CAMP WASTEWATER SYSTEMS

Wastewater Treatment for Camping Properties

Purpose & Scope:

This document is intended to provide guidance to the Council on the basics of wastewater management at BSA camping properties throughout the United States. It is not intended as a design manual or textbook. Rather, it is intended to provide the reader with a working knowledge of the principles and application of the various technologies that should be used as input for good design choices.

Given the number of treatment options available, our experience has shown that the best practice is to first look at appropriate technology (those treatment options that will work given the specific soils, loading and climate of the camp) and the regulatory approach used to permit wastewater (sewage) systems.

Replaces:

DS 150 – Sewage Disposal System

DS 151 – Septic Tank

DS 152 – Percolation Tests

DS 180 – Maintenance & Operation of Septic Tanks

DS 182 – Maintenance & Operation of Distribution Fields

DS 183 – Maintenance & Operation of Grease Traps

DS 184 – Maintenance & Operation Sewers

DS 185 – Maintenance & Operation Latrines

Related References:

D-Ref 601 – Campsite Washstand/ Latrine (04/06)

In Depth Design & Maintenance Manual for Vault Toilets: US Department of Agriculture; Forest Service

Council Property Maintenance System (CPMS) V1.0 (02/09)

Treatment Wetlands – Second Edition Kadlec/ Wallace 2009

Onsite Wastewater Treatment Systems Manual. U.S. Environmental Protection Agency. 2002.

Small and Decentralized Wastewater Management Systems. R. Crites & G. Tchobanoglous. McGraw – Hill, New York. 1998

Natural Wastewater Treatment Systems. R. Crites, E. Middlebrooks, and S. Reed. Taylor & Francis, Boca Raton FL. 2006.

Small-Scale Constructed Wetland Treatment Systems; Feasibility, Design Criteria, and O&M Requirements. S. Wallace & R. Knight. Water Environment Research Foundation, Alexandria VA. 2006.

Treatment Wetlands, Second Edition. R. Kadlec & S. Wallace. CRC Press, Boca Raton FL. 2008.

University Web Sites

Consortium of Institutes for Decentralized Wastewater Treatment: http://www.onsiteconsortium.org/institutions.cfm

Texas A&M University: http://ossf.tamu.edu/

University of Minnesota: http://septic.umn.edu/

North Carolina State University: http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-13/

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Version	**Description**	**Author**	**Editor**
1.0	Draft	Shane Sparks – JW/NAWE	John Stewart
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WASTEWATER TREATMENT; BIOLOGY AND CHEMISTRY

Wastewater

Wastewater is liquid waste generated by water-using activities such as toilet flushing, bathing or dish washing. Wastewater can be divided into the categories of “black water” (water associated with flush toilets) and “gray water” (water associated with bathing or washing).

Wastewater contains a variety of pollutants that can endanger human health or harm the environment and these pollutants can be classified into four categories:

- Organic material
- Nutrients (nitrogen and phosphorus)
- Pathogens (bacteria, viruses and parasites)
- Other chemicals

Detailed information about the wastewater pollutants is provided in the following sections.

Organic Matter: Organic matter includes fecal material, as well as other organics like food scraps. There are two ways of measuring the amount (concentration) of organic matter in the wastewater:

- *Total Suspended Solids (TSS),* which is a measurement of how much organic matter can be strained out on a paper filter.
- *Biological Oxygen Demand (BOD),* which is a measurement of how much oxygen the organic matter removes from the water as it decomposes.

Both TSS and BOD can be harmful to the environment. TSS can smother the bottom of streams or lakes, destroying aquatic habitat. BOD removes oxygen from the water, which can kill fish and other aquatic life. For this reason, wastewater systems that discharge to streams, lakes or other water bodies are required to remove BOD and TSS down to a regulated concentration (usually 20 mg/L for BOD and 30 mg/L for TSS). (Note: mg/L stands for "milligrams per liter" which is a unit of concentration.)

Nutrients: Nutrients are elements needed for plant growth. A noticeable effect of excessive nutrient concentrations are algae blooms in lakes and ponds. Nutrients include nitrogen and phosphorus. There are three forms of nitrogen present in wastewater:

- *Organic Nitrogen*, which is nitrogen associated with organic matter, including urine.
- *Ammonia Nitrogen* (NH_3), or (NH_4^+ when dissolved in water). Ammonia removes oxygen from water when is converted to nitrate. Ammonia is toxic to fish and is often a regulated parameter for wastewater systems that discharge to surface waters (lakes, streams, rivers, etc.) Ammonia Nitrogen in wastewater originates from urea and fecal material.
- *Nitrate Nitrogen* (NO_3^-). A byproduct of the nitrification cycle, Nitrate (in liquid form) is toxic to aquatic life, but it can be dangerous to young infants (it interferes with blood supply). For this reason the U.S. Environmental Protection Agency has set a national drinking water standard of 10 mg/L.

The sum of these three forms of nitrogen (organic + ammonia + nitrate) is termed "total nitrogen."

The second major nutrient is phosphorus, which originates as soaps, cleaning products and other industrial materials in wastewater. Most aquatic ecosystems are "phosphorus limited," meaning that adding more phosphorus will trigger algae or other aquatic plant growth. Lakes are especially susceptible to this, so wastewater systems that discharge to lakes usually have a permit which requires the removal of phosphorus to a regulated concentration (often 1 mg/L).

Pathogens: Pathogens are disease-causing organisms such as viruses and bacteria. While not common in the U.S., wastewater can also contain the eggs of intestinal worms and other parasites. For these reasons, exposure to "raw" (untreated) wastewater is dangerous and a public health threat. As a result, there are legal restrictions against failed septic systems and discharging untreated wastewater to the surface of the ground or to surface water bodies like lakes, streams and rivers.

Because of the type and variety of pathogens, it is not practical to measure all of them. The most common approach is to measure a group of bacteria called *fecal coliforms*, which indicate the presence of fecal matter in water. If treated wastewater is discharged to a lake or river, the water is disinfected so that the fecal coliform concentration is less than 200 CFU/100 mL. (Note that CFU/100 mL stands for “colony forming units” per 100 mL of wastewater volume; this is a concentration unit for bacteria in water.)

Other Chemicals: There are other chemicals present in wastewater; usually grease, and also soaps, detergents, and other cleaning products. Some cleaning products have a strong effect on wastewater concentrations. For instance, quaternary ammonia (used as disinfectant) has very high levels of ammonia nitrogen. Detergents containing TSP (tri-sodium phosphate) will add extra phosphorus to the wastewater.

Wastewater Treatment

There are three approaches to treating wastewater:

1. Physical Treatment: This includes gravity settling (allowing material heavier than water to settle out as in septic tanks), removing floating material such as oil & grease, and screening to remove trash and other debris. Physical treatment removes TSS (and the BOD associated with particulate organic matter).

2. Biological Treatment: The organic matter present in wastewater is a food source for microbes in the environment. As the microbes (bacteria, protozoa and other organisms) “eat” this organic matter, TSS and BOD is removed from the wastewater. Because most pathogens are poorly adapted to survive outside the human body, they often are eaten by protozoans and other microscopic filter feeders.

3. Chemical Treatment: This involves the addition of chemicals to the wastewater. The most common example is the use of chlorine (typically sodium hypochlorite – bleach) to disinfect wastewater. Chemicals are often used when phosphorus removal is a treatment need.

Stages of Wastewater Treatment

For most wastewater treatment systems, there are different stages (or steps) that are combined to achieve the required level of treatment. The most common classification of these stages are:

1. Primary Treatment: This involves settling of the wastewater to remove “floaters and sinkers.” The most common type of primary treatment device is a septic tank.

2. Secondary Treatment: This is the next treatment stage after primary treatment. Secondary treatment includes biological treatment of the wastewater. Under the Clean Water Act, secondary treatment implies a combined primary/secondary treatment system that produce treated water (effluent) with less than 20 mg/L of BOD and 30 mg/L of TSS. A typical example of secondary treatment is a “package plant” using mechanical aeration to grow microbes, which perform biological treatment of the wastewater.

3. Tertiary Treatment: Polishing treatment steps after secondary treatment are called “tertiary treatment.” The most common tertiary treatment steps include chemical additions to the wastewater, or filtering of the wastewater as a final treatment step. A wastewater pond can also provide tertiary treatment if used as a polishing step in the wastewater treatment process.

Note: Different treatment stages can be combined in the same unit process. Wastewater lagoons (stabilization ponds) essentially combine "primary" and "secondary" treatment in the same unit process.

Types of Biological Treatment

Biological treatment of wastewater can occur under one of two conditions:

<u>Aerobic Treatment</u> involves the use of microbes that require oxygen to consume organic matter in the wastewater. Because of the high oxygen demand in wastewater, this oxygen is usually added with mechanical blowers or mixer (unless very large ponds are used). Bacteria that perform aerobic treatment oxidize organic matter to carbon dioxide (CO_2), which is vented from the wastewater to the atmosphere. If there is enough time and oxygen availability, aerobic treatment will also oxidize organic nitrogen and ammonia nitrogen to the form of nitrate nitrogen.

