COST REDUCTION AND SELF-HELP HANDBOOK

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and

Office of Municipal Pollution Control
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DISCLAIMER

FORWARD

With the passage of the Clean Water Act in 1972, this nation committed itself to the construction of facilities necessary for the elimination of water pollution. Through the Construction Grants Program, the USEPA provided financial assistance to many communities to construct their wastewater facilities.

Selection of a wastewater technology should include consideration of both construction and operational costs. Although Federal and State financial assistance may be available for construction costs, operational costs are generally the responsibility of local communities.

The USEPA recognizes that some local communities may have difficulty in financing the construction and operation of wastewater facilities. This report is one of a series of guidance materials on financial management issues related to the cost-effective construction and operation of wastewater facilities. This particular report focuses on suggestions for identifying and remedying excessive cost factors involved in facilities operations.

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ABSTRACT

This report presents communities experiencing higher than expected operating costs for their wastewater facilities with a methodology to identify and reduce operating costs. This report may assist public works managers, elected officials and engineers involved in facility operational audits to more systematically identify potential problems and more fully consider possible options for reducing costs. All aspects of facility operating costs are explored. The cost reduction techniques outlined in the report can be used by communities desiring to take a comprehensive look at cost savings in all phases of operation as well as those communities interested in evaluating a particular aspect.

The recommendations and procedures in the report are based in large part upon actual field experience in fifteen communities. About half of the communities were experiencing significant cost/operational problems with their facilities. The remainder had initiated efforts to identify and implement cost reduction measures. The case study communities were selected by the contractor, the Wastewater Environmental Research Laboratory and the Office of Municipal Pollution Control based upon recommendations of EPA Regional Office operation and maintenance coordinators. An additional twenty communities were contacted by telephone. Their experiences are also reflected in this report.

The material covered in this report is summarized in a four page brochure entitled "Reducing the Cost of Operating Municipal Wastewater Facilities." The reader interested in other financial management aspects of operating wastewater facilities may be interested in a report entitled "Going All Nine Innings" which is currently in preparation by the Office of Municipal Pollution Control. It is scheduled for release in May 1987. "Going All Nine Innings" will include a summary of material from this handbook as well as other financial management topics not covered here. It is intended for a general audience.

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PART I: INTRODUCTION

DEFINING THE PROBLEM

BACKGROUND

Many small communities have been faced with serious financial burdens due to high-cost wastewater projects. These communities have found that they cannot support the cost of operating their wastewater facilities without imposing high user charges. This situation is created when actual operating costs exceed expectations or when the revenue base is less than expected. In most cases, both factors are evident to some extent.

The end result of a high-cost project can be manifested in different ways. The most obvious result is excessive user fees. However, many communities elect not to charge the high sewer rates, and either operate at a deficit or subsidize the sewer operations with revenues from water operations or the general fund. In some cases the lack of adequate revenues can lead to default on financial obligations (i.e., bonds and loans). In other cases a community may simply cut back on various operating expenses (e.g., cut staff, curtail use of chemicals) which can seriously impact plant performance.

Small communities are particularly vulnerable to the impacts of a high-cost project because of their limited financial capacity (i.e., limited revenue base and ability to carry debt). Part of the problem is related to the fact that certain wastewater technologies are simply not suited to small communities. The more sophisticated a treatment facility is, the less likely it is that a small community will be able to support the associated operating expenses (i.e., staff, chemicals, utilities, etc.). The special needs of a small community must be taken into account in the planning and design stages in order to avoid high-cost situations. It is particularly important that a community demonstrate its financial capability to operate a wastewater facility before it commits itself to implementing such a project.

The U.S. Environmental Protection Agency requires that a financial and management capability analysis be conducted before a Step 3 construction grant can be approved. This analysis, which is to be performed according to guidelines provided in the Financial Capability Guidebook,[1] must "demonstrate that the community has the legal, institutional, managerial, and financial capability to ensure construction, operation, and maintenance (including equipment replacement) of the proposed treatment system."[2] This requirement will hopefully prevent communities from implementing a construction project without fully appreciating the financial commitments involved.

There are many small communities, however, that have realized too late, after building wastewater facilities, that the cost of operating those facilities is far greater than they expected. These communities desperately need advice on how to minimize their operating costs in order to make the financial burden on the community, and on the individual users, as bearable as possible.

The U.S. EPA Wastewater Environmental Research Laboratory sponsored a research project charged with developing a cost reduction and self-help program to assist these communities. This handbook is the product of the initial project study effort. Although the primary focus of this handbook is to assist communities with existing wastewater facilities in helping themselves reduce their operating costs, the guidance offered should also be useful in identifying potential high-cost items (e.g., energy-intensive treatment processes or equipment) to be considered in planning and designing a new facility.

FACTORS CONTRIBUTING TO THE HIGH COST OF WASTEWATER OPERATIONS

The term "high-cost project" cannot be strictly quantified, since it is a relative term that must be defined somewhat subjectively for a particular situation. What may be considered excessively high cost in one community may be perfectly acceptable in another. It is totally dependent on how the community (i.e., local officials, individual users, and taxpayers) perceive the financial burden

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[1]Financial Capability Guidebook; prepared by Municipal Finance Officers Association and Peat, Marwick, Mitchell & Co. for U.S. EPA Office of Water Program Operations, March 1984.

[2]"Financial and Management Capability for Construction, Operations and Maintenance of Publicly Owned Wastewater Treatment Systems; Final Policy, 40 CFR Part 35, February 17, 1986.

placed on them. The limits defining what is a high cost and what is not are generally a function of a community's size, tax base, socioeconomic status, geographic location, and the level of existing public services provided.

Although it is difficult to quantify the limits of high cost related to the construction and operation of a municipal wastewater system, there are certain indicators of potential high cost problems. In fact, the U.S. Environmental Protection Agency suggests the use of such indicators to identify projects that have "a high probability of encountering financial difficulties."[1] Some of the suggested indicators are presented below. (Note that these are only guidelines; EPA encourages States to adopt these or develop additional indicators.)

INDICATORS OF POTENTIAL HIGH COST PROJECTS[2]

- <u>Capital Cost Per Household</u> - National figures indicate that new projects for which the total capital cost per household exceeds $6,000 are generally high cost. The figure for capital costs of sewer service is $4,000 per household.

- <u>Total Annual Cost Per Household</u> - On a national basis, projects tend to be high cost when the total annual cost per household exceeds 1.5% of median household income.

- <u>Capital Cost of Treatment Per 1,000 Gallons Per Day of Capacity</u> - When the cost of building a treatment facility exceeds $3,000 per 1,000 gallons capacity, the technology proposed may be inappropriate.

- <u>Annual Operation, Maintenance, and Replacement (OM&R) Cost Per Household</u> - When the OM&R for a project exceeds $100 per household, the treatment technology selected may be too complex for the community. Unlike capital cost, OM&R will increase in the future as labor, materials, and energy costs increase. If OM&R costs are high initially, the system is starting at a disadvantage.

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[1]Construction Grants 1985 (CG-85), Municipal Wastewater Treatment, Appendix K - Financial and Management Capability Information Sheet, EPA 430/9-84-004, U.S. EPA, July 1984.

[2]Ibid. Attachment A, Suggested Screening System Elements.

It is important to note, however, that these guidelines are intended only to provide a general indicator of potential high-cost problems, which relates primarily to the user's ability to pay. In some cases, it is impossible to provide wastewater service and not charge more than the minimum limits prescribed by EPA's expensive project criteria. This is especially true for smaller communities where the user base is too small to effectively spread out the minimum fixed costs of building and operating necessary wastewater facilities.

In such cases, the only recourse is to minimize the financial burden to the greatest extent possible by reducing costs and by increasing revenues without increasing individual user charges. This is essentially the purpose of implementing a cost reduction and self-help program. In order to accomplish this, three key cost determinant variables must be controlled: PROJECT COST, OPERATING COST, and REVENUE CAPACITY.

Project cost (i.e., the total cost of building a wastewater facility including engineering fees, legal fees, interest payments, and land cost, as well as construction cost) has a direct impact on total annual cost through debt service. Therefore, any reduction in total project cost will in effect reduce operating cost. The relative impact on overall operating cost will depend on the level of outside grant funding and the type of financing. Reducing project cost will have the greatest impact when the local share of capital cost and the interest rates on borrowed capital are high. These conditions often apply to small communities which typically have difficulty securing grant monies due to low rankings on state construction grant priority lists, and have difficulty in securing financing at reasonable interest rates due to the lack of sufficient tax and revenue base. Factors which can contribute to excessive project cost are listed below.

FACTORS CONTRIBUTING TO EXCESSIVE PROJECT COST

- Inadequate consideration of less-costly collection system alternatives.
- Inadequate consideration of cost-effective treatment technologies.
- Failure to seriously consider operational improvements or facilities upgrading versus plant expansion.
- Oversizing of facilities due to unrealistic growth projections and flow estimates.
- Designing overly-sophisticated facilities which are inherently expensive, energy intensive, and operationally complex.
- Failure to perform Value Engineering analysis.
- Failure to consider the impact of inflation on ultimate construction and operating costs.
- High debt service payments.
- Failure to seek most competitive bid possible.
- Excessive, unnecessary construction change orders.

Operating cost (i.e., the day-to-day cost of owning and operating wastewater facilities, including debt service, as well as operation and maintenance costs) has the most direct financial impact on a community, and is therefore often perceived as the root of the problem in a high-cost project. Actually, operating cost should be viewed more as a symptom of the problem rather than the cause. In order to attack the problem of high operating costs, the individual components of operating cost must be identified. Debt service is one major component of operating cost. Labor, operating expenses, outside services, and overhead are the other major costs components. These components are affected by many different factors. Some of the factors which can contribute to excessive operating costs are listed below.

FACTORS CONTRIBUTING TO EXCESSIVE OPERATING COST

- Maintaining larger operating staff than required.
- Excessive outlays for overtime pay.
- Cost of in-house administrative services (management, accounting, billing, payroll, revenue collection, etc.).
- Excessive power consumption/excessive utility charges.
- Excessive use of chemicals/failure to consider use of less expensive alternative chemicals.
- Excessive equipment repair and replacement caused by inadequate routine maintenance.
- Cost of outside services (professional services, treatment and disposal fees, etc.).
- Cost of miscellaneous expenses (rent, miscellaneous supplies, vehicle maintenance, etc.).
- Overhead expenses (fringe benefits, insurance, etc.).

Regardless of the magnitude of operating costs, there is usually no perception of a high-cost problem as long as operating revenues are sufficient to cover operating costs (provided excessive user fees are not being charged). Wastewater operations commonly rely on non-user charge revenues as well as user charges to cover operating cost. In some cases, a community may simply not have sufficient service base (i.e., service area population) to support wastewater operations without imposing unreasonable individual user charges. However, in many cases, excessive user charges can be reduced to reasonable limits by taking advantage of supplemental revenue generating capacity such as selling waste byproducts, staff service (e.g., lab analysis). Factors affecting the revenue capacity of a wastewater operation are listed below.

FACTORS CONTRIBUTING TO INSUFFICIENT REVENUE CAPACITY

- Inadequate user charge revenue base related to size of service population and individual user's ability to pay.
- Refusal of users to connect.
- Inequitable user charge system (e.g., not charging non-residential users their fair share).
- Excessive accounts receivable (delinquent user fees/payments).
- Reliance on user charge revenues alone without considering opportunities to generate supplemental income.
- Insufficient budgeting resulting in underestimation of revenue requirements.
- Failure to take advantage of investment opportunities.
- Diversion of revenues to pay for other services (e.g., water, road repair).

It can be seen that in order to deal with the problem of a high-cost wastewater operation, it is important to understand the various cost components involved, and the numerous contributing factors that can cause inefficient operations and excessive costs. Once these factors have been identified, the process of remedying a high-cost problem is relatively straightforward.

PURPOSE OF THIS GUIDEBOOK

The information provided in this handbook focuses on reducing operating costs and maximizing revenue capacity since these offer the greatest practical potential for mitigating high-cost impacts for communities with existing wastewater facilities. Specific guidance pertaining to the evaluation of project costs during the facilities planning stage is given in EPA's construction grants guidelines document CG-85.[1] Further guidance is provided by the EPA Report entitled "Planning Wastewater Management Facilities for Small Communities.[2] It is also suggested that a value engineering analysis be conducted during the design phase of a project in order to identify possible cost saving design modifications that might be implemented before proceeding with construction. Guidance on conducting value engineering studies is given in EPA's "Value Engineering for Wastewater Treatment Works."[3]

The second part of this handbook presents a methodology for conducting a cost reduction and self-help assessment. This is intended to show how a community should go about evaluating its own wastewater operation to identify cost saving opportunities which might be implemented. It is important that the reader realize that in order for such an assessment to be successful, it must be custom-tailored to suit the particular needs of the situation in question. It is recognized that a complete and comprehensive analysis is not always appropriate and, in many cases, simply cannot be afforded. The person conducting the assessment must concentrate on those items which offer significant cost-saving potential, and for which cost-saving measures can be practically implemented with reasonable investments of time and money. The purpose of the methodology presented in Part II is to help identify those areas where the greatest cost-saving potential exists.

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[1]Construction Grants 1985 (CG-85), Municipal Wastewater Treatment; Section 7.3, Demonstration of Financial Capability and Appendix K, Financial and Management Capability Information Sheet, EPA 430/9-84-004, U.S. EPA, July 1984.

[2]Planning Wastewater Management Facilities for Small Communities, EPA-600/8-80-030, U.S. EPA, August 1980.

[3]Value Engineering for Wastewater Treatment Works, EPA 430/9-84-009, U.S. EPA, September 1984.

The third and final part of the handbook presents specific guidelines pertaining to different methods of reducing operating costs and improving revenue capacity. These guidelines are presented in the form of cost reduction options, which are intended to illustrate the use of specific cost-saving techniques, as well as define the broad range of approaches to reducing the financial impact of wastewater operations. The intent is not to provide an all inclusive list of options, but rather to stimulate cost-saving ideas on the part of facility operators and wastewater system managers which suit their own particular situations. Specific references are cited throughout the handbook to provide further sources of information pertaining to the various methods and techniques discussed.

The handbook is meant to serve as an initial reference on the subject of reducing the cost of operating wastewater facilities. The reader must rely on his own knowledge and judgment, and that of his staff and outside consultants in applying these guidelines to develop a workable plan suiting his particular situation. The reader is encouraged to seek technical assistance and advice from the appropriate state water pollution control agency and EPA regional office.

PART II: METHODOLOGY

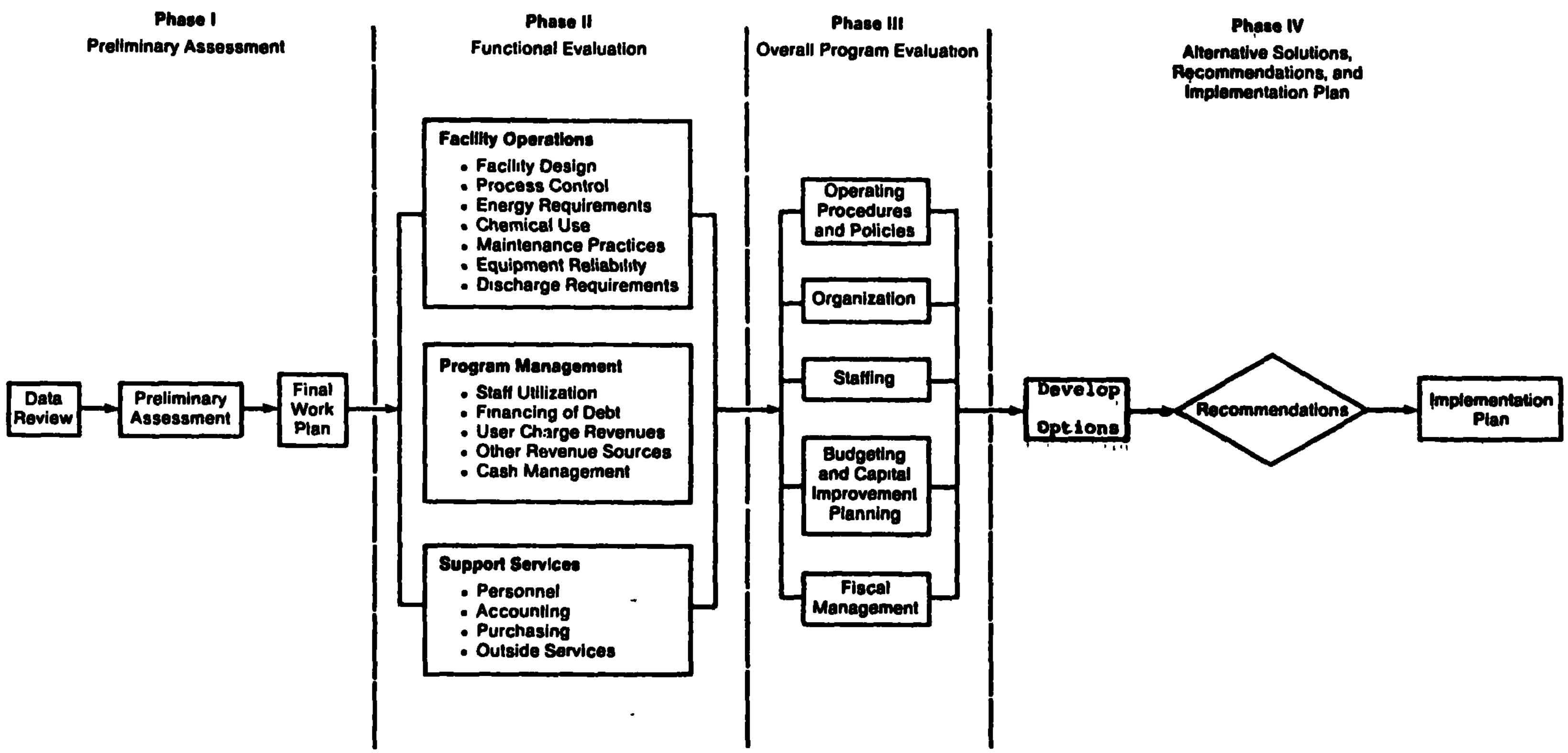
CONDUCTING A COST REDUCTION ASSESSMENT

BASIC OBJECTIVE

Every community will have its own specific reasons for conducting a cost reduction assessment. However, most will have the same basic objective: to determine what can be done to improve their financial capability to operate a public wastewater system without placing an undue burden on users and taxpayers. This usually involves reducing operating expenditures and maximizing revenues. The specific means of accomplishing this will vary from one community to another.

It is important to note that the only effective solution to a high-cost problem is one that can be implemented. Therefore, the evaluation of options and the development of a cost reduction program must consider the institutional limitations and financial capability of the community in determining whether or not a proposed measure is implementable. For the same reason, each community's approach to conducting an assessment will differ in terms of the range of alternatives considered and the depth of the analysis.

Although it would be desirable to conduct a complete and comprehensive investigation of all possible options in all cases, it must be realized that many small communities simply do not have the resources to undertake such an effort. The basic elements in a complete assessment are depicted in Figure II-1. Obviously the scope of such an effort can be very broad, touching on all aspects of wastewater facilities operation and program management. For communities with limited staff and financial resources, it may be more productive to concentrate on certain functional areas (e.g., energy requirements, staff utilization, and purchasing) which are suspected of being major contributing factors to a high-cost problem.



