illinois Pollution Control Board Stream Standards.

Effluent requirements and wastewater treatment plant design is based upon meeting the water quality standards today without adequate knowledge of the effect of future waste loads on the water quality. Therefore, it becomes imperative that projections be made as to the probable development of an area and the associated waste loads. This projected load coupled with the assimilative capacity of the receiving waters provides a guide to the degree of treatment required today as well as in the future. This type of information provides for an orderly phasing of the size of the treatment plants as well as the degree of treatment required to maintain the desired water quality.

Basin Planning

The basin plan provides an overview of the impact of pollution sources and alternative pollution control measures on the receiving water, basic information on stream flows and water quality, and requirements for jurisdictional cooperation at various levels. Because of the scope of these plans, they are the responsibility of the state or of the designated basin planning organization. Since Illinois does not have any basin planning organizations, these plans then become the responsibility of the Illinois Environmental Protection Agency.

The basic purpose of basin planning is the development of a water pollution control strategy that will maintain the desired water quality of

the surface waters of Illinois. This purpose is accomplished for a specific basin by analyzing the assimilative capacity of the stream for various contaminants and allocation of the magnitude of the contaminant input into different reaches of the stream such that the desired water quality is obtained. The assimilative capacity of a given stream at critical flow conditions is fixed. Consequently the increase in waste load associated with an increase in population or industrial activity can exceed the stream's ability to dissipate the waste. Adequate planning on a basin wide basis allows for the orderly development of the necessary control systems for each reach of the stream. Because of lead time of several years being needed to plan, finance, design and construct adequate control systems, one cannot wait until the water quality deteriorates to initiate this activity. An adequate basin plan will provide the means for anticipating the level of treatment or the other control measures that are required for present as well as future conditions.

In preparing basin plans, extensive use will be made of the land use, population, industrial and agricultural planning and projections that have been produced by other state and local planning agencies. It is not the intent that basin planning become involved in land use planning. However, it is essential that this information be available if accurate projections of waste loads and treatment requirements are to be made. There may be areas in the state where this information may be deficient. In these areas, some analysis will have to be made of those factors if adequate basin plans are to be produced.

Interim plans are necessary if pending projects are to receive federal support. The Illinois EPA has undertaken this effort and has received approval on several of the interim basin plans. The Agency has developed a planning section which is currently preparing the necessary interim plans to insure that continued federal support is received.

The final basin plans are more detailed, requiring considerably more manpower than the Agency has available. In order to develop an efficient and effective program for Illinois, Argonne National Laboratory has been contracted to develop a pilot basin plan. Argonne will prepare a model water quality basin plan for the Rock River basin. The plan will meet all applicable federal requirements as described in the U.S. EPA publication, Guidelines: Water Quality Management Planning, dated January 1971. Since the scope of this planning effort is substantial, it is expected that outside consultants will prepare the basin plans for the balance of the state. Argonne is preparing detailed technical specifications suitable for use by these contractors in developing the remaining fifteen water quality basin plans. In addition, Argonne is preparing a manual of procedures to be used by the Agency in managing and supervising water quality planning efforts in Illinois. This manual includes cost estimates for preparing basin plans, recommended management procedures, definition of working relationships with other state agencies, a methodology for selecting basin contractors, sources and location of data necessary for completing basin plans and recommended procedures for involving local representatives in the planning process.

Upon completion of the Argonne pilot study, contracts will be let to qualified applicants for the development of the remaining basin plans. The

Argonne work should be completed in the fall of 1972. Since the deadline date has been extended until July 1, 1974, it is possible for the state to meet the requirements for continued federal support. When these basin plans have been completed, the state will have a sound basis for developing water pollution control systems so that the maximum water quality improvement will be obtained for the available resources.

Metropolitan/Regional Plans

The basin planning activity identifies the total load on the stream and the assimilative capacity of the stream. Knowing what the stream can assimilate, it then becomes possible to allocate loadings for different metropolitan or regional areas. This essentially tells the region the total pounds of pollutant that can be discharged without violating water quality standards. There is no attempt in the basin plan to specify the level of treatment or the type of treatment required.

The metropolitan/regional plans are subsets of the basin plan and are the functional wastewater collection treatment plant elements for the comprehensive area wide plan as set forth in HUD area wide planning requirements. This planning will dictate the number, size, efficiency and location of treatment systems for the regional area that are required in order to satisfy the allotment developed from basin planning. These plans must satisfy the immediate needs as well as the long range needs for water quality management that develop with expanding population and industrial activity.