<u>Anaerobic Treatment</u> involves the use of microbes that do not require oxygen. These microbes convert organic matter to methane gas (CH_4), which is burned in large treatment facilities to generate heat and/or electricity. This also causes odors in pit latrines.

It is very important that <u>every</u> worker dealing with wastewater systems understands that anaerobic environments (manholes, sewers, septic tanks, etc.) create atmospheres that are not breathable and can be fatal to the people who enter them. OSHA requirements specify that working in these "confined spaces" requires specialized gas testing and ventilation equipment.

In some wastewater treatment processes, aerobic and anaerobic environments are sequenced to increase the treatment efficiency of the overall process. The most common example of this is when an aerobic treatment process is used to oxidize ammonia nitrogen to nitrate nitrogen, which is then recycled (pumped back) to the beginning of the treatment process such as a septic tank, because the anaerobic environment encourages the conversion of nitrate nitrogen to nitrogen gas, which bubbles out of the water.

Timing Issues with Biological Treatment

Biological treatment of wastewater relies on a microbial population to "eat" the contaminants present in the wastewater. This microbial population is the net result of all the individual bacteria and protozoans that grow and die within the treatment system. Bacteria cannot grow instantaneously, thus there is always a certain "lag time" between an increase (or decrease in loading) and the response of the microbial community (and associated biological treatment).

As a result, biological treatment systems are most stable when they receive a constant flow, and constant concentration of organic matter, every day. *Unfortunately, this almost never happens in Camps operated by the Boy Scouts of America, where attendance often is defined by seasonal patterns, and weekend peaks*.

Most BSA facilities will experience two very different wastewater loading patterns:

1. A “peak season” loading representing full utilization of the camp and full-time attendance of camp staff.
2. An “off season” loading that often is about 30% of the peak season loading. However, in the off season, loadings are often concentrated around weekend events, and day-to-day activities are often limited to a camp ranger or other custodial staff.

This variation in flows and loadings makes BSA camps very different than most municipal or industrial wastewater treatment facilities. In systems that rely on suspended growth (bacteria suspended in water), which is most activated sludge and package plants, the treatment cycle is governed by the hydraulic retention time (the average time wastewater spends in the treatment system). If the flow and loading changes all the time, these systems are very hard to operate consistently.

The alternative is to select processes that are more stable. This can be done by using processes with long hydraulic retention times (such as waste stabilization lagoons) or systems that use “attached growth” of bacteria (which cannot readily be “washed out” of the system). Typical examples of “attached growth” biological treatment systems include constructed wetlands, sand filters or soil-based (septic drainfield) systems.

Seasonal Operations

Due to the reality of most BSA operations, the camp ranger must develop two distinct wastewater management programs:

1. A “peak season” program when the camp is essentially 100% utilized.
2. An “off peak” program that discusses weekend activities, regularly scheduled maintenance (such as pumping of septic tanks), and the weekend-specific nature of many Scout programs.

In cold climates, winterization may be an issue, and camp rangers will need to consider how to drain pipes full of water, and if certain treatment components can be turned off during the “off peak” season.

WASTEWATER SYSTEM COMPONENTS

Wastewater systems can be broken down into three large components:

1. Collection
2. Treatment
3. Disposal

There are different technology options for all three components. A brief overview of collection, treatment and disposal technologies is presented in this guideline.

Collection Systems

Collection systems can utilize either gravity flow or pumped (pressure flow). Gravity flow sewers that do not have septic tanks require large pipes laid within a constant grade and manholes spaced at regular intervals (Figure 1). If septic tanks are placed at each building, smaller diameter pipes can be used without manholes. An example of this septic tank effluent – gravity (STEG) sewer is shown in Figure 2.

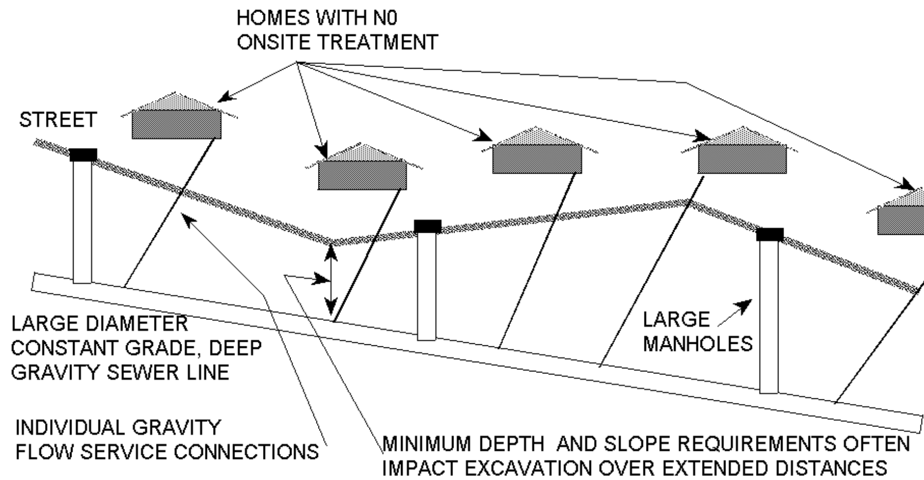

Figure 1 – Conventional Gravity Sewer

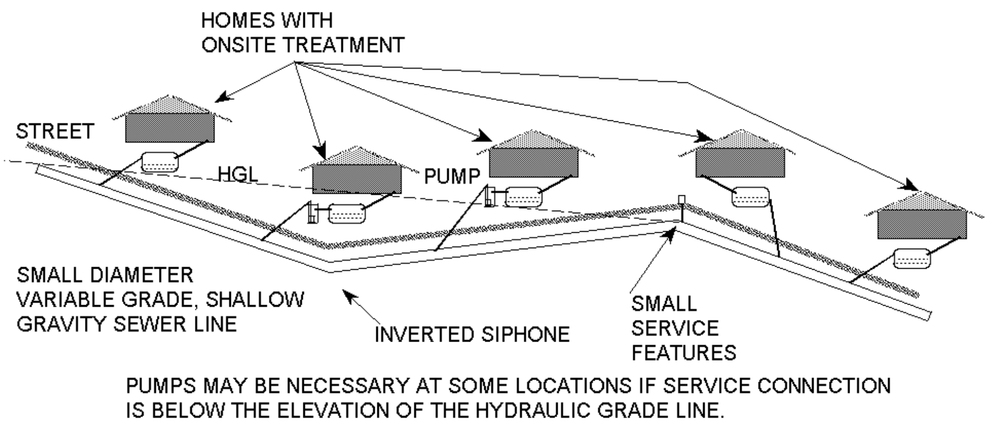

Figure 2 – Septic Tank Effluent – Gravity (STEG) Sewer

If gravity flow is not feasible, collection systems that use pumps will be required. These include collection systems that use large pumps capable of pumping wastewater solids, systems that use a septic tank to remove solids prior to pumping, and systems that use large “grinder” pumps to shred wastewater solids into small particles (Figure 3) before pumping to the central treatment area.

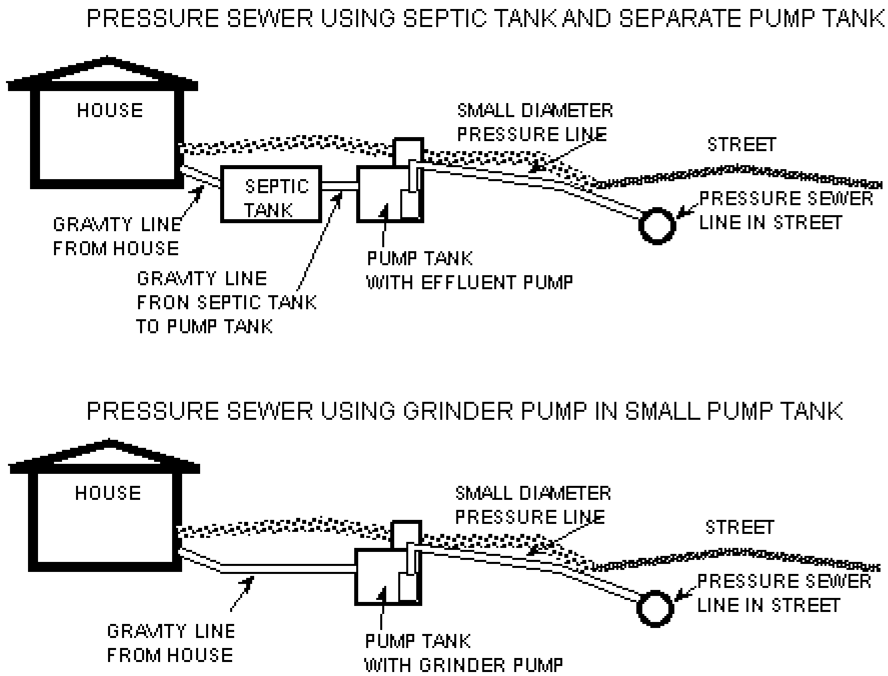

Figure 3 – Pressure Sewer Systems

Trotta, P.D., and J.O. Ramsey. 2005. Effluent Conveyance - Text. *in* (M.A. Gross and N.E. Deal, eds.) University Curriculum Development for Decentralized Wastewater Management. National Decentralized Water Resources Capacity Development Project. University of Arkansas, Fayetteville, AR

Operation and Maintenance of Collection Systems

Routine operation and inspection of collection systems is necessary for all camps. Every year, the following protocol should be followed:

1. Check rate of flow between manholes for obstruction. A dye or a colored tissue can be put in the wastewater to determine the flow rate.
2. If the line is blocked, contract with a local firm to use a sewer snake or other acceptable technology to clean the blockage.
3. Check all manholes to ensure that surface water is not entering. Remove any soil from the bottom of the manholes.