[1] Based in part on a diagram found in *Comprehensive Diagnostic Evaluation and Selected Management Issues* (EPA 430/9-82-003), U.S. EPA, February 1982.

Figure II-1. Basic Elements of a Cost Reduction Assessment.

METHODOLOGY

When conducting a cost assessment, a standard procedure should be followed whether a community intends to prepare a complete comprehensive analysis or elects to limit the analysis to certain functional areas. The five basic steps to this procedure are as follows:

- Step 1: Identify High Cost Areas (Line Items)
- Step 2: Itemize High Cost Components (Cost Centers)
- Step 3: Determine Cost Reduction Opportunities
- Step 4: Develop and Evaluate Alternative Cost Reduction Programs
- Step 5: Formulate an Implementation Plan

The relationship of these steps to the four phases depicted in Figure II-1 is shown in Figure II-2. General guidelines on how to conduct a cost assessment are presented below.

Step 1: Identify High Cost Areas

The logical place to start the search for cost reduction opportunities is to identify specific high-cost items associated with wastewater facility operations. The proper way of identifying these high-cost items is to examine wastewater utility expenditures of previous years and note items that appear to be excessive. These cost items would be prime candidates for cost reduction.

It is important for the utility manager to use accurate cost data in making the determination of high-cost items. The initial identification of high-cost areas will generally be based on existing budget information and records of expenditure accounts. The most common major line items used in budgeting wastewater operations include LABOR, UTILITIES, MATERIALS and SUPPLIES, CONTRACTUAL SERVICES, MISCELLANEOUS EXPENSES, CAPITAL OUTLAYS, and DEBT SERVICE. These major line items can be further subdivided as shown in Table II-1. <u>It is recommended that operating costs be itemized to the greatest extent possible in order to identify the specific sources of high-cost problems</u>.

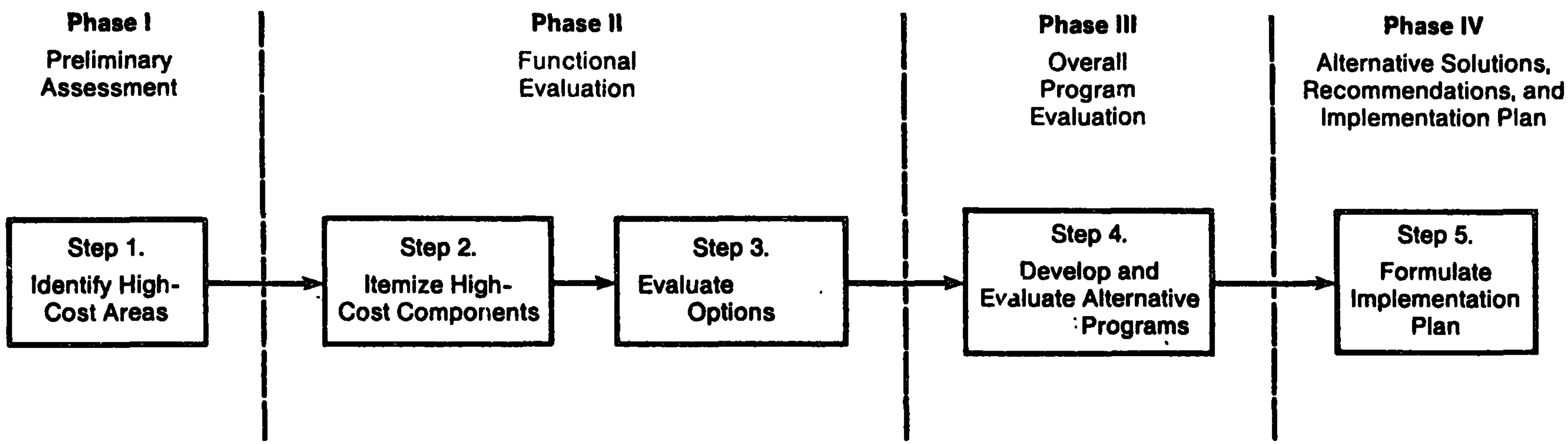


Figure II-2. Steps In Conducting a Cost Assessment.

(LINE ITEMS)

Labor (including Fringe Benefits)

- Administrative
- Operations
- Maintenance
- Support
- Contingency (overtime/part-time help, etc.)

Utilities

- Electricity
- Fuel Oil/Natural Gas
- Water

Materials and Supplies

- Chemicals
- Maintenance and Repairs
- Laboratory Supplies
- General (tools, lubricants, protective clothing, etc.)

Contractual Services

- Legal, Accounting, Revenue Collection, Engineering, etc.
- Sludge Disposal
- Treatment/Disposal Charges
- Service Contracts
- Contract Operations
- Laboratory Testing

Miscellaneous Expenses

- Office Expenses (rent, utilities, phone, postage, supplies, etc.)
- Building and Landscape Maintenance
- Vehicle Maintenance
- Motor Fuel
- Insurance
- Training and Conferences
- Equipment Rental

Capital Outlays

- Process Equipment Replacement
- Vehicles/Construction Equipment
- Plant Expansion/Upgrading
- Collection System Expansion
- Major System Repairs
- Special Studies

Debt Service

- Bond Principal and Interest
- Short-term Debt
- Automotive Loans
- Mortgage Payments
- Sinking Fund Contributions

It is important that all appropriate direct and indirect costs associated with facility operations are included in the tabulation of expenses. This tabulation can be recorded by filling in the first column ("total line item cost") in Exhibit 1 (see Appendix). Once these costs have been compiled, review the data and note those cost items which exhibit one or more of the following characteristics, as candidates for cost reduction:

1. Items which constitute a significant portion of the operating budget -- Look for cost items that constitute 20 percent or more of the total operating cost (not including debt service cost). Also note when debt service accounts for more that 40 percent of the total operating budget.

2. Expenditures over budget -- Compare annual budgets against actual expenditures for previous years to identify items that have consistently exceeded budget allocations.

3. Items which appear to be excessive in relation to experience at other comparable facilities -- Review literature on operating costs for similar-sized facilities or discuss operating costs with other communities, state agency personnel assigned to sewage operations, or professional consultants.

4. Items which have increased in cost over the past few years -- A simple calculation of average annual cost increases over the past five years by line item can be used to identify costs that have increased dramatically compared to other budget items.

5. Items which are subject to significant cost increases in the future -- Look for cost items that are likely to increase due to rate changes (e.g., electric rates) or pending contract agreements (e.g., labor union contracts, disposal service contracts).

After completing this exercise, a prioritization of potential high-cost problem areas can be done. A general rule in prioritizing problem areas is to place the most emphasis on the larger cost items where the absolute cost saving potential is usually the greatest. Remember the objective is to lower the overall cost of operating the wastewater system, so select cost items where even modest reductions (i.e., percent reduction in that cost item) can result in significant absolute cost savings in terms of the overall operating budget.

Generally labor and utilities will be the largest line items in a wastewater operations budget, typically accounting for 50 to 75 percent of total operating expenditures, excluding debt service. Therefore, there are usually many opportunities for cutting costs in these areas. However, it is important to search for potential high-cost items in all of the cost categories listed in Table II-1. Very often, significant cost savings can be achieved in what might be considered minor line items on the budget.

Step 2: Itemize High Cost Components

The next step in a cost reduction evaluation is to determine why costs are as high as they are for specific items. Some of the sources of high-cost problems may be obvious; however, the following procedure should be used in order to compile a valid data base and rationale for evaluating cost reduction options.

Once expenditures have been broken down into line items (in Step 1), the individual line item costs need to be allocated to the different system components. Typical wastewater system components include the TREATMENT PLANT, PUMP STATIONS, INTERCEPTORS AND FORCE MAINS, and COLLECTION SEWERS. A separate general administrative and support services component should be included to account for costs that apply to overall system operation. If alternative collection systems exist, other components to be considered might include GRINDER PUMP UNITS, SEPTIC TANK/EFFLUENT PUMP UNITS, VACUUM VALVES, and VACUUM STATIONS. In order to pinpoint specific sources of high costs, these components can be further subdivided as appropriate.

Exhibit 1 (see Appendix) is provided to facilitate the itemization and allocation of operating costs according to line item and system component. Exhibit 2 presents a format for distributing selected line item costs (i.e., those where high costs are suspected) among individual system subcomponents or activities. These exhibits can be used to tabulate actual expenditures, or they may be used as matrices to identify where the major expenditures are occurring, without quantifying the actual cost for each item. Both of these exhibits can and should be modified to suit a particular wastewater operation. For example, the line item terms used and the assignment of different costs to these line items should be consistent with the system of accounting presently in use.

Detailed cost information and a thorough understanding of wastewater system operations is necessary to make an accurate assessment of the causes of high operating costs. In order to fully appreciate the impact of different cost items, it is important to identify any patterns or trends (e.g., seasonal variances) affecting expenditure levels. Therefore, cost data should be available on a monthly basis, disaggregated by wastewater operation component, if possible (i.e., treatment plant, collection system, etc.).

Assembling monthly expenditures of plant operations can be a relatively simple task, basically involving just the recording of monthly bills and disbursements. Energy costs, for example, can be easily tabulated on a monthly basis by merely listing the monthly utility bills. For other cost items (for example, chemicals which may be purchased on a bulk basis) determining monthly costs necessitates the calculation of monthly usage estimates for each unit process. This can be a difficult and time-consuming task; however, it will be useful in pinpointing instances of excessive usage.

The information derived through this compilation of monthly costs is used to further refine the identification of specific operational activities which are causing operating costs to be greater than they should be.

Since most small wastewater utilities do not record their operating costs in the format just described, it may be necessary for the utility manager or plant operator to conduct a detailed facility audit to disaggregate operating costs by system component on a monthly basis. The audit itself can help utility managers and operators better understand the reasons for high-cost problems, since it forces them to critically examine all aspects of facility design, operation, and management.

Revenue data must also be reviewed in order to identify potential revenue insufficiencies, and to determine if all appropriate revenue generating opportunities are being realized. The various sources of revenue generally available to a public wastewater utility can be divided into user charge revenues and non-user charge revenues as shown in Table II-2. In compiling revenue data, it is again useful to show how revenue income varies from month to month. Exhibit 3 can be used to tabulate the pertinent revenue information.

TABLE II-2. TYPICAL REVENUE SOURCES

User Charge Revenues

Service Fees[1]

- Residential
- Commercial/Institutional
- Industrial
- Suburban (outside municipal or service area limits)

Ad Valorem Taxes

- General Property Taxes
- Improvement Assessments (taxing districts)

Non-User Charge Revenues

Special Assessments

- Connection Fees
- Development Fees
- Sewer Availability Charges

Special Service. Fees

- Septage Treatment
- Charges for Treating Wastes from Other Service Areas
- Personal Services Contracted to Others
- Service Call Charges

Sale of Byproducts

- Effluent
- Sludge/Sludge Products
- Digester Gas
- Nursery Stock, Crops

Sale of Assets

- Used Equipment, Vehicles, etc.
- Land, Buildings, etc.

Rent/Lease Income

- Land for Agricultural Use
- Buildings, Unused Storage Space
- Construction Equipment, Portable Generators, Pumps, etc.

Interest on Investments

- Construction/Reserve Funds
- Operating Accounts

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[1]Including surcharges for extraordinary use or waste strength and forfeited user discounts.

In summary, the reasons for high operating costs can be determined by reviewing operational procedures, facility design, and cost data by wastewater utility function for each of the potential high-cost problem areas identified in the preliminary assessment phase. This will, in many instances, necessitate the completion of an audit, since the financial data maintained by small wastewater utilities is typically not sufficient to isolate the specific sources of high-cost problems.

Step 3: Determine Cost Reduction Opportunities

Once the data base for cost reduction has been prepared as a result of the previous activity, alternative cost reduction measures can be identified and analyzed. The analysis of cost reduction measures can be done by members of the audit team; that is, utility managers, facility personnel, or outside consultants or specialists. This decision should be made by the utility manager.

Depending on the comprehensiveness of the data base prepared as a result of the previous steps in the assessment, a follow-up facility evaluation may be necessary. Once it is determined that a data base of sufficient detail exists, a set of options and alternative solutions for each problem area can be developed. The general format provided in Table II-3 might be used to list these options. The alternatives to be considered should include realistic solutions that will generate desired cost savings and have a reasonable chance of implementation. The evaluator should, nevertheless, consider a broad spectrum of possible solutions, so that a large number of alternative solutions can be considered.

As an aid in identifying possible cost reduction solutions, a list of representative options is provided in Exhibit 4. Table II-4 illustrates in matrix form which options might be considered to reduce costs or augment revenues in different line item cost categories.

Step 4: Develop and Evaluate Alternative Cost Reduction Programs

In order to realistically evaluate the effectiveness of proposed cost reduction measures, workable program alternatives need to be developed. This involves considering the various individual options proposed collectively, so that the system-wide implications of implementing these actions (e.g., impact on other treatment processes, impact on total manpower requirements) can be assessed. One purpose in doing this

TABLE II-3. EXAMPLE FORMAT: LISTING OF HIGH-COST ITEMS AND APPLICABLE COST REDUCTION OPTIONS

Subcomponent or activity	Line item cost element affected	Reasons for high cost	Possible corrective actions

TABLE II-4. COST REDUCTION OPTION - LINE ITEM COST MATRIX

OPTIONS (Cost category)	LABOR: Administrative	LABOR: Non-administrative	Electricity	Fuel	Water	Chemicals	Maintenance and repairs	Contractual Services	Miscellaneous Expenses	Capital Outlay	Debt Service	Revenue/Income
STAFFING												
1. Reduce Labor Requirements												
2. Share Staff												
3. Minimize Overtime												
4. Contract Staff to Others												
FACILITY OPERATIONS												
5. Energy Conservation												
6. Alternate Energy Sources												
7. Minimize Demand and Penalty Charges												
8. Chemical Use Monitoring												
9. Alternate Chemicals												
10. In-plant Water Conservation												
11. On-site Water Supply												
12. Preventive Maintenance												
13. Service Contracts												
ADMINISTRATION AND OVERHEAD												
14. Eliminate Administrative Positions												
15. Outside Administrative Support												
16. Competitive Bidding												
17. Low Maintenance Building and Grounds												
CAPITAL EXPENDITURES												
18. Capital Improvement Planning												
19. Creative Financing												
BUDGET MANAGEMENT												
20. Enterprise Accounting												
21. Expand Service Base												
22. Cash Management												

is to exactly define what is involved in carrying out a given plan (i.e., specific staff changes, organizational changes, changes in operating procedures, etc.), what it will cost (i.e., additional operating costs to be incurred, amount of capital investment required, etc.), and what is to be gained (i.e., amount of cost savings over given period of time).

A format similar to that shown in Table II-5 might be used to list the various elements of a proposed program in a fashion that allows a summation of manpower requirements and costs for individual program elements so that the net cost of implementing the program can be determined. This also allows a determination to be made of the net increase or decrease in staff that would be required.

The alternative cost reduction programs considered should be designed so that they represent different levels of implementation cost. Generally, program alternatives will fall into one of two categories:

1. Those requiring little or no cost to implement. For example, changes to operation and maintenance procedures.

2. Those requiring a significant capital outlay to implement. For example, design modifications or replacement of equipment.

Solutions involving simple management decisions which can reduce a high-cost situation should be considered for immediate implementation. More comprehensive solutions, which require time and money to implement, should be carefully evaluated to determine if the benefits (i.e., cost savings) justify the investment required. An assessment of implementation time-frame, that is short-term (over the next year) or long-term (1 to 5 years) should be part of this evaluation.

Each alternative under evaluation should be accompanied by a listing of advantages and disadvantages (see Table II-5). This information will help in selecting the most appropriate implementation strategy.

An engineering and economic analysis of each alternative should be performed to determine the cost of its implementation and the associated benefits. The level of detail and amount of data required for this analysis depends on the types of corrective measures being considered, and the complexity involved in quantifying expected cost savings. For most alternatives under evaluation, a simple payback analysis technique can be used to determine the relative attractiveness of investing in the implementation of various cost reduction measures. The output of this calculation is the number of years required to recover

TABLE II-5. DESCRIPTION OF PROGRAM ELEMENTS FOR A GIVEN COST REDUCTION ALTERNATIVE

Description of program element	Affected operation activities	Specific actions required	Increase/ decrease in staff	Capital investment	Increase/ decrease in labor cost	Increase/ decrease in energy cost	Increase/ decrease in other expenses	Impact on other processes or treatment efficiency	Other advantages/ disadvantages

the initial capital investment. The general rule of thumb in private enterprise is that the payback period should be less than 5 years, preferably less than 2 years, to justify significant investments of capital. However, the relatively long service life of a typical wastewater facility may justify longer payback periods. Examples of typical payback periods for different types of cost cutting measures that might apply to a wastewater operation are presented in Table II-6.

For major capital-intensive alternatives, a more detailed life-cycle cost (i.e., present worth) analysis should be performed. This type of analysis considers the initial capital investment, the useful life of the equipment involved, the cost to operate and maintain the equipment, and the annual operating cost savings over the period of useful life. Table II-7 presents a format which can be used in calculating life-cycle savings and simple payback period. A very thorough discussion of life-cycle and simple payback cost analysis methods is provided in the Life Cycle Cost Manual prepared by the National Bureau of Standards.[1]

The final task in the evaluation phase involves the ranking of program alternatives according to cost-effectiveness and implementability. Typically, ranking criteria include engineering feasibility, cost, legal/institutional impacts, financial capability, acceptability, and environmental impact (i.e., as it may affect compliance standards). The information generated in filling out Tables II-5 and II-7 should provide an adequate basis for ranking program alternatives.

In comparing alternatives, the distinction between low-cost implementation alternatives (i.e., involving little or no capital outlay, and having immediate short-term payback) and

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[1]Life Cycle Cost Manual for the Federal Energy Management Program, prepared for the U.S. Department of Energy by the U.S. Department of Commerce, National Bureau of Standards, NBS Handbook 135, December 1980.

TABLE II-6. TYPICAL SIMPLE PAYBACK PERIODS[1]

Cost Cutting Measure	Payback period
Preferential operation of most efficient pumps	Immediate
Electrical demand scheduling	Immediate
Hydraulic adjustments (when possible)	Immediate
Maintenance of electrical contact surfaces	Immediate
Waste heat recovery system	0 - 15 years
Boiler maintenance program	5 months
Correction of electrical power factor	8 months
Rigorous program of pump maintenance	1 - 2 years
Installation of night lighting system	1 - 2 years
Use of "fine-bubble" aeration diffusers	1 - 5 years
Recovery and use of methane gas	1 - 5 years
Replacement of incandescent with fluorescent lights	2 - 4 years
Replacement of standard motors with high efficiency motors	3 - 30 years
Installation of high efficiency variable speed drives	5 - 15 years

[1]Energy Conservation in Municipal Water and Wastewater Treatment Systems, seminar sponsored by Pennsylvania Governor's Energy Council, prepared and presented by Ayres, Lewis, Norris and May, Inc., 1983.

TABLE II-7. LIFE-CYCLE COST AND SIMPLE PAYBACK ANALYSIS

Cost saving measure	Estimated net savings in annual operating cost	Capital[1] investment required	Salvage value of capital improvement	Replacement cost of capital improvement	Net[2] Life Cycle Cost Savings (present worth)	Simple[3] payback period

[1]From Table II-5.

