Appendix K

Decentralized Wastewater Technology Descriptions

APPENDIX K

DECENTRALIZED WASTEWATER TECHNOLOGY DESCRIPTIONS

1.0 INTRODUCTION

A. **Purpose.** The purpose of this Appendix is to identify the various decentralized wastewater treatment and discharge technologies evaluated as part of Chapter 6.

Decentralized treatment and discharge technologies are systems that will not be connected to the Chatham WWTF, but handle more localized wastewater treatment. They include individual and multiple home systems that have total flows less than 10,000 gpd and do not require a groundwater discharge permit. The multiple home systems require a small wastewater collection system, and are often called cluster systems. Decentralized treatment and discharge technologies also include small wastewater treatment facilities that treat and discharge flows greater than 10,000 gpd, and therefore, require a groundwater discharge permit. Cluster systems and small wastewater treatment systems are typically designed for greater performance because they treat larger flows, and because they are usually regulated by a groundwater discharge permit.

2.0 INDIVIDUAL ON-SITE SYSTEMS

A. **Introduction.** On-site systems are used to treat wastewater from individual lots and may utilize one of several I/A technologies. Wastewater flows less than 10,000 gpd are regulated by the Title 5 code, 310 CMR 15.000. Flows greater than 10,000 gpd require a state-issued groundwater discharge permit per 314 CMR 5.00. It should be noted that Barnstable County is currently in the process of summarizing the performance of various individual I/A systems across Cape Cod, and therefore those findings may differ from the performance identified in this document which was based on the best available data at the time for these types of systems. The following is the definition of I/A technologies in accordance with Title 5 Regulations (310 CMR 15.002):

> “Alternative Systems – Systems designed to provide or enhance on-site sewage disposal which either do not contain all of the components of an on-site disposal system constructed in accordance with 310 CMR 15.100 through 15.293 or which contain components in addition to those specified in 310 CMR 15.100 through 15.293 and which are proposed to the local approving authority and/or the Department for remedial, pilot, provisional, or general use approval pursuant to 310 CMR 15.280 through 15.289.”

MassDEP has identified the allowable uses for each approved I/A system and has assigned each into one of four categories: remedial, pilot, provisional, and general use. Each of these categories is defined below.

- “The purpose of a **Piloting Approval** is to provide field testing and technical demonstration that an I/A technology can or can not function effectively under relevant physical and climatological conditions at one or more pilot facilities. Although information obtained during piloting is likely to be relevant to long term operation and maintenance concerns about a particular alternative system, approval for piloting is not intended, in and by itself, to provide a full evaluation of these issues.

- **Provisional Approval** is intended to designate alternative systems that appear technically capable of providing levels of protection at least equivalent to those of standard on-site disposal systems and to determine whether, under actual field conditions in Massachusetts with broader usage than a controlled pilot setting, general use of the alternative system will provide such protection, and whether any additional conditions addressing long-term operation and maintenance and monitoring considerations are necessary to ensure that such protection will be provided.

- Certification for **General Use** is intended to facilitate the use, under appropriate conditions, of alternative systems that have been demonstrated to provide levels of environmental protection at least equivalent to those of standard on-site systems.

- The purpose of approval for **Remedial Use** is to allow for the rapid approval of an alternative system that is likely to improve existing conditions at a particular facility or facilities currently served by a filed, failing or nonconforming system."

MassDEP has also identified I/A systems which are approved for general use and receive nitrogen reduction credits in nitrogen-sensitive areas. For the purposes of this evaluation, the various on-site treatment system technologies are grouped as follows:

1. **On-site Systems.** Approved for general use, but not credited for nitrogen removal, include:

- Title 5 septic systems.
- JET aerobic wastewater treatment.
- Orenco intermittent sand filter.
- Peat systems.

2. **Non-discharge Systems.**

- Tight tanks.
- Waterless toilets.

3. **On-site Nitrogen Removal Systems.** Also called I/A technologies, of which there are three types:

- Nitrogen removal systems approved for general use by MassDEP in nitrogen-sensitive areas, including recirculating sand filters that comply with Title 5, and RUCK systems (for flows less than 2,000 gpd).
- Nitrogen removal systems approved for provisional use by MassDEP in nitrogen-sensitive areas, including:
  - Bioclere
  - MircoFAST, Single Home FAST, and Modular FAST
  - Waterloo Biofilter
  - Amphidrome
  - ZenoGem/Cycle-Let

- Nitrogen removal systems approved for piloting use by MassDEP in nitrogen-sensitive areas, including:
  - OAR
  - RUCK CFT
  - Cromaglass WWT System
  - Amphidrome Process
  - MicroSeptec EnviroServer
  - Norweco Singulair
  - Nitrex
  - SeptiTech

B. **On-Site Systems Not Credited for Nitrogen Removal.**

1. **"Title 5 Systems".** Title 5 systems consist of a septic tank, distribution box, and a leaching area, as shown in Figure K-1. Wastewater is discharged to the septic tank, as shown in Figure K-2, where settable solids sink to the bottom of the tank, and floatables (like grease and toilet paper) rise to the surface, where they form a scum layer. Natural bacterial decomposition of organic matter occurs in the anaerobic conditions of the septic tank and produces ammonia. The liquid effluent is then discharged via the distribution box to a leaching area, where it percolates through stone bedding and the soil (receiving additional treatment) before reaching the groundwater. A typical leaching chamber and leaching trench are shown in Figures K-3, and K-4, respectively.

Septic tank effluent ammonia-nitrogen levels are generally in the range of 20 to 60 mg/l. Septic tank effluent concentrations of BOD and TSS are approximately 140 to 200 mg/l and 50 to 90 mg/l, respectively. In addition to pollutant removal in the septic tank, treatment in a Title 5 system also occurs in the stone and soil interface through the action of a biological mat. Title 5 systems reduce bacterial contamination primarily via filtration of effluent through the mat and soils beneath the leaching area. If the leaching area is designed to promote aerobic conditions, nitrification can occur, converting the ammonia nitrogen (NH_3-N) to nitrate nitrogen (NO_3-N). Once the nitrogen is in the nitrate form, it can be converted to nitrogen gas and released to the environment. Nitrogen removal rates can range from 10 to 40 percent, depending on the leaching area, system design, and loading. Nitrogen removal is not usually significant in a Title

5 system due to limited opportunities for denitrification (conversion of NO_3-N to N_2 [gas]) under typical aerobic conditions.

Soil characteristics are an important consideration for on-site systems, and many soils are not suitable for use as leaching areas. Those consisting of clay and silt (tight soils) do not percolate easily and may force the septic tank effluent to come to the surface, causing human health concerns, contaminated surface runoff, and possible shellfish bed closures.

The opposite condition can occur when the soils are sand or a sand/stone mix which percolates too fast. Fast soils generally have percolation rates of 2 minutes per inch or less, and allow the wastewater to travel through the soil with little additional treatment beyond that provided by settling in the septic tank.

Title 5 systems have the following advantages:

- Relatively low installation and maintenance cost compared to other systems.

They have the following disadvantages:

- Require pumping the septic tank every two to three years (as do all individual on-site systems).
- The effluent from the system is of a comparatively low quality, and it is high in nitrogen, which may impact drinking water supplies or coastal embayments. These systems do not provide advanced nitrogen removal.

2. **JET Aerobic Treatment System**.[1] This is an aerobic treatment system designed to achieve limits of 30 mg/L BOD and 30 mg/L TSS. Flow enters a primary settling chamber to remove solids, then enters an aerated chamber where BOD and TSS removal is achieved. Aeration is provided by a mechanical aspirator that mixes the chamber and entrains air. The system uses both suspended growth and fixed-film bacteria to achieve the above stated removals.

[1] USEPA Region I web page, 2003.

Regular maintenance is required, as this is a mechanical system. Massachusetts requires a quarterly preventative maintenance schedule be maintained for this system. A diagram of the JET Aerobic Treatment System is included in Figure K-5.

JET systems have the following advantages:

- High effluent quality.
- Allows for variances for reduction in leaching area or separation to groundwater.
- Approved for General Use in Massachusetts.

They have the following disadvantages:

- Higher capital cost and operation and maintenance costs than standard Title 5 systems.
- Requires routine maintenance, beyond the typical pumping of a septic tank.
- Currently only designed to handle flows up to 1,500 gpd.

3. **Orenco Systems Sand Filters.** Orenco Systems, Inc. manufactures an intermittent sand filter and a recirculating trickling filter, which can be installed either as a component of a new septic system or retrofitted into an existing septic tank. Intermittent sand filters are designed to disperse daily septic tank effluent flow over a distribution area throughout the course of a 24-hour period. The even distribution provides for a higher quality final effluent because it allows for more efficient use of the soil absorption system. In a recirculating trickling filter, the septic tank is fitted with a small trickling filter on top of the tank, and a PVC pump vault inside the tank. The pump vault houses both a recirculation pump and an effluent pump. Inlet holes in the pump vault allow septic tank liquid to enter the vault, where it is either recirculated to the trickling filter or pumped to a leaching area. Nitrification occurs in the trickling filter, and with a recirculation ratio of 15 to 1, the effluent is denitrified after returning to the septic tank. The mechanism for nitrogen removal is similar to the recirculating filters previously defined. A diagram of the Orenco intermittent sand and trickling filters is included in Figure K-6.

The Orenco filters have the following advantages:

- Better treatment (than treatment from a Title 5 system) can be attained and the leaching size can be reduced.
- Total nitrogen levels in the septic tank effluent have been shown to be reduced by 84 percent from 68 to 11 mg/l with an average of 10 to 15 mg/l total nitrogen discharged to the leaching area, if maintained properly.
- Septage pumping requirements are similar to those of a standard septic system.
- Proven technology.
- Both systems are approved for General Use in Massachusetts (not for nitrogen removal).
- Can be retrofit into an existing system at relatively low cost.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- The process operation is flexible, with the ability to adjust cycle times.

The Orenco systems have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- Temperature sensitive in winter.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Pumps and/or fans are used which must be maintained and periodically replaced.

4. **Peat Systems.** Peat systems were originally developed in the late 1970s in Maine and have been designed to take advantage of the natural properties of peat. The vast majority of peat systems in the United States are installed in Maine, and peat system manufacturers have received limited approval from other states, including Massachusetts, Connecticut, New Jersey, Maryland, Virginia, Ohio, North Carolina, Kentucky, and Alabama. A peat bed is installed following the septic tank and can function both as a filter and leaching area. The septic tank effluent is distributed via perforated pipes to the peat bed, where the wastewater moves through the peat and is treated by a combination of physical filtration, microbial activity, and chemical adsorption. A typical cross-section of a peat system is shown in Figure K-7.

While some nitrogen removal has been reported with this system, the nitrogen removal mechanism is not fully understood, but is assumed to involve nitrification (NH_3-N to NO_3-N) occurring in the aerobic portions of the peat bed, followed by denitrification [NO_3-N to N_2 (gas)] occurring within anaerobic microsites. The N_2 gas is then lost to the atmosphere, resulting in an overall net loss of nitrogen. Reported nitrogen removal rates in Maine vary from 60 percent to greater than 90 percent, with fecal coliform removal of 99.9 percent and BOD_5/TSS effluent quality of 10/10 mg/l. Test sites on Cape Cod report inconsistent nitrogen removal, often ranging between 30 to 40 percent. The low nitrogen removal rates on Cape Cod may be caused by the naturally acidic water on Cape Cod, which may inhibit the nitrification and denitrification processes. As a result, the peat system is not considered a nitrogen removal alternative at this time.

This alternative requires very little maintenance and has no moving parts, unless a pump is required because of site conditions. For most installations, the top surface of the peat bed is exposed at ground level; therefore, traffic and parking must be prevented from occurring over the system. Grass is slow to establish on the surface, often taking more than one growing season to establish growth. Recommended design specifications, peat type, and compaction specifications must be followed to obtain an effective peat system.

Peat systems have the following advantages:

- It is an accepted technology in the State of Maine.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- The basic system requires no pump.
- Bacterial removal rates range from 90 percent to greater than 99.9 percent.
- The effectiveness of the system does not depend on soil conditions at the site.
- It requires no special skill or knowledge for routine O&M.
- Septage pumping requirements are similar to those of a standard septic system.

They have the following disadvantages:

- MassDEP has only approved these systems for remedial use.
- Costs are typically higher than those of a standard septic system.

- Transportation cost of the peat can be expensive.
- Vehicles cannot be driven on top of a peat system.
- Low nitrogen removal rates have been recorded at test sites on Cape Cod.

C. **Non-Discharge Systems.**

1. **Tight Tanks.** Tight tanks are non-discharge systems which collect and store the wastewater until it can be removed by a septage hauler. All the wastewater generated by the household or business goes directly into the tight tank. The storage tank typically has a level indicator with an alarm, and a signal is transmitted when the liquid level reaches a certain height. When the tank is full, a septage hauler empties the tank and transports the contents to a treatment facility. This type of system has high transportation and disposal cost. The system can generate odors during pumping. Land requirements are lower for a tight tank than for a septic system because a leaching system is not used.

Tight tanks have the following advantages:

- Simple technology; tanks provide only short-term storage.
- No significant environmental concerns when they are properly sited and designed.
- Wastewater is not discharged to the ground; therefore groundwater mounding or nitrogen loading is not a concern.
- Require less land area than a septic system.
- Water use is discouraged because most water used must be transported and disposed off site at a high cost.

They have the following disadvantages:

- MassDEP does not consider tight tanks an adequate long-term solution.
- High operational costs due to frequent pumping.
- Potential for frequent pump truck traffic and odors that occur during pumping.
- Wastewater treatment and disposal issues are transferred to another location.

2. **Waterless Toilets.** Water consumption, wastewater flow, and pollutant loading can be reduced using waterless toilets. Waterless toilet systems operate by separating black

wastewater and gray wastewater. Black wastewater is toilet waste and gray wastewater is generated from non-sanitary sources, such as washing clothes and dishes and bathtub and shower use. Black wastewater is treated in the waterless toilet unit, and gray wastewater is discharged to a septic system with potential size reductions. The two most common wastewater toilet systems are composting toilets and incinerating toilets.

Composting toilets recirculate the black wastewater over remaining solids to promote a natural decomposition process. Incinerating toilets burn black wastewater and generate a small quantity of ash and gas. Composted material and ash are periodically removed from the respective systems, and air filters and exhaust units are used to minimize odors. Public acceptance of waterless toilet systems is often low due to the composting, incinerating, and handling of human waste within living spaces. A potential use of waterless toilets is in public restrooms and convenience stations. This option eliminates the need for individual users to handle human waste, and would remove the composting process, odors, and incinerating process from residential areas. Diagrams of composting and incinerating toilets are included as Figures K-8 and K-9, respectively.

Waterless toilets have the following advantages:

- Wastewater flows and loads are reduced if properly designed and installed.
- Water consumption is significantly reduced.
- Minimal environmental concerns occur when properly sited and designed.
- Composting toilets require minimal energy use.
- Size of standard septic system can be reduced to treat only gray wastewater.
- Routine maintenance is minimal and requires no special training.

Waterless toilets have the following disadvantages:

- Public acceptance is generally low.
- Incinerating toilets generally require high-energy use.
- Handling of composting toilet contents can be objectionable.
- Incineration units are likely to generate odors if not vented properly.
- Not well suited to high seasonal peak loading.

D. **On-Site Nitrogen Removal Systems (Approved for General Use in Nitrogen-Sensitive Areas).**

1. **Recirculating Sand Filters (Non-Proprietary Filters).** Sand, rock, or mixed media recirculating filters are non-proprietary systems with a recirculation tank and filter. Effluent flows from the septic tank to the recirculation tank where it is pumped to the top of the filter and over the media. A portion of the flow is recirculated back to the recirculation tank and the remaining flow is discharged to the leaching area. A diagram of a typical recirculating sand filter is shown in Figure K-10.

Anaerobic decomposition occurs in the septic tank, changing organic matter to ammonia. The ammonia is then converted to nitrate in the aerobic filter media. The recirculated effluent then undergoes denitrification in the recirculation tank, and nitrates are converted to nitrogen gas. The nitrogen gas is then lost to the atmosphere, yielding a net loss of nitrogen from the wastewater. Many variations on the basic system are available to handle specific needs of a project or site.

Maintenance includes periodic removal and replacement of the upper layers of media or backwashing. Pumps must be maintained and replaced on a schedule. In emergencies, such as power loss, the system can be designed to function as a flow-through system, with treatment equal to a standard Title 5 system.

