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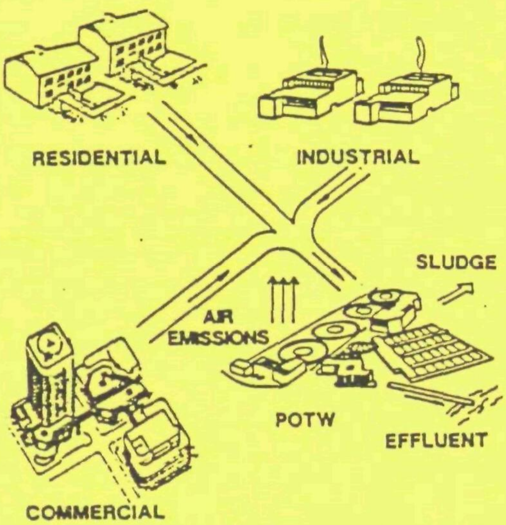
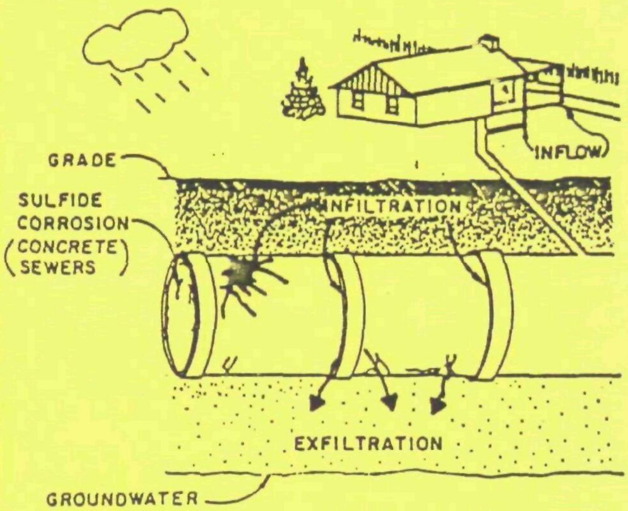
Municipal Wastewater Conveyance and Treatment

Technological Progress and Emerging Issues 1988

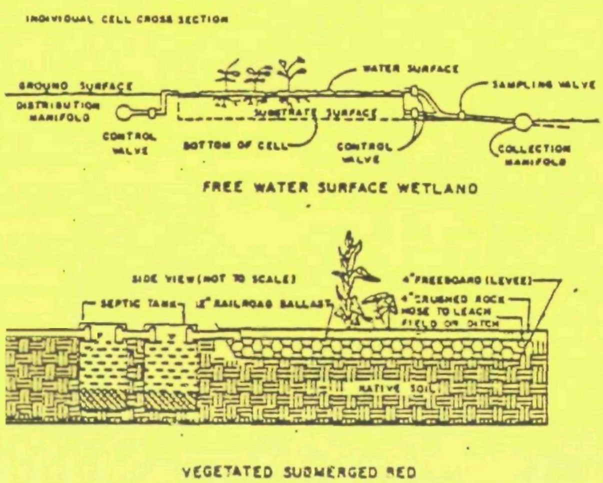
SOURCES AND FATE OF TOXICS/TOXICITY AT POTW'S



CONVEYANCE SYSTEM PROBLEMS



CONSTRUCTED WETLAND



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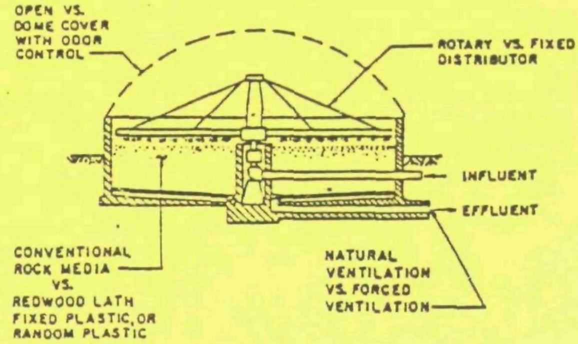

SEPTEMBER 1988

MUNICIPAL WASTEWATER CONVEYANCE AND TREATMENT

Technological Progress and Emerging Issues 1988

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER
OFFICE OF
MUNICIPAL POLLUTION CONTROL
WASHINGTON, DC 20460

PREFACE

The Environmental Protection Agency's (EPA) Office of Municipal Pollution Control (OMPC) has prepared this report to provide interested parties with an overview of technological progress and emerging issues in the collection and treatment of municipal wastewater. The report summarizes a wide range of information in three (3) major topical areas: toxics, collection and treatment technology, and operation and maintenance. Each section provides a synopsis of recent findings or developments. Where possible, references to more detailed sources of information are included for those wishing to explore any of these topics further. Included as appendices to this report are summary tables similar in form to those published in the past as part of EPA's annual "Innovative and Alternative Technology Progress Report" to which this document is a successor.

OMPC welcomes your comments and suggestions on this document. Please direct them to Mr. Peter E. Shanaghan, OMPC WH-595, 401 M Street, S.W., Washington, DC 20460.

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ACKNOWLEDGEMENTS

Many individuals contributed to the preparation and review of this report. The document was prepared by Engineering-Science, Inc. (ES) for EPA's Office of Municipal Pollution Control (OMPC).

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INTRODUCTION

The 1980's have been marked by significant technological progress in the municipal wastewater pollution control field. The Innovative and Alternative (I/A) technology program has played a major role in facilitating much of this progress.

Since 1983, EPA has issued annual "Innovative and Alternative Technology Progress Reports" to document the technical accomplishments of the I/A program. This year, in response to the challenges we face implementing the 1987 Water Quality Act (WQA), EPA is refocusing the annual technology progress report. A Report to Congress on the Effectiveness of the Innovative and Alternative Wastewater Treatment Technology Program is also being prepared.

The Water Quality Act (WQA) of 1987 affects the municipal wastewater pollution control field in a number of significant ways. These include changes in methods of financing municipal sewerage works construction, identification and control of toxic pollutants and establishing regulatory programs for sewage sludge.

"Municipal Wastewater Collection and Treatment - Technological Progress and Emerging Issues 1988" is intended to provide an overview of technical progress not only under the I/A program, but in the broader municipal technology field as well. Thus, in addition to discussing progress in I/A technologies such as land treatment, sequencing batch reactors, and alternative collection systems, the report also discusses progress in conventional technologies such as activated sludge, trickling filters, and collection system rehabilitation. This report also discusses emerging issues in the municipal wastewater field such as toxics control, sulfide corrosion of sewers, and new sludge regulations.

EPA's technology transfer efforts are evolving to meet the new challenges we face. This document is but one example of that evolutionary process. Across the Agency, a number of initiatives are underway which will help provide the technical community with the information needed to meet our nation's clean water goals. Examples of these initiatives include Region V's Special Evaluation Projects, Region VI's Feedback-to-Design Program and the National Small Flows Clearinghouse. A summary of these initiatives is provided in Appendix A.

EXECUTIVE SUMMARY

This report provides an overview of technological progress and emerging issues in the conveyance and treatment of municipal wastewater. It is a successor to EPA's annual "Innovative and Alternative Technology Progress Reports". The three major topics covered in this report are: toxics, conveyance and treatment technology, and operation and maintenance.

TOXICS

Despite the great advances made in recent years to control toxic discharges through implementation of pretreatment programs, many POTW's may still be contributing to toxic pollutant related water quality problems. Section 304(l) of the Clean Water Act (CWA) as amended by the 1987 Water Quality Act (WQA) requires States to, among other things, prepare a list of waters not expected to achieve applicable water quality standards for toxics due to point source discharges. NPDES permit limitations are to be imposed on these point sources to ensure that water quality standards will be met. Thus, many POTW's may soon be facing either chemical specific permit limits for toxics or whole effluent toxicity limits. In addition, POTW's may face a variety of responsibilities under a number of other environmental statutes including the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation and Liability Act.

Toxic pollutants and toxicity in POTW effluents may be contributed by a range of sources including industrial, commercial, and residential users as well as the POTW itself. Where toxics or toxicity are present in a POTW's effluent, additional source control can be implemented or additional removals can be achieved through either optimization of existing treatment process performance or additional treatment processes.

MUNICIPAL WASTEWATER TECHNOLOGY

CONVEYANCE SYSTEMS

<u>Current Issues</u> - EPA is currently studying three major conveyance system issues: sulfide corrosion, rainfall induced infiltration and sewer exfiltration. Accelerated, severe corrosion in the County Sanitation District of Los Angeles County prompted Congress, as part of the 1987 WQA, to require EPA to study sulfide corrosion in wastewater conveyance and treatment systems. Significant progress has been made in the study and major factors influencing sulfide corrosion have been identified. Similarly, problems experienced by the East Bay Municipal Utilities District of California prompted Congress to direct EPA to study rainfall induced infiltration (RII). RII may be defined as stormwater which enters the sanitary sewer system indirectly through openings and defects in sewer pipes and manholes located above the permanent groundwater table. The RII study is focusing on a national assessment of the problems associated with RII, connection methods/approaches, and key factors impacting the occurrence and magnitude of RII. The last conveyance system issue under study is sewer exfiltration. EPA's Domestic Sewage Study identified exfiltrating sewers as a potential sources of

groundwater contamination, but noted that information necessary to assess the impact of sewer exfiltration was lacking. The sewer exfiltration study has been undertaken to fill this information need.

Sewer Rehabilitation - Sewers that have been damaged by corrosion, cracking, or joint disruption are subject to infiltration and exfiltration. Various no-dig rehabilitation techniques have been developed to facilitate sewer repair in high traffic flow urban areas. Techniques for sliplining existing sewers with resin impregnated felt tubing or plastic pipe have been developed and marketed by several companies. Localized sealing systems using resin injection equipment and various types of packers with television inspection systems are available. Building sewers have been found to be major source of the infiltration into sewer systems. Methods to internally inspect and seal building sewers without costly excavation and the need to access private property are being developed.

Alternative Conveyance Systems - Under the innovative/alternative technology program, substantial experience has been gained over the last ten years with alternative conveyance systems. Alternative conveyance systems are designed to overcome the economic disadvantages of conventional gravity sewers in less developed areas. The three principal categories of alternative conveyance systems are pressure, vacuum, and small diameter gravity sewers. EPA is working with other Federal Agencies to evaluate the experiences gained from operation of these systems.

TREATMENT TECHNOLOGY

There are many processes available to effectively treat municipal wastewater. These can be grouped into preliminary, primary, secondary, and tertiary or advanced treatment. Preliminary treatment consists of unit operations such as screening and grit removal to improve downstream operations and processes and to protect mechanical equipment. A 1987 EPA report "Preliminary Treatment Facilities Design and Operational Considerations" highlights recent advances in these unit processes.

Secondary Treatment - Secondary treatment is defined in terms of effluent quality by the Secondary Treatment Regulation at 40 CFR Part 133. Widely used technologies to achieve secondary treatment include lagoons, activated sludge, and trickling filters. A number of recent advances have occurred in these technologies. The EPA Summary Report "The Causes and Control of Activated Sludge Bulking and Foaming" provides information on possible solutions to these common activated sludge problems. Sequencing Batch Reactors may be an activated sludge option that makes sense for some small communities. The EPA Summary Report "Sequencing Batch Reactors" details design and operational considerations for this technology. The Trickling Filters/Solids Contact Process is a promising technology for upgrading existing trickling filter plants.

Greater than Secondary Treatment - Several processes are available to achieve treatment levels equal to or more stringent than secondary. The most widely used or most promising of these technologies are land treatment, constructed wetlands, and biological phosphorus removal. Land treatment involves the controlled application of wastewater onto the land surface to achieve treatment through natural physical/ chemical and biological processes during contact with the vegetation and soil. The I/A program has significantly advanced the understanding and use of land treatment systems by funding 249 slow rate systems, 71 rapid infiltration systems, and 49 overland flow systems. Constructed wetlands are man-made systems which employ aquatic vegetation to assist in the treatment of wastewater. Various demonstration projects in Europe and

North America indicate that these systems have considerable potential for small community wastewater treatment application. Biological Phosphorus Removal processes are variations of the activated sludge process which employ an anaerobic stage (Phosphorus release) followed by an aerobic stage (Phosphorus uptake in excess of normal). Several of these systems are patented. The major continuous flow systems are the A/O Process, Modified Bardenpho Process, Phostrip Process, and Modified Activated Sludge.

Disinfection - Chlorination is by far the most common method of wastewater disinfection in the U.S. However, dechlorination is being more frequently required due to concerns about the toxic effects of chlorine residuals. Through the I/A program, considerable experience has been gained with disinfection by Ultraviolet Irradiation. In light of these factors, EPA is undertaking a review of its 1976 Municipal Wastewater Disinfection Policy.

SLUDGE TREATMENT

Changing Sludge Regulations - EPA is well along the way toward proposing the first round of comprehensive technical regulations covering incineration, ocean disposal, landfill, land application and distribution and marketing practices. The agency has also reproposed its State Sludge Management Program Regulations in conjunction with proposed changes to the NPDES permit regulations.

EPA has, for many years, actively encouraged the beneficial utilization of sewage sludge and has recently established an awards program to recognize efforts promoting sludge beneficial use.

Recent Advances in Sludge Processing Technologies - Dewatering is a physical unit operation used to reduce the moisture content of sludge. Recent advances in sludge dewatering include: mechanical-assisted air drying, vacuum-assisted drying beds and planting reeds into drying beds. Composting is a sludge management option that employs biological decomposition to convert sludge into a stable humus. EPA is studying the major types of in-vessel sludge composting systems and will produce a guide for design, evaluation and procurement of in-vessel systems with attention to odor control. Incineration is a sludge management option which reduces the quantity of solid material by combustion of organic solids. EPA recently conducted a study on emissions from incinerators as they are normally operated.

OPERATION AND MAINTENANCE TECHNICAL ASSISTANCE

Since 1982, EPA has implemented an on-site municipal wastewater treatment plant operator training and compliance assistance program for small communities. Under Section 104(g)(1) of the Clean Water Act, States provide "over-the-shoulder" assistance to small plants up to 5 mgd size. This training also addresses financial management problems and issue resolution with local officials.

A comprehensive performance evaluation (CPE) seeks to determine if major facility upgrades are required or if a Composite Correction Program will produce the required effluent quality. A CPE consists of an evaluation of major unit processes, identification and prioritization of performance limiting factors, and assessment of the ability of a composite correction program to improve performance. In national surveys, operator application of concepts and testing to process control and administrative policies were found to be significant performance limiting factors. EPA is currently preparing a report on its analysis of performance limiting factors.

SECTION 1

CHALLENGE OF TOXICS FOR POTW'S

THE ISSUE IS WATER QUALITY

Meeting our Nation's water quality goals will require new or expanded toxic discharge control initiatives by many publicly owned treatment works (POTWs). As shown in Figure 1, toxic pollutants originate from a number of sources including direct industrial discharges, stormwater discharges, and urban and agricultural runoff (non-point sources). In addition, despite the great advances made in recent years to control toxic discharges through implementation of pretreatment programs, many POTWs may still be contributing to toxic pollutant related water quality problems. Congressional concern that some waters would not meet water quality standards due to toxic pollutants even after implementation of technology based controls, ie., BAT, pretreatment standards, and new source performance standards, is reflected in the amendments to the Clean Water Act made by the 1987 Water Quality Act.

Section 304(l) of the Clean Water Act, as amended by the 1987 Water Quality Act requires States to identify and list waters impaired by point and non-point source discharges of toxic or non-toxic pollutants, as well as the amounts of such pollutants discharged by each source.

Within the context of the Clean Water Act, there are several key terms applying to surface water toxics control. These terms are defined as follows:

"Priority pollutant" - Any of the 126 pollutants listed in Appendix D of 40 CFR Part 122. The 126 priority pollutants are derived from the 65 classes of compounds listed at 40 CFR 401.15.

"Toxic pollutant" - Any pollutant listed as toxic under Section 307(a)(1) of the CWA. EPA has listed 65 classes of compounds under Section 307(a)(1) of the CWA, and these categories or compounds are located at 40 CFR 401.15.

"Toxics" - Refers to any pollutant or combination of pollutants which causes toxicity to aquatic life or terrestrial life or causes adverse human health affects.

"Whole effluent toxicity" - The aggregate toxic effect of an effluent measured directly with a toxicity test. A toxicity test measures the degree of response of an exposed test organism to a specific chemical or effluent.

IDENTIFYING IMPAIRED WATERS - SECTION 304(l) LISTS

"Long List" - A comprehensive list of waters which are not expected to meet water quality standards for their established designated uses after application of technology based limits due to point or non-point source discharges of toxic or non-toxic pollutants.

SOURCES OF TOXICS/TOXICITY IN SURFACE WATERS

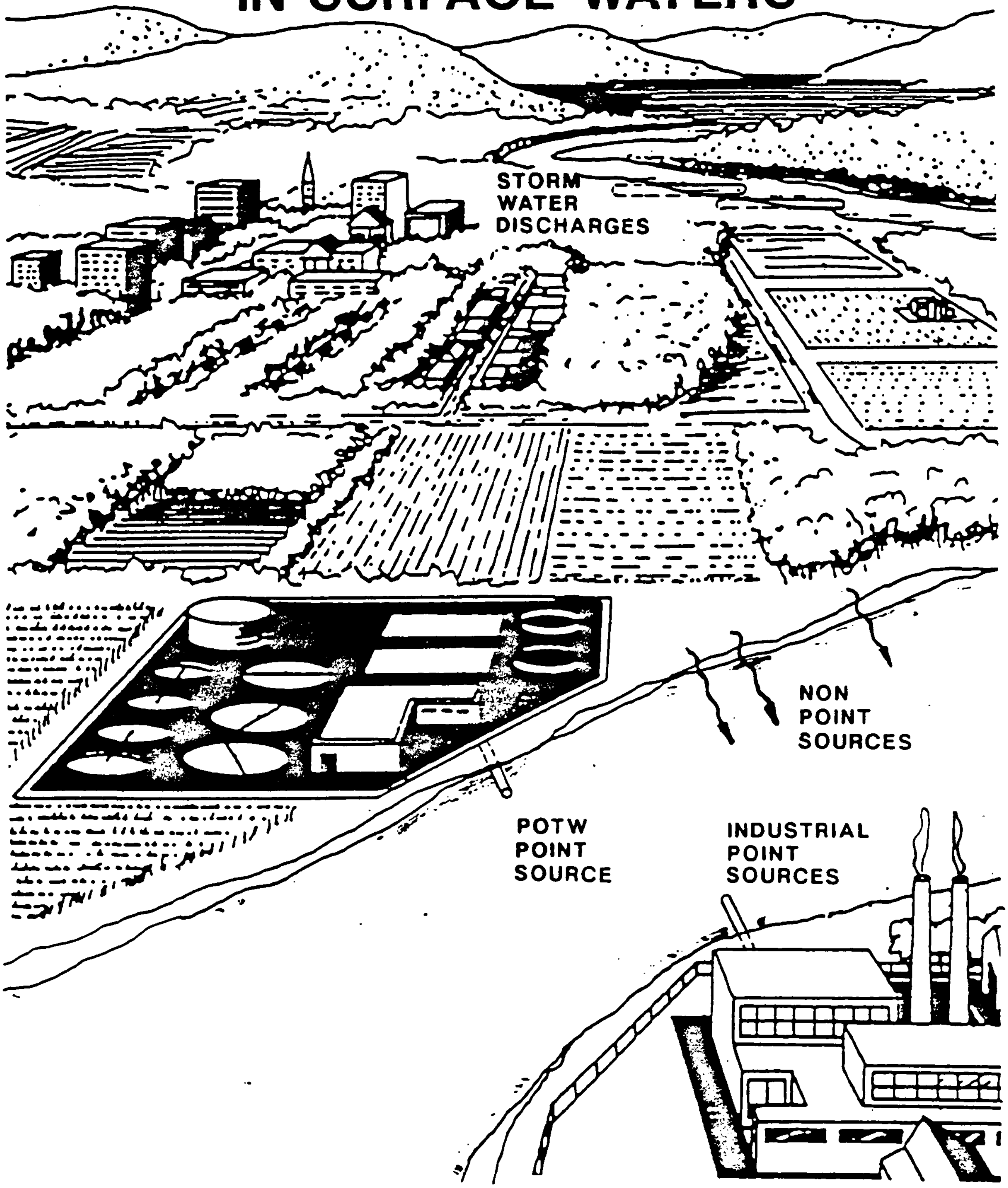


FIGURE 1

"Short List" - List of waters not expected to achieve applicable water quality standards which may be narrative, i.e., "no toxic substances in toxic amounts" or numerical, i.e., numeric criteria within water quality standards for Section 307(a) toxic pollutants, after application of technology based limits and pretreatment standards due entirely or substantially to point source discharges of Section 307(a) toxics.