If repairs or replacements are necessary in the collection system, a local engineering firm should be hired to ensure all applicable state regulations are met in the new design.

Treatment Systems

There are many different wastewater treatment systems, and different treatment units are often combined into the overall treatment process to achieve the required level of treatment. The level of treatment that is required is a function of how the wastewater is disposed of, and what regulatory standards apply to the discharge. This section summarizes small-scale treatment systems that are commonly encountered in Scout facilities.

Primary Treatment

Septic Tanks

Septic tanks are the most common type of primary treatment system for small wastewater applications. Most new septic tanks are constructed of precast concrete or fiberglass materials. Pour in place septic tanks are no longer used except in specialized situations. Septic tanks rely on physical treatment (gravity settling) to remove "floaters and sinkers" from the wastewater (Figure 4). The septic tank environment is anaerobic. Organic matter trapped in the tank gradually undergoes biological treatment. Accumulated solids must be removed from the tank by a pumper truck. The frequency of pumping depends on how heavily the tank is loaded; typically tanks are pumped every 1 to 3 years.

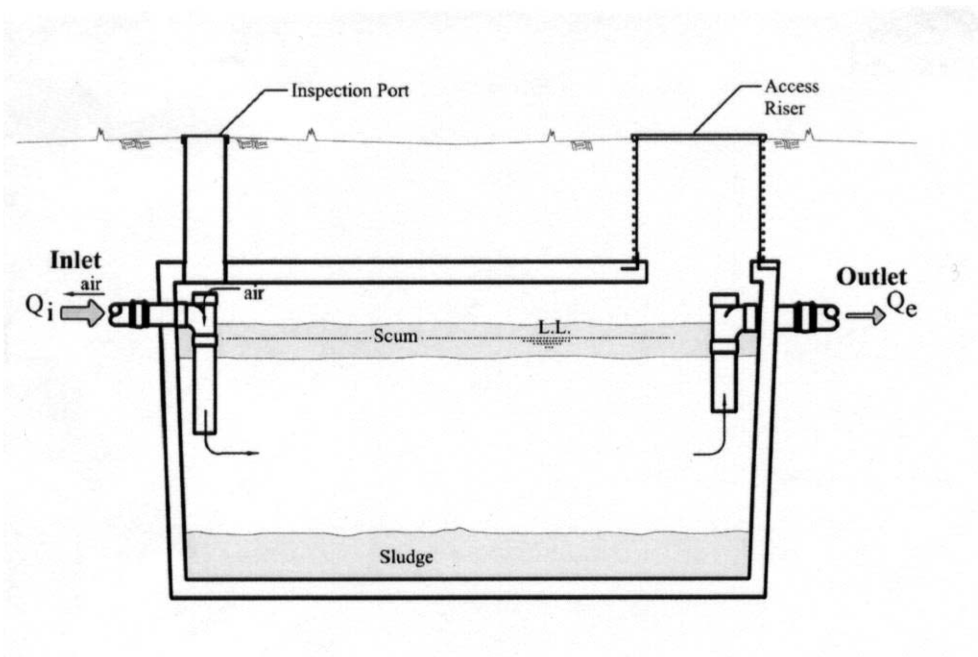

Figure 4 – Septic Tank

Septic tanks are sized using prescriptive codes that often specify a minimum tank size based on the number of bedrooms in a home. For non-residential applications, the tank is often sized to be 2 to 3 times the wastewater design flow. Experienced wastewater designers and engineers should be consulted to ensure septic tanks are sized appropriately.

Operation and Maintenance of Septic Tanks

Septic tanks shall be inspected annually to determine the amount of accumulated scum and sludge. Records of septic tank measurements, inspections, and pumping should be submitted to CPMS for record keeping purposes. Septic tank risers will be provided for inspection holes and to facilitate inspection and pumping. Septic tanks will be pumped when the scum and or sludge levels in the tank dictate, but pumping is recommended every three years. The bottom of the scum layer should never be closer than three inches to the bottom of the outlet device and the top to the sludge layer should never be less than 8 inches from the bottom of the outlet device.

When septic tank pumping is necessary, this should always be done by a commercial firm. A local pumping contractor should be hired on a regular basis to remove sludge and scum buildup in the tanks. All sludge and liquid should be disposed of in a manner that meets all applicable state regulations.

Frequent use of anti-bacterial soap in waterless dishwashers can be toxic to the bacteria in the septic tank and cause a reduction in the treatment abilities of the wastewater treatment system. All dishwashing chemicals should be chlorine-free and acceptable for use in a private wastewater system.

If excessive odors are noticed from a septic tank, or the septic tank is overflowing, the following steps should be taken:

1. Check sludge depth to determine need for cleaning.
2. Determine if tank capacity is sufficient for the wastewater flow.
3. Check baffles in septic tank for proper operation.
4. Check drainfield for breakthroughs. The drainfield may have lost its ability to infiltrate wastewater.
5. Bacteria in septic tank may have been killed by cleaning compounds. Stop using chlorine dishwasher cleaners.
6. Determine if roots have clogged sewer lines.

Grease Traps

A grease trap is necessary for all Scout camps with kitchen facilities, and it works by separating grease and food particles from the wastewater. Grease is lighter in weight and will float to the surface if the water temperature has lowered sufficiently to permit it to congeal. Excess grease in a tile field will tend to clog the soil and lower its absorption capacity. Grease in quantity will lower the efficiency of the septic tank. Grease in the grease traps must be removed once per month and checked periodically throughout the year. Heavy detergent use will limit the effectiveness of the grease trap.

<u>Grease Control – Best Managerial Practices</u>

Fats, oils, and greases from kitchen facilities can have a negative impact on the wastewater collection and treatment system. By following these best management practices you will help prevent blockages in your plumbing system.

1. "DRY WIPE" all pots, pans, cooking utensils, plates and other dishware prior to dishwashing. Dining and cooking utensils should be dry wiped with disposable paper or cloth material, and the wipers should be disposed in garbage receptacles. The method of cleaning plates, as tables are cleaned, needs to be changed so that plates are dry wiped into garbage receptacles to ensure grease wastes are not being washed into the sewer system.
2. Recycle waste cooking oil.
3. Post "NO GREASE" signs above sinks and on front of dishwashers.
4. Water temperature for dishwasher should be 140^{O} F or less. Temperatures in excess of 140^{O}F will dissolve grease, but it will re-congeal or solidify after it flows to the sewer collection system.
5. Use a minimum amount of detergent for dishwashing. Detergent surfactants can have negative impact on grease control, and will save you money.

6. Remove all garbage disposal units connected to sinks or other connections to the sewer. Sink garbage grinders or disposal systems will contribute grease discharge to the sewer. Food waste should be recycled or disposed of in solid waste garbage receptacles.
7. "Dry" clean kitchen floors instead of washing down floors. Sweeping or using a minimal amount of cleaner and water with a mop will also save you money.
8. Train kitchen staff and other employees that grease control is important and inform them how they can help ensure best management practices are implemented.

<u>For Grease Control Equipment:</u>

Grease interceptors (underground containment tank usually from 250 gal. to 1,000 gal. capacity)

1. Know where the grease interceptor is located and witness cleaning/maintenance activities to ensure it is operating properly.
2. At a <u>minimum</u>, have the grease interceptor cleaned or "pumped out" quarterly or every 90 days. For some larger facilities (or those that generate a lot of grease) the grease interceptor should be cleaned monthly. <u>KEEP RECORDS OF CLEANING</u> - Date, Time, Hauler or Company that cleaned, volume removed, etc.

Chemical Toilets

A toilet that collects waste in a small storage container typically filled with a chemical disinfectant that destroys bacteria in the wastewater and reduces odors. These toilets are typically covered with a fiberglass, insect resistant shell. Chemical toilets should only be used for large short-term events and are not intended for full-time use. In addition to cleaning and general upkeep, these toilets need daily service to remove the accumulated liquids and supply new chemical reserves to the collection basin.

