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Wastewater Treatment Systems for Rural Communities

Commission on Rural Water Washington, D.C. 1973

Design: James True
Layout: Suzy Marsh
and Clare Wilson
Typesetting: Service Composition
Helvetica Light and Medium
Paper: Finch, Pruyn, and Company
Printed by Universal

Library of Congress Catalog
Card Number 73-77740
Printed in USA

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Walter J. Moberg, Jr. is a student of Architecture and Urban Planning at Princeton University. He joined the research and writing effort during summer employment, bearing principal responsibility for the catalogue of equipment available (Appendix C). He continues to serve as a consultant to NDWP.

Foreword

This book is a guide to systems and components available for treating wastewaters in rural areas.

It should assist designers and planners of wastewater treatment facilities for rural communities in laying out preliminary system plans including significant cost components. Similarly, it should provide the potential client (a water and wastewater district, for example) with sufficient information on available alternatives to enable him to exercise an informed choice among those presented by the consulting engineer for his consideration.

In addition, it is intended that this book show government agencies, such as environmental and public health regulatory bodies, agencies committed to economic development and social transition, loan guarantors, and legislative bodies, that a range of alternatives does indeed exist for providing effective wastewater treatment in isolated areas at reasonable cost. This information should also be of value to the home-building and home improvement industries as well as individual rural homeowners faced with the problem of providing waste disposal and treatment facilities for their families.

This book begins with a chapter on basic concepts of domestic sewage and treatment processes appropriate to rural settings. In Chapter Two, the role and use of soils in wastewater treatment and disposal are described.

The third chapter reviews traditional systems and design approaches for wastewater treatment systems. New or unusual methods for wastewater collection and conveyance and treatment and disposal where the traditional approaches are not appropriate are described in Chapter Four.

Included are specially engineered above-ground mounds and subsurface soil disposal systems for use when the native soil is not suitable for accepting settled sewage; composite systems in which sewage is either ground up at the house or settled in modified septic tanks and pumped under pressure in small diameter sewers to a central treatment facility; spreading of treated sewage effluent on the surface of the land by spray irrigation; and the use of treated wastewater as a resource for fire protection.

Chapter Five describes the traditionally poor record of maintenance and service of small plants and suggests types of management organization that can provide proper plant maintenance and service. Some basic information about the characteristics of septage, the material pumped from septic tanks, is also included in Chapter Five. This information should be useful in the design of facilities for the safe treatment and disposal of this often overlooked residual of on-site treatment.

The final chapter provides a basis for anticipating the costs of components and systems for treating wastewater in rural communities. Because many of the design approaches discussed in this book represent departures from traditional methods, there has not been sufficient experience upon which to base reliable cost estimating procedures for several of them.

Three appendices are included. Appendix A, an original contribution by Alfred P. Bernhart of the University of Toronto, presents a rational approach for determining building lot sizes on the basis of soil suitability for wastewater disposal. Appendix B reviews the role of the National Sanitation Foundation in testing the performance of appropriately sized components of wastewater treatment systems for rural communities.

Appendix C contains a representative selection of equipment which can be used in rural (and suburban, for that matter) wastewater treatment systems. Illustrations and data sheets abstracted from manufacturer-supplied information are organized along functional lines (e.g., collection and conveyance, treatment, disposal). (New or revised equipment data sheets will be provided in future revisions or supplements.) Appendix C also contains an index of manufacturers whose equipment appears in this book.

Over one hundred manufacturers were contacted to obtain the information presented in Appendix C. About seventy replied, and about fifty offered the details requested. Several of the units included in Appendix C are so new that finished brochures are not yet available. A few are used abroad (in Sweden and Japan, for example), but have not yet been introduced into the American market. Many units illustrated are departures from the usual approach to wastewater treatment and should therefore be of interest to a wide readership.

The authors received considerable assistance from many individuals in writing this book. William H. Bender, recently retired Assistant Director for Soil Survey Interpretations, Soil Conservation Service, U.S. Department of Agriculture (USDA) collaborated with the authors in writing the sections about the fundamentals of soils in relation to wastewater disposal. John T. Winneberger, private consultant, of Berkeley, California; the late E. E. MacNamara of Lehigh University, Bethlehem, Pennsylvania; and W. J. Meyer, Soil Scientist, Virginia State Department of Health, Richmond, Virginia, all made valuable contributions to the material on soils. As indicated previously, Alfred P. Bernhart of the University of Toronto made a substantial contribution to this book.

The authors are also grateful to the individuals named in the summary data sheets in Appendix C and the companies which they represent for their cooperation and the materials they supplied.

Numerous graphic exhibits, including all of Appendix C, first appeared in a report written by the authors for National Demonstration Water Project (NDWP) while they were on the staff of the MITRE Corp. The authors express their appreciation to the MITRE Corp. for the loan of the original copies of graphic materials.

The authors' colleagues on the Commission on Rural Water have provided encouragement and invaluable assistance in the task of reviewing earlier versions of this book. Judith A. Segal of the Office of Economic Opportunity and Michael D. Campbell, Director of the National Water Well Association's Research Facility in Columbus, Ohio, deserve special recognition for their contributions. The authors also wish to thank Stanley Zimmerman, Executive Director of NDWP, for his assistance in this regard.

In conclusion, the authors happily acknowledge the contributions to this book of the editor, Shirley True, and the designer, James True. The transformation of the manuscript into a finished book was a most satisfying experience for the authors as a result of their close association with the Trues during the production process. The collaborative effort permitted, for example, the creative use of marginal spaces and coordination of the text and visual exhibits.

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Bethesda, Maryland
Princeton, New Jersey
January, 1973

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Abbreviations

ABS	acrylonitrite-butadiene-styrene plastics
AC	alternating current
AGA	American Gas Association
AGMA	American Gear Manufacturers Association
amp	ampere
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing and Materials
AWC	available water capacity
BHP	brake horsepower
BOD	biochemical oxygen demand
BOD_5	biochemical oxygen demand over a five day period
ca	circa (approximately)
CFD	cubic feet per day
CFM	cubic feet per minute
CGA	Canadian Gas Association
Cl_2	chlorine
CS	Commercial Standard
DC	direct current
DO	dissolved oxygen
E. coli	Escherichia coli
FA	free air
FAA	Federal Aviation Administration
FHA	Federal Housing Administration
FmHA	Farmers Home Administration
FOB	free on board
fps	foot (feet) per second

g/cm³	grams per cubic centimeter
GPCD	gallons per capita per day
gpd	gallons per day
gph	gallons per hour
gpm	gallons per minute
hp	horsepower
Hz	Hertz
ID	inside diameter
IPS	iron pipe size
IPT	internal pipe thread
Kwh	Kilowatt hour
lb.	pound(s)
LP	liquid propane (gas)
mg/l	milligrams per liter
ml	milliliter
MLSS	mixed liquor suspended solids
mm	millimeter
mph	miles per hour
MPN	most probable number (usually expressed as number per hundred milliliters)
NA	not applicable
NAS	National Association of Sanitarians
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NPS	normal pipe size
NPT	national taper pipe thread
NRC	National Research Council
NSF	National Sanitation Foundation
NWS	National Weather Service
OD	outside diameter
ph	phase
PPD	pounds per day
ppm	parts per million
PSI	pounds per square inch
PSIG	gauge pressure in pounds per square inch
PVC	polyvinylchloride (plastic or resin)
RPM	revolutions per minute

SCFM	standard cubic feet per minute
SG	specific gravity
TDH	total dynamic head
T.O.	threshold odor
TSS	tertiary suspended solids
USASI	United States of America Standards Institute
USFS	United States Forest Service
USPHS	United States Public Health Service
USWB	United States Weather Bureau (now National Weather Service)
V	volt
VA	Veterans Administration
W	watt
W.C.	water column

Chapter One

A Primer on Small Sewage Treatment Systems

Scope of the Problem

Urban sewage treatment plants are simple in concept, but they are quite complex in their hardware and special engineering is generally provided. Rural modes of waste management, on the other hand, are complex in concept, but so simple in their hardware that special engineering is rarely needed. For rural needs, hardware is managed by simple codes or prefabrications.

In many places, a rural home has a pressurized water system and its own sewer with a complete treatment plant and disposal arrangement. This is usually the septic tank system. In some cases, more sophisticated treatment units replace the septic tank, but still utilize a customary subsurface disposal field.

Sometimes in rural areas, several homes are served by a community sewer which may either terminate at the nearest water course or at a scaled-down version of a municipal treatment plant, commonly referred to as the package plant. Package plants are often unreliable in operation and wastewater treatment is frequently incomplete even when they do operate properly. Water quality control boards are demanding better treatment. In many places, disposal to water courses has been forbidden.

Some rural homes do not have pressurized water systems. In such instances, a pit privy provides a relatively complete system, which in practice constitutes an excellent device. Rather than a pit privy, sometimes disposal of human waste can be managed by incineration or other sophisticated techniques.

Maintenance in rural situations is generally not provided, and the life of almost any wastewater management system will be prematurely terminated by a combination of poor design and near total neglect.

Historical trends in the availability and quality of wastewater treatment are illustrated in Figure 1. About 70 per cent of the population was served by sewers in 1968. Of these, about 92 per cent had waste treatment facilities. The 30 per cent of the population not served by sewers depended on some fifteen to seventeen million septic tank and cesspool installations, and five to ten million households used more primitive techniques such as privies or direct discharge to watercourses.

This book addresses the unsewered 30 per cent or so of the present population and the choices available for treatment of domestic wastes. Future populations and the type of sewerage services they will need are also of concern.*

The Nature of Domestic Sewage

Sewage from individual homes is a complex brew—it consists of all manner of things that go down drains or are flushed down toilets. The composition of sewage varies from day to day, from house to house, even from hour to hour. On the average, domestic sewage consists of about 99.9 per cent water (weight) and 0.02 to 0.03 per cent suspended solids and other soluble organic and inorganic substances. [1†] Sewage also contains bacteria, viruses, and other microorganisms from the digestive tract, respiratory tract, and skin, which make their way to toilets and drains.

In a single family house, the laundry and kitchen each account for about 10 per cent of the wastewater volume, while the bathtub, shower, and handwash basins account for about 40 per cent, and the toilets account for the remaining 40 per cent. [2] The organic chemical content of domestic sewage comes primarily from human wastes, soaps, and food wastes (especially in homes where a garbage grinder is used).

The Sewage Treatment Process

Sewage treatment has as its goals:

(1) The removal of solids;

(2) The stabilization of organic oxygen-demanding compounds;

(3) The killing of disease-causing microorganisms; and

(4) The removal of other harmful chemical substances and disagreeable colors and odors.

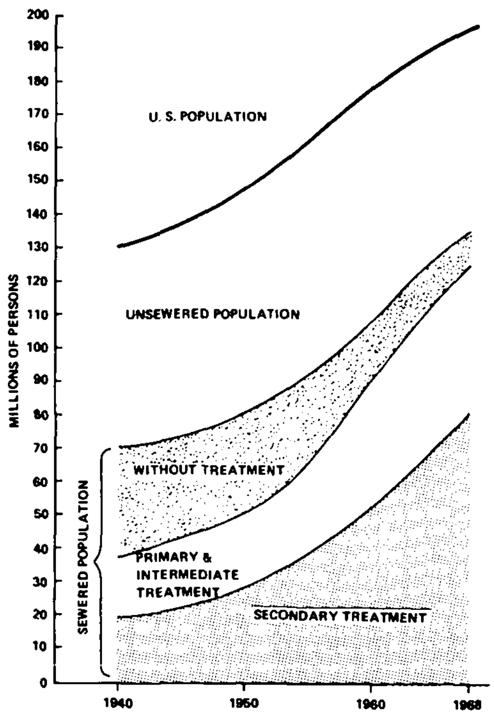
Biochemical Oxygen Demand (BOD)

The amount of treatment required before effluent can be discharged (the "strength" of the sewage) is the amount of the various materials present which must be removed. One measure of the amount of organic material present is the biochemical oxygen demand (BOD), which is the total amount of oxygen utilized by microorganisms in converting wastes to more or less fully oxidized end-products called stabilized sewage. If sewage is only partially broken down, i.e., not fully stabilized, it will later require more oxygen from its environment to complete the oxidation process.

* For the corresponding problem of water supply, see Michael D. Campbell and Jay H. Lehr, *Rural Water Systems Planning and Engineering Guide*, Commission on Rural Water, Washington, D.C., 1973.

† Numbers in brackets refer to References at the end of the book.

Fig. 1. Growth of public wastehandling services.



Source: *Economics of Clean Water*, Vol. 1, U.S. Dept. of the Interior, Federal Pollution Control Administration, March 1970, p. 75.

The most common way a BOD measurement is made is by diluting a sample of sewage with water containing a known amount of dissolved oxygen and incubating the mixture in a tightly sealed bottle for five days at 20°C (68°F). The amount of oxygen used during the five days is determined by measuring the amount remaining and subtracting it from the starting amount. This type of BOD determination is referred to as a BOD_5, indicating the five-day process. It accounts for about 80 per cent of the oxygen used in the oxidation process which, of course, may take more than five days. Often the non-specific term BOD is used, and more often than not it denotes the five-day (BOD_5) value. Typical values of BOD for raw domestic sewage are several hundred milligrams per liter (mg/l*).

Levels of Treatment

The terms *primary, secondary,* and *tertiary* usually refer to the level of treatment provided by a system. These systems typically use sewers to collect and convey wastewater from homes to centralized plants which treat the sewage.

The removal of settleable solids is a physical procedure which can be done with screens and gravitational settling. This part of the treatment process is often called *primary treatment.*

Intermediate treatment is the removal of a high percentage of suspended solids and a substantial percentage of colloidal matter, but little dissolved matter. A significant amount (25 to 35 per cent) of the BOD is removed in primary and intermediate treatment because it is tied up in the solids which are removed.

Secondary treatment is the reduction of BOD through biological digestion of the sewage (including dissolved organic substances) to yield stabilized sewage (effluent). The success of secondary treatment is absolutely dependent on the maintenance of an active culture of microorganisms which feed on the sewage and stabilize it as a consequence of their metabolic processes.

The removal of organic and inorganic compounds not removed in primary or secondary treatment is accomplished by a number of different processes and is collectively referred to as *tertiary treatment,* also called *advanced wastewater treatment* (AWT).

Chlorination is often used to meet goal (3) of the sewage treatment process, the killing of disease-causing microorganisms, but it doesn't always work. The inadequacy of chlorination arises in part from improper adjustment of equipment and insufficient maintenance and in part from the resistance of microorganisms. Other methods such as irradiation with ionizing radiation (ultraviolet, radioactive isotopes), use of ozone, and pasteurization are beginning to be used.

*Roughly equivalent to parts per million (ppm).

More About Microorganisms

Microorganisms (microbes) are important both as constituents of sewage and as digesters of sewage. Biological wastewater treatment systems are designed to promote and protect microbial growths to accelerate the decomposition of waste products.

Microorganisms include the algae, which are either single cells or aggregations of similar cells, or more complex structures in which the cells are specialized. Algae are not constituents of sewage, but they grow in water containing sewage. They are simple plants which contain chlorophyll and are capable of photosynthesis, the production of oxygen and carbohydrates in the presence of light. At night, in the absence of light, they utilize large amounts of oxygen and deplete surface waters of this vital constituent.

The fungi are plants which are devoid of chlorophyll and therefore unable to synthesize carbohydrates. The fungi include single-celled yeasts and multicellular molds and mushrooms.

Bacteria are yet another type of microorganism. The bacteria are single-cell organisms. A few types carry on photosynthesis; most do not. Many bacterial types operate similarly to yeasts in fermenting sugar and starches to alcohols and simple organic acids. Some form slimes. Bacteria differ structurally from yeasts and other fungi. (For example, they are somewhat smaller and do not have a well-defined cell nucleus.) Bacterial cells range from about 0.5 micron to about 5 microns in size. (A micron is equal to one-millionth of a meter or 1/25,400 of an inch.) Yeasts start at about this range and go up to about 30 microns or more in length. Cholera, typhoid fever and paratyphoid fever are diseases caused by bacteria.

Viruses are some ten to one hundred times smaller than bacteria. Because they lack the machinery to function on their own, they can function and reproduce only inside a living cell. Viruses are responsible for diseases such as polio and viral hepatitis, as well as the common cold.

Protozoa are very simple animal organisms. They range in size from tens up to thousands of times larger than bacteria. The protozoa include organisms which are responsible for amebic dysentery and malaria. The former can be transmitted through feces. Because most protozoa require oxygen, their disappearance from sewage can be used as an indicator of insufficient oxygenation.

Metazoa are multi-cellular animals (including man). One particular type of small metazoan, the rotifer, is abundantly present in well-aerated sewage and feeds on sewage and the smaller microorganisms. Snail fever, one of the most widespread water-borne diseases in the world, is caused by a metazoan flatworm.

Since sewage contains fungi, metazoa, protozoa, bacteria, and viruses, it can be a source of disease caused by these organisms unless it is adequately treated before being discharged to surface or ground waters.*

* For a discussion of waterborne diseases and rural water problems in general, see *Water and Wastewater Problems in Rural America*, Commission on Rural Water, Washington, D.C., 1973.

Coliforms and Contamination

Microbiological contamination of water and aquatic animals is often inferred on the basic of a coliform count. Because of the virtually universal presence of the coliform *Escherichia coli (E. coli)* in the mammalian intestinal tract and because of the ease with which *E. coli* can be identified and counted in a water sample, the quantitative presence of this organism has come to be used as an index of contamination of water with human wastes. (Most strains of *E. coli*, by the way, are not generally harmful to humans in small numbers.)

The coliform test is not infallible, however. The methods normally used for identifying *E. coli* show positive results for other related bacteria which fall into the coliform group. One member of the coliform group, *Aerobacter aerogenes*, is normally found on plants and in the soil, yet reacts identically to *E. coli* in the simple tests. Further, there are many types of bacteria and microorganisms in addition to the coliforms in the intestinal tract. A positive coliform test can result from the presence of the soil bacterium *A. aerogenes* and the absence of fecal contamination, and a negative coliform test result doesn't rule out the presence of other harmful organisms, especially the more hardy viruses.

An interesting feature of bacteria and other microorganisms is that they are hardy. They exist in nature at remarkable extremes of temperature, pressure, humidity, and salinity. Treatments less thorough than complete sterilization under precisely controlled laboratory-type conditions won't kill all of them. Chlorination as it is practiced in treatment plants, for example, will not kill all bacteria, nor will it deactivate all viruses. The hardiest will remain.

Aerobic and Anaerobic Treatment in Individual Home Systems

Sewage itself is a complex substance, but the biological mechanisms which take place in sewage are even more complex. The principal means for differentiating between treatment processes is on the basis of whether or not free oxygen is utilized by the microorganisms in the breakdown. Those which must have free oxygen are called aerobes and those which are inactive in an oxygenated environment are called anaerobes. However, there is a type known as *facultatives* which carries out its processes without the need for free oxygen, but can also function adequately when oxygen is present. Even in a well-aerated system, inner layers of slime-coated aggregates are oxygen-deficient and thus provide a habitat for anaerobes. The anaerobes can become dominant at a later time when the dissolved oxygen is depleted. The dominance of aerobes in relation to anaerobes reflects the abundance of free oxygen.

On a quantitative basis, water becomes saturated with oxygen at dissolved oxygen (DO) values of 9.02 mg/l at 20°C (68°F). If sewage has a BOD of several hundred, then each liter of sewage will require several hundred milligrams of oxygen for stabilization, some twenty to thirty times more than is dissolved in the water. If more oxygen is not supplied by natural absorption or mechanical mixing, the initial supply will be used up rather quickly, and the mixture will "go septic." Flowing waters have advantages for assimilating sewage effluents because of dilution and aeration opportunities. Stationary waters, such as lagoons, must depend on oxygen absorption at the air-water interface, and, depending on temperature conditions, lower layers are often anaerobic while the upper layers are aerobic.

On-Site Treatment

Septic Tanks

On-site treatment of domestic sewage can be accomplished by decomposition and seepage into the soil (a privy) or by incineration, but most permanent installations utilize liquid medium techniques. The most familiar option is the septic tank, which by its very name implies anaerobic conditions (sepsis refers to bacterial action in the absence of air). Actually, there are two components of a septic tank system: the septic tank itself, which removes the settleable solid matter, and the subsoil disposal system (trench bed, leach field), which receives the effluent from the septic tank. Both components of the system provide sewage treatment, and, typically, more treatment is provided in the disposal system than in the septic tank. Septic tanks and cesspools depend on seepage of the liquid portion of sewage into soils where the sewage can be treated aerobically by soil microorganisms. Their oxygen is supplied by diffusion through the soil.

Aerobic Tanks

Aerobic tanks can achieve an effluent of lower BOD than septic tanks, typically in the 20 to 100 mg/l range, but certainly not fully stabilized. Further treatment can be achieved either with subsurface discharge in soils or, where permitted by code, by surface discharge to land or bodies of water after suitable disinfection with chlorine or by other approved methods.

While there may be considerable difference in "strengths," sewage effluents from septic tanks, aerobic tanks, and cesspools all require some additional amount of stabilization before they can be regarded as fully treated and safe for other uses, including drinking. Furthermore, a residual sludge builds up in all of the processes, and the sludge must be removed from the system periodically. Disposal of sludge, especially septic sludge, often poses difficult environmental problems.

Factors to Consider in Selecting an On-Site Treatment System

If the soil is capable of absorbing and treating effluent, and if there is sufficient space for soil absorption systems on the lot (original plus room for an alternate in the event of failure), then a septic tank should be chosen because it is cheaper than an aerobic tank (several hundred vs. over a thousand dollars). In addition, septic tanks have no moving parts which require servicing or electric power, both of which add to operating costs. Aerobic tanks require regular servicing of the air compressor and are subject to breaking down in the absence of maintenance.

Because properly functioning aerobic tanks can produce an effluent which may be less demanding of the soil than septic tank effluent, many states and localities permit smaller soil absorption systems for aerobic tanks than for septic tanks. A reduction in soil absorption area could represent a savings of several hundred dollars, reducing somewhat the spread between initial costs of septic and aerobic tanks. More importantly—especially for areas with marginal soils' capability for receiving effluent—aerobic-tank effluent, adequately disinfected by a method harmless to soil bacteria (ozonation, ultraviolet irradiation, or pasteurization, for example), reduces the threat to public health that the effluent could pose if the soil system were to fail. These relative advantages would be negated, of course, if the aerobic tanks and disinfection units were not properly maintained. Regular servicing and maintenance is a necessity.

Treatment Processes in Small Community Treatment Systems

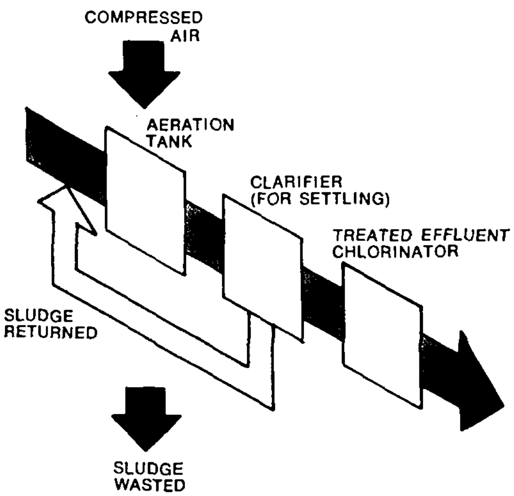
Lagoons

One of the more prevalent methods for treating wastewater in small communities uses a lagoon or stabilization pond. If a shallow pond of effluent is kept well mixed and aerated, aerobic processes can prevail. Algae can participate in the biochemical breakdown of sewage in lagoons because of the exposure to sunlight. When mixing is poor and the lagoon is run anaerobically, the dead and decaying algae help to deplete the dissolved oxygen, and the result can be a foul-smelling open septic tank. In a facultative pond, the upper layers of water (the water can separate into thermal layers if there is little physical mixing) operate aerobically, while the lower layers are anaerobic. Mechanical aerators can be floated atop the pond to keep the entire pond aerobic.

Imhoff Tanks

An Imhoff tank is the community analogue of a septic tank. It is a two-story device, the upper level of which is a conical hopper which receives incoming raw sewage. The solids settle to the bottom of the cone and pass through an opening to the lower chamber where they undergo further decomposition. Gas from the decomposing sewage is drawn off from the lower chamber and may be used as a fuel for drying sludge.

ACTIVATED SLUDGE PROCESS



Activated Sludge Processes

In the conventional activated sludge process, gelatinous masses (flocs), which are communities of many types of microorganisms, are kept in suspension in an aeration tank where air is bubbled through the mixture to provide the oxygen required by the microorganisms to consume the sewage. Because the flocs are heavier than water, they sink as sludge if not kept in suspension. From the aeration tank, partially treated sewage (called mixed liquor) flows into the clarifier, where clear water flows out the top and solids (aerobic colonies) sink to the bottom as activated sludge. Part of the activated sludge is then returned to the aeration chamber where it is re-aerated and kept in suspension to help provide treatment for the incoming raw sewage and the treatment cycle continues.

There are several modifications of the activated sludge process. Two are the *extended aeration modification* and the *contact stabilization modification.* In the extended aeration modification, the sewage is detained in the aeration chamber for a long time (as much as twenty-four hours) to obtain the desired degree of treatment. In the contact stabilization modification, the activated sludge is conditioned for several hours in a re-aeration (or stabilization) zone before being returned to the mixed liquor for contact with raw sewage. The extra aeration of the concentrated sludge enables it to digest the sewage more quickly, permitting higher throughput in a contact stabilization plant than in a conventional activated sludge plant. Contact stabilization requires close supervision by skilled operators, else the process can go awry.

The conventional activated sludge process is sensitive to highly uneven (shock) loads of sewage. For this reason, small scale activated sludge plants are normally designed to operate in the extended aeration mode, which is somewhat less sensitive to shock loading. Small plants for subdivisions (package plants) are normally scaled-down versions of the big municipal plants. Many of the individual home aerobic plants are designed as further scaled-down versions of larger activated sludge plants, or designers at least attempt to retain as many of the principles of the activated sludge process as they can.

Trickling Filters

If the gelatinous colonies of aerobic and facultative organisms are allowed to form on a medium having a large surface area, such as a bed of rocks, shredded tree-bark, or corrugated plastic materials, wastewater can be stabilized as it slowly passes over the slimy surface. After large solids are either removed from sewage or ground up, the wastewater can be trickled through an extended filter consisting of the slime-coated materials. This is the principle of the trickling filter plant. At least one manufacturer has taken advantage of the mechanical simplicity of the trickling filter and has designed a plant of subdivision proportions.

Physical-Chemical Sewage Treatment

The processes described so far (except incineration) make use of natural biological processes for stabilizing sewage. Several manufacturers have developed plants which use combinations of physical processes, such as radiation, grinding, and heat, and chemical processes, such as ozone and other oxidizers and coagulants, for solids removal, stabilization, and disinfection, as well as removal of other constituents. Physical-chemical plants are especially adaptable for use aboard ship where it might be difficult to maintain a mixed liquor. They are also suited to land areas where severe climate might limit the usefulness of biological processes. One very promising physical-chemical technique, reverse osmosis, uses mechanical pressure and membranes with exceedingly small passages to strain impurities from the wastewater. It is likely that such advanced techniques will be adapted for use in rural areas. To the extent that they are independent of biological processes and at the same time based on rugged physical and chemical processes, these techniques may someday be preferred to present methods.

Chapter Two

The Role of Soils in Wastewater Disposal

Soil Characteristics Relevant to the Application of Wastewater

The term soil in a generic sense means the surface layer of the earth's crust. It is formed by the interaction of weather, plants, and animals on rock and other materials coating the earth's surface and may range in thickness from a few inches to five or ten feet. It is the link between the rock core of the earth and life on its surface.

Soil serves as the medium which absorbs and filters effluent from domestic treatment units. How well the system works depends on the rate at which the effluent moves into and through the soil. Some soils absorb effluent rapidly, others slowly. If the sewage is not absorbed readily, unfiltered sewage may reach the ground surface or may pass rapidly through the soil and contaminate ground water.

Man has attempted to apply many classification systems for soils based on various criteria for specific purposes. The most useful systems for understanding the role of soils as treatment media for wastewater involve descriptions of the particles making up the mineral fraction of the soil and the arrangement of these particles to each other, both in the horizontal and vertical directions.

A soil is an assemblage of mineral particles interspersed with voids. These voids, which may or may not be directly interconnected, are called pores and can be occupied by gases, liquids, and living organisms. The total amount of voids per unit volume is referred to as *pore space*. The solid portion of the soil mass, the mineral particles, is often referred to as the *skeletal portion* of the soil, and the pattern of arrangement of the individual particles or aggregates formed from them, the *soil structure*.

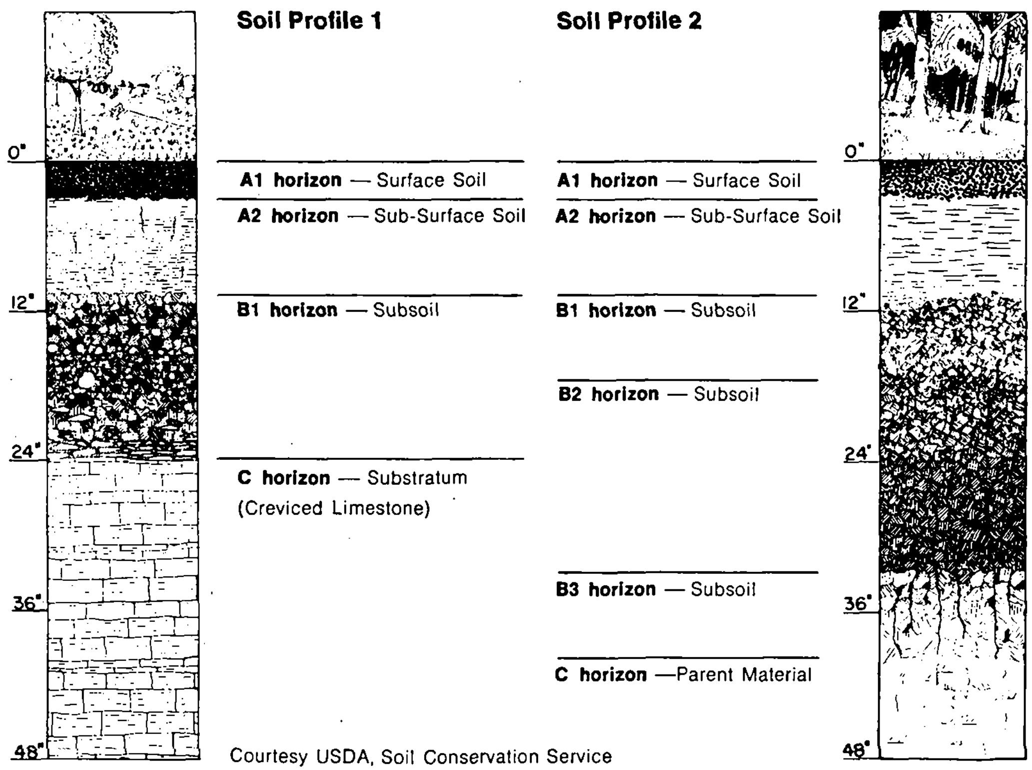
The average soil has about 50 per cent pore space. This 50-50 division is based on an average oven-dry bulk density of 1.3 g/cm^3 bulk soil (solids and void space) and a particle density of 2.6 g/cm^3. Under normal conditions, after gravitational water has been drained from the soil following a rainfall, the water held in the soil will vary from about 30 per cent of the bulk volume to 15 per cent. The air space will vary accordingly from 20 to 35 per cent.

The solid part of soil is composed of minerals and small amounts of organic matter. The minerals are in the form of gravel, sand, clay and silt. A few soils are entirely organic in nature. These are formed in peat and muck of different thicknesses ranging from a few inches to over fifty feet.

The Soil Profile

The process of soil formation is a dynamically evolving system wherein the rock of the earth is continuously converted by disintegration, decomposition, eluviation, deposition, compaction and alteration. Soil evolution continues through active processes such as weathering and produces a series of horizontal layers in the soil. The resulting horizontal layering is known as the *soil profile*. The nature of the soil profile, and thus, the nature of the soil, determines its capacity to recycle wastewater.

Most soils are weathered or developed to depths of two to five or six feet. *Soil horizons* (layers) develop parallel to the earth's surface. Usually there are two or more. The major horizons are commonly referred to as surface soil, subsoil, and substratum or parent material, or by the letters A, B, and C. There can be several identifiable subhorizons within each major horizon. All of these horizons develop as a result of physical, chemical and biological processes working together, each playing its part in soil formation. Each horizon differs from the others in one or more of the major properties of texture, structure, porosity, and color. The ability of the soil to absorb and renovate wastewater

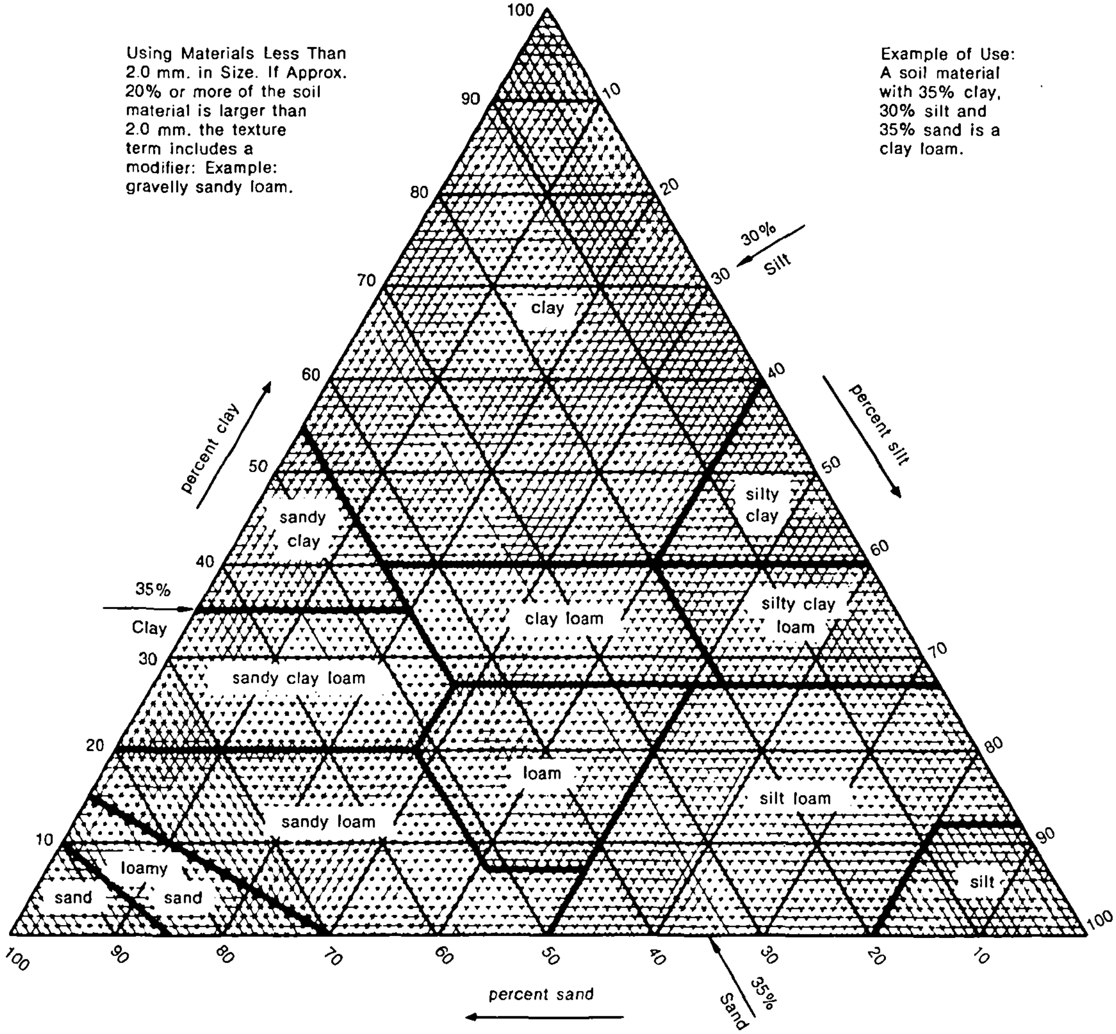


Courtesy USDA, Soil Conservation Service depends most upon the soil properties of texture, structure, internal drainage, depth and slope.

Soil Texture. Texture refers to the per cent of sand, silt and clay in a soil. The texture is specified individually for each soil horizon because it is seldom the same throughout an entire soil profile.

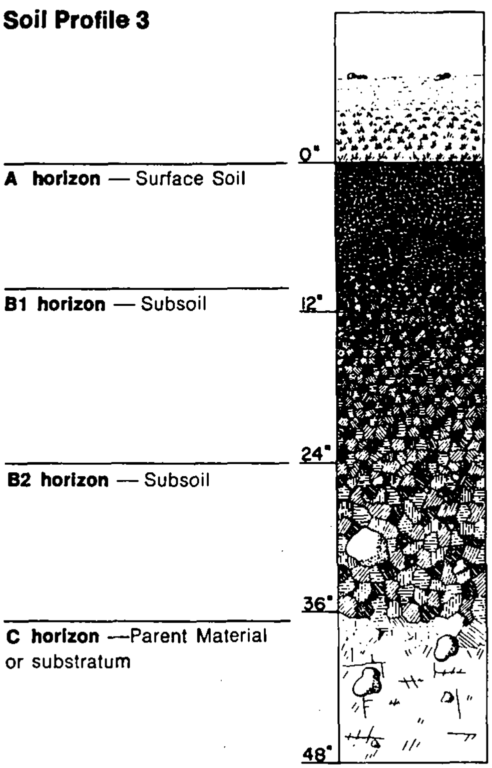
The most convenient system of soil classification for use in wastewater considerations is the U.S. Department of Agriculture (USDA) Textural Classification. [3] Texture is determined by the relative proportions of sand, silt and clay in a soil. Sand, silt and clay differ from each other in their particle sizes. For this reason, texture is sometimes called "particle size" or "soil separates." The USDA textural classification of a soil is determined from the texture triangle in Figure 2. A soil having about 20 per cent sand,

Fig. 2. Guide for USDA Soil Textural Classification. Courtesy USDA



70 per cent silt, and 10 per cent clay, for example, falls right in the center of the zone of silt loams. Conversely, the average silt loam has the sand-silt-clay makeup just cited. Of the three particle sizes, sand is the largest, silt particles are next in size, and clay particles are the smallest. The sizes according to the USDA system are:

Texture Name	*Diameter (Millimeters)*
Very coarse sand	2.00-1.00
Coarse sand	1.00-0.50
Medium sand	0.50-0.25
Fine sand	0.25-0.10
Very fine sand	0.10-0.05
Silt	0.05-0.002
Clay	Under 0.002



Texture is determined in the laboratory by mechanical analysis. Particles larger than 2.0 mm are classed as gravel and are screened out before doing the particle size analysis. The different-sized sands are screened by means of sieves; and the remainder of the sample, silt and clay separates, are calculated from their settling speeds in water. Silt settles out in about thirty-three minutes and clay in about twenty-two hours.

Texture is determined in the field by rubbing the soil between the fingers. Proficiency is gained only through experience and practice with samples of known texture.

There is a great difference in the physical and chemical activity of the different-sized soil particles. The greatest amount of activity takes place on the surface of clay particles. The surface area of a pound of clay particles, for example, may be as high as twenty-five acres, whereas the surface area of a pound of sand particles will be only three to five acres. The surface area of the clay particles thus imparts the chemical and physical behavior characteristics of clay to those soils which contain a higher percentage of clay than of sand and silt. Silt supplies some activity but not as much as clay. The gravel and sand fractions are inactive chemically, but perform important functions by making soils crumbly (friable) and by providing larger pore space for internal drainage and percolation.

Clay provides soil with plasticity, shrink-swell potential, water and air retention, and cohesion. It also enables soil to react chemically, to hold wastewater and its nutrients, and to recycle the nutrients into plants before they can leach into ground water. Sands, on the other hand, permit nutrients and water to move through the soil more rapidly and thus impose a greater hazard for the contamination of ground water than do soils with appreciable amounts of clay and silt.

Soil Structure. Soil structure is the natural grouping of soil particles, called aggregation. A synthetic aggregate can be made by mixing glue with a teaspoonful of sand, silt, and clay. The cementing agents in the soil that promote aggregation and hold the particles together are organic colloids, silica and sesquioxides. As aggregates begin to form in the soil, they develop a definite arrangement by horizons. Soil structure, or aggregation, modifies the effects of texture upon air and water movement and ease of plant root penetration.

The common kinds of structure are:

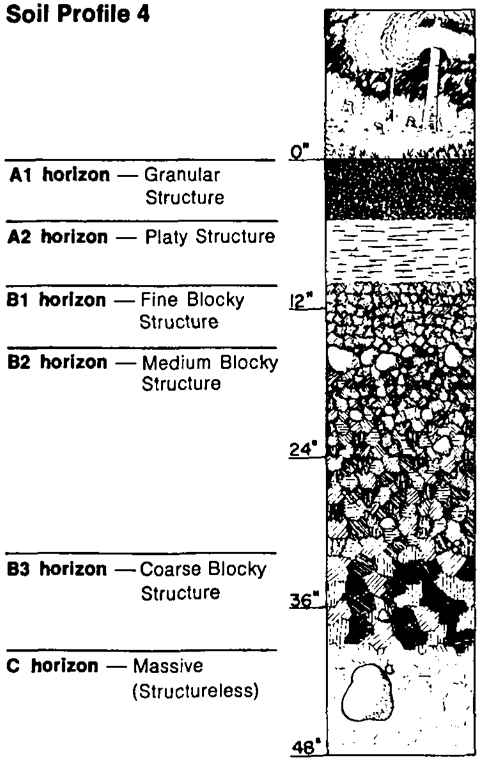
Granular—Rounded aggregates; common to but not restricted to the surface horizon.

Platy—Flat plates; common to but not restricted to the subsurface.

Blocky—Cube-like aggregates typical of most subsoils.

Other kinds of structure include prismatic, columnar and several variations of blocky, but the above three kinds best demonstrate the principles of soil water movement as modified by structure.

Soil Profile 4



There are two kinds of non-aggregated arrangement of soil particles, or structureless soils:

Single grain arrangement in sandy soils where each soil particle is a separate entity. Thus there are no aggregates and no modification in water movement by soil structure. Dune sand is an example.

Massive arrangement of soil particles, in which the soil texture arrangement is in the form of a solid mass except for random cracks that develop as a result of soil wetting, drying, freezing and thawing.

The size, shape and arrangement of aggregates and the extent to which the plates or blocks overlap each other has an influence on water movement within and between the different horizons. Thus, structure determines to a great extent the amount of water entering the soil (infiltration) and the amount moving through the soil (percolation and permeability). Granular and blocky structure (without overlap) allow water to move freely in a more or less direct or straight line path. Platy and blocky structures with overlapping of the blocks and plates impede water movement because of the circuitous path that water must follow around the ends of the overlapping plates and the overlapping blocks. Only small amounts of water move through the aggregates and then very slowly. Water movement is rapid through single grain structureless soils and slow through massive structureless soils.

Internal Soil Drainage (Wetness). Soil drainage is important to wastewater application because a poorly drained soil cannot supply the oxygen required by soil microbes for stabilizing sewage and because the liquid has no place to go if the soil won't drain.

The movement of soil water, especially excess water that moves downward as a result of gravity or of draining out, is called internal soil drainage or natural drainage. It is controlled by texture, structure, pans (impenetrable layers), height of the seasonal water table, and underlying layers.

A clue to a soil's natural drainage or wetness is the color or variation in color of the soil profile. One of the main coloring substances—other than organic matter which is gray-black—is iron. When air is replaced by water in the soil pores over long periods of time, iron exists in the reduced (ferrous) state and is gray in color. When the air supply is high in proportion to water in the pores, the iron is in the oxidized (ferric) state (hematite) and is a red-brown or bright color compared to gray. Soils with bright colors are called *well drained,* and soils with the predominantly dull gray colors are called *poorly drained.* If, over a long period of time a soil has been alternately wet and dry, a combination of the two forms of iron develops and a third, called limonite, which is yellow also develops. This produces a mottled color—a mixture or variegation of colors. Soils with only fair drainage may have an intermingling of colors such as gray, yellow, red, and brown. Examples of the chemical reactions that occur in soil are shown in the box below.

4 FeO Ferrous oxide gray	+	O_2 oxygen	oxidation $\longrightarrow$ $\longleftarrow$ reduction	2 Fe_2O_3 Ferric oxide Red-Brown (Hematite)
Fe_2O_3 Ferric Oxide Red-Brown (Hematite)	+	H_2O Water	hydration $\longrightarrow$ $\longleftarrow$ dehydration	$Fe_2O_3 + H_2O$ Hydrated Ferric Oxide Yellow (Limonite)

A soil with poor internal drainage is characterized by predominantly gray surface and subsurface horizons. The color results from reduced iron and indicates prolonged wetness. (However, one must not confuse a well-drained soil which may be colored dark grayish-black by a high content of organic matter with a poorly-drained soil.) A well-drained soil has a dark gray-brown surface colored by organic matter and a subsoil of bright reddish-brown coloring. The parent material or substratum may contain gray or mottled colors. A soil with intermediate natural internal drainage has a surface horizon colored by organic matter and mottling or a mixture of red, brown and gray colors in the subsoil.

Movement of Wastewater in Soils

Water retention within the soil and water movement through the soil are the two properties of special interest in considering soil as a disposal medium. Water retention is governed largely by surface-tension forces, while water movement is governed by other forces, mainly gravitational and capillary, and is opposed by the surface-tension forces.

A variety of factors affect the pattern of soil water movement: namely, absorption capacity, infiltration, percolation-permeability, depth to and nature of underlying parent material, depth to water table, amount of water present in the soil, and mineralogy. [3, 4, 5]

Absorption Capacity. The absorption capacity of the soil, or the amount of liquid it can hold, is to a large extent a function of the soil structure. The smaller the size of the interconnections between pores, the greater the water-retaining capacity because of surface tension forces. Since pore size is in part a function of particle size, the finer the particle size, the smaller the pores, and the larger the particles, the larger the pores between the particles. With larger particles surface tension is lower and water moves through it more easily. In general, within any given climatic regime, the capacity of the soil to hold wastewater is greatest in clays and least in sands. Aggregation of silts and clays into soil structural units, creating larger apparent particle sizes, usually increases water movement rates. The properties of soil which affect its liquid-holding capacity also affect the ease with which the liquid can move in the soil, or permeability.

Infiltration. Infiltration is the entry of water into the soil. The infiltration rates of soils differ greatly with particle size distribution, the structure of the soil, vegetative cover, clay mineral type, and moisture content. An unvegetated clay soil, for example, tends to develop a crusty layer following rainfall due to destruction of the soil structural units. Such a crust impedes infiltration and enhances runoff. On the other hand, in sands the infiltration rate is usually high, even after compaction by rainfall impact. Few generalizations concerning infiltration rates are valid over the great number of climatic and physiographic zones of the United States, although soils with considerable organic matter in the topsoil tend to have higher infiltration rates than soils with lower organic matter content. Likewise, soils that are highly aggregated usually have higher infiltration rates than soils with poor structure.

Permeability. Permeability is the ability of the bulk soil to transmit water and is commonly measured as the rate of water movement through the soil. It is usually determined as a constant rate when the soil is saturated, and it is commonly expressed in units of inches per hour.

The open spaces, voids, or interstices in the soil are receptacles which store and transmit water. The size, type, shape and arrangement of the voids are the chief contributing factors to water movement and storage and are determining factors in the permeability. Water movement (percolation) occurs chiefly through the larger macropore spaces and is a function of the number of these spaces and their continuity. Water movement through pores is greatly impeded if they contain entrapped air. Studies have shown that in sterile soils permeability gradually increases with water flow because of the removal of entrapped air from the soil pores. The flow of water has also been found to be greatly impeded in long submerged soils by the production of gums in soil pores by microorganisms. Another factor affecting soil permeability is the tendency for soil minerals and organic matter to hydrate in water. This process decreases the size of soil pores and limits the freedom of flow.

Permeability may be generally evaluated by observing the soil profile and by estimation of such physical properties as texture, structure, and color. Soil-survey procedures are usually supplemented by field and laboratory tests on the soils at representative sites. Field observations are made through soil-survey procedures with careful attention to soil structure and overlap and to soil horizons that are high in clay, cemented, or otherwise dense in appearance. Such observations usually indicate whether soils are readily permeable or relatively impermeable. Soils of apparently low permeability need close study.

Percolation. Percolation is an overall or gross measure of the movement of water in the soil after the water has infiltrated through the very top soil layer. Knowledge of the rate of the movement of water into and through the soil, the *percolation rate,* is prerequisite to any wastewater treatment involving the soil. The common unit of measurement is minutes per inch, the inverse of permeability units. Percolation rates usually vary from soil horizon to soil horizon, with the limiting rate for any soil profile being the lowest rate in any one horizon.

At present, there are different methods of characterizing the varying percolation properties of the soil (both saturated and unsaturated). Many states have established regu-

How to Make a Percolation Test. [4,5]

1. Dig six or more test holes four to twelve inches in diameter and about as deep as you plan to make the trenches or seepage bed. Space the holes uniformly over the proposed absorption field. (See Figure 3 for a diagram of a test hole and test hole distribution. Roughen the sides of each hole to remove any smeared or slickened surface that could interfere with water entering the soil. Remove loose dirt from the bottom of the holes and add two inches of sand or fine gravel to prevent sealing.

2. Pour at least twelve inches of water in each hole. Add water as needed to keep the water level twelve inches above the gravel for at least four hours — preferably overnight during dry periods. (If percolation tests are made during a dry season, the soil must be thoroughly wetted to simulate its condition during the wettest season of the year. The results should then be the same regardless of the season.)

3. If water is to remain in the test holes overnight, adjust the water level to about six inches above the gravel. Measure the drop in water level over a thirty-minute period. Multiply that by two to get inches per hour. This is the percolation rate. After getting the percolation rate for all the test holes, figure the average and use that as the percolation rate.

4. If no water remains in the test holes overnight, add water to bring the depth to six inches. Measure the drop in water level every thirty minutes to four hours. Add water as often as needed to keep it at the six-inch level. Use the drop in water level that occurs during the final thirty minutes to calculate the percolation rate.

5. In sandy soils, where water seeps rapidly, reduce the time interval between measurements to ten minutes, and run the test for only one hour. Use the drop that occurs during during the final thirty minutes to calculate the percolation rate.

6. Percolation tests for seepage pits are made in the same way except that each contrasting layer of soil needs to be tested. Use a weighted average of the results in figuring the size pit you need.

lations governing the permissible ranges for percolation rates according to the types of effluent—whether from septic tank installations or aerobic system effluents, for example.

In wastewater investigations the rate of movement of water in the soil is normally inferred from a percolation test, which is a measure of both infiltration and permeability. (Recent studies by soil scientists and sanitary engineers suggest that estimates of percolation can also be obtained from the study of soil morphology and soil profile characteristics. [6] This method will be described shortly in the section on the use of soil surveys.)

Percolation tests help determine the absorption capacity of the soil and the size of the absorption field. Most local regulations require that trained personnel, generally from local health departments, do the testing.

Inaccuracies in percolation tests have been documented, and are usually related to how tests are done and the time of year tests are conducted, that is, whether the soil is wet or dry. Results are reliable only if the soil moisture is at or near field capacity when the test is made. Excessive percolation rates are obtained when there are small cracks or crevices in the soil because of insufficient moisture. False rates are also obtained when percolation tests are made in naturally wet soils which are dry during periods of low rainfall and are not thoroughly moistened before testing. A generally accepted percolation test procedure is given in the box on page 16.

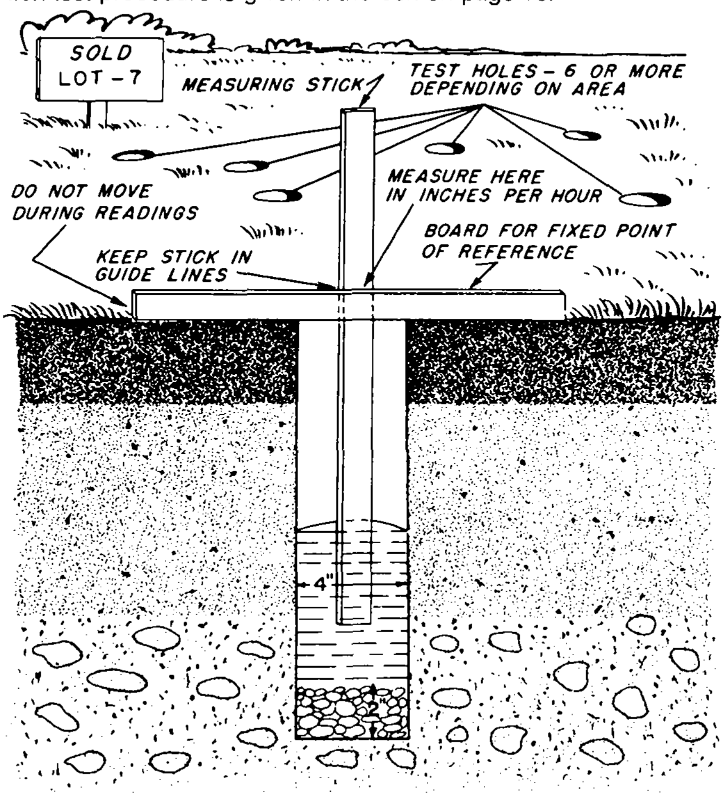


Fig. 3. Percolation test hole with other test holes properly distributed over the field in the background. A measuring stick is shown in the test hole in the foreground.
Courtesy USDA, Soil Conservation Service.

Percolation data do not represent just the vertical movement of water through soils, but are complicated by lateral transmissions. The relationship between permeability and percolation, as well as the general classes into which they fall, was illusrtated by Foth and Turk: [7]

		Classes	Permeability *(inches per hour)*	Percolation *(minutes per inch)*
Slow:	1.	Very Slow	less than 0.05	greater than 1200
	2.	Slow	0.05-0.20	300-1200
Moderate:	3.	Moderately Slow	0.20-0.80	75-300
	4.	Moderate	0.80-2.50	24-75
	5.	Moderately Rapid	2.50-5.00	12-24
Rapid:	6.	Rapid	5.00-10.00	6-12
	7.	Very Rapid	more than 10.00	less than 6

Depth and Nature of the Underlying Parent Material. The nature of the substratum immediately under the soil profile may exert stresses on the capability of the soil to adequately serve as a treatment medium for the conversion of wastewaters to clean water. Dense substrata, either of clay materials or of such rock types as shale, argillite, or cemented sandstones, prevent or limit vertical movements of fluids. Highly fractured substrata underlying shallow soil profiles may promote such rapid water movements as to foster contamination of ground water.

The influences of the substrata on water movements within the soil profile are functions of the thickness of the profile, as well as the nature of the substrata. The thicker the soil mantle, the less the influence of the substrata on the capability of the soil to process wastewater. This relationship has resulted in many states creating suitability classifications based on the depth to and nature of the substratum.

The Use of Soils in Wastewater Systems

General Principles for Applying Wastewater to Soil Absorption Systems

The following principles apply to both surface (spray irrigation, for example) and subsurface absorption systems:

(1) *Wastewater should not be applied in amounts which exceed the water-holding capacity of the soil.* This will keep the soil pores from filling with water to the exclusion of air, and it will permit the biological and chemical renovating processes including aeration, filtration and stabilization, to proceed normally. It will mean that plants can grow well and take up contaminating elements such as nitrogen and phosphorus. (Phosphates applied in excess of plant needs will have a better chance of being held on the surfaces of clay particles.) It will also prevent the leaching to ground water of nitrates not used up during the growing season. In addition, this precaution will minimize runoff or overland flow that might reach wells, streams or other bodies of open water.

(2) *The rate of application of nutrients contained in wastewaters should not exceed plant growth requirements.* This will help to prevent the contamination of ground water. The plants (which contain the converted nutrients) should then be removed by cropping, and the residues (e.g., corn stalks) should also be removed rather than plowed back or in any way recycled to the soil. Otherwise plant material will accumulate to dangerous levels in soils, and the nutrients can be leached by rains and carried to ground water.

The Use of Soil Surveys in Planning Systems

The soil survey of a county or other area includes descriptions of soils, interpretations for soil use, and maps showing the location and extent of each kind of soil.

They are made by the Soil Conservation Service in cooperation with state agricultural experiment stations and other federal and state agencies. Local or county offices of the Extension Service or of the Soil Conservation Service, the soil conservation district, or the state agricultural experiment station can furnish information about the availability of soil survey materials.

The survey points out the limitations of various soils and the hazards in using them for different purposes. Soil surveys published in recent years give interpretations and other information useful in planning nonfarm soil uses, including septic tank sewage and lagoon disposal systems. Older surveys give interpretations only for farm uses, but the soil descriptions contain basic information from which interpretations for nonfarm uses can be made. Anyone needing such interpretations usually can get help from the local conservation district or the extension service.

The Use of Soil Maps. Soil maps can substitute for percolation tests, according to Morris, Newbury and Bartelli. [6] They have offered several advantages of using soil maps in determining the suitability of building sites for soil absorption sewage disposal systems:

—Interpretations of the soil mapping unit will indicate whether or not the soil at a particular site is subject to an intermittent high water table. This will avoid the criticism of variability of the percolation test rates, resulting from the tests being conducted during different seasons of the year.

—The suitability of a site can be based on the performance of the soil at five (or probably more) other site locations instead of merely the six test holes on one site. By this method, the confidence limits would be greatly improved, from 30 to 95 per cent.

—The use of soil maps will permit the determination of site suitability for the correlated soil types regardless of the time of the year at which the request for determination is made.

A typical soil map is shown in Figure 4.

The soil map is reliable for predicting general soil capabilities for an area of several acres. However, it may not contain enough detail to predict the limitations for a specific disposal site, because different kinds of soil can occur within short distances. The maps are likely to be least reliable in the vicinity of a soil boundary (see Figure 5). On-site evaluation by a soil scientist is usually necessary. In most cases he will use the percolation test.

Soil Factors that Affect Subsurface Absorption Fields

The Rating of Soils for Subsurface Absorption. As previously described, the Soil Conservation Service rates soils in terms of their limitations for various uses, including

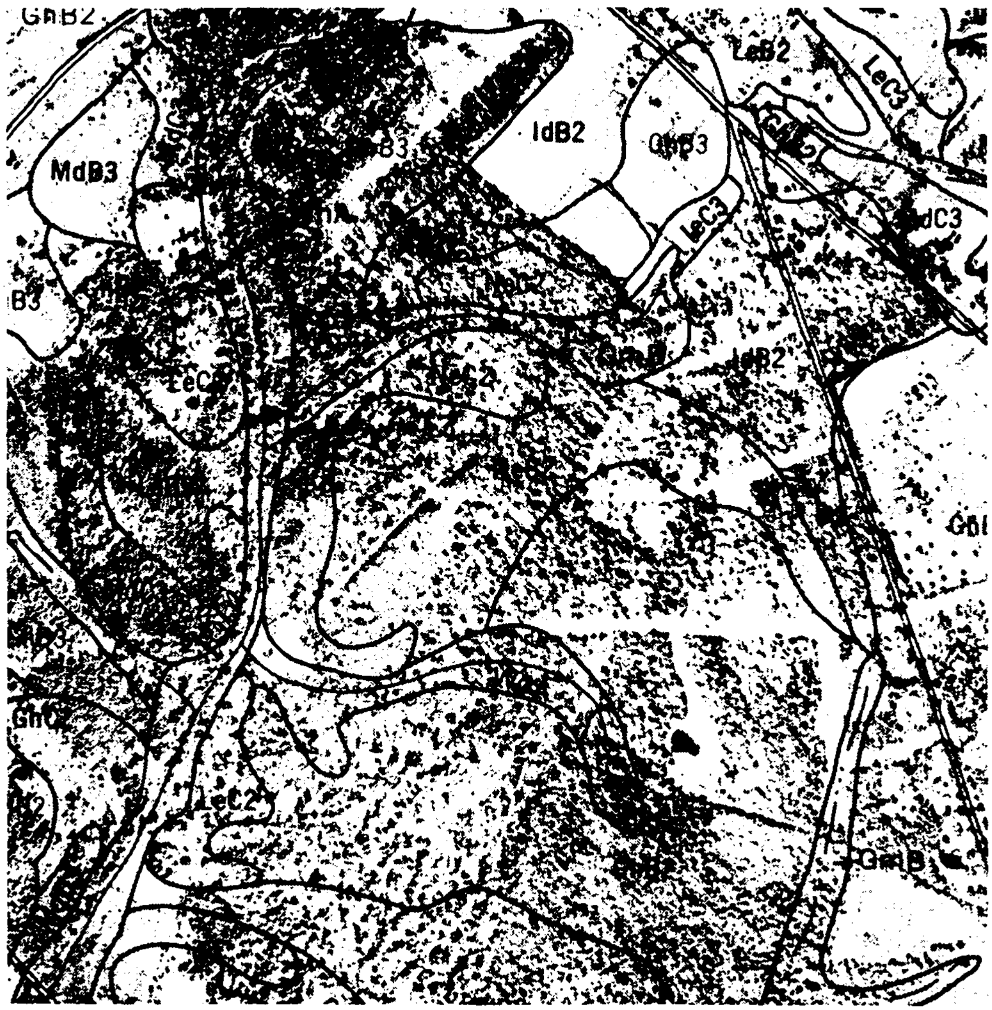


Fig. 4. Soil Map, Montgomery County, Md.
Courtesy USDA, Soil Conservation Service.

The symbols indicate the different soils and the solid lines show the extent of each. WhA is a flood-plain soil. WoA, a wet soil in upland drainage-ways. Water from higher surrounding areas runs off and concentrates in the natural drainage courses, resulting in frequent flooding. IdB2 has a dense layer of clay that is very slowly permeable to water and a high shrink-swell potential. LeB2, LeB3, LeC2, and LeC3 are shallow to rock and some have lost all original surface soil. Soil and water conservation practices to control erosion and reduce runoff are needed on all the steeper slopes, shown by C and D in the map symbol. They also require more excavation for construction and great care in installing filter fields for the effluent from septic tanks. The severely eroded areas, shown by a 3 in the map symbol, may need top-soil for good lawns and gardens.

wastewater disposal. The classifications used in rating soil limitations are defined as follows: [3]

Slight means that the soil properties are generally favorable and that the limitations are minor and easily overcome.

Moderate means that the soil properties are unfavorable but can be overcome or modified by special planning and design.

Severe means the soil properties are so unfavorable and so difficult to correct that they would require major soil reclamation and special designs. This may be costly and make it impractical to install the system.

Fig. 5. Soil map of an area in the Piedmont region. A hypothetical building lot is outlined in the upper part of the map and enlarged below. Note from detail of insert that soil boundaries shown on map may be imprecise. Courtesy USDA, Soil Conservation Service.

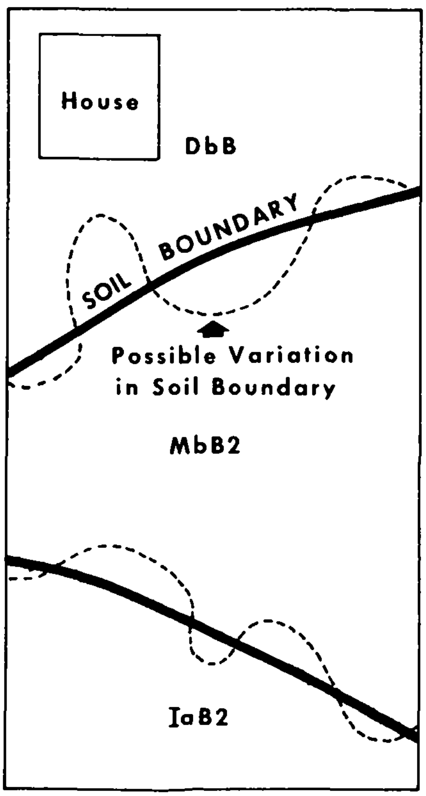


Table 1 is a guide for rating soils for septic tank absorption fields.

The soil limitation ratings are not quantitative—they are indications of the kind of problem and the magnitude of difficulty that may be encountered in the design of an effective wastewater treatment and disposal system. As soil mapping units are not always homogeneous, the limitation classification is a good guide to areas in which more detailed investigations may be needed.

While nearly all limitations can be overcome with sufficient investment, some limitations should be considered as detriments of such magnitude as to constitute areas in which subsurface disposal should not be attempted. The limitations of flood plain location and depressional topography are two examples. The limitations of high water table or steepness of slope are severe limitations, but may be overcome by implementation of soil engineering.

Selecting a Site for a Septic Tank Absorption Field. [3, 4] Soils vary so much from place to place that it is not possible to give specific guidelines on the use of soils as absorption fields that will fit all localities. In general, how well a septic tank sewage disposal system works depends on the rate at which effluent moves into the soil (infiltration) and through the soil (percolation). Several other soil characteristics may

Table 1. Soil Limitation Ratings for Septic Tank Absorption Fields.

Item affecting use	Degree of soil limitation		
	Slight	Moderate	Severe
Permeability class*	Rapid,† moderately rapid, and upper end of moderate	Lower end of moderate	Moderately slow‡ and slow
Hydraulic conductivity rate (Uhland core method)	More than 1 in./hr.†	1-0.6 in./hr.	Less than 0.6 in./hr.
Percolation rate (Auger hole method)	Faster than 45 min./in.†	45-60 min./in.	Slower than 60 min./in.
Depth to water table	More than 72 in.	48-72 in.	Less than 48 in.
Flooding	None	Rare	Occasional or frequent
Slope	0-8%	8-15%	More than 15%
Depth to hard rock,§ bedrock, or other impervious materials	More than 72 in.	48-72 in.	Less than 48 in.

*Class limits are the same as those suggested by the Work-Planning Conference of the National Cooperative Soil Survey. The limitation ratings should be related to the permeability of soil layers at and below depth of the tile line.

†Indicate by footnote where pollution is a hazard to water supplies.

‡In arid or semiarid areas, soils with moderately slow permeability may have a limitation rating of *moderate*.

§Based on the assumption that tile is at a depth of 2 feet.

Source: *Guide for Interpreting Engineering Uses of Soils*, USDA, Soil Conservation Service, Nov. 1971, p. 23.

also affect performance: soil permeability, groundwater level, soil depth, underlying material, slope, and proximity to streams or lakes. [4, 5]

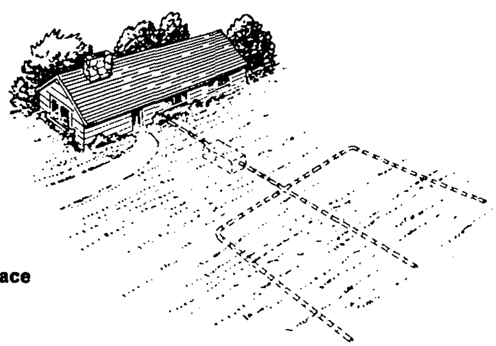
The following *guidelines* should be kept in mind both for the protection of individual and public health and for convenience in selecting the site for the wastewater absorption field:

—Soil permeability should be moderate to rapid, and the soil percolation rate should generally be sixty minutes per inch or less, unless special engineering precautions will be taken.

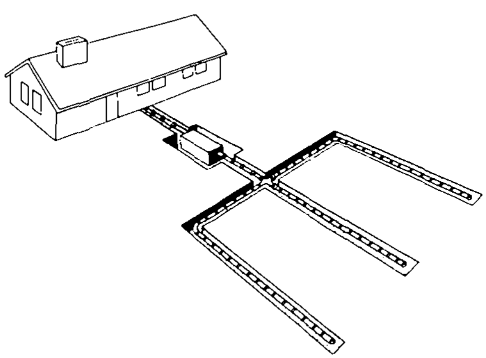
—The ground water level during the wettest season should be at least four feet below the bottom of the trenches in a subsurface tile absorption field and four feet below the pit floor in a field using seepage pits.

—Rock formations or other impervious layers should be more than four feet below the bottom of trenches, seepage bed floor, mounds or pit floor.

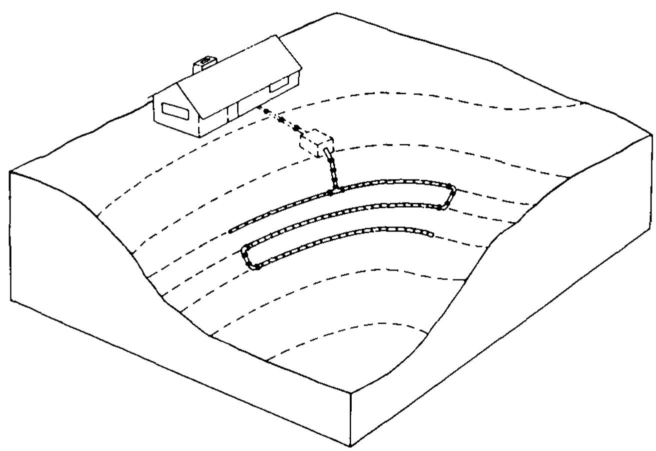
—Trenches and seepage beds are difficult to lay out and construct on slopes steeper than 15 per cent. If steep, shallow soils that are underlain by rock or other impervious material are used as absorption fields, the septic tank effluent is likely to seep to the surface.



Typical layout of septic tank and subsurface soil absorption system.



Serial distribution recommended for a soil absorption system located along the contours of a steep slope.



—The site for an absorption field should not be within fifty feet of a stream or other water body.

—A sewage disposal system should never be installed in an area subject to flooding (flood plain).

—An area in which different kinds of soil are present within short distances may not be suitable for installation of a conventional absorption field if the soils differ greatly in their absorption capacity. In such an area, a detailed inspection should be made of the site.

In addition, the designer should conform to all local health regulations. Because they vary greatly, he should become familiar with permit and inspection requirements and the penalties that may be imposed for violations.

Advice and planning assistance may be obtained from the city or county planning commission, local health department, Soil Conservation Service, extension specialist, engineering or agricultural department of colleges and universities, and the state board of health or environmental health department.

Why Subsurface Absorption Fields Fail. Inspections by sanitary engineers have shown that sewage absorption fields often fail to work properly because: (1) soils are either poorly drained or are so compact that the absorption rate is very slow, or (2) sewage has clogged the pores and reduced the absorption capacity. [3, 5, 6]

Poorly drained soils are saturated with water during wet weather and contain no space for septic tank effluent. Absorption fields in such soils may function well in dry weather and fail to function in wet weather. If a soil has a very slow absorption rate, the effluent may rise to the surface in dry weather, and in wet weather the situation is even worse.

Absorption fields also fail if the land is too steep; if there is a seasonal high water table, a shallow layer of soil over bedrock, or a cemented layer of soil just below the trench bottom; or if the area is flooded periodically.

A septic tank system should function well for many years if it is properly installed and maintained and if the soil in the disposal area is satisfactory. If the soil is not satisfactory, the sewage disposal system will not work properly, regardless of how well it was constructed and installed.

The Role of Evapotranspiration in Soil Absorption Systems

Evapotranspiration is a collective term for the processes by which water moves from the soil to the atmosphere. When conditions are favorable, part of the liquid applied to the soil may be dissipated by evapotranspiration, thus relieving the stress on the soil as the sole means of disposal. Evapotranspiration consists of evaporation, the loss of water vapor from land or water body surfaces to the air, and transpiration, the net movement of soil water through plants to the air. Evapotranspiration is also known as transvap and consumptive use, as well as by its abbreviation, ET.

In order for water to be transpired, it must first enter a plant. Thus, soil moisture which is below the root zone is unavailable for transpiration. As water is evaporated from the land surface, more water moves upward through the soil and against gravity to take its place. The process is capillary action, akin to the working of a wick. The capillary movement depends on the texture and structure of the soil—narrow pores result in greater capillary forces, but the water cannot move easily (permeate) unless there is reasonable continuity between pores. Clays have small pores, but many clays are more impermeable than others because of their structure. Sands are usually highly permeable, but the large pores develop lower capillary forces, and the water may not be sucked upward as well as in tighter soils. A sandy loam or loam might be expected to have the optimum combination of pore size and structure to promote capillary movement.

Measurement and Estimates of Evapotranspiration

Evaporation is normally measured at meteorological stations with big cylinders about the size of a child's wading pool. These are called pans, and the standard pan in the U.S. is called a Class A pan. The upper limit of evapotranspiration, or potential evapotranspiration, is about 70 to 80 per cent of Class A pan evapotranspiration. Potential evapotranspiration may be attained during the growing season when the soil is well-moistened (at field capacity).

Potential transpiration is also assumed by some authorities to be equal to lake evaporation which, as it happens, turns out to be between 70 and 80 per cent of Class A pan evaporation. Thus, no matter which data are used, the estimated values of potential evapotranspiration should work out to be fairly close to each other. Figure 6 shows contours of equal average annual lake evaporation for the forty-eight contiguous states.

Evaporation and evapotranspiration are greatest during the period May through October, which is also the growing season. In the northern forty-eight contiguous states around 80 per cent of evaporation occurs during May-October, while in the South about 60 to 70 per cent occurs during May-October. [8] Evapotranspiration can be counted on as more of a year-round process in the South than in the North.

Engineering Design with Evapotranspiration

In figuring how much of the liquid volume applied to the soil can be disposed by evapotranspiration, the amount of rainfall which enters the soil must be subtracted from potential evapotranspiration. Proper grading and drainways can minimize the amount of precipitation which is absorbed by maximizing runoff from the area of the soil absorption system, but conservative engineering practice assumes that evapotranspiration minus precipitation on a month-by-month basis is a reasonable estimate of the assist that evapotranspiration can provide. Table 2 shows how to estimate the assist that may be expected from evapotranspiration in Roanoke, Virginia, and in Albuquerque, New Mexico. These examples demonstrate that evapotranspiration can be expected to provide a reasonable assist in parts of the Southwest, but it should not be counted on too greatly in Appalachia.

Bernhart has been able to make considerable use of evapotranspiration. His studies in Ontario indicate that evapotranspiration can be helpful all year round with proper grading, vegetative cover, and the maintenance of aerobic conditions in the absorption bed. (See Appendix A.)

Soil Factors That Affect Sewage Lagoons

A sewage lagoon (aerobic) is a shallow lake used to hold sewage for the time required for bacterial decomposition. Sewage lagoons require consideration of the soils for two

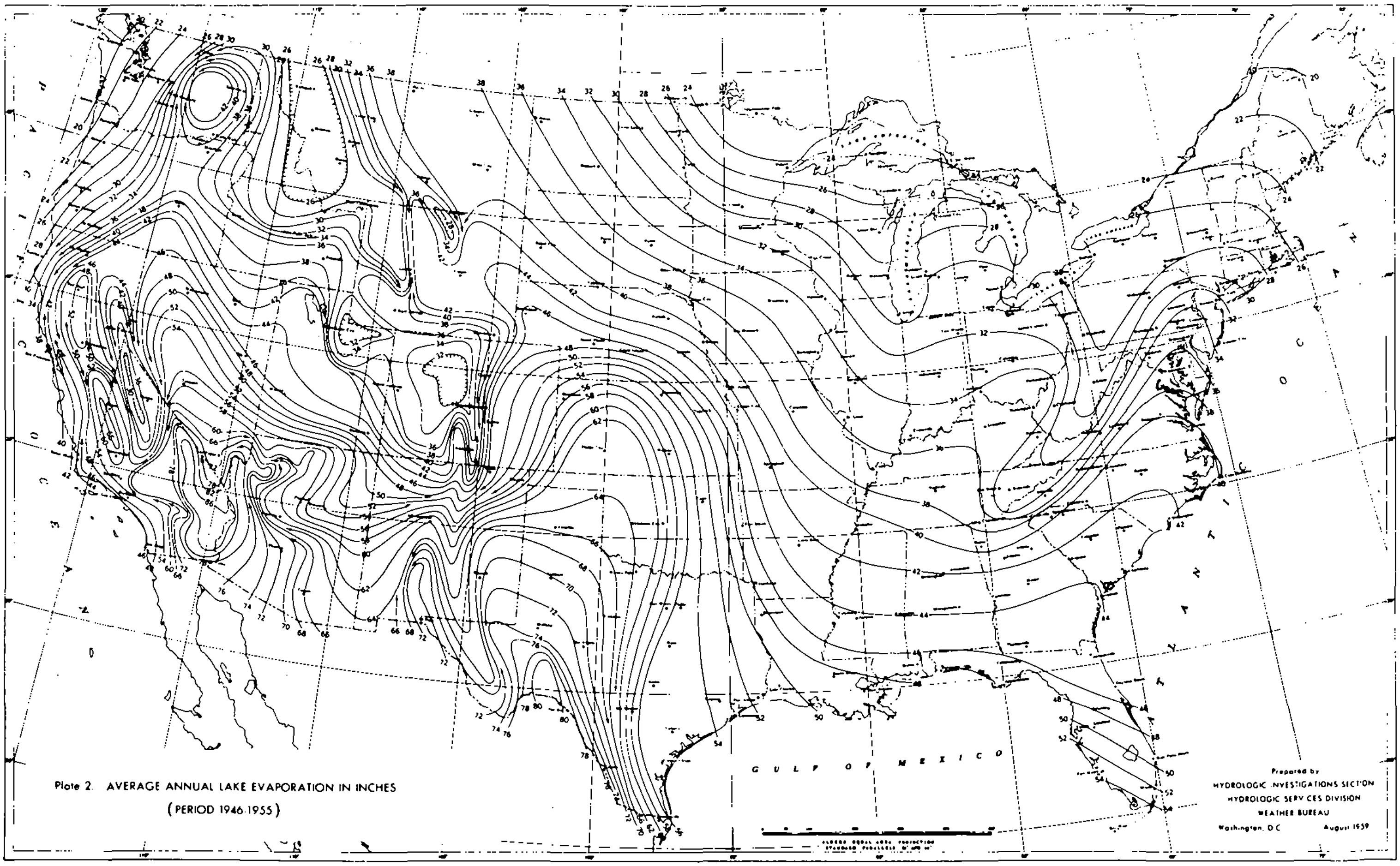


Fig. 6. Average annual lake evaporation for the forty-eight contiguous states. Courtesy National Weather Service, Wash., D.C.

functions: as a vessel for the impounded area and as soil material for the enclosing embankment. Enough soil material suitable for the structure must be available, and when the lagoon is constructed, it must be capable of holding water with minimum seepage. The material should be free of coarse fragments (over ten inches in diameter) that interfere with compaction.

Basin Floor. Soil requirements for basin floors of lagoons are: (1) slow rate of seepage, (2) even surface of low gradient and low relief, and (3) little or no organic matter. Official specifications for lagoons state that the depth of liquid should be not less than two feet and generally not more than five feet, that the floor should be level or nearly so, and

Table 2. How to Estimate Assist From Evapotranspiration.

	Lake Evaporation (A)	Precipitation (B)	A Minus B = Net Evapotranspiration
Roanoke, Virginia			
JAN	0.95	3.12	NIL
FEB	1.39	2.86	NIL
MAR	2.55	3.53	NIL
APR	3.55	3.10	0.45
MAY	4.42	3.79	0.63
JUN	5.10	3.80	1.30
JUL	5.19	4.25	0.94
AUG	3.39	4.63	NIL
SEP	3.36	3.26	0.10
OCT	2.50	3.21	NIL
NOV	1.23	2.70	NIL
DEC	0.84	2.98	NIL
Albuquerque, New Mexico			
JAN	1.76	0.41	1.35
FEB	2.39	0.38	2.01
MAR	4.09	0.48	3.61
APR	6.11	0.47	5.64
MAY	7.81	0.75	7.06
JUN	9.17	0.57	8.60
JUL	8.58	1.20	7.38
AUG	7.42	1.33	6.09
SEP	6.36	0.95	5.41
OCT	4.30	0.75	3.55
NOV	2.38	0.38	2.00
DEC	1.64	0.46	1.18

Source: Data from *Final Report, Research Study on Sewage Disposal Through Evapotranspiration of Plants*, prepared for National Association of Home Builders Research Foundation, Inc. by Engineering-Science, Inc., 1971, Chapter III and Appendix A.

that the materials for the basin floor should be so nearly impervious as to preclude excessive loss of liquid. [9] The relatively impervious soil material should be at least four feet thick. This is especially important where the local water supply comes from shallow wells that may become contaminated.

Slope. Slope must be low enough and soil material thick enough over bedrock to make smoothing for uniformity of lagoon depth practical. Greater slope is allowable if soil material is more than six feet deep, but generally smoothing is impractical where slope is more than 7 per cent. If the soil is nearly level and therefore requires little or no smoothing, it need not be more than four to six feet deep.

Flooding. Floodwaters must not overtop embankments because they interfere with functioning of the lagoons and carry away polluting sewage before sufficient decomposition has taken place. Ordinarily, therefore, places susceptible to flooding should not be used for sewage lagoons. If, however, floodwaters are slow-flowing and rarely (if ever) more than about five feet deep—not deep enough to overtop lagoon embankments—flooding will not be a problem.

Depth to Water Table. Depth to water table can be disregarded if the lagoon floor consists of soil material at least two feet thick that is impermeable or nearly so; but if the material is permeable, even if no more than slowly permeable, depth to water table is critical. Unfiltered wastewater should not be allowed to contact ground water. It is best if the water table is below a depth of sixty inches at all times. If the water table seasonally rises to depths between forty and sixty inches, a hazard exists. If it rises to a depth less than forty inches for an extended period, a serious hazard exists.

Other Soil Properties. Soils containing moderate to high amounts of organic matter are unsuitable for the basin floor even if the floor is underlain by suitable soil material. The organic matter promotes growth of aquatic plants, and they are detrimental to proper functioning of the lagoon.

Soils that contain fragments more than ten inches in diameter are undesirable as sites for sewage lagoons because such fragments interfere with the manipulation and compaction needed to prepare the basin floor.

The Rating of Soils for Use as Lagoon Sites

The guide used by the Soil Conservation Service to rate soils for sewage lagoons is shown in Table 3.

Table 3. Soil Limitation Ratings for Sewage Lagoons.

Item affecting use	Degree of soil limitation		
	Slight	Moderate	Severe
Depth to water table (seasonal or year-round)	More than 60 in.	40-60 in.*	Less than* 40 in.
Permeability	Less than 0.6 in./hr.	0.6-2.0 in./hr.	More than 2.0 in./hr.
Depth to bedrock	More than 60 in.	40-60 in.	Less than 40 in.
Slope	Less than 2%	2-7%	More than 7%
Coarse fragments, less than 10 inches in diameter; percent, by volume	Less than 20%	20-50%	More than 50%
Percent of surface area covered by coarse fragments more than 10 inches in diameter	Less than 3%	3-15%	More than 15%
Organic matter	Less than 2%	2-15%	More than 15%
Flooding †	None	None	Soils subject to flooding
Soil groups (Unified) ‡ (rated for use mainly as floor of sewage)	GC, SC, CL, and CH	GM, ML, SM, and MH	GP, GW, SW, SP, OL, OH, and PT

*If the floor of the lagoon is nearly impermeable material at least two feet thick, disregard depth to watertable.

†Disregard flooding if it is not likely to enter or damage the lagoon. (Low velocity and the depth less than about five feet.)

‡Unified soil classification system is used mainly for engineering practices.

Source: *Guide for Interpreting Engineering Uses of Soil*, USDA, Soil Conservation Service, Nov. 1971, p. 27.

Chapter Three

Traditional Approaches to Wastewater Systems Design

General Planning and Design Criteria

Functions of Sewage Works

Sewage, or wastewater, is defined as just about anything that goes down the drain—excreta, washwater, ground garbage, and so forth. The structures and equipment which handle and treat sewage are collectively called sewerage or sewage works. Sewers are the conduits that convey sewage to treatment plants. The functions of a sewage works include:

Collection of sewage from the house,

Conveyance of sewage to the treatment site;

Treatment of sewage;

Disinfection of treated effluent; and

Disposal of effluent.

This chapter is concerned with general guidelines for planning and designing systems or important parts of systems for treating wastewater in rural areas. The state-of-the-art for performing these functions is surveyed in Appendix C where representative equipment is shown and described.

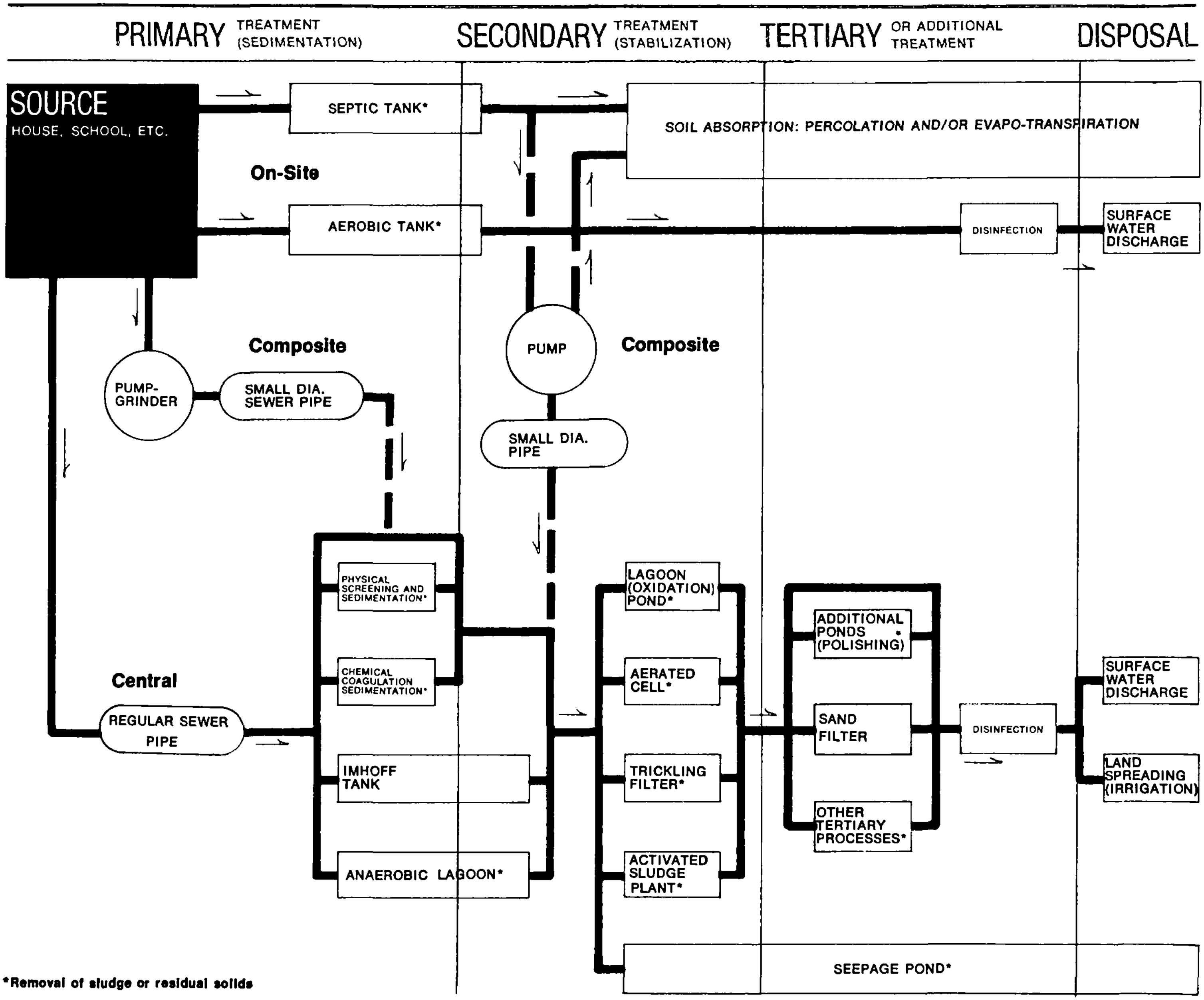
The five functions of sewage systems are not always performed in discrete or obvious steps. A properly functioning soil absorption system, for example, provides treatment, removal of infectious agents, and disposal of effluent in a manner that will not endanger the general environment or individual health. The general design criteria in this chapter are, however, organized on a functional basis.

Figure 7 illustrates sewage treatment processes that are generally available to rural communities. They are organized according to three basic approaches: on-site treatment, centralized treatment, and a composite of the two; as well as the extent of treatment—primary, secondary, and tertiary.

Collection and Conveyance of Wastewater

Protection within the house. Wastes from toilets, sinks, baths, and household drains are conveyed through waste lines in the house plumbing to the house sewer. Local,

Fig. 7. Sewage treatment processes generally available to rural communities.



*Removal of sludge or residual solids

state and national plumbing codes provide elaborate specifications of designs, materials and critical dimensions involved in connecting water-using fixtures and appliances to the house plumbing. These codes guard against backflow of wastewater and of gases from decomposing wastes to the fixtures, appliances, or drains and prevent cross-connections (by siphoning or leakage through open joints, for example) between water supply lines and waste lines. The codes should be followed. In some cases, there may be valid reasons for attempting to obtain changes to or variances from local codes (to substitute plastic pipe for pipes made of other traditional materials, for instance).

Once in the receptacles and lines, wastes should not be accessible to the house side of the system. Water traps (the U- or J-shaped waste pipes under sinks and built into toilets) act as barriers between the house and the waste lines. Air gaps in lines and vent pipes protect against back-siphoning of wastes. The vent pipes also provide an alternate means of escape for sewer gases other than into the house. A check valve may be placed in the house sewer to prevent back-up of sewage into the house, but check valves are not commonly found unless specified by code.

Beyond the house. Whether the house sewer leads to a septic tank tens of yards away or through a sewer network to a plant many miles away, the capacity of a wastewater conveyance system depends upon the hydraulic head designed into it (either by pitch relative to gravity or by pressure from a pump) and the effective cross-sectional area of the conduit. This area can be reduced by the accumulation of scale, greases, grit and solid debris, and the system should be designed so that the wastewater will attain a self-cleaning, or scouring, velocity—enough speed of flow to keep settleable solids in suspension. The scouring velocity should be attained with sufficient frequency and duration to prevent solids' build-up.

On the assumption that with time solids will build up despite the best design and installation practices, access must be provided for cleanout of sewers. Access, grade requirements, i.e., slope of sewer pipe and other specifications, are normally contained in state or local codes.

Joints should be watertight, and open legs of *T*- or *Y*-connections should be closed off to prevent tree roots from growing through cracks or openings in pursuit of water and to prevent liquids from escaping. In appreciable quantities, escaping liquids can erode the soil and bedding material from around pipes and cause cave-ins. The pipe would then be less able to sustain loads and more subject to breakage. Moreover, stripped of its insulating soil, the pipes would be subjected to damage from freezing. Escaping sewage can also contaminate ground water.

Pipe should be laid at sufficient depth and with proper bedding to protect it from overhead traffic loads, vibrations, frost heaves and other movement of the soil.

The obvious must not be overlooked: the entire sewer system must be mapped in detail, including the locations and types of joints, cleanouts, and manholes. This will permit the location of faulty sections and the avoidance of sewer lines during excavation for other structures.

Means for venting or otherwise preventing the buildup of explosive sewer gases, such as open manholes, should be designed into the system.

A positive means of signalling failure of all mechanical devices upon which flow depends, such as grinders and pumps at the house and lift stations along the line, should be provided. Lift stations raise the level of sewage when further increases in depths of gravity sewer lines become impractical or when the sewage must be carried over a hill.

If the sewer carries only wastewater, it is called a sanitary sewer. If it carries only runoff from natural sources such as precipitation it is a storm sewer. Sewers which carry sanitary wastes and runoff in the same conduit are called combined sewers. Combined sewers are much more expensive to build (extra size for peak overloads) and to maintain than sanitary sewers. In many sewered areas, runoff is handled by a system of drainage ditches. It is important that storm runoff or flood waters not get into sanitary sewers for reasons of sanitation and to prevent overloading of the sewers and the treatment works.

Seepage of water from saturated soil into sewers is very hard to prevent. Where there is infiltration into the sewer, the opportunity for sewage to seep out also exists. Therefore, sewers should not be run below the water table if possible, and they should be designed to minimize contamination of groundwaters in the event of seepage.

Sewers should also be designed to keep out rodents and insects, both of which act as disease vectors. Because it is virtually impossible to deny these animals entry into storm or combined sewers, they should therefore be designed to make exit difficult. Sewer inlets should also minimize the danger of entry by small children or pets.

Treatment

Treatment works should be built with sufficient integrity and surge capacity to accept all incoming loads without permitting inadequately treated effluent to escape to the environment. This includes related practices of rodent and insect control and denial of access to farm animals or to the general public (by fences, for example).

Treatment works, whether on-site or central systems, should not be built on land which is subject to flooding. The land should be graded to promote runoff and to divert it away from the treatment works. The soil upon or into which the treatment works are built should be strong enough to support the heavy loads of concentrated volumes of water. The soil should either be adequately sealed or of sufficient thickness to prevent seeping or spilled sewage from reaching ground water.

For central plants, an all-weather road access should be provided not only for repair vehicles, but for vehicles which remove accumulated solids and sludge. This calls for roads which can support heavy machinery. If the plant is designed to receive the contents of septic tank pumping trucks, adequate washdown and grading for drainage should be installed. Sufficient space for the flow of truck traffic should be provided to minimize both delays and accidents.

Many central plants in rural areas will be scaled down versions of municipal plants. They will have been sold as a "package" of standard components (tanks, pumps, blowers, etc.). It is unlikely that there will be a full time operator. At a minimum, the plant should be provided with failure alarms and a protected place for operating and maintenance logs. The alarms should be capable of working in the event of power loss, since plants are often knocked out by lightning overloads, or downed power lines. The operating and maintenance logs should contain schedules and spaces for recording the results of routine tests, inspections, process adjustments, and service procedures as well as spaces to record all failures, repairs and emergency corrective procedures. The log should be checked regularly by the administrative officers of the operating company as it can both indicate level of performance of the system and warn of impending failures and needs for equipment overhaul or replacement.

Either backup power should be provided (combustion engine generators, for example), or there should be a holding tank or basin capable of detaining sewage flow in the event of prolonged power failure. The tank or basin should be capable of detaining the sewage for a time exceeding the anticipated period of failure. Such provisions could be coordinated with the design of excess or surge capacity to effect overall savings in plant costs. Power failures should not result in the discharge of untreated sewage, and this holds for on-site as well as central systems.

Disinfection

Disinfection is a part of the overall treatment process. It is often mentioned separately because it is an add-on process to most plants. As Appendix C points out, disinfection as currently practiced is an iffy procedure. The disinfection apparatus in a small plant rarely works as well as anybody—designer, operator, or user—expects, even when it appears to be operating properly. Disinfection for small systems is a process which could benefit greatly from improved design and development.

At a minimum, dispensers of disinfecting chemicals or germicidal lights should be outfitted with alarms and flow shutdown capabilities when they run out of their chemical charge or otherwise malfunction. If properly sized and serviced (this can be checked in the log), they should not run out of chemicals. Even when the chemicals are in abundant supply, however, tests must be made regularly to ensure that they are being suplied in sufficient concentrations to satisfy the demands of the effluent.

Disposal

When the treated effluent is disposed to the environment it should be sufficiently converted, disinfected and diluted so that it will not endanger human health or degrade environmental quality beyond acceptable limits. It is the role of state standards to define the point beyond which a discharge can be presumed unacceptable.

Effluent disposal is achieved by evaporation, by percolation through soil and by discharge to watercourses. Effluent should not leave the treatment plant or region of the drainage field in a septic state. Likewise, septic effluent should not be applied to the surface of the ground. (A later section discusses surface spreading of effluents.)

As with the treatment works, the disposal area should not be subject to flooding. Land disposal areas should be at least several feet above seasonally-high ground-water levels. Disposal areas should also be down-gradient from water supply wells or downstream from surface supply points.

The problem of sludge disposal should also be anticipated in the design of the system. Sewage sludge or solids may be disposed in landfills or composted. They should never be spread on the land without receiving a protective cover of earth. Land disposal areas should be operated in conformance with sanitary landfill standards. Where sanitary disposal is not feasible, combustion or trucking to municipal or regional plants should be explored.

Self-Contained Systems

There are several systems which are fairly well contained in a single piece of equipment. For example, an incinerator toilet (described in Appendix C) will collect excreta, convey it to the combustion chamber, and treat and disinfect the waste by burning. Because the unit disposes of liquid and volatile contents to the atmosphere (which could lead to other problems), only an ash of small volume is left for disposal by the homeowner.

The pit privy is another example of a self-contained system. When the pit is nearly full, the privy can be moved to a new location and the pit covered with topsoil.

Basis for Estimating System Size

All methods of designing a system for treating and disposing of domestic sewage use a common approach. The designer compares the amounts and constituents of sewage (influent) to the amounts and constituents of effluent that can be discharged according to law or other design specifications. The comparison indicates how much of each constituent must be removed from the sewage by the treatment process. With a knowledge of the quantity to be treated and the required treatment efficiency, the designer should, in principle, be able to find in catalogues the unit that comes closest to meeting his needs. This is certainly the approach that can be taken in a preliminary engineering design/feasibility study.

In order to be able to make the straightforward computations referred to above, several estimates of important parameters must be known. This section provides information needed to make these estimates.

Influent Characteristics. *Volume*. Volume generation estimates range from 30 gallons per capita per day (GPCD) to about 100 GPCD. The amount is dependent to some extent on the standard of living of the people involved. For example, higher incomes permit the purchase of water-using appliances such as dishwashers and clothes washers. If sewage production by a house were metered as is water use, it would often be found that water consumption exceeds sewage production. This is because water used for such purposes as lawn watering and car washing is not discharged as sewage.

Convenient aids for estimating sewage flows are included in the Public Health Service's *Manual of Septic Tank Practice*. They are reproduced in Tables 4, 5, and 6.

Note that, according to Table 4, per capita consumption rises as more waste generating devices are put into use. This table can be used to work backwards to estimate flow per fixture. For example, toilets can be estimated as generating 15 to 30 GPCD, and the collection of showers, washbasins, etc., another 15 to 30 GPCD. A home with one bathroom unit and a kitchen sink would probably account for only 40 to 50 GPCD.

Tables 7, 8, and 9 show estimated quantities of sewage flows for a variety of establishments. The tables were compiled by different sources and are included to illustrate that

Table 4. Estimated Distribution of Sewage Flows. (Gallons per day per person)

Type of Waste	Volume				
Kitchen wastes	*0	7	10	10	15
Toilet wastes	15	15	20	25	30
Showers, washbasins, etc.	15	18	20	25	35
Laundry wastes	*0	*0	*0	15	20
Total Flow (gallons)	30	40	50	75	100

*No wastes from these uses.

Table 5. Sewage Flow from Country Clubs. (Gallons per day per fixture)

Type of Fixture	Volume
Showers	500
Baths	300
Lavatories	100
Toilet	150
Urinals	100
Sinks	50

Table 6. Sewage Flow at Public Parks. (Gallons per day per fixture)

Type of Fixture	Volume
Flush toilets	36
Urinals	10
Showers	100
Faucets	15

Source: *Manual of Septic-Tank Practice*, DHEW Pub. No. (HSM) 72-10020 (Formerly PHS Pub. No. 526), Rev. 1967, pp. 44-45.

the sewage flows shown are indeed estimates and therefore do not always agree from table to table. The designer will have to exercise judgment. Local public health or environmental control authorities should be consulted in order to determine if there are mandatory design criteria for the specific location of the planned installation; these criteria, of course, prevail over any estimates presented here.

Table 7. Quantities of Sewage Flows.
(Gallons per person per day — unless otherwise noted)

Type of Establishment	Quantity
Airports (per passenger)	5
Apartments — multiple family (per resident)	60
Bathhouses and swimming pools	10
Camps:	
Campground with central comfort stations	35
With flush toilets, no showers	25
Construction camps (semi-permanent)	50
Day camps (no meals served)	15
Resort camps (night and day) with limited plumbing	50
Luxury camps	100
Cottages and small dwellings with seasonal occupancy	50
Country clubs (per resident member)	100
Country clubs (per non-resident member present)	25
Dwellings:	
Boarding houses	50
additional for non-resident boarders	10
Luxury residences and estates	150
Multiple family dwellings (apartments)	60
Rooming houses	40
Single family dwellings	75
Factories (gallons per person, per shift, exclusive of industrial wastes)	35
Hospitals (per bed space)	250+
Hotels with private baths (2 persons per room)	60
Hotels without private baths	50
Institutions other than hospitals(per bed space)	125
Laundries, self-service (gallons per wash, i.e., per customer)	50
Mobile home parks (per space)	250
Motels with bath, toilet, and kitchen wastes (per bed space)	50
Motels (per bed space)	40
Picnic Parks (toilet wastes only) (per picnicker)	5
Picnic Parks with bathhouses, shower, and flush toilets	10
Restaurants (toilet and kitchen wastes per patron)	10
Restaurants (kitchen wastes per meal served)	3

Table 7. Concluded.
(Gallons per person per day — unless otherwise noted)

Type of Establishment	
Restaurants additional for bars and cocktail lounges	2
Schools:	
Boarding	100
Day, without gyms, cafeterias, or showers	15
Day, with gyms, cafeterias, and showers	25
Day, with cafeterias, but without gyms, or showers	20
Service stations (per vehicle served)	10
Swimming pools and bathhouses	10
Theaters:	
Movie (per auditorium seat)	5
Drive-in (per car space)	5
Travel trailer parks without individual water and sewer hook-ups (per space)	50
Travel trailer parks with individual water and sewer hook-ups (per space)	100
Workers:	
Construction (of semi-permanent camps)	50
Day, at schools and offices (per shift)	15

Source: *Manual of Septic-Tank Practice,* DHEW Pub. No. (HSM) 72-10020 (Formerly PHS Pub. No. 526), Rev. 1967, pp. 43-44.

Table 8. Sewage Flow Rate Estimating Guide.†

Type of Establishment	Estimated Flow Rate *(Gallons per day)*
Apartments	250 one bedroom 300 two bedroom 350 three bedroom
Assembly Halls	2 per seat
Bowling Alleys (no food service)	75 per lane
Churches (small)	3-5 per sanctuary seat
Churches (large, with kitchen)	5-7 per sanctuary seat
Country Clubs	50 per member
Dance Halls	2 per person
Drive-In Theaters	5 per car space
Factories (no showers)	25 per employee
Factories (with showers)	35 per employee
Food Service Operations	
Ordinary Restaurant (not 24-hour)	**35 per seat at 400 ppm BOD
24-hour Restaurant	**50 per seat at 400 ppm BOD
Restaurant along Freeway (24-hour)	**70 per seat at 400 ppm BOD
Tavern (very little food service)	**20 per seat at 400 pm BOD
Curb Service (drive-in)	**50 per car space at 400 ppm BOD

Table 8. Concluded.

Type of Establishment	Estimated Flow Rate *(Gallons per day)*
Vending Machine Restaurants	*70 per seat at 200 ppm BOD
Hospitals (no resident personnel)	*200 per bed
Institutions (resident)	*100 per person
Laundries (coin-operated)	*400 per machine plus 12-hour cooling tank
Motels	100 per unit
Nursing and Rest Homes	*100 per person
Office Buildings	20 per employee
Schools — Elementary	*15 per pupil
Schools — High and Junior High	*20 per pupil
Service Stations	1000 first bay 500 each additional bay
Shopping Centers (without food service or laundries)	0.1 per square foot of floor space
Subdivisions	400 per home
Swimming Pool (average) With hot water shower	3-5 per swimmer (design load) 5-7 per swimmer (design load)
Trailer Parks (without service building) (With service building)	150 per trailer space 175 per trailer space
Vacation Cottages	50 per camper
Youth and Recreation Camps	50 per camper

*Includes food service waste.

**Aeration tanks for these require 48-hour detention period.

†Flow rates are average rates established by many of the state health departments throughout the United States. Please consult the District Sanitary Engineer in your area for any state or local individual design requirements.

Courtesy Pollution Control, Inc.

Table 9. Package Treatment Plant Sizing Data.

Type of Facility	Flow Rate *(GPCD)*	#5 Day B.O.D. *(lbs./capita /day)*	Runoff hours	Shock Load Factor
Airports — (per passenger)	5	.020	16	low
Airports — (per employee)	15	.050	16	low
Apartments — Multiple family	75	.175	16	med.
Boarding Houses	50	.140	16	med.
Bowling Alleys — per lane (no food)	75	.150	8	med.
Campgrounds — per tent or travel trailer site — central bathhouse	50	.130	16	med.
Camps — Construction — (semi-permanent)	50	.140	16	med.

Table 9. Continued.

Type of Facility	Flow Rate (GPCD)	#5 Day B.O.D. (lbs./capita /day)	Runoff hours	Shock Load Factor
Camps — Day (no meals served)	15	.031	16	med.
Camps — Luxury	100	.208	16	med.
Camps — Resort (night and day) with limited plumbing	50	.140	16	med.
Churches — per seat	5	.020	4	high
Clubs — Country (per resident member)	100	.208	16	med.
Clubs — Country (per nonresident member present)	25	.052	16	med.
Courts — Tourist or Mobile home parks with individual bath units	50	.140	16	med.
Dwellings — Single — family	75	.170	16	med.
Dwellings — Small, and cottages with seasonal occupancy	50	.140	16	med.
Factories — (gallons, per person, per shift, exclusive of industrial wastes. No showers.	25	.073	8	high
Add for showers	10	.010		
Hospitals	250+	.518	16	med.
Hotels — with private baths (2 persons per room)	60	.125	16	med.
Institutions — other than hospitals (nursing homes)	125	.260	16	med.
Laundromat	400	varies	12	high
Motels — (per bed space)	40	.083	16	med.
Motels — with bath, toilet, and kitchen wastes	50	.140	16	med.
Offices — no food	15	.050	8	high
Parks — Picnic (toilet wastes only) (gallons per picnicker)	5	.010	8	high
Parks — Picnic, with bathhouses, showers, and flush toilets	10	.021	8	high
Restaurants — (kitchen wastes per meal served)	7	.015	8-12	high
Restaurants — (toilet and kitchen wastes per patron)	10	.021	8-12	high
Restaurants — additional for bars and cocktail lounges	3	.006	8-12	high
Schools — Boarding	100	.208	16	med.