"Mini List" - List of waters which are not expected to achieve numeric water quality standards for Section 307(a) toxics after application of technology based limitations due to point or non-point source discharges.

IMPACT ON PUBLICLY OWNED TREATMENT WORKS (POTWS)

For each stream segment or waterbody on the Short List, the State must identify the specific point sources, including POTW's, discharging any Section 307(a) toxic pollutant and the amount discharged.

The State must then prepare an Individual Control Strategy (ICS) for each waterbody or segment on the Short List. The ICS generally consists of an NPDES permit for each point source along with documentation of the total maximum daily load and the wasteload allocation for individual discharges. Dischargers must comply with all NPDES permit limitations by June 1992.

POTW PERMIT LIMITS FOR TOXICS

POTW permits may contain two types of limits for toxics:

Chemical-Specific Limits - Numerical limits derived from water quality criteria or State water quality standards. They are expressed as concentrations of the pollutant (mg/L) or loadings (lbs/day).

Whole-Effluent Toxicity Limits - Whole-effluent toxicity is the aggregate toxic effect of an effluent measured directly with a toxicity test. In a toxicity test, an effluent sample is collected and diluted, usually with receiving water, in test chambers. Test organisms are placed in these test chambers for specified periods of time. At various points during the testing period, the number of organisms affected in each chamber is counted (the endpoint can be mortality, reduced growth, etc.) and the lowest effluent concentration that causes that endpoint is calculated. The endpoint is usually stated as an LC50 (the effluent concentration at which 50 percent of the test organisms are killed) or a No Observed Effect Level or NOEL (the highest effluent concentration at which no unacceptable effect will occur even at continuous exposure).

In a permit, the LC50 or NOEL may be expressed in terms of Toxic Units (TU) as defined by:

$$TU = \frac{100}{LC50 \text{ or } NOEL}$$

where LC50 or NOEL is expressed as percent effluent in dilution water.

Toxic Units are properly expressed as acute (TUa) or chronic (TUc) depending upon the type of toxicity measured. Acute toxicity involves a stimulus severe enough to rapidly induce a response, typically 96 hours or less. Chronic toxicity involves a stimulus that lingers or continues for a relatively long period of time, often 1/10 of the life span or more.

In addition to permit limits established under the authority of the Clean Water Act, POTW's may face regulation under a number of other enviornmental statutes designed to control toxic and hazardous materials. These statutes include the Resource Conservation and Recovery Act (RCRA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); the Toxic Substances Control Act (TSCA); and the Clean Air Act (CAA). EPA is preparing a booklet entitled "Overview of Toxic Pollutant Issues for POTW's. This booklet will be available in late 1988 and will assist POTWs in understanding their responsibility under these newer environmental statutes.

SOURCES OF TOXICS

The toxic pollutants and toxicity present in municipal wastewater are contributed by a range of sources. As shown in Figure 2, although major industrial users controlled under the pretreatment program can be a significant source of toxic pollutants and toxicity, toxic pollutants and toxicity are also contributed by commercial users and households. For smaller POTWs and POTWs with few industrial users, commercial and household sources can be the predominant source of toxic pollutants and toxicity. Additionally, in-plant sources such as in-plant recycle streams and excessive chlorination can contribute significantly to effluent toxicity.

TOXICS REMOVAL CAPABILITIES OF POTWS

The fate of toxic pollutants and toxicity in municipal wastewater will depend on the nature and characteristics of the individual constituents. Research is ongoing to define the fate of specific pollutants. Although many organic toxic pollutants are degraded during biological treatment, some may partition to the air or the sludge. As toxic metals are not biodegradable, the removal that does occur results from their partition to the sludge. Thus, while the treatment provided by POTWs can reduce specific toxic constituents and can reduce the overall toxicity of the wastewater, partitioning of toxic pollutants may cause pollution problems in other media, ie., air or sludge.

Process performance data from research studies and from studies at POTWs demonstrates that conventional POTW treatment processes are capable of removing significant fractions of toxic pollutants from the wastewater. Under optimum conditions, over 95 percent removal of volatile and semi-volatile organics can be achieved. Trace metal removals vary, depending on the metal, between 20 and 90 percent.

Actual removal performance in POTWs for toxic organics is more variable and treatment efficiencies are generally lower than predicted under optimum conditions. This lower removal performance is the result of the fluctuating concentrations of toxic pollutants generally present in municipal wastewaters and poorer acclimation of the biological treatment process to specific toxic pollutants.

Substantial removal of toxicity can also be achieved by POTWs. Where non-refractory readily biodegradable toxics are responsible for the measured toxicity, complete removal of toxicity can be achieved by a POTW; however, where refractory toxics are present on an intermittent or continuous basis, the pass-through of residual toxicity will occur. Moreover, this residual toxicity generally cannot be attributed to identifiable toxic pollutants.

SOURCES AND FATE OF TOXICS/TOXICITY AT POTW'S

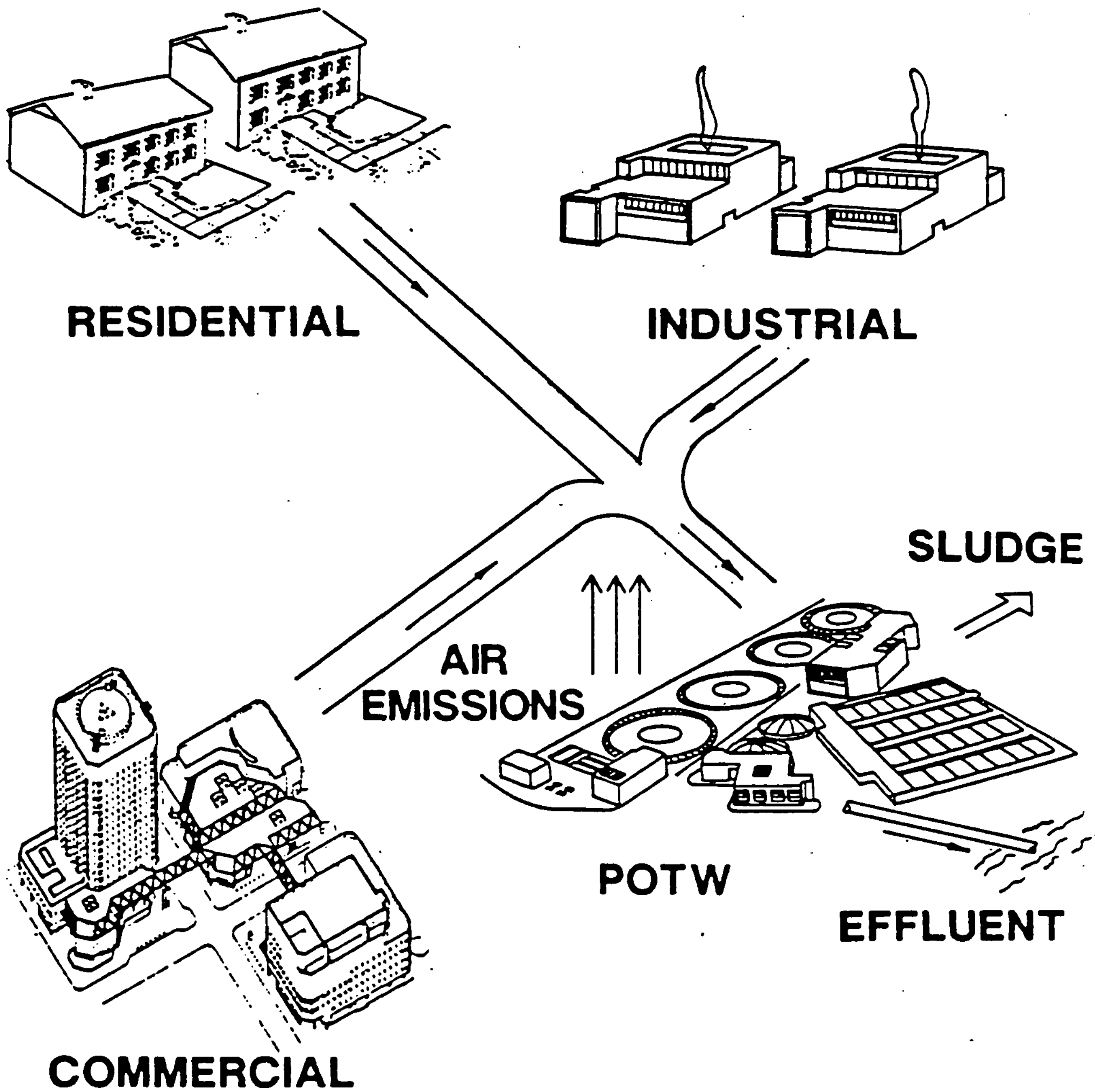


FIGURE 2

ENHANCING POTW TOXICS AND TOXICITY REMOVAL

Where toxics or toxicity are present in a POTW's effluent, additional source control can be implemented or additional removal of toxics and toxicity can be achieved through optimization of treatment facility process performance.

Industrial and commercial source control of toxicity can be implemented through local pretreatment limitations based on the authority of the Clean Water Act and the General Pretreatment regulations. Toxics and toxicity control can be justified to insure water quality protection, sludge quality protection, eliminate treatment process operational problems, worker health and safety and to limit air emissions.

Based on the conditions present at a specific POTW, several technical approaches to industrial and commercial source control can be used. These approaches are outlined as follows:

- o Allowable Headworks Loading Method -- numeric limits are based on the maximum loadings of pollutants that will allow compliance with receiving water quality criteria or sludge quality criteria or protection against treatment interferences.
- o Collection System Method -- numeric limits are based on worker health and safety criteria.
- o Industrial User Management Method -- based on an in-depth review of IU practices the municipality can set narrative limits for chemical management practices (e.g., chemical substitution, spill prevention).
- o Technology-Based Limits -- numeric limits are based on levels that can be feasibly and economically achieved by comparable industries.

When additional industrial source control does not sufficiently reduce effluent toxicity, a POTW will have to improve the toxicity removal capabilities of its own treatment processes. This may involve operation and maintenance changes to optimize toxicity removal through existing processes. Toxics and toxicity removal is related to the removal performance of conventional parameters thus, through stabilization of plant performance, a parallel reduction in effluent toxics and toxicity can be achieved. If this is insufficient, then new additional treatment processes, e.g., filtration, may need to be considered.

EPA is currently preparing a Handbook for Managing Toxic Pollutants in POTWs which is expected to be available late 1988.

SECTION 2

MUNICIPAL WASTEWATER TECHNOLOGY

CONVEYANCE SYSTEMS

Current issues in conveyance system technology include:

- o Sulfide Corrosion
- o Rainfall Induced Infiltration
- o Sewer Exfiltration
- o Sewer Rehabilitation
- o Alternative Conveyance Systems

Figure 3 depicts infiltration, exfiltration, and sulfide corrosion.

CONVEYANCE SYSTEM PROBLEMS

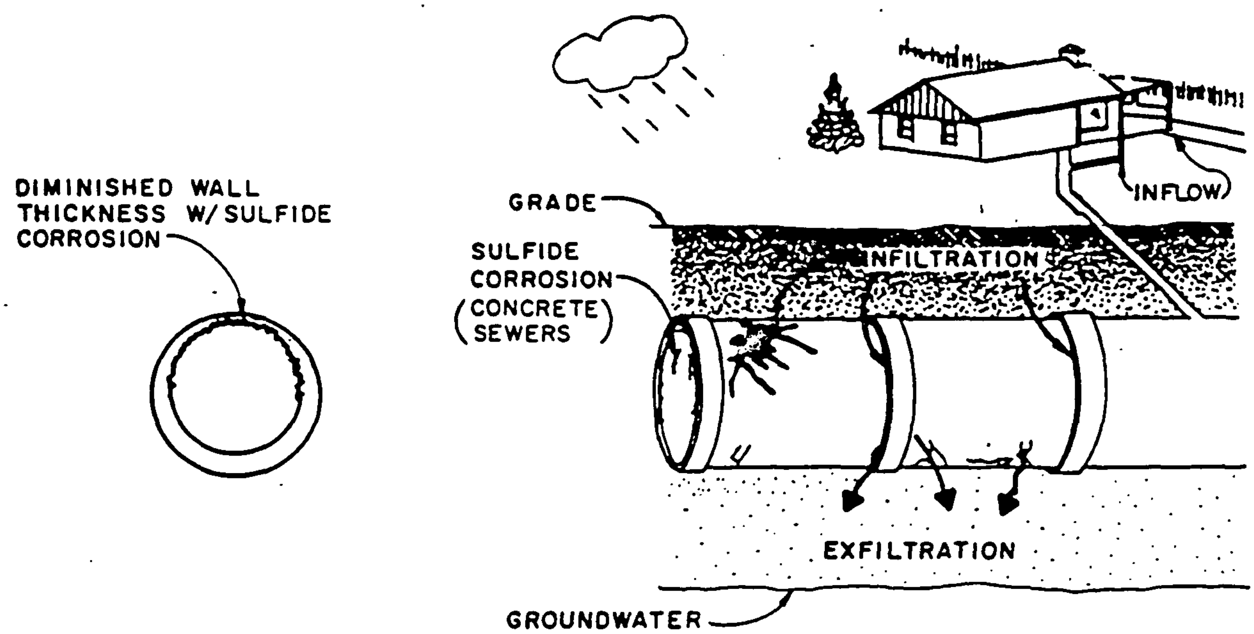


FIGURE 3

SULFIDE CORROSION

Accelerated, severe corrosion of the sewers and parts of the wastewater treatment plant in the County Sanitation District of Los Angeles County (CSDLAC) convinced Congress that sulfide corrosion needed additional study. The corrosion rate in CSDLAC is ten times that seen in the early 1970's and four times the rate predicted based on the observed sulfide levels. At the same time corrosion increased in CSDLAC sewers, the concentration of metals and cyanides in the wastewater decreased.

EPA analyzed limited information on 34 cities with corrosion potential to identify factors associated with corrosion. Corrosion seemed more prevalant <u>after turbulent flow</u> that can entrain hydrogen sulfide gas into the headspace of the pipes; after force mains, in manholes and in flow transition structures; <u>after long detention times</u>; and <u>in cities with warmer sewage temperatures</u>. In addition all four cities that transmit wastewater treatment sludge in the conveyance system had corrosion.

Other factors did not ensure corrosion incidence in the 34 cities even though they may favor anaerobic conditions: <u>separate vs. combined sewers,</u> which have less dilution of sewage and surcharging, systems serving <u>large populations, long transmission distances,</u> <u>slow flow</u>, and <u>regionalized treatment systems</u>. Actually, three systems with many treatment plants (9, 16, or 30) also have corrosion in the conveyance system.

EPA visited six sewer systems with known corrosion problems besides the County Sanitation Districts of Los Angeles County. These six systems experienced corrosion <u>at turbulent points</u> where force mains discharge to gravity sewers, at lift stations, in laterals near interceptors, at changes in grade or direction, pump station discharges, and drop connections; <u>after excessive sewage detention time</u> caused by hydraulically oversized sewers, flat slopes, or slow flow; and <u>in warm temperature sewage</u>. All six cities had one to four sites with rapid corrosion rates, estimated to corrode at least an inch of concrete in 33 years. However, no cities appear to have corrosion rates as high as the County Sanitation Districts of Los Angeles County.

Remaining tasks to complete the Report to Congress include completing the preparation of proceedings from a sulfide corrosion workshop attended by corrosion experts, further study of sulfide corrosion and contributing factors, analysis of existing data on the extent of corrosion in other cities, and a summary of control measures for existing and new sewers.

RAINFALL INDUCED INFILTRATION

Rainfall Induced Infiltration (RII) may be defined as storm water which enters the sanitary sewer system indirectly through openings and defects in sewer pipes and manholes located above the permanent groundwater table. RII produces a flow response in the sewer system which is directly influenced by the intensity and duration of rainfall and is often characterized by a rapid response in wastewater flow to rainfall. RII is also a significant contributor to peak wet weather flows. The East Bay Municipal Utility District (EBMUD) in Oakland, California for example, has experienced short-term peaking factors of up to 22:1. RII is similar to groundwater infiltration (GWI) in terms of the types of defects through which extraneous flow enters the sewer system, but its response to rainfall is similar to that of direct storm water inflow (SWI).

Section 523 of the Water Quality Act of 1987 directs EPA to study problems associated with RII, and specifically methods of regulating RII into the sewer systems of EBMUD. An integral part of the study will focus on a national assessment of the problems associated with RII, correction methods/approaches, and key factors impacting the occurrence and magnitude of RII. The assessment will rely on a four city survey as well as a detailed analysis of nine cities to ascertain how RII has been documented for each system.

Key factors that affect RII relate to both the physical characteristics of the sewer system and the natural characteristics of the service area. Key factors in the physical characteristics of the sewer system that affect RII include:

- o Sewer construction (pipe/joint material, bedding/backfill)
- o Sewer condition (number and types of defects; this is highly dependent on age, maintenance, extent of root instrusion, etc.)
- o Sewer profile with respect to impermeable soil layers.
- o Sewer depth below the ground surface and with respect to the groundwater table.
- o Sewer density (amount of pipe per unit area).

Key factors in the natural characteristics of the service area that affect RII include:

- o Soil characteristics (porosity, moisture content)
- o Geologic characteristics (depth to bedrock)
- o Ground water (Perched water table occurrence and duration)
- o Topography.

Other activities of the study include an evaluation of the costs and effectiveness of controlling RII through analysis of "model" conveyance systems and control strategies. The objective of this analysis will be to determine the cost-effective level of RII control (transport and treatment cost savings greater than RII correction cost). Also included will be an assessment of RII flows on wastewater treatment plant performance.

SEWER EXFILTRATION STUDY

The 1984 Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act called for a Domestic Sewage Study which has been completed and submitted to Congress. The Domestic Sewage Study addressed: the type, size and number of hazardous waste generators discharging to municipal conveyance systems; the types and quantities of hazardous wastes discharged to sewers; and the significant generators' wastes and constituents not regulated in a manner sufficient to protect human health and the environment. This study identified both the possibility of groundwater contamination from sewer exfiltration and the unavailability of information needed to make proper impact assessment and recommended additional research, data conveyance and analysis.

As a result of these recommendations, the Sewer Exfiltration Study was initiated to determine if groundwater contamination from exfiltrating sewers is a problem. Earlier work included use of an existing mathematical model relating exfiltration to infiltration based on laboratory studies. This model was found invalid during field studies for verification and calibration.

Most recently field work including groundwater sampling has been conducted at three sites where:

1. Sewers carry a significant portion of industrial effluents.
2. Exfiltration is occurring.
3. Pollutants may be migrating to ground water.

The sampling program included the 126 priority pollutants, total phenolics, chlorides, viruses, bacteria and other pollutants. Samples taken included:

- o Sewage.
- o Soil adjacent to the sewer.
- o Upgradient ground water.
- o Downgradient ground water.

Additional work may be conducted depending on the results of the sampling work and the availability of funding.