Stabilization Ponds

Wastewater Stabilization Ponds are passive treatment systems that perform both the functions of primary and secondary treatment. Two types of pond systems are commonly used. The first type are ponds that are aerated with mechanical mixers or blowers; these systems have a continuous discharge commonly designed to achieve a 30-day detention time to allow for stable treatment performance. The second type of pond systems are controlled discharge lagoons; these ponds are sized large enough so that water is only released twice per year (in the spring and fall). Controlled discharge lagoons have less stringent discharge standards because the treated water is released during periods of high stream flows.

Figure 5 – Aerated Pond System with FWS Constructed Wetland

Because of their mechanical simplicity and stable treatment performance, wastewater stabilization ponds can be an option for many Scout camps. However, stabilization ponds are not suitable in areas of high groundwater, and often have to meet stringent setback requirements from the nearest building or residence. Setback requirements vary from state to state but generally are greater than 1,000 feet. New pond systems also have to meet leak testing requirements, which often require a plastic liner system. Ponds accumulate sludge, and there is a deferred cost for sludge removal.

Secondary Treatment

Aerobic Treatment Units

These systems, commonly called “package plants” or “ATUs” are compact mechanical systems that offer drop-in-place ease of construction for secondary wastewater treatment (Figure 6). The internal configuration varies widely between manufacturers. Operating and maintaining these systems has proven to be challenging at many Scouting facilities due to the constantly changing wastewater flows and loadings.

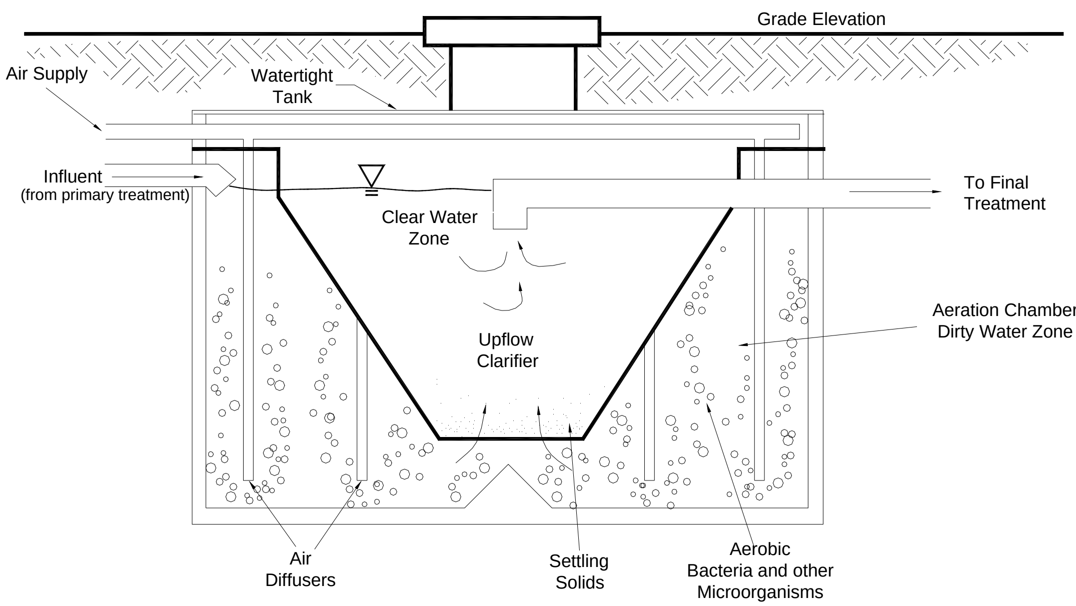

Figure 6 – Typical Aerobic Treatment Unit

Seabloom, R.W. and J.R Buchanan. 2005. Aerobic Treatment of Wastewater and Aerobic Treatment Units Text. in (M.A. Gross and N.E. Deal, eds.) University Curriculum Development for Decentralized Wastewater Management. National Decentralized Water Resources Capacity Development Project. University of Arkansas, Fayetteville, AR

Media Filters

The term “media filter” refers to a wide range of attached-growth treatment systems used for secondary treatment. Some of these filters are intermittent (Figure 7), and apply wastewater in small pulses, and some are recirculating, where a pump is used to cycle wastewater through the filter many times (Figure 8). Media filters are essentially “bacteria hotels” that house and contain the bacteria needed for biological treatment of the wastewater. A variety of medias have been used to provide the surface area the bacteria attach themselves to, including sand, gravel, peat, cloth, crushed glass, crushed concrete, slag, etc.

Figure 7 – Intermittent Filter using Cloth Media, Duluth Minnesota

Figure 8 – Recirculating Gravel Filter under Construction

Loudon, T.L., T.R. Bounds, J.R. Buchanan and J. C. Converse. 2005. Media Filters Text. *in* (M.A. Gross and N.E. Deal, eds.) University Curriculum Development for Decentralized Wastewater Management. National Decentralized Water Resources Capacity Development Project. University of Arkansas, Fayetteville, AR.

Media filters offer comparable treatment performance to aerobic treatment units, but are much more stable in their response to changes in wastewater flows and loadings. Thus, for most Scout facilities, they offer a better choice than aerobic treatment units.

Microfiltration

Typically used in situations with advanced wastewater treatment needs, microfiltration can provide effluent levels of near drinking water quality. Essential a filtration process, contaminants are removed in the wastewater through a microporous membrane. Suspended solids and solutes of high molecular weight are retained, while water and low molecular weight solutes pass through the membrane.

Microfiltration units requires daily operation and maintenance, a highly trained operator, and have large power demands due to the necessity of large pumping pressures to force the water through the membranes. These units are only recommended in sensitive environmental conditions, such as the Florida Keys, where high quality wastewater effluent is required before discharge.

Constructed Wetlands

The term “constructed wetlands” covers a wide variety of treatment systems that involve the use of aquatic plants. In terms of the BSA, there are two types of constructed wetlands that have been used to date:

- Free water surface (FWS) wetlands that are essentially man-made equivalents of open-water marshes.
- Subsurface flow (SSF) wetlands that use a gravel bed (planted with wetland vegetation) as the treatment media

In many instances, constructed wetlands can be viewed as “low tech” versions of media filters, as they enjoy the same stable treatment performance, but trade more land area for less mechanical complexity.

Free Water Surface (FWS) wetlands are often use to “polish” effluent from pond systems (see Figure 5), both to improve treatment efficiency and to stabilize treatment performance. In the State of Ohio, FWS wetlands have been used as a means of effluent disposal (Figure 9), through the combined routes of evapotranspiration (water used by plants) and infiltration (water soaking into the ground).

Figure 9 – FWS wetlands, State of Ohio

Subsurface Flow (SSF) wetlands have been used by the BSA at the Northern Tier High Adventure Base for secondary wastewater treatment, and also for grey water treatment for camps on Big Munson Island associated with Florida Sea Base.

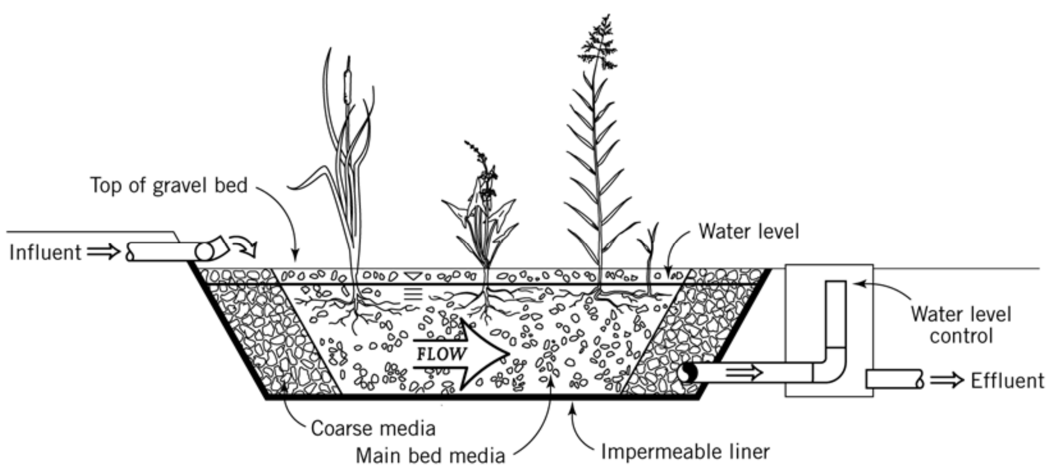

Figure 10 – Subsurface Flow Constructed Wetland

From Wallace & Knight (2006) Small-scale constructed wetland treatment systems: Feasibility, design criteria and O&M requirements. Final Report, Project 01-CTS-5, Water Environment Research Foundation (WERF); Alexandria, Virginia

SSF wetlands are attractive because they are gravity-fed systems and the water is not exposed during the treatment process

Tertiary Treatment

Disinfection

In applications where treated water (effluent) will be disposed of on the land surface, disinfection of the water is usually required as a final treatment step. Disinfection of wastewater is commonly done in one of two ways:

- Chlorination
- Ultraviolet light (UV)

The most common disinfection method is chlorination; chlorine is added to the water to kill any pathogenic organisms. In the past, chlorine gas was commonly used as the disinfectant; however due to security concerns (chlorine gas is very poisonous), it is used less and less. For small-scale systems, liquid sodium hypochlorite (bleach) is slowly added to the water with a metering pump (Figure 11). There are also tablet chlorinators, that use tablets that slowly dissolve in water. Field experience with tablet chlorinators shows that it is difficult to maintain a consistent dose of chemical and good treatment performance. One major benefit of the liquid sodium hypochlorite approach is that the metering pump and be ramped up or down to adjust the dose in response to different flow rates and seasons.

