The Effectiveness of Municipal Wastewater Treatment

Past and present federal policy on pollution enforcement continues to have significant impacts on the effectiveness of wastewater treatment at the local level.

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In February 1991, the United States Environmental Protection Agency (EPA) released a report that claimed that "a strong enforcement program is one of our highest priorities for the Agency" and "we must maintain an enforcement program that will . . . promote pollution prevention."[1] James M. Strock, then Assistant Administrator for Enforcement, stated in his introductory letter that "enforcement is the means by which we assure that the promise of our environmental laws and regulations are realized."

EPA regulators believe a stronger emphasis on enforcement is the most promising way to improve the compliance rates of municipal wastewater treatment plants. Prior to its increased enforcement efforts, the EPA sought to improve performance and ensure compliance through technical support and training assistance combined with financial aid through the municipal wastewater treatment Construction Grants Program (CGP). This program, established as part of the 1972 Federal Water Pollution Control Act (FWPCA), provided approximately $60 billion in grants and loans to help fund municipal wastewater treatment systems. In many ways, the program directly linked compliance enforcement with a community's financial ability to construct or upgrade a plant. Enforcement measures were rarely applied to communities eligible for federal funding, even if the community's plant routinely violated federal standards.[2]

The Water Quality Act of 1987 signaled the end of federal funding for municipal plants because direct federal grants to communities were phased out and replaced with loans from State Revolving Funds (SRFs). While the federal government has provided initial capitalization grants to help establish SRFs, all federal assistance under the Clean Water Act (CWA) will end in 1994 since the CWA has not been renewed. Even though temporary provisions have been made to continue to fund SRFs until the CWA is reauthorized, states and municipalities will share increased responsibility for funding wastewater treatment plants, and the lack of federal funding will no longer be an acceptable excuse for noncompliance.

Funds available through SRFs are only a small fraction of funds needed to upgrade municipal plants. EPA's 1992 Needs Survey estimated that $137.1 billion would be needed for wastewater treatment over the next 20 years.[3] Partly in response to the lack of funding, the EPA established the Public-Private Partnerships Initiative. Currently known as Partners Rebuilding America, this program was created primarily to develop "innovative financing approaches" to construct or maintain plants without federal funding.[4] Through this program the EPA intended to increase private-sector involvement in wastewater treatment from financing to ownership.[5] Although public-private partnerships or privatization have been viewed by the EPA predominantly as an option to relieve the financial burdens of municipal plants, the agency also recognized that privatization can reduce costs, speed project construction, guarantee proper performance, and preserve jobs.[6]

Current debate indicates that Congress and the EPA may not turn over wastewater treatment responsibility to the states and local communities in 1994 as currently planned. In 1991, Senator Max Baucus proposed federal legislation that called for a partial return to the grant system. Currently, several bills propose to extend federal funding of SRFs beyond 1994. Others seek to allocate a portion of federal funding for direct grants to specific projects or encourage suspension of the 20 percent state matching grant requirements. Extension of federal capitalization grants, conversion of loans to grants, provision of grants to specific communities and elimination of state matching funds all encourage communities to view wastewater treatment as a federal responsibility and discourage communities from discovering other ways to meet their treatment needs.

The performance of a municipal wastewater treatment plant can be evaluated in a number of ways. Typically, a plant is judged to be performing satisfactorily if the quality of its treated effluent meets the requirements of its National Pollution Discharge Elimination System (NPDES) permit. Overall compliance as reported by the EPA and responsible state agencies normally refers to the percentage of a group of treatment plants that satisfy their NPDES permits. National water pollution control policy, as reflected by the FWPCA and in the NPDES permits, has received serious criticism and is a matter of ongoing public debate.

Municipal Wastewater Treatment Plant Compliance

Compliance History. The 1972 FWPCA and its amendments provide the basis for the current policies regulating municipal wastewater treatment plants (MWTPs). This act represented the first attempt by the federal government to take responsibility for establishing water quality goals and enforcing regulations and also to establish plans to achieve those goals. The act's two main goals were to achieve fishable and swimmable water by 1983 and to eliminate all discharges of pollutants into navigable waters by 1985.

In support of these goals, the act established the NPDES. Compliance with the NPDES is routinely used as one way to evaluate plant performance. This system requires point-source dischargers to obtain a permit before commencing any discharge. Each permit specifies the type and amount of pollutants allowed as well as a time schedule by which compliance with the limitations is required. For regulatory purposes, the permit also specifies sampling methods and schedules as well as requirements that outline the obligation to report collected data to the appropriate regulating authority.

Before the passage of the FWPCA, effluent limitations were set by individual states. The FWPCA required effluent limits to be based on what was technologically achievable rather than what any state might judge most appropriate for its individual water courses and effluent discharge points. Thus, all MWTPs were required to meet effluent standards achievable through the use of best practicable waste treatment technology. Although the descriptive technological titles and the corresponding levels of treatment have changed, these particular effluent limitations have always been linked to a specific technological capability.

The FWPCA required municipal dischargers to meet secondary treatment guidelines by July 1, 1977, as well as to install best practicable water treatment technology by July 1, 1983. Soon after the act was passed, the EPA esti-

mated that 50 percent of existing municipal dischargers would not be able to meet the secondary treatment guidelines by 1977. Based on data from the 1976 Needs Survey, the Water Pollution Control Federation (since renamed the Water Environment Federation) estimated that only 33 percent of municipal dischargers would be able to meet the secondary treatment deadline.[7] As late as September 1978, the EPA stated that "[a]n analysis of compliance indicates that the majority of publicly owned treatment works (POTWs) have not completed construction necessary to meet the 1977 treatment requirements."[8]

In 1977, amendments to the FWPCA were passed and the act was renamed the Clean Water Act. This act changed several of the deadlines facing municipal treatment plants. Any plant that discharged into marine waters could apply for a waiver of the secondary treatment guidelines if the applicant could show that the discharge would not harm the ocean environment. An extension of the 1977 deadline until 1983 was available to plants that lacked adequate federal funding to complete construction by the 1977 deadline. The 1981 Construction Grants Amendments extended this deadline to July 1, 1988.

In December 1983, a United States General Accounting Office (GAO) report to the EPA Administrator stated that "noncompliance with permit limits was widespread, frequent, and significant."[9] The GAO randomly selected 531 major dischargers (municipal and industrial) and found that:[9]

> *[M]unicipal dischargers exceeded their permit limits more frequently than industrial dischargers. For example, about 59 percent of the municipals exceeded their concentration limits for more than six months while only 33 percent of industrials exceeded those limits for more than six months in the 18-month period reviewed.*

Of the dischargers experiencing significant noncompliance (defined as exceeding permit limits for one or more pollutants by 50 percent or more for at least four consecutive months), 69 percent were municipal.

By the time National Municipal Policy enforcement rules took effect in 1985, more than 60 percent of the nation's major municipal plants were meeting effluent limitations. Of the remaining plants that needed upgrading, 70 percent achieved compliance by the July 1, 1988, deadline. About 30 percent of the more than 400 remaining plants were considered technically in compliance because they were subject to legally enforceable compliance schedules.[10]

TABLE 1
Secondary Treatment Compliance as of July 1, 1988

	Total*	In Compliance
Major POWTs**	3,731	88%
Minor POWTs***	11,755	85%

Notes: * Includes all plants except for those whose operational discharge data were not confirmed and those who were not in compliance but expected to be by 9/30/88. ** Greater than 10,000 population or 1 milion gallons per day (mgd). *** Less than 10,000 population or 1 mgd. Data from Ref. 11.

The EPA estimated that 88 percent of the major municipal dischargers were in compliance by the July 1, 1988, deadline for secondary treatment — a significant increase in just three years.[11] Table 1 shows that 85 percent of minor municipal dischargers met the same goal. However, not all dischargers were included in the EPA's study.

The EPA stated that, as of January 1990, "89 percent of all major municipals . . . [had] completed construction to meet final effluent limits."[1] This statement did not include plants that were experiencing difficulties with operation and maintenance or other problems that prevented compliance but did not require construction to improve performance. In addition, it did not include those plants that were subject to interim limits as part of an enforceable compliance strategy designed to meet final limits.

As late as 1992, the GAO reported that compliance problems had not been fully documented since the EPA's compliance monitoring was "limited to major and significant minor wastewater treatment facilities."[12] Twenty percent of states believe noncompliance will increase, especially as new wastewater regulations such as stormwater permits and toxic discharge limits are enforced. Utah has expressed concern that its state health depart-

ment may be forced to condemn entire towns unable to afford wastewater plant upgrades.

Interpretation of Compliance Figures. Several limitations impact evaluations of the significance of the above compliance figures. Significant noncompliance indicates that these plants are routinely discharging prohibited effluent rather than experiencing a one-time problem. Although two plants can receive the same volume of inflow and both can be defined as not complying, it is possible for one to experience a greater number of individual violations, and thus treat a larger amount of water in a prohibited manner. Also, compliance figures are based on individual plants rather than the quantity of water treated. It cannot be determined what percentage of water is not meeting permit limitations. Furthermore, compliance, as defined by the EPA, only refers to plants that have permits and, therefore, are able to comply or not comply with permit limits. If all the plants that needed permits had permits, noncompliance figures might be significantly higher.

In 1984, the EPA permit backlog was estimated at 16,062 applications, most of which had been on a waiting list since 1982. Over 98 percent of the applications were for minor municipal plants.[13] Because of inadequate funding, staff shortages and the complexity of the permit process, the EPA could not even *identify* all the plants needing permits. Even when identified, some EPA regions or states did not attempt to permit minor dischargers.

