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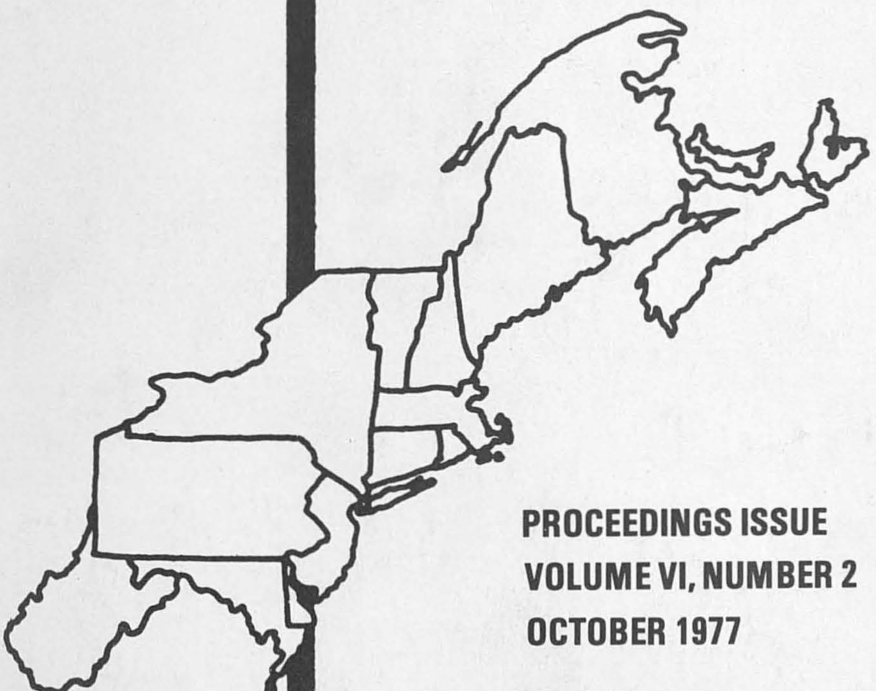

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Impact of Wastewater Treatment Regulations on Rural Communities*

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Federal and state laws require all communities to construct and operate facilities to treat domestic sewage. The 1972 Amendments to the Federal Water Pollution Control Act (P.L. 92-500) require that all facilities provide the "best practical treatment" by 1977. They established the goal of "best available treatment" by 1983. The U.S. Environmental Protection Agency (EPA) defines best practical treatment as secondary treatment. It is the premise of this paper that required treatment levels and cost sharing arrangements specified in the current wastewater treatment laws impose relatively greater economic costs on small rural communities than on larger communities.

Two recent popular articles demonstrate the potential impact of the current regulations on the economic well-being of rural communities. The Pennsylvania Supreme Court ruled that Ramey, Pennsylvania must construct and operate a sewage treatment facility. The assessed valuation of real property in the community is $400,000[1/], while the cost of constructing the proposed sewage treatment facility is estimated to be $1.3 million (1). The Wall Street Journal reports that Walton, N.Y. (pop. 3,744) is under a federal mandate to construct a sewer system and a sewage treatment plant at a cost of $9 million (3). In addition to a $200 per residence sewer connection fee, debt service and operating costs for the treatment facility will result in a 30 percent increase in the town's operating budget.

To offset the impact of system costs and to account for the public goods nature of wastewater treatment, the federal government and most state governments provide subsidies for construction of municipal wastewater treatment facilities. Title II of P.L. 92-500 authorized the EPA to provide a subsidy to cover up to 75 percent of the costs of constructing sewage treatment facilities. Only those items which are integral parts of the treatment process are eligible for 75 percent grants. Rural communities (less than 10,000 population) not qualifying for EPA grants can receive a subsidy for up to 50 percent of construction costs from the Farmers Home Administration (P.L. 92-419). Individual communities cannot receive federal grants in excess of 75 percent of construction costs. Many states provide an additional 10 to 15 percent subsidy for construction costs.

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* Comments by Donald Epp and Frank Goode of The Pennsylvania State University and Lee Christensen of the Economic Research Service were very helpful.

