XII. APPENDIX B

DECENTRALIZED MANAGED WASTEWATER SYSTEMS (DMWS) IN DETAIL

General Description

Decentralized wastewater systems (DWS) cover a wide variety of collection, treatment, and disposal systems. In most cases, the sewage flows first from the building sewer to an interceptor (septic) tank, which is designed to be watertight, has access risers to the ground surface for ease of inspection and maintenance, and is equipped with an effluent filter in the outlet tee to prevent solids from escaping. This interceptor tank is the first and a very key component in nearly all decentralized wastewater systems. The solids, which settle in the tank, decompose and diminish in volume but still must be pumped out periodically. Research has shown that in properly constructed and maintained tanks, pumping may not be needed for 10-12 years, or possibly longer. These solids, called septage, are subsequently disposed of at a central treatment facility, or stabilized and land applied at an approved site.

Conventional septic systems utilizing subsurface soil absorption drain fields are an effective and reliable option where site and soil conditions are favorable, and where the systems are properly maintained. These systems have been in use for decades, the technology is sound, and they are the least expensive of any DWS to install, operate, and maintain. However, today's technology has introduced a number of alternative systems that can be used over a much broader range of site and soil conditions than the conventional septic system. Some of these are described in the following paragraph.

Alternative treatment systems include small aerobic treatment plants utilizing the activated sludge process, similar to large municipal treatment facilities; biofiltration systems using a variety of filter mediums such as sand, peat, synthetic textile, or open cell foam, utilizing either a single pass or recirculating; and fixed film aerated systems combining both attached and suspended biological growth processes. The treated effluent is then dispersed into the soil for further treatment, or it may be disinfected and discharged to a surface stream. Permitting and testing requirements are less costly when discharging into the soil, so that is the preferred method of disposal. There are several alternative soil disposal methods available including non-gravel trenches utilizing infiltration chambers, low-pressure distribution, drip dispersal, and spray irrigation. Disinfection methods for systems discharging to a surface stream include tablet chlorination/dechlorination, ultraviolet (UV) light, and ozone.

In cluster systems (decentralized wastewater systems serving more than a single home), the liquid effluent from the interceptor tank is conveyed to the treatment system through a common collection line. Thus, these collection lines are called effluent sewers. Effluent sewers have several cost advantages over centralized "big pipe" sewers: (1) they are smaller in diameter, (2) they do not need to be installed as deep or laid on grade, and (3) they do not require manholes for access. There are two types of effluent sewers, gravity and pressure. Gravity systems are known as STEG, for septic tank effluent gravity, and pressure systems are known as STEP, for septic tank effluent pumping. Following collection, there are a number of treatment and disposal system alternatives that can be used in cluster systems, depending primarily on the number of connections. These options fall into the same categories as described above for treatment and disposal, only on a larger scale. Cluster systems utilizing DMWS are generally considered feasible up to approximately 100 homes.

Benefits

The primary benefit of managed decentralized wastewater systems is an improvement to the public health and environment in any area where they are used. This is due to the elimination of illegal discharges ("straight pipes") into surface streams, and the elimination of failing or poorly performing soil absorption systems that contaminate the groundwater supply.

Beyond these primary benefits, however, there are secondary benefits of managed DWS, discussed as follows.

Benefits to public utilities:

1. DMWS allow utilities to add sewer service to their other services, expanding both their customer base and their revenue base.
2. DMWS are economical to install. An entire decentralized system (including collection, treatment, and disposal) often will cost less than extending a conventional gravity sewer line, especially in less populated areas. DMWS also conserve the capacity of the central treatment facility, thus avoiding the expense of a plant expansion.
3. DMWS are economical to operate and maintain. They require routine maintenance every few months and their performance can be monitored and controlled using remote telemetry. Two or three employees can maintain DWS systems serving hundreds of homes.
4. DMWS often allow utilities to acquire land for treatment facilities at minimum expense, as developers may deed over land for treatment in exchange for the benefits of a managed decentralized wastewater system.

Benefits to homeowners:

1. Home sites become available in areas where central sewers do not exist and/or conventional septic systems do not work.
2. Homeowners are relieved of maintaining an onsite sewer system.
3. Monthly sewer rates are typically lower than with centralized systems because the costs of installing and maintaining the DWS are lower.

