NEVADA DIVISION OF
ENVIRONMENTAL
PROTECTION

GUIDANCE MANUAL (1.0)

ON SITE SEWAGE DISPOSAL SYSTEMS
FOR COMMERCIAL APPLICATIONS

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GUIDANCE MANUAL

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Scope and Purpose

The scope and purpose of this guidance manual is to assist the professional engineer in designing an On Site Sewage Disposal System (OSDS) that meets Nevada statutes and regulations for water protection as well as protecting public health. The guidance manual has been developed to follow the Nevada Administrative Code as well as address current technology with respect to on site wastewater disposal. It is intended to be a dynamic document that is meant to be amended as new on site wastewater disposal technology emerges. The initial manual is numbered (1.0). This will allow the design engineer to ensure that he/she has the latest version for use.

Not every design situation may be covered by the guidance manual. If a design engineer finds himself in a situation where more technical guidance is necessary, they are advised to contact the Nevada Division of Environmental Protection (NDEP), Bureau of Water Pollution Control and speak to the staff engineer in charge of the Onsite Sewage Disposal System program. NDEP may be contacted for specific questions at (775) 687-9468.

The guidance manual provides a framework for the design of the OSDS. The division or administrative authorities that provide this document to the public do not assume liability for the installation, operation, maintenance or safety of the OSDS. Further, the State makes no warranty, expressed or implied, and assumes no liability for the information or conclusions contained in this manual.

Nevada's ground water quality standards require that the discharger control the zone of influence of effluent disposal. The zone of influence is the land area below which the ground water is degraded to a poorer quality than drinking water by effluent disposal.

Impacts of Effluent on Groundwater

Most people think a system is failing when effluent either ponds on the soil surface causing a wet seepy area, or when sewage backs up into the house or business. However, it is also important to prevent a third, less commonly thought-of failure—contamination of groundwater and surface water. Approximately 30 percent of North American households use septic systems for wastewater disposal, with these same households utilizing groundwater for drinking and other domestic uses.

As water percolates through the soil, it is purified and in most cases requires no treatment before being consumed. However, when the soil is overloaded with a treatable contaminant, or when the contaminant cannot be treated by the soil, the quality of the underlying groundwater may change significantly.

Pollution of groundwater is usually very difficult to correct, since the only access to the water table is through wells, trenches (if the water table is high enough), or natural discharge points such as springs. An incident of groundwater pollution often becomes a problem which persists for many years.

Choosing Technology for Onsite Systems

Conventional onsite technology consists of a septic tank and gravity flow to a series of soil treatment trenches. New choices have become available in recent years, including sand filters, peat filters, constructed wetlands, mechanical aerobic, drip irrigation, and variations on both the conventional septic tank and the conventional soil treatment system. Using combinations of technologies, figuring out which choices are best suited to different sites, and sizing systems using these new technologies can be confusing.

Performance/Alternative

The bottom line in selecting any of these technologies is making sure the wastewater is treated before it's discharged into the environment. Another way to look at treatment is to think of getting rid of the problems before the water is used again. Once the goals of treatment are established, such as the removal of pathogens and nutrients, various technologies can be analyzed for their effectiveness. For instance, the conventional choice (a septic tank and trenches with four feet of soil separating the system from bedrock or saturated soil) does an excellent job of removing pathogens, but will not do much to eliminate nutrients such as nitrogen.

Performance standards for treatment of septic tank effluent are based on these conventional systems: The performance goal of any new technology should be to do as well as a conventional system measured at 4-foot below the trenches. Numerically, the standards are zero fecal coliform, less than one milligram per liter phosphorous, and a nitrate level lower than drinking water standards before the water reaches the environment.

Once it's been established that a technology can provide the desired level of treatment, the next criterion is reliability. In analyzing reliability, identify the part(s) of the system where things could go wrong. When one component of the system fails or breaks, will it alter or shut down the treatment process? As an example, consider aerobic treatment units. An aerobic treatment unit functions very well as long as it's getting air. As soon as the air is turned off, it's no longer an aerobic treatment unit--it becomes a septic tank very quickly. The design of a septic tank and an aerobic treatment unit are significantly different. Most aerobic units can't function as conventional septic tanks. The addition of air is critical to the reliability of the aerobic system.

Regular monitoring of its operation is necessary to make sure the aerobic treatment unit is operating the way it is intended. If a component is easily broken, it's not reliable. That doesn't mean it can't be chosen, but there must be a comprehensive management plan in place that includes frequent monitoring and regular maintenance of the less-reliable parts of the system.

Management of the System

Management is taking care of the entire system, through both **operation** and **maintenance**. Operation is the day-to-day upkeep of the system, and every system will have some operational requirements. Maintenance is the attention to the routine critical processes of the system that ensures the proper operation and long life, such as changing the oil in your car or tractor. A conventional septic system has a three-part maintenance requirement: using the right amount of water; pumping the septic tank at regular intervals (typically once every two years); and staying off of or otherwise protecting the soil treatment area. Newer technologies have more demanding management requirements. An aerobic treatment unit's requirements are similar to, but more complicated than those of the conventional septic tank are. Not only must it be pumped out periodically, but also it must also always be receiving air (oxygen). The most critical maintenance practice is to be sure that air is entering the tank. Reliability and management are connected; in this case, airflow has to be checked and any problems quickly rectified for the aerobic treatment unit to be reliable. Each of the new technologies has its own maintenance requirements.

Another aspect of management is also related to reliability: **monitoring.** Every system has to be checked to see that it performs as designed. Monitoring can involve additional steps in critical areas such as lakeshore, river/stream and source water protection areas. It may require periodic sampling before the effluent is discharged. It may also require telemetry monitoring for commercial systems that rely on advanced treatment systems located in remote areas.

A final important aspect of management is replacement. As an onsite system wears out, it must be fixed. In a conventional system, replacement occurs every twenty to forty years. With new technologies and new models of system management, as each part of a system is replaced, it can also be updated, possibly minimizing the expense of total replacement by prolonging system life.

Designing with Management in Mind

How can the designer of these systems relate technology and management? In the past, there was a standard technology (septic tank and four feet of soil) and standard management (pumping the tank every two to three years). With the new choices, that's no longer the case. New technology is forcing new management strategies. As each new option is added to a system, the management of that system must change. If it doesn't, the system won't work the way it's intended to. For those systems that need additional management to ensure reliability, an adequate management plan is critical. <u>Management strategies must be specific to the treatment system.</u>

The converse is also true: the management available will limit the technology chosen. If proper management isn't in place, problems with the system will show up very quickly. An example of this maybe a holding tank, which stores wastewater and has to be pumped as soon as it becomes full. A holding tank may fill in one week. Therefore, a holding tank is limited in its application because the cost associated with hauling the sewage away for final treatment.

Before a technology is chosen, the costs, management requirements, reliability, performance, and future plans all must be considered. When designing a new system, all of the pieces need to fit together, so the system will work well into the future. An example of lack of planning is the situation where small house lots on a lake are each responsible for their own wastewater treatment. If every lake had a central treatment plant, and each house had a sewer hookup, as they do in cities, the small lots would not pose a problem. Many were developed with well and septic systems. Community sewer was not considered when these lots were plotted, and eventually the current owners will pay the price.

Cost

The cost of solving these problems has two parts: the cost of the technology (taking into account the reliability and longevity of the system) and the cost of the management (taking care of it). Both kinds of costs need to be considered "up front" in the planning process. All of the information on new technologies—performance, longevity, management, and flexibility—needs to be considered in order to make the right choices for each specific location.

Consider:

Cost Management
Reliability
Performance
Future

In addition to the tables below, additional information may be found at:
http://cfpub.epa.gov/owm/septic/septic.cfm?page_id=283

Table A. Commonly used treatment processes and optional treatment methods

Treatment objective	Treatment process	Treatment methods
Suspended Solids removal	Sedimentation	Septic tank
	Filtration	Septic tank effluent screens Soil infiltration Media filters (sand, gravel, peat)
Carbonaceous BOD removal/ammonium removal	Aerobic, suspended growth reactors	Extended aeration Fixed film activated sludge Sequencing batch reactors
	Fixed film aerobic reactor	Soil infiltration Trickling filter Fixed film activated sludge Media filters
Nitrogen transformation	Biological nitrification (N) Denitrification (D)	Activated sludge (N) Sequencing batch reactor (N) Fixed film bio-reactor (N) Recirculating media filter (N,D) Fixed film activated sludge (N) Anaerobic upflow filter (N) Anaerobic submerged media reactor (D)
	Ion exchange	Cation & anion exchange
Phosphorus removal	Physical/Chemical	Infiltration by soil & other media Chemical flocculation and settling Iron-rich packed bed media filter
	Biological	Sequencing batch reactor
Pathogen removal	Filtration/Predation/Inactivation	Soil infiltration Packed bed media filters Granular (sand, gravel, etc.) Peat, textile
	Disinfection	Hypochlorite Ultraviolet light
Grease removal	Flotation	Grease trap Septic tank
	Adsorption	Mechanical skimmer
	Aerobic biological treatment (incidental removal will occur, overloading possible	Aerobic biological systems

Source: U.S. EPA Onsite Wastewater Treatment Systems Manual, 2002.

Table B. Primary considerations for selecting type of Onsite Sewage Disposal System.

Type system	Consider when:	Maintenance	Drawbacks
Gravel Drain field	Soil percolation rate is 5 to 120 min/in. Bottom of trenches and beds at least 4 ft. above highest expected groundwater level.	Pump septic tank at least every 2-3 years. Prevent deep rooted vegetation over drain field. Prevent soil compaction over drain field	Excessive water use may overload the system. Garbage disposal use increases pumping frequency (and BOD loading).
Pressure Dosing	Drain field is more than 500 linear ft. Dosing is required on mound and sand filters as well.	Pump septic tank at least every 2-3 years. Flushing and cleaning of small diameter distribution pipe.	Cost of pump and energy to run pump.
Mound System	Soils with slow or fast percolation rates. Shallow soil cover over fractured or porous bedrock. High groundwater table.	Pump septic tank at least every 2-3 years. Pumps and siphons must be maintained. Flushing and cleaning of small diameter distribution pipe.	Costs are higher than conventional systems due to design costs and materials.
Gravelless Drain field System/Chambers	Site is remote or difficult to reach. Typical drain field materials (gravel) not available or expensive.	Pump septic tank at least every 2-3 years. <u>Note</u>: septic tanks not recommended for fabric wrapped pipe.	Potential problems in sandy soils.
Sand Filter	Repairing existing malfunctioning system. Site is an environmentally sensitive area. Soils with slow percolation.	Pump septic tank at least every 2-3 years. Maintenance varies by design. Dosing chamber pumps, controls and timer sequence must be checked.	Cost is high where media is expensive or must be transported long distances. Pumps require electricity.
Recirculating Textile-based Packed Bed Filter	Similar to sand filter	Inspect and pump septic tank and recirculating tanks as needed based upon scum and sludge accumulation (typically 8-10 years). Periodic maintenance visits required to clean pump screen and perform regular maintenance.	Costs are higher than conventional systems.
Peat Filter	Similar to sand filter	Pump septic tank at least every 2-3 years. Rake filter surface every year.	Peat must be replaced about every 8 years.
Aerobic Treatment Unit	Soil characteristics are not appropriate for a traditional septic tank/drain field. Goundwater table is high or shallow bedrock exists. Small lot. Traditional septic system has failed. Desirable to extend the life of a drain field.	Inspect and pump secondary settling chamber as needed (may be as frequent as 3-6 months). Mechanical parts require periodic checks, maintenance and repair.	Costs more to install than other systems. Problems with sudden heavy loads or neglect. Electrical costs and associated maintenance. Requires final treatment in drain field, sand filter, or other system.
Holding Tank	There is no suitable effluent treatment area. Temporary or seasonal use only.	More frequent pumping is required. Alarm or visible float needed to indicate when the tank is 75 percent full	Restricted water use. Pumping and disposal costs.
Constructed Wetlands System	Soil cannot treat wastewater before it percolates to groundwater, such as clay soils. Aesthetics are important.	Pump septic tank at least every 2-3 years. Prevent trees from growing in wetland cells. Maintain wetland plants.	Costs are higher than conventional systems due to professional design costs and materials.