Table 9. Concluded.

Type of Facility	Flow Rate (GPCD)	#5 Day B.O.D. (lbs./capita /day)	Runoff hours	Shock Load Factor
Schools — Day, without cafeterias, gyms, or showers	15	.031	8	high
Schools — Day, with cafeterias, but no gyms or showers	20	.042	8	high
Schools — Day, with cafeterias, gyms, and showers	25	.052	8	high
Service Stations — (per vehicle served)	12	.021	16	med.
Shopping Centers — (no food — per sq. foot)	0.1		16	med.
Shopping Centers — (per employee)	15	.050	16	med.
Stores — (per toilet room)	400	.832	16	med.
Swimming pools and bathhouses	10	.021	8	high
Sports Stadiums	5	.020	4-8	very high
Theatres — Drive-In (per car space)	5	.010	6	high
Theatres — Movie (per auditorium seat)	5	.010	6	high
Trailer Parks — per trailer	150	.350	16	med.

Courtesy Pollutrol Technology, Inc.

Strength of Sewage. As described in Chapter One, the efficiency with which a treatment system can purify (oxidize) organic wastes is frequently measured in terms of BOD (BOD_5) removal. It is important to know how much organic material, again expressed as BOD, is imposed on the treatment plant. For estimating the organic loading, one-sixth (0.17) of a pound of BOD per person per day is generally used. This means that if the wastewaters produced by each person in a day's time were to be purified by nature, about one-sixth of a pound of pure oxygen would be used up in the first five days of the purification process. If the raw wastes are dumped into surface waters, over one pound of dissolved oxygen has to be provided per person per week, else the water will become stagnant. For homes which use garbage grinders, the organic loadings is often estimated about 50 per cent higher, i.e., 0.25 pounds of BOD per capita per day.

If 0.17 pounds of BOD per day are loaded into 100 gallons of water, the resulting wastewater has an average BOD of about 200 mg/l (or ppm); that would be about 300 mg/l if a garbage grinder were used. If one person accounts for 0.17 pounds of BOD per day, but only 50 gallons of wastewater, the resulting wastewater will have a BOD of about 400 mg/l, i.e., it will be "stronger" than when the BOD was distributed over 100 gallons. Table 10 presents estimates derived by a sewage plant manufacturer of daily BOD loadings as well as wastewater volumes and the resultant strength estimates. Note that the BOD_5 of domestic sewage averages 200-400 mg/l.

One Hundred Gallons a Day Reconsidered. Though the criteria of 100 GPCD and 0.17 lb. BOD per person per day are generally accepted in the U. S., they are probably

Table 10. Suggested Daily Flows and BOD Considerations.*

Class	Persons Per Unit	Daily Flow Per Person *(gallons)*	Pounds BOD Per Person: Avg.	Pounds BOD Per Person: With Garbage Grinder	Avg. Sewage Strength, 5 day BOD in ppm
Subdivisions, Better	3.5	100	0.17	0.25	205
Subdivisions, Average	3.5	90	0.17	0.23	220
Subdivisions, Low Cost	3.5	70	0.17	0.20	290
Motels, Hotels, Trlr. Pks.	2.5	50	0.17	0.20	400
Apartment Houses	2.5	75	0.17	0.25	225
Resorts, Camps, Cottages	2.5	50	0.17	0.20	400
Hospitals	per bed	200	0.30	0.35	200
Factories or offices	per person	20	0.06	—	360
Factories, incl. showers	per person	25	0.07	—	340
Restaurants	per meal	5	0.02	0.06	450
Schools, Elementary	per student	15	0.04	0.05	320
Schools, High	per student	20	0.05	0.06	360
Schools, Boarding	per student	100	0.17	0.20	205
Swimming Pools	per swimmer	10	0.03	—	360
Theatres, Drive-In	per stall	5	0.02	—	450
Theatres, Indoor	per seat	5	0.01	—	250
Airports, Employees	per employee	15	0.05	—	450
Airports, Passengers	per passenger	5	0.02	—	480
Bars, Employees	per employee	15	0.05	—	450
Bars, Customers	per customer	2	0.01	—	800
Dairy Plants	per 1000# milk	100-250	0.56 to	1.66	650-2000
Public Picnic Parks	per picnicker	5-10	0.01	—	250
Country Clubs, Residents	per resident	100	0.17	0.25	205
Country Clubs, Members	per member	50	0.17	0.20	400
Public Institutions (non-hospital)	per resident	100	0.17	0.23	205

*Consult with your state and local health department or pollution control agency for specific data.
Courtesy Suburbia Systems, Inc.

too high for strictly domestic sewage. Values of 0.08 to 0.12 lb. BOD and 58 GPCD have been suggested as more representative of domestic sewage. In 1969 and 1970, for example, Zanoni and Rutkowski sampled fresh sewage from the Nicholson Meadows Subdivision of Cudahy, in suburban Milwaukee, Wisconsin. [10] The subdivision contained 270 dwelling units, of which 226 were single family homes in the $24,000 to $27,000 bracket. The measured per capita loadings of the strictly domestic wastewater were:

BOD (5-day, 20°C)	0.10 lb./person/day
Chemical oxygen demand	0.20 lb./person/day
Suspended Solids	0.08 lb./person/day
Wastewater flow	58 GPCD

Also, Bernhart has derived a design loading of 55 GPCD on the basis of extensive sampling in Ontario, Canada (Appendix A).

(Note too that design criteria for a Japanese septic tank and an aerobic tank described in Appendix C are 0.0287 lb. BOD and 13.2 gal. of water per person per day.) Domestic sewage treatment systems designed on the basis of 0.17 lb. are, therefore, likely to have excess capacity from the start.

Sizing of System Components

The key design parameters for sizing a system are: (1) the total water volume (hydraulic) loading, and (2) total BOD (organic) loading. The entire system should be capable of handling all of the hydraulic loading and all of the organic loading plus a reasonable reserve for growth and surges. Surges occur because water is not used uniformly throughout the day and because every now and then more people than average generate sewage—during holiday visits, for example. Peak flow is normally estimated to be about three times normal flow.

If a system is being sized to serve several homes, consideration should be given to making it big enough to accommodate as many more homes as might be expected to hook up within a reasonable (defined mainly in economic terms) amount of time. If the system will initially serve families with low standards of living that could be expected to rise, consideration should also be given to building in excess capacity to accommodate the increased water use that will surely accompany the rise in living standards.

Sewage treatment plants are normally rated on daily capacities, which are, in turn, usually figured on the basis of fairly constant flow. Actual flow occurs unevenly throughout the day, and is usually confined to "runoff" periods of from two to sixteen hours (see Table 9). Many manufacturers recommend increasing the capacity of the plant over the daily-loading capacity by a factor equal to twenty-four hours divided by the runoff period. As an example, consider a sewage plant built to serve a mobile home park with four hundred inhabitants (16-hour runoff period from Table 9 and 50 GPCD from Table 10). The hydraulic loading of 20,000 gpd would be multiplied by the ratio 24/16 (= 1.5), and a 30,000 gpd plant would be recommended. According to the information developed from manufacturer-supplied data (see chapter on costs), the extra 10,000 gpd capacity could be expected to have a purchase cost between $3,500 and $13,500. Design alternatives to increased plant size might be explored: some type of holding facility in front of the plant which would smooth out the rate of loading or a plant with a long detention time, such as a 180-day lagoon which would be relatively immune to variations during the day.

As implied by the above considerations, a system should be somewhat oversized, but only enough to provide for the specific excess-capacity requirements that can be reasonably anticipated. The classic safety-factor approach of multiplying anticipated needs by two or three or more should not be used for several reasons:

—Many mechanical units operate efficiently only within limited ranges of their rated hydraulic and organic capacities. A unit twice as big as what is needed could tie the customer to a unit that will never work efficiently and that might never attain the original design performance levels.

—Larger units cost more to buy, more to install, and, often, more to maintain. The customer should only pay for what he needs or is likely to need within the planning horizon.

—*Money wasted on things not needed is not available to purchase other needed items.* Even with a fixed budget, surplus funds could be used to purchase more complete treatment rather than wasted on excess capacity.

There are, of course, exceptions. For example, a 1000-gallon septic tank often costs so very little more than a 750-gallon unit that the extra expenditure can be justified on the basis of improved performance. Treatment in septic tanks improves with detention time; bigger septic tanks detain a given amount of sewage longer than smaller tanks and therefore provide more complete digestion. In addition, sludge can accumulate for longer times in a bigger septic tank before a pump-out becomes necessary, thus saving on maintenance costs. The largest septic tank obtainable before costs (including transportation) begin to soar should be used. For example, if the volume can be doubled for a 25 per cent increase in total installed price of a septic tank, it could be worth it. There are few hard and fast rules; judgment is required.

Traditional Systems Design

From just about any environmental point of view a privy of sound construction which is properly maintained represents an excellent solution to the disposal of human excreta. Many directors of health departments in counties with rural populations would be happy to see their residents with safe sanitary privies. This book, however, concentrates on systems for those who prefer water carriage of wastes, such as sinks and flush toilets. [For descriptions of safe privy-construction and maintenance techniques, see 11 and 12. Many state and local health departments also publish guidelines on preferred techniques for privy construction.]

Water Carriage Systems

Many homeowners who have pressurized water are likely to have indoor plumbing, including flush toilets. The outlets of toilets, sinks, showers and other fixtures normally run into a single pipe which leaves the house. This is the house sewer, which is a solid pipe of at least a four-inch diameter.

The house sewer, or lateral, may then lead to any of three receptacles: (1) directly to a body of water, watercourse or drainage ditch without receiving any treatment; (2) to an on-site treatment plant such as a cesspool, septic tank or aerobic tank; or (3) to a branch sewer of a community collection sewer system which will eventually lead either to a treatment plant or, as is unfortunately the case in many communities, directly to surface waters or drainage ditches without benefit of treatment facilities. Direct discharge of untreated sewage to surface waters, either from individual homes or from community sewerage systems is illegal in most jurisdictions.

On-Site Wastewater Systems

Cesspools. Cesspools and seepage (or leaching) pits are covered open-joint walled pits dug into the soil. Cesspools receive raw sewage from which solids settle to the bottom and undergo anaerobic decomposition. Liquids seep out through the walls of the pit. Some cesspools are connected to seepage pits which receive settled sewage effluent. Septic tanks can also empty to seepage pits. Cesspools and seepage pits are generally more expensive alternatives than their more usual analogues, septic tanks and subsurface soil absorption systems. Also, the pits require deep porous soils to provide sufficient absorption area. Such deep soils with considerably deeper water tables or hardpans are rare occurrences.

Septic Tanks. The septic tank and soil absorption system represent the most frequently used on-site water carriage disposal system. On most lots of several acres, there will usually be an adequately-sized area with proper soil conditions for the use of a subsurface soil absorption system large enough to serve a single family. When soils are uniformly good over a large area, it may be possible to operate septic tank systems successfully on lots smaller than one acre. However, people usually build where it suits them and the builder, if he is allowed to do so, installs a septic tank convenient to the house. This is where a great many problems begin.

Many septic tank systems fail because they were not designed properly in the first place: the soil wasn't suitable; or the absorption field was undersized; or the tank was too small for the family; or the whole system was inundated by a seasonally high water table, and so forth.

Septic tank systems may also fail because they are not properly installed. Proper installation means that: (1) soils with appreciable clay content should never be excavated for absorption system construction when they are wet—a wet clay is easily sealed tight by a digging instrument;(2) construction crews should never walk on the bottoms of trenches or absorption beds; and (3) heavy construction machinery should not be run over a soil absorption system.

Also, careful attention should be paid to insure that a septic tank is not installed backwards (or upside down, for that matter).*

Good installations of proper tanks may eventually fail, even with the best of use. Poor maintenance can shorten the lifetime drastically, and good maintenance and a few design tricks can add many years to the life of a system. Good maintenance procedures include annual or bi-annual checking of the sludge and scum layers to make sure that they do not occupy too much of the space that is needed for the liquid phase and also to keep the scum or sludge particles from getting out into and clogging the disposal system. A septic tank should be pumped out when the bottom of the scum mat is within three inches of the bottom of the outlet device, or the top of the sludge is within the distances specified in Table 11 of the bottom of the outlet.

Table 11. Guide for Determining When to Pump Out a Septic Tank.

Liquid capacity of tank *(gallons)*	Liquid Depth *(feet)*			
	2.5	3	4	5
	Distance from bottom of outlet device to top of sludge *(inches)*			
750	5	6	10	13
900	4	4	7	10
1,000	4	4	6	8

Locating a septic tank to inspect it is often difficult. Accurate records of septic tank and absorption field location are rarely kept and almost never passed from one homeowner to the next upon transfer of ownership. Many homeowners who have moved from urban areas aren't aware that they are served by a septic tank rather than a sewer. Consequently, most septic tanks are not serviced until there is visible evidence of failure. Then the serviceman may spend many hours trying to find the tank. Septic tank inspection ports should therefore be served by a manway that is extended to grade and terminated with an easily seen and recognizable cover plate. It is also possible to embed two- or three-inch pipe into and through the top of the tank and to extend the pipe several inches above grade, where it should be terminated with a tightly fitting solid end cap. The pipe can be used for sounding the tank to obtain sludge and scum depth information.

*The authors observed a soil absorption system which was constructed with solid-walled sewer pipe instead of perforated drain-field pipe. The only seepage in that field was at the open end of the laterals. The system was reportedly designed by an engineering firm, but no knowledgeable person supervised its installation. On the occasion of the authors' observing the system it was being re-excavated, and the pipe was being replaced with brand new solid-walled sewer pipe because, it was said, "the old pipe leaked at the joints." Somebody failed to realize that the pipe must leak along its length to permit the effluent to get into the ground.

The longer sewage is retained in the septic tank, the more treatment it receives. All else being equal, bigger septic tanks will give more complete treatment. Many authorities recommend multi-compartment tanks to separate fresh from treated effluent. Capacity as well as compartmentalization can be conveniently obtained by using two or more tanks in series. This alternative may be much less expensive than obtaining a custom-made compartmented tank.

The Public Health Service's *Manual of Septic Tank Practice* [5] is often regarded as the most authoritative publication in the field. While it may have some flaws, especially as regards the approach to sizing and constructing soil absorption systems, the Manual is one of the most comprehensive engineering guides available. Most states or counties have their own versions, which differ from the Manual as regards certain minimum dimensions, inspection frequencies and other practices.

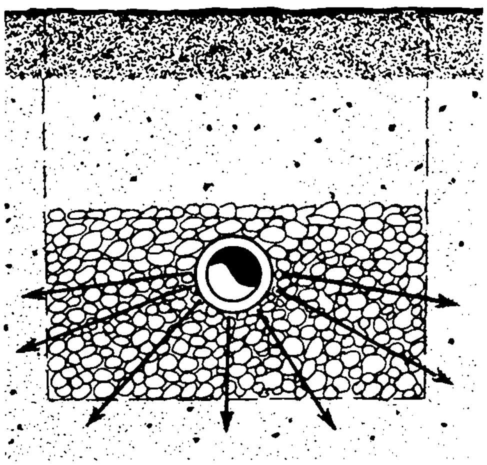
Aerobic Tanks. Aerobic treatment tanks are highly scaled-down versions of activated sludge plants. Most use the extended aeration mode. Some are compartmentalized and complex; others are little more than a septic tank supplied with an air bubbler. Many aerobic tanks are described in detail in Appendix C.

Aerobic tanks can, under proper conditions of design, installation and operation, achieve a significantly higher quality effluent than most septic tanks. The effluent can have a lower BOD and suspended solids content as well as a non-zero dissolved oxygen content. The effluent will also contain aerobic microorganisms. Aerobic tanks have been reported to work well in soils that were considered marginal for receiving septic tank effluent. (See, for example, Bernhart's work on aerobic soil systems in Appendix A.) Further, Laak has indicated that smaller soil absorption systems than are required for septic tanks can be used to receive the effluent from aerobic tanks. [13] Several states permit smaller soil systems with aerobic tanks.

While the evidence in favor of some type of aerobic tanks is impressive, it is far from conclusive, and it is also beclouded by operational difficulties when routine maintenance and service are lacking. For this reason, it is recommended that where on-site treatment is appropriate, septic tank systems be installed. Where the soil is not suited to septic tank effluents, aerobic tanks may be considered, but there is no guarantee that they are suited to all soils either. Other disposal alternatives, such as composite systems and mounds, which are described in the next chapter should be considered for use in difficult situations, perhaps in conjunction with aerobic tanks. It is expected that further use of aerobic tanks and controlled investigations will yield more conclusive evaluations of the advantages of these systems.

The Soil Absorption System

Effluent from on-site treatment tanks is almost always directed into the native soil through perforated pipes embedded in gravel fill. Seepage pits are often used for soil absorption, but because they must be dug deep to provide the required infiltration sur-



Effluent in a typical subsurface soil absorption system seeps out through holes (or spaces) in the pipe (or tile) and passes through the gravel embedding material and into the soil. Since the bottom of the trench usually clogs, most of the liquid normally seeps through the sidewalls.

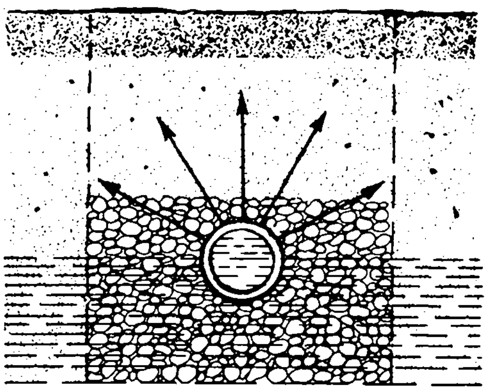
face area, a system of absorption trenches of equal or better performance can usually be installed for less money. When liquid is infiltered at shallow depths in trenches or beds, a portion can percolate downward and be filtered by the soil before eventually reaching ground waters; some can be pulled up by capillary forces for evaporation from the surface of the ground, and some can be taken up by plant roots and released to the atmosphere by plant transpiration. Liquid which is not filtered by percolation or dissipated by evapo-transpiration will either run down through cracks and fissures in the ground unfiltered or will eventually rise above the ground (daylight) and run off or puddle.

One objective of soil system design is to eliminate residual effluent since it is dangerous and offensive. This objective can be attained if a few important design guidelines are followed. The following factors must be considered.

Soil Aeration. The soil should be kept well-aerated and continuous inundation should be avoided. The designer must respect the soil mantle as a living filter, a biological community, as well as a physical strainer and a chemical reactor. If the soil is waterlogged for too long, important soil organisms will suffocate, and the make-up of the biological community will change from aerobes to anaerobes. Aerobes oxidize wastes and keep soil pores open; anaerobes break down wastes less completely and one way or another give rise to soil-clogging processes.

Depth to Rock, Sand or Gravel. At least four feet of soil material between the bottom of the trenches or seepage bed and any rock formations is normally considered to be necessary for absorption, filtration, and purification of septic-tank effluent. In areas where the water supply comes from wells and the underlying rock is limestone, more than four feet of soil may be needed to prevent unfiltered effluent from seeping through the cracks and crevices that are common in limestone.

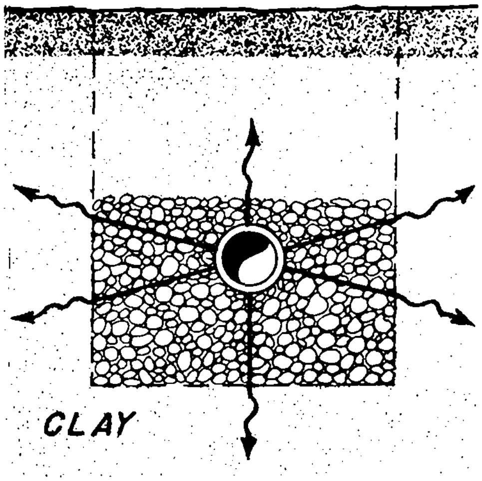
Different Kinds of Soil. In some places soil changes within a distance of a few feet. Having different kinds of soil in an absorption field is not significant if the different soils have about the same absorption capacity. But it may be significant if the soils differ greatly. Where this is so, serial distribution of effluent is recommended so that each kind of soil can absorb and filter effluent according to its capability. (The sketch on page 49 illustrates the serial distribution arrangement on a steep slope.)



The high water table at tile level forces the effluent upward to the surface. This creates an unsanitary condition and health hazard.

Ground Water Level. In some soils the ground-water level is a foot or a few feet below the surface the year round. In other soils the ground-water level is high only in winter and early spring. In still others, the water level is high during periods of prolonged rainfall. A sewage absorption field under any of these conditions will not function properly; it will also contaminate the ground water, a precious resource whose protection is too often overlooked.

If the ground-water level rises to the subsurface tile or pipe, the saturated soil cannot absorb effluent. The effluent remains near the surface or rises to the surface and the area becomes a foul-smelling, contaminated mudfield.



Septic-tank effluent moves into compact, plastic soil very slowly. Such soils should not be used for absorption fields.

Soil Permeability. Soil permeability is influenced by the amount of gravel, sand, silt, and clay in the soil; the kind of clay; and other factors. Water moves faster through sandy and gravelly soils than through clayey soils.

Some kinds of clay expand so much when wet that the pores of the soil swell shut. This slows water movement and reduces the capacity of the soil to absorb septic-tank effluent.

Slope. Slopes of less than 15 per cent usually do not create serious problems in either construction or maintenance of an absorption field provided the soils are otherwise satisfactory.

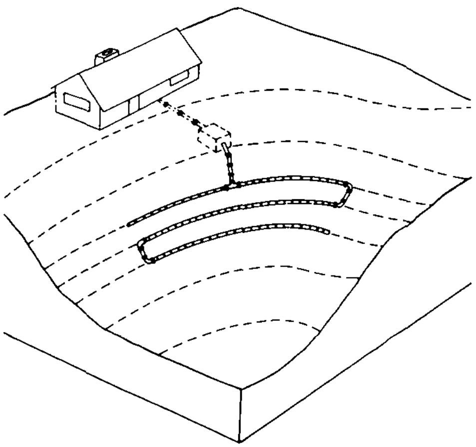
On sloping soils the trenches must be dug on the contour so that the effluent flows slowly through the tile or pipe and disperses properly over the absorption field. Serial distribution is advised for a trench system on sloping ground.

On steeper slopes, trench absorption fields are more difficult to lay out and construct and seepage beds are not practical. Furthermore, controlling the downhill flow of the effluent may be a serious problem. Improperly filtered effluent may reach the surface at the base of the slope, and wet contaminated seepage spots may result.

On a steep slope, if there is a layer of dense clay, rock, or other impervious material near the surface and especially if the soil above the clay or rock is sandy, the effluent will flow above the impervious layer to the surface of the slope and run unfiltered down the slope.

Proximity to Streams or Other Water Bodies. Local regulations generally do not allow absorption fields within at least fifty feet of a stream, open ditch, lake, or other watercourse into which unfiltered effluent could escape.

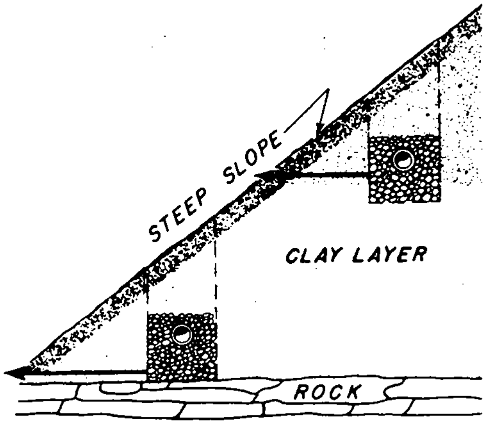
The flood plain near a stream that is subject to flooding should not be used as an absorption field. Occasional flooding will impair the efficiency of the absorption field; frequent flooding will destroy its effectiveness.



Serial distribution recommended for a soil absorption system located along the contours of a steep slope.

Soil Absorption Capacity. Knowing the absorption capacity of the soil also helps determine the size of absorption field. The slower the rate of absorption, the larger the field required. If the soil has too slow a rate of absorption, local ordinances may prohibit installing a sewage system and thus prevent building a house. And some soils, regardless of the size of the lot, are not suitable for use as an absorption field.

Sizing A Soil Absorption System. The soil system should be sized on the basis of expected loading and the capacity of the particular soil for accepting the liquid. There are many formulas for sizing a soil system to treat and dispose of septic tank effluent. The approach is not an exact science and there is much room for interpretation. The basic design objective is to distribute a well-settled effluent uniformly over a sufficiently



If an absorption field is placed on a steep slope where there is a layer of dense clay, rock, or other impervious material near the surface, the effluent will flow above the impervious layer to the surface and run unfiltered down the hillside.

large surface of soil. The loading of each unit area of soil surface must not exceed the capacity of the surface layer to process and pass the effluent, nor must it be greater than what the bulk soil behind the interface can handle day in and day out. In an attempt to simplify the design concepts, meaningful parameters like gallons/square foot/day or inches/square foot/day have often been replaced with surrogate parameters like number of bedrooms in the house which is to be served by the on-site system. The following procedure for determining the size of the system is recommended:

1. Check with local authorities and determine whether or not there is a prescribed way of doing things; if there is room for judgment, continue.

2. Estimate how much wastewater will be generated on a daily basis and add a bit of leeway for peak use periods. Also, build in reserve capacity if loading can be expected to increase in the future.

3. If absorption fields have traditionally worked well in the area, and if the soil, topography, and geology are similar to the conditions where septic tanks have been working well, be guided by local experience and scale up or down on the basis of expected loading.

4. If there hasn't been much experience with conditions similar to the site being considered, the loading rates suggested in Table 12 may be used as a guide.

5. If there has been a history of soil system failures in the area for conditions similar to the site being considered, use McGauhey and Winneberger's "most conservative" design criterion of 0.03 ft./day (equivalent to 4 square feet/gallon/day) for a loading rate. [14]

Table 12. Guide for Estimating Loading Rates of Soil Absorption Systems.

Percolation Rate *(minutes/inch)*	**Maximum loading rate *(gal./sq. ft.*/day)***
1 or less	2.5
2	2.0
3	1.6
4	1.4
5	1.3
10	1.0
20	0.72
30	0.48
40	0.42
60	0.36
over 60	0.25 — "most conservative" approach

*Active infiltration surfaces are sidewalls of disposal trenches.
Source: J. T. Winneberger, Private Communication, Nov. 1972.

6. Remember that even the most-conservative criterion will not get water through a completely impermeable soil; nor does it say anything about whether there's enough bulk soil behind the soil interface to provide adequate renovation; it merely tells how much surface area you need to get the wastewater into the soil with continued use.

7. The required sidewall area of trenches is the daily loading (e.g., gal./day) divided by the acceptable loading rate (e.g., gal./sq. ft./day). If a bed is used rather than trenches, more area will be required (400 gal./day ÷ 0.48 gal./sq. ft./day, for example, calls for about 830 sq. ft. of sidewall which can be provided with 208 linear feet of 2-foot deep trench). It would require more than 830 sq. ft. of bed surface to dispose of the 400 gal. load.

8. Make sure there's enough good land left to install another absorption field should the first one fail. A much better solution is to install both absorption fields at the outset when all the construction equipment is already on-site and available, and use a diversion valve (see Appendix C for an example) to alternate use between the two fields on a yearly basis. The combined lifetime could turn out to be much greater than the sum of lifetimes of two separate fields each operated until failure.

Actually, the alternating use of dual fields is recommended as part of the most-conservative approach and its value is recognized by a number of health departments. Sidewalls (vertical surfaces) are considered to be more efficient absorption surfaces for continuous service than beds (horizontal surfaces). The suggested sizing procedures discount trench bottom areas entirely. If a bed is used, it should have more than the area recommended for trench sidewall, but how much more is hard to say. In either case, much depends on the quality of the effluent (more stabilized and oxygenated effluent from aerobic tanks is said to require less absorptive surface than septic effluent); the degree of aeration maintained in the soil; and the contribution of evapotranspiration to dissipating some of the liquid. Bernhart's approach to soil-system sizing in Appendix A is based on the quality of the effluent and the degree of aeration of the soil. His recommended loading rates lie closer to the most-conservative approach than to the numbers in Table 12.

Uniform Loading of the Soil System. It is important that the soil be loaded uniformly to maintain continuous operations. However, it is virtually impossible to load the soil uniformly with drain tile or perforated pipe because the openings in the pipe are so big that the effluent all runs out in the first third or so of trench length. With time, effluent eventually reaches the far end because the bottom clogs progressively down the length of the trench. If the effluent is applied in large doses by means of a siphon or pump—a day's worth or more at a time—more-even distribution down the length of the field may be possible. Winneberger has suggested pumping the effluent under pressure through small plastic pipe with holes drilled in it. The small pipe should be inserted concentrically in the large drainfield pipe for protection.

Using Land Management to Ease the Load on the System. The ground surface over a bed or trench should be slightly arched upward to promote runoff of precipitation. Drainage and diversion trenches and grading should be used to shield the entire on-site system area from as much runoff as possible. These measures will lessen the loading on the system from natural precipitation and reserve maximum capacity for handling effluent.

Shrubs planted around the soil absorption area will also add to the evapotranspirative capability. Some authorities counsel that trees should not be planted too close to the beds or trenches lest their roots grow into the distribution lines; others maintain that tree roots grow into the gravel area but do not disturb pipes because there is plenty of moisture and less resistance to growth in the gravel bed proper. Local agronomists should be consulted about the behavior of locally-suited plant species.

Filled Land Not Suitable for Absorption. A drainage field should not be constructed on recently filled land. Soil texture is a property of the distribution of different sizes of soil particles, and structure relates to the way the particles agglomerate to form pores, clods and channels. Both texture and structure are important determinants of a soil's ability to handle liquids. Even if a soil fill of proper texture is used, the structure will have been destroyed by the excavation and filling operations, and it can take years for the structure to be reestablished. Where it is necessary to use fill material (see, for example, a subsequent section on absorption mounds), the fill should never be compacted, because compaction will close the pores. As water percolates through an unsettled fill it will carry along some of the fines (the smallest particles). The fines may be deposited in the pores at the interface between the fill and the native soil, resulting in partial blockage. This can be minimized by avoiding abrupt changes in soil texture between fill and native soil (by installing the fill in layers of different texture, for example) and by ensuring that the pores of the native soil have not been sealed off—by roughening the surface, avoiding digging a wet clay soil, and so forth.

Water Softener Backwash Can Ruin the Soil Field. Soils used for effluent disposal can be harmed by waters backwashed from water softeners. The clay components of soils are made structurally stable in part by the electrical charges on their constituent ions, especially calcium and magnesium ions.* Water softener backwash brine contains high concentrations of sodium ions, and these exchange places with calcium and magnesium ions in the clay matrix. The exchanging of ions changes the forces that hold the clay together and cause it to lose its structure—the clay becomes tighter and seals.

Centralized Community Wastewater Treatment Systems

Traditional approaches to the design of centralized systems usually include a collection of sewers which converge toward the treatment plant. The more sparse the population,

*An ion is an atom or group of atoms that bears a net electrical charge. When table salt dissolves, for example, its sodium atoms become positively charged as they separate from its chlorine atoms. The result is positive sodium ions and negative chloride ions.

the longer the runs of sewer that will be required to serve them. Smith and Eilers derived per capita lengths of sewers in the United States. [15] Close to 1,800 communities with populations less than 500 (average population 387) had about 37 feet of sewer per capita, over 5,000 communities with populations between 1,000 and 5,000 (2,304 average population) had about 26 feet per capita; 1,200 communities with populations between 10,000 and 25,000 (average size 12,920) had about 19 feet of sewer per capita; and 145 communities of over 100,000 population (average population 511,212) were able to serve their residents with about 9½ feet per capita. The national average was 14.3 feet per capita (2 billion feet of sewer serving 140 million people).

Conventional sewers are normally an expensive component of a system. With sewer costs in the $15 to $20 per foot range (see chapter on costs) and about 20 feet more sewer per capita than the national average, smaller communities pay a premium of some $300 to $400 per capita for sewers. Under these circumstances, economics would seem to argue heavily in favor of small cluster or on-site disposal systems for sparsely-populated areas. Small central systems can also be built according to some fairly new designs at significantly reduced costs (see section on composite systems in the following chapter).

General planning and design criteria have already been presented for collection and conveyance components of a conventional central system. Specific design criteria may be found in a variety of sources. [For example, see 16.] Also, state agency design criteria should be obtained prior to undertaking project design.

The Treatment Plant. Large municipal plants may be custom-designed to meet the particular flow patterns and wastewater characteristics of the communities they serve. Each of the individual process components, such as sedimentation or stabilization, is likely to be served by special equipment which reflects the latest advances in process engineering. Thus, very large plants are not usually very much alike.

At the small community level, however, plants will normally be purchased as a package of fairly standard items. Manufacturers normally scale the package up or down, depending on design volume, without varying the basic designs or layouts appreciably. The following discussion highlights some of the important process variables to look for in evaluating plant design, though the purchaser will normally not have much choice among the options offered in the package.

Design Flow and Loading Rate. It has been noted that most of the flow from subdivisions will occur during a sixteen-hour period, say from around 7:00 a.m. to 11:00 p.m. Peaks of about three times normal flow will also occur. If a plant is chosen strictly on the basis of daily-load capacity, the treatment efficiency is likely to suffer for several reasons. First, the biological mass of the sludge is sensitive to surge loadings—the degree of sensitivity is dependent on the process. Second, and perhaps more important, the clarifier, or chamber in which the sludge settles and from which the clear supernatant is allowed to overflow, has flow limits above which there will be a high carry-over of solids.

Conventional activated sludge plants are sensitive to shock loads of food for the microorganisms. When a surge of food comes in and there isn't enough free oxygen around for its conversion, some microbes will get oxygen by converting nitrates to nitrogen gas. The nitrogen gas will make the sludge flocs more buoyant, and they will rise and overflow the clarifier—the plant "belches."

Sustained high loadings, especially during the start-up of a new plant, can so overfeed the culture of microorganisms that they will bloat and not form dense flocs. The lightweight flocs won't settle well, and they will also flow out with the effluent. This process is called *bulking.* Either by belching or by bloating, the plant will lose some of the biomass that is needed for treatment of sewage, and treatment efficiency will fall. At the same time, the BOD and suspended solids in the effluent will rise beyond acceptable limits. This is detrimental to the functioning of soil absorption systems and to the purity of receiving waters.

The objective is to keep the plant on a steady loading schedule and not overload it. This is much easier to accomplish in big plants than in small plants because big ones not only have the smoothed loading which results from an averaging over many individual users, but big plants also have process monitors and operators to control flow rates, aerator rates, chemical inputs, and so forth. As noted in an earlier section, some manufacturers recommend the use of plants which are oversized with respect to total daily-loading rates in order to accommodate peak rates and non-uniform loading patterns. Other manufacturers have designed for the non-uniformity of loading patterns by employing discrete batch rather than continuous flow-through processes. As long as the batch size is capable of handling peak loadings without having to overflow or bypass the plant, the batch-design plant is of adequate size. Designers may modify flow-through plants to include some elements of batch processing by metering sewage from a large holding or surge tank which can also double as a primary treatment tank.

Process Parameters for Activated Sludge Processes. The conventional activated sludge process and the contact stabilization and extended aeration modifications differ in several process parameters. They are compared in Table 13, which shows normal ranges or average values. It should not be interpreted as a prescriptive standard. The conventional and contact stabilization plants maintain a culture which is about 3.5 times the size of the applied BOD load, i.e., the mean sludge residence time, or "sludge age," is about 3.5 days. The extended aeration plants maintain very mature cultures with sludge ages normally in excess of ten days, i.e., the circulating sludge has over ten times the weight of the influent BOD. That way, the extended aeration plants are less sensitive to small variations, but their cultures can be easily starved if food is withheld. It also takes a bit longer to reach process maturity in an extended aeration plant because of competition between adding large loads to build up sludge biomass and having to restrain loading in order to avoid bloating which leads to a bulking floc. Contact stabilization plants are also more able to handle shock loads than conventional plants. The excess handling capacity results from the high degree of aeration of the microorganisms in the re-aeration, or stabilization, zone.

The extended aeration plants require about three times more air per pound of BOD removal, but since they take about three times longer to remove the BOD, blowers of about the same capacity may be used. Where more than one blower is used, at least two-thirds of the aeration requirements should be met with the largest temporarily out of service. The air should be filtered before passing through the aeration device (diffuser, bubbler) because aerators partially blocked by accumulated oil and particulate matter require more electrical power to get the required air through, and fully plugged aerators require shutdown and repair. The dust content should be less than 0.10 mg per 1000

Table 13. Comparison of Process Parameters for Conventional Activated Sludge Process, Contact Stabilization Modification, and Extended Aeration Modification.

Process Parameters	Conventional Activated Sludge	Contact Stabilization Modification	Extended Aeration Modification
Air Requirements (20 C, 1atm. pressure)			
Cubic feet per pound of BOD removed	700-1000	700-1000	2000-3000
Cubic feet per gallon of wastewater treated	0.5-1.25	0.5-1.25	2-3
BOD Loading			
pounds per day per 1000 cubic feet of aeration tank(s) capacity	30-40	30-50 (higher in some cases)	12.5
pounds per day per 100 pounds mixed liquor solids	35	30-40	5-10
sludge age (mixed liquor solids divided by BOD loading) days	3.5	3.5	>10
Mixed liquor Suspended Solids			
milligrams/liter	2500	*Contact zone:* 2000-3000 *Stabilization zone:* 5000-8000	2500-6000 (~ 4000 optimum)
Aeration Period			
Hours	6-8	*Contact zone:* 0.5-1.5 *Stabilization zone:* 4-5	24
Sludge Returned (as percentage of solids loading)			
range	15-75	50-150	50-200
average	30	100	100

cubic feet of filtered air to minimize clogging. The air should not contact lubricating oil in the pumps.

Conventional plants must dispose of (or "waste") about 70 per cent of their sludge, while extended aeration plants normally have to waste little sludge. Extended aeration plants will normally have to be emptied of accumulated sludge only two to three times per year—a big operational and maintenance advantage.

Contact stabilization plants require solids control in two chambers (contact and stabilization) as opposed to one (the aeration chamber) in conventional and extended aeration plants. In general, the extra control makes contact-stabilization plants less amenable to unattended operation and explains why so many of the small activated sludge plants are of the extended-aeration type.

Properly operated activated sludge plants should be capable of 85 to 95 per cent BOD reduction. Extended aeration plants with mature cultures convert nearly 100 per cent of incoming organic loads to sludge biomass. Therefore, most of the BOD that appears in the effluent of a well-designed and properly operated plant will be attributable to the respiration of microorganisms carried over as suspended solids in the effluent. This is why it is so important to have a clarifier of sufficient capacity and design (aided by efficient overflow baffles and surface skimmers) to minimize suspended solids in the effluent. Adequate clarifier capacity will handle surge loads, and proper clarifier design will minimize the overflow of a belched (rising) or bloated (bulked) sludge.

Some localities will require final filters or ponds for "polishing" the effluent. Sand filters used for polishing are not maintenance-free. They will eventually clog unless they are periodically backwashed and they can attract filter flies. While ponds can be an aesthetic asset to a plant and can support aquatic life, they do, however, require space and the extra land can be costly.

Chapter Four

Alternate Approaches to Wastewater Systems Design

The unusual approaches to the design of rural wastewater treatment systems included in this chapter are recommended for use where traditional solutions are not feasible. They are in keeping with the spirit of providing environmentally safe and effective treatment alternatives at reasonable cost. Included are engineered above-ground mounds and subsurface evapotranspiration systems, which may be appropriate for use when the native soil is not suited for conventional effluent absorption; the use of small-diameter pressure sewer systems for sparsely populated communities in order to bring the per capita cost of sewering in rural areas within striking distance of conventional urban gravity sewers; and the return of treated wastewater to the ground by spray irrigation techniques as an alternative to disposal to surface waters.

Above-ground Mounds for the Disposal of Effluent

There are at least two approaches for providing soil treatment where the native soils are not suitable for accepting effluent from sewage treatment tanks—where, for example, shallow soils are underlain by hardpan, creviced or channeled rock, or there is a high ground water table. One approach uses a specially engineered artificial soil bed designed to dispose of liquid by evapotranspiration. It is described in the section which follows. The other approach uses above-ground mounds.

Mounds were developed in North Dakota and are often called NODAK systems in recognition of their origin. They were described at least as early as the 1950's by Salvato. [12] The success of mounds in the extreme environments of North Dakota augers well for their general applicability. Presumably, in the extreme winter environments, evapotranspiration is maintained in part by evergreen plantings.

The design of a successful mound requires a firm understanding of the principles of movement of liquids through soils because a mound must be custom-designed to the particular soil conditions. Mounds are constructed from soil, sand, and gravel which are trucked to the disposal site. Effluent is pumped up to absorption trenches or to an absorption bed located in the interior of the mound. If the terrain slopes properly, it may be possible to build the mound downslope of the sewage treatment tank and thereby avoid the need for a pump. Mounds are normally trapezoidal in cross-section with the wider dimension at the base. (See Figure 8.) The absorption trenches or bed are no wider than the top of the trapezoid, and the tapered sides serve to divert precipitation from the mound and to help contain effluent within the mound area. The top of the mound is arched upward slightly to aid in runoff diversion also. The top and sides of the mound are normally planted in grass to increase evapotranspiration from the mound and to reduce erosion of the mound by wind and rain. Similarly, the border may be planted with shrubs or trees. Care must be exercised to prevent growth of roots into the sewage distribution pipes.

Effluent entering the mound receives treatment in the mound soil just as it does in properly suited native soil. Much of the moisture may be removed by evapotranspiration, and the remaining liquids are expected to infiltrate the native soil beneath the mound without daylighting. Infiltration into the native soil is enhanced by the trapezoidal geometry which provides a much greater ground contact area than the bottom area of the trenches alone.

At least one health department has provided design standards for mounds—a handout from the Monroe County, New York, Department of Health is reproduced in Figure 9.

General Design Criteria

There are two key features of mound design: (1) there should be about two feet of suitable soil, preferably a sandy loam or a loam, between the bottom of the soil absorp-

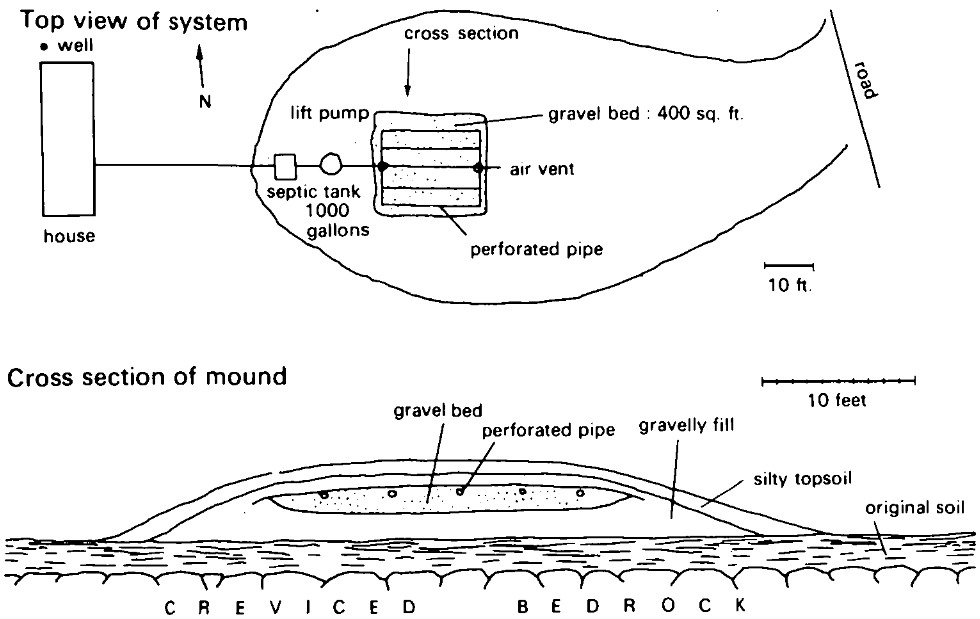
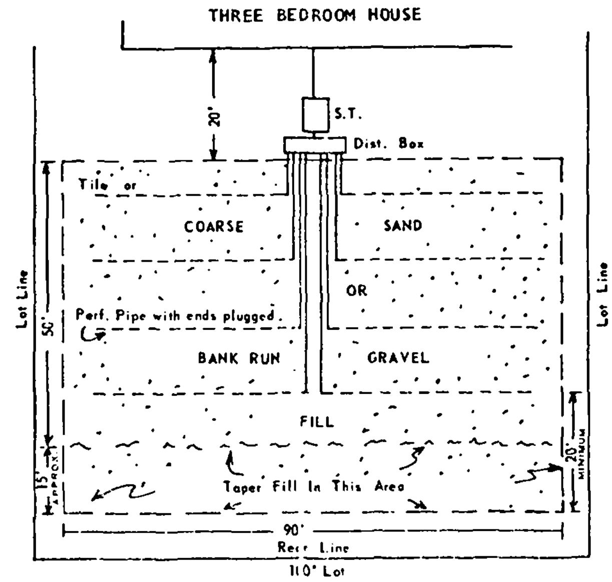


Fig. 8. Top view and cross section of above ground mound. Source: J. Bouma, W. A. Ziebell, W. G. Walker, P. G. Olcott, E. McCoy, and F. D. Hole, *Soil Absorption of Septic Tank Effluent, A Field Study of Some Major Soils in Wisconsin*, Information Circular No. 20, Geological and Natural History Survey, Madison, Wisc., 1972.

Fig. 9. Design standards for the evapo-transpiration (mound) sewage disposal system. Courtesy Monroe County Dept. of Health, Rochester, New York.

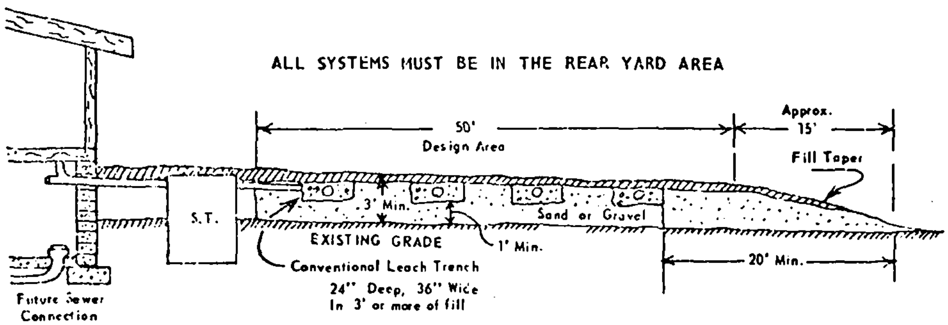


Two (2) bedroom consisting of 3,000 square feet must have 200 feet of leach.
Three (3) bedroom consisting of 4,500 square feet must have 225 feet of leach.
Four (4) bedroom consisting of 6,000 square feet must have 275 feet of leach.
Five (5) bedroom consisting of 7,500 square feet must have 325 feet of leach.

Sand bed must be 100 feet from well.

A heavy berm material (soil) must be between house and evapo-transpiration bed.

ALL SYSTEMS MUST BE IN THE REAR YARD AREA



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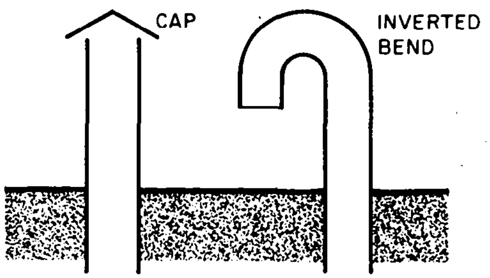
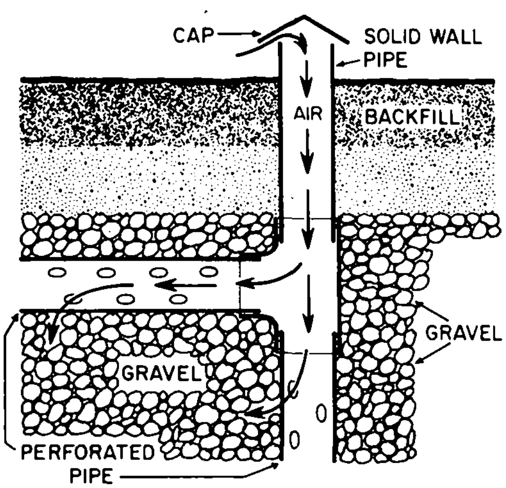
tion bed or trenches and the native topsoil, and (2) effluent should be applied as uniformly as possible over a sufficiently large soil absorption system in the mound. A sandy loam or loam will provide the best hydraulic flow and filtering characteristics for effluent percolating downward. At the same time the sandy loam or loam will be efficient in drawing liquid to the outer surfaces of the mound by capillary forces, and will thus contribute to evaporation of water from the mound. Two feet of unsaturated sandy loam will provide a transit time of from twenty-four to forty-eight hours, which will greatly enhance the degree of renovation of the wastewater before it reaches the native soil. [17]

The second major design criterion is closely related to the first. Uneven distribution of effluent can result in saturation and too rapid percolation through the fill soil in regions of concentrated application. The renovative capabilities of the soil would then be seriously compromised. Conventional distribution systems (drain tile or perforated four-inch plastic tubing, for example) spread the effluent very unevenly. Winneberger recommends a design in which effluent is accumulated and transported to the distribution lines in the mounds in doses, under positive hydrostatic pressure. The effluent distribution lines are small diameter plastic pipe (one to two inch) in which small smooth holes (about one-eighth inch) are drilled in pairs about every foot. These pipes are placed concentrically in conventional four-inch perforated drainfield pipe with the perforations facing downward. The larger pipe is embedded in the gravel of the absorption bed or trench, as in a conventional subsurface soil absorption system. The larger pipe both protects the small pipe and provides a means of access should repair be necessary. A batch of wastewater, when pumped under pressure to the small tubing, will dose the absorption system much more evenly than it could if it were applied directly to the large pipe. Breezers, or vertical vent stacks are placed at the ends of the lines. The breezers extend above the mound surface and allow air into the trench or bed, thus fostering aerobic conditions. [18]





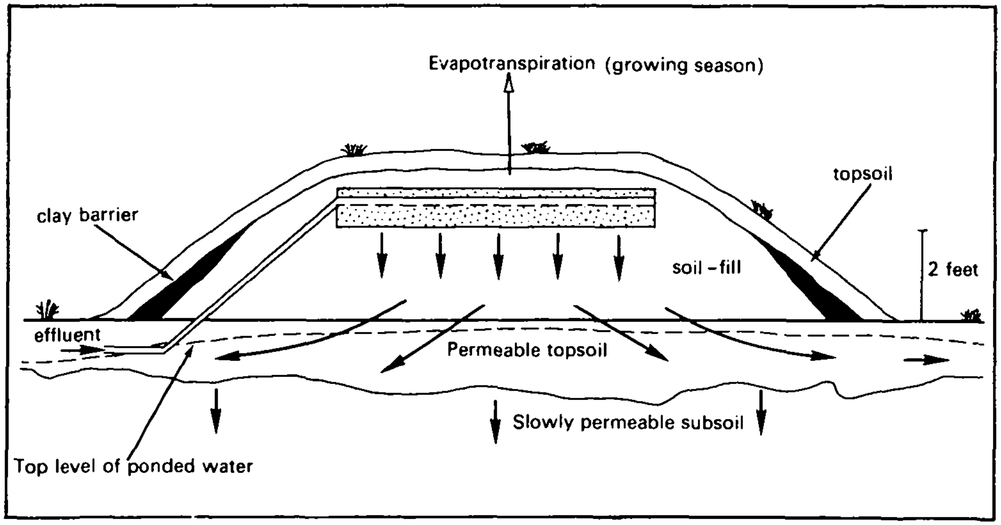
Most sources agree that the tapered fill sides of the mounds should extend about 20 feet from the upper surface of the mound, i.e., in cross-section, the base of the mound should be about 40 feet wider (20 feet on each side) than the top. Winneberger has described a mound 160 feet long, 3 feet wide at the top, 43 feet wide at the bottom and with the 20-foot taper fill around all four sides. The mound has a volume of 11,500 cubic feet (about 425 cubic yards), neglecting the volume of the soil absorption system. Soil of 30 per cent available void space would offer about 25,000 gallons of potential storage in the mound. An absorption trench one foot wide and two feet deep filled with gravel of 40 per cent void space and running the length of the mound would offer about 960 gallons of storage space, or around three days' volume of effluent from an average home. About 600 to 900 gallons should be pumped (or drained under hydraulic head from a tank located up-slope) into the mound all at once from a dosing tank which follows the septic tank in series. The intermittent dosing schedule is intended to give the soil a chance to rest and recover between loadings. Winneberger also recommends dual side-by-side trenches which are dosed on alternate annual cycles by means of a diversion valve as in the case of subsurface systems. Care should be taken to choose a pump and fittings that will not be corroded by acidic septic tank effluent. The dosing tank should be provided with an access port for removal of accumulated solids deposits. [18]

The native ground surface beneath the mound should be cleared of all plants, large rocks and debris prior to construction. The role of the original topsoil is important to the flow regime, and none of it should be removed or compacted prior to construction of the mound. The surface may be broken up with a rototiller and left rough. Since digging or compressing soils when they are wet destroys permeabilities, no construction activity should take place when the soils are wet. The fill material should not be compacted, except for clay barriers which may be used at the base in some designs (see Bouma's approach below). Ideally, the mound material should be allowed to settle in place for several years before the mound is put into service, though it would not be practical to do so in most instances. A natural settling period of several months to a year would be helpful.

Specialized Designs

Bouma suggests two major approaches to mound design depending upon whether the mound is (1) over slowly permeable soil or hardpan located less than three feet below the soil surface, or (2) over creviced or channeled bedrock within three feet of the soil surface. In the first case, the design objective is to provide a base just wide enough to disperse the wastewater and to permit horizontal flow through the native soil without causing the effluent to daylight as it moves away. This type of mound will normally have a long rectangular shape. The sides of the mound will include a relatively impermeable clay barrier to help force the water down into the native soil and to prevent daylighting through the sides of the mound.

Fig. 10. Mound system over slowly permeable soils within three feet of soil surface. Source: J. Bouma, et al., *Soil Absorption of Septic Tank Effluent, A Study of Some Major Soils in Wisconsin,* Info. Circ. No. 20, Geological and Natural History Survey, Madison, Wisc., 1972.



The design objective for mounds built over soils underlain with shallow-creviced bedrock is to tailor the hydraulic conductivity of the fill to that of the native soil such that flow is gradual, uniform, and even, down to the bedrock. This will presumably permit the wastewater to receive adequate treatment before reaching the channels in the bedrock which can be direct conduits to ground water. This type of mound need not be long and narrow; more pleasing and economical shapes are possible. Figures 10 and 11 illustrate how these mounds are constructed. [Bouma's designs are presently undergoing continued demonstration and testing. For his results to date, see 17.]

Machmeier* has developed designs for individual mounds for sandy and clay soils. His design specifications for "gopher mounds" are shown in Figures 12 and 13. Note that the mounds incorporate dual-trench systems, which are to be alternated on an annual cycle.

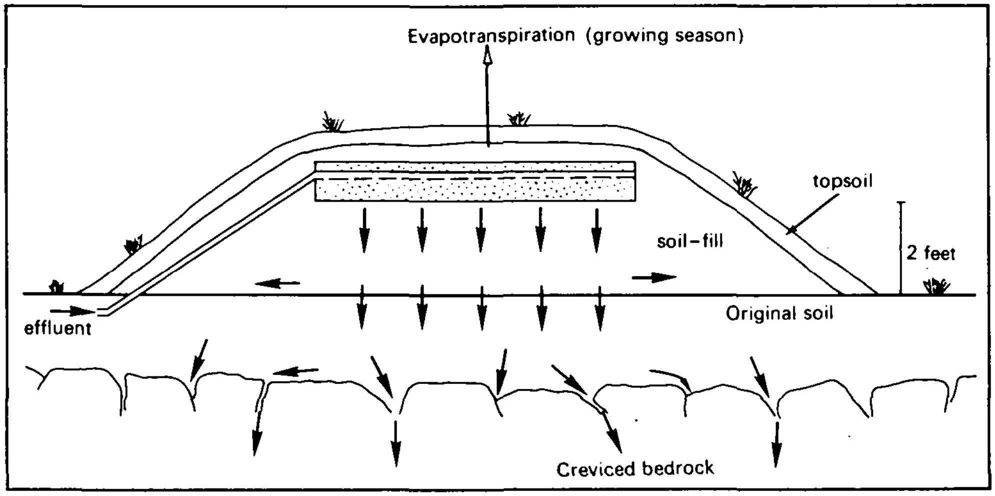


Fig. 11. Mound system over creviced bedrock within three feet of soil surface. Source: J. Bouma, et. al., *Soil Absorption of Septic Tank Effluent, A Study of Some Major Soils in Wisconsin,* Info. Circ. No. 20, Geological and Natural History Survey, Madison, Wisc., 1972.

Specially Engineered Subsurface Soil Absorption Systems†

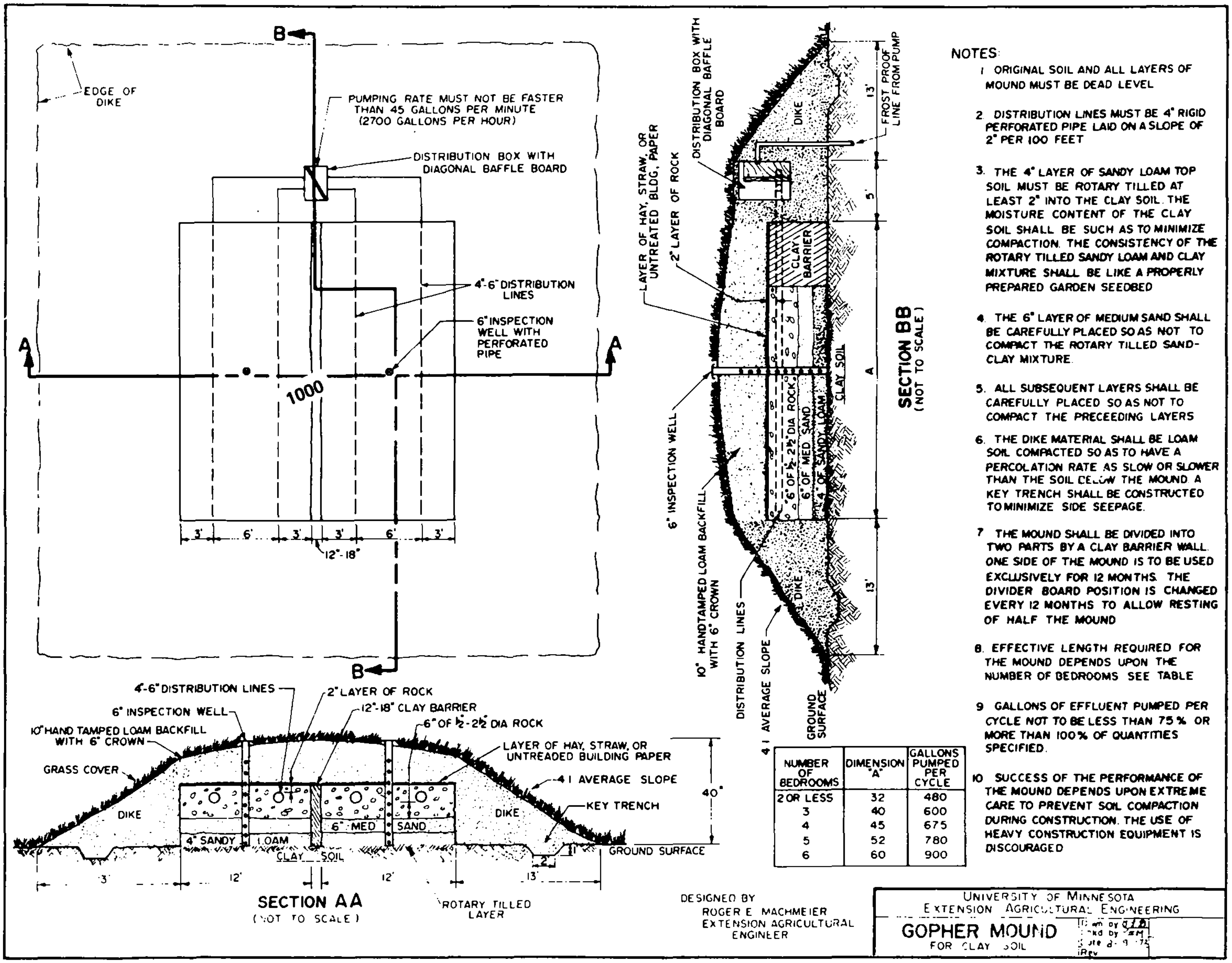
Hancor, Inc. has developed several systems which make use of their products for subsurface disposal of septic or aerobic tank effluent. Three of these systems are shown on the following pages.

Their Inverted Channel Air-Flow™ System is a modification of the Sheldon system. The drain holes are laid facing upward so effluent fills the entire length of the lateral before being able to trickle out into the trench. Solids settle out in the tubing, thus reducing the solids loading on the soil infiltration surfaces. The solids are removed periodically by flushing out the system as shown in Figure 14. The inverted system also ensures that effluent will be deposited fairly uniformly along the entire length of the trench. In conventional systems, effluent usually seeps out in the first several feet of the lateral, and only reaches the far end when the soil has become clogged along its length. An improved version of the system places the distribution lines within fifteen inches of the

*Roger E. Machmeier, Extension Agricultural Engineer, University of Minnesota, Institute of Agriculture, St. Paul, Minnesota 55101.

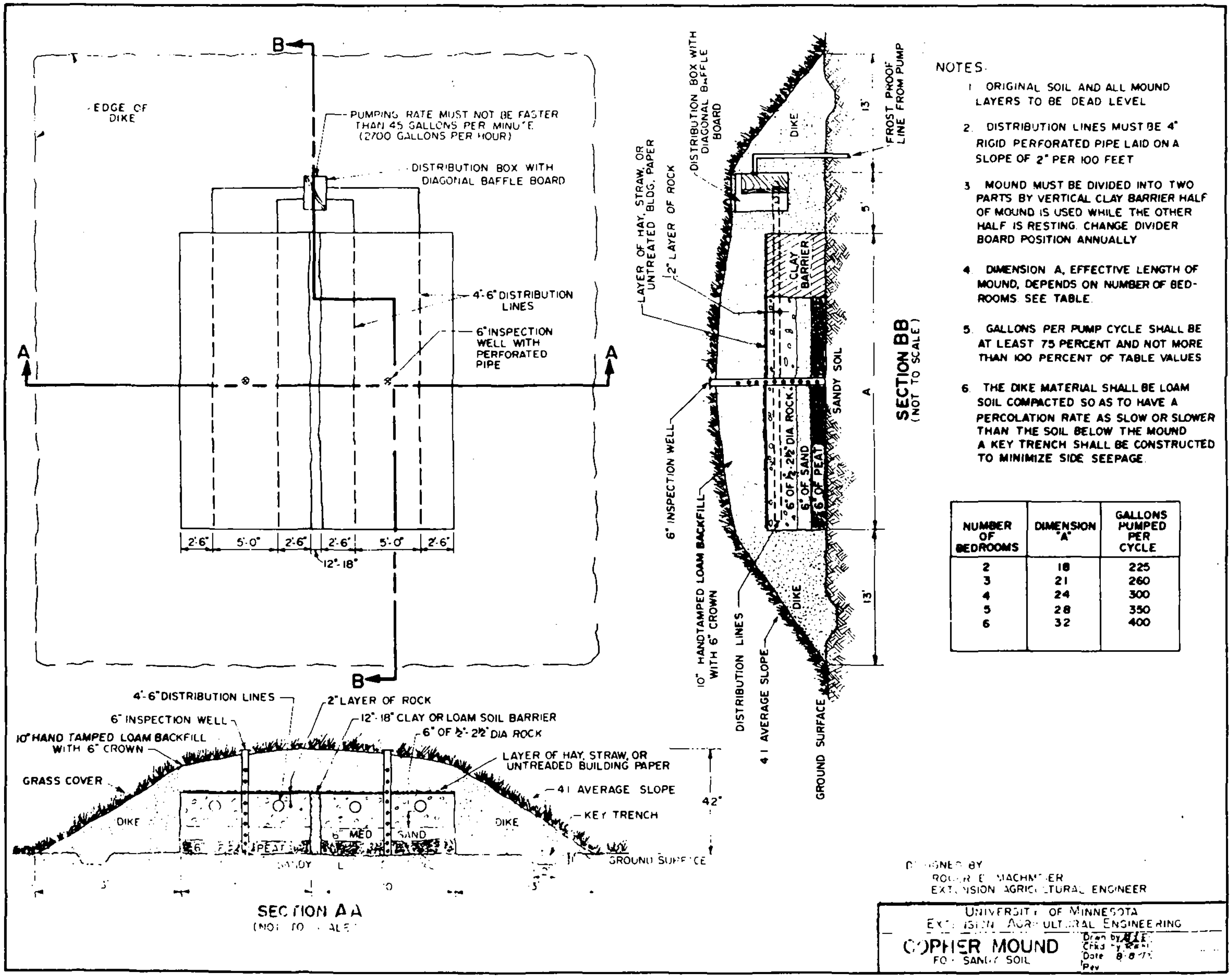
†Courtesy Hancor, Inc.

Fig. 12. Gopher Mound for Clay Soil. Source: University of Minn., Dept. of Agricultural Engineering.



NUMBER OF BEDROOMS	DIMENSION "A"	GALLONS PUMPED PER CYCLE
2 OR LESS	32	480
3	40	600
4	45	675
5	52	780
6	60	900

Fig. 13. Gopher Mound for Sandy Soil.
Source: University of Minnesota, Dept. of Agricultural Engineering.



NUMBER OF BEDROOMS	DIMENSION "A"	GALLONS PUMPED PER CYCLE
2	18	225
3	21	260
4	24	300
5	28	350
6	32	400

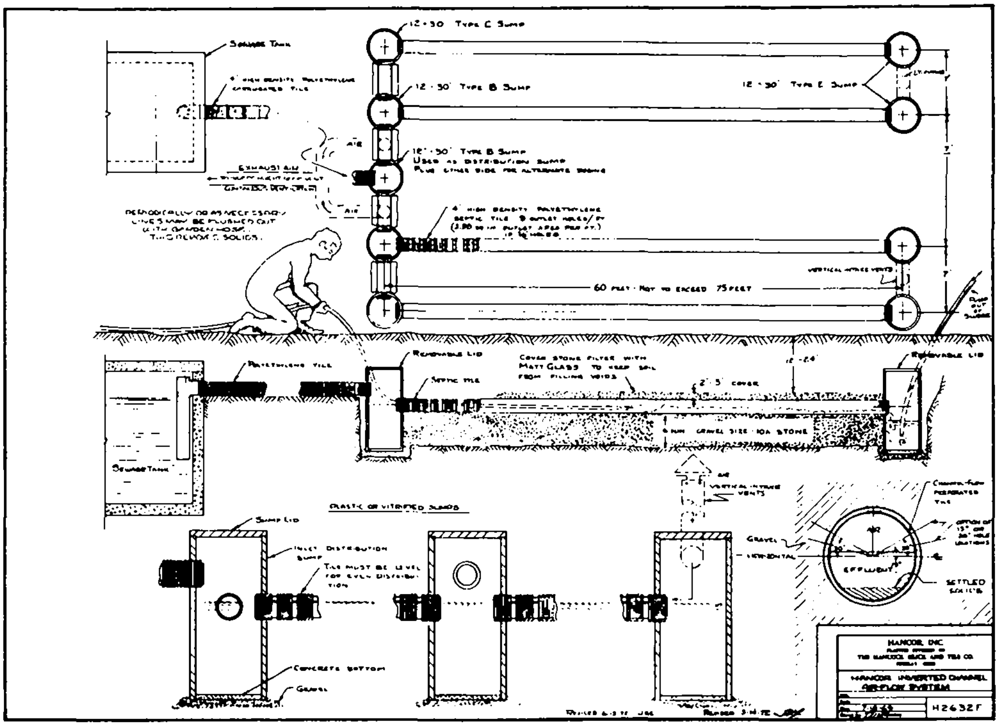


Fig. 14. Hancor Inverted Channel Air-flow System. Courtesy Hancor, Inc., Findlay, Ohio.

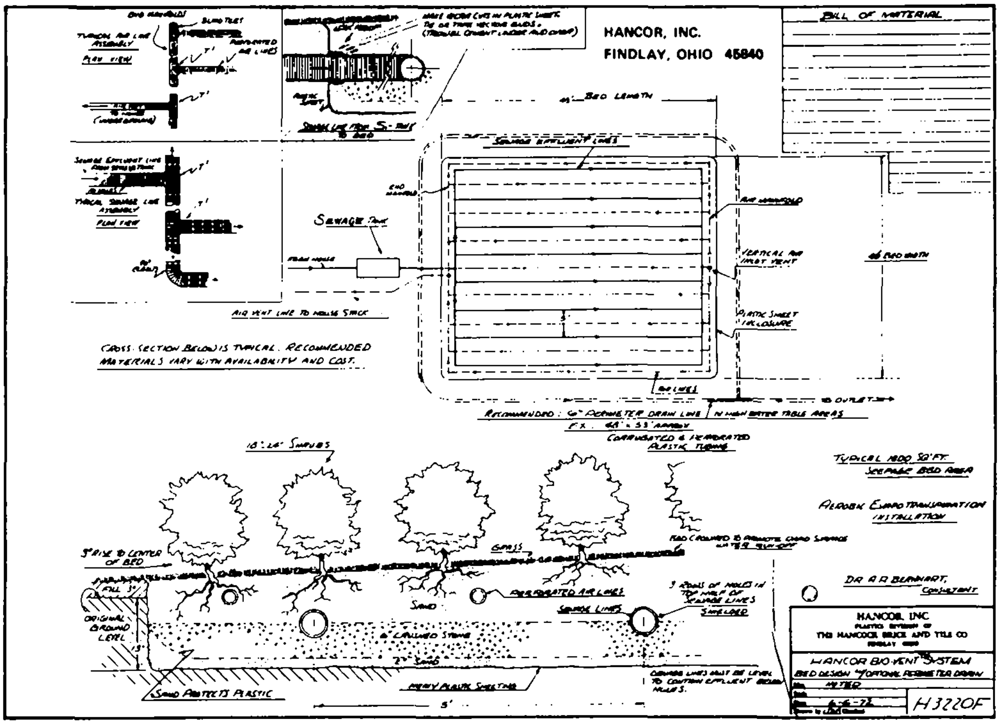
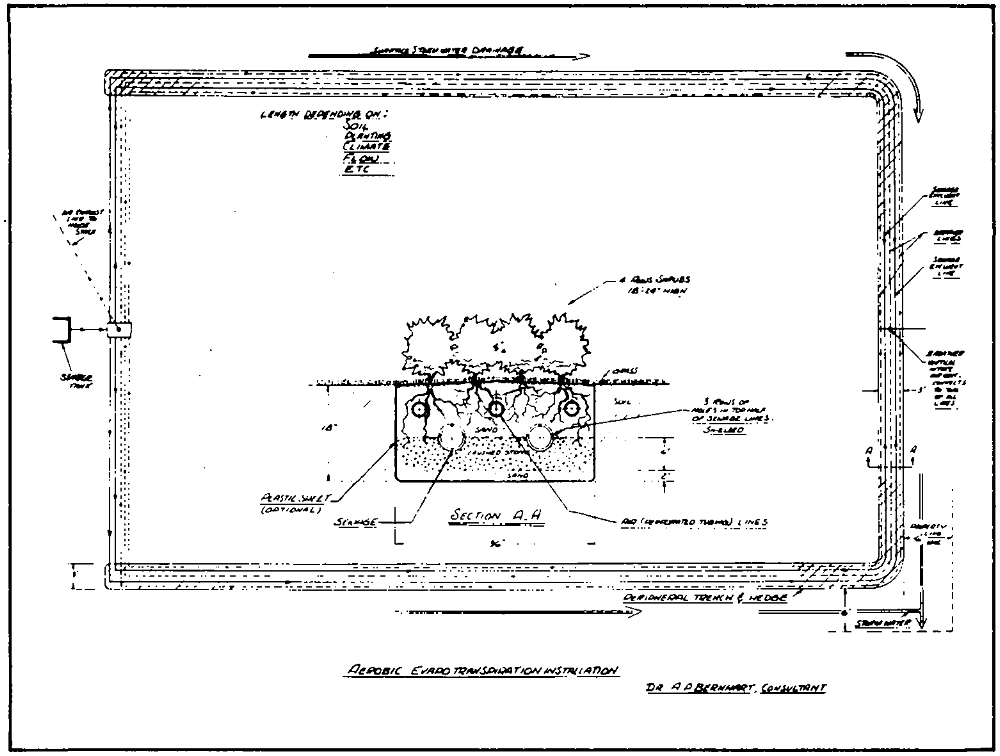


Fig. 15. Hancor Bio-Vent™ System (Bed design with optional perimeter drain shown.) Courtesy Hancor, Inc., Findlay, Ohio.

ground surface to enhance uptake of liquids and nutrients in the aerated root zone. The sumps are also extended to grade to permit easier access.

The Hancor Bio-Vent™ Bed and Bio-Vent™ Trench Systems, shown in Figures 15 and 16, were designed in collaboration with Bernhart, whose work is reported in Appendix A. The beds and trenches are innovative in that they include perforated air lines which run through the soil parallel to the effluent distribution laterals. The air lines are supplied by a vent pipe at the far end of the field. The near end of the air lines are connected to the plumbing ventilation stack at the house. The draft through the system can be improved by placing a wind turbine atop the house stack. These systems incorporate Bernhart's principles regarding improved performance of aerated soil absorption systems as compared to conventional systems.

Fig. 16. Hancor Bio-vent™ System (Trench design shown.)
Courtesy Hancor, Inc., Findlay, Ohio.

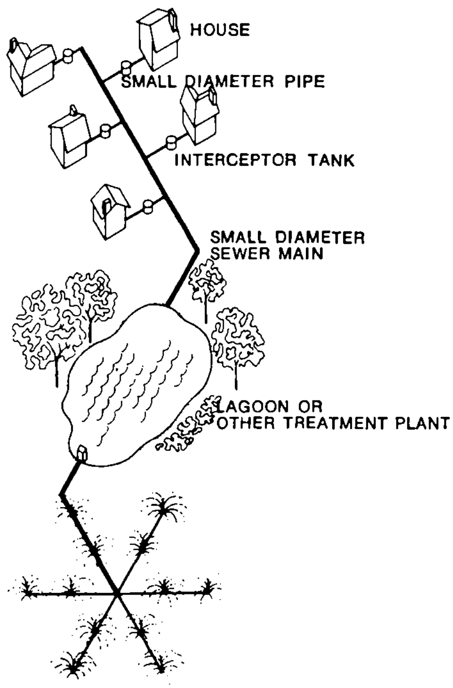


Composite Systems Using Pressure Sewers

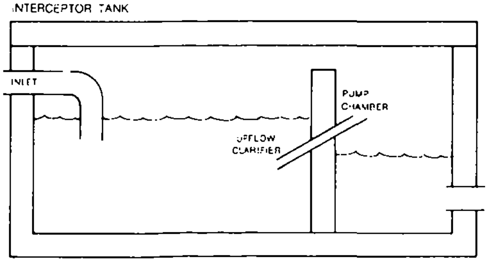
Most conventional systems are designed to treat sewage on-site (septic tank and soil absorption field, for example) or at a central location (municipal sewer system feeding into a treatment plant). A *composite* system includes both on-site and centralized treatment facilities. One example is the incorporation of homes with septic tanks and homes served by a conventional municipal sewer system into a sanitary district. Strictly speaking, this would be a combination of on-site and centralized systems, but this section is more concerned with systems which split the treatment for each home between on-site and centralized facilities.

Basic Design Concepts

The basic feature of a composite system that makes split treatment feasible is the use of small diameter pipe (approximately two inch) as pressure mains in place of conventional large diameter gravity flow sewer mains. For example, the Farmers Home Administration (FmHA) of the U.S. Department of Agriculture recently helped to finance projects in which two-inch polyvinyl chloride (PVC) pipe was bid in unclassified soil material with a cover of six feet for fifty-one cents per foot. Three-inch PVC was bid at seventy-one cents, and four-inch PVC was bid at ninety-seven cents. Conventional gravity sewers installed on grade cost about ten times as much. [19]



INTERCEPTOR TANK



Before sewage can be expected to pass through such small pipe, solids must be reduced to very small sizes. Devices which break up solids in sewage are called comminutors. Combination grinder and pump units can be placed at each house for an installed price of $1,200 to $1,800. The grinder-pumps can force the comminuted sewage through the small pipes to a suitable central treatment facility. Several grinder-pump units are shown in Appendix C.

Aside from high initial cost, one drawback of grinder-pump units is that the homeowner is vulnerable to pump breakdowns. The entire system would also be vulnerable to an electrical power failure. If homes are close enough for several to empty sewage through the conventional household sewer pipe into a single tank serving the group in common, two grinder-pumps can economically be placed in the tank, thus offering some stand-by capability in the event of breakdown of one.

The ground-up sewage will contain greases which can cause clogging problems downstream unless the system is designed with utmost attention to hydraulics. Settled septic tank effluent is relatively free of both grease and solids and may be a better candidate for pumping. It may therefore be advantageous to install a modified septic tank which will settle solids from the sewage and remove the requirement for a grinder. In such an arrangement, a simple submersible sump pump can be used, at costs of about $250 and up installed. Pumps are also illustrated in Appendix C.

Design Parameters

Rose has described a composite system using modified septic tanks and small diameter pressure mains. [19] He calls the modified tanks *interceptor tanks.* The system envisioned by Rose was based on an average wastewater production of 4,200 gallons per family per month, which is equivalent to an average of about 0.1 gallons/minute (gpm) or 140 gallons/day (gpd). Based on an assumed fifteen-minute peak demand factor of three times average, ten families would account for as much as 3 gpm (10 × 3 × .1 gpm). Thus, a 10-gpm pump would serve ten families with a comfortable safety factor. A 1000-gallon tank with 70 per cent effective storage space (30 per cent occupied by sludge and/or air voids) would be sufficient to hold four hours worth of flow for the ten families at the peak rate of 0.3 gpm per household. It would take a 2,000-gallon tank to provide twenty-four-hour average detention for the ten families at 140 gpd per family. In that case, two 1000-gallon tanks in series would be preferable to a single 2000-gallon tank, because more complete settling could be expected to result from two tanks in series.

The tanks would resemble septic tanks with an added sump compartment for pumping. The pipes connecting the first tank compartment to the second (pump sump) could be inclined upward in the flow direction (upflow) to provide additional solids separation capability. All tanks and pump equipment should be accessible from grade level for inspection, repair, and pumping of accumulated sludge at regular intervals.

The lines should be sized on the basis of creating a scouring velocity of at least 1 foot/second (fps) with 3 fps preferable.* Solids which may settle from the wastewater at low flow velocities should be resuspended and swept along (scoured) at the indicated velocities. The velocity of flow is found from the formula:

$$\text{velocity (fps)} = \frac{\text{flow rate (gpm)}}{2.45 \times [\text{diameter (inches)}]^2}$$

Accordingly, a two-inch pipe would pass 10 gpm at about 1 fps, so that a pump of at least 10-gpm capacity should be used with two-inch pipe to achieve adequate scouring velocities. A two-inch pipe could handle, at a velocity of 3 fps, the flow for a community of one hundred families simultaneously producing sewage at the peak rate of 0.3 gpm each. Thus a two-inch pipe would also be adequate as a trunk sewer. Air relief valves may have to be installed at elevated points in the line to relieve a gas-bound condition. Gas may be formed from decomposing sewage. Gas is also introduced into the line when it is opened for inspection or for new tap-ins.

The hypothetical community of one hundred homes could also be served by vacuum sewer mains. In that case, the sump compartments of the tanks would be outfitted with heavy float valves to permit flushing in discrete doses and to permit the attaining of scouring velocities. Two 20-gpm horizontal centrifugal booster pumps capable of developing 10 pounds/square inch (psi) suction throughout the system should be capable of handling the chore. [19] The advantage of a vacuum collection system is that only one pumping source would be required for the entire community, and the single pump could be provided with standby power in the event of a power failure.

*Cecil W. Rose, Farmers Home Administration, USDA So. Bldg., Washington, D.C. 20250. Personal communication, May, 1972.

If the topography is favorable for elevating the tanks with respect to the sewers, the tanks could be fitted with float valves and dosing siphons. They would empty into the sewers under a gravity head alone, and with a modest fall along the sewer line it might be possible to design a system that would not even require mechanical pumps.

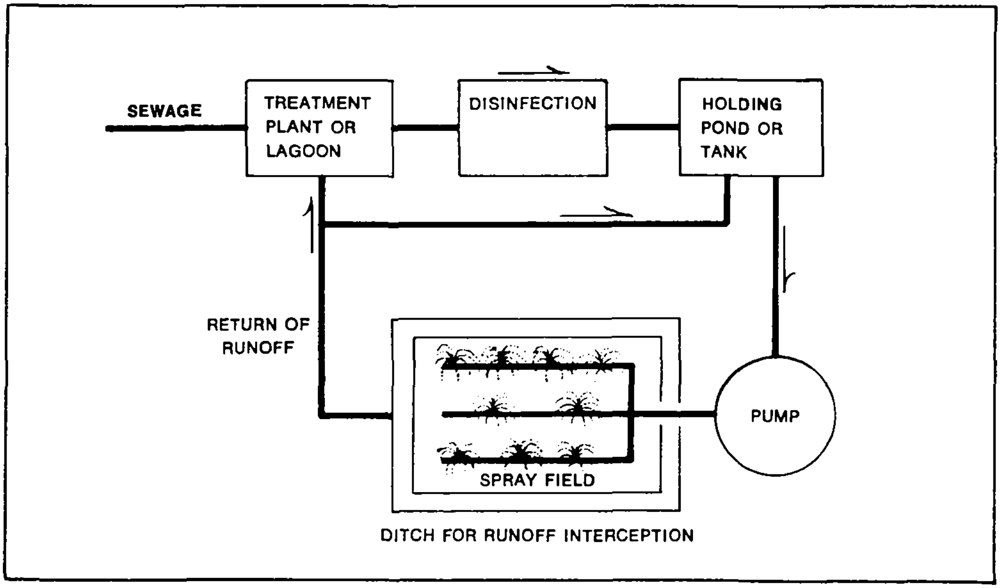
The scouring of long lines can be insured by placing a large (approximately 1000 gal.) flushing tank at the end of the line and permitting it to discharge once a day by means of a clock-controlled solenoid valve.

Land Spreading by Spray Irrigation

General Concepts

It has been estimated that by the mid-1960's more than 1,300 sewage treatment systems in the United States disposed of the effluent from their treatment plants by spreading it onto the land. Land spreading by flood, trickle, or spray irrigation is a feasible means of tertiary treatment. The process is illustrated schematically in Figure 17. Most of the considerations and precautions which apply to subsurface percolation of effluents also apply to surface spreading: the need to protect ground water quality, the clogging of soils under continuous inundation, contamination with microorganisms, and so forth. [20] Contamination with microorganisms is particularly important with spray irrigation since the aerosol created by the spray nozzles can contain and transport microorganisms. For this reason, some authorities require coliform counts ranging from swimming water quality (several hundred coliforms per 100 milliliters of water) to drinking water quality (generally less than 2 per 100 ml.). Irrigation of steeply sloping lands should also be executed with care to avoid soil erosion problems and possible concentration of effluent in converging runoff rivulets.

Fig. 17. Schematic diagram of spray irrigation *of treated effluent.*



Surface spreading of effluent may be used merely as a means of getting rid of liquid in a manner that will not pollute surface waters. Many systems, however, make positive use of the dissolved nutrients in wastewater for beneficial irrigation of crops. It has been calculated, for example, that 60 to 100 pounds of nitrogen, 60 to 100 pounds of phosphorus, and 20 to 40 pounds of potassium are available in each acre-foot of typical sewage effluent used for irrigation. [21] Yields of crops grown in soils thus irrigated are often more than 100 per cent greater than in non-irrigated plots. The increased yields continue for a few years after irrigation with effluent has been stopped.

Hortenstine concluded that:
"Spray irrigation of sewage wastewater on agricultural land is a feasible and efficient method of wastewater renovation. Removal of organic particles, nitrogen, phosphorus, and other constituents from the water is effected by the soil-plant system and this system can be maintained indefinitely under proper management." [21]

The land onto which wastewater is sprayed is much more than a gigantic mechanical filter. Heavily polluted water cannot be dumped onto porous soil and receive adequate treatment. The soil must be managed as a complex biological community, a "living filter." Maintenance of the living filter depends on a dense crop of living plants to remove nutrients in the wastewater. Soil must not become waterlogged, or it will become anaerobic and the soil organisms and plants which renovate the wastewater will die. Spraying operations should therefore be halted in wet weather when the ground is saturated. Likewise, toxic materials should not be applied, nor should materials toxic in large doses be allowed to accumulate in the soil.

According to Huckle, "One of the most important characteristics of a soil that affects its suitability for sprinkler irrigation is the water it can hold for plant consumption. This is available water capacity (AWC) of a soil, and is the range of soil water between the point where plants permanently wilt and field capacity. Field capacity is the amount of water held by the soil after free drainage has taken place. AWC is measured in inches of water per inch or foot of soil." [22] The frequency of applying irrigation water depends on the AWC in the plant root zone, the rate at which soil moisture is consumed and transpired by the plants, and the soil drainage.

Septic tank effluent should not be sprayed directly without additional treatment, nor should effluent from an anaerobic lagoon be sprayed, without first passing through an aerobic lagoon. This precaution is to minimize odors and prevent overloading of the soils' aeration capacity.

No spraying should be done on bare or disturbed soil. Even if the area is not cropped, ground cover is necessary to protect the soil from erosion, to shield the surface from droplet impact, to provide for evapotranspiration, and to increase infiltration rates. [23] A covered field will accept up to 85 per cent more water than an area with little or no vegetation. [24]

General criteria and rules of thumb for designing land spreading systems for partially treated sewage are described below. The criteria are included as flexible guides and should not be interpreted as rigid standards.

Area Requirements

Size of Spray Field. The amount of land required for spray irrigation may be approximated by the quotient of the amount of effluent generated (e.g., acre-inches per day) and the allowable application rate (e.g., inches per day). For instance, if a design value of 100 GPCD is used, 1000 people will call for 100,000 gpd which is equivalent to 3.68 acre-inches per day.* If the allowable application rate (to maintain field capacity) is 0.25 inches per day, then 3.68/.25 = 14.72 acres of land will be required for the spray area *(or for the flood area if flood irrigation is used). This combination of parameters is* equivalent to a loading of 68 people/acre.

* 1 Acre-inch = 27,154 gallons
1 Acre-foot = 325,848 gallons
1 Million gallons per day = 695 gallons per minute
= 36.8 Acre-inch per day
= 3.07 Acre-feet per day
= 1105 Acre-feet per year

Actually, a loading of about 100 population equivalent per acre is a rather conservative rule of thumb, since in warm weather about 0.5 inches of effluent per day can be applied to good soils under cultivation, and 0.5 inches per day would correspond to about 150 population equivalent per acre. The more conservative criterion of 100 people per acre is to be preferred for a permanent system because the soil should, on the average, receive only about half its maximum infiltrative capacity. [25] This can be accomplished by uniform spreading at half-maximum rates of application, or, preferably, by alternating spraying between two or more fields with weekly (or longer) resting periods. [23] The resting cycles permit aerobic conditions to be reestablished in the soil which would otherwise become clogged and anaerobic under prolonged waterlogged conditions. The situation is much the same as in the practice of alternating soil absorption (tile, drainage) fields in a septic tank installation.

The above rules of thumb are very general and exclude the important effects of temperature. The ability of the soil to process effluent is related to temperature, as illustrated by the following guidelines suggested by Cochran: [25]

Mean Temperature (°F)	Allowable Application Rate *(inches/day)*	Required Spray Field Area *(for 1,000 Population @ 100 GPCD and Alternating or Half-maximum Usage, in acres.)*
70	0.64	11.4
60	0.50	15
50	0.36	20
40	0.20	36
30	0.07	104

Accordingly, for mean temperatures of 50°F, about two acres per 100 population equivalent are required.

Many localities which experience freezing temperatures in winter require sufficient storage capacity to accommodate the total winter's effluent. The greater the storage, the more spray area that will be required for warm weather spraying. For example, if six months' worth of effluent is stored in the winter, then twelve months' worth of effluent will have to be applied in six warm months, effectively doubling the acreage requirements.*

A loading of 100 population equivalent per acre corresponds to about 17 pounds of BOD_5 per acre per day. This value is within the recommended BOD_5 daily loading limit of 10 to 20 pounds per acre of surface area for lagoons in cold climates. The area required by a lagoon, if used, is in addition to the spray field area.

Lagoon Area. If a lagoon is used to stabilize the sewage prior to spraying, it is recommended that a maximum BOD_5 loading of 15 to 20 pounds/acre/day be used in cold climates (ice cover more than one-third of the year) and up to 50 pounds/acre/day in winter and 150 pounds/acre/day in summer in warm climates. The greater loading rates depend on photosynthetic production of oxygen by algae which is only appreciable on warm sunny days. If recommended loading rates are exceeded, the ponds can go anaerobic and bad odors will be produced. Also, the wastes will receive less complete treatment. The low loading rates for cold climates will permit a rapid turnover of the pond from anaerobic to aerobic conditions when the ice cover thaws in early spring (surface reaeration by physical means alone in the absence of algal photosynthesis is in the 12 to 16 pound/acre/day range). [26]

Lagoons which depend upon natural processes for aeration should not be more than about five feet deep because sunlight can penetrate only several feet, and a very deep pond would become anaerobic below the zone of sunlight. However, ponds ten feet or more deep can be operated with mechanical aerators, which keep the water circulating and aerated. A minimum depth of three feet will help to control weed growth and mosquito breeding. [23] The surface area required for lagoons of various depths and holding periods is shown in Table 14.

The lagoon bottom should, in general, be sealed to prevent seepage of sewage into the soils where it could contaminate ground water. An exception is a pond underlain by soil of sufficient depth and quality to permit intentional use as a seepage pond which is designed to lose a large portion of its contents by seepage. Most ponds will, of course, also lose considerable amounts of water by evaporation.

Total Area of Spray Installation. The total size of the installation will be the sum of the lagoon (and/or holding pond) areas, plus the spray field, plus additional surrounding ditch and buffer zone areas. Interceptor ditches should be used on sloping land to

*Six months' storage followed by six months' spraying has several advantages, however. Among them: lower operational costs for the spraying part of the system; added treatment over the longer detention time; nutrients tend to be bound up in algal and protozoan cells and thus are released more slowly after being applied to the soil.

catch surface runoff of effluent and prevent it from reaching areas outside the facility or surface waters. The intercepted runoff effluent should be returned to the lagoon or holding pond or tank. Diversion ditches should be provided to minimize the storm runoff which impacts on the lagoon and spray field.

Buffer zones of 400 to 800 feet are often recommended to protect neighbors from contamination by aerosols. [25] Protection is increased if trees or tall shrubs are planted around the spray area. The plant roots can also be used to advantage as a subsurface barrier to horizontal travel of effluent. If possible, the site should be more than one-fourth of a mile from developed areas. [27, 28] The buffer requirements may be reduced if the effluent is disinfected prior to its being sprayed. However, unless the designer has a strong basis for confidence in the effectiveness and reliability of the disinfection process, this expedient is best not used. (Disinfection may be required in some locations.)

System Components and Layout

It is important that solids be removed from the effluent before spraying. This can be accomplished by sedimentation in lagoons as well as by screening through twenty- to forty-mesh screens. Screening or a settling tank should be used with wastes from agitated lagoons with high solids contents.

Larger nozzle diameters on sprinklers reduce clogging but increase droplet size. Small droplet size is desirable because it promotes evaporation before the spray even reaches the ground.

Pumps should be relatively immune to clogging. Centrifugal pumps are recommended, and if suction lift is required, the pumps should have a self-priming feature. [24]

Materials should be chosen carefully, as some chemicals in wastewater are corrosive to brass, aluminum and galvanized steel. The lines which feed the sprinklers can be buried below ground (solid set) or set above ground. Above ground lines have the

Table 14. Lagoon Surface Area for 1,000 Population Equivalent.
(@ 100 GPCD)

Depth *(feet)*	Holding Time *(days)*			
	7	30	180	360
4	.54 acres	2.3	13.8	27.6
6	.36	1.5	9.1	18.4
8	.27	1.1	6.9	13.8
10	.21	.9	5.5	11.0

Source: Robert A. Cochran, "Disposing of Human Sewage Effluent through Spray Fields and Living Soil Filters," private communication through Western Rain Bird Sales, Northwestern District, 626 Whitman, Walla Walla, Wash. 99362, Nov. 17, 1971.

advantage of portability, but they are subject to freezing in cold weather, and in warm weather their contents can decompose anaerobically (putrefy) if they are not drained after each use. Above ground lines are often made of aluminum, which can be subject to corrosion. Solid set lines are usually of polyvinylchloride (PVC), asbestos cement or steel construction. They can be set below the frost line with only risers and nozzles protruding. As with all systems subjected to inundation, contact of dissimilar metals should be avoided to prevent electrolytic decomposition.

Common sprinkler spacings are 80 ft. by 80 ft., 80 ft. by 100 ft., and 100 ft. by 100 feet. [24] Unlike strict agricultural applications where the design objective is to spread water on the soil evenly, the objective of spray irrigation of effluent is to dispose of as much water as possible into the soil without injuring the living filter or causing excessive runoff. Therefore, sprinkler coverage should not be overlapped in effluent spraying. [23] The spray field should be properly graded and underdrained where necessary. Both measures prevent ponding of effluent. Effluent from the drains should be returned to the lagoon if sufficient renovation has not occurred.

Cochran has prepared the following rules of thumb for sprinklers placed 80 ft. by 80 ft. (equivalent to seven sprinklers per acre): [25]

12.5 gpm per sprinkler = 0.18 inch per hour
16.0 gpm per sprinkler = 0.24 inch per hour
20.5 gpm per sprinkler = 0.30 inch per hour

The maximum recommended precipitation rates are:

Light sandy soil	0.3 to 0.7 inch per hour
Medium textured soil	0.2 to 0.4 inch per hour
Heavy textured soil	0.1 to 0.2 inch per hour

Spraying should be on an intermittent schedule. This requires an arrangement for dosing or rotating among different sprinklers. Sepp recommends dosing at the rate of 10 minutes per hour in hillside installations. [23] The intermittent spraying not only minimizes surface runoff, but it takes advantage of the evaporation losses that are possible in air unsaturated with moisture. Cochran observed situations of rapid sequencing among sprinklers (6 minutes on—54 minutes off) where there was 100 per cent evaporation, i.e., absolutely no water intake into the soil, as compared to 12 per cent evaporation in a conventional system. On hot days of low humidity, rapid sequencing could be done for about 10 hours of daylight followed by long-set irrigation for the remaining 14 hours to supply moisture for plant growth. [25] This approach could significantly reduce the acreage requirements by disposing of more liquid through the evaporative route.

Whatever the spraying schedule, most authorities recommend that it be effected by well-designed automatic controls rather than manually. This reduces the influence of the human element and requires less operation control. The savings in expert operator time that are possible with automatic controls can be applied to a program of regular inspection of the spray equipment and fields by the operator, since nozzles can clog and jam, runoff rivulets can grow to undesirable size, and so forth.

In addition to the buffer zones and protective plantings discussed earlier, the entire installation should be fenced or otherwise secured to prevent public access.

The Use of Treated Wastewater as a Resource for Fire Protection

Many rural communities will want fire protection services built in along with water supply and wastewater treatment systems. Treated wastewater can be a valuable resource for fire protection in communities where supplies of drinking water are limited. The opportunity of so using treated wastewater should not be overlooked by the community in formulating a fire protection plan.

For most small communities, peak fire-fighting demands will exceed domestic demands. This means that if the same water supply is used for both drinking and firefighting, the sizing of mains will be dominated by fire-flow considerations. Practically speaking, six- eight- or perhaps even ten-inch diameter mains will be required for delivering adequate fire-fighting flows, when two- or four-inch mains would have done the job for domestic water supply alone.

Domestic and fire-flow requirements are compared in Table 15, which was derived on the basis of the following criteria:

a) *Minimum design for domestic demand:* based on 3.5 people per household connection which decreases from 1.5 gpm at about 29 connections to 0.5 gpm per connection at about 290 connections and beyond.

b) *Peak fire flow* (in gallons per minute): $1020\sqrt{P}\,(1.0 - 0.01\sqrt{P})$, where P is the population *in thousands.* [29]

c) *Duration of fire* is 4 hours (1 and 2 story buildings generally adequately spaced to prevent spreading of fire).

d) *Residual line pressure* is a minimum of 20 pounds per square inch (psi) with the hydrant open. Pressure to be supplied either as city line pressure or by use of local elevated storage tanks.

Note that for populations under approximately 50,000, fire-flow requirements will always exceed domestic demand. Further, it is doubtful that criterion (c) would be satisfied at populations much beyond 10,000, i.e., houses would probably be close enough to permit the spread of fire at populations greater than 10,000.

It follows that at the low population levels which will be served by rural water supply systems, *significantly more water storage capacity,* as well as water transmission capacity, would have to be added over and above domestic supply needs to meet fire protection requirements. Even then, if the fire were to spread, the community could be seriously endangered. Wastewater treatment systems that collect effluent at a central point—either a community or a composite system—can and should form a part of a fire protection plan, if only as a reserve supply of fire-fighting water.

The total amount of water (in gallons) needed to meet the 4-hour criterion is 240 times the peak fire flow (in gallons per minute, gpm). Since the domestic demand criterion appears to have been based on a 100 GPCD water usage, it may be conservatively assumed that only 75 GPCD becomes treated wastewater which is held in reserve. If the total 4-hour fire flow (240 times peak) is divided by the daily production of treated wastewater (figured at 75 GPCD), the result is the number of days' accumulation of treated wastewater that would be required to meet the 4-hour supply criterion for *one* fire. Table 16 shows the total 4-hour flow and the number of days' accumulation of treated wastewater required to satisfy the criteria.

It can be seen from the table that a storage system such as a lagoon or deep aeration basin, or even a system of cisterns sized for a month's storage of wastewater will have sufficient water for fighting anywhere from three to thirty fires. Polishing lagoons or deep

Table 15. Estimated Peak Domestic and Fire-fighting Demands on a Small Water Supply System.

Population *(thousands)*	Peak Domestic Demand (gpm)	Peak Fire Flow (gpm)
0.1	43	322
0.2	57	454
0.3	70	556
0.4	85	641
0.5	100	716
0.6	105	783
0.7	110	846
0.8	125	904
0.9	135	958
1.0	145	1010
2.0	285	1422
3.0	430	1736
4.0	570	1999
5.0	715	2230
10.0	1430	3124
20.0	2860	4358
50.0	7145	6702

tanks are often used for additional secondary treatment and also for storage in effluent irrigation-disposal systems for times when either excess rainfall or freezing temperatures do not permit irrigation.

The mere presence of adequate wastewater does not give any protection against fires. There must be a way of getting it to the fires. This can be accomplished by having separate fire and water supply mains. The fire mains could be supplied from both drinking water and treated wastewater sources in an emergency. Depending upon population distribution, holding cisterns for treated wastewater could be placed strategically throughout the community. They would be filled through small diameter pipes supplied by low capacity pumps at the wastewater treatment plant. The supply rate to the cisterns would be such that it could take days or even weeks to fill them, since their contents would be used infrequently. Storage cistern water would be pumped to the fire by pumper trucks operated by the fire company. Conveyance lines could be eliminated entirely if water trucks were available.

In any of these cases, the protection gained from using treated wastewater and the cost of supplying treated wastewater should be compared to the protection and costs associated with an all-drinking-water system. For example, if drinking water is available

Table 16. Total Four-Hour Fire-Flow Needs and Number of Days' Accumulations of Treated Wastewater Required.

Population *(thousands)*	Total Four-Hour Fire-Flow Need *(thousand gallons)*	Number of Days' Accumulation of Treated Wastewater *(@ 75 GPCD)*
0.1	77	10.3
0.2	109	7.3
0.3	133	5.9
0.4	154	5.1
0.5	172	4.6
0.6	188	4.2
0.7	203	3.9
0.8	217	3.6
0.9	230	3.4
1.0	242	3.2
2.0	341	2.3
3.0	417	1.9
4.0	480	1.6
5.0	535	1.4
10.0	750	1.0

from plentiful high-quality surface supplies, then the cost of providing drinking water for fire protection will be accounted for mainly in the oversized mains and pumps, and the hydrants. On the other hand, if drinking water comes from a source of poor quality and limited capacity, then the added costs of excess drinking water treatment capacity and storage for contingencies could be significant.

Chapter Five

Operation of Rural Wastewater Systems

In the operation of municipal sewer and sewage treatment systems, the costs of equipment and manpower for maintenance and monitoring are spread out over a large user community which pays for sewage collection and treatment services but does not participate in the provision of those services.

Maintenance in rural situations, on the other hand, depends to a large degree upon the cooperation and participation of individuals in the community served. In the traditional septic tank installation, for example, once the local health department licenses and approves the system, the householder is on his own. He is the owner and the operator of the septic tank and soil absorption system. If the system fails and his toilets back up, he is likely to correct the situation. On the other hand, if the system fails by allowing septic tank effluent to break through the surface of the ground or by permitting effluent to reach groundwaters before receiving sufficient treatment in the soil, the situation may not be recognized, and it is unlikely that it would be corrected if it were recognized unless a third party complained to the health authorities.

These problems are the result of traditional system practices in the U. S., but such problems need not be invariably associated with the use of individual wastewater systems. Individual wastewater systems in rural communities could be used effectively and economically if there were generally a better understanding of the principles upon which they should be designed and if management organizations were developed to assume responsibility for their operation and maintenance. Such management organizations are discussed more fully later in this chapter.

Maintenance and Service

Septic Tank Systems

Septic tanks should be inspected every year or so for sludge build-up. Depending on the size of the tank and rate at which it is loaded, the sludge should be pumped every two to three years to prevent sludge from being carried out of the tank and permitted to clog distribution lines, and to preserve sufficient volume in the tank to permit effective detention of the incoming wastewater. (Specific guidance on pump-out is given in

Table 11.) Aside from this minimal maintenance and, possibly, the diverting of the effluent from one absorption field to another in installations employing alternate fields, there is little regular attention required.

Aerobic Systems

Individual aerated systems, on the other hand, are dependent on regular maintenance since they employ an electrically-powered aeration device. The air compressors require routine inspection, oiling, and replacement of vanes, seals or filters. If a compressor fails, the system will shift from an aerobic to an anaerobic (septic) state within a day or so. For this reason, many jurisdictions require that individual home aerobic units be of sufficient volume to act as acceptable septic tanks should the aerator fail.

In addition, it has been reported that sludge bulking, a decrease in density of the sludge to the point that it will not settle, sometimes occurs in individual aerobic systems, especially in response to highly variable loading patterns. Carryover of bulked sludge may cause adverse effects on a soil absorption system, but documentation is lacking.

The homeowner must have some means of determining that an aerobic system has broken down without his having to sample and check the effluent regularly as in a municipal plant. National Sanitation Foundation Standard 40* requires a positive means of alarm to signal failure. Several parties have suggested the tying of an alarm signal to a relay that will turn off a key household electrical circuit such as the one that powers the television or even the water supply to the toilets in the event of failure. A few manufacturers dispose of treated wastewater in batches by means of a pump. (See Appendix C.) If the compressor fails, the pump circuit can be rendered inoperative. In that case, once the tank capacity had been reached, the plumbing fixtures in the house would not drain or flush. This approach provides an incentive to the homeowner to get the system fixed as well as a means for preventing the discharge of poorly treated sewage because effluent can't overflow through the pump.

Presently, service is at best an unevenly supplied and chance affair. The market for individual aerobic systems is generally too small to support an adequate service organization. Several of the more responsible manufacturers of aerobic systems have recognized that the small size and fragmented nature of the market prevents them as individual companies from offering adequate service. They are attempting to form an association which would try to organize service facilities to maintain products of a number of manufacturers. A pooling of service resources, at least in the short range, may help to improve the overall workability of individual aerobic systems and thus remove a key obstacle to their acceptance by many local authorities.

*See Appendix B.

Package Plants

Package plants face similar service problems. A facility which serves from tens to a few hundred homes is not normally sufficiently capitalized or supported to pay for full-time operational and maintenance personnel. If several subdivisions cooperate, they can share the costs of staff. Institutional factors can, of course, make cooperation a tenuous and difficult quality. For example, if all subdivisions are equal, who bears the administrative burden and responsibilities of the employer? If an administrative staff is to be established, how does it relate to the constituent subdivisions? How does it have to relate to the county or state?

At least one manufacturer of package plants builds service into the pricing and operation of their systems. Their service arrangements include routine testing of effluent quality and reporting of same to the owner. While this might reasonably be provided in a territory with many installations, it is difficult to see how such services could be provided economically for isolated plants.

The California State Department of Public Health, Bureau of Sanitary Engineering, conducted a survey of sewage disposal in communities in the Sierra Nevada Mountains and part of the San Bernardino Mountains which illustrates how efficiency is affected by the absence of servicing. [30] The area surveyed included all or part of twenty-three counties, and a good portion of the area was under the management of the National Forest Service or National Park Service.

At the completion of the study, the Bureau pointed out that "there is a great need for provisions for reliability of treatment and disposal operations in order to protect the public health."

It was also recognized that "small treatment plants often do not have full-time operators who are competent to handle breakdowns."