1/ In Pennsylvania assessed valuation is not necessarily equal to appraised value. In fact it is likely to be less than appraised value. Data on appraised value is not available.

Subsidies for construction costs only tend to bias communities toward selection of capital intensive treatment technologies, which are not necessarily the least cost treatment alternative from a national perspective. Marshall and Ruegg (2) argue that the existing system of subsidies often biases nonfederal interests against selection of the least-cost combination of treatment techniques from a national perspective when faced with a budget constraint and/or a given standard of abatement. They conclude that federal sharing of all costs equally will eliminate the bias. Elimination of the bias towards capital intensive treatment techniques would result in a greater degree of abatement per dollar spent on pollution control.

The current wastewater treatment regulations have an additional impact on rural communities. Namely, existing requirements for wastewater treatment favor larger communities over smaller ones due to higher per unit treatment costs in small communities. To provide an equal impact on all communities, Federal subsidies would have to provide more grant monies per capita to small communities than larger ones to equalize treatment costs. Smaller communities incur greater per unit costs which are not offset by available subsidies for wastewater treatment. This analysis examines the economies of size in wastewater treatment, the impact of existing cost sharing arrangements, and alternative solutions for reducing the costs to rural communities. The impact of wastewater treatment regulations on rural communities is not measured. Rather, a problem which policy makers need to contemplate when promulgating regulations such as P.L. 92-500 is identified.

Economies of Size

Average wastewater treatment costs fall as facility size increases for a given degree of wastewater treatment. Several recent studies demonstrate the economies of size in wastewater treatment costs. Two Environmental Protection Agency studies (4, 8) provide cost estimates for wastewater treatment processes. Pound, Crites, and Smith (5) compare various treatment alternatives as does another study by Young and Carlson (9). Young (10) examines the impact of variations in input costs on the costs of land treatment of wastewater.

The economies of size relationships in wastewater treatment unit processes are illustrated in Table 1. Each of the treatment techniques illustrated in Table 1 exhibits large decreases in per unit costs as facility size increases.[2/] Average treatment costs for a 0.5 million

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2/ Table 1 is not meant to list all treatment alternatives. It is to be used to illustrate relative differences in costs rather than absolute differences. Care should be exercised in comparing the treatment techniques listed in Table 1. Different combinations of the treatment processes listed will result in different effluent qualities. For example, aerated lagoons produce a poorer quality of effluent than either activated sludge or trickling filter treatment. Also it is unlikely that aerated lagoons will be used prior to an advanced treatment technique other than land application.

Table 1

AVERAGE UNIT PROCESS WASTEWATER TREATMENT COST FOR VARIOUS FACILITY SIZES (1973 DOLLARS)[a/]

Treatment Technique	Type of Cost	Facility Size (millions of gallons per day) 0.1	0.5	1.0	5.0	10.0
		- - -	Cents per 1000 gallons		- - -	
Primary:						
Sedimentation	O&M[b/]	32.0	14.0	10.0	5.5	4.1
	Capital[c/]	30.5	14.3	10.7	5.0	2.8
	Total	62.5	28.3	20.7	10.5	6.9
Secondary:						
Trickling filter	O&M	19.5	9.0	6.6	3.9	2.8
	Capital	32.7	15.4	11.4	6.0	4.3
	Total	52.2	24.4	18.0	9.9	7.1
Activated Sludge	O&M	43.6	17.5	12.0	6.1	4.4
	Capital	33.4	17.5	12.2	6.8	4.9
	Total	77.0	33.0	24.2	12.9	9.3
Aerated lagoon	O&M	24.1	11.9	5.9	2.3	1.7
	Capital	22.2	6.8	4.5	2.2	1.7
	Total	46.3	18.7	10.4	4.5	3.4
Tertiary:						
Nitrification	O&M	X[d/]	8.3	6.0	2.8	2.2
	Capital	X	6.9	5.0	2.7	2.4
	Total	X	15.2	11.0	5.5	4.6
Nitrification, denitrification	O&M	X	15.2	11.3	5.9	4.9
	Capital	X	12.6	9.1	4.7	4.0
	Total	X	27.8	20.4	10.6	8.9
Lime addition, filtration, sludge recalcination	O&M	X	31.0	26.3	14.5	12.3
	Capital	X	44.8	35.3	20.8	13.8
	Total	X	75.8	61.6	35.3	26.1
Lime addition, filtration, sludge recalcination, ion exchange	O&M	X	41.8	35.6	20.9	17.7
	Capital	X	50.3	40.0	24.3	17.0
	Total	X	92.1	75.6	45.2	34.7
Land application via solid set irrigation	O&M	17.9	11.9	8.4	7.0	6.6
	Capital	115.4	49.0	38.8	29.2	27.7
	Net crop revenue	(10.6)	(10.6)	(10.6)	(10.6)	(10.6)
	Total	122.7	50.3	36.6	25.5	23.7