Benefits to developers:

1. A prime residential location can be developed in a timely manner rather than waiting for a central sewer line to be extended.
2. Development density can also be increased by as much as 20% because homes can be sited on smaller lots than conventional septic systems require.
3. The presence of a publicly owned and operated sewer system is a selling point to homeowners.

The net effect of any increased residential and commercial growth from the use of DMWS, particularly in an area previously considered undevelopeable due to sewer problems, is additional tax revenue for the local government.

Management and Ownership

Decentralized wastewater systems are used by 25% of homes in the United States and in 33% of new development. This growth in decentralized wastewater systems increases the potential for health and water quality problems if these systems are poorly managed. This is such a great concern that EPA in 2003 developed a comprehensive set of voluntary management guidelines to help local governments in implementing and enhancing the performance and reliability of their decentralized wastewater treatment systems. These management guidelines are useful when a locality is wrestling with the decision of how to implement a decentralized approach.

EPA's management guidelines provide five management models as conceptual approaches with progressively increasing management controls as sensitivity of the environment and/or treatment complexity increases. The purpose of the models is to provide a guide to match the needed management controls to the potential public health and water quality risks presented by decentralized systems in a particular area. The five management models are listed on the following page.

Decentralized wastewater systems, where proper management is provided, are permanent components in the nation's wastewater infrastructure. Regulatory agencies recommend that decentralized systems be managed by a public utility. The reasons are obvious. Billing and operating infrastructure are already in place. Technical skills for pumps and electrical controls fit well with the operating skills required for small community systems. It is also possible for a utility to subcontract with a qualified entity to provide its operating services.

Decentralized wastewater systems are gaining in popularity, but these systems are only recommended where there is a management system in place to protect the public health and environmental quality, the investment, and community resources. Each locality must decide what its involvement will be.

The Five Management Models

Management Model 1 - "Homeowner Awareness" specifies appropriate program elements and activities where treatment systems are owned and operated by individuals property owners in areas of low environmental sensitivity. This program is adequate where treatment technologies are limited to conventional systems that require little owner attention. To help ensure that timely maintenance is performed, the regulatory authority mails maintenance reminders to owners at appropriate intervals.

Management Model 2 - "Maintenance Contracts" specifies program elements and activities where more complex designs are employed to enhance the capacity of conventional systems to accept and treat wastewater. Because of treatment complexity, contracts with qualified technicians are needed to ensure proper and timely maintenance.

Management Model 3 - "Operating Permits" specifies program elements and activities where sustained performance of treatment systems is critical to protect public health and water quality. Limited-term operating permits are issued to the owner and are renewable for another term if the owner demonstrates that the system is in compliance with the terms and conditions of the permit. Performance-based designs may be incorporated into programs with management controls at this level.

Management Model 4 - "Responsible Management Entity (RME) Operation and Maintenance" specifies program elements and activities where frequent and highly reliable operation and maintenance of decentralized systems is required to ensure water resource protection in sensitive environments. Under this model, the operating permit is issued to an RME instead of the property owner to provide the needed assurance that the appropriate maintenance is performed.

Management Model 5 - "RME Ownership" specifies that program elements and activities for treatment systems are owned, operated, and maintained by the RME, which removes the property owner from responsibility for the system. The program is analogous to central sewerage and provides the greatest assurance of system performance in the most sensitive of environments.

There are many Decentralized Managed Wastewater Systems (DMWS) alternatives currently available as new technologies and systems continue to emerge. This expansion in the number of alternatives is due in part to the growing recognition that DMWS are a cost-effective solution for the handling of many of today's wastewater problems, particularly in rural areas.

The following pages contain a short description of several DMWS alternatives, divided into the categories of collection, treatment, and disposal. It is anticipated that DMWS projects developed by this study will draw primarily from these alternatives. Many of these alternatives are already being used in the 13 county study area; so actual experience with their installation and operation will be helpful when selecting the most applicable DWS for a particular project.

COLLECTION SYSTEMS

Grinder Pump Systems

Low-pressure sewer systems are beginning to solve many wastewater problems. A small grinder pump with the necessary controls have been integrated into a compact, watertight unit, which is placed underground near each house or business. The sewage flows to the unit where it is ground into small particles and pumped through small-diameter pressure pipes, buried at shallow depths, to a treatment plant.