Source: adapted from National Small Flows Clearinghouse

Glossary of Wastewater Terms

Biochemical Oxygen Demand - Five Day (BOD_5): A five day laboratory test which determines the amount of dissolved oxygen used by microorganisms in the biochemical oxidation (breakdown) of organic matter. BOD concentrations are used as a measure of the strength of a wastewater.

Dosing Tank: A tank that collects wastewater and from which wastewater is discharged into another treatment or dispersal step; equivalent to a dosing chamber.

Drain field (conventional): An area in which perforated piping is laid in drain rock-packed trenches for the purpose of distributing the effluent from a wastewater treatment unit.

Distribution Laterals (pressure dosed): Usually small diameter PVC pipe with orifices evenly spaced, used to uniformly distribute wastewater over a treatment zone in an enclosed component or drain field.

Effective (Particle) Size, (E.S.= D_{10}): The size of a sand filter media grain in millimeters, such that 10% by weight of the media sample is smaller.

Effluent: Liquid that is discharged from a septic tank, filter, or other on-site wastewater system component.

Fecal Coliform (bacteria): Coliform bacteria specifically originating from the intestines of warm-blooded animals, used as an indicator of pathogenic bacterial contamination.

Filter: A device or structure for removing suspended solid, colloidal material, or BOD from wastewater.

Filter Fabric: Any man-made permeable textile material used with foundations, soil, rock, or earth.

Filter Media: The material through which wastewater is passed for the purpose of treatment.

Single Pass Sand Filter: A sand filter in which primary treated wastewater is applied periodically, providing intermittent periods of wastewater application, followed by periods of drying and oxygenation of the filter bed. Wastewater applied to the surface of a single pass sand filter flows through that filter media once before going onto the next treatment step.

Particle Size: The diameter (in millimeters) of a soil or sand particle, usually measured by sedimentation or sieving methods.

Particle Stratification: Separation of particles according to size due to movement of particles in either air or water.

Recirculating Sand (Gravel) Filter: A sand (gravel) filter which processes liquid waste by mixing sand filter filtrate with incoming septic tank effluent and recirculating it several times through the sand filter media before discharge to a final treatment/dispersal unit.

Sand Filter: A biological and physical wastewater treatment unit consisting (generally) of an underdrained bed of sand to which primary treated effluent is periodically applied. Filtrate collected by the underdrain(s) is then transferred from the filter to an approved soil absorption system or other treatment step. Pretreatment of wastewater prior to the sand filter step, can be provided by either a septic tank or another approved treatment device.

Sandy Loam: Soil in which the sand fraction is still quite obvious, containing 25% or more medium sand. It is dominantly a loam, which is composed of sand, silt, and clay particles.

Soil Texture: The relative proportions of soil separates (sand, silt, and clay particles) in a particular soil. USDA soil textures are utilized in this Guidance Manual

Total Suspended Solids (TSS):, measure of solids that either float on the surface of, or are in suspension in, water or wastewater. A measure of wastewater strength, often used in conjunction with BOD_5.

Uniformity Coefficient (C.U.): A numeric quantity which is calculated by dividing the size of a sieve opening which will pass 60% by weight of a sand media sample by the size of the sieve opening which will pass 10% by weight of the same sand media sample. (Note that 50% of the sample is retained between the two). The uniformity coefficient is a measure of the degree of size uniformity of the sand particles in sand media sample. As the U.C. value approaches one (1), the more uniform in particle size the sand media is. The larger the U.C., the less uniform the particle size.
CU = Particle Diameter $_{60\%} = D_{60}$ Particle Diameter$_{10\%}$ D_{10}

Wastewater: Water-carried human excreta and/or domestic waste from residences, buildings, commercial establishments or other facilities.

1. EXEMPTIONS

The Nevada Administrative Code (NAC) allows the division to grant exemptions provided the requested exemption is justified by an engineer, provides for a similar level of protection to the environment/public health and involves an advancement in technology, alternative method of construction, improvement in materials or operation. The design engineer should not take this provision to mean that unacceptable locations for subsurface disposal systems (i.e. unsuitable soils, bedrock, high groundwater) or areas of high nitrogen in the groundwater will be allowed. The purpose of the exemption is to allow greater flexibility in designing an OSDS that generally meets the site requirements of the current NAC. To avoid delays or denials, it is strongly recommended that the design engineer contact the division (Bureau of Water Pollution Control) to discuss any proposed exemption before the design and application process begins.

2. NITROGEN MANAGEMENT AND NITROGEN RESTRICTED AREAS

Rural population areas in Nevada have utilized private wells and individual sewage disposal systems (ISDS) for many years. In areas where the septic density has been shown to impact groundwater (i.e. Silver Springs, Spanish Springs, areas of Grass Valley) the division will no longer approve conventional OSDS as a means of sewage treatment and disposal. Further, NDEP will not approve subdivisions that propose the use of ISDS in these nitrogen restricted areas. A nitrogen restricted area will be declared after groundwater quality and/or the septic density is exceeded. Generally, the sensitive area will more than likely evolve from a nitrogen management area that continues to demonstrate elevated levels of nitrate-nitrogen in the groundwater. Total nitrogen levels approaching or exceeding 10 mg/l will cause an area to be declared a nitrogen restricted area.

A nitrogen restricted area does not imply the division will deny all further growth, rather, it requires that commercial or centralized sewage treatment and disposal, or other acceptable method must be developed with nitrogen reducing capability if further growth is to continue.

In declaring a nitrogen restricted area, the division will hold a public hearing in the affected area and present supporting data for the action. The division may ask the State Health Officer or his representative to participate and provide support for the action.

Further, because of the public and environmental health problems associated with elevated levels of nitrogen in the groundwater, the division will direct the county, city or other legal entity to provide a plan for addressing the groundwater pollution in the affected area. There should be no surprise when NDEP requires such an action, as the affected jurisdiction will have already been informed of the process when the area in question became a nitrogen management area.

Note: Waters of the state belong to all current and future citizens of Nevada and no person or entity has the right to pollute these waters and continue doing so. Protection of our valuable water resources is the division's mission.

3. DOMESTIC SEWAGE

On site wastewater disposal systems designed in accordance with the requirements of NAC 445A, of the Onsite Sewage Disposal Systems regulations, other technical standards and the engineering practices described in this manual are intended for the treatment and disposal of domestic sewage.

Domestic sewage consists of wastes incidental to the occupancy of commercial applications. It contains toilet wastes, laundry wastes, wash water, kitchen wastes and possibly wastes from garbage grinders. Wastes from small restaurants and commercial laundries are also considered as domestic sewage, although the composition is not typical, and therefore special design may be required for a subsurface sewage disposal system which receives them.

Table 3-1, Constituent mass loadings and concentrations in typical domestic wastewater[a]

Constituent	Mass loading (grams/person/day)	Concentration[b] (mg/l)
Suspended Solids (Total)	35 - 75	155 - 330
Bio-chemical Oxygen Demand (BOD_5)	35 - 65	155 - 286
Total Nitrogen	6 - 17	26 - 75
Total Phosphorus	1 - 2	6 - 12
Fats, oils and grease	12 - 18	70 - 105
Coliform Bacteria (fecal)	----	10^6 - 10^8 /100ml

[a] For typical standard water-using fixtures and appliances.
[b] milligrams per liter; assumed water use of 60 gallons/person/day (227 liters/person/day).
Source: U.S. EPA Onsite Wastewater Treatment Systems Manual, 2002.

Wastewater containing chemical or biological pollutants and concentrations significantly outside this range, or which may contain non-biodegradable synthetic organics, carcinogens or biotoxins should not be considered domestic sewage, since it may not be properly treated or disposed of by Onsite Sewage Disposal Systems designed to receive domestic sewage. These wastes must be disposed of in accordance with laws and regulations established by the Nevada Division of Environmental Protection under the authority of individual permits. Following is a partial list of such wastes:

-Industrial process wastes
-Photographic wastes
-Liquid agricultural manure
-Slaughter house wastes
-Food processing wastes
-Waste oils
-Car wash wastes
-Waste from mining
-Dry cleaning wastes
-Milk Wastes

SUSPENDED SOLIDS (TOTAL)

Total suspended solids (TSS) in effluent can clog the infiltrative surface or soil interstices, reducing the life of the disposal field. A properly functioning septic tank will reduce the TSS in the effluent through sedimentation prior to entry to the disposal system . An effluent filter will further reduce the TSS load to the disposal field. Therefore, it is imperative that the treatment tank be inspected routinely for sludge buildup and pumped regularly to avoid short circuiting of effluent into the disposal system.

BIO-CHEMICAL OXYGEN DEMAND (BOD)

Bio-chemical oxygen demand, commonly referred to as BOD, is a measure of the amount of biodegradable organic chemicals in the wastes. BOD can create taste and odor problems in well water and cause leaching of metals from sold and rock into ground water. A properly functioning septic tank will reduce the BOD in the effluent. Further reduction occurs as the effluent comes in contact with bacterial growth in the leaching system and the aerated soil zone above the ground water table.

A large leaching system constructed in moderately permeable soils and effectively dosed is efficient in reducing BOD, and will minimize ground water pollution. On the contrary, leaching systems constructed in highly permeable soils, particularly where the ground water is shallow, may have an adverse affect on ground water, since in this case the amount of beneficial bacterial growth in the leaching system would be minimal, distribution through the system might be quite irregular and movement of the effluent through the soil would be rapid.