[a/] The cost estimates are based on information provided by references (4) and (8).

[b/] Operation and maintenance costs.

[c/] Assumes that the discount rate is 5-5/8 percent and the discount period is 20 years.

[d/] Insufficient data is available to extrapolate to this facility size. It is unlikely that this type of treatment process can be constructed and operated by small communities.

gallons per day (mgd) treatment facility[3/] are 2-1/2 to 3 times higher than the costs for a 10 mgd treatment facility. Therefore, requiring uniform levels of treatment for all communities imposes higher per unit costs on smaller communities.

Increasing the degree or level of treatment for a given facility size increases average costs. An increase in the level of treatment can be thought of as adding a secondary treatment process, such as a trickling filter or activated sludge process, to a primary sedimentation facility. For instance, a 1 mgd secondary treatment facility consisting of an activated sludge unit following primary sedimentation would cost 44.9¢/1,000 gallons. Additional treatment can be obtained by adding an advanced treatment technique, such as land application, to the secondary treatment facility. When higher treatment levels are required, the economies of size relationships illustrated in Table 1 indicate that the absolute cost differences between various sizes of communities increase. For example, the addition of an advanced treatment process providing for nitrification-denitrification costs the 1 mgd facility an additional 20.4¢/1,000 gallons or a total of 65.3¢/1,000 gallons of wastewater treatment. A similar 10 mgd facility would cost 25.1¢/1,000 gallons (8.9 + 9.3 + 6.9) or 40.2¢/1,000 gallons less than the smaller 1 mgd facility.

Existing Cost-Sharing Arrangements

Subsidies are available to offset a portion of wastewater treatment plant construction costs. EPA will cover 75 percent of construction costs, or the Farmers Home Administration will pay for 50 percent of construction costs. The net treatment costs to the local community without a subsidy and at the two subsidy levels are shown in Table 2. Even with subsidies, smaller communities continue to pay substantially higher per unit costs for wastewater treatment than larger communities. With a 50 percent capital subsidy, the average costs of an activated sludge unit process to the local community for a 0.5 mgd facility decrease from 33¢/1,000 gallons to 26.2¢/1,000 gallons. With a 75 percent subsidy they decline to 21.9¢/1,000 gallons. For a 5.0 mgd facility, local average costs are reduced from 12.9¢/1,000 gallons to 9.5¢/1,000 gallons with a 50 percent subsidy for capital costs and to 7.8¢/1,000 gallons with a 75 percent subsidy. The construction subsidies reduce the per gallon costs more for the 0.5 mgd treatment facility than for the 5.0 mgd treatment facility. The costs to the 0.5 mgd facility decline by 11.1¢/1,000 gallons with a 75 percent capital subsidy while the costs to the 5.0 mgd facility fall by 5.1¢/1,000 gallon treatment costs (21.9¢ for the 0.5 mgd facility versus 7.8¢ for the 5.0 mgd facility).

3/ Assuming that one person generates 100 gallons of wastewater per day, 10,000 people will generate 1 mgd. The inclusion of industrial wastes will reduce the community size associated with a particular wastewater flow. The analysis assumes that the wastewater originates from domestic sources. If industrial wastes which can be treated jointly with domestic sewage are present, small communities will benefit from treatment economies of size and local treatment costs will be lower.