These systems offer savings in construction costs over gravity sewers and their operating cost is low. A one horsepower pump can pump the wastewater for a long distance with positive elevation changes of more than 100 feet. The homeowner generally pays the electrical cost for the grinder pump.

Vacuum Systems

Vacuum systems are used in flat areas, where gravity systems are problematic. They may also be used where there is a high water table, or seasonal groundwater problems. The sewage flows by gravity from each house or business to a valve pit located on the property. The valve pit is so named because it contains the vacuum interface valve that prevents the system vacuum from entering the house plumbing. When the valve pit (with capacity of 10 gallons) fills up, the interface valve opens and the contents of the pit are evacuated into the vacuum lines. The sewage then travels through the vacuum lines to a station where it is collected and then pumped on to the treatment plant.

The advantages of grinder pump/vacuum systems over conventional gravity systems include:

1. Easier to work around buried utilities, trees, or other obstacles.
2. Since lines are buried only 3-5 feet deep, less dewatering is required during construction.
3. Manholes are eliminated.
4. Lower construction cost.

Effluent Sewers

The concept of effluent sewers is a recent development that sprang from the managed decentralized wastewater industry. Effluent sewers are ideal for rural communities, new residential subdivisions, commercial properties, replacement of failing systems, sewer system expansions, and any site conditions(flat, hilly, shallow bedrock, and high groundwater). Here's how it works:

Watertight effluent sewer systems are one of the best solutions for collecting wastewater and transporting it for treatment. The operation is quite simple. Sewage flows from the house or business to a watertight tank, where it is pretreated (primary treatment). Only the filtered effluent is discharged through the service line to a central collection line. Where the house or business is located at a higher elevation than the collection line, a gravity discharge system is used. When the house or business is located below the collection line, a pump is required. Effluent sewers offer several cost savings over conventional gravity sewers.

Save on Installation Costs:

1. The installation cost is less than half that of conventional sewers due to smaller line size and shallow burial depth
2. Inexpensive, small-diameter collection lines are used.
3. Expensive manholes and lift stations are eliminated.
4. Ease of installation makes system well suited for community "self-help" programs.
5. In new developments, the purchase of most equipment is deferred until lots are developed.

Save on Operation and Maintenance Costs:

1. No maintenance costs associated with line blockage.
2. Residential tanks typically need pumping only once every 10-12 years.
3. Homeowners pay the electrical cost for operating the pump in residential tanks.

Save on Treatment Costs:

1. The pretreated effluent can be treated using one of several low cost alternative treatment systems, or the effluent may be mixed again with the sewage in a conventional gravity sewer and treated at a municipal treatment plant.
2. Treatment facilities can be sized more economically, since the whole system is watertight.
3. There is not as great a need to allow for infiltration and inflow from stormwater flows or high groundwater.
4. The treatment cost is reduced because the influent is a higher quality due to pretreatment in the tanks.

The only potential drawbacks to effluent sewers have to do with operation and maintenance requirements. Effluent sewers have components that conventional sewers do not have, such as interceptor tanks that need to be inspected and pumped and mechanical parts that use electricity. These may cost more to operate and require more frequent and regular maintenance than conventional sewers.Other potential disadvantages with effluent sewers include the possibility of service disruptions due to mechanical breakdown and power outages.

Conventional Gravity Collection

Conventional gravity is sometimes the most practical collection system for a project area, despite the higher cost of installation. This is the case when building lots are small, or the location of water wells or other utilities prevent the use of individual septic tanks. In this instance, the sewage from several homes may be collected using conventional gravity lines and discharged into one large primary treatment tank, where one of the various treatment/disposal methods can be applied.

TREATMENT SYSTEMS

Sand Filters

Sand filtration has been used as a method of treating wastewater for over a hundred years, but mainly in larger community systems. Only in the last 25 years or so have they been used for individual homes and small cluster systems. Sand filters are designed as either intermittent (single pass) or recirculating, and the configuration can be rectangular, square, or circular.