The data collected by the Bureau were startling; some of it follows:

"Experience has shown that interruption in sewage treatment is a relatively common occurrence. In 1964, the Bureau of Sanitary Engineering conducted a study of the public health aspects of sewage collection and disposal in the Central Valley. The results indicated that 56 per cent of the plants had experienced equipment outages during the preceding year. Chlorination equipment was reported out of service by 18 plants, with the outage varying from an hour to an entire year. Sedimentation units were out of service in 36 plants or 11 per cent of the plants. The sedimentation outages varied from an hour to 9 months. Trickling filters were reported inoperative by 20 plants and 17 digesters were reported out of service. The outages in these critical biological units ranged from an hour to 9 months. Thirty three per cent of the plants reported the necessity of bypassing untreated sewage for periods ranging from 6 hours to an incredible 300 days!"

In summary, the data collected presented the following unpleasant picture:

"55 per cent of community subsurface disposal systems had failed, 27 per cent of evaporation-percolation ponds (only) had failed, 33 per cent of ponds and hillside spray or irrigation systems had failed, 45 per cent of hillside spray (only) systems had failed, and 51 per cent of the systems with planned surface discharges had failed."

In design work, the consulting engineer should choose processes and equipment while bearing in mind that maintenance will most likely not be provided.

Management Organizations

The development of collective public (perhaps municipal) institutions which would assume responsibility and/or authority for approving designs and installations and for providing routine inspection, maintenance, and corrective action in the event of failure is the most needed advance in small wastewater treatment system practices. Such public entities are reportedly commonplace in several European countries.

Although the concept is novel in this country, recently established public entities for California subdivisions utilizing septic tanks have been described by Winneberger and Anderman. [31] The "total management" concept developed through their efforts involves six "Criteria for Public Entities to Manage Septic-Tank Practices or Other Individual Sewage Disposal Systems." They state that the criteria are not concerned with the form of the public entity but rather the "kind of results needed to do the job." Their criteria are:

1. The legal entity should be responsible for the outcome of practices which have historically been relegated to the health department and the public.

2. The legal entity should provide services including:
a) design of each individual system,
b) inspection of installations, and
c) maintenance of individual systems.

3. The legal entity should maintain adequate records to provide proper guidance to the program.

4. The legal entity should provide professional skills needed to improve practices, such as
a) a full-time environmentalist to perform needed work, and
b) services of consultants for initial instruction and unusual workloads, special problems and occasional review. (During slow development, a consultant might serve until the workload justifies employment of a full-time sanitarian.)

5. The legal entity should have the authority and power to provide community collection systems whenever and wherever needed.

6. The legal entity should carry on a comprehensive watershed protection program (where appropriate) in conjunction with the local health entity, the state pollution control entities, and other pertinent public entities."

The Georgetown Divide Public Utility District, in cooperation with the El Dorado County Health Department,* adopted an ordinance for the Auburn Lake Trails subdivision which attempts to do the total management job as outlined by Winneberger and Anderman. This is a noteworthy accomplishment, since Auburn Lake Trails contains almost 1,800 building lots which are designed for septic tank installations.

Another view of sewage disposal districts has been offered by Quigley and Beatty, [32] who made the following preliminary observations about Town Sanitary Districts (legal entities, in Wisconsin):

". . . control over improper waste disposal hinges on the constituents. If it is too expensive to correct problems, or if there is no direct nuisance created by malfunctioning systems, a Town Sanitation District may be no more effective than individuals. One Town Sanitation District [in their survey] did not report it because of high repair costs. The discharge went downstream. The county sanitarian discovered the problem after a few *years* [emphasis supplied] and put pressure on the district. If an individual home-owner does not repair a faulty disposal system it is that individual's decision until the problem is reported. In a Town Sanitary District one householder can refuse to repair a malfunctioning system only if all the members of that district decide not to comply. If one member wants the system to function he can require all of the disposal units to be repaired. Whether or not members would know if their district's system(s) were failing is not known. In areas where soil absorption systems do *not* function well and [sic] there is a greater incentive for members to tolerate malfunctioning systems. Town Sanitary Districts seem reluctant to allocate money for wages for the general clerical work necessary to operate the Town Sanitary District such as the posting of hearings or the soliciting of aid.

". . . the District appears to be suited for cluster development since efficiency in TSD operation is directly related to population density. The TSD does not appear to be well suited to supervise treatment units in low density or scattered developments in the present form. Any economies of scale result from semi-concentrated development."

Taken together, the two views presented on collective public entities for managing rural wastewater facilities seem to suggest that:

(1) In areas where people live close enough together for one man's sewage to potentially endanger another's health, the establishment of some kind of collective public body

*931 Spring Street, Placerville, Calif., 95667.

to provide for a total management represents the only workable long-term solution to maintaining environmental health and sanitation, and

(2) the success of the public body in coping with failure and maintenance problems is quite strongly related to the members' perception of the impact of the problem on their well-being as balanced by the financial impacts of proposed actions.

An implication of the second observation is that certain performance standards for monitoring, reporting and corrective action should be imposed on any collective management entity. The standards would themselves be meaningless unless somebody checked to ascertain that they were being satisfied. This could be a county, state, or federal certification agency, or a private national agency with a meaningful and recognized accreditation program.

Disposal of Septage

Septic tanks are normally emptied of excessive accumulations of sludge and scum by suction pumping through a hose into a tank truck sometimes referred to as a "honey wagon." Kolega* and his associates have named the pumped contents of septic tanks *septage*. The disposal of septage can pose public health and environmental problems, since septage contains large concentrations of microorganisms and oxygen-demanding substances. Pump truck operators ("honey dippers") have been known to discharge septage into streams and rivers, drainage ditches, municipal sewers and on open land when they were not likely to be observed. Responsible practice in communities utilizing septic tanks requires adequate planning for the proper disposal of septage in order to avoid problems associated with unauthorized and unsupervised disposal.

Kolega and his colleagues have determined the properties of septage from 180 samples of material which were delivered to the Metropolitan District Commission water pollution control facility in East Hartford, Connecticut. One of the study's objectives was to derive criteria for designing septage treatment and disposal facilities on the basis of biological, physical, chemical and volumetric aspects of septage. Their findings are summarized in the information which follows.

Properties of Septage [33, 34]

The physical-chemical properties of septage vary considerably, as shown in Table 17.

The coefficients of variation (standard deviation of the sample expressed as a percentage of the sample mean) of the measured properties are generally well in excess of 50 per cent, which indicates that septage is highly variable in the measured properties. This is not unexpected since, in practice, pumping is apparently the universal "first cure" for a failing septic tank system, regardless of the reason for failure—accumulated sludge, high water table, or clogged absorption field. Thus, some pumpings will contain high concentrations of sludge, and others from systems that failed for reasons unrelated to

*Department of Agricultural Engineering, The University of Connecticut, Storrs, Conn. 06268.

Table 17. Physical-Chemical Properties of Septage.

Property of Septage	Median	Weighted Mean	Standard Deviation	Coefficient of Variation, as a Percentage
BOD of Septage, mg/l	2,912	3,840	4,410	115
BOD of Supernatant, mg/l	1,528	1,860	1,240	67
COD* of Septage, mg/l	16,803	25,600	26,900	105
COD of Supernatant, mg/l	5,280	6,690	7,280	109
Total Solids, percent	1.45	2.37	2.69	113
Volatile Solids, percent of total solids	70.5	67.5	15.4	23
Ash (fixed solids), percent of total solids	29.2	32.4	15.4	48
Total Suspended Solids, mg/l	2,302	2,530	1,410	56
Volatile Suspended Solids (ignition), mg/l	1,343	1,880	1,390	74
Organic Nitrogen, mg/l	12	32.7	45.7	140
Free Ammonia, mg/l	62	71.7	41.7	58

*Chemical oxygen demand.

sludge accumulation will be dilute. Also, time lapses between pumping of septic tanks and emptying of the honey wagon could figure into the variability of the measured properties.

In view of the wide variability of the properties of septage, Kolega prepared cumulative distribution curves of the measured properties. Those for BOD and total solids are reproduced in Figures 18 and 19. They should be useful as design curves in planning septage disposal facilities.

The use of the design curves is illustrated in Figure 18, where the 50th percentile for BOD is at 2900 mg/l, and the 75th percentile is at 6350 mg/l, more than twice as great as the value at the 50th percentile. Conservative facility design based on the 75th percentile value could result in costs substantially greater than designs based on median values. The incremental costs of conservative design with respect to BOD might be justified on the basis that a temporary overload of BOD might disrupt operations. Inasmuch as an overload of solids would probably be less disruptive than a BOD overload, the designer might wish to be less conservative with respect to total solids. Similarly, the content of organic nitrogen in septage is a convenient design parameter

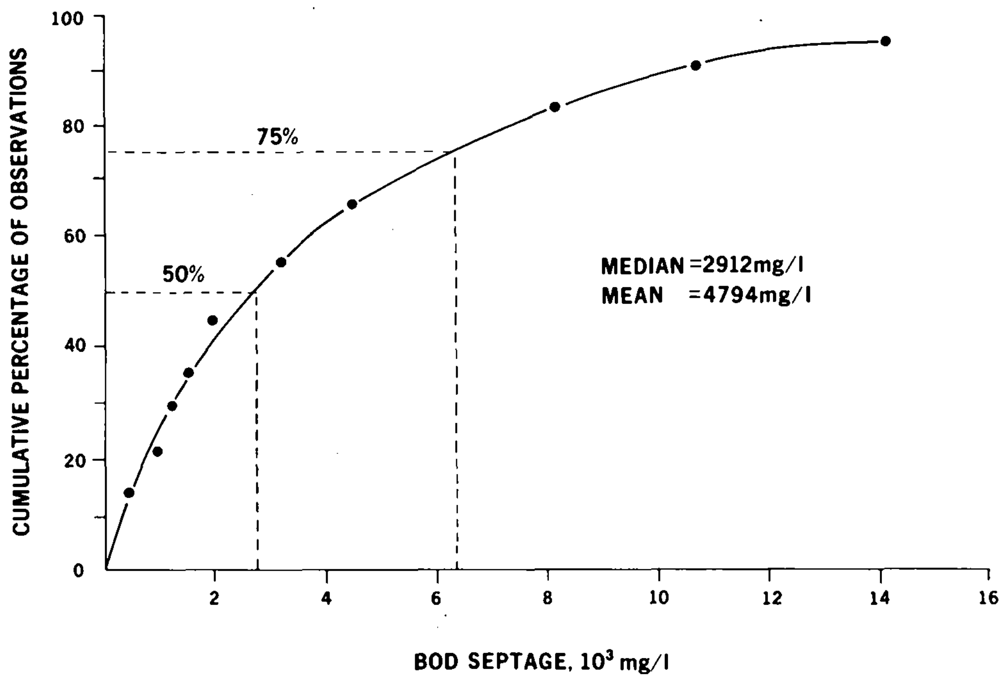


Fig. 18. BOD design curve for septage.
Source: J. J. Kolega, B. J. Cosenza, A. W. Dewey, and R. L. Leonard, "Septage: Wastes Pumped from Septic Tanks," Paper No. 71-411, 1971 Annual Meeting of the Amer. Soc. Agric. Eng., Pullman, Wash., June 27-30, 1971.

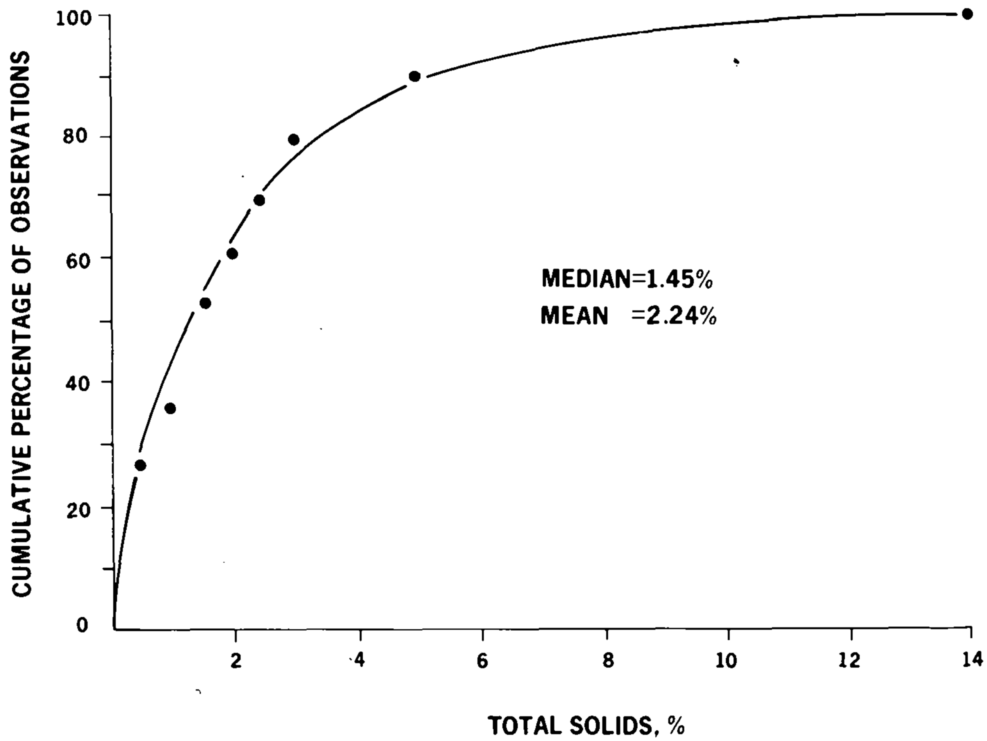


Fig. 19. Total solids design curve for septage.
Source: J. J. Kolega, B. J. Cosenza, A. W. Dewey, and R. L. Leonard, "Septage: Wastes Pumped from Septic Tanks," Paper No. 71-411, 1971 Annual Meeting of the Amer. Soc. Agric. Eng., Pullman, Wash., June 27-30, 1971.

for land disposal by means such as plow-furrow-cover and sub-sod injection where excess nitrogen application could result in contamination of ground waters. [35]

Volumes of Septage

In a study based on mail surveys of households in unsewered areas to determine the incidence of pumping and on sampling of data from septic tank pumpers, it was estimated that, for Connecticut, the per capita production of septage in unsewered areas is between 65 and 70 gallons per year. [34] This figure is based on traditional practices, i.e., the absence of universal routine inspection and pumping, when indicated. A community of septic tanks maintained by a water and wastewater company should receive periodic inspection. Individual tanks should be pumped out when the scum and sludge buildup becomes excessive. The pumping frequency would probably increase under the recommended management practices, and the per capita production of septage (albeit, perhaps, a more dilute septage) would thus increase as well.

Incremental Cost of Treating Septage

The incremental cost of treating septage at a municipal sewage treatment plant was estimated to be 17.4 times as great as the incremental cost of treating an equivalent volume of sewage. [34] The estimate was based on the assumptions that 40 per cent of the incremental cost of treating normal sewage is attributable to handling the water content and that the remaining 60 per cent is about equally divided between primary and secondary treatment. The primary treatment costs were then inflated by the ratio of total solids in septage to total solids in sewage (40.5:1), and the secondary treatment costs were inflated by the corresponding BOD concentration ratio (16.2:1). While this estimate is offered as a basis for the rational setting of septage handling rates at sewage treatment plants employing primary and secondary treatment, it is realized that elements other than attributable cost enter into rate-setting procedures.

Chapter Six

Costs of Wastewater Treatment Systems

Introduction

Suggested retail costs for some of the major components of wastewater systems are presented in Appendix C. One of the big cost items not represented there is sewers. Two different estimates of sewer costs are included in this chapter in addition to estimates of costs based on community size.

In rural areas, household sewage generally receives treatment on-site in a system serving either one or a very few homes, or it is conveyed to a central community system which serves many households. As a rule, there are economies of scale which make a central plant less costly on a per-house basis (when the central system is used near its capacity) than an individual on-site unit. This holds true for initial capital costs as well as operating and maintenance (O&M) expenses. Furthermore, it may be easier for a skilled operator to maintain one plant in tip-top shape than to maintain many small plants, especially for sparsely populated areas where there are great distances between plant sites.

The equalizer, however, is the cost of piping sewage to the central plant. This principal holds true for a big municipal system as well as a package system for a small subdivision. The cost of piping sewage includes not only the cost of the pipe itself, but the cost of excavating and laying the pipe, as well as the cost of pumps (lift stations) which may be required in places where a gravity flow system cannot be designed. Gravity flow systems can be expensive in rural areas because of the great depths which are reached at the end of long runs of sewer, i.e., the fall of sewer required to keep the sewage moving accumulates with distance. In rough terrain, excavation costs will rise considerably.

Very often, therefore, central systems will not be economically feasible although they may be desirable for purposes of maintenance and control. Small diameter pressure sewers would, of course, increase the range of feasibility for community systems (see the section on composite systems.)

Costs of Central Systems

A comprehensive assessment of the costs of wastewater collection and treatment in the U.S. has been made by Smith and Eilers. [36] Their report contains best-fit estimating relationships (log-log regression equations) of the form $Y = AX^B$, where Y is the per capita cost (either initial capital cost or annual cost) for a community of population X (the design population). A and B are constants that make the estimating line fit best the points on a graph of per capita costs versus community size. Most of the costs in the Smith and Eilers report were expressed in 1968 dollars.

The estimating relationships of Smith and Eilers have been adjusted upward to 1973 dollars on the basis of an assumed 6.25 per cent annual inflation rate in the cost of constructing and operating sewage works, i.e., the costs have been inflated by $(1.0625)^5$, or 1.35. The adjusted costs are presented in Table 18 for community sizes of 100, 200, 500, and so forth, up to 10,000. Where two estimates, represented by *M* and *S*, are given for a cost (primary sedimentation plants, for example) they represent independent findings attributed to either Michel or Smith on which Smith and Eilers based their

Table 18. Estimated Per Capita Initial and Annual Costs of Waste Treatment System Components for Various Community Sizes. (1973 dollars)

		$Y = AX^B$		Community Size						
Item	**Source**	**A**	**B**	**100**	**200**	**500**	**1,000**	**2,000**	**5,000**	**10,000**
Initial Costs										
Waste Stabilization Ponds	M	3,865.24	−0.6050	238.33	156.69	90.01	59.18	38.91	22.35	14.70
Primary Sedimentation Plants	M	912.17	−0.3274	201.96	160.96	119.24	95.03	75.74	56.11	44.72
	S	695.12	−0.2890	183.68	150.33	115.36	94.42	77.28	59.30	48.54
Activated Sludge Plants	M	1,232.19	−0.3088	297.22	239.95	180.81	145.97	117.85	88.80	71.69
	S	524.81	−0.2100	199.53	172.50	142.31	123.03	106.36	87.74	75.86
Trickling Filter Plants	M	1,275.78	−0.3105	305.33	246.21	185.24	149.37	120.45	90.62	73.08
	S	428.73	−0.2000	170.68	148.59	123.71	107.69	93.75	78.05	67.95
Ancillary Works	M	116.45	−0.0896	77.08	72.44	66.73	62.71	58.93	54.29	51.02
Sewers		2,745.71	−0.2356	927.80	788.01	635.01	539.33	458.07	369.13	313.51
Annual Costs										
Waste Stabilization Pond O&M	M	23.46	−0.4172	3.44	2.57	1.76	1.31	0.98	0.67	0.50
Primary Sedimentation O&M	M	33.68	−0.2600	10.17	8.49	6.69	5.59	4.67	3.68	3.07
	S	11.39	−0.1750	5.09	4.51	3.84	3.40	3.01	2.57	2.27
Activated Sludge O&M	M	40.64	−0.2460	13.09	11.04	8.81	7.43	6.26	5.00	4.22
	S	40.05	−0.2400	13.26	11.23	9.01	7.63	6.46	5.19	4.39
Trickling Filter O&M	M	74.24	−0.3569	14.35	11.20	8.08	6.31	4.93	3.55	2.77
	S	71.04	−0.3400	14.84	11.73	8.59	6.78	5.36	3.92	3.10
Sewer O&M		4.93	−0.1976	1.98	1.73	1.44	1.26	1.10	0.92	0.80
Customer Service & Accounting	M	101.55	−0.4500	12.78	9.36	6.20	4.54	3.32	2.20	1.61
General & Administrative	M	309.29	−0.5000	30.93	21.87	13.83	9.78	6.92	4.37	3.09

Source: R. Smith and R. G. Eilers, *Cost to the Consumer for Collection and Treatment of Wastewater*, U.S. Environmental Protection Agency, Advanced Waste Treatment Research Laboratory, Cincinnati, Ohio, July 1970.

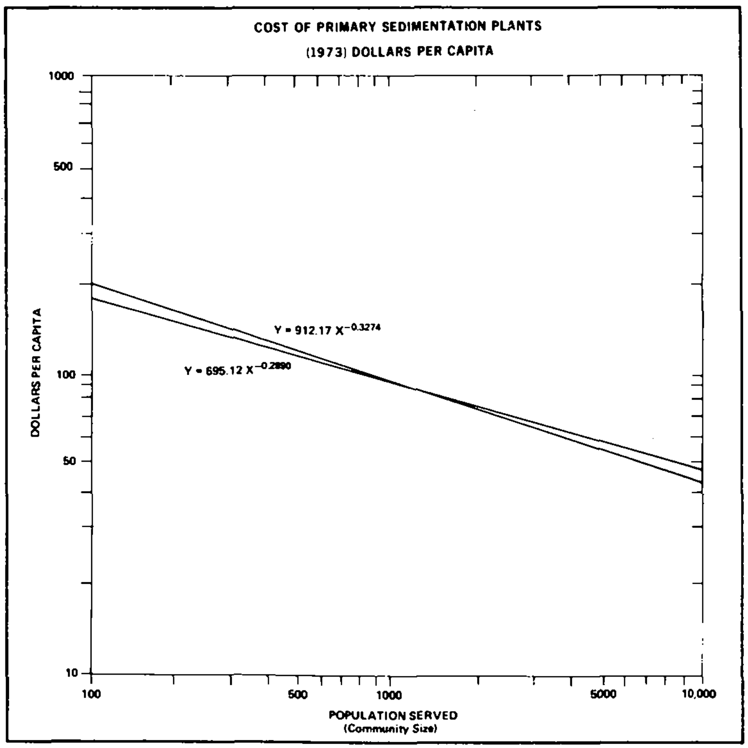
estimates. The independent values are preserved in Table 18 in part to indicate that a range of estimates exists. The values of *A* (adjusted to 1973 dollars) and *B* are also given in Table 18 to permit the calculation of costs for arbitrary community sizes.

The capital cost relationships are also illustrated graphically in Figures 20 through 23. O&M costs have not been presented as graphs because they are less likely to be reliable guides for future costs than are the capital cost relationships. (Less than adequate maintenance of small systems in the past means that the cost of proper maintenance is probably considerably greater than what is indicated by past experience.)

One of the most interesting conclusions that can be drawn from Table 18 and the associated graphs is that the costs of sewers dominate all other costs. Smith and Eilers partitioned their sample into classes of discrete community-size ranges and computed the average per capita cost and length of sewers for each class. Their results are shown in Table 19, in which costs have been again inflated to 1973 dollars. If average per capita cost is divided by average per capital length of sewer, the result is the average cost per foot of sewer. Note that the smallest community averages about four times as much sewer length per capital as the largest. Also, sewer construction costs for the smallest communities average almost 40 per cent higher than for the largest.

Fig. 20. Per capita construction costs of various collection & treatment system components. *(1973 dollars)*
Source: R. Smith and R. G. Eilers, *Cost to the Consumer for Collection and Treatment of Wastewater,* U.S. Environmental Protection Agency, Advanced Waste Treatment Research Laboratory, Cincinnati, Ohio, July 1970.

Fig. 21. Per capita cost of primary sedimentation plants. *(1973 dollars)*
Source: R. Smith and R. G. Eilers, *Cost to the Consumer for Collection and Treatment of Wastewater,* U.S. Environmental Protection Agency, Advanced Waste Treatment Research Laboratory, Cincinnati, Ohio, July 1970.



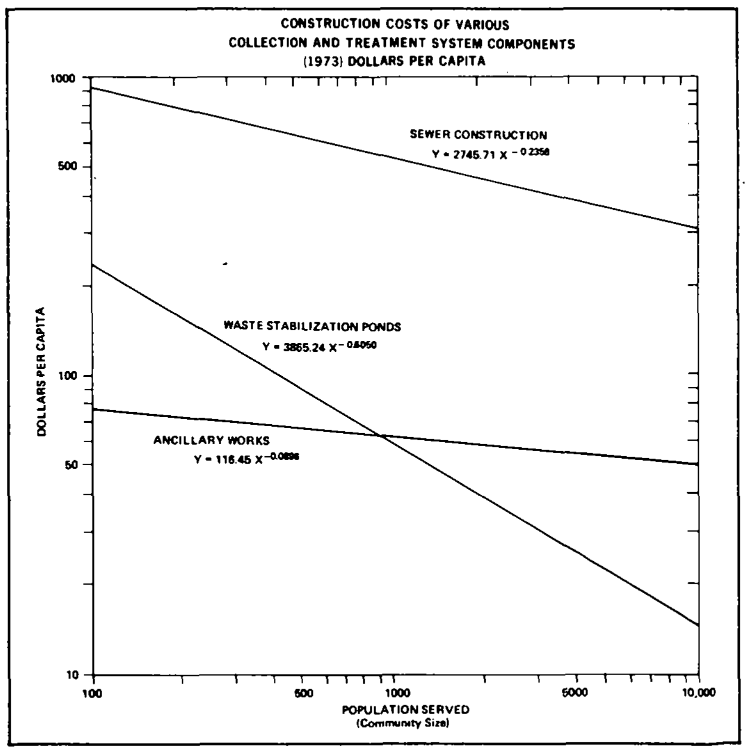


Table 19. Construction Costs and Lengths of Sewers for Various Community Sizes. (1973 dollars)

Community Size	Number of Systems in Class	Avg. Service Population per System	Avg. Sewer Cost per Capita *(dollars)*	Avg. Sewer Length per Capita *(feet)*	Avg. Sewer Cost per foot *(dollars/foot)*
Less than 500	1,791	387	676.38	36.93	18.32
500– 1,000	2,259	809	568.57	32.10	17.71
1,000– 5,000	5,375	2,304	444.37	26.32	16.89
5,000– 10,000	1,516	6,312	350.45	21.73	16.13
10,000– 25,000	1,200	12,920	296.03	18.96	15.61
25,000– 50,000	422	30,089	242.57	16.15	15.02
50,000–100,000	203	66,114	201.50	13.91	14.48
100,000 and over	145	511,212	124.45	9.43	13.20

Source: R. Smith and R. G. Eilers, *Cost to the Consumer for Collection and Treatment of Wastewater,* U.S. Environmental Protection Agency, Advanced Waste Treatment Research Laboratory, Cincinnati, Ohio, July 1970.

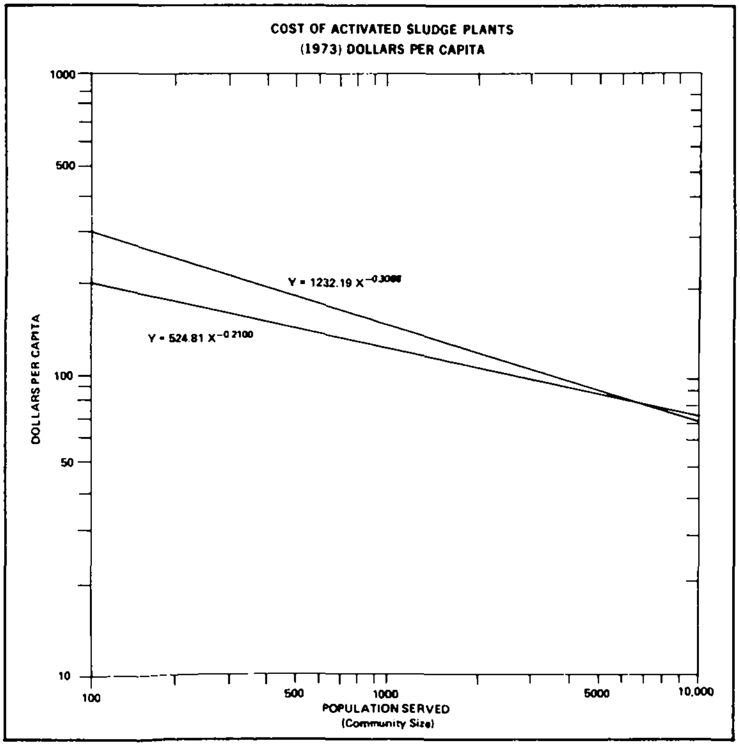


Fig. 22. Per capita cost of activated sludge plants. ***(1973 dollars)***
Source: R. Smith and R. G. Eilers, *Cost to the Consumer for Collection and Treatment of Wastewater,* U.S. Environmental Protection Agency, Advanced Waste Treatment Research Laboratory, Cincinnati, Ohio, July 1970.

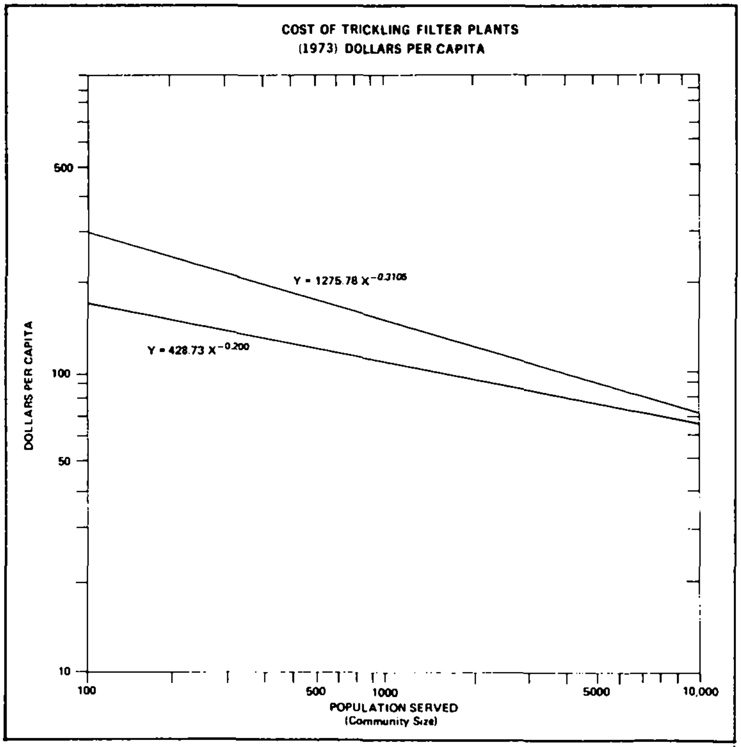


Fig. 23. Per capita cost of trickling filter plants. ***(1973 dollars)***
Source: R. Smith and R. G. Eilers, *Cost to the Consumer for Collection and Treatment of Wastewater,* U.S. Environmental Protection Agency, Advanced Waste Treatment Research Laboratory, Cincinnati, Ohio, July 1970.

An Estimate of Sewer Construction Costs in Rural Areas

The Smith and Eilers' data for sewers includes all costs of sewer construction. A breakout of average preliminary sewer construction cost estimates appropriate to rural areas are shown in Tables 20 and 21.

As an example, consider an 8-inch Average Sanitary Sewer (@ $10.00/ft.) in a region of high water table that requires dewatering during construction (@ $2.00/ft.) and replacement of a gravel roadway (@ $2.00/ft.) in addition to manholes (@$1.00/ft.) and house wyes (tapoffs, @ $0.50/ft.). The total is $15.50 per foot of branch sewer, to which the cost of sanitary service from the road to the property line must be added (@ $6 to 8 per foot of sanitary service). For an average property line setback of 20 feet, sanitary service would add about $0.25 to the cost of each foot of branch sewer. The total cost is about $16 per foot of branch sewer, about the same as the average sewer cost for communities between 5,000 and 10,000 population (Table 19).

Table 20. Preliminary Sewer Construction Cost Estimates.

Type of Sanitary Sewer	Cost *(dollars/foot)*
8", Type R	$8-10
8", Type E	11-12
8", Average	9-11
10", Average	12
12", Average	14
15", Average	17
18", Average	20

Both tables courtesy Z. R. Miller, William & Works, Engineers, 250 Michigan St., N.E., Grand Rapids, Michigan 49503, private communication, Nov. 14, 1972.

Table 21. Preliminary Additive Cost Estimates for Sewer Construction.

Items	Cost *(dollars/foot)*
Constant	
Manhole (assumes 1 every 400 feet)	$1
House Connection Wyes (assumes 1 every 600 feet)	.50
6" Sanitary Service (house sewer)	6-8
Variable	
Concentrated Area	2
Dewatering	2
Bituminous Roadway* Replacement	4
Concrete Roadway* Replacement	10
Sidewalk Replacement	4
Gravel Roadway* Replacement	2

Miscellaneous	Cost *(dollars)*
Average Lift Station	$20,000/each
4" Force Main	5/foot
6" Force Main	7/foot
Rock Excavation	10-40/cu. yd.
Bore and Jack†	80/foot

*20-ft. wide

†Enclosed tunnel bored under railroad track, etc.

The above figures are typical average figures. They are appropriate to preliminary design estimates only. Actual costs will vary considerably with topography, geology, population density and local code requirements.

Costs of Package Plants

The purchase costs of 2,000 to 50,000-gpd package plants illustrated in Appendix C (the equipment catalogue) lie between:

$3,000 plus $0.35 per gallon rated daily capacity,
and
$3,000 plus $1.35 per gallon rated daily capacity.

Normally, sludge digesters, disinfection devices, grating covers, comminutors, larger pumps, and several other items are optional at extra cost. Installation costs are extra, and they can amount to 20 to 50 per cent of the basic purchase price.

Costs of On-Site Systems

Aerobic tanks vary in list price from $600 to over $2,000 (see Apendix C for more information). On the average, about $1,200 per unit can be used for preliminary design estimates. Septic tanks can be purchased for about $100 to $200. The soil absorption fields will vary greatly in price with labor rates, soil conditions and code requirements. Anywhere from $200 to $800 should be budgeted for soil absorption systems which serve aerobic tanks, and anywhere from $200 to $1,200 for soil systems which serve septic tanks.

Operating costs for aerobic tanks will be about $2 to 3 per month for electricity, another dollar for chlorine where used, and some $50 to $100 per year for a service contract. Septic tanks will require pumping about once every two to three years (less frequently for intentionally oversized septic tanks) at a cost of about $25 to $75 (much more if the access covers are underground and the homeowner doesn't know where the tank is located).

Cost Comparisons—Annualization

Insofar as systems may be compared on the basis of cost alone, one useful and valid approach to cost comparisons involves annualization. This approach can be illustrated as follows: consider a system that costs $200,000 and has a design lifetime of twenty years. This may seem like $10,000 per year ($200,000 ÷ 20), but because the $200,000 would most likely have to be borrowed, interest also has to be paid on the loan. At 8 per cent interest for twenty years, a total of $407,400 would have been paid back at the rate of $20,370 per year—more than twice the "cost" (initial principal) of the system.

The multiplier which is used to convert initial principal to annual payment at interest is called an *annualization factor.* Annualization factors for system lifetimes ranging from one to fifty years for interest rates between 4 and 11.5 per cent (in .5 per cent increments) are tabulated in Table 22. The table is a handy reference since all but the most recent handbooks containing annuity tables usually do not include interest rates above 6 per cent. While municipal bonds and government loans at such low interest rates are available, loans from private sources will probably bear interest rates closer to 8 per cent.

Annualized costs are convenient for comparing alternative system configurations. For example, in areas having low population density the use of many small treatment plants instead of one or a few large centralized plants may be justified on the basis that they cost less than the total cost of the large plants and the sewer lines that would be required to reach the central plant(s). It would be a mistake merely to compare initial capital costs, since lifetimes of the various components are likely to be different and because the recurring costs, which could also be expected to differ, should be considered. It is likely that a part of the savings of capital for sewers that would be realized in multiple small-unit systems might be offset by increased recurring maintenance costs for the small systems.

A summary of costs which should be included in the calculations for all systems considered is as follows:

—Annualized first costs, including
basic equipment
all accessories, connecting lines, etc.
all installation costs, including utility connections
design costs, inspection costs, etc.

—Replacement costs

—Recurring costs (on a comparable annual basis), including
utility charges
chemicals and other operating supplies
maintenance and service.

As an example of annualized cost determination, consider a hypothetical home aerobic plant which costs $1200 plus $100 to install. It has a design lifetime of thirty years, except for the compressor which has a ten-year lifetime and a replacement cost of $150. The soil absorption system costs $400 (installed) and has a design lifetime of fifteen years. Operating costs are estimated at $25 per year for electricity and $50 per year for a service policy.

Table 22. Annualization Factor.

Yrs.	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%
1	1.04000	1.04502	1.05001	1.05501	1.06001	1.06500	1.07000	1.07500	1.08000	1.08501	1.09001	1.09501	1.10000	1.10500	1.11000	1.11500
2	0.53020	0.53401	0.53781	0.54163	0.54544	0.54926	0.55310	0.55693	0.56077	0.56462	0.56847	0.57233	0.57619	0.58006	0.58394	0.58781
3	0.36035	0.36378	0.36722	0.37066	0.37411	0.37758	0.38105	0.38454	0.38803	0.39154	0.39506	0.39858	0.40212	0.40566	0.40921	0.41278
4	0.27549	0.27875	0.28202	0.28530	0.28860	0.29190	0.29523	0.29857	0.30192	0.30529	0.30867	0.31206	0.31547	0.31889	0.32233	0.32577
5	0.22463	0.22780	0.23098	0.23418	0.23740	0.24064	0.24389	0.24717	0.25046	0.25377	0.25709	0.26044	0.26380	0.26718	0.27057	0.27398
6	0.19076	0.19388	0.19702	0.20018	0.20337	0.20657	0.20980	0.21305	0.21632	0.21961	0.22292	0.22625	0.22961	0.23298	0.23638	0.23979
7	0.16661	0.16971	0.17282	0.17597	0.17914	0.18233	0.18555	0.18880	0.19207	0.19537	0.19859	0.20204	0.20541	0.20880	0.21222	0.21566
8	0.14853	0.15161	0.15472	0.15787	0.16104	0.16424	0.16747	0.17073	0.17402	0.17733	0.18068	0.18405	0.18744	0.19087	0.19432	0.19780
9	0.13449	0.13758	0.14069	0.14384	0.14702	0.15024	0.15349	0.15677	0.16008	0.16343	0.16680	0.17021	0.17364	0.17711	0.18060	0.18413
10	0.12329	0.12638	0.12951	0.13267	0.13587	0.13911	0.14238	0.14569	0.14903	0.15241	0.15582	0.15927	0.16275	0.16626	0.16980	0.17338
11	0.11415	0.11725	0.12039	0.12357	0.12679	0.13006	0.13336	0.13670	0.14008	0.14349	0.14695	0.15044	0.15396	0.15753	0.16112	0.16475
12	0.10655	0.10967	0.11283	0.11603	0.11928	0.12257	0.12590	0.12928	0.13270	0.13615	0.13965	0.14319	0.14576	0.15033	0.15403	0.15771
13	0.10014	0.10328	0.10646	0.10969	0.11296	0.11628	0.11965	0.12306	0.12652	0.13002	0.13357	0.13715	0.14078	0.14445	0.14815	0.15190
14	0.09467	0.09782	0.10103	0.10428	0.10759	0.11094	0.11435	0.11780	0.12130	0.12484	0.12843	0.13207	0.13575	0.13947	0.14323	0.14703
15	0.08994	0.09312	0.09634	0.09963	0.10296	0.10635	0.10980	0.11329	0.11683	0.12042	0.12406	0.12774	0.13147	0.13525	0.13907	0.14292
16	0.08582	0.08902	0.09227	0.09558	0.09895	0.10238	0.10586	0.10939	0.11298	0.11661	0.12030	0.12404	0.12782	0.13164	0.13552	0.13943
17	0.08220	0.08542	0.08870	0.09204	0.09545	0.09891	0.10243	0.10600	0.10963	0.11331	0.11705	0.12083	0.12466	0.12855	0.13247	0.13644
18	0.07899	0.08224	0.08555	0.08892	0.09236	0.09585	0.09941	0.10303	0.10670	0.11043	0.11421	0.11805	0.12193	0.12586	0.12984	0.13387
19	0.07614	0.07941	0.08275	0.08615	0.08962	0.09316	0.09675	0.10041	0.10413	0.10790	0.11173	0.11561	0.11955	0.12353	0.12756	0.13164
20	0.07358	0.07688	0.08024	0.08368	0.08719	0.09076	0.09439	0.09809	0.10185	0.10567	0.10955	0.11348	0.11746	0.12149	0.12558	0.12970
21	0.07128	0.07460	0.07800	0.08147	0.08305	0.08861	0.09229	0.09603	0.09983	0.10370	0.10762	0.11159	0.11562	0.11971	0.12384	0.12802
22	0.06920	0.07255	0.07597	0.07947	0.08305	0.08669	0.09041	0.09419	0.09803	0.10194	0.10591	0.10993	0.11401	0.11813	0.12231	0.12654
23	0.06731	0.07068	0.07414	0.07767	0.08128	0.08496	0.08871	0.09254	0.09642	0.10037	0.10438	0.10845	0.11257	0.11675	0.12097	0.12524
24	0.06559	0.06899	0.07247	0.07604	0.07968	0.08340	0.08719	0.09105	0.09498	0.09897	0.10302	0.10713	0.11130	0.11552	0.11979	0.12410
25	0.06401	0.06744	0.07095	0.07455	0.07823	0.08198	0.08581	0.08971	0.09368	0.09771	0.10181	0.10596	0.11017	0.11443	0.11874	0.12310
26	0.06257	0.06602	0.06956	0.07319	0.07690	0.08069	0.08456	0.08850	0.09251	0.09658	0.10072	0.10491	0.10916	0.11346	0.11781	0.12221
27	0.06124	0.06472	0.06829	0.07195	0.07570	0.07952	0.08343	0.08740	0.09145	0.09556	0.09974	0.10397	0.10826	0.11260	0.11699	0.12143
28	0.06001	0.06352	0.06712	0.07082	0.07459	0.07845	0.08239	0.08641	0.09049	0.09464	0.09885	0.10312	0.10745	0.11183	0.11676	0.12073
29	0.05888	0.06242	0.06605	0.06977	0.07358	0.07747	0.08145	0.08550	0.08962	0.09381	0.09806	0.10236	0.10673	0.11114	0.11561	0.12011
30	0.05783	0.06139	0.06505	0.06881	0.07265	0.07658	0.08059	0.08467	0.08883	0.09305	0.09734	0.10168	0.10608	0.11053	0.11502	0.11956
31	0.05686	0.06044	0.06413	0.06792	0.07179	0.07575	0.07980	0.08392	0.08811	0.09237	0.09669	0.10106	0.10550	0.10998	0.11451	0.11908
32	0.05595	0.05956	0.06328	0.06710	0.07100	0.07500	0.07907	0.08323	0.08745	0.09174	0.09510	0.10051	0.10497	0.10948	0.11404	0.11864
33	0.05510	0.05875	0.06249	0.06634	0.07027	0.07430	0.07841	0.08259	0.08685	0.09118	0.09556	0.10000	0.10450	0.10904	0.11363	0.11826
34	0.05432	0.05798	0.06176	0.06563	0.06960	0.07366	0.07780	0.08201	0.08630	0.09066	0.09508	0.09955	0.10407	0.10864	0.11326	0.11791
35	0.05358	0.05727	0.06107	0.06498	0.06897	0.07306	0.07723	0.08148	0.08580	0.09019	0.09464	0.09914	0.10369	0.10829	0.11293	0.11760
36	0.05289	0.05661	0.06043	0.06437	0.06840	0.07251	0.07672	0.08099	0.08534	0.08976	0.09424	0.09876	0.10344	0.10797	0.11263	0.11733
37	0.05224	0.05598	0.05984	0.06380	0.06786	0.07201	0.07624	0.08055	0.08492	0.08937	0.09387	0.09843	0.10303	0.10768	0.11236	0.11709
38	0.05163	0.05540	0.05928	0.06327	0.06736	0.07153	0.07580	0.08013	0.08454	0.08901	0.09354	0.09812	0.10275	0.10742	0.11213	0.11687
39	0.05106	0.05486	0.05877	0.06278	0.06689	0.07110	0.07539	0.07975	0.08419	0.08868	0.09324	0.09784	0.10249	0.10718	0.11191	0.11667
40	0.05052	0.05434	0.05828	0.06232	0.06646	0.07069	0.07501	0.07940	0.08386	0.08838	0.09296	0.09759	0.10226	0.10697	0.11172	0.11650
41	0.05002	0.05386	0.05782	0.06189	0.06606	0.07032	0.07466	0.07908	0.08356	0.08811	0.09271	0.09736	0.10205	0.10678	0.11155	0.11634
42	0.04954	0.05341	0.05740	0.06149	0.06568	0.06997	0.07434	0.07878	0.08329	0.08786	0.09248	0.09715	0.10186	0.10661	0.11139	0.11620
43	0.04909	0.05298	0.05699	0.06111	0.06533	0.06964	0.07404	0.07850	0.08303	0.08763	0.09227	0.09696	0.10169	0.10645	0.11125	0.11608
44	0.04866	0.05258	0.05662	0.06076	0.06501	0.06934	0.07376	0.07825	0.08280	0.08741	0.09208	0.09678	0.10153	0.10631	0.11113	0.11596
45	0.04826	0.05220	0.05626	0.06043	0.06470	0.06906	0.07350	0.07801	0.08259	0.08722	0.09190	0.09663	0.10139	0.10619	0.11101	0.11586
46	0.04788	0.05185	0.05593	0.06012	0.06442	0.06880	0.07326	0.07779	0.08239	0.08704	0.09174	0.09648	0.10126	0.10607	0.11091	0.11577
47	0.04752	0.05151	0.05561	0.05983	0.06415	0.06855	0.07304	0.07759	0.08221	0.08688	0.09150	0.09635	0.10115	0.10597	0.11082	0.11569
48	0.04718	0.05119	0.05532	0.05956	0.06390	0.06833	0.07283	0.07741	0.08204	0.08673	0.09146	0.09623	0.10104	0.10588	0.11074	0.11562
49	0.04686	0.05089	0.05504	0.05930	0.06366	0.06811	0.07264	0.07723	0.08189	0.08659	0.09134	0.09613	0.10095	0.10579	0.11067	0.11556
50	0.04655	0.05060	0.05478	0.05906	0.06344	0.06791	0.07246	0.07707	0.08174	0.08646	0.09123	0.09603	0.10086	0.10572	0.11060	0.11550

First, the initial plant cost of $1200 may be separated into $1050 for the thirty-year basic plant plus $150 for a ten-year compressor. The $1050 is annualized over the full thirty-year period, but the compressors are annualized over their ten-year lifetime only.

Assume an interest rate of 8 per cent. The computations are as follows:

Basic system	$1050	
Installation	100	
Total	$1150 × .08883* (for 30 years, 8%) =	$102.15
Compressor	$ 150 × .14903* (for 10 years, 8%) =	22.35
Soil absorption system	$ 400 × .11683* (for 15 years, 8%) =	46.73
Annualized capital costs		$171.23
Service policy (annual)		50.00
Operation costs (annual)		25.00
Total annual cost		$246.23
	or about $20.50 per month†	

At 4% interest, the costs are:

Basic system	$1150 × .05783* (for 30 years, 4%) =	$ 66.50
Compressor	$ 150 × .12329* (for 10 years, 4%) =	18.49
Soil absorption system	$ 400 × .08994* (for 15 years, 4%) =	35.98
Annualized capital costs		$120.97
Service policy (annual)		50.00
Operation costs (annual)		25.00
Total annual cost		$195.97
	or about $16.30 per month†	

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*Annualization factor.

†Actually, if the loan were to be paid in monthly installments, the monthly costs quoted above would have to be adjusted slightly. Note that each component of the system was annualized at the figure corresponding to its lifetime, and that annually recurring costs (e.g., operation and maintenance) are added after all fixed costs are annualized. In actuality, a homeowner would probably not choose to finance a system in precisely the manner described above. Annualization is a convenient fiction which puts costs on a constant yearly basis for the sake of comparison with other systems which are similarly costed. Incidentally, the example illustrates how a loan subsidy of half the 8 per cent interest rate could lower the monthly cost to the household by about $4.00.

Introduction to Appendix A

This Appendix contains a method proposed in April, 1972, by Alfred P. Bernhart, D.Sc., Associate Professor of Civil Engineering, University of Toronto, Toronto, Ontario, Canada, for determining sizes of building lots in areas where sewage is to be disposed on site. The method presumes that either a single septic tank or aerobic tank will be used and that disposal will be accomplished in a subsurface soil disposal system which operates predominantly either by aerobic or by anaerobic processes. The soil absorption system can operate in the aerobic mode if the oxygen supply is enhanced with venting arrangements called breezers or breathers (see Chapter Four). Whether aerobic or anaerobic, the soil absorption system will depend heavily on infiltration and evapotranspiration for disposal of effluent.

The method consists of breaking the lot into functional areas which include areas for subsurface disposal and drainage as well as for structures, recreation and a special provision for safe separation between the sewage-containing soil and a well used for drinking water.

Bernhart's early work was described in his now out-of-print book, "Treatment and Disposal of Waste Water From Homes" (Toronto, 1967). The material included here on lot sizing is an extension of that work. Some of the details, especially the propositions governing the safe protective distance between the seepage bed and well, are based on safe figures taken from literature data. Experiments to verify and possibly to reduce the proposed safe protective distances are presently being conducted at Bernhart's University of Toronto laboratories.

Bernhart's volumetric calculations are based on the Imperial gallon, which is equivalent to about 1.2 U. S. gallons. He assumed a design value of sewage production of 160 gal (Imp.) per household per day, or 192 gal (U.S.) per household per day, a figure which was statistically researched and verified for southern Ontario households. That amounts to about 55 gal (U.S.) per capita per day (GPCD). Most U. S. design criteria generally call for 75 to 100 GPCD. As clean water becomes a scarcer and more costly *commodity, it can be anticipated that water-saving techniques such as flow control and* recycling of gray water for toilet flushing will reduce consumption rates significantly. For now, however, considering regulations on expected sewage flows in some U.S. states, Bernhart's calculations should be modified by changing the daily flows from a household ("F") from 160 gal (Imp.)/day, or about 200 gal (U.S.)/day, to 300 or 400 gal (U.S.)/day per household.

By comparison, Bernhart's use of evapotranspiration and infiltration rates [gal (Imp.) per square foot per day] need not be modified because the inaccuracies inherent in their measurement generally exceed the 20 per cent difference between Imperial and U. S. gallons by a considerable degree.

Appendix A

Contents

A Rational Approach to Determining Sizes of Building Lots According to Their Capabilities for On-Site Wastewater Treatment and Disposal

By Alfred P. Bernhart, D.Sc.

April 1972

Method to Determine Property Sizes

A Five-Step Calculation and Design Procedure for suburban, rural or recreational lots in areas where the wastewater is disposed by soil infiltration and evapotranspiration and where water is supplied by individual wells.

For the purpose of the property size determination, the lot is composed of four component parts (Figure 1):

1. The ***building area,*** B, which contains the house, garage, driveway, patio, swimming pool and ornamental areas in front of the house.

2. The ***green area,*** G, which has as its main function the disposal of wastewater. It should be beautifully landscaped with grass and shrubbery and is not suitable for active sports.

3. The ***drainage area,*** D, which serves to funnel the storm water effluent away from the property.

4. The ***well protection area,*** P, which insures that a "protective distance" exists between the mouth of the water supply well and the soil infiltration bed of the neighbouring lot.

All component areas can be determined by blanket calculations carried out for all subdivision lots or each component area can be individually designed for each lot. The latter method generally leads to slightly smaller property sizes.

The Five-Step Method

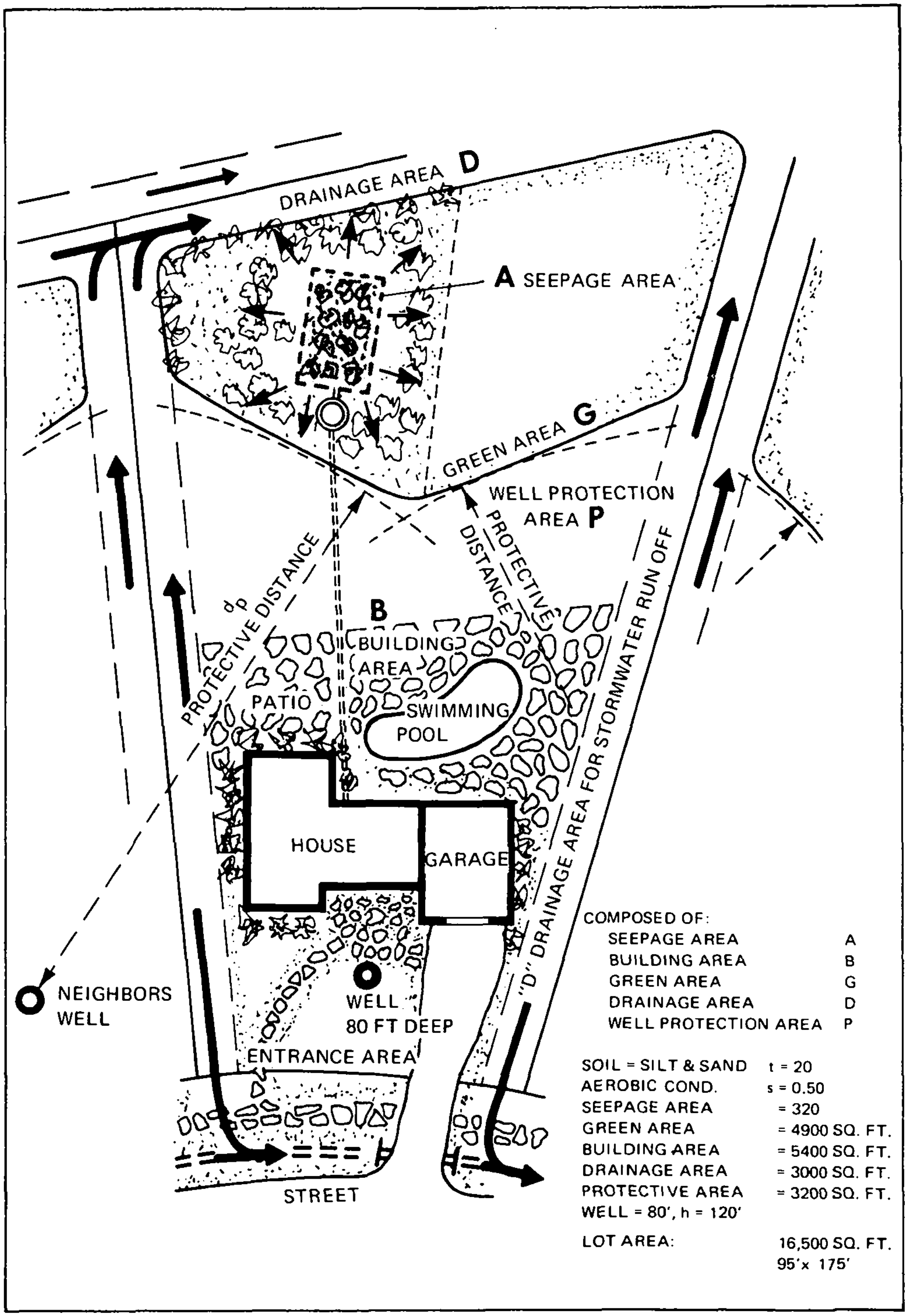
Step 1: The Seepage Bed Area

The seepage bed area, as a vital part of the green area, serves to filter the preconditioned wastewater, infiltrate it into the soil and evapotranspirate it into the air.

The calculation of the seepage area is based on these parameters:

— type of soil
— pollution load of the wastewater
— biological condition of the wastewater
— climatic and surface conditions
— design characteristics of the seepage bed
— flow quantity of wastewater

Fig. 1. Diagrammatic sketch of property lot.



$$A = \frac{F \cdot L}{S}$$

A = area of seepage bed, in square feet
F = flow of wastewater, in gallons per day
L = pollution load of the wastewater (a factor)

$$= \frac{BOD + SS}{120}$$

S = seepage rate in gallons per square foot per day
S_i (infiltration) $+ S_e$ (evapotranspiration)

(a) The ***type of soil*** can be determined by the percolation test. As outlined in a separate chapter, the proposed indicator is the time "t" in minutes which is needed for the water table of clean water to sink one inch. For example, a loam-silt mixture has a percolation time "t" of 45 minutes per inch.

(b) The ***pollution load L*** depends on the selected treatment, either aerobic or anaerobic-septic (Figures 2a and 2b). The L value of the treatment unit should be pre-established by a permanent unit-certificate or by individual effluent tests. For example, the L value may be 1.0 for aerobic units (BOD = 50, SS = 70) or it may be 1.8 for anaerobic-septic tanks (BOD = 150, SS = 70).

(c) The ***design of the seepage bed*** can stimulate or prevent aerobic biological conditions (Figure 3). Aerobic conditions are superior for the purpose of wastewater disposal because of the more balanced prey-predator relations among the microorganisms. A constant opening of soil pores thus occurs, together with an increase in temperature.

(d) The ***infiltration rate*** S_i (in gallons per square foot per day)* depends on the soil type and on the biological condition of the wastewater. Values derived from experiments at the University of Toronto and from field studies in southern Ontario are tabulated in Table 1. For example, for a loam-silt mixture with t = 45 minutes, the infiltration rate is 0.28 gal/sq. ft. day for aerobic conditions and 0.10 gal/sq. ft. day for anaerobic-septic conditions.

(e) The ***evapotranspiration rate*** S_e (in gallons per square foot per day) depends on the surface planting of the seepage bed; on the permissible rise of the wastewater table below the surface, (the ground becomes spongy, for example, if the wastewater table rises to within 2″ below the surface); and again on the biological condition of the wastewater. The energy production by aerobic microorganisms is vital for the high evaporation rate, which occurs under aerobic wastewater conditions.

Evapotranspiration rates are tabulated in Table 2. If, for example, the wastewater table in a well-landscaped seepage bed with aerobic conditions should be 6″ to 9″ below the surface during summer, the evapotranspiration rate is 0.11 gal/sq. ft. day. If, in the same bed, the wastewater table could be permitted to rise to 2″ to 3″ below the surface during winter, the evapotranspiration is 0.08 gal/sq. ft. day. Thus the annual average is about 0.10 gal/sq. ft. day.

For anaerobic-septic conditions the respective figures would be 0.02 and 0.01 gal/sq. ft. day, with an annual average of 0.016 gal/sq. ft. day.

*Note: All volumes in Imperial gallons: 1 gal (Imp.) = 1.2 gal (U.S.)

Fig. 2a. Recommended design for aerated tanks.

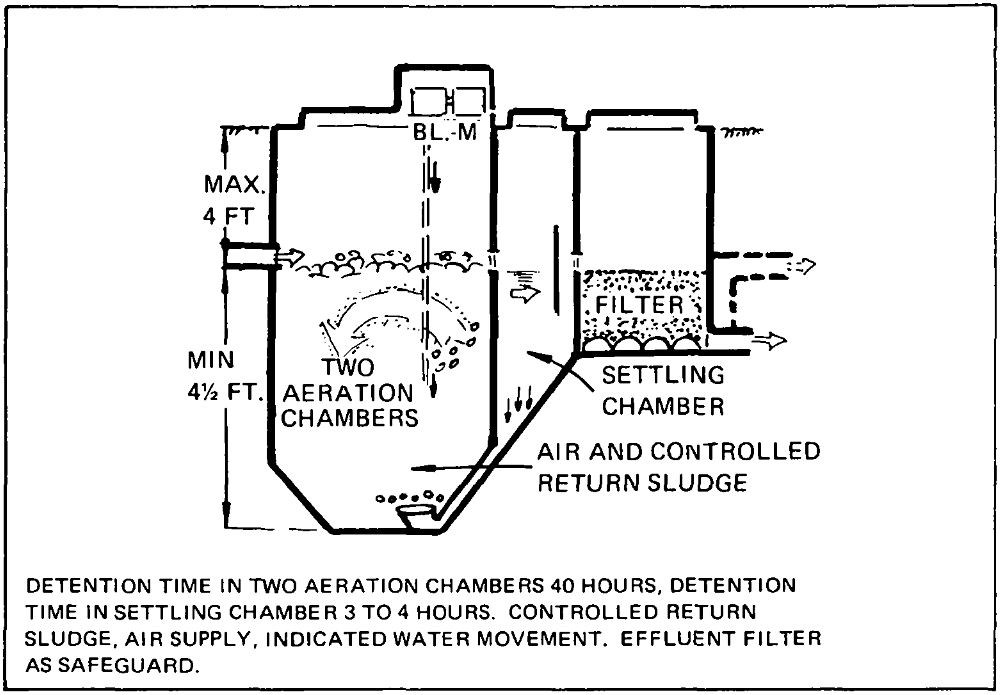


Fig. 2b. Recommended design for septic tanks.

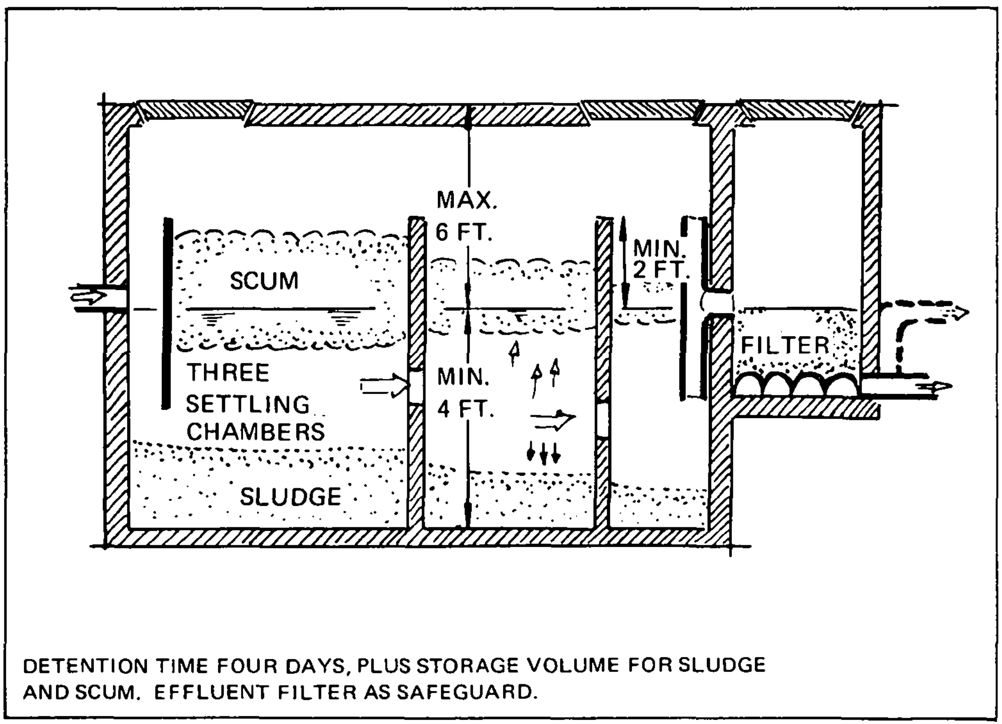
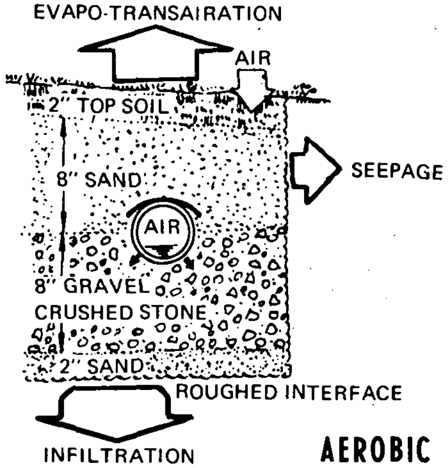
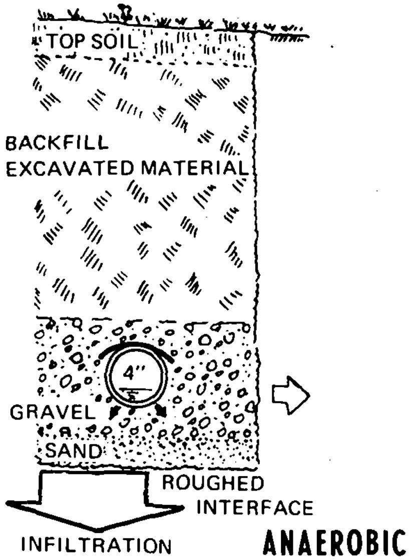


Fig. 3. Aerobic Seepage Bed or Trench, Anaerobic Seepage Bed or Trench.



THE BED IS SHALLOW AND COVERED WITH SAND AND GRASS, FOR AERATION FROM THE SURFACE AND FOR EVAPO-TRANSPIRATION. SAND REACHES DOWN TO DISTRIBUTION PIPE FOR CAPILLARIC RISING OF WASTEWATER. TAR PAPER PROTECTS JOINTS AND OPENINGS OF PIPES AGAINST SAND FALLING INTO PIPES. SURFACE OF ORIGINAL SOIL IS "ROUGHED" – A SEPARATE CONSTRUCTION PROCESS.



DEPTH AND TIGHT BACKFILL MATERIAL AS USED IN CUSTOMARY TRENCHES PREVENTS AEROBIC ACTION IN WASTE WATER.

(f) The ***combined seepage rate*** S is the sum of S_i and S_e in gal/sq. ft. day. The rates are diagramatically shown in Figure 4 for a well-planted seepage bed surface and a wastewater table 6" to 9" below the surface during summer and 2" to 3" below the surface in winter.

Table 1. Soil Infiltration Rates.
For Various Soils
For Aerobic and Anaerobic Conditions

Type of Soil	Percolation Time (min./in.)	Infiltration Rate (gal/sq. ft. day)		
		Aerobic S_i	Anaerobic S_i	Clean Water
Sand 0.3-1.0 mm	1	0.57	0.53	754
Sand 0.1-0.9 mm	5	0.54	0.45	151
Fine sand, garden soil 0.05-0.8 mm	10	0.50	0.37	75
Fine sand	15	0.46	0.29	50
Silt and sand	20	0.42	0.24	37
Silt 0.01-0.7 mm	30	0.36	0.17	25
Loam and silt	45	0.28	0.10	17
Loam, silt and clay	60	0.23	0.06	12.5
Clay and silt 0.05-0.5 mm	90	0.15	0.02	8.5
Clay, shale	120	0.10	0.00	6.2

Note: 1 gal/sq.ft.day = 57.7"/month

Table 2. Evapotranspiration Rates.
For Different Bed Surfaces, Variable Wastewater Tables, Aerobic and Anaerobic Conditions

Distance from Surface to Wastewater Table (inches)	Surface Treatment of Bed	Evapotranspiration Rate S_e							
		Aerobic				Anaerobic			
		Average for Summer (gal/sq. ft. day)	Average for Winter (gal/sq. ft. day)	Average for Year (gal/sq. ft. day)	Average for Year (in./mo.)	Average for Summer (gal/sq. ft. day)	Average for Winter (gal/sq. ft. day)	Average for Year (gal/sq. ft. day)	Average for Year (in./mo.)
2 to 3	Grass, shrubs	0.18	0.08	0.13	7.5	0.07	0.01	0.04	2.3
2 to 3	Bare	0.11	0.03	0.07	4.0	0.03	0.006	0.02	1.2
6 to 9	Grass, shrubs	0.11	0.02	0.07	4.0	0.02	0.004	0.012	0.7
6 to 9	Bare	0.06	0.01	0.04	2.3	0.005	0.002	0.004	0.2

For example:

S = 0.37 gal/sq. ft. day for aerobic conditions
and S = 0.12 gal/sq. ft. day for anaerobic conditions
both for a loam-silt mixture (t= 45 min.).

(g) The ***quantity or flow of wastewater*** F depends on the habits of the residents in the home. The average flow from an average household is about 160 gal/day. Large households or high-income families use 25 to 50% more water; small and low-income families use 10 to 20% less.

(h) The ***seepage bed areas,*** as the result of $A = \frac{F \cdot L}{S}$, are tabulated in Table 3 and diagramatically shown in Figure 5 for F = 160 gal/day; for L = 1.0 for aerobic and L = 1.8 for anaerobic conditions; and for S_e as indicated in paragraph 3. For our example of an average household with F = 160 on a lot with a soil of loam and silt (t = 45), the seepage bed areas are:

$$A = \frac{160 \times 1.0}{0.37} = 435 \text{ sq. ft. for aerobic conditions}$$

$$\text{and } A = \frac{160 \times 1.8}{0.12} = 2400 \text{ sq. ft. for anaerobic conditions}$$

Fig. 4. Combined seepage rates.

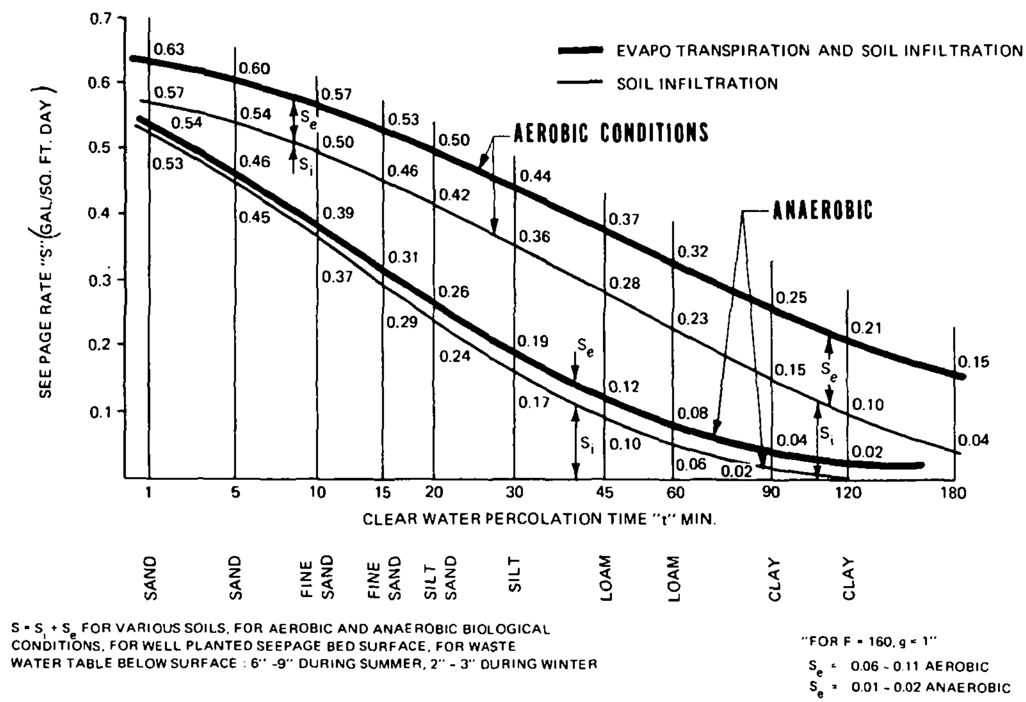
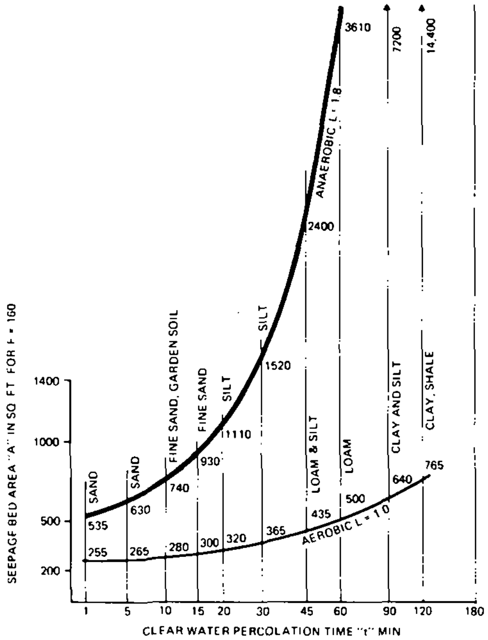


Fig. 5. Seepage bed area.



A = FL/S FOR VARIOUS TYPES OF SOILS FOR F = 160 GAL/DAY.
L = 1.0 AND 1.8, S AS TABULATED IN TABLE III

Table 3. Area of Seepage Bed.

$$A = \frac{F \cdot L}{S}$$

(S as shown in Figure 4)

		AEROBIC F = 160, L = 1		ANAEROBIC F = 160, L = 1.8	
	Percolation Time (t in min.)	**S (gal/sq. ft./day)**	**A (sq. ft.)**	**S (gal/sq. ft./day)**	**A (sq. ft.)**
Sand	1	0.63	255	0.54	535
Sand	5	0.60	265	0.46	630
Fine sand	10	0.57	280	0.39	740
Fine sand	15	0.53	300	0.31	930
Silt and sand	20	0.50	320	0.26	1110
Silt	30	0.44	365	0.19	1520
Loam and silt	45	0.37	435	0.12	2400
Loam	60	0.22	500	0.08	3610
Clay and silt	90	0.25	640	0.04	7200
Clay	120	0.21	765	0.02	14400

Step 2: The Green Area

The main purpose of the green area is the disposal of wastewater by soil infiltration and by evapotranspiration. It contains, as major features, the seepage bed and a safety area around it. The portion of the wastewater which has filtrated horizontally away from the seepage bed is evapotranspirated and soil-infiltrated in the safety area.

Both the seepage bed and the safety area are surface-graded to slope towards the drainage area for fast discharge of storm water. The layout and spatial arrangement within the green area should be such that a complete new seepage bed, including its safety area, can be constructed in case of unforeseen failure of the first installation.

The green area, in particular the seepage bed and the safety area, should be grass covered and heavily planted with bushes and small trees. Existing large trees greatly help evapotranspiration and should therefore be preserved.

No buildings, slabs, flagstone patios, pavement, tennis courts, or swimming pools are permitted in the green area. Gravelled surfaces should be kept to a minimum. The green area, especially the seepage bed area and the safety area, cannot be used as a playground or active sports area.

If calculated, the equation for the green area G in square feet is:

$$G = \left(4{,}000 + \frac{A}{S^{1/2}}\right) \frac{F}{160}$$

A = seepage area in square feet (as in Table 2 and Figure 5)
S = seepage rate, $S_i + S_e$, aerobic or anaerobic (as in Tables 1 and 2 and Figure 4)
F = Flow of wastewater

In our example for a soil with t = 45 min, for F = 160 gal/day,

for aerobic conditions: A = 435 sq. ft., S = 0.37,
G = ~ 5950 sq. ft.

for anaerobic conditions: A = 2400 sq. ft., S = 0.12,
G = 61,500 sq. ft.

The required area is considerably smaller if the wastewater is in an aerobic biological condition, compared to the larger area requirement, if anaerobic-septic conditions prevail. The reason is the significantly higher amount of energy produced by aerobic microorganisms, which translates into increased temperature and intenser evaporation. Also, the larger aerobic microorganisms (the protozoa) feed on the smaller but vastly more numerous bacteria, keeping their number in check and thus re-opening the soil pores, which may be plugged by clusters of bacteria.

Depending on the biological condition of the wastewater, as well as on the type of soil, some figures for green areas are tabulated in Table 4.

The design procedure is:

(a) Dimension for seepage bed, for example for the aerobic bed of 435 sq. ft. = 30 ft. × 15 ft.

(b) "Safety frame" around seepage bed (wider if seepage rate is lower, as indicated in Figure 6):

$$\text{Width of frame in ft.} \quad f = \frac{6 \text{ ft.}}{S}$$

In our example for aerobic conditions, the width of the frame

$$= \frac{6 \text{ ft.}}{S} = 16 \text{ ft.}$$

Table 4. Green Area.
(square feet)
For F = 160 gal/day, S as in Figure 4.

Type of Soil	Percolation Time (t in min.)	Seepage Rate		Green Area	
		Aerobic	Anaerobic	Aerobic	Anaerobic
Sand	1	0.63	0.54	4510	5360
Sand	5	0.60	0.46	4580	6020
Fine sand	10	0.57	0.39	4660	7040
Fine sand	15	0.53	0.31	4770	9400
Silt and sand	20	0.50	0.26	4910	12,350
Silt	30	0.44	0.19	5250	22,300
Loam and silt	45	0.37	0.12	5950	61,500
Loam	60	0.32	0.08	6800	164,000
Clay and silt	90	0.25	0.04	9140	—
Clay	120	0.21	0.02	12,000	—

(c) Area of seepage bed plus safety frame (Figure 7) is:

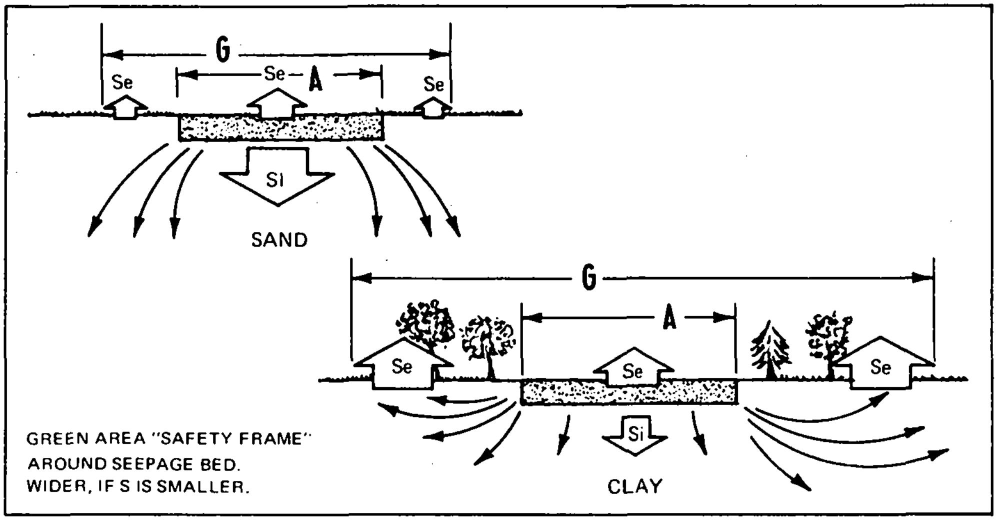
62 ft. × 47 ft = 2920 sq. ft.

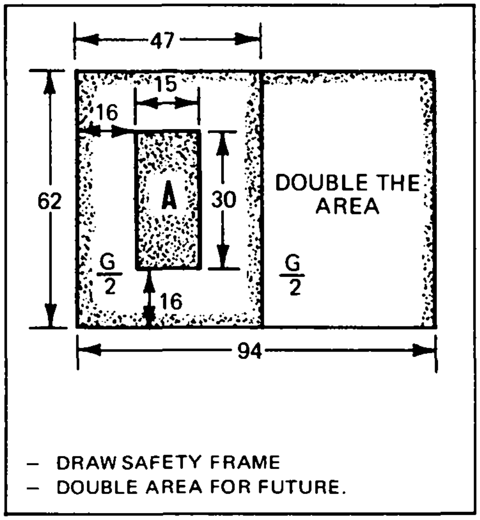
(d) Doubling the area to allow a possible reconstruction of the seepage area (Figure 7):

2920 sq. ft. × 2 = 5840 sq. ft.

Fig. 6. Green area "safety frame".

Fig. 7. Design of green area.

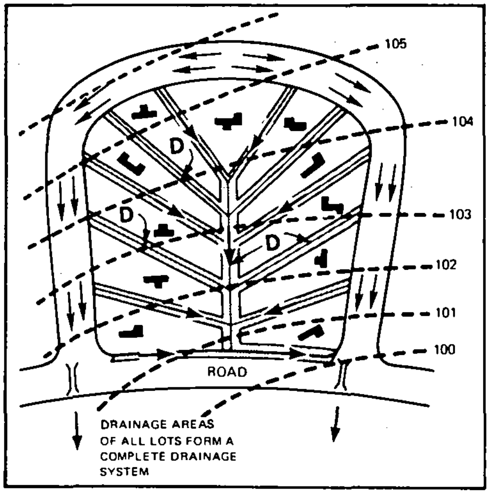




Step 3: The Drainage Area

The drainage area serves to channel all stormwater runoffs and snow melting water quickly away from the property. In most cases, the drainage area forms a "frame" of grassed shallow swales around the property (Figure 1). Green area and building area are graded to slope directly towards the drainage swales. The drainage areas of all lots of a subdivision combine in a surface drainage system, which generally adheres to the natural topography (Figure 8).

Fig. 8. Drainage areas.



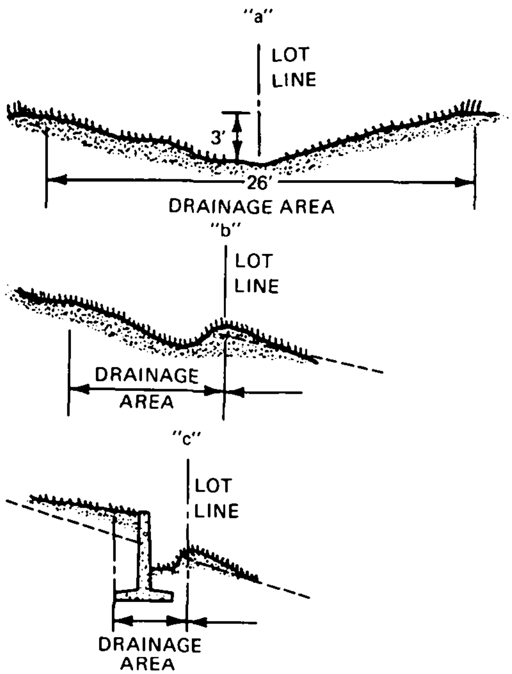
No obstructions of the flow of water are permissable; neither are patios, buildings, or long pipes. At driveways and road crossings, culverts of a maximum length of 40 feet are permissible.

Under near ideal topographic conditions, such as a gentle slope of the land between 1 per cent and 2 per cent, the width of the drainage frame is about 10 feet. If the natural slope is too flat or too steep, much wider drainage strips are required. In a very flat area, for example, the main drainage ditch has to be 3 feet deep after 400 feet of flow. This requires a strip of 26 feet width, perhaps shared by two lots (Figure 9).

Wider strips are also required for steep sites, where small steps or waterfalls may be needed to break the water velocity. The bottom of the ditch should always be entirely within the uphill lot (Figure 9). In steep terrain, the drainage area may be reduced by installing retaining walls (Figure 9).

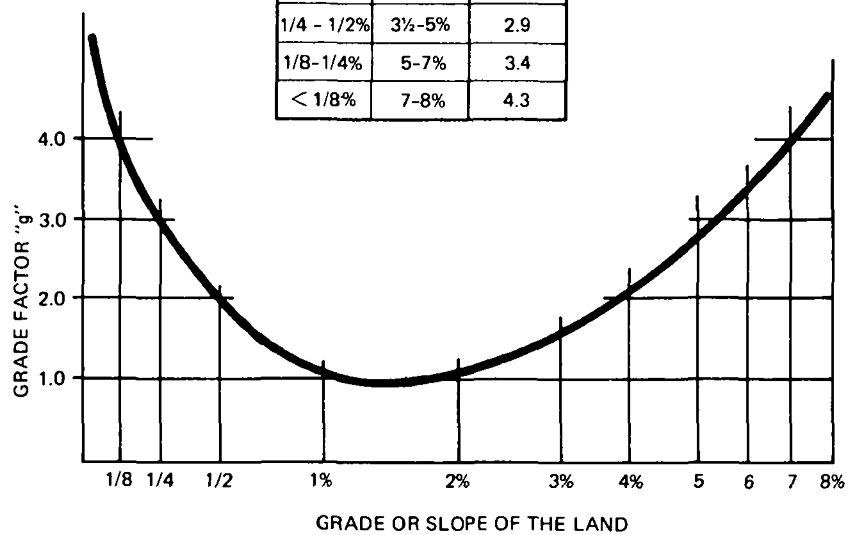
It is assumed that biological conditions in the storm water swales will always be aerobic, regardless of the biological condition of the domestic wastewater, since the storm water contains dissolved oxygen. Therefore the aerobic seepage rate is applied for that portion of the storm water which infiltrates and evapotranspirates.

Fig. 9. Drainage areas.



a – WIDE STRIP IN FLAT TERRAIN
b – DITCH ALWAYS ON UPHILL SIDE OF LOT LINE
c – RETAINING WALL MAY REDUCE DRAINAGE AREA IN STEEP TERRAIN

Fig. 10. Grade factor for drainage area.



SLOPE OF GROUND		g
1%-2%		1.0
1/2-1%	2-3½%	1.6
1/4 - 1/2%	3½-5%	2.9
1/8-1/4%	5-7%	3.4
< 1/8%	7-8%	4.3

If *calculated*, the equation for the Drainage Area D in square feet is:

$$D = 1500 \frac{g}{S}$$
aerobic

g = grade factor = 1.0 for ideal slopes, increasing up to 4.5 for flat and for steep terrain (see Figure 10)

S = seepage rate (see Table 5)

In our example for a loam-silt mixture with t = 45 min and for a natural slope of the land between 1% and 2%, the drainage area is:

$$D = 1500 \times \frac{1.0}{0.37} = 4080 \text{ sq. ft.}$$

This is, for a green area of 62 ft. × 94 ft. and the anticipated building area of 62 ft. × 70 ft., a frame of a width of 10 ft. to 11 ft. The width of the drainage "frame" would be much narrower, e.g., only 4 feet around the larger green areas required if wastewater conditions are anaerobic. Calculated drainage areas for prevailing conditions are tabulated in Table 5.

If *designed*, the drainage area "frame" could be plotted around the green area. For example, with a drainage area of 62 ft. × 94 ft. and a predesigned building area of, for example, 4000 sq. ft. (approx. 62 ft. × 65 ft.), if the width of the frame is chosen as 10 feet, the drainage area would be about 3000 sq. ft. (see Figure 11).

Table 5. Drainage Area.

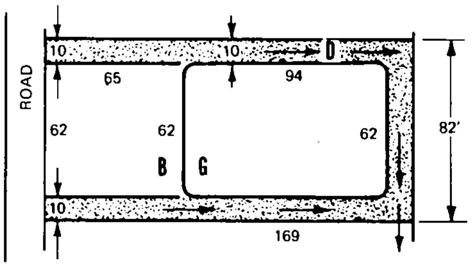
For various types of soil; for aerobic and for anaerobic conditions

Calculated in square feet as: $D = 1500 \times \frac{g}{S}$

For S as shown in Figure 4; F = 160 gal/day; g (grade factor) = 1.0

Type of Soil	Percolation Time (t in min.)	Seepage Rate aerobic	Drainage Area aerobic anaerobic
Sand	1	0.63	2600
Sand	5	0.60	2800
Fine sand	10	0.57	3000
Fine sand	15	0.53	3200
Silt and sand	20	0.50	3600
Silt	30	0.44	4200
Loam and silt	45	0.37	5400
Loam	60	0.32	6500
Clay and silt	90	0.25	10,000
Clay	120	0.21	15,000

Fig. 11. Drainage area.



FORMS A "FRAME" AROUND LOT

Step 4: The Building Area

In the building area are located the house, garages, driveway, swimming pool, terraces, patios, tennis courts, etc. Also part of the building area, for this purpose, is the setback or entrance area which is needed for aesthetic, architectural reasons. Also contained in the building area, far away from the green area, is the water supply well.

Individual design is the best way to establish the building area (Figure 1). The design should consider all needs of the home owner and should include possibilities for future expansion of house, garage, etc. If land area is very expensive, a "no expansion" agreement may replace the latter consideration.

The ***tabulated figures*** (Table 6) are another alternative to finding the building area. The expected types of houses and activities are the proposed parameters. Again, the proposed "expansion safety" percentage and perhaps part of the pool-patio area-allotment could be eliminated by a "no expansion" agreement.

For ***overall calculations*** of the building area B in square feet, two equations are offered.

$$B = 2000 + \frac{G + D}{2.5} \quad \text{or} \quad B = 4000 + \frac{G + D}{5}$$

The equation which leads to a smaller building area governs. In our example, G = 5800 sq. ft., D = 4080 sq. ft., $B = 200 + \frac{9880}{2.5} = 6000$ sq. ft., or $B = 4000 + \frac{9880}{5} = 6000$ sq. ft. The result is the same in either equation (Table 7).

Table 6. Building Area.
(square feet)

Size of Home	Floor Area Outside Measurement	Garage and Driveway	Patios and Pool	20% Safety Expansion	Entrance or Front Yard	Building Area
Small house	1500	500	500	500	1000	4000
Medium house	2000	700	1000	800	2500	7000
Large house	3000	1000	1500	1100	5000	12000
Estate-type house	4000	2000	3000	2000	8000	19000

Table 7. Building areas.
(square feet)
For F = 160 gal/day, S as in Figure 4.

Type of Soil	Percolation Time (t in min.)	Seepage Rate		Building Areas	
		Aerobic	Anaerobic	Aerobic	Anaerobic
Sand	1	0.63	0.54	4860	5180
Sand	5	0.60	0.46	4960	5540
Fine sand	10	0.57	0.39	5060	6080
Fine sand	15	0.53	0.31	5300	6520
Silt and sand	20	0.50	0.26	5420	7200
Silt	30	0.44	0.19	5880	9300
Loam and silt	45	0.37	0.12	6270	17,400
Loam	60	0.32	0.08	6660	38,200
Clay and silt	90	0.25	0.04	7840	—
Clay	120	0.21	0.02	9400	—

Step 5: The Well Protection Area

If the water for the neighborhood is supplied by individual wells and if the wastewater is disposed by individual infiltration beds, an additional well protection area assures that the necessary protection distance exists between the intake of each homeowner's well and his neighbour's wastewater infiltration beds.

An additional well protection area is *not* required if:

(a) the neighbourhood is supplied from a municipal water system;

(b) the wastewater is not infiltrated into the ground, for example, if it is entirely evapotranspirated;

(c) the water supply well is deep enough and the lot is large enough so that the protective distance is "built-in," meaning that it exists without allocating an additional area.

Seeping downward through a variety of soil strata, the wastewater is purified by a combination of physical, biological and chemical forces. For this purification, vertical travel is much more effective than horizontal travel. Most physical and bio-degradable impurities have usually disappeared after a vertical infiltration of 8 to 12 feet, while chemical pollutants and viruses are more persistant and can be detected down to 25 to 30 feet of depth. Consequently, the depth of a well is extremely important in preventing its pollution by infiltrated wastes.

Another important factor for the purification is the type of soil, fine grained and fine pored soils offering much superior elimination of pollutants. Thus clay and silt are much better than sand in this case.

The worst possibility of well pollution occurs if the wastewater flows toward the well in a soil crevice, without any purification occurring. Where such soil conditions exist, total evapotranspiration of the wastewater is one possible answer.

The ***horizontal protective distance*** (Figure 12) can be *calculated* as:

$$h = \frac{180{,}000\sqrt{s_i}}{d^{3/2}}$$

h = horizontal protective distance in feet; measured from the water supply well to the nearest limit of any neighbour's "green area." The distance to the owner's "green area" should be about 15% to 20% shorter, so any indication of wastewater pollution of the well would come from the owner's sewage.

d = depth of well, in feet; most likely a drilled well of a diameter of only a few inches.

s_i = anaerobic infiltration rate, in gal/sq.ft./day, average for all soil strata encountered while drilling the well.

The required horizontal protective distances are tabulated in Table 8 and diagrammatically shown in Figure 13, for various depths of wells and for various types of soil, whereby the percolation time is the average of all soil strata encountered during well drilling.

Properly, lots of reasonable proportions, such as a width to length ratio of 1:2 to 3.5:4 have a *built-in protective distance, if the water supply well is located in front of the house at a setback*

Fig. 12. Horizontal Protective Distance.

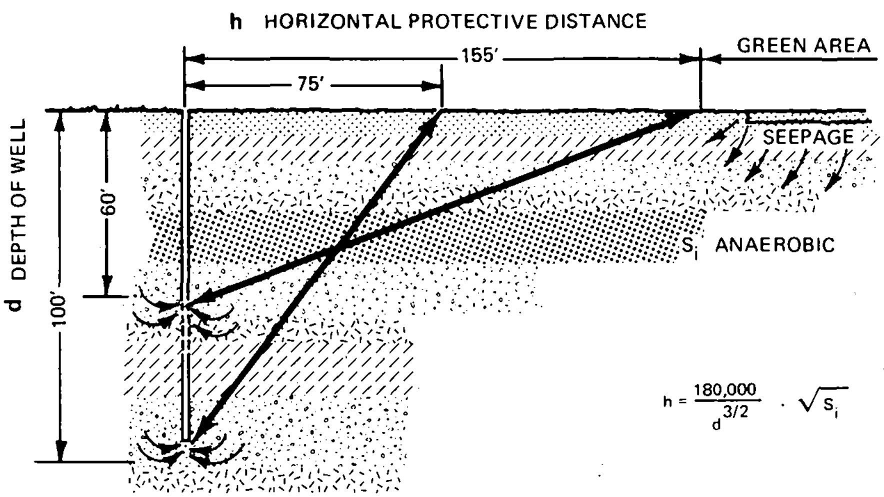
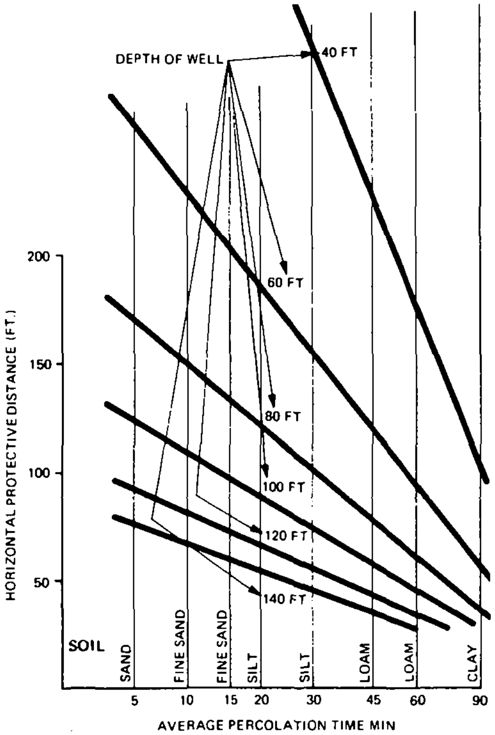


Fig. 13. Horizontal protective distance.



DEPENDING ON DEPTH OF WELL AND ON TYPES OF SOIL.

Table 8. Horizontal Protective Distances.
(h for Wells)
For various depths and soils

$$h = \frac{180{,}000}{d^{1/2}}\sqrt{s_i} \text{ (horizontal protective distance in feet)}$$

d = depth of well in feet
s_i = infiltration rate, anaerobic, in g/sq. ft.

Type of Soil	Percolation Time (t in min.)	Seepage Rate anaerobic	Depth of Well (feet) 40	60	80	100	120	140
Sand	5	0.45	480	260	170	120	90	75
Fine sand	10	0.37	430	235	150	110	85	66
Fine sand	15	0.29	380	210	135	100	75	60
Silt	20	0.24	350	190	125	90	65	55
Silt	30	0.17	295	160	105	75	55	45
Loam	45	0.10	225	120	80	60	45	35
Loam	60	0.06	175	95	60	45	35	30
Clay	90	0.04	140	80	50	35	30	20

of about 20 feet. For our example, for soil strata of loam and silt mixture and with aerobic wastewater conditions (total lot area 17,600 sq. ft., the built-in horizontal protective distance, h, is 120 feet. Tabulated in Table 9 are all built-in horizontal protective distances, depending on soil types and biological wastewater conditions.

Therefore, no additional well protection area P is needed if the horizontal protection distance as calculated, or as tabulated in Table 8, is shorter than the built-in protection distance as tabulated in Table 9.

Table 9. "Built-In" Horizontal Protective Distances Between Well and Green Area.

Type of Soil	Percolation Time (t in min.)	Aerobic Conditions: Lot Size	Aerobic Conditions: Built-In Protective Distance	Anaerobic Conditions: Lot Size	Anaerobic Conditions: Built-In Protective Distance
Sand	1	60 x 200	75-80	60 x 220	85-90
Sand	5	60 x 200	80-85	62 x 230	90-95
Fine sand	10	60 x 212	85-90	65 x 248	95-105
Fine sand	15	60 x 222	85-90	75 x 256	110-125
Silt and sand	20	62 x 226	90-95	80 x 290	120-140
Silt	30	65 x 235	95-105	95 x 380	130-150
Loam and silt	45	70 x 252	100-120	150 x 562	140-160
Loam	60	75 x 266	125-135	220 x 946	170-190
Clay and silt	90	80 x 340	140-150	—	—
Clay	120	85 x 384	155-165	—	—

An additional well protection area is required, however, if the built-in protective distance (Table 9) is shorter than the required protective distance (Table 8). This can be done by *design*, as indicated in Figure 14. For example, the total area B + G + D of a lot in silty soil (t = 30) and with aerobic wastewater condition is 15,300 sq. ft. (Tables 4, 5, 7). It has a "built-in" horizontal protective distance of 105 feet. The required horizontal protective distance for an 80 foot well in similar soil strata is 100 feet (Table 8). In this case, no additional well protection area is needed (Figure 14). If, however, a 40 foot well would be selected under the same conditions, a horizontal protective distance of 295 feet (Table 10) would be needed. To achieve this distance between well and green area, an additional well protection area P of 12,000 sq. ft. is required (Figure 14). Also, the drainage area increases by about 34,000 sq. ft., thus making the total required lot area 307,000 sq. ft.

Fig. 14. Influence of well depth on lot size. (feet)

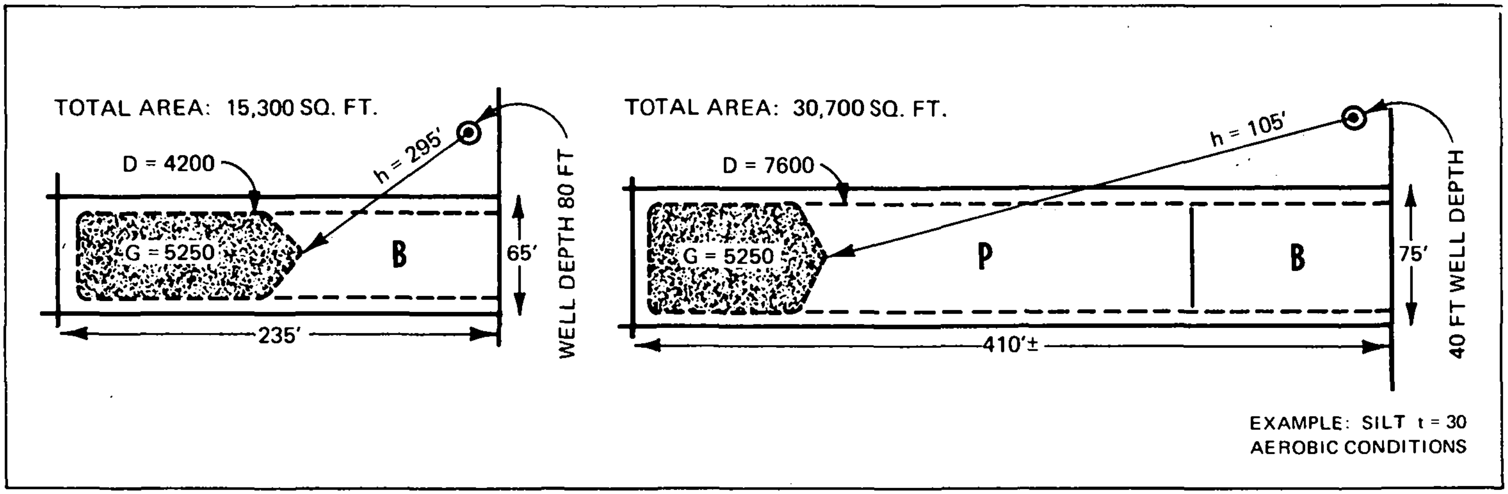


Table 10. Minimum Depth of Well Without Protection Area.
(feet)

Type of Soil	Percolation Time (t in min.)	Aerobic	Anaerobic
Sand	1	140	140
Sand	5	130	120
Fine sand	10	120	120
Fine sand	15	120	100
Silt	20	100	80
Silt	30	80	70
Loam	45	60	60
Loam	60	50	50
Clay	90	40	—
Clay	120	40	—

It follows that under the same soil conditions, a shallower well requires a larger lot size. In other words, deeper wells can be used to reduce the lot sizes. The minimum well depths which do not require additional well protection area for various soil conditions are tabulated in Table 10.

There are no restrictions for the surface of the well protection area. It can be used as an extension of the building area or for active sports or similar activities.

Summary

$$\text{Lot} = G + D + B + P$$

$$G = \left(4000 + \frac{A}{S^{3/2}}\right)\frac{F}{160}$$

$$A = \frac{F.L.}{S}$$

$$D = 1500 \cdot \frac{g}{S}$$

$$B = 2000 + \frac{G + D}{2.5}$$

$$\text{or} = 4000 + \frac{G + D}{5}$$

$$h = \frac{180{,}000 \cdot \sqrt{S_i}}{d^{3/2}}$$

$G =$ Green area
$D =$ Drainage area
$B =$ Building area
$P =$ Well protection area
$A =$ Seepage bed area
$F =$ Flow of wastewater
$L =$ Pollution load of treated wastewater
$S =$ Seepage rate $S_i + S_e$
$S_i =$ Infiltration rate
$S_e =$ *Evapotranspiration rate*
$g =$ grade factor
$h =$ horizontal protective distance
$d =$ depth of water supply well

A summary of total lot areas for various soil conditions and for aerobic and anaerobic-septic biological conditions are tabulated in Table 11 and are diagrammatically shown in Figure 15, without additional well protection area ($P = 0$) and for $F = 160$, $g = 1.0$, $S_e = 0.06$-0.11 (aerobic) and $S_e = 0.01$-0.02 (anaerobic). Also listed in Table 11 are the "built-in" horizontal protective distances and the corresponding minimum depth of water supply wells. A visual comparison of lot sizes for aerobic and anaerobic conditions is attempted in Figure 16.

The increase in lot size, if a well protection area P is required, is illustrated in Figure 17. The lot size in a district with silty soil ($t = 30$) and with aerobic wastewater conditions, for example, is 15,300 sq. ft. or 65 ft. × 235 ft. Such a lot has a "built-in" protective distance of about 100 ft., which means that no additional well protection area is required if the well is 80 ft. deep (Table 8).

If the well is only 60 ft. deep, the required horizontal protective distance is 155 ft., and thus an additional well protection area of 4200 sq. ft. is needed. The total lot area is now 19,500 sq. ft. or 75 ft. × 260 ft. As another example (Figure 17), if the district's soil is loam with silt ($t = 45$), the lot size is 17,700 sq. ft. or 70 ft. × 252 ft., with a built-in $h = 120$. Thus the minimum well depth is 60 ft. If the well is only 40 ft. deep, h becomes 230 ft., which requires an area P of 10,400 sq. ft., for a total lot area of 28,000 sq. ft. or 85 ft. × 230 ft.

EXAMPLE: Lot size determination for a lake area cottage subdivision in the Muskoka Recreational District about 140 miles north of Toronto.

Conditions:

—Soil: rock, gently sloping towards the lake with about 12 feet of sandy topsoil above the rock.

—Layout: all lots front on the lake.

—Water supply: individual units, pumping water from the lake.

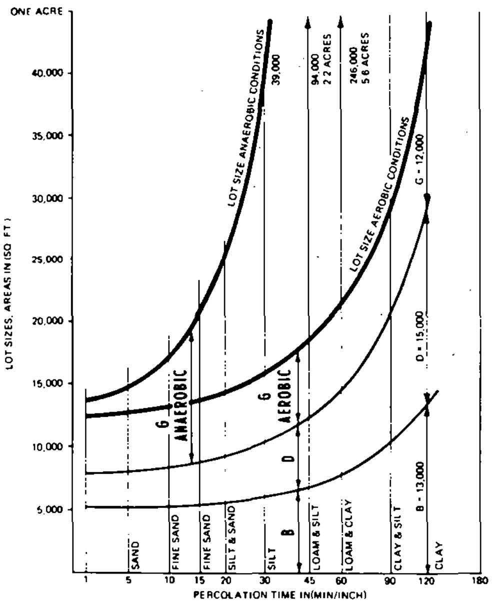
—Wastewater disposal: entirely by evapotranspiration.

Decision or assumptions:

—Water consumption and wastewater flow per cottage:
F = 160 gal per day.

—To be installed: an aerobic treatment unit, which reduces the pollution load to
BOD = ~ 50 mg/l and SS = ~ 70 mg/l
for an L value of 1.

Fig. 15. Summary of lot areas.



FOR VARIOUS SOILS AND ANAEROBIC/AEROBIC CONDITION WITH MINIMUM DEPTH OF WELLS ESTABLISHED BY "BUILT IN" PROTECTIVE DISTANCE OR FOR "NO WELLS" DEVELOPMENTS

Table 11. Summary of Lot Areas.