Figure 11 – Chemical metering pump for sodium hypochlorite

The other approach is to use ultraviolet light (UV) (Figure 12). The wavelength of the UV light damages the cell structure in bacteria, meaning that pathogens are unable to reproduce and die off. UV systems have an advantage in that they do not require chemicals. However, UV systems are either on or off; they are not adjustable. Also, regular cleaning of the UV bulbs is needed to maintain consistent performance. UV disinfection typically has a higher maintenance cost compared to a chemical addition (chlorination).

Figure 12 – example of small UV disinfection units

Camp staff should be aware that sodium hypochlorite is a dangerous chemical. Similarly, UV lamps can burn the skin and eyes. Staff should always have the proper health & safety training when working with wastewater systems.

Other Wastewater Treatment

In certain applications, additional treatment may be required, especially for systems that must meet very stringent nutrient standards (such as in the Florida Keys) and systems where treated effluent will be reused. Generally, these types of treatments will include chemical additions and filtration of the effluent. These standards apply to only a small fraction Scout facilities and it is not practical to go into more detail on them given the scope of this manual.

Composting Toilets

Composting toilets are biological toilets that are also known as non-liquid saturation systems. **Figure 13** is a schematic of a composting toilet from Clivus Multrum, Inc.

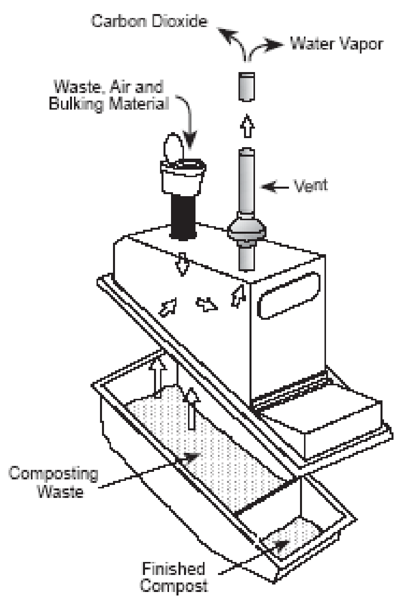

Figure 13: Schematic of a Composting Toilet (Clivus Multrum, Inc)

A composting toilet works by capturing the nutrients in waste and breaking them down into simple, stable compounds that have high value as plant nutrients. Waste is broken down by mesophilic organisms, which thrive in temperature from 69 to 112 degrees Fahrenheit (F), such as bacteria, fungi, and red worms. Pathogens in the waste are killed by the active bacteria and organisms in the compost and the long residence time that the waste has in the composter.

A composting toilet needs nitrogen, carbon, and oxygen to function properly. The toilet waste provides the nitrogen and the ventilation shaft provides the oxygen, but carbon needs to be added to the system. Carbon can be added in the form of any type of bulking material (wood shavings, etc.) that will promote good aeration and moisture levels within the composter. Biological additives are available that speed up the composting process, which may be useful at camps with a relatively short composting season.

Three end products are created by the composter. The largest product is the compost, which looks, feels, and smells like topsoil and is safe to handle. Solid compost is removed no more than once per year. The second end product is a concentrated liquid that is very rich in nutrients and can be a very beneficial fertilizer. This product is clean and can sustain agricultural production without the ruination of soil. The third end product is gas. Carbon dioxide and water vapor are both produced, but are harmless as they are the same gases that humans exhale.

Regular maintenance to the composting unit includes the addition of bulking material (once weekly), 1-3 gallons of fresh water per day, raking and the removal of the liquid end product (once weekly). A liquid removal system is standard in most composting toilets and can gravity flow the product to a storage tank where it can be applied to soil via irrigation. If soil irrigation is not possible due to regulatory requirements, the liquid has to be removed approximately once or twice a year.

Composters work best in temperature above 65 degrees Fahrenheit. If the average temperature of the camp is below that, heat may need to be applied to the composter. Propane heating may be necessary if solar heat is not strong enough to thaw the composter out after the winter months. Biological additives are available that speed up the composting process, which can be useful if the camp is located in an area with a short composting season.

Pit Latrines

A pit latrine is essential a hole in the ground with a restroom building over it. All liquid waste infiltrate into the soil and the solids accumulate to levels that eventually require pumping or the complete abandonment of the toilet. A vent is typically installed in the building to facilitate air movement in the pit and reduce odors.

Pit latrines generally experience frequent odors and without frequent cleaning, can be a home to a number of different insects. For all camps, the installation of new pit latrines should be avoided except in specialized cases. In many states, new installations are considered Class V injection wells and are subject to stringent state rules for wastewater treatment. If installation is necessary, all new vault toilets should incorporate the U.S. Forest Service Sweet Smelling Toilet Design Features.

General Operations and Maintenance

All wastewater treatment systems require operations and maintenance to meet state standards, and to ensure the system is meeting design guidelines. The following guidelines are general and apply to all wastewater treatment technologies/systems:

1. The Scout executive will ensure operators are adequately trained and certified in accordance with operator requirements of the Regulating Agency. The Scout executive will designate, in writing, primary operators, and backup operators who have adequate training and skills to operate the systems. Camps that operate only individual, onsite systems will have appropriately trained operators
2. The Scout executive will develop training plans and assure that operators receive any required or appropriate training.
3. The Scout executive will assure that required records are maintained in permanent files for periodic review by the regulatory agency, and that reports are submitted on a timely basis as requested by the regulatory agency.
4. When wastewater system modifications or new construction are proposed, the Scout executive will submit plans and specifications to the regulatory agency for approval. A copy of the plans and specifications will be kept on file at the site and at the service center.
5. All toilet facilities will be cleaned and resupplied as often as necessary to maintain a high degree of sanitation.
6. Adequate sanitation facilities will be required for activities in remote areas such as river rafting, horseback riding, backcountry biking, backpacking or similar activities.
7. Personnel who routinely come into contact with sewage, or those who work in or inspect wastewater treatment facilities, will have a current immunization for tetanus.
8. In the event of a major wastewater spill, the regulatory agency will be notified within one business day. Facilities and equipment contaminated with sewage as a result of leaks or spills will be thoroughly washed down with water and detergent. In this situation, the camp ranger should contact the Scout executive immediately.

Disposal Methods

The method of effluent disposal determines how the wastewater system will be regulated and permitted.

Regulatory Impacts of Disposal Methods

There are two broad categories of effluent disposal; surface and subsurface. The disposal method and the size of the system will determine what regulatory agency permit the system requires, the frequency of monitoring and reporting, and whether or not a licensed operator will be needed to operate the system, as summarized in Figure 14.

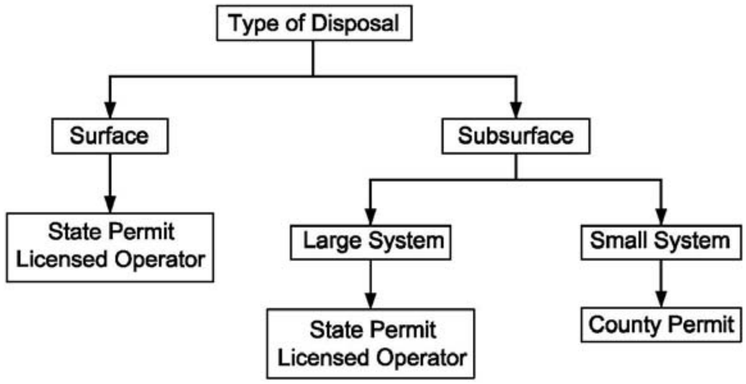

Figure 14 – Regulatory Impacts of Disposal Methods

Surface Water Discharge Regulations

Surface water discharges will always be permitted by the state environmental protection agency, regardless of size. This relates back to the passage of the Clean Water Act by Congress in 1972. Under the Clean Water Act, the U.S. Environmental Protection Agency (EPA) established the National Pollutant Discharge Elimination System (NPDES), which required all point-source discharges of wastewater to obtain a discharge permit from EPA. Since that time, almost all states have taken over implementation of the NPDES permit program for their states. Since all NPDES permits originated with a federal program, there is a certain degree of uniformity in all NPDES permits. Generally speaking, all NPDES permits (or the state-administered equivalent program) will require the following:

- A minimum of secondary treatment (except for controlled-discharge ponds).
- Sampling and monitoring of the treatment efficiency of the system.
- A requirement that the system be operated by a trained, licensed operator
- Monthly reporting of the system performance back to the regulatory agency.
- Financial and legal penalties if the system is consistently out of compliance with the permit limits.