Recirculating sand, rock, or mixed media filters have the following advantages:

- Approved for General Use in nitrogen-sensitive areas by MassDEP.
- Septage pumping requirements are similar to those of a standard septic system.
- Well proven technology with operating history since the 1970s.
- Do not require a high level of technical skill to operate when designed and installed correctly.
- Better treatment can be attained and the leaching size can be reduced.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- The process has operational flexibility, with capability to adjust cycle times.

- Removal rates range from 60 percent to greater than 90 percent for nitrogen, depending on the system. BOD_5 and TSS effluent quality of 10 mg/l can be achieved.

They have the following disadvantages:

- More maintenance is required than for a standard septic system due to mechanical and electrical components.
- Generally require a larger land area than a standard septic system. Land surface may be occupied by the filter unit and not available for other use.
- Systems are sensitive to temperature and must be protected from freezing.
- Costs are typically higher than those of a standard septic system.
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2. **RUCK System.** The RUCK system is designed to divide the black (toilet wastes) and gray (non-toilet wastes) wastewater and treat each in separate septic tanks. The two flows are typically piped separately from a home (or group of homes) and divided to either a black water or gray water septic tank. Black water flows through the RUCK filter constructed of sand or other media in which nitrification occurs. The effluent is then returned to an anaerobic tank and mixed with the gray water to promote denitrification, using the gray water as a carbon source. The gray wastewater septic tank effluent is discharged through a distribution box to a standard leaching area. These systems are used primarily for nitrogen removal. Figure K-11 presents a diagram of the RUCK system.

The RUCK system has the following advantages:

- Approved for General Use in nitrogen-sensitive areas (for flows less than 2,000 gpd).
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Low operational and maintenance costs.
- Nitrogen removal rates range from 40 to 80 percent, depending upon the system and site. Effluent quality of BOD_5/TSS of 20/30 mg/l leaving the system.
- Routine maintenance requires no special training.

The RUCK system has the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- Requires more space than a standard septic system.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Pumps and/or fans are used which must be maintained and periodically replaced.
- Retrofitting the plumbing to separate black and gray wastewater flows can be difficult and expensive.

E. **Other Nitrogen Removal Systems.**

1. **General.** The remaining nitrogen removal systems can be grouped into recirculating treatment technologies. Recirculating treatment technologies are a category of alternative treatment systems which are used in combination with standard septic systems. These systems typically include a recirculation chamber and a media to support microbial growth, which biologically treats the wastewater prior to discharge through a leaching system. A percentage of the wastewater is recirculated through the system, depending on influent quality, required effluent quality, and system design.

Recirculating treatment technologies vary in the type of media used, the wastewater pumping arrangement, and the overall system configuration. Some of these systems are produced by a specific manufacturer and are commonly referred to by their trade names. This section identifies and describes many of the recirculating treatment technologies and respective manufacturers which are currently approved for use in Massachusetts. The main disadvantage of these systems is the six- to eight-week startup period for biomass development. Summer residences are typically used only over a three-month period; therefore, these systems do not provide the maximum performance during the first half of the residence use. Recirculating treatment technologies are further grouped as those approved for "Pilot" or "Provisional Use" in nitrogen-sensitive areas and those that are not.

2. **Systems Approved for "Pilot" and "Provisional Use" in Nitrogen-Sensitive Areas.**

a. **Bioclere.** Bioclere is a trickling filter and pump unit in one manufactured unit, designed to treat the anaerobic effluent from a septic tank, which is high in ammonia. The filter media is PVC or polypropylene. Effluent from the septic tank is pumped to a distributor, which spreads the wastewater over the top of the media, where aerobic conditions allow nitrification to occur, converting ammonia to nitrate. In the media, anaerobic microsites also form where some limited denitrification (NO_3-N to N_2 [gas]) can take place. However, the majority of denitrification occurs when the effluent is collected at the base of the filter, and about 70 percent of the flow is recirculated back to the anaerobic septic tank. The rest of the effluent is discharged to a leaching area. A diagram of a Bioclere treatment unit is shown in Figure K-12.

Installation of the Bioclere tank is relatively simple. One treatment unit contains a pump, distributor, and filter media. The treatment unit can either be retrofitted into existing septic systems by reusing the septic tank, piping, and leaching area, or it can be installed into new systems. The sealed double wall of the treatment unit provides insulation to minimize cold weather impacts. Nitrogen reductions of 70 to 85 percent have been achieved. The system can handle flow variations by varying the recirculation rates, and the units can handle increased flow by inserting additional media into the unit.

The Bioclere system has the following advantages:

- Well proven technology in Massachusetts.
- Approved for General Use in Massachusetts.
- No significant environmental or public acceptance concerns when properly sited and designed.
- The process operation is flexible, with ability to adjust cycle times and add additional media.
- The basic system has low operation and maintenance costs. The pump contained in the unit is easily accessible for replacement, when required.
- Septage pumping requirements are similar to those of a standard septic system.
- Better treatment can be attained and the leaching size can be reduced.

- Nitrogen removal rates range from 70 percent to greater than 85 percent.

They have the following disadvantages:

- Costs are typically higher than those of a standard Title 5 system.
- Maintenance agreements are required and have an associated cost.
- More maintenance is required than a standard Title 5 system due to mechanical and electrical components.
- Generally require a larger area than a standard Title 5 system.

b. **Mini- and Single Family-FAST.** The modular fixed activated sludge treatment (FAST) systems are constructed using a submerged filter unit installed below ground in a configuration similar to that of a standard septic tank. Wastewater enters the primary settling zone of the tank, where primary solids removal is achieved. Flow is then recirculated through the submerged FAST filter, which is located at the effluent end of the tank, by means of a centrally located draft tube. A small portion of the recirculated wastewater flow is periodically discharged to a leaching area. An enclosed blower supplies air to the system in order to support bacterial growth on the filter media. Nitrification and denitrification are achieved as part of the FAST system design and result in a total nitrogen removal rate of 70 percent or greater. A diagram of the FAST system is included as Figure K-13.

The FAST system has the following advantages:

- Proven technology in Massachusetts.
- Septage pumping requirements are similar to those of a standard septic system.
- The basic system uses a small mechanical aerator, which is accessible for service or replacement.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Generally requires same land area as a standard septic system.

The FAST system has the following disadvantages:

- Costs are typically higher than those of a standard Title 5 system.
- More maintenance is required than a standard Title 5 system due to mechanical and electrical components.
- Pumps and/or fans are used which must be maintained and periodically replaced, and require a backup power source.
- The blower can be relatively noisy in a quiet residential area and therefore must be enclosed.

c. **Amphidrome.** The Amphidrome process combines filter technology with a biofilter, an equalization tank, a clearwell, and the common components of a septic system. Wastewater flows by gravity from an equalization/septic (anoxic) tank through the biofilter into a clearwell. Wastewater is then pumped in reverse through the biofilter to the anoxic tank. The biofilter alternates between aerobic and anoxic conditions, providing nitrification and denitrification as the cycle is repeated. Wastewater is allowed to cycle through the system several times before it is discharged. A diagram of the Amphidrome system is included as Figure K-14.

The Amphidrome process has the following advantages:

- Utilizes deep bed filter technology, which has a good historic performance record.
- Septage pumping requirements are similar to those of a standard septic system.
- It has demonstrated very good nitrogen removal in several cluster and commercial installations on Cape Cod.

The Amphidrome process has the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- Pumping requirements are high due to internal treatment configuration.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Pumps and/or fans are used which must be maintained and periodically replaced.

d. **Waterloo Biofilter.** The Waterloo Biofilter consists of a 6-foot by 6-foot by 4-foot enclosure which includes filter media, an air ventilation system, and a wastewater distribution system. The distribution system pumps effluent from the septic tank and sprays it over the surface of the media. Wastewater trickles through the media while air is blown through the system. The system uses a small ventilation fan and an effluent pump timed via a control panel to dose effluent at frequent intervals over a 24-hour period. The effluent is collected at the base of the biofilter and a portion is recirculated back through the media, while the rest is discharged to a leaching area. The mechanism for nitrogen removal is similar to the recirculating filters described earlier. A diagram of the Waterloo Biofilter is included as Figure K-15.

The Waterloo Biofilter has the following advantages:

- Septage pumping requirements are similar to those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- The process operation is flexible, with the ability to adjust cycle times.
- The basic system uses a small pump, which has low operational and maintenance costs. The pump is easily accessible for service or replacement.
- Although the design hydraulic loading rate is 10 gal/ft2/day, it can handle surges of up to 49 gal/ft2/day for several days with little effect on effluent quality.
- Better treatment can be attained and the leaching size can be reduced.
- Removal rates for nitrogen range from 60 percent to greater than 90 percent, depending upon the system and site. Effluent BOD5 and TSS are expected to be <10 mg/l in the winter and often <5 mg/l at other times of the year. Fecal coliform removal 99.0 to 99.5 percent.

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- Systems are sensitive to the temperature of the septic tank effluent entering the system from the septic tank. Insulation of the septic tank is recommended.
- More maintenance is required than a standard septic system due to mechanical and electrical components.

- Pumps and/or fans are used which must be maintained and periodically replaced.
- Denitrification unit periodically requires recharging with material like sawdust or leaves to serve as a carbon source for denitrification.

e. **ZenoGem/Cycle-Let by Zenon Inc.** The ZenoGem system is a membrane filtration/biological treatment process that can produce a well-treated effluent for discharge or reuse. Wastewater is first collected in the septic tank prior to flowing through an activated sludge treatment and membrane filtration process. The system is often followed by disinfection using ultraviolet light.

Figure K-16 illustrates the ZenoGem system with typical associated components. The unique component of this system is the Permaflow® ultrafiltration module which separates the treated water (permeate) from the biological mixed liquor.

The ZenoGem system has the following advantages:

- Septage pumping requirements are similar to those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Better treatment can be attained and the leaching size can be reduced.
- Membrane filtration provides excellent removal rates for TSS and fecal coliform.

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system, and membrane system costs may be higher than other I/A technologies.
- More maintenance is required than a standard septic system due to mechanical and electrical components.

f. **OAR System.** The OAR system (illustrated in Figure K-17) is comprised of two tanks. The first tank is aerated using compressed air to provide aerobic conditions for the reduction of BOD, TSS, and to nitrify ammonia. The aerobic tank is also heated to provide suitable conditions for these biological processes and to aid in nitrification during the winter months. The effluent from this tank enters the anoxic or denitrification tank where nitrate nitrogen is converted into nitrogen gas. This process requires a supplemental carbon source to aid in the denitrification process. Denitrifying bacteria are also added to this tank to aid in the nitrogen removal process.

The OAR system has the following advantages:

- Septage pumping requirements are similar to those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Better treatment can be attained and the leaching size can be reduced.

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- System requires supplemental carbon and denitrifying bacteria.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Chemical storage is required.

g. **Cromaglass System.** The Cromaglass system (illustrated in Figure K-18) is a type of sequencing batch reactor (SBR) treatment process. The system operates in five stages: fill, aeration, denitrification, settling, and discharge. Flow enters the first stage, where solids settle out and the remainder of the flow passes through a non-corrosive screen. After passing through the screen, the wastewater is aerated and mixed using submersible pumps. The pumps are then shut down to provide an anoxic condition to promote denitrification. Flow is then pumped to the clarifiers for final settling, and then flow is pumped from the clarifiers for effluent discharge to the leaching facilities.

The Cromaglass system has the following advantages:

- Septage pumping requirements are similar to those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Better treatment can be attained and the leaching size can be reduced.

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Pumps are used which must be maintained and periodically replaced.

h. **MicroSeptec EnviroServer.** This system (illustrated in Figure K-19) is a type of fixed film-suspended growth extended aeration system. Wastewater enters the septic tank for solids removal and then flows into the aerobic tank, where the wastewater is aerated for BOD removal and nitrification. Flow from this tank is discharged into a settling tank for final clarification and to allow flow to be recycled back to the septic tank to promote denitrification. The system is also equipped with a thermal oxidizer to aid in the decomposition of primary sludge.

The MicroSeptec system has the following advantages:

- Septage pumping requirements are less than those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Better treatment can be attained and the leaching size can be reduced.

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Pumps are used which must be maintained and periodically replaced.

i. **Norweco Singulair.** This system (illustrated in Figure K-20) is a type of extended aeration system. The treatment process is contained within a three-chambered tank. The first chamber provides solids settling, the second chamber is the aerobic zone where the wastewater is aerated to promote BOD removal and nitrification, and the third chamber is the final settling chamber. This chamber is equipped with a filtration unit to aid in clarification prior to effluent disposal. The system is followed by a recirculation chamber to pump 10 to 20 percent of the flow back to the first chamber for nitrogen recycle.

The Singular system has the following advantages:

- Septage pumping requirements are similar to those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Better treatment can be attained and the leaching size can be reduced.

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Pumps are used which must be maintained and periodically replaced.

j. **NITREX System.** This system (illustrated in Figure K-21) is a filter unit that can be added to the end of an I/A system. The system requires a nitrified effluent to work, therefore a treatment process beyond a normal septic system is required to proceed with this system. The filter media is contained in a tank and is a flow through system by gravity. The media is comprised of wood chips and cellulose.

The Nitrex system has the following advantages:

- Septage pumping requirements are similar to those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Better treatment can be attained and the leaching size can be reduced.
- Does not require pumping.
- No supplemental carbon required

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- Requires pretreatment to provide a nitrified effluent to the system.
- Does not provide any additional treatment beyond nitrogen removal.
- Media life is unknown and is expected to need replacement in 10 to 20 years.
- It may require alkalinity feed to the nitrification portion of the process.

k. **SeptiTech System.** This system (illustrated in Figure K-22) is a fixed-film-type system. The first two tanks or chambers of the system provide solids settling and the anoxic zone for denitrification. The second chamber contains trickling filter media and wastewater is recirculated within this chamber for treatment. Flow is also recirculated back to the anoxic zone to promote denitrification.

The SeptiTech system has the following advantages:

- Septage pumping requirements are similar to those of a standard septic system.
- No significant environmental or public acceptance concerns when they are properly sited and designed.
- Better treatment can be attained and the leaching size can be reduced.
- No supplemental carbon required

They have the following disadvantages:

- Costs are typically higher than those of a standard septic system.
- More maintenance is required than a standard septic system due to mechanical and electrical components.
- Pumps are used which must be maintained and periodically replaced.

3.0 CLUSTER TREATMENT SYSTEMS

Cluster treatment systems are systems which fall between individual on-site systems and large municipal facilities designed to serve large areas of a town. These systems are typically designed to treat and discharge wastewater generated within small neighborhoods or developments. The main difference between cluster systems and centralized wastewater treatment facilities is the location of the treatment and effluent disposal. For the purpose of this project, centralized wastewater facilities are those which collect wastewater from various planning areas and discharge them at the facility site (i.e., the existing Chatham WWTF) or remote sites that may or may not be located within the planning area from which the wastewater was generated.

Cluster systems can range in size from serving small groups of homes or businesses to an entire planning area. Cluster treatment systems may utilize any one of the on-site technologies described previously in this chapter, or could be served by a small wastewater treatment system for flows over 10,000 gpd. Because cluster systems are designed to handle "clusters" of properties, they require a collection system to transport the wastewater from the properties to the treatment facility.

The following cluster technologies are described in Appendix J:

- RBC
- SBR
- Zenon

Other technologies commonly used for cluster systems are described below.

A. **Amphidrome.** The Amphidrome process is a fixed-film, sequencing batch-type process designed for nitrogen removal. It combines filter technology with a biofilter, an anoxic/equalization tank, and a clearwell. Wastewater flows by gravity from the anoxic/equalization tank through the biofilter into a clearwell. Wastewater is then pumped in reverse up through the biofilter to the equalization tank. The Amphidrome biofilter alternates between aerobic and anoxic treatment as the cycle is repeated. Wastewater cycles through the system before it is discharged. The Amphidrome system is capable of nitrogen removal without modifications or additions; however, it often requires a supplemental carbon source be provided.

The Amphidrome process has the following advantages:

- Tanks are typically below ground; therefore, visual impacts are minimal.
- Allows secondary treatment and nitrogen removal in a single reactor.
- Potential for air emissions is minimal, as filters are enclosed and below ground.
- The process also provides physical filtering, as well as biological nitrogen removal.

The Amphidrome process has the following disadvantages:

- It is a relatively new treatment configuration and there are limited installations on which to judge performance. The performance to date has been very good.
- Large headloss and below-grade installation requires effluent pumping.