Bacteria growing under conditions where the effluent is either strong or ample store polysaccharides as slime capsules, which then cover the soil particles at the trench bottom-soil interface, causing a reduction in pore diameter of the soil. This clogging effect reduces the soil infiltrative capacity. Formation of this clogging mat can cause premature hydraulic failure of the absorption area if the pores become entirely clogged. Proper sizing of the OSDS can help to ensure that the clogging mat will not become entirely plugged.

NITROGEN

Nitrogen in domestic sewage exists in different chemical forms depending on the degree of oxidation. Fresh sewage is high in organic nitrogen. After the septic tank, it is primarily ammonia (85%). After discharge of the effluent to the infiltrative surface, aerobic bacteria in the biomat and upper vadose zone convert the ammonia in the effluent almost entirely to nitrite (NO_2) and then to nitrate (NO_3). Nitrogen in its nitrate form is a significant ground water pollutant. Effluent from aerobic tanks contains nitrogen primarily in the form of nitrate.

Nitrate nitrogen is an essential nutrient for the growth of plants and algae, and is an end product of any properly functioning leaching system. Nitrates are not readily removed by filtration through soil, so that ground water underlying a leaching system will receive a certain amount of nitrate loading. Since nitrate ions (NO3-) have a negative charge, they are not attracted to soils, and are very mobile. Typically, septic systems remove approximately 30% of total nitrogen with the remaining 70% being discharged to the ground water. There are many other nitrogen sources in the environment which also will contribute nitrates to the ground water, such as fertilizers, rotting vegetation and the atmosphere itself.

Once nitrates reach the ground water, the only mitigative effect to this contamination is by dilution with the native groundwater. The effectiveness of this dilution is dependent upon the amount of nitrate entering from other sources in the area, including agricultural practices and other onsite systems, along with the hydrogeologic conditions of the groundwater system. High concentrations of nitrate (greater than 10 mg/l) levels in drinking water wells pose a hazard to the health of infant children who consume the water regularly. Methemoglobinemia or “blue baby syndrome” is a disease in infants that reduces the blood’s ability to carry oxygen and also causes problems during pregnancy.

PHOSPHATE

Phosporus in septic tanks effluent comes from two main sources: detergents containing phosphates and human excreta. Phosphate is a nutrient essential for plant growth. Only a small amount may be required to stimulate a considerable algae growth in surface water. Domestic sewage contains small, but significant amounts of phosphates. Phosphates in sewage combine readily with certain minerals normally present in soils, such as iron and aluminum, to form insoluble deposits which are readily removed by filtration through only a foot or two of soil. Phosphorus is removed from wastewater by being chemically bound by minerals and held on exchange sites on soil particles. Minerals that bind with phosphates are iron, manganese and aluminum. The capacity of the soil to retain phosphorus is finite. When the adsorption sites are filled, newly added phosphorus must travel deeper in the soil to find fresh sites. Soils higher in clay content have more of these minerals and binding sites than soils high in sand, so phosphorus movement is generally less in finer-textured soils. Laboratory studies on sands indicate that the rate of phosphorus movement is approximately eight inches per year; in clay soils it’s about three inches per year. If the treatment system is functioning properly, and proper setbacks are maintained from surface waters, problems from phosphorus movement to surface water or groundwater should be minimal.

OIL AND GREASE

Oil and grease, formerly known as fats, oil and grease (FOG) cause problems in the septic/treatment tank. The scum layer that builds up must be removed to prevent solids carryover. Further, oil and grease in the leach field can lead to the clogging. In sand filters this is especially troubling. Oils and grease that accumulate within the filter limit the transfer of oxygen and can ultimately lead to filter failure.

COLIFORM BACTERIA

Coliform bacteria are a type of bacteria which are indigenous to the intestinal tract of humans and warm-blooded animals. Therefore, they are always present in sewage. The presence of coliform bacteria indicates that disease causing pathogenic organisms might also be present. High concentrations of coliforms are found in the septic tank effluent and throughout the leaching system. They are removed by filtration, sedimentation and adsorption through the soil. Normal operation of septic tank/subsurface infiltration systems results in retention and die-off of most, if not all, observed pathogenic bacterial indicators within 2 to 3 feet. Once bacteria and viruses are caught in the soil, they eventually die because of soil conditions such as temperature or moisture levels. Some bacteria are killed by antibiotics, given off naturally by soil fungi and other organisms. Others are preyed upon by soil bacteria

VIRUSES

Viruses are smaller than bacteria and are not as readily removed by filtration. The mechanisms for removal are adsorption, biological enzyme attack and natural die-off. Also, viruses are better able to survive in harsh environments than coliform bacteria, and therefore require a much longer time for natural die-off in ground water. They have been known to travel over great distances in groundwater.

NON-TYPICAL DOMESTIC SEWAGE

Kitchen wastes are relatively high in grease, sometimes containing over five times the concentration of domestic sewage. The wastes may also be quite warm due to the amount of hot water used in machine dishwashing. This, together with the high detergent level in the waste, tends to keep the grease in an emulsified condition so that it is not easily removed by floatation or settlement in the septic tank. Grease removal is enhanced by mixing the kitchen wastes with cooler sewage such as toilet wastes. For this reason, it is not advisable to construct separate systems for kitchen wastes.

Wastes from garbage grinders are extremely high in settleable solids. However, they are also very high in grease, due to ground-up foods, and BOD resulting from organic decomposition in the septic tank. Garbage grinders are not recommended for commercial systems served by subsurface sewage disposal systems. Increasing the size of the septic tank will provide more storage volume for settleable solids, but it will not necessarily reduce the BOD of the effluent unless the tank is pumped frequently. Experience has shown that pumping the septic tank more frequently is more effective in preventing problems resulting from garbage grinders than by increasing the tanks size itself.

Laundry wastes are normally low in nitrogen and high in phosphates. This has a tendency to retard bacterial action in a septic tank which receives only this type of waste, but should have no adverse affect when discharged in limited quantities to a septic tank which also receives toilet wastes.

Laundry wastes also contain cloth fibers called lint which bio-degrade very slowly. It also contains high amounts of oils and coliform bacteria, presumably shed from the body on soiled clothes. Laundry wastes can cause excessive clogging of soil by the formation of a mat formed from strained lint and emulsified oils, and by inorganic phosphates. Some type of filtration system for lint removal ahead of the septic tank is beneficial for commercial laundry systems**.** Outlet filters can also be utilized to prevent lint and other fibrous material from entering the leaching field.

The backwash from swimming pool and spa filters may be high in settleable solids, but the solids themselves are relatively stable. Pool filter backwash must be directed to a dedicated leaching system or on to the surface of the ground as directed by NDEP's General Permit for this type of discharge. It is not allowable to discharge the backwash into the septic tank serving the building since the hydraulic load created would have a tendency to wash solids from the tank into the leach fields.

In summary, the wastewater quality and quantity is extremely important to ascertain before designing a soil based on-site wastewater treatment system. The design and performance of a disposal trench, sand filter, as well as other soil based treatment systems, is based on typical domestic wastewater which has been pretreated by passing the wastewater through a septic tank.

4. ENGINEERING REPORT/APPLICATION FOR CONSTRUCTION

The engineering report is considered an application for construction for an Onsite Sewage Disposal System (OSDS), as well as a request to be covered under the general permit GNEVOSDS-41000. The division has opted to regulate On Site Sewage Disposal Systems under a general permit, making the permitting process more timely for the engineer and owner of the treatment and disposal system. A general permit may be issued to a similar class of dischargers. In this case, only those Onsite Sewage Disposal Systems that discharge no greater than 15,000 gallons per day in flow, receives only domestic waste and utilizes subsurface disposal are eligible for coverage. All other applications must apply for and obtain an Individual permit.

A . SUBMISSION 0F ENGINEERING PLANS

NAC 445A of the Onsite Sewage Disposal System regulations requires preparation and submission of detailed engineering designed plans for commercial sewage disposal systems. Plans for the design of OSDS must be prepared by a professional engineer registered in the State of Nevada. It should be realized that subsurface sewage disposal may not be feasible on properties where impervious soil, seasonally high ground water, or extremely shallow soil coverage over bed rock exists. It is essential the design engineer or staff engineers working under his direction personally inspect the property, observe and review soil test data prior to designing an OSDS.

The purpose for preparation of the engineering report and detail plan is to identify site limitations and clearly demonstrate how the engineer proposes to overcome the limiting conditions. Upon completion of the report and design plan, the engineer must sign and seal each of the copies submitted to the division or administrative authorities for review. The engineer's submission must include a report of the findings of his investigation, design calculation, a general statement as to the suitability of the site for sewage disposal purposes, the particular advantages of the design proposed, and a detailed plan for construction of the sewage disposal system.

The OSDS regulations lists major items such as existing and proposed elevation contours, property lines, building locations, water courses and other essential information which must be shown on the plan. The following is a checklist of minimum standard items which should be considered as part of a well prepared engineering plan:

B. CHECK LIST - DESIGN PLANS

1. ☐ Name, address and current phone number of the applicant.
2. ☐ Legal description of the property (lot, block, T.R.S., APN).
3. ☐ Original signature, date and seal of design engineer on each copy of plans
4. ☐ Plan drawn to scale; 1" = 30', 40' ,50' etc.
5. ☐ Lot size with dimensions of property lines
6. ☐ Indicate wells, septic systems and other potential sources of pollution on adjacent properties. If none exist, note on plan.
7. ☐ North arrow clearly indicated.
8. ☐ Distance within 500' to any watercourse indicated, including ponds, lagoons, streams, creeks, rivers, etc. If none, indicate so.
9. ☐ Test hole locations (minimum of 2), including perc test holes (if performed).
10. ☐ Location of each actual or proposed well or drinking water source with protective radius indicated. Depth, casing and surface grout seal must be noted.
11. ☐ OSDS location with separations clearly indicated.
12. ☐ Distance to city or community sewer. If none, indicate.
13. ☐ Calculation used by the engineer to determine capacity of OSDS.
14. ☐ Capacity of septic tank or treatment device.
15. ☐ Slope across the absorption system area.
16. ☐ Depth, length, width and spacing of the absorption trenches, beds, etc.
17. ☐ Location of water supply lines, building sewer lines and underground utilities.
18. ☐ Location of structures, paved areas, driveways, trees, pools, etc.
19. ☐ Location of the reserve absorption area, equal to original area.
20. ☐ Soil characteristics, depth to water table and bedrock, percolation test results, soil descriptions and design specifications must accompany the submittal.
21. ☐ Provide detailed specifications for materials to be used such as fill, force main piping, pump model & manufacturer, tank dimensions, etc.
22. ☐ Invert elevations at inlet and outlet of septic/treatment tank, inlets and outlets at distribution boxes and at all leach fields.
23. ☐ Details of treatment tank, pumping chambers, effluent distribution and absorption areas. Special care must be taken to insure D-boxes are level.