[2]NLCCS = Present worth of Annual Net Savings − Present worth of Capital Investment + Present worth of Salvage Value − Present worth of Replacement Cost
(Present worth factor is a function of useful life period, usually 20 to 30 years, and discount rate)
(Inflation is not included except for cost items subject to unusual escalation such as energy costs).

[3]SPP = $\frac{\text{Capital Investment}}{\text{Annual Net Savings - Annualized Replacement Costs}}$

capital-intensive alternatives should be kept in mind. Most utility managers and facility operators will be quick to accept cost cutting measures involving no significant up-front investment. However, in order to achieve maximum long-term cost saving benefits, certain capital outlays will usually be required. The implementation of a few low budget cost cutting measures does not in itself constitute a valid, complete cost reduction program effort, but should only be considered the initial phase in carrying out an effective long-term program. Therefore, the more capital-intensive options should not necessarily be rejected on the basis of high cost, if they appear to be cost-effective over the long term. If funds cannot be made available for such investments at the present time, they might be considered in later phases of program implementation with proper capital improvements planning.

Step 5. Formulate an Implementation Plan

The implementation plan defines a strategy for setting a course of action to place the selected cost reduction program into operation. The implementation plan is developed in the following manner:

1. Select preferred cost reduction program based on the alternatives evaluated.

2. Formulate a plan of action which identifies individuals, departments, agencies, etc. responsible for implementation; projects an implementation schedule and cost estimate and outlines the financial arrangements for implementing the preferred solutions.

3. Develop a mechanism for ongoing performance evaluations.

The alternatives evaluation step described previously examined sets of alternative cost reduction measures aimed at alleviating high-cost problems. The evaluation culminated in a ranking of alternatives, considering advantages, disadvantages, cost, and economic cost-effectiveness.

The results of this analysis should be reviewed with the wastewater facility personnel and local officials in selecting a preferred solution. Part of this final review process should be an examination of legal, institutional, and financial constraints that may affect implementation (e.g., limits of authority provided by operating charter, provisions of service agreements).

Final agreement on the desired solutions will provide the basis for developing an implementation plan; that is, a plan of action to serve as a guide for placing the cost reduction measures into operation. The implementation plan should, at a minimum, indicate the following:

1. "Who" will be responsible for implementing the cost reduction measures.

2. "When" will the measures be put into operation.

3. "How" will the cost reduction measures be carried out.

4. "How much" will it cost to implement.

The plan should, therefore, identify individuals and responsibilities, establish a timetable for certain actions, identify funding requirements, allocate resources, and define the specific steps that must be taken to put these measures into practice. The implementation of a program should be planned and scheduled to minimize the impact on facility operations.

Performance objectives should be established in order to measure the success of specific cost reduction measures, and also to monitor overall facility operations. These performance targets should be evaluated on a periodic basis through a monitoring program to track operating costs and facility performance. This monitoring and performance evaluation effort will provide the means to assess whether the cost reduction measure is meeting expectations, and whether other (perhaps more drastic) measures should be considered to reduce operating costs.

SUMMARY

The guidelines presented in Part II are intended to provide a general procedure to be followed in conducting a cost reduction assessment. The methodology presented attempts to systematically itemize the specific sources of high-cost problems, and then develop cost cutting solutions for the key high-cost items.

A list of possible cost reduction options to be considered is provided in Exhibit 4; however, the specific details of a proposed cost cutting measure will be determined by the design and operating characteristics of the facility or piece of equipment in question. This requires an intimate knowledge of a particular system's design and operation. Therefore, it is strongly recommended that the assessment be conducted as a team effort involving personnel directly responsible for different aspects of system operations (i.e., plant operator, maintenance foreman, utility manager, municipal manager, bookkeeper, consultant, etc.). This will assure that the cost saving proposals developed are not only effective, but also practical and implementable.

Carrying out this type of assessment also serves as a means of evaluating overall facility performance, and can be used to address other problems not directly related to high cost (e.g., non-compliance with permit requirements). If, in fact, a facility is experiencing serious operational performance problems, an expanded diagnostic evaluation may be warranted. Specific guidance on conducting "comprehensive diagnostic evaluations" and "composite correction programs" is available from U.S. EPA.[1,2] If such an evaluation is to be performed, much can be gained by considering cost reduction opportunities at the same time as part of the analysis effort. It is important in conducting any assessment of a wastewater facility operation to consider the technical as well as the economic factors involved in optimizing system operation.

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[1] Comprehensive Diagnostic Evaluation and Selected Management Issues, U.S. EPA-OWPO, EPA 430/9-82-003, February 1982.

[2] Improving POTW Performance Using the Composite Correction Program Approach, U.S. EPA-CERI, EPA 625/6-84-008, October 1984.

PART III: OPTIONS FOR REDUCING COSTS

OVERVIEW

As stated in the Introduction, the cost reduction options presented here do not represent an all-inclusive list of cost-saving techniques. However, every attempt has been made to identify a broad and diverse range of alternatives for reducing operating costs and maximizing revenues. This is intended to help plant managers and operators identify cost reduction opportunities that might be applicable to their particular situation.

The options discussed here relate to the various high cost areas identified in Step 1 of the Cost Reduction Methodology (labor, energy, chemicals, etc.) as well as other factors affecting the overall efficiency of a wastewater operation (e.g. excessive equipment breakdown, poor plant performance, insufficient revenues, etc.). Table III-1 lists possible options that might be effective in reducing costs and improving operational efficiency in several different areas. Specific cost reduction opportunities are addressed in the following discussion.

REDUCING LABOR COSTS

Labor cost is a direct function of staff size and staff composition. Therefore, the key to reducing labor costs is to provide the required range of operating skills with the fewest number of staff possible, without compromising plant performance or operator safety. Some of the methods that can be applied to accomplish this include:

- Productivity Incentives
- Flexible Scheduling
- Contracting Staff to Others
- Private Contract Services
- Public Agency Contract Services
- Cooperative Agreements
- Automated Process Monitoring

Further information on how these techniques might be applied to reduce labor cost is presented below.

Table III-1

Summary of Cost Reduction Opportunities

Problem	Cost Reduction Opportunities	Direct Benefit
High labor costs	o Productivity incentives	o Reduces total staff requirements
	o Flexible scheduling	o Improves staff utilization/minimizes overtime
	o Contracting staff to others	o Generates additional revenue/offsets labor costs
	o Private contract services	o Reduces staff requirements/controls costs
	o Public agency contract services	o Reduces staff requirements
	o Cooperative agreements	o Serves mutual staff needs
	o Automated process monitoring	o Eliminates extra shifts
High energy costs	o Energy conservation	o Minimizes energy consumption given existing equipment and facilities
	o Load management	o Minimizes demand charges
	o Power factor adjustment	o Minimizes power factor penalty
	o Time of use scheduling	o Takes advantage of lower off-peak rates

Table III-1
(continued)

Problem	Cost Reduction Opportunities	Direct Benefit
High energy costs (continued)	o Rate negotiation	o Reduces total charges
	o Alternative energy sources	o Lessens dependence on public utilities
	o Fuel conversion	o Takes advantage of low cost fuel availability
	o Energy recovery	o Reduces energy purchases
	o Process and equipment modification	o Reduces energy consumption and demand/ improves power factor
High chemical costs	o Chemical use monitoring	o Eliminates chemical wastage
	o Process modifications	o Reduces chemical requirements
	o Alternative chemicals	o Accomplishes equal treatment using less expensive chemicals
	o Competitive bid purchasing	o Minimizes purchase price of a given product
Excessive water use	o In-plant water conservation	o Reduces water consumption
	o Effluent reuse	o Reduces net water consumption
	o On-site wells	o Provides less expensive water supply

Table III-1
(continued)

Problem	Cost Reduction Opportunities	Direct Benefit
Excessive breakdowns/ high repair costs	o Preventive maintenance	o Extends equipment service life
	o Spare parts inventory management	o Expedites repairs/ minimizes down time
	o Service contracts	o Limits repair costs to fixed service fee
	o Life cycle bidding of equipment purchases	o Shifts repair cost liability to vendor
Poor plant performance	o Process monitoring and control	o Improves treatment performance
	o Process and equipment modifications	o Improves treatment performance, reduces energy and labor requirements
	o Operator training	o Improves individual operating skills
	o Performance incentives	o Encourages operating personnel to take performance standards more seriously
	o Private contract services	o Improves efficiency of facility operations
	o I/I correction programs	o Minimizes peak flow impacts/increases net flow capacity/reduces chemical use and pumping requirements

Table III-1
(continued)

Problem	Cost Reduction Opportunities	Direct Benefit
Poor plant performance (continued)	o Water Conservation by users	o Increases net flow capacity/reduces chemical use and pumping requirements
	o Flow equalization facilities	o Improves treatment performance/reduces peak energy/demand
High Administrative and overhead expenses	o Internal reorganization number administrative	o Eliminates or reduces personnel
	o Regional administrative and support services	o Eliminates need for administrative and support personnel
	o Private contract services	o Provides administrative and support functions at fixed service fee
	o Low maintenance building and landscaping features	o Reduces maintenance costs
	o Competitive bid purchasing	o Minimizes purchase prices
	o Competitive employee benefit and insurance packages	o Minimizes cost of fringe benefits and insurance
	o Cutbacks in travel, etc.	o Reduces expenses
	o Reevaluate existing contracts for outside services	o Possible cost savings by performing services in-house or with other contractors

Table III-1
(continued)

Problem	Cost Reduction Opportunities	Direct Benefit
Unbalanced budget and insufficient revenues	o Enterprise accounting	o Achieves self sufficiency
	o Aggressive revenue collection	o Increases revenue income
	o Service base expansion	o Increases revenue capacity
	o Supplemental sources of income	o Increases total income
	o Case management	o Takes advantage of investment income opportunities
High capital improvement costs	o Creative financing	o Minimizes long-term debt service
	o Capital improvement planning	o Allows municipality time to make financial arrangements for future capital projects; sets clear priorities
	o Capital reserve funds	o Reduces amount of capital that needs to be borrowed
	o Privatization	o Private sector provides capital investment

Productivity Incentives

The most obvious incentive that can be offered to improve individual productivity is monetary reward (e.g., salary increases, bonuses). Time off (e.g., extra holidays, vacation time) can also be an incentive reward. However, it may be difficult to apply an explicit formula which measures and rewards for productivity, especially in smaller operations. Nonetheless, employees should be made aware that individual productivity will be weighed heavily in performance reviews. Having staff fill out daily logs or timesheets which detail specific tasks performed day-to-day may provide useful information for evaluating individual productivity.

A more subtle and possibly more effective means of maximizing staff productivity is to provide a work atmosphere which encourages individual contribution and development. The most important element of such an approach is effective communication between management and staff which encourages feedback from the operating staff (e.g., suggestions for improving an operation or cutting costs). Employees should be encouraged to take pride in their work and given opportunity for developing individual skills and experience (e.g., outside and on-the-job training). It is very important to define job functions as broadly as possible to avoid "pigeon-hole" assignments with limited responsibility. Ideally, each employee should be exposed to all phases of a facility's operation. This tends to provide the employee with a greater appreciation of his individual role and responsibilities, and also provides a cross training of staff which allows one individual to cover for another as needed without sacrificing operations efficiency.

Individual productivity may be difficult to measure quantitatively, but it is fairly easy to tell when there is room for improvement. When individual productivity is high, the operation will generally run very smoothly, even in the event of occasional emergencies (e.g., equipment breakdown, process upset).

Flexible Scheduling

Multiple work shifts and overtime charges can significantly increase labor costs. In many cases, it may be possible to eliminate these extra shifts through flexible work scheduling. For example, "flex-time" type arrangements can be made to allow some people to come in late and leave later. This can extend the period of time that the facility is manned without paying overtime. Another approach would be to have specifically defined overlapping shifts (e.g., 7 a.m. to 4 p.m. and 11 p.m. to 8 p.m.) which also results in at least one person being on duty for a greater portion of the day, while the facility is fully staffed for several hours each day, so that certain jobs which require more than one person (e.g., safety backup, major repairs) can be done.

Having a well defined daily work schedule for each staff member will help maximize staff utilization. By scheduling routine maintenance chores (e.g., equipment lubrication, pump station inspection) so as not to conflict with times when operator attention is required for process monitoring and control (e.g., diurnal peak flows) one person can attend to more than one job function. It may be appropriate to have different schedules for different times of the year. For example, longer work days may be necessary to meet the demands of peak seasonal flows for several months while shorter days are in order the rest of the year. The relaxed work schedule in the off-season compensates for the extra effort during the peak flow season, which would otherwise require overtime pay.

Another means of avoiding overtime charges is to provide "comp-time" (time off with pay) in lieu of overtime pay. Under such an arrangement, the employee is given one hour off at straight time pay for every hour of overtime. This avoids paying a premium for overtime. The time taken off should be prearranged with supervisors to avoid disruption of normal operations.

Operating schedules might also be altered to reduce manpower requirements. For example, by converting to a batch treatment process, operator attention would only be required for the duration of the batch treatment. In another example, the manpower required to man a septage or sludge receiving facility could be reduced significantly by restricting discharges to certain times during the day.

ILLUSTRATION - FLEXIBLE SCHEDULING

The operators at the 1 mgd Block Island, Rhode Island Sewage Treatment Facility adopted an innovative system of staff scheduling to meet unique operating conditions. Their work force schedule is designed to accommodate the dramatic fluctuation in diurnal and seasonal sewage flows. The Island's summer population is nearly ten times greater than its winter population. In order to reduce overtime hours and yet provide sufficient staff time at the plant to handle routine and emergency maintenance procedures, the full-time staff (of two persons) operate on an alternating 8-day/4-day off schedule during the summer, with overlapping 2-day periods between two operators to handle major maintenance activities (e.g., inspection of pump stations). The extra time devoted to the plant operations during the summer (resulting from on-call requirements and extended work shifts), is compensated by a shorter workweek during the winter (off-peak) months. Paid overtime is therefore eliminated through this "comp-time" arrangement. This has helped keep salary costs under control and has enabled the operating staff to maintain second jobs without affecting their commitments to the plant and conveyance system operations.

Obviously, work schedules must fit the specific needs of the facility in question, and also be acceptable to the staff. Nonetheless, in most cases, there is great opportunity for reducing labor costs by simply modifying work schedules to maximize staff utilization.

Contracting Staff to Others

If an operating staff is not fully utilized, it may be possible to contract out some of the staff (on a part time basis) to other municipalities or private interest. This brings in additional revenue which can offset labor costs, and may possibly avoid the need to cut staff. It is very possible that nearby municipal treatment plants or privately owned treatment facilities may be in need of a trained operator or maintenance person, but cannot support a full-time staff. The feasibility of such an arrangement will depend on the amount of unutilized staff time available and the ability to schedule outside services so as not to conflict with an individual's primary operation and maintenance responsibilities.

Another way of taking advantage of underutilized staff is to share staff with other municipal departments. A formal arrangement can be made where a certain split of time between departments is specified. Alternatively, each department can simply pay on an hourly basis for the time actually spent.

Private Contract Services

A wide variety of services related to the operation and management of wastewater facilities can be performed by private firms under contract. These contract services range from one-time special studies (e.g., engineering reports, financial audits) and common retainer-type arrangements to total plant management (i.e., contract operations). The use of temporary labor services (i.e., using temporary labor service agencies) and equipment service contracts are other forms of contract services that can be provided by the private sector.

Contract services can be used to supplement existing administrative and technical staff functions, or they can be used to replace these functions entirely. The degree to which contract services are employed will determine the extent of staff reduction possible. Of course, the benefit of reduced labor costs resulting from staff cuts must be weighed against the cost of the contract services.

In order for contract services to be cost-effective, some net reduction in operating cost or financial liability must be realized by the operating agency. This should take into account the savings in direct salary costs as well as fringe benefit costs, insurance costs, and miscellaneous expenses (e.g., staff training, work clothes, tools). In some cases, the cost of contract services may equal or even exceed current labor related costs, but still be cost-effective if certain cost liabilities are shifted from the operating agency to the contractor. For example, under a typical contract operations agreement, the contractor agrees to provide a specific service (e.g., operate a treatment facility within certain performance limits) for a set fee over a specified period. If the actual cost of maintaining the agreed upon performance limits is greater than projected (e.g., chemical requirements are underestimated, or additional manpower is needed), the operating agency is not obligated to pay those additional unexpected costs. It should be noted that the provisions for financial liability will vary from one contract to another, and must be mutually agreed upon by the contractor and the operating agency.

The basic premise in contract services is that a given task can be performed more efficiently by a private contractor due to the fact that costs have to be controlled in order to make a profit. This often results in improved facility performance (i.e., compliance with discharge requirements) as well as cost savings. In fact, in a contract operations arrangement, the contractor may incur financial penalties (e.g., reduction of service fees) if a certain level of performance is not achieved.

Another advantage that a full-service contract operations arrangement offers to the operating agency (i.e., sewer authority or municipality), is improved budget stability. Except for extreme unforeseen events, such as major equipment breakdown or facility damage, the contractor usually bears the risk of cost overruns. Once the service fee is negotiated, the actual expenditure for that line item is set as far as the operating agency is concerned. Long-term contracts can have the added advantage of protection the operating agency from unusual inflation and price escalation.

A contract operations arrangement also relieves the operating agency of certain administrative and supervisory duties (e.g., personnel management, dealing with labor unions, subcontractors, regulatory agencies). In addition, access to expert technical advice through the contractor's staff may reduce outside engineering consultant fees. Finally, the operating agency's overall insurance liability may be decreased since they are not directly responsible for the operating personnel.

ILLUSTRATION - CONTRACT OPERATIONS

The City of Lebanon, Oregon contracted with a large private operation and maintenance firm to provide complete contract operations at its 3 mgd activated sludge treatment plant. The private firm provided its own plant superintendent (that position was vacant) and retained all existing wastewater personnel. After the first year of the contract, the performance of the plant was significantly improved, a backlog of neglected maintenance items was attended to, energy demand was reduced by 25 percent, and the contractor stayed within the projected operating budget.

In another case, the City of Vancouver, Washington recently awarded a 10-year contract to a private contract operations firm based on a successful previous contract with the same firm. The renewed contract actually resulted in a substantial savings over the previous contract. As a result, an anticipated sewer rate increase was not necessary.

Contract services may offer significant cost reduction potential, particularly in smaller communities unable to provide the skilled staff required to operate a wastewater facility. However, care must be taken in developing a contractual agreement which will guarantee contractor performance and also limit the financial liability of the operating agency.

Public Agency Contract Services

Public agencies, such as local sewer authorities or regional sewer districts can provide contract services much like private firms do. This can range from very specific operation and maintenance tasks (e.g., pump station maintenance) to complete contract operations. However, in most cases, this is done on a cost reimbursement basis rather than on a fixed price contract, as it is more common in private contract operations. Public agencies are less likely to assume primary responsibility for treatment facility performance.

Although public agency contract services may not offer some of the advantages of private contract services (e.g., budget stability based on fixed price contracts, shifting of cost and performance liability), they may be attractive to smaller wastewater operations which cannot justify full-time staffs of their own. Very often, regional sewer districts or metropolitan sewerage agencies have ample manpower and technical resources to provide such services to communities outside their normal service areas. This is sometimes referred to as "circuit rider" or "satellite" operations.