B. **MicroFAST and Modular FAST Systems.** Two standard fixed activated sludge treatment systems -- the MicroFAST and modular FAST -- are manufactured as fixed-film, aerobic processes that can be modified for nitrogen removal. MicroFAST systems are designed for flows up to approximately 40,000 gpd and include individual units which can each treat up to 9,000 gpd. For flows greater than 40,000 gpd, the modular FAST system is used which includes a large tank packed with submerged fixed media. Wastewater flows from the primary treatment process through the FAST media and is recirculated through a distribution system. A small portion of the recirculated wastewater flows through a clarifier and is periodically discharged to a leaching area. Nitrification and denitrification are achieved using two anoxic tanks and a reaeration tank. These additional process tanks are part of the modular FAST treatment facility for flows over 40,000 gpd. The modular FAST system can be designed with additional septic tanks to achieve necessary anoxic and reaeration zones, and because it is modular, it allows the system to be designed around the owner’s needs. Blowers supply air to the system to support bacterial growth on the filter media. Diagrams of a MicroFAST and modular FAST system are shown on Figure K-23.

The modular FAST system has the following advantages:

- Relatively low space requirements.
- Shown effective for nitrogen removal as well as secondary treatment.

- Approved for General Use in Massachusetts and for Provisional Use in nitrogen-sensitive areas.

They have the following disadvantages:

- Requires skilled operation.
- Higher energy costs for aeration.
- High process control requirements to optimize performance.

C. **Bioclere.** Bioclere is a trickling filter and clarifier in one manufactured unit, designed to treat the anaerobic effluent from a septic tank, which is high in ammonia. The filter media is PVC or polypropylene. Effluent from the septic tank is pumped to a distributor which spreads the wastewater over the top of the media, where aerobic conditions allow nitrification to occur, converting ammonia to nitrate. In the media, anaerobic micro-sites may also form where some limited denitrification (NO_3-N to N_2 [gas]) can take place. However, the majority of denitrification occurs when the effluent is recollected at the base of the filter, and about 70 percent of the flow is recirculated back to the anaerobic septic tank. The rest of the effluent is discharged to a leaching area. Bioclere systems treating flows greater than 10,000 gpd often incorporate denitrification filters for nitrogen removal.

Installation of the Bioclere is relatively simple. One treatment unit contains a pump, distributor, and filter media. The sealed double wall of the treatment unit provides insulation to minimize cold weather impacts. The Bioclere can be used year-round or seasonally. However, it takes approximately six weeks for the microbial layer (biomass) to be established on the filter media before full treatment is achieved. Nitrogen reductions of 70 to 85 percent have been achieved. The system can handle flow variations by varying the recirculation rates, and the units can handle increased flow by inserting additional media into the unit.

The Bioclere system has the following advantages:

- Well proven technology in Massachusetts.
- No significant environmental or public acceptance concerns when the system is sited and designed.

- The process operation is flexible, with ability to adjust cycle times and to add additional media.
- The basic system has low operation and maintenance costs. The pump contained in the unit is easily accessible for replacement, when required.

The Bioclere system has the following disadvantages:

- The Bioclere units extend above the ground and may require additional vegetative landscaping to reduce aesthetic impacts.
- Pumps and/or fans are used which must be maintained and periodically replaced.

D. **Wetland-Based Treatment Processes.** There are two main types of natural or wetland-based treatment processes that could be considered for cluster systems: (1) constructed wetlands, and (2) solar aquatics. However, because of their large land area requirements, these processes are to be considered under the centralized wastewater treatment facilities options only.

E. **Filtration.** For many small wastewater treatment facilities there is a need for additional effluent polishing which may include additional denitrification and/or solids removal. Typically this is accomplished using an effluent filter, typically a granular media type (sand and/or anthracite), and depending on the effluent limits required, supplemental carbon may be required for denitrification. The following describes two common technologies used to accomplish this.

1. **Slow Sand Filtration.** Slow sand filters are a type of treatment process that is very effective in removing total suspended solids, turbidity, and organics from wastewater. Recent research has also shown that simultaneous nitrification and denitrification occur in slow sand filters, and effluent total Kjedahl nitrogen (TKN) as low as 0.6 mg/L and total nitrogen (TN) as low as 1.5 mg/L can be achieved. The size of the sand media ranges from 0.15 mm to 0.35 mm, with an effective size of 0.2 mm. The filtration rates of slow sand filters usually ranges from 2.5 – 6 m^3/m^2/day. Filtration rate and sand size are the key factors to nitrification and denitrification efficiencies and total nitrogen removal efficiency. Nitrification efficiency is most sensitive to filtration rate and sand size. A diagram of a slow sand filter is presented in Figure K-24.

Advantages of Slow Sand Filters:

- Lower unit filtering, operation and maintenance costs than rapid sand filters.
- Highly effective in removing bacterial contaminants.
- Reduction in iron, manganese, nitrate and turbidity are achieved.

Disadvantages of Slow Sand Filters:

- Higher construction costs than rapid sand filters.
- Large area of land is required.

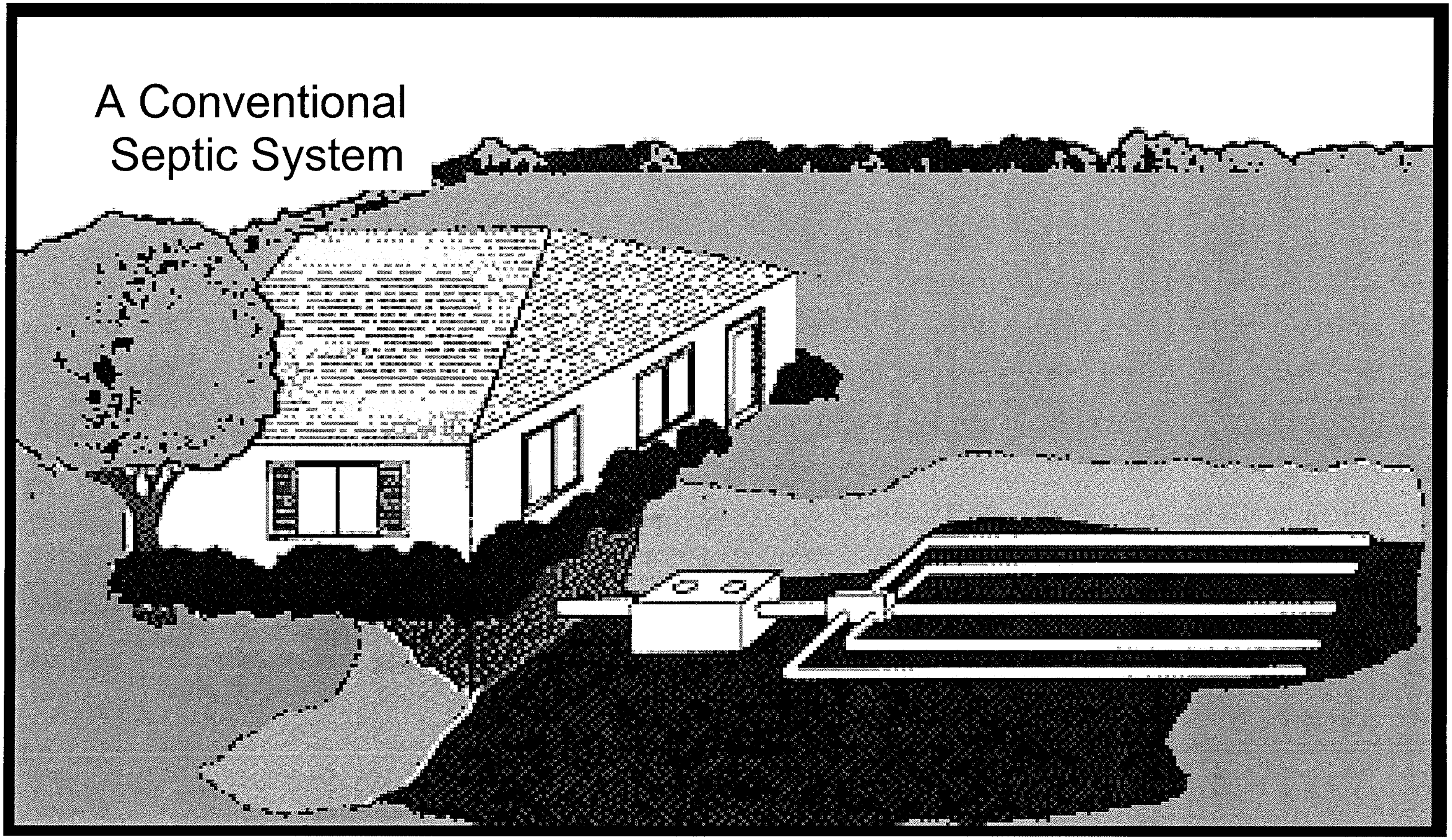
2. **Rapid Sand Filtration.** The major difference between a rapid sand filter and a slow sand filter is the sand size. The size of rapid sand filters ranges from 0.35 mm – 1.0 mm. Filtration rates range from 100 – 300 m^3/m^2/day or approximately 50 times the rate of slow sand filters. Figure K-25 shows the picture of a rapid sand filter.

Advantages of Rapid Sand Filters:

- Effective in treating higher solids loadings than slow sand filters.
- Produce higher output than slow sand filters.
- Less land is required.
- Commonly applied to small wastewater treatment facilities.

Disadvantages of Rapid Sand Filtration

- Complicated to operate.
- Pretreatment is often required.
- Higher unit filtering, operation and maintenance costs than slow sand filters.
- Ineffective in nitrogen removal.



Source: Massachusetts DEP, http://www.mass.gov/dep/water/wastewater/yoursyst.htm

Data Source: Mass GIS
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Technology Screening Report\
70098FK-1_Septic System Diagram .mxd

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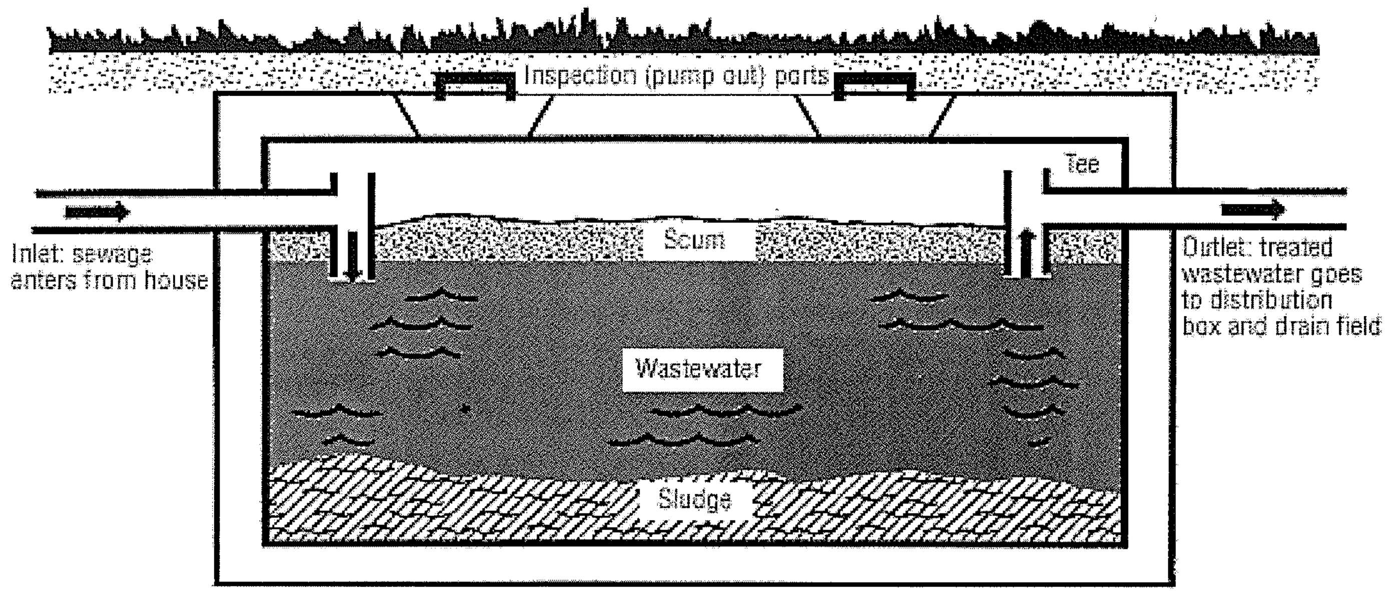
TITLE 5 SEPTIC SYSTEM DIAGRAM

FIGURE K-1



Source: Massachusetts DEP, http://www.mass.gov/dep/water/wastewater/yoursyst.htm

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\70098 Chatham\CWMP Figures\Report Figures\Technology Screening Report\70098FK-2_Septic Tank Diagram .mxd

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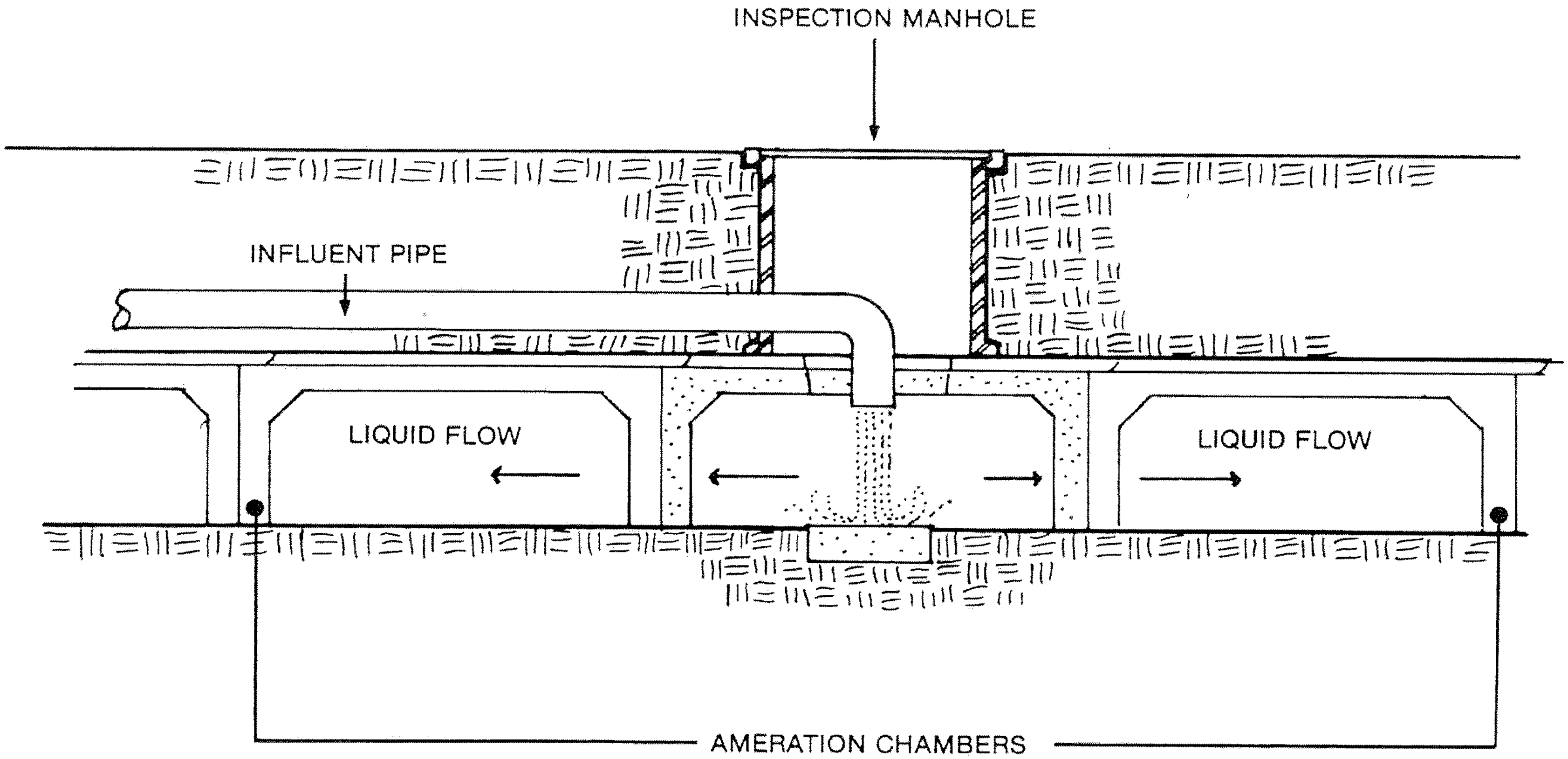
TITLE 5 SEPTIC TANK DIAGRAM