Treatment begins in a watertight primary holding tank, where solids settle out and treatment takes place in an anaerobic environment. Flow from the tank to the sand filter can then be by gravity, although pressure distribution either by pump or siphon is preferred for better distribution. The bottom and sides of the sand filter are constructed watertight, using either a membrane liner, or a concrete tank. The effluent is distributed equally over the top of the sand filter by a network of PVC supply laterals. Sand depth is typically 30 inches, overtop a gravel substructure containing the underdrain piping. The effective size and uniformity coefficient of the sand are critical parameters in sand filtration, to insure optimum treatment and to minimize future maintenance due to clogging.

The hydraulic loading rate is 1.0 gallon per day per square foot (gpd/SF) for intermittent sand filters, and 4.0 gpd/SF for recirculating sand filters. The recirculation ratio is typically 4:1 for a recirculating sand filter, utilizing a pump tank and a low head sewage pump. Excellent treatment can be achieved by a recirculating sand filter, with BOD and TSS in the range of 10 mg/l. Also, recirculating sand filters are efficient environments for nitrification and denitrification of wastewater.

Peat Filters

Peat has been used for treating wastewater for many years. Peat is the partially decayed organic matter consisting of roots, stems, leaves, flowers, fruits and seeds found in peat bogs. It is a reliable, low maintenance treatment system, and is rated an advanced secondary treatment system by the Virginia Department of Health.

Treatment occurs when filtered effluent from a watertight septic tank is dosed and evenly distributed onto a bed of peat. The peat fibers, because of their natural water binding ability, retain the wastewater for 36-48 hours. Treatment is achieved by a combination of physical, chemical, and biological interactions between the wastewater and the fibrous media. The long contact time results in very efficient single pass treatment performance, i.e. BOD and TSS < 10 mg/l.

Peat systems are pre-packaged in polyethylene or fiberglass modules, and work effectively for 8-15 years before the biofibrous peat requires replacement. The wastewater loading rate is 5.0 gallons per day per square foot, resulting in a relatively small treatment area. The tea-colored odorless effluent can be dispersed into a shallow gravel bed and then into the ground, or discharged into a stream after disinfection. A number of the peat modules can be configured together for cluster systems serving more than one home.

Textile Filters

This treatment system is an efficient, recirculating packed-bed filter, which uses a non-woven textile material to treat residential and commercial wastewater to very high effluent standards (less than 10/10 mg/l for BOD and TSS). Although packed bed filter technology has been around for some time, the textile process has only been developed and perfected within the last ten years. This treatment system is also rated as advanced secondary treatment by the Virginia Department of Health.

Because of its large surface area and water holding capability, the textile filter unit is very compact. The commercial, or multi-family unit measures only 16 feet x 8 feet x 3 2 feet, and is capable of treating an average of 2,500 gallons per day (gpd) with a peak flow of 5,000 gpd. The treatment unit can be furnished as a single complete module, or it can be combined with other modules to reach the desired plant capacity. Smaller single-family treatment units are also available.

Effluent from watertight septic tanks flows into a recirculating blend tank, which precedes the textile filter treatment module(s). This tank contains two turbine submersible pumps, which alternately time-dose the filters at a maximum loading rate of 50 gallons per day per square foot. A small volume of air is continuously pulled across the filters to enhance treatment. After flowing through the filters, the effluent is collected and flows through a recirculating splitter valve, which retains 80% for blending with the incoming septic tank effluent, and the other 20% is discharged either into the ground or directly into a stream after disinfection. The treatment system can be remotely monitored using web-based telemetry.

Activated Sludge Plant

There are many plants that fall into this category of treatment, and which are recognized by the Virginia Department of Health as being capable of treating residential strength wastewater to secondary effluent limits (30 mg/l for both BOD and TSS). The treatment system described here is known as a FAST system, which is an acronym for fixed activated sludge treatment. It is a fixed film, aerated system utilizing a combination of attached and suspended growth, all in a single tank. It is designed to treat wastewater from single-family homes, clusters of homes, or small communities.