This planning is the responsibility of the area wide planning offices as designated by HUD. These APO's must develop the necessary plan documents such that federal funding will continue. It is not the purpose of this water quality management planning to undertake land use planning, but to use land use planning and population and industrial projections developed by the area planning agency. If this information is not available, it becomes the responsibility of the area planning agencies to develop it in conjunction with the water quality management planning activity.

The federal government recognized that few metropolitan areas have such local planning completed. There is a provision for interim plans and some of the regions in Illinois have completed their interim plan requirements. To assist the local agencies in this planning effort, the state is providing financial assistance. Most of the local planning agencies are understaffed and underfinanced and cannot conduct the water quality planning on their own. Some, albeit limited, federal funds are available to assist the local agencies in developing the comprehensive plan as required by HUD and EPA.

While the basin plans are an integral part in developing the most cost effective system for controlling water pollution, it is at the regional level where the true savings are found. The basin plan allocates a certain portion of the stream assimilative capacity to the local area. It then becomes the responsibility of the local agency to optimize the control system to meet these allowable loads. It is through the development of

regional water quality management systems that true cost reductions are obtained.

BENEFITS OF REGIONALIZATION

The benefits derived from regional systems are as follows:

Capital costs and operation and maintenance costs are lower per unit quantity of wastewater treated.

Reliability of the treatment system is significantly improved because of multiple process units and the more efficient maintenance program.

Improved operation resulting from more competent operating personnel.

Improved overall process efficiency resulting from adequate facilities and personnel for operation and maintenance.

Capital Costs

Initial costs per unit of treated wastewater are significantly decreased because the size of the treatment plant increases. Smith (1968) analyzed the costs of treatment systems and found that for the activated sludge process, the capital investment per 1,000 gallons of wastewater treated decreased from ten to eleven cents for a one mgd capacity plant to six cents for a ten mgd capacity plant (1967 dollars). The cost savings is due to the economies of scale. Any handbook for estimating construction costs will show that unit costs of material and equipment associated with these processes decreases as the size or quantity of material used increases. This is also true for such costs as engineering fees, performance bonds, etc.

There are many examples one can cite that show savings due to economy of scale. The total cost reduction can be seen from the data from an engineering economic evaluation of regional systems in New York (Metzler, 1971) (See Table 1). Without regionalization the area served by the Albany County Sewer District, comprised of seven municipalities, would have had eight treatment plants. The total capital costs for this nonregional system would be \$78,500,000. The proposed regional system would have two plants for the same population, but at a cost of only \$53,100,000. This resulted in a capital cost savings of \$25,400,000.

Another example, for Rensselaer County Sewer District #1, showed that a regional sewer district would reduce the number of plants from three to one with a cost reduction from \$38,940,000 to \$32,100,000. The cost saving was not as dramatic, being only \$6,840,000. It was, however, significant.

Operation and Maintenance Costs

Cost savings in this category are associated with personnel costs, energy and chemical costs. The number of personnel required is a function

TABLE 1. Cost Comparisons--Regional Systems (New York)

Item	Albany County Sewer District		Rensselaer County Sewer District No. 1	
	Separate Local Systems	Regional System	Separate Local Systems	Regional System
Total capital cost	\$78,500,000	\$53,100,000	\$38,940,000	\$32,100,000
First year O & M	1,999,000	1,010,000	861,000	695,000
First year amortization	4,540,000	2,178,000	1,937,000	1,100,000
First year O & M and amortization	6,539,000	3,188,000	2,798,000	1,795,000
Plants	8	1 @ 35 mgd 1 @ 19 mgd	3	1 @ 25.5 mgd
Operating personnel	110	35	51	28
Municipalities	7	7	6	6
Population served	225,000	225,000	101,700	101,400

Source: Metzler, 1971

of the number of plants as well as the size of plants. Using the Albany County example (see Table 1), 110 operating and maintenance personnel are required for the eight plants as compared to only 35 for the two regional plants. Not only is there a cost reduction, but there is also less strain on the reservoir of experienced, qualified operating and maintenance personnel.

Energy and chemical costs are lower for volume consumption. Costs (1967) for electrical energy range from .98 to 2.22¢/kwh for small plants to 0.6 to 1.3¢/kwh for large plants. The cost of chlorine (1967) also decreased with increasing consumption; small plants -- \$9.10 to \$17.50/100 lb, large plants -- \$4.15 to \$9.10/100 lb. The purchase of readily available chemicals in bulk quantities always produces a lower unit cost for the chemical.