FIGURE K-2



Source: Shorey Precast, 2000

Data Source: Mass GIS
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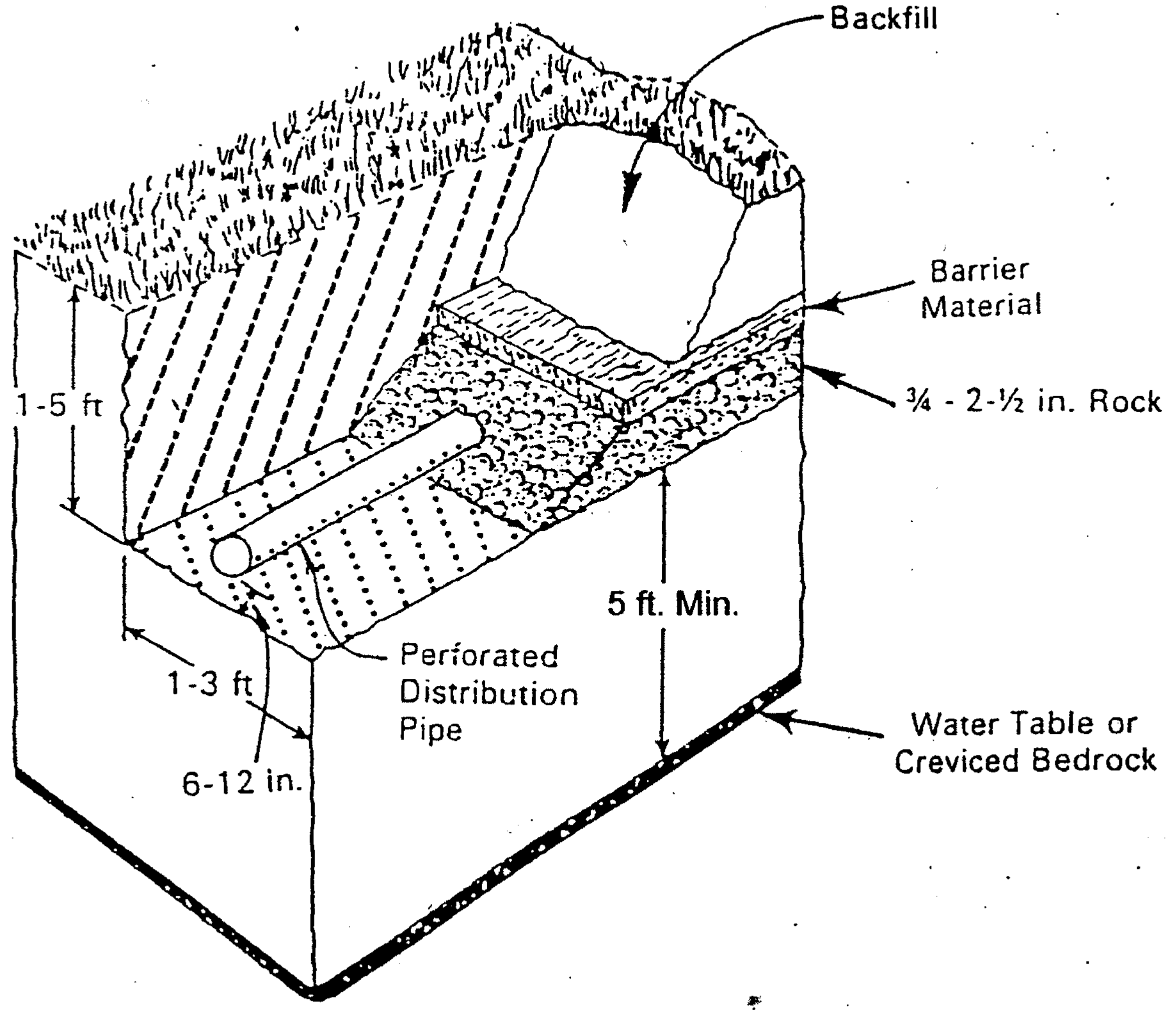
LEACHING CHAMBER SYSTEM

FIGURE K-3



Data Source: Mass GIS
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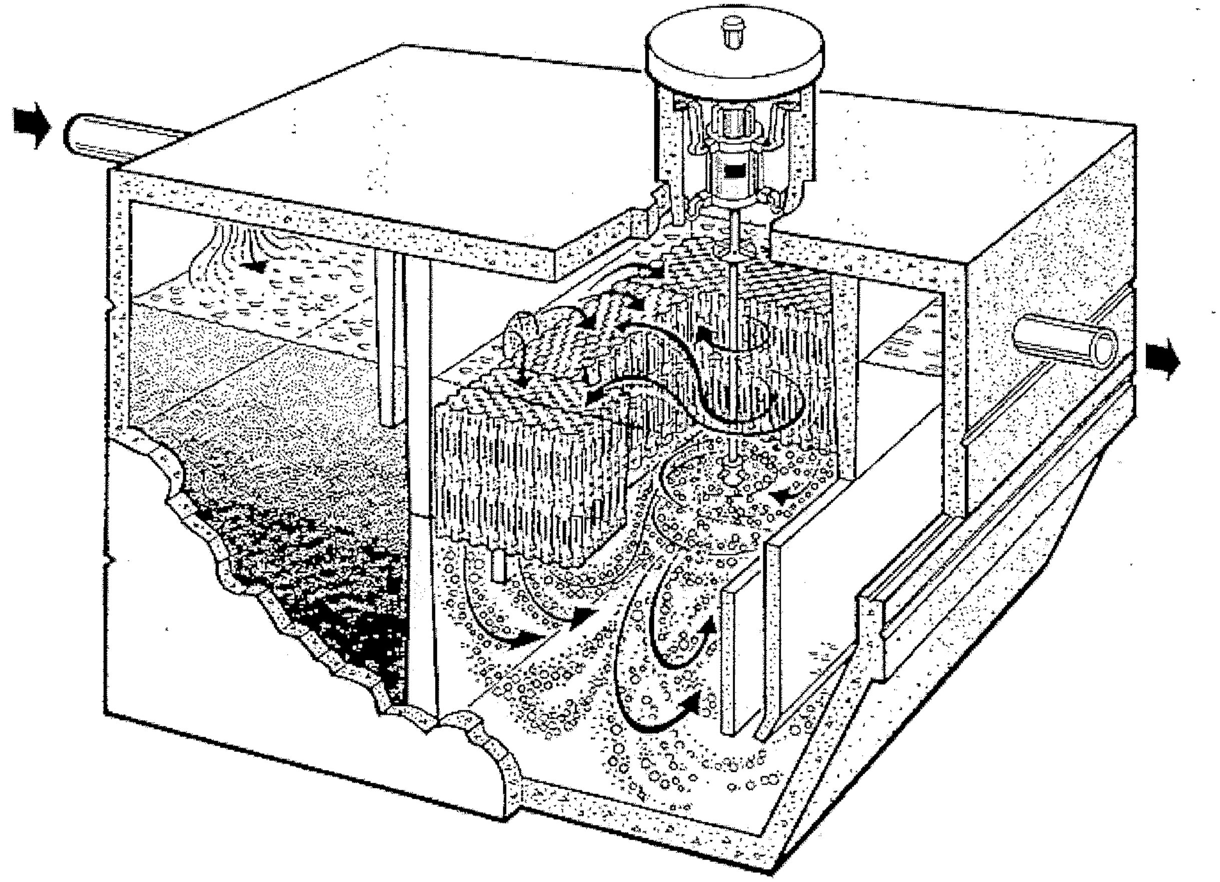
LEACHING TRENCH DIAGRAM

FIGURE K-4



Source: USEPA Region 1, January 2007
http://www.epa.gov/ne/assistance/ceitts/wastewater/techs/jetaerobic.html

Data Source: Mass GIS
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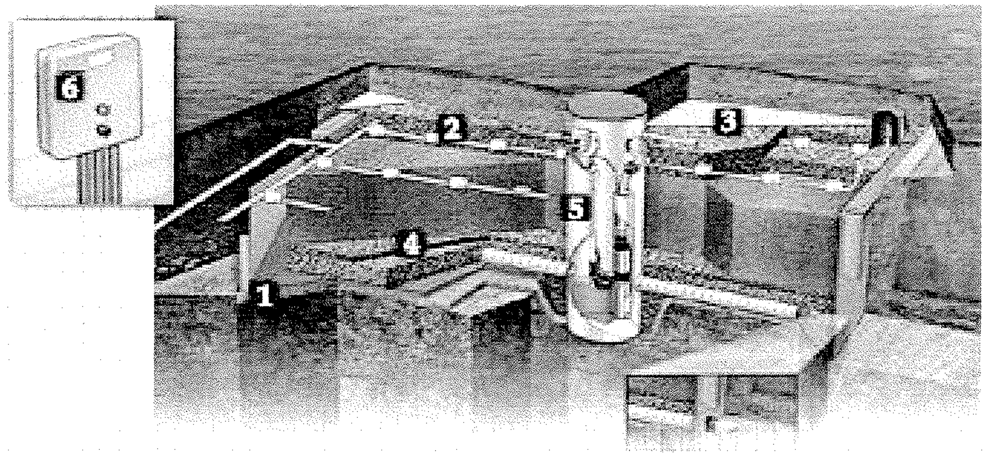
JET AEROBIC TREATMENT SYSTEM

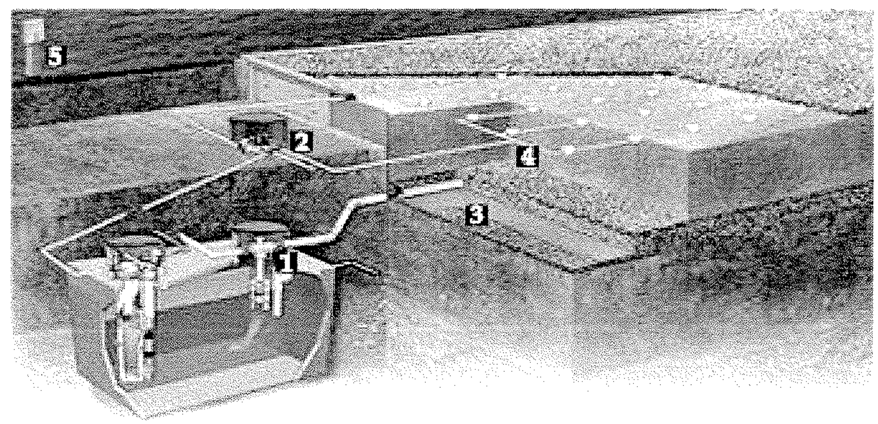
FIGURE K-5



INTERMITTENT SAND FILTER
1) Liner
2) Manifold kit
3) Filter fabric
4) Air cool kit
5) Pump basin
6) Control Panel

Source: Orenco Systems 2000©

RECIRCULATING SAND FILTER
1) Recirculating splitter valve
2) Distributing valve assembly
3) Liner
4) Manifold kit
5) Control panel



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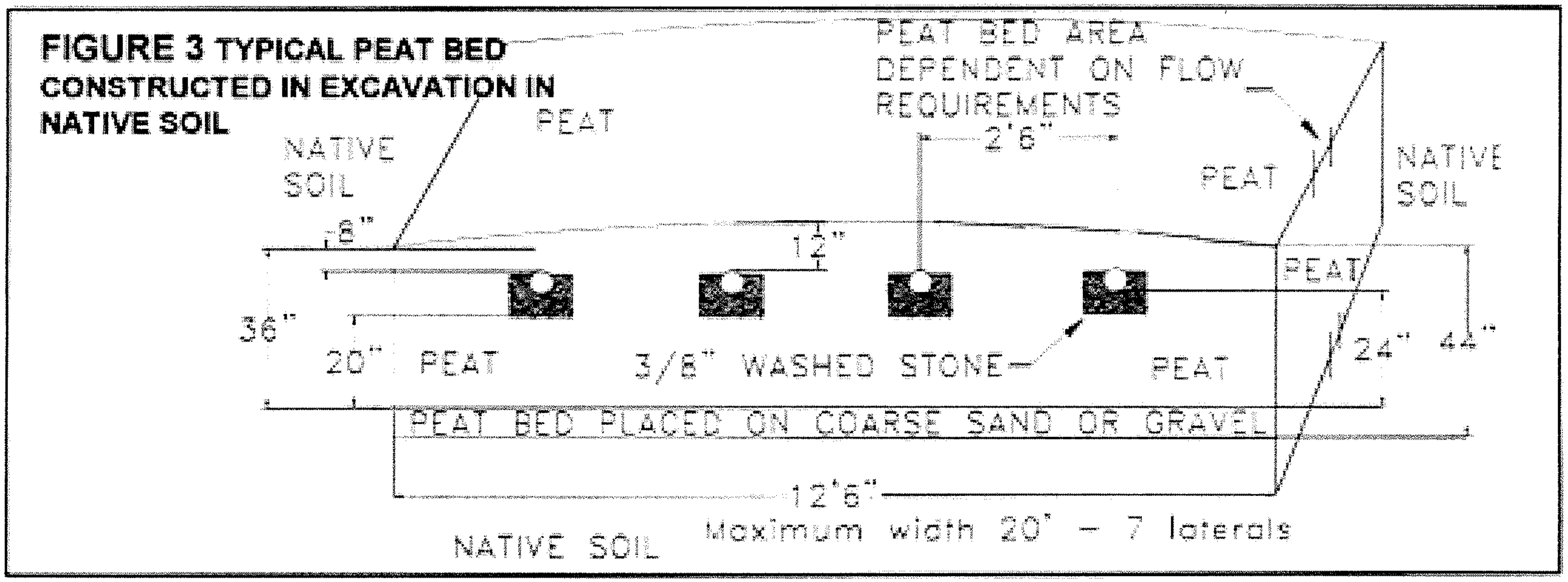
ORENCO INTERMITTENT AND TRICKLING FILTERS

FIGURE K-6



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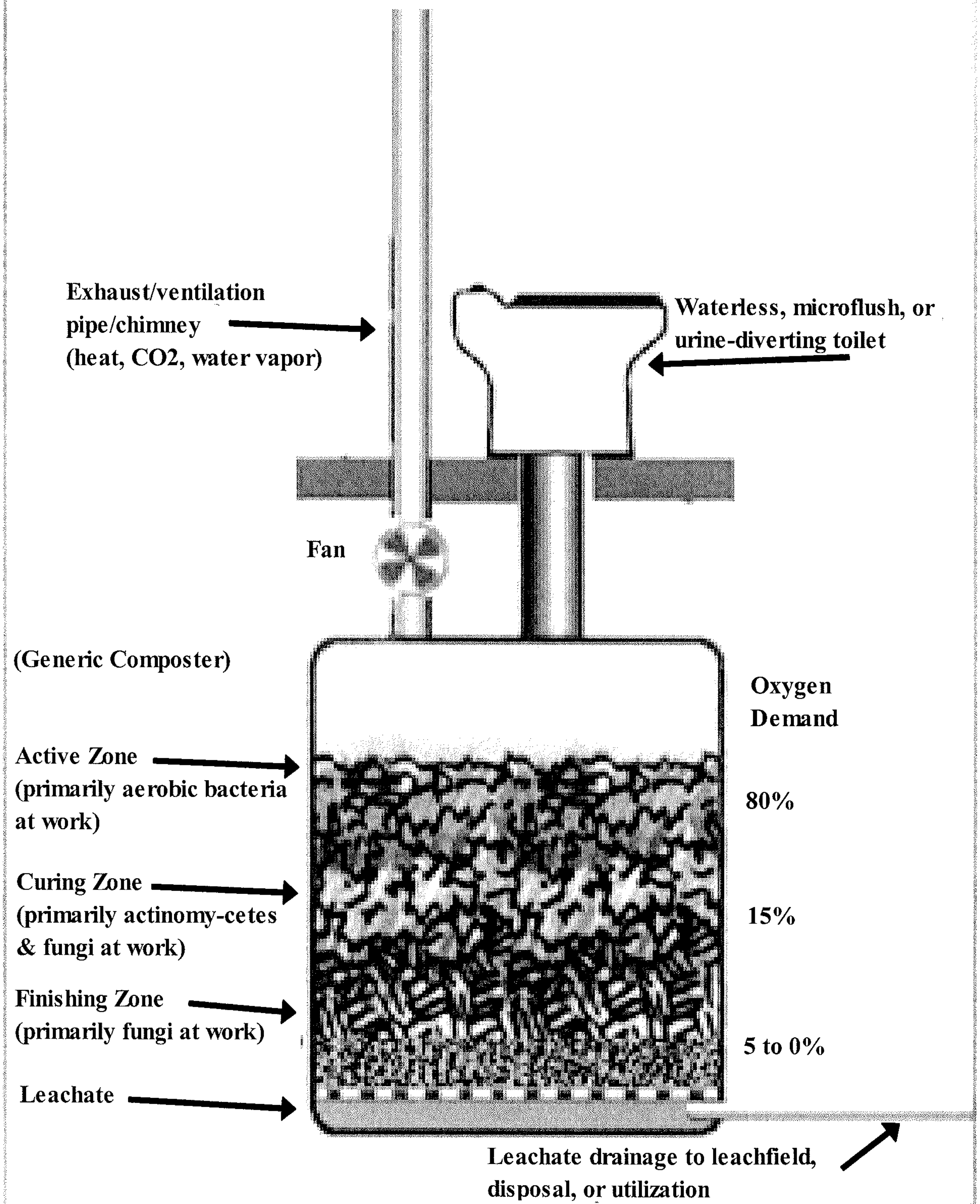
PEAT MOSS SYSTEM CROSS-SECTION