By the end of fiscal 1992, the nationwide permit backlog accounted for 15 percent of the 583 major and 29 percent of the 3,418 minor municipal plants. If this large number of unpermitted minor dischargers were to receive permits, overall municipal compliance rates might drop since minor dischargers historically have lower compliance rates than major plants.

Finally, a knowledge of the procedures used to monitor, sample and evaluate effluent quality is essential to understand compliance. Compliance rates, even for a well-defined class of plants, do not actually indicate the percentage of plants producing effluent within the permit limitations. There are several reasons why this discrepancy may exist. For example, the existence of a violation may never be revealed to the regulatory agency. This may be because the violation did not coincide with sampling or the discharger did not file the required discharge monitoring report (DMR). The GAO has reported that serious discharge noncompliance could be concealed by the large number of incomplete or missing DMRs.[9]

Even if a plant submits a DMR with the quantity or type of effluent in violation of permit limitations, noncompliance is not always assumed. The same GAO report stated that not all EPA regions or states treated incomplete DMRs as violations, and many laboratories analyzing the discharge as part of the DMR preparation were not able to perform an accurate analysis of the effluent. Through its Discharge Monitoring Report Quality Assurance Program, the EPA submits samples to laboratories analyzing effluent to ensure accuracy. Results from its 1980 and 1982 surveys revealed that 68 percent of municipal samples were analyzed incorrectly for one or more pollutants.[9] Determining compliance is somewhat subjective in that the regulatory agency must determine by what amount the effluent limitation can be exceeded.

Even with these noted limitations, these figures indicate that a significant number of individual plants have experienced difficulty complying with permit requirements. However, it is obvious that the above compliance figures are inadequate to evaluate the effect of compliance on the amount of water treated, or even the general progress toward the goals of the FWPCA. The terms, *compliance, noncompliance* and *significant noncompliance* have a number of different definitions and can be applied to several different requirements established under the FWPCA and its amendments.

Assessment of MWTP Performance

EPA Performance Evaluations. As part of the 1972 FWPCA, the EPA Administrator is charged with conducting an annual survey to compare the efficiency of wastewater treatment plants constructed with federal grant funding with the efficiency planned for the plant before it was built. Four years after the act's passage, Walter G. Gilbert, chief of the EPA's Municipal Operations Branch in the Office of Water, used these annual surveys as a database to deter-

mine the relation between operation and maintenance (O&M) and MWTP performance. These surveys, combined with data from an EPA O&M program started before the passage of the FWPCA, provided data needed to evaluate 1,517 municipal plants.

To determine if plants were meeting their original design performance objectives, Gilbert focused on five-day biological oxygen demand (BOD) and total suspended solids (TSS) removals. His results indicated that one-third of the plants failed to meet the design BOD removal criteria and one-half failed the design TSS criteria. A similar survey, conducted by the state of Illinois, also indicated that plants built with federal grant money were not meeting design criteria.[14]

Gilbert also examined the ability of the secondary treatment plants to meet secondary treatment standards as defined by the FWPCA under the CWA. These standards require at least an 85 percent removal of both BOD and TSS, and stipulate 30 mg/L as the maximum allowable concentration of either parameter. Although Gilbert's study concluded that less than 50 percent of the secondary plants were meeting design criteria, many of the plants were in operation before this level of treatment was established as a goal, and thus not all plants examined were *designed* to meet these parameters. However, the examination did reveal a positive relationship between operational flexibility and compliance. Trickling filter plants had the most trouble meeting the secondary criteria; activated plants performed best.

Gilbert identified several factors influencing the performance of grant-funded plants:[14]

- Plants with detailed maintenance schedules and records consistently performed better than plants with poor records.
- The best performers commonly had an O&M manual that was written specifically for that plant rather than just for that plant's design type.
- Inadequate knowledge of the treatment process led to poor treatment.
- The amount of money spent on training per salary dollar was consistently higher for plants performing above design criteria.
- Excluding plants that were hydraulically or organically overloaded, the most significant factor contributing to poor performance was the operator's inability to utilize fully the facility's design capacity.

In the mid-1970s, the EPA funded a two-part study of municipal treatment plants in response to data released in the 1973 and 1974 editions of the Clean Water Report to Congress.[15] These reports indicated that one-third of MWTPs constructed with federal funding were not meeting design criteria. Initially, two private contractors were hired to identify, quantify and rank the major factors that limit biological wastewater treatment plant performance. Although the focus was limited to treatment problems resulting from what was commonly described as poor O&M, the contractors noted that this category actually included a wide range of factors including staffing, salaries, design, management, budget and traditional maintenance factors.

The results of the study were similar to Gilbert's findings, but much more detailed. The number one performance-limiting factor present, regardless of plant location or treatment type, was that operators were not applying treatment concepts and testing to process control. This factor was present in all but two of the 50 facilities studied and was the leading cause of poor performance at 15 plants. A lack of sufficient understanding of general sewage treatment principles ranked as the second highest contributor to inadequate performance. The third highest factor was a lack of proper technical guidance. Other factors identified included inadequate laboratory procedures, lack of process flexibility and improper design — resulting in many incomplete and marginally operable facilities.[16]

Initial results from the study prompted further efforts to identify performance-limiting factors and develop a corrective plan for improving performance. The plan, the Composite Correction Program (CCP), is still used today to optimize municipal plant performance. Although the additional study still focused on O&M, the results revealed that over 20 percent of the plants studied required major facility design modifications in order to maintain continuous compliance with secondary standards. Since facilities with noticeable design inade-

TABLE 2
CCP Main Recommendations

Operating Personnel

- Improve understanding of treatment process through increased training & operator certification.
- Recognize the extent of problems that can occur & seek assistance in problem solving.
- Accept assistance as a beneficial experience rather than as a reflection of poor ability.

Plant Managers & Municipal Officers

- Recognize the importance of on-site training & well-trained operators.
- Provide the necessary budget for training & adequate salary for plant operators.
- Document the design potential of plants & require that assistance be provided by qualified personnel.

Regulatory Agency

- Expand enforcement activities for plants violating NPDES permits.
- Seek plant performance improvement before resorting to additional construction.
- Improve personnel capability to correct the occurrence of improper technical guidance.
- Focus guidance on the limiting factors identified by the CCP study.

Equipment Suppliers

- Provide flexibility & controllability of equipment.
- Provide realistic O&M requirements.
- Improve technical capability of startup personnel.

Engineering Consultants

- Improve design, especially for CCP-identified design problems.
- Improve training of personnel to avoid the frequent occurrence of improper technical guidance.
- Develop capabilities to implement CCP.

Note: From Ref. 16

quacies were eliminated from consideration when choosing the initial plants, it is clear that a significant number of plants have design deficiencies that are not obvious.

Application of the CCP study to noncomplying plants was successful enough that the consultants recommended its further development and application on a broader scale. A final report, based on the full three and a half year study (including detailed evaluations of five plants), produced a number of recommendations directed at the five groups of people that have significant involvement in the wastewater treatment process (see Table 2).

Performance-Limiting Factors & Corrective Recommendations. Performance-limiting factors identified by Gilbert and the CCP study fell into five areas:

- Problem recognition;
- Knowledge and training;
- Design, construction and technology;
- Finance; and,
- Enforcement.

Failure to recognize problem areas appeared to have significant impact on a plant's ability to comply. The areas that contributed to poor performance could not be addressed until they were recognized. Failure to recognize the problems allowed continued poor performance. Examples that illustrate the problem of recognition include inadequate emphasis placed on proper training and advice, failure to recognize what design/equipment problems are most likely to occur, poor documentation of the potential performance levels to be expected, and ignorance of the potential for improved performance without the need for additional construction.

Inadequate operator application of treatment concepts, insufficient knowledge of general sewage treatment principles, and incorrect technical guidance have limited the ability of operators and owners to run even plants where there are no design or budgetary limitations. Knowledge of treatment concepts and proper training are inadequate at a number of levels. Wastewater treatment technology has advanced significantly since the passage of the 1972 FWPCA and the training of operators, staff, regulatory personnel and consultants is not always adequate to design, construct or maintain treatment plants.

Although plants with obvious design flaws or equipment troubles were excluded from the CCP study, the EPA recognized that:[17]

A major conclusion of this survey was that errors in design were severely limiting the opera-

tor's ability to achieve maximum performance from the facility.

As a result, the EPA published a handbook to help identify and correct design deficiencies in existing plants and prevent the same mistakes from occurring during the design and construction of new plants.

This handbook stated that performance and reliability problems, as well as poor safety practices and decreased flexibility of plant process control, could result from design deficiencies. Design deficiencies included the improper selection of equipment and the inability to make accurate estimates of future plant-operating conditions, including the consistency and amount of inflow expected (a situation that would result in the construction of improperly sized plants that would be difficult to modify or upgrade).