The treatment unit mounts is a special design two compartment tank. Settling occurs in the first compartment, which functions as a conventional septic tank. Effluent then flows into the treatment compartment where the FAST module is located. Microorganisms in the inner aerated media chamber digest the wastewater and turn it into a clear, odorless, high quality effluent. The treatment process includes a remote blower that delivers large volumes of air into the system, creating vigorous water movement for oxygen transfer. Conditions are present which allow nitrification and denitrification to occur in the same tank, allowing the system to reduce nitrogen levels by over 70%.

Systems are available in sizes ranging from 500 to 9,000 gpd. The units are lightweight yet durable, and are simple to install. They are very low maintenance, with the blower being the only moving part in the system. The attached growth process in the system assures that organisms remain inside the system and are not flushed out during times of peak hydraulic flows.

DISPOSAL METHODS

Trench Drainfield

The Virginia Department of Health has design standards for trench drainfields that are used in conventional subsurface soil absorption systems, depending upon the various soil classifications. A standard gravity trench contains a 4 inch perforated pipe surrounded by graded crushed stone or gravel to provide the void space (storage) for the effluent while awaiting absorption by the soil. Trenches are typically 18 inches deep with 12 inches of crushed stone or gravel. Treatment is provided by filtering action of the gravel and the soil, and by chemical action in the soil. Effluent can also be dispersed into conventional trenches by low-pressure distribution utilizing either a pump or siphon. Low pressure perforated lines normally are 1-1/4 inch in diameter.

Gravelless Trench

There are several types of gravelless trench drainfield products approved for use in Virginia, including chambers and a geo-synthetic aggregate system. These systems provide a greater surface area and storage volume than gravel or crushed stone, thus increasing the area of infiltration and hydraulic conductivity into the soil. As a result of this increased efficiency, a reduction in the normally required adsorption area is allowed with the use of gravelless systems. Advantages of these systems include ease of installation, which reduces labor and equipment costs, and a longer drainfield life.

Drip Dispersal

Drip dispersal of wastewater is a rapidly developing technology, which evolved from the agricultural subsurface irrigation industry. It is a method of applying wastewater effluent in an even and controlled manner over an adsorption area where final treatment and disposal occurs. Drip system components include a septic tank or aerobic treatment unit, a filtration system to protect tubing emitters against clogging, small diameter tubing with emitters designed to evenly disperse the effluent along the tubing, and a control center that operates the mechanical and electrical components of the system.

The major factors in designing a satisfactory drip dispersal system are distribution, dosing, placement, and pre-treatment. Distribution is important, especially in soils that do not percolate well. With a drip system, the effluent can be distributed more evenly over a large area so as not to exceed the capacity of the soil to absorb the hydraulic load. Dosing of effluent is important to maintain the aerobic status of the soil to prevent clogging or "slimming up" of soil interfaces and subsequent failure. Subsurface drip systems are usually divided into zones, which permit short term dosing with several hours of rest and re-aeration between each dose. Two to eight doses per day has been shown to be satisfactory for dosing.

Placement refers to the concept of placing the effluent in the soil horizon most conducive to absorption, treatment, and re-aeration. In soils with a high water table this usually means at least an 18-inch separation between the seasonal water table and the point of injection. For soils with restrictive clay horizons, the effluent should be injected as high above the restrictive horizon as possible. Generally, water tables and restricting layers must be deeper than 36 inches for conventional gravity trenches to function adequately. With drip systems, injection lines can be installed as shallow as 6 inches below the surface, which means that the water table and restricting layers can be as shallow as 24 inches. This shallow burial depth also allows soil evaporation and plant transpiration to take place. Pretreatment becomes important when working in fragile soil conditions to prevent polluting surface and ground water resources. A drip dispersal system can make onsite disposal of wastewater possible where before it would have been prohibited.

Point Discharge

There are times when an adequate subsurface disposal site is not available, or the cost of developing one is cost prohibitive. When this happens, the only choice is to obtain a discharge permit from the Department of Environmental Quality (DEQ). With adequate maintenance, the effluent from an alternative treatment system will meet secondary treatment standards (i.e. 30/30 mg/l for BOD and TSS), and can be discharged to a perennial stream after applying some form of disinfection. The fecal coliform level must not exceed 200 colonies per 100 ml to meet discharge limits. Three primary disinfection methods are chlorination, ultraviolet light, and ozone. When discharging to a stream, stricter monitoring (sampling and testing) will be required.