FIGURE K-7

DIAGRAM OF A TYPICAL COMPOSTING TOILET PROCESS



Source:Oikos®, © 1996-2002

Data Source: Mass GIS
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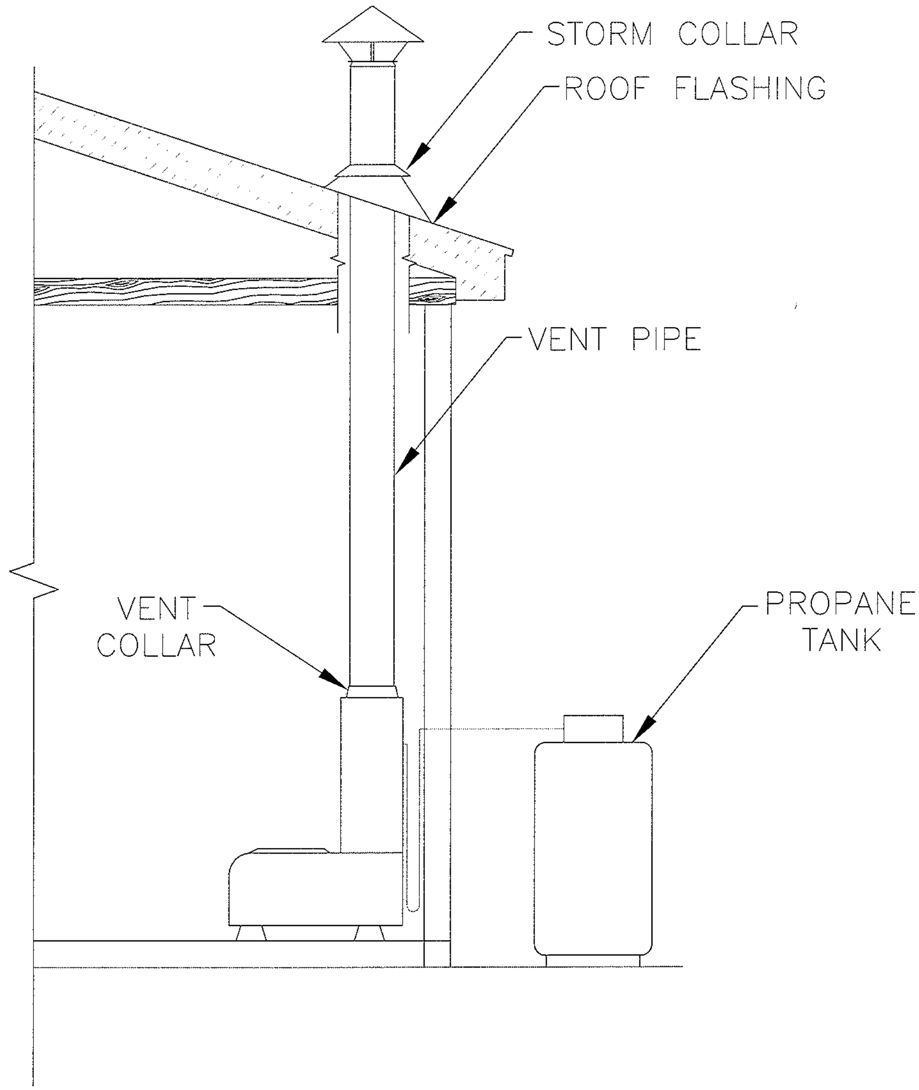
COMPOSTING TOILET DIAGRAM

FIGURE K-8



Source: Barnstable County Department of Health, June 2003

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\70098FK-9\CWMP Figures\Report Figures\Technology Screening Report\70098FK-9_Incinerate .mxd

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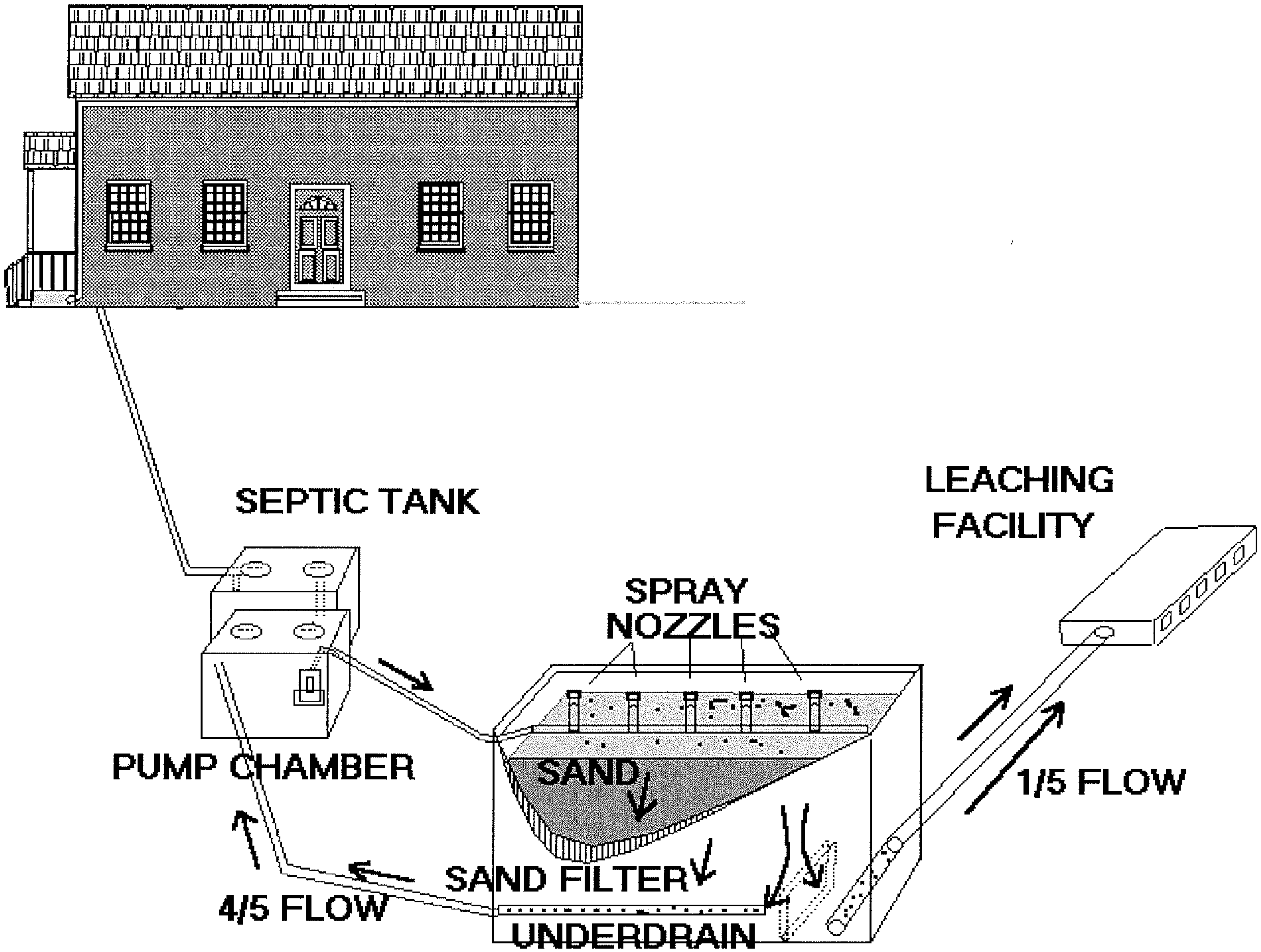
INCINERATING TOILET DIAGRAM

FIGURE K-9



Source: Barnstable County Department of Health, June 2003

Data Source: Mass GIS
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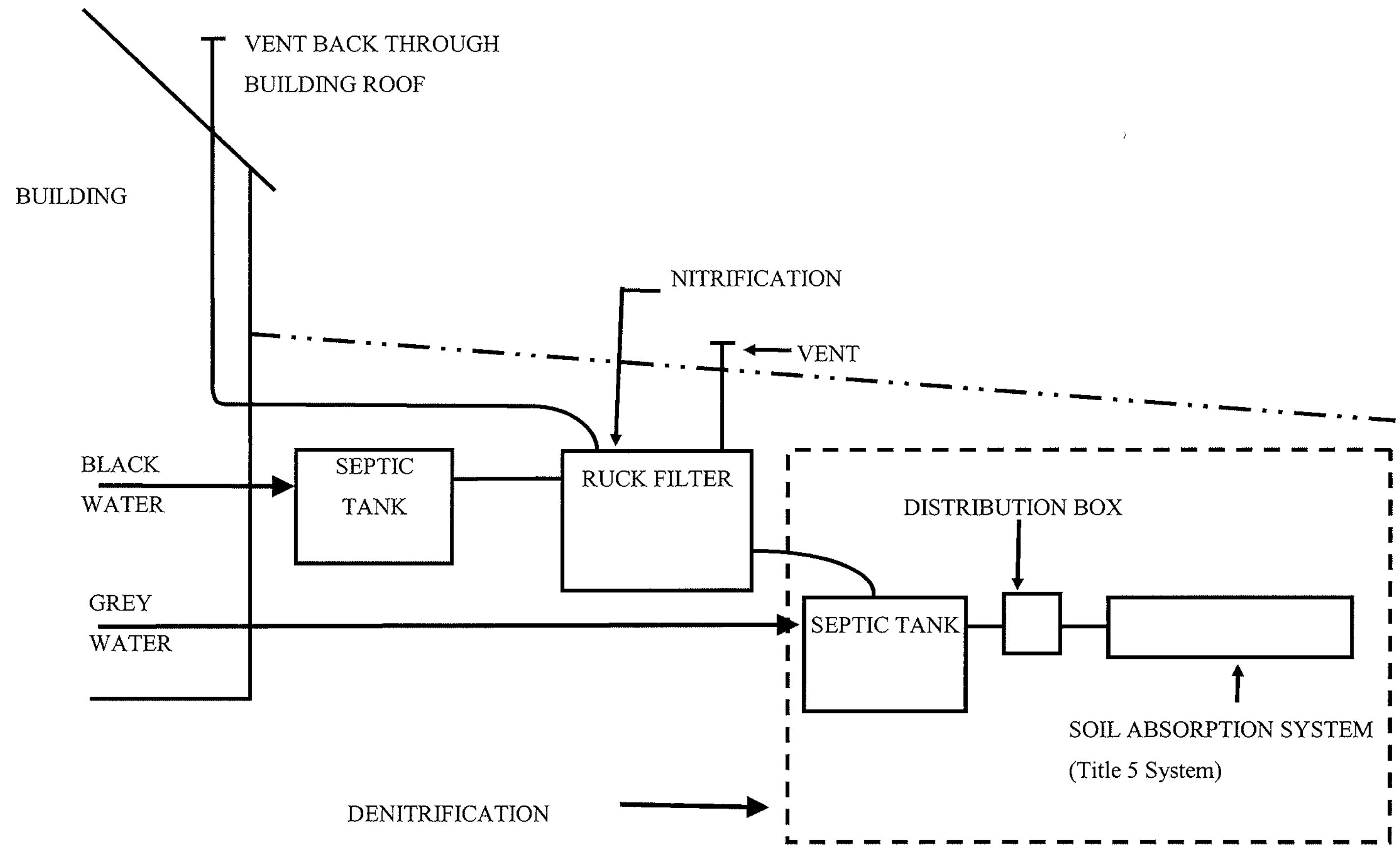
RECIRCULATING SAND FILTER

FIGURE K-10



Source: RUCK Systems, Inc., June 2003

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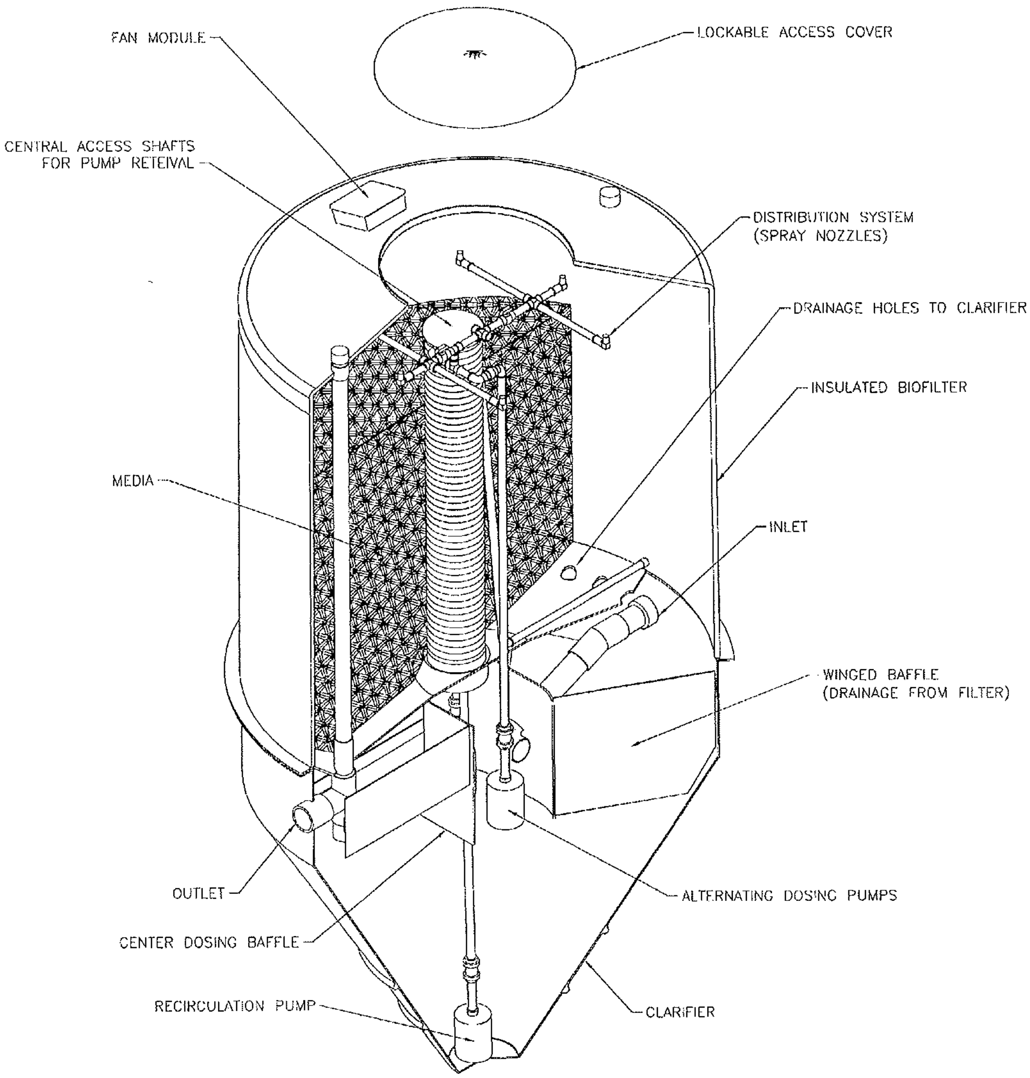
RUCK SYSTEM DIAGRAM