	Percolation Time (t in min.)	Seepage Rate	G (sq. ft.)	D (sq. ft.)	B (sq. ft.)	Lot Area (sq. ft.)	Lot Area (ft. x ft.)	Well Protective Distance (ft.)	Well Depth (ft.)
AEROBIC CONDITIONS									
Sand	1	0.63	4510	2600	4860	12000	60 x 200	75-80	140
Loam and silt	45	0.60	4580	2800	4960	12300	60 x 206	80-85	130
Sand	5	0.57	4660	3000	5060	12700	60 x 212	85-90	120
Fine sand	10	0.53	4770	3200	5300	13300	60 x 222	85-90	120
Fine sand	15	0.50	4910	3600	5420	14000	62 x 226	90-95	100
Silt and sand	20	0.44	5250	4200	5880	15300	65 x 235	95-105	80
Silt	30	0.37	5950	5400	6270	17600	70 x 252	100-120	60
Loam	60	0.32	6800	6500	6660	19900	75 x 266	125-135	50
Clay and silt	90	0.25	9140	10000	7840	27000	80 x 340	140-150	44
Clay	120	0.21	12000	15000	9400	36400	95 x 384	155-165	40
ANAEROBIC CONDITIONS									
Sand	1	0.54	5360	2600	5180	13100	60 x 220	85-90	140
Sand	5	0.46	6020	2800	5540	14300	62 x 230	90-95	120
Fine sand	10	0.39	7040	3000	6080	16100	65 x 248	95-105	120
Fine sand	15	0.31	9400	3200	6520	19100	75 x 256	110-125	100
Silt and sand	20	0.26	12350	3600	7200	23100	80 x 290	120-140	80
Silt	30	0.19	22300	4200	9300	35800	95 x 380	130-150	70
Loam and silt	45	0.12	61500	5400	17400	84300	150 x 562	140-160	60
Loam	60	0.08	164000	6500	38200	208700	220 x 946	170-190	50
Clay and silt	90	0.04							
Clay	120	0.02							

$$G = \left(4000 + \frac{A}{S^{1/2}}\right)\frac{F}{160}$$ See Table 4

$$D = 1500\,\frac{g}{S}$$ See Table 5

$$B = 2000 + \frac{G + D}{2.5} \text{ or } 4000 + \frac{G + D}{5}$$ See Table 7

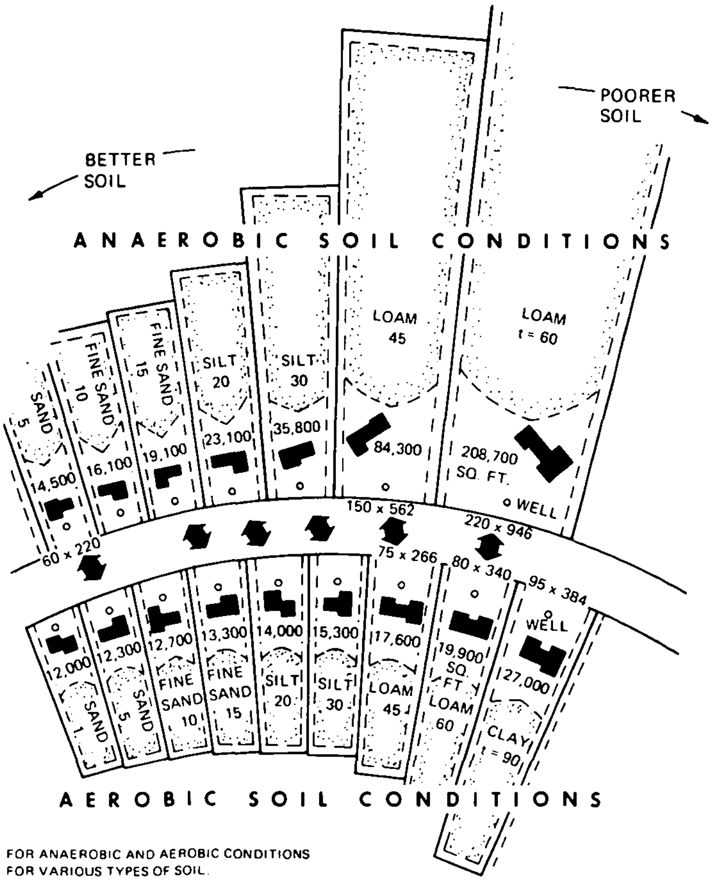
—To be constructed: an aerobic evapotranspiration bed, 18″ deep (partly imported sand) with waterproof side beams, with grass and shrubbery planted above and beside. No soil infiltration is anticipated ($S_i = 0$).

—The wastewater table is kept 6″ to 9″ below the grass surface during summer ($S_e = 0.11$) but is permitted to rise to 2″ to 3″ below the surface during winter ($S_e = 0.08$); thus the average $S = S_i + S_e = 0.1$ gal/sq.ft./day.

Lot Area Calculated:

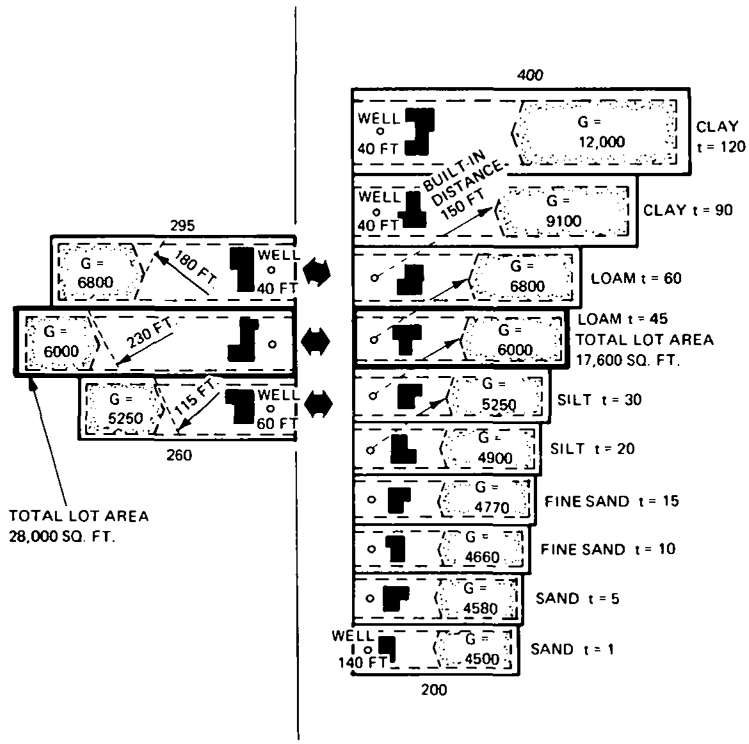
—*Lot area* = B + G + D in square feet. Well protection area does not need to be considered, since no soil infiltration is anticipated and no wells will be built.

Fig. 16. Comparison of lot sizes.



FOR ANAEROBIC AND AEROBIC CONDITIONS FOR VARIOUS TYPES OF SOIL.

Fig. 17. Comparison of lot sizes.



DEPENDING ON DEPTH OF WELL AND CONSEQUENTLY ON PROTECTIVE DISTANCE ALL EXAMPLES FOR AEROBIC CONDITIONS

—*Green Area G:* (F = 160, S = 0.1)

$$G = (4000 + \frac{A}{S^{3/2}}) \times \frac{F}{160}$$

$$A = \frac{F \cdot L}{S} = \frac{160 \times 1.0}{0.1} = 1600 \text{ sq. ft.}$$

$$G = (4000 + \frac{1600}{0.1 \times 0.33}) \times 1.0 = 53{,}000 \text{ sq. ft.}$$

—*Drainage Area D:* (g = 1, S = 0.1)

$$D = 1500 \times \frac{g}{S} = 15{,}000 \text{ sq. ft.}$$

—*Building Area B:*

$$B = 4000 + \frac{G + D}{5} = 4000 + \frac{68{,}000}{5} = 17{,}600 \text{ sq. ft.}$$

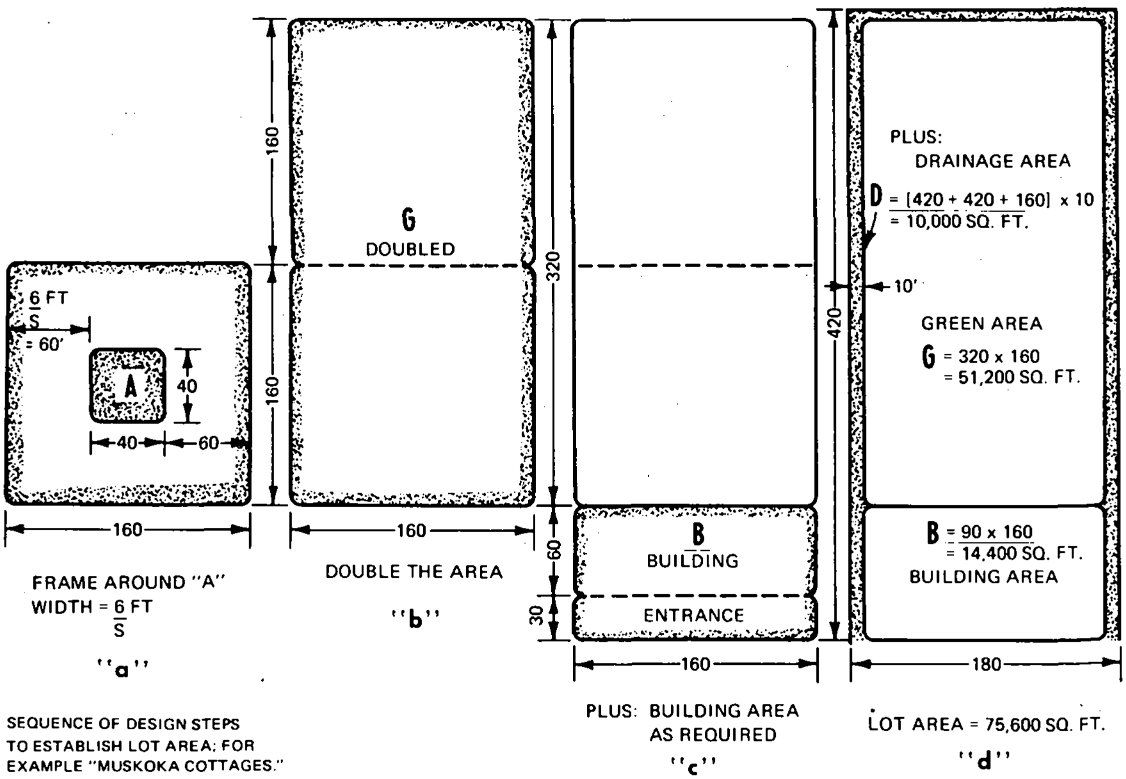
(or B from table = 12,000 sq. ft.)

—Lot area = 53,000 + 15,000 + 17,600 = 85,600 sq. ft.

Lot Area Designed: (Figure 18)

—Seepage area A calculated: $A = \frac{F \cdot L}{S} = 1600$ sq. ft.

Fig. 18. Sequence of design steps.



—Frame around A with a width of $\frac{6\text{ ft.}}{S} = \frac{6}{0.1} = 60$ ft.

—Double above area for G = 2 (160 × 160) = 51,200 sq. ft.

—Design a building area 60 ft. deep and a building entrance area 30 ft. deep: B = 14,400 sq. ft.

—Design a 10 ft. wide "frame" around the lot for storm water swales
10 ft. × 1000 ft. = 10,000 sq. ft.

—The total *lot area* is 51,200 + 14,400 + 10,000 = 75,600 sq. ft.

—Therefore, a detail design for each lot often leads to smaller lot areas, and pays off where land is expensive.

Possibilities for lot layout and location of buildings are shown in Figure 19.

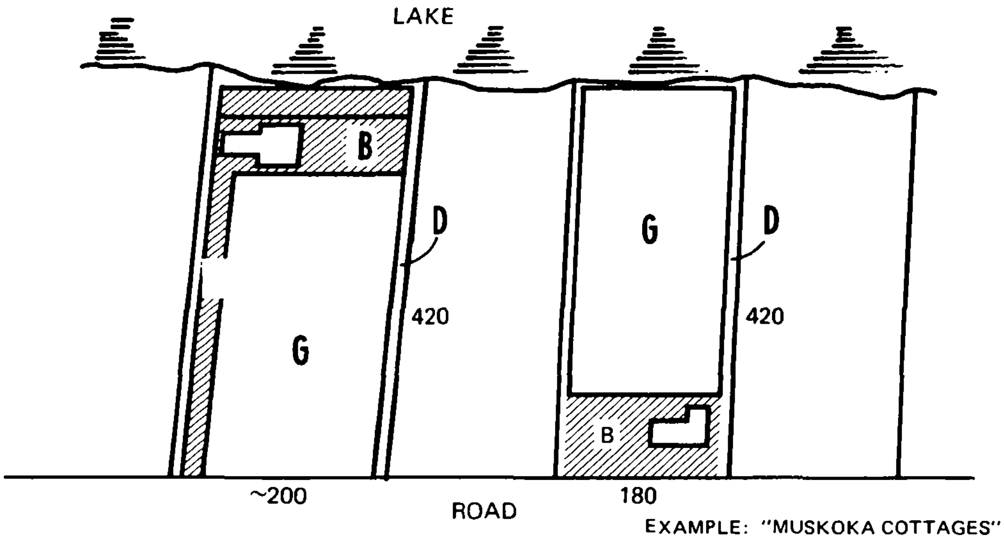


Fig. 19. Lot layout.

Conclusion

The presented method of lot size calculations should make it possible to design subdivisions for single family houses which employ the best possible disposal of the wastewater, namely to return it to plant life and into soil, from where the water originally came. The proposed area calculations, together with improved methods of wastewater treatment, as well as the application of filtration and evapotranspiration phenomena, assure that sufficient area is available on each lot for wastewater disposal, stormwater disposal and protection of the water supply, in addition to the spaces needed for the major living activities.

Difficulties and failures, which have discredited individual wastewater units and water supply systems in the past, will be avoided in the future if the methods described here are used. They may also contribute to improvement of our much abused environment.

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Soil Sci.
Soil Science

Soil Sci. Soc. Am. Proc.
Soil Science Society of America. Proceedings

Trans. Am. Geophys. Union
Transactions. American Geophysical Union

Trans. Am. Soc. Civil Engrs.
Transactions. American Society of Civil Engineers

Water and Sewage Works

Performance Standards and the National Sanitation Foundation

Introduction

While the most frequently quoted engineering guide to septic tank system design is the U.S. Public Health Service's *Manual of Septic Tank Practice,* most states and local jurisdictions have their own specifications regarding a variety of water supply and wastewater treatment systems. Because the specifications for all equipment vary so widely among jurisdictions and are so frequently subject to change, they are not included here. The same variability holds for zoning practices, lot sizing (an approach is presented in Appendix A), critical separation distances between treatment works and structures, and so forth. To obtain the latest engineering specifications for the type of installation anticipated, contact responsible agencies in the area of interest.

Engineering standards for wastewater treatment equipment and materials have been published by a variety of agencies. Performance standards, which are concerned with how a unit is expected to perform in a realistic operating environment rather than specific engineering design, have been established for individual aerobic wastewater treatment plants and other processes and devices by the National Sanitation Foundation. The following is a description of the NSF program in Wastewater Technology prepared by Heinz B. Russelmann, P.E., Director, Wastewater Technology, National Sanitation Foundation.

Wastewater Technology Program at the National Sanitation Foundation

The National Sanitation Foundation at Ann Arbor, Michigan, is a not-for-profit organization dedicated to the solution of problems for an improved environment. Areas of concern include drinking water supply, liquid waste disposal, solid waste handling, swimming pool equipment, restaurant equipment, etc., represented by thousands of products manufactured by industries in the United States, Canada, Europe and Asia.

The purpose of the Foundation is to gain consensus among manufacturers, governmental regulatory officials and the users of products in defining necessary standards of construction and criteria for performance. In this way, designers and manufacturers of processes and devices may be guided to use sound practices of sanitation, regulatory officials may have a rational basis for decision-making in the acceptance of products, and users may have reasonable assurance that public health principles have been employed.

The National Sanitation Foundation Testing Laboratory, Inc. tests products according to published standards and criteria and may authorize the issuance of the NSF Seal in recognition of conformance with the standards. Published listings identify the conforming products and periodic inspections of manufacturing processes validate their continuing conformance.

In matters of wastewater treatment, the National Sanitation Foundation provides the following services:

1. Testing of small sewage treatment plants which have been prefabricated and factory assembled. Such plants, generally having capacities from 2,000 gallons per day, are intended to serve small communities, schools, shopping centers, institutions and commercial or industrial facilities. They provide compact and economical means for wastewater treatment especially in small areas of population concentration or rural settings where treatment must be provided centrally and until regional systems can be justified. They can provide phased increases of capacity on a modular basis as population or development increases. The Foundation has developed a Standard Performance Evaluation Method by which a package-type plant may be tested. Upon completion of the 100-day operating schedule, a report of performance is issued to demonstrate the capability of the plant under the specified test conditions. The test data are available for review by designing engineers and regulatory officials in their consideration of a particular plant to meet a local sewage treatment need. Those manufacturers who have submitted plants for testing, for which data are available, are identified in a published list. Testing is done at the Ann Arbor research site.

2. Testing of small plants intended for installation on individual home-sites. NSF Standard No. 40 for Individual Aerobic Wastewater Treatment Plants was conceived by representatives of industry, public health agencies and a variety of governmental agencies and professional groups. It does not attempt to define design requirements except in the very general sense of compatibility with the use environment, operation and maintenance, repairability, serviceability and safety. A plant must demonstrate that, on the basis of 90 per cent probability during the six-month test period, effluent quality shall not exceed one of two classifications: 20 milligrams per liter BOD_5 and 40 milligrams per liter suspended solids for the higher quality discharge; 60 milligrams per liter BOD_5 and 100 milligrams per liter suspended solids for the lesser quality discharge. In this standard, responsibility is defined with regard to the manufacturer or the distributor to assure proper installation and a service program for inspection and maintenance. A recommended one year warranty is included.

Plants have been submitted by manufacturers and have undergone tests at the Ann Arbor research site for conformance with the standard. Those bearing the NSF Seal have demonstrated that the required effluent quality has been produced under the defined test conditions. Those manufacturers whose plants meet the requirements of the standard are listed by the Foundation.

3. Performance evaluations of special processes or devices under the provisions of NSF Basic Criteria C-9. Special test protocols are developed to measure the performance of the plant against the manufacturer's claims and sound principles of sanitary engineering practice. Upon testing, the Foundation reports on performance and may identify compliance with the requirements through the issuance of the NSF Seal.

Figures 24 through 27 illustrate several aspects of the NSF wastewater treatment plant testing program.

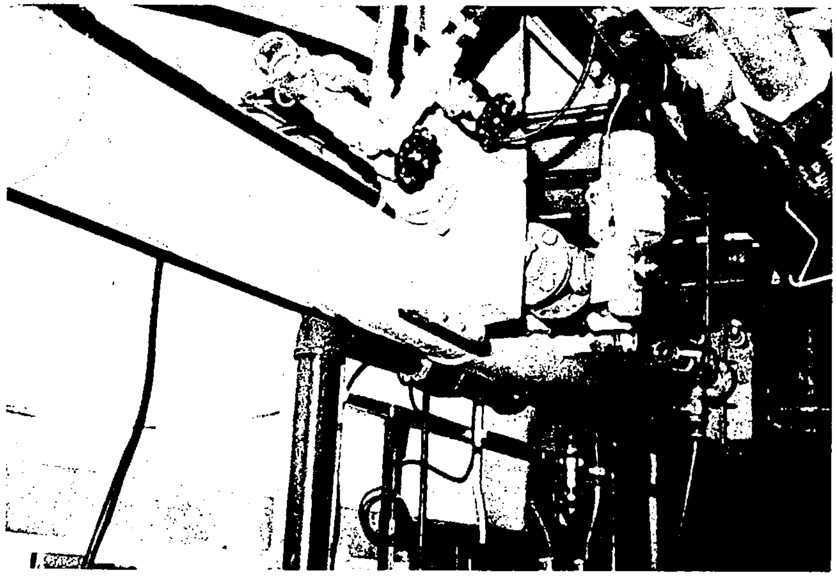


Fig. 24. Main sewage sampling manifold (upper left to lower right) and programmable sampling station (upper center).

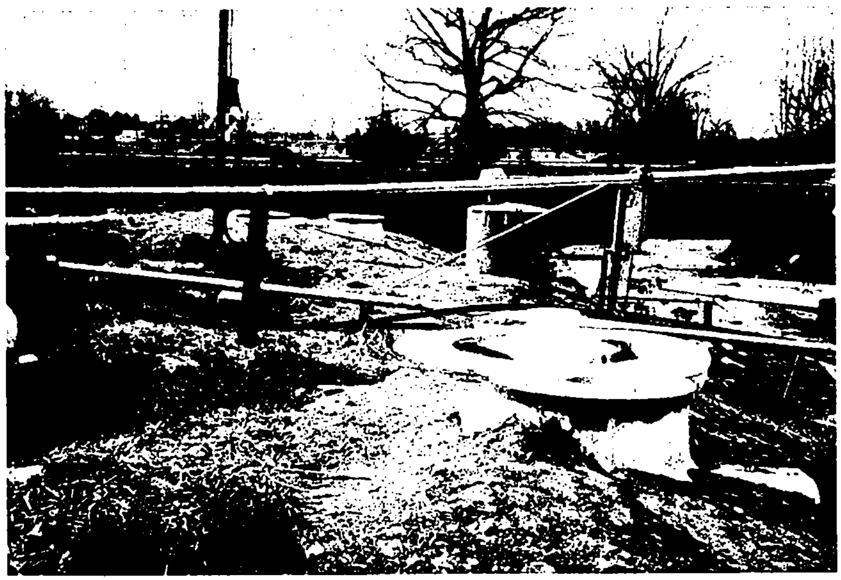


Fig. 25. Several individual home aerobic wastewater treatment plants undergoing performance testing.

Fig. 26. Activated sludge package treatment plant (right) and chemical tablet chlorinator (center) being tested.

Fig. 27. Wastewater test evaluation laboratory.

Appendix C

Survey of Available Equipment and Equipment Data Sheets

Introduction

The summary information included here on representative selections of sewage treatment equipment applicable to rural communities is organized along functional lines — wastewater conveyance, treatment, disposal, and so forth. Emphasis in the selection reflects the relative importance to rural areas of the particular classes of equipment. Most of the information-collection effort was directed at individual home (on-site) aerobic treatment units. The second greatest effort was made to obtain information on package treatment plants of subdivision size.

Data were obtained directly from the manufacturers and this Appendix could not have been assembled without the cooperation of the manufacturers represented herein. It is recognized that some products may perform better than others. Until all the units are evaluated objectively under standardized conditions, however, meaningful performance comparisons will be impossible. The information which appears on the summary data sheets is, therefore, as it was furnished by the manufacturers. The non-availability of comparative data places the burden of selectivity upon the designer.

Manufacturer-contact information has been supplied on every summary data sheet. The data sheets are provided as a guide to what is available on the market, and, perhaps, for preliminary system design purposes. Readers are advised in each case to contact the manufacturer for latest specifications and pricing information.

Self-Contained Systems

Introduction

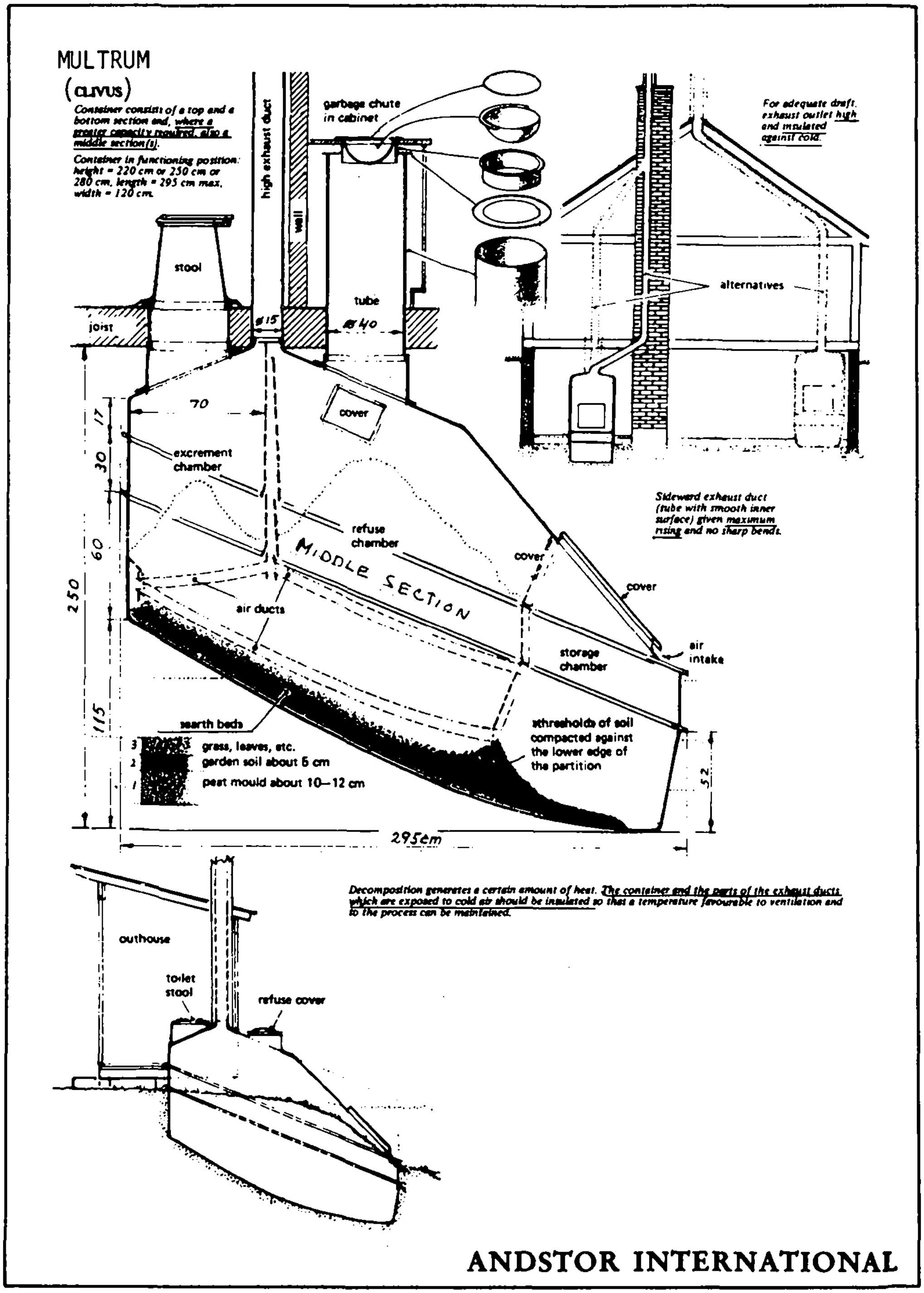
In almost any rural community there are likely to be at least a few homes that cannot be served by the more common on-site disposal systems or sewer lines at reasonable cost — an isolated house high up on a steep rocky hill or a few houses on a small island with a very high water table, for example. In such instances, systems for completely treating or containing toilet wastes (sanitary wastes) so that no treatment load is placed on the immediately surrounding environment should be considered. If water carriage of wastes is desired, a holding tank can be installed. The tank would need to be pumped out periodically and its contents disposed in a sewage treatment facility. With the holding tank arrangement, the pumping truck essentially takes the place of the sewer as the means of conveying wastes to the treatment plant.

If water carriage of wastes is not a necessity, privies may be employed. Privy design information may be found in works by Salvato [12] and Wagner and Lanoix. [11] Privies may be designed for infiltration of decomposed waste materials into the soil or as watertight vaults which are pumped as holding tanks are pumped.

A prefabricated version of a privy system which utilizes aerobic composting of solid wastes from kitchen and toilet is shown in this section. Aerobic composting is ensured by a system of airducts and draft tubes. The unit is manufactured abroad, but growing interest among conservation groups in the U.S. has led the manufacturer to seek U.S. licenses to manufacture and/or distribute the system. The compost which is taken from the system is reportedly suitable for use as garden fertilizer or soil conditioner. The unit has been engineered to permit either household installation or installation in an outdoor privy.

An incinerator toilet is also included here. This particular unit is available for operation with either natural gas or propane gas. An electric incinerator toilet is reportedly available from another manufacturer, but the authors were unable to obtain information from the manufacturer.

Incinerator toilets reportedly operate for about $2.00 per month fuel costs for a family of three. [37] Operating skills are minimal, as the incineration cycle is either automatically actuated when the seat cover is closed, or the cycle is initiated by setting a timer dial. Some minor odors are generated during the incineration, but these are only apparent when atmospheric conditions cause down-drafting into the house.


MULTRUM
(CLIVUS)
Container consists of a top and a bottom section and, where a greater capacity required, also a middle section(s).
Container in functioning position: height = 220 cm or 250 cm or 280 cm, length = 295 cm max, width = 120 cm.
high exhaust duct
wall
garbage chute in cabinet
stool
tube
joist
ø15
ø40
70
cover
excrement chamber
refuse chamber
MIDDLE SECTION
cover
cover
air ducts
air intake
storage chamber
earth beds
3 grass, leaves, etc.
2 garden soil about 5 cm
1 peat mould about 10—12 cm
thresholds of soil compacted against the lower edge of the partition
17
30
60
250
115
52
295cm
For adequate draft, exhaust outlet high and insulated against cold.
alternatives
Sideward exhaust duct (tube with smooth inner surface) given maximum rising and no sharp bends.
Decomposition generates a certain amount of heat. The container and the parts of the exhaust ducts which are exposed to cold air should be insulated so that a temperature favourable to ventilation and to the process can be maintained.
outhouse
toilet stool
refuse cover
ANDSTOR INTERNATIONAL

ANDSTOR INTERNATIONAL
VIREBERGSVAGEN 7, BOX 1023
S-171 21 SOLNA 1, SWEDEN
TEL. 08/82 00 73
Attn: Mr. Sten O. Haeger, Director in Charge of Licensing

MULTRUM

DOMESTIC CONVERTER-COMPOSTER

FEATURES

1. Multrum converter is a glass fiber polyester plastic container with air-intake and ventilation duct.
2. Unit comes with toilet bowl and garbage duct (disposal-type wastes).
3. Aerobic decomposition of waste by chimney or forced draft (no odor), uses no water or supplies.
4. Decomposed material can be removed and used as fertilized humus, after 1-2 years.
5. Water evaporates from heat of decomposition.[2]
6. Grey water treatment available. Sludge from grey water can be put in composter.

OPERATION

1. Before use, an earth bed should be added to container floor.
2. Toilet wastes are deposited through open bowl to excrement chamber and move down-slope to storage.
3. Kitchen wastes are added to refuse chamber which collides with excrement in flowing towards storage.
4. High exhaust duct sucks air (through seat and side-holes) past and through wastes to decompose waste and remove gases.
5. Grey water system for other water wastes can be coordinated with composter.

MODEL NUMBER (MAJOR)	DIMENSIONS[1] LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
MULTRUM	10'	4'	8'3"		5 person design capacity	ca.1000	(See below)			house-life (ca. 30-50 years)	None[2]		Peat & soil	

[1]Dimensions are for converter only, not grey water disposal system, not including stool or draft tube.
[2]In cold environs, electrical heating pad required.

SIZING & GROWTH POTENTIAL

1. Designed for 1-family use. If larger capacity needed, sections can be added.
2. Available in 7'3" and 8'3" height models.

COSTS

1. Costs are not yet established for the U. S. A.

INSTALLATION REQUIREMENTS

1. Stool with seat must be placed in floor. Refuse tube must also be located in floor.
2. Concrete supports for tank in house; gravel needed if outside excavation done.
3. Startup should employ experienced person.

OPERATION & MAINTENANCE REQUIREMENTS

1. If small amounts of kitchen wastes are added, then organic material (leaves, etc.) should be added.
2. Poisonous materials and synthetics cannot be added.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5	SS	DO	COD	WATER FLOW		OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
MULTRUM	(Solid waste product)				40[3] (R)		15-30° C (temperate)	No noise, No odors[4]	U.S.Patent & European use	

[3]Reduction of normal household water consumption (toilet flushing).
[4]No odor inside if properly installed with adequate draft; exhaust has slight odor.

WARRANTIES, GUARANTEES, & SERVICE

1. Service facilities and support not yet established. Service contracts may be sold with the equipment.

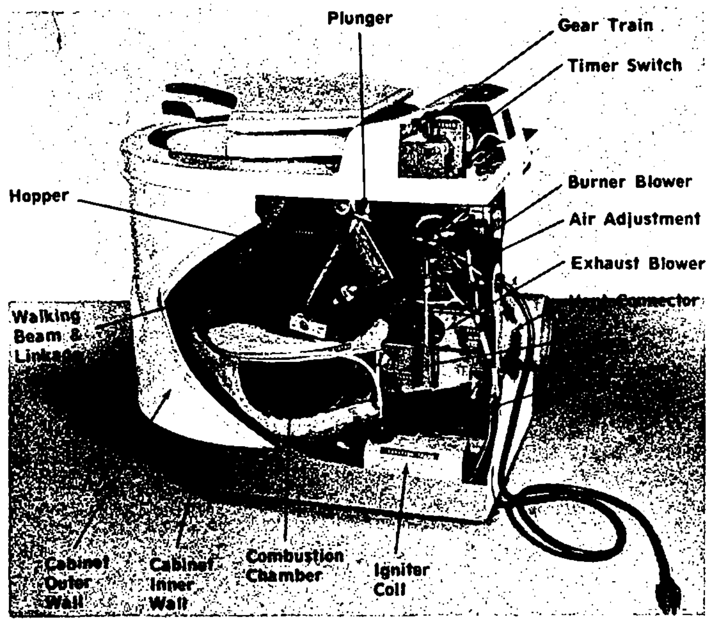
TECHNICAL PERFORMANCE

1. Approved by authorities in Sweden, Norway, and Finland.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. U. S. license presently being sought, while U. S. Patents have been obtained.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



DESTROILET® INCINERATOR TOILETS

MERE INDUSTRIES, INC., WALWORTH, WISCONSIN 53184

Compact, self-contained toilet system

Electricity and gas operation supplies up to 60 flushes per day

LAMERE INDUSTRIES, INC.
227 N. MAIN ST.
WALWORTH, WISCONSIN 53184
(414) 275-2171
Attn: Mr. John C. Trimble, Vice-President, Sales

DESTROILET®

INCINERATOR-TOILET SYSTEM

FEATURES

1. Dry sanitary toilet, destroys all liquids, reduces solids and eliminates bacteria.
2. Propane or natural gas incineration of wastes.
3. Automatically timed cycle burns (10-14 min) and cools (6 min).
4. Cycle may be interrupted at any time for further use, burning cycle then reset for longer cycle.
5. High-powered blower removes odors, heat, and vapors.
6. Seat activates unit, no levers or switches to manipulate.
7. Switches safeguarded, incinerates only when seat is closed.
8. Three major models for three electrical ratings (12, 115, and 220 V AC).
9. All models in either natural, propane or butane configurations.

OPERATION

1. Seat cover raised, timer set, toilet used.
2. Seat cover closed, timer starts, use completed.
3. At end of burning cycle, timer turns off gas and ignition.
4. At end of next 6 minutes, timer turns off all functions.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)[1]	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	OTHER[2]		
54P5B 54N5B	$21\frac{3}{4}$"	16"	20"	95[3]	up to 60 flush/day	1.0	395.00	75.00	(See below)	12 years	115 V AC 300 W 60 Hz	Gas - 25,000 BTU/hr	1/5 lb. propane per flush[4]	
54P9B 54N9B	"	"	"	"	"	"	"	"	"	"	220 V AC 300 W 50-60 Hz	"		
54P2B 54N2B	"	"	"	"	"	"	"	"	"	"	12 V DC at 50 amp	"		

[1] FOB, Walworth, Wisconsin.
[3] 105 lb. shipping weight.
[2] Gas: 6" W.C. natural or 11" W. C. LP; operating pressure: 3 1/2" W.C. natural (internal second stage regulation) or 11" W.C. LP (appliance pressure).
[4] Proportionate volume natural gas/flush; 3/8" NPT male line.

SIZING & GROWTH POTENTIAL

1. Fits anywhere with space for 8' flue and utilities.
2. Recommended for 4-6 person use (weekly cleaning).

COSTS

1. Operating costs would include electrical, gas and servicing costs.
2. Installation costs include construction of flue line.

INSTALLATION REQUIREMENTS

1. Indoor installation with gas line to be piped into 3/8 NPT male inlet. (Shut-off valve recommended outside of toilet; can be located in unit, also.)
2. Electrical hook-up needed (12, 115, 220 V).
3. Construction of vertical vent with natural draft.

OPERATION & MAINTENANCE REQUIREMENTS

1. Under normal use (4-6 people), unit should be cleaned weekly.
2. Cleaning: vacuum ashes, clean bowl and incinerate with 8 oz. clean water.
3. Automotive spark plug used, replaceable.
4. Color coded wiring diagram for easier diagnosis.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS[5]	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
54P5B 54N5B	NA	NA	NA	NA			Unlimited	Minor outside noise and odors	AGA,[6] NSF and CGA	
54P9B 54N9B	"	"	"	"			"	"	"	
54P2B 54N2B	"	"	"	"			"	"	"	

[5] When unit is used while combustion chamber is hot, flue carries odors until burning cycle continues.
[6] Applies only to domestic household use.

WARRANTIES, GUARANTEES, & SERVICE

1. All electrical, gas, and safety components U/L or AGA approved.
2. 1 yr. guarantee on overall quality and 5 yrs. on combustion chamber (free of defects in material and workmanship); does not include labor and shipping charges on repair.
3. Any LP gas company will service and install at local wage and material rates.
4. Qualified dealer installation recommended (or gas appliance installation certification).

TECHNICAL PERFORMANCE

1. Destroilet Model 5 conforms to NSF Standard No. 24, issued NSF Seal.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Additional installation requirements for vertical vent: 4" dia., 2' above roof, 8' minimum height; flue joints sealed because of pressure; rain cap on top.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Wastewater Collection and Conveyance Subsystems

Introduction

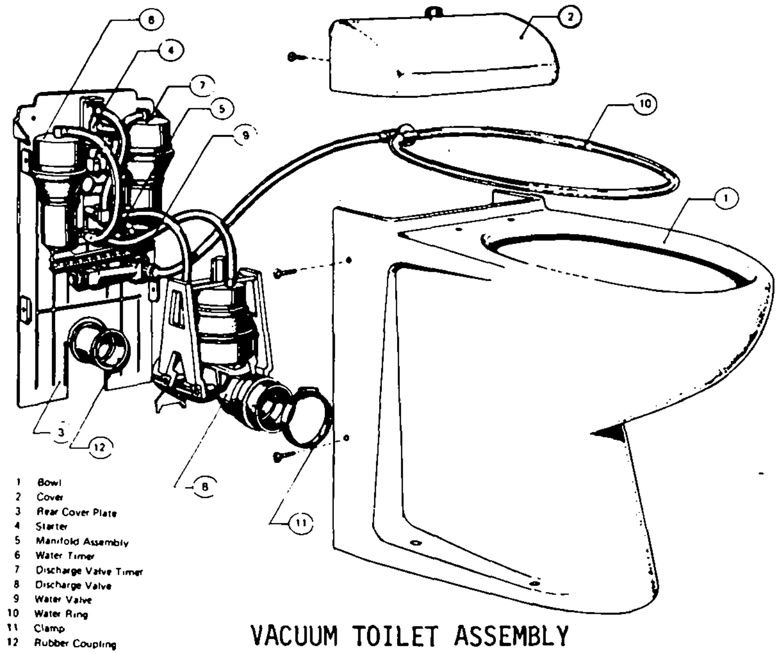
In addition to conventional sewers, combinations of pressure or vacuum pumps and small diameter mains can be assembled to move sewage from the home under pressure (positive or negative) to the treatment plant. This section includes a variety of pressure pumps and pump stations. As indicated, some are intended primarily for pressure sewer systems.

Wastewater from which settleable solids have been removed can be moved with a smaller pump than raw sewage. A composite system which employs interceptor tanks (similar to septic tanks) and small pumps was described in Chapter Four. A pump for individual house use for pressurized effluent systems (which are fed by septic or aerobic tanks) is described in this section.

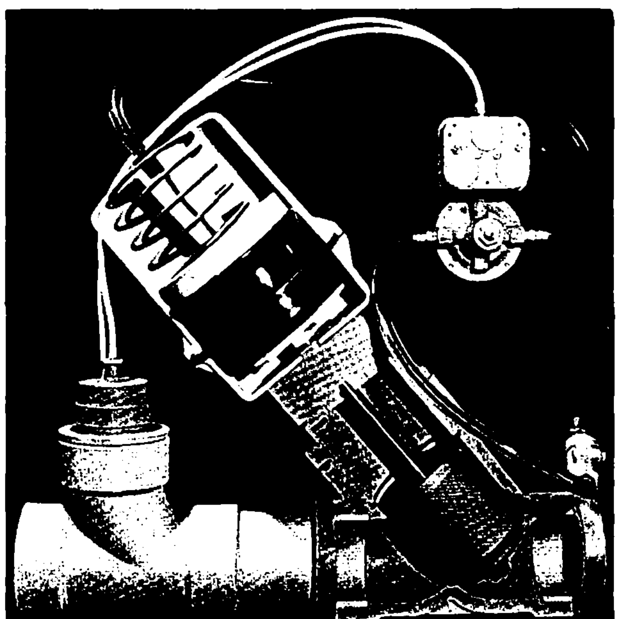
Pumps with integral grinders or macerators which reduce solids to small sizes and pump the comminuted raw sewage under pressure are also shown.

In addition, a vacuum sewer system is briefly described. Because of special design requirements for vacuum systems, the manufacturer prefers to custom design and market an entire collection and conveyance system rather than individual components.

The use of small diameter mains through which sewage is moved under positive pressure or vacuum offers special advantages over gravity mains. The pressure mains can be laid independent of grade within the head limitations of the pumping systems; trenches need be just deep enough to be below the frost line, thus reducing excavation costs; small diameter plastic pipe can accommodate bends more readily than conventional sewer lines, thus they can conform more easily to terrain features or curving layouts of subdivision lots. There are, of course, cost tradeoffs between savings on mains and other first costs and continuing maintenance requirements and replacement costs for pumping stations associated with pressure sewers. Such tradeoffs should be factored into the choice of a system.

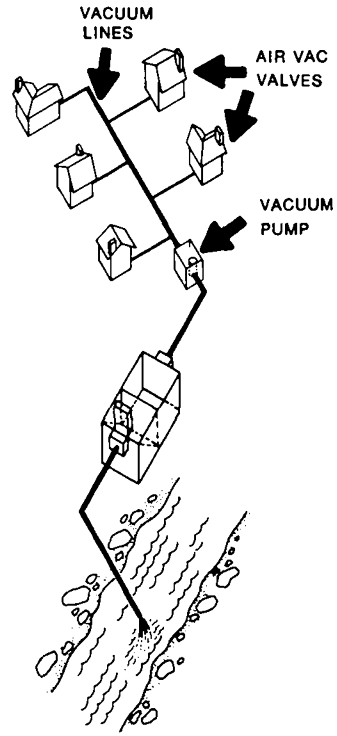


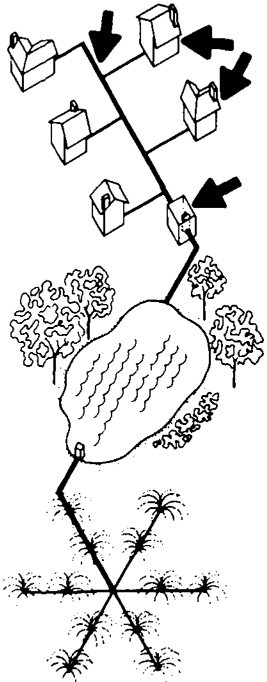
VACUUM TOILET ASSEMBLY



AIR VAC VALVE

AIRVAC
The Vacuum Sewage System





AIR VAC/DIVISION OF NATIONAL HOMES CONSTRUCTION CORP.
P. O. BOX 109
ROCHESTER, INDIANA 46975
(219) 223-3980
Attn: Mr. Marvin Simpson, General Manager

AIR VAC

VACUUM SEWAGE SYSTEM

FEATURES

1. Designed for communities of more than about 100 homes.
2. Uses 3" or 4" polyvinyl chloride (PVC) sewer pipe.
3. Collection station is only source of power consumption, making system which can eliminate vulnerability to power failure with single-location standby power.
4. Main components: optional vacuum toilet which uses one-third gallon of water per flush (illustrated, upper); AIRVAC valve (illustrated, lower); PVC sewer mains; vacuum pump(s), collection and reserve tanks.

OPERATION

1. Relies on vacuum (negative pressure) for the transportation of sewage.
2. Collection system is under constant vacuum and is separated from the building by the AIRVAC valve.
3. Collected liquid, once past the AIRVAC valve, moves through vacuum system as a plug.
4. Eventually plug spreads from fricition forces; plugs are re-formed in traps in the vacuum mains.
5. Vacuum mains empty into collection tank.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			

SIZING & GROWTH POTENTIAL

1. Intended for relatively densely populated communities with upwards of 100 housing units.

COSTS

1. Engineered as a complete system on a custom basis by the manufacturer.
2. No cost data supplied.

INSTALLATION REQUIREMENTS

1. Compatible with existing plumbing using gravity flow in house or vacuum toilets in new installations.
2. AIRVAC valve is interface between house plumbing and vacuum mains.
3. Requires expert installation service.

OPERATION & MAINTENANCE REQUIREMENTS

1. Uses no manholes, but has cleanout ports instead.
2. Manufacturer's description seems to indicate need for a full-time operator with plumbing and pump maintenance skills.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE

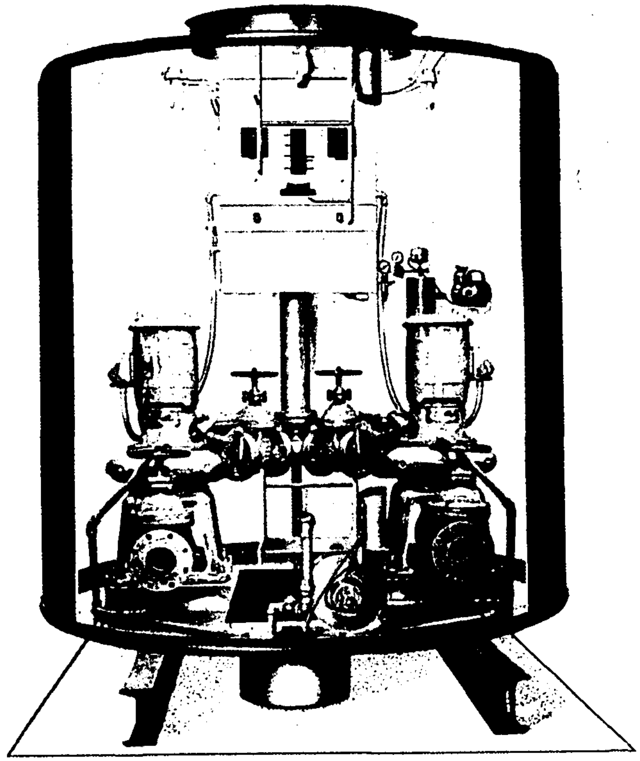
TECHNICAL PERFORMANCE

1. System has about 10 feet of useable lift (another 10 feet dissipated as friction). Within these limits, mains can be installed in shallow trenches independent of grade.

COMMENTS

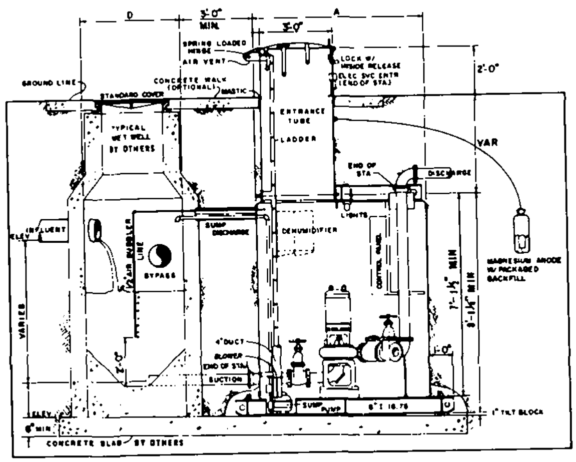
ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

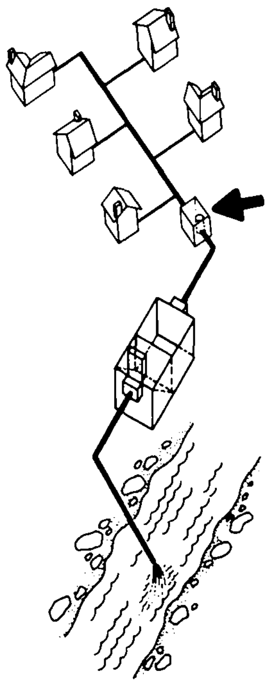


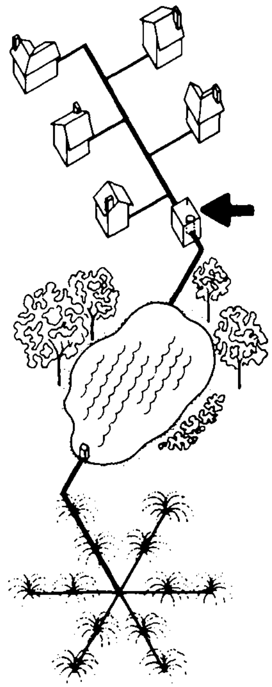
TEX-VIT PUMP STATIONS

CAN ★ TEX® INDUSTRIES



TYPICAL WET-PIT INSTALLATION





CANTEX INDUSTRIES
P. O. BOX 340
MINERAL WELLS, TEXAS 76067
(817) 325-3344
Attn: Mr. Ralph F. Conte, Vice-President, Process Equipment Division

TEX-VIT

PRE-FABRICATED PUMP STATIONS

FEATURES

1. Pre-fabricated steel lift stations can be unit-installed with self-contained systems for sewage pumping applications.
2. Two or three vertical pump styles, sump pump, dehimidifier, entrance tube, control panel, attractive interior.
3. Corrosion resistent, magnesium anodes.
4. 4", 6" or 8" pipe sizes.

OPERATION

1. Influent collects in wet well, is sucked in at V-bottom to lift station.
2. Pumps which are piped to the wet well lift sewage to higher elevation for further conveyance or treatment.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	DIMENSIONS: WIDTH	DIMENSIONS: HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)	COSTS (DOLLARS): INSTALL COST	COSTS (DOLLARS): OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)	UTILITY REQUIREMENTS	OPERATING SUPPLIES	PIPE SIZE
4" Frame 2 pumps	7' (minimum) round		8'1¼" [1] (min.)		2 pumps	NA				20	Standard Ratings		Influent	4" or 6"
4" Frame 3 pumps	"		"		3 pumps	"				"	"		"	4", 6" or 8"

[1] Does not include entrance tube (varies).

SIZING & GROWTH POTENTIAL

1. 6" frame, 3 pump style with 10" piping available in Tex-Vit models.
2. "Tex-Quad" systems for larger demands.
3. Modifications for wet pit pumping possible.

COSTS

INSTALLATION REQUIREMENTS

1. Excavation and concrete pad with 1" tilt block required.
2. Plumbing, electrical, crane operation skills required.
3. Wet well (by others) should precede pump station.

OPERATION & MAINTENANCE REQUIREMENTS

1. Qualified operator required for regular maintenance.
2. Automatic control system for unattended operation.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year from date of acceptance or 18 months from date of shipment warranty on parts and workmanship. Repaired or replaced free of charge.
2. Replacement parts and service available from factory. Factory service invoiced at $100/day (labor).
3. Cantex provides start-up serviceman free; operator training available.

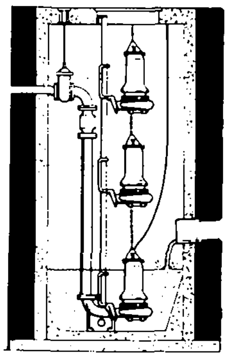
TECHNICAL PERFORMANCE

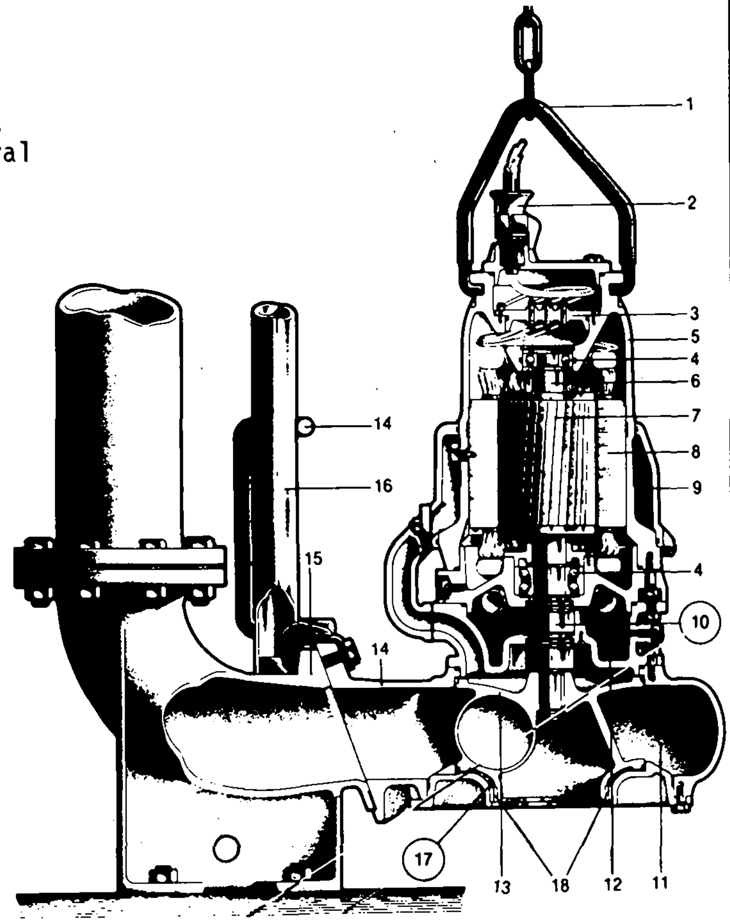
COMMENTS **ACCURATE AS OF** July 31, 1972

1. Additional information on costs, technical performance available from manufacturer.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Typical Wet-Pit Installation and Guide-Post Removal



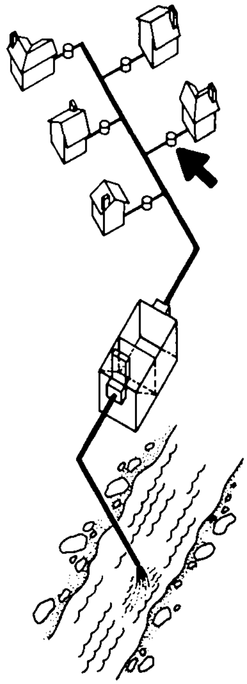


CROSS SECTION

FLYGT PUMPS

Major Components

1 Lifting handle
2 Cable entry gland
3 Terminal board
4 Ball bearing
5 Stator casing
6 Shaft
7 Rotor
8 Stator (class F insulation)
9 Stator cooling jacket
10 Seal cartridge housing a double mechanical seal with tungsten carbide faces.
11 Volute
12 Oil reservoir
13 Single-vane non-clog impeller
14 Sliding bracket
15 Automatic discharge connection
16 Guide bar
17 O-Ring; reduces leakage and wear
18 Replaceable wear rings



FLYGT CORPORATION
129 GLOVER AVE.
P. O. BOX 857
NORWALK, CONNECTICUT 06856
(203) 846-2051
Attn: Mr. Ken Nicholls, Manager, Liquids Handling Division

FLYGT® PUMPS

SEWAGE LIFT PUMPS

FEATURES

1. Single vane, centrifugal impeller-type submersible pump lifts sewage. 2 small models (residential) discussed.
2. CG-2.0 HP (3400 RPM) motor operates on single or 3 phase 220/440 or 550 volt service, or CP-2.5 HP (1750 RPM) motor operates on 230/460 or 575 volt service.
3. Different models available for all capacities.
4. 3" and 4" discharge line on CG and CP models.
5. Pumps can run dry.
6. Pump removed from basin on access guide bars by chain without entering wet well.

OPERATION

1. Pump is placed on discharge connection in bottom of wet pit where sewage flow collects.
2. Level sensor turns pump on when liquid reaches certain level, and sensor turns pump off when level is low.
3. Sewage is pumped to higher elevation for further conveyance or treatment.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)[1]	RATED CAPACITY (GPM)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST[3]		ELECTRICITY (RATING)	WATER PRESSURE		
CG 3065	$19\frac{1}{2}$"	13"	$11\frac{1}{2}$"	100	20-170 @ 45'-10' TDH[2]	NA	750		15-25/ year		220/440 or 550 V AC	Gravity flow to pump	None	
CP 3082	12"	19"	$30\frac{1}{2}$"	300	20-420 @ 40'-10' TDH	"	1250		20-30/ year		230/460 or 575 V AC	"	"	

[2]TDH=Total Dynamic Head
[1]Shipping wt. with cable and chain.
[3]2-3 Kwh/day and 3-4 Kwh/day @ 2-3¢/Kwh.

SIZING & GROWTH POTENTIAL

1. CG is horizontally mounted unit and CP is vertically (as in picture) mounted unit.
2. Range of units: 3"-14" discharge line; 2.0 HP-88 HP.

COSTS

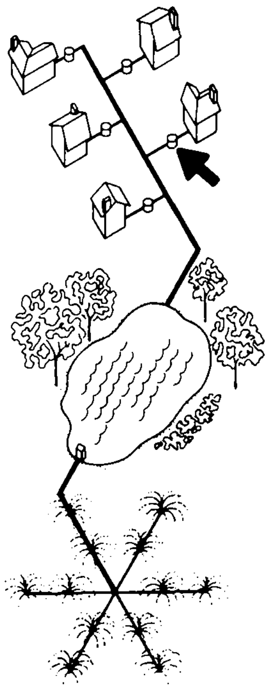
1. Base price includes pump discharge connection, chain and electric cable. Control panels, access frames, level controls, piping and valving are extra cost options.

INSTALLATION REQUIREMENTS

1. Excavation to discharge with precast concrete ring-basin for influent collection and pumping.
2. Electrical and sewage pump engineering skills needed for installation.

OPERATION & MAINTENANCE REQUIREMENTS

1. Operation works automatically by level sensors and control panel.
2. Semi-annual inspection of pump by experienced person; can be lifted to ground elevation by hand with cable.



MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
Both							Submersible	Minor noise and no odor		

WARRANTIES, GUARANTEES, & SERVICE

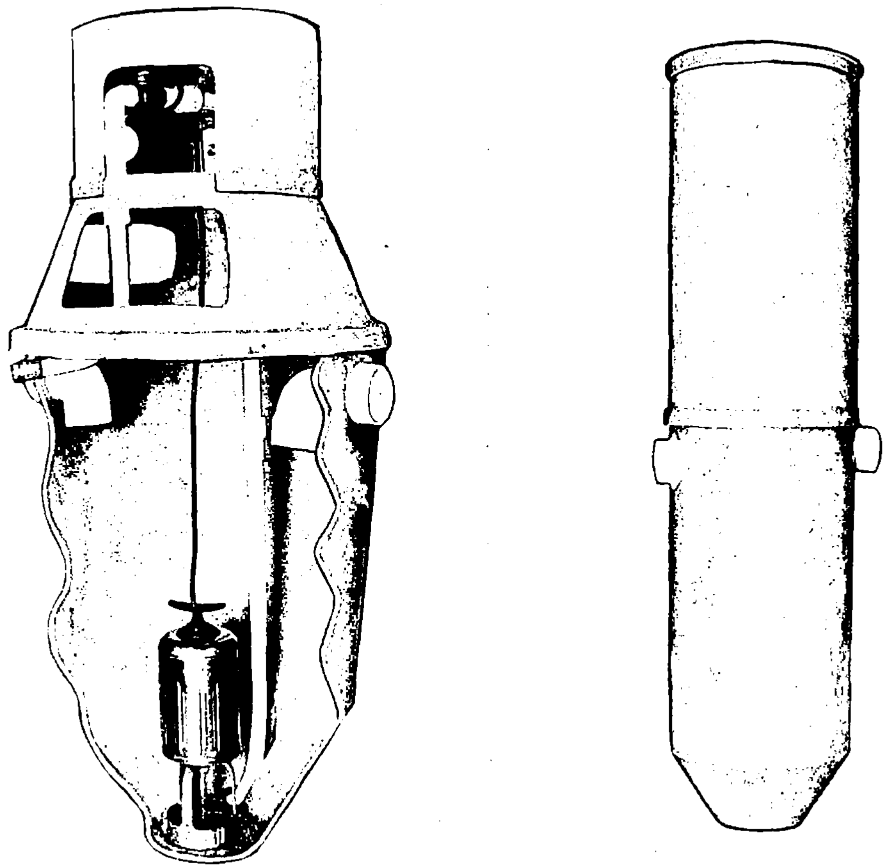
1. 5 year pro-rated warranty on parts and workmanship. Labor included for 1 year.
2. Service policies available from authorized, established FLYGT Service Centers.
3. No required inspection at service facilities.

TECHNICAL PERFORMANCE

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Picture shows large-sized system application.
2. Magnetic overload unaffected by changes in ambient temperature.

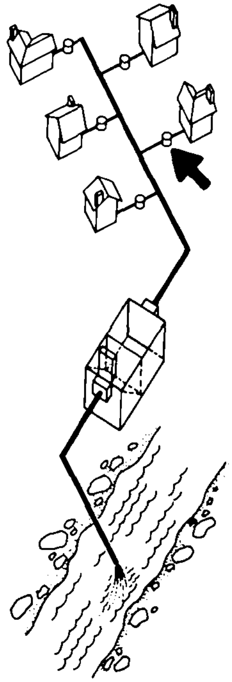
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

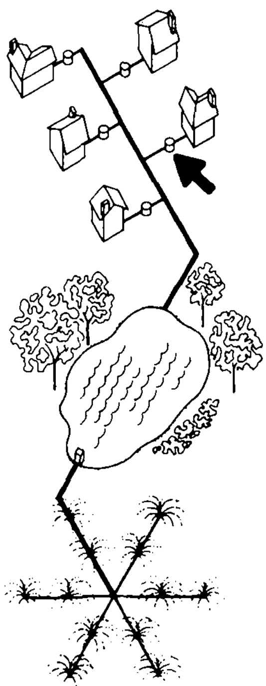


TULSA UNIT© MACERATING PUMPS

PRESSURIZED SEWER SYSTEM

Fiberglass tanks with submersible pumps grind and lift sewage





H & B INDUSTRIES, INC.
219 NORTH DETROIT AVE.
TULSA, OKLAHOMA 74120
(918) 585-9191
Attn: Mr. J. D. Burkholder, Vice-President

TULSA UNIT©

PRESSURIZED SEWER SYSTEM

FEATURES

1. Macerating pressure pumps that lift sewage to higher elevations for gravity flow to treatment or sewer.
2. Single residence design capacity.
3. System monitoring box has warning light installed in house.
4. Fiberglass tanks ard stainless stell construction.

OPERATION

1. Pump macerates wastes and lifts them to gravity flow into treatment tanks or sewer.
2. Pump operates 18-20 min./day on 20-35 second pumping cycles.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Tulsa I	30"	Round	95"			71	650.00[1]	175-200 (varies)		40+ [2]	230 V AC 7.5 amp		None	
Tulsa II	20"	Round	95"			ca 50	425.00[1]	150-200 (varies)		"	"		"	

[1]FOB Tulsa, Oklahoma. [2]Except electric motor.

SIZING & GROWTH POTENTIAL

1. 50 and 70 gallon capacities, pump-out to 8-11 gallon residues.

COSTS

1. List price does not include electrical cable or straight pipe sections.

INSTALLATION REQUIREMENTS

1. Tank buried in-line between house and treatment tank.
2. Excavation, pipe (solvent welding PVC), and electrical skills required.

OPERATION & MAINTENANCE REQUIREMENTS

1. Maintenance performed by sewer district.
2. Spares (pump and motor) for numbers of units operating: 1 per 50, 2 per 100, 3 per 100+.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
Both							Maximum of 115 feet TDH	Minor noise and no odors	See below	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year guarantee on all parts, four year pro-rata warranty.
2. H&B inspects hydraulics, trains contractors for installation.

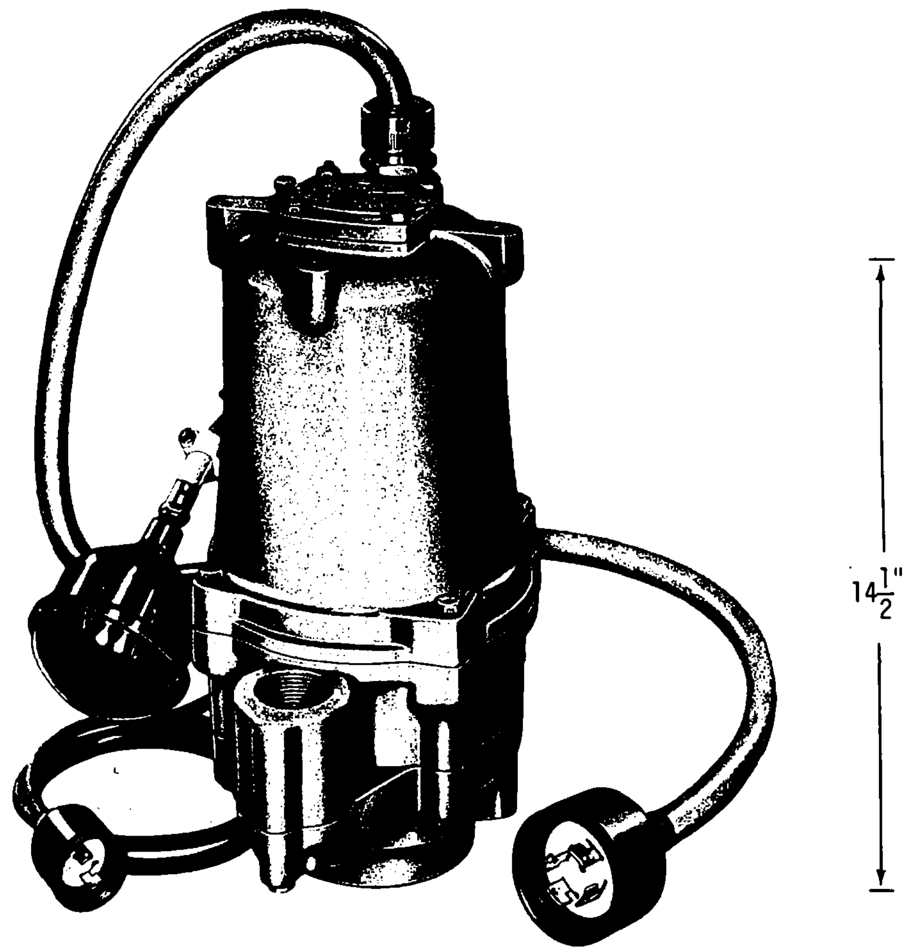
TECHNICAL PERFORMANCE

1. Tulsa I and II: Pumps 4.8 GPM at 42 PSI; shut-off pressure equals 52 PSI; maximum flow equals 30 GPM at 16 PSI.
2. No codes for pressure systems, company has negotiated with authorities in 12 states.

COMMENTS

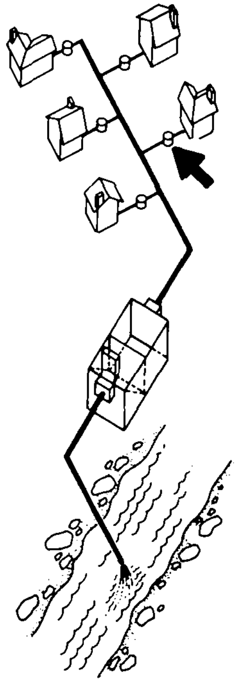
ACCURATE AS OF July 31, 1972

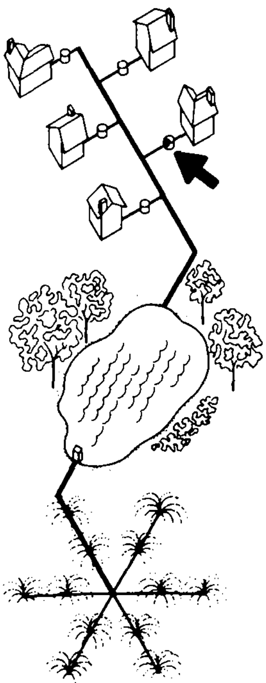
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



HYDR-O-GRIND™ GRINDER PUMPS

Centrifugal pump grinds and lifts sewage





HYDROMATIC PUMP CO.
HAYESVILLE, OHIO 44838
(419) 368-4844
Attn: Mr. Marvin A. Brown, Exec. Vice-President

HYDR-O-GRIND™

SEWAGE GRINDER PUMP SYSTEMS

FEATURES

1. Centrifugal type sewage pump grinds sewage and pumps ground sewage at 30 GPM for 50 ft of head to 5 GPM for 90 ft of head.
2. One basic model (1 1/2 HP) for several motors: 115 or 230 volt single phase or 230, 460 or 575 volt three phase.
3. Simplex or duplex stations available with fiberglass basins.
4. Pump lifts out on guide rails by chain for service and maintenance.

OPERATION

1. Sewage pit collects sewage and level sensors operate pump.
2. Pump macerates sewage with removable stainless steel grinder.
3. Macerated sewage is pumped to higher elevation in 1 1/4" discharge line for further conveyance or treatment.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPM)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST 1	OPERATE COST		ELECTRICITY (RATING)			
SPG-150A	$9\frac{9}{16}$"	$7\frac{1}{8}$"	$14\frac{1}{2}$"	80	5-30	NA	$995.	$135. (Varies)	15-25/ year	10-15	(Footnote 2)		None	

[1] Price shown charged to users per pump by plumber-electrician contractors in Texas (excavate, plumb, fill and wire). Sample (not necessarily typical) installation.

[2] 115 V, 230 V, 460 V, or 575 V (12-3 Full Load amp), 1 or 3 phase.

SIZING & GROWTH POTENTIAL

1. Simplex and duplex systems available.
2. Duplex system sized for 4 to 6 one-family homes.

COSTS

1. List price is for 1 ph 230 V pump. Simplex pump with fiber-glass basin sells for $1,200.
2. Mercury switches for level control and flooding alarm light are extra cost options.

INSTALLATION REQUIREMENTS

1. Excavation to discharge lines, and steel, concrete or fiber-glass basin laid in.
2. Electrical skills and plumbing skills needed for installation.

OPERATION & MAINTENANCE REQUIREMENTS

1. Operation is automatic, by level sensor switches.
2. Periodic maintenance is required by electrician/installing contractor. Unit can be lifted by hand to ground elevation along access posts.
3. Motor is sealed in oil for life.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
SPG-150A	NA	NA	NA	NA			Submersible; Up to 90' TDH	Minor noise and no odors.	Patented	

WARRANTIES, GUARANTEES, & SERVICE

1. Company will replace or repair pumps for any defect of material or workmanship free of charge for 1 year from date of purchase or 18 months from date of manufacture, whichever comes first.

TECHNICAL PERFORMANCE

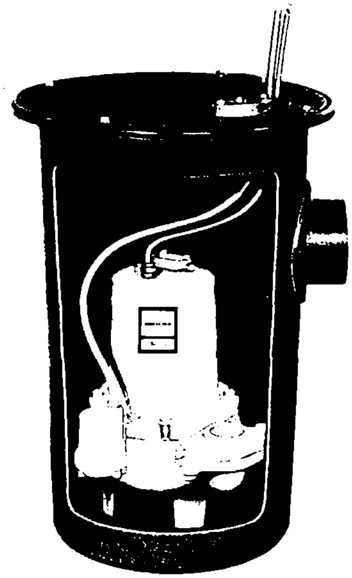
1. U. S. Patent No. 3,650,481. Other patents, U. S. and foreign, pending.
2. Unit grinds rags, wood, plastic, paper, and rubber into fine particles for small diameter pipe pumping.

COMMENTS

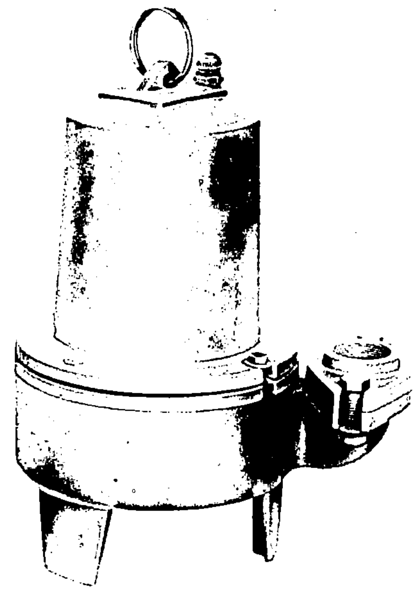
ACCURATE AS OF July 31, 1972

1. Non-overloading pump will not build up dangerous pressure if discharge line is shut off (centrifugal type).

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



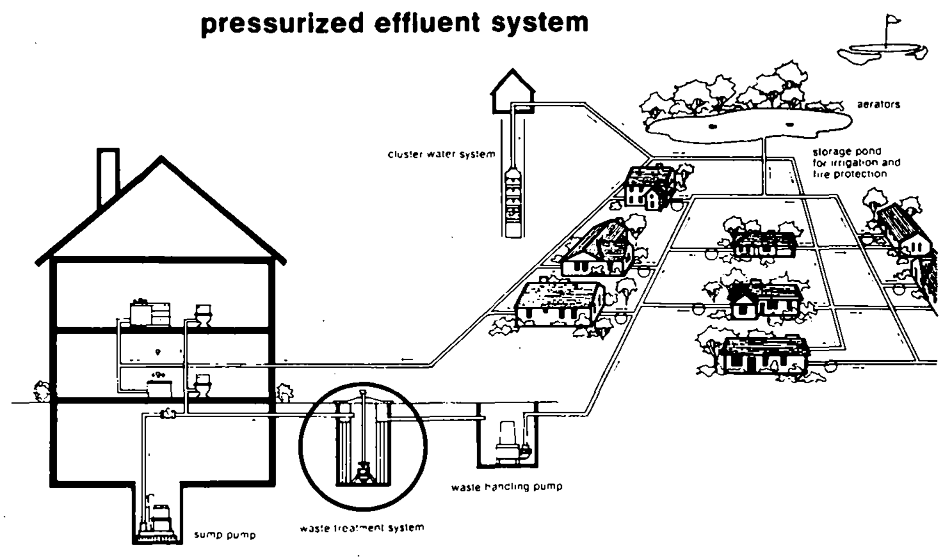
PUMP WITH FIBERGLASS BASIN

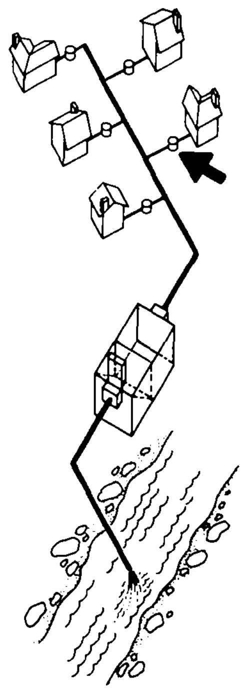


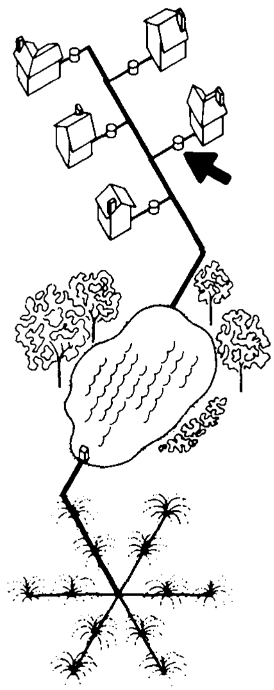
MULTI-FLO SP PUMP

MULTI-FLO

pressurized effluent system







MULTI-FLO, INC.
500 WEBSTER ST.
DAYTON, OHIO 45401
(513) 224-7622
Attn: Mr. J. Robert Krebs, Exec. Vice-President

MULTI-FLO PUMPS

SUBMERSIBLE SEWAGE PUMPS

FEATURES

1. 1/2 HP or 1 HP cast-iron and stainless steel sewage pumps lift liquids and solids up to 2" in diameter.
2. Two vane impeller type pump lifts sewage at 5' of head: 1/2 HP, up to 140 GPM; 1 HP, up to 180 GPM.
3. 1650 or 1750 RPM single or 3-phase operation.
4. 2 or 3" discharge; simplex and duplex system.
5. Multi-Flo engineers pressurized effluent systems (lower picture) for community treatment of wastes utilizing on-site tanks, pumps, lagoon aeration.

OPERATION

1. Pump is placed at bottom of wet pit where sewage collects.
2. Level sensors turn pump on and off according to flow.
3. Sewage is pumped to higher elevation for further treatment or conveyance.

PRESSURIZED EFFLUENT SYSTEM

1. Sewage from houses in communities are treated on-site by small aerobic plants.
2. Effluent is pumped to storage pond for irrigation and fire protection, aerators eliminate odors, treat effluent.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPM)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)	PHASE	OPERATING SUPPLIES	DISCHG. SIZE NPT
SP-5	14"	$12\frac{1}{2}$"	19"	104	10-140 @ 25' - 5' TDH[2]	NA	165 - 215	Varies	1/2 HP		115,230 VAC 230,460 VAC	single ph three ph	None	2" or 3"
SP-10	"	"	"	107	10-180 @ 37' - 5' TDH[2]	"	240 - 300	"	1 HP		230 VAC 230,460 VAC	single ph three ph	"	"
Level Control[1]	$3\frac{11}{16}$"	round	$4\frac{1}{16}$"	4	(on-off)	"	30.75	Negligible	Negligible				"	NA

[1]Pump mounted. [2]TDH = Total Dynamic Head

SIZING & GROWTH POTENTIAL

1. Complete simplex or duplex systems in fiberglass basins available.
2. Ten or more homes can be put on pressurized system (lower picture) for mass disposal systems - manufacturer designs.

COSTS

INSTALLATION REQUIREMENTS

1. Excavation with basin or wet pit required.
2. Plumbing/electrical skills required for installation.

OPERATION & MAINTENANCE REQUIREMENTS

1. Motor sealed in oil for life.
2. Occasional check-ups; can be lifted to elevation with chain-on-ring assembly by hand.
3. Operation automatic with level sensors.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET
SP-5	NA	NA	NA	NA			Submersible; liquids up to 150°F	Minor noise. No odors.	
SP-10	"	"	"	"			"	"	

WARRANTIES, GUARANTEES, & SERVICE

1. Warranty information available from manufacturer.

TECHNICAL PERFORMANCE

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Multi-Flo treatment tanks, recycling systems, surface aerators are found elsewhere in the manual.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Septic Tanks and Accessories*

Introduction

Septic tanks are watertight chambers which retain sewage long enough for most of the solids to settle out and for some degree of anaerobic digestion of the sewage to take place. The solids and partially decomposed sludge settle to the bottom of the tank and accumulate. A scum of lightweight material (including fats and greases) rises to the top. The partially clarified liquid is allowed to flow out a pipe just below the floating scum layer. Proper baffling can offer additional protection against scum outflow.

Septic tanks come in many shapes. Several are illustrated in Figure 28. Construction details which show the sludge and scum layers are illustrated in Figure 29. Normal materials for construction are concrete and steel. Redwood is also used. Fiberglass reinforced plastic septic tanks are manufactured abroad.

Septic tanks can provide sufficient treatment to reduce suspended solids by 40 to 75 per cent and BOD by some 25 to 65 per cent. Bacterial concentrations in the effluent may be reduced also, but septic tanks cannot be relied upon to remove disease-causing microorganisms, and, depending on all sorts of uncontrollable conditions, septic tank effluent could actually have a greater concentration of microorganisms than the raw sewage (though dangerous organisms probably do not multiply inside septic tanks). Septic tank effluent is also malodorous. Septic tanks provide primary treatment and a bit of secondary treatment.

Over time, settling of solids causes the sludge to build up. This action reduces the effective volume of the tank, and thereby the average detention time of sewage is decreased. When the sludge builds up high enough, the sewage may flow through so fast that it will pull some of the sludge along with it. Sludge also tends to "boil" during warm weather. This is a matter of gases forming in the sludge, lifting particles to the surface and then dropping them. Boiling, as well as short-circuiting, can lead to sludge carry-over. The sludge can eventually clog the distribution lines and cause sewage to back up into the house. Materials that are carried out of the tank and which do not settle in the distribution lines pass to the subsurface soil absorption system. The added strain on the soil system may significantly hasten its failure. Therefore, septic tanks should be inspected on a regular basis and, when necessary, pumped out. Pumping is typically required every two to three years, but this depends greatly on many variables such as the size of the tank, the rate at which it is loaded, and the type of materials with which it is filled. (See Table 11 for a guide to septic-tank pumping.)

Much could be done to improve basic designs of septic tanks to reduce solids carry-over and to improve other performance parameters. An improved tank of foreign manufacture, as well as accessories for tanks and a device for additional treatment of septic tank effluent, are included in this section.

*[For detailed explanations and design criteria, see 5, 12, and 36.]

Fig. 28. Septic Tanks: General Shapes.
Source: *Manual of Septic-Tank Practice*, U.S. Public Health Service, DHEW Pub. No. (HSM) 72-10020 (formerly PHS Pub. No. 526) Rev. 1967, p. 31.

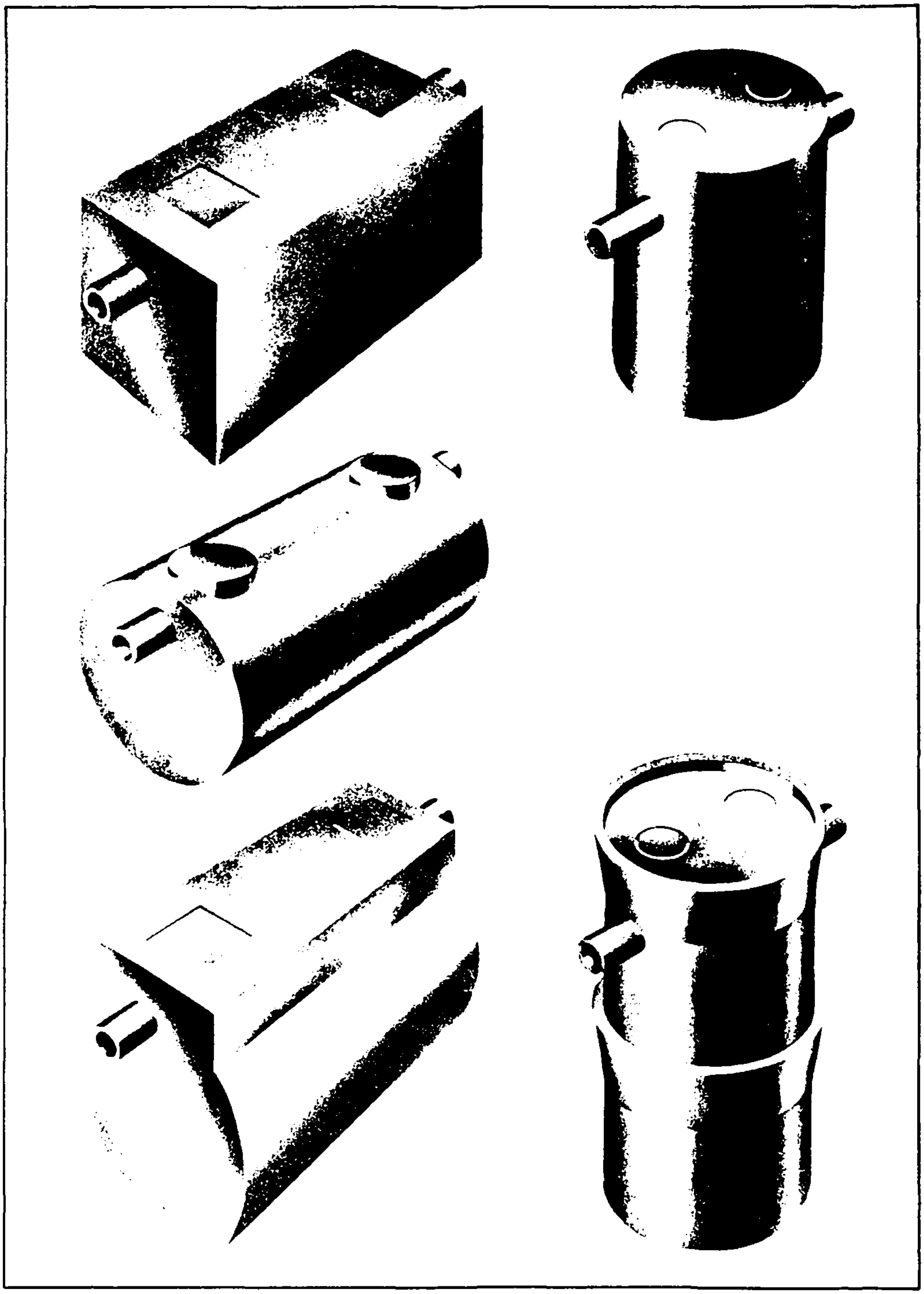
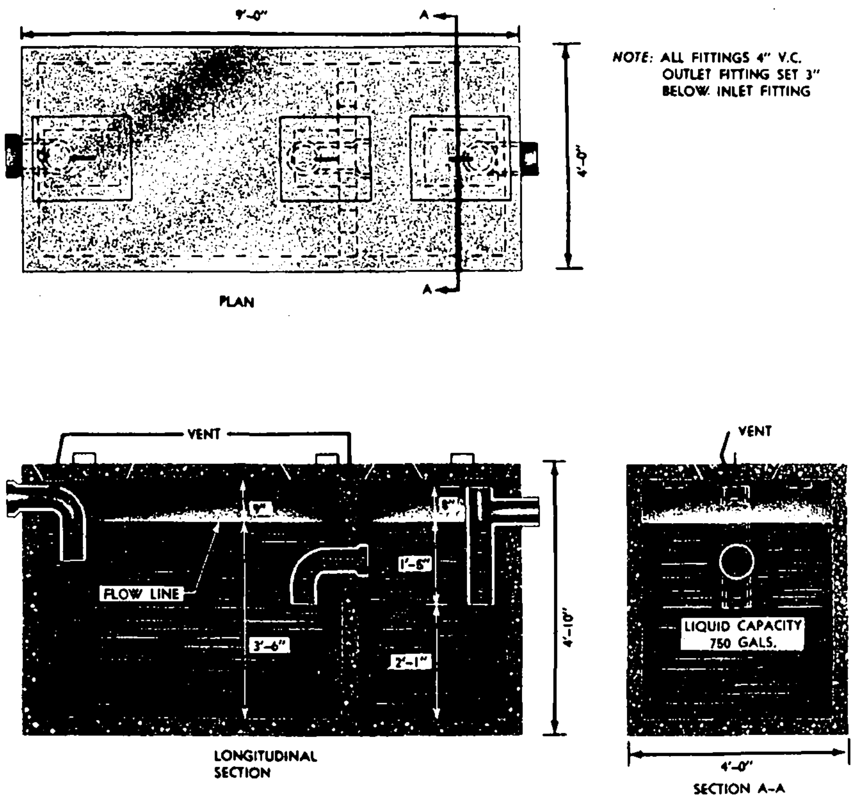
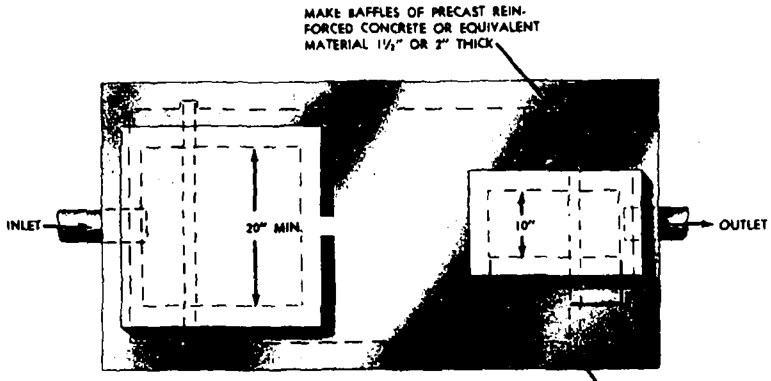
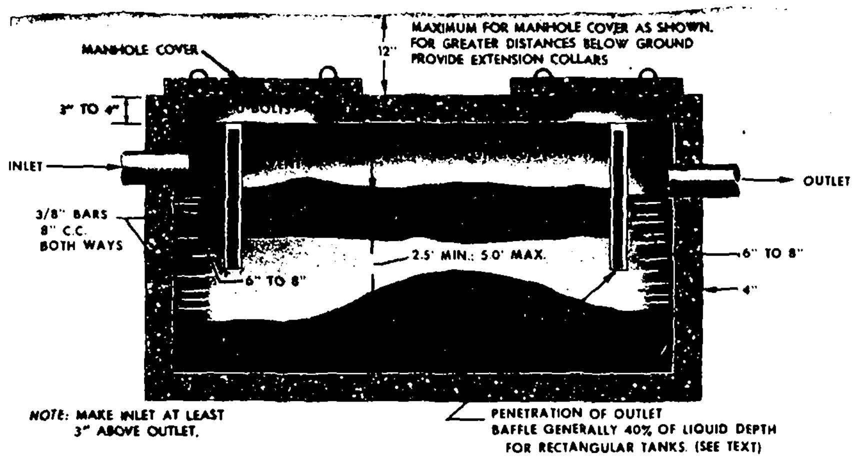


Fig. 29. Septic Tanks: Two Designs.
Source: *Manual of Septic-Tank Practice*, U.S. Public Health Service, DHEW Pub. No. (HSM) 72-10020 (formerly PHS Pub. No. 526) Rev. 1967, pp. 33 and 35.

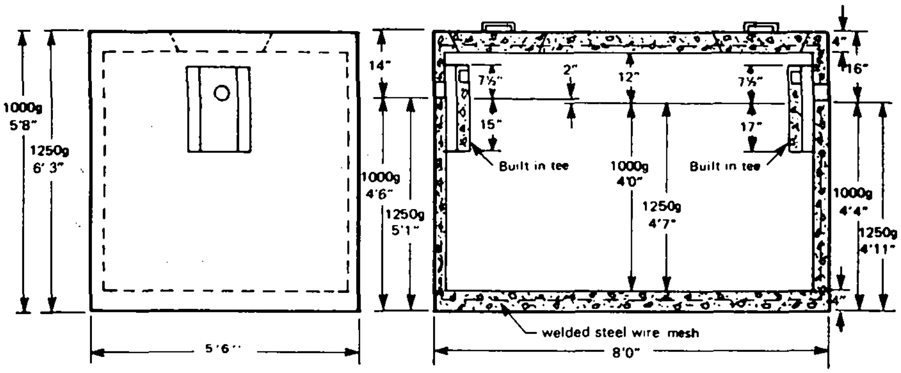




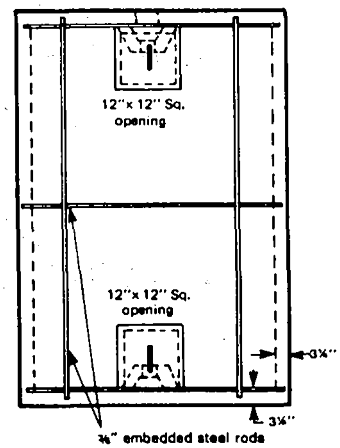
PLAN



SECTION ON
CENTER LINE



NOTES:
Acmelite sealant between all shiplap joints.
Concrete tees - cast in place - furnished with tank
Add 1'0" to length and width of septic tank to determine size of excavation required.

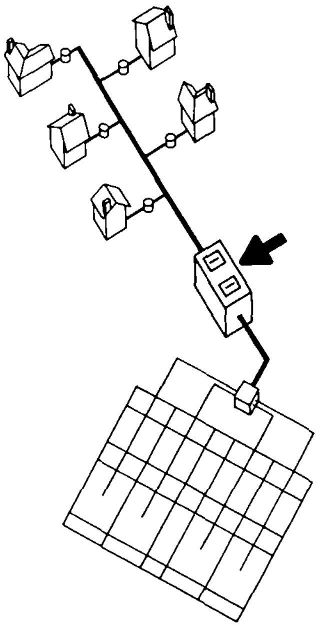


SEPTIC TANKS

PRECAST CONCRETE SEPTIC TANKS

American Precast

Precast septic tanks for 600 - 20,000 GPD demands



AMERICAN PRECAST CORP.
164 MEADOW ST.
FRAMINGHAM, MASSACHUSETTS 01701
(617) 877-5250
Attn: Mr. Edward A. Rollins, Vice-President, Commercial/Ameration Division

SEPTIC TANKS

PRECAST CONCRETE SEPTIC TANKS

FEATURES
1. Pre-cast concrete, steel reinforced septic tanks with capacities of 600 to 20,000 gal.
2. 4,000 PSI test on all concrete units.
3. Reinforcement witn 6 x 6 No. 10 welded wire mesh and embedded steel rods.
4. h-10 (grassed areas) and H-20 (traffic bearing) models.
5. Iron pipe and concrete tees, two manholes, Acmelite sealant between all joints.
6. 10,000 to 2C,000 gal. units have two or three chambers.

OPERATION
1. Sewage flows into tank, solids settle for anaerobic treatment.
2. Scum floats on top of sewage, liquid supernatant flows from middle of liquid through tee to discharge.

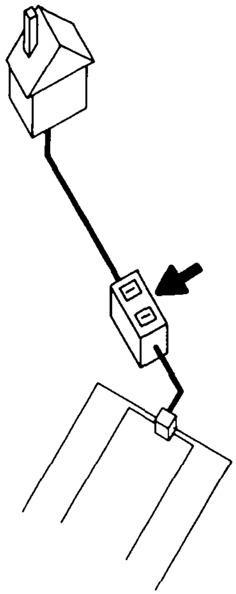
MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
600 gal	7'	3'5"	5'8"		Depends on re-tention time	600				Unlimited	None		Sewage	
5000 gal	14'	7'	11'			5000				"	"		"	
10000 gal	36'4"	9'	7'			10000				"	"		"	
20000 gal	28'	7'	12'			20000				"	"		"	

SIZING & GROWTH POTENTIAL
1. Sizing depends on local codes; generally a liquid volume (40-60% of total) of at least 2 day detention time is needed.
2. Nineteen sizes in H-10, H-20, regular and low profile styles.

COSTS

INSTALLATION REQUIREMENTS
1. Excavation, gravel base, pipe hook-up, discharge arrangements.

OPERATION & MAINTENANCE REQUIREMENTS
1. Periodic pumping out (3 to 5 years).



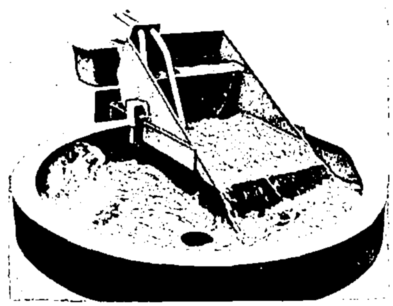
MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE

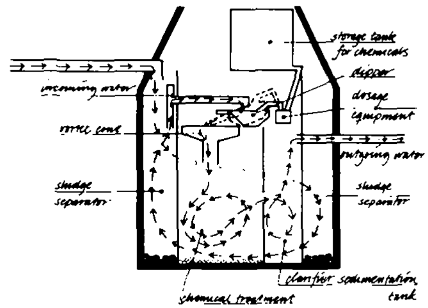
TECHNICAL PERFORMANCE
1. All sizes have been engineered to comply with VA, FHA and state specifications.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. American Precast also manufactures Ameration Chambers, found *on page 280*, *distribution boxes, leaching pits, siphon and* pump chambers and treatment plants.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



CHEMICAL DIPPER
AND VORTEX CONE

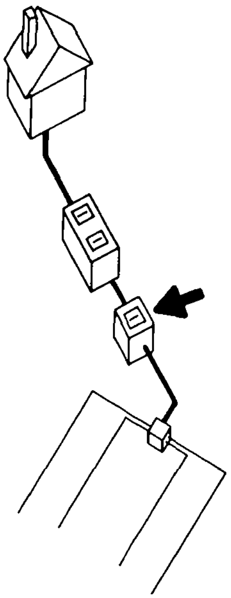


CROSS SECTION
TREATMENT TANK

WALLAX

ANTICIMEX

Post septic-tank chemical precipitation system



ANTICIMEX BOLAGEN
VASAGATAN 46, FACK
101 10 STOCKHOLM 1, SWEDEN
TEL. 08/23 15 60
Attn: Mr. Douglas Dickson,
Anticimex AB-Water Purification Department

WALLAX

SMALL CHEMICAL PRECIPITATION PLANT FOR DESLUDGED WASTEWATER

FEATURES

1. Flow-through design; PVC plastic construction.
2. *Two-tank unit: (a) Septic tank (3-chambered), (b) Chemical* mixing and sedimentation tank.
3. Can add chlorine in the form of sodium hypochlorite (bleach) for added disinfection.
4. No pumps or electricity required; all hydraulic.

OPERATION

1. Desludged wastewater led into WALLAX by gravity from septic *(or aerobic)* tank.
2. Water flows into tipping box (dipper).
3. When full, dipper sends water plus aluminum sulfate (Alum) coagulant to spin cone and then to clarifying sedimentation tank.
4. Dipper returns to upright position and gets recharged with Alum automatically.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	DIMENSIONS: WIDTH	DIMENSIONS: HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)	COSTS: INSTALL COST	COSTS: OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)	UTILITY REQUIREMENTS	OPERATING SUPPLIES	
Septic tank					528	343								
WALLAX proper				44	"	185							Alum[1]	
Combined					"	528								

[1] Approximately 1.7 lb. Aluminum Sulfate per 1000 gal. wastewater.

SIZING & GROWTH POTENTIAL

COSTS

1. *Approximately $1200 for complete system, but not yet* marketed in U. S.

INSTALLATION REQUIREMENTS

1. Requires leveling, some foundation work.

OPERATION & MAINTENANCE REQUIREMENTS

1. *Refill chemicals and pump out sludge on 3-6 month cycles or* longer, depending on use.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5 (R)	SS (R)	DO	COD	Phos-phorus		OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	OTHER
Combined	Up to 70	Up to 80			90 (R)					Bacterial reduction up to 99%.
										Works well with varying loads and independent of climate; used in direct discharge (to surface water) mode in Sweden.

WARRANTIES, GUARANTEES, & SERVICE

1. Service policy executed with installer/distributor at time of sale; renewable.
2. Sold with fixed fee parts and labor complete service contract in Scandinavia.
3. Will not be sold in U. S. until suitable service organization can be found.

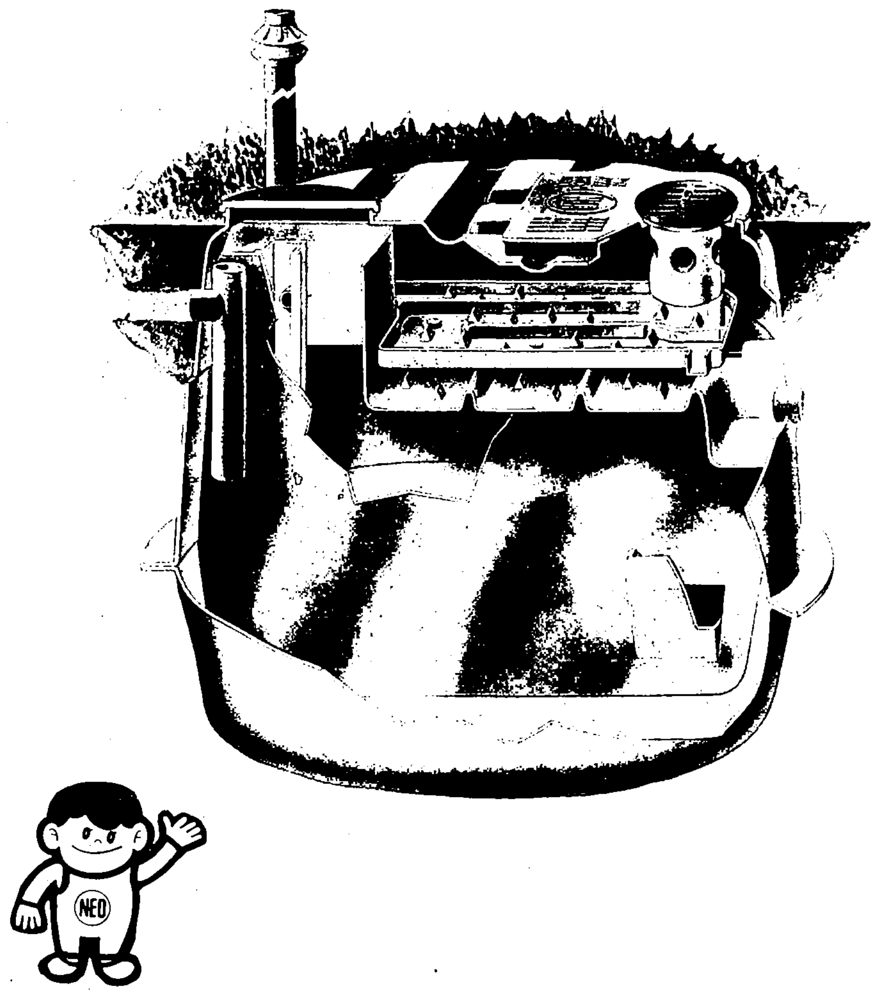
TECHNICAL PERFORMANCE

1. Already tested by Swedish Environmental Protection Board; undergoing testing at ER-Namnden (Swedish Council similar to ASTM). Also being tested at University Extension, *University of Wisconsin, Madison, Wisconsin.*

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Swedes place a premium on phosphorus removal to prevent "secondary" BOD from delayed build-up and decay of algae; unit has significant phosphorus removal.
2. If used with chlorination capability, could be suited to vacation homes.

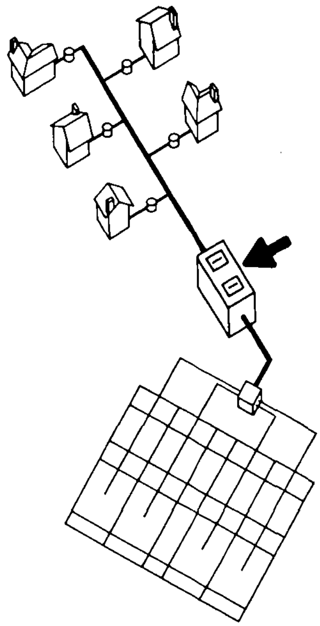
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



NEO SEPTIC TANKS - ST

NEO 西原ネオ工業株式会社

Two-chambered septic tanks with oxidation plate bed for anaerobic-aerobic treatment



NISHIHARA ENVIRONMENTAL SANITATION RESEARCH CORP., LTD.
c/o DR. TAKASHI ASANO
MONTANA STATE UNIVERSITY, DEPARTMENT OF CIVIL ENGINEERING
BOZEMAN, MONTANA 59715
(406) 587-3121 ext. 566
Attn: Dr. Asano

NEO SEPTIC TANKS-ST

AEROBIC-ANAEROBIC SEPTIC TANKS

FEATURES

1. Septic tanks with flow-through anaerobic digestion followed by aerobic oxidation (oxidation plate bed) for polishing.
2. Designed for treatment of flush toilet water only, other wastewaters not used (therefore lower rated capacity).
3. 2 chambered unit, sedimentation-anaerobic treatment chambers with effluent passing over wedges on oxidation plate bed for polishing and discharge.
4. 9 different sized models for populations of 5 to 50 persons.
5. Heavy duty polyester resin (FRP) construction.

OPERATION

1. Influent enters first chamber by gravity flow, primary sedimentation takes place.
2. Supernatant flows into second chamber, fine suspended matters and floatables undergo anaerobic digestion.
3. Effluent flows onto and through wedge-maze of "Oxidation Plate Bed" for aerobic digestion.
4. Effluent flows past disinfectant pellet tube for chlorine contact (optional) before discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST 1	OPERATE COST 2	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
ST-15	69"	57"	55"		5 persons 3	400	363	120	17	15+	None		Disinfectant, if required	
ST-20	73"	61"	61"		10 persons 3	531	423	120	21	"	"		"	
ST-30	83"	71"	69"		20 persons 3	827	626	156	26	"	"		"	
ST-60	101"	89"	93"		50 persons 3	1648	1243	286	39	"	"		"	

1 Includes shipping cost.
2 Operation cost = sludge pumping and disinfecting costs in Tokyo.
3 Toilet wastewater only.

SIZING & GROWTH POTENTIAL

1. Hydraulic and waste load sizing based on 13.2 GPCD and 0.0287 lb. BOD_5/capita/day.
2. Model numbers correspond to ten times tank volume in M^3 (Model 20 has 2.0 M^3 volume).

COSTS

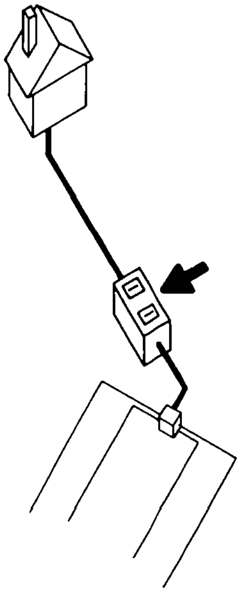
1. All prices are based on $1 = 300 yen.
2. Piping and special earthworks are extra costs.
3. Maintenance cost based on sludge disposal (pumping).

INSTALLATION REQUIREMENTS

1. Ventilation tube must extend high enough (3m+) to prevent odor problems (provides oxygen for aerobic treatment part).
2. Simple excavation skills required plus vent hook-up knowledge.
3. Above ground cover/accessway.
4. Reinforcement work necessary for deep excavations or roadside installation.

OPERATION & MAINTENANCE REQUIREMENTS

1. Once or twice a year sludge pumping and general check-ups, disinfectant supply checks.



MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 (R)	SS (R)	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	Oxidation Plate Bed Area (square feet)
ST-15	65+	50+					Temperate zone conditions	No noise and minor odors 4	Japan Ministry of Int. Trade & Ind. No.1726	23.5
ST-20	"	"					"	"	"	28.4
ST-30	"	"					"	"	"	39.3
ST-60	"	"					"	"	"	71.1

4 Minor odors at vent.

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty for all parts and tank body.
2. Franchised dealership for construction and user services.
3. Back-up education, sales promotion, and advertisement by Nishihara Corporation.
4. U. S. distributors under negotiation.