SEWER REHABILITATION TECHNIQUES

Sewers that have been damaged by corrosion, cracking or joint disruption or failure are subject to infiltration, exfiltration and rainfall induced infiltration. As shown in Figure 4, open excavation for repairs in high traffic flow urban areas poses considerable economic and logistic problems. To avoid the need to reroute traffic,

NO DIG VS OPEN TRENCH SEWER REHABILITATION

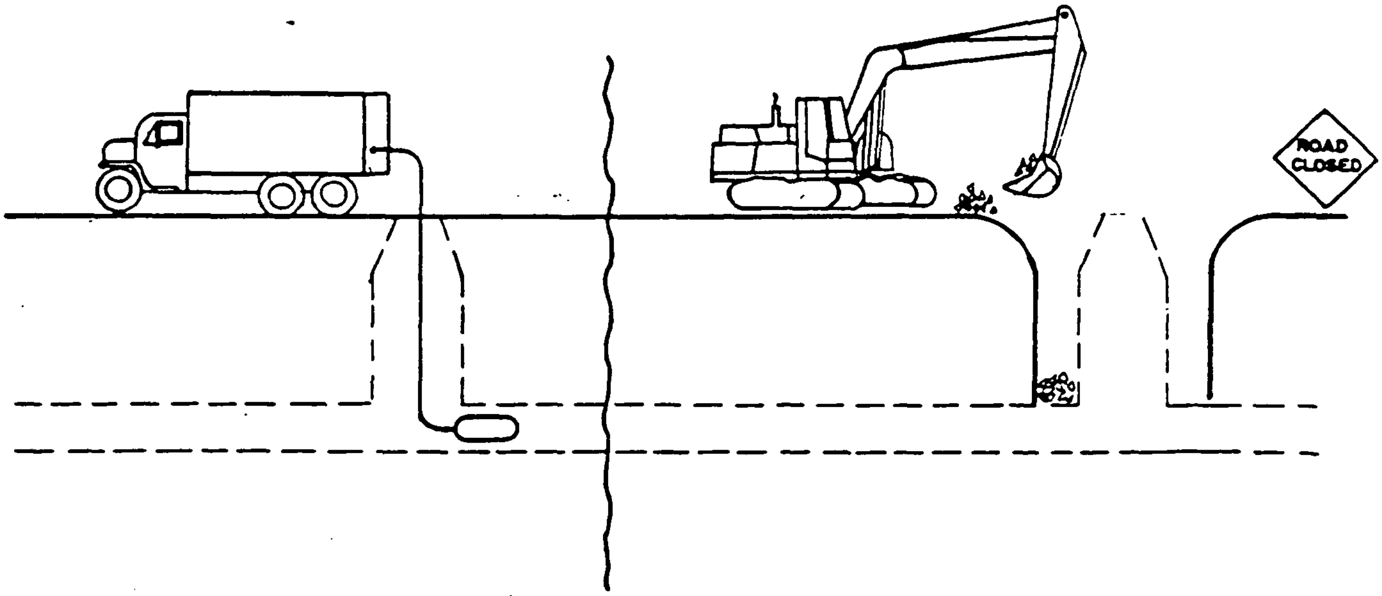


FIGURE 4

demolish and replace roadways, etc., various no-dig rehabilitation techniques have been developed. Repair technologies include:

- sliplining
- sprays
- seals

Sliplining processes either reduce the existing pipe diameter slightly or stretch or expand the existing diameter. The Insituform process, patented and licensed by Insituform of North America, Inc., Tennessee, uses a thin (1/8") resin impregnated felt tubing. The tube is inserted into the line via an existing access point and cold water pressure forces the tubing through the pipe. The material is inverted and pressed against the pipeline by the water. The resin is cured to a smooth hard surface by heating the water. A more chemically resistant resin is available, if needed. Advantages include independence of process from pipe material being repaired, efficiency and use of existing access points. Disadvantages include sensitivity to objects penetrating into the pipe and difficulty in recapping pipe connections. This process has been available in the U.S. since 1977.

Expansion of pipe diameter has been successfully used in Europe and the United States using the Pipeline Insertion Method (PIM) developed in Great Britain and licensed in North America to the PIM Corporation of New Jersey. The pipe bursting process consists of passing a tool (called a burster) through an existing buried pipeline between two excavations. It is pneumatically or hydraulically driven and is guided by a steel winch cable strung through the existing pipeline and connected to a constant tension winch located at the reception pit. The burster follows the line and grade of the existing pipeline. The tapered front section of the burster fits inside of the existing pipeline, bursting the pipe into small pieces and compressing the fragments into the surrounding soil, creating an annular space through which a polyethylene pipe of the same size or larger is simultaneously installed. Upsizing capabilities are currently limited to two additional pipe sizes from the existing pipe size. The tail section of the burster acts as a shield for the replacement pipe that is pushed in from the launch pit, using a hydraulic jacking unit. The hydraulic or compressed air lines that power the burster are strung through the replacement pipe. Manufacturer's literature claims that the pipe bursting process is capable of replacing pipelines up to twenty inches in diameter. (This technique was used to replace six-inch clay pipe sewers with eight-inch polyethylene sewers in Contra Costa, California in 1987.)

Two methods for relining standard plastic pipe have been developed. Subterra's Rolldown System uses a physical "rolldown" of a slightly larger polyethylene liner by 10 percent to allow insertion into the pipe to be repaired. The liner is pressurized in place to expand and form a snug fit. North West Gas of the U.K. developed a comparable sewer lining system which uses polyethylene pipe swaged through a die after heating which after sliplining reverts to its original diameter in three weeks or within 24 hours if pressurization is used.

Localized sealing systems using resin injection equipment and various types of packers with television inspection systems are available. The television camera is moved through the sewer which is remotely inspected by the operator monitoring the closed-circuit television screen. Detected leaks are filled with various types of grout depending on the service. Several different types of packers which force the grout into the pipe defects are commercially available. The packer is pulled behind the camera so the line can be inspected and sealed as needed. These are particularly useful for pipe joints.

Manholes may often be a significant source of infiltration. The use of the Perma-Form® Manhole System, portable/removable forms with special inserts to allow active lines to remain in use while a new concrete manhole is poured in place provides manhole rehabilitation without open excavation and major traffic disruption. Manufacturer's literature cites cost-savings, convenience, and versatility as major advantages. The system is patented and licensed by AP/M of Iowa.

Several types of epoxy liners and resins are available to trowel or spray on large diameter pipe with worker access. Some can be applied under water and cure to form an effective seal.

Building sewers have been found to be a major source of the infiltration into sewer systems. Methods to internally inspect and seal building sewers without costly excavation and the need to access private property are being developed. The Cues LSS® and LIS® are commercially available techniques from Cues Inc., of Florida. The Cues Lateral Inspection System LIS® permits inspection of lateral sewers from the main sewer. A launcher assembly allows a small camera to be launched up to thirty feet inside the lateral sewer to check for leaks. The Cues Lateral Sealing System LSS® is a refined version of the joint sealing packers used to internally grout mainline sewer joints. As shown in Figure 5, an inflatable inversion tube extends into the lateral under air pressure. The unit is designed to air test both the joint and the three to eight foot section of lateral filled with the inversion tube. If leaks are discovered, grout is injected from the mainline packer to flow into the lateral in the annular space around the inversion tube and seal leaks. The Insituform process previously discussed has also been used to repair laterals.

NO DIG LATERAL SEWER REHABILITATION

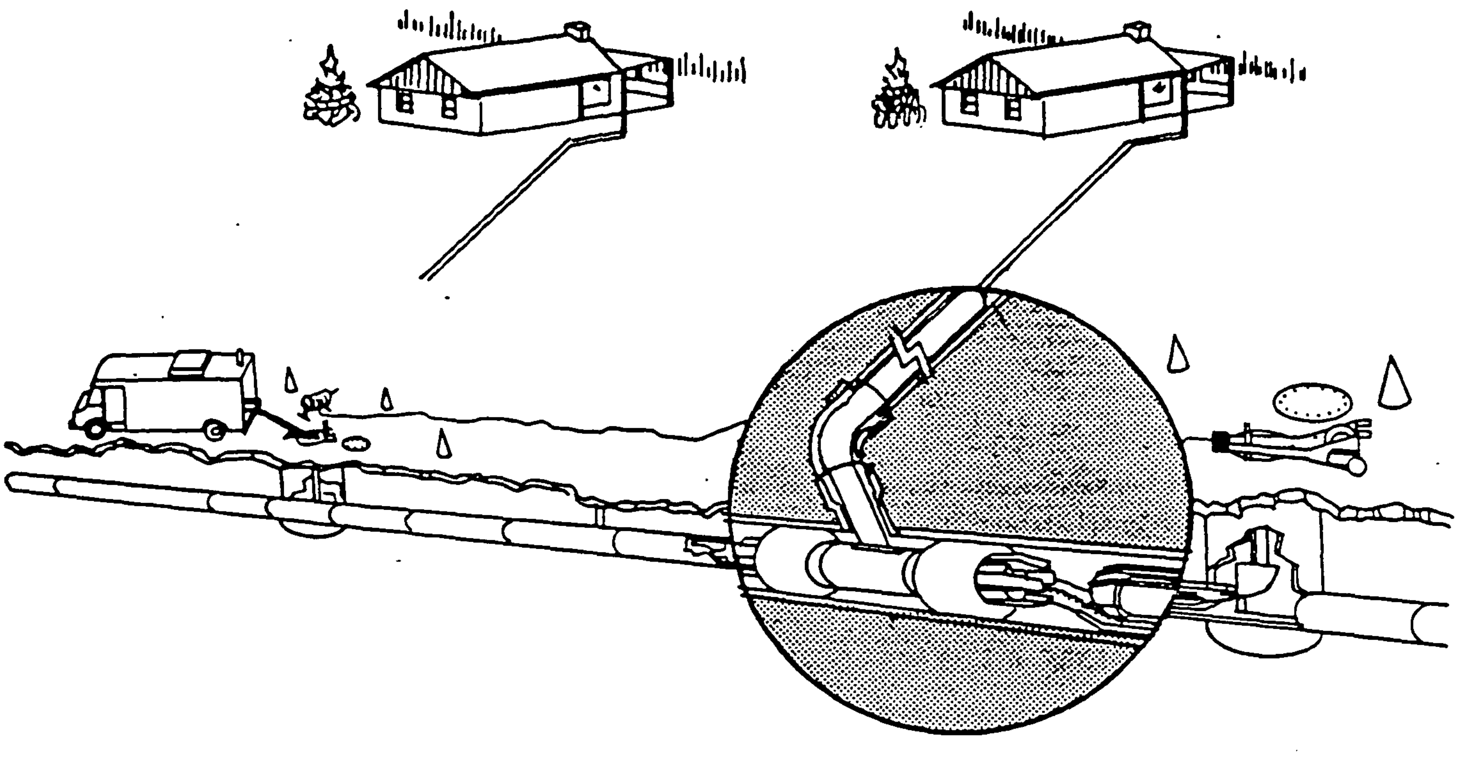
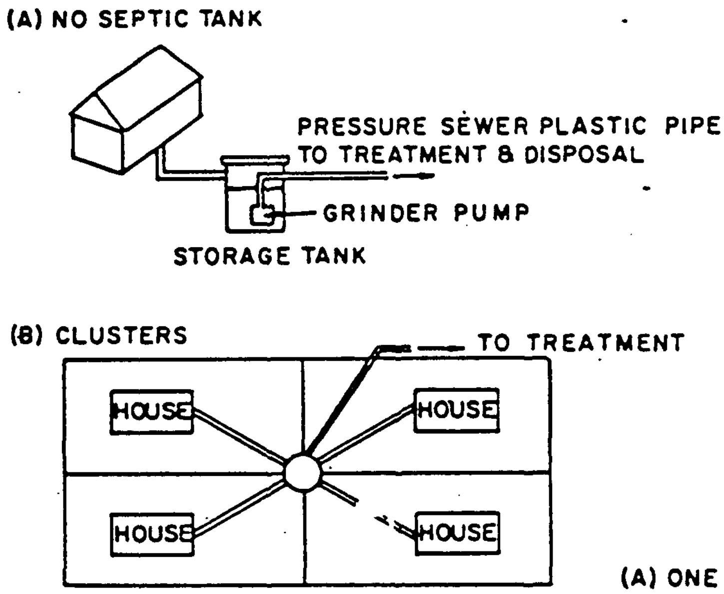


FIGURE 5

ALTERNATIVE CONVEYANCE SYSTEMS

Alternative sewers are wastewater conveyance systems which are designed to overcome the economic disadvantages of conventional gravity sewers in less developed areas. The high cost of conventional sewers often prohibit centralized conveyance of wastewater in small communities where on-site treatment and disposal systems are not viable. The lower costs of alternative sewer systems are due to the use of smaller diameter pipes, shallower burial depths and use of preliminary treatment and/or motive force devices. The three primary categories of alternative conveyance systems are pressure, vacuum and small diameter sewers. Under EPA's Innovative/Alternative technology program, substantial experience has been gained over the last ten years with alternative conveyance systems.

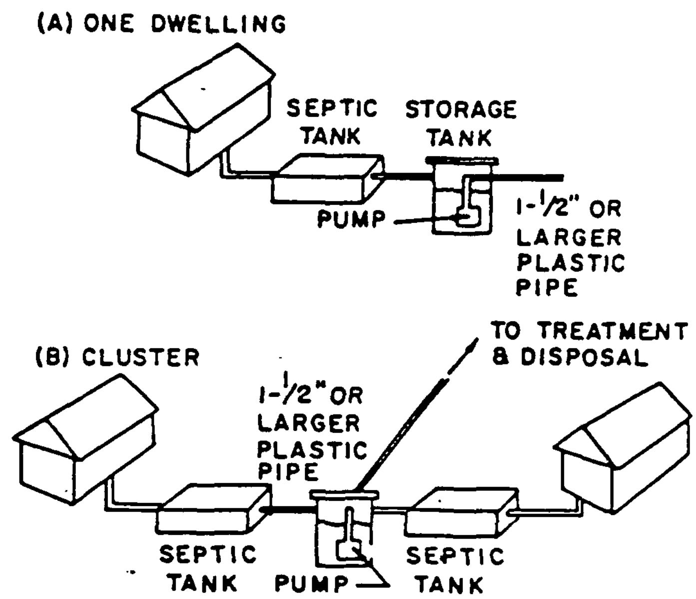


PRESSURE SEWERS, GP
(GRINDER PUMP)

FIGURE 6

Pressure sewers consist of two types: Grinder Pumps (GP) as shown in Figures 6 and the Septic Tank Effluent Pump (STEP). The grinder pump unit grinds sewage and pumps it through small-diameter plastic pipe to central or alternative treatment and disposal. The unit does not use the septic tank. This unit can be used for one or several homes.

The STEP unit as shown in Figure 7, can be adapted for one dwelling or a cluster of dwellings. Liquid from the septic tank is pumped through small diameter plastic pipe to further off-site treatment and disposal. The accumulated solids must be periodically pumped from the septic tank.

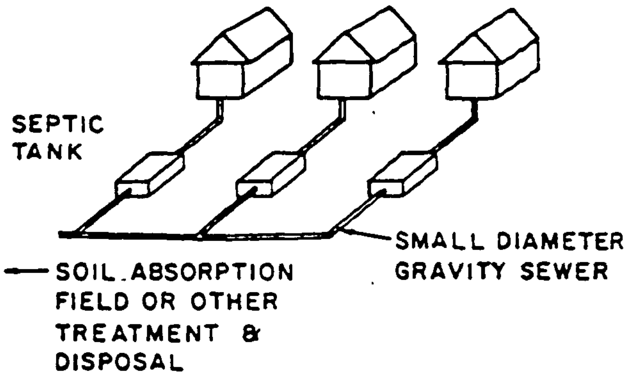


PRESSURE SEWERS, STEP
(SEPTIC TANK EFFLUENT PUMP)

FIGURE 7

Pressure Sewer Design Tips

a. Mercury level control switches are the most reliable,
b. Pumps should be fully submerged to minimize dangers from explosion,
c. Approximately 5 percent spare pressurization units should be maintained for emergency response,
d. On-lot installations should incorporate redundant valving to ensure unit isolation from the system,
e. All on-lot activity should be preceded by appropriate public relations contacts, and site condition should be recorded before and after construction, and
f. Pipe sizes chosen and their fittings should be readily available from local commercial sources.



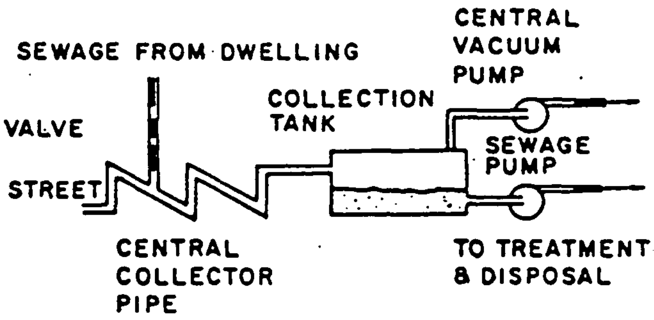
SMALL-DIAMETER GRAVITY SEWERS
(COLLECTION SYSTEM)

FIGURE 8

The small-diameter gravity sewers shown in Figure 8 use 4" to 6" pipe to transport liquid from the septic tanks to further off-site treatment and disposal.For proper operation, the septic tanks require periodic pumping to remove accumulated solids.

Small Diameter Gravity Sewer Design Tips

a. Use of pipe sizes of less than 100-mm (4-in.) should only be considered in reaches where significant positive gradient exists.
b. Typically, about 80 percent of existing septic tanks need to be replaced.
c. All SDG sewers should be designed to be flushed, even though the need has not yet arisen.



VACUUM SEWERS
(COLLECTION SYSTEM)

FIGURE 9

The vacuum sewer shown in Figure 9 depends on a vacuum pump to extract the sewage from one or more dwellings into a conveyance tank. A sewage pump then forces the collected sewage from the tank to the off-site treatment and disposal facilities.

Vacuum Sewer Design Tips

a. Vacuum station designs should maximize the ability to test each incoming line to the conveyance tank to identify problem locations.
b. Vacuum stations should be automated to permit 24-hour/day monitoring of key parameters to minimize any delays between occurrence and repair initiation.
c. Up to eight dwelling units have been successfully served by one vacuum valve where high population densities exist.
d. Service line connections to vacuum mains should enter the latter from above.

TREATMENT TECHNOLOGY

There are many processes available to effectively treat municipal wastewater. These can be broadly grouped into preliminary, primary, secondary, and tertiary or advanced treatment. Preliminary treatment is often used to protect downstream equipment in most plants, but may be the only treatment provided to stormwater flows. Classification of treatment processes as primary, secondary and tertiary is based on the achievable level of treatment, ie., BOD and/or suspended solids removal or location in the process stream, ie., order. Thus, clarification may be part of primary, secondary or tertiary treatment. Likewise, a land treatment process may be a tertiary step if it follows conventional secondary treatment or be designed to provide better than secondary removals while being the sole treatment process. Figure 10 in the section, Preliminary Treatment, shows the relative use of some preliminary treatment processes in the U.S. according to EPA's 1986 Needs Survey. Figure 11 in the section, Secondary Treatment, shows the relative usage in the U.S. of some major processes providing secondary or better than secondary treatment.

PRELIMINARY TREATMENT

Preliminary treatment consists of unit operations such as screening, comminution and grit removal to improve downstream operations and processes and to protect mechanical equipment. In September 1987, the EPA issued a report, "Preliminary Treatment Facilities Design and Operational Considerations", EPA 430/09-87-007. Findings of this report are summarized below.