ILLUSTRATION-CONTRACT SERVICES BY REGIONAL SEWERAGE AGENCIES

Several regional sewerage agencies have found success in providing operational and maintenance services to outlying rural communities. The Harbor Springs Area Sewage Disposal Authority (HSASDA), in Harbor Springs, Michigan, and the Kent County Department of Public Works (KCDPW), in Grand Rapids, Michigan, provide routine and emergency operation and maintenance services to small communities outside their normal service areas. Each community has an operating contract with the regional agency. Service charges are based on the actual services rendered (i.e., a time and materials-type arrangement). Field staff in both of these agencies complete a detailed weekly timesheet that identifies their time spent on different accounts and operational activities.

In Washington County, Oregon, the Unified Sewerage Agency (USA) operates two small package plants (less than 1 mgd capacity each) under contract with two municipalities. A USA field crew of two persons spend half of their time at each facility. This crew essentially travels between the two plants for routine inspections and corrective maintenance.

The concept of public agency contract services should be carefully considered along with the option of private contract services, recognizing the difference in the types of contracts alluded to above. The feasibility of such an arrangement will depend on the proximity of the nearest existing municipal or regional wastewater operations and their staff resources.

Cooperative Agreements

Neighboring communities might also consider entering into a cooperative agreement where they share wastewater operations personnel when neither can support a full-time staff on its own. This can be done by either forming a joint public authority or service district, or through an intermunicipal agreement. The intermunicipal agreement, which would be the least complicated from a legal and administrative point of view, would require one of the municipalities to assure responsibility for staff management and administration.

ILLUSTRATION - COOPERATIVE AGREEMENTS BETWEEN MUNICIPALITIES

The two small communities of Montrose and Portland, Arkansas (population of about 1,000 each), for example, share one operator between their two sewage treatment facilities. This individual also serves as the water supply system operator for the combined municipal water supply system. Special radio communications have been set up between the two cities for emergency maintenance calls. This arrangement saves both cities the cost of employing a full-time person, and enables part of the labor costs to be absorbed by the water supply system as well.

In another example, the South Fork Sewer and Water District, in Wallace, Idaho, recently purchased a high pressure sewer cleaning machine which greatly increases the efficiency of the sewer cleaning operation. The purchase of the expensive equipment was made possible through a cooperative agreement with neighboring communities. The district shares the equipment with one city, and provides sewer cleaning services to another.

This type of intermunicipal cooperation can result in considerable cost savings for the participating municipalities. However, in order for this type of arrangement to work, groups of two or more municipalities with small wastewater facilities must be in reasonable proximity of one another, and must recognize the mutual need and common benefit of such an agreement.

Automated Process Monitoring

It may be possible to eliminate existing night shifts by installing automatic process monitoring and alarm systems. Assuming the primary function of the night shift is to monitor plant operation and respond to emergencies, much of the associated labor cost can be eliminated by relying on an automated monitoring system to record operating data and contact on-call operators or maintenance personnel in the event of a serious system malfunction (e.g., power failure, pump station failure) using an automatic dialer.

Recent advances in microcomputer and microprocessor technology provide considerable capability in process monitoring as well as remote process control. Although the cost of these systems may be high, the savings in labor costs may result in relatively short payback periods.

REDUCING ENERGY COSTS

At most wastewater facilities, energy (i.e., electricity, gas, fuel oil) is a major budget item. With the continuing escalation of electricity and fuel prices, energy costs have to be controlled to prevent a corresponding escalation in sewer rates. More and more energy saving features are being incorporated into sewage treatment plant design as a result of these recent trends. There are also many opportunities for reducing energy costs at existing facilities. The range of options include:

- Energy Conservation
- Electrical Load Management
- Power Factor Adjustment
- Time of Use Scheduling
- Rate Negotiation
- Alternate Energy Sources
- Fuel Conversion
- Energy Recovery
- Process and Equipment Modification

A more specific discussion of options follows.

Energy Conservation

The objective of an energy conservation program is to minimize non-productive energy consumption without making major modifications to existing equipment. Energy conservation opportunities in a wastewater operation can be divided into two categories, those related to lighting and heating systems, and those related to treatment process and pumping systems.

Very often, the energy requirements associated with lighting and heating treatment works buildings (e.g., process buildings, control rooms, laboratory, administrative offices) can be significant. Simple conservation measures such as turning lights off in unoccupied areas and lowering thermostat settings can have a noticeable effect on energy costs.

The concept of zone heating should be applied if possible so that different areas of a building can be heated only to the degree needed for a specific use. For example, an empty garage does not need to be heated at all, and an unoccupied process building does not need to be maintained at room temperature unless the treatment process is temperature sensitive. In all cases building insulation should be utilized to the maximum extent possible to minimize heat loss from heated areas.

In plants operated on a dayshift basis, the heating system should be "turned down" overnight. The same applies to hot water heaters. In some cases computerized HVAC control systems may be appropriate, although the cost of installing such a system must be justified in terms of annual net cost savings. It may be possible to integrate HVAC control with other computerized control systems (e.g., electrical load management or process control systems).

Lighting costs can be reduced by disconnecting or removing the light bulbs from selected light fixtures in areas where illumination appears excessive or unnecessary. However, care should be taken to assure adequate lighting exists in all areas where personnel safety is a concern. Another option is to replace existing light fixtures (e.g., incandescent and mercury vapor lamps) with more efficient units such as fluorescent and high pressure sodium lamps. This may be particularly applicable in cases where large outside areas need to be illuminated.

In treatment process and pumping systems, energy requirements can be reduced by selectively controlling the use of certain process equipment. The most obvious example is aeration equipment, which can be turned on or off based on actual air requirements. This requires continuous process monitoring which can be done manually or with the aid of automated computerized control systems. Selective use of pumping systems (e.g., operating a smaller pump at near peak efficiency for a longer period rather than operating a larger pump in a series of shorter periods) can also reduce total energy consumption. In some cases, it may be possible to take a process unit off-line completely without significantly affecting treatment performance and thus save the energy required to operate the unit. This is particularly applicable where redundant process units exist.

If heated treatment processes (e.g., heat treatment of sludge, anaerobic digestion) are used, insulation of treatment units and external process piping should be considered to minimize heat loss and thereby reduce energy requirements.

Finally, water conservation by service area customers, and infiltration/inflow correction programs can indirectly reduce energy requirements by reducing pumping requirements.

ILLUSTRATION - ENERGY CONSERVATION

The chief operator at the Watkins Glen, New York sewage treatment facility initiated an in-house energy audit which resulted in the implementation of several energy conservation measures. Lighting and heating conservation measure alone resulted in a 23,000 kilowatt-hour drop in energy usage in one three-month period. In addition, a redundant treatment process line (including a clarifier, aeration basin, and aerobic digester) was shut-down. These measures together with other minor process and equipment modifications reduced energy consumption by over 300,000 kilowatt-hours in the first year the program was implemented. This resulted in a net cost savings of over $3,000 in spite of a 30 percent electric rate increase.

Although the cost saving resulting from an individual energy conservation measure sometimes appears insignificant, the cumulative effect of implementing a plant-wide conservation program can be dramatic.

Electrical Load Management

Any treatment plant operator realizes that electrical energy cost is not only a function of the amount of power consumed (i.e., kilowatt hours), but is also a function of the rate at which the power is consumed (i.e., "demand"). Power demand is defined as the maximum average electrical load (measured in Kilowatts) over a given time interval, usually 15 minutes, exerted at any time during a billing period. Most power utilities impose a "demand charge" in addition to the base rate for Kilowatt-hours consumed. Rate structures vary from one utility to another, and can be very complex in terms of the calculation of demand charges.

Very often the demand charge is determined not only on the basis of peak demand for the current billing period but also on the basis of peak demands in previous billing periods (e.g., as a function of the mean peak demand of the previous 11 months). Therefore, a single high peak demand can affect power costs for up to a year after the demand occurred. This points out the importance of controlling electrical loads to the greatest extent possible in order to minimize demand charges.

A treatment facility will always have certain peak power demands that cannot be avoided due to the starting and running of high horsepower electrical motors. However, by scheduling the operating cycles of different power equipment to avoid coinciding periods of high demand, the average electrical load (i.e., the basis for demand charges) can be minimized. This approach to controlling power Demand is referred to as "load management."

Electrical load management programs can be as simple as establishing a daily operating schedule for starting and stopping certain high load power equipment (e.g., pumps, blower motors) to avoid coinciding demand peaks. More effective load management can be accomplished by continuously monitoring plant-wide power demand and cutting back on the use of certain equipment when demand reaches a given point. There should be a predetermined priority for cutting back different electrical uses based on the importance of that use. For example, HVAC equipment might be temporarily shut down before resorting to turning off pumps and aeration units. This technique, known as "load shedding" can be implemented using computerized automated control systems. Such control systems are becoming more practical with recent developments in microcomputer technology (i.e., small personal and business computer systems).

One option to simply shutting off certain equipment during high demand periods is to switch to alternate sources of power (e.g., self-generated electricity) during these periods. This option is discussed later in this section.

<u>Power Factor Adjustment</u>

In addition to basic energy charges and demand charges, many rate structures include a power factor adjustment which can increase energy costs. The power factor is a measure of electrical efficiency related to the degree to which electrical current is out of phase with voltage. Certain types of electrical equipment (e.g., induction motors and certain variable-speed drives) have inherently low power factors. Such equipment requires more current to produce a given amount of power. This is not reflected in the measurement of real power (i.e., kilowatt-hours), and therefore utilities charge a penalty to recoup the cost of generating the additional current.

The power factor for an electrical motor is very sensitive to motor load. Power factor decreases significantly when a motor is under loaded (i.e., operated at less than its rated horsepower). With the variation in pumping and aeration requirements at a typical treatment plant, it is inevitable that motors will be operated at less than their rated capacity a large part of the time, thus creating a low power factor.

High power factor penalties can be reduced by (1) replacing induction motors with synchronous type motors which have high factors, (2) adjusting operating cycles so that motors operate at nearer their rated capacities, or (3) installing corrective power factor capacitors. Synchronous motors are very expensive and generally not cost-effective, except in very large motor applications (1,500 hp or larger). In many cases operating cycles are dictated by uncontrollable diurnal and seasonal flow variations and cannot be modified.

In most cases, the use of power factor capacitors represents the most practical and cost-effective means of correcting a low power factor. These capacitors cause current and voltage to be out of phase in the opposite direction and, therefore, counteract the effect that induction motors and other coil type devices have on power factor. They can be installed higher on the individual pieces of equipment having low power factors, or they can be installed at a central location in the plant's electrical system. Although these capacitors are fairly expensive, costing from several hundred to several thousand dollars each, the savings in power factor penalties can pay for the capacitors in a few years. If the power factor is improved significantly, there may even be a credit to the energy charge.

Time of Use Scheduling

Many utilities charge different rates for energy use depending on the time of day, charging higher rates during peak use hours (typically early morning, mid-day, and early evening). In such cases, the use of electrical equipment should be scheduled to the maximum extent possible in off-peak periods. This can be done manually or with the use of timer controls.

Any scheduling of equipment use should be coordinated with electrical load management objectives as discussed earlier. In fact, time of use scheduling and load management can be integrated using computerized control systems which seek to optimize the use of electrical equipment so that overall energy costs are minimized. Automated control systems can be very expensive, and may be difficult to justify unless significant reductions in utility charges can be realized.

Rate Negotiation

It should be obvious from the preceding discussions that electrical energy costs are greatly influenced by the rate structure established by the power utility. Most wastewater facilities are treated as industrial users by power utilities and therefore are subject to rate schedules specifically developed for industrial uses. As a general rule, these rate schedules do not take into consideration the unique operating constraints that a wastewater treatment facility is subject to.

For example, an unusual storm event can cause a dramatic increase in pumping requirements due to excessive inflow into the sewer system. Under certain rate schedules the wastewater facility owner would have to pay an excessive demand charge based on this single event. In some cases, a single high demand event such as this might affect demand charges for up to a year following the event. In situations such as this the wastewater facility owner should seek relief from these excessive charges from the power utility.

A waiver from time of use charges might also be sought on the basis that sewage high flow periods tend to coincide with peak power use periods and cannot be controlled by the wastewater facility operator. It may be possible to convince the power utility to grant certain concessions (e.g., increase the flat energy use charge) but waive demand and time of use charges. Most power utilities will be willing to negotiate the terms of the rate schedule. If the power utility refuses to grant the desired concessions an appeal to the State Public Service Commission might be warranted.

Alternate Energy Sources

It is unlikely that a wastewater operation can be totally independent of power utility companies (through the use of alternate energy sources). However, it may be possible to significantly reduce the amount of electricity and fuel purchased, and thereby reduce energy costs. Of course, the capital and operating costs of energy generation equipment (e.g., diesel generator, windmill, hydropower turbine) must be taken into account in computing the long term cost-effectiveness of alternate energy sources.

In some cases the economic feasibility of such an option will depend on the availability of a primary energy source (e.g., steady prevailing winds, stream with hydropower potential). In other cases the availability and cost of fuel will be a factor. However, in all cases the cost-effectiveness of using alternate energy sources is ultimately determined by the magnitude of avoided purchase costs. This will be a function of current prices and rate structures, and the total quantity of energy that can be self-generated.

The most obvious alternate source of electrical energy at a wastewater treatment plant is the emergency standby generator (usually diesel powered) required for back-up power in event of power outages. These generators are usually designed to meet the total energy requirements of a treatment facility, but normally stand idle most of the time. Since back-up generators are usually required equipment at most plants, there is essentially no capital investment. The only additional costs incurred are the cost of fuel and the cost of the extra maintenance required.

Although standby generators can generate enough power to operate an entire plant, they are intended to operate only for short periods of time, and are generally not appropriate for 24-hour operation. If 24-hour power generation is desirable, redundant equipment would be required to provide back-up in case of breakdown, and to allow for routine maintenance. In most cases, this would require the purchase of additional equipment which can be a significant capital investment.

A more practical use of existing standby generators is to supplement purchased power supply during peak use periods. This is a particularly effective means of avoiding premium charges when time of use rates apply. Standby generators can be easily be timed to "kick-in" during those times of the day when the higher rates are in effect. Standby generators can be also be used in lieu of load shedding during periods of high demand to minimize demand charges.

Other more nonconventional methods of generating electricity onsite include windpower systems, low-head hydropower systems, photo voltaic systems, geothermal power generators and fuel cells. The use of photo voltaic cells, geothermal power generators, and fuel cells in wastewater plant applications is very limited due to the current cost and state of art of these technologies. Windpower and low-head hydropower systems generally have more applicability, but are somewhat geographically limited. Windpower systems are best suited to the plains states, mountainous regions and coastal areas, while the use of low-head hydropower systems require reasonable proximity to a stream with hydropower potential, preferably with a existing dam structure. The capital cost of these systems will vary greatly depending on site requirements, but in general such systems are fairly capital intensive and will require a large initial investment, and will have relatively long payback periods.

Alternate sources of heat for space heating and process heating purposes include heat pumps, active and passive solar systems, and geothermal systems. Except for geothermal systems, these alternate energy sources are normally limited to space heating and water heating applications. The use of geothermal systems is obviously dependent on the existence of a suitable geothermal heat source. The coincidental location of an existing treatment plant near such a source is very unlikely, but if such a source exists, the feasibility of tapping it should be investigated.

Heat pumps have been successfully used in residential and commercial applications for years. The same systems can be used to provide more economical space heating in wastewater operation buildings. Most HVAC systems can be easily adapted to use a heat pump. The major capital investment will be the cost of the heat pump unit itself, and the cost of installing a well if groundwater serves as the heat source/sink.

The use of solar heating systems can reduce fuel consumption in conventional heating systems, but it is unlikely that such systems will provide a major space heating contribution unless buildings are specifically designed with solar heating in mind. This is particularly true for passive systems where building orientation is critical. Active systems with roof collectors that can be positioned to maximize solar exposure are somewhat adaptable, but involve more hardware (i.e., collectors, piping systems, pumps, storage systems) and are more capital intensive (i.e., greater capital investment and longer payback periods) than passive systems. Nonetheless, opportunities for utilizing solar heat that do not involve major structural retrofitting or major capital expense should be seriously considered as a means of reducing fuel and/or electricity consumption.

ILLUSTRATION - ON-SITE POWER GENERATION

A 1.2 mgd treatment plant on Block Island, Rhode Island is totally powered by two 150-kw diesel powered generators eight months of the year. The use of the on-site generators is necessitated by the fact that the generating capacity of the relatively small private power utility on the island is extremely limited during the spring and summer tourist season when energy demand is high. The plant operators have determined they can produce electricity for less than it would cost to purchase it from the power utility under the current rate schedule. The only reason the generators are not used year round is that the energy requirements are drastically reduced in the off-season due to lower flows: It is also more cost-effective to purchase the power. The use of the on-site generators has been so successful that the plant operators are investigating other possible uses (outside of the plant) for the excess power generated.

The opportunities for using alternate energy sources will vary from site-to-site. Although certain alternatives may, at first, sound totally impractical, no alternative should be ruled out until a preliminary cost analysis is done. It should be kept in mind that alternate energy sources can also provide the added advantage of protection from future utility price escalation.

Fuel Conversion

Significant cost savings may be realized by switching from one type of fuel to another for space heating, process heating, and vehicle operation. This usually requires some retrofitting or modification of equipment, and thus involves an up-front capital investment. Modifying furnaces and boilers in space heating, digester heating, and heat treatment systems to burn natural gas instead of fuel oil is a common example of fuel conversion. Converting vehicles (e.g., cars, trucks, forklifts, backhoes) to operate on propane gas rather than gasoline is another example. Another option worth considering is the use of waste oil in place of distilled fuel oil.

The cost-effectiveness of such conversions will depend largely on the prevailing prices and local availability of different fuels. Long range price trends as well as current prices should be considered in evaluating fuel conversion options. One means of mitigating the effect of future price increases is to secure long term supply contracts. Such contracts should be awarded by competitive bidding in order to obtain the lowest-pricing possible.

If fuel conversion programs are implemented, the equipment replaced (e.g., burners, engine carburetors, storage tanks) should be retained in case it is decided to switch back to the original fuel at some point in the future. It is also possible to modify equipment to accommodate multiple fuels.

Energy Recovery

A significant amount of energy is generated by the operation of wastewater treatment facility. Much of this energy is in the form of side products (e.g., digester gas) and waste heat which can be recovered and used to help satisfy the energy requirements of the plant.

The use of digester gas (byproduct of anaerobic digestion) is probably the most recognized method of energy recovery in wastewater operations. Digester gas, or "biogas" as it is sometimes referred to, has many potential uses. It can be used as fuel for furnaces and boilers serving both space heating and process functions such as digester heating and sludge heat treatment. It can also be used to fuel internal combustion engines which might be used to drive pumps, air blowers, electric generators or vehicles.

In order to utilize digester gas, certain burner and engineer modifications are required. A gas cleaning unit, compressor, and storage tank must also be provided in most cases. The cost of these items and any other ancillary equipment (e.g., special pumps, power drives, electric generators) should be included in the payback analysis. The cost-effectiveness of digester gas recovery is largely a function of the volume of gas generated. Therefore, it may be difficult to justify biogas recovery systems in small treatment plants (i.e., less than 1 MGD).