These requirements will apply to a surface discharge, regardless of the size of the system. So a small system (1,000 gallon per day) will have essentially the same monitoring and permitting costs as a large system (100,000 gallon per day). For this reason, it is generally not cost-effective to operate small, surface discharging systems if an alternate method is available. Controlled discharge ponds may be an exception due to the seasonal nature of the discharge, resulting in low monitoring and maintenance requirements.

Subsurface Discharge Regulations

Regulations around subsurface disposal have evolved from local septic codes. As a result, there are no uniform standards, and regulations vary widely state to state and sometimes even county by county. Since septic codes were written for single-family homes, there is a transition point to where a system is considered “big” and a permit from the state environmental protection agency is required. This “permit threshold” (the transition from a local County permit to a State permit) is not uniform and, again, varies state by state.

As a general rule of thumb, subsurface disposal systems require less monitoring and reporting than surface discharge systems. The exception is injection wells, where federal law applies once again and a high level of treatment is required. Injection wells are not often a disposal alternative that would be sought by a Scouting operation.

The combination of regulatory programs and different disposal methods is summarized in Figure 15.

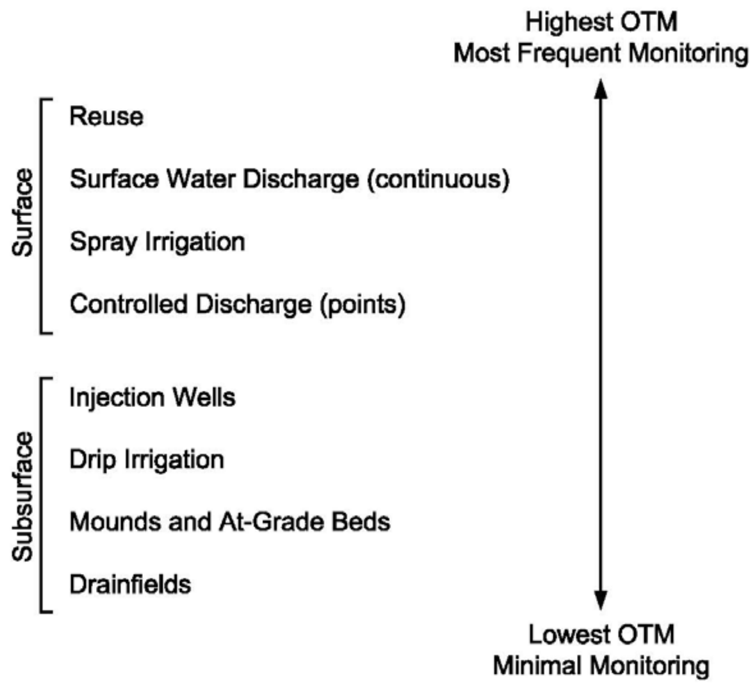

Figure 15 – Disposal methods and level of monitoring, reporting and O&M

Surface Discharge Alternatives

Surface discharge alternatives are regulated based on the assumption that treated effluent will interact with people and the environment. The degree of exposure to treated effluent determines the level of treatment required, and the frequency of monitoring and reporting.

<u>Reuse</u>

Systems that reuse, or recycle treated wastewater for irrigation or other purposes (such as toilet flushing) are often stringently regulated. The degree of treatment is often determined by the level of public access, and projects with full public access, for example irrigation of food crops or golf courses will have more stringent limits than projects where reuse water is restricted to areas without public access. Reuse standards vary state by state. The California standards (Title 22) are some of the most stringent in the U.S., and are often used by other states that do not have their own reuse standards. Generally, wastewater treatment systems with produce reuse water will require tertiary treatment and very frequent monitoring.

Surface Water Discharge

Systems that discharge continuously to surface waters (streams, rivers, lakes, and natural wetlands) will have to meet a minimum of secondary treatment and disinfection. Due to changing regulatory standards, many of these systems are now being required to remove ammonia nitrogen, and in some case, phosphorus from the wastewater. A licensed operator is required, and generally the facility will have to submit a report each month summarizing the treatment performance. The frequency of sampling is a function of the size of the system, and larger systems will have more frequent monitoring (daily or weekly).

Spray Irrigation

Systems that use spray irrigation (Figure 16) are typically operated only during the growing season (in northern climates), so storage of water in a pond or tank during the off season may be required. These systems are often sized so that the nutrients in the wastewater are applied at agronomic rates so they can be utilized by the plants. Disinfection is usually required, and the site may have to be fenced off and subject to setback distances. There are usually restrictions against irrigating during rain events, or irrigating saturated or frozen soils where effluent could run off the site and enter adjacent surface waters.

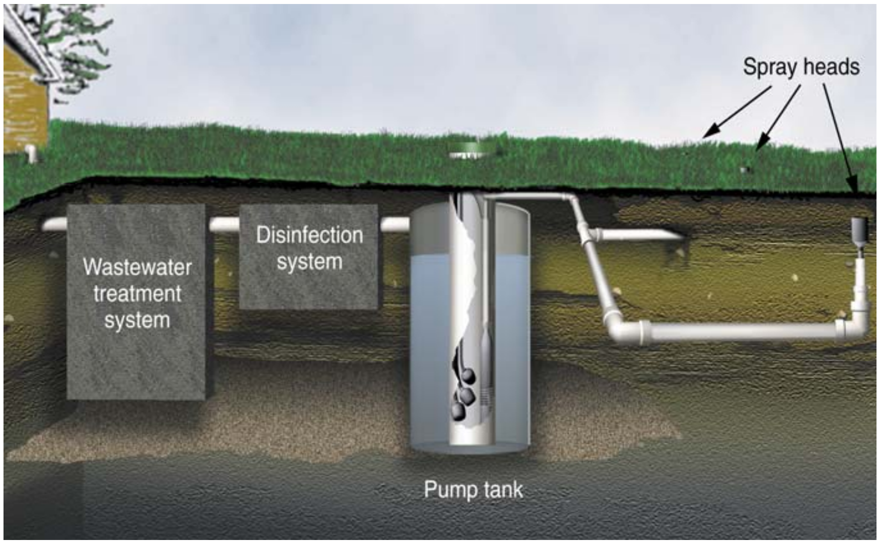

Figure 16 – Small-scale spray irrigation system

Controlled Discharge

Controlled discharge systems are usually storage ponds that are drained twice per year (in the spring and the fall) during periods of high stream flows. Because of the dilution that is presumed to occur, these systems have less stringent treatment standards and less reporting requirements than other surface discharge alternatives.

One variation on controlled discharge that has been implemented at Scout facilities in Ohio is to use FWS constructed wetlands as the holding cells. Due to a combination of evapotranspiration (water used by the plants) and infiltration, these become almost zero-discharge systems if sized properly (see Figure 9).

Subsurface Discharge Alternatives

Subsurface discharge alternatives (with the exception of injection wells) are regulated on the assumption that the effluent will not interact with people. For systems that discharge to soil (drip irrigation, mounds, at-grade beds, and drainfields), the soil becomes a treatment media that removes TSS, BOD, and pathogens from the wastewater. Numerous studies have shown that movement of the wastewater through 3 feet of soil will do almost a complete job of treatment. Disposal technologies should have a minimum of 12 inches of soil cover to prevent freezing and wastewater surfacing. Over the years, local counties (and later, states) have developed prescriptive codes on how to determine the size of the soil area required.

One of the major problems with soil-based systems is that the continual loading of organic matter (TSS, BOD) into the soil matrix creates a clogging mat that eventually plugs up the soil, causing the system to fail. Septic tanks only remove about 40 to 60% of the organic matter and rely on the soil treatment to provide the biological and filtration needed for subsurface discharge. Thus, soil-based systems have a finite life of 10 to 20 years. One approach is to do additional pretreatment (secondary treatment after the septic tank with a media filter or constructed wetland) to reduce, delay or eliminate the clogging effects. Soil-based systems also require native soils and, once installed, the disposal area needs to be protected from vehicle and foot traffic. Poor location, such as under a parking lot, causes soil compaction, which will shorten the life of the wastewater disposal field.