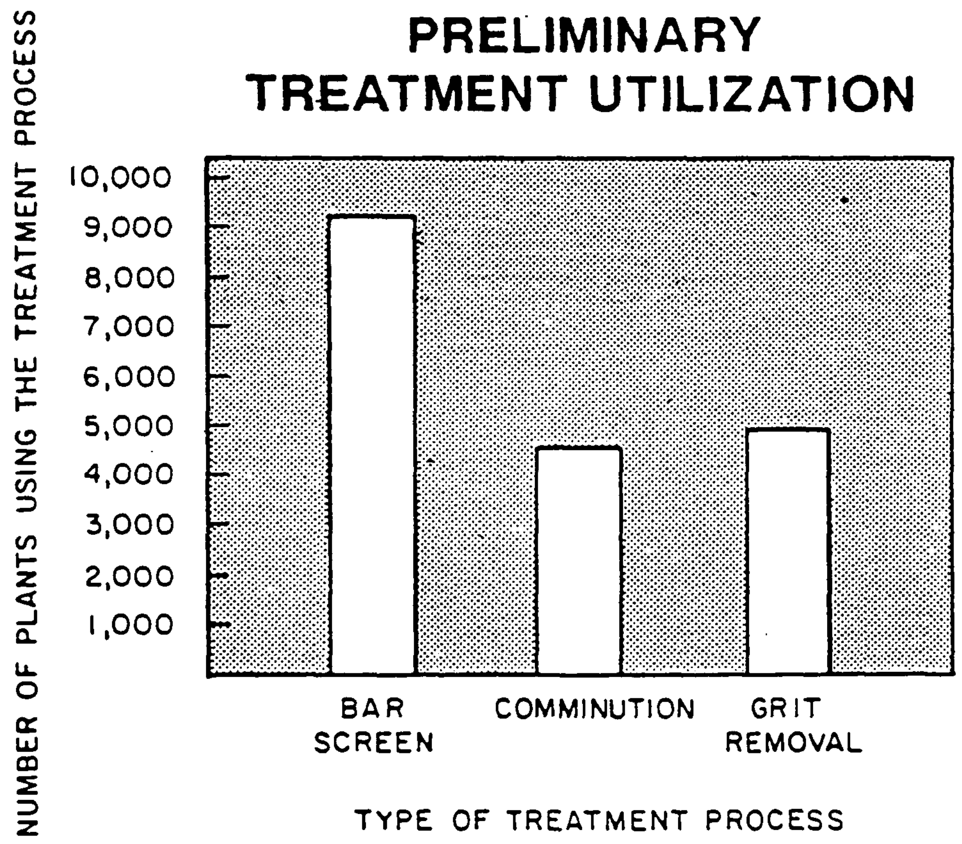


FIGURE 10

PRELIMINARY TREATMENT DESIGN CONSIDERATIONS FOR SMALL PLANTS:

- o Staffing - small staff and non-specialized personnel require a treatment system that is mechanically simple, reliable and needs only part-time attention.
- o Type of Sewer System - the type of conveyance system (combined or separate) influences the amount of grit, screenings and grease present in the wastewater and the maximum flow and variation of the flow. Alternative conveyance systems may not require preliminary treatment at the treatment plant.
- o Climate - the possibility of screenings freezing which makes them difficult to handle and may damage equipment must be considered.
- o Type of Downstream Treatment - affects the amount of preliminary treatment necessary. Plants with primary treatment are less sensitive to preliminary treatment shortcomings.

PRELIMINARY TREATMENT DESIGN CONSIDERATIONS FOR LARGE PLANTS:

- o Type of Conveyance System - Combined sewers will bring in larger quantities of grit and screenings and will have greater ratios of peak to average flow than separate systems.
- o Industrial Influences on Waste Stream Characteristics - The type of industry can affect the size and quantity of grit and screenings.

ADDITIONAL CONSIDERATIONS:

- o Inadequate grit removal will result in excessive wear of mechanical equipment employed downstream and in sludge processing.
- o Inadequate screening will result in increased maintenance labor for downstream and sludge handling mechanical components.
- o Fine screens may often be preferable to any system of grinding and return of solids to the flow.

SECONDARY TREATMENT

Secondary and more advanced treatment processes include those unit processes which reduce the organic content by biological, chemical and/or physical means. Table 1 summarizes the Secondary Treatment Regulations found in 40 CFR Part 133. The remaining topics discuss the recent developments in secondary treatment, treatment equivalent to secondary treatment, and greater than secondary treatment methods.

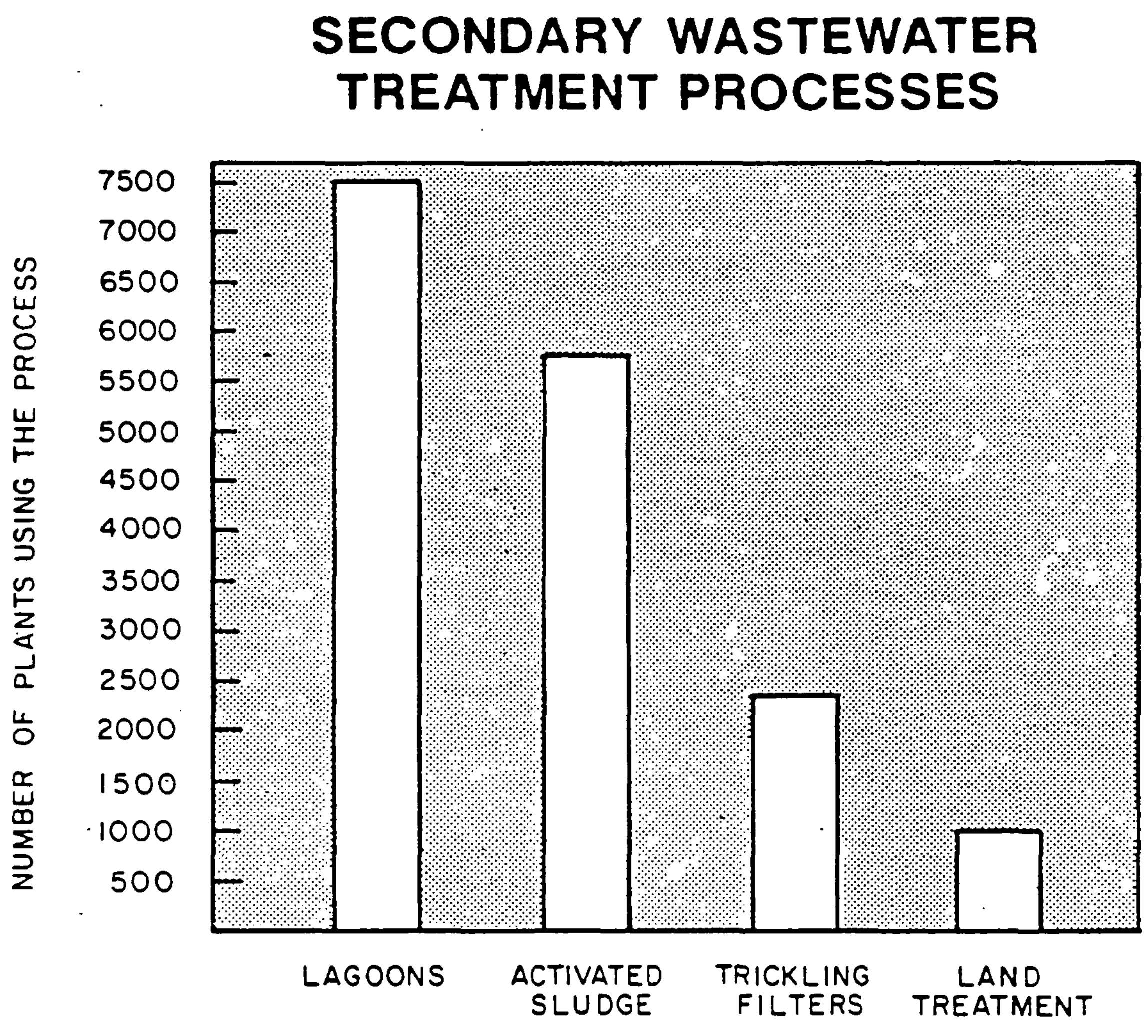


FIGURE 11

TABLE 1
PART 133 - SECONDARY TREATMENT REGULATION

133.102 - Secondary Treatment	133.103 - Special Considerations	133.104 - Sampling and Test Procedures	133.105 - Treatment Equivalent to Secondary Treatment
The minimum levels of effluent quality in terms of BOD_5, SS and pH are shown below ($CBOD_5$ may be substituted for BOD_5) a. BOD_5 / $CBOD_5$ 30-day average $\leq$30 mg/L / $\leq$25 mg/L 7-day average $\leq$45 mg/L / $\leq$40 mg/L 30-day average $\geq$85% / $\geq$85% % removal b. SS 30-day average $\leq$30 mg/L 7 day average $\leq$45 mg/L 30-day average $\geq$85% % removal c. pH: 6-9 unless the POTW demonstrates that: 1. Inorganic chemicals are not added to waste stream as part of treatment process. 2. Contributions from industrial sources do not cause the pH to be less than 6 or greater than 9.	a. Combined Sewers: Attainable percentage removal levels during wet weather decided on a case-by-case basis. b. Industrial Wastes: Certain POTWs receiving industrial flows whose categorical standards are less stringent may be able to adjust the values for BOD_5 and SS upwards. c. Waste Stabilization Ponds: When waste stabilization ponds are the principal treatment process and data indicate SS levels cannot be achieved, States may establish adjusted SS limitations to reflect local conditions. d. Less concentrated influent wastewater from separate sewers: A lower removal requirement may apply. e. Less concentrated influent from combined sewers during dry weather: A lower percentage removal requirement may apply.**	a. Procedures should be in accordance with 40 CFR Part 136. b. COD or TOC may be substituted for BOD_5 when a long-term BOD: COD or BOD: TOC correlation has been demonstrated.	Facilities may be eligible for adjusted effluent quality values shown below if they meet the guidelines in 133.101(g):* a. BOD_5 / b. SS 30 day-average $\leq$45 mg/L / 45 mg/L 7 day-average $\leq$65 mg/L / $\leq$65mg/L 30 day-average $\geq$65% / $\geq$65% % removal. c. pH: 6 - 9 d. Alternative State Requirements: BOD_5 and SS levels may be adjusted for trickling filters and waste stabilization pond facilities. e. $CBOD_5$ limitations: $CBOD_5$ may be substituted for BOD_5. The levels must not be less stringent than 30 day average, $<$40 mg/L, 7 day average, $<$60 mg/L, 30 day average percent removal, $<$65 percent. f. Permit adjustments: Permit adjustments to this part may not be less stringent. More stringent limitations can be required based on effluent values achievable through proper O&M of treatment works.

* 1) The BOD_5 and SS effluent concentrations consistently achieved through proper O&M exceed the minimum level of the effluent quality set forth in 133.102(a) and 133.102(b).
2) A trickling filter or waste stabilization pond is used as the principal process.
3) The treatment works provide significant biological treatment of municipal wastewater.

** Proposed rule, Federal Register, Vol. 52, No. 180, p. 35210-35214, September 17, 1987.

ACTIVATED SLUDGE - RECENT PROGRESS ON OLD PROBLEMS

Control of Bulking and Foaming - Bulking and foaming are two common problems that can arise at an activated sludge facility. The EPA Summary Report "The Causes and Control of Activated Sludge Bulking and Foaming" EPA/625/8-87-012 provides information on possible solutions to these problems.

Bulking sludge is very light, occupies an increased volume and does not settle. Filamentous bacteria interfere with compaction and settling. Different filamentous bacteria thrive under various conditions. Depending on the bacteria involved, different control stratagies are indicated.

Foaming can occur during start-up when solids concentrations and sludge age are low. This usually white foam disappears as the process stabilizes. A persistent white foam may indicate a low sludge age or the presence of non-biodegradable substances in the wastewater. A heavy brown foam on the aeration tanks and clarifiers may be due to a high sludge age or filamentous organisms.

To control sludge bulking:

1. Identify filamentous bacteria. Microscopic examination of activated sludge using a visual reference such as Sewage Organisms: A Color Atlas from Lewis Publishers may be helpful in identifying the bacteria present.
2. Determine probable cause based on bacteria present and plant operating conditions. Different species of bateria will thrive under different conditions, ie., low dissolved oxygen, low F/M ratio, nutrient deficiency, etc..
3. Determine if operational changes can correct the problem.
4. Are major design or long-term operational changes required?
   - Process manipulation during design change implementation.
   - Chemically enhanced settling.
   - Selective filamentous bactericides.

To control foaming, it is necessary to understand how the foam develops, Nocardia sp have been found in large numbers in the heavy brown foams. Nocardia sludge flocs may be hydrophobic and therefore cling to air bubbles resulting in foam. High sludge age, low F/M ratios, high suspended solids levels and warm oil and grease in the wastewater have been associated with high Nocardia levels.

Very stable foams can be broken by high volume sprays. A strong pretreatment program and enforcement can keep oils and greases from industry and commercial establishments out of the POTW. Several process changes can be used including:

- Reduce sludge age (cannot be used if nitrification being performed).
- Increase F/M ratio (cannot be used if nitrification being performed).
- Add anaerobic digester sludge (cannot be used if nitrification being performed).
- Physical removal, chlorination and ferric chloride addition.
- Avoid recycling the removed foam.

Sequencing Batch Reacters (SBRs) - Sequencing Batch Reactors perform activated sludge treatment in a fill-and-draw operation. Aeration, sedimentation and decanting are carried out sequentially in a common basin as shown in Figure 12. The tank is filled with influent wastewater and aerated to remove the soluble BOD. The aerators are then turned off allowing the sludge to settle. The effluent is drawn off and solids are wasted. The process then begins again with refilling the tank.

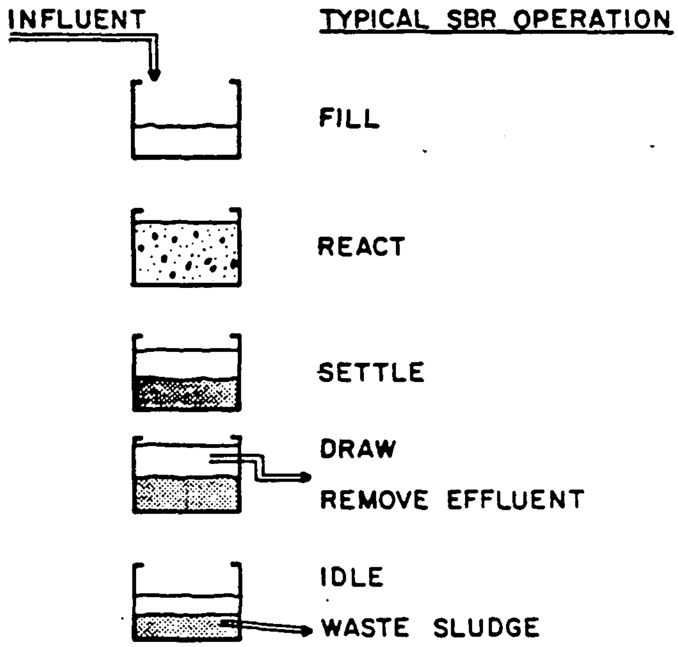


FIGURE 12

Sequencing Batch Reactors offer an option for small communities needing a high level of treatment. The advantages of SBRs for small communities are economy, flexibility, simplicity and reliability. Full-scale SBR Systems are operating in Culver, IN and Poolesville, MD and several other U.S. locations. Compared to conventional continuous flow systems, an SBR offers several operating advantages:

1. The tank can tolerate greater peak flows and BOD shock loads by acting as an equalization basin.
2. Process cycle can be adjusted to accomplish a wide variety of treatment goals.
3. Level can be varied to keep treatment cycle length constant at low flows.
4. No return activated sludge pumping.
5. No external clarifier is needed. Solid liquid separation occurs under near ideal conditions with no short circuiting.
6. Filamentous growth is easier to control.
7. No chemical addition needed for phosphorus removal.
8. The process can be operated to provide both nitrification and denitrification.

Operation problems have generally involved minimizing discharge of floating and settled sludge in the decant step. Increased timing and level control sophistication is required for larger systems. Details can be found in the EPA Summary Report "Sequencing Batch Reactors", EPA/625-8-86/011.

TRICKLING FILTERS

Trickling filters consist of a contact media that supports a biological film. The wastewater is distributed for uniform percolation downward while air currents move upward through the bed and supply oxygen to the microorganisms. The trickling filter effluent and sloughed solids are then collected and clarified for further processing or discharge. Figure 13 shows the conventional construction of a trickling filter contrasted with recent advances on the basic technology.

TRICKLING FILTER
CONVENTIONAL VS. RECENT ADVANCES

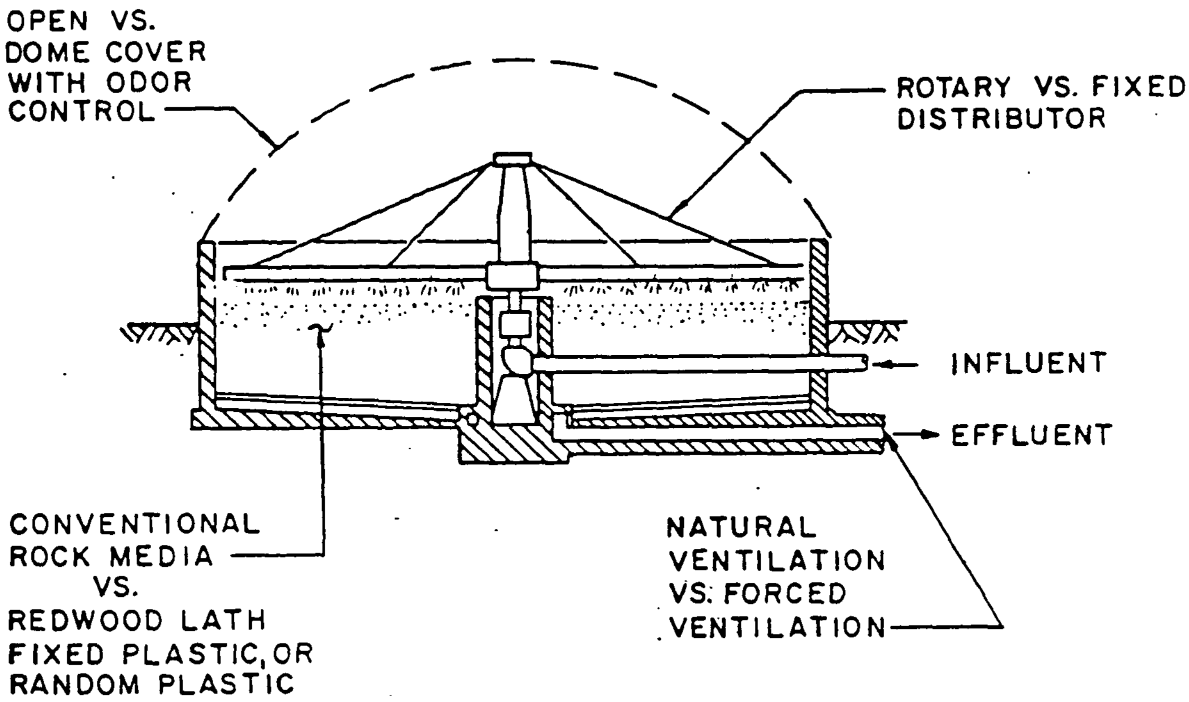


FIGURE 13

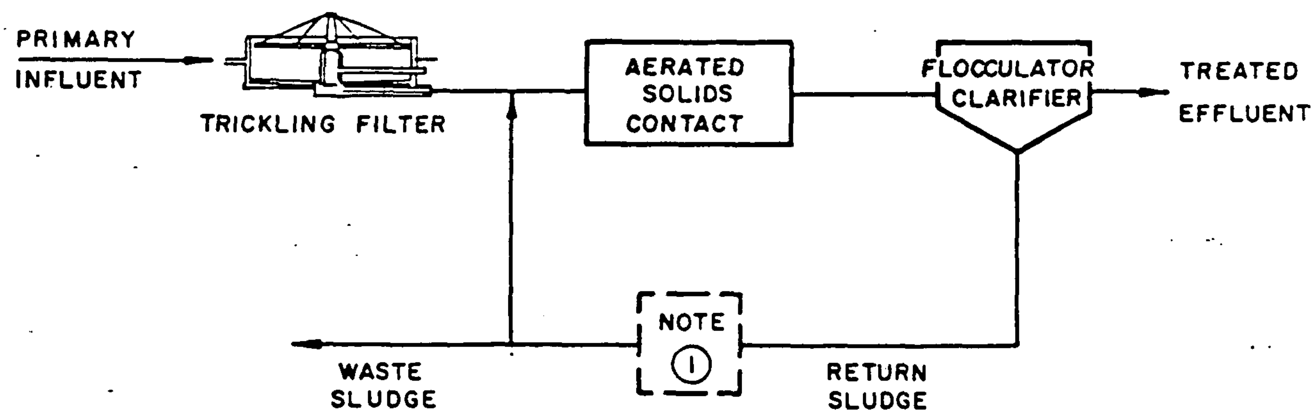
New Regulations - Old Plants - Trickling filters used to be one of the most popular processes in the country because of their economic operation, consistent performance and ability to withstand shock loads and wide variations in sewage concentration and composition. In 1975, there were almost twice as many trickling filter (TF) plants as activated sludge plants. The EPA 1986 Needs Survey information in Figure 11 shows a reversal of this usage. Many of these plants are older and do not consistently meet current secondary effluent standards, although they still achieve significant biological treatment. Under the final secondary treatment regulations, TF plants are defined as treatment equivalent to secondary and States can recommend alternative effluent requirements reflecting the performance of TF plants within the State, ie., alternative State requirements as shown in Table 1 on page 19.