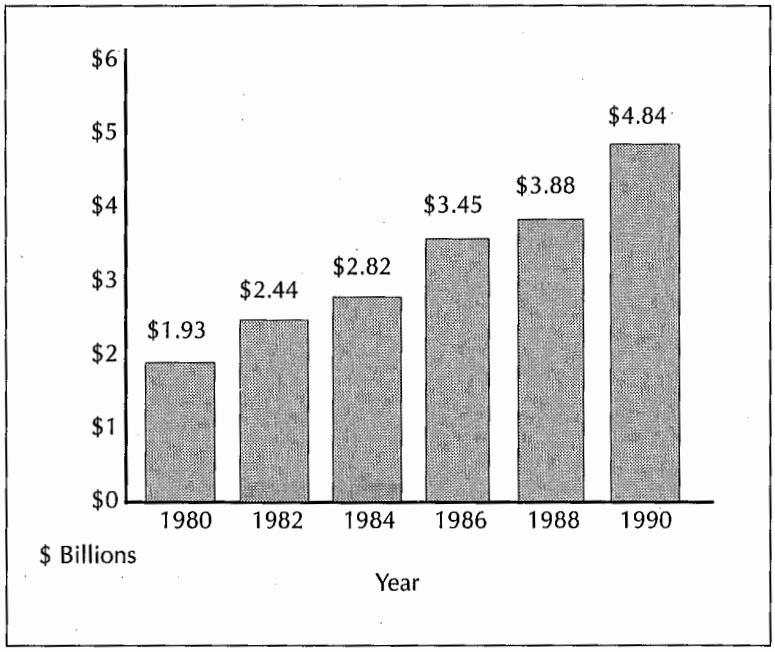

FIGURE 1. Annual O&M expenses for 144 AMSA members.

Despite almost $60 billion granted to plants under the CGP, local plants were still facing budgetary restrictions. While the EPA's 1992 Needs Survey estimated that $137.1 billion would be required to meet wastewater needs for the next 20 years, this estimate did not include O&M costs.[3] The lack of money appropriated for training, salaries and benefits has contributed to poor staff quality and performance. Inadequate expenditures on O&M needs has accelerated plant deterioration and has started a vicious cycle of requiring more O&M expenditures to cope with the physical decline of the plant.

As technology advances, O&M costs will rise and communities must be prepared to face significantly higher costs in the near future. As shown in Figure 1, the Association of Metropolitan Sewerage Agencies (AMSA) predicts that O&M expenses will rise at nine to 11 percent per year — in effect doubling the cost every eight years.

The Effect of Federal Assistance For Municipal Wastewater Treatment on Compliance

The financial ability of a community to construct and operate a wastewater treatment plant directly affected the community's ability to comply with the CWA. In an attempt to equalize the ability of communities to comply with the act, Congress provided enormous amounts of funding for MWTPs through the CGP. Because encouraging compliance was the program's primary goal, penalties for noncompliance were linked to the financial ability of a community to support a properly operating plant. Compliance deadlines were extended and enforcement efforts were withheld from communities waiting to receive a federal grant. In addition to funding, the federal government provided technical assistance to ensure efficient use of federal funds and to promote self-sustaining community O&M programs.

Construction Grants Program. The CGP's effects on performance and compliance must be considered for at least two reasons. First, the CGP can be viewed as a positive influence on compliance in that it provided funding for plants that were experiencing significant com-

pliance problems. The Association of State and Interstate Water Pollution Control Administrators, testifying before a House subcommittee on a February 1989 proposal by then President Bush to cut funding to the CGP, expressed a common belief that municipal noncompliance would escalate with lower funding.

A second reason for considering the structure and influence of the CGP is its impact on local government finance and responsibility. The enormous amounts of CGP funds available to local governments frequently displaced local spending for wastewater treatment plant construction and encouraged communities to view wastewater treatment as the federal government's responsibility. In 1973, when federal grants for wastewater treatment were just beginning, the displacement of local funds was estimated to be 200 percent of the federal grant funds, thus producing a net decrease in funds available for wastewater treatment.[18] In addition, the promise of federal funds specifically targeted to increase compliance provided perverse incentives for communities not to comply (since compliance was rarely enforced and noncompliance actually increased the chance that a local government would receive a grant).

The CGP has allocated about $53 billion in grants and $7 billion in loans for the construction of wastewater treatment plants through individual states.[19] Each state received a portion of the year's allocated funds based on the state's population and projected wastewater needs. The money was allocated through a required state Project Priority List, which ranked projects in order of need.

Initially, states had a tendency to fund projects as soon as they were eligible because unused state money reverted back to the federal government if the money was not used within a specified time period. However, many states found that their share of the federal money was inadequate to meet the state's needs because of stricter funding eligibility restrictions and a limited amount of funding available for each state. As a result, states announced that their share of federal funds would be available on a need basis only. Need was judged primarily on the ability or inability of a plant to comply with regulations. Most states allocated the money to the areas with the worst performance.

Not all municipalities constructing plants during the program's existence received federal funds. However, almost all plants were influenced by the program. Seeing the availability of free federal funds, many plants sought federal funding to upgrade existing plants. Not all of these plants were in need of improved treatment to meet effluent standards. The early period of the program provided federal funding to support reserve capacity that was not needed to comply with the FWPCA. The liberal funding of projects resulted in many communities that, almost twenty years later, still have plants with adequate capacity and low sewer rates.

Local officials desired new plants for a number of reasons. Although the CGP eventually disallowed the funding of reserve capacity, plants were still built with future needs in mind. Plants were typically designed for a 20- to 30-year period. Many communities realized the importance of wastewater treatment capacity in attracting new industry. New industry created jobs, funded other projects and contributed to the overall economic welfare of the community. As a result, the desire to construct plants with large amounts of free federal money commonly outweighed the benefits of operating existing plants in a fashion that would achieve compliance.

Many local officials openly admitted to the pressures placed on them by the public to construct new plants and minimize local costs. If the local officials tried to finance a new plant with local funding by increasing sewer fees, the community would be likely to vote them out of office. This pressure was routinely passed to the plant operators to not improve performance since it would hurt the community's chance to get a grant.

The influence of free federal money did not end once the grant was received. The existence of federal funding encouraged local governments to believe that the financing of wastewater treatment is not primarily a local responsibility. This theme was further impressed on plant operators even after they received notification of grant funding. The final approval for all aspects of design and construction rested with the EPA. Although the EPA informed them of their responsibility for design and construc-

tion, local communities were rarely held accountable when problems arose.

Numerous reports have documented the poor controls over federal grant money.[20-22] The U.S. Comptroller General reported that grant money had been used to finance the construction of such aesthetically valuable features as a red tile roof, stucco exterior, decorative arches, reflecting pool and a mosaic tile fountain — all at wastewater treatment plants.[20] The GAO found that "local agencies — the grantees — have not had adequate financial management systems to provide efficient and effective accountability and control over funds received from the agency."[21]

One town manager admitted that his town was "relatively poor and was not satisfied with merely constructing a plant whose design was compatible with existing surroundings; it wanted the facility to serve as a catalyst for upgrading the area."[20] This particular plant was surrounded by a 15-foot high red tile/stucco fence that cost $200,000. In another example, federal grants paid for 55 percent of the cost of a $30,000 mosaic tile fountain constructed for the sole purpose of displaying the effluent from an advanced wastewater treatment plant. The program enabled some local wastewater treatment agencies to expand their operations without having to spend local money or risk the political consequences of using local money.

The concern over "our own money" is not unusual. Initially, Congress and the EPA treated lack of funding as an acceptable excuse for noncompliance. Municipalities learned that if federal funds were not available, they would not be forced to comply with the deadlines of the FWPCA. Section 301(i)(l) of the CWA allowed plants not meeting the 1977 deadlines as a result of inadequate federal funding to request an extension until July 1, 1983. The act stated that if construction were required to meet discharge limitations, but "construction cannot be completed within the time frame . . . or the United States has failed to make financial assistance under this act available in time," the Administrator or the state could issue a permit containing a compliance schedule to have the plant construction completed "no later than July 1, 1983." Thus, the act clearly placed responsibility for funding with the federal government, and the failure of the government to provide funds was an acceptable excuse for noncompliance.

Local officials, who realized that a new wastewater treatment plant provided economic benefits to the community as a whole, were faced with a dilemma. Deliberate noncompliance, although technically illegal, was difficult to spot and rarely subject to enforcement, especially if a plant was waiting for a federal grant. In addition, money could be saved by reducing compliance efforts. Compliance, on the other hand, required local O&M expenditure and could actually hinder the chance of receiving a federal grant. As a result, the primary goal of operation usually centered on the ability of the local plant to receive outside grant funding and thereby minimize local costs.

Noncompliance moved a community farther up on the state priority list and encouraged state officials to provide construction funds to improve compliance through the construction of a new plant. Some officials believed that it was impossible to achieve compliance until a grant was received and, therefore, did not try to improve performance. Others refused to participate in the CCP study fearing that the study might improve plant performance and diminish their chances for a grant.

In 1978, the EPA issued its *Interim National Policy and Strategy for Construction Grants, NPDES Permits, and Enforcement Under the Clean Water Act*, which outlined necessary enforcement strategies to improve compliance.[8] One of the policy's goals was to encourage movement into the grant process by notifying POTWs that if they did not apply for a grant within a certain time period, they would lose the opportunity to receive a grant. In addition, MWTPs with a history of delay despite EPA pressure to comply, and MWTPs that had been determined to have adequate physical structures capable of meeting effluent limitations but were not meeting those limitations, were suggested as candidates for referral for judicial action.

The Construction Grants Amendments of 1981 ended reserve-capacity funding and reduced the federal share of design and construc-

tion costs to 55 percent. The 1984 National Municipal Policy warned communities that continued lack of federal funding would not be accepted as justification for noncompliance.