5. ALTERATION OF EXISTING OSDS

An alteration may be required for an OSDS when the ownership changes and/or flows or characteristics of the sewage have also changed. An example would be when a strip mall occupant (formerly a clothing store) moves out and a restaurant moves in. If the OSDS was not designed to accommodate the additional flow and organic loading created by the food establishment, there could be premature failure. The division recognizes the need to allow modifications to the original design to improve the OSDS. Some latitude will be given the design engineer to improve on the system, provided there is no harm to the public health or environment.

6. INSPECTONS/CERTIFICATIONS

The engineer or staff engineers are required to perform inspections during all phases of construction. A Certificate of Completion must be filled out by the engineer and submitted to the division for it record. A sample form letter is included below (Form 6-1).

Once the division receives the Certificate of Completion, it will issue coverage under the general permit. Written verification will be sent to the engineer and/or permittee for their records.

If the OSDS is operated without a permit, enforcement action will ensue. It is highly recommended the engineer take photo documentation depicting the phases of construction, as, the division may request this submittal (See Appendix D). While not inclusive, the following is provided as a guideline for critical component/process inspections:

<u>Septic Tank</u>

- □ Tank is level.
- □ Inlet invert is 2” above invert of outlet.
- □ Compartment fitting in place (baffle).
- □ Tank coating (concrete/metal).
- □ Ensure manholes are to grade.
- □ Battery tanks supported under bottom to prevent differential settlement.
- □ Tank is watertight.

<u>Disposal Area</u>

- □ Filter material is clean and properly sized.
- □ Correct material used for covering filter material.
- □ Check to ensure no smearing of trench or sidewall occurred.
- □ Verify correct amount of filter material used (depth, length).
- □ Trench spacing and length correct.
- □ Proper separations maintained.

Distribution Box

- □ Set level (concrete pad or other means).
- □ Box coating (concrete/metal).
- □ Invert of inlet is 1” above outlets (all of which are at same level).
- □ Baffled, if necessary to ensure equal flow.

Form 6-1.

On Site Sewage Disposal System
Certificate of Completion

Project Name____

This certificate is to be completed by the engineer who certifies the design in the Engineering Submittal. It shall be submitted to the following address after construction completion:

Nevada Division of Environmental Protection
Bureau of Water Pollution Control
Permits Branch
901 S. Stewart Street, Suite 4001
Carson City, Nevada 89701

<u>Engineer's Certification</u>

I certify that the On site sewage Disposal System has been constructed in accordance with the approved Plans and Specifications and that the Onsite Sewage Disposal System is complete and ready for operation. I also certify that a copy of the as-built plans and specifications and an Operations and Maintenance Manual has been given to the permittee/owner/operator for their use.

Print name: ___________________________________

Signature: ____________________________________

Date: ____

Date license expires: _____________________________

Seal (signed and dated)

7. ANNUAL REPORTS/SAMPLING

The permittee or his representative will be required to submit an annual report as required in the general permit. At minimum, the permit will require the permittee or their operator to certify in writing that the OSDS was operated and maintained in accordance with the NAC and permit conditions, as well as the engineer approved design specifications and Operations and Maintenance (O & M) manual. The engineer should therefore exercise great care and thought in developing an O & M manual that is easy to understand and follow for the permittee or operator.

Effluent Samples may also be required to be taken on a routine basis. The engineer should take this consideration into account during the design of the OSDS and provide for sampling locations, if necessary. See Appendix N for an example O & M checklist. In addition, facilities that rely on advanced treatment systems may be required to install remote telemetry to assist the operators to respond immediately.

8. SETBACKS

Setbacks listed in NAC 445A. are the minimum distance required. The division will not allow a reduction in the stated distances without the design engineer's details that demonstrates similar protective characteristics. While probably not allowed in most cases, decreasing the distance between the OSDS and a public water supply well will require the Bureau of Drinking Water to review and approve the request.

Be aware that the minimum setback distance may also be increased for various reasons, including:

- Depth to water table.
- Soil profile (i.e. bedrock, very permeable soils).
- Site characteristics.
- Mounding analysis indicates the need.
- Nitrogen management area.
- Wellhead protection area.

9. SEPTIC /TREATMENT TANK CAPACITY

The estimated sewage flow found in NAC 445A and Table 9-1 below is based on the Uniform Plumbing Code, the U.S. EPA design manual and experience of the division. It is important to note that some applications will vary considerably from table 9-1 and the design engineer must take special circumstances into account during the design phase. As an example, a restaurant located on an interstate may see much more traffic and restroom use than a facility located just outside the community. Areas where passenger busses stop for rest breaks will also increase flows beyond normal.

Further, a RV park or dump station should be sized much larger (at least 2 times) due to the concentrated strength of the effluent, as well as the sanitary solution (often a blue formaldehyde base), which inhibits microbial activity. Continued dumping with sanitary solution could adversely affect the treatment capability of the tank.

Table 9-1. Estimated Sewage Flow

TYPE OF OCCUPANCY	ESTIMATED FLOW OF SEWAGE (GALLONS PER DAY)
Airports	15 per employee and 5 per customer
Automobile washes (sand/oil interceptor required)	5 per passenger vehicle
Bowling alleys	150 per lane
Camps:	
Campground with central comfort station	35 per person
With flush toilets, no showers	25 per person
Day camps (no meals served)	15 per person
Summer and seasonal	50 per person
Churches:	
Sanctuary only	5 per seat
With kitchen facilities	7 per seat
Dance halls	5 per person
Factories:	
With showers	35 per employee
Without showers	25 per employee
With cafeteria facilities	Add 5 per employee
Hospitals:	250 per bed
With kitchen facilities	Add 25 per bed
With laundry facilities	Add 40 per bed
Institutions (Residential):	
General	75 per person
Nursing homes	125 per person
Rest homes	125 per person
Laundries:	
Self-service (lint trap required)	500 per machine
Commercial	Per manufacturer's specifications
Mobile home parks	300 per space
Offices	20 per employee
Picnic parks (with toilets only)	20 per parking space
Recreational Vehicle Parks [a.]	
With water hookups	100 per space
Without water hookups	75 per space
Motels with bath, toilet and kitchen wastes	100 per room
Motels without kitchens	80 per room

TYPE OF OCCUPANCY	ESTIMATED FLOW OF SEWAGE (GALLONS PER DAY)
Restaurants and cafeterias [b.] (Grease trap/interceptor required)	20 per employee
With toilets	Add 7 per customer
With cocktail lounge	Add 2 per meal served
With garbage disposal (not recommended)	Add 1 per meal served
With kitchen waste	Add 6 per meal served
With kitchen waste, disposable service	Add 2 per meal served
Schools:	
Teaching staff and other employees	20 per person
Kindergarten or elementary school	15 per pupil
Junior high school, middle school or high school	20 per pupil
With gym and showers	Add 5 per pupil
With cafeteria	Add 3 per pupil
Boarding school (including all waste)	100 per person
Service stations [b.]	
With toilets	1,000 for first bay
Each additional bay	Add 500
Stores/shopping centers [b.]	
Staff	20 per employee
With public restroom	1 per 10 square feet of floor space
Swimming pools (public)	10 per person
Theaters and auditoriums:	
Indoor	5 per seat
Drive-in	10 per space

If the estimated flow of sewage for the intended occupancy is 3,000 gallons or less per day, the minimum required capacity of the septic tank is equal to the estimated flow times 1.5. If the estimated flow of sewage for the intended occupancy is more than 3,000 gallons per day, the minimum required capacity of the septic tank is equal to the estimated flow plus a sludge storage volume of 1,500 gallons.

[a.] Recreational vehicle waste is high strength and is generally discharged with a sanitary solution that inhibits microbial activity. Therefore, in sizing the system, a factor of safety of 2.0 times the volume determined from Table 9-1 shall be used. Increased pumping frequency must also be provided.

[b.] Systems serving high volume establishments such as restaurants, convenience stores and service stations located near interstate type highways and similar high-traffic areas, require special sizing considerations due to expected above average sewage volume. Minimum estimated flows for these facilities shall be 3.0 times the volume determined from Table 9-1.

10. SEPTIC TANK CONSTRUCTION

A. SEPTIC TANKS AND GREASE TRAPS -GENERAL

A properly functioning septic tank serves three main purposes:

1. It removes most of the settleable solids through sedimentation and grease removal through flotation.
2. It produces an effluent of relatively uniform physical, chemical and biological quality from a raw sewage with widely fluctuating characteristics.
3. It produces some reduction in pollutant levels in the effluent.

The removal of settleable solids is important in protecting the disposal system from excessive sludge and slime build-up and possible clogging. A relatively uniform effluent promotes the development of a stable biomat in the leach field which is important in reducing groundwater pollution. The septic tank will reduce influent BOD levels by about 25 to 30 percent. Most of this reduction is due to the venting of certain gases, such as methane. Solid organic particles are removed by settlement, and a certain amount of soluble organic chemicals are removed by the formation of bacterial cells within the tank.

However, no significant BOD reduction results from this without regular removal of the accumulated sludge. A relatively stable biological system soon is established in a septic tank in which most of the organic solids are converted to soluble organic chemicals and gases. This chemical decomposition results in a relatively slow build-up of sludge in the tank, most of which is biologically stable in the absence of oxygen. The septic tank will produce about 10 percent reduction in nitrogen and 30 percent reduction of phosphate in the effluent, mostly by combining these chemicals in the relatively stable biological sludge. The proper venting of gases is very important in the efficient functioning of a septic tank. An excessive buildup of scum or grease may interfere with this, and it is important that large volumes of grease not be discharged into the septic tank. There must always be space between the scum layer and the top of the tank. The inlet baffle should be open at the top to allow venting.

The baffle wall between the first and second compartments must be open at the top, for the same reason. The efficiency of the septic tank as a settling unit is reduced when the velocity of the liquid moving through the tank is increased. This may be caused by a tank which is too small or too shallow due to an excessive depth of sludge in the bottom. The lack of a proper inlet baffle will tend to allow liquid entering the tank to short-circuit across the surface of the tank, particularly if the liquid is warm and consequently less dense than the liquid in the tank. The settling efficiency of a septic tank can be greatly improved by constructing the tank with two compartments. This results from both further reduction of velocity currents within the tank and from reduction in gas information in the second compartment. Gas bubbles formed within decomposing sludge layer will cause solids to float and possibly go out the outlet. In a two compartment tank, practically all of the sludge digestion and gas formation takes place in the first compartment.

B. SEPTIC TANK CONSTRUCTION

Presently**,** most septic tanks are constructed of precast concrete sections which are assembled in the field. Such precast tanks come in various sizes. Larger capacities may be obtained by installing two tanks in series. The outlet of the first tank is joined to the inlet of the second tank. Normally this is done with pipe baffles extending to approximately mid-depth of each tank. In this way, the tanks may be considered equivalent to one large two compartment tank. The first tank in series should be twice the capacity of the second tank in order to be consistent with the requirement that 2/3 of the total volume of a two compartment tank be in the first compartment. Regardless, the first tank in the series must have no less than one day detention time.