Table 2

AVERAGE UNIT PROCESS TREATMENT COSTS FOR VARIOUS FACILITY SIZES WITH A CAPITAL SUBSIDY (1973 DOLLARS)[a]

Treatment Technique	Capital Subsidy Level (Percent)	Facility Size (millions of gallons per day) 0.1	0.5	1.0	5.0	10.0
		(¢/1000 gallons)				
Primary: Sedimentation	0	62.5	28.3	20.7	10.5	6.9
	50	47.3	21.2	15.4	8.0	5.5
	75	39.6	17.6	12.7	6.8	4.8
Secondary: Trickling filter	0	52.2	24.4	18.0	9.9	7.1
	50	35.8	16.7	12.3	6.9	5.0
	75	27.7	13.4	9.4	5.4	3.9
Activated Sludge	0	77.0	33.0	24.2	12.9	9.3
	50	60.3	26.2	18.1	9.5	6.8
	75	52.0	21.9	15.0	7.8	5.6
Aerated lagoon	0	46.3	18.7	10.4	4.5	3.4
	50	35.2	15.3	8.2	3.4	2.6
	75	29.6	13.6	7.0	2.8	2.1
Tertiary: Nitrification	0	X[b]	15.2	11.0	5.5	4.6
	50	X	11.8	8.5	4.2	3.4
	75	X	10.0	7.2	3.5	2.8
Nitrification, denitrification	0	X	27.8	20.4	10.6	8.9
	50	X	21.5	15.8	8.2	6.9
	75	X	18.4	13.6	7.1	5.9
Lime addition, filtration, sludge recalcination	0	X	75.8	61.6	35.3	26.1
	50	X	53.4	43.8	24.9	19.2
	75	X	42.2	35.1	19.7	15.8
Lime addition, filtration, sludge recalcination, ion exchange	0	X	92.1	75.6	45.2	34.7
	50	X	67.0	55.6	33.0	26.2
	75	X	54.4	45.6	27.0	22.0
Land application via solid set irrigation	0	122.7	50.3	36.6	25.6	23.7
	50	65.5	25.8	17.2	11.0	9.8
	75	36.2	13.6	7.5	3.7	2.9

[a] The cost estimates are developed from data presented in Table 1.

[b] Insufficient data is available to extrapolate to this facility size. It is unlikely that this type of treatment process can be constructed and operated by small communities.

Although the capital subsidies reduce per unit treatment costs more for smaller communities than for larger communities, direct examination of Table 2 does not reveal whether the subsidies provide a greater percentage reduction in local treatment costs for small or large facilities. The impact of the capital subsidies on relative costs can be determined by examining the percentage of total costs paid by the local community (Table 3). The data in Table 3 indicate that the level of subsidy has little effect on the local percentage of total costs. None of the local percentages of total costs vary by more than 5 percent with the exception of land application which falls by 10 percent as facility size increases. As facility size increases the local percentages rise for four of the treatment alternatives: primary sedimentation, trickling filters, lime addition and lime addition followed by ion exchange. Local percentage shares fall as facility size increases for activated sludge, aerated lagoons, nitrification, and land application. Local percentage shares are relatively constant for nitrification-denitrification.

Analysis of the local percentage shares of average costs indicates that the current subsidy arrangements can cover approximately the same share of total costs regardless of community size. To determine whether or not the capital subsidy actually reduces the impact on smaller communities, one would need to compare total expenditures on wastewater treatment to subsidized expenditures for a range of community sizes. To conclude that the subsidy reduces the impact of the regulations on smaller communities, subsidized expenditures would have to cover a greater proportion of treatment costs for smaller communities than for larger communities. Construction grants for wastewater treatment facilities awarded under P.L. 92-500 are presented by community size categories in Table 4. Comparable data on total expenditures are unavailable as the EPA only records grant expenditures and does not maintain records on total expenditures for wastewater treatment.