This policy marked a fundamental shift in the agency's compliance efforts. Federal grants were still intended to promote compliance, but a community's lack of funding was no longer an allowed excuse for noncompliance. Plants were warned to meet regulations without federal funding or face enforcement. But much damage resulted from the previous connection between compliance and funding. Plant owners and operators were constantly reminded of the connection. Congress and the EPA — through previous policy that included the massive outlay of funding, lax enforcement and repeated deadline delays — impressed local officials with three themes:

- The outlay of free money was an admission by Congress that it was the federal government's responsibility to construct wastewater treatment plants.
- Deadline delays indicated that local governments would not be penalized for the federal government's failure to provide enough money or the EPA's failure to provide enough guidance.
- Lax enforcement clearly demonstrated that compliance was not important enough for the EPA to justify enough time and manpower to seek out those plants that were not complying.

The established connection between funding and compliance hindered the goals of the CGP. Rather than encourage compliance through federal funding, it created perverse incentives that made it advantageous in the eyes of owners and operators *not* to comply or even attempt to improve performance.

Congress and the EPA intended the CGP to serve as a temporary form of assistance designed to encourage compliance, not as a perpetual source of funds for wastewater treatment plant construction. That the CGP was not intended to be a continuous source of money was clearly stated to all participants from the very beginning of the program. In 1987, then President Ronald Reagan attempted to block passage of the 1987 CWA amendments. His veto message, addressed to the House of Representatives, stated his reasons for objecting to continued CGP funding:[23]

> *The Clean Water Act construction grant program, which this legislation funds, is a classic example of how well-intentioned, short-term programs balloon into open-ended, long-term commitments costing billions of dollars more than anticipated or needed. Since 1972, the federal government has helped fund the construction of local sewage treatment facilities. This is a matter that historically and properly was the responsibility of state and local governments. The federal government's first spending in this area was intended to be a short-term effort to assist in financing the backlog of facilities needed at the time to meet the original Clean Water Act requirements.*

Operator Knowledge & Training. In conjunction with the CGP, the EPA worked closely with local officials and state agencies to ensure that communities had the technical expertise to operate their wastewater plants. The EPA-funded CCP study revealed that compliance was best promoted when regulators enforced performance standards and abstained from recommending particular compliance methods. When local officials followed regulatory technical advice, they believed that they were meeting performance requirements regardless of actual compliance to limitations.

However, specific recommendations provided by the EPA or state agencies were not always correct and did not always result in compliance or improved effluent quality. For example, staffing estimates provided in EPA publications sometimes varied from field usage, often exceeding what was necessary.[24] The resulting salary expenditures reduced the funds otherwise available for training and other O&M expenses. The CCP study consultants made the following observation:[25]

> *An aspect of regulatory agency activity that confused owners and redirected their activities away from achieving required effluent quality was that of providing specific operations or maintenance recommendations. Owners often relig-*

iously carried out these recommendations and were subsequently confused and frustrated when they found that they were facing still more requirements when compliance was not achieved. Additionally, assistance was perceived by the facility owners as a relief from local responsibility for effluent compliance.

The EPA's technical assistance and operator-training programs were designed to foster the development of a national base of skilled water pollution control personnel and technical information materials that would help protect the federal investment in wastewater treatment facilities.[26] The Water Quality Improvement Act of 1970 provided financial support for an EPA pilot-operator training program. Working with states, local communities, educational institutions and trade associations, the EPA provided a wide range of training programs that included management training, advanced treatment training, general skills workshops, informational seminars for local officials, correspondence study programs and preventive maintenance training.

Since the goal was to develop self-sufficient operator-training programs, the EPA recommended providing for on-site technical assistance that would be given by experienced O&M personnel, preferably state employees. The EPA discouraged states from using contract assistance approaches; instead it promoted an approach for self-sufficiency that could be acheived by states hiring qualified technical assistance personnel in state training centers or other responsible state program offices.

The CCP study determined that many local plant operators authorities did not realize the potential impact of operator actions on plant performance and, therefore, did not place an adequate emphasis on operator knowledge and training. Evident in the corrective recommendations issued by the study was the belief that operator education would receive more emphasis if its importance were recognized.

However, local participation in the CCP study was not mandatory. Local officials or operators who had reasons not to seek improvements at their plant would have reasons not to participate. The consultants noted that some municipalities refused to participate since they were reluctant to invest or focus their attention toward existing facilities while external construction grant funds were available. One official stated that "at this time it would be senseless to spend additional money on our present sewer treatment plant. Our plant is inadequate and has never functioned properly."[25] Even the possibility of future grant funding discouraged plant operators and local officials from improving operator training or plant performance.

The EPA's advice was not limited to the O&M of existing plants. Local officials in Garland, Texas, accepted an EPA recommendation and adopted an innovative technology. Under the CGP, certain innovative or alternative technologies received increased grants relative to conventional treatment methods. Garland took the extra funding and built a $30 million physical-chemical treatment plant. Seventeen days after startup the plant failed. William E. Dollar, Garland's Director of Public Works, claimed that "because this was such a new process, we depended on . . . the EPA to let us know" about the technology.[27] Initially, the EPA provided glowing recommendations about the technology. After the plant failed, the EPA sued Garland for failure to meet discharge permits. Garland sued the engineers involved with the project and again asked the EPA for help. Dollar claimed the town spent "almost a year in numerous meetings trying to get clear directions from the EPA." Eventually, Garland was forced to seek the help of an engineering consulting firm.

Like federal funds through the CGP, technical advice was provided by the EPA to foster compliance and local self-sufficient wastewater treatment programs. But, also like federal funding, federal technical assistance encouraged states and communities to view wastewater treatment as a federal responsibility. In an environment of free technical advice, lax enforcement and unclear assignments of responsibility, communities had little incentive to develop self-sufficient technical capabilities.

Design, Construction & Maintenance. The CCP study revealed that there were numerous design, construction and maintenance problems present in federally funded facilities. The ex-

tent of these design failures was particularly surprising given that plants with obvious design flaws were excluded from study. Design improvement and increased flexibility and controllability of equipment were the two physical plant recommendations that resulted from the CCP study.

Under the CGP, wastewater treatment plants were designed for a 20-year life. As a result, treatment requirements needed 20 years after the startup of the plant had to be estimated before design or construction began. Although the lack of accurate knowledge about future treatment needs would seem to have encouraged the use of flexible designs that would accommodate unpredicted changes, this did not appear to happen. As a result, plants ten years into operation may be restricted by equipment designed on the basis of an inaccurate future-needs prediction.

CGP regulations required EPA or state-agency approval of all design changes and construction upgrades of federally funded plants. The process of receiving design and construction approval from the EPA was a long and complicated process. Review of the three-step grant application could add as much as six years to the construction process; delays averaged two to four years.[28] In addition, some communities waited on state priority lists for ten years before receiving notification of grant eligibility. The enormous demand for grants, combined with lengthy regulatory reviews, hindered the EPA's ability to provide more frequent design reviews. In contrast, communities constructing plants without federal assistance (and therefore without EPA design restrictions and review delays) were free to employ more flexible designs, such as modular plants, that could accommodate future upgrades.

The EPA's 1982 *Handbook: Identification and Correction of Typical Design Deficiencies at Municipal Wastewater Treatment Facilities* identified many of the problems relating to restricted operation or lack of flexibility.[17] The handbook's intent was to provide "design engineers with guidance that will make their designs more operable and maintainable at less cost, as well as more flexible in providing adequate performance." The introduction to the handbook stated that design deficiencies contribute to a decrease in the flexibility of plant process control. Design flaws addressed in the handbook that relate to the lack of flexibility included:

- Inadequate process and operation flexibility;
- Inadequate consideration of seasonal impacts on operating efficiency;
- Inadequate estimation of present and future flows;
- Inability to adjust and control process equipment in response to changes in waste characteristics; and,
- Inadequate consideration of maintenance needs including: the lack of provision for by-passing flow, inability to dewater tanks for repair and the lack of a back-up unit.

The handbook also identified the problems resulting from adopting 20- to 30-year design lives. In many cases, the predicted design flow or treatment capability was based on inaccurate data. Numerous problems have resulted from errors of basing design on average flow and loadings (rather than peak), as well as from the failure to recognize the connection between treatment ability and seasonal influences when designing outdoor lagoons.

The 1980 GAO report stated that:[22]

> *Accountability under EPA's construction grants program is complicated by the many parties involved in the design and construction of a treatment plant: EPA regional officials, state regulatory agencies, municipal officials (the grantee), design engineering firms, industrial contributors, and finally, construction contractors and sub-contractors.*

The report concluded that clear assignments of accountability would improve performance without the need for additional federal funding.

At the time the GAO report was published, the CWA placed responsibility for proper plant performance on local officials. However, local governments were prohibited from implementing design plans that did not meet the approval of state and EPA officials. When plants failed to meet design expectations, local

officials blamed inadequate state and federal reviews. State and federal officials claimed that their reviews of design plans were never intended to thoroughly evaluate the design's ability to provide proper wastewater treatment.

The design and construction of wastewater treatment plants under the CGP was hindered by an inability to identify and hold accountable those responsible for providing inaccurate or improper design advice. As a result, construction and design became a lengthy and complicated process that frequently resulted in the construction of improperly designed plants that were incapable of producing effluent in compliance with NPDES effluent permits. The same problems existed in relation to providing technical training and O&M advice. As a result, plant operators could not guarantee the accuracy of advice furnished by regulatory agencies, local officials or private parties.

The inability to identify and hold accountable those responsible for providing inaccurate or improper advice was compounded by the availability of extensive federal subsidies for construction costs and training programs as well as the failure of regulatory agencies to enforce NPDES effluent permits. Since local governments were financially responsible for only a fraction of the construction and training assistance, they had little incentive to ensure the efficient expenditure of wastewater funds. In addition, since local governments were rarely held accountable for poor plant performance, they had little incentive to expend local resources to improve the accuracy of available advice or to seek new sources of information.