Metal, fiberglass or polyethylene plastic septic tanks are also acceptable, providing they are equivalent to a two compartment concrete tank in size, dimensional requirements and strength. They normally are used in locations which are inaccessible to the heavy truck which is necessary to carry the concrete tank. Plastic tanks can be hand-carried to inaccessible locations. However, such tanks should not be used in areas of high ground water unless proper anti-bouyancy measures are taken (because they are light weight and tend to float, particularly when the liquid level is low during cleaning).

Poured in place septic tanks must be designed by the engineer for all structural loads and water table conditions.

Tank geometry affects the hydraulic residence time in the septic tank. Length-to-width ratio and liquid depth must be considered carefully. It has been demonstrated that a length-to-width ratio of 3:1 or greater reduces short-circuiting and improve suspended solids removal.

Septic tanks must:

Be watertight, including at all joints and connections.
Be placed on level, stable ground that will not settle and is accessible for pumping. Follow the manufacture's instructions on plastic or fiberglass tanks.
Have at least 2 compartments or be placed in a series. The 1st compartment must be 2/3 the total tank volume and have capacity for one day detention.
The invert of the inlet shall be at least 2" but not more than 4" higher than the invert of the outlet pipe.
Inlet and outlet baffles should be 4" schedule 40 sanitary tees or equivalent

- □ Inlet & Outles ≥ 4-6" above and 12" below the liquid level, but no more than 30% of depth.
- □ Top of both inlet and outlet tee shall be ≥ 2" from the lid.

Compartment partition – slots or holes at 1/3 the liquid depth and 8" clearance above the fluid level.
Pump access openings must be within 12" of finished grade or have a riser installed to within 12" of finished grade.

- □ 2 openings ≥ 18". 1 over the inlet and 1 over the outlet, and inspection ports over the inlet and outlet.

If the riser is at or above the grade it must be secured.
Have a liquid depth of at least 30” and maximum of 72”.
Be protected against flotation under high water table conditions.
Have a final cover that is crowned or sloped to shed surface water.

□ Compliant with the *Standard specification for Precast Concrete Septic Tanks* (C 1227), published by the American Society for Testing and Materials (ASTM 1998).

Note: To prevent structural support problems to the building foundation, the septic tank location must not be closer than specified in the Uniform Plumbing Code or local building codes.

C. SEPTIC TANK MAINTENANCE

Septic tanks should be inspected at intervals of no more than every year to determine the rate of scum and sludge accumulation. If inspection programs are not carried out, a pump out frequently of once every two to three years is reasonable. Once the characteristic sludge accumulation rate is known, inspection frequently can be adjusted accordingly. The tank should be cleaned whenever the thickness of the scum layer is two inches or more, or the sludge level is within 12 inches of the bottom of the outlet baffle. Scum can be measured with a stick to which a weighted flap has been hinged or with any device that can be used to feel the bottom of the scum mat. The stick is forced through the mat, the hinged flap falls into a horizontal position, and the stick is raised until the resistance from the bottom of the scum is felt. A long stick rapped with rough, white toweling and lowered to the bottom of the tank will show the depth of sludge and the liquid level of the tank. After holding the stick in place several minutes, the sludge layer can be distinguished by sludge particles clinging to the toweling.

Septic tank operation and maintenance.

1. Climbing into septic tanks is very dangerous, as the tanks are full of toxic gases, such as, hydrogen sulfide. Do not enter a septic tank!
2. The manhole, not the inspection opening, should be used for pumping so as to minimize the risk of harm to the inlet and outlet baffles. Inlet and outlet baffles should be inspected for damage or clogging whenever the septic tank is cleaned. It is particularly important that missing or damaged outlet baffles are replaced promptly, since floating solids can be carried into the leaching system, clogging it and requiring expensive repairs.
3. It is not necessary to leave solids in the septic tank as an aid in starting digestion.
4. When pumped, the septic tank need not be disinfected, washed or scrubbed.
5. Chemical or biological additives should not be added to a septic tank. They are unnecessary and probably ineffective. Furthermore, certain chemical additives such as chlorinated hydrocarbons may be carcinogenic and cause groundwater or well pollution if added to the septic tank. Ordinary amounts of bleaches, lye, caustics, soaps, detergents and approved drain cleaners will not harm the operation of the septic tank.

6. Materials not readily decomposed, such as sanitary napkins, coffee grounds, cooking fats, bones, wet-strength towels, disposable diapers, facial tissues, cigarette butts, etc., should not be flushed into a septic tank. They will not degrade in the tank and can clog the inlet or outlet.

D. GREASE TRAPS/INTERCEPTORS

Grease traps/interceptors are intended as pretreatment units for kitchen wastes only, before discharge to conventional septic tanks. In a large restaurant or cafeteria, the sewer serving the dishwasher, pot sink, floor drains and food preparation sinks and equipment should be separated from the toilet wastes inside the building and connected to a grease trap/interceptor located outside the building. The grease trap/interceptor is deeply baffled and is sized to allow food particles to settle and floating grease to rise to the top of the unit. Some studies suggest that properly sized grease traps/interceptors are capable of removing up to 60% of oil and grease and 50-80% of the BOD and TSS.

Grease traps/interceptors are not intended for decomposition of the accumulated solids, and should therefore be cleaned frequently. To facilitate this, cleanout manholes on grease traps/interceptors should be extended to grade. Grease traps/interceptors will not remove emulsified grease from the kitchen wastes. Kitchen waste may contain considerable amounts of emulsified grease where dishwashers are connected to the system discharging large amounts of hot water and detergent. Some removal of emulsified grease may be produced in the septic tank where the kitchen waste is cooled by mixing with toilet waste and comes in contact with solid particles and gas bubbles produced by biological decomposition. It may not be practical to use outside grease traps/interceptors in large office buildings or schools where the cafeteria is connected into the main sewer system. Also, it may not be feasible to install an outside grease trap/interceptor on an existing restaurant. In such cases, small, inside grease traps/interceptors located in the kitchen may be used. Pump/clean as required.
Note: Kitchen grease traps/interceptors are regulated by the appropriate health authority. Therefore, the design engineer must consult with that entity regarding any sizing or location requirements.

E. EFFLUENT SCREENS

Effluent screens (commonly called effluent filters or septic tank filters) which can be fitted to the septic tank outlets, are commonly available. Screens prevent solids that either are buoyant or are re-suspended from the scum and sludge layers from passing out of the tank. Mesh, slotted screens, and staked plates with openings from 1/32 to 1/8 of an inch are available. Usually the screens can be fitted into the existing outlet tee or retrofitted directly into the outlet. An access port directly above the outlet is required so the screen can be removed for inspection and cleaning.

Effluent screens result in effluents with significantly lower suspended solids and BOD concentrations. They also provide an excellent, low-cost safeguard against neutral-buoyancy solids and high suspended solids in the tank effluent resulting from solids digestion or other upsets.

Effluent Screens or filters are basically fine plastic screens to prevent solids from passing. There are many sizes, and shapes being used. Some fit right inside the 4” sanitary tee outlet, others are more box shaped, and some have built in protection for when they are pulled out.

By using an effluent screen, the design engineer may be able to reduce orifice openings in a pressure distribution disposal line, resulting in the use of a smaller pump (energy savings).

Note: effluent screens should not be removed for inspection or cleaning without first plugging the outlet, or pumping the tank to lower the liquid level below the outlet invert. Solids retained on the screen can slough off as the screen is removed.

F. OUTLET PIPES

Schedule 40 plastic or equivalent must be used for tank outlet pipes and they must be properly supported between the end of the septic tank and the edge of the excavation so that it will not sag or be broken during backfilling. The soil around the pipe extending from the septic tank must be compacted to original density for a length of three feet beyond the edge of the tank excavation. All penetrations through the septic tank wall must be watertight.

G. CLEANING ACCESSES

If the tank cover is below final grade, cleaning access extensions are needed. The cleaning access cover should be secured or have proper soil cover to prevent children or unauthorized individuals from attempting to get into the tank. If the cleaning access is covered with less than six inches of soil, the cover should be secured to prevent unauthorized access. This is for purposes of safety, since the gases in a septic tank may be toxic or cause asphyxiation. There have been instances where people have drowned by falling into septic tanks through improperly protected cleaning accesses.

H. INSPECTION PORTS

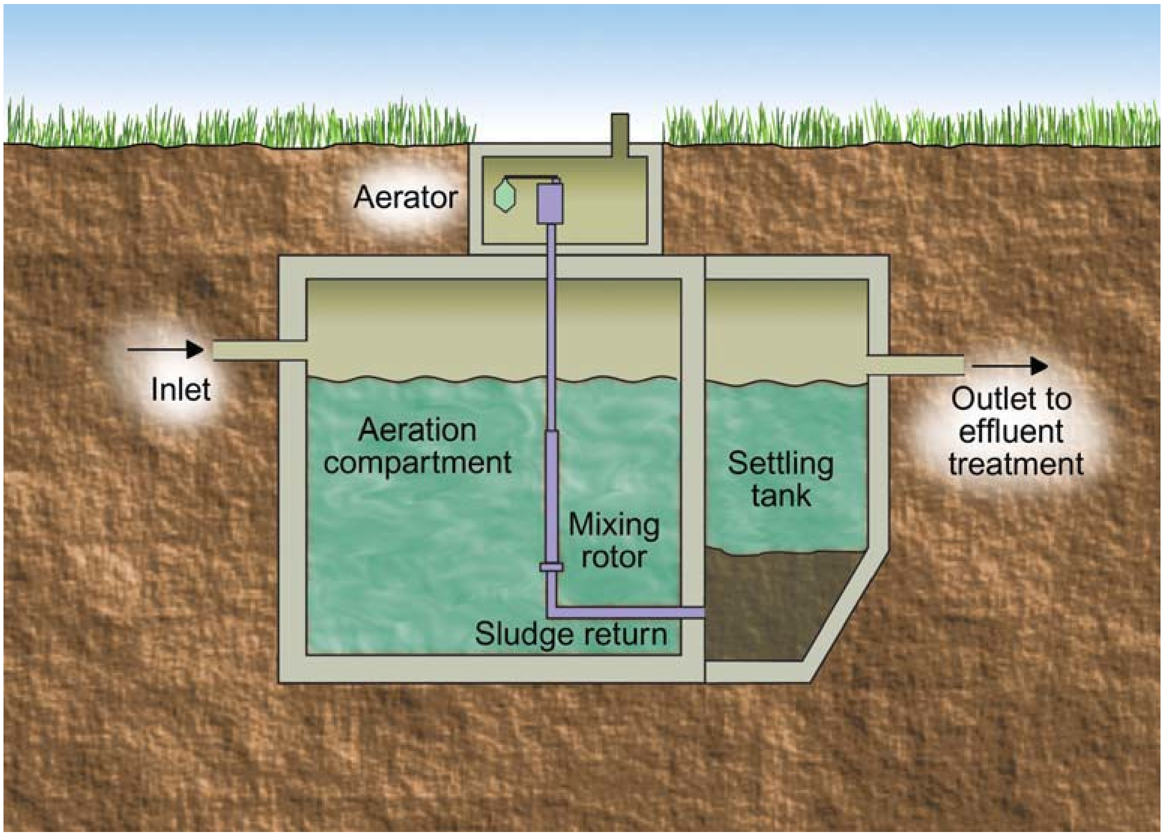
When required, inspection ports must be located over both the inlet and outlet devices. The purpose of the inspection ports is for checking and cleaning the baffles, effluent filters, and for periodically evaluating the amount of sludge in the tank

11. AEROBIC WASTEWATER TREATMENT UNITS

Aerobic Wastewater Treatment Unit

An aerobic wastewater treatment unit consists of several processes that function together to provide a high quality effluent. These are gross solids removal, aeration, clarification, and sludge return. These processes are generally contained within separate chambers of a single tank. A series of tanks can be configured to have wastewater pass through an aerobic treatment train.