Improving Trickling Filter Performance - The Trickling Filter/Solids Contact (TF/SC) process shown in Figure 14 is one of the most promising technologies for upgrading existing trickling filter plants. Benefits are:

- relatively low capital cost
- high quality effluent
- ability to withstand high organic loading

Trickling Filter/Solids Contact - This is a multiple step process using a trickling filter, an aerobic solids contact period and/or flocculation and secondary clarification. Upgrading an existing plant requires the addition of aerobic solids contact equipment and possibly flocculation capability.

TRICKLING FILTER/SOLIDS CONTACT PROCESS



NOTE (1) SOME VARIATIONS USE RETURN SLUDGE AERATION INSTEAD OF AERATED SOLIDS CONTACT OR WITH AERATED SOLIDS CONTACT.

FIGURE 14

Soluble BOD is reduced in the trickling filter. Initial flocculation and additional soluble BOD removal occurs in the aerobic solids contact step. Flocculation may occur in the solids contact tank and/or in a flocculator/clarifier resulting in better secondary clarification.

The TF/SC process is characterized by:

- o primary soluble BOD removal in the trickling filter
- o return sludge mixed with trickling filter effluent
- o particulate BOD and suspended solids reduction via flocculation
- o aerated solids contact time less than one hour
- o aerated solids contact solids retention time less than two days

<u>Case Studies</u> - Field investigations were conducted by the U.S. EPA in 1984 at Oconto Falls, WI; Tolleson, AZ; Medford, OR; Chilton, WI and at Morro Bay, CA in 1986. Plant operating records from other TF/SC plants were used to supplement the field investigations. Approximately fifteen TF/SC systems have been constructed under the I/A program.

LAGOONS

Lagoons are widely used for municipal wastewater treatment in small communities. Nearly 7,500 lagoons are in operation nationwide. Discharge may be eliminated as in total containment ponds, periodic as with hydrograph controlled release lagoons or continuous to another downstream treatment process or receiving stream.

Driven by groundwater quality concerns, numerous States require liners for all lagoons while others evaluate the need for liners on a case-by-case basis. In the design or evaluation of a lagoon, the following aspects must be considered:

- o Siting - soils, hydrogeology, geology
  - proximity of receiving streams
  - proximity of population
  - proximity to water supply sources

- o Design - sizing
  - number of cells in series
  - liner system

- o Construction - subgrade preparation
  - liner installation

- o Operation and Maintenance - routine inspection and O&M tasks
  - groundwater monitoring

<u>Liner Systems</u> - Liners are generally of two types, compacted soil or synthetic.

Lagoon liner selection is based on:

- o wastewater characteristics
- o local hydrogeology
- o ground water use and proximity of wells
- o predicted lagoon life and closure requirements
- o applicable regulations regarding seepage rates, liner materials, permeability

Types of lagoon liner material:

- o earthen (clay)
- o admixed (soil cement, asphalt, bentonite)
- o synthetic (PVC, polyethylene, hypalon, etc.)

Selection of the material depends on its compatibility with the waste, ability to withstand local temperature and sunlight conditions, anticipated permeability, life expectancy, installation and repair factors and cost. The U.S. EPA has prepared a design manual for "Municipal Wastewater Stabilization Ponds", EPA 625/1-83-015.

ROTATING BIOLOGICAL CONTACTORS (RBC'S) 100 PERCENT MODIFIATION/REPLACEMENT (M/R) GRANTS

Of approximately 550 municipal RBC installations in the U.S., a considerable number have experienced significant equipment malfunctions. Some of these failures resulted from a lack of full-scale operational and design information. Although normally considered a conventional treament facility, comprehensive information from the EPA has only been available since 1984. EPA published a brochure in May 1984 called "Rotating Biological Contactors Checklist for a Trouble-free Facility" and a detailed publication in September 1984, called "Summary of Design Information on Rotating Biological Contactors", EPA 430/9-84-008.

Section 202(d) of the Water Quality Act of 1987 authorizes the funding of modification or replacement of biodisc equipment in POTW's if:

1. The equipment failure to meet design specifications was not due to negligence, and
2. The failure significantly increased capital and/or operation and maintenance costs.

An M/R grant can cover 100 percent of the planning design and construction costs. Preaward costs are not eligible for funding. The M/R project must meet all requirements of EPA's construction grant program and other applicable regulations. The 100 percent M/R grants are only available to plants in which the EPA has an interest in the RBC's through prior grant assistance. Regular Construction Grant Assistance at 55 percent share for conventional techologies or 75 percent share for I/A technologies may be available for M/R of non-grant funded RBC's if applicable construction grant program requirements are met. It should be noted that construction grants cannot be awarded lawfully under the Title VI State Revolving Fund (SRF) program.

To receive an RBC M/R grant, an applicant must prove that:

1. The RBC facility failed to meet its design performance specifications.
2. The failure was not due to the negligence of any party.
3. The capital, operation and maintenance costs to maintain compliance are significantly higher than originally planned.
4. For projects using plans and specifications prepared after September 1984, the design considered the EPA information published in May and September 1984 or justify the nonconsideration of this information.
5. The M/R project meets all requirements of EPA's construction grant and other applicable regulations.

6. The M/R project is within the fundable range of the State's annual priority list.
7. The State certifies the project for funding from its regular allotments and funds appropriated after 4 February 1987.

Greater detail on M/R Grants for RBCs was published in the Federal Register, Wednesday, 4 May 1988 (Vol. 53, No. 86, pp 15820-15822). Additional information may be found in a memorandum from the Director of the EPA Municipal Facilities Division to Regional Water Management Division Directors dated July 31, 1987 with attached questions and answers.

GREATER THAN SECONDARY TREATMENT

Several processes can be used to provide secondary or better than secondary effluent quality. The following discussion is limited to three groups of processes which are widely used or which show great promise; land treatment, constructed wetlands, and biological nutrient removal.

LAND TREATMENT

Land treatment involves the controlled application of wastewater onto the land surface to achieve treatment through natural physical, chemical and biological processes during contact with the vegetation and soil.

EPA's Innovative/Alternative Technology program has significantly advanced the understanding and use of land treatment systems.

The three major land treatment processes and the number funded under the I/A program are:

- slow rate - 294
- rapid infiltration - 71
- overland flow - 49

The design parameters for these processes are discussed in detail in the Technology Transfer Process Design Manual for Land Treatment of Wastewater, 1981 (EPA 625/1-81-013). Since then, supplements have been published to incorporate new information on design, construction and operation. Table 2 on page 28 highlights the important features of these processes and includes the new information.

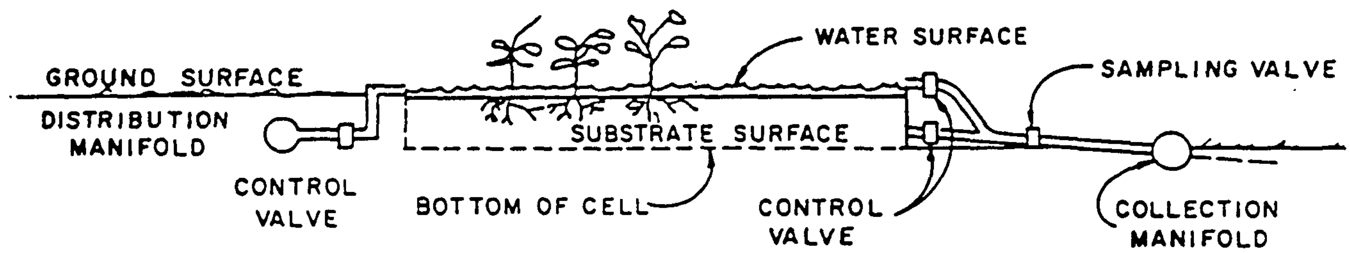
CONSTRUCTED WETLANDS

Constructed wetlands are man-made systems which employ aquatic vegetation to assist in the treatment of wastewater, primarily from small communities. They are normally divided into two types as shown in Figure 15. The first type is characterized by a free-water surface with dense aquatic vegetation growing from the bottom and emerging from the shallow water. This type is called a free-water surface wetland (FWSW), and it primarily utilizes the considerable plant surface area as a growth medium for oxidizing bacteria and development of plug flow hydraulics. These generally long-narrow systems are presently being used to treat acid mine drainage as well as municipal wastewaters.

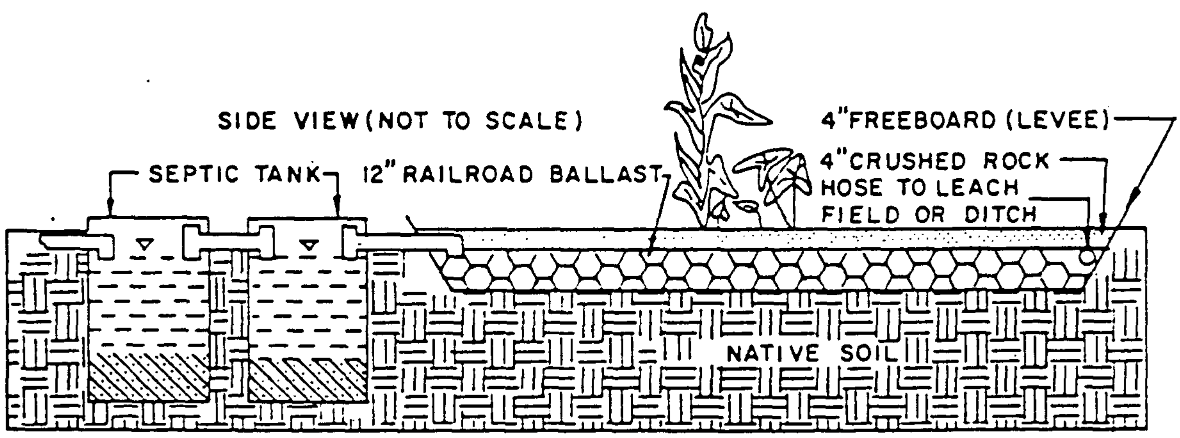
The second and newer type of constructed wetland is the vegetated submerged bed (VSB) which employs submerged, horizontal flow through a porous medium in which emergent aquatic plants are grown. The VSB systems purify wastewaters by horizontal filtration mechanisms, enhanced by the substantial root (rhizomes) development, and bacterial growth on these surfaces.

CONSTRUCTED WETLAND

INDIVIDUAL CELL CROSS SECTION



FREE WATER SURFACE WETLAND



VEGETATED SUBMERGED BED

FIGURE 15

TABLE 2

COMPARISON OF LAND TREATMENT METHODS

Parameter	Slow Rate	Rapid Infiltration	Overland Flow
Process Objectives	Wastewater Treatment Irrigation to utilize nutrients. Irrigation to conserve potable water. Preservation of greenbelts and open space.	Wastewater Treatment	Wastewater Treatment
Distribution System	Surface systems, sprinkler	Surface systems	Surface systems, sprays, sprinklers
Path of Applied Wastewater	Evapotranspiration and percolation	Mostly percolation	Surface runoff, evapotranspiration & some percolation.
Vegetation	Required	Optional	Required
Minimum Preapplication Treatment Recommended	Primary sedimentation	Primary sedimentation	Screening, comminution
Typical Weekly Hydraulic Loading rate, CM	1.3 - 10	10-240	6-40
Annual Loading Rate, M	0.5-6	6-125	3-20
Field Area Required, ha	23 - 280	3 - 23	6.5 - 44
Slope	Less than 20% on cultivated land; less than 40% on non-cultivated land.	Not critical	2 - 8 percent
Soil Permeability	Moderately slow to moderately rapid.	Rapid (sands, sandy loams)	Slow (clays silts)
Climate restrictions	Storage often needed for cold weather and precipitation.	None	Storage usually needed for cold weather.
Depth to groundwater	0.6 - 1m (minimum)	1m during flood cycle; 1.5 - 3m during drying cycle.	Not critical.

Treatment performance of these constructed wetlands has not been well characterized, but more than 20 systems have been funded under the U.S. EPA I/A Program. Various demonstration projects in Europe and North America indicate that these systems, particularly the VSB type, have considerable potential for small community wastewater treatment application. Removal of biodetgradable organic matter and, when lightly loaded, nitrogen can generally be accomplished to a significant degree. Actual plant uptake of nitrogen and phosphorus is relatively insignificant. Nitrogen removal, therefore, is accomplished by bacterial action. Significant phosphorus removal can be temporarily accomplished in VSB systems with the use of limestone media, but the duration of this effect has not been established.

Construction requirements for both types of constructed wetlands include the use of bottom flow barriers (liners). Emergent vegetation must be planted and nurtured and has heretofore primarily consisted of cattails, bulrushes and reeds either alone or in combination. Other plant species have been tested and several non-planned species tend to grow in concert with the planted varieties in their natural habitat. Critical design features include inlet and outlet structures, length-to-width ratios, and slopes.

Due to the infancy of the development of this technology, exact design details are not yet available. Studies by the U.S. EPA, Tennessee Valley Authority, Water Research Centre (U.K.), Water Quality Institute (DK) and Environment Canada, along with a variety of other interested organizations are underway at this time to develop reliable design and management guidance.

Beyond design considerations for constructing wetlands, a legal question exists regarding whether or not constructed wetlands are waters of the United States. By law, only secondary quality effluent may be discharged to waters of the U.S., therefore, natural wetlands may only be used for effluent polishing.

Constructed wetlands designed for wastewater treatment are generally excluded as "waters of the U.S.", while wetlands constructed for other purposes, specifically to provide values and functions of natural wetlands, are not. Multiple use wetlands may or may not be waters of the U.S., subject to secondary effluent standards. These wetlands must be evaluated on an individual case basis. The EPA prepared a "Report on the Use of Wetlands for Municipal Wastewater Treatment and Disposal", EPA 430/09-88-005 which addressed these issues.

BIOLOGICAL NUTRIENT REMOVAL

The purpose of biological nutrient removal processes is to reduce the amount of nutrients such as ammonia, organic nitrogen and phosphorus that are discharged to the environment.

<u>Biological Nitrogen Removal</u> - Involves the conversion of ammonia and organic nitrogen to nitrate and/or nitrogen gas. Where total nitrogen levels below 5 ppm are required, the system should be thoroughly piloted with the specific waste stream. Consistent achieval of low levels of total nitrogen may require multiple processes in series.

- Nitrification
- Denitrification
- Oxidation ditch (simultaneous nitrification/denitrification)

Biological Phosphorus Removal - Biological Phosphorus Removal (BPR) processes are variations of the activated sludge process which employ an anaerobic stage (phosphorus release) followed by an aerobic stage (phosphorus uptake in excess of normal). A number of processes have been developed recently for phosphorus (P) removal. Several of these systems are patented. The major continuous flow systems employed in the U.S. are described below:

- A/O Process (patented) - A conventional activated sludge process preceded by an anaerobic stage, to which return sludge is introduced. Successful application requires a high BOD_5/P ratio in the incoming wastewater to obtain low levels of effluent P. The A/O process is shown in Figure 16.

A/O PROCESS FLOW DIAGRAM FOR PHOSPHORUS REMOVAL

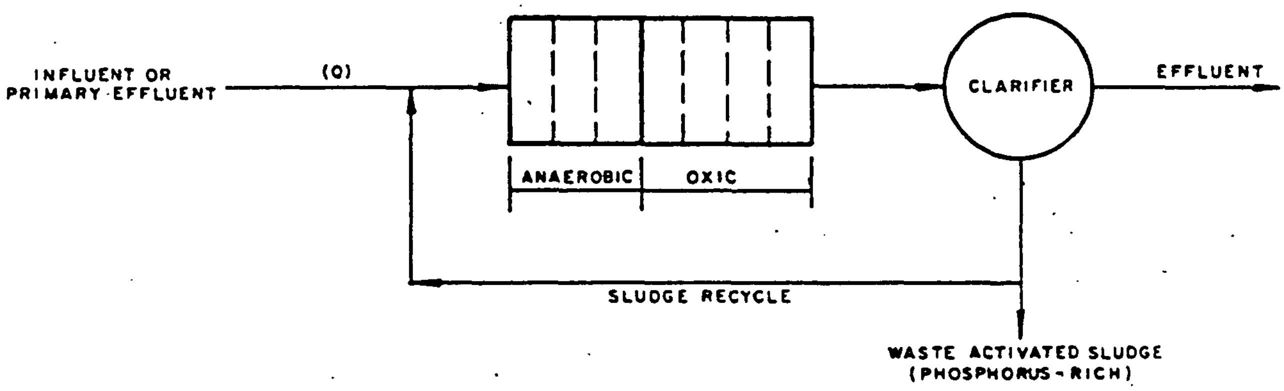


FIGURE 16

- Modified Bardenpho Process (patented) - This system employs an anaerobic stage followed by two sequential anoxic-aerobic stages with internal recycle of mixed liquor from the first aerobic stage to the first anoxic stage in addition to the necessary sludge recycle to the anaerobic stage. This system, as shown in Figure 17, also requires a high incoming BOD_5/P ratio for successful operation.

BARDENPHO PROCESS FLOW DIAGRAM

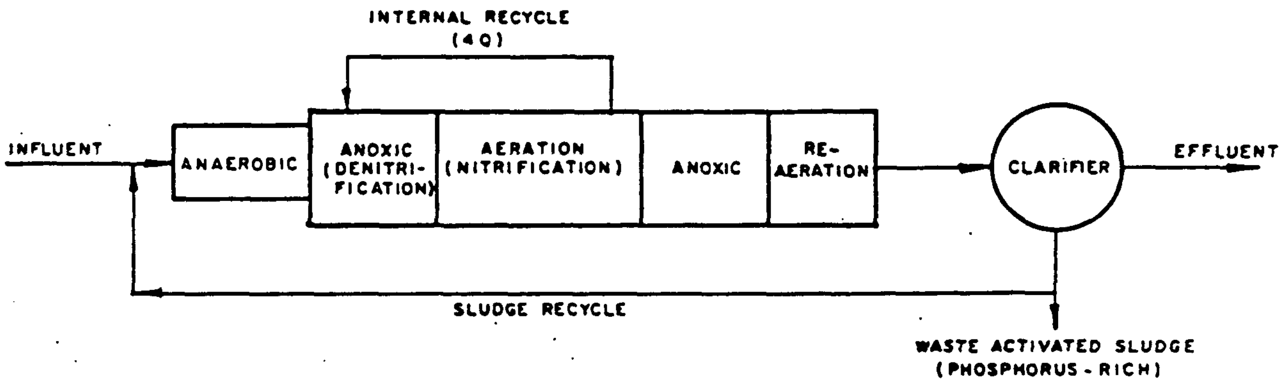


FIGURE 17

- Phostrip Process (patented) - A mixed biological/chemical P removal system wherein the waste activated sludge is diverted to an anaerobic stripper for P release from the microorganisms, the latter being recycled to the aeration tank. The supernatant from the stripper is treated with lime to precipitate the released P. Influent BOD_5/P ratios are less critical to this system. The Phostrip Process is shown in Figure 18.