A detailed soils investigation, including percolation testing (or other approved methods to determine hydraulic conductivity of the soil) is necessary for the siting of all drainfields. An experienced onsite installer or engineer with soil science experience is required for these testing procedures. In addition to the soil testing requirement, all states require certain setback distances from water bodies, buildings, wells, etc. For larger installations, Scout executives should contract with an engineering firm to complete the required testing and design of the disposal systems to ensure all setback distances are properly met.

Injection Wells

Unlike other subsurface disposal methods, injection wells are subject to federal regulation. EPA considers wells that inject treated wastewater to be "Class V" injection wells (see: http://www.epa.gov/OGWDW/uic/class5/index.html). The basic premise of this regulation is that the introduction of fluids into the subsurface cannot degrade drinking water resources. For wells that inject directly into the groundwater, this may trigger a limit on total nitrogen (due to the 10 mg/L drinking water limit for nitrate nitrogen).

Injection wells are also used in coastal areas (such as the Florida Keys) where a direct ocean discharge would affect coral reefs. These systems are generally subject to very strict treatment standards.

Drip Irrigation

Subsurface drip irrigation is used to distribute effluent from a septic tank or secondary treatment system into the soil environment. Drip systems are susceptible to damage from gophers and other rodents, and thus generally are more maintenance intensive than other types of soil disposal systems. However, drip systems can be installed on sloping sites and in triangular areas, which is an advantage. Because drip systems are installed into the existing soil matrix, generally 3 feet of vertical separation is needed between the drip emitter lines and the seasonal high water table.

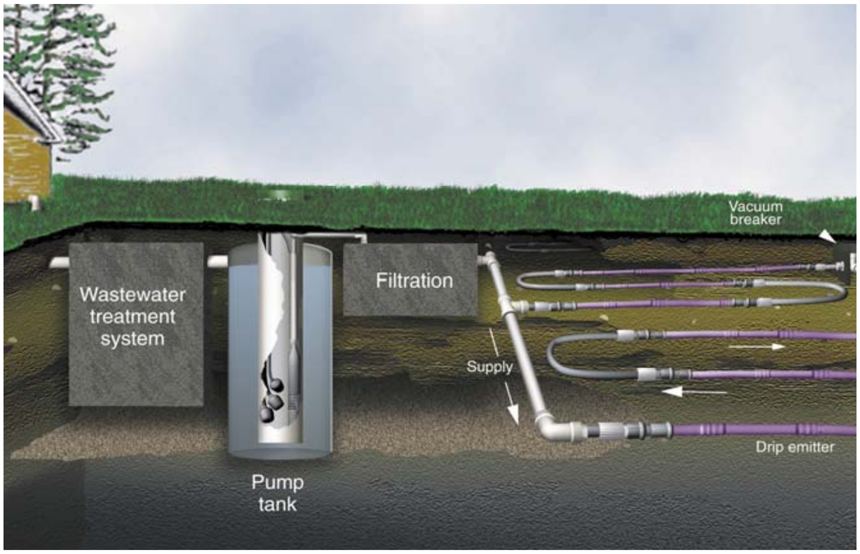

Figure 17 – Drip Irrigation System

Mounds and At-Grade Beds

These systems are used when there is not 3 feet of vertical separation in the soil. Mound systems generally have a 2-foot sand layer (with one foot of native soil below) while at-grade beds have a thinner sand layer (generally the sand is used to level the area) prior to construction of the distribution layer. These systems require pressure distribution, so a dosing pump will be required.

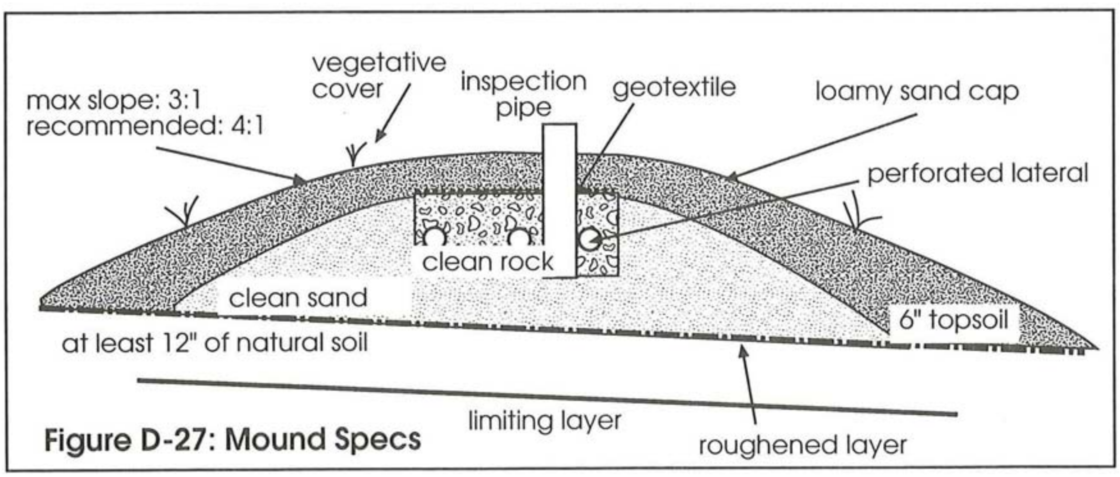

Figure 18 –Mound System

Drainfields

Drainfields are used to distribute effluent into the soil. They are used when there is more than 3 feet of vertical separation between the bottom of the drainfield trench and the seasonal high water table. Because drainfields typically use gravity distribution, they are the simplest of the subsurface discharge alternatives. These systems can be installed with gravel or chambered trenches. Chambered technologies are typically lower cost, easier to install and can eliminate the need for large amounts of gravel.

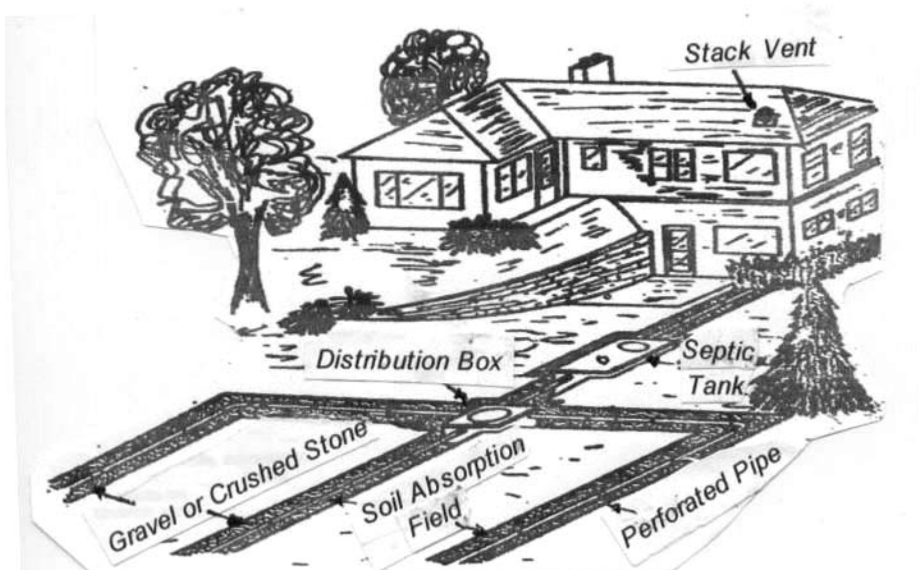

Figure 19 – Drainfield System

Operation and Maintenance of Soil Disposal Systems

General operation and maintenance of soil based wastewater systems can be completed by the camp ranger. At least once per month, and more frequently during peak camping season, the Ranger should perform a visual inspection of the soil disposal field. The ranger should observe and note the location of any suspected wastewater breakthroughs. If breakthroughs are located, the ranger should work with a trained operator to identify the proper course of action to remediate the issue.

In addition to observing wastewater breakthroughs, the camp ranger should keep the drainfield clear of trees and bushes, which can send roots into drainfield equipment and shorten the life of the drainfield.

Technology Selection

The process of selecting which wastewater technologies are appropriate for a given site is a complex process depending on the interaction of three different issues:

1. The regulatory framework (both state and local regulations)
2. The site conditions (high water table, poor soils, etc.)
3. The size of the system

Because of these factors, each project is unique and it is not possible to offer a universal set of guidelines that will cover all facilities. Engineers or other wastewater professionals are often retained to conduct technology selection reports and design wastewater systems. Figure 19 presents a flow chart that is intended to be used as a general planning tool. The goal of this flow chart is to point facility managers in the direction of the simplest wastewater technologies that will fit their situation.