Some indication of the impact of the current subsidy program can be derived from a comparison of the population distribution of communities and construction grant awards (Table 4). Small communities (less than 5,000 people) have received less from the construction grants program than larger communities (greater than 25,000 people). Communities with a population less than 5,000, 12 percent of the urban population, received 9 percent of the dollars awarded for construction grants, while communities with populations in excess of 25,000, which contain 67 percent of the urban population, received 72 percent of the grant monies. Fifty-seven percent of the construction grants (Table 4) were awarded to communities with less than 5,000 people, the population category of 82 percent of the communities (Table 4). Communities larger than 25,000 people, 5 percent of all communities, received 19 percent of the awards.

The construction grants program does not offset the inequality of the higher per unit treatment costs which smaller communities must pay to comply with wastewater treatment requirements. For the grants program to reduce the impact of economies of size demonstrated in Table 1, small communities would have to receive more per capita of the grant monies than larger communities. The data in Table 4 demonstrates that small communities receive less than larger communities, indicating that the current subsidy programs do not reduce the negative effects suffered by the smaller communities due to P.L. 92-500.

Table 3

PERCENT OF ANNUAL UNIT PROCESS TREATMENT COSTS PAID

BY THE LOCAL COMMUNITY FOR TWO SUBSIDY LEVELS

Treatment Technique	Capital Subsidy Level (Percent)	Facility Size (millions of gallons per day)				
		0.1	0.5	1.0	5.0	10.0
Primary:						
Sedimentation	50	75.7	74.9	74.4	76.2	79.7
	75	63.4	62.2	61.4	64.8	69.6
Secondary:						
Trickling filter	50	68.6	68.4	68.3	69.7	70.4
	75	53.1	54.9	52.2	54.5	54.9
Activated sludge	50	78.3	79.4	74.8	73.6	73.1
	75	67.5	66.4	62.0	60.5	60.2
Aerated lagoon	50	76.0	81.8	78.8	75.5	76.5
	75	63.9	72.7	67.3	62.2	61.8
Tertiary:						
Nitrification	50	X[a/]	77.6	77.3	76.4	73.9
	75	X	65.8	65.4	63.6	60.9
Nitrification, denitrification	50	X	77.3	77.4	77.4	77.5
	75	X	66.2	66.7	67.0	66.3
Lime addition, filtration, sludge recalcination	50	X	70.4	71.1	70.5	73.6
	75	X	55.7	57.0	55.8	60.5
Lime addition, filtration, sludge recalcination, ion exchange	50	X	72.7	73.5	72.4	75.5
	75	X	59.1	60.3	59.7	63.4
Land application via solid set irrigation	50	53.4	51.3	47.0	43.0	41.4
	75	29.5	27.0	20.5	14.4	12.2

[a/] Insufficient data is available to extrapolate to this facility size. It is unlikely that this type of treatment process can be constructed and operated by small communities.

Table 4

DISTRIBUTION OF CONSTRUCTION GRANTS FOR WASTEWATER TREATMENT WORKS AWARDED UNDER

P.L. 92-500 COMPARED TO THE DISTRIBUTION OF URBAN POPULATION

Community Size	Urban population[a/]		Dollars awards[b/]		Awards[b/]		Communities[a/]	
	Number (millions)	Percent	Amount (millions)	Percent	Number	Percent	Number	Percent
Less than 2500	9.7	7	458	6	2,263	43	13,237	72
2501-5000	6.7	5	254	3	749	14	1,911	10
5001-10000	9.8	8	480	6	621	12	1,397	7
10001-25000	17.6	13	1,014	13	649	12	1,134	6
25001-50000	15.7	12	898	11	319	6	453	3
More than 50,000	72.6	55	4,897	61	697	13	384	2
Total	132.2	100	8,044	100	5,303	100	18,516	100

[a/] Source: (6)

[b/] Source: (7)

Reducing the Costs to Rural Communities

It has been shown that existing subsidy arrangements do not reduce the inequities of sewage treatment regulations on rural areas. Two suggested approaches for reducing the inequity of sewage treatment regulations for small communities are: requiring less wastewater treatment in rural areas when possible or relating the federal share of total costs to community size or income.