FIGURE K-11

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\70098 Chatham\CWMP Figures\Report Figures\Technology Screening Report\70098FK-11_RUCK.mxd



ISOMETRIC VIEW OF BIOCLERE

Source: AquaPoint

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\70098 Chatham\CWMP Figures\Report Figures\Technology Screening Report\70098FK-12_BIOCLERE.mxd

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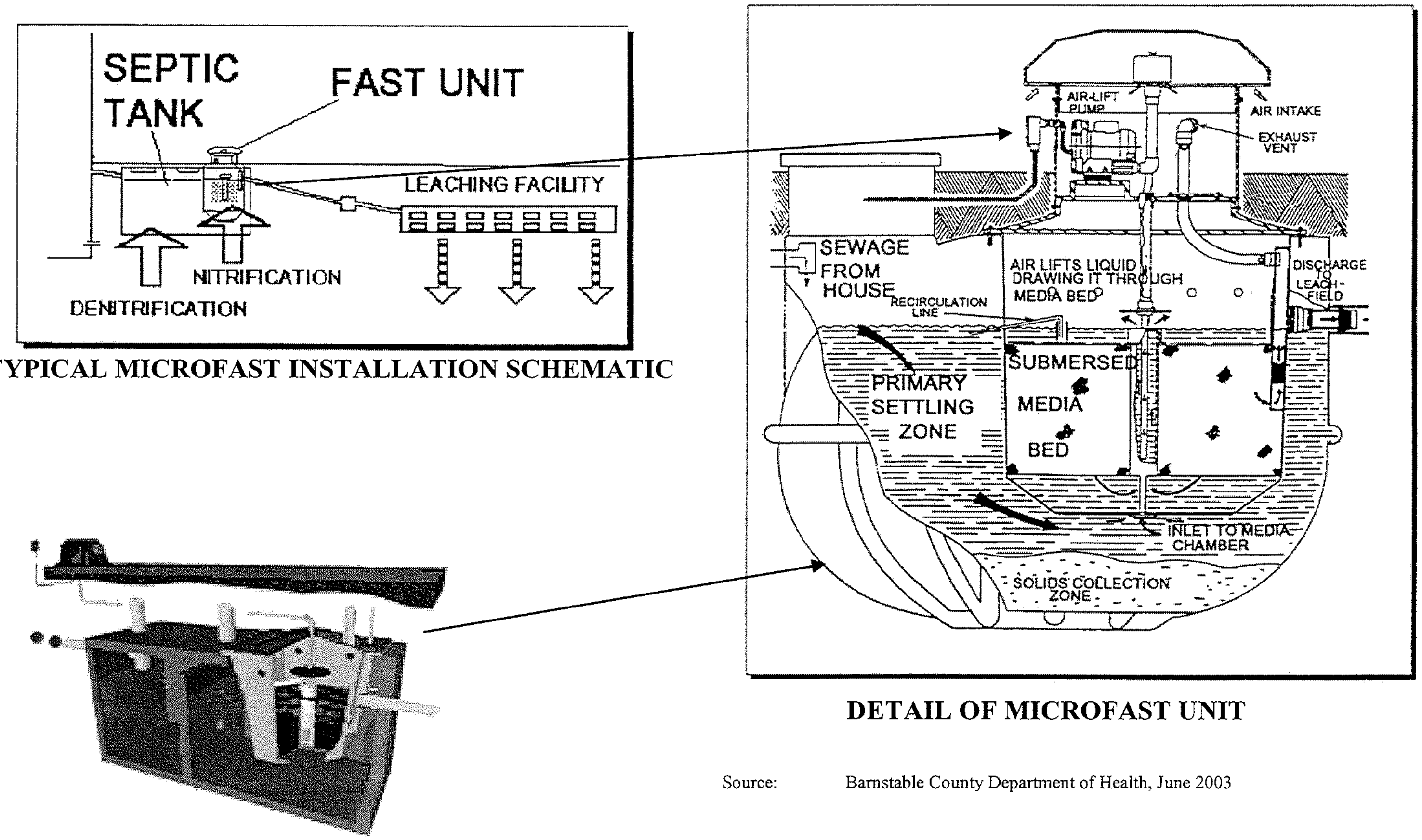
BIOCLERE TREATMENT UNIT

FIGURE K-12



TYPICAL MICROFAST INSTALLATION SCHEMATIC

DETAIL OF MICROFAST UNIT

Source: Barnstable County Department of Health, June 2003

MICROFAST UNIT INSTALLED IN SEPTIC TANK

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\70098 Chatham\CWMP Figures\Report Figures\Technology Screening Report\70098FK-13_FAST.mxd

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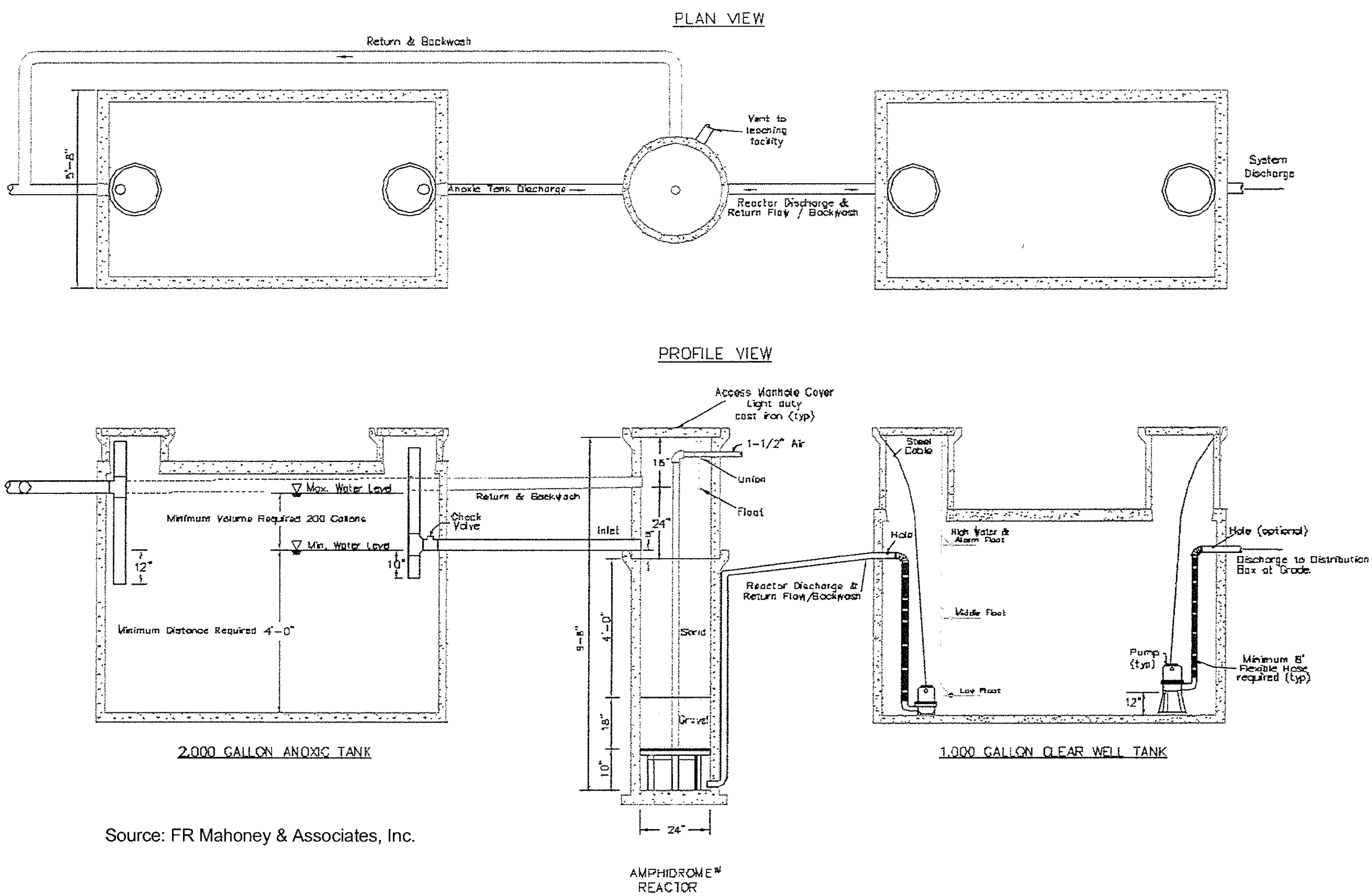
FAST TREATMENT SYSTEM (MICROFAST)

FIGURE K-13



Source: FR Mahoney & Associates, Inc.

Data Source: Mass GIS
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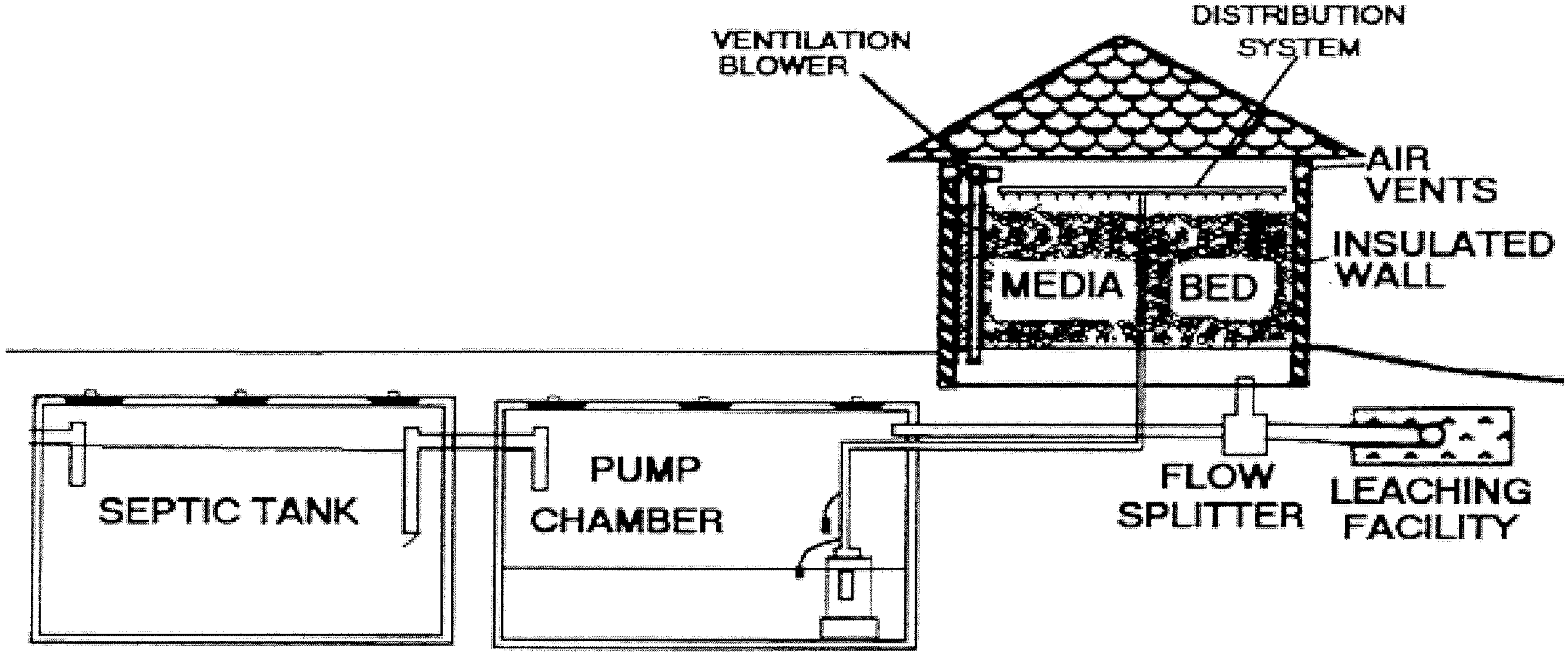
AMPHIDROME SYSTEM

FIGURE K-14



Source: Buzzards Bay Project, June 2003

Data Source: Mass GIS
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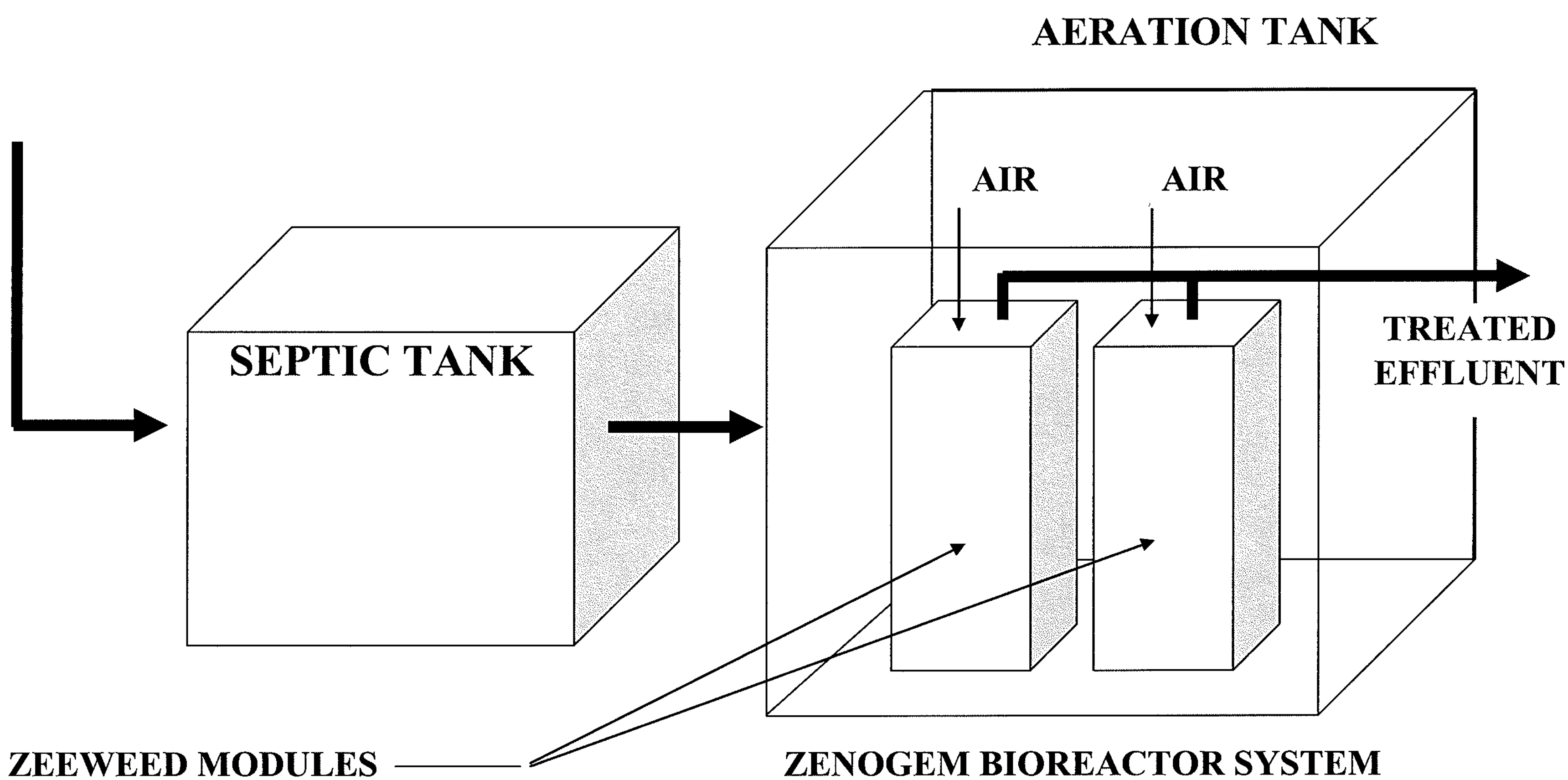
MANAGEMENT PLAN

WATERLOO BIOFILTER

FIGURE K-15



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File Location: J:\GIS\GIS Project Folder\Job#\70098 Chatham\CWMP Figures\Report Figures\Technology Screening Report\70098FK-16_ZENOGEM