Waste heat can be generated from many sources in a wastewater treatment plant including pumps, compressors, electrical motors and transformers, heated process units, process piping, combustion equipment, internal combustion engines and engine exhaust. The amount of heat that can be recovered from noncombustion equipment is generally insignificant; however, the heat generated by this equipment can contribute to warming interior building spaces depending on its location. Waste heat recovery from high temperature combustion processes (i.e., incinerators, furnaces, and internal combustion engines) is more effective, but requires that fairly complicated energy recovery systems be installed. In most cases such systems are not practical for small treatment facilities.

One potential source of recoverable energy that is usually overlooked is the sewage itself. For example, sewage effluent can serve as the heat source/heat sink for a heat pump system used for space heating. The effluent is an ideal heat source and sink since its temperature fluctuates very little year-round. Wastewater heat pump systems require special design to prevent fouling and corrosion problems, and therefore will generally be somewhat more expensive than conventional heat pump units. Another recently developed energy recovery method takes advantage of the hydraulic head created by the sewage flow to drive a turbine powered electric generator. These low-head hydropower generating systems, which can be installed interceptor sewer lines or plant outfalls, can operate on as little as 10 to 20 feet of head.

Another relatively simple energy recovery device is the air to air heat exchanger which extracts heat from exhaust ventilation air and preheats fresh outside air used in space heating. This method can be particularly effective in process buildings that require 100 percent outside ventilation air. Without an air to air heat recovery system, the heat loss associated with exhaust ventilation air can be significant.

ILLUSTRATION - HEAT PUMP ENERGY RECOVERY SYSTEM

The recently upgraded Hasting, Nebraska Water Pollution Control Facility utilized a water to air sewage effluent heat pump energy recovery system. The heat pump is part of a total energy management system at the 5.4 MGD plant which also includes the use of multi-fuel boilers and air to air heat recovery systems. The total cost of heat pump energy recovery system was $605,000, while the associated savings in operating costs amounts to $24,000 per year.

"Treatment Plant Heating Requirements Trimmed," R. M. Helgoth; C. G. Arnold, Public Works, August 1984.

Process and Equipment Modification

There are numerous process and equipment modifications that can be made to improve the overall energy efficiency of a wastewater facility. However, before implementing any process or equipment change, the potential long term operating cost savings must be carefully weighed against the initial capital cost. The lost salvage value of the replaced equipment (i.e., its current value based on remaining service life less any real salvage value) should also be taken into account.

If the treatment facility is operating at less than design capacity, it may be possible to eliminate redundant treatment units (i.e., parallel process trains). This can result in significant energy savings, and may improve the performance of individual treatment units, since it is likely they will be operating nearer their ideal design loading. Such modifications should be applied first on a trial basis to assure that effluent quality is not adversely affected.

Energy savings can also be realized by controlling the operating cycles of pumps and aeration equipment. By operating such equipment on an intermittent rather than continuous basis, total energy consumption is reduced. By scheduling the operating cycles of different equipment to avoid coinciding use, peak energy demand can also be reduced. These operating schedules should be designed to assure that minimum operational design criteria are not compromised. In most cases this can easily be accomplished without continuously operating pump and aeration equipment.

Certain equipment modifications can improve energy efficiency and thus reduce energy consumption. For example, pump impellers can be changed to improve pumping efficiency when actual flow conditions differ from the original design assumptions. Changing the sheaving of motor drives might also be considered. Different types of pumps may be inherently more efficient under certain conditions (e.g., screw pumps vs. centrifugal pumps under low head conditions). Likewise, certain types of aeration equipment will be more energy efficient than others depending on the application. The relative efficiency of diffused air versus surface aeration versus brush type aerators must be evaluated on a case by case basis.

However, when the type of aeration system is given, there are certain modifications that can be implemented to improve energy efficiency. With mechanical surface aerators and brush type aerators, horsepower requirements, and therefore energy requirements, are a function of immersion depth. This can be adjusted by either raising or lowering the aerator or by adjusting outlet weir levels. Ideally, the aerator blades or brushes should be at the minimum depth required to maintain minimum D.O. levels. In diffused air systems conversion from coarse bubble to fine bubble diffusers can result in noticeable energy savings.

The use of more efficient motors and power drive equipment will also reduce energy consumption. The efficiency gains possible with high efficiency motors are greater for smaller horsepower motors (i.e., 5 to 8.5 % for a 1 hp vs. 2% for a 100 hp motor); however, the total net energy savings possible are greater for the larger motors since total energy consumption is greater. When motor load conditions vary greatly (i.e., pumping and aeration requirements cover a wide range) variable speed power drives may be the preferred means of matching motor horsepower and load (as opposed to using throttling or bypass valves). The increase in overall efficiency gained must be weighed against the capital cost of this equipment which can be relatively expensive.

Besides focusing on particular pieces of equipment in searching for energy reduction opportunities, the modification of whole unit process operations should also be considered. Sludge management, for example, can involve relatively high energy requirements. One option that might be considered is off-site sludge dewatering and disposal (i.e., trucking liquid sludge to a regional treatment facility). The economies of scale at a larger treatment facility may result in a net savings in total treatment and disposal costs even when the additional hauling cost is taken into account. Shutting down dewatering and/or incineration operations at the smaller facilities will result in significant energy cost savings. Short of off-site treatment, certain pretreatment options might be considered (e.g., using centrifuges to lower the moisture content of the sludge and thus reduce incinerator fuel requirements), or equipment replacement may be in order (e.g., use of belt filter in lieu of vacuum or plate and frame filter). Since such modifications require significant capital investments, they must be justified by a thorough cost-effectiveness analysis.

ILLUSTRATION - PROCESS MODIFICATION

At the Saline, Michigan 1.4 MGD treatment plant a considerable savings in energy costs was realized by modifying the operation of the return sludge pumps. The pumps which had been operated in a continuous recycle mode, were placed on an intermittent operating cycle. This caused an increase in average sludge solids concentration and reduced sludge recycling by over 200,000 gallons per day. This reduced energy consumption by 38,200 kilowatt-hours per year and resulted in an annual savings of $1,900. Implementation cost (automatic timers) was negligible).

ILLUSTRATION - EQUIPMENT MODIFICATION

Plant operators at the Wheaton, Illinois sewage treatment plant replaced coarse bubble diffusers with fine bubble diffusers in order to improve the energy efficiency of their aeration process. By comparing the performance of fine and coarse bubble diffusers in side-by-side aeration basins, the operators determined that the fine bubble diffusers consumed 30 to 40 percent less energy than the coarse bubble diffusers under controlled conditions (i.e., maintaining a given D.O. level). The use of the fine bubble diffusers reduced the number of blowers that needed to be on line at any given time from three to two, which reduced the average peak electrical demand by 33 percent. After one year of operation energy consumption was reduced by 12 percent (from 660 kwhr/million gallons to 580 kwhr/million gallons). The conversion to fine bubble diffusers resulted in a total savings of $14,800 per year in direct energy costs and $6,000 per year in avoided demand charges. These savings were achieved by converting only one of two aeration basins. A total savings of $33,000 per year is projected when the other basin is converted.

Process and equipment modifications generally involve some capital investment. It may be difficult to justify such investments, especially when the modification involves abandoning a major piece of equipment or structure which has much of its design life remaining. Nonetheless, the resulting long term energy savings may more than justify the initial investment and lost salvage value. Payback periods can range from less than a year to over twenty years. Obviously, a very careful cost-effectiveness analysis must be done before implementing any major process or equipment modification.

REDUCING CHEMICAL COSTS

Chemicals are used in wastewater treatment processes for many different purposes, including disinfection, pH adjustment, sludge conditioning, nutrient addition, coagulation and flocculation. Very often the physical-chemical mechanisms involved in chemical addition are not fully understood by plant operators, and chemical misuse can result. Too often, chemical addition is done on a "trial and error" basis (i.e., "If a small amount of chemicals works, larger dosages will work even better"). This usually results in wasting chemicals, which can be very expensive. Even when properly applied, the use of chemicals can involve significant operating costs. Aside from the cost of the chemicals themselves and the cost of maintaining chemical storage and feed equipment, there may be additional costs due to secondary process impacts (e.g., the cost of handling excess sludge generated by lime addition). Therefore, every attempt should be made to minimize chemical usage and associated operating costs. Specific measures that might be considered include:

- Chemical Use Monitoring,
- Process Modification,
- Use of Alternate Chemicals, and
- Competitive Purchasing.

These methods are discussed below.

Chemical Use Monitoring

Chemical dosages should be determined by laboratory testing, and confirmed by full-scale operational monitoring. It is common for chemical feed metering pumps to be initially calibrated and then left alone. Ideally, these systems should be checked weekly, or at least once or twice a month to be sure they are consistently delivering chemicals at the calibrated feed rate. The feed devises should be recalibrated if necessary.

Periodic testing (e.g., monthly jar tests) should be performed to confirm that the chemical dosages being applied are correct. Changes in wastewater characteristics (e.g., flow, waste strength) can significantly increase or decrease the dosages required. It may be possible to develop a correlation between certain waste characteristics (e.g., flow, BOD, Total Phosphorus) and chemical dosage based on a compilation of test data collected over a period of time. This would allow daily adjustment of chemical dosages based on the continuous monitoring of key wastewater parameters. Although the correct dosages would still need to be confirmed by periodic jar tests, these could be done less frequently.

With certain types of chemical addition, continuous monitoring is required as part of a feedback control system. This controls the amount of chemical applied (e.g., disinfection systems where chlorine dosage is controlled to maintain a given chlorine residual and neutralization systems where the addition of acid or base is controlled as a function of the measured pH). It is important that such systems compensate for lag time (the time between chemical addition and measurement of effect) so that overdosages do not occur. The dosages for flocculation, nutrient addition and sludge conditioning systems can be based on periodic testing, once a history of typical waste characteristics is established. Within certain limits chemical dosages can be adjusted based on operator judgement in response to observed changes in process performance (e.g., to improve settling or dewatering properties). However, such adjustments should be within the range of dosages dictated by the results of the periodic jar tests.

Process Modifications

The amount of chemicals required for various chemical addition purposes can be controlled to some degree by making certain process modifications. In fact, it may be possible to eliminate the need for certain chemicals altogether by maximizing the performance of different unit processes. For example, it may be possible to maintain stringent effluent requirements (e.g., suspended solids concentrations less than 20 mg/l) without the use of flocculant aids by maintaining proper sludge age and food to mass ratio (F/M) in order to produce a sludge with good settling characteristics. This is done primarily by controlling sludge wasting. Another means of meeting stringent suspended solids limitations is to maximize the performance of the secondary clarifiers. Maintaining proper sludge blanket depth is a key factor in this regard. In some cases, equipment modifications (e.g., increasing weir length to reduce solids overflow) may be appropriate.

When chemicals are used for odor control or H_2S control (e.g., prechlorination, sodium permanganate, hydrogen peroxide) other non-chemical treatment methods should be considered. For example, pre-aeration can be used in lieu of chemical oxidizing agents. Certain structural modifications in collection systems and inlet structures (e.g., the use of drop inlets) can also be effective in controlling H_2S and odor problems.

The method and point of chemical addition can also affect the amount of chemicals used. Some chemicals (e.g., polymers) require dilution and aging in order to maximize their effectiveness. If such chemicals are not properly prepared, excessive dosages will be required to produce the desired result. Likewise, proper mixing and time of contact must be provided when any chemical is applied to wastewater of sludge. The point of addition can greatly affect the degree of mixing and time of contact that occurs. Improper application techniques not only result in excessive chemical use, but also reduce the effectiveness of the treatment.

ILLUSTRATION - CHEMICAL CONSERVATION THROUGH PROCESS MODIFICATION

When the annual bids for chemical purchase at the Watkins Glen, N.Y. treatment plant were received in 1980, the price of lime had increased 21 percent and the price of ferric chloride had increased 60 percent over the year before (these chemicals are used for vacuum filtration sludge conditioning). This prompted the chief operator to initiate an intensive chemical conservation program. The program had two basic elements or phases. In the first phase, net sludge production was reduced by holding the sludge in aerobic digesters for longer periods of time. This reduced chemical use by almost 10 percent. In the second phase the F/M ratio in the aeration basin was reduced to the maximum extent possible by reducing sludge wasting and increasing sludge recycling. This reduced sludge production and resulted in an additional 36 percent reduction in chemical use.

Any proposed process modification should be tested at near full scale conditions to assure that process performance and effluent quality are not compromised. Plant operators should be encouraged to conduct such experiments in order to better understand the response of the plant to different conditions and operational modes.

Alternate Chemicals

In many cases, different chemicals can be used for a given purpose. A good example is sludge conditioning where lime, ferric chloride, alum and organic polymers are often used interchangeably. In most cases polymer addition will be more cost-effective in terms of the cost of chemicals required to accomplish the desired degree of conditioning. Although lime is less expensive pound for pound, significantly greater quantities of lime are required. On the other hand, additional chemical handling facilities (e.g., mixing tank, aging tank) may be required when converting from lime and ferric chloride or alum to polymer, which will obviously involve some capital investment. Polymers might also be applied in conjunction with other conditioning chemicals in order to reduce the dosages required for the other chemicals used. Another consideration that should be taken into account when lime addition is involved is the added cost of handling and disposing of the increased amounts of sludge generated. Lesser quantities of sludge are generated than with other chemicals. The associated cost savings should be included in the analysis of cost-effectiveness when evaluating chemical addition alternatives.

Using different forms of a particular chemical agent (e.g., ferrous chloride instead of ferric chloride) may also prove cost-effective if the alternate forms of chemical are available at a lower price. However, differing dosage requirements must be considered in determining the net savings based on equivalent performance.

The cost of chlorine for disinfection is a significant item in most treatment plant operating budgets. Several other disinfection options exist (e.g., ultraviolet radiation, on-site sodium hypochlorite generating). However, conversion to such systems can involve significant capital cost. Nonetheless, long-term annual operating savings may warrant such conversions.

ILLUSTRATION - USE OF ALTERNATE DISINFECTANT

When a new 2 MGD wastewater treatment facility was built by the French Creek District in North Ridgeville, Ohio in 1975, it included a disinfection system using sodium hypochlorite instead of chlorine. The hypochlorite solution is prepared on-site using electrolytic cells. This eliminates the cost of chlorine purchases and the hazards associated with chlorine handling.

The hypochlorite system consists of an electrolytic unit, DC rectifier, two brine pumps, recycle tank, two recycle pumps, heat exchanger, storage tank, two product pumps, an acid flushing system, water softener, and salt storage containers. The system consumes approximately 25,000 KWH of electricity and 18,000 pounds of salt per year. The cost of producing the hypochlorite solution is about $0.34 per pound of solution (at $0.042/KWH and $0.034/pound of salt). The cost of purchasing hypochlorite from a local commercial supplier would be $1.32 per gallon ($1.05/pound). The resulting cost saving is over $3,000 per year.

Plant operators should experiment with the use of different chemicals and combinations of chemicals to determine if alternate chemicals might accomplish an equivalent treatment effect at a lesser cost. Operators should attempt to keep current about recent developments in the use of different chemical additives. The use of bacterial additives might also be considered for certain purposes (e.g., odor, grease, and H_2S control) in lieu of chemicals.

Competitive Purchasing

Considerable savings can be realized by simply seeking the "best deal" when purchasing chemicals. Competitive bids should be sought from different suppliers. Long term supply contracts, with or without escalation clauses, can be an effective means of controlling chemical costs. Supply contracts should include specific performance standards or specifications in order to guarantee the quality of the product supplied. The performance of any chemical additive should be periodically tested (e.g., jar testing) to assure that the product meets the guaranteed specifications.

Documentation of daily chemical use and trends of changing chemical use over time can be used as an indicator of possible variations in chemical quality. Jar testing should be performed to confirm any suspected discrepancies from performance specifications. If the supplied chemicals do not meet specifications, the supplier should either replace them or offer some monetary compensation depending on the terms of the supply contract.

Chemicals purchased in large quantities will typically cost less than chemicals purchased in small quantities. Before purchasing a bulk quantity of chemical, first be sure that the chemical can be used prior to its losing effectiveness due to long-term storage. Another factor to consider is transportation cost. The cost incurred to transport the chemical may exceed the cost of the chemical itself. Therefore, the local availability and method of carrier should be investigated.

The cost associated with chemical addition is also related to the form in which the chemical is purchased (i.e., liquid, powder, or gas). Labor requirements may be less for chemicals which are fed from stock solution versus those which require preparation, (e.g. mixing or dilution). However, the costs of a liquid chemical will generally be higher than a chemical purchased in powder form. Therefore, the reduced labor requirements need to be weighed against the higher purchase price.

REDUCING IN-PLANT WATER USE AND WATER SUPPLY COSTS

A wastewater treatment plant is typically not a major water user; however, a reduction in water use will generally result in some cost savings. If alternate sources of water supply can be utilized, water utility fees can be significantly reduced or eliminated. Options to consider include:

- In-Plant Water Conservation;
- Effluent Reuse; and
- Independent Water Supply.

These methods are discussed below.

In-Plant Water Conservation

Considerable water can be conserved by ceasing wasteful water use practices. Water conservation measures to consider include the repair of leaky faucets and valves; limiting the amount of water use for equipment washdown, cleaning walkways, etc.; and control of landscape watering. The use of sprays to control foaming in aeration basins and clarifiers can often be cut back without sacrificing effectiveness. If such sprays are used, they should be checked daily and adjusted as needed to provide the necessary foam control with minimum water use. Other water consuming process equipment (e.g., pump seals and packing) should also be inspected daily to assure that water is not used.

Plant-wide water use should be monitored on a weekly or monthly basis to detect unusual peaks or increasing trends of water use. This may indicate excessive water use or a supply line leak. When such trends are observed, the source of the excessive use or leak should be isolated and corrected.

Flow restricting devices can be installed on certain plumbing fixtures (e.g., shower heads and washroom faucets) to further reduce water use. Water-saving toilets might also be considered. Existing toilets can be modified to reduce water use.

While individual measures such as these might only accomplish modest water savings, the cumulative effect of a plant-wide water conservation program can be dramatic.

ILLUSTRATION - WATER CONSERVATION PROGRAM

As part of an overall cost-cutting campaign, a water conservation program was instituted at the Watkins Glen, N.Y. Treatment Plant. This consisted mainly of making a conscientious effort to monitor and control water use throughout the plant. Daily inspections of pump packings, seals, and sprayers were conducted, and leaky plumbing fixtures were repaired. The installation of water saving spray heads in the foam control spray equipment reduced water usage from 6 gallons per minute to 1.4 gallons per minute. Further water usage reductions were realized when a redundant parallel treatment train was taken off-line.

The net reduction in annual water use over a two-year period was just over 1,000,000 cubic feet of water. This represented a reduction of 70 percent, and over $8,000 in water bills.

The key to implementing an effective in-plant water conservation program is to carefully monitor water use throughout the plant. Cases of excessive water use will generally be fairly obvious when such monitoring is done. Records of monthly water use should be plotted and compared against previous years to determine the effectiveness of implemented conservation measures.

Effluent Reuse

The use of plant effluent to supplement an outside water supply can help reduce water utility bills. Plant effluent can be used in many non-potable applications such as equipment washdown, chemical mixing, and landscape watering. The treated effluent would normally be obtained from either the chlorine contact tank or post aeration basin. This would require the installation of a pumping and piping system (which should be clearly labeled as non-potable water).