PHOSTRIP PROCESS FLOW DIAGRAM

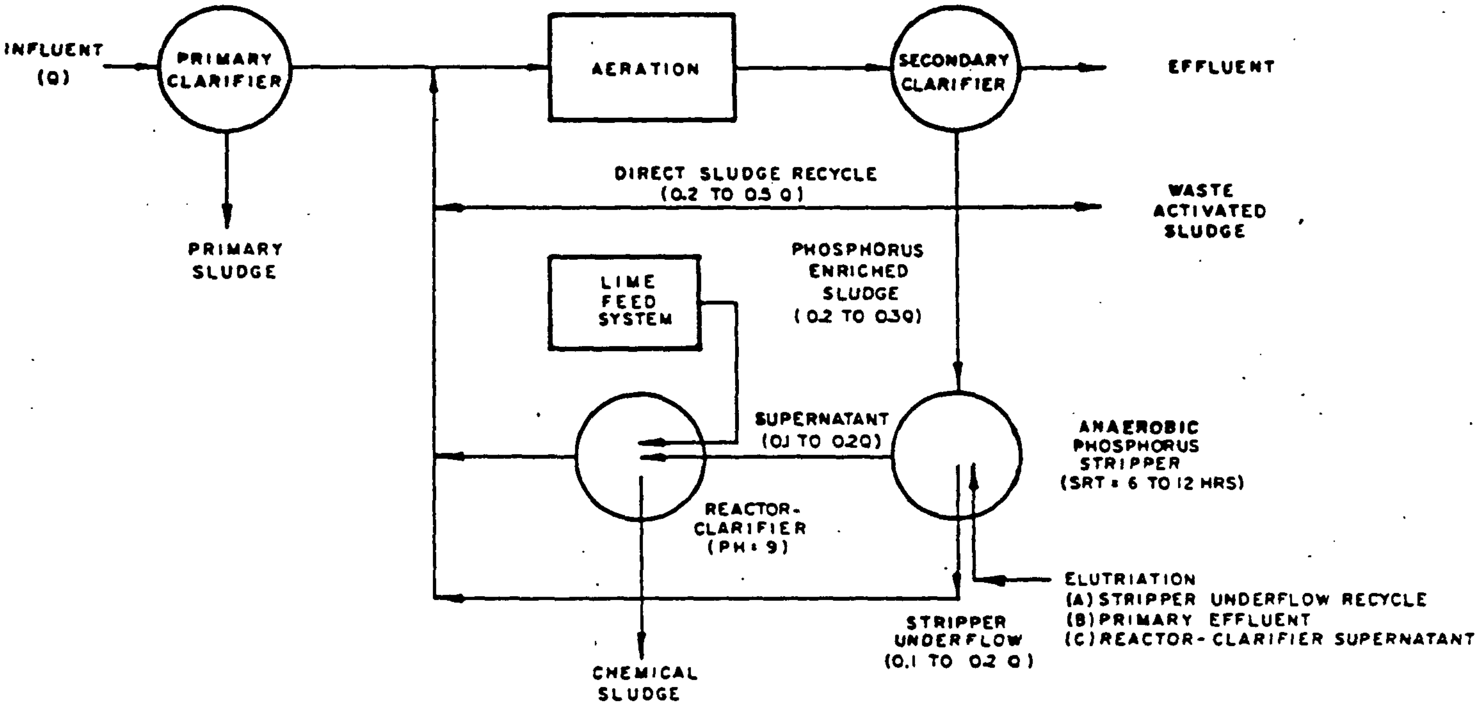


FIGURE 18

- Modified Activated Sludge - Several existing activated sludge treatment plants have been modified to perform biological phosphorus removal by providing sludge recycle to an anoxic/ anaerobic stage prior to aerobic treatment where influent wastewaters have high BOD_5/P ratios.

Several other biological processes have been developed, but not applied widely in the U.S. These include: 1) the sequencing batch reactor (SBR), which can be programmed for successful P removal by employing an unaerated fill stage with high BOD_5/P wastewaters; 2) modified phased-isolation ditches; and 3) the University of Cape Town (UCT) process. Total effluent phosphorus levels belows 1 ppm have been achieved enough to be considered available. Where low levels are required, a complete pilot program should be undertaken to verify that the influent stream and process are able to consistently meet the requirement.

EPA is currently preparing a Handbook on Retrofitting POTW's for Nutrient Removal in the Chesapeake Bay Drainage Basin which is expected to be available in the near future.

DISINFECTION

Disinfection involves the destruction of disease-causing organisms in wastewater to minimize public health risks.

Chlorination is by far the most common method of wastewater disinfection in the U.S. However, because of recent concerns over the toxicity associated with chlorine residuals, dechlorination is being required more frequently and alternate technologies are getting more attention. Alternate disinfection by Ultraviolet (UV) irradiation and ozonation have been used successfully at some POTWs. Considerable experience has been gained with UV disinfection through the I/A program.

UV IRRADIATION

Advantages:

- Absence of residuals in wastewater effluent and therefore does not impact receiving waters.
- Less rigorous control required since an overdose would not affect the receiving waters.
- Process is relatively simple and flexible.

Disadvantages:

- Difficult to monitor performance due to lack of residuals.
- Fouling of the quartz sleeves or Teflon\ tubes must be controlled by regular cleaning, thus increasing maintenance costs.
- High suspended solids concentrations, color and turbidity can interfere with or absorb the UV radiation and reduce performance.

Design Considerations:

- o Low pressure mercury arc lamps are currently the most efficient source of UV radiation.
- o Temperature effects should be minimized by slipping "O-ring" spacers over the lamps to prevent direct contact with the cooler quartz sleeve.
- o Fittings holding the quartz sleeve should be tight and leakproof to prevent fouling on the inside of the sleeve.
- o The control panel should be remote from the UV reactor.
- o The ballasts must be properly mated with the lamps and thermally protected to shut down if they overheat.
- o The electrical wiring should be properly sized and be resistant to UV radiation effects.
- o Large debris should be prevented from entering the UV system.
- o Because of past experience, a simple mechanical cam timer is recommended over an automatic shut-off system to reduce UV output during selected time periods.
- o The system should be modularly designed to allow isolation of any unit from the plant flow.

The existing EPA Municipal Wastewater Disinfection Policy dates back to July 1976. Since that time, much has been learned about residual chlorine toxicity to aquatic-life. Also, much experience has been gained with alternative disinfection technologies under the I/A program. In light of this new and increased knowledge, EPA is reviewing its 1976 Disinfection Policy. The review will include an evaluation of the public health, water quality, and technology aspects of municipal wastewater disinfection as well as a summarization of EPA Regional and State Policies implemented since 1976.

SLUDGE TREATMENT

CHANGING SLUDGE REGULATIONS

The new sewage sludge provisions of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987, requires EPA to undertake a number of activities, some of which were already underway when the Amendments were passed. These include:

- o Identification and regulation of toxic pollutants of concern present in sewage sludge; establishing numerical limits and specifying acceptable management practices (or other alternative standards where necessary) for sewage sludge containing such pollutants.
- o Requiring compliance with the new management practices and numerical limits no later than one year after their publication (or 2 years if construction is required).
- o Prior to promulgation of new regulations, impose conditions in NPDES permits issued to POTWs or take other measures as deemed appropriate to protect public health and the environment.
- o Include requirements implementing the new regulations in NPDES permits issued to POTWs or any other treatment works treating domestic sewage unless such requirements have been included in a permit issued under appropriate provisions of CWA, RCRA, MPRSA, CAA or under State permit programs approved by the Administrator.
- o Issue procedures for approval of State programs within a fixed time frame.
- o Issue permits to impose the requirements to treatment works not otherwise subject to NPDES permits.

In addition, the new CWA Amendments contain provisions that:

- o Make it unlawful for any person to dispose of sludge from a POTW or any other treatment works treating domestic sewage for any use except in accordance with the new regulations.
- o Authorizes inspection, monitoring, and entry by EPA and designated states.
- o An affected citizen may bring suit for violation of sludge requirements.
- o Authorizes criminal sanctions for violations of sludge requirements.
- o Authorizes $5 million starting in FY87 to fund scientific studies, demonstrations, and public education/information programs designed to promote safe and beneficial management or use of sewage sludge; authorizes grants to States, public or non-profit agencies, institutions, organizations and individuals and cooperative efforts in carrying out these activities.

EPA is well along the way toward proposing the first round of comprehensive technical regulations (40 CFR Part 503) covering incineration, ocean disposal, landfill, land application, distribution and marketing practices. EPA has proposed a schedule which may be subject to court modification for issuing these regulations in conjunction with a lawsuit filed against the Agency. The proposed schedule calls for the new regulations to be proposed for public comment by April 1989 and, following completion of a new survey to create a reliable national sludge quality database, to issue the regulations in final form by October 1991.

Proposed State Sludge Management Program Regulations (40 CFR Part 501) were issued for public comment on 4 February 1986 (51 Fed. Reg. 4458). However, the new CWA Amendments require the use of permits to impose the new technical regulations. On 9 March 1988 the Agency reproposed the Part 501 regulations in conjunction with proposed changes to the Part 122, 123 and 124 NPDES permit regulations (in 53 Fed. Reg. 7642) that will allow EPA or delegated states to use NPDES or other permits where designed to control sewage sludge use and disposal practices. EPA anticipates publishing these regulations in final form by April 1989. In order to follow through with the new Section 405 requirement to impose controls on sewage sludge use and disposal practices in NPDES permits issued to POTWs until the new technical regulations become effective, EPA has developed and issued a "Strategy for Interim Implementation of Sludge Requirements in Permits Issued to POTWs" for public comment on 31 May 1988 (in 53 Fed. Reg. 19817). The Agency has also issued for use and comment draft "Guidance for Writing Case-by-Case Permit Requirements for Municipal Sewage Sludge" and a draft "POTW Sludge Sampling and Analysis Guidance Document" (both dated June 1988).

Where possible, current EPA policy (49 Fed. Reg. 24358) encourages the use of sludge management practices involving beneficial use in preference to strict disposal options such as conventional landfilling and ocean disposal practices. For years, EPA has actively encouraged and assisted in the development and implementation of various practices and processes leading to the beneficial utilization of sewage sludges. In addition to supporting a number of long term research and demonstration projects, the Agency has also assisted in the development of detailed design guidance for various beneficial use practices and technologies. Finally, EPA has established a new awards program in cooperation with WPCF, to recognize outstanding operating projects, research studies, and technology development efforts which promote beneficial uses of municipal sludge.

RECENT ADVANCES IN SLUDGE PROCESSING TECHNOLOGIES

Dewatering is a physical unit operation used to reduce the moisture content of sludge in order to decrease the volume, facilitate handling and/or prepare for further treatment (composting, land application, incineration). Recent developments in sludge dewatering include:

- Mechanical-Assisted Air Drying of very wet sludge (5-6 percent solids) is being accomplished by use of turning machines (to 60 percent solids in 6 to 8 weeks instead of 6-8 months).
- Vacuum-Assisted Drying Beds - simple system yielding 10-15 percent solids from 5-6 percent solids in 24 hours. Achieving dryer sludges requires stockpiling, mechanical agitation, and/or sand bed drying.
- Planting reeds into drying beds allows continuous use of the beds for 5 to 10 years without requiring sludge removal.
- Allowing fresh layers of sludge each to be frozen in cold northern climate; will yield 35-50 percent solids when thawed.
- A combination gravity thickener plus belt filter press is more efficient than a belt filter press alone at dewatering and will on the average yield several percentage points dryer sludge.
- A new, possibly more efficient centrifuge is being tested by the Metropolitan Sanitary District of Greater Chicago.

COMPOSTING

Composting is a sludge management option that employs biological decomposition to convert sludge into a stable humus that can be applied to the land as a soil conditioner and low grade fertilizer.

Type of composting systems:

- Windrow
- Static Pile
- In-Vessel

In-Vessel Composting - Recent developments:

- A study of pathogens in compost products reported in the May/June 1988 issue of Biocycle (Vol. 29, No.5, p. 244).
  - Showed products free of most pathogens, but some exhibited regrowth potential for Salmonella.
  - Indicated need for completeness of composting to forestall Salmonella regrowth.

- o Study underway of major types of in-vessel sludge composting systems will result in a guide for design, evaluation and procurement of in-vessel system and especially for odor control. An EPA Guide will be published soon.

Odor Control:

- o First step is to inventory all sources, types and amounts of odor.
- o Then, determine the meteorological conditions, the terrain, and the location of odor receptors.
- o Then, select appropriate air conveyance, scrubbing and/or dilution technologies as related to the meteorology as it changes during the day, the terrain, potential odor receptors and the source, type and amount of odor.

Air/Moisture Management:

- o Examine the process air path with regard to length, corrosion resistance of air handling system, energy requirement, moisture removal provisions and avoidance of rewetting the composting sludges.
- o Determine extent of avoidance of interior building fog and other noxious aerial environmental conditions in which compost system operators must work.
- o Select dewatering equipment which will provide a sludge with an appropriate moisture content for composting.

Stabilization:

- o Additional attention should be given to the production of a stable product.
- o A respiration test can be useful to indicate completeness of composting/product stability.
- o Total fecal coliform levels may be useful as an indication of stability and the extent of potential for Salmonella regrowth.

INCINERATION AND HEAT DRYING

Incineration is a sludge management option which reduces the quantity of solid material by combustion of organic solids. Heat drying is a unit operation which reduces the moisture from the wet sludge so that it can be incinerated or processed into fertilizer.

Recent Developments:

- o Recent study conducted on emissions from incinerators as they are normally operated. "Emissions of Metals and Organics from four Municipal Wastewater Sludge Incinerators - Preliminary Data" by Harry Bostian, Eugene Crumpler, Michael Palazzolo, Keith Barnett, Robert

Dikes. Published in "Proceedings of the Conference on Municipal Sewage Treatment Sludge Plant Management" by Hazardous Materials Control Research Institute, Silver Spring, Maryland, 1988.

- o Multiple Hearth systems were emitting significant levels of volatile heavy metals (e.g., Cd and Pb).
- o Also volatile organic compounds like chloroform and benzene were being created by the combustion process and emitted at significant levels.
- o A fluidized bed system had less emissions than the multiple hearth system.
- o Additional control measures will likely be needed to meet more comprehensive new sludge incinerator/heat dryer regulations now being developed.
- o Another EPA study is underway to look at actual energy and costs of sludge incineration.

SLUDGE STABILIZATION

Sludge stabilization processes are designed to reduce pathogens, eliminate odors and reduce the potential for putrefaction. These processes include:

- o Biological reduction of volatile organics.
- o Chemical reduction of volatile organics.
- o Addition of heat for disinfection or sterilization.
- o Addition of chemicals for disinfection or sterilization.

Recent Developments:

- o Operation of <u>Anaerobic Sludge Digesters</u> can be simply modified to improve effective pathogen reduction -- Draw off previously digested sludge each time before refilling with undigested sludge.
- o Sludge stabilization with <u>Kiln Dust</u> (a lime material) is a newly approved technology that will further reduce pathogens (PFRP). Several municipalities are now installing facilities for this type of treatment.

SECTION 3

OPERATION AND MAINTENANCE TECHNICAL ASSISTANCE

CLEAN WATER ACT 104 PROGRAM

Since 1982, the U.S. EPA has implemented an on-site municipal wastewater treatment plant operator training and compliance assistance program for small communities. Under Section 104(g)(1) of the Clean Water Act, State training entities receive Federal funds to provide "over-the- shoulder" assistance to small plants up to 5 mgd size. Experienced state personnel work onsite with operators and officials to solve compliance problems.

Following comprehensive onsite diagnostic evaluations, site specific training is conducted to augment on going State Certification training programs. This bridges the gap between theoretical classroom type training and the application of specific problem solutions to specific plant problems and local situations. This training also addresses financial management problems and issue resolution with local officials. Onsite trainers will be given special financial management training at a series of regional seminars during the last quarter of 1988. Two manuals, one for short term solutions and the other for a more in-depth methodology will be available following regional workshop evaluations. These manuals should be in print by midyear 1989. A periodic newsletter entitled "Onsite Oversite" is circulated three or four times a year, to over 400 people involved in the outreach training effort. This publication is used to keep trainers informed of success stories from other trainers; EPA headquarters and regional policy decisions; national, regional and state workshops and other events that would be of interest to participants in this expanding onsite training effort.

The program has also helped states improve their inhouse compliance/technical assistance program coordination.

COMPREHENSIVE PERFORMANCE EVALUATION (CPE)

In many instances, especially for larger facilities, State or Federal compliance inspectors may require a non-compliant facility to undergo a comprehensive performance evaluation. A comprehensive performance evaluation seeks to determine if major facility upgrades are required or if a Composite Correction Program (CCP) will produce the required effluent quality.

A CPE consists of the following five steps:

- o Major unit process evaluation.
- o Performance limiting factor identification.
- o Performance limiting factor prioritization.
- o Ability to improve performance with a CCP assessment.
- o CPE results report.

CPE's have also been used to evaluate I/A projects seeking 100 percent modification/replacement grants. CPE's have been performed at facilities utilizing technologies which have included: intrachannel clarifiers, composting, draft tube aerators, powdered activated carbon with wet air regeneration, ultraviolet disinfection, and alternative sewers.

COMPOSITE CORRECTION PROGRAM (CCP)

If the major unit processes are evaluated to be adequate to meet the required effluent standards, a composite correction program can be implemented. A composite correction program identifies operating changes that can result in improved performance. Details may be found in the EPA Handbook "Improving POTW Performance Using the Composite Correction Program Approach" EPA-625/6-84-008 and addendum. If the major unit processes are determined to be marginal, a CCP may be attempted before committing to upgrading the facility. If the CPE determines the processes are inadequate, an upgrade will be needed to meet the effluent quality. The CPE report will typically contain the following sections:

- o Introduction
- o Facility Background
- o Major unit process evaluation
- o Performance limiting factors
- o Projected impact of a CCP
- o CCP costs

OPERATOR TRAINING AS A PERFORMANCE LIMITING FACTOR

In a national operation and maintenance survey, operator application of concepts and testing to process control was found to be a major factor limiting performance at 86 percent of the plants surveyed. Operators may have had formal training on the major unit processes, but did not have the training to optimize the process operation or may not have access to all necessary process monitoring equipment. Site specific training to optimize plant performance may be required as part of a composite correction program or 104 program.

ADMINISTRATIVE POLICIES AS PERFORMANCE LIMITING FACTOR

In an evaluation of treatment facilities employing innovative and alternative technologies, administrative policies were identified as a major factor at over half the plants in limiting performance. Operator application of concepts was the major factor at all the plants in this I/A survey.

This suggests that administrators must support operator training as it relates to plant problems as much as they devote efforts to develop and control budgets, reduce bond indebtedness, etc. Administrators need to be aware of the plant operation and maintenance problems as faced by the operators to insure optimum plant performance to meet effluent requirements and to provide for infrastructures protection. Other performance limiting problems that are the result of inferior administrative policies include inadequate operating budget, user charge systems, staffing problems and inadequate preventive maintenance programs. EPA is currently preparing a report entitled "Analysis of Performance Limiting Factors" which is expected to be available in late 1988.

APPENDIX A

TECHNOLOGY TRANSFER INITIATIVES BY REGION V, REGION VI AND THE NATIONAL SMALL FLOWS CLEARINGHOUSE

REGION V

WATER MANAGEMENT DIVISION
MUNICIPAL FACILITIES BRANCH

Special Evaluation Projects

The Municipal Facilities Branch in Region V conducts Special Evaluation Projects (SEP's) to:

- o Provide a "snapshot" of the status of a technology in Region V.
- o Assess the performance of a technology in some detail based upon a year or more of operating data.
- o Assess program issues.

SEP's have been conducted since 1983 and are typically initiated and completed within one year by Regional staff with assistance from State agencies.

Special Evaluation Project topics have included:

- Ultraviolet Disinfection
- Vacuum Assisted Sludge Drying Beds
- Alternative Conveyance Systems - Capital Costs
- Alternative Conveyance Systems - Operation and Maintenance
- Swirl Concentrators for Combined Sewer Overflow Control
- Project Performance Certification
- Powdered Activated Carbon Treatment - Wet Air Regeneration
- Trickling Filter Nitrification
- High Density Polyethylene Lagon Liners
- Variable Grade Sewers
- Low Pressure Sludge Oxidation Unit Process

For more information, contact:

Charles Pycha, I/A Coordinator
Water Management Division - Region V
230 South Dearborn Street
Chicago, IL 60604
(312) 886-0259

REGION VI

WATER MANAGEMENT DIVISION
CONSTRUCTION GRANTS BRANCH

Feedback-to-Design

The Region VI Construction Grants Branch is establishing a significant Feedback-to-Design program as part of their technology transfer activities. Using a personal computer, the Region has created a database with which to track the performance of a number of technologies.