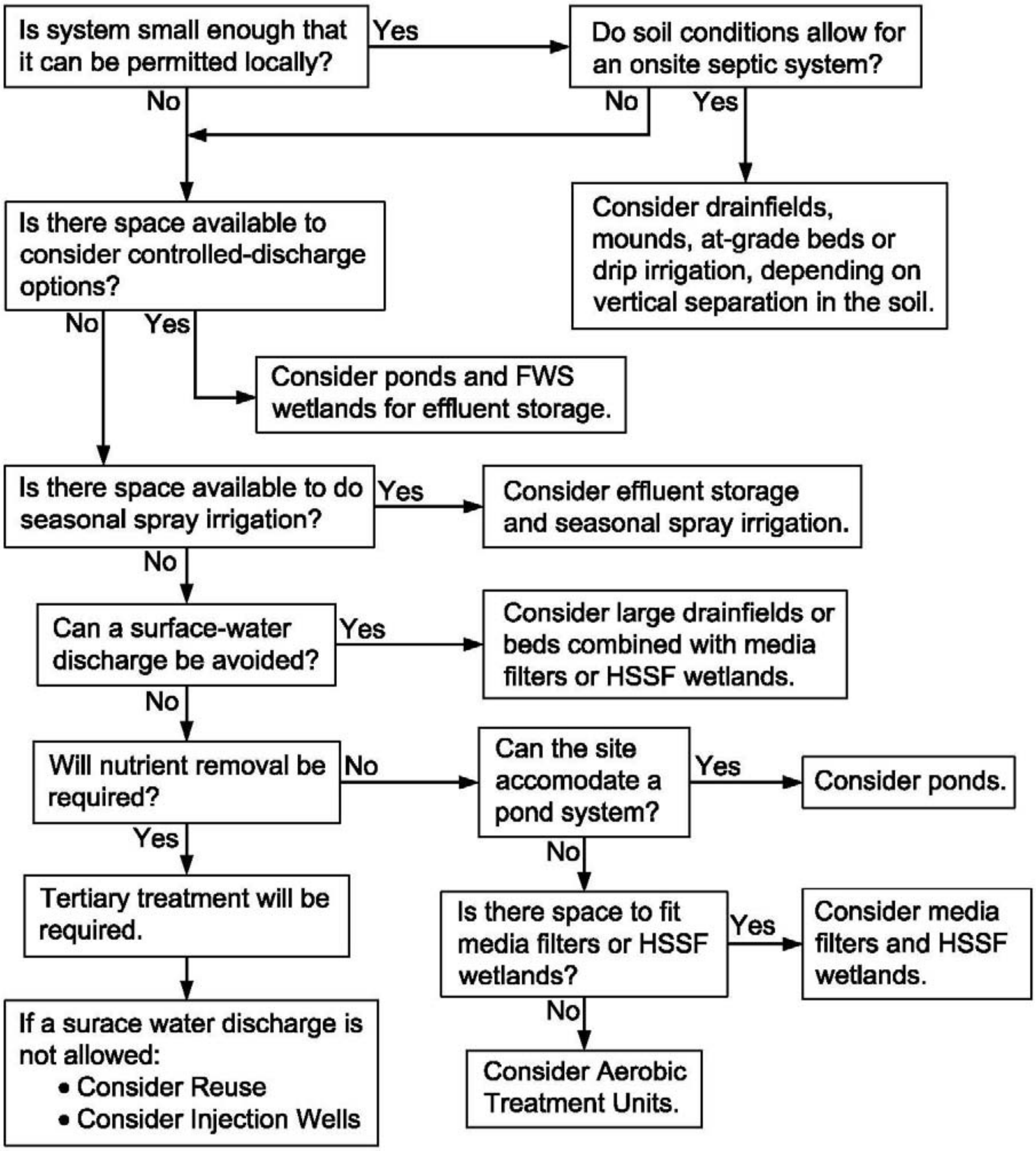

Figure 20 – Wastewater Technology Selection Flow Chart

Glossary:

Aerobic Waste Treatment: The stabilization of wastes through the action of microorganisms in the presence of oxygen.

Anaerobic Waste Treatment: Waste stabilization brought about through the action of microorganisms, which exist in the absence of oxygen.

Back Country Systems: Systems not readily serviceable by motorized vehicles or boat. They are found in remote areas frequented by backpackers, hikers and other park users.

Barrel Toilet: A toilet which collects waste in a barrel or drum which can be sealed when full and transported by truck or helicopter to a treatment plant for proper disposal.

Biochemical Oxygen Demand (BOD): The amount of oxygen required to stabilize decomposable organic matter.

Cesspool: Covered open-joint walled pits that receive raw sewage.

Chemical Oxygen Demand (COD): The amount of oxygen required to stabilize decomposable organic and oxidizable inorganic material.

Chemical Toilet: A toilet that collects wastes in a small storage container filled with a chemical disinfectant, which destroys microorganisms and controls odor. Usually covered with an enclosed insect proof structure.

Coliform: A group of bacteria commonly found in soil and intestines of man and other warm-blooded animals. The presence of coliforms in surface and/or ground waters is a general indicator of recent human and/or animal fecal contamination.

Composting Toilet: A toilet that promotes aerobic decomposition and stabilization of human waste through the addition of a carbon source (e.g., wood shavings). Requires regular operations to function properly.

Confined Space: Any space that by design has limited openings for entry and exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants, and which are not intended for continuous employee occupancy. Confined spaces include but are not limited to storage tanks, ship compartments, process vessels, pits, vats, silos, degreasers, reaction vessels, boilers, ventilation and exhaust ducting, sewers, manholes, tunnels, trenches, underground utilities, septic tanks, wet wells, and pipelines.

Dissolved Solids: The material contained in a liquid, which shall pass through a glass fiber filter. Examples include iron, calcium, magnesium, potassium and sodium in combination with chloride, sulfate, bicarbonate, carbonate and nitrate.

Effluent: Wastewater flowing out of a reservoir, basin, sewage treatment plant, industrial treatment plant or marine sanitation device.

Evaporator Toilet: A toilet that evaporates liquid from human waste to decrease the weight prior to removal from the site.

Fecal Coliform: A group of bacteria in the coliform group, which inhabits the intestines of all warm-blooded animals. The presence of fecal coliforms in surface and/or ground waters is a good indicator of recent human and/or animal fecal contamination.

Front Country Systems: Those systems accessible by motorized vehicle or boat.

Intrinsically Safe: Equipment designed so that there is no possibility of creating an ignition source.

Lagoon: A pond containing raw or partially treated wastewater in which aerobic, facultative and/or anaerobic stabilization occurs.

NPDES: The National Pollutant Discharge Elimination System is a program developed by the EPA to control discharge pollution of natural waters and is found in EPA 40 CFR 122.

Permit: An authorization, license or equivalent control document issued by EPA or an "approved State" to implement the requirements of NPDES (National Pollutant Discharge Elimination System).

Primacy Agency: A State agency authorized by the Environmental Protection Agency (EPA) to administer the program. If a state has not requested this authorization, EPA is the Primacy Agency.

Primary Treatment: The physical removal of solids from wastewater involving settling or flotation.

Privy: A hole dug in the ground for the disposal of human waste. Usually covered with an insect proof enclosure.

Sanitary Survey: A detailed investigation of the features of a wastewater system and conditions, which may impact the ability of the system to adequately treat wastewater.

Secondary Treatment: Biological treatment of wastewater which produces an effluent with a monthly average of 30 mg/l of BOD and suspended solids, 200 fecal coliform/100 ml and a pH between 6 and 9.

Septage: The liquid and solid material removed from a septic tank, cesspool, vault toilet or similar domestic wastewater treatment system or holding tank when the system is cleaned or maintained.

Septic Tank: A watertight, covered tank designed and constructed to receive sewage from a building sewer. It separates solids from the liquid, digests organic matter; stores digested solids through a period of detention, and allows clarified liquids to discharge.

Sludge Digestion: The further decomposition and stabilization of solids removed from primary and secondary treatment processes. This process uses microorganisms, which can be either aerobic or anaerobic.

Suspended Solids: Those solids that are visible and in suspension in water. May be settleable or non-settleable.

Tertiary Treatment: Additional treatment following secondary treatment designed to achieve a specific effluent quality.

Total Organic Carbon (TOC): A measure of the total carbon as carbon dioxide in a liquid after all inorganic carbon has been removed or accounted for.

Total Solids: The combined sum of the suspended and the dissolved solid material in wastewater.

Vault Toilet: A toilet with a watertight underground tank, which totally contains all wastewater, which enters. The tank shall be emptied periodically and the wastes properly disposed. It requires adequate ventilation to control odor and should be easily pumped out. Usually covered with an enclosed, insect-proof structure.

Wastewater: Liquids and waterborne solids from domestic, industrial or commercial uses that have been used in man's activities. If improperly controlled, or inadequately treated, it can cause human illness and/or pollution of the environment.

Waters of the United States: All natural ground and surface waters that meet the criteria of 40 CFR 122.2.

Regulations:

State regulations of each state can be found on the following web site:

http://www.acacamps.org/publicpolicy/regulations/

The following table can be used to record the name and contact information of anyone who should be contacted in the event of an unauthorized discharge.

Name	Position	E-mail	Phone

The following Log should be used to memorialize notifications made in behalf of the BSA

Date	Person Notified	Nature of the Notification