The cost-effectiveness of installing such a system will depend on the current water rates being paid and the extent to which effluent can be used for non-potable uses throughout the plant.

Independent Water Supply

It may be possible to reduce or eliminate the need for outside water supply by developing an independent source of water supply; for example, an on-site well. This obviously requires a suitable source of water, which must be of potable quality if it is to be a totally independent water supply. The cost of developing the necessary water supply facilities (usually an on-site well, storage tank, and pumping system) and operating the system must be taken into account when evaluating the potential cost savings possible by eliminating water utility charges. The comparison of life cycle costs should consider the likelihood of future water rate increases.

REDUCING MAINTENANCE AND REPAIR COSTS

Excessive maintenance and repair requirements can have direct cost impacts (e.g., expenditures for time and materials and outside services), as well as indirect impacts such as process downtime. This may also increase expenditures for emergency storage or alternate treatment measures. Since most treatment plants are fairly equipment intensive, the potential for mechanical breakdown always exists. The financial impacts of these breakdowns can be mitigated by controlling the frequency and duration of these events, and by limiting financial obligations through service contracts, extended warranties, or insurance policies. Specific methods of controlling maintenance and repair costs are discussed under the following headings:

- Preventive Maintenance.
- Spare Parts Inventory Management.
- Service Contracts, Warranties, and Insurance.

Preventive Maintenance

Preventive maintenance is doing all the things necessary to keep equipment running smoothly. Preventive maintenance sounds easy, but it is sometimes difficult to train people to pay attention to the small tasks such as regularly checking equipment and providing routine maintenance (e.g., equipment lubrication, checking seals). Too often, mechanical equipment is ignored until is breaks down, at which time significant effort and expense is incurred to make the needed repairs. Routine equipment checks and maintenance requiring a few hours per week can minimize the number of unscheduled shut-downs and emergencies due to major mechanical failures.

A comprehensive preventive maintenance program should include the following elements:

1. Operator/Maintenance Staff Orientation - Plant operations staff should be familiar with the design and function of all mechanical equipment. They should be able to detect signs of problems that might lead to equipment failure, and be able to pinpoint the source of the trouble when such problems develop. All available equipment information (e.g., technical specifications, vendor brochures, operating manuals) should be carefully studied, and on-site training conducted by the respective equipment vendors and/or the design engineer.

2. Record of Equipment Specifications - A complete record of all technical information pertaining to mechanical equipment should be maintained on file to facilitate easy reference. These files should include detailed equipment specifications, plans, shop drawings, parts lists, operation and maintenance manuals, and any other information pertaining to equipment design, operation, maintenance, and repair.

3. Maintenance Planning and Scheduling - Based on a review of equipment specifications, operation and maintenance manuals, and manufacturer literature, preventive maintenance objectives should be established, and a plan for carrying out the necessary activities developed. This should include a detailed schedule that specifies when various maintenance tasks are to be performed on individual pieces of equipment. This schedule should provide for routine inspection as well as periodic equipment overhaul as required.

4. Maintenance Log - A complete record of all maintenance and repair performed on each piece of equipment should be maintained on file. It should contain such items as work classification, number of hours worked, type of job, name and number of equipment, parts or supplies required, purchase order number, receipt, and total cost. These records should be kept as maintenance history records. Such records can be used to detect trends of increasing breakdown frequency or increasing maintenance requirements which might indicate the need for equipment overhaul or replacement.

5. Record of Expenditures - A detailed account of all expenditures related to preventive maintenance should be kept for cost control purposes, and also to provide input to the preparation of realistic operating budgets. All costs representing time and materials (including the cost of service contracts) should be accounted for.

Most preventive maintenance may be performed by plant personnel, even if they have only self-taught mechanical knowledge; however, some preventive maintenance and most corrective maintenance will require special training. The equipment must be repaired quickly and properly. Many pieces of equipment have a warranty period; unqualified adjustments may nullify warranties. All warranty information should be filed until they expire. Untrained plant personnel should assist and learn from outside mechanical contractors and vendor personnel in order to be prepared for the next maintenance or breakdown task.

In some situations, contract maintenance services become attractive and cost-effective. (See discussion of "Service Contracts.") This is especially true when specialized tools, equipment or specially trained personnel are required for system maintenance.

Effective preventive maintenance program requires a thorough understanding of system operations and maintenance needs as determined from the interpretation of well-kept operating and service records. The use of computers for planning preventive maintenance and storing reference data (e.g., equipment specifications, parts lists, O&M instructions) is becoming popular. Computerized systems can greatly facilitate the monitoring of day-to-day maintenance requirements and the updating of maintenance logs. Sharing the computer with other departments (e.g., process control, spare parts inventory) can often justify the initial capital cost. If a computer is not available, there are several manual scheduling methods that can be used. Some form of card-file system is probably the most common. Regardless of the recordkeeping/ "tickler" system used, it is important to maintain a complete and up-to-date record of all maintenance activities in order to assure that necessary preventive maintenance is not neglected.

Spare Parts Inventory Management

A preventive maintenance program cannot be effectively implemented without managing a plant's spare parts inventory so that critical maintenance and repairs can be performed in a timely manner. This first requires the preparation of a complete listing of all critical spare parts, tools, and materials that should be on hand at all times. The availability of various items through local suppliers should be considered in preparing this list. The use of salvaged parts and used equipment should also be considered as an alternative to purchasing new spare parts. The spare parts inventory should not be allowed to grow too large since a very large parts inventory can easily become unmanageable and require a very large capital investment.

Items to include in a spare parts inventory range from bearings, seals, couplings and belts, to pumps, motors, and power drives. In addition, an adequate stock of tools and lubricants should be provided. This is especially important if specialized tools or lubricants are required.

It may be possible to standardize certain parts and materials so that more than one piece of equipment can use the same spare parts. Parts standardization is one area where high potential cost savings can be realized. Many pieces of equipment in wastewater treatment have similar components. For example, many pumps, aerators, blowers, compressors, conveyors and mixers use common bearings, grease seals, and other similar components.

Most equipment manufacturers do not make these components themselves. They purchase bearings, seals, and other items from component manufacturers and install them into their system. Because it is very expensive to develop and manufacture unique components (such as bearings or seals), most equipment manufacturers design their equipment so that standard size; readily available subcomponents are used. However, equipment manufacturers often assign their own part numbers to a bearing or seal that may be purchased from a component manufacturer. Therefore, it may be difficult to determine when similar components are used. Usually the equipment manufacturer will provide the original part number and manufacturer's name upon request. Very often it will be determined that more than one piece of equipment will use the same "generic brand" parts. This makes it possible to reduce the total inventory of spare parts, since common stock parts can be shared by different pieces of equipment. Also, by having the standard part numbers, replacement parts can usually be purchased locally at lower cost. Typical items that can usually be standardized include:

- Bearings;
- Grease/Oil Seals;
- Drive Motors;
- Gears;
- Packing;
- Mechanical Pump Seals;
- Electrical Components (breakers, solenoids, timers, resistors, transistors, etc.);
- Metal Stock (channel, box angle iron, diamond plate, grating, etc.); and
- Lubricants.

Numerous and sometimes large quantities of lubricants are often stored at wastewater treatment facilities due to the various types of equipment in operation. The space required to store and the difficulties involved in maintaining an adequate stock of lubricants is often costly. Therefore, it is often desirable to limit the number of lubricants by purchasing equivalent types which can be used interchangeably for the various equipment. The total cost of lubricants will probably also be reduced since "generic brands" can be used in place of expensive "name brand" products. Oil company distributors can often prepare a list of equivalent lubricants and required quantities to stock based on the model number and type of equipment used. Usually this inventory service is free of charge so long as the lubricants are purchased from the oil company distributor providing the service.

An inventory of equivalent lubricants can be performed in-house after carefully reviewing equipment maintenance manuals. However, it is important that maintenance personnel familiarize themselves with the various lubricants available. Many pieces of equipment have been prematurely worn out or have required replacement of bearings and other parts because someone has ordered the wrong lubricant. It is necessary to check manufacturers recommendations.

Once a complete list of required spare parts (including quantities of each part required) is prepared, the needed spare (e.g., parts, tools, lubricants) should be purchased. All items should be stored in a clean, well-protected stock area and organized so that an item can be easily located when needed. A record of items added to and taken from the inventory should be maintained so that the spare parts manager is always aware of stock levels. A standard procedure for reordering supplies should be established. Such a procedure should specify when to reorder stock. This will assure that the stock is adequate, minimize paperwork and avoid oversupply of items.

Arrangements should be made with suppliers to establish standard procedures for purchasing, including delivery time. This should also be done for items not stocked in the spare parts inventory so that downtime will be minimized. The spare parts manager should be prepared to order any item that might be needed to replace or repair any piece of equipment in the plant. The spare parts manager should also be familiar with the shipping options to expedite delivery when a critical item is needed.

In order to expedite the purchase of a needed spare part or piece of equipment not in the spare parts inventory, purchasing approval from the authority's administration or governing board should be prearranged. Certain dollar limits (should be established and there should be a procedure for verifying such purchase approval (e.g., by the plant superintendent or plant manager). Such an arrangement will avoid unnecessary delays in order approvals.

Finally, it is very important to keep a record of all expenditures incurred in maintaining the spare parts inventory (e.g., the cost of purchasing new supplies, the cost of rebuilding salvaged parts, labor costs associated with managing and staffing the spare parts department). This provides useful input to the preparation of future operating budgets. The current asset value of the spare parts inventory should be determined every year for accounting purposes.

The use of computerized information systems can greatly facilitate the efficient management of a spare parts inventory. Such systems can be used to maintain a record of current stock inventory and to indicate when items need to be reordered. Programs can also be developed to assist in the purchasing of spare parts by maintaining a listing of available suppliers, current prices, shipping options, purchase order arrangements and ordering details for different items. If a computer is not available, a reliable manual filing system should be used.

Service Contracts, Warranties, and Insurance

One means of reducing maintenance and repair costs is to limit the operating authority's responsibility or liability for certain maintenance and repair items. For example, service contracts can be entered into through which a manufacturer or local vendor will maintain a given piece of equipment for a set fee. The terms of such service contracts will vary. The cost-effectiveness of a service contract, as compared against providing the necessary maintenance in-house, must be evaluated on a case-by-case basis. Service contracts are often especially attractive when special skills or tools are required to perform a maintenance task. Such contracts might be considered for especially complex mechanical equipment (e.g., centrifuges, vacuum filters, belt filter presses) and for unique maintenance tasks such as sewer cleaning, tank cleaning, and major equipment overhauls. In every case, the cost of a service contract should be compared to the cost of performing the service in-house. The current demands on maintenance staff should also be considered in assessing the merits of outside service contracts. If a service contract is being considered, competitive bids shold be sought from different service vendors.

Another means of reducing repair costs is to extend the warranties on certain pieces of equipment. Such warranty extensions can often be arranged when purchasing a piece of equipment. Although certain exceptions may apply, extended warranty will generally cover most repairs and can greatly reduce repair costs, especially in the event of a major breakdown. The potential avoided repair costs must be weighed against the cost of the extended warranty. Routine equipment maintenance must still be provided in-house; in fact, failure to provide required maintenance may nullify the warranty.

Some manufacturers or vendors many offer the option of "life cycle bidding" when purchasing equipment. With such a bid, the manufacturer or vendor guarantees that maintenance and repair costs will not exceed a certain amount over a specified period of time (conceivably through the projected life of the equipment). Maintenance and repair costs exceeding this amount are absorbed by the manufacturer or vendor, although certain restrictons may apply (e.g., mechanical failures due to abuse will not be covered). Again, the potential cost savings over time must be weighed against the increase in purchase price associated with this type of bid.

The cost of equipment replacement and repair due to unusual events such as explosion, fire, hail, lightning, and wind, can often be covered under extended fire insurance or comprehensive physical damage insurance policies. Damages due to the failure of certain types of equipment can also be covered by insuring individual pieces of equipment (e.g., boiler and machinery physical damage insurance). The cost of such insurance policies must be justified by the potential cost savings (i.e., avoided losses). A sewer authority can also insure itself to cover unusual maintenance and repair costs. This involves setting up a contingency fund for major repairs and equipment replacement not otherwise provided for in the the operating budget. This avoids the cost of insurance premiums; however, there is always some risk that the contingency fund will not be sufficient to cover repair costs.

There are several methods to reduce the cost liability associated with equipment maintenance and repair. The economic tradeoffs between the varous options must be carefully assessed. In some cases, service contracts, extended warranties, and insurance policies may be applied even though they are determined not to be cost-effective. This might be done to create a more stable operating budget, protected from the risk of incurring unexpected high repair costs at anytime. Although this may not in itself result in cost savings, it can help stabilize revenue requirements from one year to the next by eliminating many of the unknown cost factors in the operating budget.

CONTROLLING ADMINISTRATIVE AND OVERHEAD EXPENSES

Administrative and overhead expenses include all expenditures not directly related to the day-to-day operation of the treatment system. This includes administrative salaries (i.e., plant manager, superintendent, clerical support, etc.) as well as miscellaneous expenses (i.e., office expenses, building and landscaping maintenance, vehicle maintenance, insurance, etc.) and outside services (e.g., legal, accounting, engineering, and data processing services). Since the expenditures in these areas are relatively small compared to the large ticket budget items (e.g., staff labor, utilities, chemicals), little attention is given to cost control. However, the potential cumulative cost savings resulting from controlling administrative and overhead expenses can be significant, and should be considered. Some of the cost reduction measures that might be applied include:

- Consolidation or Elimination of Administrative Positions;
- Competitive Bidding/"Comparison Shopping";
- Low Maintenance Building and Landscaping Features;
- Cutbacks in Non-Operating Expenses; and
- Contract Operations/Privatization.

These topics are discussed below.

Consolidation or Elimination of Administrative Positions

In most cases, a small wastewater operation cannot justify a full-time administrator. Very often administrative duties will be assumed by the plant superintendent or chief operator; however, this may become a significant burden. When it is not possible for the superintendent or chief operator to assume these responsibilities, a part-time administrator might be sought. This generally proves to be impractical.

Another option to share an administrator with other small wastewater operations. Such an arrangement might be coordinated through a regional sewer agency. It may also be possible to contract for such services through a professional services contractor. The concept of full contract operations is discussed later in this section.

Whatever arrangement is selected, care must be taken to assure that the necessary administrative functions are provided. The cost-effectiveness of a contract services arrangement versus having a full-time administrator should be evaluated.

Competitive Bidding/"Comparison Shopping"

When purchasing supplies and equipment, every effort should be made to obtain a given item for the least cost. With major items such as vehicles, competitive bids should be sought from different suppliers. On smaller items, price quotes should be sought from several vendors before making a purchase. This also applies to items such as employee benefit packages and insurance programs. For example, less expensive hospitalization and insurance policies may be available.

If certain services are provided under contract by professional service contractors (e.g., engineers, law firms, accountants) these contracts should be evaluated to determine if the same services might be provided by others at a lesser cost. The practicality and cost-effectiveness of providing such functions with in-house staff should also be evaluated.

Every expense item should be considered. However, administrators should note that paying more for a particular item may be justified in some cases (e.g., when an extended warranty or life-cycle bid is involved). Current expenditures should be reviewed monthly and compared against the project expense budget. Evidence of excessive expenditures should be investigated to assure that the expenses are legitimate and that excessive prices are not being paid for particular items.

Low Maintenance Building and Landscaping Features

The effort devoted to building and site maintenance can often demand a considerable amount of manpower. Such maintenance is usually provided by the plant operating staff. It may be possible to reduce the labor requirements associated with this task by installing low maintenance building and landscaping features such as aluminum siding or masonry building exteriors in lieu of surfaces that require painting. Stone, gravel, or mulch ground cover in lieu of grassed areas will eliminate the need for frequent mowing.

Although such features should be incorporated during the design and construction stages, certain steps can be taken to reduce maintenance requirements of exiting facilities. Any capital investment required for such renovation projects must be justified by payback in avoided annual maintenance costs.

Cutbacks in Non-Operating Expenses

In evaluating the expense budget, particular attention should be paid to expenditures for non-operating expenses, such as travel, and conference attendance, Such expenditures should be justified on a case-by-case basis and should not be taken for granted. The budget for travel and conference attendance should be shared to the greatest extent possible, so that all staff can take advantage of legitimate training and professional development opportunities.

Contract Operations/Privatization

One very effective means of controlling administrative and overhead costs is to delegate the resonsibility for plant administration to a private contractor. Contract operations and privatization are two ways to accomplish this. Under a contract operations arrangement, the municipality or sewer authority contracts with a private contractor who assumes full responsibility for staffing and operating the public wastewater facilities for a predetermined fixed fee. The term of such a contract can be one (1) to five years (5) years or more depending on state laws.

In a privatization arrangement, the wastewater facility is owned and operated by a private concern, which in turn provides wastewate services to a municipality or other defined service area under a service agreement. In such an arrangement, the private owner is usually completely responsible for all operating costs. The term of a privatization service agreement will typically be twenty (20) to twenty-five (25) years. The feasibility of privitization may be subject to modification in tax codes.

Contract operation and privatization arrangements can take many different forms. The assignment of operational and financial responsiblities will vary. The contractual agreements can become very complex. Legal and financial liabilities must be carefully evaluated.

Contract operations and privatization are attractive only if the service can be provided at less cost to the user than possible with a publicly operated system. Aside from the direct cost savings involved, such contractual arrangements can offer the municipality or sewer authority protection from the risk of unusual and unexpected future increases in operating cost depending on the terms of the contract agreement. An obvious disadvantage to such an arrangement is that the municipality relinquishes control of the wastewater operation. This should not have any detrimental effect if the interests of the municipality are fully protected by the terms of the service agreement. The advice of legal, financial, and engineering experts should be sought before entering into such an agreement.

CONTROLLING CAPITAL EXPENDITURES

The capital cost of building, enlarging and upgrading sewage treatment and collection facilities is normally financed by local governments or public authorities, with supplemental Federal and state grants. Over the past decade, construction and equipment costs have risen dramatically, as well as the cost of financing (e.g., interest costs). Concurrently, cut-backs in Federal and state grants have made it expensive and sometimes economically infeasible to implement planned capital improvements.

The result is that wastewater utilities must carry higher debt service burdens. To help control the rising cost of financing capital improvements, several alternative financing techniques have emerged. Those that appear applicable to wastewater utility operations include:

- o Creative financing.
- o Capital improvement planning.
- o Capital reserve funds.
- o Privatization.

Creative Financing

The escalation of construction costs and interest rates, combined with the decreasing availability of Federal construction grant funding and the constraint of local debt limits has had a significant impact on the ability of many communities to finance capital projects. This has led to the development of a number of innovative financing techniques which can raise capital for needed wastewater facilities. Very often when community leaders realize the true cost of financing a wastewater project through conventional methods (e.g., general obligaiton bonds, revenue bonds, special assessment bonds), they recognize a need to consider innovative financing alternatives.

In the past, the tax exempt status of municipal bonds was sufficient incentive to encourage the purchase of relatively low interest securities. This is no longer the case. Increasing interest rates in the prime lending market have driven up municipal bond interest rates, thus increasing the debt service burden on the municipality issuing the bond. Securing bond insurance or a bank letter of credit may improve a municipality's credit rating and lower the interest rate on the bond issue. However, certain costs are involved.