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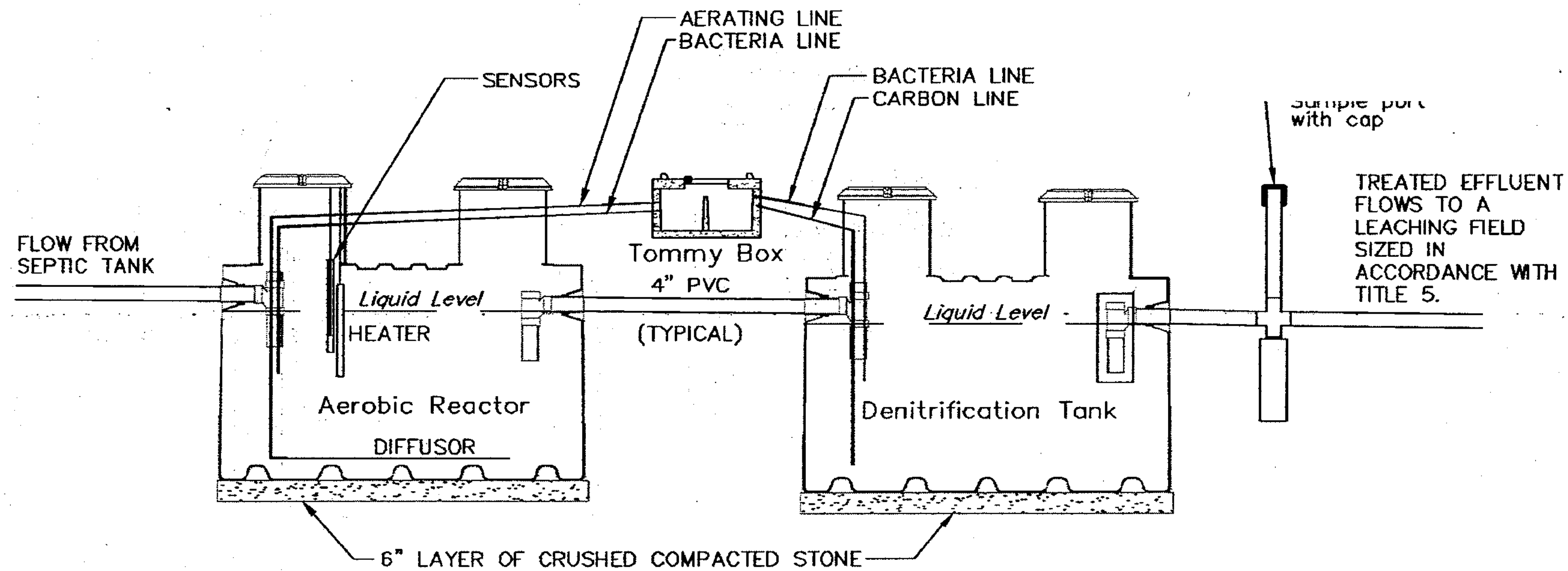
COMPREHENSVE WASTEWATER
MANAGEMENT PLAN

ZENOGEM

FIGURE K-16



Source: Environmental Operating Solutions, Inc.

Data Source: Mass GIS
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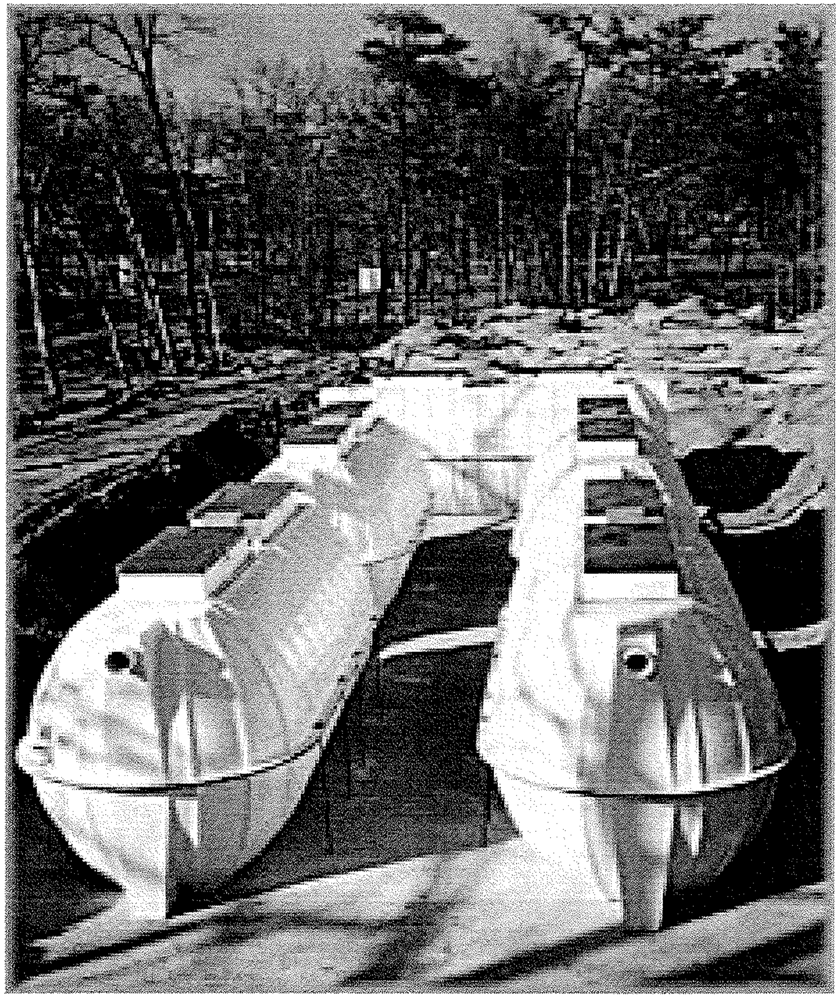
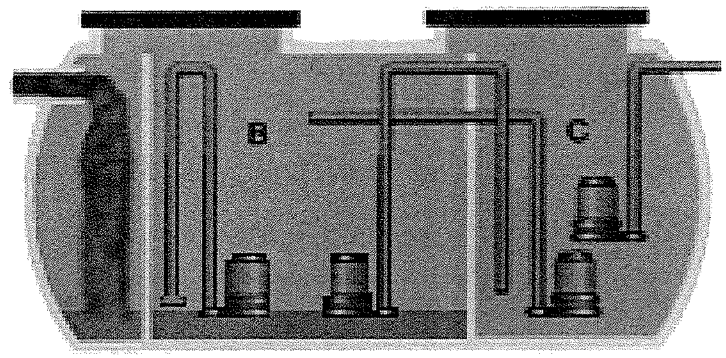
COMPREHENSVE WASTEWATER
MANAGEMENT PLAN

OAR SYSTEM

FIGURE K-17





Source: Cromaglass Corp.

Data Source: Mass GIS
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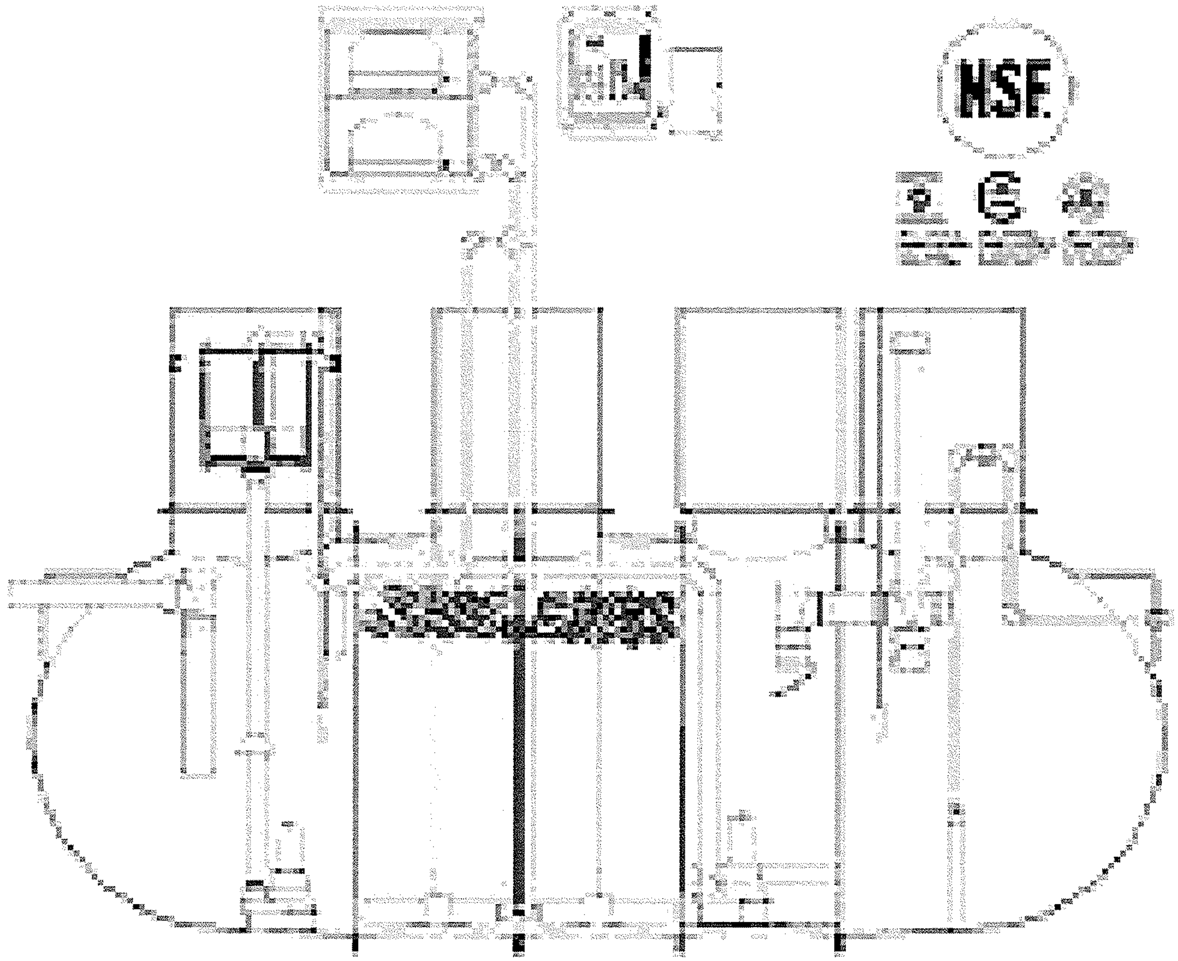
TOWN OF CHATHAM, MASSACHUSETTS COMPREHENSVE WASTEWATER MANAGEMENT PLAN

CROMAGLASS SYSTEM

FIGURE K-18



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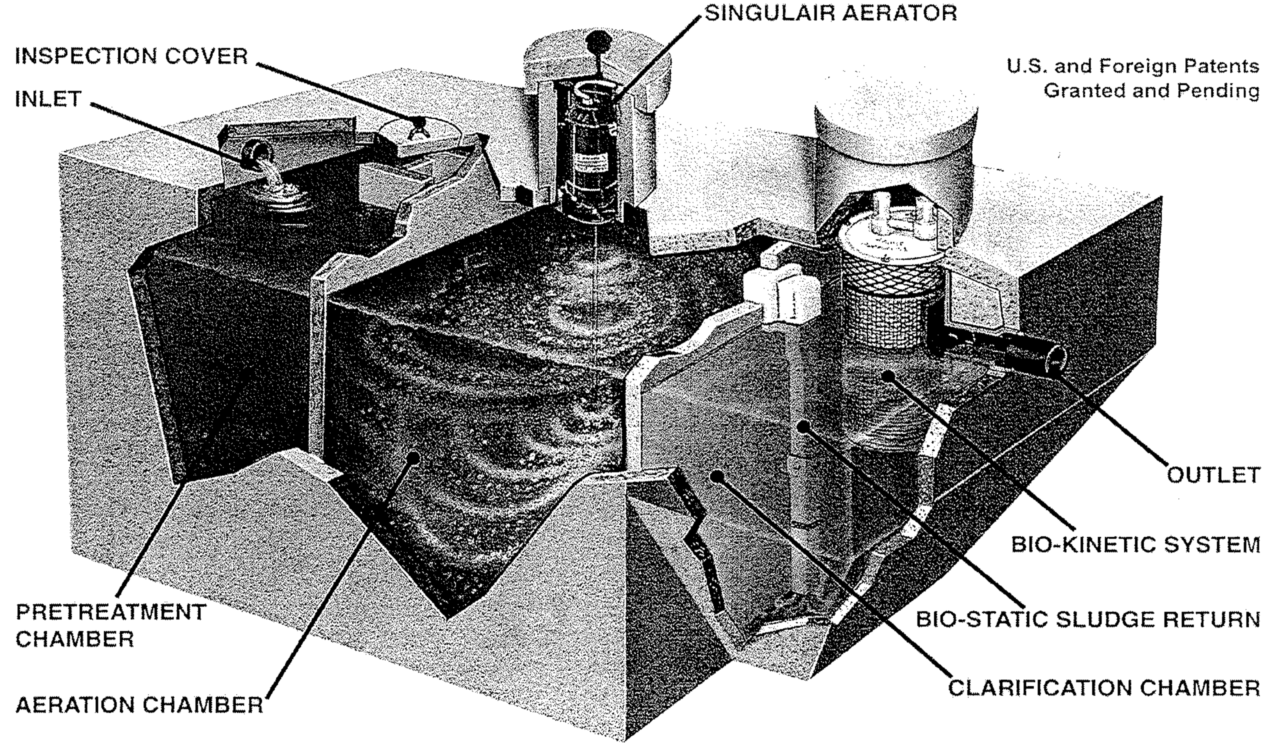
Date: 7/2007 Project No. 70098

TOWN OF CHATHAM, MASSACHUSETTS
COMPREHENSVE WASTEWATER
MANAGEMENT PLAN

MICROSEPTEC ENVIROSERVER SYSTEM

FIGURE K-19



Source: Norwalk Wastewater Equipment Company, Inc.

Data Source: Mass GIS
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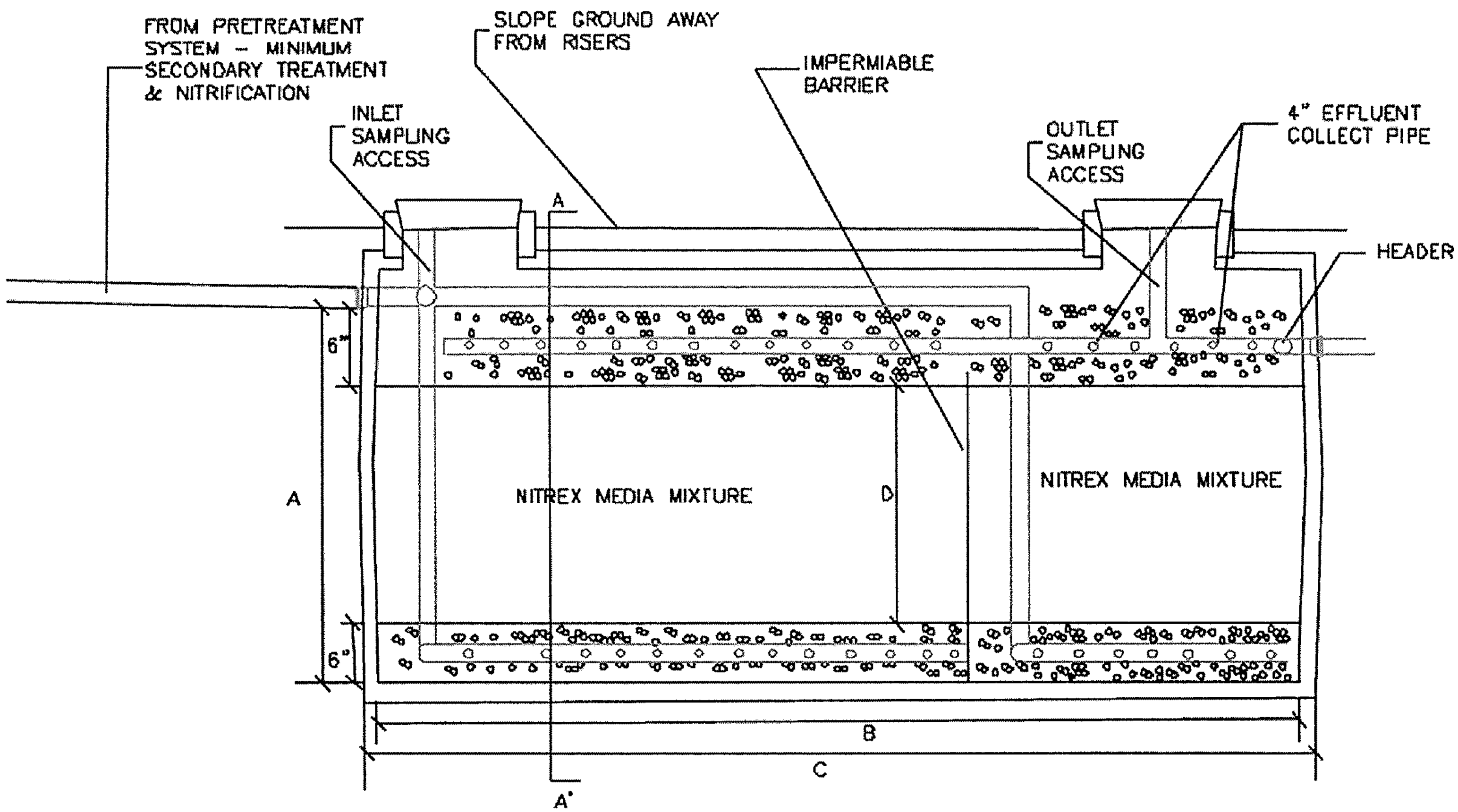
TOWN OF CHATHAM, MASSACHUSETTS
COMPREHENSVE WASTEWATER MANAGEMENT PLAN