TECHNICAL PERFORMANCE

1. To enhance SS removal, a pit installation ahead of percolation bed may be recommended.

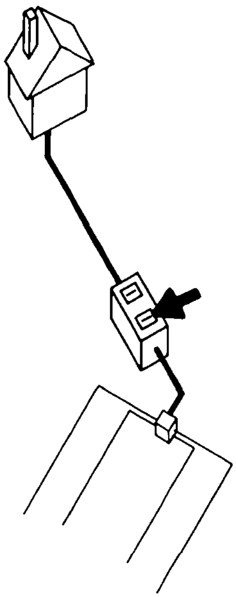
COMMENTS ACCURATE AS OF July 31, 1972

1. Not yet marketed in the U. S.
2. Cost information is based on standard cost figures in the mainland Japan.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

SEPTIVATOR®
STOPS SEPTIC TANK ODOR
CURES CLOGGED TANKS

Heat exchanger for creating warmer septic tank conditions and better bacterial growth



THE SEPTIVATOR CO.
2834 LEXINGTON AVE. RD.
LEXINGTON, OHIO
(419) 884-1631
Attn: Mr. Gilbert Schneider

SEPTIVATOR ®

SEPTIC TANK HEATER

FEATURES
1. Thermostatically controlled electrical resistance heat exchanger for septic tanks, Imhoff tanks, trash traps and aeration compartments.
2. 3 sized models for 750 - 2000 gal. tanks.
3. Heat exchange boosts biological digestion rates, sludge reduction, BOD reduction.
4. Reduces demand on airlift sludge returns and skimmers.

OPERATION
1. Septivator is hung at entrance to septic tank or in aeration compartments to heat influent.
2. Periodic heating (few hours/day) adds extra heat for biological reduction of wastes.
3. Increases digestion, eliminates odor, reduces scum and foam.
4. Reduces sludge from 60% to 80% in trash traps.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
300	3" round		16"			to be used in 750	95.	50-100	15-25/ year	20	120 V AC @ 300 W		None	
600	"		19"			used in 1000 - 1250	145.	"	25-50/ year	"	120 or 240 V AC @ 600 W		"	
1250	"		31"			used in 1500 - 2000	195.	"	50-150/ year	"	120 or 240 V AC @1250 W		"	

SIZING & GROWTH POTENTIAL
1. Multiple septivators can be and have been used in larger installations.

COSTS
1. Costs include only Septivator-heating unit enclosed in pipe jacket and electrical cord. Not tanks or other equipment (extra).

INSTALLATION REQUIREMENTS
1. Equipment needed for installation is 1/2 inch galvanized pipe, LB's, 14/2 U.F. cable, and cord connectors.
2. Electrician skills needed to install.

OPERATION & MAINTENANCE REQUIREMENTS
1. No routine service needed, decreases pumping out service frequency on septic tanks.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS	DO (A)	COD						
600	23%[1]							No noise or odors.	Under testing, to be tested at Univ. of Wisc.	

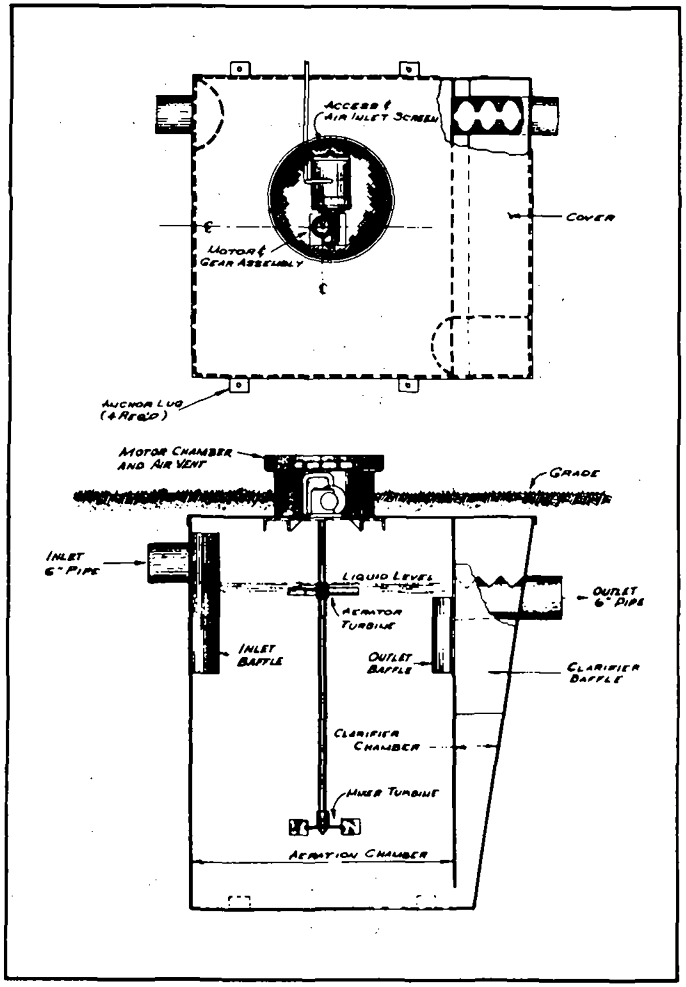
[1]As tested by Dr. R. Laak. percentage improvement over cold septic tank used as a control.

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year guarantee of workmanship and material, sold on a satisfaction guaranteed or money-back basis.
2. Dealer installation and service.

TECHNICAL PERFORMANCE
1. U. S. Patent No.: 3,196,105.
2. Changes Ph from 6.2 to 7-7.5.
3. Reduces BOD, SS, COD and sludge.

COMMENTS ACCURATE AS OF July 31, 1972

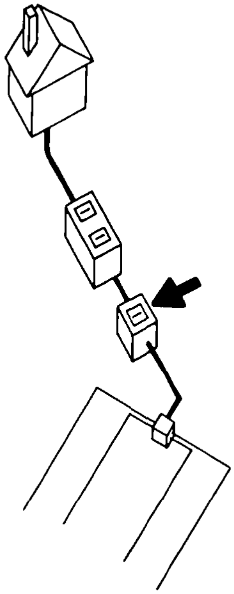
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



MONOTANK

Suburbia

Post septic tank mechanical aeration for further treatment



SUBURBIA SYSTEMS, INC.
3785 WEST 95TH ST.
P. O. BOX 6217
LEAWOOD, KANSAS 66206
(913) 649-4994
Attn: Mr. L. C. Sandy, Vice-President, Sales

MONOTANK

POST SEPTIC TANK AEROBIC UNIT

FEATURES
1. Aerobic sewage treatment tank to treat effluent from septic tank.
2. Mechanical aeration has dual level turbine for liquids and solids oxygenation.
3. Fiberglass-reinforced thermoplastic tank.
4. 1/2 HP motor for aerator.

OPERATION
1. Septic effluent enters tank, is aerated periodically.
2. Supernatant flows into clarifying area, solids flow back to aeration tank.
3. Clear liquid is discharged over weir.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Monotank	4'6"	3'6"	5'	350	500	620					110 V AC			

SIZING & GROWTH POTENTIAL
1. Single size model.

COSTS

INSTALLATION REQUIREMENTS
1. Excavation, piping hook-up and electrical skills needed.
2. Grating at surface necessary.

OPERATION & MAINTENANCE REQUIREMENTS
1. Twice annual oiling of gear box needed.
2. Pumping out occasionally needed.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS	DO	COD						
Monotank	Up to 85							Minor noise and no odors.		

WARRANTIES, GUARANTEES, & SERVICE
1. Life-time warranty on plastic tank.

TECHNICAL PERFORMANCE

COMMENTS **ACCURATE AS OF** July 31, 1972
1. More information available from manufacturer.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Individual Home Aerobic Treatment Units

General Physical Descriptions

On-site aerobic tanks can be as simple physically as a septic tank into which compressed air is introduced and bubbled through the sewage to maintain aerobic rather than septic conditions. One manufacturer varies this approach by circulating the liquor through a pressure vessel where greater amounts of oxygen can be dissolved in the liquid than under atmospheric pressure. There are indeed a variety of approaches to maintaining aerobic conditions.

Most of the plants fall into the 300 to 1000-gpd size range, with the majority of these at or below 600 gpd. The smaller units obviously depend on processes which treat sewage faster than a septic tank in order that more treatment (e.g., 1.5-2.0 times as much BOD reduction as a septic tank) may be given in less time (one day average retention time as compared with two days design objective for a septic tank). One approach to speeding up treatment is to break up solids mechanically, thus yielding more surface area on which the microorganisms can operate. Methods for breaking up solids include the use of propellers to create turbulence, high pressure jets which converge at a solid surface, vigorous blowing of air through "diffusers" coupled with a tank geometry that will encourage turbulence, and rotating disks that at once break up solids and mix air with the liquid.

Ever mindful that solids carry-over into the final effluent should be minimized, manufacturers have taken a variety of steps to screen solids from the outlet. The approaches include weirs or skimmers for floating scum, settling of solids through hydraulic design of a clarifying chamber, and mechanical filtering through a felt-like pad or bag. The mechanical filter bag is said to also perform additional biological treatment by virtue of the communities of microorganisms which subsist within the filter matrix and feed off materials in the liquids which pass through.

Between the breaking up of solids near the inlet and the screening of solids at the outlet, a remarkable variety of arrangements for sewage treatment has been employed. Process flow is attained passively by gravity and hydraulic displacement, by pumps, and by rather elaborate assemblies of air lifts. The more elaborate the provision for process flow, the more distinct the separation into individual chambers. For example, one system has five chambers and five airlifts. At the other extreme, there are units where chambers are really zones created by baffles and in which process flow is by hydraulic displacement.

One family of units uses redwood bark as a trickling filter medium and recirculates the liquor over and through the filter.

Another manufacturer obtains multiple-use duty from one chamber by sequencing operations: a single chamber acts as an aeration chamber when solids are kept in suspension by an active air diffuser; the same chamber acts as a settling chamber when the air compressor is turned off in the wee hours of the morning; the chamber becomes the discharge chamber when the clarified supernatant is pumped out at the end of the daily cycle; and, finally, when the air compressor is turned back on, the sludge is re-aerated much as in a contact stabilization plant.

Costs

The cost picture* is complicated by two things: (1) at least two Japanese manufacturers and one Swedish manufacturer plan to market their units in the U.S., but have not as yet established firm pricing; and (2) many manufacturers have been vague in distinguishing between the various costs involved with their units. Examples of the latter uncertainty are encountered with units which are designed for mating to locally obtained tanks. It was *not clear when a manufacturer stated "installed in dealer-furnished tanks"* whether the quoted list price of the unit also included the cost of the tank (which could cost several hundred dollars). Nor would most manufacturers speculate about the range of installation costs or about the soil absorption system requirements. Further, a few units contain disinfection devices such as chlorinators or ozonators, but others do not come so equipped. If disinfection is required for a particular installation, $200 to $300 should be added to the cost of units not equipped with disinfectors.

Most of the units fall in the $600 to $1200 range as quoted by the manufacturers. Several of the larger units (above 750 gpd) cost more than $2000, but these could serve more than one housing unit. Many of the lower-priced units ($600 to $800) may have been quoted without the tank. As a general guideline, then, it would be reasonable to expect to pay between $1000 and $1200 for a home aerobic plant of sufficient capacity to meet the requirements of many states (which are based on septic tank sizing principles as a hedge against aerobic plant failures).

Depending on all sorts of particulars, such as labor rates, skill requirements, soil suitability and local practices, installation costs ranging from $200 to about $800 (includes the soil absorption system) can be anticipated. At this point these are merely educated guesses, though they compare well with the limited information about installation furnished by some manufacturers.

Operating costs of about $2 to $3 per month for electricity plus about $1 per month for chlorine chemicals can be anticipated. Electrical consumption will, of course, vary among units, and cost will also vary with local power rates.

Maintenance costs will range between $50 and $100 per year for service contracts.

The initial capital cost and maintenance costs are likely to be very sensitive to market considerations. Promotional costs presently account for a large share of list prices. When

*At present pricing levels, most aerobic units (even without the soil absorption system) cost more than a septic tank and its soil absorption system combined. Aerobic units become competitive when soil limitations rule out conventional septic tank systems.

and if sales volumes increase and permit higher production rates, economies of scale can be expected to lead to price decreases (fixed production and promotion costs can be spread over more units).

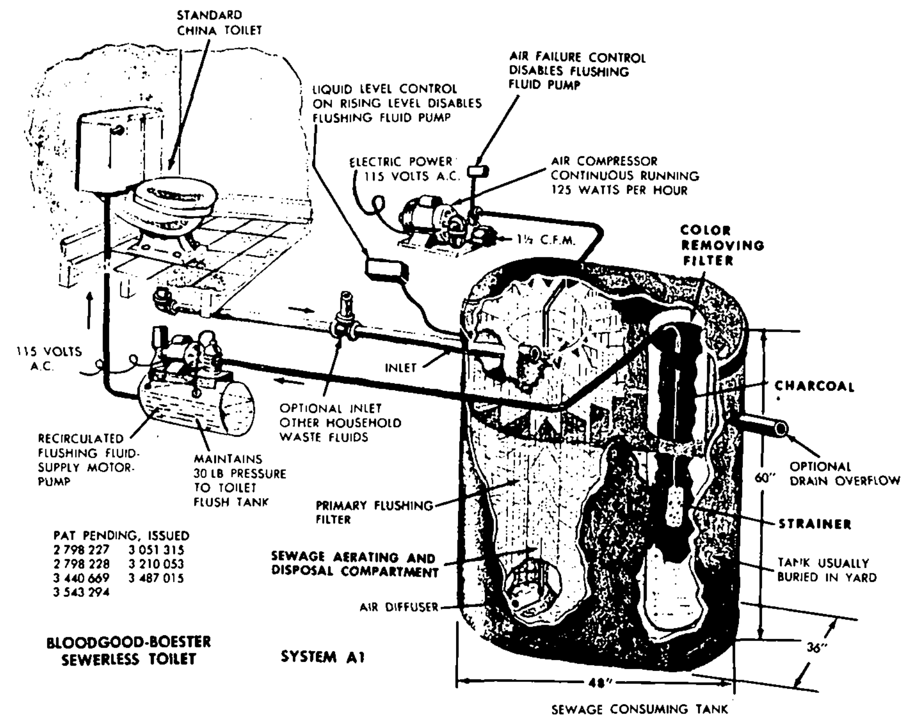
Performance

All of the physical differences and costs are subordinate to performance. Performance includes not only the immediate and long-term reduction of impurities, but reliability of the unit, ease of maintenance, and even the ability of a unit or system design to respond to the highly variable loadings that might be expected from individual homes (house-to-house variations in loading tend to be smoothed out in a centralized collection and treatment system).

Under variable loading conditions, aerobic plants are subject to sludge bulking, a phenomenon characterized by the failure of the sludge to settle. Consequently, the bulked sludge can be carried out into the distribution lines and can cause clogging. In large plants, the operators can react to the bulking and minimize its effects. The problem can be more severe in small unattended units.

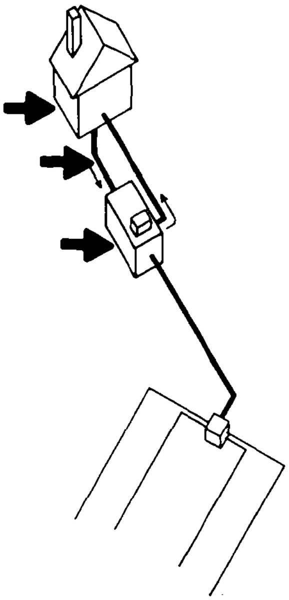
The performance standards and criteria developed by the National Sanitation Foundation (especially Standard Number 40 for individual aerobic units) are included in Appendix B. Though NSF Standard Number 40 is the only generally agreed upon industry-wide standard in the U. S., to date only four of the sixteen manufacturers represented herein have submitted units for testing under the Standard. Though failure to obtain NSF testing and approval does not mean that a plant will not perform adequately, there is little basis for assessing performance data (e.g., "90-plus per cent BOD removal") submitted by manufacturers who have not undergone NSF testing. It should be noted that the NSF tests under Standard 40 do not assess a plant's ability to respond to variable surges or shock loadings.

Whatever the peak performance, it can only be maintained if as much attention is invested in supervising the installation and ensuring the continued care and servicing of the plant as goes into the initial choice of a unit. Without regular attention by competent service personnel, even the best of plants can become dangerous polluters. If septic tanks and soil absorption systems have been ruled out, and if long-term servicing by qualified personnel cannot be reasonably anticipated, the designer should consider other alternatives such as composite and centralized systems employing sewers (even if the costs of sewer lines far exceed the costs of individual systems), incinerator toilets, or privies.



SEWERLESS TOILET
Division of
AERA-FILT SYSTEMS, INC.

Diffused aeration system for recycling wastewater



AERA-FILT SYSTEMS, INC.
P. O. BOX 567
LAFAYETTE, INDIANA 47901
(317) 742-4205
Attn: Mr. Carl Boester, President

SEWERLESS TOILET

DIFFUSED AIR, EXTENDED AERATION UNIT

FEATURES

1. Uses system recycled water (clear and odor-free, but colored for toilet use) to dispose of human waste.
2. For use where water is in short supply.
3. For use where sewage liquid discharge is difficult.
4. Three models, all use air diffusion, systems A-1 and A-3 use filtration.
5. System A-2 has two tanks, separates "grey" and "black" wastes.
6. System A-1 also has charcoal filter.
7. Effluent is taken from sewage tank (or grey water tank) and pumped for toilet flushing re-use.
8. Optional drain overflow pipe for excess tank water.

OPERATION

A. System A-1 and System A-3
1. Toilet is flushed with pumped water (30 PSI) from tank.
2. Water from toilet (other water optional) goes to tank (gravity) is diffused, filtered, then passes through charcoal filter and piped for re-use. (System A-3 without charcoal filter.)
3. Control system: failure of pump, compressor or overflow disables toilet.

B. System A-2
1. Toilet water from pumped flushing goes to tank and is aerated and effluent discharged for disposal.
2. Second tank takes other household water, diffuses and recycles supernatant for toilet flushing.
3. Same controls as System A-1.

MODEL NUMBER (MAJOR)	DIMENSIONS [1]			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST [2]		ELECTRICITY (RATING)			
A-1	48"	36"	60"		1 family	275-300	See costs below		Electricity - 20/year		115-120 V AC; 60 Hz		None	
A-2	Two 48" spherical tanks				"	600 total	"		"		"		"	
A-3	36"	36"	60"		"	150-200	"		"		"		"	

[1] Also space needed for air compressor and fluid flushing motor pump.

[2] Service costs additional.

SIZING & GROWTH POTENTIAL

1. More toilets can be added to system with larger tank(s) and larger capacity pump and compressor (1 1/2 CFM) service.

COSTS

1. List costs available from dealer include pump, compressor, controls, piping and tanks.
2. Installation costs according to situation (see requirements).

INSTALLATION REQUIREMENTS

1. Outside excavation for cylindrical fiberglass tanks.
2. Electrician service for installation of pump and compressor.
3. Plumber/installer service for hookup of recycling plastic piping to toilet.
4. Discharge arrangements needed for System A-2.

OPERATION & MAINTENANCE REQUIREMENTS

1. Controls disable flushing pump, notifying owner of breakdown or overflow of system.
2. Pumping of sewage required, possible cleaning of filters.
3. Disinfectant cleaning of colored toilet bowl and colored water.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO (A)	COD	WATER FLOW [3]					
A-1	98	98	6 ppm		up to 50 (R)		Indoor facilities, tank underground		Patents pending; issued.	
A-2					"		"		"	
A-3	98	96	6 ppm		"		"		"	

[3] Reduction of normal household water consumption.

WARRANTIES, GUARANTEES, & SERVICE

1. Warranty on parts, no liability for performance.
2. Sold only out of main plant; service by locally qualified plumber/installer.

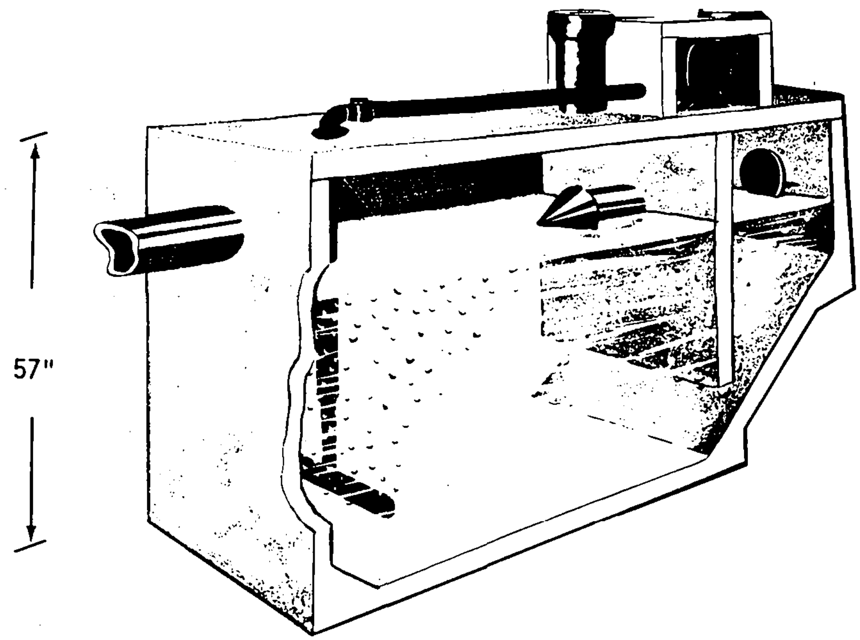
TECHNICAL PERFORMANCE

1. U. S. Patents pending, issued: 2,798,227; 3,051,315; 2,798,228; 3,210,053; 3,440,669; 3,487,015; 3,543,294
2. Aera-Filt also makes a pasteurizing model, Patent No.3,487,015.

COMMENTS — ACCURATE AS OF July 31, 1972

1. Plastic filter acts as dual-media sludge treatment and strainer (100 micron).
2. A further description and illustration of System A-3 is found on page 296.

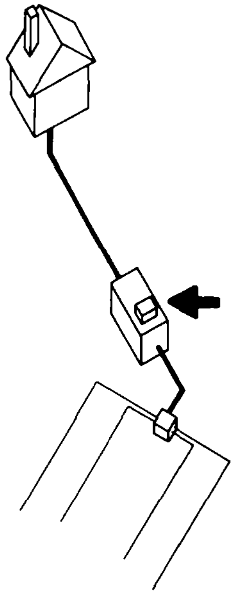
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



SEPTI-CARE AEROBIC TANKS

ALLENAIRE, INC.

Diffused aeration home aerobic system



ALLENAIRE, INC.
379 NILES-CORTLAND RD., S.E.
WARREN, OHIO 44484
(216) 856-4680
Attn: Mr. R. D. Allen, President

SEPTI-CARE

AEROBIC TREATMENT UNIT

FEATURES
1. Two-chambered concrete aerobic treatment unit with aeration equipment attached.
2. Diffuser circulates air in aeration chamber and airlift sludge return in clarifier produces activated sludge process.
3. Time control operates part-time aeration and part-time settling.
4. Alarm light indicates malfunctions.
5. Rotary lobe blower delivers 16,000 CFD @ 3 PSI.
6. Diffuser made of 1" dia. A.B.S. plastic pipe tee bar with 48 0.09" holes in down position.

OPERATION
1. Influent flows into aeration chamber and is aerated.
2. Aerated influent flows through skimmer to clarifier chamber and solids settle.
3. Clarifier solids are airlifted by sludge return to aeration chamber.
4. Clear supernatant flows under weir to discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS[1] LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)[1]	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
800	6'6"	4'6"	57"		800	700	See Costs below	Varies	20-30/year[2]	10[3]	110 V AC 60 Hz			
1200	Proportionally larger model				1200		"	"	"	"	"			
1500		"			1500		"	"	"	"	"			

[1] Dimensions and tank capacities depend on locally made tank sizes.
[2] Based on part-time use of 1/3 HP motor.
[3] Operational equipment expectancy; longer life if properly serviced.

SIZING & GROWTH POTENTIAL
1. Septi-Care equipment can be adapted to any concrete tank system, built as specified, for capacities up to 1500 GPD.

COSTS
1. Septi-Care sells control switch, blower, valve, diffuser, sludge return and skimmer.
2. Service policy extra after one year, pumping-out also extra.

INSTALLATION REQUIREMENTS
1. Septi-Care recommends local sludge pumping personnel to install unit.
2. Septic tank excavation needed plus plumber/electrician skills required for start-up.

OPERATION & MAINTENANCE REQUIREMENTS
1. Owner must occasionally check alarm light.
2. Semi-annual maintenance checks, plus occasional pumping-out, cleaning and oiling.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 (R)	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
800	80-90							Minor noise and no odors		
1200	"							"		
1500	"							"		

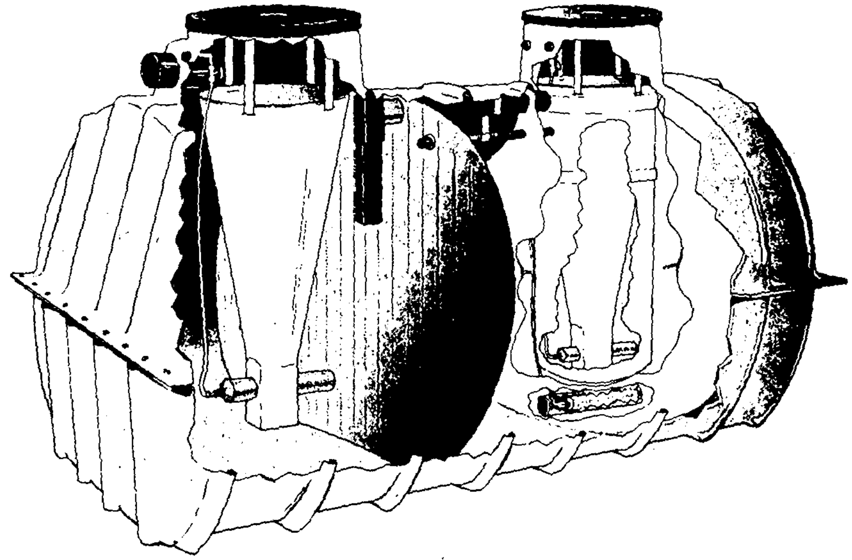
WARRANTIES, GUARANTEES, & SERVICE
1. Warranty on all mechanical parts for one year. Pro-rated replacement for five more years.
2. Septi-Care dealer installs, starts up, and maintains for one year.
3. Dealer offers service contract of two service checks.
4. Further yearly policy offered.

TECHNICAL PERFORMANCE

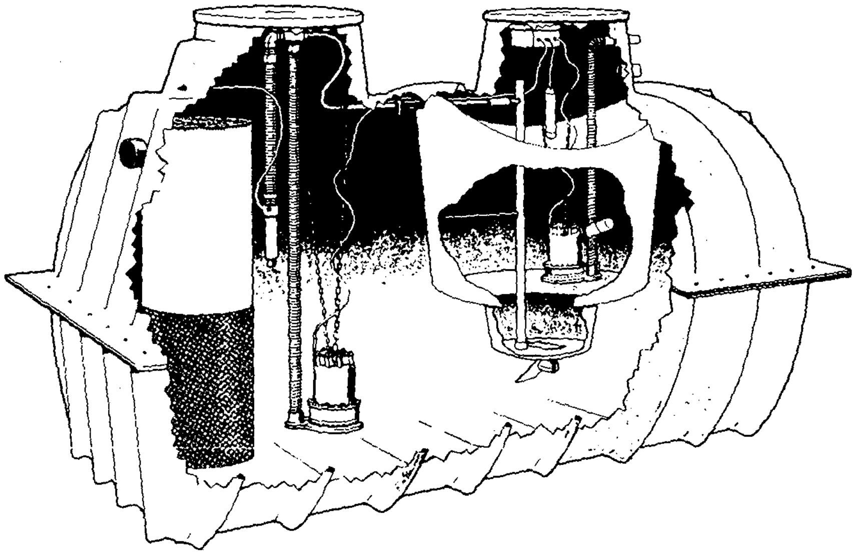
COMMENTS

ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

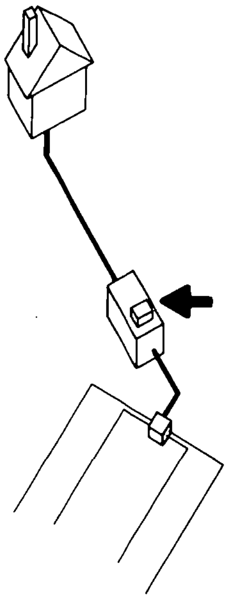


MODEL CA-900 DIFFUSED AERATION, FILTRATION SYSTEMS



MODEL C-5 MULTI-BATCH TREATMENT SYSTEMS

Cromaglass Corporation



CROMAGLASS CORPORATION
BOX 1146
WILLIAMSPORT, PA. 17701
(717) 326-3396
Attn: Mr. Allan N. Young, President

CROMAGLASS®

DIFFUSED AIR, FILTER BAG UNIT

FEATURES CA - Models
1. Cylindrical fiberglass aeration tank, one and two-chambered versions.
2. Filter bag in final compartment allows biological treatment (similar to trickling filter) and solids removal.
3. Both compartments offer diffused aeration.
4. Four model-sizes available.

Model C-5
1. No filter bag
2. Has positive "fail-safe" feature--if pumps are inoperative, no effluent can be discharged.

OPERATION CA - Models
1. Influent enters first compartment, is aerated, sludge settles.
2. Supernatant flows into second chamber, is aerated and passes through round filter bag.
3. Treated effluent leaves second chamber through discharge.

Model C-5
1. Influent enters comminution chamber and is aerated in second chamber, then pumped to settling chamber from which it is pumped for disposal.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD) 1	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.) 2	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
CA-610	70"	round	70"	280	500	500	995.		See below	Filter: 5-10 yr. Motor: 10+	110/440 V AC		Only if disinfect required	
CA-900	8'	cyl	5'		900	900	1195.		"	"	"		"	
C-5	8'	cyl	5'	437	480	900	1195		"	pumps 1-5 yrs.	"		"	
CA-1510	10'6"	5"	70"	638	1500	1500	2500-3000		"	"	"		"	

1 Based on 24 hr. detention time. 2 Tank has unlimited life-time.

SIZING & GROWTH POTENTIAL
1. Sized by GPD demand on system, extra modules can be added.

COSTS
1. Shipping costs average $25 within 200 miles; $50-$100 within 500-2000 miles.
2. Annual service policy costs $50-$75. Minor charge for new vanes or bearings (no labor charges).

INSTALLATION REQUIREMENTS
1. Standard excavation with gravel fill; possible concrete pad tie-down in high water table areas.
2. Factory training recommended for operator/service men.

OPERATION & MAINTENANCE REQUIREMENTS
1. Inspect tank compressor and motor, and air lines three to four times per year.
2. Change carbon vanes every nine months to two years.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS	DO	COD						
CA-610	85-95 3						Unlimited 4	No odors 5	FHA, FAA, Coast Guard; testing-NSF	
CA-900	"						"	"	"	
C-5	"						"	no odors no noise		
CA-1510 CA-1510	"						"	"	"	

3 Based on 500 GPD flow. (Cromaglass Performance Data booklet) 4 Tank should be insulated in Arctic cold. 5 Possible noise can be easily insulated.

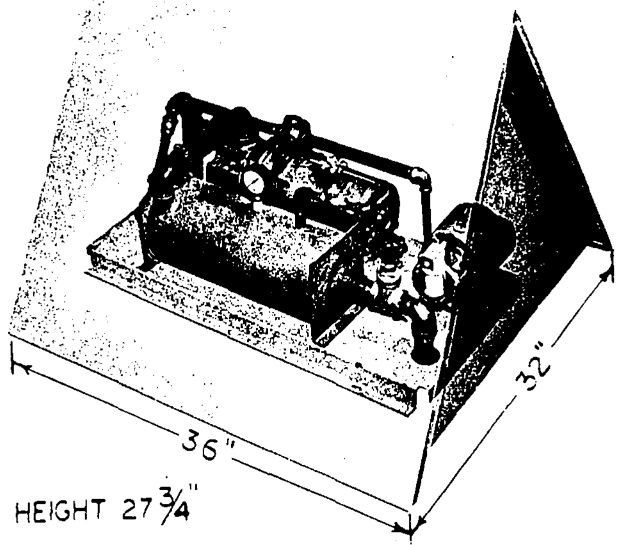
WARRANTIES, GUARANTEES, & SERVICE
1. One year warranty on all moving parts, unlimited warranty on fiberglass tank and plastic parts.
2. National, International, factory personnel service.
3. Dealer and distributor support.

TECHNICAL PERFORMANCE
1. Testing is presently being performed at NSF, Ann Arbor, Michigan, on the CA-610 and CA-900.
2. Model C-5 is a brand new item in the Cromaglass line.

COMMENTS ACCURATE AS OF Nov. 24, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

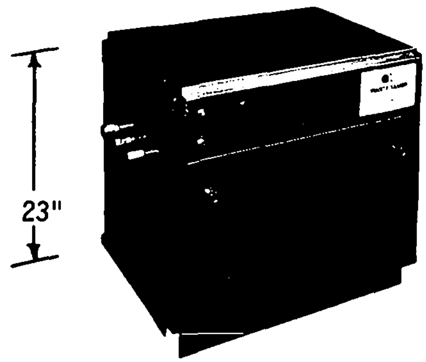
Pneumatic Pump
Height 58-5/8"



HEIGHT 27¾"

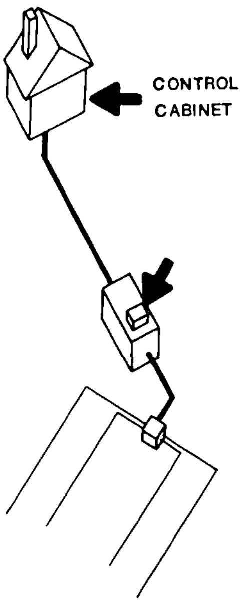
Model S-1000

Model 600-8RC
Control Cabinet



WASTE-TAMER™ PRESSURIZED SYSTEMS

ENVIRONMENTAL SERVICES, Inc.



ENVIRONMENTAL SERVICES, INC.
GRANITE AND WEST STREETS
MIDLAND PARK, NEW JERSEY 07432
(201) 652-3332
Attn: Mr. Fred C. Johnson, Water Treatment Division

WASTE-TAMER™

PRESSURE-CHAMBER AERATED TREATMENT SYSTEM

FEATURES
1. Multi-compartment tanks (furnished by dealer) provide primary settling, oxygenation, final settling.
2. S-1000 and S-1500 control units mounted on top of tank in A-frame shelter; 600-8RC control unit mounted remotely, e.g., house, garage.
3. Control unit consists of compressor and pumps (protected from corrosion).
4. Instead of single tank, can use 2 or 3 in series. Can thus utilize in-place septic tank as part of system.

OPERATION
1. Control unit works by pumping sewage from tank compartments into pressure chambers where air is pumped into fluid at higher-than-atmospheric pressure.
2. Pumps move 30 times the contents of the tanks through the pressure chambers per day, thoroughly mixing and oxygenating the sewage.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
S-1000	L x W x H = 160 ft.^{3}			135 ship'g	600	1200 to 1500	700.	750-1000		10 year min.	115 V; 1 ph; 60 Hz; 7.9 amp		None	
S-1500	L x W x H = 400 ft.^{3}			165 ship'g	1500	3000	900.	"		"	115 V; 1 ph; 60 Hz; 9.9 amp		"	
600-8RC	L x W x H = 160 ft.^{3}			250 ship'g	600	1200	762.	"		"	115 V; 1 ph; 60 Hz; 6.0 amp		"	

SIZING & GROWTH POTENTIAL

COSTS
1. Average package installations have been between $1400 and $1800 (total).

INSTALLATION REQUIREMENTS
1. Electrical work.
2. 600-8RC requires air piping work and indoor installation of control box.
3. S-models require protective shelter.
4. Septic tank installers can install except for electrical.

OPERATION & MAINTENANCE REQUIREMENTS
1. Quarterly checks for compressors and pumps.
2. No skill required for operation.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	OTHER
	BOD_5 (R)	SS	DO	COD						
S-1000	up to 95						-20° to 95° F	Minor noise and no odor	See below	Designed for 2.21 lb. BOD/day load, 48 hour retention, tank to be furnished by dealer.
S-1500	"						"	"		Designed for 3.3 lb. BOD/day load, 48 hour retention.
600-8RC	"						"	"		Designed for 1.36 lb. BOD/day load, 48 hour retention, tank to be furnished by dealer.

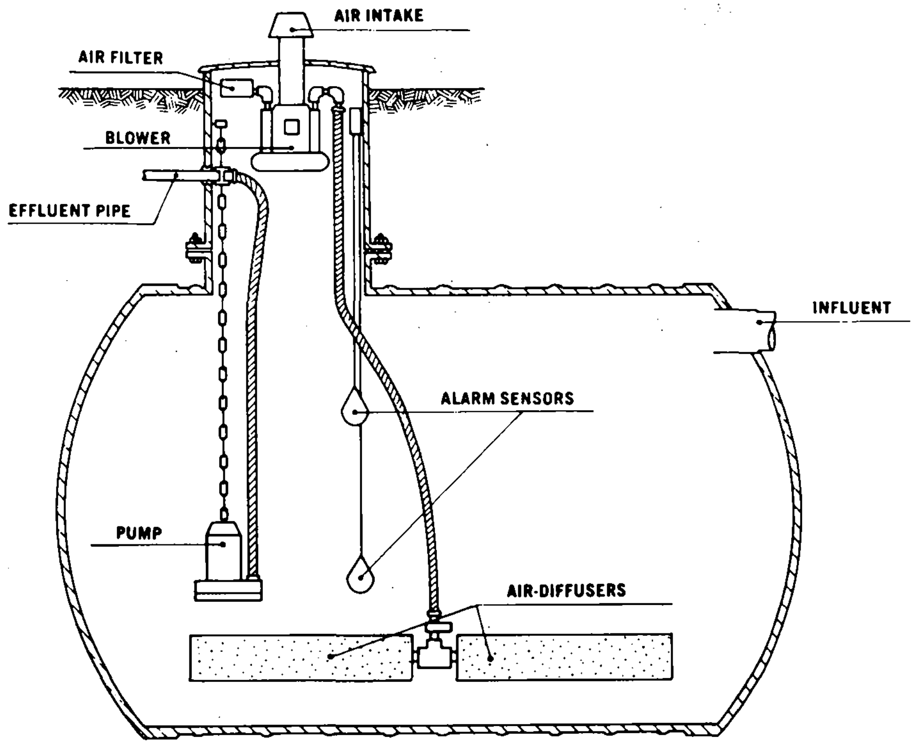
WARRANTIES, GUARANTEES, & SERVICE
1. 1 year warranty on parts and workmanship; replacement parts at cost, plus labor for replacement beyond warranty.
2. 1 year service policy included in sale price.
3. Renewable service policy includes routine maintenance twice a year, one emergency call per year; extra charge for more emergency calls.

TECHNICAL PERFORMANCE
1. Have been approved in Pennsylvania, Maryland, Wisconsin, Colorado, New Jersey, Vermont.
2. Tested by Edward C. Hess, Associates, Stroudsburg, PA.

COMMENTS

ACCURATE AS OF July 31, 1972

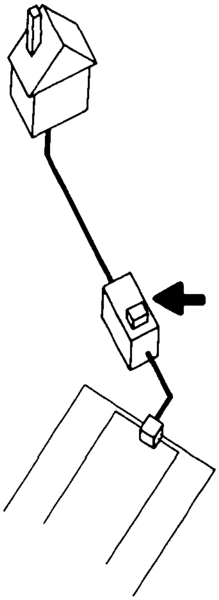
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



FLYGT MINI-PLANT

FLYGT

Diffused aeration, fill and draw system



FLYGT CORPORATION
129 GLOVER AVE., P. O. BOX 857
NORWALK, CONNECTICUT 06856
(203) 846-2051
Attn: Mr. Joseph S. LaValle, Division Manager, Residential Systems

FLYGT® 4291

DIFFUSED AIR, CONTACT STABILIZATION UNIT (FILL & DRAW)

FEATURES
1. Batch treatment process, daily aeration treatment with nightly "pumping out" of supernatant (fill and draw system).
2. Foam plastic air diffuser aerates wastewater and breaks up sludge.
3. Accessway component with basic system functions can be sold with concrete tank or fiberglass container.
4. Level sensors operate pumping ignition and stopping.
5. Alarm lights indicate malfunctions.
6. Centrifugal blower provides compressed air for diffuser.

OPERATION
1. Blower circulates air through diffusers, induces upward flow mixing all day and evening (14-20 hours).
2. After timed mixing, timer stops blower, allows 3 hour sedimentation and settling cycle.
3. After settling, timer activates pump (1/2 hour) and clear supernatant is pumped out.
4. Pump starts and stops by level sensors activated at prescribed water levels.
5. After pumping, cycle is renewed, aeration begins.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)		OPERATING SUPPLIES	
4291	See s	izing &	growth		400-600 depending on tank	See Sizing	1200-1500 [1]	See Costs below	30-60/year	25-30	230 V AC[2] 1 ph		None	

[1] With pre-cast concrete tank or fiberglass tank, available from local distributor.

[2] 115 V AC also available but 230 V AC recommended.

SIZING & GROWTH POTENTIAL
1. Tank capacity adaptable to local regulations by use of concrete tank and manway components.
2. Excess capacity for up to 48 hours collection of wastewater.

COSTS
1. Installation costs slightly higher than septic tank installation costs.
2. Operating costs: 600 W pump 10-15 min./day and 375 W blower 14-20 hrs./day.
3. Optional disinfection at additional cost (iodine feeder).

INSTALLATION REQUIREMENTS
1. Excavation for septic tank-like unit, gravel fill around concrete box (exact leveling not required).
2. Certified electrician to connect electrical components.
3. Manway: 2" (minimum) above ground to avoid flooding.

OPERATION & MAINTENANCE REQUIREMENTS
1. Now-and-then observance of system warning lights by owner required.
2. One or two times a year have unit checked and sludge pumped.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5 (R)	SS (R)	DO (A)	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
4291	90	90	ca 5				Unlimited[3]	Minor noise and no odors	NSF, Univ. of Wisc.[4] & European testing	

[3] Unit operated in Arctic conditions (Lapland).

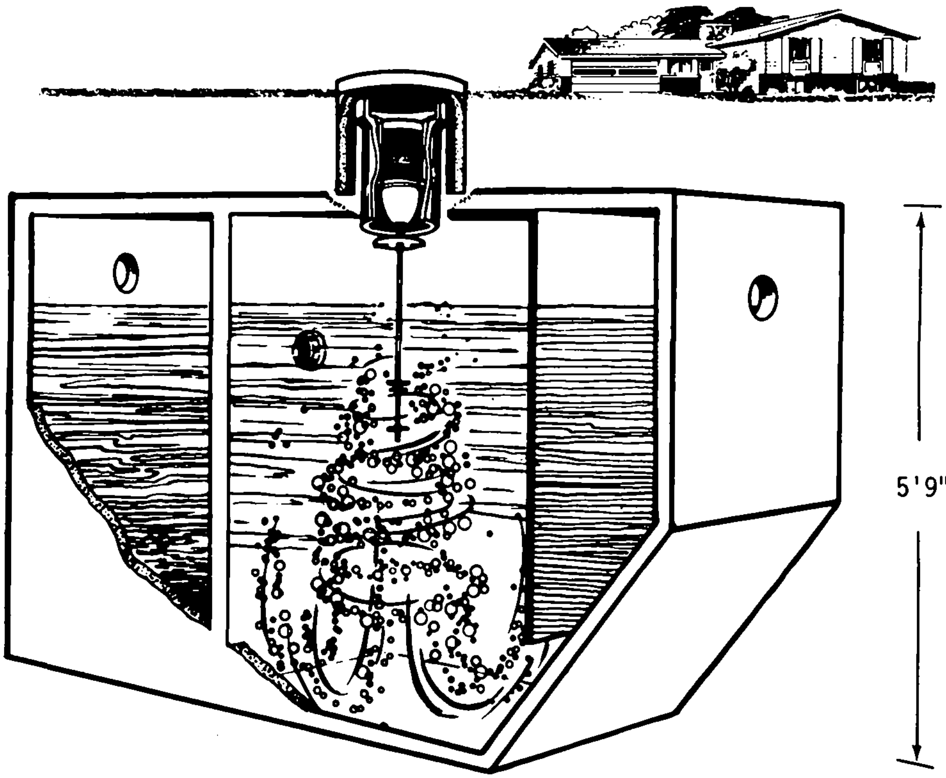
[4] Presently under testing by NSF (Standard No. 40) and University of Wisconsin.

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year guarantee on all parts from day of installation. Parts changed without any cost to owner.
2. 2 year service policy (NSF Standard No. 40 type).
3. Service offered by dealer, directed from main office in Connecticut.

TECHNICAL PERFORMANCE
1. Tested in Sweden by Swedish National Protection Agency (ca 1970); also tested in France and England.
2. Timer controls can be adjusted for different conditions.
3. Alarms notify malfunctions to owner, timer operates 12 hours after power failure.

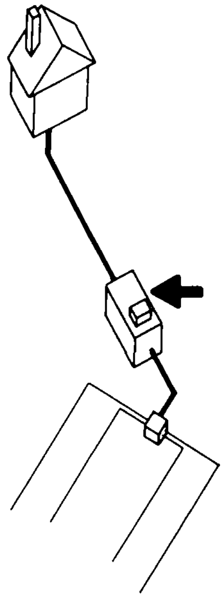
COMMENTS **ACCURATE AS OF** July 31, 1972
1. Arrangements for purchase and installation can be made through main office.
2. Units are sold in most European countries.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



JET® HOME PLANT

Mechanical Aeration Treatment Plant



JET AERATION CO.
750 ALPHA DRIVE
CLEVELAND, OHIO 44143
(216) 461-3100
Attn: Mr. William F. Neal, Sales Manager

JET® HOME PLANT

MECHANICAL AERATION UNIT

FEATURES
1. Three chambered flow-through mechanical aeration unit: (1) settling tank, (2) aeration chamber, (3) clarifier.
2. Two models of mechanical mixers: Model 100-G and 101-FP (1/6 HP, 1725 RPM).
3. Extensive service and warranty possibilities.
4. Warning light indicates mechanical breakdown of aerator.

OPERATION
1. Sewage enters first chamber, solids settle out.
2. Supernatant flows into aeration chamber, mixer periodically diffuses air into liquid.
3. Treated liquid flows under baffle to clarifying chamber, solids settle and slide down inclined side to aeration chamber.
4. Effluent flows over weir to discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT[1]				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Home Plant (J-135)	9'8"	4'9"	5'9"		600	1200	575.	ca 100	20-30/ year	20-25 on mechanical equipment	115 V AC		None[2]	

[1] Does not include aeration port.

[2] Unless chlorinator added.

SIZING & GROWTH POTENTIAL
1. Tank is oversized 50% for surge periods.
2. Mechanical aerator can be set for longer aeration periods to accommodate larger demand on system.

COSTS
1. After 2 years free service, extended service contracts are available, at $20-$40/year.
2. Optional chlorinator costs $80. $50/year operating.
3. Shipping costs average $3 each to the distributor. (Aeration and control equipment is shipped, tank furnished by dealer.)

INSTALLATION REQUIREMENTS
1. Simple excavation done by dealer/installer with simple electrical hook-up. No leveling required.
2. Gravel pad under tank not required.

OPERATION & MAINTENANCE REQUIREMENTS
1. No maintenance by owner.
2. Service policy has 6 month inspection checks; few skills necessary for maintenance.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO	COD						
Home Plant (J-135)	90+	80-90					0° F and up	Minor noise and no odors	Eligible for FHA - VA home loans	

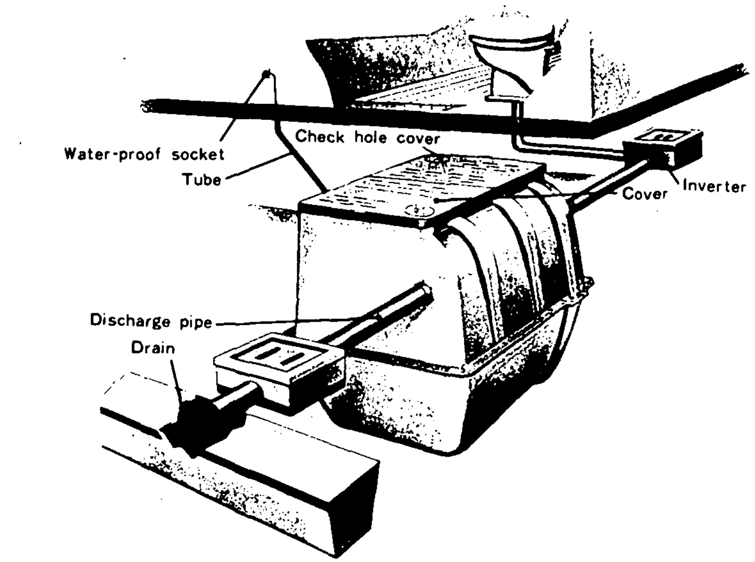
WARRANTIES, GUARANTEES, & SERVICE
1. Guaranteed BOD_5 of 50 ppm or less with 200 ppm loading.
2. List price includes 2 year guarantee, complete service (6 month checks) for 2 years, and 50 year warranty.
3. Units are sold by licensed local distributors who manufacture tanks and install equipment and provide service contracts, trained by Jet personnel at the factory.
4. Additional service contracts available.

TECHNICAL PERFORMANCE
1. Guaranteed BOD reduction.

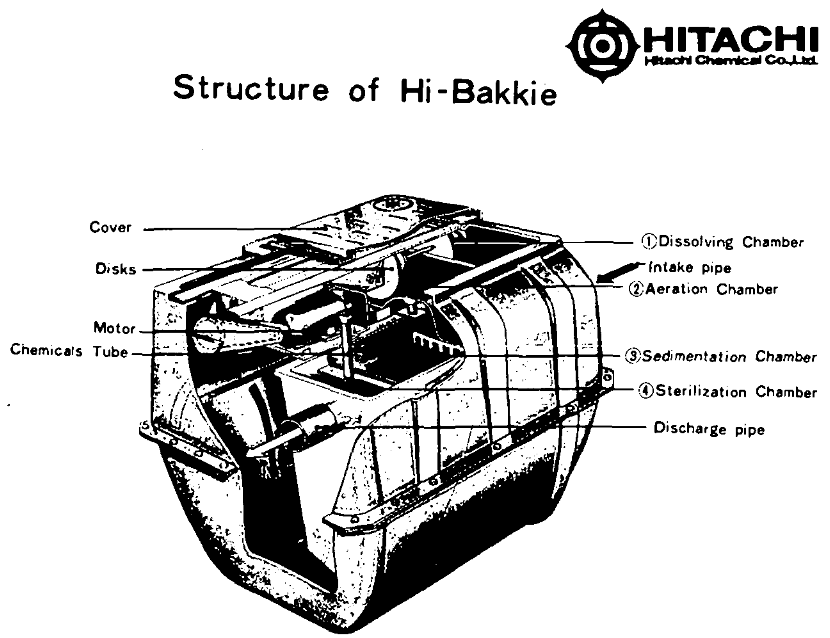
COMMENTS **ACCURATE AS OF** July 31, 1972
1. New floodproof aerator also available.

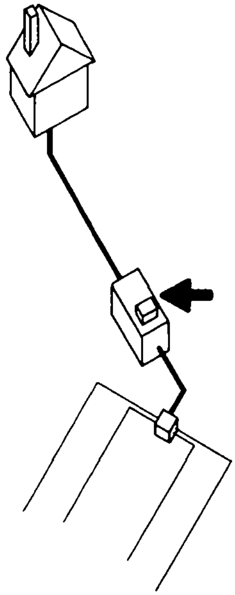
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Piping System of Hi-Bakkie



Structure of Hi-Bakkie





HITACHI CORPORATION (JAPAN)
c/o MARUBENI AMERICA CORPORATION
200 PARK AVENUE
NEW YORK, N. Y. 10017
(212) 973-6500
Attn: Mr. R. J. Barbour

HI-BAKKIE

DISK-AERATION, ACTIVATED SLUDGE SANITATION SYSTEM

FEATURES

1. Electric motor-driven continuously revolving plastic disks in dissolving and aeration chambers.
2. Sedimentation chamber with sludge return.
3. Sterilization chamber uses tablets made of chlorine compound.
4. Tank made of fiberglass reinforced plastics (FRP), drive shaft of stainless steel, ferroconcrete tank cover, zinc chromate surface on frame.

OPERATION

1. Sewage broken up in dissolving chamber by rotating disks; also receives aeration from disks which pick up oxygen.
2. Further treatment in aeration chamber disks keep solids in suspension.
3. Solids settle in sedimentation chamber; sludge is returned to aeration chamber.
4. Clarified liquid treated with chlorine tablets in sterilization chamber.

MODEL NUMBER (MAJOR)	DIMENSIONS		WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)[1]	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	DISK RPM
	LARGEST DIAMETER	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
M-200	69 3/4"	69"	1057	528	246,187, 87,8	Not yet in U.S.	marketed			80 W		Chlorine Tablets	140
M-320	79 1/2"	74"	1620	845	423,274, 135,13	"				150 W		"	"
M-470	85 3/8"	82"		1242	608,420, 198,16	"				300 W		"	"
M-620	93 3/8"	88"		1638	819,539, 259,21	"				300 W		"	"

[1]Dissolving, aeration, sedimentation and sterilization chambers, respectively.

SIZING & GROWTH POTENTIAL

1. Units come in prescribed sizes.

INSTALLATION REQUIREMENTS

1. Delivered as assembled unit.
2. Approximately 1/2 day for installation.

COSTS

1. Not yet established for U. S. market.

OPERATION & MAINTENANCE REQUIREMENTS

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS	DO	COD						
M-200	75-95							Odor-free		
M-320	"							"		Scheduled for testing at National Sanitation Foundation under Standard No. 40.
M-470	"							"		
M-620	"							"		

WARRANTIES, GUARANTEES, & SERVICE

1. Building dealer/contractor network for sales and service.

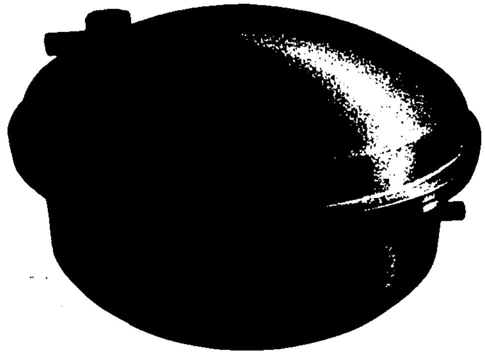
TECHNICAL PERFORMANCE

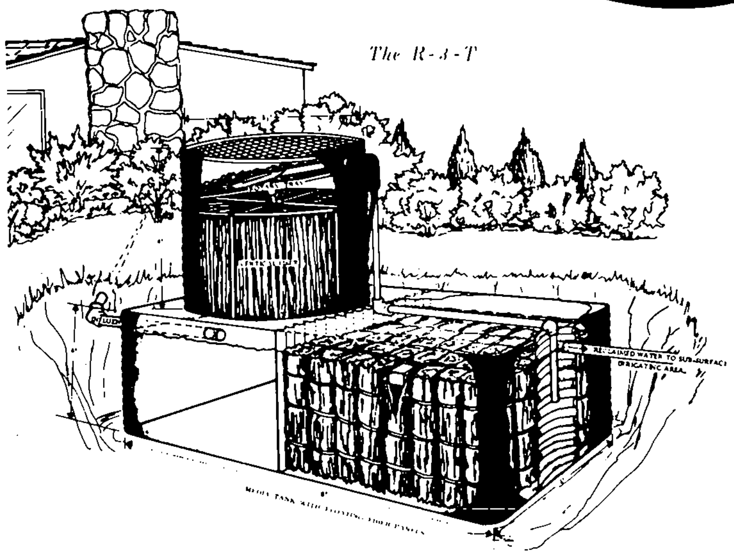
COMMENTS **ACCURATE AS OF** July 31, 1972

1. Still manufactured only in Japan.
2. Seeking U. S. manufacturing sources.
3. No princing information (pending U. S. manufacture).

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

THE ANNELGESTER



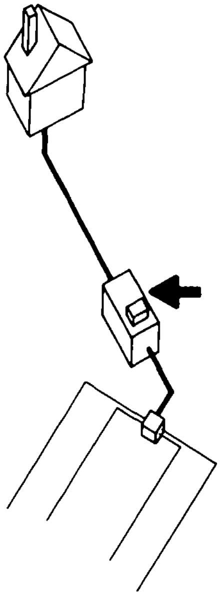


THE ANNELGESTER TRICKLING FILTER SYSTEM

Microphor

Flow-through redwood bark trickling filters

R-3-T system has sludge return



MICROPHOR, INC.
475 EAST SAN FRANCISCO AVE.
WILLITS, CALIFORNIA 95490
(707) 459-5563
Attn: Mr. John Mayfield, Exec. Vice-President

ANNELGESTER

REDWOOD TRICKLING FILTER UNIT

FEATURES

1. Flow-through waste treatment unit contains redwood bark.
2. Trickling filter process uses air circulation past redwood bark on which bacterial slimes form and produce biological digestion.
3. Circular and rectangular-shaped plastic polyethylene units, or larger corrugated metal models.

OPERATION

1. Sewage flows through redwood bark and is filtered.
2. Filtering acts as biological trickling of wastes past organic slimes.
3. Wastewater and some reduced solids are discharged for leaching field-type disposal.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
D-750	6'3"	round	38"	300	1,000		375.			10	None		None	
D-1000	8'	4'	31"	500	2,000		1100.			"	"		"	
D-2000	12'	6'	$3\frac{1}{2}$'	1450	3,000		3100.			"	"		"	
D-4000	20'	6'	$3\frac{1}{2}$'	2250	10,000		4500.			"	"		"	

SIZING & GROWTH POTENTIAL

1. R&S series package plants available at up to 30,000 GPD with aeration (800-3600 W); also available with tertiary treatment.

INSTALLATION REQUIREMENTS

1. Either subsurface or surface installation, minor installation skills needed (no electricity, etc.).

COSTS

1. Costs for tanks and tank equipment only.
2. Low-flush toilet system and hook-ups available at extra price.

OPERATION & MAINTENANCE REQUIREMENTS

1. No moving parts for maintenance.
2. In case of overload, conventional pumping is possible.
3. Occasional replacement of bark required.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	INLET AND OUTLET DIAMETER
	BOD_5 (R)	SS (R)	DO	COD	OTHER[1] (R)					
D-750	50	60			95		-20° to 160° F when buried	No noise, slight odor[2]	FHA	3" NPT
D-1000	"	"			"		"	"	"	"
D-2000	"	"			"		"	"	"	6" NPT
D-4000	"	"			"		"	"	"	"

[1]Settleable solids [2]Slight odor at vent.

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on defective parts.
2. Dealer supplies equipment and service policies at extra price.

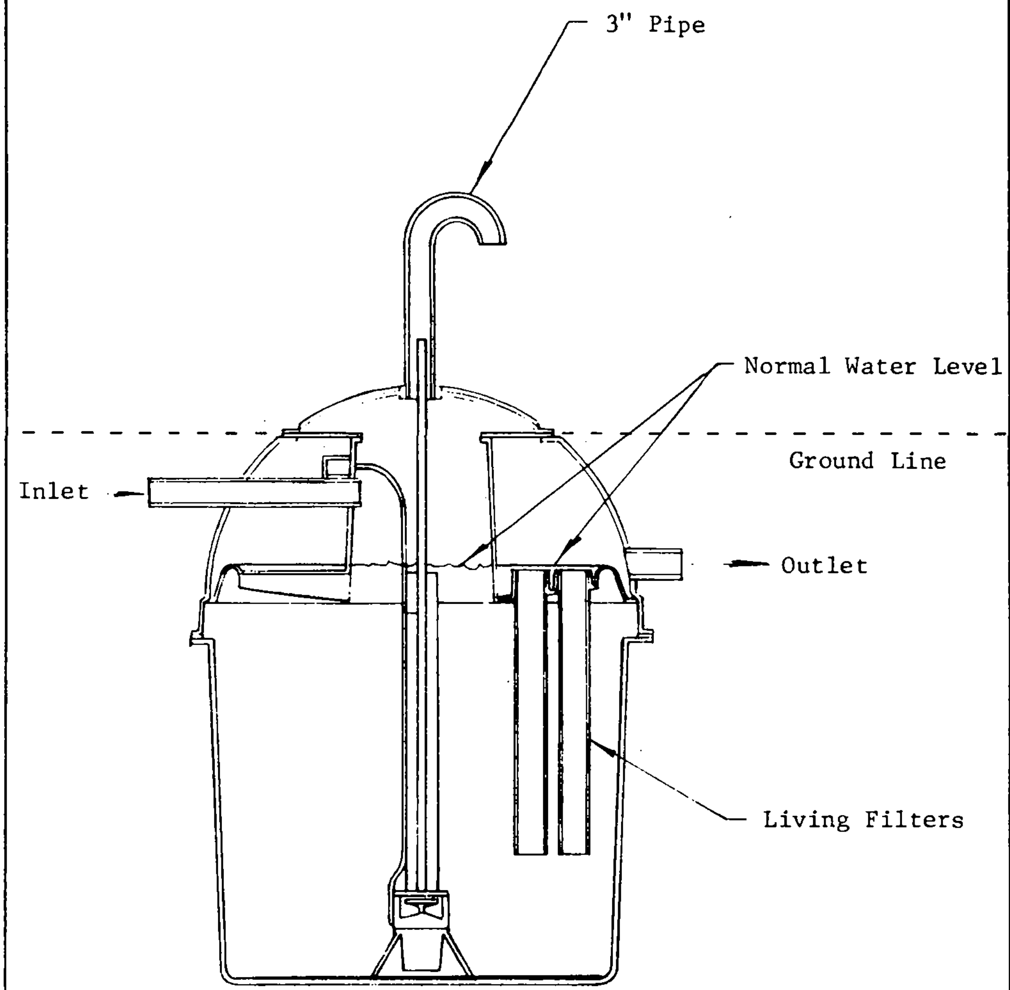
TECHNICAL PERFORMANCE

1. Chlorinated effluent has coliform count of less than 1/100 ml MPN.
2. Small Annelgesters have undergone testing at the Stewart Laboratories in Knoxville, Tennessee, during 1972.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. R-3-T system for individual homes, starting at 500 GPD available. (Pumped recycling trickling filter, 3-8 ppm DO, 90%+ BOD_5 removal, etc.)
2. Low-flush toilet systems and large Annelgester application described on page 300.

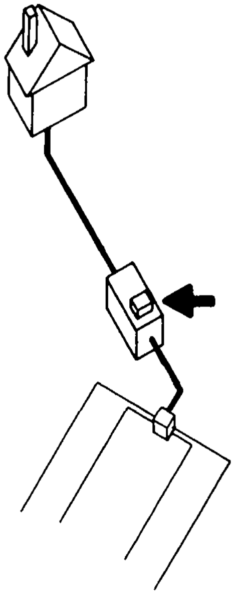
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



MULTI FLO HOME SYSTEMS
FOR WASTEWATER TREATMENT

Positive effluent filtration

MULTI·FLO
waste treatment
systems · pumps



MULTI-FLO INC.
500 WEBSTER ST.
DAYTON, OHIO 45401
(513) 224-7622
Attn: Mr. J. Robert Krebs, Exec. Vice-President

MULTI-FLO FT

AERATED FLOW-THROUGH FILTER UNIT

FEATURES
1. Submerged aeration and positive effluent filtration in fiberglass tanks.
2. Diffused aeration provides 2000 ft^3 air per pound BOD_5.
3. "Living Filter" bags act as solids removal and biological treatment (similar to trickling filter).
4. Alarm system indicates malfunctions.

OPERATION
1. Liquid wastes flow into aeration tank.
2. Submerged aerator bubbles air into liquid for aerobic treatment.
3. Draft tube creates circulation for activated waste treatment.
4. Liquid leaves system through a controlled porosity up-flow living filter, over weir to discharge or disinfection.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST 1		ELECTRICITY (RATING)			
FT-.3	54"	39"	77"	350	300	300	1000.	100-300 Varies	25-50/ year	3-5	115 V AC 1/4 Kw		None	
FT-.5	72"	61"	77"	500	500	500	1200.	"	"	"	"		"	
FT-1.0	90"	79"	88"	1000	1000	1000	2000.	"	"	"	115 V AC 1/2 Kw		"	
FT-1.5	96"	85"	94"	1500	1500	1500	2500.	"	"	"	"		"	

[1]Operating costs given are electrical only, maintenance costs extra.

SIZING & GROWTH POTENTIAL
1. Sizing to be based on local codes. Above units designed for 75 GPCD.
2. Aeration designed with 2000 ft^3 per lb. BOD_5.

COSTS
1. *Customer or installer furnishes interconnecting piping and* electrical work.
2. Chlorination or pasteurization equipment available.

INSTALLATION REQUIREMENTS
1. Open excavation with 6" clearance around tanks. Level bottom at proper elevation with fine sand or pea gravel base. Backfill uniformly.
2. Plumber/electrician skills required for installation.
3. 4" inlet and discharge connections; 3" pipe - air intake.

OPERATION & MAINTENANCE REQUIREMENTS
1. *First year: free quarterly inspections to note odors, check* alarm system.
2. Call for local service if necessary.
3. Occasional pumping out required.
4. Discharge arrangements necessary.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO (A)	COD						
FT-.3	85	85	4-6 ppm				Temperate. Domestic.	No noise.[2] No odors.	NAS-NRC Publn. 586	
FT-.5	"	"	"				"	"	"	
FT-1.0	"	"	"				"	"	"	
FT-1.5	"	"	"				"	"	"	

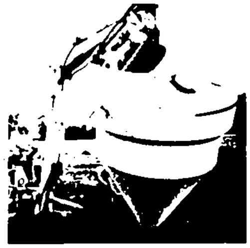
[2]Submerged motor.

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year manufacturer's warranty on workmanship and material.
2. Service contract included first year: parts, labor, two inspections.
3. Service contract available on annual basis.
4. Factory authorized and trained local service groups.
5. Periodic review of distributor activities by factory management.

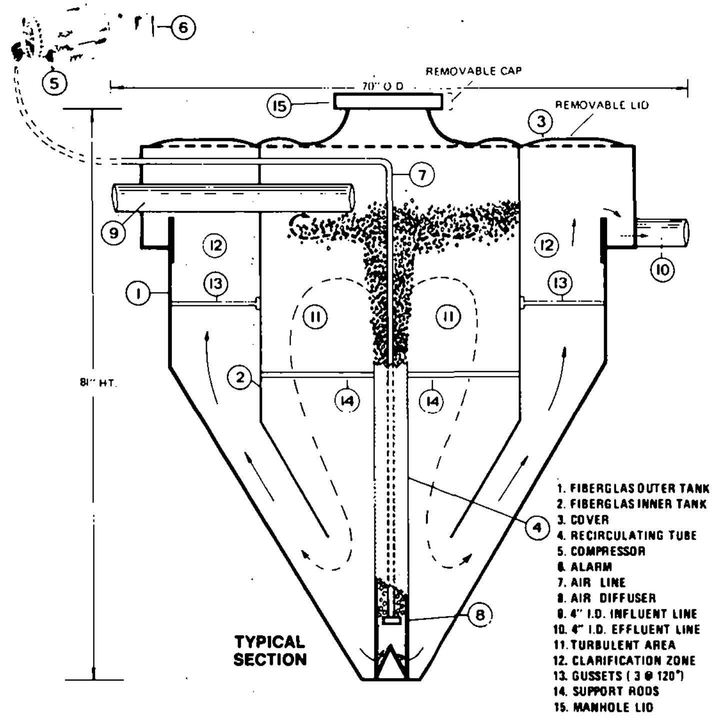
TECHNICAL PERFORMANCE
1. Effluent settleable solids are negligible.
2. Patents pending and issued.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. Aeration tanks similar to FT tanks used with Multi-Flo systems RS-1 and RS-2, pages 302-305.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

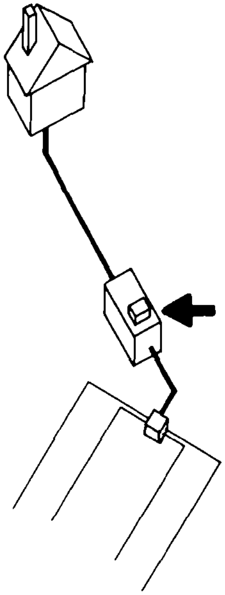


Backhoe Installation



NAY-SCI™, THE ANSWER, AEROBIC TREATMENT UNIT

NAYADIC SCIENCES, INC.



NAYADIC SCIENCES, INC.
VILLAGE OF EAGLE
UWCHLAND, PA. 19480
(215) 458-8545
Attn: Mr. Gilbert Murray, Exec. Vice-President

NAY-SCI,™ THE ANSWER

EXTENDED AERATION TREATMENT UNIT

FEATURES
1. Activated sludge and extended aeration units for 6 to 25 person demands.
2. 3/16" fiberglass cone tank.
3. 1750 RPM blowers deliver air to diffusers.
4. Low pressure pneumatic indicator alerts owner.
5. Optional disinfection (Cl_2 tank and chlorinator) extra.

OPERATION
1. Influent enters cone and drops towards aerator at bottom of cone.
2. Aeration circulates sludge (activated) up through sludge tube to combine with incoming waste.
3. Supernatant flows up sides and over circular weir to discharge pipe.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	WIDTH	HEIGHT[1]	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)[2]	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)		OPERATING SUPPLIES	
Model 6	68"	round	75"	280	6 person design capacity	600	995.	depends on site	See below	50+	3 ph 60 Hz 115 V		1/4 HP compressor	
Model 10	6'6"	round	7'4"	300	10 person design capacity	1,050	1150.	"	"	"	"		1/3 HP compressor	
Model 25	8'	10'	8'9"	750	25 person design capacity	2,500	3495.	"	"	"	"		"	

[1]Extra height for manhole extension or cover: Model 6, 8"; Model 10, 20"; Model 25, 18". [2]Suggested Retail.

SIZING & GROWTH POTENTIAL
1. Models are designed to have thresholds of 6, 10, or 25 people using the units. Extra or larger modules must be incorporated for expansion beyond threshold.

COSTS
1. Distributor service. Policies depend on type of service required. Contracts range from $25 to $40/year.
2. Retail price includes compressor and all auxiliary equipment.

INSTALLATION REQUIREMENTS
1. 24" x 24" x 10" deep gravel bed under cone recommended.
2. No other structural supports.
3. Plumbing skills and backhoe operation skills necessary for proper installation (leveling required).

OPERATION & MAINTENANCE REQUIREMENTS
1. Occasional attention to alarm indicator required of owner in order to notify service people.
2. Visual inspection and possible pumping out of sludge, part of regular service contract.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5 (R)	SS (R)	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	AERATION RATE (CFM)
Model 6	85-90	80-85					Unlimited (Fiberglass)	Minor noise and no odors	Current NSF and Bureau of Stand. testing	3 @ 3 PSIG
Model 10	"	"					"	"		4-6 @ 3 PSIG
Model 25	"	"					"	"		6-8 @ 4 PSIG

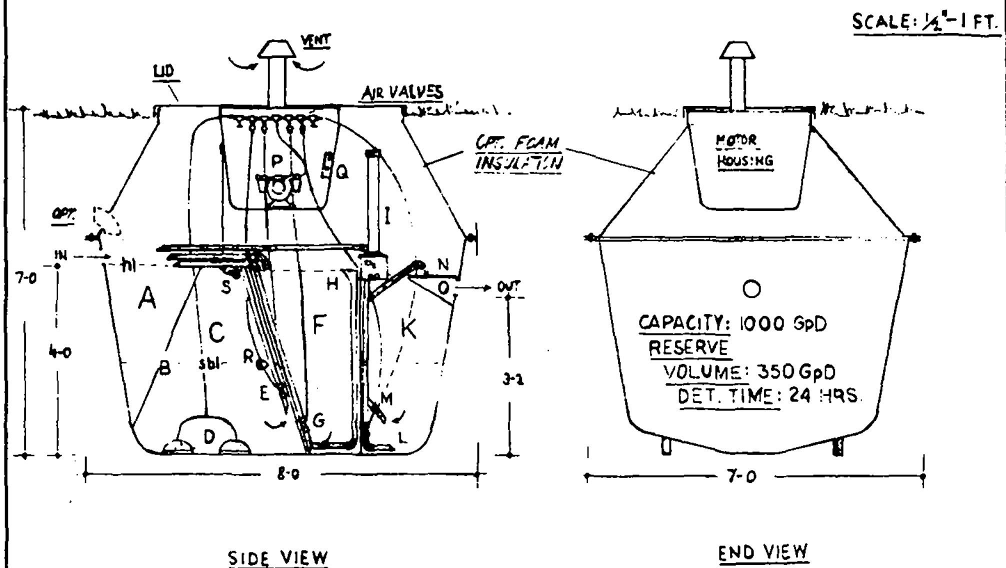
WARRANTIES, GUARANTEES, & SERVICE
1. Each model carries a full year warranty on all parts and equipment.
2. All distributors required to offer a one or two year service policy.
3. Nayadic Sciences Engineering Department backs up service.

TECHNICAL PERFORMANCE
1. Under NSF testing program (Standard No. 40).
2. Model 6 being tested at Bureau of Standards, Gaithersburg, Md.

COMMENTS

ACCURATE AS OF July 31, 1972

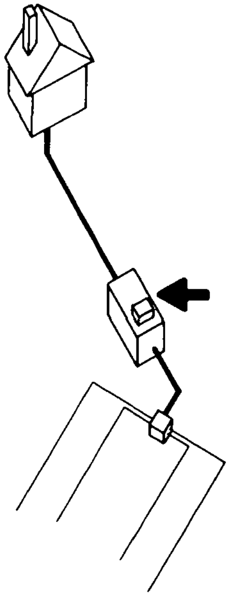
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



NEWS 1000G

NEW ENGLAND WASTEWATER SYSTEMS, INC.

A	Receiv. Chamber	L	Sludge Return
B	Perfor. Divider	M	Discharge Lift
C	Aeration Tank	N	Filter Screen
D	Diffusers	O	Disch. Chamber
E	Transfer Lift	P	Air Pump
F	Clarifier 1	Q	Control Box
G	Sludge Return	R	sbl Switch
H	Skimmer	S	hl Switch
I	Chlorinator	sbl	Stand-by Level
K	Clarifier 2	hl	High Level



NEW ENGLAND WASTEWATER SYSTEMS, INC.
ROUTE 100/P. O. BOX 412
WEST DOVER, VERMONT 05356
(802) 464-5363 or 3753
Attn: Mr. Werner Hoermann, President

NEWS 1000G

INDIVIDUAL AEROBIC TREATMENT UNIT

FEATURES

1. Reinforced fiberglass tank, lockable lid.
2. Internal parts non-mechanical, non-corroding materials; uses many air lifts for liquid transfer.
3. Air supplied by oil-less vacuum pump or Roots blower.
4. Uses Diamond Shamrock's MINI-SAN chlorinator, which uses dry SANURIL 115 Chlorine Tablets.
5. Solids separated at five points internal to unit.
6. Aeration cycling programmed to expected loading rate.
7. Has warning lights for overload.
8. Model 100G aerated distribution box available.

OPERATION

1. Effluent enters a receiving chamber which retains solids larger than 3/8". Scum and sludge from clarifier #1 and sludge from clarifier #2 also returned to receiving chamber by airlifts.
2. Aeration chamber has two ceramic air diffusers.
3. Mixed liquor transferred to clarifier #1 by airlift according to programmed rate.
4. Then to clarifier #2 which is also a chlorine contact tank.
5. Supernatant by airlift through filter screen to discharge chamber.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
1000G	96"	84"	84"		1000	1000 total	1,195.	95.[1]		10 yr.[2]	2 lines 115 V each		Saruril 115 chlorine tablets and starting culture	

[1] Start-up plus plumbing and electricity.

[2] Compressor; unit life not determined.

SIZING & GROWTH POTENTIAL

1. Capacities can be increased by installing multiples.
2. *Can absorb surge loads of up to 350 gallons from stand-by state.*

COSTS

1. Discounts of up to 30% on orders of more than 10 units shipped together, knocked-down. A $50 allowance for assembly is in effect; assembly is normally a 6 man-hour job.
2. Considerable freight savings when shipped knocked down.

INSTALLATION REQUIREMENTS

1. Backfill with fine gravel, concrete pad in high groundwater table, *special reinforcement for above-grade installation.*
2. Requires leveling.

OPERATION & MAINTENANCE REQUIREMENTS

1. Less than one day training for operator; minimum skill.
2. Service requires basic plumbing and motor/compressor skills. Routine compressor service, 15 minutes.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
1000G	Now testing							Minor noise; odor[3]		

[3] Damp, soil-like odor.

WARRANTIES, GUARANTEES, & SERVICE

1. System will be warranted as long as fully paid service contract is in effect. Manufacturer will post performance bonds for service, if required, for multi-unit installation.
2. Sold only with Service and Installation package; includes assembly, programming, seeding (culture) and start-up and one year service contract (not including plumbing and electricity) $95; service to be performed by distributor.

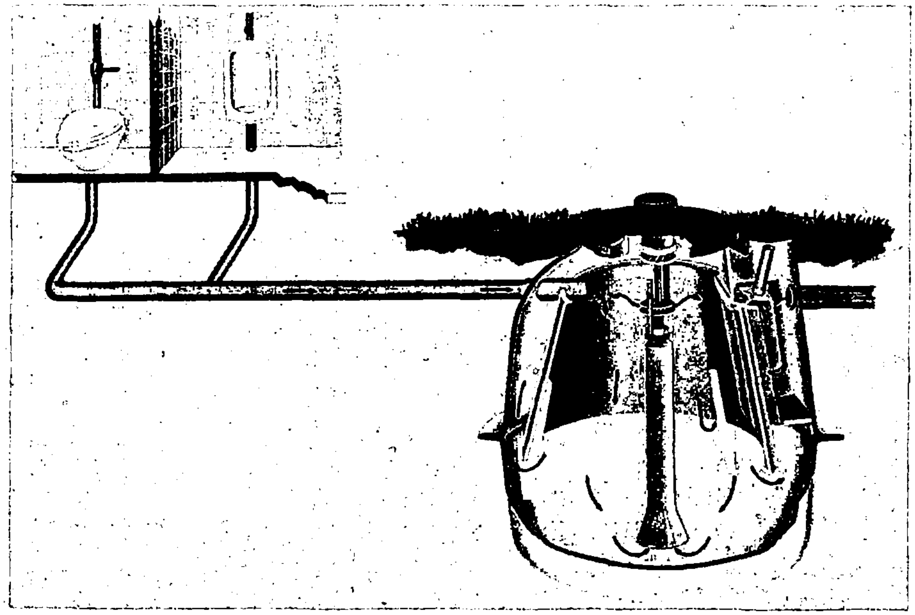
TECHNICAL PERFORMANCE

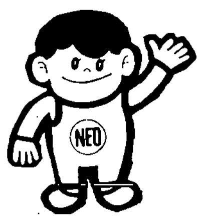
1. Surge loading capacity is available after partial emptying of wastewater from the various treatment tanks.
2. Ejection from the aeration chamber and clarifier #2 occurs periodically until a pre-set low-water level is reached.
3. Aerator then shifts from continuous to intermittent operation, and the partially empty tanks can accept the surge.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Manufacturer suggests use with their Model 100G aerated distribution box when disposal is subsurface.
2. This is a new unit still undergoing testing.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

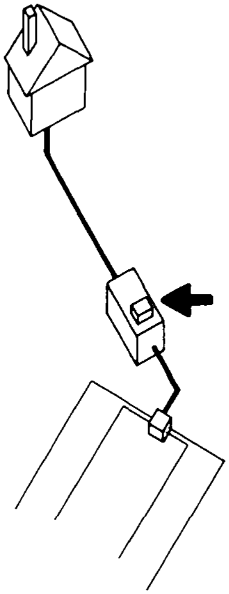




NEO AEROBIC TANKS - AR

NEO 西原ネオ工業株式会社

Mechanical aeration tanks for toilet waste treatment



NISHIHARA ENVIRONMENTAL SANITATION RESEARCH CORP., LTD.
c/o DR. TAKASHI ASANO
MONTANA STATE UNIVERSITY, DEPARTMENT OF CIVIL ENGINEERING
BOZEMAN, MONTANA 59715
(406) 587-3121 ext. 566
Attn: Dr. Asano

NEO AEROBIC TANKS-AR

AEROBIC TREATMENT PLANT

FEATURES
1. Aerobic extended aeration and activated sludge waste treatment tanks.
2. Designed for treatment of flush toilet waters only, other wastewaters not used (therefore lower rated capacity).
3. Mechanical aeration pulls sewage up central sludge tube for recycling and aeration (believed to be mechanical, not specified by manufacturer.
4. Nine different sized models for populations of 5 to 100 persons.
5. Heavy duty polyester resin (FRP) construction..

OPERATION
1. Wastewater from toilets flows by gravity to inlet of treatment tank.
2. Sewage is aerated and circulated in inner aeration chamber.
3. Mixed liquor flows to outer sedimentation ring where solids settle and return to aeration tank.
4. Supernatant flows through "tee" inlet-weir to disinfectant-detention chamber.
5. Wastewater flows past pellet-tube for disinfectant contact, then to detention chamber and discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD) [1]	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST [2]	OPERATE COST [3]		ELECTRICITY (RATING)			
AR-$7\frac{1}{2}$	50"	round	49"		5 persons	211	367.	100.	45/yr.	15+ [4]	100 V AC 50/60 Hz 1.1/1.2 amp		Disinfectant tablets	
AR-10	54"	round	49"		10 persons	275	430.	103.	45/yr.		"		"	
AR-20	66"	round	64"		30 persons	551	1043.	140.	84/yr.		100 V AC 50/60 Hz 1.5/1.7 amp		"	
AR-65	97"	round	96"		100 persons	1833	2103.	330.	154/yr.		100 V AC 50/60 Hz 2.8/3.2 amp		"	

[1]Toilet wastewater only. [2]Includes shipping cost. [4]Motor bearing design life: 5-7 yrs.
[3]Operation cost: maintenance and electricity.

SIZING & GROWTH POTENTIAL
1. Hydraulic and waste load sizing based on 13.2 GPCD and 0.0287 lb. BOD_5/capita/day.
2. Model numbers correspond to ten times tank volume in M^3 (Model 10 has 1.0 M^3 volume).

COSTS
1. All prices are based on $1 = 300 yen.
2. Piping and special earthworks are extra costs.
3. Maintenance cost based on sludge disposal (pumping).
4. Electric charges are: Model 7 1/2 and 10 - 25 W motor @ $1.51/mo.; Model 20 - 50 W motor @ $2.54/mo.; Model 65 - 100 W motor @ $4.72/mo.

INSTALLATION REQUIREMENTS
1. Excavation and electrical skills required.
2. Concrete pads recommended; above ground cover/accessway.
3. Reinforcement work necessary for deep excavations or roadside installation.

OPERATION & MAINTENANCE REQUIREMENTS
1. Calcium hypochlorite tablets used in disinfectant chamber.
2. 2 month checks recommended: aerator, disinfectant and sludge volume (occasional pumping out).
3. Special care needed for aerator in high humidity or seaside environments.

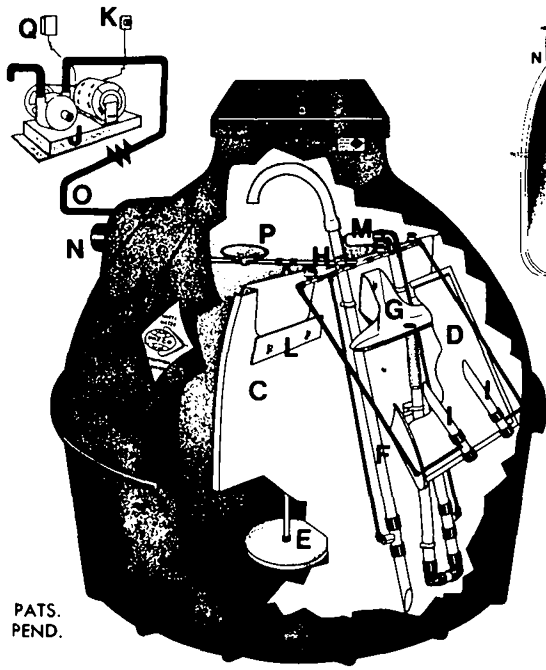
MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO	COD						
All	77+	65+					Temperate zone conditions	Minor noise and no odors	Japan Ministry of Int. Trade & Ind. No. 1726	

WARRANTIES, GUARANTEES, & SERVICE
1. One year warranty for all parts and tank body.
2. Franchised dealership for construction and user services.
3. Back-up education, sales promotion, and advertisement by Nishihara Corporation.
4. U. S. distributors under negotiation.

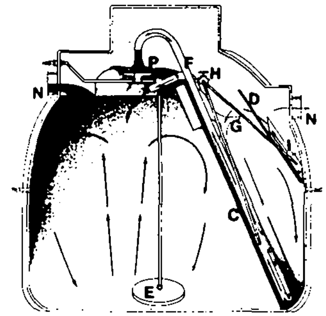
TECHNICAL PERFORMANCE
1. Aerator noise level less than 50 phon at 1 meter.
2. To enhance SS removal, pit installation ahead of percolation bed may be recommended.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. Not yet marketed in the U. S.
2. Cost information is based on standard cost figures in the mainland Japan.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



PATS.
PEND.



A - Fiberglass Tank

B - Tank Lid (Hinged and Lockable)

C - Tank Divider (Reinforced)

D - Polypropylene Filter Screen (Removable)

E - Porous Ceramic Diffuser (Silicone Treated)

F - Sludge Return - Air Lift

G - Skimmer - Air Lift (Adjustable)

H - PVC Air Line and Adjustment Valves

I - Continuous Screen Cleaner (Water Jet Back-Flush)

J - Motor and Compressor

K - Warning Signal (Flashing)

L - Adjustable Leveling Dams

M - Removable Return Elbows for Easy Cleaning

N - Fiberglass Inlet and Outlet Pipe (Socket Fit)

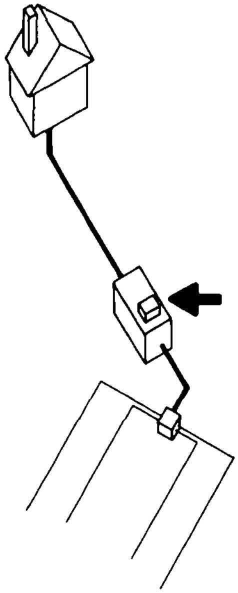
O - Air Supply

P - Foam Eliminator

Q - Circuit Box

PLAST-A-FORM EXTENDED AERATION UNIT

PAFCO®



PLAST-A-FORM CORPORATION
225 VALLEY STREET
WILLIAMSPORT, PA. 17701
(717) 326-5368
Attn: Mr. Carl W. Term

PLAST-A-FORM

FILTERED EXTENDED AERATION UNIT

FEATURES

1. Reinforced fiberglass extended aeration tanks with filtration, two sizes - 600 and 900 GPD.
2. Porous ceramic diffuser (silicone treated).
3. Rotary, oil-less, carbon vane or lubricated steel vane type blower with filter (5.9 CFM @ 2.5 PSIG).
4. Air lift sludge and skimmer returns deflect, return sewage off foam reducer plate for foam reduction.
5. Polypropylene filter screen (removable) has continuous water jet back-flush cleaner.
6. Alarm system optional, alerts malfunction.

OPERATION

1. Sewage enters fiberglass tank to main aeration chamber, solids settle out, sewage is aerated.
2. Supernatant flows over tank divider to clarifier, sludge return removes settled solids.
3. Liquid flows through filter screen to discharge, screen washed clean and solids recycled.
4. Sludge return air lifts solids back to main tank after deflecting on circular plate for dispersion and foam reduction.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST [1]		ELECTRICITY (RATING)	AIR		
AA-604	70"	Round	66"	242	600	600	695.	Varies	20/yr.		115 V AC (1/4 HP)	2380 CFD	Chlorine, if used	
AA-904	"		96"	327	900	900	945.	"	"		"	3570 CFD		

[1]Electricity only; service additional.

SIZING & GROWTH POTENTIAL

1. Tanks can be used without equipment: for grease traps, septic tanks, water reservoir.
2. Sizing is based on 24-hour detention times.

COSTS

1. Base price includes tank, motor, compressor, sludge return, diffuser and skimmer.
2. Options: A400 Warning Alarm, $33; AB 900 Grease Trap, $324; C250 Chlorine Contact tank and dispenser, $242.

INSTALLATION REQUIREMENTS

1. Excavation required, tank lid at ground elevation (maximum earth cover - 36"), avoid flood areas.
2. Compressor and motor should be inside.
3. Electrical and backfill skills required.

OPERATION & MAINTENANCE REQUIREMENTS

1. Owner must check alarm light.
2. Periodic maintenance necessary.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD5 (R)	SS	DO	COD						
AA-604	70-90							Minor noise and no odors [2]	Patents Pending	
AA-904	"							"	"	

[2]Noise abatement housing (motor and compressor) design available.

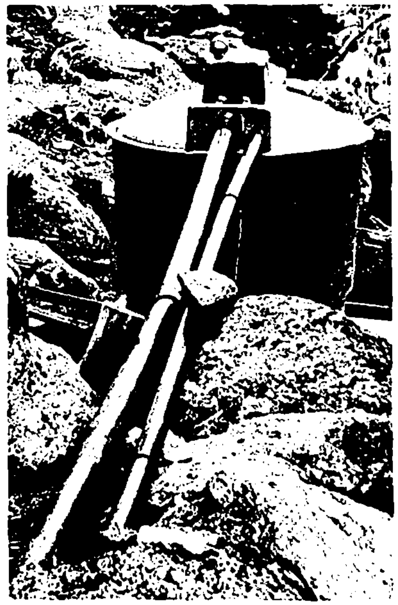
WARRANTIES, GUARANTEES, & SERVICE

TECHNICAL PERFORMANCE

COMMENTS **ACCURATE AS OF** July 31, 1972

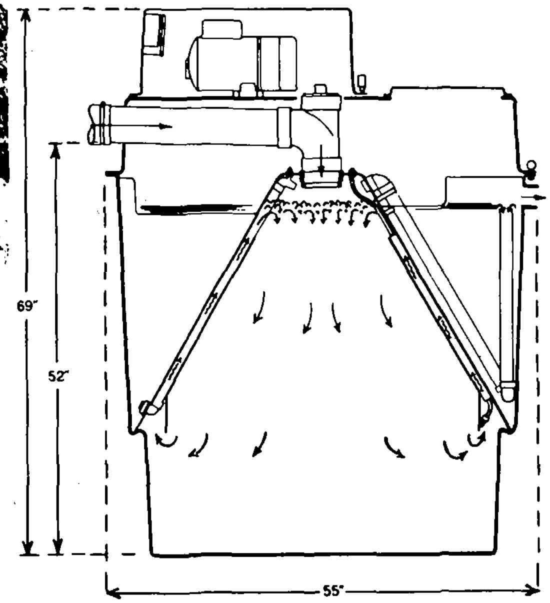
1. More information on service and installation available from dealer.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

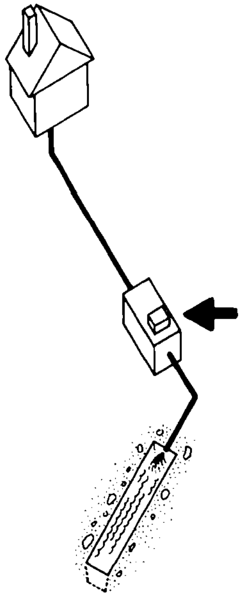


MOUNTAIN TERRAIN INSTALLATION

CROSS SECTION



CT-86® ACTIVATED SLUDGE TERTIARY TREATMENT PLANT



POLLUTION CONTROL SYSTEMS, INC.
P. O. BOX 401
10575 WEST 120TH ST.
BROOMFIELD, COLORADO 80020
(303) 469-1761
Attn: Mr. James S. Stone, President

CT-86 ®

ACTIVATED SLUDGE, TERTIARY TREATMENT HOME PLANT

FEATURES

1. Aerobic tertiary treatment unit for surface disposal or non-leaching field conditions.
2. Circular fiberglass tank with inner cone.
3. Activated sludge brought up sides of cone to treat incoming wastes.
4. 5 CFM FA continuous aeration.
5. Sludge and skimmer air lifts are activated at regular intervals for 2 minutes @ 1.3 GPM each.
6. Ozone or chlorine disinfection available.

OPERATION

1. Sewage flows into main cone and aeration chamber.
2. Air ring diffuses air up sides of cone to draw wastes back to vertex/entrance of cone (activated sludge).
3. Opening at base of cone allows supernatant to flow into settling chamber, sludge lift and skimmer periodically clean.
4. Supernatant flows over weir to disinfectant-contact chamber.
5. Effluent passes under final weir for discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY) [1]	INSTALL COST	OPERATE COST [2]		ELECTRICITY (RATING)			
CT-86 No.375	55"	round	69"	250	375	375	1,200.	300-500	96/yr.	Tank:20 Motors:10	110 V, 60 cy, 1 ph, 732 W		Chlorine: 1 bar/ week	

[1]FOB, Broomfield, Colorado. [2]Electricity @ 1-1/2¢/Kwh.

SIZING & GROWTH POTENTIAL

1. Sized for 5 person capacity; quality of effluent desired determines actual capacity, while water control devices, etc., could increase capacity.

COSTS

1. Shipping extra: plastic tank with compressor, over 15#/cf, Class #70, 300# $50.00.
2. If chlorine is used, $2/month on Tesco H109 chlorine bars.

INSTALLATION REQUIREMENTS

1. Free standing in basement, recessed in garage floor or buried (ground level) outside.

OPERATION & MAINTENANCE REQUIREMENTS

1. Replace carbon vanes and air filter @ $4/year, ozone lamp @ $10/year, timer @ $2/year.
2. Simple consciencious labor required.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)					OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD	OTHER [3]				
CT-86 No.375					0.1 ml/ liter (A)	Unlimited	Minor noise and 3 T.O. odor	U.S.Patent: No. 3,503,876	

[3]Settleable solids.

WARRANTIES, GUARANTEES, & SERVICE

1. One year warranty on parts with 90 day free service.
2. Optional service contract @ $100 per year plus parts.
3. Suggested maintenance requirements and contracted operators provided at additional cost.
4. PCS, Inc., maintains engineering staff for installation and maintenance.

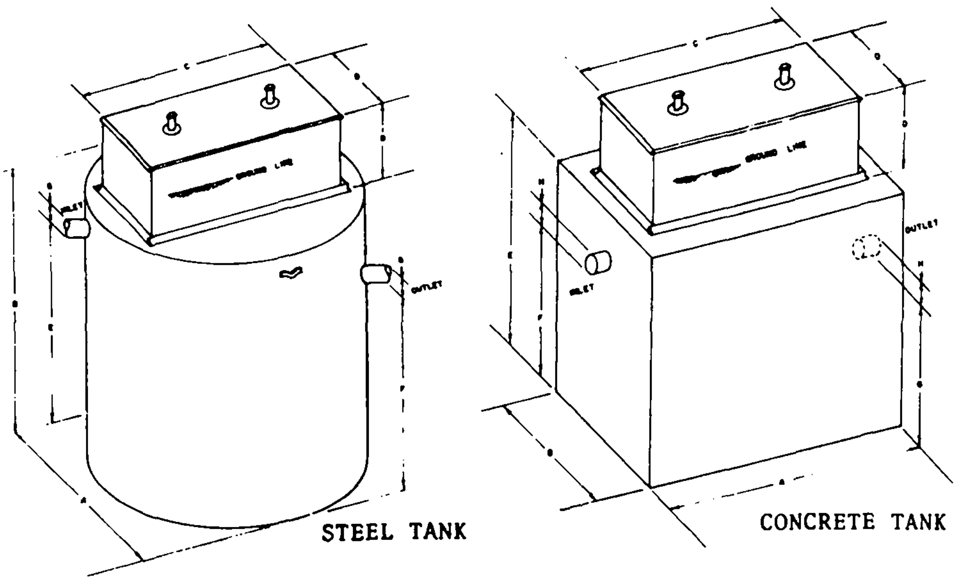
TECHNICAL PERFORMANCE

1. Wastewater discharge surpasses recreational water quality standards (less than 2 MPN coliform per 100 ml).
2. 50 units currently being tested.
3. U. S. and foreign patents pending.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Presently units available only through Colorado office.

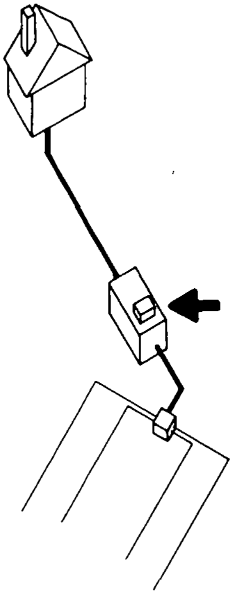
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



MICROX BATCH TREATMENT PLANTS

pollutrol technology inc.

Timed aeration process treats sewage in 20% of GPD batches



POLLUTROL TECHNOLOGY, INC.
THOMPSON'S POINT INDUSTRIAL PARK
P. O. BOX 3727
PORTLAND, MAINE 04104
(207) 773-3876
Attn: Mr. Paul Fleming, Sales Manager

MICROX

BATCH PROCESS EXTENDED AERATION UNIT

FEATURES

1. Steel and concrete tank small package treatment plants for inland or waterway discharge (many-sized models).
2. Batch, extended aeration and activated sludge processes used.
3. Timer controls batch process.
4. Warning lights signify malfunctions.
5. Microx II for inland discharge, Microx III for waterway discharge, both steel and concrete type tanks available.

OPERATION

1. First chamber is inlet/surge holding chamber, waste undergoes aeration.
2. Waste transferred by air lift to settling chamber in batches (20% of daily flow/batch).
3. Aeration followed by settling takes place in settling chamber.
4. Top 20% of liquid is pumped out, sludge is returned.

MODEL NUMBER (MAJOR)	DIMENSIONS 1			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.) 2	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB 3 FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Microx II	54-84"	round	84-96"	650-1900	300-1250	300-1250	1,155.-2,395.	Varies	40-100/year	20-40 on steel tank 4	115 V AC		Chlorine, if used	
Microx III	65-84"	round	87-96"	800-1900	500-1000	500-1000	1,670.-2,520.	"	"					

[1]Steel tank dimensions. [2]Aeration tank. [3]FOB, Portland, Maine. [4]Equipment averages 5 years.

SIZING & GROWTH POTENTIAL

COSTS

1. Effluent pump costs $140. extra.
2. Base price includes tank and treatment equipment.
3. Operating costs are for electricity only.
4. Chlorination is extra.

INSTALLATION REQUIREMENTS

1. Licensed plumber and excavator skills needed.
2. Operator has minor responsibilities.
3. Treatment tank to be coated with Bitumastic-50.

OPERATION & MAINTENANCE REQUIREMENTS

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO (A)	COD						
All	90-95	90-95	2-5 mg/l				Unlimited in U.S.	Minor noise and no odors	Several states approve	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on parts and workmanship.
2. Service contracts available at $117 to $156 /year.
3. Dealer installs unit, offers service contract.
4. Pollutrol trains operators, maintenance personnel.

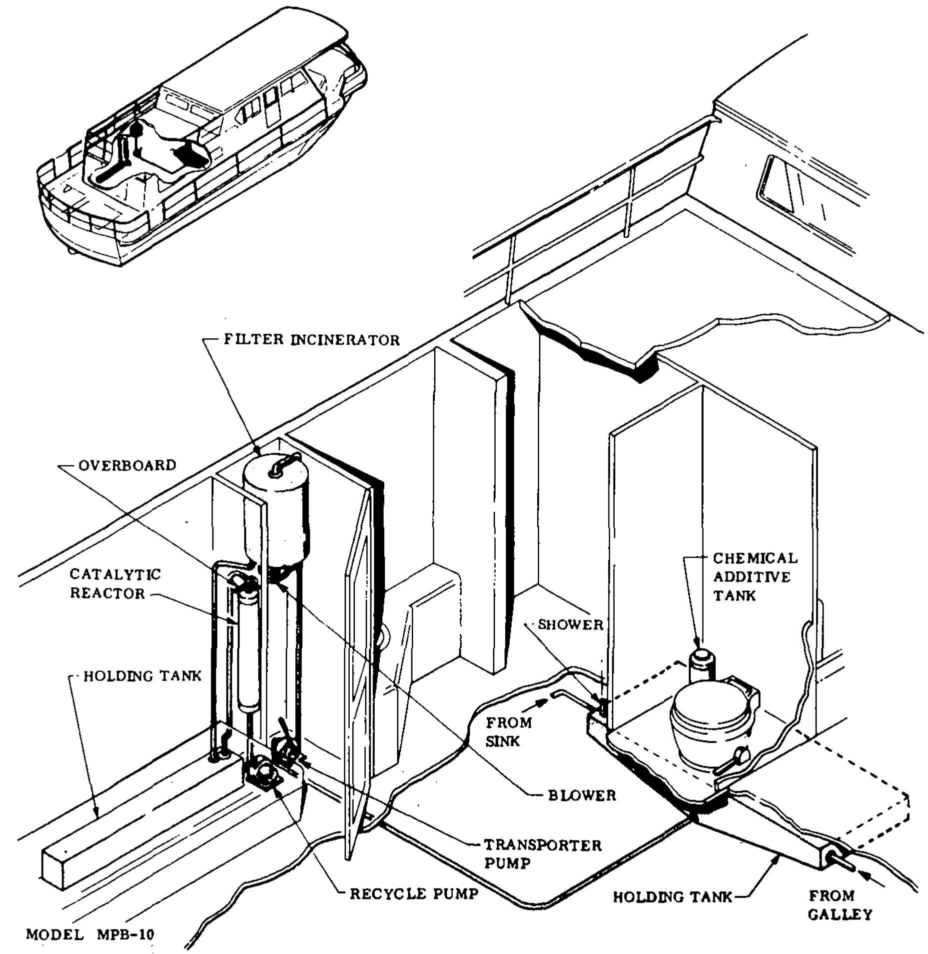
TECHNICAL PERFORMANCE

1. Up to 100% coliform reduction.
2. NSF testing Puritrol Model 3M, 3000 GPD. See page 230.

COMMENTS

ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



THIOKOL MPB-10 CHEMICAL
TOILET SYSTEM

Thiokol / WASATCH DIVISION
A DIVISION OF THIOKOL CHEMICAL CORPORATION

Present houseboat design representative of future land-based units

Filter-incineration, chemical coagulation treats sewage

THIOKOL CHEMICAL CORPORATION
WASATCH DIVISION
P. O. BOX 524
BRIGHAM CITY, UTAH 84302
(801) 863-3511
Attn: Paul D. Nance, Manager
Advanced Pollution Control Systems

THIOKOL MPB-10

CATALYTIC REACTOR, FILTER-INCINERATOR SYSTEM

FEATURES
1. Small houseboat chemical, self-contained, toilet system.
2. Filter incinerator and catalytic reactor process wastes.
3. Overboard discharge.
4. Owner-operated processing.
5. Level indicator with audible alarm sounds when primary tank fills, for operator to process.
6. Models for 1-5 process operations per day.

OPERATION
1. Primary tank fills from wastewaters, alarm sounds.
2. Operator activates pump to move water through filter bed (5 minutes) to secondary holding tank.
3. Operator activates recycle pump to process supernatant through catalytic reactor while solids are incinerated (30 minutes).
4. Treated water is pumped overboard and next process operation can take place in 1 hour.

MODEL NUMBER (MAJOR)	DIMENSIONS DIA[1]	DIA[2]	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)[3]	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)[4]	OTHER[5]	OPERATING SUPPLIES[6]	
MPB-10 (15)	12" 12" 12"	5" 5" 7"	5 to 7'		15 60 60	15	ca $500.		See Costs Below	20	20 80 80	0.36 1.44 1.44	0.36 0.72 0.72	
MPB-10 (30)	12" 17"	7" 9.1"	"		120 100	30			"	"	160 100	2.88 2.40	1.44 1.20	
MPB-10 (50)	17"	9.1"	"		250	50			"	"	250	6.0	3.0	
MPB-10 (100)	24"	13"	"		500	100	ca $1000.		"	"	550	12.0	6.0	

[1] Filter bed diameter.
[2] Catalytic Reactor diameter.
[3] Primary holding tank capacity.
[4] Watt-hours @ 12 V DC.
[5] lb/day Propane gas.
[6] GPD 6% Hypochlorite.

SIZING & GROWTH POTENTIAL
1. Sizing for houseboat design; to be adapted to land-based models.
2. Future land-based models will probably be in the range of 50-2000 GPD.

COSTS
1. Costs are not determined for land-based models under development.
2. More system costs for houseboats available from dealers.
3. Operating costs would include electricity, gas, and hypochlorite.

INSTALLATION REQUIREMENTS
1. Installation by skilled plumber/dealer.
2. No excavation needed, small compartments needed for operations.

OPERATION & MAINTENANCE REQUIREMENTS
1. Daily operation by owner (future ones automated).
2. Service by dealer.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 (R)	SS (R)	DO	COD (R)			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
MPB-10 (15)	99	99		80			32° to 150°F	Minor noise. No odors.		
MPB-10 (30)	"	"		"			"	"		
MPB-10 (50)	"	"		"			"	"		
MPB-10 (100)	"	"		"			"	"		

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year warranty on parts and workmanship.
2. Land-based service facilities under development.