In sum, the failure of the CGP to encourage self-sufficient local government wastewater treatment programs resulted from two factors:

- The CGP process was marked by an inability to identify and hold accountable those responsible for the provision of inaccurate or improper design, construction or operation advice.
- The CGP failed to provide incentives for local communities to pursue efficient wastewater treatment plant construction and operation.

Over time, recognition of these problems in an environment of decreasing federal funding and increasing treatment needs led Congress, the EPA and local governments to explore new ways of providing municipal wastewater treatment.

Changes in State & Federal Approaches to Municipal Wastewater Treatment

State Revolving Funds. Title VI of the 1987 Water Quality Act introduced the State Revolving Fund Capitalization Grant Program (SRFCGP) that was designed to gradually convert wastewater treatment plant funding from federal grants to state loans. While the act extended the grant program by authorizing EPA allocation of construction grants until 1990, it also set forth a schedule for ending all forms of direct federal funding by the end of fiscal 1994. By that time, states were expected to have self-sufficient wastewater treatment programs. However, the federal government has retreated from this intent.

Congress recognized that the transition to state responsibility would be difficult since states were accustomed to decades of federal support (some of them prior federal attempts to develop self-sufficient state programs). Therefore, Congress encouraged states to develop self-sufficient funding programs by authorizing federal capitalization grants for approved SRFs.[30] A revolving fund provides a continuous source of funds if the fund's proceeds are loaned, not granted, to communities. The funds are sustained through repayment of loans made from the capitalization grants.

Congress allocated $8.4 billion for capitalization grants between 1990 and 1994. States were also allowed to capitalize their SRFs with a portion of their construction grant funds that were available through 1990. In order to qualify for capitalization grants, states were required to provide a 20 percent match to the federal share and authorized to reserve four percent of the grant funds for administrative costs. In addition, states had to establish an EPA-approved state environmental review program (SERP) and all SRF-funded projects had to undergo SERP reviews.

To establish a SRF, a state had to submit an application form that included a description of the SRF structure and an Intended Use Plan

(IUP) that specified how the state will use grant funds to help local governments meet the requirements of the CWA. Each year thereafter, the state must submit an updated IUP and an annual report. These reports detailed the state's efforts to comply with SRF administrative requirements (such as federal accounting and auditing procedures) and ensured that projects funded by SRF funds have complied with at least 46 different federal regulations including 16 different Title II requirements that were carried over from the CGP that specifically address wastewater treatment, as well as at least 30 different federal laws and executive orders attached to federal funding.[30] Title II requirements applied only to projects funded by the federal capitalization grant, not to projects funded by state matching funds or funds resulting from repayment of earlier SRF loans.

Unlike the CGP, states were primarily responsible for ensuring that communities adhere to funding regulations. Rather than directly review individual projects, the EPA would oversee compliance with funding regulations through its review of state annual reports. If the EPA's Office of Inspector General determined that a state had not administered the SRF in compliance with federal standards, federal capitalization grants to the state's SRF would be suspended. If the state fails to take corrective action, the capitalization grants would be awarded to another state.

Funds from a qualifying SRF must be loaned to communities at or below market interest rates. Negative interest and grants were prohibited. While SRFs could be used to fund pollution control projects other than wastewater treatment, states must ensure that funds were first directed toward facilities not yet in compliance with the CWA. After complying with this first-use requirement, states could assist the development of other water pollution control projects such as the prevention of nonpoint source or estuary pollution. All states have met first-use requirements.

Since the SRFCGP converted federal grants to loans that had to be repaid, local officials were encouraged to provide the best treatment at the least cost and to avoid unnecessary features. The SRFCGP also increased the flexibility of wastewater treatment funding by allowing SRFs to be used to provide guarantees for local loans, to purchase municipal bond insurance, or to refinance existing local government wastewater treatment debt obligations. In addition, by providing a renewable source of wastewater treatment funding, Congress attempted to end continued state and local government reliance on federal funds and finally establish self-sufficient treatment programs.

Detailed information on the ability of SRFs to finance efficient wastewater treatment is not yet available.[31] However, initial findings indicate that the need to repay loans is resulting in the construction of more appropriate and efficient wastewater treatment facilities. For example, some communities that were encouraged by the CGP to finance expensive, centralized facilities are now turning to low-cost on-site systems.[12] State officials expect SRF financing to result in the construction of lower-cost facilities.

Although the SRF appears to be an improvement over the CGP, numerous aspects of the SRF still inhibit efficient investment in MWTPs capable of meeting effluent standards. States claim current program regulations hinder the ability of communities to finance appropriate wastewater treatment methods. SRF loans can only be used to purchase land if the land itself is part of the treatment process. Thus, communities may receive assistance for the acquisition of land to develop wetland filtration projects but not for treatment plants or easements for sewer collection systems. The EPA included land purchase restrictions in the CGP to prevent the purchase of unnecessary land that could later be used for other purposes. Forty-two states responding to a 1992 GAO SRF survey reported that land restrictions should be waived.[12] According to an official in charge of Florida's program, the cost of land for unsewered communities can represent about 20 percent of the project's cost. The GAO noted that states were capable of determining necessary land requirements and concluded "that an across-the-board restriction on the eligibility of land purchases for SRF assistance is counterproductive for many local governments."[12]

The GAO also criticized SRFCGP restrictions that limited loan terms to 20 years and the EPA's failure to provide knowledgeable EPA

staff to assist states in developing SRFs. Currently, communities receive 20-year loan terms regardless of the design life of the facility.

As a result, some communities may find it difficult to finance facilities with longer design lives while others may find that loan repayments extending beyond the design life hinder the ability to upgrade a previously financed plant. The GAO recommended matching loan terms to the estimated design life of the facility. The GAO also concluded that states lack the expertise to manage SRFs and suggested that the EPA increase state technical and administrative assistance through additional training and hiring of EPA regional staff. Such recommendations were likely to discourage states from accepting responsibility for SRF administration.

The SRFCGP also restricted a community's ability to provide the most appropriate treatment method for its needs. For example, SRF loans could not be used to finance the portion of a wastewater treatment facility owned by the private sector. In addition, Congress continued to restrict the flexibility of the treatment selection process through the carry-over of numerous CGP Title II provisions that included requirements that local governments select treatment technologies meeting EPA approval. Communities also had to demonstrate that they considered innovative or alternative treatment methods for projects funded from funds equivalent to those granted by the federal capitalization funds.

The disadvantages of the SRFCGP resulted from the ways in which it resembled the CGP and discouraged local governments from developing self-sufficient wastewater treatment programs. This effect resulted from the continued federal regulation of the wastewater funding process administered by the states and of the treatment selection process undertaken by local governments. According to the WEF Executive Committee, "administrative burdens imposed by the Federal government upon obtaining revolving loan funds . . . add unnecessarily to facility costs, discourage use of these funds by smaller municipalities, delay the construction of facilities, and reduce states' flexibility to allocate loan funds according to their own priorities."[32]

Public-Private Partnerships. As a result of the cumbersome requirements of federal funding, decreased funding, stricter wastewater regulations, and decaying infrastructure, many local and state governments have turned to various forms of privatization or public-private partnerships to solve their wastewater treatment problems. Studies investigating capital-intensive services, such as wastewater treatment, have revealed that economics (either the lack of eligibility for a federal grant or the high cost of running a plan) is commonly cited as the number one reason for considering private-sector involvement.[33] However, communities that have increased the private sector's role in either the production or provision of wastewater treatment have found that economics is not the only factor to consider. The EPA lists five basic reasons for communities to consider public-private partnerships:[4]

- Access to more sophisticated technology;
- Cost-effective design, construction and/or operation;
- Flexible financing, including the use of private capital;
- Delegation of responsibility and risk; and,
- Guaranteed cost.

Even during the height of the construction grants program, some communities elected to forgo federal funding and use their own funds to meet their treatment needs. EPA Assistant Administrator of Water Lawrence Jensen described the effects of the CGP program:[34]

Federal dominance inadvertently fostered an atmosphere of passive dependency. Action on existing needs and planning for future growth was thwarted as some municipalities stood in the federal waiting line. Conversely, many communities were not interested in this waiting game and proceeded to find suitable financing solutions on their own. These communities overcame obstacles and realized substantial benefits as they proceeded, thus making the grants trade-off worthwhile. Some notable advantages include cheaper and more efficient construction, ability to select local design preferences, greater responsiveness to economic growth, fewer procedural requirements, enhanced flexibility to address fu-

TABLE 3
The Wastewater Treatment Plant Ownership/Operation Continuum

	Traditional Treatment	Contract Services	Turnkey Facility	Developer Financing	Privatization	Merchant Facility
Decision to Provide	Public	Public	Public	Public	Public	Private
Design	Public	Public	Private	Either	Private	Private
Financing	Public	Public	Public	Private	Private	Private
Construction	Public	Public	Private	Either	Private	Private
Ownership	Public	Public	Public	Either	Private	Private
Operation & Maintenance	Public	Private	Either	Either	Private	Private

Note: Based on a table from Ref. 6.

ture changes, and greater certainty as to the timing of services to customers.