Figure 11-1. Aerobic Wastewater Treatment Unit.



Source: Iowa Dept of Natural Resources

Aerobic Wastewater Treatment Units use biological processes to transform both dissolved and solid constituents into gases, cell mass, and non-degradable material. An important feature of the biological process is the synthesis and separation of microbial cells from the treated effluent. The treatment process involves a variety of aerobic and facultative microorganisms living together that can decompose a broad range of materials. The organisms live in an aerobic environment where free oxygen is available for their respiration. Aerobic Wastewater Treatment Units can be used to remove substantial amounts of BOD_5 and TSS that are not removed by simple sedimentation in a conventional septic system.

The biological process also involves the nitrification of ammonia in the wastewater and the reduction of pathogenic organisms. Nitrification is the breakdown of ammonia (NH3+) to nitrate (NO3-) by microorganisms in aerobic conditions. Aerobic Wastewater Treatment Units treat wastewater well enough to meet secondary treatment standards (30 mg/l BOD. 30 mg/l SS). A document written by James C. Converse, Ph.D., “Assessing performance of on-site treatment units that treat the wastewater aerobically” is found in Appendix ?.

12. NITROGEN REMOVAL WASTEWATER TREATMENT UNITS

Biological Denitrification

When nitrogen removal is required, one of the available methods is to follow biological nitrification with biological denitrification.

Denitrification is accomplished under anaerobic or near anaerobic conditions by bacteria commonly found in wastewater. Nitrates are removed by two mechanisms:
(1) Conversion of NO_3 to N_2 gas by bacterial metabolism and (2) conversion of NO_3 to nitrogen contained in cell mass which may be removed by settling (Figure 12-1).

In order for denitrification to occur, a carbon source must be available. Domestic wastewater contains a substantial amount of carbon and is generally used for denitrification. Where carbon is added, it is most commonly in the form of methanol. The methanol must be added in sufficient quantity to provide for cell growth and to consume any dissolved oxygen which may be carried into the denitrification reactor.

Usually 3 to 4 pounds of methanol per pound of nitrate are required. Careful control of methanol feed is necessary to prevent waste of chemicals. In addition, if excess methanol is fed to the system, unused methanol will be carried out in the effluent causing excessive BOD.

Denitrification may be carried out in either a mixed slurry reactor or in fixed bed reactors. Denitrification filters carry out both denitrification and filtration in the same unit. Mixed slurry systems consist of a denitrification reactor, re-aeration basin and clarifiers. Re-aeration prior to clarification is required to free the sludge from trapped bubbles of nitrogen gas.

Denitrifying bacteria grow very slowly and are extremely sensitive to temperature.

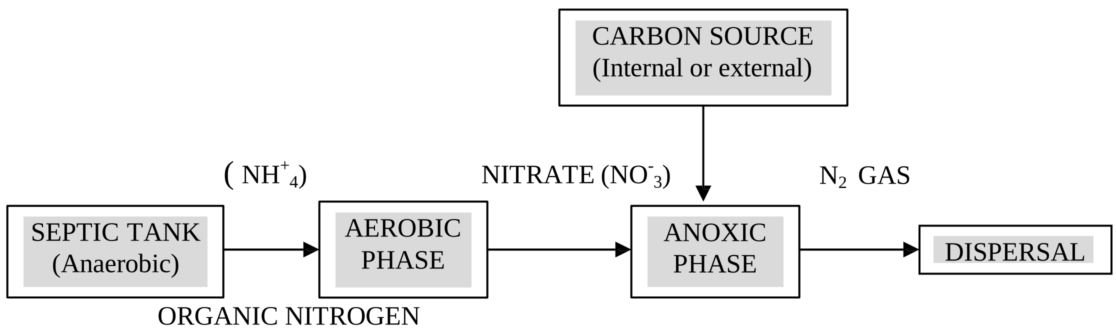
Denitrification rates have been shown to increase five-fold when the temperature is increased from 10°C to 20°C. Thus, operating parameters such as sludge age and retention time must be varied with temperature.

The pH in denitrification systems must be carefully controlled. The optimum pH is from 6.0 to 8.0.

Denitrification is a very sensitive and difficult process to operate. Constant monitoring of pH, methanol feed and temperature is essential to successful operation.

Figure 12-1

Biological Nitrification/Denitrification in Onsite Sewage Disposal Systems



----------------- NITRIFICATION -------- I ------------------- DENITRIFICATION-----------

For detailed information on enhanced nutrient removal involving nitrogen, refer to Appendix K.

13. DOSING TANKS

A. DOSING THE DISPOSAL SYSTEM

The primary objective in laying out the dosing arrangement of any subsurface disposal system is to assure that all portions of the subsurface disposal system are utilized before failure can occur. An equal or uniform application of sewage effluent throughout the subsurface disposal system is also considered to be desirable. The growth of slime layers on the infiltrative surfaces appear to be the most important factor in producing a relatively uniform usage of the leaching area.

B. INTERMITTENT DOSING

Intermittent dosing is necessary where there is a system of leaching trenches, beds or filters containing a large amount of perforated distribution pipe. Intermittent dosing causes sewage effluent to be carried farther along the perforated pipe, preventing excessive loading on the inlet ends of the subsurface disposal system which could cause heavy slime growth and premature soil clogging. It allows an increase in the length of leaching trench which can be effectively used. There is also some advantage in using intermittent dosing where it is necessary to divide effluent equally to a number of separate leaching units, either trenches, pits, or galleries. Intermittent dosing will flood, or at least raise the liquid level in the distribution box sufficiently to assure that the volume of effluent discharged through each outlet in the box will be more or less equal.

Another perceived advantage of intermittent dosing is the "rest period" which a leaching system receives between doses. There may be some marginal benefit where the period between doses is long enough for the leaching system to drain completely and allow air to reach the slime layers.

C. SEWAGE PUMPING STATIONS

For large sewage disposal systems, dual alternating pumps must be provided. For OSDS with between 500 ft to 1,000 ft of disposal field, a single pump with emergency storage volume in the pump chamber must be provided. High level indicators or alarms and extension of access manholes to grade are required for all pump lift stations. When used as dosing mechanisms, pump controls should be set to discharge 60% to 75% of the volume of distribution pipes. It is important to ensure the leach pipes are not fully pressurized, as the situation could possibly damage the piping system, or inject effluent into the disposal area at a rate greater than the treatment capacity of the biomat. The soil texture will dictate the dosing frequency.

Pumps should be located under the access manhole to facilitate inspection and repair. Installation of a union or other means to permit pump removal is essential. A check valve and gate value are typically installed after the union to prevent back flow. These units should also be situated beneath the access manhole for ease of maintenance. The force main usually remains full of liquid and must be placed in a trench below grade to prevent freezing. Draining of the force main back to the pump chamber through a small diameter hole located after the check valve may be necessary to prevent freezing for shallow installations. If a “weep hole” is provided for the force main then it is important to raise the distribution box feeding the highest component of the leaching system to prevent a backflow from the system. Because of the corrosive nature of effluent discharged from the septic tank, use of PVC, polyethylene piping or equivalent valving and fixtures is recommended. Where dual alternating pumps discharge through a single force main, separate check or gate valves must be provided on each pump discharge line to facilitate removal of one pump while keeping the second pump operational.

Sharp bends in the force main should be avoided whenever possible. Use of thrust blocks may be required when directional changes in the force main are necessary. Wiring leads and float control wires are normally attached to a vertical pump rail with plastic connectors rather than free hanging. Enough extra wiring will be needed to allow the pump and piping assembly to be freely lifted out of the chamber and riser for servicing. The lift chain should be made of a non-corrosive material, such as, plastic or nylon. The electrical connections and assembly shall be installed by a licensed electrician under proper permits.

Large sewage pump lift stations usually are controlled by a series of 3 or 4 mercury float switches which activate the pumps depending upon flow conditions. The lowest float turns the pump off when the discharge cycle is completed. The second float activates the lead pump and in the case of duplicate alternating pumps, cycles the electrical control to switch the standby pump to lead position. A third float is installed to activate the standby pump during periods of peak flows. In that case, discharge piping must be sized to handle flows from both pumps. The fourth float is a high level alarm which activates audible or visible alarms located at the station or maintenance facility. The alarm should also be set to be activated if the pumps fail to alternate

Electrical connections should not be made within the pump chamber in order to prevent problems associated with corrosion. The connections may be placed in a waterproof electrical box located above ground or inside a building. The alarms and pump power supply must be connected to different electrical circuits. All electrical work associated with pump station installation must be done in accordance with the State Building Codes and requires a separate electrical permit.

Pump Stations

A. Pumps/electrical panels shall be sewage effluent rated and meet state electrical code requirements for installation and testing.

B. Each pump shall have an elapse time meter, dose counter to record pump running time. Elapse time meter and dose counter shall be located in the pump panel.

C. Quick disconnect couplers or equivalent quick disconnect system is required for all sewage pumps.

D. Suitable non-corrosive screening or effluent filters should be considered prior to the pump chamber for effluent pumps discharging to drain field areas.

E. All pump chambers shall have access to finish grade for inspection and maintenance.

F. All pump chambers shall meet the requirements outlined in "Design Standards for On-site Wastewater System Tanks" (Section 10).

14. DISTRIBUTION BOX

Distribution boxes can be set easily and firmly to exact elevation and provide central locations from which the effluent flow to several separate leaching units can be controlled. Furthermore, distribution boxes are readily accessible and relatively easy to find with accurate as-built plans. If a sewage problem arises, it is possible to inspect the boxes and determine which of the various leaching units are functioning properly and which are not. Effluent flow can then be redirected to the functional units by adjusting the elevations of the box outlets or by plugging the outlets to the failing units. This is done without damage to any part of the leaching system. In practice, distribution boxes should be used at all distribution system junctions where effluent is directed to any leaching unit on a different elevation, or to more than two units on the same elevation.