Summary of Cost Savings

Reduction in the capital amortization and operating and maintenance costs to an annual per capita cost show the real savings per person served by regional systems. Using data reported for New York State, the first year per capita cost for Albany County would be \$29 for the nonregional solution compared to \$14.20 for the regional system. For Rensselaer County Sewer District #1, the nonregional system would cost a total of \$27.60 per capita for the first year compared to \$17.70 for the regional system. From these analyses, the savings from regional systems can be very substantial. In urbanized areas, no new systems should be built without a thorough

economic analysis of the potential for regional treatment systems.

It should not be assumed that simply building larger and larger plants necessarily gives the least cost solution. The costs of the interceptor system must be considered. As the interceptor lines become longer, the costs for transporting the wastewater increases. However, there is an optimum size treatment plant, unique to each area, which can be determined by a thorough economic analysis of that area. Therefore, the goal of regionalization is to develop that system, whether it be one or more plants, that will provide the maximum water quality improvement for the minimum dollars spent.

Non-Economic Benefits of Regionalization

The reliability factor for the larger treatment system is improved for two reasons. There is a greater multiplicity of process units in the larger plants so that the shutdown of any one unit causes a smaller incremental increase in load applied to the remaining units. The treatment efficiency is reduced to a lesser degree than in the smaller plants when one process unit may account for half the treatment capacity of the plant. Perhaps an even more important factor is the maintenance. With a larger and experienced maintenance staff, a program maintenance can effectively prevent most failures of process units. When failure does occur, the maintenance staff of a larger plant can be better equipped and trained so that the down time of any unit can be greatly reduced.

Currently there is a shortage of experienced and capable operating personnel. It is generally possible to meet the personnel needs, but unfortunately these operators may be inexperienced and cannot adequately perform the required tasks. The plant efficiency suffers as a result. The proliferation of the smaller treatment plants accentuates this problem by placing a greater demand on the available operators. Many of the small plant operators receive little or no training or assistance necessary to develop operating skills. They continue to operate in the same inadequate fashion from day to day. In the larger plant, the resources are available to obtain at least some experienced operators. It is then possible to provide in-plant training for new employees. The overall operating skills within the plant can be maintained at a high level under these conditions. This problem may ease in the next decade if the federal and state training programs develop as planned.

SUMMARY

The previous discussion has indicated that the benefits of water quality management planning are basically one of developing the most cost effective program to achieve the desired water quality. This means that with the limited amount of public funds available, the goals of water quality can be achieved without exhausting these funds. Every community, as well as the state, has pressing demands for their resources, whether it be for water pollution control, streets and highways, education, etc. The current

heavy tax burden on the citizens of this state requires that those responsible for expenditure of public funds do so in the most cost effective way. The construction of high levels of treatment where it is not warranted is a poor investment of public money. The water quality improvement achieved by this money may be negligible whereas if it had been spent in an area contributing more load to the receiving water, the improvement may have been substantial. There are numerous recorded cases in which certain communities, for one reason or another, had access to large sources of federal and state money. They greatly expanded their treatment facilities with little or no improvement in the receiving stream. The water quality degradation resulted from upstream discharges of gross pollution. Had the money been spent on the upstream discharges, the water quality would have improved markedly without the extensive treatment provided by the more fortunate communities.

The goal of the water pollution effort is to achieve a water quality that will permit use of the water for designated purposes. To treat beyond that level is unwarranted. However, without a complete analysis of the physical and demographic characteristics of the basin, it is not possible to determine what the level of treatment must be to achieve the required water quality standards. It is essential that future development of the area be predicted and this inserted into the analysis for determining the allowable loads from given areas. With this type of analysis the state can be assured of achieving the desired water quality goals with a minimum of economic burden on the taxpayers.

LITERATURE CITED

- Federal Register, July 2, 1970. 18 CFR 601.32-33, Vol. 35, No. 128.
- Metzler, D. F., and M. J. O'Toole, 1971. "Regional Wastewater Utilities in New York State," Jour. Water Poll. Control Fed., 43(1):9.
- Smith, Robert. 1968. "Cost of Conventional and Advanced Treatment of Wastewater," Jour. Water Poll. Control Fed., 40(9):1546.