The cost of wastewater treatment for small communities can be reduced by tailoring the required level of treatment to local water quality conditions. In many regions of the United States small discharges of partially treated wastes will not have a significant effect on the environment. The volume of water in receiving streams is relatively large compared to the population density so the streams can assimilate more wastes. An aerated lagoon system can be substituted for activated sludge or trickling filter facilities.[4/] Septic tanks can be used rather than using a centralized treatment system.[5/] Under existing cost sharing regulations individual septic tanks are not eligible for subsidies,[6/] while centralized collection and treatment systems are eligible. Conversely, some rural communities will need to treat their wastes to a high degree since they are located in environmentally sensitive areas.

An alternative solution is a transfer of additional resources to rural communities using subsidies. If society imposes demands for advanced levels of treatment on rural communities, it may elect to share a larger proportion of treatment costs. The failure of existing cost-sharing formulas to reduce the impact on rural communities is discussed in the previous section. The subsidy could increase as community size and/or per capita income decrease. The subsidy could cover up to 100 percent of construction costs and some proportion of operation and maintenance costs. An expensive treatment facility is useless if the local community cannot afford to operate it. For example, O&M costs for activated sludge treatment following primary sedimentation for a 0.5 mgd facility are 21.5¢/1,000 gallons, while for a similar 10 mgd facility total costs are 16.2¢/1,000

4/ Aerated lagoons provide a similar degree of treatment to activated sludge and trickling filter systems except that they discharge more suspended solids.

5/ Collection costs have not been included in the analysis. Collection costs may increase the impact on rural communities. Many rural communities do not have centralized wastewater treatment or their sewer systems are old and deteriorated, thus new collection systems may be required.

6/ Since septic tanks are used primarily in rural areas, their ineligibility for subsidies increases the relative impact of wastewater treatment regulations on rural communities. The availability of capital subsidies for centralized treatment may encourage the use of a centralized treatment system when in fact septic tanks are the least cost treatment method for the region.

gallons (Table 1). Thus, with a 100 percent capital subsidy, treatment operation costs for the 0.5 mgd facility are higher than the unsubsidized costs for the 10 mgd facility. If the 10 mgd facility receives a 75 percent capital subsidy, local costs are 10.4¢/1,000 gallons (Table 3). For the smaller facility to have similar local treatment costs, a 100 percent capital subsidy and a 50 percent subsidy for O&M costs is required.

As with any subsidy program, care should be exercised to ensure that least-cost treatment facilities are constructed. The cost-sharing arrangement chosen should not encourage construction of a multitude of small treatment plants. Treatment plant size within a region should be determined so as to minimize the sum of treatment and collection costs.

Summary

The analysis identifies the equity implications of the current wastewater treatment law (P.L. 92-500) which need to be considered when similar types of regulations are developed. Requiring rural communities to achieve high levels of wastewater treatment results in significant cost burdens on rural communities due to higher per unit treatment costs. Average treatment costs for a 0.5 mgd treatment facility are 2-1/2 to 3 times higher than the costs for a similar 10 mgd facility.

Existing capital subsidies for treatment plant construction fail to offset the inequities to rural communities. If all communities receive subsidies, smaller communities will receive a greater absolute cost reduction, although the percentage of total costs borne by the local community are relatively constant between facility sizes (Table 3). Examination of EPA grant awards under P.L. 92-500 reveals that larger facilities have received a greater proportion of the grant monies than their proportion of total population would indicate. When economies of scale enter the analysis the impact on rural communities of the grant allocations is magnified.

The equity impact of P.L. 92-500 on rural communities can be reduced through modifications in treatment requirements or transfers of funds to rural areas. Treatment costs for rural communities can be reduced by tailoring the required treatment level to the natural assimilative capacity of the receiving stream. This solution will not be applicable for those regions with severe water quality problems. For those communities who must treat their wastewater to secondary and tertiary levels, additional transfers of funds to rural communities is the only solution to reduce the cost burden from the requirements. Existing cost-sharing rules are shown not to reduce the relative cost differences between small and large communities for advanced wastewater treatment. A portion of operation and maintenance costs may need to be subsidized to reduce the effect on rural communities. Any subsidy arrangement which is devised must ensure that construction of less than optimal sized treatment facilities is not encouraged.

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