INSTALLING DISTRIBUTION BOXES

Distribution boxes should be set as <u>level</u> as possible, particularly splitter boxes which must have all outlets on the exact same elevation. They should be placed on a sound, frost-proof footing. All splitter box outlets should be checked again after installation. This usually is done by means of a tripod level or by filling the box with water to the outlet level. Larger distribution boxes, containing six or more outlets, should be provided with a manhole or opening to grade which would facilitate inspection and cleaning. It is important that all distribution box knockout holes be sealed around the entering pipes so that effluent will not escape.

Distribution boxes use gravity to equally divide the septic tank effluent to the trenches/laterals. The wastewater flows from the septic tank into the distribution box. A leveling device placed in each outlet is required to distribute the flow equally to all outlet pipes. The wastewater flows by gravity in watertight pipes to the trenches/laterals.

15. MONITORING PORTS

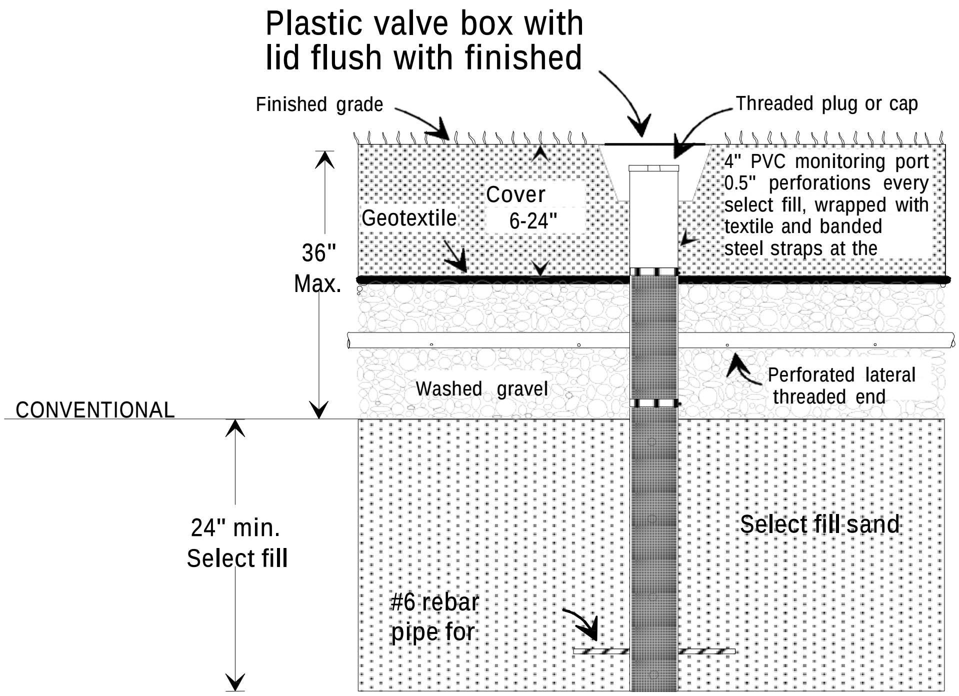
Monitoring ports provide a means to observe any ponding at critical depths in the trench or bed. The ports should extend from the bottom of the infiltrative surface to final grade. If flooding is a concern, the port should extend above grade to provide protection. The bottom should be open and the top capped. The pipe section within the gravel or sand should be perforated to permit a free flow of water.

Figure 15-1

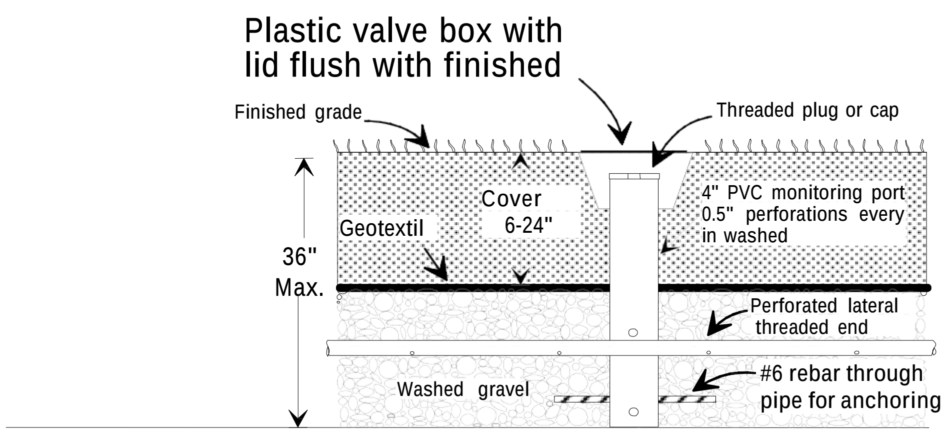
Monitoring Port Section

N.T.S.

Sand-lined trench/bed detail



Conventional trench detail



16. PERCOLATION TESTS

MINIMUM NUMBER OF DEEP TEST AND PERCOLATION HOLES

If a percolation test is to be used, a minimum of two test holes must be dug in the area of the proposed leaching system to a depth of at least four feet below the probable bottom of the deepest leaching unit. At least one percolation test should be conducted at the probable depth of the bottom of the primary and reserve leaching system areas. More deep pits and percolation tests should be made if there are any significant variations in the soil characteristics, either in depth or from location to location, or if rock or high water is found. Where the sewage disposal system is large and will cover a considerable area, the test holes should be made throughout the disposal area to provide more meaningful information than randomly located holes. At each test hole, the soil must be identified and the depth to impermeable layers and ground water noted.

PERFORMING THE TEST

If utilized, a minimum of two percolation tests must be performed. The test hole is hand dug with a shovel or post hole digger. There should be no large stones or boulders on the bottom or side of the hole which could give misleading results. A fixed reference point is established, usually consisting of a stick or nail on the side of the hole or across the top. Also, a 4" perforated pipe (leach line with added holes) may be used to keep the integrity of the hole. Presoaking is performed to test the soil in saturated situations found in the working leach field. From this point, the depth to the top of the water in the hole is measured at regular intervals and recorded. The time that the reading was made is also recorded. The depth of the bottom of the test hole below ground surface must be recorded in order to relate the percolation rate to the various layers of soil.

It should be noted that the percolation test is not an accurate predictor of the actual performance of the leach field. The percolation test is only useful in identifying soil permeabilities that are very rapid or very slow. There is no direct relationship between the observed short-term percolation rate determined with clean water and the long-term acceptance rate based on the application of septic tank effluent. **Detailed soil profile evaluations provide a more accurate prediction of the soil's long term acceptance rate.**

DETERMINING THE MAXIMUM GROUND WATER LEVEL

"Maximum seasonal ground water level" refers to a relatively static ground water table which exists for one month or more during the wettest season of the year. It does not refer to a short term "perched" water table, a capillary water zone, or a temporary subsurface flooding condition which may occur following a heavy rainfall or snow melt. All of these ground water conditions are significant, however, and must be recorded and taken into account in designing the leaching area. Most importantly, a high ground water table which lasts for a month or more is very likely to be caused by hydraulic limitations of the soil or topography, not by temporary conditions of rainfall or flooding.

Soil mottling is one of the best indicators of seasonal ground water. Mottling consists of contrasting patches of color in the soil, and may be either gray, orange or reddish. The variations in color are caused by a chemical oxidation of certain minerals containing iron. Orange or reddish mottles indicate oxidized iron and a relatively well aerated zone of soil. Gray mottling indicates that poor soil aeration has kept the iron minerals in a chemically reduced state. Orange and reddish mottling frequently is found in the capillary water zone just above the seasonal high ground water level. Much of the ground water evaporation takes place in this zone, and it is probable that over a period of years a certain amount of soluble iron is deposited at this point as the ground water evaporates.

Layers of relatively bright orange or reddish mottles separating an upper layer of tan or brownish soil from an underlying grayish soil is a reliable indicator of the seasonal maximum ground water level. However, investigators should not rely too heavily on indistinct or non-typical soil mottling, or on the absence of soil mottling. Such indications are best interpreted by an experienced soil scientist.

There are several situations where soil mottling or its absence can be misleading. Frequently, stratified deposits of sand and gravel will show distinct orange or reddish mottling well above the maximum ground water table. This appears to be caused by capillary retention and evaporation of rainfall runoff in layers of fine grained soil, causing deposition of iron in these layers. Perched water tables may also cause some mottling above the normal maximum ground water level. A careful examination usually will reveal both reddish and grayish mottles where seasonal perching is significant.

17. SOILS ANALYSIS

SOIL IDENTIFICATION

Coarse grained soils, such as sand and gravel, are readily identified by rubbing the soil between the fingers. However, some care should be taken to note the size and shape of the grains. Flat grained soils will compact easily and may cause trouble with leaching systems, particularly when used as fill material. Sand and gravels to be used as fill should be examined as to the uniformity of the particle sizes. If all of the particles are approximately the same size, it would be good for leaching purposes, but if there is wide range of particle sizes, it would be poor for this purpose. It should be noted that the term "well graded" is used to refer to a soil which has a wide range of particle sizes.
The term originated because this type of fill material was best suited to road construction. However, it would not be "well graded" for the purposes of sewage disposal.

Fine grained soils, such as silt, clay and even very fine sand, are difficult to differentiate either by sight or feel. The amount of the silt in the soil is a critical consideration, since even small percentages of silt will greatly reduce the ability of a soil to transmit water. The amount of silt in a sand or gravel may be determined by placing a spoonful of the soil in a glass of water. The sand and gravel grains will settle almost immediately, while the silt particles will still be in suspension after five or ten minutes. Determination of the amount of silt in a loamy soil is more difficult. One way this can be done is by observing how easily the soil surface is smeared by digging equipment or in the hand, when moist. Soils with high silt content can be formed into a clod which can be handled without breaking, and when dried and pulverized on the hand, will have a feeling like flour or talcum powder. Some purer silts, lacking binders such as clay, will become elastic when saturated, and water may be squeezed from them.

The soil color should be noted, since it is a good indicator of how well drained it is. Light brownish, yellowish or reddish colors indicate that the soil is well drained and aerated. Bands or mottles of brighter color should be noted, particularly if they are interspersed or underlain by layers of grayish soil. This may indicate a seasonal or perched water table. Grayish or dark colors indicate poorly drained soils.

The firmness of each soil layers should be noted. Some generally firm soil layers may have narrow bands of looser, sandy soils which should not be overlooked. Similarly, some coarse grained soils are extremely stratified, with thin layers of silt which may not be readily apparent.

Water level and soil dampness must also noted, and the level measured. The presence of bedrock or refusal should also be noted. Occasionally, it is difficult to determine whether refusal is caused by hardpan or by a large bolder. In such a case, another pit should be dug about ten to fifteen feet away. If refusal is found in this pit also, it can be assumed that hardpan is present.