NORWECO SINGULAIR SYSTEM

FIGURE K-20



NOT TO SCALE

Data Source: Mass GIS
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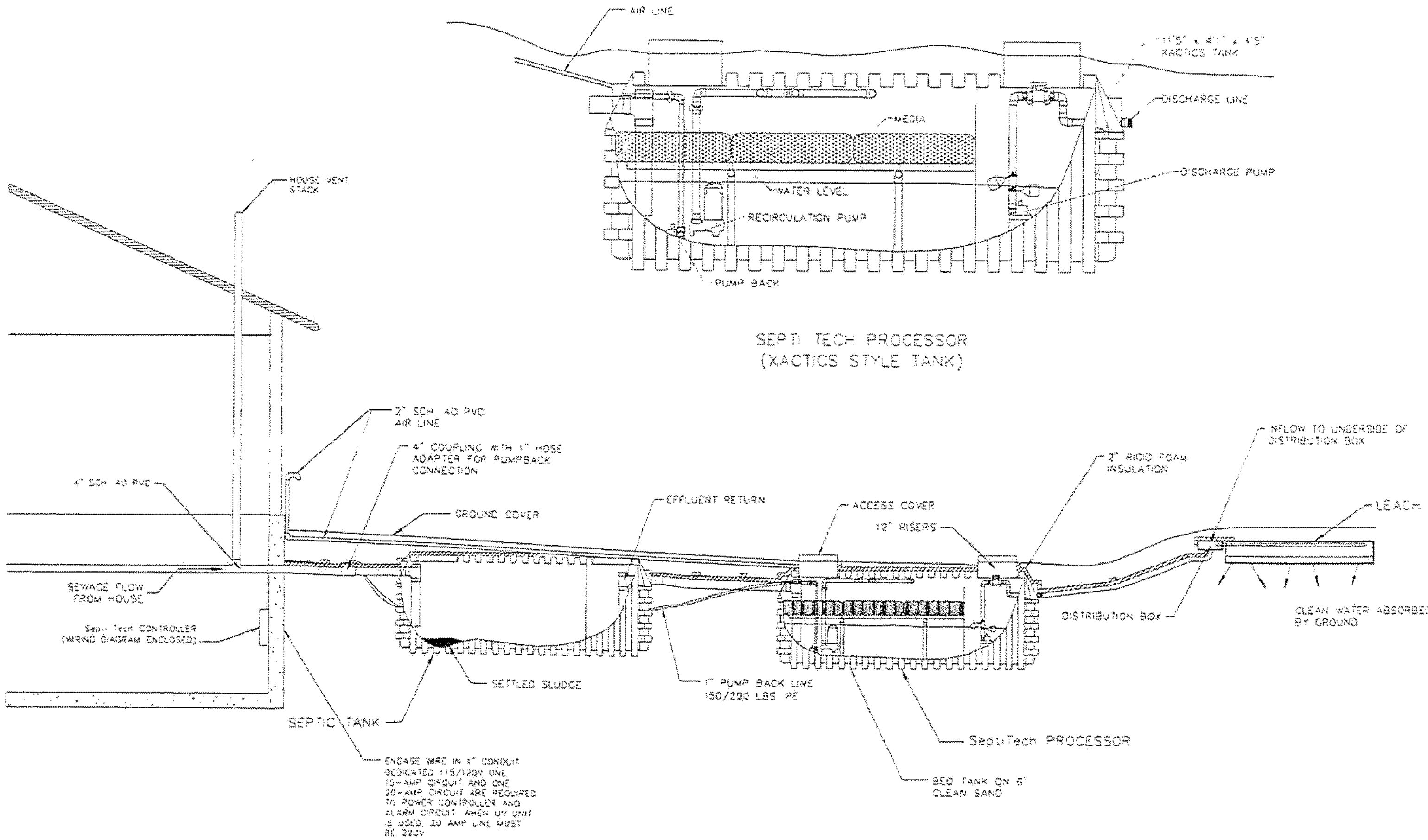
TOWN OF CHATHAM, MASSACHUSETTS
COMPREHENSVE WASTEWATER MANAGEMENT PLAN

NITREX SYSTEM

FIGURE K-21



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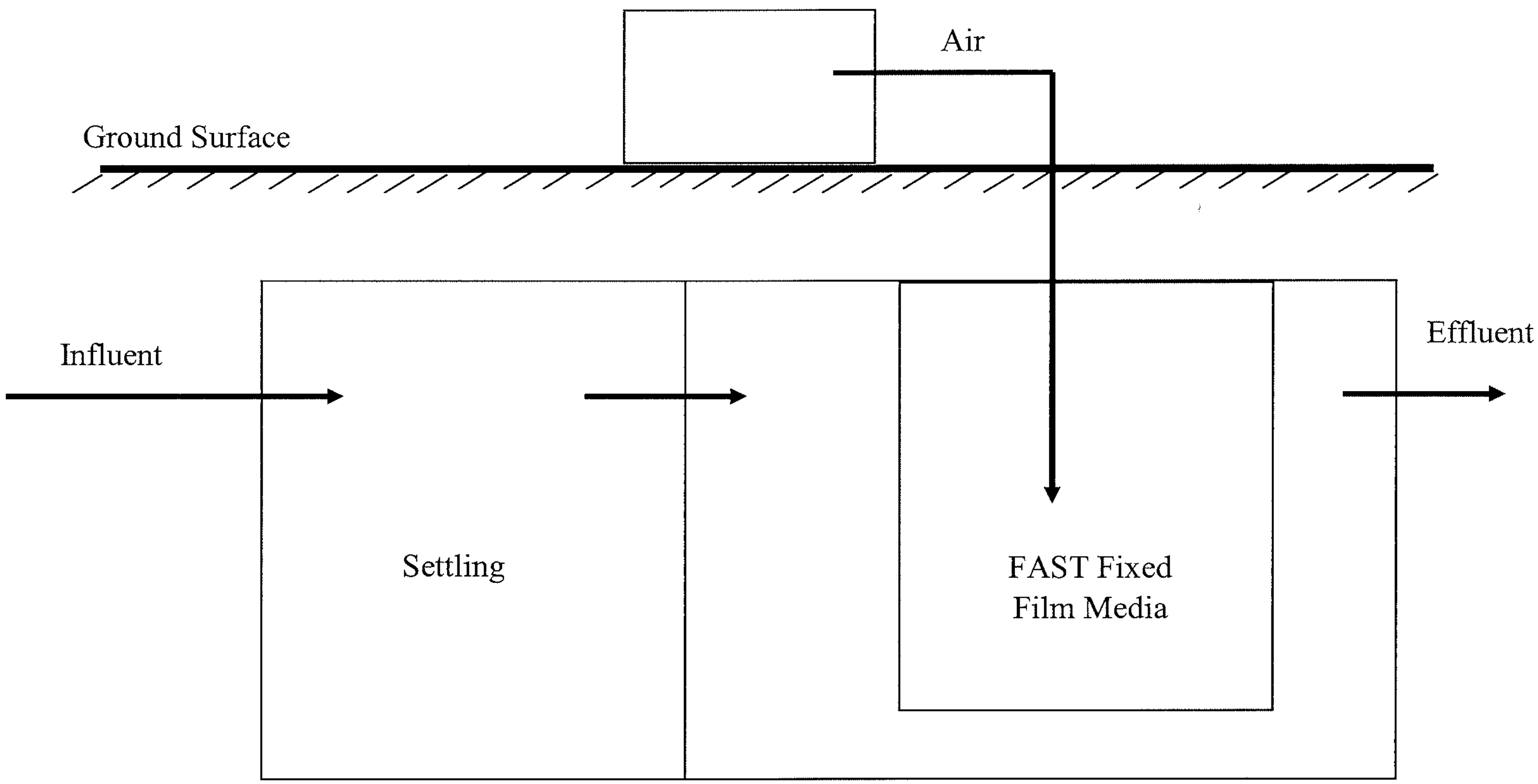
TOWN OF CHATHAM, MASSACHUSETTS COMPREHENSVE WASTEWATER MANAGEMENT PLAN

SEPTITECH SYSTEM

FIGURE K-22



Source: Biomicrobics

Data Source: Mass GIS
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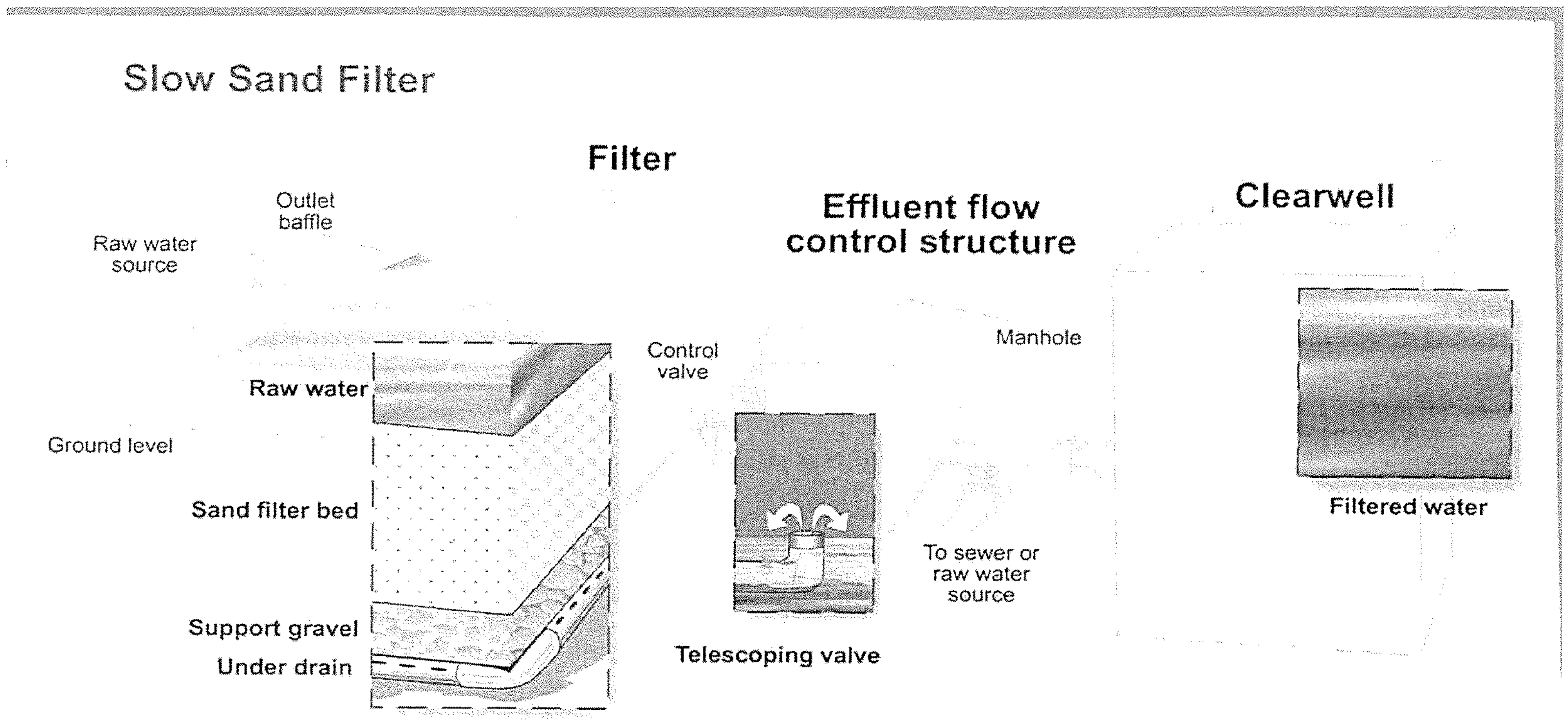
TOWN OF CHATHAM, MASSACHUSETTS
COMPREHENSVE WASTEWATER MANAGEMENT PLAN

MICRO FAST TREATMENT SYSTEM

FIGURE K-23



Source: *Drinking Water News for America's Small Communities*
Summer 1995

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\70098 Chatham\ CWMP Figures\Report Figures\Technology Screening Report\70098FK-24.mxd

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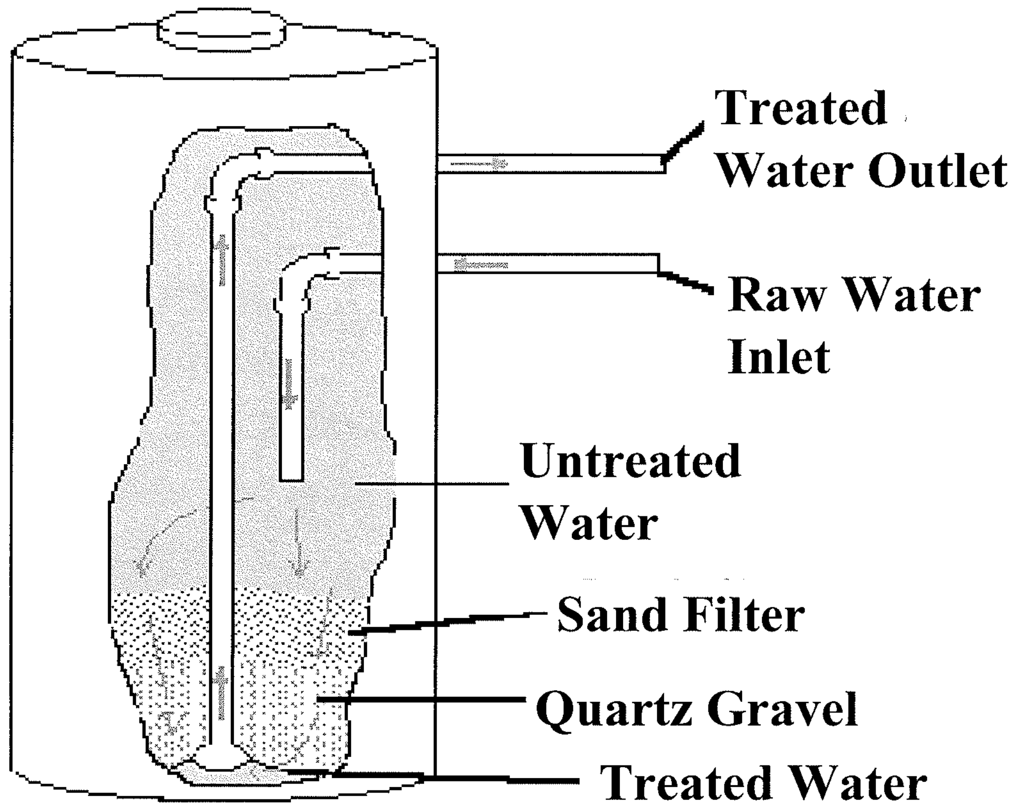
TOWN OF CHATHAM, MASSACHUSETTS
COMPREHENSVE WASTEWATER MANAGEMENT PLAN

SLOW SAND FILTER

FIGURE K-24

RAPID SAND FILTER



Source: US EPA

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TOWN OF CHATHAM, MASSACHUSETTS
COMPREHENSVE WASTEWATER
MANAGEMENT PLAN

RAPID SAND FILTER

FIGURE K-25

Data Source: Mass GIS
File Location: J:\GIS\GIS Project Folder\Job#\70098 Chatham\CWMP Figures\Report Figures\Technology Screening Report\70098FK-25_RAPID SAND.mxd