A 1989 study of wastewater treatment privatization conducted by Laurence J. O'Toole documented some of the beneficial effects of greater private-sector participation:[35]

> *Privatized design and construction of wastewater treatment facilities proceeded more smoothly, as perceived by participants, and much more quickly (by more than two years, on average) than in the grant-funded setting. Furthermore . . . output measures of effluent quality and of compliance with regulatory standards showed that privatized facilities do not suffer by comparison with . . . counterparts.*

Private involvement in providing wastewater treatment can take several different forms. Table 3 displays the most common variations of public-private partnerships. Represented are six aspects of wastewater treatment that can be the responsibility of either the public or private sector. The six aspects together encompass the entire process of wastewater treatment. The public-private continuum displays the strictly public involvement of traditional treatment on the left side, and the entirely private involvement of a merchant facility on the right. At least four combinations of public-private involvement make up the continuum between these two extremes. Not all partnerships follow these strict assignments of public or private responsibility. The wide variety of approaches allows public-private partnerships to be tailored to the specific needs of the municipality and the capability of the private sector.

Municipal wastewater treatment facilities have been constructed under each of the six different combinations of public-private partnerships displayed. The most common choices, excluding the traditional public-only model, are contract services and turnkey facilities. Privatization and merchant facilities are much less common after the Tax Reform Act of 1986, which reduced the tax incentives for private ownership. Frequently, developer financing results from a community's need to accommodate growth. Merchant facilities are characterized by full private-sector control of all service aspects, including the initial decision to provide. A merchant facility providing wastewater treatment is not common but may be more prevalent in the future as private firms offer to provide treatment plants to small unsewered communities or to communities that cannot afford to upgrade or replace their current plants.

Contract Services. The most common form of wastewater privatization is a contract under which a private firm takes responsibility for the day-to-day O&M of a publicly owned plant. The O&M contract signed by the city of Leominster, Massachusetts, illustrates several advantages of contracting out. As with all

forms of private involvement, this contract was unique, but most service contracts contain similar key features.

Leominster, with a population of 35,000 people, completed construction of a new plant in 1983. The $23-million plant was financed through the CGP, with the city contributing less than $3 million of the construction costs.[36] Leominster sought an O&M contract for the new plant for two reasons. The new plant employed advanced wastewater treatment (AWT) technology and its O&M would require more money and highly trained personnel than were available. The new sophisticated technology of the AWT plant was needed to remove phosphorus and ammonia, but it was also expected to require $1.2 million in O&M costs every year — a substantial increase over the previous $450,000 per year required for the older plant.

Leominster contracted with an environmental services firm to ensure that the plant was adequately operated and maintained for less than $800,000 per year (for a cost savings of about 30 percent). The contractor offered jobs to all seven of the plant's existing employees and provided a manager, who was selected in part by the town. As part of the operating agreement, the contractor provided a performance guarantee and liability insurance. For the initial six months of the contract, the firm provided 15 specialists to evaluate and improve not only O&M, but also nontechnical areas such as employee and community relations, administration and accounting.

The biggest change for employees was the installation of an automatic dialing alarm system, which the contractor had used at several other plants. The system automatically dials a technical assistance hotline when a treatment malfunction occurs. An electronic voice informs the operator of the location and type of problem. Leominster discovered that the automatic alarm system was more reliable than a single manned operation. The plant met effluent quality requirements within three days of startup. Technical expertise provided by the contractor saved Leominster an estimated $400,000 per year.

Contract operations illustrate several advantages of private-sector involvement. Many communities like Leominster are unable to provide the technological expertise necessary to operate a treatment plant. In some cases, political or financial pressures prevent a community from hiring the necessary personnel since the salary of a qualified operator may exceed that of the local mayor. Using a private contractor to provide O&M, however, can be attractive even to those communities that are able to afford the expense of an operator.

Unlike an individual community, private contract firms are able to take advantage of economies of scale — cost savings from large-scale production. Thus, the contractor could lower Leominster's O&M costs by providing a centralized alarm system, the cost of which is shared by the firm's other clients. Such economies of scale also extend to the bulk purchase of treatment chemicals and emergency pumps or other specialized equipment as well as to personnel that can be transported to a site as needed.

Municipal operation of wastewater treatment is also hindered by unclear assignments of responsibility and accountability. In the public management arena, political power struggles have resulted in continued noncompliance while various levels and departments of local government argue over the relative importance of wastewater treatment and the best methods of ensuring proper operation. Under a service contract, a private firm usually takes responsibility for compliance with NPDES discharge permits. The contract can ensure that the private sector is held accountable for noncompliance by requiring payment of EPA enforcement actions. In addition, the daily responsibilities for payroll, insurance, maintenance and regulatory reporting are transferred to the private firm and accountability for these issues is guaranteed through the contract. The private firm has experience at addressing these issues as they relate to wastewater treatment and, unlike municipal operators, it is free to make adjustments in daily operation without waiting to first obtain permission for the changes from the local government.

Accountability provided in the contract ensures that a private operator will either meet the contract standards established by the local government or face penalties such as fines or contract termination. Furthermore, a private

firm has an incentive not only to meet the standards established by the contract, but to exceed them. If a private firm fails to operate and maintain a plant in the most efficient, low-cost manner, it may lose its contract to a firm that can. Unlike municipal operation, contract service is not a monopoly. Competition from other contract firms serves as a constant incentive to improve performance.

Turnkey Facilities. The turnkey approach takes private involvement two steps beyond contracting out and places design and construction responsibilities in the hands of the private sector. As noted in the CCP study, even the best O&M services cannot overcome poor design or construction defects. Placing responsibility for design and construction with the same party responsible for O&M ensures a coordinated approach. Under the CGP, it was difficult to hold anyone responsible for poor design or construction defects. In addition, since few incentives for proper O&M existed and poor performance was rarely punished, the extent of design and construction defects frequently remained hidden.

The CCP study, which focused on O&M improvement techniques, deliberately excluded plants with obvious design or construction defects. Nonetheless, the study found that latent design defects "were severely limiting the operator's ability to achieve maximum performance from the facility."[17] Under a turnkey contract, a private firm designs, builds and operates a wastewater treatment plant, but the ownership remains public. The coordination of design, construction and O&M forces the private contractor to consider the relationship between the individual steps. Accountability provided under contract and competition from other firms ensures that the contractor will not make sacrifices in one area if they increase costs or place an unacceptable burden on another.

The city of Casa Grande, Arizona, chose a turnkey approach to upgrade its wastewater treatment system for the sole purpose of providing higher-quality effluent for irrigation. The city relied on an aerated lagoon and stabilization ponds for wastewater treatment. Its effluent was meeting standards, and the lagoon had enough reserve capacity to serve the area for many additional years. However, the city had only a nine-hole golf course and wanted an 18-hole course. Lack of state-approved irrigation-quality water prevented expansion.

Two consulting firms worked together to design, construct and operate the new facility. Unlike Leominster, one of the contractors wrote specific O&M manuals and trained city employees to operate the new system but did not take over the daily O&M responsibilities. The new facility was not significantly more difficult for city employees to operate, and the firm's only continuing responsibility for O&M was to furnish on-call laboratory analysis and operational support when needed.[37]

Casa Grande's turnkey contract required that the plant's upgrade be compatible with future plant expansions. One of the consulting firms constructed an upgrade that could be operated in parallel with future upgrades and provided extra capacity in two of the capital-intensive areas (the chlorine and chemical buildings). As a result, Casa Grande obtained a wastewater treatment system that could change with the city's needs. The use of such modular designs may reduce construction costs by as much as 25 percent.[38] By contrast, CGP-funded plants were frequently inflexible and, therefore, difficult to adapt to communities' changing needs because of grant funding that encouraged over-design and over-construction.

A significant advantage of turnkey contracts is the ability of design and construction engineers to coordinate the design, material procurement and construction phases. Such coordination provides more flexibility in the construction process and allows designers and construction engineers to devote more attention to the possible use of innovative design or construction techniques.[39] Under the CGP, design was primarily controlled by design engineers with little input from the contractor. Coordination of the process, achieved by the turnkey approach, can minimize change orders and reduce friction. For Casa Grande, such coordination provided significant savings:[37]

The turnkey approach saved eight weeks in the bidding/award/mobilization process alone. Additional savings to the tight construction schedule

were realized when the equipment procurement process began at the 50 percent design level . . . The turnkey approach also eliminated delays during construction by putting the engineering and construction staff in a single trailer at the site, thereby trimming communications time and reducing delays due to submittal preparation, transmittal and review.

Developer Financing. Developer financing places another aspect of wastewater treatment plant construction in the hands of the private sector, although developer responsibility for finance is not always accompanied by developer responsibility for design, construction or maintenance. In its most common forms, developer financing is characterized by private-sector design and construction of a wastewater facility that is turned over to the local government when completed, or as developer assistance that is provided directly to the local government for the construction of wastewater treatment facilities.

Developer financing is a way of "requiring growth to pay its own way."[40] Given that new communities generally do not have a tax base to finance the construction of public facilities such as wastewater treatment plants and schools, developers are encouraged to participate in financing public projects. In some areas (such as Escondido, California), financial contributions to the construction of a wastewater facility have been required in exchange for the permission to develop or the right to reserve a portion of future sewer capacity.

The city of Escondido faced three problems. The current wastewater treatment plant was operating at capacity and the city was growing. Furthermore, the city faced enforcement from the state for poor plant operation and a lawsuit from a neighboring town for failure to fulfill a sewer service contract.[6] Escondido needed an upgraded plant, increased sewer capacity and relief from the enforcement efforts and lawsuit.

As a result of several voter referenda, Escondido was prohibited from using bond financing, user fees or other forms of financing to upgrade its plant. By selling the rights to future sewer capacity to developers and citizens before the capacity was available, Escondido financed the entire cost of the plant upgrade and sewer capacity expansion and actually had funds remaining for future needs.