TECHNICAL PERFORMANCE
1. Major reductions in BOD and SS obtained by filter-chemical system for safely discharged effluent.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. This is "representative of the advanced subsystems which can and are being applied to land-based operations."
2. While this is not an aerobic system, it would be designed for individual home use.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Package Treatment Plants

Introduction

This section contains a representative selection of sewage treatment plants in the 500 to 1 million gallon per day (gpd) range. Emphasis is on units ranging from about 2,000 to 50,000 gpd capacity, which corresponds to small clusters of about six homes to subdivisions of about 150 homes. While some of the units classified as package plants may overlap the size range of individual home aerobic treatment units, they are distinct in that they are not intended to be operated by the homeowner. A package treatment plant is considered to be a relatively self-contained unit which is intended for treating sewage from several to several hundred homes. Many of the units described in this section are available in more discrete capacity steps than could be shown on the standardized data sheets. The data sheets indicate a range of capacities, but do not cover all sizes.

Most of the units employ the extended aeration mode of the activated sludge process, though one uses the contact stabilization mode. At lease two manufacturers have designed treatment plants to fit shells of residential homes for unobtrusive operation in the midst of a residential area. One of these, designed for communities of from 200 to 4,000 housing units depends on physical and chemical processes entirely. It also incinerates the sludge. Another manufacturer of a non-biological system is presently concentrating on the shipboard market, but land-based units might be available in the future.

The biological disk variation of trickling filter operation (biological slime cultivated on a disk which rotates through a trough of sewage) is available from several manufacturers and is represented in this section. A more conventional trickling filter system for the 2,000 to 12,000 gpd range is also described. The unit employs a plastic matrix to support the biological slime.

A frequent arrangement for treating sewage in small communities uses lagoons or waste stabilization ponds. Sometimes, lagoons are used to provide further stabilization to the effluent from package plants. Lagoons also provide large evaporative surfaces which reduce the volumes of effluent that would have to be disposed in surface waters or in application directly to the land. Devices which promote aeration of wastes in lagoons are covered in a subsequent section ("Aeration Devices"). Lagoons themselves are custom-designed installations and are not specifically covered in this book.

Cost

Manufacturers have generally been reluctant to quote prices, for competitive reasons. They have been even more reluctant to speculate about installation and operation and maintenance (O&M) costs. Beyond the list prices given in the data sheets, indications of installation and O&M costs should be interpreted as rough estimates only. A study of costs and manpower requirements for package plants is underway at the Iowa State

University.* It is expected that more definitive information will be available from that study in 1973.

On the basis of the list prices which were provided by some manufacturers, the following estimating relation was developed for the 2,000 to 50,000 gpd range:

$$C = 3{,}000 + A \cdot G$$

where C is the suggested list price (dollars);
G is the rated capacity (gpd)
A ranges from \$0.35 to \$1.35 per rated gpd capacity

This means that when the list prices of package treatment plants are plotted against rated daily capacities, the various cost curves lie between two lines which represent costs of: (1) \$3,000 plus \$0.35 per gpd, and (2) \$3,000 plus \$1.35 per gpd. Most of the individual cost curves are linear, i.e., manufacturers tend to scale their prices in direct proportion to the capacities of the units.

An example of the use of this equation is as follows:

plant to 20,000 gpd rated capacity (= G);

$$\begin{aligned}\text{minimum cost} &= \$3{,}000 + \$0.35 \times 20{,}000\\ &\quad \$3{,}000 + \$7{,}000\\ &\quad \$10{,}000;\end{aligned}$$

$$\begin{aligned}\text{maximum cost} &= \$3{,}000 + \$1.35 \times 20{,}000\\ &\quad \$3{,}000 + \$27{,}000\\ &\quad \$30{,}000.\end{aligned}$$

The list price of a 20,000-gpd plant would therefore range between \$10,000 and \$30,000.

Performance: The Imperative of Regular Maintenance

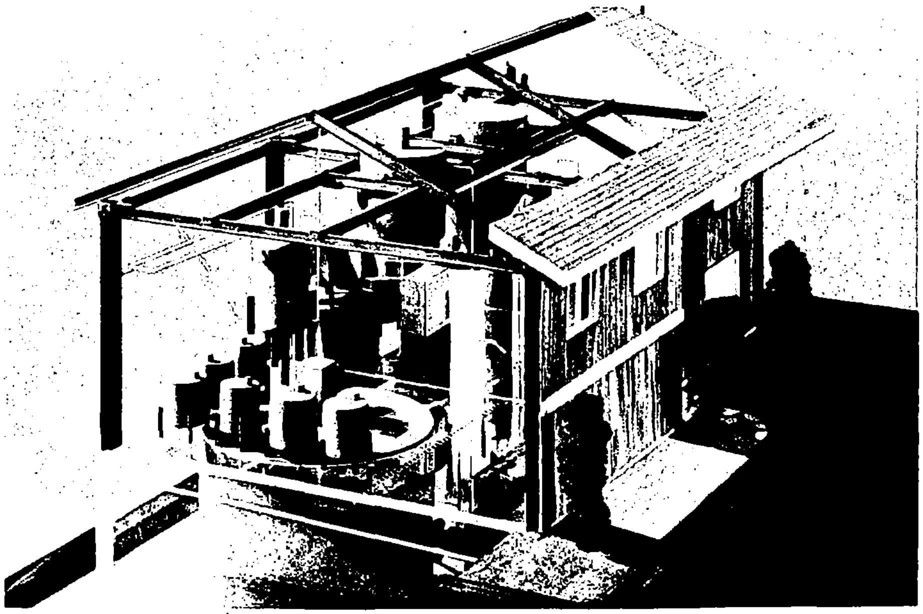
Most manufacturers claim treatment capabilities which are expressed in terms of reductions in biochemical oxygen demand (BOD) of around 90 per cent. Suspended solids (SS) reduction in the same range and chemical oxygen demand (COD) reduction of about 75 per cent are claimed by others. Such claims can be considered valid for properly installed and adjusted plants (in which mature cultures have been established, if the plants are biological). It is not likely that such optimum performance will be maintained without the regular attention of skilled operators. Regular attention includes routine

*By George E. Lamp, Jr., Assistant Professor, Industrial Engineering—Engineering Extension, 110 Marston Hall, Iowa State University of Science and Technology, Ames, Iowa 50010.

inspection, preventive maintenance, and repair or adjustment of equipment which does not operate in accordance with specifications. Regular attention should also include periodic sampling of the effluent to verify the quality of treatment.

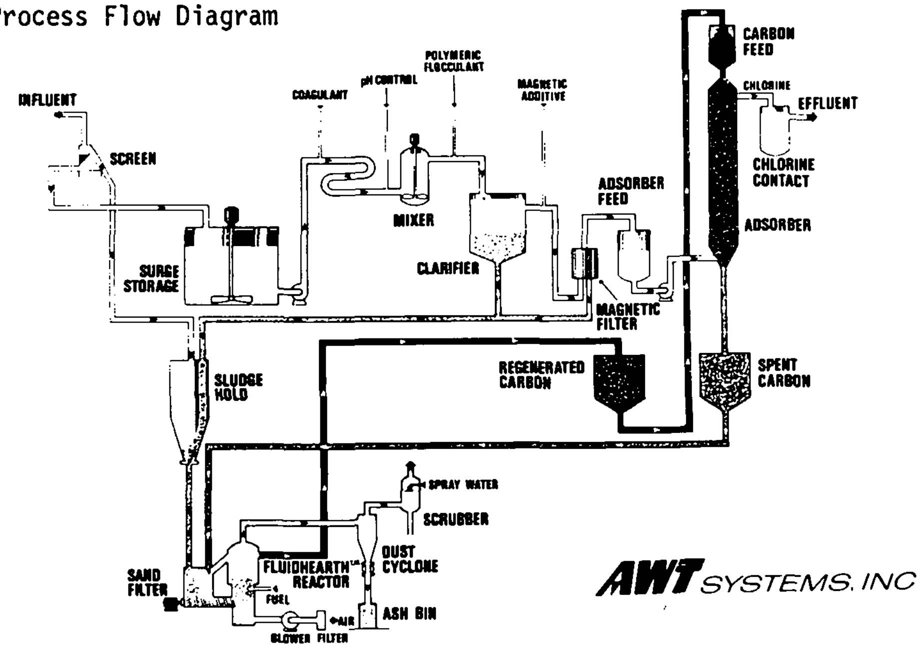
Some manufacturers furnish, along with their catalogue materials, guidance regarding simple visual checks for odor and appearance of the mixed liquor and effluent. Measurement of such other important parameters as dissolved oxygen (DO), SS, BOD, COD, chlorine residual (where chlorination is employed), and microbial concentrations (as often inferred from coliform counts or total viable counts) should be performed on a regular basis as required by state or local health or environmental protection authorities. Such tests are likely to require the services of specialists. The test values should be compared not only with state standards, but against historical data for the installation to ensure that the plant continues to perform properly.

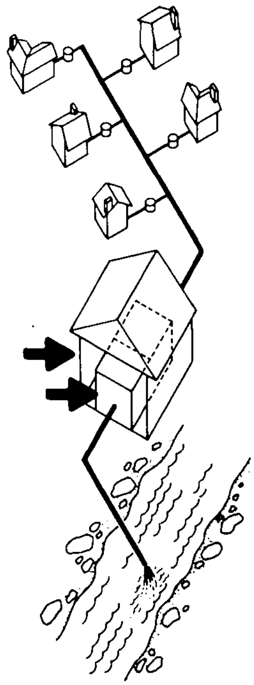
As regards performance, therefore, a manufacturer's claim and certification by a testing laboratory such as the National Sanitation Foundation are important, but provisions for reliable, competent service on a regular schedule throughout the lifetime of the plant are every bit as important as initial certification. *After the first few months or years, the plant will perform no better than the manner in which it is operated and serviced.* If the consulting engineer and the client face this fact at the outset, a lot of money and much trouble can be saved. Unless qualified maintenance can be assured, it would be far better to trade treatment capability for simplicity and reliability.



Cross-Section of Residential Unit with AWT Treatment Plant

Process Flow Diagram





AWT SYSTEMS, INC.
910 MARKET ST.
WILMINGTON, DELAWARE 19899
(302) 654-7588
Attn: Mr. John S. Maxson, Marketing Manager

FLUIDHEARTH™

PHYSICAL-CHEMICAL TREATMENT PLANT

FEATURES

1. Residential house-incorporated treatment plant for communities of 200 to 4,000 units.
2. Handles all types of wastes.
3. Incineration of sludge to 1/10 of volume.
4. Magnetic filter and chemical separation technique with carbon adsorber and disinfection (Cl_2).
5. System components adaptable, removable.
6. Relocatable system can be moved completely and set up in less than two weeks.

OPERATION

1. Process follows pattern of facing flow chart.
2. "Fluidhearth" Reactor takes activated (organic) carbon from incineration and recycles for adsorbtion of organics from treated water for further incineration.
3. Polymeric flocculant reduces process time to as short as 8 hours.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
AWT	(single family, two-story house)				150,000 to 1,000,000			$200,000 to $1.5M	29¢/1000 gal sewage		Required		See O&M Below	

SIZING & GROWTH POTENTIAL

1. Fully adaptable system; can be geared to different types and strengths of wastes or modularly increased to meet process and legal changes.

COSTS

1. Construction costs of about $1.50 per gal. of capacity.
2. Operation costs include materials and labor.

INSTALLATION REQUIREMENTS

1. Installed in two-story house with deep excavation for storage tank, within 100 ft. of adjacent homes.

OPERATION & MAINTENANCE REQUIREMENTS

1. Single employee would serve up to five plants in an area.
2. 98% of problems repaired on the spot, 24 to 48 hours for replacement of parts.
3. Conventionally available supplies: polymers, magnetic additives, etc.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 (R)	SS (R)	DO	COD	OTHER (R)		OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
AWT	95	99			98[1]		Indoor operation	Minor noise. No odors.[2]		

[1] Phosphates. [2] No noxious emissions.

WARRANTIES, GUARANTEES, & SERVICE

1. AWT provides all operation and maintenance in connection with their units.
2. AWT trains client personnel for service, or contractual arrangements can be made for AWT service.

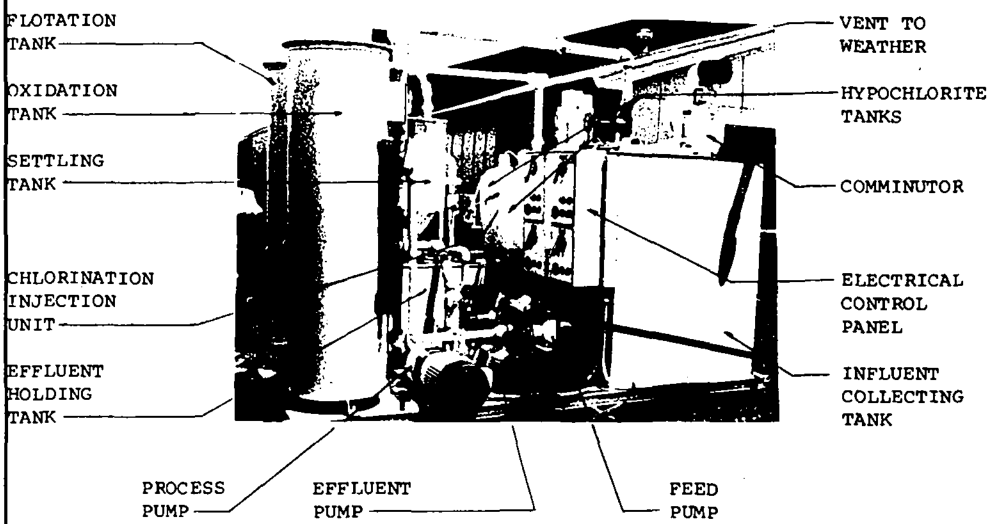
TECHNICAL PERFORMANCE

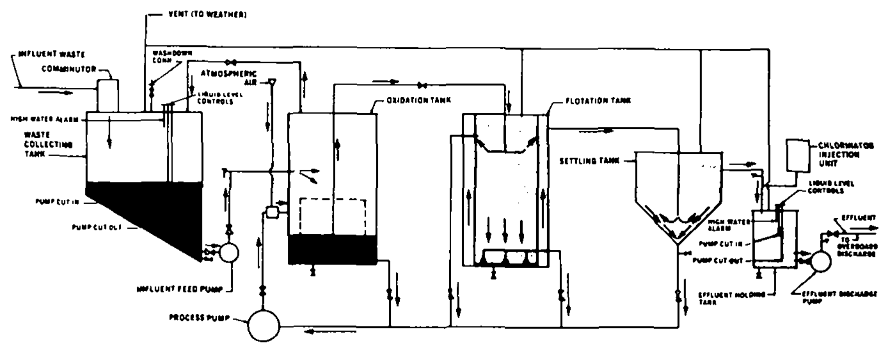
1. Final water meets U. S. Public Health Service potability standard.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. AWT systems effluent can be used for irrigation, recreational lakes, swimming pools, etc.

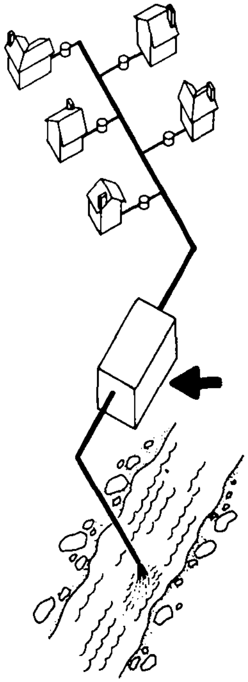
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.





FLOW DIAGRAM

CONTROLLED OXIDATION PACKAGE PLANT



AQUANOX, INC.*
140 SYLVAN AVE.
ENGLEWOOD CLIFFS, NEW JERSEY 07632
(201) 947-2477
Attn: Mr. Elton Nachman, Engineering Sales

AQUANOX

CONTROLLED OXIDATION PACKAGE PLANT

FEATURES

1. "Controlled Oxidation Process" treatment in steel package plant processes sewage in 1-1/2 hours.
2. Influent collecting tank holds 300% of hourly capacity.
3. Non-biological treatment siphons air into wastes at constant rate for balanced treatment.
4. Liquid level controls and high water alarms safeguard system and feed sewage at constant rates.
5. Four models from 500 to 5000 GPD available with chlorination or other tertiary treatment.

OPERATION

1. Comminuted waste from collecting tank is fed at constant rate to oxidation tank.
2. Influent pumped in tangential flow in oxidation tank, solids move to the outside, screened water is removed from center of tank to flotation tank.
3. Solids from oxidation tank and other parts are recycled by process pump through air induction device.
4. Skimmers and sludge returns operate, sewage is clarified, then disinfected in holding tank, then discharged.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	WATER PRESSURE		
400	5'	4'	3'6"	1300	500		$ 7,000.			15-20	110, 220/ 440 V 3 ph	40 PSI[1]	Chlorine	
401	7'	5'	4'	1700	1500		↓		ca 1.75/day	"	"	"	"	
402	8'2"	5'	4'	2300	2500		↓			"	"	"	"	
403	10'6"	5'	7'	4600	5000		$19,500.		ca 3.50/day	"	"	"	"	

[1]At orifice; 1-1/2 to 4 PSI in oxidation tank.

SIZING & GROWTH POTENTIAL

1. Influent holding tank acts as surge storage in order to allow constant flow into treatment tanks.

INSTALLATION REQUIREMENTS

1. Above ground installation; manufacturer oversees installation and start-up.
2. Electrical skills needed for 1-day installation procedures.

COSTS

1. Initial capital investments range from $1.25 to $7.00/gal. sewage treated.
2. Operating costs for 403 are based on 108 Kwh/day @ 3¢/Kwh and 25¢/day for chlorine.

OPERATION & MAINTENANCE REQUIREMENTS

1. Periodic maintenance program, operation is automatic.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO	COD (R)						
All	90-96	90-95		75+			28-120°F (Ambient room)	Minor noise. No odors.	Patents issued, pending	

WARRANTIES, GUARANTEES, & SERVICE

1. *Sale price includes up to 3 days use of technical representa*tive for installation, start-up and training of operational personnel.
2. 1 year guarantee on parts and workmanship, labor charges only.

*NOTE: International Waste Controls, Inc., has recently purchased the assets and patent rights of Aquanox, Inc.

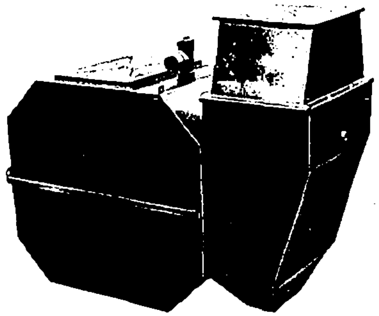
TECHNICAL PERFORMANCE

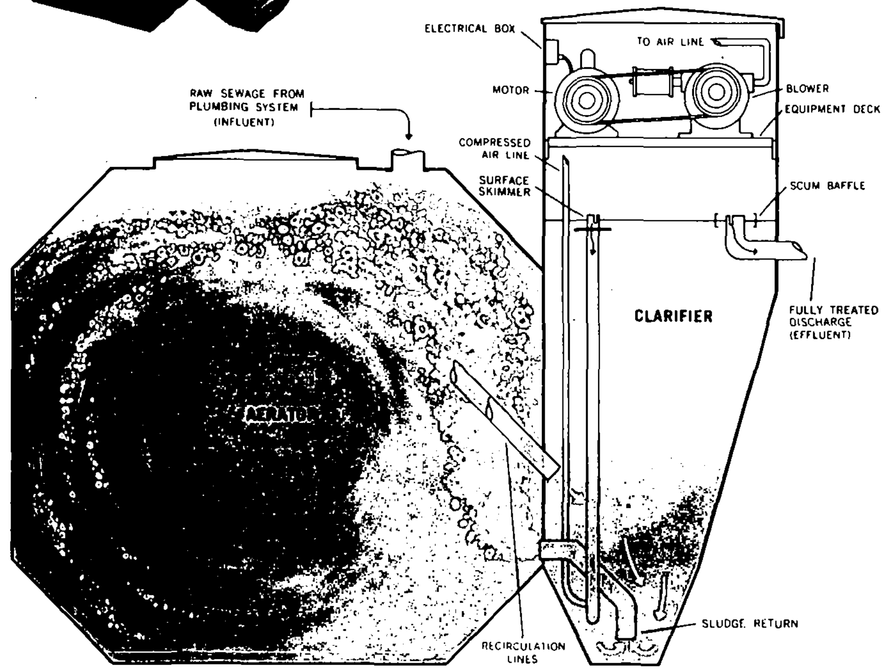
1. *New York University Research project No. 0-5515-4417 tested* from 7/70 to 9/70 found 83.69% average BOD removal and 74.08% SS removal.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Manufacturer uses "unique and exclusive patented Controlled Oxidation Process"...[which is] "non-biological and does not depend on aerobic treatment." Precise details of process remain undefined.
2. *Consult manufacturer* for exact cost ranges.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

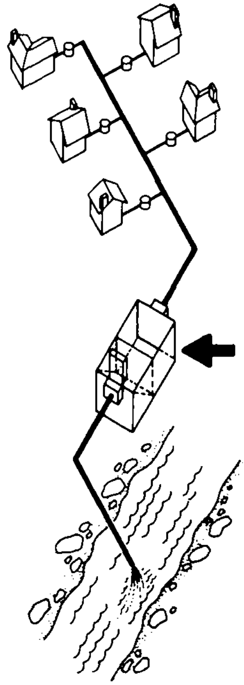




SANI-CELL® PACKAGE PLANTS

BiO2 SYSTEMS inc.

Small, activated sludge treatment plants



BIO2 SYSTEMS, INC.
1049 CENTRAL
KANSAS CITY, MISSOURI 64105
(816) 756-1450
Attn: Mr. D. O. Smart, President

SANI-CELL ®

ACTIVATED SLUDGE
SMALL PACKAGE PLANT

FEATURES
1. Total mix extended aeration, activated sludge process.
2. Designed for 100 GPCD hydraulic loading and 0.25 lb. BOD_5/person/day organic loading.
3. Units except Model 550 (fits in concrete tank) made of 12-gauge sheet steel; sandblasted and covered with coal tar epoxy resin (extra cost).
4. Aeration from oil-less compressed air blower.
5. Skimmer in clarifier chamber.
6. Model 550 has fiberglass clarifier insert.
7. Chlorine contact chamber replaces effluent weir box in units with disinfection.

OPERATION
1. Effluent enters aeration chamber where it is mixed with activated sludge.
2. Aeration supplied to yield 1.25 lb. dissolved O_2 per pound BOD_5 loading.
3. Mixed liquor goes to clarifier where floc settles; scum is skimmed; settled sludge and scum returned to aeration compartment; supernatant flows out over weir.
4. Disinfection is with 5.25% sodium hypochlorite, e.g., "Clorox."

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)[1]	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	FLOOR LOADING FILLED
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	BLOWER		
550	95"	48"	90"		600	780	875[2] + 540[3]		See Costs below		120 V 60 Hz 1 ph	1/3 HP 9 CFM		
600	"	47"	80"	1000 ship'g	"	1600	1375 + 1079[3]		"		"	"		500 lb/ sq. ft.
1200	"	84"	81"	3000 ship'g	1200	1200	2250 + 1202[3]		"		"	3/4 HP 20 CFM		"
2800	138"	95"	104"	5000 ship'g	2800	2800	4120 + 1872[3]		"		115 V 60 Hz 1 ph	1 HP 30 CFM		550 lb/ sq. ft.

[1]Total, including aeration and clarifier tanks. [2]Complete except for concrete tank.
[3]Additional prices include all extras and accessories, e.g., bigger motors, heavier steel, chlorinator, alarms, inlet screen/box.

SIZING & GROWTH POTENTIAL

COSTS
1. Operating costs similar to big self-defrost refrigerator.

INSTALLATION REQUIREMENTS
1. Require leveling; larger units will require foundation, possibly a cement pad; rock-free backfill, preferably sand.
2. Half-fill all compartments with water to prevent shiftings.
3. Bury below freezing level.

OPERATION & MAINTENANCE REQUIREMENTS
1. Routine check for color, odor.
2. After prolonged shutdown, dried deposits on skimmer and in clarifier must be removed.
3. Intermittent load adapter available (optional) to replace moisture lost between loadings (for vacation homes used on weekends, etc.).

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)					OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET
	BOD_5 (R)	SS (R)	DO	COD	TREATS (R)			
550	ca 95	ca 95			*6 people* @ 100 GPD		Odorless when operating properly	NSF: see general comments
600	"	"			"		"	.
1200	80 min 98 max	"			12 people @ 100 GPD		"	
2800	ca 95	"			28 people @ 100 GPD		"	

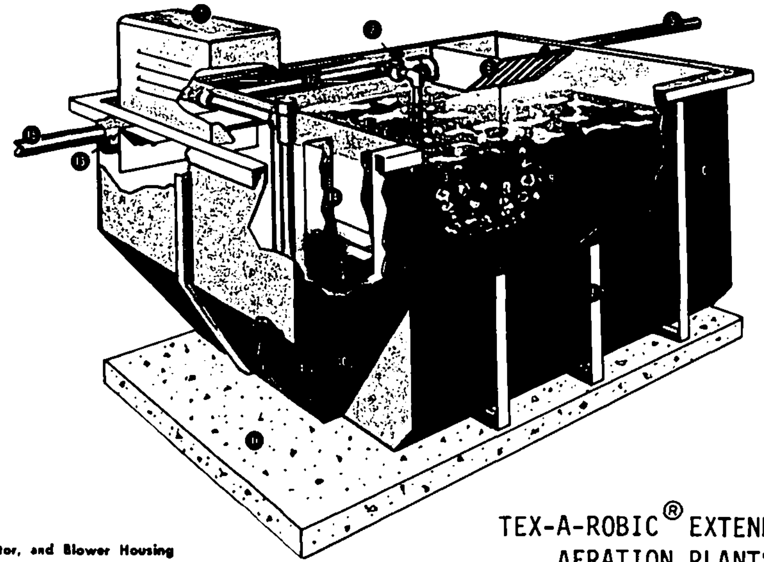
GENERAL COMMENTS
1. *Effluent said to normally contain 20 mg/l* BOD_5 and SS in lab trials and 10 mg/l for both in residential tests after 3 weeks maturing of sludge.
2. Successfully tested one model (Model 600) at National Sanitation Foundation, under criteria for extended aeration package treatment plants, not NSF Standard No. 40.

WARRANTIES, GUARANTEES, & SERVICE
1. 12 month warranty includes nominal maintenance and service.

TECHNICAL PERFORMANCE
1. All units designed for detention times as follows: Aerator, 24 hours; clarifier, 6 hours (9 hours in Model 2800); total, 30 hours (33 hours in Model 2800).
2. Air supplied to provide 1.25 lb. dissolved O_2 per lb. of BOD_5 at full loading.
3. Model 600 received NSF Certificate of Performance in November, 1972.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. *Production facilities have been maintained at the ready but are not now active.*

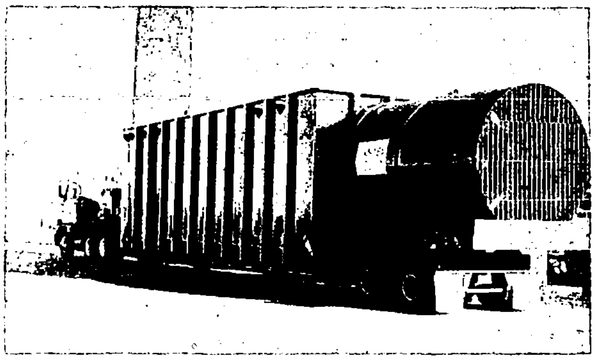
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



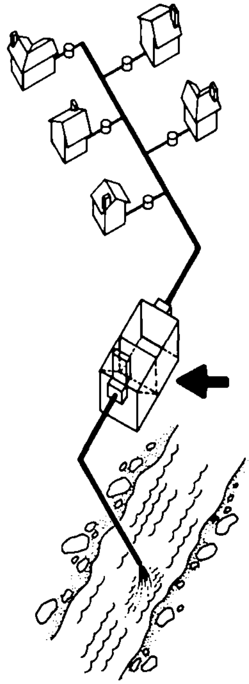
TEX-A-ROBIC® EXTENDED AERATION PLANTS

1 Motor, and Blower Housing
2 Air Supply Pipe
3 Diffuser Pipe
4 Air Lift Pump
5 Influent Pipe
6 Coated Steel Walls
7 Steel Braces
8 Bar Screen
9 Aeration Tank
10 Clarifier
11 Concrete Slab Base (By Contractor)
12 Sludge Return Line
13 Adjustable "V" Notch Weir
14 Inlet Baffle to Clarifier Chamber
15 Effluent Pipe

CAN ★ TEX® INDUSTRIES



UNITS CAN BE SHIPPED VIA TRUCK



CANTEX INDUSTRIES
P. O. BOX 340
MINERAL WELLS, TEXAS 76067
(817) 325-3344
Attn: Mr. Ralph F. Conte, Vice-President, Process Equipment Division

TEX-A-ROBIC®

EXTENDED AERATION PACKAGE PLANTS

FEATURES
1. Pre-fabricated steel, extended aeration plants from 5,000 to 25,000 GPD capacity.
2. Two chambered unit: aeration tank and clarifier.
3. Diffused aeration with air-lift sludge returns and skimmers.
4. Inlet baffle between aeration tank and clarifier.
5. Grate walkway on clarifier, bar screen at inlet, magnesium anode with packaged backfill.

OPERATION
1. Sewage enters aeration chamber through bar screen.
2. Influent is aerated, flows by velocity reducing baffle to clarifier.
3. Solids settle, sludge return operates, settled-activated sludge "air-lifted" to inlet for treatment cycling.
4. Supernatant in clarifier flows past V-notch weir to disinfection or discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	BLOWER HP
50M	13'5"	8'	11"	8700	5,000	5,833	7,250.	Varies		20	115/230 V AC - blower		Chlorine, if used	1
100M	23'8"	8'	"	13600	10,000	11,666	8,500.	"		"	"		"	1.5
150M	29'2"	9'8"	"	17666	15,000	17,500	9,750.	"		"	"		"	2
250M	38'4"	11'11"	"	20500	25,000	29,180	12,250.	"		"	"		"	5

SIZING & GROWTH POTENTIAL
1. Sizing is based on 100 GPCD @ 0.17 lb. BOD per person per day to give 12.5 to 15 lb. BOD/1000 ft.^{3} of aeration tank volume.
2. 36 models available, consult factory about other models.

COSTS
1. List price includes blowers and controls; estimating prices only.
2. Comminutors, chlorinators, stand-by blowers are optional extras.

INSTALLATION REQUIREMENTS
1. Installation involves excavation, concrete pad, welding of two parts for large plants, corrosion protection painting.
2. Plumber/electrician skills required for installation.
3. Can be installed and started up in one day.

OPERATION & MAINTENANCE REQUIREMENTS
1. Daily inspection necessary to insure blowers are operating and transfer lines are free, effluent qualities are satisfactory.
2. Operational skills necessary, requiring training in equipment and process.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 (R)	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET
All	85-90						Normal, temperate[1]	Minor noise. No odors.	NSF and state health agencies

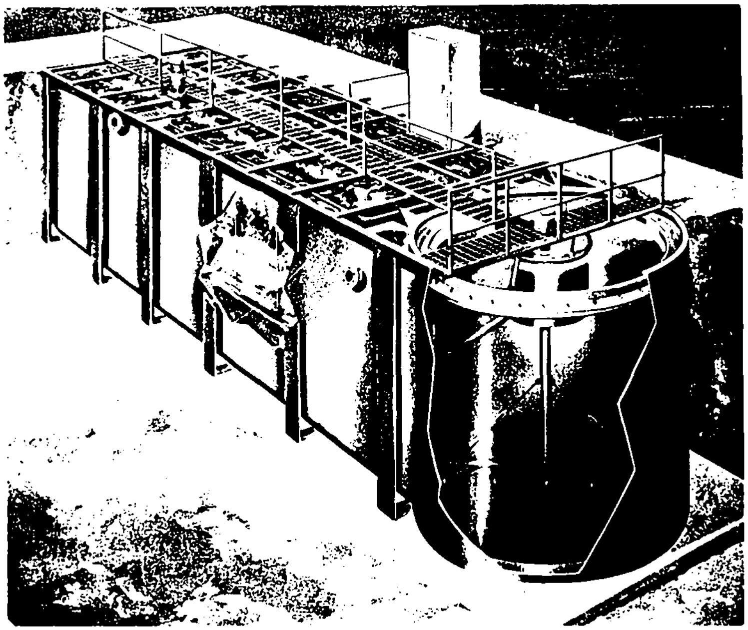
[1] In frigid climates, covers or indoor installations necessary.

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year from date of acceptance or 18 months from date of shipment warranty on parts and workmanship. Repaired or replaced free of charge.
2. Replacement parts and service available from factory. Factory service invoiced at $100/day (labor).
3. Cantex provides start-up serviceman free; operator training available.

TECHNICAL PERFORMANCE
1. All state health agencies have approved Cantex units.

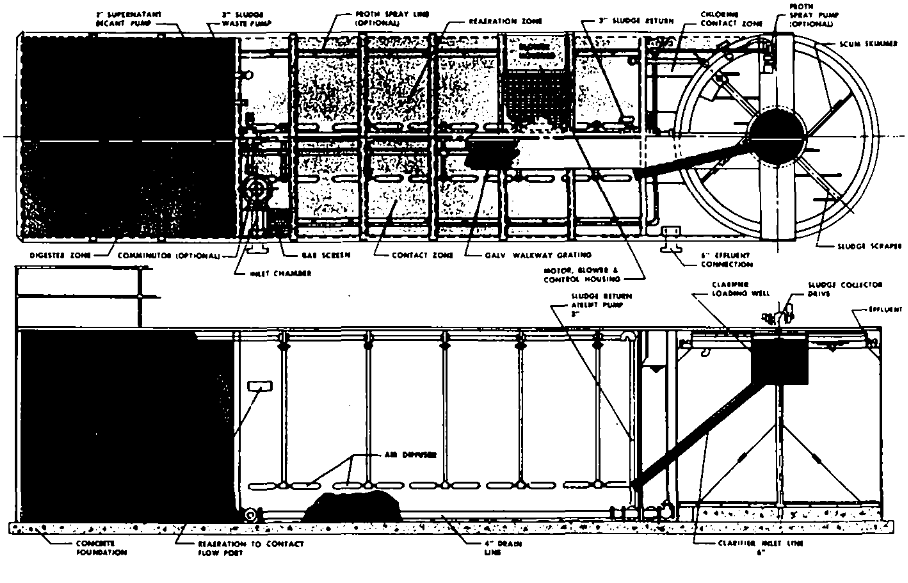
COMMENTS
ACCURATE AS OF July 31, 1972
1. Additional information on costs, technical performance available from manufacturer.

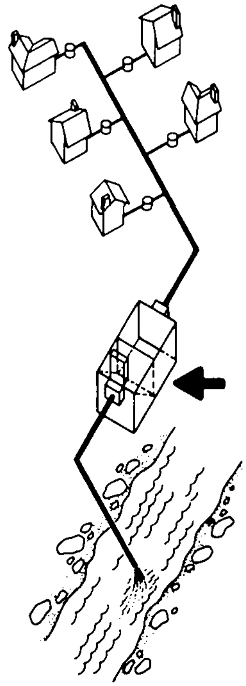
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



TEX-A-ROBIC® CONTACT
STABILIZATION PLANTS

CAN ★ TEX® INDUSTRIES





CANTEX INDUSTRIES
P. O. BOX 340
MINERAL WELLS, TEXAS 76067
(817) 325-3344
Attn: Mr. Ralph F. Conte, Vice-President, Process Equipment Division

TEX-A-ROBIC®

CONTACT STABILIZATION PACKAGE PLANTS

FEATURES
1. Rectangular, pre-fabricated steel contact stabilization package plants from 30,000 to 50,000 GPD capacities with large surge treatment abilities.
2. Five chambered unit: contact zone, reaeration zone, digester zone, chlorine contact zone, and round clarifier with sludge scraper.
3. Diffused aeration with air-lift sludge and activated sludge movements.

OPERATION
1. Sewage flows into inlet chamber through manually cleaned bar screen or optional comminutor.
2. Influent sewage flows into "contact zone" where it is mixed and aerated with activated sludge from "reaeration zone."
3. Mixture flows into "clarifier" for settling of solids, supernatant flows into chlorine contact zone for discharge.
4. Settled sludge is scraped to centered sludge return for aeration in reaeration zone.
5. Excess sludge goes to "digester zone" for collection.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)[1]	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	BLOWER HP
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
300	37'4"	11'3"	10'		30,000	27,288	See Costs Below	Varies		20	115/230 V AC - blower		Chlorine, if used	3
350	42'4"	"	"		35,000	31,465	"	"		"	"		"	"
400	45'4"	"	"		40,000	35,841	"	"		"	"		"	"
500	53'4"	"	"		50,000	43,138	"	"		"	"		"	"

[1]Average capacities; maximum capacities up to 75% more.

SIZING & GROWTH POTENTIAL
1. Sizing is based on 100 GPCD @ 0.17 lb. BOD per person per day to give 30 lb. BOD/1000 ft.^{3} of aeration tank volume.
2. Five rectangular models; circular models available from 20,000 to 1,000,000 GPD capacities.

COSTS
1. Comparable price ranges for round clarifier contact stabilization plants go from $18,000 @ 30,000 GPD to $22,000 @ 50,000 GPD (includes blowers and controls).
2. Aerated sludge holding tanks, froth controls, comminutors, chlorination equipment are optional extras.

INSTALLATION REQUIREMENTS
1. Installation involves excavation, concrete pad, welding of two parts for large plants, corrosion protection painting.
2. Plumber/electrician skills required for installation.
3. Can be installed and started up in one day.

OPERATION & MAINTENANCE REQUIREMENTS
1. Daily inspection necessary to insure blowers are operating and transfer lines are free, effluent qualities are satisfactory.
2. Operational skills necessary, requiring training in equipment and process.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS	DO	COD						
All	85-90						Normal, temperate[2]	Minor noise. No odors.	NSF and state health agencies	

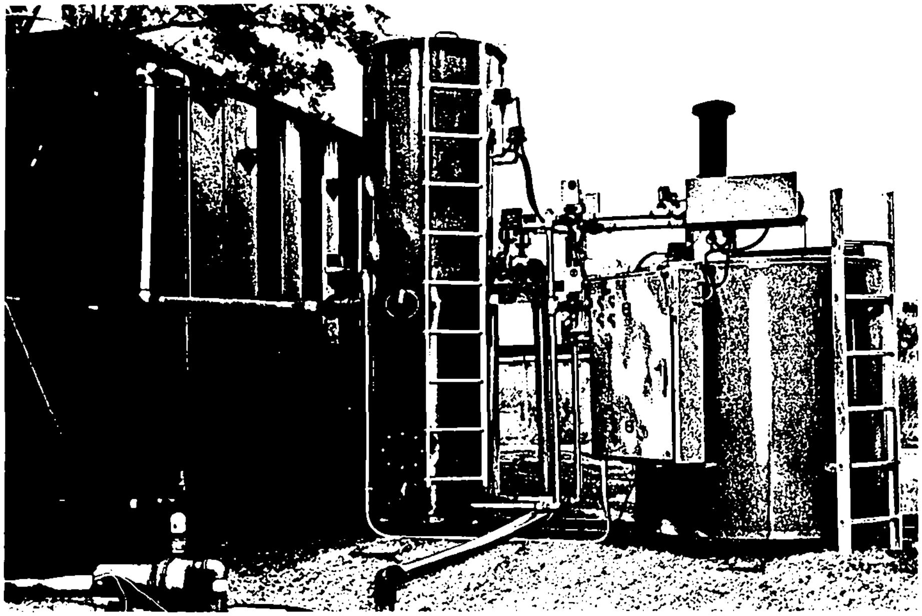
[2]In frigid climates, covers or indoor installations necessary.

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year from date of acceptance or 18 months from date of shipment warranty on parts and workmanship. Repaired or replaced free of charge.
2. Replacement parts and service available from factory. Factory service invoiced at $100/day (labor).
3. Cantex provides start-up serviceman free; operator training available.

TECHNICAL PERFORMANCE
1. All state health agencies have approved Cantex units.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. Additional information on costs, technical performance available from manufacturer.

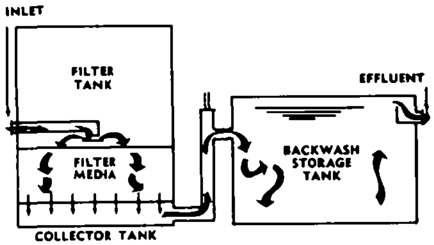
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



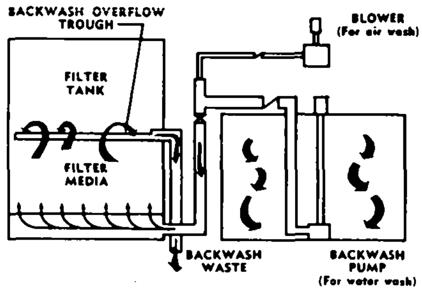
TF-2 TERTIARY FILTER

CAN ★ TEX®
INDUSTRIES

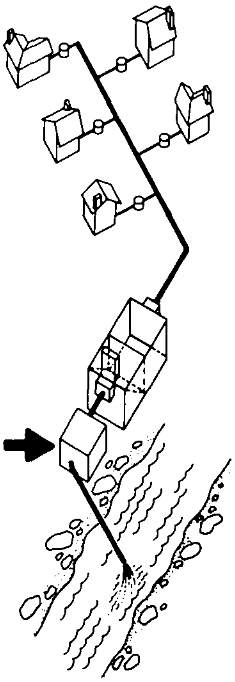
FLOW DIAGRAM



FILTER CYCLE



BACKWASH CYCLE



CANTEX INDUSTRIES
P. O. BOX 340
MINERAL WELLS, TEXAS 76067
(817) 325-3344
Attn: Mr. Ralph F. Conte, Vice-President, Process Equipment Division

TF-2 TERTIARY FILTERS

GRAVITY-TYPE FILTER-BACKWASH SYSTEM

FEATURES

1. Gravity type filter system for removing suspended solids from effluent of an activated sludge treatment plant.
2. Above grade or below grade application.
3. TF2-3 to TF2-12 models, one assembly shipments; dual compartment deep bed media filter and holding tank for backwash.
4. Automatic operation, one to four GPM/sq. ft. of filter surface.
5. Blower and water source necessary.

OPERATION

1. Effluent is filtered through one of two filters until suspended solids build-up requires backwash.
2. Filtering is switched to other filter, saturated filter is backwashed to overflow trough.
3. Backwash includes air wash, to loosen solids, followed by water wash for cleaning.
4. No "dry" filter beds, no interruption of effluent flow.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			

SIZING & GROWTH POTENTIAL

COSTS

INSTALLATION REQUIREMENTS

OPERATION & MAINTENANCE REQUIREMENTS

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year from date of acceptance or 18 months from date of shipment warranty on parts and workmanship. Repaired or replaced free of charge.
2. Replacement parts and service available from factory. Factory service invoiced at $100/day (labor).
3. Cantex provides start-up serviceman free; operator training available.

TECHNICAL PERFORMANCE

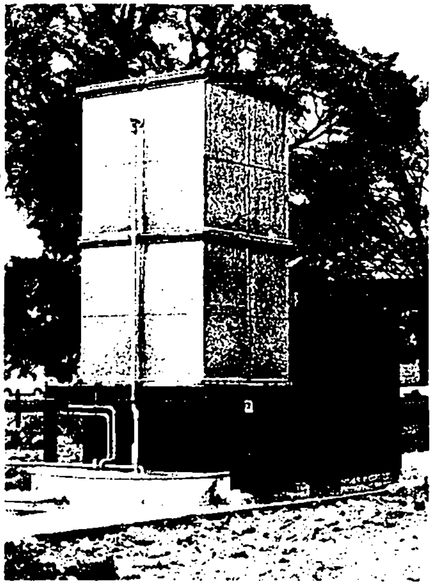
1. Cantex test results: A = Unit Flow Rate Applied (GPM/ft.^{2}); B = Avg. Filter Cycle (hrs.); C = Avg. TSS (ppm); D = Avg. Effluent TSS (ppm).

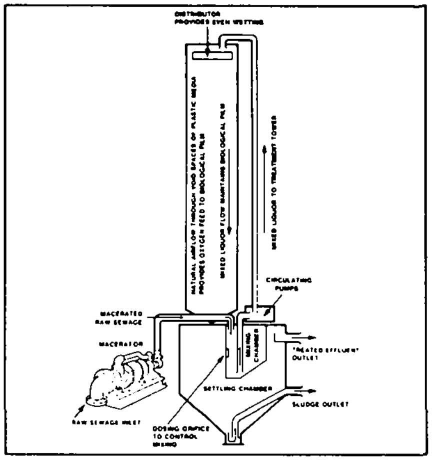
A	B	C	D
1	64	30	5
3	20	28	4.5
5	4.8	16	2

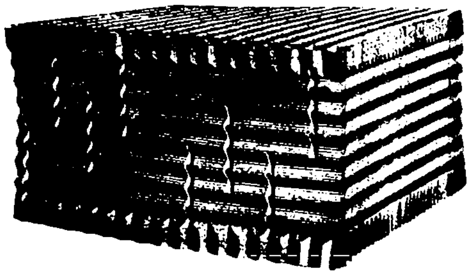
COMMENTS **ACCURATE AS OF** July 31, 1972

1. Additional information on costs, technical performance available from manufacturer.
2. Can be used in conjunction with other package plants.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



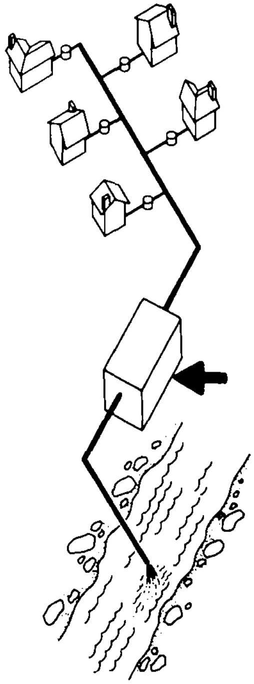




DRAVO MINIPACK

Dravo

Trickling filter treatment unit



DRAVO CORPORATION
WATER & WASTE TREATMENT DEPARTMENT
ONE OLIVER PLAZA
PITTSBURGH, PA. 15222
(412) 391-2600
Attn: Mr. Gil Von Vreckin, Regional Sales Manager

DRAVO MINIPACK

TRICKLING FILTER MEDIA ~~TREATMENT UNIT~~ TREATMENT UNIT

FEATURES

1. Vertical type package plant has plastic media filter for biological film and solids separation.
2. Corrugated plastic media evens distribution and acts as trickling filter.
3. Macerator develops mixed liquor for filter.
4. Pumps circulate sewage from mixing chamber to media.
5. Settling chamber collects sludge and provides outlet for pumping.

OPERATION

1. Sewage is macerated.
2. Mixing chamber sends mixed liquor to pumps to go to distributor in treatment tower.
3. Distributor provides even wetting as sewage trickles down through media, in natural air flow.
4. Treated water settles and supernatant discharges over weir.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)[1]	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
DPM2	5'	3'	11'		1,300		$ 6,325.				115 V AC			
↓														
SPM8	12'	9'	11'		12,000		$16,330.				"			

[1] FOB, New York City.

SIZING & GROWTH POTENTIAL

1. Seven units for 18 to 170 person capacities.
2. Detention time in settling tank is minimum of 4 hours.

COSTS

INSTALLATION REQUIREMENTS

1. Small concrete pad; below ground settling tank excavation needed.
2. Dealer or qualified installer required for macerator and pumps installations, as well as start-up.

OPERATION & MAINTENANCE REQUIREMENTS

1. Solids removed once a week (5-8% solids) or sludge holding tank provided.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 (R)	SS (R)	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
DPM2	90-95	90-95						Pump noise. No odors.		
↓										
DPM8	"	"						"		

WARRANTIES, GUARANTEES, & SERVICE

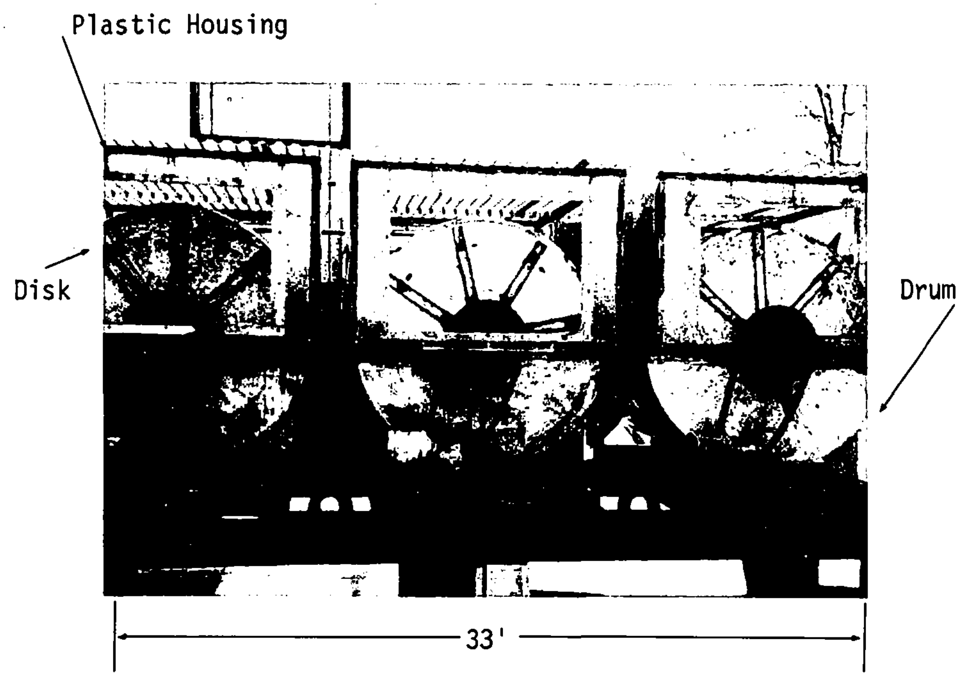
TECHNICAL PERFORMANCE

1. Loadings over 40 lb BOD/1000 cu. ft. per day applied without blocking or ponding.
2. Hydraulic loadings of 400 gal/sq.ft./day.

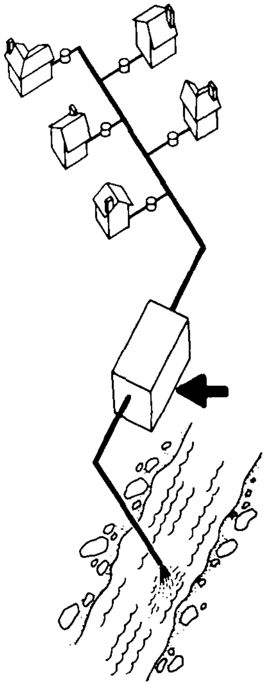
COMMENTS **ACCURATE AS OF** July 31, 1972

1. Dravo is licensed in the U. S. A. by Mono Pumps, Ltd., for manufacture and sale of Minipacks.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



THREE STAGE ROTATING BIOLOGICAL
SURFACE (DISKS) UNIT



ENVIRONMENTAL POLLUTION CONTROL DIVISION
GEO. A. HORMEL & CO.
P. O. BOX 800
AUSTIN, MINNESOTA 55912
(507) 437-5766
Attn: Mr. Robert Joost, Division Manager

3-STAGE RBS

ROTATING BIOLOGICAL SURFACE (DISKS) PACKAGE PLANT

FEATURES

1. Three stage disc-type aerobic package plant; primary, RBS, clarifier, and chlorine contact treatment.
2. Three sets of 11' diameter polystyrene discs rotate in half-drum containers of flowing sewage, carrying slime through air and sewage for aerobic treatment.
3. Primary treatment required prior to RBS.
4. Takes high shock loads.
5. Sludge scraper in clarifier pumps sludge back to primary tank; chain-gear motors turn discs.

OPERATION

1. Sewage is treated in primary state (comminution, septic tank, etc.).
2. Sewage flows over weirs to RBS section.
3. Influent flows through cylindrical troughs while discs rotating in sewage, carrying bacteria, are alternately exposed to sewage and air.
4. Biological growths on discs treat sewage (similar to trickling filter except that sewage is relatively motionless and slime is in motion).
5. Effluent flows into clarifier, sludge settles, and is returned to primary tank; supernatant disinfected, then discharged.

MODEL NUMBER (MAJOR)	DIMENSIONS [1]			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.) [2]	UTILITY REQUIREMENTS		OPERATING SUPPLIES	PLANT HP
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
RBS 10,000	7'4"	12'3"	11'10"		10,000		See Costs Below	See Install Below	See Costs Below	Discs and tanks - 20	115 V AC or as available		Sodium Hypo-chlorite	1
RBS 25,000	14'3"	"	"		25,000		"	"	"	"	"		"	1
RBS 35,000	18'8"	"	"		35,000		"	"	"	"	"		"	$1\frac{1}{2}$
RBS 50,000	25'7"	"	"		50,000		"	"	"	"	"		"	$1\frac{1}{2}$

[1] One barrel size; includes discs, clarifier, chlorine contact zone. [2] Mechanical equipment: 5 years.

SIZING & GROWTH POTENTIAL

1. 9 sizes in 5,000 GPD intervals available from 10-50,000 GPD; larger models negotiable.
2. 1 disc per 500 gal. sewage.

COSTS

1. FOB factory costs, less primary treatment, run from 40 - 60¢/GPD capacity.
2. Disc power requirements are about .005 HP/disc.
3. Chlorine costs for 30,000 GPD @ 1 ppm run about 50¢/day.

INSTALLATION REQUIREMENTS

1. Packaged plant has adjustable jack legs; requires crane installation.
2. Two man-days hook-up time; factory supervision, electrical/plumbing skills required.

OPERATION & MAINTENANCE REQUIREMENTS

1. Automatic operation; field service for start-up.
2. About 1 hour per week operational requirements; occasional pumping out of sludge.
3. Enclosure needed for outdoor operation (i.e., corrugated plastic tent shown); manufacturer will provide.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO (A)	COD (R)						
All	90+	88	1.5 ppm	85				Minor noise. No odors.	Patented; ten states	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year guarantee on parts and workmanship (does not include labor).
2. 2 year guarantee on discs.
3. Field service by company representative for four days during start-up, includes installation supervision, operation timing.
4. Factory service arrangements possible.

TECHNICAL PERFORMANCE

1. U. S. Patent No.: 3,630,366.
2. Has been operated at NSF, 1972.
3. Dr. Borchardt, University of Michigan, has evaluated system operation and performance.
4. Surface loading rate: 800 GPD/sq. ft.

COMMENTS ACCURATE AS OF July 31, 1972

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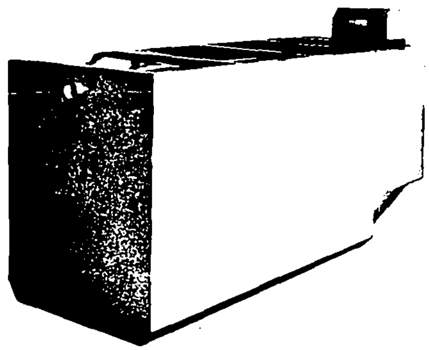
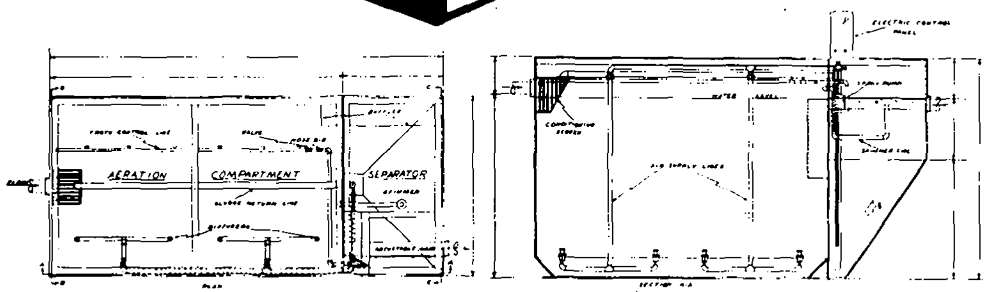
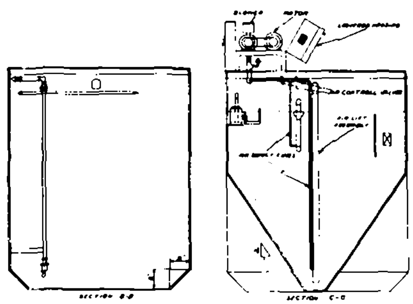


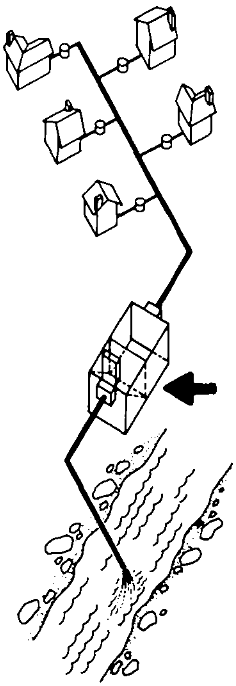




EXTENDED AERATION CO.

EXTEND-AIRE PACKAGE PLANTS

Diffused air package plants



EXTENDED AERATION CO.
P. O. BOX 822
HUNTINGTON, W. VA. 25712
(304) 429-1338
Attn: Mr. Sawyers

EXTEND-AIRE

DIFFUSED AIR EXTENDED AERATION PACKAGE PLANT

FEATURES

1. Prefabricated steel sewage plants in sizes from 500 GPD to 30,000 GPD capacity.
2. Froth control system for high detergent problems.
3. Diffused aeration with pre-screening and air lift sludge return and skimmer; inclined bar screen for initial screening.
4. Control panel for timed aeration periods with warning device.
5. Painted with chemical moisture-resistant paint for corrosion resistence; two magnesium anodes.

OPERATION

1. Sewage enters aeration chamber through conditioning screen, large solids separated.
2. Aeration with diffusers takes place periodically in first aeration compartment (24 hours).
3. Treated liquid enters separation chamber for 4 hour settling period, solids settle, air lift sludge return operates and skimmer removes scum.
4. Treated wastewater leaves over weir to discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)[1]	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
S-5	8'	4'	5'9"		500	790	2950.				110/230 V AC 1 ph		Chlorine	
M-20	12'	6'	7'9"		2000	2,500	4050.				"		"	
M-150	30'	10'	10'6"		15000	18,150	9493.				"		"	

[1]Sent prepaid and freight billed.

SIZING & GROWTH POTENTIAL

1. Larger than 15,000 GPD demands available through factory inquiry (up to 30,000 GPD).
2. Timing of aeration, flow control can accommodate larger capacities.

COSTS

1. Tertiary treatment and extra plant equipment available at additional price.
2. Entire plant salvagable.

INSTALLATION REQUIREMENTS

1. Excavation necessary, but installation can take less than one day.
2. Concrete slab necessary; leveling.

OPERATION & MAINTENANCE REQUIREMENTS

1. Dealer operation and maintenance.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	BLOWER HP
	BOD_5 (R)[2]	SS (R)[2]	DO	COD						
S-5	90	90						Minor noise. No odor.[3]		1
M-20	"	"						"		1 1/2
M-150	"	"						"		3

[2]Estimated.

[3]No odors if properly installed and operated.

WARRANTIES, GUARANTEES, & SERVICE

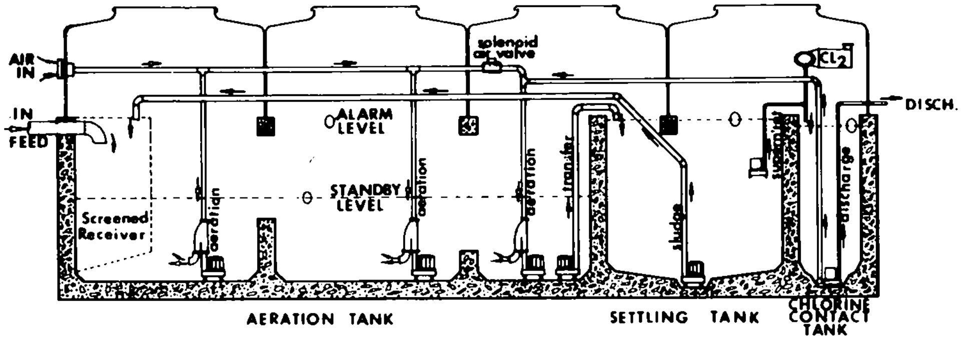
1. 1 year warranty on parts and materials.
2. Factory service, start-up, periodic inspections for one year in base price.

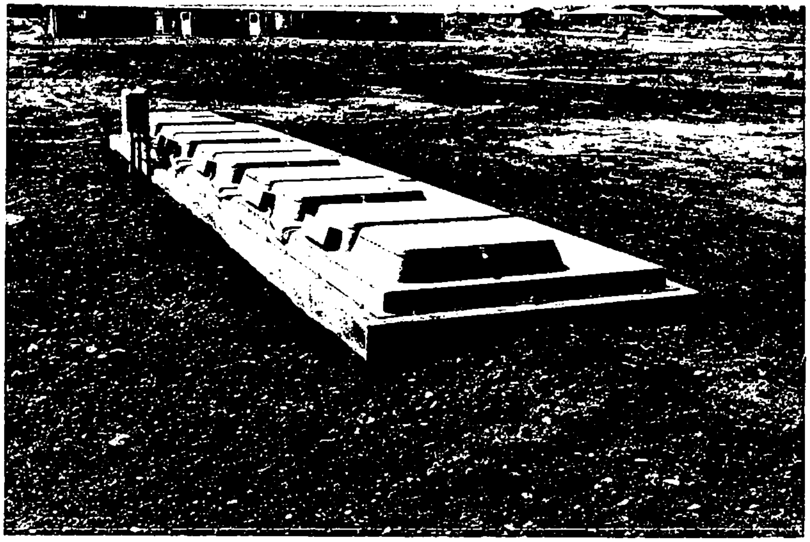
TECHNICAL PERFORMANCE

COMMENTS

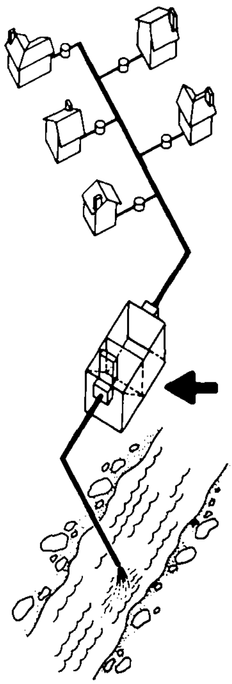
ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.





BATCH-TREAT PACKAGE PLANTS



GAEA CORPORATION (PRON "JEE-UH")
P. O. BOX 346
TUALATIN, OREGON 97062
(503) 638-7535
Attn: Mr. Thomas A. Myers, Vice-President, Marketing

BATCH-TREAT

MODULAR EXTENDED AERATION PACKAGE PLANTS

FEATURES

1. Modular system permits expansion as needed, reducing requirements for initial capital.
2. Tanks normally poured in place by dealer.
3. "Batch-Counter," furnished with each system, gives absolute count of load to help forecast need for additional modules.
4. Mixing and aeration by single phase electric submersible pumps. Air injection by jet action.
5. Fiberglass reinforced plastic covers for tanks.
6. Chlorinator provides disinfection.

OPERATION

1. Influent enters a reservoir which is separated by a screen from mixed liquor in aeration tank; sludge from clarifier #1 returned to screened reservoir every 90 minutes.
2. Aeration tank mixed liquor has 7000-8000 ppm suspended solids (MLSS); receives sludge from clarifier #2 every 90 minutes.
3. Mixed liquor batch-pumped to clarifier #1 after reaching set level. Clarifier #1 only filled when there is enough liquid in aerator. Aeration rate reduced when clarifier #1 is totally empty.
4. One-third of clarifier #1 contents pumped to clarifier #2 each 1-hr. cycle. Chlorination in clarifier #2. Clarifier #2 discharged under pump pressure each cycle.

MODEL NUMBER (MAJOR)[1]	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST[2]	TOTAL COST[2]		ELECTRICITY (RATING)			
G2	16'8"	8'4"	8'4"		5,000	4,600	5,725.	1,485.	7,300.		115 V 60 Hz		Chlorine	
G3	24'8"	"	"		8,000	7,140	7,150.	2,495.	9,750.		"		"	
G4	32'8"	"	"		11,500	9,721	8,825.	3,395.	12,500.		"		"	
G5	40'8"	"	"		15,000	12,364	10,500.	4,185.	15,000.		"		"	

[1]Model number refers to number of modules in system. [2]Estimate; see Costs below.

SIZING & GROWTH POTENTIAL

1. Modular, easily expandable; capacity breakpoints are 2500 to 50,000 GPD.

COSTS

1. Estimated total cost includes installation, tank and all components necessary to furnish a COMPLETE system. Nothing extra unless so quoted.

INSTALLATION REQUIREMENTS

1. By dealer or authorized contractor. Installed in and on poured-in-place concrete tanks per custom specifications; electrical work.

OPERATION & MAINTENANCE REQUIREMENTS

1. Bi-weekly inspection; periodic replacement of mechanical components; refill with chlorine; maintenance accomplished with hose, pipe wrench and screwdriver.
2. Maintenance requires minimum training and good mechanical aptitude.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO	COD						
All	85-95	85-95						Extremely quiet.[3] No odors.		

[3]Pumps submerged.

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year repair or replacement of defective parts, FOB shipping point of parts.
2. Dealers, located in most states, are required by the terms of their contract with GAEA to provide service and to stock spare parts for every GAEA installation.

TECHNICAL PERFORMANCE

1. Detention times can be increased by adding tanks. Gaseous chlorinators and ultraviolet disinfectors are being developed. Sludge removal once or twice per year; sludge volume about 10% of rated capacity.
2. Effluent BOD and SS expected to be less than 20 ppm. Designed for BOD loading of 30-45 lbs. per 1000 cubic feet of influent (about 0.25 lbs. BOD per 50 gal). Batch treatment minimizes effect of shock loads.

COMMENTS

ACCURATE AS OF July 31, 1972

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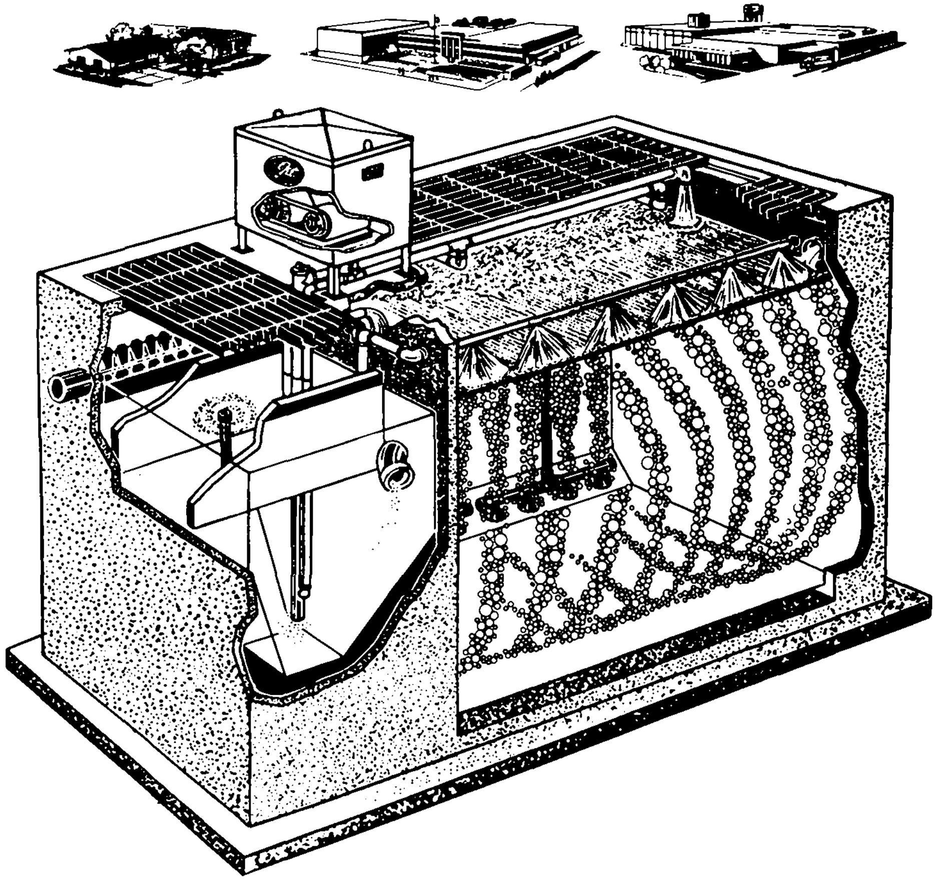
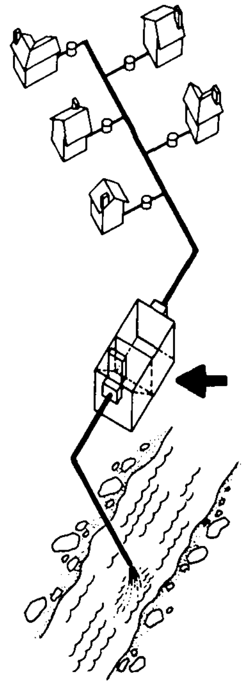


JET® PACKAGE PLANT

Diffused aeration concrete plants



JET AERATION CO.
750 ALPHA DRIVE
CLEVELAND, OHIO 44143
(216) 461-3100
Attn: Mr. William F. Neal, Sales Manager

JET® PACKAGE PLANT

AEROBIC PACKAGE TREATMENT PLANT

FEATURES
1. 36 sizes of concrete tank extended aeration process package plants from 1500 to 50,000 GPD capacity.
2. Air lift sludge returns; surface skimmer.
3. "Air-Seal" diffusers operate in aeration tank along with recirculated sprayed supernatant.
4. Adjustable effluent weir and control panel.
5. 1 to 5 HP blowers available (up to 160 CFM).

OPERATION
1. Pretreatment, such as grinders, screen, etc., brings in only treatable materials.
2. First, aeration and recycled spraying of influent wastes occur in aeration chamber.
3. Treated wastewater flows into settling tank, solids settle, sludge returned to aeration chamber, skimmer removes scum.
4. Effluent travels over adjustable weir to discharge or tertiary treatment.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
1,500	154"	82"	98"		1,500	1,900 total	1.00/gal capacity	Extra - Varies		20	115 V AC[1]		Chlorine[2]	
↓														
50,000	422"	311"	158'		50,000	64,107 total	0.50/gal capacity	"		"	"		"	

[1]Optional 230 V, 3 phase, or 460 V, 3 phase. [2]If chlorinator added.

SIZING & GROWTH POTENTIAL
1. 36 sizes of plants for 1500 to 50,000 GPD demand, can be increased by adding modules.
2. Sizing based on 24 hour detention time.

COSTS
1. Chlorination, comminution, etc., optional extra.
2. Service contracts run from $200 to $600 per year.
3. Electrical consumptions range from $14.50 to $53.00 per month.

INSTALLATION REQUIREMENTS
1. Electrician skills needed for laying power lines.
2. 6" to 8" concrete pads needed with excavations.
3. Gravel base and leveling required.

OPERATION & MAINTENANCE REQUIREMENTS
1. Daily service during start-up.
2. Jet personnel train distributors in maintenance; average intelligence and mechanical ability required.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO	COD						
1,500	90+	90+					0° F and up	Minor noise.[4] No odors.	Ten states certify.	
2,500	88[3]	85[3]							NSF certifies. Ten states certify.	
50,000	90+	90+					"	"	Ten states certify.	

[3]As tested by NSF. [4]Silencers for motors available.

WARRANTIES, GUARANTEES, & SERVICE
1. Single source, full year warranty, included in base price.
2. Locally licensed distributors manufacture tanks, install equipment and service facility.
3. Service policy for one year in base price: 10 start-up calls plus additional as necessary.
4. Owner training of service, or extended contracts available.

TECHNICAL PERFORMANCE
1. NSF Certificate of Performance was issued in November, 1970, for the JCP-25 (2500 GPD) model.

COMMENTS

ACCURATE AS OF July 31, 1972

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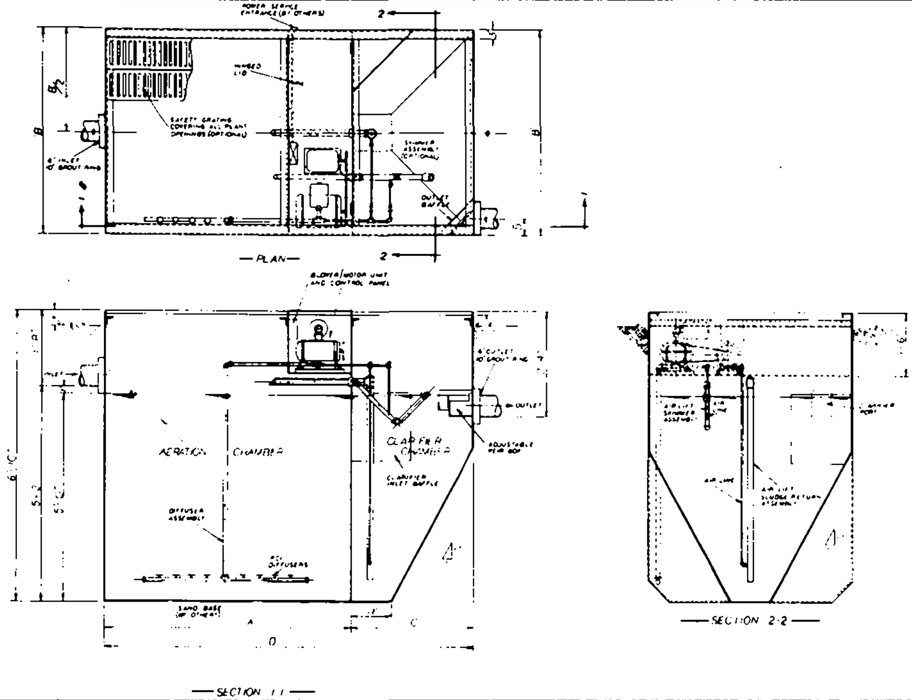
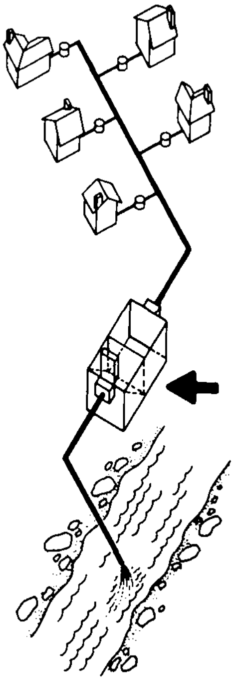


ACTIVATOR PACKAGE PLANTS

Diffused aeration, steel plants



POLLUTION CONTROL, INC.
N-WING, LUNKEN AIRPORT ADMINISTRATION BLDG.
CINCINNATI, OHIO 45226
(513) 871-2754
Attn: Mr. Fred Tipton, Vice-President

ACTIVATOR

DIFFUSED AIR PACKAGE PLANTS

FEATURES
1. Extended aeration steel package plants from 500 to 100,000 GPD capacity.
2. 1 to 20 HP Roots blower used for aeration.
3. Sludge air-lift returns, skimmers, froth control, and chlorination provided.

OPERATION
1. Sewage enters aeration chamber through submerged bar screen.
2. Influent is aerated, froth controlled, flows into clarifying chamber, solids settle, sludge returned to aeration.
3. Effluent passes through Cl_2 contact chamber to discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)[1]	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)		OPERATING SUPPLIES	
S-10	20'9"	10'	11'		10,000	10,000	9,096.	Varies		ca 20	120 V AC		Chlorine	
↓														
↓														
S-100	72"	24'	"		100,000	100,000	40,932.	"		"	240 V AC		"	

[1]Aeration tank volume only.

SIZING & GROWTH POTENTIAL
1. Modular sizing allows for increasing aeration tank capacities or adding adjacent tanks.
2. Aeration and flow controls help sizing.

COSTS
1. List prices include: basic plant, comminutor, bar screen, second blower unit, chlorine contact tank, chlorinator and housing.

INSTALLATION REQUIREMENTS
1. Concrete pad and excavation.
2. Installation by dealer/professionals; PCI directed installation owner-supplied labor.

OPERATION & MAINTENANCE REQUIREMENTS
1. Regular inspection required involves blower service, chlorination tests, etc.
2. Qualified person required for operation.
3. Occasional pumping out of sludge required.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5 (R)	SS (R)	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
All	ca 90	ca 90					Normal Temperate		FHA; one model - NSF	

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year on workmanship and material.
2. All labor paid for by owner.
3. PCI supervises start-up.
4. Service policies available.

TECHNICAL PERFORMANCE
1. NSF issued a Certificate of Performance in November, 1968, for Activator Model S-6, 6000 GPD capacity.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. Larger contact stabilization and tertiary treatment plant models available up to 200,000 GPD.

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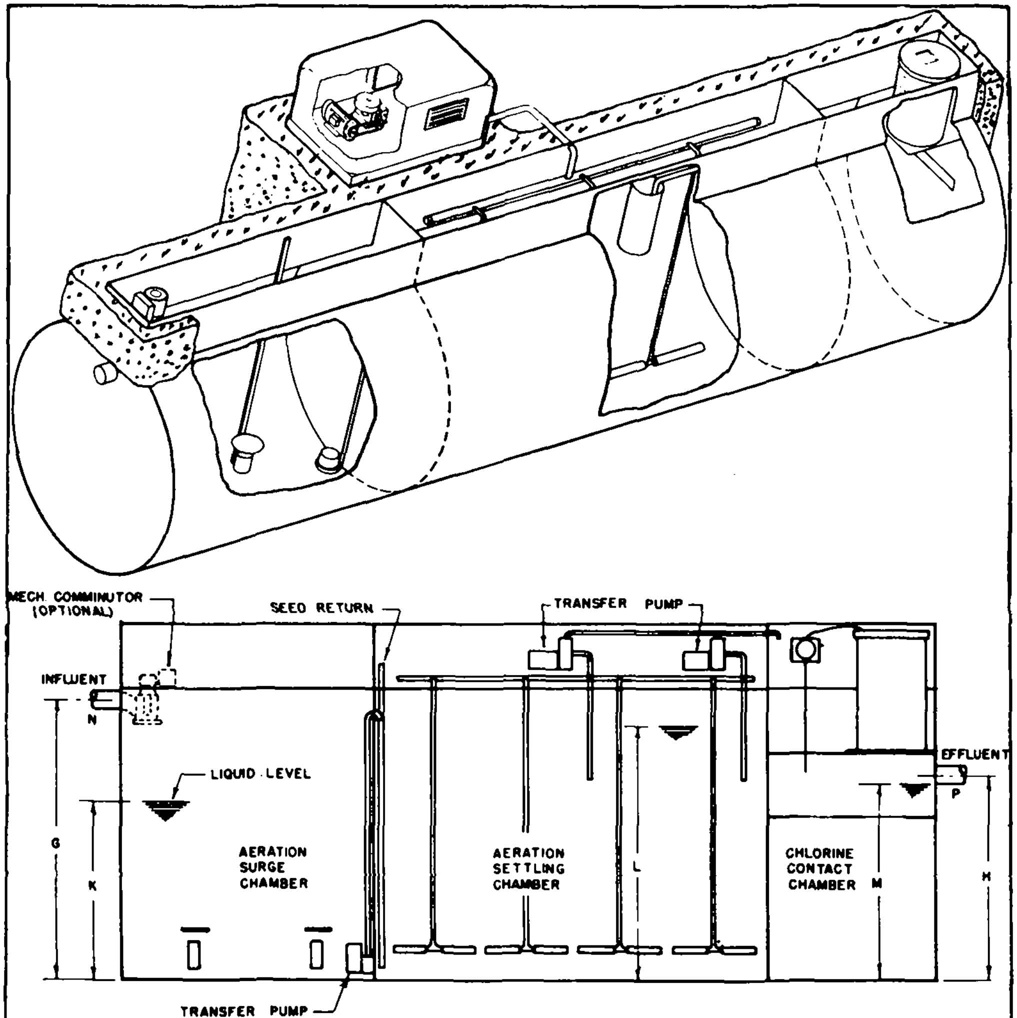
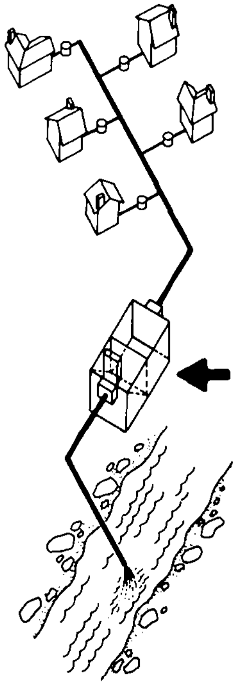


PURITROL™ BATCH PROCESS PLANTS

pollutrol technology inc.

16 hour and 8 hour runoff steel package plants



POLLUTROL TECHNOLOGY, INC.
THOMPSON'S POINT INDUSTRIAL PARK
P. O. BOX 3727
PORTLAND, MAINE 04104
(207) 773-3878
Attn: Mr. Paul Fleming, Sales Manager

PURITROL ACTIVATOR™

BATCH PROCESS PACKAGE PLANT

FEATURES

1. Batch process, extended aeration, activated sludge treatment in a cylindrical steel package plant for capacities of 1000-25,000 GPD.
2. Subsurface discharge or chlorinated surface discharge.
3. 16 hour or 8 hour runoff capacities (2 sizes of surge holding chambers).
4. 20% of daily flow batch movements.
5. Interior: anti-corrosion coated; exterior: waterproofed with bitumastic-50.
6. Blowers in adjacent equipment box deliver 19-100 CFM.
7. Transfer pumps submersible, provide batch movements.
8. Level sensors, alarm system, cam-operated batch control.

OPERATION

1. Sewage enters first chamber (surge) and is aerated.
2. Transfer pump, operated by batch control, moves 20% of daily flow (timing depends on run-off) to aeration-settling chamber.
3. Diffused aeration takes place in second chamber for pre-set time (average 24 hours total detention).
4. Aeration stops, settling of solids occurs, second transfer pump moves top 20% of liquid (5 times a day) into chlorination contact chamber (average 6 hour detention, volume - 25% of daily flow), then gravity flow discharge or effluent pumping.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.) 1	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST 2	DESIGN LIFETIME (YRS.) 3	UTILITY REQUIREMENTS: ELECTRICITY (RATING)		OPERATING SUPPLIES 4	
1,500	18'	6'	7'10"	3250	1500	2238	4,300.	Varies	100/yr.	All- 5 yr. avg.	220 V AC single ph 60 Hz		0.12	
5,000	15'7"	10'6"	12'4"	8300	5000	7540	9,650.	"	150/yr.	"	"		0.40	
10,000	38'	10'6"	12'4"	19300	10000	14170	16,450.	"	300/yr.	"	"		0.80	
25,000	59'2"	12'	13'10"	40000	25000	37600+	33,950.	"	900/yr.	"	"		2.00	

NOTE: ALL FIGURES ARE FOR 16 HR. RUNOFF SYSTEM, SLIGHTLY LARGER FOR 8 HR. RUNOFF. [1]Volume does not include Cl_2 tank. [2]Electric only; approximate cost for 16 hr. runoff (1.5-15 HP). [3]Tank life: 20-40. [4]Gal/day 12-1/2% Sodium Hypochloride @ 8-10 ppm.

SIZING & GROWTH POTENTIAL

1. Systems have 2 "runoff period" designs. The 8 hour system for daytime use (e.g., schools) has larger inlet/surge capacity for concentrated use. The 16 hour system accommodates normal residential use.

COSTS

1. Optional extras include: inlet comminutor, $1500; effluent pumps, 16' TDH $400, 40' TDH $750; gas chlorine system, $1000 - regular, $1700 - automatic changeover (walk-in building needed at extra cost for chlorination).
2. Also available: froth control systems, above ground cradle, holding tanks, concrete tanks, effluent polishing.

INSTALLATION REQUIREMENTS

1. Concrete pads for 1500-25,000 GPD recommended, sizes range from 7' x 19' x 6" to 13' x 60' x 10" (or gravel fill if no pad is built).
2. Licensed plumber and excavating contractor required (leveling).
3. 1' x 2' hatchway exposed above ground plus control box.

OPERATION & MAINTENANCE REQUIREMENTS

1. Licensed sewage treatment plant operator must be available for problems and monthly inspections.
2. Monthly inspection schedule includes blower service, chlorination tests, etc.
3. Occasional pumping out of sludge required.
4. Operating costs: electricity, chlorine, service.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5 (R)	SS (R)	DO (A)	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	INLET AND OUTLET DIAMETER
All	90-95	90-95	2-5 mg/l				Unlimited in U.S.	Minor noise. 5 No odors.	Now testing at NSF, several states approva	1500 and 5000 - 6" NPT; 10000 and 25000 - 8" NPT.

[5]Built within 20 ft. of some homes; transfer pumps submerged.

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranties on parts and workmanship (includes labor).
2. Service contracts available for distributors (depending on distance): 1500-5000 GPD, $208-$247; 5000-15000, $247-$299; 15000+, $325-$390. (Deduct 30% for seasonal installation.)
3. Dealer installs, offers service contract.
4. Pollutrol trains operators, maintenance personnel.
5. Two months free service (start-up) included in base price.
6. Maintenance and service agreements available in operating areas.

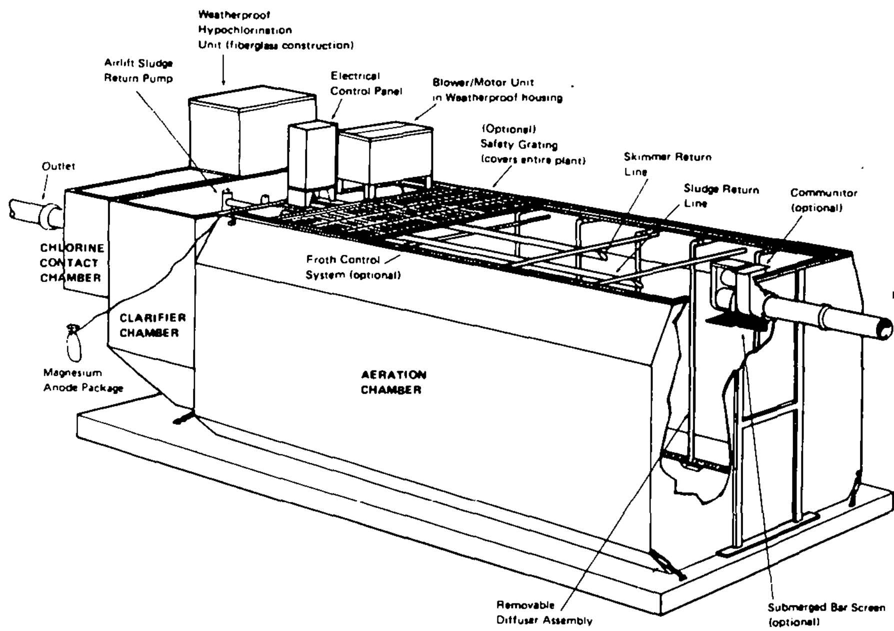
TECHNICAL PERFORMANCE

1. A Puritrol 3000 is currently being tested at the National Sanitation Foundation in Ann Arbor, Michigan (Standard No. 40).

COMMENTS

ACCURATE AS OF July 31, 1972

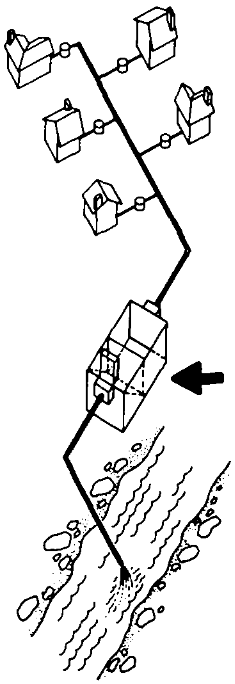
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



PURESTREAM PACKAGE SEWAGE TREATMENT PLANTS

purestream

An "extended aeration" treatment system



PURESTREAM INDUSTRIES, INC.
1450 DIXIE HIGHWAY
COVINGTON, KENTUCKY 41011
(606) 491-5990
Attn: Mr. T. R. Richardson, President

PURESTREAM

EXTENDED AERATION PACKAGE PLANTS

FEATURES
1. Pre-assembled steel package plants.
2. Three chambered construction: (1) aeration chamber, (2) clarifying chamber, (3) chlorine contact chamber.
3. Sludge air-lift and skimmer returns, removable diffused air assemblies, weatherproof housings for motor/blower, control panel and fiberglass housing for hypochlorination unit.

OPERATION
1. Sewage enters aeration chamber through submerged bar screen (optional).
2. Influent is aerated, froth controlled, flows into clarifying chamber, solids settle, sludge returned to aeration.
3. Effluent passes through Cl_2 contact chamber to discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
P-1-1	11'1"	4'	6'	1800	1000	1000		See Install. Below		20			Chlorine	
↓														
P-100-15	72'	24'	11'	87000	100,000	100,000		:"		"			"	

SIZING & GROWTH POTENTIAL
1. Plant sizes: 500-2500 GPD (500 GPD increments); 4,000-30,000 GPD (1000 GPD increments); 3,500-100,000 GPD (5000 GPD increments).
2. Modular design, easily expanded capacities.

COSTS
1. Comminutor, froth control.
2. *Reusable, high resale value.*

INSTALLATION REQUIREMENTS
1. Excavation, concrete foundation pad required.
2. Plumbing/electrical skills required.
3. Crane to off load and set plant in place.
4. Under normal conditions can be installed in one day.

OPERATION & MAINTENANCE REQUIREMENTS
1. Routine periodic checks, no special operator skills required.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO	COD						
All	85-90	85-90						Minor noise. No odors.	NSF Cert. on D-5-2	

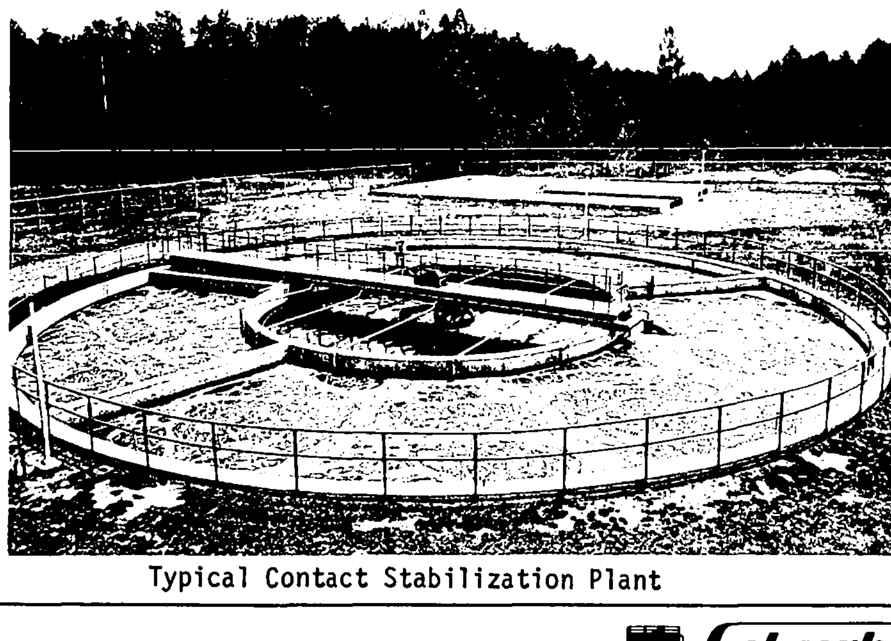
WARRANTIES, GUARANTEES, & SERVICE
1. 1 year warranty on workmanship and material.
2. Operation and inspection contracts available.
3. Operator training available.
4. Local assistance available at installation and start-up.

TECHNICAL PERFORMANCE
1. Issued NSF Certification of Performance - August 1972 on the D-5-2 (5,000 GPD).

COMMENTS **ACCURATE AS OF** July 31, 1972
1. More information on costs and performance available from manufacturer.

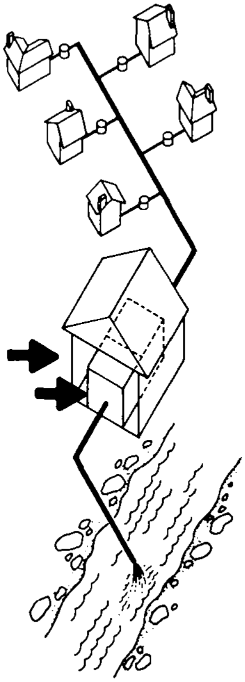
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Residential Unit (center house) with neighborhood sewage plant



Typical Contact Stabilization Plant

Suburbia



SUBURBIA SYSTEMS, INC.
3785 WEST 95TH ST.
P. O. BOX 6217
LEAWOOD, KANSAS 66206
(913) 649-4994
Attn: Mr. L. C. Sandy, Vice-President, Sales

MARAC-100

MANSARD-ROOFED PACKAGE PLANT

FEATURES
1. 100,000 GPD package treatment plant in Parkville, Missouri, built in house compatable with surroundings. (Second unit, typical contact stabilization unit, by Suburbia, in Aberdeen, North Carolina.)
2. Built 20 feet from neighboring houses.
3. Dual treatment system - expands when demand is greater.
4. Effluent chlorinated, surface discharge.
5. Turboil mechanical aerators.
6. Steel formed-concrete tanks.

OPERATION

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
MARAC 100	(1 story residence)				100,000	100,000	See Below							

SIZING & GROWTH POTENTIAL
1. Fully adaptable system - range of sizes and effluent quality geared to capacity and treatment required.

COSTS
1. Equipment cost $16,500. Total cost (house, land and all) was close to $50,000.

INSTALLATION REQUIREMENTS
1. 1 story residence with concrete tanks formed inside the house.
2. Dealer, qualified labor required.

OPERATION & MAINTENANCE REQUIREMENTS

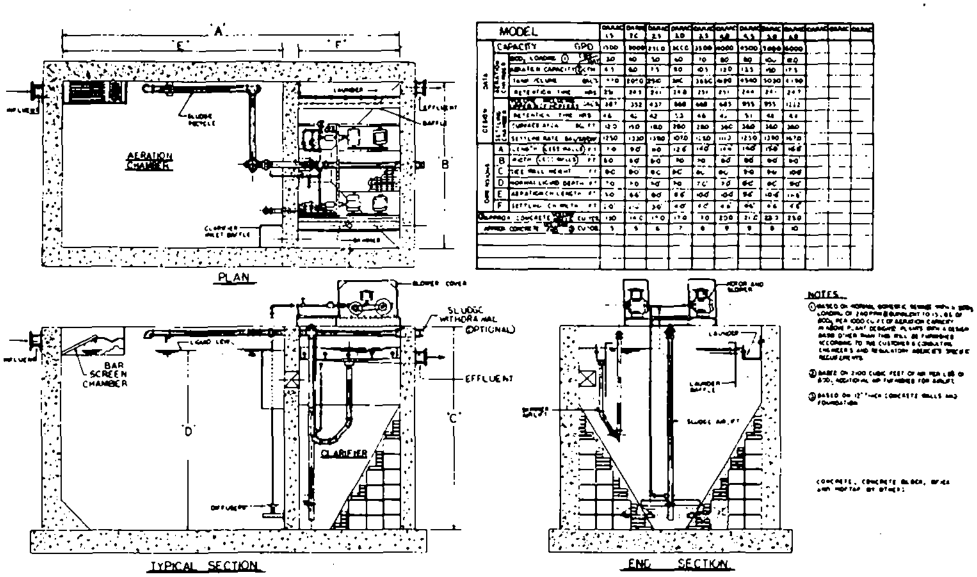
MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 (R)	SS (R)	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
MARAC 100	91+	90-95						Minor noise and no odors.		

WARRANTIES, GUARANTEES, & SERVICE

TECHNICAL PERFORMANCE

COMMENTS ACCURATE AS OF July 31, 1972
1. Guarantees, performance, sizing similar to DARAC (see page 236.).

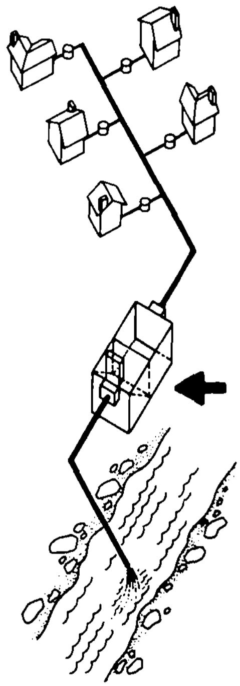
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



DARAC PACKAGE PLANTS

Suburbia

Diffused aeration package plants



SUBURBIA SYSTEMS, INC.
3785 WEST 95TH ST.
P. O. BOX 6217
LEAWOOD, KANSAS 66206
(913) 649-4994
Attn: Mr. L. C. Sandy, Vice-President, Sales

DARAC

DIFFUSED AIR EXTENDED AERATION PACKAGE PLANT

FEATURES
1. DARAC: Diffused Aeration Rectangular shape Airlift sludge return Concrete tank (by others).
2. 32 sized models of concrete design extended aeration plants from 1500-200,000 GPD.
3. Bar screen chamber, activated sludge return, two chambered unit (aeration and clarifier chambers).
4. Modular expansion (dual units), chlorination optional.
5. Hodag chemical foam suppression.

OPERATION
1. Sewage enters aeration chamber through bar screen chamber.
2. Mixed liquor is aerated and flows into clarifier.
3. Solids settle and air-lift sludge return recycles solids for inlet activated sludge contact.
4. Supernatant is skimmed and then passes over V-notch weir for disinfection or discharge.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
DARAC 1.5	7'	6'	8'	Foot-note #1	1,500	1,850					115/230 VAC		Hodag anti-foam[2]	
DARAC 6.0	16'	8'	10'		6,000	7,400					"		"	
DARAC 15.0	25'	10'	11'		15,000	17,480					"		"	
DARAC 50.0	34'	31'	11'6"		50,000	58,420					"		"	

[1]Concrete tank by others. [2]Plus chlorine, if required.

COMMENTS
1. DARAC is just one series of treatment plants. Suburbia manufactures rectangular and circular, steel and concrete tanks with mechanical or diffused extended aeration, or contact stabilization processes. Also a complete line of treatment plant accessories for plants from 500 to 1,000,000 GPD.

COSTS
1. Cost information available from manufacturer/distributors.
2. Comminution, chlorination, etc., optional extras.

INSTALLATION REQUIREMENTS
1. 18 to 122 cu. yds. of concrete for 1.5 to 50.0 models.
2. 6" to 8" concrete pads with excavations, gravel base.
3. Electrician skills, leveling required.

OPERATION & MAINTENANCE REQUIREMENTS
1. For foam suppression, Hodag anti-foam chemical @ 0.5 to 1.0 ppm required for six weeks, then appropriate reduction.
2. Regular maintenance needed, average intelligence and mechanical ability required.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO	COD						
All	90	90					Normal Temperate	Minor noise. No odors.	Patented	

WARRANTIES,GUARANTEES, & SERVICE
1. Warranty on parts and workmanship.
2. Manufacturer provides two days supervision on start-up, operator training.
3. Service policies available.
4. Concrete tank and sewage by others.

TECHNICAL PERFORMANCE
1. U. S. Patent No. 3,173,866; others pending.
2. ERC finished coating on all steel surfaces after sandblasting.

ACCURATE AS OF July 31, 1972

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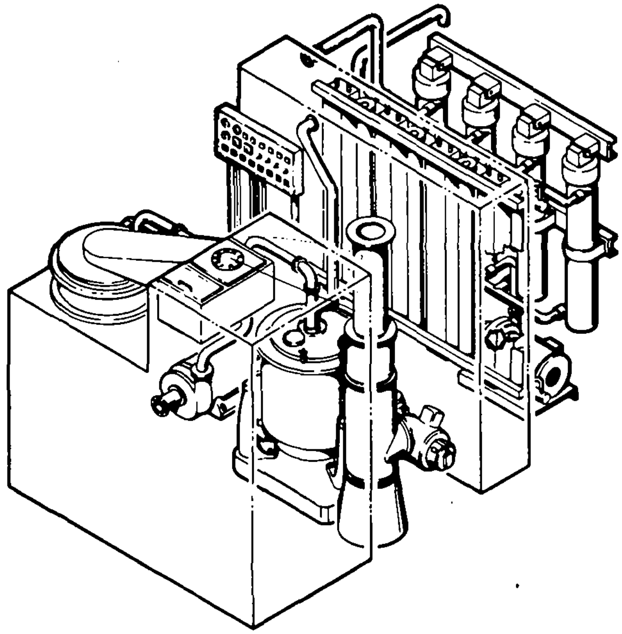
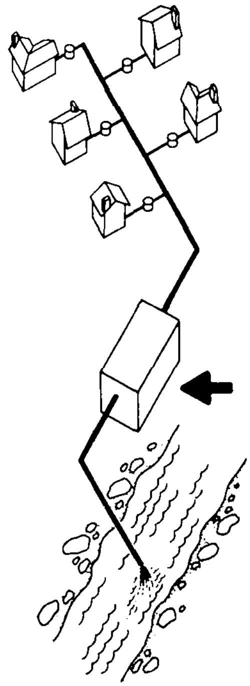


SHIPBOARD CHEMICAL PACKAGE PLANT

Thiokol / WASATCH DIVISION
A DIVISION OF THIOKOL CHEMICAL CORPORATION

Present shipboard design representative of future land-based models



THIOKOL CHEMICAL CORPORATION
P. O. BOX 524
BRIGHAM CITY, UTAH 84302
(801) 863-3511
Attn: Mr. Paul D. Nance, Manager
Advanced Pollution Control Systems

NONBIOLOGICAL WASTE TREATMENT SYSTEM

SHIPBOARD CHEMICAL PACKAGE PLANT

FEATURES

1. Large shipboard system used on Navy destroyers.
2. Centrifuge separates sludge for incineration.
3. 30 minute process time.
4. Photo-catalyzed electrochemical system (PEPCON) with ultra-violet treatment processes wastewater.
5. Audio and visual alarms control system.

OPERATION

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)		OPERATING SUPPLIES	
NBWTS				Less than 4,000	See Sizing Below						30 Kw		Oil and salt	

SIZING & GROWTH POTENTIAL

1. 6000 GPD is 200 person capacity (shipboard).
2. System can be scaled from 50 to 2,000 person capacity or in the 2000 - 100,000 GPD range.

COSTS

1. Costs for NBWTS would range from $30,000 to $100,000 for 2,000 - 10,000 GPD models.

INSTALLATION REQUIREMENTS

1. Occupies 250 cubic feet of space.

OPERATION & MAINTENANCE REQUIREMENTS

1. Diesel or oil fuel required for incineration, ca 15-20 GPD.
2. Salt needed for oxidation, ca 200-500 lb/day.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5 (R)	SS (R)	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
NBWTS	95	90-95					-30° to 150°F 30° attitude		See Tech. Perf. below	

WARRANTIES, GUARANTEES, & SERVICE

TECHNICAL PERFORMANCE

1. Treated effluent meets all federal water quality standards.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. System is "representative of the advanced subsystems which can and are being applied to landbased applications."

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Aeration Devices

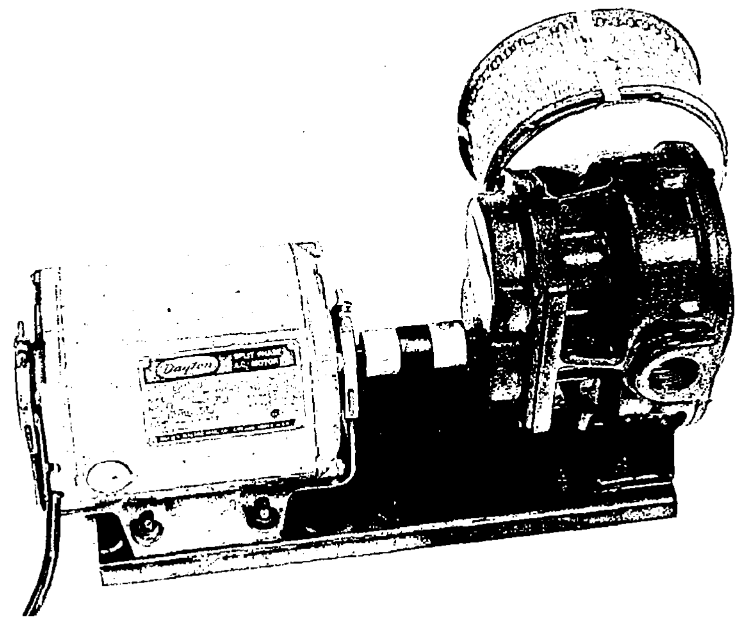
Introduction

This section contains descriptions of a variety of aeration devices for small to large-scale application. A motor-and-blower unit is available to fabricators of individual home aerobic units for under $200. On-site fabrication of individual home aerobic units in accordance with plans obtained from the manufacturer might be explored by projects which need many individual home units.*

Two brands of helical flow aerators which are intended for use in oxidation ponds (lagoons) or large tanks are included. They operate as airlifts (with air injected at the bottom) which employ integral (static) turning vanes to induce flow conditions favorable to aeration. Inasmuch as the units are fixed in place and kept underwater, they are not likely to be targets of vandalism. Since all of the moving parts are contained in the shore-based air compressors which supply the mixers by hose lines, maintenance can be simplified over aeration systems which operate on or in the pond.

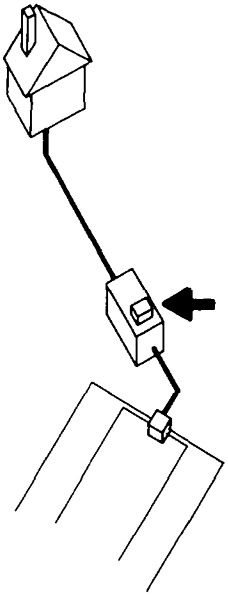
A newly-engineered floating aerator is also described. Among its virtues is the fact that no permanent installation is required other than the anchoring of mooring cables and the provision of a weatherproof and waterproof electrical line. Since the aerator and motor are submerged, the unit is also relatively immune to vandalism and surface icing, and the submerged center of gravity lends stability.