In order to make lower interest municipal bonds more attractive, several innovative types of long-term bonding options have been introduced. The more common ones include:

- o Zero Coupon and Step Coupon Bonds
- o Tender Option Bonds
- o Floating Rate Bonds

Zero coupon bonds pay no current interest and thus avoid the cost of interest payments throughout the term of the debt. This type of bond is sold at a relatively large discount so that the investor is assured of a guaranteed appreciation in principal. Step coupon bonds pay lower than normal interest rates in the early years of the bond term and produce an increasing rate of return in later years. The advantage to the municipality issuing the bond is that less interest needs to be capitalized during the construction period, reducing the size of the bond.

Tender option bonds give the bondholder the option of redeeming the bond notes before they reach maturity. Since these bonds are more liquid than a conventional 30-year bond, they will generally have lower yields (i.e., they are sold at a lower interest rate), lowering interest costs.

Floating rate bonds bear interest at a rate that varies as a function of a predetermined index, usually the prevailing prime lending rate. The objective of the issuer is to reduce current interest expenses rather than risk paying higher interest rates later in the bond term. "Adjustable floating rate" bonds have the added feature of giving the bondholder the option of tendering the bonds at specified dates during the bond term. The issuer can then adjust the rate on the tendered bonds and reissue them. "Floating fixed rate" bonds offer the option of fixing the interest rate at some point during the bond term.

The potential for increased interest yields over the long term encourages the investor to accept lower initial interest rates on floating rate type bonds. On the other hand, if interest rates do not escalate, the issuer's total debt costs will be less than they would have been with conventional fixed rate bonds. However, the issuer should understand that if interest rates do escalate, the total amount of debt service will increase. This is generally acceptable for wastewater utility operations since their cash flow position usually improves with time as the service base is expanded and revenues increase.

The applicability of these and other innovative bonding options should be thoroughly investigated with the advice of legal and bond counsel.

One alternative to issuing a bond to raise needed capital is to secure a loan. Given the size of a typical wastewater capital project, borrowing from a conventional lending institution may be impractical. It may be practical, however, to secure low interest or no interest loans through state sponsored revolving loan funds or trust funds. At least four states (California, Georgia, New Hampshire, and New Jersey) are in the process of developing such revolving fund programs other States are expected to initiate such a program. There are various other ways in which states can offer assistance to local communities in securing reasonable project financing (e.g., bond guarantees, bond banks, bond pools, matching grants.). The state municipal league should be able to identify what, if any, state agencies offer such assistance.

When it is obvious that the cost of financing a capital project will impose a significant financial burden on a community, long-term leasing and lease purchase arrangements should be considered. Under such an arrangement, a municipality or a public sewer authority would lease a facility rather than own it. Such an arrangement might include a purchase option allowing the leassee to acquire the facility at some point in time. Another approach involves selling an existing property (e.g. an operating treatment facility) and then leasing it back.

The leasing of a wastewater facility will generally involve an agreement between a municipality or public agency and a private interest (e.g., a corporation, leasing company, or group of investors) through which the private interest can achieve certain tax advantages (e.g., investment tax credits, depreciation). This is especially true for "leveraged leases" in which an investor contributes a relatively small percentage of the equity and receives the tax benefits on the full value of the asset. Such arrangements can become very complicated, but can offer significant financial benefits to both parties. This option must be carefully evaluated since Federal tax laws impose certain constraints which may affect the economic feasibility of a project. (It should be noted that potential changes in the tax law may diminish many of the current tax advantages possible through the leasing of public facilities).

ILLUSTRATION - SELF FINANCING WITHOUT GRANTS

Many communities have financed and built their own systems without Federal financial assistance. The Carlisle Suburban Authority (Carlisle, PA), the communities of Middletown, Odessa, and Townsend (New Castle County, DE), Evesham Township, NJ, the City of Wilsonville, OR, the City of Lenexa, KS, and the Borough of Ephrata, PA are all examples of small communities (with sewage treatment plants of less than 4 MGD) that have financed the construction of new or expanded sewage treatment facilities without Federal grant assistance. In fact, most of these communities have financed their sewage systems without any form of outside financial aid, relying totally on the proceeds from the sale of bonds and available municipal funds to finance the needed capital improvements. In each of these communities, growth pressures demanded improved sewage services. Therefore, a large portion of the debt service on the new facilities is assessed to new customers.

The City of Wilsonville, Oregon, for example, recovers much of the debt retirement costs for its sewage treatment plant expansion project through connection charges. The city expanded its treatment plant in 1981 from 1.0 MGD to 2.25 MGD. Connection fees were set at roughly $1,000 per equivalent dwelling unit. Revenues from the sewer connection fees have so far been sufficient to pay the bulk of the annual principal and interest costs on their general obligation bonds. Excess revenues from connection fees have also been used to maintain a reserve fund for future capital improvements and contingencies.

Self financing of a wastewater facility also gives the community increased incentive to pursue cost saving opportunities. In Ephrata, Pennsylvania, force account labor (i.e., municipal employees) was used to perform the time consuming front end renovations and groundwork for the sewage treatment plant expansion. The borough manager estimates that $1 million was saved by using force account labor, not only as a result of wage rate differentials, but also from direct control of construction costs and personal project management. In Carlisle, Pennsylvania, similar construction cost savings were made by expediting the construction phase, thereby avoiding additional interest and inflationary costs. According to Carlisle's design engineer, without outside grant assistance, the community had the flexibility to phase and schedule the construction to meet its needs. It was able, therefore, to formulate a favorable interim and long-term financing arrangement to suit the affordability of the service area residents.

ILLUSTRATION - STATE TRUST FUNDS

In an effort to provide a new source of funds for public wastewater facilities, the State of New Jersey has proposed an infrastructure trust fund to provide low interest loans or grants to local governments. Under this arrangement, the state-sponsored loans would cover a fixed portion of project costs. Loan repayments would help maintain the trust fund and provide future loans.

Under the state's proposal, the trust would make low interest loans to localities to cover a percentage of the total project cost. Local governments would repay the loans over a 15-year period. Localities would also be responsible for financing the local share of the project costs. Limited grants might also be available to help reduce this local share in some cases. New Jersey estimates that replacing current Federal and state grants with loans will result in user fees roughly 30 percent higher than they would be with grant funding. However, the cost to the community could be as much as 50 percent less than it would be if the community had to finance its projects on its own. The implementation of the state's proposal depends on a large extent on whether Federal construction grants can be used to capitalize the bank.

Federal tax laws, rulings by the Internal Revenue Service, and state enabling legislation will influence the feasibility of many of these creative financing techniques. As stated earlier, the use of these innovative financing methods can involve very complex legal agreements and financial arrangements. The implementation of such arrangements should be done under the supervision of qualified legal and financial experts.

Capital Improvement Planning

In preparing a sound financial plan for a utility, provision must be made for future capital improvements. A capital improvement plan identifies specific sewage system needs, and outlines a course of action to satisfy those needs. It is important that utility managers do not view the capital improvement plan as a "wish list," but view it as a realistic projection of facility needs, including equipment replacement, system expansion, and facility upgrading.

The types of capital improvements to be considered when projecting facility needs include:

- Sewer extensions.

- Equipment replacement (e.g., pumps, process equipment, vehicles)

- Treatment plant expansion.

- Treatment system upgrading.

Obviously, many factors influence when these types of expenditures will be incurred. The replacement of equipment can be predicted to some degree, based on estimates of service life, while the need for sewer extensions and treatment plant expansions will be determined by service area growth trends. Although it is not possible to predict exactly when these expenditures will occur, a rough estimate of capital needs over time can be prepared. For example, the replacement of a given piece of equipment can be assumed to occur at regular intervals based on an estimate of service life. The timimg of system expansion and facility upgrading should be consistent with long range plans.

Once a realistic schedule of future expenditures is developed, a reserve fund should be established to provide the capital funds when needed. This can be done in many different ways. It can be capitalized from bond proceeds (i.e., a specific amount of capital set aside in a separate interest bearing account) or it can be set up as a sinking fund, where contributions are made to a special reserve account on a regular basis. A reserve fund can also be initially capitalized and then supplemented with sinking fund contributions.

The monies deposited in a reserve fund can be from excess general revenues or they can be specifically designated in the budget and rate structure. The latter approach is preferred since this is the only way to assure that the reserve account will be adequately funded. One method of generating reserve funds is to capitalize the depreciation of the treatment plant and collection system. This treats depreciation as an operating expense, which can be included in the operating budget and recovered through service fees.

The key to effective capital improvement planning is to accurately define current and future capital requirements. This requires a fairly detailed accounting of system assets (e.g., treatment and collection system infrastructure and accessory equipment, buildings, vehicles) and periodic updating of current replacement costs. Projections of future service area population and service demand should also be periodically updated to define a realistic timeframe for system expansion.

Once prepared, the capital improvement plan should be reviewed on an annual basis, and modified, if appropriate. Sinking fund contributions might be adjusted based on such reviews. These reviews should be conducted during budget preparation.

Capital improvement planning is projection of major capital outlays. By setting money aside for future expenditures, high financing costs can be avoided. This can also eliminate the need for imposing special assessments on service area customers. Even where a major capital improvement project requires financing to raise the necessary capital, planning ahead allows time to formulate the best financing package. This makes it possible to take advantage of current investment market conditions (e.g., low interest rates, impending tax law changes), and issue debt when conditions are right.

However, the most important reason for having a capital improvement plan is that it assures that needed capital improvements will be implemented. Too often, facility improvements are put off indefinitely simply because the money is not available. An effective capital improvement plan will prevent this from happening.

Capital Reserve Funds

The concept of using reserve funds for future capital improvements was just discussed. The use of reserve funds in connection with municipal bond issues is very common. Most bond trust indentures will require a debt service reserve (usually equal to one year's debt service) to assure that funds are always available to make principal and interest payments. In this application, the reserve is used as a contingency account. Contingency type reserves can also be established to cover uncollectible accounts (i.e., delinquent customer accounts that are written off) and to provide self insurance (i.e., cover certain losses due to accidents).

While contingency type reserves set aside funds for events that may or may not occur, a capital reserve provides for expenditures that are expected to occur. For this reason, this type of special reserve requires continuing contributions to maintain the fund, as in a sinking fund. The contributions should be built into the rate structure. A portion of service fee revenues should be used to fund the reserve. Most bond indentures require certain rate covenants that mandate that rates will be established to provide a buffer of excess revenue to assure that debt service is covered. If this coverage is actually provided, the excess revenues can be deposited in a capital reserve fund. Certain connection fees and other special assessments (e.g., development fees, treatment capacity purchase fees) might also be used to fund reserves for future projects.

The use of capital reserve funds supports the concept of "pay-as-you-go" capital financing, which seeks to minimize the amount of debt required to finance a capital project by increasing the equity contribution (i.e., paying up-front). Some investment experts frown upon maximum debt financing (i.e., financing the entire cost of a project through bond proceeds). Bond issues where the utility makes a meaningful equity contribution are generally be rated higher than those involving maximum debt financing. This makes the bonds more attractive, and should result in lower interest costs. The total debt service will be less due to the smaller bond size and lower effective interest rate.

A working capital account can be used like a capital reserve fund since it provides funds to meet immediate capital requirements. However, working capital is intended to provide a cashflow buffer, and is generally limited in size (usually equivalent to 2 or 3 months operating expenses). Nonetheless, municipal finance analysts may view working capital as a form of a capital reserve, and like to see it incorporated into a utility's rate structure.

The main advantage of a capital reserve fund is that it minimizes the need for short and long term financing. The provision of such reserves makes a municipal bond more attractive to investors, making lower interest rates may be possible. Finally, the existence of capital reserves will assure that capital improvements will be implemented when needed, and not put off for lack of capital.

Privatization

Recently, there has been much interest in privatizing many traditional public sector services, including refuse collection, parking, fire fighting, water supply, and most recently, wastewater collection and treatment. Under this type of arrangement, commonly referred to as "privatization," a private interest will own and operate a public facility and charge a fee for the services provided. Privatization is being considered by more and more communities as an alternative to financing large capital projects themselves. This is particularly applicable to wastewater projects since the decreasing availability of Federally sponsored construction grants is making it increasingly difficult for many communities to raise the capital required to build or expand a wastewater facility.

Privatization can be thought of as having three components, namely:

- Financing.
- Turnkey construction.
- Full service operation and maintenance.

Privatization financing schemes will generally have the private sector contribute some amount of equity (i.e., capital) which entitles the investors to certain tax benefits. In many cases, the bulk of the capital is provided from the proceeds of tax-exempt industrial development bonds (IDBs), backed by the privatization contractor. The main feature of privatization financing is that it does not require the municipality or sewer authority to incur any debt. If IDBs are involved, they are issued by a separate agency (e.g., a local industrial development authority). Therefore the municipality's debt capacity is unaffected.

Once the financing is secured, the privatization contractor is responsible for designing and constructing the facility. Since the contractor is in charge of both design and construction, significant cost savings can be realized. Engineering costs will be less since the engineering is generally done in-house. Construction costs will be less since the design engineer has more flexibility in preparing construction specifications. Since the contractor does not have to comply with EPA construction grant regulations, design and construction time can often be cut in half. This may result in significant cost savings due to avoided cost escalation.

Upon completion of the construction phase, the contractor must demonstrate that the facility meets specified performance criteria. The contractor is responsible for starting-up the facility and providing day-to-day operation and maintenance of the facility through the terms of the service agreement. The contractor is normally responsible for all costs associated with the operation of the facility. The contractor recovers these cost through a service fee collected from the municipality.

A privatization venture involves fairly complex legal and financial arrangements which need to be documented in detailed service agreements. These agreements often consist of two parts: one dealing with the construction period and one dealing with the operations phase. Some of the items addressed in the service agreement include:

- Construction specifications.
- Construction schedule.
- Guarantees of facility performance by the contractor.
- Guarantees of waste volume and waste characteristics by the municipality.
- Basis for service fees and sharing of project revenues.
- Assigned rights and liabilities of different parties.
- Contingency provisions.
- Provisions for dealing with changes in laws that affect facility operation.

Preparing such agreements requires the efforts of a multi-disciplined team of engineering, legal, and financial experts, including bond counsel and the bond underwriter. The development of a financial agreement can also involve extended negotiations with the contractor. The municipality should be prepared to devote the effort required to prepare the necessary legal and financial agreements involved in implementing a privatization plan.

In order to be attractive, a privatization proposal must demonstrate that the necessary services can be provided for a fee less than it would cost the municipality to build and operate the needed facilities itself. However, the municipality must be assured that the contractor is committed to the long term operation of the facility. If possible, the service agreement should specify that the contractor is liable for any regulatory penalities resulting from non-compliance with discharge requirements. At the same time, the municipality must be convinced that the proposed costs are realistic, and that the contractor (i.e., the equity owner) has the financial capacity to secure the debt incurred and pay liquidated damages. Obviously, privatization requires a firm working relationship between the municipality and the contractor. This is why privatization is often referred to as a public/private partnership. In actuality, it is a legal arrangement where each party must fully understand its responsibilities and obligations. In order for the arrangement to work, the municipality and contractor must work together like partners, because, if the arrangement fails, both parties lose.

BALANCING THE BUDGET AND MAXIMIZING REVENUED

The basic objective of budgeting in a wastewater operation is to develop a financial plan that provides sufficient revenues to cover debt service, operating costs, maintenance costs, and replacement costs. In order to maintain a balanced budget, revenues must equal or exceed costs. This is accomplished by controlling costs and taking full advantage of revenue opportunities. Cost control at a wastewater utility requires sound financial planning and financial management at the administrative level, as well as day-to-day attention to cost saving opportunities on the part of the operating staff. Day-to-day cost saving measures have been discussed in previous sections. This section addresses adminstrative measures that can be taken to help balance the budget, including:

- Enterprise accounting.
- Rate setting.
- Aggressive revenue collection.
- Service base expansion.
- Supplemental sources of income.
- Cash management.

Enterprise Accounting

The key to financial planning and financial management is the adoption of a self-sustaining utility management philosophy. Under this concept, the utility's financial plan is based on generating sufficient revenues to cover the total cost of delivering a service. Increased attention to the goal of self-sufficiency can also help provide the motivation for implementing many of the cost reduction methods discussed in this document. In developing a financial plan for a self-sustaining utility, the primary goal is to account for and recover all costs incurred in operating and maintaining the sewerage system. This is often referred to as enterprise accounting.

Setting up and implementing an enterprise accounting program requires that the utility manager carefully identify all the costs involved in operating the utility and accurately determine its revenue-generating capacity. After analyzing total outlays and income, the utility should establish a rate structure that will provide the revenue required to balance the budget. When sewer rates are kept artificially low (i.e., subsidized by a municipality's general fund or water system revenues), the operating budget will usually be fixed. In most cases it will not fully provide adequate operating capital and capital improvement funds. Enterprise accounting, on the other hand, allows the utility manager to establish whatever operating and reserve accounts are required, providing adequate revenue can be generated to fund the accounts.

In developing the operating budget for an enterprise operation, the utility manager should consider long-range needs as well as day-to-day operating costs. Typical long-range cost items to consider include:

- The cost of repairing and replacing sewerage system infrastructure and equipment (e.g., pumps, blowers, sewer lines, vehicles) based on realistic projections of service life.

- Capital investment required for needed capital improvements (e.g., plant upgrading, sewer extensions).

- Increased future debt service costs, given the reality of higher interest rates and larger local shares, due to reduced Federal and state funding.

  The cost of complying with emerging regulatory requirements (e.g., plant upgrading, increased monitoring requirements, sludge disposal restrictions)

In defining opportunities for generating the revenue needed to fund the identified budget items, the following possible revenue sources should be considered:

- The potential for expanding service area and thus increasing the revenue base.

- The assessment of sewer rates based on an equitable sharing of capital and operating costs (i.e., service charges that take into account the actual volume and strength of wastewater from different sources).

- Supplemental sources of income in addition to service charge revenues (e.g., sale of effluent or sludge).

It is very important that the projection of costs and revenues be an accurate as possible in order to develop realistic budgets and financial plans.

In order to establish an effective system of accounting for costs and revenues, the utility should develop an automated system for keeping track of expenditures and revenues. this will enables the manager to closely monitor the budget and make adjustments to the financial plan on a timely basis, as required.

ILLUSTRATION - ENTERPRISE ACCOUNTING

The Kent County Department of Public Works (KCDPW) of Grand Rapids, Michigan is an example of a sewage utility that operates on an enterprise accounting-type budget. The KCDPW derives its revenue solely from user fees from its customers. The utility has established an accounting system that documents the expenses and revenues of over a dozen separate sewage systems and water systems.

The enterprise accounting system contains standard cost data plus documentation of the time spent by maintenance staff in twenty-four (24) maintenance activities. The computerized reporting system then makes this cost and manpower information available to participating municipalities (i.e., customers). This provides back-up documentation submitted with monthly invoices. Utility managers at the KCDPW are also initiating an employee productivity/performance evaluation system using the information reported in this system. The KCDPW Managers hope to utilize the information to better forecast and schedule manpower requirements, and improve overall staff efficiency in performing routine maintenance tasks.