Data collected include:

- Original design criteria
- Facility construction cost (actual)
- Monthly Operation and Maintenance Cost
- Influent and Effluent Characterization

Actual costs and performance of the projects will be compared with the original design estimates.

Technologies included in this effort are:

- Rock Filters (lagoon suspended solids control)
- Sequencing Batch Reactors
- Constructed Wetlands (Gravel Marsh)
- Rotating Biological Contactors
- Accelerated Sludge Drying (Mechanical Turning)
- Intrachannel Clarification
- Vacuum Assisted Sludge Drying Beds
- Trickling Filter/Solids Contact
- A/O
- BARDENPHO
- UNOX
- CAPTOR

One or more project of each technology type is included in the database.

Quarterly reports will be prepared for each technology type to document performance over time.

For additional information, contact:

Ancil Jones, I/A Coordinator
Region VI - 1445 Ross Avenue
Dallas, TX 75202
(214) 655-7130

SMALL FLOWS CLEARINGHOUSE
WEST VIRGINIA UNIVERSITY
1-800-624-8301

The National Small Flows Clearinghouse was established by the U.S. Environmental Protection Agency under the Federal Clean Water Act of 1977 (CWA) to gather and distribute information about small community wastewater systems.

The Water Quality Act of 1987 provides substantially increased funding for the Clearinghouse. With this increased funding, the Clearinghouse is undertaking a number of activities in support of EPA's small community outreach initiative. The three major objectives of the Clearinghouse are:

- o To provide information and assistance so that small communities can make sound wastewater management decisions.
- o To enhance the capabilities of EPA Regions and States for outreach to small communities.
- o To equip the technical community with the technology information they need to responsively serve small communities.

Recent Clearinghouse activities in support of these objectives include:

- o Publication of a new newsletter for small community officials "Managing Small Flows".
- o Award of incentive grants to local outreach programs to encourage improved delivery of information and services to local officials.
- o Publication of an improved newsletter for the technical community. "Small Flows" has been expanded and upgraded to provide more information on small community technologies.

Further information on these and other Clearinghouse activities may be obtained by calling the Clearinghouse, toll-free at 1-800-624-8301.

APPENDIX B

LIST OF NATIONAL, REGIONAL AND STATE CONTACTS FOR I/A TECHNOLOGY, SLUDGE TECHNOLOGY, AND OPERATION AND MAINTENANCE OPERATOR TRAINING

NATIONAL PROGRAM CONTACTS

<u>WASHINGTON EPA-OMPC
NATIONAL I/A
COORDINATOR</u>
Peter E. Shanaghan
(202) 382-5813
(FTS) 382-5813

<u>WASHINGTON EPA-OMPC
SLUDGE COORDINATOR</u>
John Walker
(202) 382-7283
(FTS) 382-7283

<u>WASHINGTON EPA-OMPC
SMALL FLOWS
TECHNOLOGY CONTACT</u>
John Flowers
(202) 382-7288
(FTS) 382-7288

<u>NATIONAL SMALL FLOWS
CLEARINGHOUSE
MANAGER</u>
Steve Dix
(304) 293-4191
(800) 624-8301

<u>CINCINNATI EPA-RREL
RESEARCH I/A CONTACT</u>
Jim Kreissl
(513) 569-7611
(FTS) 684-7645

<u>CINCINNATI EPA/RREL
RESEARCH SLUDGE CONTACT</u>
Joseph B. Farrell
(513) 569-7645
(FTS) 684-7611

<u>WASHINGTON EPA-OMPC
I/A TECHNOLOGY
DATA BASE MANAGER</u>
Charles Vanderlyn
(202) 382-7277
(FTS) 382-7277

<u>WASHINGTON EPA-OMPC
O&M OPERATOR TRAINING</u>
Duane A. Wilding
(202) 382-5998
(FTS) 382-5998

APPENDIX B
(continued)

	I/A CONTACT	SLUDGE CONTACT	O&M CONTACT
USEPA - REGION I	Charles Conway (617) 565-3582 (FTS) 835-3582	Bill Butler (617) 565-3564 (FTS) 835-3564	Charles Conway (617) 565-3582 (FTS) 835-3582
CONNECTICUT	William Hogan (203) 566-2373	Warren Herzig (203) 566-5760	Roy Fredricksen (203) 393-2705
MAINE	Dennis Purington (207) 289-3901	Kathy Jensen (207) 289-2811	John Moulton (207) 289-3355
MASSACHUSETTS	Robert Cady (617) 292-5713	Rick Dunn (617) 292-5590	Marc Perry (617) 292-5698
NEW HAMPSHIRE	Paul Currier (603) 271-2001	Richard Flanders (603) 271-3398	George Neill (603) 271-3503 (Concord) (603) 934-6463 (Franklin)
RHODE ISLAND	Warren Town (401) 277-3961	Chris Campbell (401) 277-2234	Ed Szymanski (401) 277-2234
VERMONT	Jeff Fehrs (802) 244-8744	George Desch (802) 244-8744	William C. Brierly (802) 244-8744
USEPA - REGION II	Bruce Kiselica (212) 264-5692 (FTS) 264-5692	Aristotle Harris (212) 264-4707 (FTS) 264-4707	Bruce Kissaelica (NJ) Ed Khadaran(NY) (212) 264-5692 (212) 264-5254
NEW JERSEY	Bob Simicsak (609) 633-1170	Helen Pettit Chase (609) 633-3662	Joe Simpkins (609) 984-4429
NEW YORK	Randy Orr (518) 457-3810	Rick Hammand (518) 457-2051	Arthur Warner (518) 457-5968
PUERTO RICO	Jose Bentacourt (809) 725-5140, Ext. 355	Baltazar Luna (809) 725-5077	

APPENDIX B
(continued)

	I/A CONTACT	SLUDGE CONTACT	O&M CONTACT
VIRGIN ISLANDS	Phyllis Brin (809) 774-3320		
USEPA - REGION III	David Byro (215) 597-6534 (FTS) 597-6534	Peter Ludzia (215) 597-9226 (FTS) 597-9226	Jim Kern (215) 597-3423
DELAWARE	Roy R. Parikh (302) 736-5081	William Razor (302) 736-4781	
DISTRICT OF COLUMBIA	Leonard R. Benson (202) 767-7603	Leonard R. Benson (202) 767-7370	James R. Collier (202) 767-7370
MARYLAND	Hitesh Nigam (301) 333-3082	Doug Proctor (301) 225-5664	Jake Bair (301) 934-2251 ext. 402
PENNSYLVANIA	Brij Garg (717) 787-3481	William Pounds (717) 787-7381	David J. English (717) 787-8184
VIRGINIA	Walter Gills (804) 257-6308	Cal M. Sawyer (804) 786-1755	Jack Vanderland (804) 257-6436
WEST VIRGINIA	Elbert Morton (304) 348-0633	Timothy Laraway (304) 348-3506	Richard Weigand (304) 348-3075 (304) 372-3400
USEPA - REGION IV	Bob Freeman (404) 347-4491 (FTS) 257-4491	Vince Miller (404) 347-4491 (FTS) 257-4491	Arthur Gurley (404) 257-3937
ALABAMA	David Hutchinson (205) 271-7761	Cliff Evans (205) 271-7761	Truman Green (205) 277-3630
FLORIDA	Bhupendra Vora (904) 488-8163	J.N. Ramaswamy (904) 488-8163	Dr. James O. Bryant, Jr. (904) 392-9570

APPENDIX B
(continued)

	I/A CONTACT	SLUDGE CONTACT	O&M CONTACT
GEORGIA	Kun Hopkins (404) 656-4769	Mike Creason (404) 656-4887	Gaynell Hill (404) 834-1468
KENTUCKY	Vince Borres (502) 564-3410	Art Curtis (502) 564-3410	Bill Eddins (502) 564-3410
MISSISSIPPI	Sitaram Makena (601) 961-5171	Johnny Biggert (601) 961-5060	
NORTH CAROLINA	Allen Wahab (919) 733-6900	Allen Wahab (919) 733-6900	John A. Campbell (919) 733-4038
SOUTH CAROLINA	Sam Grant (803) 734-5279	Mike Caughman (803) 734-5067	Dr. William Engel (803) 778-1961
TENNESSEE	Clure Winfree (615) 741-0638	Robert G. Threadjill, Jr. (615) 741-0638	Jack Hughes (615) 890-7008
USEPA - REGION V	Charles Pycha (312) 886-0259 (FTS) 886-0259	Almo Manzardo (312) 886-2105 (FTS) 886-2105	Eugene Chaiken (312) 353-2124
ILLINOIS	James Leinicke Terry Seal (217) 782-2027	Al Keller (217) 782-1696	William H. Busch (217) 782-1696
INDIANA	Robert Penno (317) 232-8636	Dan Strahl (317) 232-8736	Leonard Ashack (317) 633-0756
MICHIGAN	Brian Myers (517) 373-6626	Dale Brockway (517) 373-8750	Howard Selover (517) 243-4752
MINNESOTA	James K. Lungstrom (612) 296-7295	Steven Stark (612) 296-7169	Bill Sexauer (612) 296-7218

APPENDIX B
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	I/A CONTACT	SLUDGE CONTACT	O&M CONTACT
OHIO	Sanat K. Barua (614) 644-2798	Stuart M. Blydenburgh (614) 644-2001	
WISCONSIN	John Melby (608) 267-7666	John Melby (608) 267-7666	Tom Kroehn (608) 267-7656
USEPA - REGION VI	Ancil Jones (214) 655-7130 (FTS) 255-7130	Ancil Jones (214) 655-7130 (FTS) 255-7130	Tom Reich (214) 255-7130
ARKANSAS	Martin Roy (501) 562-8910	Mike Hood (501) 562-8910	James Bailey (501) 574-4550
LOUISIANA	Victor Sanchez (504) 295-8900	Ken Fledderman (504) 295-8900	Dirk Kavanaugh (318) 265-5590
NEW MEXICO	Robert W. Kane (505) 827-2807	David Gallegos (505) 827-2806	Cynthia Hiers-Robinson Hayward Martin (505) 646-2730
OKLAHOMA	Dr. H.J. Thung, (405) 271-7346	Dr. H.J. Thung, (405) 271-7346	Dr. William Roach (405) 733-7364
TEXAS	Milton Rose (512) 463-8513	Milton Rose (512) 463-8513	Clark Benson (408) 845-6247
USEPA - REGION VII	Rao Surampalli (913) 236-2813 (FTS) 757-2813	Rao Surampalli (913) 236-2813 (FTS) 757-2813	Pat Frey (913) 757-2813
IOWA	Wayne Farrand (515) 281-8877	Darrell McAllister (515) 281-8869	Doug Feil (319) 398-5678
KANSAS	Rodney Geisler (913) 296-5527	Rodney Geisler (913) 296-5527	Karl Mueldener (913) 862-9360)
MISSOURI	Douglas Garrett (314) 751-5723	Robert Reed (314) 751-6721	Lorene Boyt (417) 451-3583

APPENDIX B
(continued)

	I/A CONTACT	SLUDGE CONTACT	O&M CONTACT
NEBRASKA	Mahmood Arbab (402) 471-4252	Rick Bay (402) 471-2186	Rick Bay (402) 471-2186
USEPA - REGION VIII	Stanley Smith (303) 293-1547 (FTS) 564-1547	Stanley Smith (303) 293-1547 (FTS) 564-1547	Leon Malloy (303) 564-1552
COLORADO	Derald Lang (303) 331-4564	Phil Hegeman (303) 331-4564	Tom Feeley (303) 980-9165
MONTANA	Scott Anderson (406) 444-2406	Scott Anderson (406) 444-2406	Martha Ann Dow (406) 265-7821 ext. 3285
NORTH DAKOTA	Wayne Kern (701) 224-4598	Jeff Hauge (701) 224-2354	Ralph Reidinger (701) 244-2354
SOUTH DAKOTA	Dave Templeton (605) 773-4067	Leon Schochenmaier (605) 773-4059	Bill Alsenbrey (605) 773-3296
UTAH	Kiran L. Bhayani (801) 538-6146	Dan Filip (801) 538-6146	Charles Tolson (801) 226-5000
WYOMING	Mike Hackett (307) 777-6351	J. Alan Edwards (307) 777-6351	Bill Mixer (307) 268-2368
USEPA - REGION IX	Susan Johnson (415) 974-8266 (FTS) 454-8266	Patty Connaughton (415) 974-8587 (FTS) 454-8587	Tony Resnik (415) 454-8340 (COMM) 974-8340
ARIZONA	Ron Frey (602) 257-2231	Barry Abbott (602) 257-2238	John McClain (602) 886-3331

APPENDIX B
(continued)

	I/A CONTACT	SLUDGE CONTACT	O&M CONTACT
CALIFORNIA	David Meza (916) 739-4317	Archie Mathews (916) 322-4567	Donald Proter (619) 744-4150
HAWAII	Hiram Young (808) 548-4127	Dennis Tulang (808) 548-6769	Robert Rhein (808) 548-6455
NEVADA	James Williams (702) 885-5870	Wendall McCurry (702) 885-4670	Julian Bielawski (702) 885-4670
USEPA - REGION X	Tom Johnson (206) 442-2887 (FTS) 399-2887	Dick Hetherington (206) 442-1941 (FTS) 399-1941	Tom Johnson (206) 399-2887
ALASKA	Richard Marcum (907) 465-2610	Stan Hungerford (907) 465-2610	Judy Urquart (907) 465-2673 Bill Fagen (907) 465-2610
IDAHO	Allan Stanford (208) 334-5855	Susan Martin (208) 334-5855	Veronica Fitz (208) 385-1115
OREGON	Ken Vigil/Gary Sage (503) 229-5622	Richard J. Nichols (503) 229-5324	Thomas Gonzalez (503) 928-2361
WASHINGTON	Joe Williams (206) 459-6086	Jim Knudson (206) 459-6597	Dave Jansen (206) 459-6081 Myron Saikewicz (206) 459-6088

APPENDIX C

SUMMARY OF INNOVATIVE TECHNOLOGIES

TABLE C-1

STATE	WASTEWATER TREATMENT: AERATION/ MIXING	CLARIFIERS	DISINFECTION	ENERGY CONSERVATION AND RECOVERY	FILTRATION	LAGOONS	LAND TREATMENT	NITRIFICATION	NUTRIENT REMOVAL	OXIDATION DITCHES	SLUDGE TREATMENT: DRYING BEDS/ LAND APPLICATION	INCINERATION	COMPOSTING	DIGESTION	MISC. (1)	TOTAL
ALABAMA	11	4	1		1	5				5	1		1		2	31
ALASKA						1					1	1		2	1	6
ARIZONA		1	2	1		1			1		1				1	8
ARKANSAS		1	1		2	2	3		2						2	13
CALIFORNIA		2	1	3	3	1		1	1		4			1	2	19
COLORADO	2		1		1			1	1		1					7
CONNECTICUT	1		2													3
DELAWARE	1	1								1						3
FLORIDA	2					5			1				1		3	12
GEORGIA				2			1									5
GUAM																0
HAWAII															1	1
IDAHO	1	1			1	1				1				1	2	8
ILLINOIS	1	3	1		3	12	2		1	1	1				1	28
INDIANA	2	1				10		1			1				3	18
IOWA	2	1	1	1					3	1				3		12
KANSAS	1	1	3			2				1	2				1	11
KENTUCKY	1	7			1	2	2				1		1		2	17
LOUISIANA		4	1			3	1			4						13
MAINE	2	1	3	1	1	3	1								3	15
MARYLAND	1	1	4						4					2		12
MASSACHUSETTS	1		2	1				2	1						3	10
MICHIGAN	1	1			1				1	1					3	8
MINNESOTA	1	1	5	7	1	1	1	1	3	1	1			2	1	26
MISSISSIPPI		1				8	1		1						1	12
MISSOURI	2	4	2	1	2							1			4	16
MONTANA		1	1				1		2					1	2	8
N. MARIANA ISLANDS																0
NEBRASKA									1		1				2	4
NEVADA				1					2							3
NEW HAMPSHIRE			1													1
NEW JERSEY							1			1	3				8	13
NEW MEXICO	1				1										1	3
NEW YORK	6	2	4	1	1			1	2	5		1	1		4	28
NORTH CAROLINA	8				1					2	1	1		1	2	16
NORTH DAKOTA							1									1
OHIO	3	4	3	3	3					1	1		1		11	30
OKLAHOMA	1	2	2	1	1		1			2	2			4	2	18
OREGON	1	1		1			1				1		1		1	7
PENNSYLVANIA	3	1			2		1		4	2		1		2	3	19
PUERTO RICO																0
RHODE ISLAND	2			1												3
SOUTH CAROLINA	1	1		1	1	1	1			1	1		2	2	1	13
SOUTH DAKOTA	3					1	1								1	6
TENNESSEE	11	3			1	2	1		1	3				1	2	25
TEXAS	1	1				2	3			1	2				8	18
TRUST TERRITORIES																0
UTAH		1					1									2
VERMONT			1	1											1	3
VIRGIN ISLANDS																0
VIRGINIA	2	3	2		3	1	1	1	1	6	1				2	23
WASHINGTON			1	1											1	3
WASHINGTON, D.C.															4	4
WEST VIRGINIA	3	4							1	1				1	1	11
WISCONSIN	2	2	1	3	1										3	12
WYOMING	1		4		1	1									2	9
TOTAL	83	63	50	31	33	65	28	8	34	41	27	5	8	23	98	595

(1) MISCELLANEOUS CATEGORY INCLUDES BOTH SLUDGE AND WASTEWATER MANAGEMENT TECHNOLOGY WHICH COULD NOT BE SEPARATED USING AVAILABLE DATA

APPENDIX C

SUMMARY OF ALTERNATIVE TECHNOLOGIES

TABLE C-2

STATE	ON-SITE TREATMENT: SEPTIC TANK/SOIL ABSORPTION (SINGLE FAMILY)	MOUNDS	EVAPOTRANSPIRATION BEDS	AEROBIC UNITS	SAND FILTERS	SEPTIC TANK/SOIL ABSORPTION (MULTIPLE FAMILIES)	SEPTAGE TREATMENT AND DISPOSAL	OTHER ON-SITE TREATMENT	LAND TREATMENT: AQUACULTURE/ WETLANDS MARSH	OVERLAND FLOW	RAPID INFILTRATION	SLOW RATE IRRIGATION	PREAPPLICATION TREATMENT OR STORAGE	OTHER LAND TREATMENT
ALABAMA												2		
ALASKA						2							1	
ARIZONA									3		1	12	1	
ARKANSAS	1						1					4	2	1
CALIFORNIA		1				7	3		3	2	14	20	24	
COLORADO												2	1	1
CONNECTICUT					1	2	7				1			
DELAWARE						2					1			
FLORIDA										1	2	20		
GEORGIA										2		20		
GUAM											2			
HAWAII												2		
IDAHO					2			1	1		4	9	10	1
ILLINOIS	5	1			13					3	1	3		3
INDIANA		2				2								1
IOWA					1				3			2	3	
KANSAS									1		1	16	9	
KENTUCKY	1				2	2			2	1		2		
LOUISIANA										6		2	2	
MAINE	3				5	5						1		
MARYLAND	3	2			2		3	1	2	2	1	5	4	2
MASSACHUSETTS					1		19				2	1		
MICHIGAN	2					6			1	1	3	13		
MINNESOTA	8	8			2	5		1			1	14	11	
MISSISSIPPI										11		2		
MISSOURI		1			1							15		
MONTANA											3			
N. MARIANA ISLANDS														
NEBRASKA									1		2	5		
NEVADA											5	6	5	
NEW HAMPSHIRE					4	3	7			2				
NEW JERSEY						1	11						1	
NEW MEXICO												6	5	
NEW YORK	1	2			12	2	4	1		2				
NORTH CAROLINA												21		
NORTH DAKOTA		4								1		6		
OHIO	2			1			3					1		1
OKLAHOMA								1				31	16	
OREGON			2		3				2		1	6	9	1
PENNSYLVANIA	3	1		1	1	2			2		1	5	2	1
PUERTO RICO														
RHODE ISLAND							2							
SOUTH CAROLINA											1	9		
SOUTH DAKOTA									5			1	3	
TENNESSEE	2									2	8	1	4	
TEXAS	2									1	1	11	10	1
TRUST TERRITORIES						6		1						
UTAH												3	2	
VERMONT					2	1						1		
VIRGIN ISLANDS														
VIRGINIA							3			3	1	1		
WASHINGTON		1				2			1			3	4	2
WASHINGTON, D.C.														
WEST VIRGINIA	1							1						
WISCONSIN		2									8		5	9
WYOMING											3	2		
TOTAL	34	25	2	3	52	50	63	7	27	49	71	294	134	24