*Just such an aerobic system, fabricated on-site with cinderblock materials and waterproofing, was observed by one of the authors on a visit to the Appalachian Environmental Health Demonstration Project, 108 South Kentucky Avenue, Corbin, Kentucky 40701. As far as a visual check could determine, the unit was working properly after over a year of service. The mixed liquor in the aeration chamber was brown, with no noticeable odor.



THE DOMESTIC STANDARD AIR BLOWERS ALLENAIRE, INC.

Figure 8 rotor-operated blowers



ALLENAIRE, INC.
379 NILES-CORTLAND RD., S.E.
WARREN, OHIO 44484
(216) 856-4680
Attn: Mr. R. D. Allen, President

THE DOMESTIC STANDARD

COMPRESSED OILLESS AIR BLOWER

FEATURES
1. Two "figure 8" lobed rotors on parallel shafts cause positive movement of air @ 2-4 PSI.
2. Two models: 1725 RPM, 1/3 HP, split phase motor and 3450 RPM, 3/4 HP, split phase motor; offered on NEMA 48 Frame.
3. 1" NPT.
4. Units produce 10 to 30 CFM air, at 1/3 to 3/4 HP.

OPERATION
1. Air enters rotor chamber, sucked in by rotors.
2. Tight clearance rotors rotate in opposite directions, pulling air around outside of chamber for compressed discharge.
3. Gears (oiled), driven by motor, operate rotors.

MODEL NUMBER (MAJOR)	DIMENSIONS[1] LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)[2]		OPERATING SUPPLIES	
1725 RPM	18"	$9\frac{1}{4}$"	$8\frac{3}{4}$"		NA	NA	See Costs below				115 V AC 6.8 amp		Electricity Air	
3450 RPM	19"	"	"		"	"	"				115 V AC		"	

[1]Includes stand, motor, blower and air filter.

[2]Depends on rating of motor; standard equipment rating given.

SIZING & GROWTH POTENTIAL
1. Sizing for motors from 1500 to 3600 RPM.
2. Blowers may be operated at a distance from appliance: 1725 RPM units: over 100 ft. away, use 1-1/4" diameter delivery tube; 3450 RPM units: 10-100 ft. away, use 1-1/2" diameter delivery tube; over 100 ft. away, use 2" diameter delivery tube.

COSTS
1. Blower and motor sells to tank fabricators @ $186.

INSTALLATION REQUIREMENTS
1. If blower is outside, it should be incorporated in blower vault (e.g., 33" x 28" x 24" concrete [6320 cu. in.] vault; 2" walls with air intake).
2. Not flood proof; must be protected from weather.

OPERATION & MAINTENANCE REQUIREMENTS
1. RPM below 1500 or above 3600 not recommended.
2. Oversized air filter; replacement needed occasionally.
3. Oiling required after two years of household use.
4. Motor needs one drop SAE 10 oil each side every 6 months.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
1725 RPM	NA	NA	NA	NA				No data on noise.	Patented	
3450 RPM	"	"	"	"				"	"	

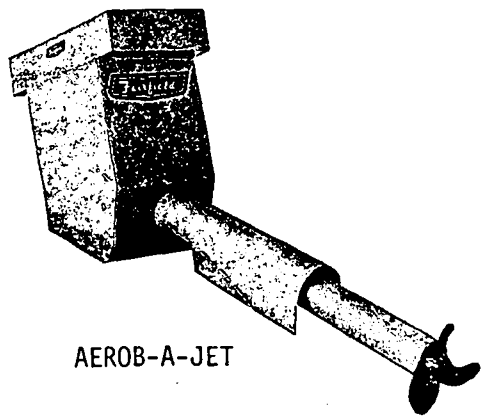
WARRANTIES, GUARANTEES, & SERVICE
1. Equipment guaranteed free of defects, service offered free for one year (parts and labor).
2. For next five years, a percentage of list price or replacement parts warranty is offered.
3. Extended service contracts offered.

TECHNICAL PERFORMANCE
1. U. S. Patent No.: 3,281,063.

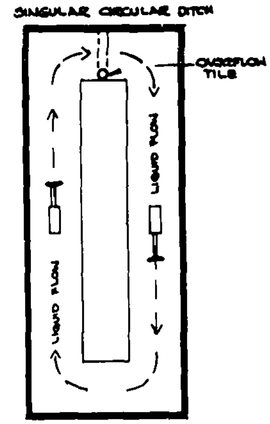
COMMENTS

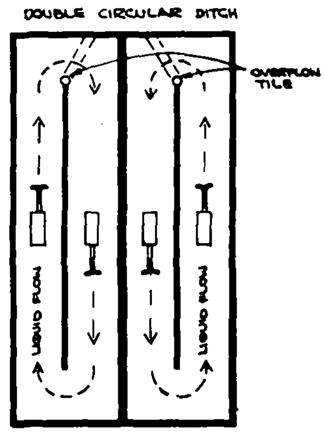
ACCURATE AS OF July 31, 1972

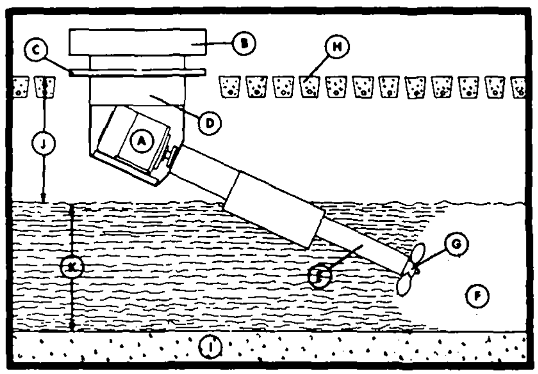
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



AEROB-A-JET







SIDE VIEW . . . FAIRFIELD AEROB-A-JET

(A) motor; (B) chamber cap; (C) mounting angle; (D) chamber; (E) drive tube; (F) slurry (water and wastes); (G) propeller; (H) slatted floor; (I) bottom of ditch; (J) 23-26" slurry surface to bottom of mounting; (K) 21" minimum.

AEROB-A-JET MECHANICAL AERATION SYSTEMS

Fairfield

Propeller-type sewage flow inducers for livestock waste treatment

FAIRFIELD ENGINEERING AND MANUFACTURING CO.
601 WEST KIRKWOOD ST.
FAIRFIELD, IOWA 52566
(515) 472-4181
Attn: Mr. R. C. Evans, Vice-President, Sales

AEROB-A-JET

MECHANICAL OXIDATION, UNIT FOR WASTE DITCHES

FEATURES

1. Motor driven propeller extension in steel housing aerates and moves waste slurry from pig wastes at a rate of 1 foot per second.
2. Designed for use with cow and pig wastes as liquid flow inducers for sub-floor oxidation ditches.
3. Removes odors, discharges to lagoon.
4. Direct shaft-driven propeller extends from Aerob-A-Jet housing into slurry.

OPERATION

1. Wastes from livestock pass through slatted floor to open pit oxidation ditch.
2. Rotating propeller accelerates liquid wastes in ditch, introducing dissolved oxygen through bubbles for aerobic treatment; motion of liquid disperses solids for suspended treatment.
3. Treated wastes pass through overflow to discharge in lagoon or field spreading purposes.

MODEL NUMBER (MAJOR)	DIMENSIONS [1]			WEIGHT (LB.)	RATED CAPACITY	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	MOTOR HP (RPM)
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
18173 -0	18"	14"	23"	280	360 Nursery Pigs	NA	895.		See Costs Below		220 V AC 1 ph		Used in oxidation ditch	3 (1800)
18173 -1	"	"	"	"	"	"	"		"		220/460 V AC 3 ph		"	"

[1] Aerob-A-Jet housing only, not including 4' propeller extension.

SIZING & GROWTH POTENTIAL

1. Can be put in circular ditches of varying capacities; one unit can serve 180 gestating sows or 60 lactating sows or 360 nursery pigs or 180 finishing pigs.

COSTS

1. Operating costs are primarily electrical; continuous automatic operation.

INSTALLATION REQUIREMENTS

1. Installation designed for concrete oxidation ditch with overflow discharge.
2. Slatted floor provides waste access to flowing sub-floor slurry.

OPERATION & MAINTENANCE REQUIREMENTS

1. Periodic inspection; enclosed motor has housing which can be reached from the top.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
Both							Indoor housing submerged propeller	Minor noise. No odors.	Patent Pending	

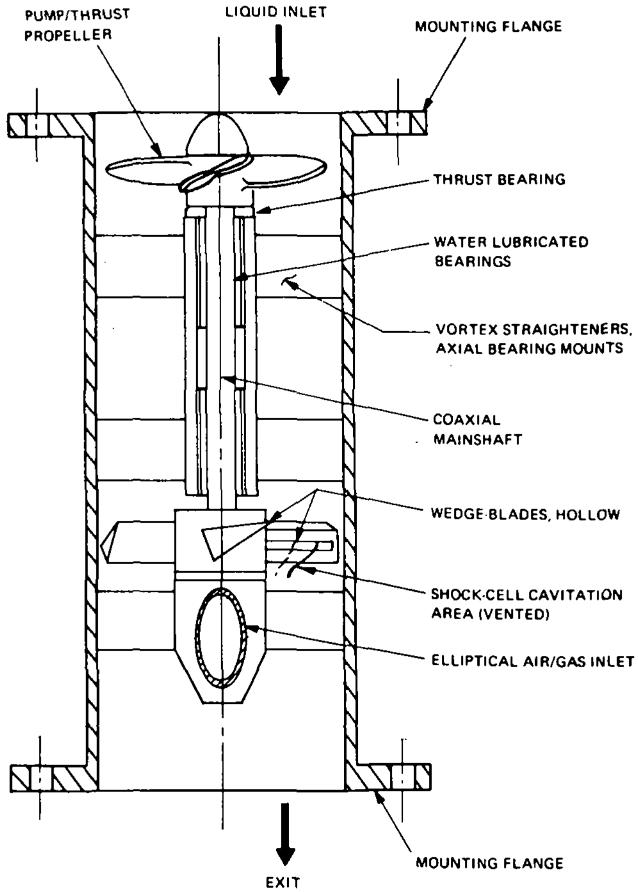
WARRANTIES, GUARANTEES, & SERVICE

TECHNICAL PERFORMANCE

COMMENTS **ACCURATE AS OF** July 31, 1972

1. System was designed for livestock use; human or industrial waste potentials not yet developed.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

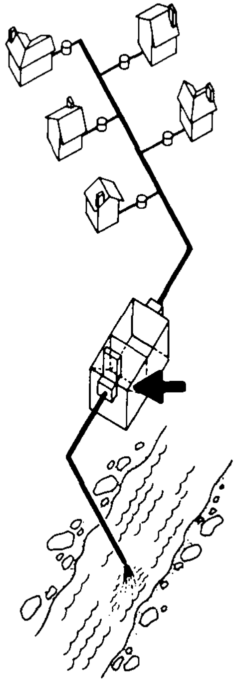


HYDRAJECTOR

U.S. Pat. No. 3,206,176

HYDRAJECTOR IN-LINE MIXERS

HYDRAJECTOR



HYDRAJECTOR CORPORATION
P. O. BOX 30516
SANTA BARBARA, CALIFORNIA 93105
(805) 968-0211
Attn: Mr. Robert M. Bush, President

HYDRAJECTOR ©

MIXER-SELF-INJECTING AMBIENT AIR/OXYGEN/OZONE/ETC.

FEATURES

1. Self-powered and reactor (free-wheeling system pump driven) mixers have two sets of propellers for in-line mixing applications (aeration, disinfection, etc.).
2. Moving (pumped) water required for application (manufacturer or existing system supplied); mixer creates turbulent interface between drawn air and wastewater or effluent.
3. Model 106 injects 75 CFM ambient air @ 1200 GPM flow.
4. Average bubble size 0.050"; smallest bubble size (microscopically photographed) 0.00025".
5. If water already is being pumped from A to B, Hydrajector can be added in-line with some additional power consumption from pump.

OPERATION

1. Reactor unit is single shaft with two propellers; first prop is reactor; second prop has wedge-shaped, cavitating, ventilating blades.
2. Negative pressure behind blades sucks in ambient air.
3. One moving member, water lubricated "Cutlass-type" bearings; little or no maintenance.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
106	32"	8" round		40	2M [1]	NA	See Costs Below	Low - Varies	See Features Above	5-25 (Materials dependent)	220/440 VAC 3 ph 34-17 amp [2]		Injecting gas (air, etc.) [3]	
40	18"	4" round		20	144,000 [1]	"	"	"	"	"	220/440 VAC 3 ph 9-4.5 amp [2]			

[1]Or system pump capacity. [2]Or available pump. [3]Plus electricity or available pump.

SIZING & GROWTH POTENTIAL

1. Will design to suit.
2. Can be used for injecting air, oxygen, ozone, etc.

COSTS

1. Costs quoted on request, materials and application dependent.

INSTALLATION REQUIREMENTS

1. Customer provides mating, standard bolt flanges.
2. Hydrajector should be placed near water pipeline discharge.
3. Minimal plumbing skills required for installation.

OPERATION & MAINTENANCE REQUIREMENTS

1. Nominal; annual blade inspection.
2. Pumping of water-effluent required for all installations; if in-line pumping not existing, manufacturer will supply.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
106	NA	NA	NA	NA			Ambient	Quiet running	Patented	
40	"	"	"	"			"	"	"	

WARRANTIES, GUARANTEES, & SERVICE

1. 90 day manufacturers warranty.
2. Other warranties, etc., negotiable.

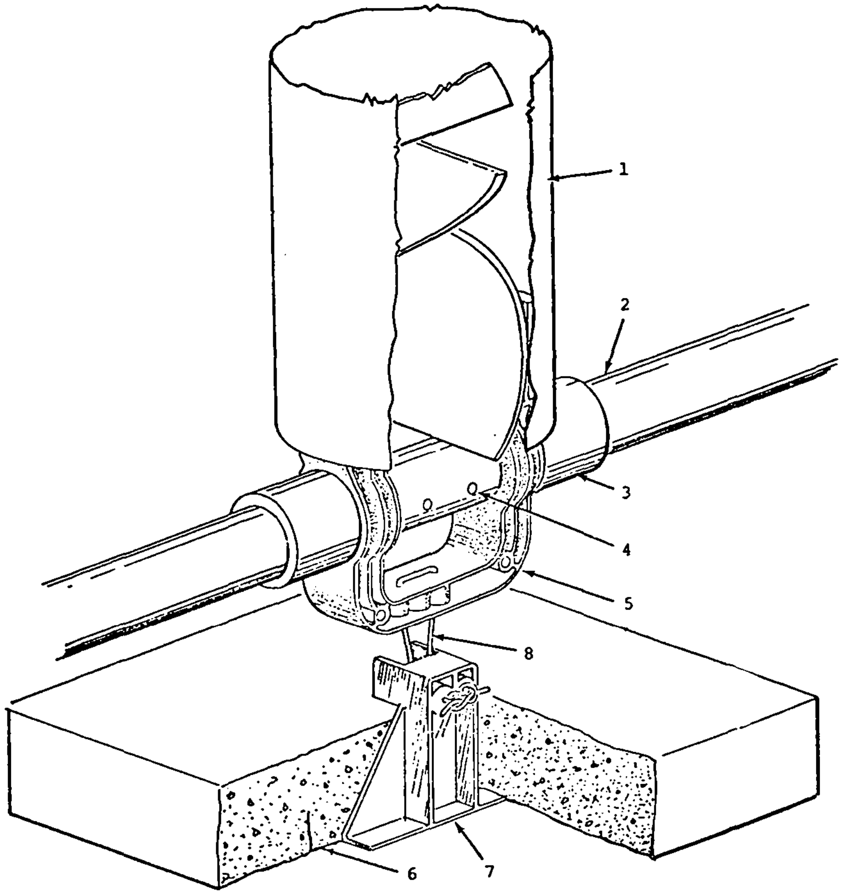
TECHNICAL PERFORMANCE

1. U. S. Patent No. 3,206,176.
2. Other patents pending.
3. Can be operated indoors, outdoors; also as floating or submerged units.

COMMENTS

ACCURATE AS OF July 31, 1972

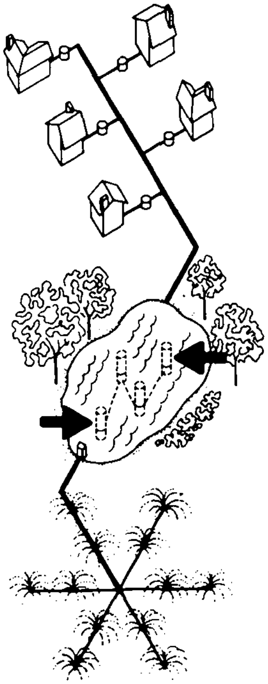
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



STATIC AERATOR™
AERATION TUBES

Kenics

1 - Aerator, 5 elements (1 element shown)
2 - Polyethylene pipe
3 - Polyethylene coupling
4 - Air supply orifice
5 - Aerator mounting bracket
6 - Concrete block
7 - Anchor bracket
8 - Adjustable tether



KENICS CORPORATION
ONE SOUTHSIDE RD.
DANVERS, MASSACHUSETTS 01923
(617) 774-8600
Attn: Mr. Alvin Brass, Regional Salesman

STATIC AERATORS™

HELICAL COMPONENT AERATION TUBES

FEATURES

1. 12" diameter, 5' long,high density polyethylene tubes with several helical static mixer components (see page 250). in which air is bubbled for turbulent flow DO transfer.
2. Used primarily in lagoons and aeration tanks.
3. Turbulent flow, one diameter size: 12" for liquid depths of 5 to 20 feet.

OPERATION

1. Air is pumped in small diameter lines, weighted to the bottom of an aeration chamber, to the base of the aerator.
2. Air is released into the base of the weighted aerator, sucking in surrounding liquid.
3. As the air bubbles and liquid move up the module, turbulent mixing and oxygen-water interface occurs, breaking down air bubble size and increasing DO content of water.
4. Aerated liquid leaves to recycle with surrounding water.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPM)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	AIR TRANSFER
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	OTHER		
Static Aerator	12" round		5'	15	1000	NA	See Costs Below	Varies		Plastic - unlimited		Compressed Air	Air and liquid	25-40 SCFM

SIZING & GROWTH POTENTIAL

1. Modules can be sized for literally any degree of dispersion or volume of flow; for example, in a 20 ft. deep lagoon, 12" aerators @ 1 per 1500 sq. ft. might be sufficient.
2. Can be used in aeration tanks at treatment plants, also.

COSTS

1. Aerators priced by quantity ordered; for 1 to 50 aerators, $300 per aerator; for 100+ aerators, $150 per aerator.

INSTALLATION REQUIREMENTS

1. In lagoons, a blower source must provide adequate air and air lines must be weighted down.
2. Aerators should be anchored down, fitted and sized by qualified installer/sanitary engineer.

OPERATION & MAINTENANCE REQUIREMENTS

1. Operation of blower, calculation of actual and desired DO content by the amount of mixing necessary for proper control.
2. Maintenance small, turbulance cleans aerators, periodic checking of system by operating engineer.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
Static Aerator	NA	NA	NA	NA			Submerged, unlimited		Patented	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on parts and workmanship.

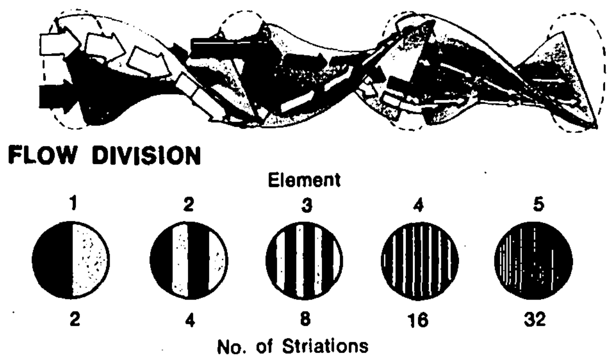
TECHNICAL PERFORMANCE

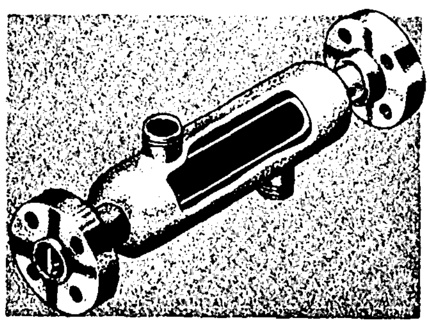
1. Aerators can be fitted to most any lagoon or tank operation; optimum depth for maximum efficiency is between 10 and 20 ft.

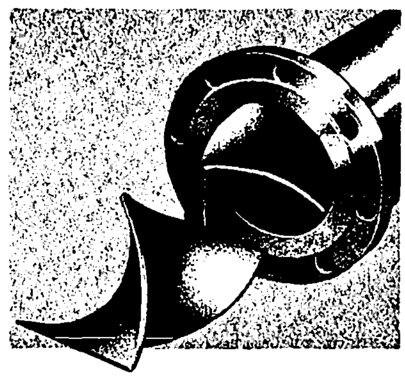
COMMENTS

ACCURATE AS OF July 31, 1972

1. Operating principle of "flow division" and static mixer elements found on page 250 with static mixer product descriptions.



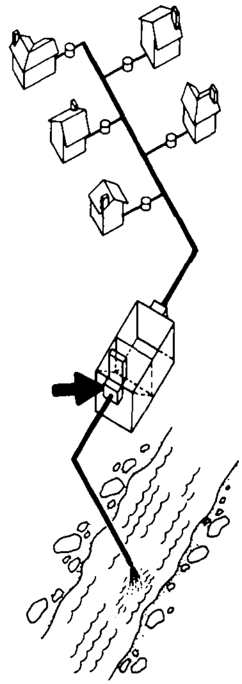




STATIC MIXER® MIXING, BLENDING TUBES

Kenics

Static helical component mixing systems



KENICS CORPORATION
ONE SOUTHSIDE RD.
DANVERS, MASSACHUSETTS 01923
(617) 774-8600
Attn: Mr. Alvin Brass, Regional Salesman

STATIC MIXER ®

HELICAL COMPONENT AERATION TUBES

FEATURES

1. Cylindrical stainless steel or carbon steel tubes with 6 to 21 fixed internal helical elements. (Standard modules available in glass and PVC.)
2. Used for blending, mixing, or dispersion in-line operations.
3. Three basic types: Standard units (3/16" - 3"), Standard modules with specially scaled internal edges (1/2" - 12"), and Custom modules (3/16" - 48") of most any material.
4. Plain, flanged or threaded ends.
5. No moving parts, flow stratification provides for oxygen transfer.

OPERATION

1. Liquids or liquid-gas components to be mixed are pumped through (in-line) mixer modules.
2. As the liquids pass through the modules and are mixed by the static helical components, flow division, inversion, reversal and back mixing occur, forcing complete dispersion of particles and maximum interface of materials.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	NPS DIA.		HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
KMOD-10	1/2" to 12"		0.5'-9.7'				130 - 2,950.	Varies						
KMOD-20	1/2" to 3"		2.8'-9.5'				420 - 1,894.	"						

SIZING & GROWTH POTENTIAL

1. All sizes of mixers of different materials and purposes available for desired mixing.

COSTS

1. List costs do not include end connections. End connections, installed, cost (for 1/2" - 12" NPS): (1) Male pipe thread, $6 - $31; (2) Stainless steel flange (150 PSI), $44 - $496; (3) Carbon steel flange (150 PSI), $25 - $184.

INSTALLATION REQUIREMENTS

1. Must be installed in-line with moving liquid.
2. Plumbing skills: plain flanged or threaded ends.

OPERATION & MAINTENANCE REQUIREMENTS

1. Operation of mixer, calculation of actual and desired DO or blended compound content by the amount of mixing necessary for proper control.
2. Maintenance small, turbulence cleans mixers; periodic checking of system by operating engineer necessary.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
All	NA	NA	NA	NA			Unlimited; heat transfer capability		Patented	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on parts and workmanship.

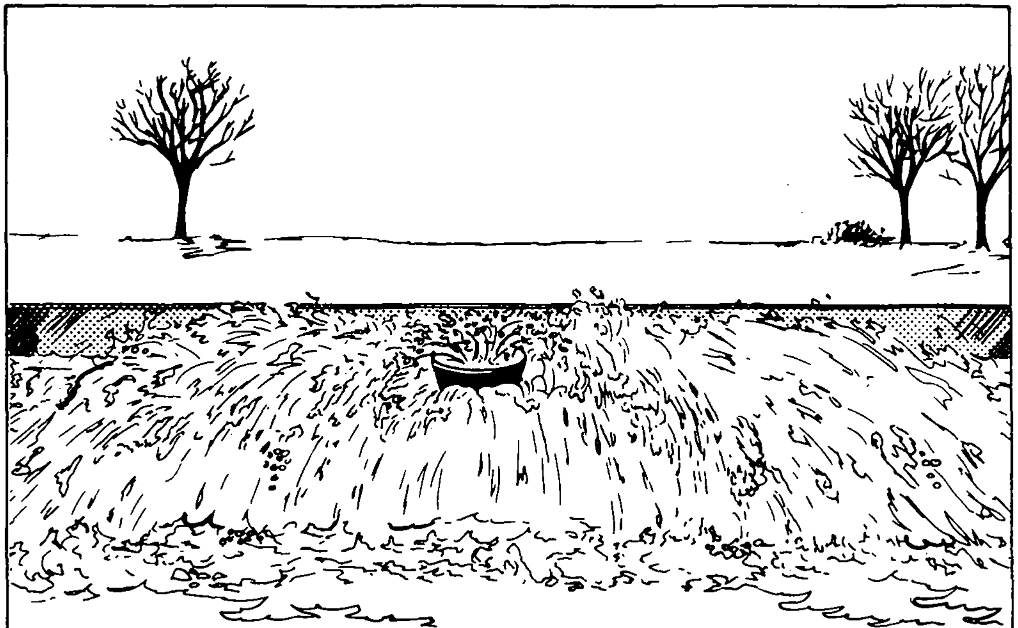
TECHNICAL PERFORMANCE

1. Patented, 3,286,992; also patented in principle foreign countries.
2. Pressure drops over empty pipe of same dimensions range from 5-6 times (for laminar flow without ripples) to 75-150 times (for turbulent flow).

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Four times the density of modules is required by laminar flow without ripples than by turbulent flow.
2. Static aerator systems found on page 248, uses the same principle of operation in aeration applications.

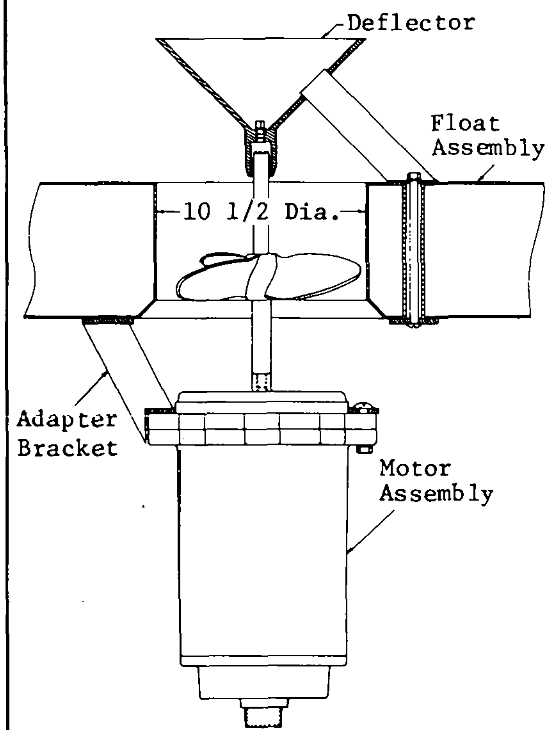
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

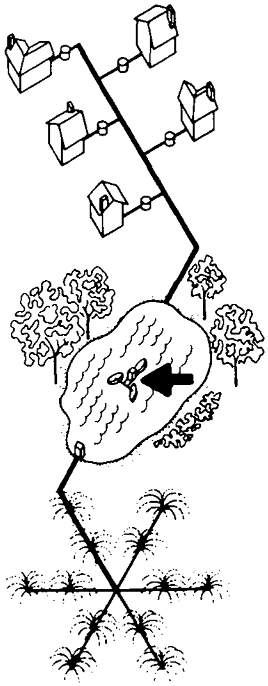


MULTI•FLO

waste treatment systems - pumps

MULTI FLO AERATORS





MULTI-FLO, INC.
500 WEBSTER ST.
DAYTON, OHIO 45401
(513) 224-7622
Attn: Mr. Robert C. Black, Director of Marketing

MULTI-FLO SA

FLOATING AERATORS

FEATURES
1. Non "tip-over"mechanical floating aerators for lagoon or shallow pond aeration.
2. Submerged motor and aerator by same manufacturer stabilizes floatation, reduces vandalism risks.
3. Non-icing in cold climates.
4. Propeller-deflector mechanism.

OPERATION
1. Surface aerator sucks wastewater under flotation with propellers and discharges against deflector.
2. Turbulent interface of wastewater and air increases dissolved oxygen in water for aerobic treatment of wastes.
3. Circulation of aerated water achieves distribution of treatment.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD) [1]	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
SA-1	30"	30"	20"	98	8,000	Varies with process	400.	Minimal (Varies)	Minimal (Varies)	3-5	120 V AC 1 HP		None	
SA-2	36"	36"	27"	185	16,000	"	720.	"	"	"	230/460 V AC 2 HP		"	
SA-3	"	"	"	"	24,000	"	1,050.	"	"	"	230/460 V AC 3 HP		"	
SA-5	"	"	"	215	40,000	"	1,500.	"	"	"	230/460 V AC 5 HP		"	

[1] Based on 2 lb. BOD_5/1000 gal. sewage; is used in lagoons sized for 6 day retentions.

SIZING & GROWTH POTENTIAL
1. Capacity depends on amount of treatment required and corresponding detention times.

COSTS
1. Electrical cable and mooring cables furnished by manufacturer.
2. Control equipment provided by installer.

INSTALLATION REQUIREMENTS
1. No special skills required beyond electrical hook-up.
2. Anchor mooring cables and attach electrical cable.

OPERATION & MAINTENANCE REQUIREMENTS
1. Semi-annual inspection.
2. Bi-annual oil change recommended.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5 [2]	SS	DO [2]	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
All							All climates	Minor noise [3] No odors.	Patent applied for.	

[2] BOD_5 reduction; DO increase. [3] Submerged motor.

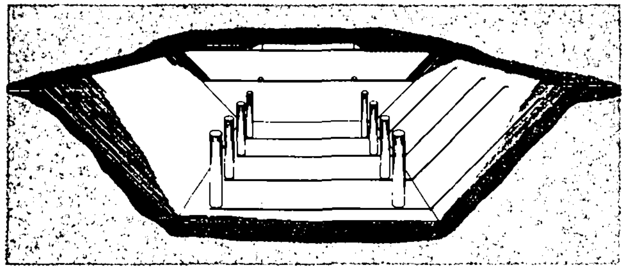
WARRANTIES,GUARANTEES, & SERVICE
1. 1 year manufacturers warranty on workmanship and material.
2. Factory authorized and trained local service groups.
3. Periodic review of distributor activities by factory management.

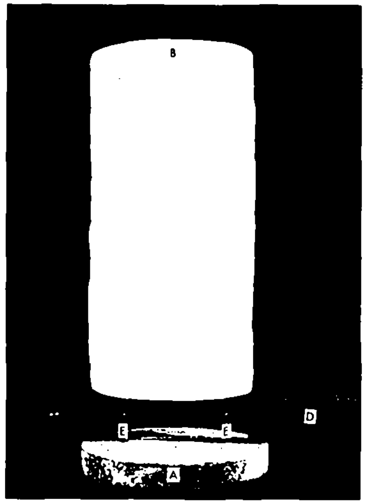
TECHNICAL PERFORMANCE
1. Oxygen transfer rate in excess of 1.3 lb. O_2/HP hour; use standard application data for process employed.
2. Patent applied for.

COMMENTS

ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.





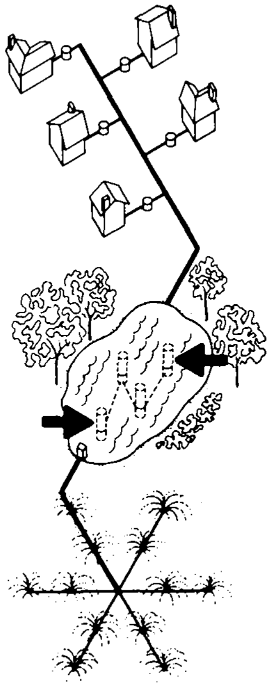
HELIXOR

Legend
A - Anchor
B - Outer tube
C - Helix
D - Air Supply
E - Orifice on each side of helix

HELIXOR® AERATION TUBES

POLCON CORP

Helical component, plastic aeration tubes



POLCON CORPORATION
222 CEDAR LANE, SUITE 305
TEANECK, N. J. 07666
(201) 692-1616
Attn: Mr. David Heiner, General Manager

HELIXOR®

HELICAL COMPONENT AERATION TUBES

FEATURES

1. One-piece 18" diameter, extruded polyethylene tube with monolithic helix component into which air is bubbled, sheared and combined with liquid for DO transfer.
2. Used in lagoons and aeration tanks.
3. Turbulent flow; spiral velocities over 4 ft/sec.
4. One diameter size; 18" for unit lengths of 3' to 12'; air supply of 24-28 SCFM, and liquid depths of 5' to 20'.

OPERATION

1. Air is pumped to the base of the aerator in small diameter lines, weighted to the bottom of an aeration chamber.
2. Air is released through two orifices to each side of the helical component, pulling up surrounding liquid as an air lift.
3. As the air bubbles and liquid flow moves up the module, turbulent mixing and oxygen-water interface occurs, increasing the DO of the water.
4. Aerated liquid leaves, to recycle with surrounding water.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Helixor	18" diameter		3' to 12'	7 lb/ft									Compressed Air	

SIZING & GROWTH POTENTIAL

1. Modules can be sized for any aeration system of reasonable depth.
2. Polcon also markets package plants with Helixor aeration for 5000 to 40,000 GPD (48 SCFM).

COSTS

1. List price includes module only; connections, air lines, accessories are extra.
2. Pricing dependent on location and quantity ordered.

INSTALLATION REQUIREMENTS

1. In lagoons, a blower source must provide adequate air and air lines weighted down.
2. Aerators should be anchored down, fitted and sized by qualified installer/sanitary engineer.

OPERATION & MAINTENANCE REQUIREMENTS

1. Operation of blower, calculation of actual and desired DO content by mixing necessary for proper control.
2. Maintenance small; turbulence cleans aerators, periodic checking of system by operating engineer necessary.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
Helixor							Unlimited; Heat transfer Capabilities		Patented	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on materials and workmanship.
2. Manufacturer/distributor must supervise installation in order to guarantee performance.

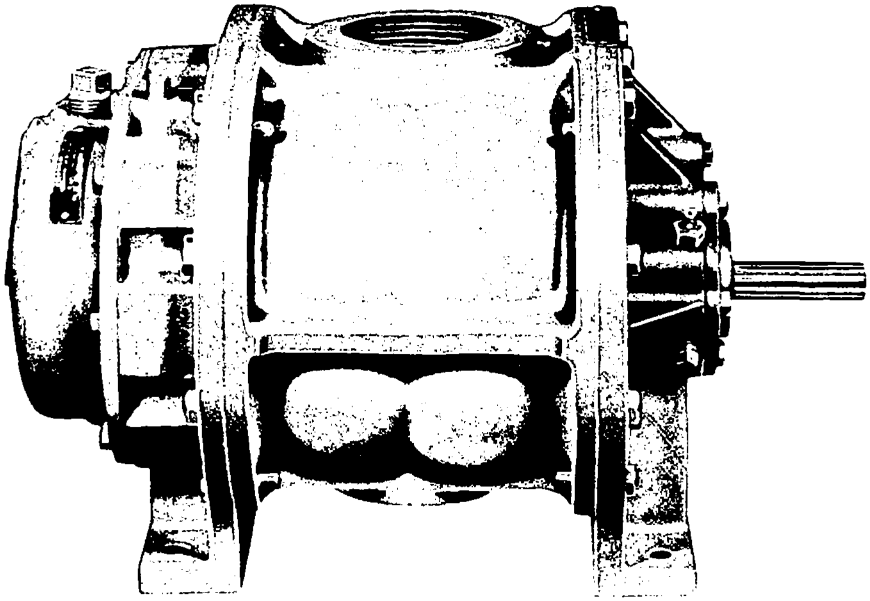
TECHNICAL PERFORMANCE

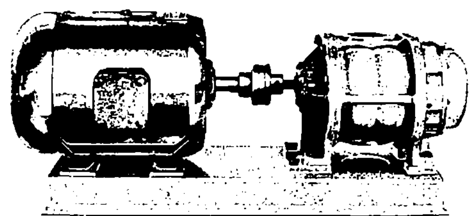
1. With an air consumption of 25 SCFM, a 12' Helixor transfers about 4.1 lb O_2/hr.
2. U. S. Patent No. 3,452,966.

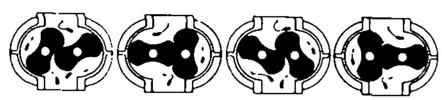
COMMENTS **ACCURATE AS OF** July 31, 1972

1. Modules oxygenate water without causing adverse thermal stratification, making them applicable to stream or lake rehabilitation, and not injurious to water life.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.





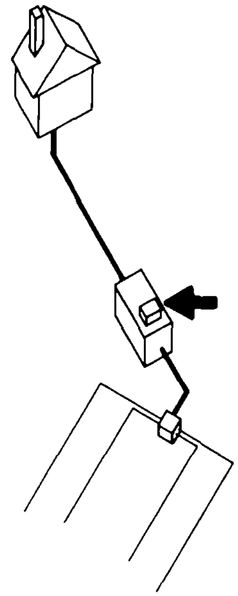


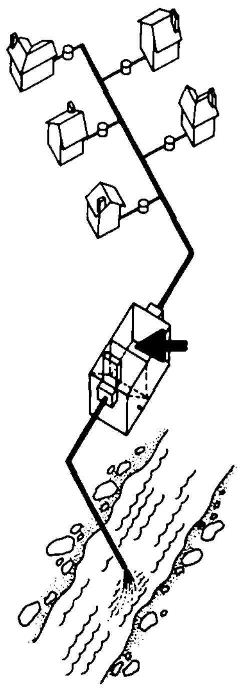
Direct drive through coupling

ROOTS AF BLOWERS

ROOTS
AF BLOWERS

Twin-lobed rotary blowers





POLLUTION CONTROL, INC.
N. WING, LUNKEN AIRPORT ADMINISTRATION BLDG.
CINCINNATI, OHIO 45226
(513) 871-2754
Attn: Mr. Fred Tipton, Vice-President

ROOTS AF BLOWERS

TWO-LOBED ROTARY BLOWERS

FEATURES

1. Compressed air blower acts as blower or vacuum pump..
2. Two "figure 8" lobed impellers on parallel shafts cause positive movement of air @ 3-6 PSI.
3. Pressure and vacuum relief valves and muffler filters available at extra cost.
4. Capacities from 4 - 510 CFM, motor requirements vary from 575 to 2600 RPM @ .35 - 16.9 BPH.
5. One piece casing, straight tooth spur gears, timing gears splash lubricated, lip type carbon shaft seal.

OPERATION

1. Air enters impeller chamber, sucked in by impellers.
2. Tight clearance impellers rotate in opposite directions, pulling air around outside of chamber.
3. Relief valves open to relieve over-pressure or over-vacuum conditions.
(See facing diagram for details.)

MODEL NUMBER (MAJOR)	DIMENSIONS [1]			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	RATED CAPACITY
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
22 - frame size	$10\frac{5}{16}$"	$8\frac{3}{4}$"	$6\frac{7}{8}$"	43	NA	NA					Motor: 115-230 V AC		Oil	4-27 CFM @ 1160-2600 RPM
710 - frame size	$27\frac{1}{16}$"	$22\frac{7}{8}$"	$19\frac{1}{2}$"	490	"	"					"		"	238-570 CFM @ 575-925 RPM

[1]Blower dimensions only (not motor).

SIZING & GROWTH POTENTIAL

1. Pulley, sheave, coupling, direct connection, or V-belt drive arrangements can be adapted to motor and blower.
2. 7 main sizes, available at 3 RPM ratings each, volume and pressure can be regulated by motor size and RPM.

COSTS

1. Cost information available from manufacturer or distributor.

INSTALLATION REQUIREMENTS

1. Blower may be installed outside if proper lubrication is made (30-50 SAE depending on ambient temperature, PSI, etc.).
2. Electrical and piping skills required, filter-muffler needed in sandy locales, firm base needed, inlet screen recommended.

OPERATION & MAINTENANCE REQUIREMENTS

1. Regular maintenance and inspection recommended.
2. Oiling and checking for wear can be done by operator, adjustments should be made after consulting factory.
3. If unit is shut down for 24-48 hours, it should be flushed with oil and kerosene to prevent rusting.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
All	NA	NA	NA	NA			Air at SG of 1.0	Noise.[2] No odors.		

[2]Noise abatement materials (mufflers, silencers, etc.) available.

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on workmanship and material.
2. All labor paid for by owner.
3. Motor unit guaranteed separately, by respective manufacturer.
4. Service can be included with sewage plant maintenance.

TECHNICAL PERFORMANCE

1. Ratings based on air at specific gravity of 1.0.
2. Non-vibrating relief valves assure constant pressure, units claim constant volume regardless of temperature, barometric pressure.

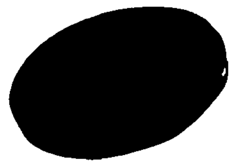
COMMENTS

ACCURATE AS OF July 31, 1972

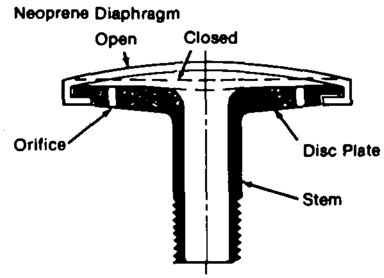
1. Roots AF blowers made by:
Roots Blower and Vacuum Pump Division
Dresser Industries
Connersville, Indiana
for distribution by Pollution Control, Inc.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Disc Plate Unit

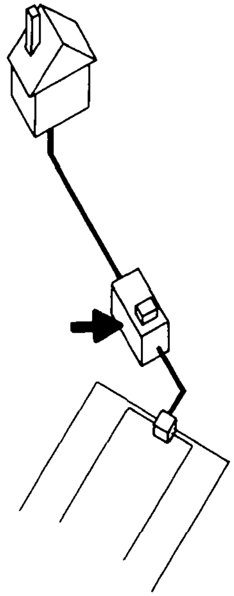


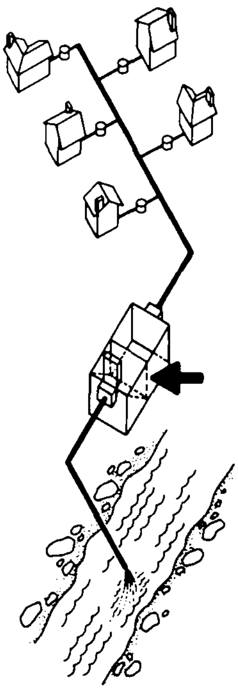
Air Chek Diaphragm



TYPICAL CROSS SECTION

ACTIVATOR HYDRO-CHEK AIR DIFFUSERS





POLLUTION CONTROL, INC.
N. WING, LUNKEN AIRPORT ADMINISTRATION BLDG.
CINCINNATI, OHIO 45226
(513) 871-2754
Attn: Mr. Fred Tipton, Vice President

ACTIVATOR

HYDRO-CHEK AIR DIFFUSER

FEATURES

1. Plastic two part diffuser: (1) disc plate, (2) neoprene diaphragm.
2. Non-clog diaphragm closes orifices upon loss of pressure.
3. Ten 0.125 inch diameter orifices discharge air downward.

OPERATION

1. Air pumped from compressor enters diaphragm and flows down through orifices.
2. In rising outside of diffuser, air bubbles hit diffuser plate and increase oxygen transfer efficiency by shearing into smaller bubbles.
3. When air stops, diaphragm is forced by outside pressure to be seated against disc plate, restricting backflow of tank water into diffuser.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			

SIZING & GROWTH POTENTIAL

COSTS

INSTALLATION REQUIREMENTS

1. Simple pipe-fitting diffuser head, plumbing skills recommended.

OPERATION & MAINTENANCE REQUIREMENTS

1. Turbulent flow of air on diaphragm eliminates algae build-up, no maintenance.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE

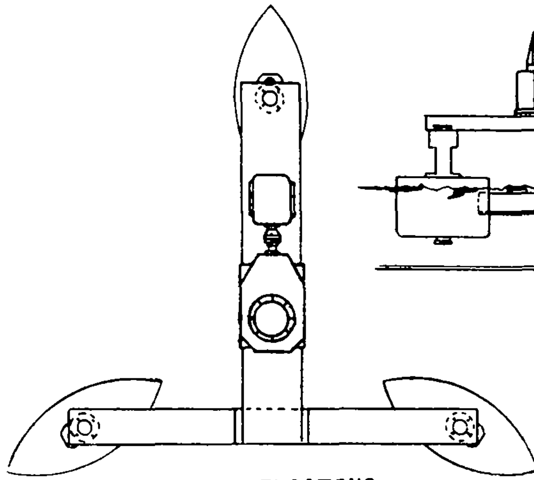
TECHNICAL PERFORMANCE

1. Minimum oxygen transfer of 12%.
2. Designed for 2 to 5 CFM, will operate at up to 20 CFM at loss of pressure.

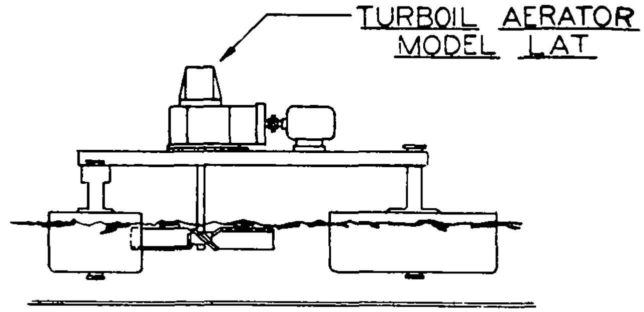
COMMENTS **ACCURATE AS OF** July 31, 1972

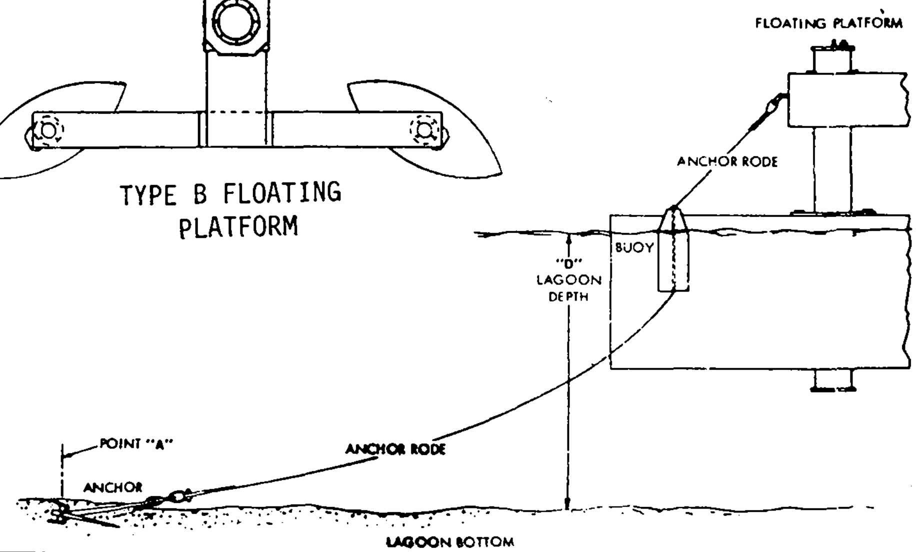
1. Information on sizing, costs and technical performance available from manufacturer.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



TYPE B FLOATING PLATFORM



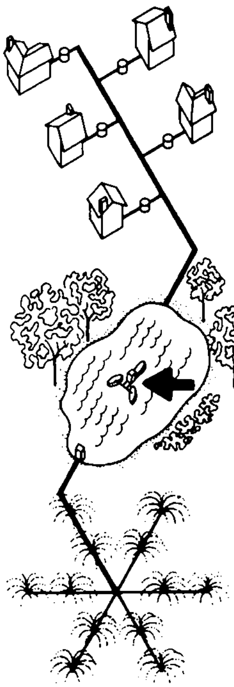


ANCHORING ASSEMBLY FOR TYPE B FLOATING PLATFORM

TURBOIL® FLOATING AERATORS

Suburbia

Lagoon anchored surface aeration with or without decking (Types A and B)



SUBURBIA SYSTEMS, INC.
3785 WEST 95TH ST.
P. O. BOX 6217
LEAWOOD, KANSAS 66206
(913) 649-4994
Attn: Mr. L. C. Sandy, Vice-President, Sales

TURBOIL® AERATORS

FLOATING AERATORS

FEATURES
1. Pontoon-type floating aerators for lagoon or shallow pond aeration; four mechanical turbines.
2. Turboil aerator with motor and "hollow quill" shaft mounting; geared speed reducers.
3. Closed cell polyurethane-filled stainless steel pontoons covered with Hysol Epoxy Resin System CG-4227 and HZ-3487.
4. Two pontoon configurations: Type A, with safety tread deck; Type B, without decking.
5. Type LAR and LAT motors.

OPERATION
1. Surface aerator floats on top of lagoon water, anchored by cables to lagoon floor.
2. Mechanical mixer "stirs" water, adding dissolved oxygen to water for aerobic treatment and liquid motion for suspension of solids.
3. Circulation of aerated water achieves distribution of treatment.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			

SIZING & GROWTH POTENTIAL
1. Floating aerator platforms Type A and B come with Models LAR and LAT aerators.
2. For Turboil aerators from 1 to 150 HP, pumping capacities of 4,000 to 132,000 GPM are estimated.

COSTS
1. Auxiliary legs for lagoon bottom support are optional extras.

INSTALLATION REQUIREMENTS
1. No special skills required beyond electrical hook-up.
2. Anchor mooring cables and attach electrical cable.

OPERATION & MAINTENANCE REQUIREMENTS
1. Periodic inspection, oil change.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year warranty on parts and workmanship (labor extra).
2. Performance guarantees on oxygen transfer and mixing specifications.

TECHNICAL PERFORMANCE
1. Standard oxygen transfer efficiency of 3-4 lb O_2/HP hour; use standard application data to process employed.
2. Aerator drive rated in accord with AGMA 430.03.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. More information on pricing and sizing available from manufacturer.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Disinfection Devices

Introduction

Even with properly operating equipment, present standards and practices for water treatment do not assure complete disinfection.* When disinfection devices are improperly adjusted or when they are subject to malfunctions, the likelihood of their passing disease-causing organisms on to the receiving medium increases significantly.

The development of effective and highly reliable disinfection units is of great priority.

A variety of disinfection devices which can be used for disinfecting wastewater are described in this section. The most widely used method of disinfection is chlorination. Chlorine can be introduced in the gaseous state, as a solution of hypochlorite (household bleach, for example), and as solid hypochlorite or other chemical compounds of chlorine. Whatever the form of introduction, the approach is to provide enough chlorine so that all organisms and substances that combine with chlorine will combine completely. An indication of the presumed sufficiency of the chlorination is a residual of free chlorine.

Chlorination takes time to kill organisms. Systems are designed such that the product of residual chlorine concentration and the chlorine-effluent contact time will equal a designated value which depends on the temperature and pH (alkalinity or acidity) of the water. Several chlorinators are described in this section.

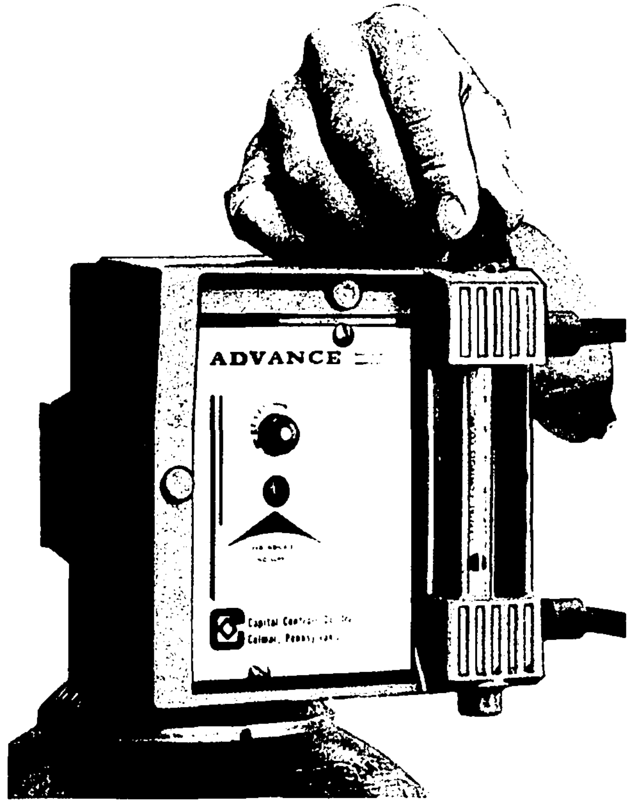
Ozone, O_3, is a powerful agent for disinfection. Ozone can be created from oxygen gas by passing air through an electric discharge or through intense ultraviolet radiation of proper wavelengths. Ozone rich air is bubbled through the effluent, and as in the case of chlorine, it disinfects by oxidizing vital organic compounds which are constituents of microorganisms.

Ultraviolet radiation as well as ionizing radiation from other sources such as radioactive isotopes can be used to kill microorganisms. The ionizing radiation breaks apart key molecules which contain the basic information the cell needs in order to function. The completeness of kill depends on the wavelength and the intensity and duration of the radiation, as well as the amount of material (glass, water, for example) it must penetrate. Ionizing radiation units have been developed for municipal plants, but they are not generally available for small rural systems.

Pasteurization, or the killing of microorganisms contained in a liquid medium with prolonged application of heat, is another method of disinfection which may be especially

*The *Washington Post* reported contaminated drinking water in two Massachusetts cities with drinking-water treatment systems which "are not merely 'good' but of higher quality than those used for 'most of our waters' in the United States." [38] The water supplies of the two cities were found to contain viruses that cause disease in man. The discovery was said to be the first of its kind for properly treated water in the U.S.—previously discovered viruses in treated water supplies had been traced to malfunctions in treatment procedures.

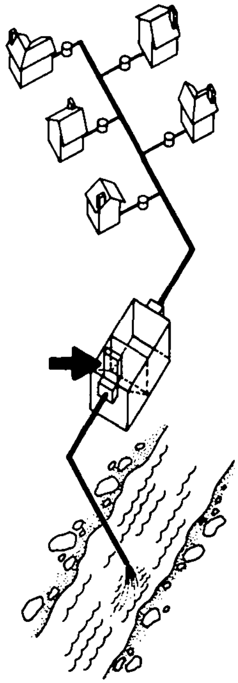
applicable to on-site treatment plants. By efficient design, energy can be transferred from the pasteurized treated effluent to the influent or to the mixed liquor through the use of heat exchangers. The resultant rise in temperature will generally speed up the processing of the sewage. One manufacturer plans to make pasteurization units for small plants available in the near future.



ADVANCE CHLORINATORS

CAPITAL

Mounted In-Line chlorinators



CAPITAL CONTROLS CO.
ADVANCE LANE
COLMAR, PA. 18915
(215) 822-2801
Attn: Sales Manager

ADVANCE CHLORINATORS

MOUNTED, IN-LINE CHLORINATORS

FEATURES
1. Vacuum operated gas chlorinators have flow meter, vacuum regulator valve box and in-line ejector.
2. Regulator cuts off chlorine when water supply or vacuum is lost.
3. Wall, cylinder, ton container, and cabinet mounted models.
4. Out-of-gas indicators.
5. Remote injection mounting possible.
6. Indoor or outdoor installation.

OPERATION
1. Chlorine gas is drawn through controller by in-line vacuum.
2. Gas passes through rotameter and flow rate adjusting valve.
3. Water under pressure passes through injector creating a vacuum for drawing gas into water supply.
4. Chlorine solution enters point of application via diffuser.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Wall mounted	6 "	3 "	6"		0.3-100 ppm	NA	600 - 1000		See Costs Below		None, unless booster pump needed		Chlorine, water for ejector, pump	
Ejector	$2\frac{1}{2}$"	$2\frac{1}{2}$"	3"											

SIZING & GROWTH POTENTIAL
1. Sizing is determined by ppm desired:
   PPD = GPM x .012 x ppm desired
   or 1 ppm = 8.34 lb./M gals. of effluent.
2. Operation possible at 1/20 of maximum rating.

COSTS
1. Chlorine costs run about 15-17¢/lb. for 150 lb. cylinders and about 6-9¢/lb. for ton containers.
2. Booster pumps run about $115 - $500.

INSTALLATION REQUIREMENTS
1. Can be installed cylinder mounted, ton-container mounted, wall in-line or cabinet mounted.
2. Installation by qualified personnel: need water for injector (can use offshoot of effluent), booster pumps, vent, chlorine gas.

OPERATION & MAINTENANCE REQUIREMENTS
1. Four modes of operation possible: residual control, flow proportioning, compound loop control, manual on-off.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE
1. 3 year warranty on parts and workmanship.
2. Factory service - $50 for overhaul and shipping; temporary replacement furnished for repair period.

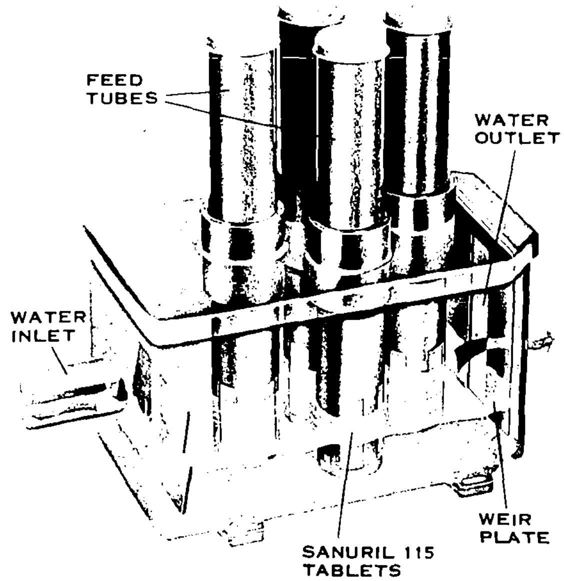
TECHNICAL PERFORMANCE
1. Up to 8000 PPD capacities available.

COMMENTS

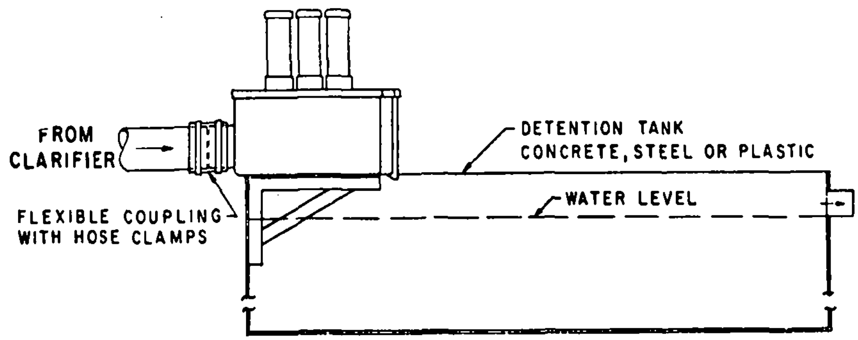
ACCURATE AS OF July 31, 1972

1. Residual analysis and related equipment available.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

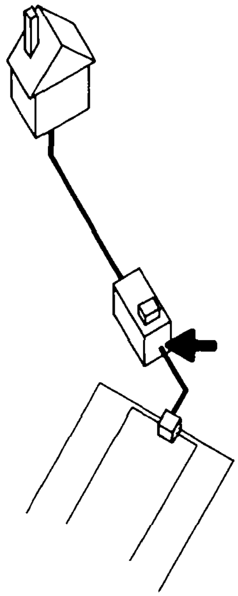


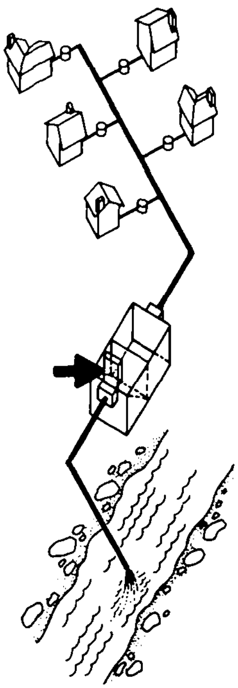
Chlorinator



SANURIL® PELLET FEED CHLORINATORS

Diamond Shamrock Corporation





DIAMOND SHAMROCK CORPORATION
T. R. EVANS RESEARCH CENTER
P. O. BOX 348
PAINESVILLE, OHIO 44077
(216) 352-9311
Attn: Mr. Roland Horvath, Manager, Sanuril Systems

SANURIL®

PELLET FEED CHLORINATOR

FEATURES

1. Four models of reinforced polyester fiberglass chlorinators operate within the range of individual home to 100,000 GPD flows.
2. Each has tubes descending into flow-through compartment, where Sanuril 115 tablets in tubes slowly disintegrate into water stream.
3. "Mini-San"® Model 200 for home unit; Model 100 for small package plant; Models 1000 and 1001 (similar) for larger capacities.

OPERATION

1. Wastewater flows past Sanuril 115 tablets in compartment for chlorine-saturation; more flow, more tablet exposure.
2. Sanuril System is placed on effluent flow line or within system to disinfect treated wastewater with 0.5 to 2 ppm depending on set-up.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT[1]				SUGG. LIST (FOB FACTORY)[2]	INSTALL COST[3]	OPERATE COST		ELECTRICITY (RATING)			
Model 200	21"	8"	10"		Up to 1,500	NA		1/2 man-day, if retrofit	See Costs Below	10	NA		Sanuril 115 Tablets	
Model 100	"	"	9"		Up to 10,000	"	160.	"	"	"	"		"	
Model 1000	22"	13"	12"		10,000-50,000	"	285.	"	"	"	"		"	

[1] 24' feed tubes hold 29 tablets. [2] FOB, Ashtabula, Ohio. [3] Minimal installation costs if factory installed. (Actual prices will be quoted competitively)

SIZING & GROWTH POTENTIAL

1. Sanuril Systems are adaptable and may be put in parallel configurations for larger flows; practical maximum is 100,000 GPD.

COSTS (Prices subject to change without notice.)

1. Cost/unit is less by larger quantities.
2. Average operating cost is 2-4¢/1000 gal of water @ 0.5-1.0 ppm and 30 minute detention time.
3. Sanuril 115 Tablets average $52/45 lb pail or $109/100 lb drum.

INSTALLATION REQUIREMENTS

1. Mounted in-line between clarifier and detention tank or in detention tank.
2. 3 1/2" or 4" PVC pipes fit inlets on Models 100 and 200; 6" PVC on Model 1000.

OPERATION & MAINTENANCE REQUIREMENTS

1. Monthly recharging necessary.
2. 60 day maximum chlorine capacity.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD	E. Coli (R)					
Sanuril 115 Tablets					98.3[4]		Unlimited Exposure		U.S. Patents	

[4] Based on 3500 GPD tests.

WARRANTIES, GUARANTEES, & SERVICE

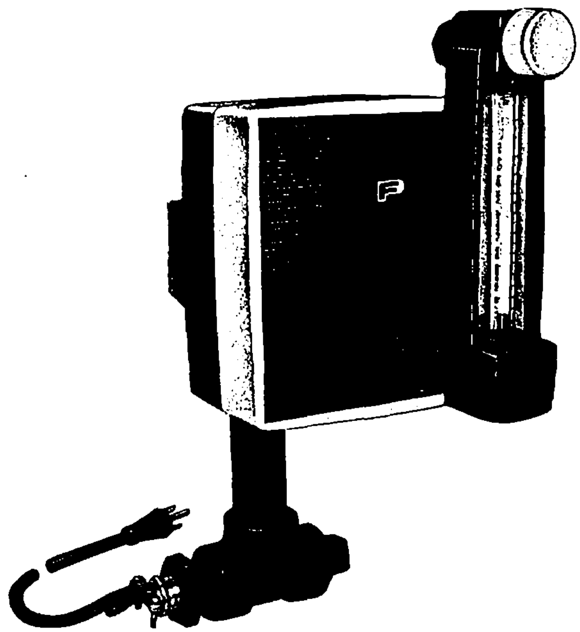
TECHNICAL PERFORMANCE

1. Sanuril 115 Tablets (3 1/8" dia. x 13/16" @ 4 1/2 oz.) have 70% Cl_2 content minimum. U. S. Patent Nos: 3,165,521 and 3,445,383.
2. Under testing by NSF, Ann Arbor, Michigan.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Units are sold by sewage treatment equipment manufacturers and their representatives.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

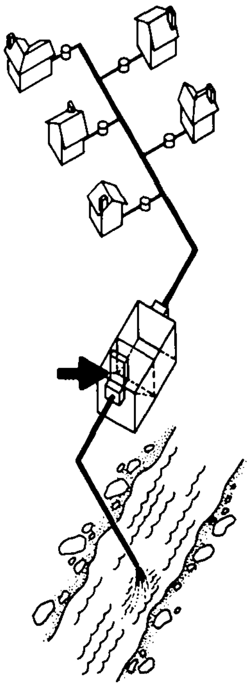


Wall Mounted Model

FISCHER & PORTER

F & P CHLORINATORS

Mounted In-Line Chlorinators



FISCHER & PORTER CO.
WARMINSTER, PA. 18974
(215) 675-6000
Attn: Mr. William Nagel, Product Marketing Manager-Chlorinators

F&P CHLORINATORS

MOUNTED, IN-LINE CHLORINATORS

FEATURES

1. Vacuum operated gas chlorinators have flowmeter, vacuum regulator valve box and in-line ejector.
2. Regulator cuts off chlorine when water supply or vacuum is lost.
3. Wall, cylinder, ton container, and cabinet mounted models.
4. Out-of-gas indicators.
5. Remote ejector mounting possible.
6. Indoor or outdoor installation.

OPERATION

1. Chlorine gas is drawn through controller by in-line vacuum.
2. Gas passes through rotameter and flow rate adjusting valve.
3. Water under pressure passes through injector creating a vacuum for drawing gas into water supply.
4. Chlorine solution enters point of application via diffuser.

MODEL NUMBER (MAJOR)	DIMENSIONS [1]			WEIGHT (LB.)	RATED CAPACITY	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
70C 1710	$6\frac{3}{16}$"	$7\frac{9}{16}$"	8"		1-500 PPD	NA			See Costs Below		None, unless booster pump needed		Chlorine, water for ejector, pump	
70C 1730	"	$10\frac{5}{16}$"	"		"	"	600 - 1100		"					
70C 1750	18"	10"	58"		1-300 PPD	"			"					
Ejector [2]	$11\frac{7}{16}$"	$3\frac{1}{4}$"	$8\frac{5}{8}$"											

[1] For gas dispenser - control box; 1710 - Cylinder mounted, 1730 - ton container mounted, 1750 - cabinet model.
[2] For 1" ID hose.

SIZING & GROWTH POTENTIAL

1. Sizing is determined by ppm desired:
   PPD = GPM x .012 x ppm desired
   or 1 ppm = 8.34 lb./M gals. of effluent.
2. Operation possible at 1/20 of maximum rating.

COSTS

1. Chlorine costs run about 15-17¢/lb. for 150 lb. cylinders and about 6-9¢/lb. for ton containers.
2. Booster pumps run about $115 - $500.

INSTALLATION REQUIREMENTS

1. Can be installed cylinder mounted, ton-container mounted, wall in-line or cabinet mounted.
2. Installation by qualified personnel: need water for injector (can use offshoot of effluent), booster pumps, vent, chlorine gas.

OPERATION & MAINTENANCE REQUIREMENTS

1. No special training required for operation.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE

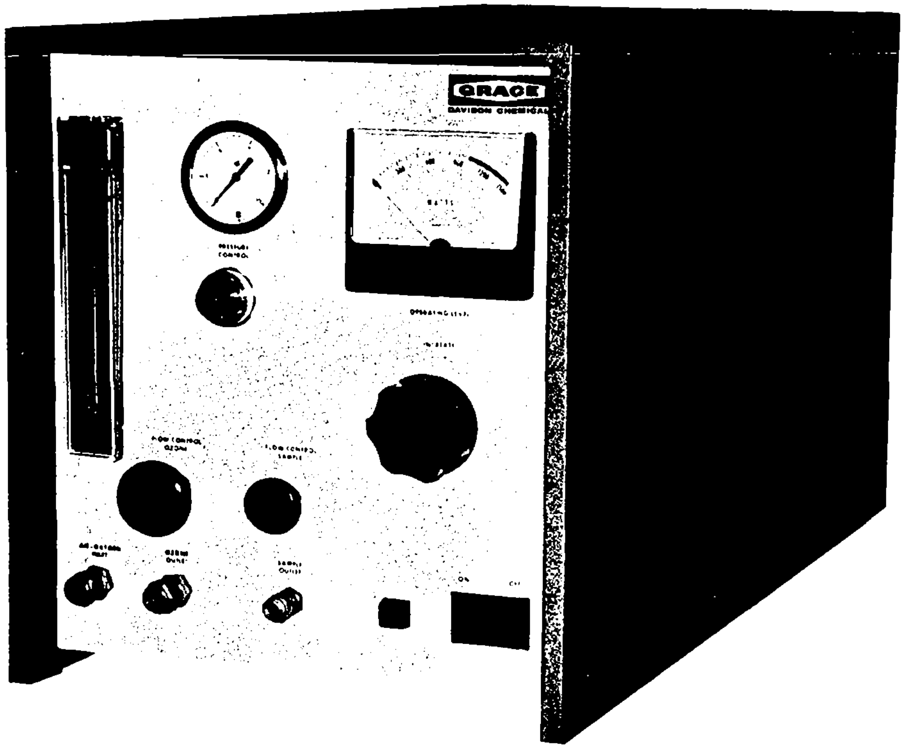
1. 1 year warranty on parts and workmanship.
2. Exchange policies available, factory service is about $50 plus $25 for stand-by replacement.

TECHNICAL PERFORMANCE

COMMENTS **ACCURATE AS OF** July 31, 1972

1. All models shipped with standard accessories including installation and operating instructions. Ejector is designed to handle all pressure conditions.
2. Multiple-point and larger capacities available with automatic changeover.
3. Residual analyzers and related equipment available.

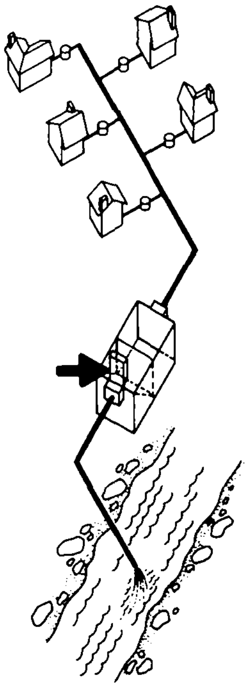
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



MODEL LG-2 OZONATOR

GRACE OZONE CORONA GENERATORS

GRACE DAVISON CHEMICAL



W. R. GRACE & CO.
DAVISON CHEMICAL DIVISION
10 E. BALTIMORE ST.
BALTIMORE, MARYLAND 21203
(301) 727-3900
Attn: Dr. H. M. Rosen, Manager, Pollution Control Systems

OZONE GENERATORS

OZONATORS-CORONA GENERATORS PLUS AIR PREPARATION PACKAGE

FEATURES

1. Skid-mounted ozonators, requiring only electrical and end-use connections.
2. Advanced solid-state, air cooled technology and extensive safety circuits.
3. Fully integrated circuits operated from central control panel.
4. Ozone finds application in the following: a) Disinfection, b) BOD-COD reduction, c) Odor control, d) Taste and color reduction in potable supplies.
5. Two modes of operation are illustrated. Disinfection alone can be achieved at 2 ppm O_3. Disinfection and BOD reduction are achieved above 25 ppm O_3.

OPERATION

1. Clean, dry (-40°F dewpoint) air is produced by means of compressor-dryer package.
2. Ozone is generated from oxygen in air stream passed through corona discharge.
3. Ozone released for contact under slight pressure.
4. Contact achieved through available low-cost specially designed systems.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD) [1]	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	OZONE PROD. (PPD)
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST [2]		ELECTRICITY (RATING)			
LG-2-CDA	26"	15"	44"	320	60,000 / 4,800	NA	3,250.		'15	15-20	115 V AC 60 Hz 1 ph		None	0.8
LG-4-CDA	120"	48"	66"	2300	336,000 / 26,887	"	17,500.		14	"	220 V 60 Hz 1 ph		"	4
LG-8-CDA	126"	"	"	2400	660,000 / 52,800	"	20,100.		"	"	220 V 60 Hz 1 or 3 ph		"	9
LG-16-CDA	129"	"	80"	2500	,320,000 / 105,600	"	23,700.		"	"	"		"	18

[1] Disinfection @ 2 ppm/BOD Reduction @ 25 ppm. [2] Operating costs for Kwh/lb. O_3.

SIZING & GROWTH POTENTIAL

1. Modular units may be built up or expanded to meet specific requirements.

COSTS

1. Automatic pacing, monitoring available at additional cost.
2. Operating costs shown include only electrical costs; electrical costs for LG-2 @ 2 ppm for 60,000 GPD is about 30-45¢/day (@ 2-3¢ per Kwh).

INSTALLATION REQUIREMENTS

1. Protection from rain and snow with provision for ventilation; 4-6" concrete pad.
2. Manufacturer supplies contact specifications.
3. Electrical and plumbing (end-use connections) skills required.

OPERATION & MAINTENANCE REQUIREMENTS

1. Compressor-dryer as recommended by manufacturer.
2. Sewage plant operator oversees; automatic pacing available.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 [3] (R)	SS [4] (R)	DO (A)	COD [5] (R)	BACT. (R)	COLOR (R)				
LG-2-CDA	0.8 lb.	30-40%	Saturation	0.5 lb.	99-100%	60-80%	Effluent - 110°F maximum	Min. noise. No odors.	NEMA and NEC	
LG-4-CDA	4 lb.	"	"	2.0 lb.	"	"	"	"	"	
LG-8-CDA	9 lb.	"	"	5.5 lb.	"	"	"	"	"	
LG-16-CDA	18 lb.	"	"	11.0 lb.	"	"	"	"	"	

[3] BOD reduction with 25 ppm O_3 dosage (~1 lb./lb. O_3). [4] Froth separation. [5] COD reduction with 25 ppm O_3 dosage (~0.5 lb./lb. O_3).

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year guarantee on parts and labor. Components other than manufactured by Grace carry original manufacturer's warranty.

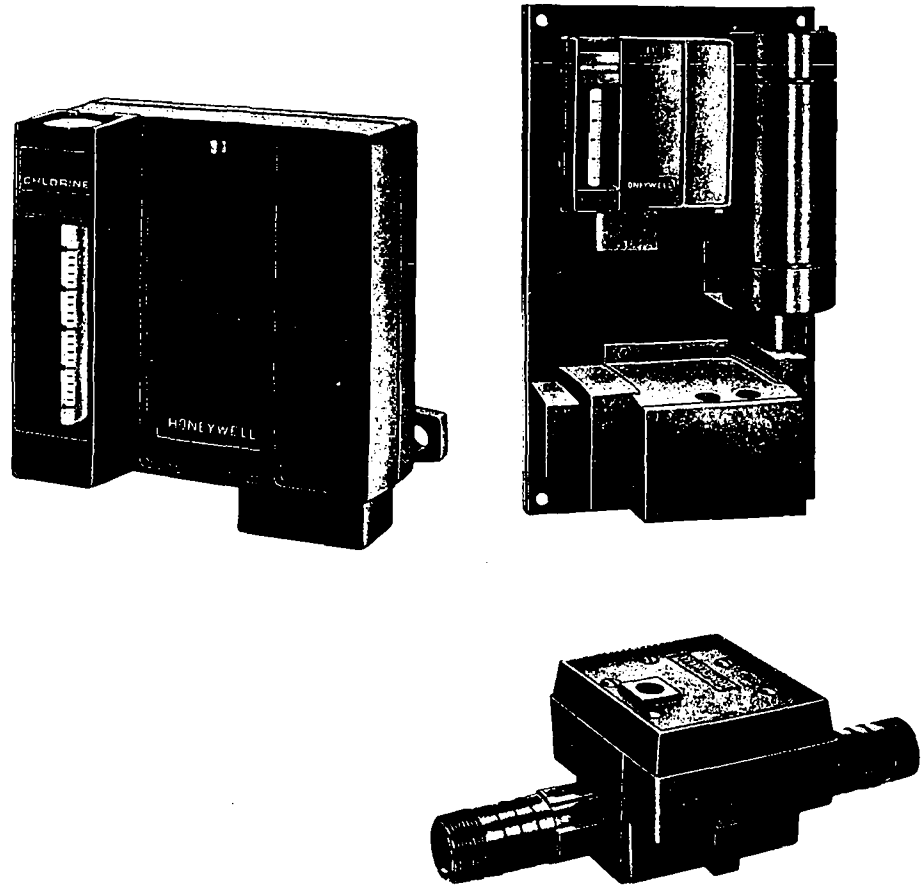
TECHNICAL PERFORMANCE

1. Guaranteed to produce at rated capacity if operated according to recommended procedures.

COMMENTS

ACCURATE AS OF July 31, 1972

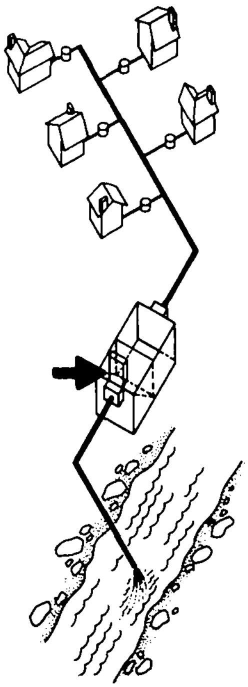
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



HONEYWELL CHLORINATORS

Honeywell
The Automation Company

Mounted In-Line Chlorinators



HONEYWELL
INDUSTRIAL DIVISION
1100 VIRGINIA DRIVE
FORT WASHINGTON, PA. 19034
(215) 643-1300
Attn: Water Management Division

HONEYWELL CHLORINATORS

MOUNTED, IN-LINE CHLORINATORS

FEATURES

1. Vacuum operated gas chlorinators have flow meter, vacuum regulator valve box and in-line ejector.
2. Regulator cuts off chlorine when water supply or vacuum is lost.
3. Wall, cylinder, ton container, and cabinet mounted models.
4. Out-of-gas indicators.
5. Remote injection mounting possible.
6. Indoor or outdoor installation.

OPERATION

1. Chlorine gas is drawn through controller by in-line vacuum.
2. Gas passes through rotameter and flow rate adjusting valve.
3. Water under pressure passes through injector creating a vacuum for drawing gas into water supply.
4. Chlorine solution enters point of application via diffuser.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
S543-21 (Wall)	$6\frac{3}{8}$"	$6\frac{1}{8}$"	$9\frac{1}{4}$"	25	4-500 PPD		600 - 1200		See Costs Below		None, unless booster pump needed		Chlorine, water for ejector, pump	
S543-25 (Cabinet)	$26\frac{3}{4}$"	15"	66"	200	"		1400 - 1600		"		"		"	
Injector	$11\frac{1}{2}$"	$4\frac{5}{16}$"	$3\frac{5}{8}$"	3										

SIZING & GROWTH POTENTIAL

1. Sizing is determined by ppm desired:
   PPD = GPM x .012 x ppm desired
   or 1 ppm = 8.34 lb./M gals. of effluent.
2. Operation possible at 1/20 of maximum rating.

COSTS

1. Chlorine costs runs about 15-17¢/lb. for 150 lb. cylinders and about 6-9¢/lb. for ton containers.
2. Booster pumps run about $115 - $500.
3. Automatic pacing runs about $1000 extra.

INSTALLATION REQUIREMENTS

1. Can be installed cylinder mounted, ton-container mounted, wall in-line, or cabinet mounted.
2. Installation by qualified personnel: need water for injector (can use offshoot of effluent), booster pumps, vent, chlorine gas.

OPERATION & MAINTENANCE REQUIREMENTS

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on parts and workmanship.

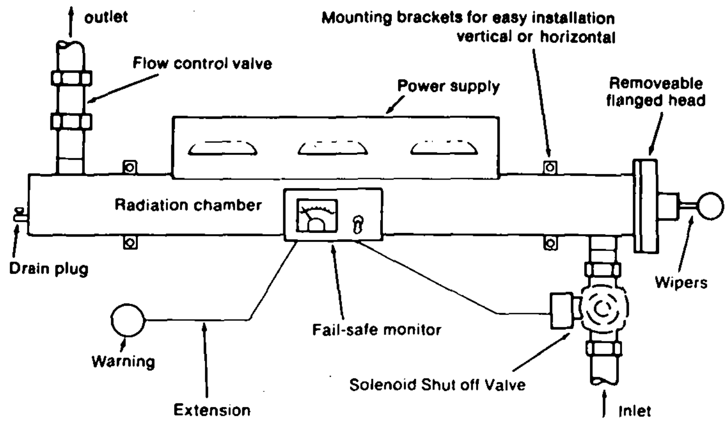
TECHNICAL PERFORMANCE

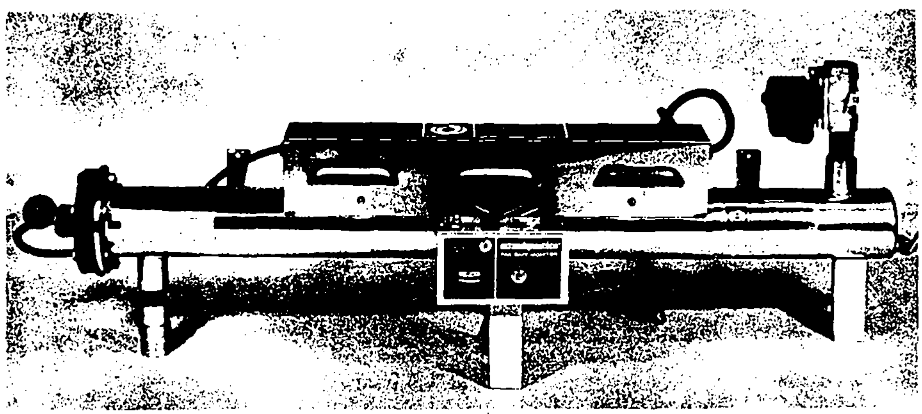
1. Molded ABS housing; tantalum-tungsten springs.
2. Controller accuracy of ± 4% over 20:1 range.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Honeywell also carries other flow control and metering devices for in-line applications.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



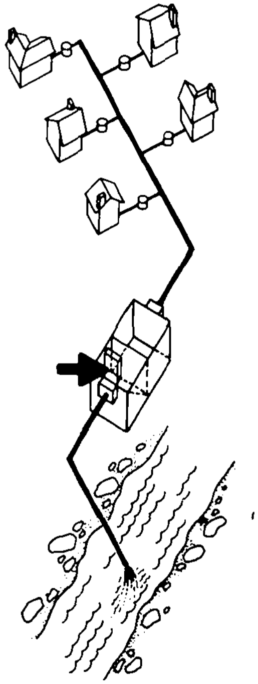


MODEL 500 SF PURIFIER

ULTRA DYNAMICS® PURIFIERS

ULTRA DYNAMICS CORPORATION

Ultra-violet in-line purification-disinfection units



ULTRA-DYNAMICS CORPORATION
2 WAIT STREET
PATERSON, NEW JERSEY 07524
(201) 684-5900
Attn: Mr. Dale E. Wiltrout, Director of Marketing

ULTRA-DYNAMICS® PURIFIERS

ULTRA-VIOLET DISINFECTION UNIT

FEATURES
1. Electronically monitored cylindrical ultra-violet disinfection units of 304 stainless steel purify water at constant flows of 300 to 72,000 GPH.
2. In-line units have "fail-safe" monitor with solenoid shut-off and alarm for malfunctions, 60 second quartz and U.V. lamp change, drains, removable flange heads, flow control valves.
3. U.V. lamp enclosed in quartz jacket with manual or automatic wiper-cleaners.
4. Special "Al-Bac" lamps offer O_3 and H_2O_2 protective residual.

OPERATION
1. Effluent enters radiation chamber through solenoid shutoff valve inlet.
2. Treated wastewater passes through chamber, ultra-violet radiation is emitted by lamp, passes through quartz jacket and is absorbed by organisms which are destroyed on impact.
3. Treated water leaves chamber at constant flow regulated by flow control valve.

MODEL NUMBER (MAJOR)[1]	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPH)[2]	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST[3]	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
500-SF	41"	$10\frac{1}{2}$"	7"	38	500	NA	$650. (Lamp - $39)	See Costs Below	27/yr.	Lamp - 1 yr.	120 V AC 60 Hz 40 W		None	
2000-SF-HP	"	$15\frac{1}{2}$"	$12\frac{1}{2}$"	79	2000	"	$1530. (Lamps - $156)	"	110/yr.	"	120 V AC 60 Hz 160 W		"	
6000-2 SF-HP	52"	$12\frac{1}{2}$"	$27\frac{1}{2}$"	145	6000	"	$3063. (2" Female IPS)	"	220/yr.	"	110/120 V 50/60 Hz 400 W		"	
12000-4 SF-HP	$57\frac{1}{2}$"	"	$57\frac{1}{2}$"	290	12000	"	$5625. (2" Female IPS)	"	438/yr.	"	110/120 V 50/60 Hz 640 W		"	

[1] Model # = GPH rated flow for 60% transmission (30,000 Ultrads @ 50°-80°F), S = Standard Power Supply, F = Fail Safe Monitor.
[2] Capacity at 30,000 Ultrads. [3] Includes electricity @ 2 1/2 ¢/Kwh plus annual lamp replacement.

SIZING & GROWTH POTENTIAL
1. Different sized models from 250 to 2000 GPH in 3/4" or 2" inlet IPS. Models 3000-12000 GPH in 2" inlet IPS or 3" or 4" standard flange.
2. For 220 volt/50 Hz operation, step-down transformer needed.

COSTS
1. For models 3000-12000, the 3" or 4" standard flange costs slightly more.
2. All models available with or without "fail-safe" monitor controls or automatic quartz jacket wipers.
3. Accessories include: "fail-safe" monitors (1-4 sensors), chart recorders, shut-off valves, flow control valves (5-90 GPM).

INSTALLATION REQUIREMENTS
1. Electrical and plumbing skills required for in-line installation - after pressure tank, meter or secondary treatment - ca 30-60 min. installations.
2. 120 V AC standard equipment.

OPERATION & MAINTENANCE REQUIREMENTS
1. On manual wipers, activate once daily (push-pull).
2. Replace lamps every 10 months continuous operation.
3. Occasional cleaning and water quality testing, viewing of lamp through view ports.

MODEL NUMBER (MAJOR)[4]	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5	SS	DO	COD	(R) Bio-Organisms	OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	U.V. Lamps
500-SF					99.9% kill	15-100 PSI working pres.; temperate env.	No noise, taste or odors.	U.S., foreign Patents granted and pending	1 - U.V. (1-chambered purifier) 7,500 hr. life
2000-SF-HP					"	"	"	"	4 - U.V. (1-chambered purifier) 7,500 hr. life
6000-2 SF-HP					"	"	"	"	8 - P-247 Extra (2-chambered purifier) High Intensity "Al-Bac"
12000-4 SF-HP					"	"	"	"	16 - U.V. (4-chambered purifier) 7,500 hr. life

[4] "HP" in model number = High Penetration Power Supply (P-163 transformers).

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year parts and workmanship.

TECHNICAL PERFORMANCE
1. 2537 Angstrom wavelength employed, kills bacteria, virus, fungus, spores and algae (polio, amebic cyst, hepatitis, ear fungus, etc.).
2. Guaranteed to exceed U.S. Public Health requirements (16,000 ultrads) with 30,000 ultrad minimum output.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. Ultra-Dynamics also manufactures different types of residual treatments for non-biological or other water quality problems.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Disposal of Treated Wastewater

Introduction

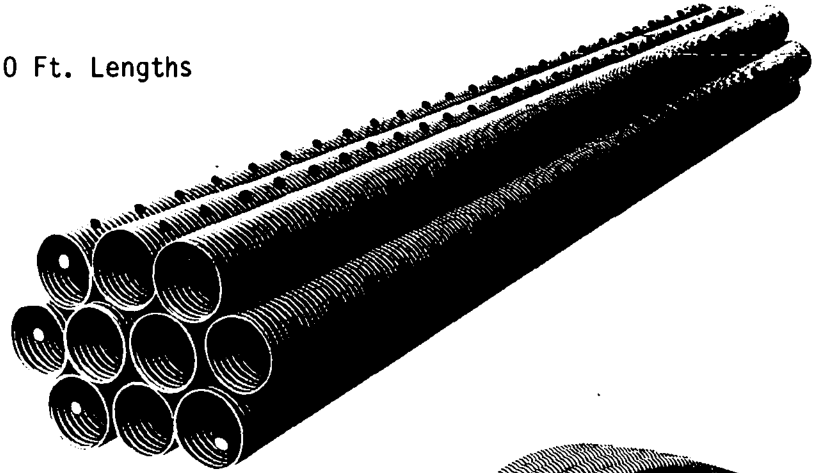
This section describes miscellaneous components for disposing of treated wastewater. Perforated bituminous fiber pipe and perforated corrugated high-density polyethylene pipe are included. The pipe conveys effluent from sewage treatment tanks through the subsurface soil absorption field. The effluent seeps out through the perforations and into the field. Clay tile (one-foot lengths of clay pipe) is also used for soil absorption fields. The tiles are laid with spacings of ⅛-inch to ¼-inch to permit the effluent to seep out.

A fairly recent approach to subsurface disposal involves distribution of effluent into precast concrete chambers which are open at the bottom and which cover the absorption bed. The chambers may be installed with the tops at or below grade level. A system of vents is designed to maintain aerobic seepage conditions in the bed. Covers in the top surface of the chambers may be removed to permit access to the bed for inspection and repair. Restoration of a clogged bed can be speeded up by removing the cover and breaking up the clogging layer with a rake.

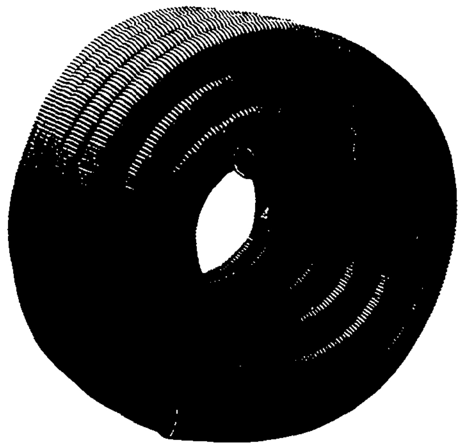
A two-way effluent diversion valve is described. The valve enables the user to switch the effluent from one soil absorption system to another in a dual installation. The alternating cycles are said to greatly prolong the lives of the fields.

Finally, sprinkler nozzles for spray irrigation and a large tower-like rotating sprayer for the same purpose are described.

10 Ft. Lengths

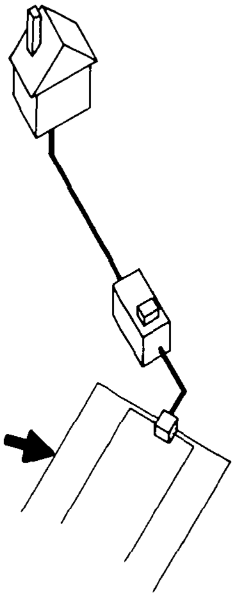


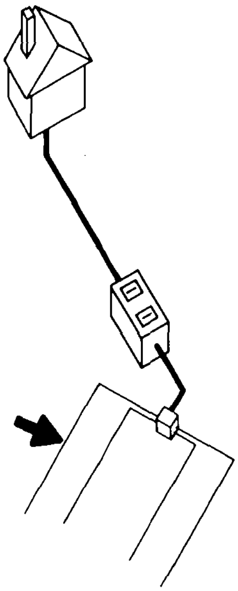
180 Ft. Rolls



ADS CORRUGATED PLASTIC TUBING

Corrugated plastic disposal tubing (4" diameter)





ADVANCED DRAINAGE SYSTEMS, INC.
1880 MACKENZIE DR.
COLUMBUS, OHIO 43220
Attn: Mr. W. B. Evans, Vice-President, Marketing

ADS® TUBING

CORRUGATED PLASTIC DISPOSAL TUBING

FEATURES

1. High density polyethylene perforated leaching field tubing available in long rolls or 10 ft. lengths.
2. Corrugated rings minimize thickness (weight) and maximize strength of plastic style.
3. Resistant to chemicals, deterioration and roots; meets 600 lb. crushing strength test.
4. 1/2" three hole style (9/ft.) has 1.98 sq. in. of drainage per foot; 3/4" hole and 2 hole styles offered.

OPERATION

1. Wastewater flows into pipe and through holes into leaching trench.
2. Pipes bend with movement of environment.
3. Recommended operation with gravity flow and zero internal pressure.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)[1]	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
402	10' & 180'	4" round		180' - 72 lb. .4/ft.			Varies: ca 15¢/ft.		None	Unlimited			Water and effluent	

[1]If properly installed.

SIZING & GROWTH POTENTIAL

1. Adapters to pipe or tile available.
2. Couplings, bends, etc., available; "split" or "snap-on" types.

COSTS

1. Adapters available at additional costs.
2. Priced competitively.

INSTALLATION REQUIREMENTS

1. Should be installed under proper bedding conditions, i.e., sand, crushed gravel 2 inches below and 8 inches above, for maximum strength.

OPERATION & MAINTENANCE REQUIREMENTS

1. Designed for underground water and sewage conveyance only.
2. Flow capacities similar to smooth-walled pipe as water or effluent fills up corrugated rings, for water on water flow interface.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	PERFORATIONS			CRUSHING STRENGTH 3-pt. BEARING[2]	AVERAGE "N"
	BOD_5	SS	DO	COD						ROWS	HOLE SIZE	SPACING		
402	NA	NA	NA	NA			Subsurface, gravity flow	No odors, if proply installed	CS228-61 FHA Mat. Release - 619A	3 2	1/2" 3/4"	4" @ 120° 4" @ 150°	600+	0.14

[2]lb./linear ft.

WARRANTIES, GUARANTEES, & SERVICE

1. Defective material replaced (labor not included).
2. ADS Corrugated plastic drainage tubing is guaranteed for 100 years when installed according to the specifications of SCS Code 606.
3. Installation recommendations and additional information/materials available from dealers.

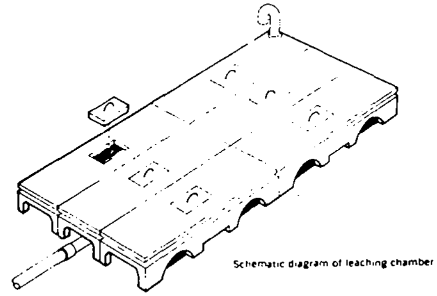
TECHNICAL PERFORMANCE

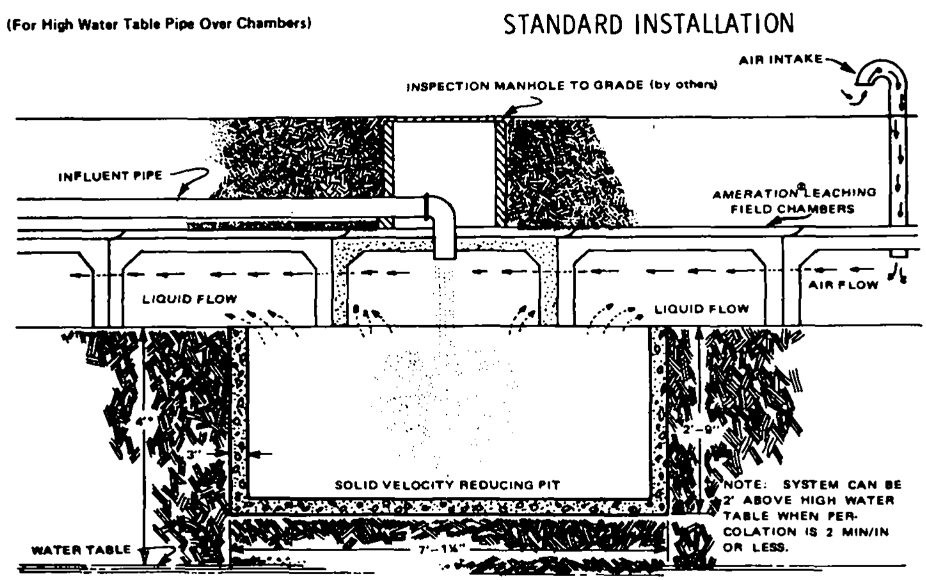
1. Patents pending.
2. ADS tubing meets CS 228-61, exceeds FHA materials release No. 619A, conforms to SCS, Code 606.
3. Tubing has crushing strength in excess of 600 lb. in accordance with ASTM C-4-55.
4. Tested by Patzig Laboratories in 1971 and Toledo Testing Laboratory in 1970 for structural and chemical strengths and workmanship.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Other tubing with or without perforations offered for other agricultural needs (drainage, water and air conveyance).

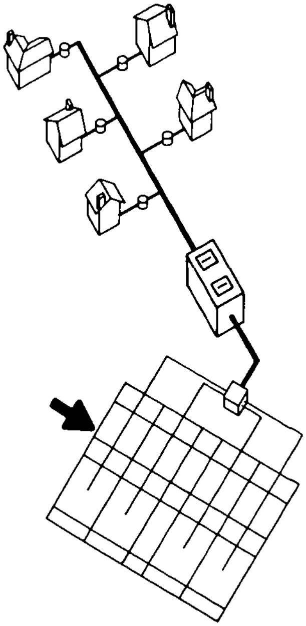
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.





AMERATION® CHAMBER LEACHING SYSTEM

American Precast



AMERICAN PRECAST CORPORATION
164 MEADOW ST.
FRAMINGHAM, MASSACHUSETTS 01701
(617) 877-5250
Attn: Mr. Edward Rollins, Vice-President, Ameration Division

AMERATION CHAMBER®

SUBSURFACE LEACHING CHAMBER

FEATURES

1. Precast concrete chambers formed by interlocking modules form underground effluent disposal cavern; intended to replace conventional leaching fields.
2. Manholes in roof for inspection/service.
3. Surface air vents to the chambers for air circulation and supply permit aerobic environment and resting/drying out of bed.
4. 100% use of leaching infiltration bottom area; shock load advantages.
5. Gravity flow on bed surface, supply lines collect in velocity-reducing pit.

OPERATION

1. Concrete chambers interlock to form a hollow underground cavern 18" deep.
2. Sewage tank effluent piped (gravity flow) to velocity-reducing pit.
3. Effluent flows over surface as with an intermittent sand filter.
4. Effluent infiltrates soil under aerobic conditions.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	DELIVERY COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	
Std. Module	13'	43"	$18\frac{1}{2}$"	3500	Sized by demand		1.70/ sq.ft.	0.20/ sq.ft.	0.20/ sq.ft.		None		Effluent	
H-20 Module	"	$45\frac{3}{4}$"	$20\frac{1}{2}$"	4000	"		2.10/ sq.ft.	"	"		"		"	

SIZING & GROWTH POTENTIAL

1. Increased infiltration area reduced total bed area; sized by system effluent output.
2. "Standard" for use under grassed fields; H-20 for use under traffic (up to H20 wheel loads).

COSTS

1. List cost does not include: velocity pits, piping, excavation (material costs).
2. Installation and delivery costs vary.

INSTALLATION REQUIREMENTS

1. Excavation, crane operation and disposal field design skills required.
2. Leveling and 8" x 16" x 1-1/2" concrete pads (to prevent settling) required.
3. Sand bed at least 30" below grade @ 1 foot cover required.

OPERATION & MAINTENANCE REQUIREMENTS

1. Bed can be cleaned and scraped through manholes for re-use; velocity pit can be pumped out.
2. Occasional inspection of bed manholes.
3. Chambers are interlocked to prevent infiltration of backfill.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
Std. Module	NA	NA	NA	NA			Subsurface, extensive soil applications	No odor, if Prop'ly installed	Patented	
H-20 Module	"	"	"	"			"	"	"	

WARRANTIES, GUARANTEES, & SERVICE

1. Guarantees to equal or exceed specifications set forth.
2. Replacement, free of charge, for defects in materials and workmanship for three years, if properly installed.
3. Systems designed/managed by American Precast personnel.

TECHNICAL PERFORMANCE

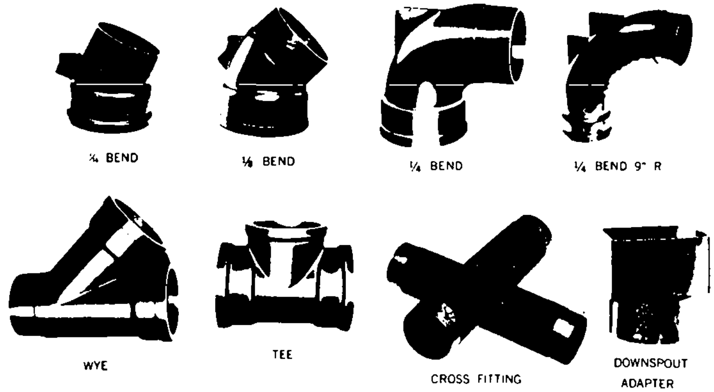
1. U. S. Patent No. 3,339,366.
2. Unrestricted flow of air and effluent provides aerobic environment, cavern allows "drying out" in rest periods.
3. Installations made for schools, apartment houses, motels, subdivisions, individual homes, etc.

COMMENTS

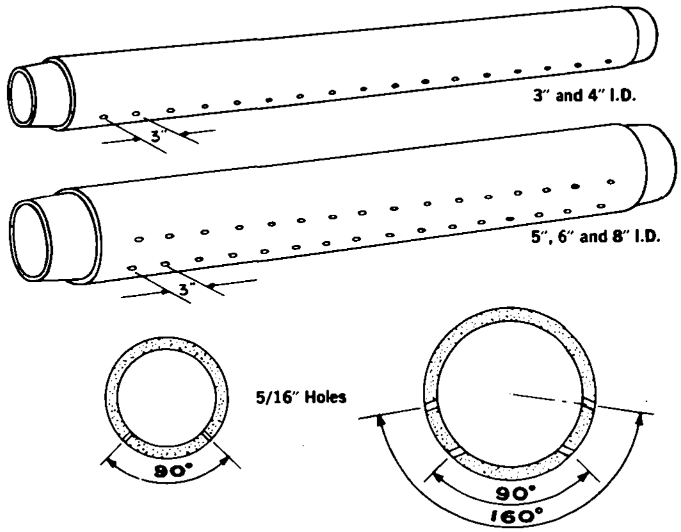
ACCURATE AS OF July 31, 1972

1. More information on pricing and requirements available from manufacturer.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

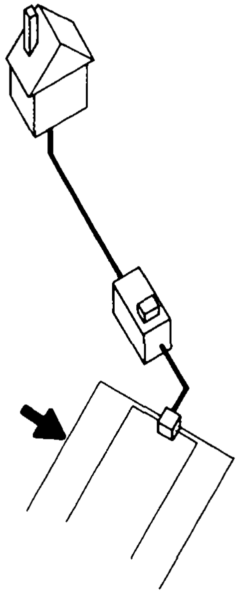


DESIGN OF ORANGEBURG PERFORATED PIPE



FLINTKOTE® PIPE PRODUCTS GROUP

ORANGEBURG® PIPE



THE FLINTKOTE COMPANY
PIPE PRODUCTS GROUP
ORANGEBURG, N. Y. 10962
(914) 359-3300
Attn: Mr. Frank Carlin, Manager, Fibre Pipe Sales

ORANGEBURG PIPE®

BITUMINOUS FIBRE PIPE (PERFORATED)

FEATURES
1. Round pipe made of pitch-impregnated wood fibre.
2. Used for conveyance of sewage and water between house and septic tank and leaching field, between septic systems and sewers, and combinations thereof.
3. Perforated pipe used for leaching fields (discussed on this sheet).
4. Inert materials, resistant to chemicals and deterioration and root-resistant.
5. Different sized diameters, smaller has two rows of holes, larger has four rows of holes, all in bottom half of pipe for distribution of effluent in disposal field.
6. Coupling sealed by friction-heated coupling rings or other fastening adapters for joining non-foreign pipes.

OPERATION
1. Unperforated pipe carries influent from house to septic or treatment tank.
2. Treated and settled effluent leaves tank in pipe to distribution box or "tee" and "wye" spreaders.
3. According to area required for disposal of effluent, several lines of perforated pipe carry water on slight slope and deliver water to disposal field through holes.

MODEL NUMBER (MAJOR)[1]	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
4" Type B	8'	4" round		2.0 lb/ft	NA	NA					NA		Influent or Effluent	
4" Type C	"	"		2.6 lb/ft	"	"					"		"	
6" Type C	5'-8'	6" round		5.4 lb/ft	"	"					"		"	

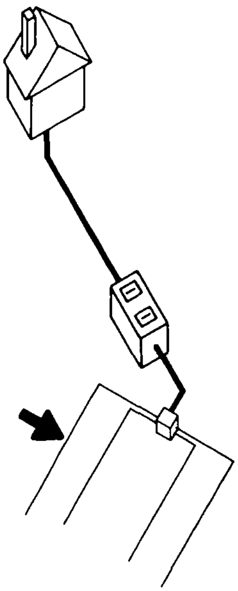
[1]Major pipe sizes by diameters (perforated).

SIZING & GROWTH POTENTIAL
1. Larger and smaller diameters available.
2. Up to 4" diameter - 2 rows of perforations; 5" and over - 4 rows of perforations.
3. Different lengths and multiple coupling and routing accessories available.

COSTS
1. Priced competitively.

INSTALLATION REQUIREMENTS
1. Trench and drainage bed system with sewage hook-up application.