In return for the needed access rights to the sewers, developers and individual citizens paid for contracts with the city that designated the amount of capacity purchased. Initially, access rights were sold for $1,650 per equivalent dwelling unit (EDU). One EDU is the equivalent of 270 gallons per day, which is the estimated daily amount required for a family of four. Seven years later the price of one EDU had risen to $3,300.

In this arrangement, the city of Escondido was responsible for individual contracts and required all people seeking access to the sewers to purchase a contract with the city. The first purchasers who bought rights before the plant was built received an exemption from future increases of connection fees as an incentive to help finance the plant. Escondido also signed a contract with the neighboring city of San Diego to provide additional sewage treatment for that city. Private-sector involvement was limited to the purchase of access rights that financed the entire project.

Full Privatization. While all forms of public-private partnerships can be described as forms of privatization, full privatization has its own unique meaning. When a facility is described as being fully privatized, the responsibility for the design, construction, financing, ownership and O&M rests entirely with the private sector. The popularity of full privatization decreased due to the changes in tax laws in the mid 1980s. These changes made private ownership much less attractive and hindered the ability of communities to issue tax-exempt bonds to finance privatized facilities.

The 1986 Tax Reform Act eliminated or reduced several incentives for private investment in wastewater treatment facilities. Previously, private investors received a ten percent Investment Tax Credit for the purchase of certain types of depreciable property. For a typical wastewater treatment plant, this credit applied to 80 to 90 percent of the total cost.[41] The 1986 act also lengthened depreciation schedules. Depreciation allows an investor to recognize the declining value of an asset as it ages by writing off a percentage of the asset's cost each year of the asset's life. The 1981 Accelerated Cost Re-

covery System encouraged investment by allowing investors to depreciate an asset over a time period shorter than its useful life. For wastewater treatment plants, 80 to 90 percent of assets qualified for five-year depreciation schedules. By lengthening the depreciation period of treatment plants from five to 15 years, the 1986 act reduced the amount of cash available to support an investment in its early years.

Tax reform also hindered the ability of local governments to issue tax-exempt bonds to finance wastewater treatment. Until 1968, all income received by investors from state or local bonds was tax-exempt. The Revenue and Tax Expenditure Control Act of 1968 eliminated the exemption for most bonds if more than 25 percent of the bond proceeds were used by a nongovernmental entity in a trade or business and bond repayment for more than 25 percent of the bonds was guaranteed by property taxes or revenues generated by the business. Bonds used to finance projects failing either test were tax-exempt. Bonds passing both tests were defined as taxable industrial development bonds (IDBs). Exemptions from these two tests, known as the *use of proceeds* and *security interest* tests, were granted for numerous projects, including wastewater treatment.

The 1986 Tax Reform Act redefined IDBs as public activity bonds (PABs) and reduced the percentages of the use of proceeds and security interest tests to ten percent. For example, even a *publicly* owned wastewater treatment plant serving industrial users under a contract that differed from the contract provided to the general public could end up in the PAB category if the industrial use exceeded ten percent of the plant's capacity (average industrial use is 16 percent).[42] Wastewater plants operated under contract operations by the private sector were also classified as PAB projects unless the contract life was limited to no more than five years, the private operator's compensation was not based on profit sharing and the local government had the option of terminating the contract at the end of three years without penalty.

Although the 1986 act retained the previous tax exemption for wastewater treatment plants, such projects had to comply with state volume caps that limited the amount of PABs that a state could issue to the equivalent of $50 per resident, with a minimum of $150 million allocated to each state. Unlike airports and docks, which are excluded from volume caps, wastewater treatment facilities must compete with other projects such as multifamily housing and student loans for the limited amount of tax-exempt financing available under the cap.

A report prepared for the EPA's Office of Wastewater Enforcement and Compliance contended that restrictions on private wastewater treatment contracts by the 1986 Tax Reform Act might "prevent the parties involved from negotiating a contract which is more cost effective for the local government."[42] As a result of these tax law changes, private involvement since 1986 more often takes the form of a turnkey agreement with a private O&M contract.

Several proposals have been made to modify or reclassify bond legislation to provide communities with greater flexibility. The Anthony Commission — an ad hoc Congressional committee established by Representative Beryl Anthony in 1988 to study the effects of the 1986 Tax Reform Act on the municipal bond market — recommended the creation of tax-exempt public-activity bonds that could be used to finance privately owned and operated wastewater plants. The commission's proposals extended the allowable operation contract length from five years to the facility's economically useful life, but prevented private owners or operators from taking any cost recovery deductions.[43] In 1991, Senator Pete Domenici introduced federal legislation to create infrastructure bonds for environmental infrastructure projects that would exempt such projects from volume caps and allow accelerated depreciation. The EPA's Environmental Financial Advisory Board recommended a similar approach for environmental facilities mandated by federal law.

In November 1993, legislation to remove an impediment to private investment in municipal wastewater treatment plants was introduced in Congress by Senator Frank Lautenberg (S. 1681) to amend the FWPCA to permit some privately owned public treatment plants to be treated as publicly owned treatment plants. Because privately owned treatment works generally must meet more onerous treatment requirements (by providing uniform

regulatory treatment), the act could help attract private investment to municipal facilities.

Two privatized wastewater treatment plants built before the tax-law change are located in Auburn, Alabama. Auburn was low on the state list to receive funding through the CGP even though both of the city's wastewater treatment plants were operating at capacity and were having trouble maintaining effluent quality.[6] Auburn is typical of many towns in that it waited years to receive federal money, only to find that it had to build plants without federal assistance. After 12 years of waiting for the federal grant, Auburn finally decided to investigate the privatization option to finance two new plants with specially issued bonds. An engineering and consulting firm was hired to design, construct, operate and own the new plants. Although the firm was not solely responsible for the financing, it did contribute $10 million in equity to reduce outstanding debt and debt-service payments. In return for its involvement, the consultant received the benefits of the favorable tax laws and the city's previous wastewater employees were all trained and offered positions in the new plants. The city expects to save $25 million over the life of the 25-year contract.

In 1993, the EPA selected wastewater treatment plants in three cities (Franklin, Ohio; Indianapolis, Indiana; and, Silverton, Oregon) as pilot projects to test privatization under Executive Order 12803. The April 1992 order established federal policy in favor of requests by state and municipal governments to sell or lease infrastructure enterprises that had received federal grants, explicitly including wastewater treatment plants. By allowing local governments to reimburse the federal treasury for only the undepreciated portion of federal grant financing (and not the entire amount), the order removed an important impediment to privatization.

A private firm has offered to buy one of the pilot projects, the Franklin (Ohio) Area Wastewater Treatment Plant. Under a 20-year service agreement, the firm would maintain constant inflation-adjusted rates and charge a negotiated fee to the municipality, which would collect customer fees. The original cost less depreciation value for the plant is $6.8 million, which is close to the transfer price of $6.1 million that the contractor will have to pay to service the four-million-gallon-per-day plant's debt and cap the rates at their present levels. The transfer is expected to be completed by mid-summer 1994.

Privatization & Performance. The various benefits of privatization result from the clear identification of responsibility and accountability, which accompanies private-sector involvement, and from incentives naturally arising in a competitive environment that encourage efficient construction and operation. *Clear assignments of responsibility are linked to accountability through a privatization contract.* In an extensive study of capital-intensive privatization, John G. Heilman and Gerald W. Johnson concluded that privatization shifts "[a]ccountability mechanisms . . . from traditional local political processes to the contract and to the ongoing partnership between the privatizer and the authority."[44]

This transfer from the political process to the contractual setting places the provision of wastewater treatment in a competitive environment where private firms continuously compete to be the best provider of a community's needs. It also removes the day-to-day responsibility for protecting the community's wastewater needs from public officials and places it with the private sector, where it is protected by a partnership contract and legal enforcement.

Under a proper privatization contract for design, construction and O&M, the responsibilities of both parties are clearly defined. The municipality knows what it can expect from the private firm and the private firm knows what it must do to fulfill the contract. In addition to responding to the threat of legal action such as contract termination or financial penalties for poor performance, the private sector must also respond to financial constraints. Not only does the private firm realize that lack of funding will not be an acceptable excuse for noncompliance, but the private firm has an incentive to perform the service at the least possible cost while still meeting the terms of the contract. If a firm fails to operate an efficient plant, it may lose its business to one that does.

Clear assignments of responsibility, combined with proper accountability, can ensure

that incentives exist for proper performance. In the federal-funding environment, incentives exist that encourage noncompliance. These incentives encouraged the pursuit of lower local O&M expenditures, federal grant funds and new MWTPs for the purpose of improving local economic conditions. Since local governments were not held accountable for improperly designed plants, there were few incentives to seek proper performance and compliance with NPDES effluent permits. If it is not possible to identify and hold accountable those responsible for poor compliance, such incentives will remain a tempting course of action for local governments.

Privatization also provides incentives that encourage the constant pursuit of improved wastewater treatment technology. Economist John Donahue has noted that the benefits of innovation are not only related to improved responsibility and accountability for risks and profits:[45]

> *For a municipal agency, the potential* payoff *for innovation is limited to whatever lower costs or higher quality can be achieved within the city limits. Except in the biggest cities, it seldom makes sense for public works departments to make large investments in innovation. A private contractor, however, can claim proprietary rights to innovations, diffuse new methods through its operations, and use technological advances as a competitive edge to expand its market.*

Privatization provides a strong incentive for firms to develop improved treatment technologies and operation methods because the firm that does not constantly struggle to improve will be forced out of the market by others pursing improvements for their own benefit. Thus, privatization captures the benefits produced by competition and provides these benefits to the local government that remains protected from the risks of research and development by the privatization contract.