In the Village of Dexter, Michigan (population 1,750), the Village Manager has recently automated the revenue and expenditure data utilized in the municipal budget. The manager now has access to expenditures and revenue data by department (e.g. sewer, water, refuse collection) on a monthly basis. The monthly print-out shows a comparison of monthly expenses and revenues, year-to-date totals and the annual budget by line item within each municipal service fund account. The information is used to track expenses and identify high-cost items as part of the budget control and preparation process.

If properly implemented, enterprise accounting should improve the efficiency of any wastewater operation. The key to its success is that the utilities manager become more aware of cost control and revenue enhancement opportunities. To put it simply, a wastewater operation should be managed as if it were a private enterprise (i.e., a profit making venture). The only difference is that there is no profit per se; any income in excess of total operating expenditures is applied to reserve accounts to serve future needs (e.g., to fund capital improvement projects).

Although enterprise accounting may force utilities to raise service fees, very often other sources of revenue can be identified to help generate the supplemental income required to support the operating budget. In most cases, enterprise accounting will give the utilities manager more flexibility in budgeting a wastewater operation. This is because the manager can budget whatever is appropriate provided there is a plan for generating the required revenue.

Rate Setting

A vital part of enterprise accounting is establishing a rate structure. This discussion is presented to highlight the principle of "fair and equitable" allocation of costs in the rate setting process. That is, not only should rates be set to generate sufficient revenue (as required in enterprise accounting), but the rates should reflect the actual cost of providing service to different classes of users.

Establishing fair and equitable user fees can be a complicated process, particularly for service areas where the quality and quantity of wastewater generated by different users varies widely. Utility managers have to decide how to best allocate the costs of system O, M, & R (operation, maintenance, and replacement) and debt service as part of their annual budgetary process. The first step is to accurately determine the total user charge revenue requirements. In some cases, the cost of the wastewater operation is subsidized with funds from general tax funds or from the revenues of other utility operations (particularly water supply systems). In such cases, the user charge revenues do not reflect true operating costs. In determining true operating costs, reserve funds should be included to provide for future replacement and capital improvement needs.

The following items should be considered in developing a rate structure:

- The basic user charge should assess all users of wastewater services for their proportionate share of operating costs based on the strength, volume, and flow rate of their discharge. The operating costs should include debt service and administrative costs, as well as day-to-day O&M costs.

- A reserve fund for future replacement of major equipment should be established. The reserve fund should be a budgeted item each year (based on an assumed depreciation rate) and be allowed to accumulate (e.g., in a sinking fund) to provide immediate funds for equipment replacement when needed.

- A reserve fund for future capital improvements (i.e., system expansion, upgrading, and rehabilitation) should be established to provide a source of local share capital for future projects.

ILLUSTRATION - MODIFICATION OF RATE STRUCTURE

Public opposition to the high costs of sewerage services in Sussex County, Delaware, forced the County to reevaluate its user charge system. The County provides water and wastewater utility services to several water and sanitary sewer districts in the coastal (recreational) part of the county. Sanitary sewer district residents were paying between $350 and $500 per year for sewer services under a uniform rate structure (i.e. a front footage assessment to cover debt service and a flat rate per EDU to cover O&M expenses). High seasonal peak flows demanded that the newly constructed treatment facility have a large capacity which was underutilized much of the time. Repayment of the very large debt placed an unfair financial burden on the full-time resident users who were not responsible for the peak summer flows. A consultant hired by the County recommended a modified rate structure based on recovering the actual costs of providing sewer service, as a function of the peak and average flow characteristics, wastewater strength, and the number of full-time and part-time residents. The recommended user charge system resulted in a more equitable distribution of user fees among full-time and part-time residents. Given the more reasonable fee structures, new customers were more willing to connect to the system and the effective service area was significantly expanded. The combination of modified sewer rates and expanded service area reduced the typical homeowner's sewer service charge by as much as 50 percent.

Rate structures, therefore, can influence the cost of service to the customer and affect the ability of a utility to raise the necessary funds to operate, maintain, and repair the system on a continuing basis. Concern about rate structures and operating costs incurred in small municipalities has been expressed by many state regulatory agencies, including the Oregon Department of Environmental Quality (DEQ), the New Jersey Department of Environmental Protection (DEP), and the Illinois Environmental Protection Agency (EPA). The Oregon DEQ has offered technical assistance and advice to communities on how to improve their financial planning. The New Jersey DEP, in conjunction with the EPA, has sponsored the publication of a series of guidebooks on the financial management of wastewater facilities. The Illinois EPA, on the other hand, is considering reviewing wastewater utility audit reports and rate structures in order to identify financial problems and to monitor operations costs on an annual basis. The EPA Region I Office (in Boston, MA), along with participating New England States, has recently sponsored financial management workshops for municipal officials, and financed the publication of a Utility Management Manual which describes many financial management options.

Aggressive Revenue Collection

Once a budget is prepared and user rates are established, it becomes the responsibility of the utility to collect the revenue from the service area customers. The utility must assure the timely receipt of customer payments in order to maintain a positive cash flow.

Many techniques are being used by the public and private sector to alleviate the problem of delinquent payments. Some of these techniques include:

- o Use of preaddressed (and/or postage paid) return envelopes.
- o Stiff late payment penalties.
- o Prompt notification of overdue payments (automated cost reporting systems can help managers monitor delinquent accounts).
- o Use of computerized billing and recordkeeping system.
- o Post office box arrangements (payment checks are delivered daily to the utility's bank for immediate deposit).

- Bank collection arrangements which enable customers to pay utility bills over-the-counter at local banks.

- Customer budget plans designed by the utility to spread the cost of service uniformly over the year. (This helps the customer budget his or her resources on a monthly basis.)

ILLUSTRATION - AUTOMATING BILLING AND RECORDKEEPING

The automated cost reporting system utilized in Dexter, Michigan enables the town manager and clerk to devote more time to billing and collecting delinquent bills. It also allows the Village to bill on a monthly basis, thus helping to spread the annual cost of service in lower monthly installments and to better monitor and reduce the number of delinquent accounts. These changes helped improve the village's case flow position.

Monthly billing requirements and concerns for delinquent accounts led the South Fork Sewer and Water District to automate their billing system. Each of the 1,000 sewer accounts in the District has a computerized payment file which shows payment histories, water usage, and service performed. The recordkeeping and billing system enables the District to maintain tight control over the status of unpaid bills.

Service Base Expansion

One method of dealing with increasing operating costs is to expand the revenue producing base of the wastewater utility. Service base expansions can only be done if the treatment plant has the available capacity. This available capacity may be used to treat wastewater, septage, or sludge from adjacent communities through various arrangements as illustrated below:

- Small independent treatment facilities (e.g., developer-built facilities or small public utility systems) can be phased out and connected to a central treatment plant which has usable capacity.

- Two independent treatment systems can be connected on a "load-shifting" basis. That is, during peak flows an overloaded plant can send wastewater flows to an underutilized plant for treatment. In this way, both plants remain operational and expansion of the overloaded plant can be avoided, or at least delayed.

- Septage from septic tank pumping, and sludges from other existing wastewater treatment systems can be accepted for a fee. In most cases, only minor capital improvements will be required to accommodate the treatment of septage and additional sludge, and the increase in operating cost should be nominal. Therefore, the fees collected can produce a significant return on revenue.

- Unsewered developments can be added to the treatment system through the extension of sewer collection lines. If the plant is underutilized, the additional flow to the plant through an expanded customer base may contribute to improved plant performance. Using up available plant capacity may not be feasible in every case; however, there is a potential for generating additional revenue by using the facility to its maximum capacity.

- Local sewer connection ordinances (i.e., laws requiring that a developed property connect to the public sewer system if service is available) should be enforced.

- In cases where the demand for sewer service is great but treatment capacity is limited, plant expansion may be justified. A thorough cost-effectiveness study should be done to determine if the increased revenues justify the capital investment.

Even if plant expansion is not required, expanding the service base may involve considerable capital investment (e.g., extension of sewer lines, phasing out existing smaller treatment facilities, installation of sewer lines to connect to the main treatment plant, retrofitting the existing plant to accommodate septage or sludge handling and treatment).

Special legal and institutional issues associated with the expansion of the user base need to be examined. Significant technical issues involving the treatment of septage or sludges at an existing plant (e.g. the impact of shock loads) also need to be addressed.

While expanding the user base through the addition of more customers or by providing additional treatment services may offer significant financial advantages, the technical feasibility of such plans must be carefully evaluated. Projections of service demand and facility needs must be accurate and realistic. The costs and benefits of alternative user base expansion scenarios should be thoroughly examined to evaluate the full potential of various options.

ILLUSTRATION - EXTENDING SERVICE TO NEW CUSTOMERS

In Sussex County, Delaware, household sewage service bills of up to $500 per year caused much dissatisfaction and protest from County residents. In order to reduce the high user charges which resulted from the construction of a new sewage treatment plant, the County expedited the completion of local facilities plans which allowed the eventual connection of an additional 2,500 customers to the system. These new customers now constitute a third of the total user base for the treatment facility. User charges for system customers were reduced dramatically by the addition of these customers.

ILLUSTRATION - SUPPLEMENTAL INCOME FROM SEPTAGE TREATMENT

Many sewage utilities have found that offering septage treatment services provides an additional source of revenue. In Somersworth, New Hampshire, for example, a 2.6 MGD facility treats on the average about 7,500 gallons per day of septage delivered to the plant by private haulers. Annual revenues from septage treatment fees were $12,000 in 1982, which represents ten percent (10%) of the sewage department's annual revenues.

Supplemental Sources of Income

Additional income from treatment system operations can be realized through creatively promoting the resources available at the plant. Additional revenue from the sale of treatment system by-products, such as sewage effluent, sewage sludge, methane gas, and other recoverable products, is possible with a little imagination and salesmanship. Many communities underestimate the value of the waste material being produced at their wastewater treatment plants. With a sound marketing plan and good public relations effort, selling waste material can be an effective means of raising revenue. The reuse of residual wastes may also eliminate or reduce the cost of otherwise disposing of these residuals.

Some examples of raising supplemental income include:

- Sewage effluent and sludge can be sold directly to farmers to irrigate tree nursery products and crops. Sewage utilities can also grow crops or nursery stock by irrigating with sewage effluent to market locally.

- Land application of septage or sewage sludge, which also serves as a nutrient base for crop production.

- Other recoverable products, such as methane gas, could become a marketable product to local industry.

- Contract services to other utilities (see discussion on "Contracting Staff to Others" in "Reducing Labor Costs" Section).

- Interest income (see discussion on "Case Management").

The feasibility of selling effluent or recovering waste by-products should be carefully evaluated before attempting to implement such a program. This evaluation should consider technical feasibility (i.e. the ability to consistently produce the desired by-product), as well as market demand and public acceptability. If the demand for the product is not great enough, the additional income generated may not cover the capital investment and increased operating costs involved, despite the savings in disposal costs that may be realized. Public protests (e.g. objection to land application of effluent or sludge products) may delay or even prevent the implementation of by-product reuse schemes. The posture of local and state regulatory agencies can also have great impact on the feasibility of reuse plans.

ILLUSTRATION - SUPPLEMENTAL SOURCES OF INCOME

Producing a Case Crop Using Effluent Irrigation

The sewage treatment facility in the City of Roosevelt, Utah, is being used to irrigate land which grows a cash crop for the utility. The treatment facility consists of a facultative lagoon with winter storage and land disposal, designed to serve a population of about 22,000 people. The land disposal system consists of center-pivoted sprayed irrigation units that operate over a total wetted area of 268 acres. An alfalfa cash crop is harvested at this site (3 or 4 times each year). Total revenues from the sale of the harvested crop were $58,900 in FY 1980, $59,400 in FY 1981, and $59,600 in FY 1982.

The decision to utilize a cash crop in conjunction with the spray irrigation system in Roosevelt City was made in consultation with a plant/soil scientist from the Utah State University Cooperative Extension Service and a local advisory group, composed of farmers from the area. Field evaluations and productivity studies were performed by the Cooperative Extension Service representative. The proposed cropping plans and economic feasibility studies were then reviewed by the local advisory group, which recommended alfalfa as the cash crop with rotation of grain to establish the alfalfa.

While operating revenues appear to be substantial, a comparison of revenue and expenditures for the cash crop enterprise (prepared by the City's auditors) shows operating expenses exceeding revenues from the annual harvests. The operating expenses of labor, supplies, cutting and bailing, utilities, and equipment repair (of the irrigation system) were shown in the report to constitute a significant portion of the total operating cost. According to the city finance director, a positive cash flow can be realized if additional land area were irrigated. The City is considering different crop management practices in an effort to increase hay production.

This example illustrates the importance of carefully estimating operating costs, and being realistic in projecting the revenue potential for such ventures.

Equally important in this case is the need for continuous follow-up and performance evaluation of the project by knowledgeable persons (e.g., farmers and crop management specialists in this case) to review the techniques used, and formulate recommendations to enhance the productivity and efficiency of operations.

Lease of Effluent Irrigated Cropland

At the Township of Gratton, Michigan, sewage facility revenues from the leasing of an irrigated apple orchard constitute one source of operating revenue. A local farmer pays a $6,600 per year fee to the Township to lease the orchard site which includes the use of effluent from the Township's wastewater facility for irrigation water. This revenue represents about nine percent (9%) of the total annual operating budget for the sewage collection and treatment system in the Township. The Township is also planning to harvest timber from hardwood trees planted at another sewage disposal site where effluent is used to irrigate the land.

Selling Effluent

In Hillsboro, Oregon, the Unified Sewage Agency sells sewage effluent in the summer months to a golf course and to a tree farm for irrigation. Proceeds are about $7,500 per year. The sewage agency personnel have estimated the average revenue for the sale of effluent to be $10 per acre-foot. Revenues from the sale of effluent for irrigation will vary according to the climate, proximity to users, and price and availability of alternative water supply sources for irrigation.

Selling Methane Gas

The sale of methane gas from the Unified Sewage Agency's Forest Grove Facility (2.5 MGD) to a nearby industrial park is also under consideration. The adjacent businesses would use the gas to help fuel their boilers.

Recovering Other Waste Products

The Unified Sewage Agency has also discovered that silver chloride, recovered from spent COD solutions in their laboratory, is a marketable product. In 1982, the recovered silver chloride was sold for about $100. The spent COD solutions are normally disposed of without attempting to recover the silver chloride.

Selling Sludge

The Galesburg Sanitary District has been applying sludge to a sod farm adjacent to the treatment plant. This saves the district the cost of hauling the sludge 17 miles to a landfill and results in a savings of $60,000 a year in sludge disposal costs. The District has contracted with an individual to operate the sod farm on the District's land. The contractor plants grass seed, maintains it, and then pays the District for each square yard of sod harvested.

These extra sources of revenue, however small, can be used to supplement the operating budget. They can also be utilized to set up funds for special purposes. For example, an "incentive fund" to serve as a basis for merit awards, could be established, or a special fund for training seminars and travel for plant operations personnel could be maintained. These creative uses of the utility revenues have the added benefit of encouraging creativity and pride in the operations staff. The main advantage of having supplemental sources of income is that the utility does not have to depend entirely on service fees to raise the needed revenues, and thus may avoid unpopular rate increases.

Case Management

As mentioned in the previous section, the interest in investments can produce supplemental income for a wastewater utility. Very often, this additional revenue can be realized without a lot of time or effort on the part of the utility manager. Case management is the process of managing the utility's fiscal resources in order to take advantage of cash availability for investment and maximize the yield on investments.

There are basically two options that a community can choose in implementing a cash management program. The two options are:

- Consolidate temporarily idle cash from available fund accounts within the utility operation into a single special fund for investment, and invest the available monies in low risk securities (e.g., treasury bills, certificates of deposit, repurchase agreements).

- Participate in local government investment pools coordinated and managed by county or state agencies. Idle cash for investment can be found in a variety of fund accounts (e.g., water and sewer operating budgets, revenue sharing funds, tax collection funds, and construction and capital improvement funds). These idle monies may be simply awaiting use, set aside for pending payments, held in reserves required by law, used as operating reserves, or collected in a revenue account. Interest earnings from pooled cash investments are typically credited to the contributing funds based on the proportion of their contribution. Generally, cash flow management accounting systems (i.e., automated record keeping systems) are necessary to track and forecast cash needs and balances. Cash flow forecasts, for example, can tell the case manager how much idle cash will be available for investment, when and for how long. Simple computer programs can be written to track the status of investment funds. Some banks offer this service as part of their financial management services to municipalities and utilities.

Local government investment pools can be organized through the auspices of the state or be created by local governments themselves in cooperation with independent administrative and investment advisors. Consolidating separate accounts into a pooled cash fund increases the flexibility of the investments. It enhances the ability to invest larger sums of money for longer periods of time, generally resulting in higher interest rates and higher yields. Investments should be made in safe and liquid interest bearing funds to ensure that monies are available upon demand and that investments are protected from market defaults. Despite the advantages of cash management, many local units of government are reluctant to pool their resources into a county or statewide pooled investment fund. In order for such investment pools to be successful, the participating agencies must be comfortable with the fund manager and trust that sound investment decisions will be made. It may take some time to earn this trust, but once established, investment contributions and average yields could increase noticeably.

Over a dozen states and a multitude of localities have organized local government investment pools. State operated local investment pools, for example, managed some $2.5 million in assets in 1981. The participation in a state operated investment pool can help simplify cash management for small communities that have neither the staff nor the resources to develop a full-scale cash management program of their own.

ILLUSTRATION - INVESTMENT POOLS

In Kent County, Michigan, investment pooling is coordinated and managed by the county treasurer's office. During 1982, about twenty-eight townships, cities, and villages earned over $585,000 in interest through the county's pooled investment fund program. (The invested balance for the local government unit pool in that year was $4.7 million. Interest yields in the pooled fund program for the year averaged over 14 percent, which is at least twice the interest yield which the local governments were accustomed to receiving in their normal investment practices. The participants in the local government unit pool included rural townships, some of which invested debt fund proceeds from the sale of bonds used to finance sewer and water projects. Other townships invested both operating and debt fund revenues into the county pool.

In the City of Portage, Michigan, a pooled cash management program was initiated by the city manager and finance Department in 1980. The system consolidated idle cash from thirty-six different fund accounts in the city government. These included the general operating fund, water and sewer operating and debt funds, and a variety of other debt and operating funds. In fiscal 1981, the total city-wide interest earnings from the 36 funds was $1.2 million. In the subsequent fiscal year, it was $1.6 million - the equivalent of most 4 mils of property tax. The interest earnings from the Pooled Investment Program are roughly three (3) times what they were before the cash management and investment pool programs were initiated.

Pooled investment (and cash management) programs operate within a defined framework of legal and administrative constraints. Legal constraints consist of Federal, state, and local laws and regulations that restrict or otherwise affect local cash management practices. Federal laws and regulations, for example, strictly govern investments of grant funds and money from the sale of municipal bonds. Other Federal regulations require special treatment of interest earned on investments of Federal funds (e.g., revenue sharing).

As with other local government functions, the powers, duties, and responsibilities of municipalities in the area of cash management are set forth by state law (except for home rule municipalities). Local laws may restrict the fund manager in a number of ways as well. This makes it essential that the fund manager carefully review all local ordinances, state statutes, and Federal laws, and seek professional advice to avoid legal problems. State municipal leagues may be able to offer information regarding the use of such investment programs in a particular state.