OPERATION & MAINTENANCE REQUIREMENTS



MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	PERFORATIONS ROWS;SPACING	CRUSHING STRENGTH 360° BEARING[2]	AVERAGE "N"	FLOW CAPACITIES 1% SLOPE (GAL/MIN)[3]
	BOD_5	SS	DO	COD									
4" Type B	NA	NA	NA	NA				No odors, if prop'ly installed	ASTM, AASHO and Federal	2 ; 3" at 90°	4300	0.011	93
4" Type C	"	"	"	"				"	"	2; "	5300	"	93
6" Type C	"	"	"	"				"	"	4; "	7200	"	295

[2]1 inch deep - lb./linear ft.; at 3 pt. bearing: Type B--4" = 1000 lb./linear ft.; Type C--4" = 2040 lb./linear ft.

[3]Unperforated pipe.

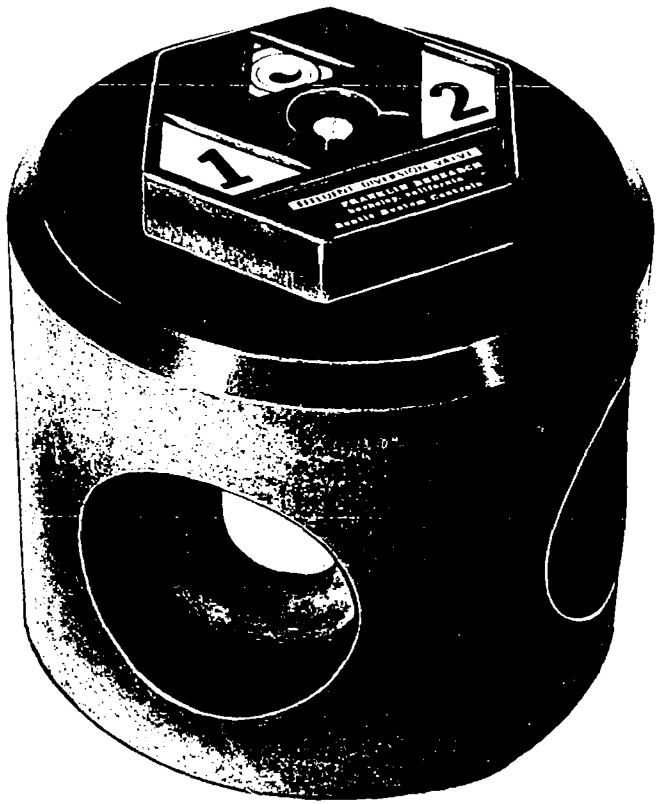
WARRANTIES, GUARANTEES, & SERVICE

TECHNICAL PERFORMANCE
1. ASTM - D2312-69. (Leaching fields)
2. ASTM - D2311-69. (Drainage)
3. ASTM - D2818-69. (Heavy Wall)
4. AASHO - M177-70 I (Heavy Wall)
5. Federal Spec. - SS-P-1540A. (Heavy Wall)
6. Member of Bituminous Pipe Institute.

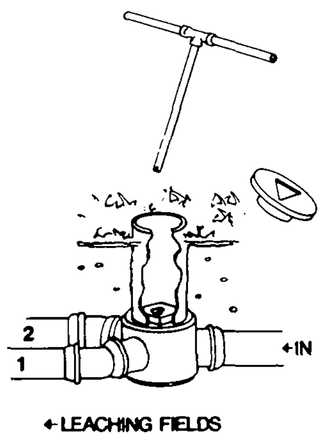
COMMENTS

ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



DIVERSION
VALVE

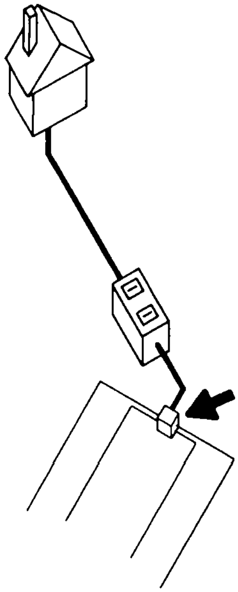


Typical
Installation

EFFLUENT DIVERTER

FRANKLIN
RESEARCH

Leaching field "switch-gate" for two-field dosing.



FRANKLIN RESEARCH
1220 SIXTH ST.
BERKELEY, CALIFORNIA 94710
(415) LA 4-5123
Attn: Mr. George F. French, President

EFFLUENT DIVERTER

LEACHING FIELD EFFLUENT DOSING VALVE

FEATURES

1. Three-way polyurethane and stainless steel valve which can be switched to permit septic-tank effluent to flow in either of two leaching fields.
2. Two telescoping sections come to the ground with cover for access to switch with long T-bar.
3. For pressurized or gravity flow operations.

OPERATION

1. Diversion valve has one connection to septic tank, two to leaching fields.
2. Once a year owner is notified to switch valve by opening cover and inserting T-bar to turn switch, changing the flow of sewage water, to "dose" fields and allow for unused field's recuperation from anaerobic slime.
3. Chart on handle for recording switches.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)[1]	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)[2]	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
DV03 Gravity Flow	8" round		8"	ca 5-10		NA	$85.	See Costs Below	None	50				
DV04 Pres-surized	"		"			"	$97.	"	"	"				

[1]Weight without extensions. [2]FOB, Berkeley, California.

SIZING & GROWTH POTENTIAL

1. Available with adapters for any pipe connections.
2. 3" - 4" pipes should be used for primary connections.

COSTS

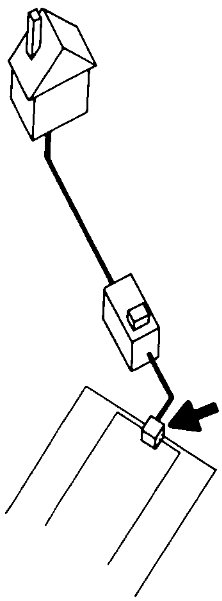
1. Pressurized unit cost includes molded-in fittings for any type of connecting pipe.

INSTALLATION REQUIREMENTS

1. Excavated replacement of distribution box - simple connections and no leveling.
2. Unskilled labor appropriate for installation.
3. Up to 48" depth allowed.

OPERATION & MAINTENANCE REQUIREMENTS

1. Once a year switching of valve.



MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
Both	NA	NA	NA	NA			-50°F to 130°F			

WARRANTIES, GUARANTEES, & SERVICE

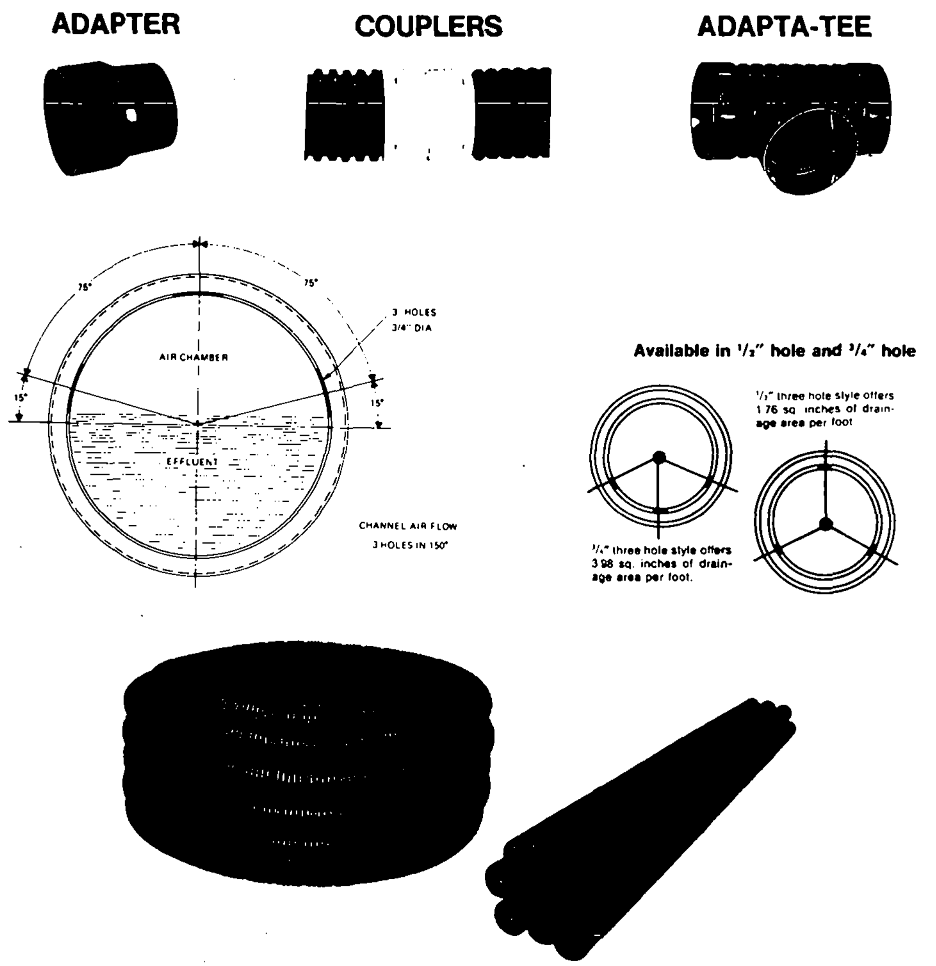
1. Once a year, for 10 years, owner is notified by mail to switch valve.
2. Free replacement where failure is due to manufacturer's defect.

TECHNICAL PERFORMANCE

COMMENTS

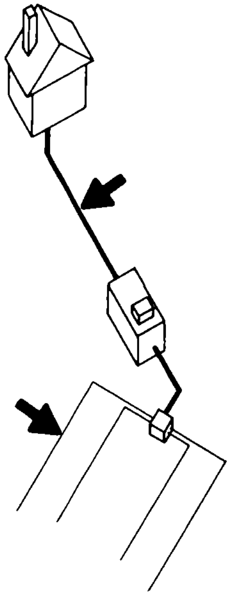
ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



CHANNEL FLOW® CORRUGATED PLASTIC DISPOSAL TUBING

HANCOR, INC.



HANCOR, INC.
P. O. BOX 1047
FINDLAY, OHIO 45840
(419) 422-6521
Attn: Mr. Fred Crates, Quality Control Department

CHANNEL FLOW®

CORRUGATED PLASTIC DISPOSAL TUBING

FEATURES

1. High density polyethylene flexible perforated tubing available in long rolls for leaching fields.
2. 1/2" three-hole style (9/ft.) has 1.76 sq. in. of drainage per foot; 3/4" three-hole style (9/ft.) has 3.98 sq. in of drainage per foot.
3. Corrugated rings to minimize thickness (weight) and maximize strength of plastic style.
4. Can be installed "flow-down" or in inverted flow position for even distribution.
5. 2" ID "Turf-Flow" used for air conveyance; 7'/lb., 90 perforations/ft. @ .008 x 3/8"; 500 foot rolls.

OPERATION

1. Wastewater flows into pipe and through holes into leaching trench.
2. Pipes bend with movement of environment.
3. Recommended operation with gravity flow and zero internal pressure.
4. "Turf-Flow" tubing can be used in draft-air system to aerate drainage beds. See page 65.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)		OPERATING SUPPLIES	
4" Channel Flow	10' and 225'	4" round		225' (4")@ 78 lb	NA	NA	Varies		None[1]		NA		Water and Effluent	

[1]If properly installed.

SIZING & GROWTH POTENTIAL

1. Adapters for tube to pipe or tile available.
2. Couplings, bends, etc., available; bends have self-contained couplings.

COSTS

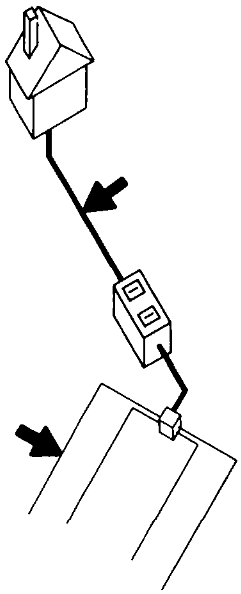
1. Adapters available at additional cost.
2. Priced competitively.

INSTALLATION REQUIREMENTS

1. Must be installed under proper bedding conditions; sand, crushed gravel - 2 inches below and 8 inches above for maximum strength.

OPERATION & MAINTENANCE REQUIREMENTS

1. Designed for underground water and sewage conveyance only.



MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	PERFORATIONS: ROWS	HOLE SIZE	SPACING
4" Channel Flow	NA	NA	NA	NA				No odor if properly installed	CS 228-61 ASTM D1248[2]	3 3	3/4" 1/2"	4" at 60° and 120° 4" at 60° and 120°

[2]Type III, Grade 4, Class C Polyethylene, except for electrical properties.

WARRANTIES, GUARANTEES, & SERVICE

1. Materials guaranteed for CS 228-61 (Commercial Standard) performance.
2. Installation recommendations and additional information/materials available from dealers.

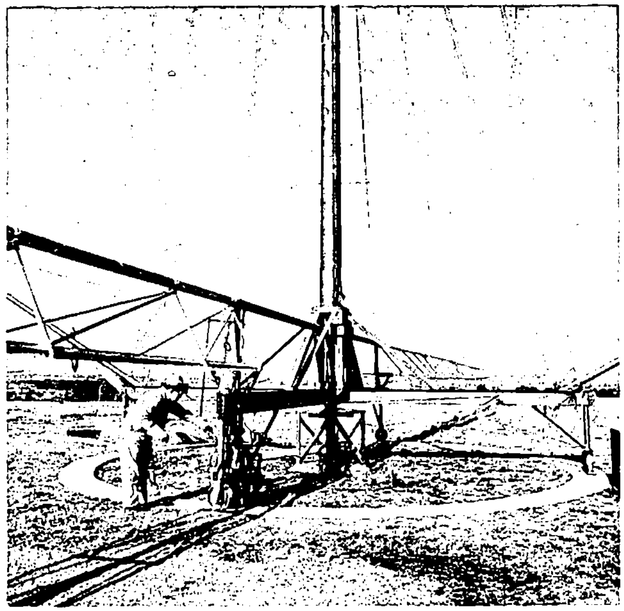
TECHNICAL PERFORMANCE

1. Tubing also meets FHA Materials Release No. 699.
2. ASTM D 543-56T tests for various major chemical resistance.
3. Flow capacities similar to smooth walled pipe as water or effluent fills up corrugated rings for water on water flow interface.

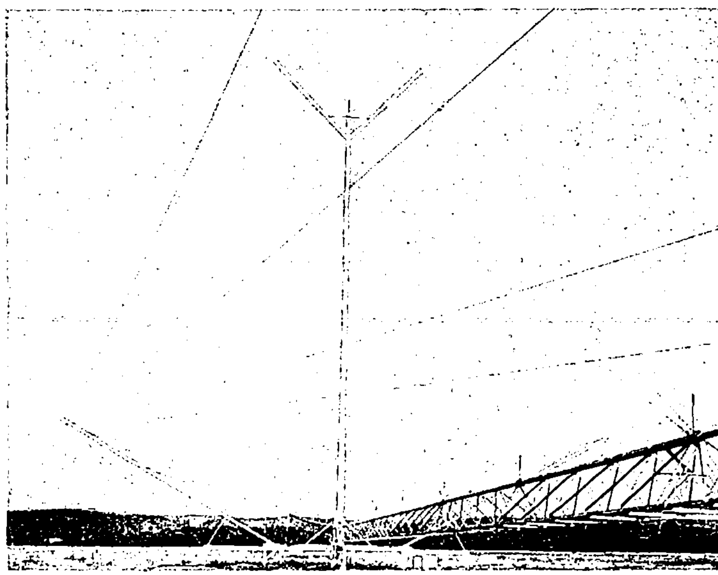
COMMENTS **ACCURATE AS OF** July 31, 1972

1. Other sized tubing with or without perforations offered for other agricultural needs (drainage, and water and air conveyance).
2. Hancor components described are shown in system described in pages 62-66.

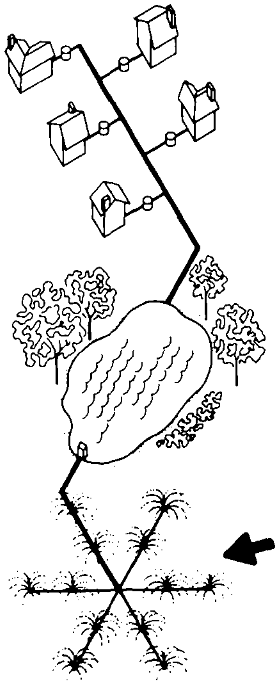
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



MCDOWELL AQUATOWER



Spray Irrigation-Disposal System



MCDOWELL MANUFACTURING CO.
P. O. BOX 665
DUBOIS, PA. 15801
(814) 371-6550
Attn: Mr. L. H. Parrott, President

AQUATOWER

SPRAY IRRIGATION, EFFLUENT DISPOSAL UNIT

FEATURES

1. Large modular system with aluminum or epoxy-coated (corrosion-resistent) truss booms supported by cables carries spray irrigation lines for disposal of effluent.
2. Water pressure of effluent should supply energy to turn tower via hydraulic motor (35 or 70 PSI models).
3. Optional electrical drive (1/3 HP) for low-pressure effluent.
4. Water spray rate ranges from 1/2"/9 hours to 1/2"/21 hours for 1 acre to 20 acres.

OPERATION

1. Water pressure from effluent line operates motor which turns tower on concrete track. Water is sprayed at different intervals along two booms to spray-irrigate land and dispose of wastewater.
2. Piping and couplings available in aluminum or PVC coatings.
3. Ground clearance varied to suit terrain.
4. 14 sprinklers capable of spraying from 2 to 50 GPM.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	EFFLUENT PRESSURE		
Aqua-tower 1 acre	200'	2' to 30'	50'	9000	10,000 (1 acre)	NA	$ 6,000.	$1,000. (varies)	Minor Service Only		Optional Equipment 115 V AC	35 or 70 PSI	Effluent, hydraulic fluid	
↓														
Aqua-tower 20 acre	810'	2' to 120'	98'	12000	700,000 (20 acre)	"	$13,000.	$3,000. (varies)	"		"	"	"	

SIZING & GROWTH POTENTIAL

1. Modular system can be adapted to different topography and irrigation demands over a wide range of capacities and sizes by adding truss sections and nozzles.

COSTS

1. *Costs vary for installation site topography, location, season.* Must be factory or distributor installed/supervised.
2. Optional motor driven unit for low-pressure effluent costs extra.

INSTALLATION REQUIREMENTS

1. Factory or distributor installation.
2. All equipment truck transported to site (one truck non-wide load).
3. Steel erection personnel and plumbing skills required.

OPERATION & MAINTENANCE REQUIREMENTS

1. *Operation is automatic. Operator (sewage plant or otherwise)* must monitor system for volume, speed, etc.
2. Minor regular service: oiling, checking nozzles for plugging.
3. Only $200 worth of replaceable moving parts; can be installed by unskilled labor.
4. Flood-type spray nozzles recommended for wintertime.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
All sizes							-15° to 140° F	Minor noise. No odors.		

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year on parts and workmanship.
2. 1 year guarantee includes full year service contract.
3. Service beyond 1 year supplied by sewage plant operators, trained by McDowell personnel.

TECHNICAL PERFORMANCE

1. Capable of withstanding 80 MPH winds.
2. Recommended for silty-sandy conditions with treated industrial or residential effluent.
3. 30' diameter concrete track needed for turning of system.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Concept was developed and tested through the Pennsylvania State University, Waste Water Renovation and Conservation Research Project.

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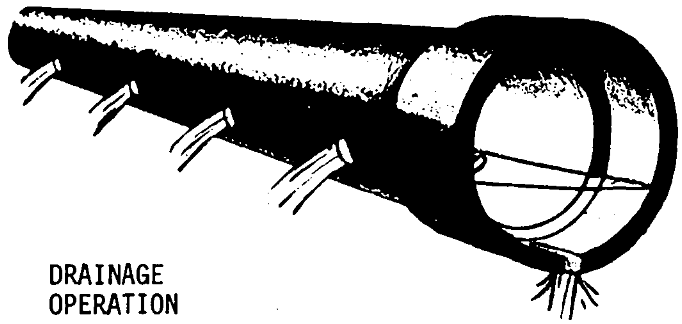
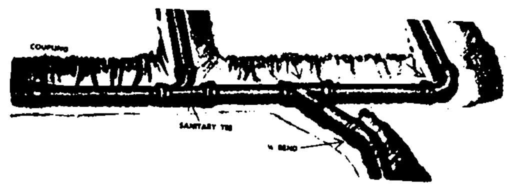
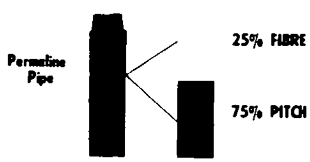
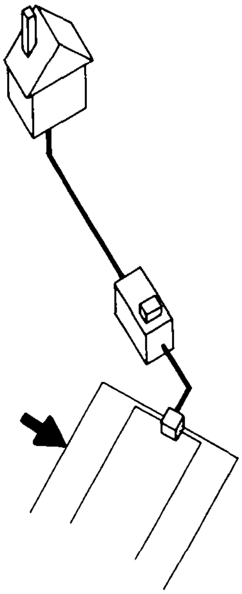






ME PERMALINE PIPE

FIBRE PRODUCTS DIVISION*
McGraw-Edison Company
*BERMICO-PERMALINE PRODUCTS



MCGRAW-EDISON CO.
FIBRE PRODUCTS DIVISION
P. O. BOX 238
WEST BEND, WISCONSIN
(414) 334-5566
Attn: Mr. M. P. Crivello, Chief Engineer, R&D

M-E PERMALINE

BITUMINOUS FIBRE PIPE (PERFORATED)

FEATURES

1. Round pipe made of pitch-impregnated wood fibre.
2. Used for conveyance of sewage and water between house and septic tank and leaching field, between septic systems and sewers, and combinations thereof.
3. Perforated pipe used for leaching fields (discussed on this sheet).
4. Inert materials resistant to chemicals and deterioration and root-resistant.
5. Different sized diameters; smaller has two rows of holes, larger has four rows of holes, all in bottom half of pipe for distribution of effluent to disposal field.
6. Coupling sealed by friction-heated coupling rings or other fastening adapters for joining non-foreign pipes.

OPERATION

1. Unperforated pipe carries influent from house to septic or treatment tank.
2. Treated and settled effluent leaves tank in pipe to distribution box or "tee" or "wye" spreaders.
3. According to area required for disposal of effluent, several lines of perforated pipe carry water on slight slope and deliver water to disposal field through holes.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
UP31C to UP37C	5', 8' or 10'	2" to	6" round	4" - 2.7 lb/ft	NA	NA				40 (varies)			Influent or Effluent	

SIZING & GROWTH POTENTIAL

1. Unlimited.

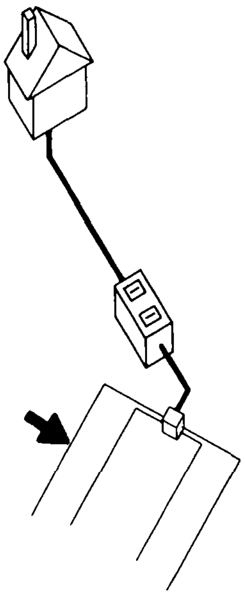
COSTS

1. Priced competitively with clay and plastic pipe.
2. Installation saves 65% on labor costs over clay.

INSTALLATION REQUIREMENTS

1. Trench and drainage bed system with sewage hook-ups.

OPERATION & MAINTENANCE REQUIREMENTS



MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	PERFORATIONS	CRUSHING STRENGTH	FLOW CAPACITIES 1% SLOPE (GAL/MIN)
	BOD_5	SS	DO	COD								
UP31C to UP37C	NA	NA	NA	NA				No odors, if prop'ly installed	See Tech. Perf. Below	2"-4": 2 rows of 5/16" holes at 3" spacing @ 90° 5"-6": 2 or 4 rows of	Greater than clay pipe	50-300
										5/16" holes at 3" spacing @ 90° and 200°	BPI standards	

WARRANTIES, GUARANTEES, & SERVICE

TECHNICAL PERFORMANCE

1. Bureau of Standards Comm. Standard No. CS116-54, Federal Spec. SS-P-356, and AASHO Designation M158-57, M177-60.
2. Member of Bituminous Pipe Institute.

COMMENTS ACCURATE AS OF July 31, 1972

1. M-E Permaline is basically the same as the L-M Permaline pipe (formerly marketed series).

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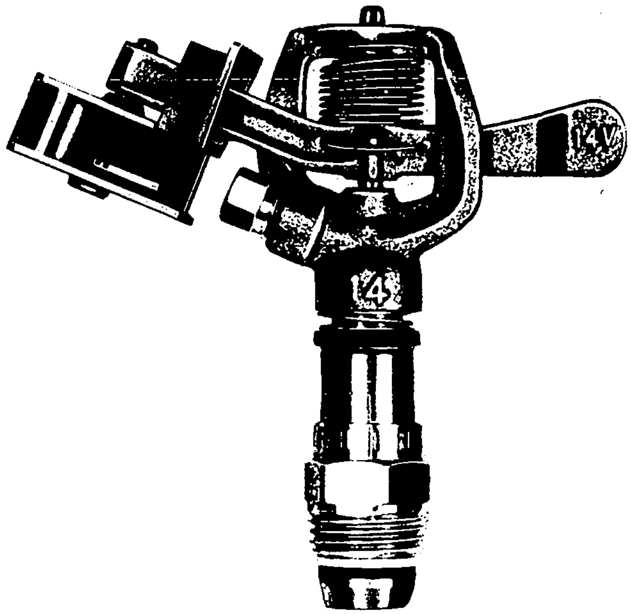


14 V-TNT

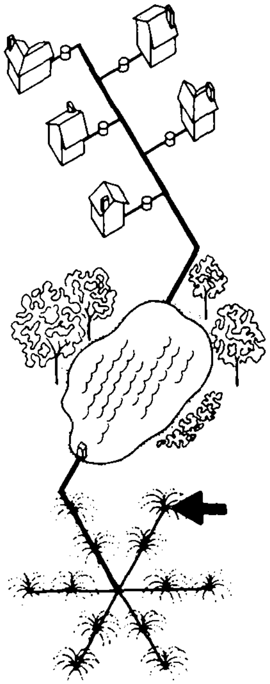
½" male TNT bearing only. Cast bronze body and arm with patented self-flushing nylon "V" wedge drive. Brass straight bore nozzle, bearing sleeve, and nipple. Stainless steel arm spring and bearing spring. Available on special order with nylon nozzle.

PERFORMANCE FOR 14 V-TNT

Highest point of stream is 6′ above nozzle.*

P.S.I.	Nozzle 1/16"		Nozzle 5/64"		†Nozzle 3/32"		Nozzle 7/64"	
	Dia.	GPM	Dia.	GPM	Dia.	GPM	Dia.	GPM
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	59	0.62	63	0.97	68	1.40	71	1.89
35	60	0.67	64	1.05	69	1.51	72	2.05
40	61	0.72	65	1.12	70	1.62	74	2.20
45	62	0.76	66	1.19	71	1.72	75	2.32
50	63	0.80	67	1.25	72	1.80	76	2.44
55	64	0.85	68	1.29	73	1.88	77	2.56
60	65	0.88	69	1.34	74	1.98	77	2.69

RAIN BIRD®



RAINBIRD SPRINKLER MANUFACTURING CO.
7045 NORTH GRAND AVE.
GLENDORA, CALIFORNIA 91740
(213) 335-1203
Attn: Mr. Robert Gray

RAINBIRD®

SPRINKLERS FOR SPRAY IRRIGATION

FEATURES
1. A full line of sprinklers, control valves, automatic controllers and related accessories for agricultural, golf course and athletic field, and sewage effluent spray irrigation.
2. Two units selected to illustrate range of performance.

OPERATION
1. 14 V-TNT full circle impact sprinkler (illustrated) recommended for low application rates (as on sloping land).
2. 70E-TNT full circle impact sprinkler gives higher application rates and larger spray circles.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPM)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	WATER PRESSURE [1]		
14V-TNT				0.4 ship'g			$5.70 each				NA	30-60 PSI	Water or Effluent	
70E-TNT				2.6 ship'g			$17.50 each				"	50-80 PSI	"	

[1]At spray nozzle.

SIZING & GROWTH POTENTIAL

COSTS
1. Spray system includes pumps, piping, valves, controls, etc., in addition to sprinklers. Contact sales engineer for design assistance.

INSTALLATION REQUIREMENTS

OPERATION & MAINTENANCE REQUIREMENTS

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	AREA COVERED
	BOD_5	SS	DO	COD						
14V-TNT										60 to 70 foot diameter circular pattern.
70E-TNT										125 to 181 foot diameter circular pattern.

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year guarantee on parts returned to manufacturer.
2. Sales engineers located throughout U.S.

TECHNICAL PERFORMANCE

COMMENTS

ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Water Consumption Reduction Techniques

Introduction

Reducing the amount of water consumed by a household will generally reduce the amount of wastewater generated. Less wastewater volume can be translated, within reasonable limits, into smaller treatment facilities. This can be especially important when the soil has to be used to absorb wastewater. Reduced per capita water demands can also mean that more people can be served by a well of fixed capacity or that the same population can be served by water systems of lesser capacities. Water consumption can be reduced by careful use by individuals, by reducing the amount of water that flows through plumbing fixtures, and by recycling water used for certain functions.

Water conservation on an individual level is an important aspect of water consumption reduction, but this book is concerned with items which can be designed into a household water system to reduce consumption even without the active cooperation of the homeowner. Such opportunities are presented by toilets which use less water per flush, by in-line fittings which limit the flow through a fixture such as a showerhead, by pressure reducing valves when the water supply pressure exceeds 50 pounds per square inch (psi), and by reuse of washwater and even treated water from toilets for flushing toilets.

A 1969 study by General Dynamics estimated net annual savings from various flow reduction devices as follows: [39]

Two faucet aerators	$ 0.67
Flow control showers	10.00
Shallow trap water closets (toilets which use less water)	4.39
Automatic flush valves	2.15-3.30
Reuse of washwater (not the systems shown in this section)	−4.75 (a net loss)

The net savings were estimated on the basis of average water and sewer charges saved, savings in fuel for heating of water, straight proration (no amortization) of capital costs over equipment lifetime, and installation costs. The estimates would vary considerably as water and wastewater treatment rates change according to local conditions.

The $10 net annual savings estimated for flow control showers was based on a $30 installed price prorated over fifteen years to yield $2 per year in costs against a $12 gross annual savings in water and sewer costs and water heating bills. If the $12 gross saving is compared with the list price of about $3 for shower flow control devices (which can be screwed in-line between showerhead and water pipe in a few minutes time), it is clear that capital can be recovered in less than a year. Similarly, if one estimates that water consumption can be reduced by about 15 per cent overall by installing a pressure reducing valve in a house supplied with 80 psi pressure, the savings would amount to $10.80 annually based on a straight percentage of a $6 monthly water bill. Since the valves cost less than $20 to purchase, capital can be recovered in about two years for new installations and three or four years for retrofits in existing plumbing (where installation costs would be significant).

Table 23 shows two estimates of water flow reduction prospects that were made for the various household consumption profiles shown in Table 4.

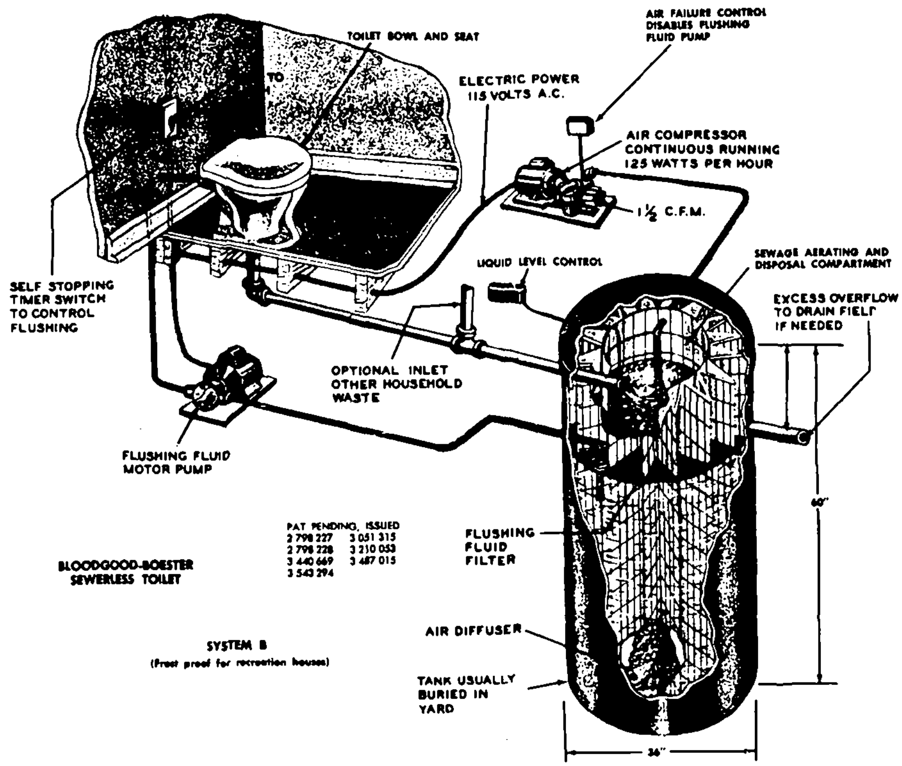
Table 23. Water Flow Reduction Estimates.

Total Water Consumption Without Flow Reduction (GPCD)	Savings, with Flow Control and Low-Flush Toilets (GPCD)	Savings, with Flow Control and Recycled Washwater for Flushing (GPCD)
30	11	20
40	13	22
50	17	29
75	20	35
100	26	44

Both estimates assumed that pressure reducing valves and/or flow control fittings reduced flow through shower, lavatory and sink fixtures by 33 percent. This reduction was assumed to be half-effective in kitchens, yielding about a 15 per cent reduction because about half of the water demand in a kitchen is for filling fixed-volume containers, such as sinks, pots, and kettles, and is therefore independent of flow rate. The other half is used for washing hands, rinsing dishes, and so forth, and would depend on the flow rate. No reduction was postulated for laundry use, which was assumed to be a fixed-volume demand. The two estimates differed only for toilet-flushing. The first estimate assumed a 40 per cent reduction based on using a low-flush toilet requiring three gallons per flush instead of the usual five.* The second estimate assumed that toilets were supplied with recycled washwater and therefore that a 100 per cent saving of flush water was effected.

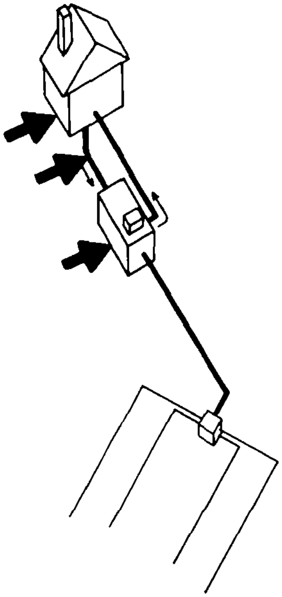
The numbers indicate that water consumption can be reduced by as much as 30 to 50 per cent (from normal consumption rates of 50 to 75 GPCD) with the use of flow reduction techniques presented in this section.

*The low-flush toilet is offered by at least one U.S. manufacturer of plumbing equipment. It is not illustrated in this section, but is generally available through plumbing supply houses.



SEWERLESS TOILET
Division of
AERA-FILT SYSTEMS, INC.

Diffused Aeration System for recycling wastewater.



AERA-FILT SYSTEMS, INC.
P. O. BOX 567
LAFAYETTE, INDIANA 47901
(317) 742-4206
Attn: Mr. Carl Boester, President

SEWERLESS TOILET

RECYCLING DIFFUSED AIR EXTENDED AERATION UNIT

FEATURES

1. Uses system recycled water (clear and odor-free, but colored for toilet use) to dispose of human waste.
2. For use where water is in short supply.
3. For use where sewage liquid discharge is difficult.
4. Effluent is taken from sewage tank and pumped for toilet flushing re-use.
5. Optional drain overflow pipe for excess tank water.

OPERATION

1. Toilet is flushed with pumped water (30 PSI) from tank.
2. *Water from toilet (other water optional) goes to tank (gravity)* and is aerated and filtered.
3. Control system: failure of pump, compressor or overflow disables toilet.

MODEL NUMBER (MAJOR)	DIMENSIONS [1]			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST [2]		ELECTRICITY (RATING)			
A-3	36"	36"	60"		One family	150-200	See Costs Below		20/year		115-120 V AC; 60 Hz		None	

[1] Also space for air compressor and fluid flushing motor pump.

[2] Electricity only; service costs additional.

SIZING & GROWTH POTENTIAL

1. More toilets can be added to system with larger tanks and larger capacity pump and compressor service.

COSTS

1. List costs available from dealer include pump, compressor, *controls, piping and tanks*.
2. Installation costs according to situation (see Requirements).

INSTALLATION REQUIREMENTS

1. Outside excavation for cylindrical fiberglass tanks.
2. Electrician service for installation of pump and compressor.
3. Plumber/installer skills for hook-up of recycling plastic piping to toilet.
4. Overflow discharge arrangements needed.

OPERATION & MAINTENANCE REQUIREMENTS

1. Controls disable flushing pump, notifying owner of breakdown or overflow of system.
2. Pumping of sewage required, possible cleaning of filters.
3. Disinfectant cleaning of colored water and colored toilet bowl.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO (A)	COD	WATER FLOW					
A-3	98	96	6 ppm		Up to 50 (R) [3]		Indoor facilities; tank underground		Patents pending; issued	

[3] Reduction of normal household water consumption.

WARRANTIES, GUARANTEES, & SERVICE

1. Warranty on parts, no liability for performance.
2. Sold only out of main plant; service by locally qualified plumber/installer.

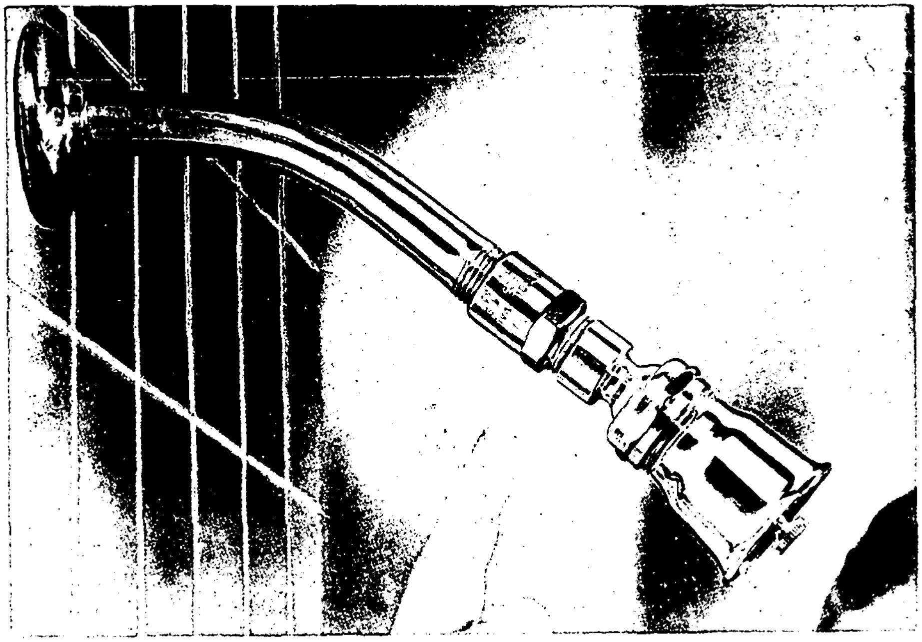
TECHNICAL PERFORMANCE

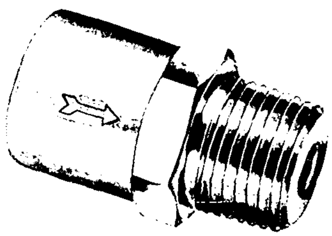
1. U. S. Patents pending, issued: 2,798,227; 2,798,228; 3,440,669; 3,543,294; 3,051,315; 3,210,053; 3,487,015

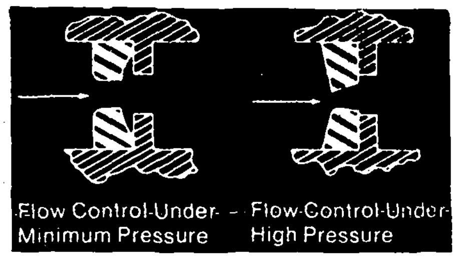
COMMENTS **ACCURATE AS OF** July 31, 1972

1. Plastic filter acts as dual-media sludge treatment and strainer (100 micron).
2. Other similar Aera-Filt recycling systems found on page 170. System similar to Multi-Flo systems, pages 302-305.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.







DOLE® FLOW REDUCING VALVES

EATON

Water volume reducing valves for retrofitting household fixtures

EATON CORPORATION
CONTROLS DIVISION
191 EAST NORTH AVE.
CAROL STREAM, ILLINOIS 60187
(312) 682-8025
Attn: Mr. John E. Wenzel

DOLE® FLOW CONTROLS

FLOW REDUCING VALVES

FEATURES

1. Valves fit individual fixtures.
2. All chrome-plated except FMC Series, which is nickel plated.
3. Maintain constant flow (volume) at pressures from 15 PSI to 125 PSI with only 5-8% variation over this range.
4. Average flow accurate to within 10% of nominal (rated) flow.

OPERATION

1. Flexible orifice varies its area inversely with the pressure to maintain constant flow rate.
2. Orifices are wide open up to 12-15 PSI; then start closing off with increased pressures.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	WATER PRESSURE		
G Series	1/2"	lines,	NPT	0.2	NA	NA	$3.52				NA	Up to 125 PSI		
FMB	3/8" compr NPT i	lines, ession nlet	copper outlet,	"	"	"	$3.05				"			
FMC Series	1/2"	lines,	NPS	"	"	"	$2.80				"			
FMA	3/8"	lines,	NPT	"	"	"	$2.80				"			

SIZING & GROWTH POTENTIAL

COSTS

INSTALLATION REQUIREMENTS

1. Minimal. Requires less than 5 minutes per fixture in original installation work.

OPERATION & MAINTENANCE REQUIREMENTS

1. None; devices are self-cleaning.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)					OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	DESIGN FIXTURE [1]
	BOD_5	SS	DO	COD	WATER FLOW (A)				
G Series					2, 2.5, 3, 4 GPM	Up to 160° F	None		For shower control; fits standard shower heads: GS=2; GO=2.5; GM=3; GL=4 GPM.
FMB					1.5 GPM	"	"		For lavatories with 3/8" copper compression fittings.
FMC Series					2, 3, 4 GPM	"	"		For household and commercial sinks.
FMA					1.5 GPM	"	"		For lavatories with 3/8" threaded fittings.

[1]Also available for drinking fountains, water closet tanks, irrigation systems, etc.

WARRANTIES, GUARANTEES, & SERVICE

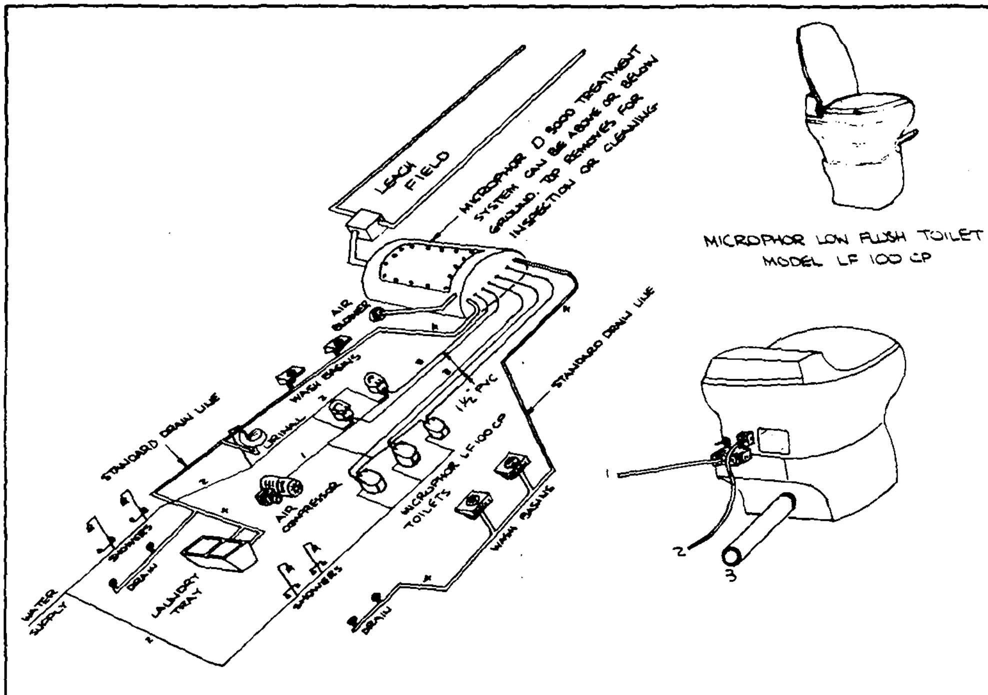
TECHNICAL PERFORMANCE

1. Should be used even if house has a pressure regulator at main inlet because even with regulated pressure individual appliances can consume more water than necessary.

COMMENTS **ACCURATE AS OF** July 31, 1972

1. Recommended for all showers, lavatories, and kitchen sinks which people tend to let run independently of volume delivered for as long as they need washwater.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



Microphor

Low Flush Toilet Treatment System Combination

This sketch portrays the rest room facility at Russian Gulch State Park which has operated successfully. It is a new concept in providing sanitary flush toilets, a well treated effluent and a minimum of water use. This facility restored a plugged leach field and *reduced the toilet water use from 3000 to 150 gallons per day.*

Five Microphor Low Flush toilets were installed in place of the existing toilets. A *Microphor Treatment System* was buried out of sight near the building. The effluent was conducted to an existing leach field.

There are extreme cases where the effluent must be pumped from the area. In that case, *Microphor* effluent can be pumped economically at high pressure through small pipes using open impeller pump since there are virtually no solids.

Operation: The sketch shows our *Michophor Low Flush Toilet Model LF 100 CP* which flushes on only 1½ quarts of water. After use, the user simply steps on the pedal, which drops the waste into a hopper while clean (from water line marked 2) water cleans the bowl. Releasing the pedal closes the hopper and introduces a five second charge of compressed air (from air supply line 1). This ejects the waste through pipe 3 to the *Microphor Treatment System* Model D 3000. In the D 3000 the solids and dissolved organics are filtered out and a well treated effluent is discharged. At Russian Gulch this effluent was readily absorbed in a leach area that had perviously failed.

Installation: In existing facilities the standard toilets are removed and the *Microphor* Model LF 100 CP is bolted in place. The air compressor and air lines (marked 1) are installed. Water at city pressure is connected to hose (marked 2). Waste discharge pipe (marked 3) is usually 1½" PVC schedule 40. The treatment system can be up to fifteen feet away and up to twenty-four inches higher than the toilets.

MICROPHOR, INC.
475 EAST SAN FRANCISCO AVE.
WILLITS, CALIFORNIA 95490
(707) 459-5563
Attn: Mr. John Mayfield, Exec. Vice-President

LOW FLUSH TOILET

WATER-SAVING TOILET SYSTEM

FEATURES

1. Low flush toilet systems: System LF-100 goes with additional treatment units (Annelgester); System TA-200 is self-contained aerated treatment system.

OPERATION

1. Process explanation is found on facing page.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	WATER PRESSURE		
LF-100	14"	16"	18"		Depends on System		$256.				None	1-1/2 qt./ flush	1 oz. oil/ month[1]	
TA-200	26"	26"	30"		3 person capacity		$475.				200 W Intermit.	"	"	

[1]Plus chlorine, if used.

SIZING & GROWTH POTENTIAL

COSTS

1. Price for LF-100 is toilet only.
2. Price for TA-200 is complete unit.

INSTALLATION REQUIREMENTS

1. Indoor installation.
2. Plumbing skills needed for set-up.

OPERATION & MAINTENANCE REQUIREMENTS

1. Minimal water supply needed.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD	OTHER					
LF-100	NA	NA	NA	NA	NA		25-160°F	None	FHA and VA	
TA-200	95 (R)	97 (R)	"	"	98[2] (R)		25-160°F without freeze protection kit	Slight noise and odors.[3]	NSF #23 Seal	

[2]Settleable solids. [3]Slight odor at vent.

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year warranty on defective parts.

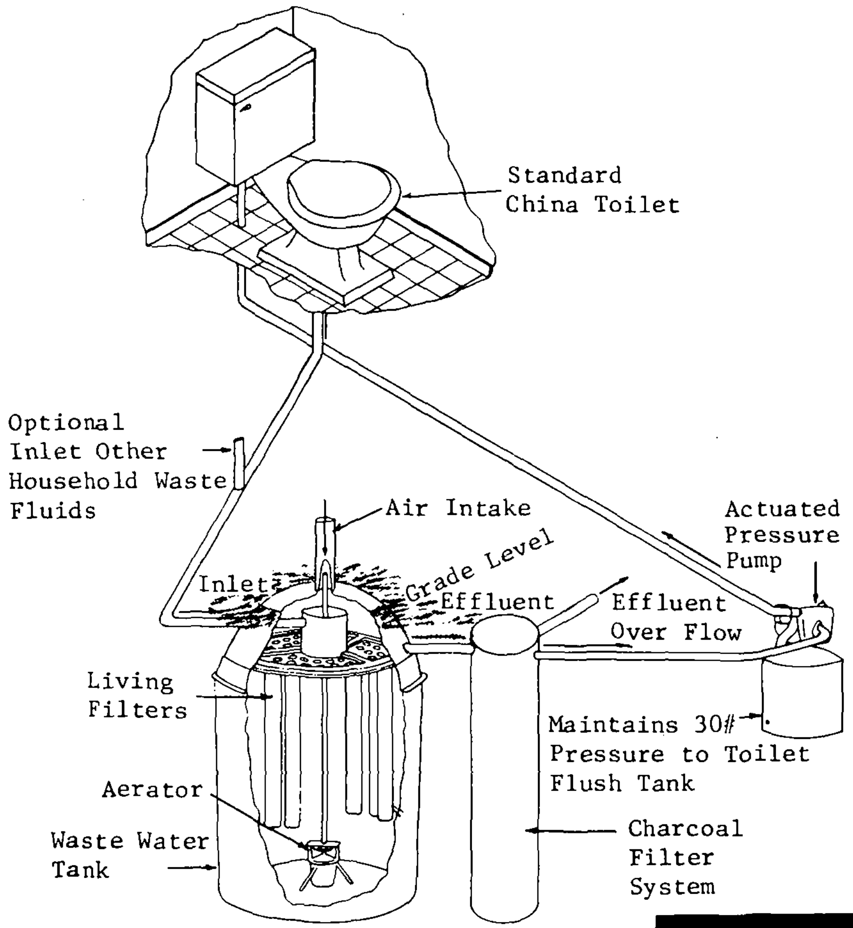
TECHNICAL PERFORMANCE

1. California Dept. of Parks backs the low-flush system.
2. The D-3000 total system (low-flush and treatment) claims 92% BOD, 88% COD, and 99% SS reduction.
3. NSF has tested the H-10 and the TA-200 under Watercraft Sewage Disposal Devices (NSF Standard #23) and issued them and NSF Seal.

COMMENTS

ACCURATE AS OF July 31, 1972

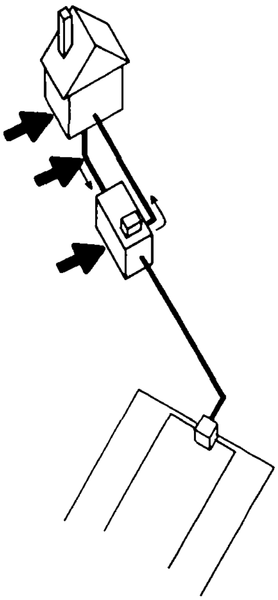
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



MULTI·FLO
waste treatment
systems · pumps

MULTI FLO HOME SYSTEMS
FOR RECYCLING WASTEWATER (UNIT RS-1)

For use where flushing water is not available or in short supply.
For use where sewage liquid discharge is forbidden.



MULTI-FLO, INC.
500 WEBSTER ST.
DAYTON, OHIO 45401
(513) 224-7622
Attn: Mr. J. Robert Krebs, Exec. Vice-President

MULTI-FLO RS-1

RECYCLING EXTENDED AERATION FILTRATION UNIT

FEATURES
1. Single sewage tank system uses system recycled water (effluent) as flushing fluid to dispose of human waste.
2. For use where water is in short supply or where sewage liquid discharge is difficult.
3. Submerged motor-diffused aeration and positive effluent filtration in main tank.
4. Second tank has charcoal filter for color removal and further treatment.
5. Optional inlet for other household waste fluids and outlet for overflow discharge.
6. Alarm system indicates malfunction.

OPERATION
1. Toilet is flushed with pumped water (30 PSI) from tank.
2. Water from toilet (other water optional) flows to tank, is aerated, filtered, flows to activated charcoal filter.
3. Discharge from charcoal filter is pumped to toilet for reuse.
4. Overflow effluent discharged.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD) 1	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
RS-1-.3	54"	39"	77"	680	300	300	1421	100-300 Varies	5-8/ month	3-5	115 V AC 1/2 Kw		None	
RS-1-.5	72"	61"	77"	825	500	500	1621	"	"	"	"		"	
Pump	24"	24"	22"											
Carbon Filter	14"	14"	48"											

[1]Toilet waters only, see Sizing below.

SIZING & GROWTH POTENTIAL
1. RS-1-0.3 suitable for 15 people with peak loadings to 24 total; RS-1-0.5 for 25 people with peaks to 40 total.
2. More toilets can be added to system within range of capacity.

COSTS
1. Customer or installer furnishes interconnecting piping and electrical work.
2. Chlorination or pasteurization equipment available.

INSTALLATION REQUIREMENTS
1. Open excavation with 6" clearance around tanks. Level bottom at proper elevation with fine sand or pea gravel base. Backfill uniformly.
2. Plumber/electrician skills required for installation.
3. 4" inlet and discharge connections; 3" pipe - air intake.

OPERATION & MAINTENANCE REQUIREMENTS
1. First year: free quarterly inspections to note odors, check alarm system.
2. Call for local service if necessary.
3. Occasional pumping out required.
4. Discharge arrangements necessary.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO (A)	COD	WATER FLOW					
RS-1-.3	90	90	4-6 ppm		Up to 40 (R) 2		Normal Domestic	Low noise. 3 No odors.	NAS-NRC Publn. 586	
RS-1-.5	"	"	"		"			"	"	

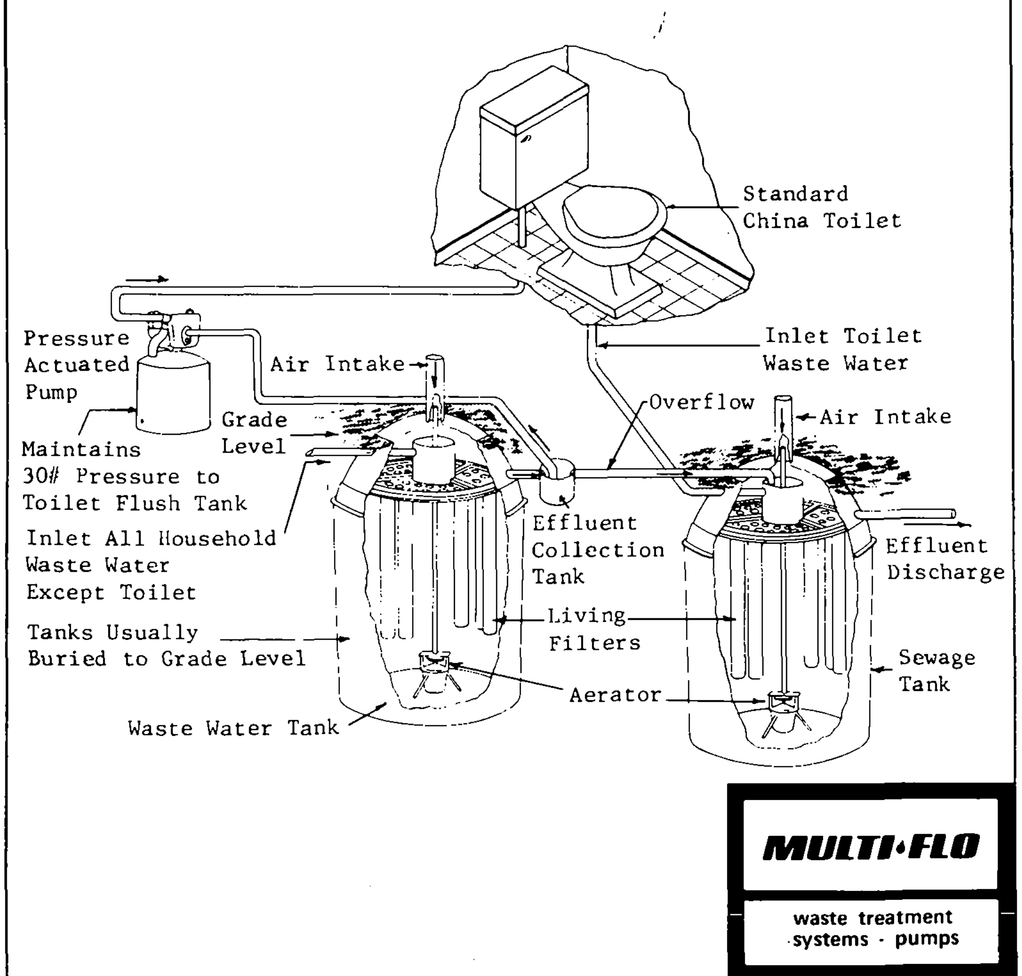
[2]Reduction of normal household water consumption. [3]Aerator motor submerged.

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year manufacturer's warranty on workmanship and material.
2. Service contract included first year: parts, labor, two inspections.
3. Service contract available on annual basis.
4. Factory authorized and trained local service groups.
5. Periodic review of distributor activities by factory management.

TECHNICAL PERFORMANCE
1. Effluent settleable solids are negligible.
2. Patents pending and issued.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. Can be made frost-proof for resorts.
2. Similar Aera-Filt systems A-1 and A-3 found on pages 170, 296. Also similar to Multi-Flow RS-2, page 304.
3. Aeration tanks similar to Multi-Flo FT, page 186.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

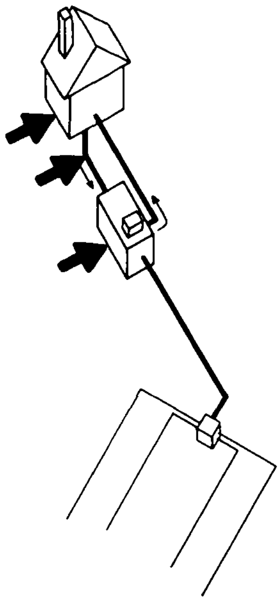


MULTI FLO HOME SYSTEMS
FOR RECYCLING WASTEWATER (UNIT RS-2)

For use where flushing water is not available or in short supply.

For use where sewage liquid discharge is forbidden.

Uses treated and filtered
bath and laundry water
for flushing



MULTI-FLO, INC.
500 WEBSTER ST.
DAYTON, OHIO 45401
(513) 224-7622
Attn: Mr. J. Robert Krebs, Exec. Vice-President

MULTI-FLO RS-2

RECYCLING EXTENDED AERATION POSITIVE FILTRATION UNIT

FEATURES

1. Dual sewage tank system uses system recycled water from all household wastewater except toilet ("grey" water) as flushing fluid for toilets.
2. First tank collects household waste waters which are used for flushing; second tank takes toilet wastes ("black" waters) and first tank overflow for discharge.
3. For use where water is in short supply or where sewage liquid discharge is difficult.
4. Submerged motors; diffused aeration and positive effluent filtration in both tanks.
5. Alarm system indicates malfunctions.

OPERATION

1. Wastewaters from household except toilet flow into wastewater tank and are aerated, filtered, pass over weir to effluent collection tank.
2. Water in collection tank is pumped (30 PSI) to toilet for flushing, overflow goes to sewage tank.
3. Toilet waters are taken by sewage tank, aerated, filtered, pass over weir to discharge or disinfection.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)[1]	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
RS-2-.3	120"	39"	77"	1030	300	300	2421	300-500	8-11/ month	3-5	115 V AC 3/4 Kw		None	
RS-2-.5	160"	61"	77"	1325	500	500	2821	"	"	"	"		"	
Pump	24"	24"	22"											
Storage Tank	14"	14"	48"											

[1]See Sizing below.

SIZING & GROWTH POTENTIAL

1. RS-2-.3 for 15-20 people, peak loadings to 40 total; *RS-2-.5 for 30-40 people, peak loadings to 60 total.*

COSTS

1. Customer or installer furnishes interconnecting piping and electrical work.
2. Chlorination or pasteurization equipment available.

INSTALLATION REQUIREMENTS

1. Open excavation with 6" clearance around tanks. Level bottom *at proper elevation with fine sand or pea gravel base.* Backfill uniformly.
2. Plumber/electrician skills required for installation.
3. 4" inlet and discharge connections; 3" pipe - air intake.

OPERATION & MAINTENANCE REQUIREMENTS

1. First year: free quarterly inspections to note odors, check alarm system.
2. Call for local service if necessary.
3. Occasional pumping out required.
4. Discharge arrangements necessary.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS[3]	STANDARDS & CODES MET	
	BOD_5 (R)	SS (R)	DO (A)	COD	WATER FLOW					
RS-2-.3	90	90	4-6 ppm		Up to 40 (R)[2]		Normal Domestic	Low noise. No odors.	NAS-NRC Publn. 586	
RS-2-.5	"	"	"		"		"	"	"	

[2]Reduction of normal household water consumption. [3]Aerator motors submerged.

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year manufacturer's warranty on workmanship and material.
2. Service contract included first year: parts, labor, two inspections.
3. Service contract available on annual basis.
4. Factory authorized and trained local service groups.
5. Periodic review of distributor activities by factory management.

TECHNICAL PERFORMANCE

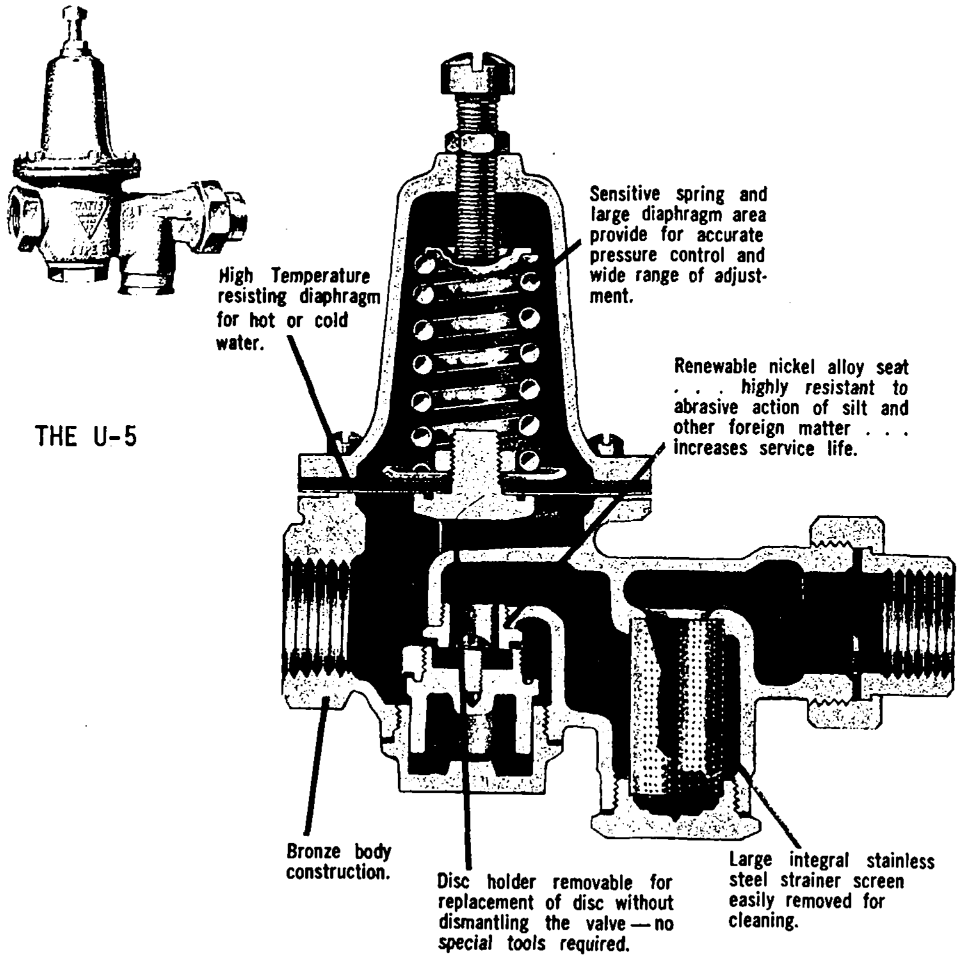
1. Effluent settleable solids are negligible.
2. Patents pending and issued.

COMMENTS

ACCURATE AS OF July 31, 1972

1. Similar to Aera-Filt system A-2, page 170. Also similar to Multi-Flo RS-1, page 302.
2. Aeration tanks similar to Multi-Flo FT, page 186.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



THE U-5

WATTS PRESSURE VALVES

WATTS REGULATOR COMPANY

Water pressure-reducing valves for water and fixture-saving purposes

WATTS REGULATOR CO.
LAWRENCE, MASS. 01842
(617) 688-1811
Attn: Mr. Joseph Keegan, Advertising Manager

WATTS PRESSURE VALVE

WATER PRESSURE REDUCING VALVE

FEATURES

1. Bronze bodies.
2. Integral strainers.
3. Union fittings.
4. Installed at house inlet downstream of lawn-watering tap-off.
5. Saves water by reducing excessive pressures so that less water flows when tap is open.

OPERATION

1. Regulates from water main pressures of up to several hundred pounds to reduced pressures (adjustable) in 50 PSI range.
2. Reduced pressure in the system will be further reduced from the set-point (e.g., 50 PSI) as increasing volumes flow to meet demands of appliances. This "reduced pressure fall-off" varies from 0 to about 20 PSI.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.) [1]	RATED CAPACITY (GPM) [2]	TANK CAPACITY (GAL.)	COSTS (DOLLARS) [1]			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	WATER PRESSURE		
U5	$5\frac{3}{4}$ to 11"	$2\frac{7}{8}$ to $5\frac{1}{2}$"	$5\frac{7}{8}$ to $12\frac{1}{4}$"	3-23	16	NA	$14.70 to $90.75				None	Up to 300 PSI at inlet		
U5LP	"	"	"	"	"	"	$15.45 to $95.30				"	Up to 200 PSI at inlet		
U135	$5\frac{3}{4}$ to $11\frac{1}{2}$"	$2\frac{7}{8}$ to $5\frac{5}{8}$"	$6\frac{7}{8}$ to $13\frac{5}{8}$"	4-30	19	"	$16.00 to $118.05				"	Up to 300 PSI at inlet		
223S	7 to $16\frac{5}{8}$"	$3\frac{1}{2}$ to $4\frac{5}{8}$"	7 to $15\frac{1}{4}$"	5-46	23	"	$17.65 to $142.00				"	Up to 250 PSI at inlet		

[1] Cost and weights are dependent on sizes of water lines. Lowest values given are for half-inch lines.
[2] In 0.5" lines at 20 PSI reduced pressure fall-off, i.e., 20 lb total pressure loss (due to demand) on house side of valve.

SIZING & GROWTH POTENTIAL

1. U5 recommended for residential use; 223S sized for motels, schools, etc.

COSTS

1. Trade prices of U5 are $14.70 for 0.5", $16.65 for 0.75", and $26.05 for 1" sizes (home sizes).
2. Built-in by-pass feature (for thermal expansion) costs about 3% extra.

INSTALLATION REQUIREMENTS

1. U5, U5LP, U135 have union.
2. Installation should take 15-30 minutes for home size.

OPERATION & MAINTENANCE REQUIREMENTS

1. Once set to desired outlet pressure, requires no attention other than cleaning strainer (perhaps once a year, depending on water quality) and pressure check (perhaps every 5 years).

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	PRESSURE RANGES (All valves adjustable through range.)
	BOD_5	SS	OO	COD						
U5	NA	NA	NA	NA			40° - 200° F water temp.		See Technical Perf. below	Regulates to standard range (25-75 PSI). Factory set at 50 PSI, recommended pressure.
U5LP	"	"	"	"			"			Regulates to lower pressures (10-35 PSI). Mainly for dishwashers, booster heaters, etc.
U135	"	"	"	"			"			Regulates to standard range (25-72 PSI).
223S	"	"	"	"			"			"

WARRANTIES, GUARANTEES, & SERVICE

TECHNICAL PERFORMANCE

1. Conforms with standards of American Society of Sanitary Engineering (Std. 1003), Southern Standard Building Code - Plumbing, City of Los Angeles and W. P. O. A. Uniform Plumbing Code.

COMMENTS **ACCURATE AS OF** July 31, 1972

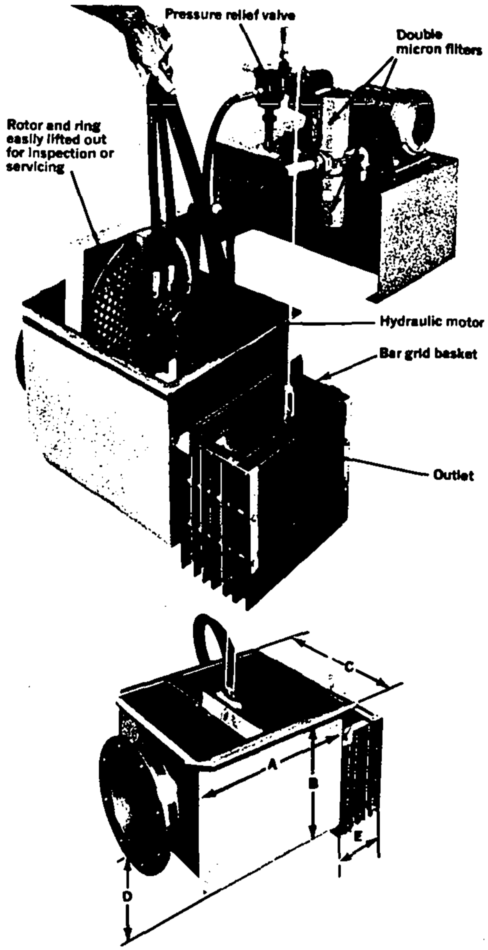
1. 50 PSI recommended for residential use.
2. Approximately 33% more water flows at 80 PSI pressure than at 45 PSI. Much of this excess is wasted. Therefore, pressure regulator recommended in buildings where pressure exceeds 50 PSI.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Accessories

Introduction

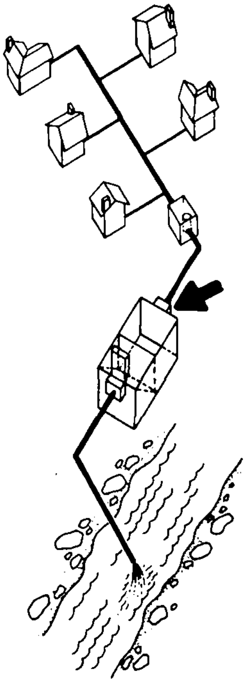
This section contains a miscellany of accessories for use in sewage treatment systems. Included are grinders (comminutors), level-sensing switches, a lagoon-flow monitoring device, and a self-contained portable test kit for performing microbiological analyses (for determining the adequacy of sewage disinfection procedures, for example).



BIF WASTE DISINTEGRATOR

BIF SaniTroL
A UNIT OF GENERAL SIGNAL CORPORATION

Hydraulic system grinds pre-treated sewage



BIF SANITROL
P. O. BOX 41
LARGO, FLORIDA 33540
(813) 584-2157
Attn: Mr. Norman Smith, Vice President, Sales

BIF WASTE DISINTEGRATOR

HYDRAULIC WASTE DISINTEGRATOR

FEATURES

1. Stainless steel submerged disintegrator reduces solids to less than 1/4" in size, for wet well or pre-treatment applications.
2. Electrically driven hydraulic motor weights only 22 lb. (110 or 220 V AC), has warning light, operates at up to 150 PSI oil pressure.
3. Vertical to horizontal mounting in channel or flume box with bar grid discharge screening.
4. Remote power pack with slip-fitting removable disintegrating assembly.
5. 15-5 Micron filters used in motor.
6. 6 models for 100 to 1200 GPM capacities; hoses in 5' to 50' lengths.

OPERATION

1. Sewage flows into channel chamber and contacts grinding rotor and ring.
2. Sewage is ground, flows through bar grid for lower discharge.
3. Power failure flow or over-capacity flow passes over top of unit to avoid stoppage.

MODEL NUMBER (MAJOR)	DIMENSIONS LENGTH	WIDTH	HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPM)[1]	TANK CAPACITY (GAL.)	COSTS (DOLLARS) SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS ELECTRICITY (RATING)		OPERATING SUPPLIES	INLET SIZE
71	27"	$14\frac{3}{4}$"	$16\frac{1}{8}$"		100	NA	1550		1 HP		110 or 220 V AC 1 ph			4"
91	27"	$14\frac{3}{4}$"	$16\frac{1}{8}$"		150	"	1885		$1\frac{1}{2}$ HP		"			6"
121	32"	$17\frac{3}{4}$"	$17\frac{1}{8}$"		400	"	2450		2 HP		"			8"
161	36"	$21\frac{3}{4}$"	22"		750	"	3150		3 HP		"			12"

[1]Capacity at vertical style mounting.

SIZING & GROWTH POTENTIAL

1. 50% larger capacities for horizontal mounting styles.
2. Model 161-2 has 2 16" rotors for double 161 capacities.

COSTS

1. List price includes pump; oil reservoir; motor; gages; filters; fluid flow adjuster; plus steel flanged flume and bar grid basket.
2. Replacement rotors or rings run $100 - $175 per set.

INSTALLATION REQUIREMENTS

1. In-line installation with flange connections for flow through grinding before treatment.
2. Angle supports required for wet well installations.
3. Plumbing and electrician skills needed for installation; similar to comminutors.

OPERATION & MAINTENANCE REQUIREMENTS

1. Unit can be hand lifted for inspection or repair.
2. Not clogged by metal, glass or plastics.
3. Periodic inspection/maintenance.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE) BOD_5	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
All	NA	NA	NA	NA			Submerged or Dry-run	Minor noise.	U.S.Forest Svc specifies for parks	

WARRANTIES, GUARANTEES, & SERVICE

1. 1 year guarantee on parts and workmanship.
2. Recommended accessory items (flow switch, alarm, etc.) furnished upon order.

TECHNICAL PERFORMANCE

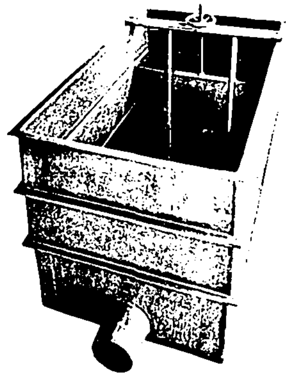
1. Rotor and ring grinding parts made with abrasive silicon carbide granules set in high-density epoxy resin reinforced with fiberglass and stainless steel wire.
2. Hydraulic motor is "Orbit" (Gerotor type) by Char-Lynn of Minnesota or equivalent.

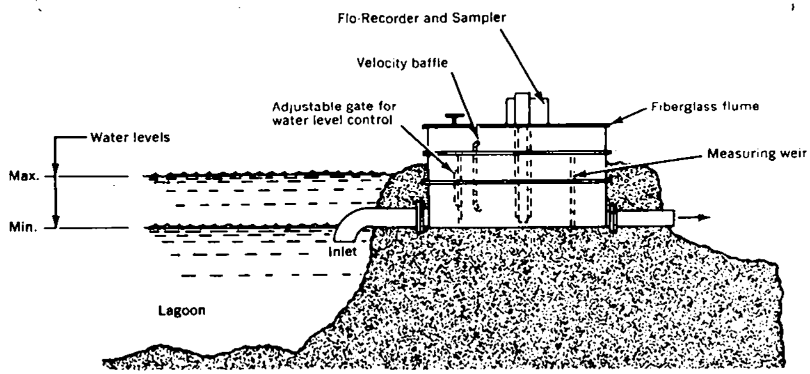
COMMENTS

ACCURATE AS OF July 31, 1972

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

Fiberglass
Flume

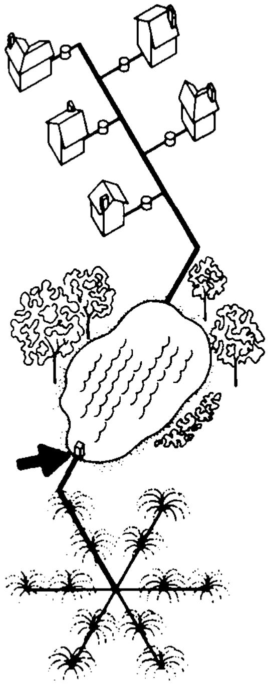




Elevation

BIF LAGOON MONITORING SYSTEM

BIF SaniTroL
A UNIT OF GENERAL SIGNAL CORPORATION



BIF SANITROL
P. O. BOX 41
LARGO, FLORIDA 33540
(813) 584-2157
Attn: Mr. Norman Smith, Vice-President, Sales

BIF LAGOON MONITOR

LAGOON FLOW MONITORING SYSTEM

FEATURES
1. Fiberglass flume (up to 1000 GPM) placed at lagoon discharge point; can be outfitted for lagoon level control, flow recording and sampling; optional disinfection equipment.
2. Measuring weir and adjusting gate meets most state health authority requirements for weed and pest control.
3. Can record volume on a daily, monthly and accumulated basis.
4. Provides 30 day strip chart for graphic indications of flow.

OPERATION
1. Lagoon discharge flows into flume, with base of flume at minimum lagoon level.
2. Adjustable gate for water level controls discharge.
3. Gravity Flo-Recorder measures flow.
4. Flo-Ratio Sampler lifts samples either on flow and/or time basis with cams on a program rotor (8 to 1 range).
5. Refrigeration unit can stabilize biological contents for sampling.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPM)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
60-111 Flume	6'	3'6"	3'6"	Fiber-glass	Up to 1000	NA	1072	Varies			110 V AC[1]		None	

[1]Or DC operation with recorder.

SIZING & GROWTH POTENTIAL
1. Flumes available in sizes starting at 12" x 48" x 16" @ 100 GPM to 1000 GPM; made to customer specifications.
2. Parallel installations available for larger or multi-discharge applications.

COSTS
1. List price includes fiberglass flume only; control gate for lagoon level control, flow recorder and sampler are optional additions.
2. ST1000B Flow Recorder: $1055 with 4 ft. extension and 30 day strip chart and totalizer; ST41-2 Sampler (5 ft.), $705.

INSTALLATION REQUIREMENTS
1. Installation of flume requires excavation and pipe connection at discharge point in lagoon shore.
2. Electrical and plumbing skills required for installation of components; flume involves simple installation.

OPERATION & MAINTENANCE REQUIREMENTS
1. Periodic inspection and controlling at equipment; extended automatic unattended operation possible.

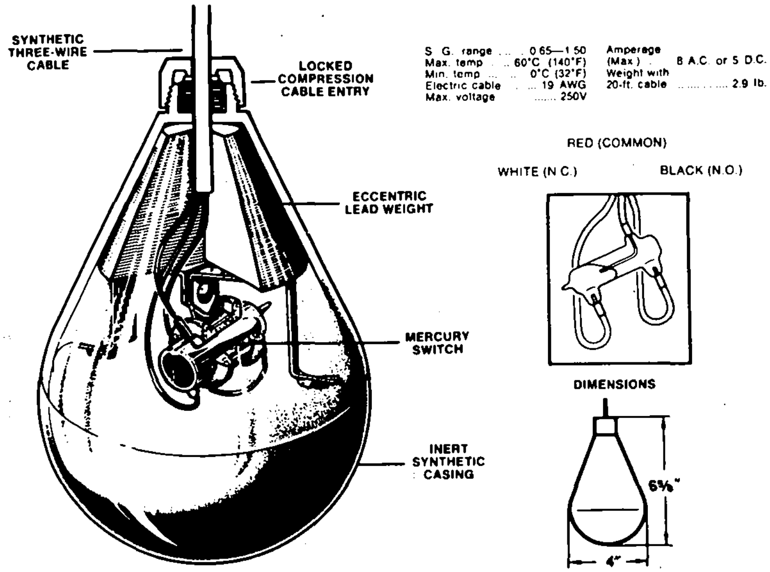
MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

WARRANTIES, GUARANTEES, & SERVICE
1. Warranty on parts and workmanship.
2. Distribution through locally licensed dealers of sewage treatment and control equipment.

TECHNICAL PERFORMANCE

COMMENTS **ACCURATE AS OF** July 31, 1972
1. More information available from manufacturer on samplers, recorders, sensitizers, refrigeration sampling, etc.

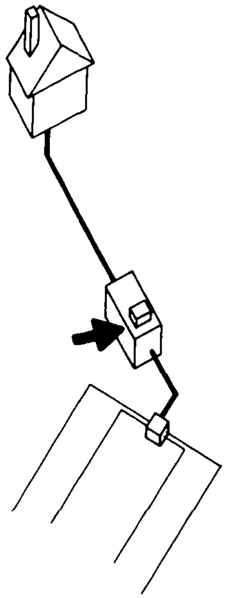
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

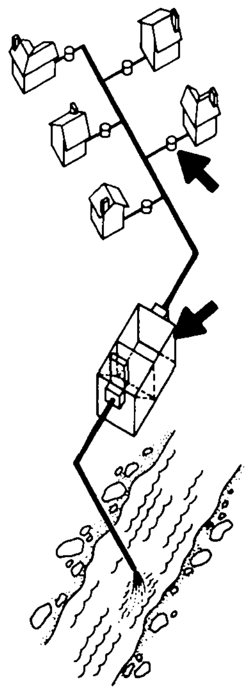


FLYGT LEVEL SENSORS - ENH-10

FLYGT

Mercury switch water level sensing switch for directing tank or flow operations





FLYGT CORPORATION
129 GLOVER AVE.
P. O. BOX 857
NORWALK, CONNECTICUT 06856
(203) 846-2051
Attn: Mr. Ken Nicholls, Manager, Liquids Handling Division

FLYGT® ENH-10

MERCURY SWITCH LIQUID LEVEL SENSOR

FEATURES
1. Polypropylene cased, mercury switch liquid level sensor.
2. Models for use in liquids from 0.65 to 1.50 specific gravity (standard: 0.95 - 1.10 SG).
3. Used to activate circuits operating motors, pumps & valves.
4. Especially used in tanks or pits for turning on and off pumps at pre-set liquid levels for pumping out of wastes (as in a lift station).
5. Sensor hangs in liquid by synthetic cable.

OPERATION
1. Mercury switch operates "on-off" circuit when float body of sensor is moved to floating position by rising liquid or moved to initial hanging position by descending liquid.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Standard	4" round		$6\frac{5}{8}$"	2.9[1]	NA	NA	45-60		None	life of tank	110-250 V 8 amp (max)		None	

[1] With 20 ft. cable.

SIZING & GROWTH POTENTIAL
1. Multiple sensors can be hung at different heights for different control processes.

COSTS
1. Comes with 20 to 60 foot cable.

INSTALLATION REQUIREMENTS
1. Sensors are hung from top of container to desired activation level by cable.
2. Electrician should connect to transformer and control box.

OPERATION & MAINTENANCE REQUIREMENTS
1. No maintenance; level of sensor can be adjusted, however, for change in flows or process.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						

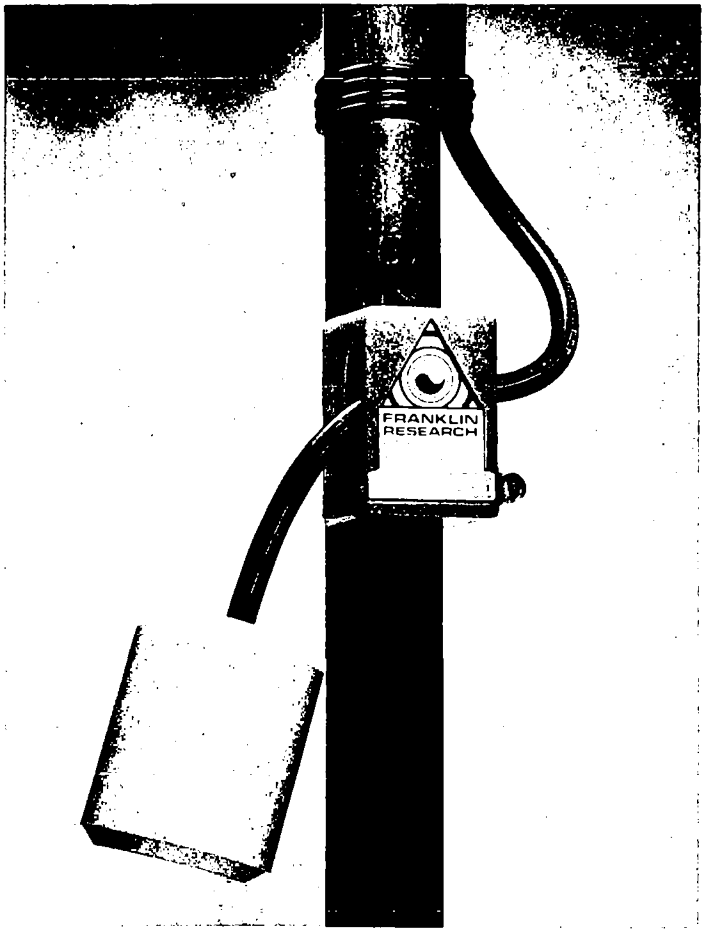
WARRANTIES, GUARANTEES, & SERVICE
1. 1 year warranty on parts and workmanship (labor not included).
2. Units sold by manufacturer or through local distributors.

TECHNICAL PERFORMANCE
1. Use in sewage lift station should incorporate 24 volt transformer in control panel.

COMMENTS

ACCURATE AS OF July 31, 1972

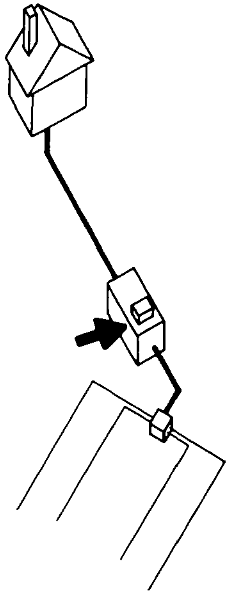
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

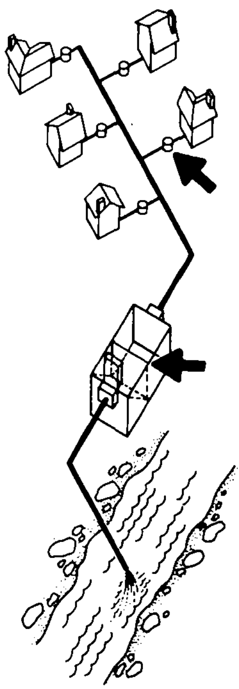


FRANKLIN RESEARCH LEVEL SENSORS

FRANKLIN RESEARCH

Mercury switch water level sensing switch for directing tank or flow operations





FRANKLIN RESEARCH
1220 SIXTH ST.
BERKELEY, CALIFORNIA 94710
(415) LA 4-5123
Attn: Mr. George F. French, President

LEVEL SENSOR

MERCURY SWITCH LIQUID LEVEL SENSOR

FEATURES

1. Mercury level sensor switch cast in urethane float body.
2. Stainless steel and neoprene components.
3. Attaches with screw-clamp to any pipe or upright.
4. For use in septic tanks, lift stations, or treatment tanks for turning on and off motor (pump, blower, or alarm system).

OPERATION

1. Mercury switch is set for "on-off" at specified positions relative to level of water.
2. Float body rides on surface of water to pinpoint level.

MODEL NUMBER (MAJOR)	DIMENSIONS: LENGTH	DIMENSIONS: WIDTH	DIMENSIONS: HEIGHT	WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS): SUGG. LIST (FOB FACTORY)[1]	COSTS (DOLLARS): INSTALL COST	COSTS (DOLLARS): OPERATE COST	DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS: ELECTRICITY (RATING)	UTILITY REQUIREMENTS	OPERATING SUPPLIES	
LS-1	4"	$2\frac{1}{2}$" round			NA	NA	$19.	See Install. Below	None	Life of tank	0 - 230 V AC or DC 1 amp		None	
LS-2	"	"			"	"	$23.	"	"		0 - 230 V AC or DC 5 amp		"	

[1]FOB, Berkeley, California.

SIZING & GROWTH POTENTIAL

1. Multiple sensors can be placed on same or different uprights for different control processes.

COSTS

1. Comes with 5 feet of #18/2 heavy-duty neoprene cable; extra cable 40¢/foot.

INSTALLATION REQUIREMENTS

1. Can be installed on any pipe-like upright in tank by operator or dealer. Only tool needed is screwdriver.
2. Electrician should connect to control box.

OPERATION & MAINTENANCE REQUIREMENTS

1. No maintenance; however, level of sensor can be adjusted for change in flows or processes with a screwdriver.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE): BOD_5	SS	DO	COD			OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
LS-1	NA	NA	NA	NA			-30°F to 150°F	No noise or odors.		
LS-2	"	"	"	"			"	"		

WARRANTIES, GUARANTEES, & SERVICE

1. Units sold by manufacturer or ordered through sewage treatment equipment distributors.

TECHNICAL PERFORMANCE

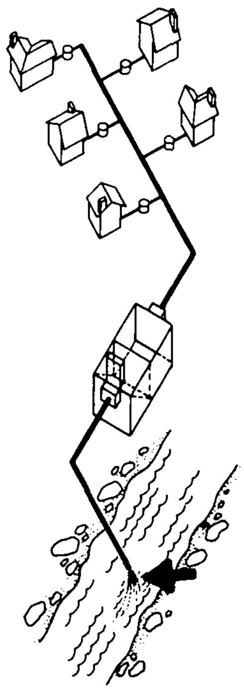
COMMENTS **ACCURATE AS OF** July 31, 1972

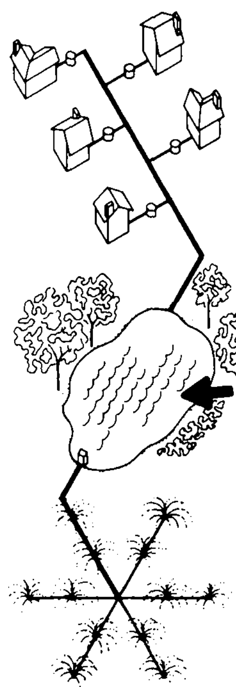
1. Shipments are made via Greyhound Package Express.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

COLI-COUNT™ WATER TESTERS

MILLIPORE





MILLIPORE CORPORATION
BEDFORD, MASSACHUSETTS 01730
(617) 275-9200
TOLL-FREE: (800) 225-1380
Attn: Mr. Clifford F. Frith

COLI-COUNT ™

WATER TESTER FOR BACTERIAL CONTAMINATION

FEATURES

1. Pocket-sized self-contained unit.
2. Effective for waters containing more than 1000-1500 organisms per 100 milliliters.
3. Special dehydrated coliform growth medium embedded in sponges behind membrane filter.
4. 1 milliliter sample drawn through filter by capillary action, coliforms adhere to filter.
5. Portable field-type or laboratory incubators of corrosion resistant materials.

OPERATION

1. Remove assembly from sterile package.
2. Remove Coli-Count paddle from case.
3. Immerse paddle in water for 30 seconds.
4. Shake off excess water, return to case.
5. Incubate 18-20 hours at 35°C ± 5°C.
6. Count coliform colonies which show up as distinctive blue-to-green color.

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)			
Coli-Count	1"	$\frac{1}{2}$"	3"		(Footnote 1)	NA	See Costs Below	Negligible	1) Elec. 2) Operator		Incubators (See Below)		Test Water	
Incubator	6"	$10\frac{1}{4}$"	$11\frac{1}{2}$"	$6\frac{1}{4}$	28 Coli-Counts	"	90.	"	"		115 V AC 50/60 Hz 40 W		Coli-Counts	
Portable Incubator	$15\frac{1}{2}$"	$10\frac{1}{2}$"	$11\frac{1}{2}$"	11	24 Coli-Counts	"	295.	"	"		6, 12, 24 V DC or 115/230 V		"	

[1] 1-80 colonies/milliliter (undiluted)

SIZING & GROWTH POTENTIAL

1. Large ranges of colonies can be recorded with further dilution of test samples.

COSTS

1. Packed in quantities of 100 @ $130.00 and 24 @ $32.50.
2. Laboratory incubator, approx. $130.00 with kit parts.
3. Portable field water analysis kit, including incubator, approx. $395.00.

INSTALLATION REQUIREMENTS

1. Lab incubator runs on standard 115 V AC. Portable incubator runs on standard 115 V AC as well as automobile battery through cigarette lighter outlet or other type batteries.

OPERATION & MAINTENANCE REQUIREMENTS

1. Operator with high school science background can make test after few days on-the-job training. Student of college biology or other science background can learn technique in a few hours.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
Coli-Count	NA	NA	NA	NA			See Tech. Perf. Below		Used in 43 states to test for bacteria	
Incubator	"	"	"	"			"		"	
Portable Incubator	"	"	"	"			"		"	

WARRANTIES, GUARANTEES, & SERVICE

1. Millipore supplies well-written and illustrated guides and holds free familiarization seminars throughout the country on a rotating schedule. Extensive applications support.

TECHNICAL PERFORMANCE

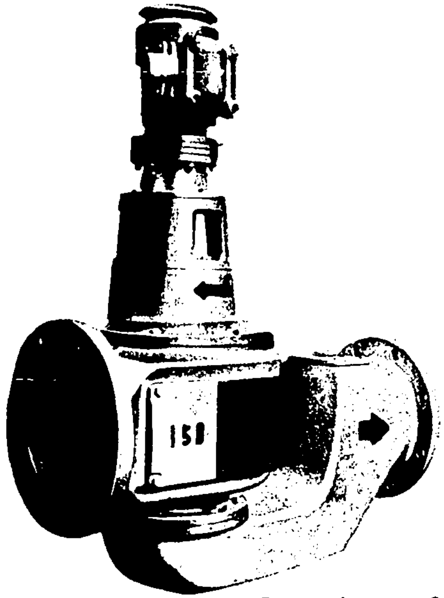
1. This is not accepted as a "Standard Method."
2. Designed to pick up gross conta mination, i.e., 1,000 MPN
3. Operating ranges: Coli-Count - ± 5°C, controlled temperature, stable ambients; Incubators - Operate 27-60°C ± 1°C in ambients as low as -40°C.

COMMENTS

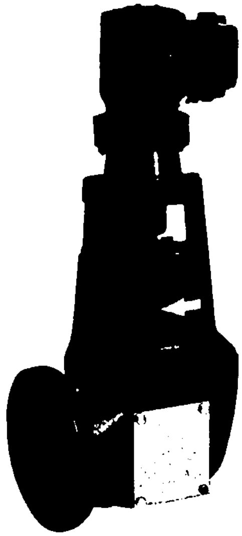
ACCURATE AS OF July 31, 1972

1. Millipore has an extensive line of microbiological analysis equipment which does follow "Standard Methods." Coli-Count intended mainly for routine check or rough analysis where gross contaimination is suspected.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



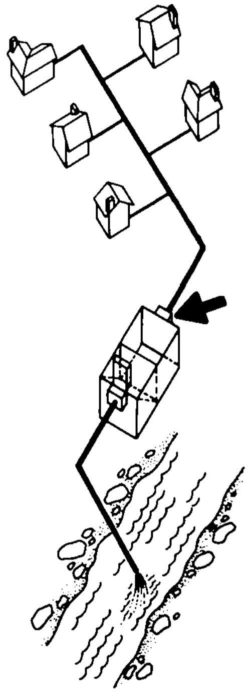
Comminutor 150



Comminutor 100

NISHIHARA COMMINUTORS

NEO 西原ネオ工業株式会社



NISHIHARA ENVIRONMENTAL SANITATION RESEARCH CORP., LTD.
c/o DR. TAKASHI ASANO
MONTANA STATE UNIVERSITY, DEPARTMENT OF CIVIL ENGINEERING
BOZEMAN, MONTANA 59715
(406) 587-3121 ext. 566
Attn: Dr. Asano

NEO COMMINUTORS

SEWAGE COMMINUTORS

FEATURES
1. Motor driven stainless steel comminuting device for in-line flow through disintegration and reduction of waste particles.
2. SM-Cyclo gear motor, continuous operation.
3. Sintered tungsten carbide tip of stud cutter, steel line and stationary cutters.
4. Optional reversing device allows removal of unbreakables from cutters.
5. 125 lb. standard flanges.

OPERATION
1. Sewage enters comminutor through inlet.
2. Revolving and stationary cutters reduce sewage and pull sewage through.
3. Discharge takes place out bottom of device or continues in-line with 180° outlet pipe for further conveyance or treatment.

MODEL NUMBER (MAJOR)	DIMENSIONS[1]			WEIGHT (LB.)[1]	RATED CAPACITY (GPD)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	DRUM SPEED (RPM)
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	MOTOR HP		
100	$14\frac{3}{16}$"	$11\frac{23}{32}$"	$30\frac{3}{8}$"	185	Average Max: 53,000	NA					230/460 V AC; 3 ph; L48 TENV	1/4	Grease	50 @ 60 Hz
150	$17\frac{9}{16}$"	17"	$31\frac{3}{8}$"	254	Average Max: 0.21 M	"					"	1/4	"	40.7 @ 60 Hz
250	$26\frac{5}{8}$"	$23\frac{11}{32}$"	$43\frac{3}{8}$"	573	Average Max: 0.79 M	"					230/460 V AC; 3 ph; M56 TENV	1/2	"	50 @ 60 Hz
350	$20\frac{3}{32}$"	$20\frac{3}{32}$"	$45\frac{17}{32}$"	662	Average Max: 1.8 M	"					230/460 V AC; 3 ph; 143 T TEFC	1	"	"

[1] Dimensions and weight do not include 180° inlet pipe.

SIZING & GROWTH POTENTIAL
1. 180° return elbows (continued in-line flow) available; drive shaft extensions from motor to comminutor available for flexible placements.
2. Average maximum flows given; absolute maximums up to 100% greater capacities.

COSTS
1. Extended drive shafts and return elbows are optional extras.
2. Electrical costs proportional to HP output.

INSTALLATION REQUIREMENTS
1. Model 100 has 5-3/16" inlet with 10" flange; Model 150 has 7-7/8" inlet with 13-1/2" flange; 250, 10" inlet, 16" flange (return elbows, same dimensions).
2. Plumbing and electrical skills required for installation.
3. Models 350 and 500 have concrete inlet and flow-through trough.

OPERATION & MAINTENANCE REQUIREMENTS
1. Periodic maintenance necessary (not daily).
2. Grease ports allow extended unattended operation.
3. Cutter replacement simple; any sewage plant personnel can replace.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	CUTTING FORCE (lb)
	BOD_5	SS	DO	COD						
100	NA	NA	NA	NA			All weather; indoor or outdoor	Motor noise. No odor.		163
150	"	"	"	"			"	"		134
250	"	"	"	"			"	"		156
350	"	"	"	"			"	"		185

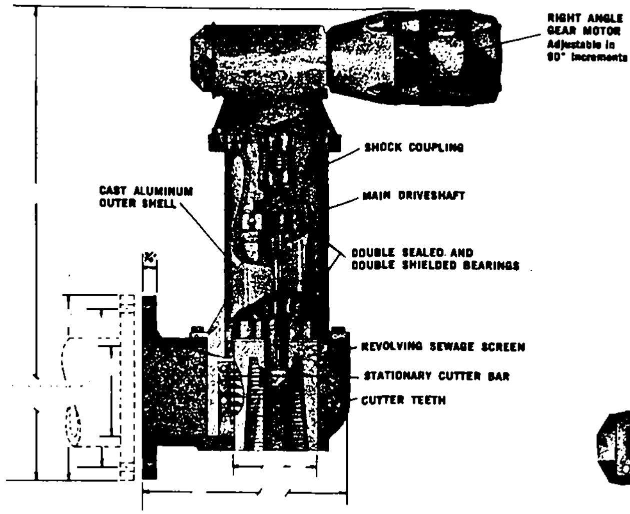
WARRANTIES, GUARANTEES, & SERVICE
1. 1 year warranty on parts and workmanship.
2. U. S. Agent: Wilwerding-Ward Systems, Inc., of San Jose, California.
3. Back-up education, sales promotion, and advertisement by Nishibara Corporation.

TECHNICAL PERFORMANCE

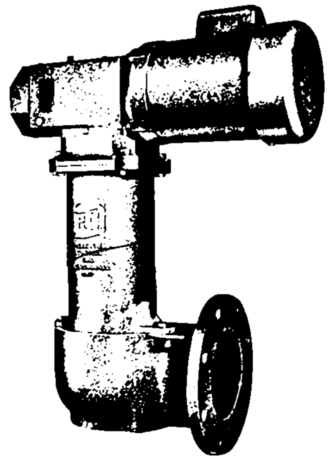
COMMENTS

ACCURATE AS OF July 31, 1972

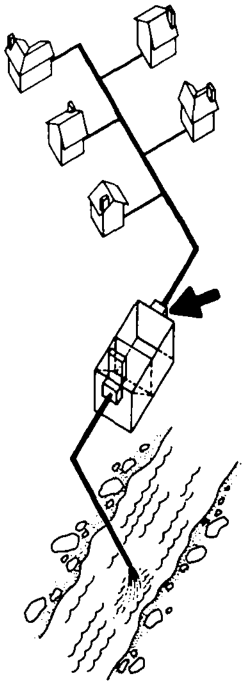
NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.



TYPICAL CROSS SECTION



ACTIVATOR COMMINUTORS



POLLUTION CONTROL INC.
N. WING, LUNKEN AIRPORT ADMINISTRATION BLDG.
CINCINNATI, OHIO 45226
(513) 871-2754
Attn: Mr. Fred Tipton, Vice-President

ACTIVATOR

SEWAGE COMMINUTORS

FEATURES
1. Motor driven aluminum comminuting device for in-line flow-through disintegration and reduction of waste particles to 1/4" or smaller with 12-1/4" cutter teeth.
2. Westinghouse 1/2 HP right angle gear motor; integral type with single reduction worm gearing Class No. 3.
3. Programmed timing control stops unit in case of clogging, overload protection circuitry.
4. Sewage can overflow through top inlet trough to flow chamber and discharge in case of power failure.
5. *Revolving aluminum screen with 4 adjustable cutter teeth.*

OPERATION
1. Sewage enters comminutor through open top inlet trough.
2. Large pieces are sheared and ground between stationary and revolving cutter teeth.
3. Ground sewage (less than 1/4") passes through revolving sewage screen to discharge at bottom of housing.
4. Overflow passes through open top inlet to flow chamber located outside of comminutor prior to treatment or pumping (in case of breakdown or over-surge).

MODEL NUMBER (MAJOR)	DIMENSIONS			WEIGHT (LB.)	RATED CAPACITY (GPM)	TANK CAPACITY (GAL.)	COSTS (DOLLARS)			DESIGN LIFETIME (YRS.)	UTILITY REQUIREMENTS		OPERATING SUPPLIES	
	LENGTH	WIDTH	HEIGHT				SUGG. LIST (FOB FACTORY)	INSTALL COST	OPERATE COST		ELECTRICITY (RATING)	WATER PRESSURE		
P-5	18"	11"	$30\frac{1}{8}$"	110	0-175	NA					10 115/230V or 30 230/460V	Flow-through [1]	None	
P-8	"	$13\frac{1}{2}$"	"	140	0-300	"					"	"	"	

[1] Minimal flow-through pressure necessary.

SIZING & GROWTH POTENTIAL
1. Both sizes available with 180° return elbows (*continued in-line flow; same direction*).
2. Drive shaft extensions from motor to comminutor available for greater flexibility.

COSTS
1. Extended drive shafts and return elbows are optional extras.
2. Electrical costs are for 1/2 HP continuous operation.

INSTALLATION REQUIREMENTS
1. P-5 has 6" ID inlet with 11" flange and 5 1/8" outlet; P-8 has *8" ID inlet with 12 1/2" flange and 8 1/8" outlet.* (Return elbow outlet has same dimensions as inlet.)
2. Electrical and plumbing skills needed for installation.

OPERATION & MAINTENANCE REQUIREMENTS
1. Periodic maintenance necessary; included in package plant service contract.

MODEL NUMBER (MAJOR)	TECHNICAL PERFORMANCE-OUTPUT (R = % REDUCTION, A = ACTUAL VALUE)						OPERATING RANGES (TEMP, OTHER)	NOISE & ODORS	STANDARDS & CODES MET	
	BOD_5	SS	DO	COD						
P-5	NA	NA	NA	NA			Temperate; outdoor operation	Motor noise. No odors.	AGMA	
P-8	"	"	"	"			"	"	"	

WARRANTIES, GUARANTEES, & SERVICE
1. 1 year warranty on parts for defective material or workmanship, to be determined by manufacturer. All labor costs extra.
2. PCI distributors offer plant service contracts covering comminutor maintenance.

TECHNICAL PERFORMANCE
1. Gear motor approved by American Gear Manufacturers Assoc.
2. P-5 provides up to 707 in/lb of torque @ 35 RPM and P-8 up to 773 in/lb of torque @ 23 RPM.

COMMENTS **ACCURATE AS OF** July 31, 1972
1. Each comminutor furnished with spare set of stationary and rotating cutters.

NOTE: The above data are based on information supplied by the manufacturer. Demonstration Water Project cannot assume responsibility for their accuracy. Please contact manufacturer for latest specifications and prices.

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d. MOP-4, *Chlorination*—under revision, old edition out of print.
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