The avoidance of costly regulations and restrictions that accompany private involvement in providing wastewater treatment fosters another benefit. Removing many of the federal restrictions governing wastewater treatment construction places the municipality and the private sector into a partnership where both sides seek similar goals. Heilman and Johnson note that involvement of the EPA "introduces the at least partially competing values of the regulatory process."[44]

For example, competing values may encourage the EPA to compensate a community and its design engineers for regulatory burdens by approving expensive treatment plant designs. In addition, by fostering incentives that made it desirable not to comply with clean water regulations, the CGP discouraged local governments from improving wastewater treatment capacity and performance.

In the area of design and construction, the differences between competing goals and complementary goals is clear. O'Toole studied two plants in the same town — one CGP grant-funded and one privatized. He found that in a public setting "designers tend to view change order requests as a challenge to the quality of the original design and thus seek to defend their turf."[46] In comparing the contracting costs of two plants, O'Toole notes that "substantial transaction costs were accrued in negotiations with the grant-funded designer. However, in the privatized case, the builder and the designer had complementary incentives and early agreement was reached."

Privatization also avoids the necessity of regulatory and municipal reviews of design changes. Such reviews are conducted to ensure that changes meet federal quality and funding eligibility requirements. In a grant-funded setting these reviews can take weeks or even months. Privatization avoids design change delays while shifting responsibility for quality assurance and cost control from the regulatory agency to contractual guarantees.

If the construction and the financing aspects of the partnership are not connected to federal funds, federal rules and regulations attached to grant funds can be avoided. When money was in grant form it was easier to comply with such standards since someone else was paying for the majority share. But now myriad regulations including bidding procedures and pay scales significantly raise the cost of securing funding.

Restrictions that accompany federal funding include the Davis-Bacon Wage Act, which re-

quires that all workers on federally funded projects receive the prevailing wage rates of the area. O'Toole notes that this policy reduces wage competition and drives up the cost of construction. As a result of protests by construction firms, the Department of Labor reduced prevailing wage rates in 1983. For one treatment plant bid alone, the estimated savings from reducing the wage rates by an average of 35 percent was $300,000 to $500,000 or almost 13 percent of total job costs.[47]

Summary

Clearly, federal policy has had an impact on the effectiveness of municipal wastewater treatment. If the goal of these policies has been clean water, these policies have not always attained that goal (no matter their intent). For federal policy to be truly effective, it would need to integrate the following:

- Environmental and fiscal policy must be coordinated so that activities engaged in one policy arena would not be negated by the other.
- Goals and pollutant limits should be clearly stated, but the means to achieve them left up to states and communities.
- Fiscal policies should not narrow the range of solutions that should be available to communities — and allow for innovative solutions.

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REFERENCES

1. U.S. EPA, *Enforcement Four Year Strategic Plan: Enhanced Environmental Enforcement for the 1990s*, February 1991.

2. Robertson, J., "Municipal Compliance With the Clean Water Act," *West Virginia Law Review*, Vol. 90, 1987.

3. U.S. EPA, *1992 Needs Survey Report to Congress*, September 1993.

4. U.S. EPA, *Public-Private Partnerships for Environmental Facilities: A Self-Help Guide for Local Governments*, May 1990.

5. U.S. EPA, *Paying for Progress: Perspectives on Financing Environmental Protection*, Fall 1990.

6. U.S. EPA, *Public-Private Partnership Case Studies: Profiles of Success in Providing Environmental Services*, September 1989.

7. "Survey Predicts 33 Percent Municipal Compliance With 1977 Deadline," *Journal of the Water Pollution Control Federation*, Vol. 49, 1977.

8. U.S. EPA, *Interim National Municipal Policy and Strategy for Construction Grants, NPDES Permits, and Enforcement Under the Clean Water Act*, September 1978.

9. U.S. GAO, *Wastewater Dischargers Are Not Complying With EPA Pollution Control Permits*, 1983.

10. "Cities Toe the Line on Wastewater Rules," *ENR*, Vol. 220, 1984.

11. Truitt, R., "Noncompliant POTWs Can Minimize Penalties With a Proactive Strategy," *WATER/Engineering & Management*, Vol. 135, 1988.

12. U.S. GAO, *State Revolving Funds Insufficient to Meet Wastewater Treatment Needs*, 1992.

13. Chou, L., & Carter, K.B., "The Enforcement Dilemma," *Journal of the WPCF*, Vol. 56, 1984.

14. Gilbert, W.G., "Relation of Operation and Maintenance to Treatment Plant Efficiency," *Journal of the WPCF*, Vol. 48, 1976.

15. U.S. EPA, *Clean Water: Report to Congress 1973-1974*, 1975.

16. Hegg, R.A., *et al.*, *Evaluation of Operation and Maintenance Factors Limiting Municipal Wastewater Treatment Plant Performance: Phase II*, U.S. EPA, Municipal Environmental Research Laboratory, August 1980.

17. U.S. EPA, *Handbook: Identification and Correction of*

Typical Design Deficiencies at Municipal Wastewater Treatment Facilities, April 1982.

18. Jondrow, J., & Levy, R.A., "The Displacement of Local Spending for Pollution Control by Federal Construction Grants," *American Economic Review*, Vol. 74, No. 1-2, 1984.

19. U.S. EPA, *Partners Rebuilding America: Public-Private Partnerships in Wastewater Finance*, May 1993.

20. U.S. Comptroller General, *Multibillion Dollar Construction Grant Program: Are Controls Over Federal Funds Adequate?*, 1977.

21. U.S. GAO, *EPA's Construction Grant Program—Stronger Financial Controls Needed*, 1978.

22. U.S. GAO, *Costly Wastewater Treatment Plants Fail to Perform as Expected*, 1980.

23. U.S. President, *Water Quality Act of 1987—Veto Message on H.R. 1*, January 1987.

24. Clark, R.H., "Developing Operating Budgets for New Small Municipal Wastewater Treatment Facilities," *Cost Engineering*, Vol. 28, No. 8, August 1986.

25. Hegg, R.A., *et al.*, "Achieving Wastewater Compliance With Reduced Grant Support," *Journal of the WPCF*, Vol. 56, September 1984.

26. U.S. EPA, *A Preliminary Report to Congress on Training for Operators of Municipal Wastewater Treatment Plants*, 1984.

27. "City Victim of Technology," *ENR*, Vol. 212, No. 16, 1984.

28. Reed, K.S., & Young, C.E., "Impact of Regulatory Delays on the Cost of Wastewater Treatment Plants," *Land Economics*, Vol. 59, No. 1, 1983.

29. WPCF Plant Operations Committee, "Criteria for Project Performance Certification," *Journal of the WPCF*, Vol. 60, No. 1, 1989.

30. Starr, B.L., *Funding Wastewater Treatment Facilities: The Complete Guide to the New State Revolving Fund Program*, 1988.

31. U.S. EPA, *SRF Final Report to Congress*, October 1991.

32. WEF, "Financing Water Quality Improvements," in *Recommendations for the Reauthorization for the Clean Water Act*, April 19, 1991.

33. Johnson, G.W., & Heilman, J.G., "Metapolicy Transition and Policy Implementation: New Federalism and Privatization," *Public Administration Review*, Vol. 47, 1987.

34. Jensen, L., "Facing the Challenge," *American City & Country*, September 1984.

35. O'Toole, L.J., "Goal Multiplicity in the Implementation Setting: Subtle Impacts and the Case of Wastewater Treatment Plant Privatization," *Policy Studies Journal*, Vol. 18, 1989.

36. Girouard, R.J., & Phillips, D.L., "Contract Operations Save Over $1 Million," *Public Works*, Vol. 116, 1985.

37. James, K.R., "Turnkey Treatment Plant Upgrade," *Public Works*, Vol. 119, 1989.

38. Guzek, R.S., "The Economics of Privatizing Wastewater Treatment Facilities," *The Privatization Review*, Summer 1990.

39. Lick, D.M., & Maier, T.E., "Michigan Public-Private Partnerships," *PM*, March 1990.

40. Hurley, J.M., "Developer Financing of Public Wastwater Service Infrastructure," *Journal of the WPCF*, Vol. 60, No. 5, May 1988.

41. Watson, D.J., & Vocino, T., "Changing Intergovernmental Fiscal Relationships: Impact of the 1986 Tax Reform Act on State and Local Governments," *Public Administration Review*, July/August 1990.

42. Smith, J.N., & Lyman, M.S., *Legal and Regulatory Barriers to Private Investment in Sewage Treatment Facilities*, prepared for the U.S. EPA, February 1992.

43. Spain, C.L., "GFOA Says Problem Persists: How to Define Tax-Exempt State, Local and Government Bonds," *The Bond Buyer*, March 1, 1993.

44. Heilman, J.G., & Johnson, G.W., *A Feasibility Study of the Privatization of Public Wastewater Treatment Works*, prepared for the U.S. Geological Survey, January 1989.

45. Donahue, J.D., *The Privatization Decision*, Basic Books: New York, 1989.

46. O'Toole, L.J., "Alternative Mechanisms for Multiorganizational Implementation: The Case of Wastewater Management," *Administration and Society*, Vol. 21, No. 3, 1989.

47. "Wage Protest Cuts Job's Cost 13%," *ENR*, October 13, 1983.