APPENDIX C

SUMMARY OF ALTERNATIVE TECHNOLOGIES

TABLE C-2 (Cont'd)

STATE	COLLECTION SYSTEMS				ENERGY RECOVERY/SLUDGE		SLUDGE TREATMENT				OTHER			TOTALS
	PRESSURE SEWERS/ EFFLUENT PUMP	PRESSURE SEWERS/ GRINDER PUMP	SMALL DIAMETER GRAVITY SEWERS	VACUUM SEWERS	90% METHANE RECOVERY/ANAEROBIC RECOVERY	SELF-SUSTAINING INCINERATION	LAND SPREADING OF POTW SLUDGE	PREAPPLICATION TREATMENT	COMPOSTING	OTHER SLUDGE TREATMENT OR DISPOSAL	AQUIFER RECHARGE	DIRECT REUSE	TOTAL CONTAINMENT PONDS	
ALABAMA	1	2	3		3		2		2					15
ALASKA			1		1	1	1		1	1				10
ARIZONA					3		1			1		1	1	24
ARKANSAS		10	2		1		2							24
CALIFORNIA	8		4	1	5	1	2	2	1	2		2	1	103
COLORADO		1			1		2				1			9
CONNECTICUT					4	1			1					17
DELAWARE		2	1				2	1	2					11
FLORIDA					3			1	2		1	3		33
GEORGIA	2		1		3	1	5							34
GUAM														2
HAWAII													1	3
IDAHO	2		2		3		6						1	42
ILLINOIS	5	2	18		13		47	7		5		4		130
INDIANA	2	4	13		5		19							48
IOWA	2	3	1		6		24	2						47
KANSAS					5	2	20		1	2			27	84
KENTUCKY	2	4	5	2	2		13							38
LOUISIANA	1		1				1							14
MAINE	1	1							6					22
MARYLAND	2	21	3	2	2		4		5					66
MASSACHUSETTS			1		2	2	1		4					33
MICHIGAN	1	2	1		4		10							44
MINNESOTA	8	6	7		9		24	1	2					107
MISSISSIPPI	1	3	1				3			1				22
MISSOURI	6	18	15		1		27			8				101
MONTANA					2		9			1			5	28
N. MARIANA ISLANDS			1											1
NEBRASKA					3		5	3	2	2			32	55
NEVADA					3								4	23
NEW HAMPSHIRE		1							1					18
NEW JERSEY		2		2			1	3	5	1				27
NEW MEXICO					1					1				13
NEW YORK	3	16	16	2	16	1	2		2	1				86
NORTH CAROLINA	1	2	1		6		4			1				36
NORTH DAKOTA	3	2	14										17	47
OHIO	2	5	2		11		34	3	3					68
OKLAHOMA						1	5	2	1				29	86
OREGON	5		4		5		4	3	1	2			1	49
PENNSYLVANIA	6	15	11		3		5		3	2				64
PUERTO RICO									1					1
RHODE ISLAND						1			1					4
SOUTH CAROLINA			2		1		5							18
SOUTH DAKOTA	1	1	2		4		11	1				1	7	45
TENNESSEE	5	6	10	2			5		1	1				39
TEXAS	3	4	1		6		20	8	1	1		4	1	75
TRUST TERRITORIES			1											8
UTAH					1		1		1					8
VERMONT		3	1				12							20
VIRGIN ISLANDS														0
VIRGINIA	3	2	2		5	2	9	1	3	3		5		43
WASHINGTON	2	1	1		2		1	1					2	23
WASHINGTON, D.C.									1					1
WEST VIRGINIA	6	10	5	10	2									35
WISCONSIN	1	3	3		4		15			1				51
WYOMING					1		2						3	11
TOTAL	88	152	151	21	152	13	366	39	54	37	2	20	132	2066

APPENDIX D

LIST OF INNOVATIVE/ALTERNATIVE TECHNOLOGY PUBLICATIONS

TITLE	ORDER SOURCE
CURRENT I/A TECHNOLOGY FOLDOUTS	
Alternative Wastewater Collections Systems: Practical Approaches	1,2,3,4
Aquaculture: An Alternative Wastewater Treatment Approach	1,2,3,4
The Biological Aerated Filter: A Promising Biological Process	1,2,3,4
Biological Phosphorous Removal: Problems and Remedies	1,2,3,4
Composting: A Viable Method of Resource Recovery	1,2,3,4
Counter-Current Aeration: A Promising Process Modification	1,2,3,4
Disinfection with Ultraviolet Light	1,2,3,4
Hydrograph Controlled Release Lagoons: A Promising Modification	1,2,3,4
Innovative and Alternative (I/A) Technology: Wastewater Treatment to Improve Water Quality and Reduce Cost	1,2,3,4
Innovations in Sludge Drying Beds: A Practical Technology	1,2,3,4
Intermittent Sand Filtration	1,2,3,4
Intrachannel Clarification: A Project Assessment	1,2,3,4
In-Vessel Composting	1,2,3,4
Land Application of Sludge: A Viable Alternative	1,2,3,4
Land Treatment Silviculture: A Practical Approach	1,2,3,4
Less Costly Wastewater Treatment for Your Town	1,2,3,4
Large Soil Absorption Systems: Design Suggestions for Success	1,2,3,4
Methane Recovery: An Energy Resource	1,2,3,4

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TITLE	ORDER SOURCE
CURRENT I/A TECHNOLOGY FOLDOUTS (cont.)	
Natural Systems for Wastewater Treatment in Cold Climates	1,2,3,4
Operation of Conventional WWTP in Cold Weather	1,2,3,4
Overland Flow An Update: New Information Improves Reliability	1,2,3,4
Rapid Infiltration: Plan, Design and Construct for Success	1,2,3,4
Rotating Biological Contactors	1,2,3,4
Sequencing Batch Reactors: A Project Assessment	1,2,3,4
Side-Streams in Advance Waste Treatment Plants: Problems and Remedies	1,2,3,4
Small Wastewater Systems: Alternative Systems for Communities and Rural Areas	1,2,3,4
Vacuum-Assisted Sludge Dewatering Beds: An Alternative Approach	1,2,3,4
Vacuum-Assisted Sludge Drying (Update)	1,2,3,4
Wastewater Stabilization Ponds: An Update on Pathogen Removal	1,2,3,4
Water Reuse Via Dual Distribution Systems	1,2,3,4
Wetlands Treatment: A Practical Approach	1,2,3,4
Planning Wastewater Facilities for Small Communities	1,2,3,4
I/A RESEARCH REPORTS	
Alternative On-Site Wastewater Treatment and Disposal Systems on Severly Limited Sites; EPA/600/2-86/116; PB87-140992/AS	1,5,6
Alternative Sewer Studies; EPA/600/2-85/133; PB86-131224/AS	1,5,6
Alternative Sewer Systems in the United States; EPA/600/D-84/095; PB84-177815/AS	1,5,6

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TITLE	ORDER SOURCE
I/A RESEARCH REPORTS (cont.)	
Determination of Toxic Chemicals in Effluent from Household Septic Tanks; EPA/600/2-85/050; PB85-196798	1,5,6
Large Soil Absorption Systems for Wastewaters from Multiple Home Developments EPA/600/2-86/023; PB86 164084/AS	1,5
Handbook Septage Treatment and Disposal; EPA/625/6-84-009	1,5,6
Small Diameter Gravity Sewers: An Alternative Wastewater Collection Method for Unsewered Communities EPA/600/2-86/0270; PB 86 173622/AS	1,5
Status of Porous Biomass Support Systems for Wastewater Treatment: An Innovative/Alternative Technology Aswsessment EPA/600/2-86/019; PB 86 156965/AS	1,5
Handbook Estimating Sludge Management Costs; EPA/625/6-85/010; PB86-124542/AS	1,5,6
Municipal Sludge Composting Technology Evaluation; EPA/600/J-86/139; PB87-103560/AS	1,5,6
Toxic and Priority Organics in Municipal Sludge Land Treatment Systems EPA/600/2-86/010; PB 86 150208/AS	1,5
Process Design Manual Land Application of Municipal Sludge; EPA/625/1-83-016	1,5,6
Design Manual Municipal Wastewater Stabilization Ponds; EPA/625/1-83-015	1,5,6
The Lubbock Land Treatment System Research and Demonstration Project: Volume IV Lubbock Infection Surveillance Study EPA/600/2-86/027D; PB 86 173622/AS	1,5
Process Design Manual for Land Treatment of Municipal Wastewater; EPA/625/1-81-013 and Supplement; EPA/625/1-81-013a	1,5,6

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TITLE	ORDER SOURCE
I/A RESEARCH REPORTS (cont.)	
Technology Assessment of Aquaculture Systems for Municipal Wastewater Treatment; EPA/600/2-84/145; PB84-246347/AS	1,5,6
Technology Assessment of Wetlands for Municipal Wastewater Treatment; EPA/600/2-84/154; PB85-106896/AS	1,5,6
Evaluation of Color Infrared Aerial Surveys of Wastewater Soil Absorption Systems; EPA/600/2-85/039; PB85-189074/AS	1,5,6
Land Application of Municipal Sludge; EPA/625/1-83/016	1,5,6
Characterization of Soil Disposal System Leachates; EPA/600/2-84/101; PB84-196229/AS	1,5,6
Emerging Technology Assessment of Phostrip, A/O and Bardenpho Process for Biological Phosphorus Removal; EPA/600/2-85/008; PB85-165744/AS	1,5,6
Implementation of Sequencing Batch Reactors for Municipal Treatment; EPA/600/D-84/022; PB84-130400/AS	1,5,6
Technology Assessment of Sequencing Batch Reactors; EPA/600/2-85/007; PB85-167245/AS	1,5,6
Technology Evaluation of Sequencing Batch Reactors; EPA/600/J-85/166	1,5,6
Summary Report: Fine Pore (Fine Bubble) Aeration Systems; EPA/625/8-85/010	1,5,6
Evaluation of Anaerobic, Expanded-Bed Contactors for Municipal Wastewater Treatment; EPA/600/D-86/120; PB86-210648/AS	1,5,6
Autothermal Thermophilic Aerobic Digestion in the Federal Republic of Germany; EPA/600/D-85/194; PB85-245322/AS	1,5,6
Biological Phosphorus Removal - Technology Evaluation; EPA/600/J-86/198; PB87-152559	1,5,6

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(continued)

TITLE	ORDER SOURCE
I/A RESEARCH REPORTS (cont.)	
Full-Scale Studies of the Trickling Filter/Solids Contact Process; EPA/600/J-86/271; PB87-168134/AS	1,5,6
Trickling Filter/Solids Contact Process: Full-Scale Studies; EPA/600/2-86/046; PB86-183100/AS	1,5,6
Forecasting On-Site Soil Absorption System Failure Rates; EPA/600/2-86/060; PB86-216744/AS	1,5,6
Innovative and Alternative Technology Assessment Manual; EPA/430/9-78/009; (MCD-53)	1,3,6
Technology Evaluation of the Dual Digestion System; EPA/600/J-86/150; PB87-116802/AS	1,5,6
Costs of Air Pollution Abatement Systems for Sewage Sludge Incinerators: EPA/600/2-86/102; PB87-117743/AS	1,5,6
Wastewater Treatment Plant Instrumentation Handbook; EPA/600/8-85/026; PB86-108636/AS	1,5,6
OTHER I/A PUBLICATIONS	
Is Your Proposed Wastewater Project Too Costly? Options for Small Communities	1,2,3
Management of On-Site and Small Community Wastewater Systems; EPA/600/8-82-009	1,2,3,5
Planning Wastewater Management Facilities for Small Communities; EPA/600/8-80-030	1,2,3,5
Design Manual: On-Site Wastewater Treatment and Disposal Systems; EPA/625/1-80-012	1,3,5
It's Your Choice - A Wastewater Treatment Handbook for the Local Official	1,2
Looking at User Charges - A State Survey and Report	1,2,3

TITLE	ORDER SOURCE
OTHER I/A PUBLICATIONS (cont.)	
Touching All the Bases: A Financial Handbook for Your Wastewater Treatment Project	1,2
ORDERING CODES	
I/A TECHNOLOGY VIDEO TAPES	
Small Diameter Effluent Sewers (11 minutes)	1,2
Sand Filters (9 minutes)	1,2
Upgrading Small Community Wastewater Treatment (20 minutes)	1,2
Planning Wastewater Facilities for Small Communities (15 minutes)	1,2

APPENDIX D
(continued)

The Documents listed in this table can be ordered from the following addresses, as designated by document.

1. ENVIRONMENTAL QUALITY INSTRUCTIONAL RESOURCES CENTER (IRC)
   The Ohio State University
   1200 Chambers Road - Room 310
   Columbus, OH 43212
   (614) 292-6717

2. NATIONAL SMALL FLOWS CLEARINGHOUSE
   258 Stewart Street
   Morgantown, WV 26506
   1-800-624-8301

3. EPA-OMPC-MFD (WH-595)
   401 M Street, S.W.
   Washington, DC 20460

4. EPA Regional Offices
   For Telephone Numbers, see Appendix B

5. EPA-Center for Environmental Research Information (CERI)
   26 West Martin Luther King Drive
   Cincinnati, OH 45268
   (513) 569-7562

6. NATIONAL TECHNICAL INFORMATION SERVICE (NTIS)
   5285 Port Royal Road
   Springfield, VA 22161
   (703) 487-4650

NOTE: Depending upon ordering source, there may be a charge for some documents.

APPENDIX E

INNOVATIVE/ALTERNATIVE FIELD TEST PROJECTS

FACILITY	TECHNOLOGY	STATUS	COMMENTS
FAYETTEVILLE, AR	*A/O PROCESS BIOLOGICAL NUTRIENT	COMPLETED	DEMONSTRATED GOOD BIOLOGICAL AND PHOSPHORUS REMOVAL DURING WINTER MONTHS
PARAGOULD, AR	BAFFLE SYSTEM/ SERPENTINE FLOW WITH DUCKWEED	COMPLETED	COMPREHENSIVE PERFORMANCE EVALUATION APPROVED
PHOENIX, AZ	DIGESTER GAS SCRUBBING	COMPLETED	FIELD TEST REPORT UNDER REVIEW BY STATE AGENCY AND EPA
HAYWARD, CA	*OXYTRON PURE-OXYGEN FLUID BED REACTOR	COMPLETED	DEMONSTRATED ENERGY SAVINGS APPROXIMATELY 23-35% COMPARED TO CONVENTIONAL ACTIVATED SLUDGE
CITY OF GUSTINE, CA	AQUACULTURE/MARSH POLYCULTURE	COMPLETED	DEMONSTRATED BOD AND SUSPENDED SOLIDS REMOVAL COULD BE ACHIEVED ALSO REFINED THE DESIGN CRITERIA
MONTEREY, CA	ADVANCED SECONDARY CROP IRRIGATION	COMPLETED	DEMONSTRATED ADVANCED SECONDARY TREATMENT ADEQUATE FOR FOOD CROP PRODUCTION
SAN DIEGO, CA	AQUACULTURE/PULSED AND FIXED BED ANAEROBIC HYBRID ROCK-REED FILTERS	ONGOING	

APPENDIX E

INNOVATIVE/ALTERNATIVE FIELD TEST PROJECTS

FACILITY	TECHNOLOGY	STATUS	COMMENTS
IDAHO CITY, ID	RAPID INFILTRATION/ WETLANDS	COMPLETED	ONLY PARTIALLY SUCCESSFUL
DECATUR, IL	SWIRL CONCENTRATOR FOR CSO	COMPLETED	FULL SCALE FIELD TEST DEMONSTRATED TOTAL BOD REMOVALS OF 13-44%
WAUCONDA, IL	TRICKLING FILTER/ SOLIDS CONTACT	COMPLETED	REPORT IN PREPARATION
DENHAM SPRINGS, LA	ROCK-REED FILTER SYSTEM	UNDER CONSTRUCTION	
HOMER, LA	INTRA-CHANNEL BOAT CLARIFIER	UNDER CONSTRUCTION	
OPELOUSAS, LA	CAPTOR PROCESS	PLANNED	
JACKMAN, ME	PHOSPHORUS REMOVAL/ STABILIZATION POND	ONGOING	
YARMOUTH, MA	SEPTAGE TREATMENT	COMPLETED	DEMONSTRATED SEPTAGE COULD BE TREATED COST EFFECTIVELY WHILE ACHIEVING NUTRIENT REMOVAL REQUIREMENTS

APPENDIX E

INNOVATIVE/ALTERNATIVE FIELD TEST PROJECTS

FACILITY	TECHNOLOGY	STATUS	COMMENTS
DEER ISLAND, MA	SLUDGE COMPOSTING	ONGOING	
RISING SUN, MD	*PHOTOZONE ACTIVATED OZONE DISINFECTION	COMPLETED	DEMONSTRATED NOT COST EFFECTIVE COMPARED TO UV DISINFECTION
LITTLE BLUE VALLEY, MO	BURNS/MACDONALD INTRA-CHANNEL CLARIFIER	COMPLETED	DEMONSTRATED INTRA-CHANNEL CLARIFIER SYSTEM WORKS-FULL SCALE PLANT BUILT
DEVILS LAKE, ND	LEMNA (DUCKWEED) PROCESS FOR REDUCING SUSPENDED SOLIDS/ PHOSPHORUS	COMPLETED	DEMONSTRATED GOOD POTENTIAL FOR SS AND PHOSPHORUS REMOVAL
ROSWELL, NM	*BROWN BEAR SLUDGE DRYING	ONGOING	
CHEMUNG COUNTY, NY	TRICKLING FILTER/ SOLIDS CONTACT	COMPLETED	DEMONSTRATED CAPABILITY OF SINGLE STAGE FILTER FOR BOD REDUCTION/NITRIFICATION
HORNELL, NY	SEEDED BACTERIAL NITRIFICATION	COMPLETED	DEMONSTRATED CHEAPER METHOD FOR NITRIFICATION
TOLEDO, OH	SWIRL CONCENTRATOR	COMPLETED	DEMONSTRATED LESS THAN 20% SOLIDS AND BOD REMOVAL

APPENDIX E

INNOVATIVE/ALTERNATIVE FIELD TEST PROJECTS

FACILITY	TECHNOLOGY	STATUS	COMMENTS
GRAND STRAND, SC	ADVANCED WASTE TREATMENT/WETLANDS	ONGOING	
CRAIG-NEW CASTLE, VA	UV DISINFECTION	ONGOING	
MOUNDSVILLE, WV	*CAPTOR POROUS BIOMASS ACTIVATED SLUDGE IN CONVENTIONAL SLUDGE	COMPLETED	DEMONSTRATED CONSISTENT SECONDARY SLUDGE CONCENTRATION OF 3.6% WITHOUT SLUDGE THICKENING
CLEAR WATER, WI	*ZIMPRO FILTRATION PRIMARY EFFLUENT USING PULSED BED FILTER	COMPLETED	DEMONSTRATED 56% SOLIDS AND 28% BOD REMOVAL

*MENTION OF TRADE NAMES OR COMMERCIAL PRODUCTS DOES NOT CONSTITUTE EPA ENDORSEMENT OR RECOMMENDATION FOR USE.