DESCRIBING SOILS

Each layer of soil with different physical characteristics, such as particle size, color or compactness, should be described separately, and its boundary levels noted. Soils usually are described as gravel, sands, silts or clays, depending on their dominant particle size, in accordance with the following table:

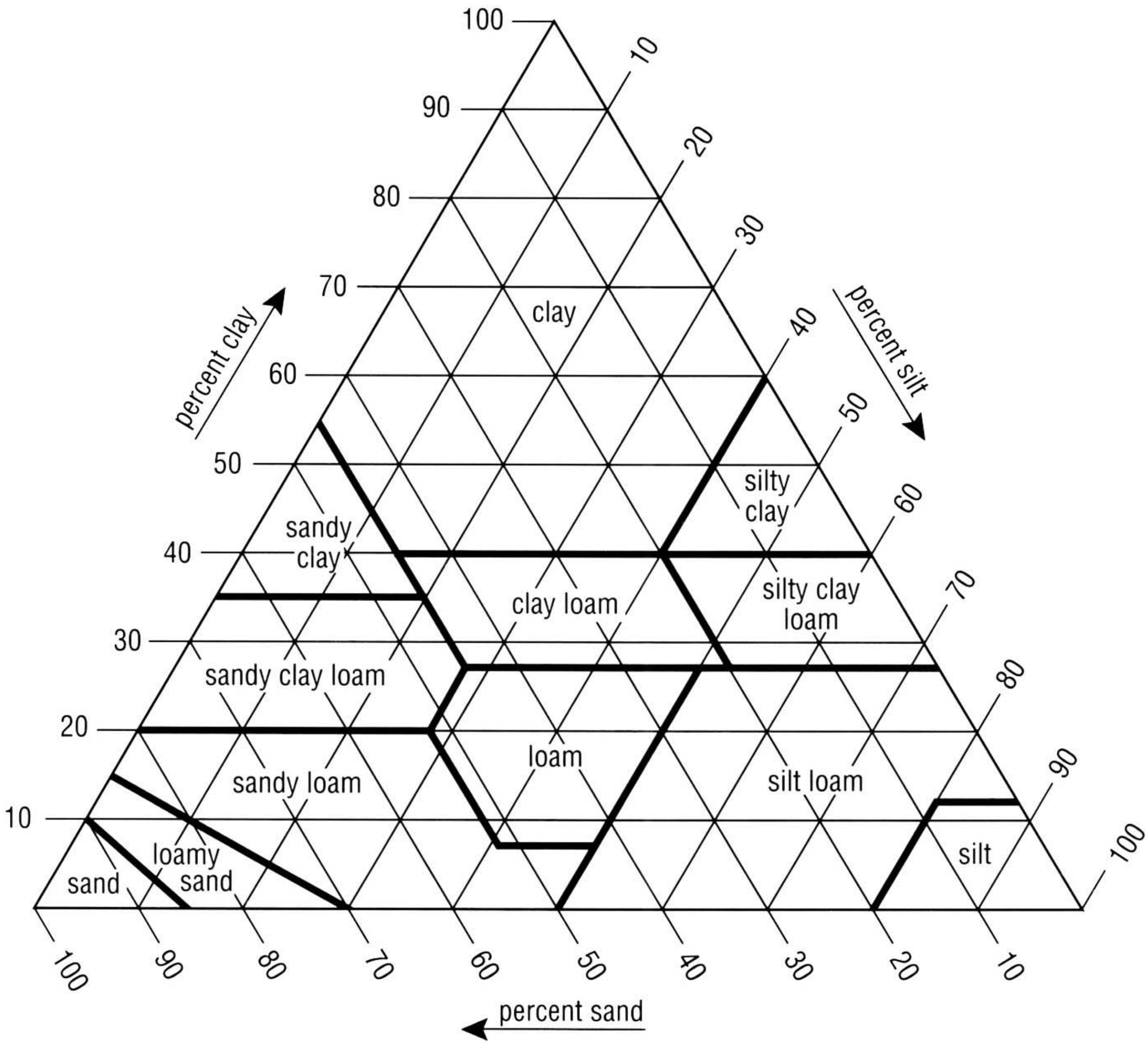
Table 17-1. Soil types and examples

Soil Type	**Particle Size**		**Example**	**# Sieve Size**
	(inches)	**(mm)**		
Gravel	3.0 - 0.19	76 - 4.75	Lemons to peas	3” - #4
Coarse Sand	0.19 -0.08	4.75 - 2.0	rock salt	#4 - #10
Medium Sand	0.08 - 0.02	2.0 - 0.425	sugar	#10 - #40
Fine Sand	0.02 - 0.003	0.425 - 0.075	powdered sugar	#40 -#200
Silt	<0.003	0.075-0.002	talcum powder	pass #200
Clay		< 0.002 -		pass #200

The USDA textural classification was developed to reflect water movement in soils and is the system used in sizing onsite systems. USDA texture classes are given as percentages of sand, silt and clay.

Figure 17-1 is a diagram commonly called the soil textural triangle, which is used to identify the soil texture based upon the percent of sand, silt and clay. Be careful to enter the triangle along the proper lines for the three particle sizes. At any point on the soil triangle, the sum of the percentages of sand, silt and clay should total 100 percent.

Figure 17-1. Soil texture triangle



Source: USDA

The Twelve Soil Textural Classes

Clay is a fine-textured soil material. When wet, clay is quite plastic and can be very sticky. When the moist soil material is squeezed, it forms a long, flexible ribbon; when moist and smeared, it is shiny. A clay soil material leaves a slick surface when rubbed with a long stroke and firm pressure. Due to its stickiness, clay tends to hold the thumb and forefingers together.

Silty Clay has characteristics similar to clay. It contains approximately equal amounts of silt and clay. It is both sticky and smooth-feeling.

Sandy Clay also has characteristics similar to clay. It has nearly equal parts sand and clay, and very little silt. It has a sticky feel. Individual sand particles may also be felt.

Clay Loam is a fine-textured soil. The moist soil material is plastic and will form a cast that will bear much handling; when formed into a long ribbon, it breaks readily. When kneaded in the hand it does not crumble readily but tends to work into a heavy compact mass.

Silty Clay Loam is a fine-textured soil similar to clay loam. It generally contains more silt than clay, and can have up to 20 percent sand. It has a slightly sticky feel, and is rather stiff. It also feels smooth or floury.

Sandy Clay Loam is composed primarily of sand with small, nearly equal, amounts of clay and silt and has characteristics similar to clay loam. It is slightly to fairly sticky-feeling. Individual sand grains may be felt.

Silt is too fine to be gritty to the touch, but its smooth, slick, or greasy feel lacks any stickiness.

Silt Loam is a soil material having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called "silt." When pulverized, it feels soft and floury. When moist, the soil readily runs together and puddles. It cannot be formed into a ribbon.

Loam is a relatively even mixture of sand, silt and clay. A loam feels somewhat gritty, yet fairly smooth and highly plastic. The term "loam" is not related to the term "topsoil." Loam textures refer to the mineral fraction of the texture and not with how much organic matter (blackness) the soil has.

Sandy loam is similar to loam, but contains a higher percentage of sand, with enough silt and clay to make it somewhat sticky. Individual sand grains can be seen readily and felt.

Loamy Sand is a soft, easily squeezed soil that is only slightly sticky. Individual sand particles can be felt.

Sand is commonly loose and single-grained, but it may be cemented together. Individual grains can be readily seen or felt. Squeezed in the hand when dry, it falls apart when pressure is released and does not form a ribbon. Squeezed when moist, it forms a cast that crumbles when pressure is released or when touched. For adequate sizing of onsite systems in sand, the size of the sand grains must be determined.

Field Determination of Soil Texture

The determination of soil texture is made in the field mainly by feeling the soil with the fingers, and sometimes by examination under a hand lens. This requires skill and experience, but good accuracy can be obtained if the site evaluator frequently checks his or her estimation against laboratory results. Soil samples of known textural classes may be obtained from:
United States Department of Agriculture
Soils Conservation Service
http://www.nv.nrcs.usda.gov/contact/index.html#soils

To determine the soil texture, moisten a sample of soil one to two inches in diameter. There should be just enough moisture so that the consistency is like putty. Too much moisture results in a sticky material, which is hard to work. Press and squeeze the sample between thumb and forefinger. Press the thumb forward to try to form a ribbon from the soil. The amount of sand in the sample can be determined by “washing off” the silt and clay, and feeling for sand particles. Sand particles can be seen individually with the naked eye and have a gritty feel to the fingers. Many sandy soils are loose, but some are not. Silt particles cannot be seen individually without magnification; they have a smooth feel to the fingers when dry or wet. Clay soils are sticky.

The way a wet soil “slicks out” or develops a long continuous ribbon when pressed between the thumb and fingers gives a good idea of the amount of clay present. If the soil sample forms a ribbon (loam, clay loam or clay) it may be desirable to determine if sand or silt predominate. If there is a gritty feel and lack of smooth talc-like feel, then sand very likely predominates. If there is not a predominance of either the smooth or gritty feel, then the sample should not be called anything other than a clay, clay loam or loam. If a sample feels quite smooth with little or no grit in it, and will not form a ribbon, the sample would be called silt loam. The content of particles coarser than two millimeters cannot be evaluated by feel. The content of the coarser particles is determined by estimating the proportion of the soil volume that they occupy.

An experienced site evaluator can determine the texture of soil quite accurately using both feel and sight. A good estimate of the textural class can be made using the following procedure. Final sizing of systems without the aid of a percolation test should only be attempted by an experienced site evaluator with adequate training or by a soil scientist who can accurately determine the soil texture and structure.

Procedure

1. Moisten a sample of soil the size of a golf ball, but don’t get it very wet. Work it until it is uniformly moist, then squeeze it out between your thumb and forefinger to try to form a ribbon,

2. Second decision. If the moist soil is

a) extremely sticky and stiff: one of the **clays**

b) sticky and stiff to squeeze: one of the **clay loams**

c) soft, easy to squeeze, only slightly sticky: one of the **loams**

3. Third decision. Try to add an adjective to refine the description.

a) The soil feels very smooth: **silt** or **silty**

b) The soil feels somewhat gritty: no adjective

c) The soil feels very, very gritty: **sandy**

4. At this point, the lines on the triangle jog a bit, and sandy loams are distinguished. If the soil is a sandy loam, determine the amount of sand present.

a) Very sandy (85% to 100%): **sand**

b) Quite sandy (70% to 85%): **loamy sand**

c) Somewhat sandy (50% to 70%): **sandy loam**

5. To distinguish between silt loam and silt, consider how slick or floury the soil feels.

a) very slick: **silt**

b) somewhat slick: **silt loam**

See Figure 17-1, the USDA soil texture triangle.

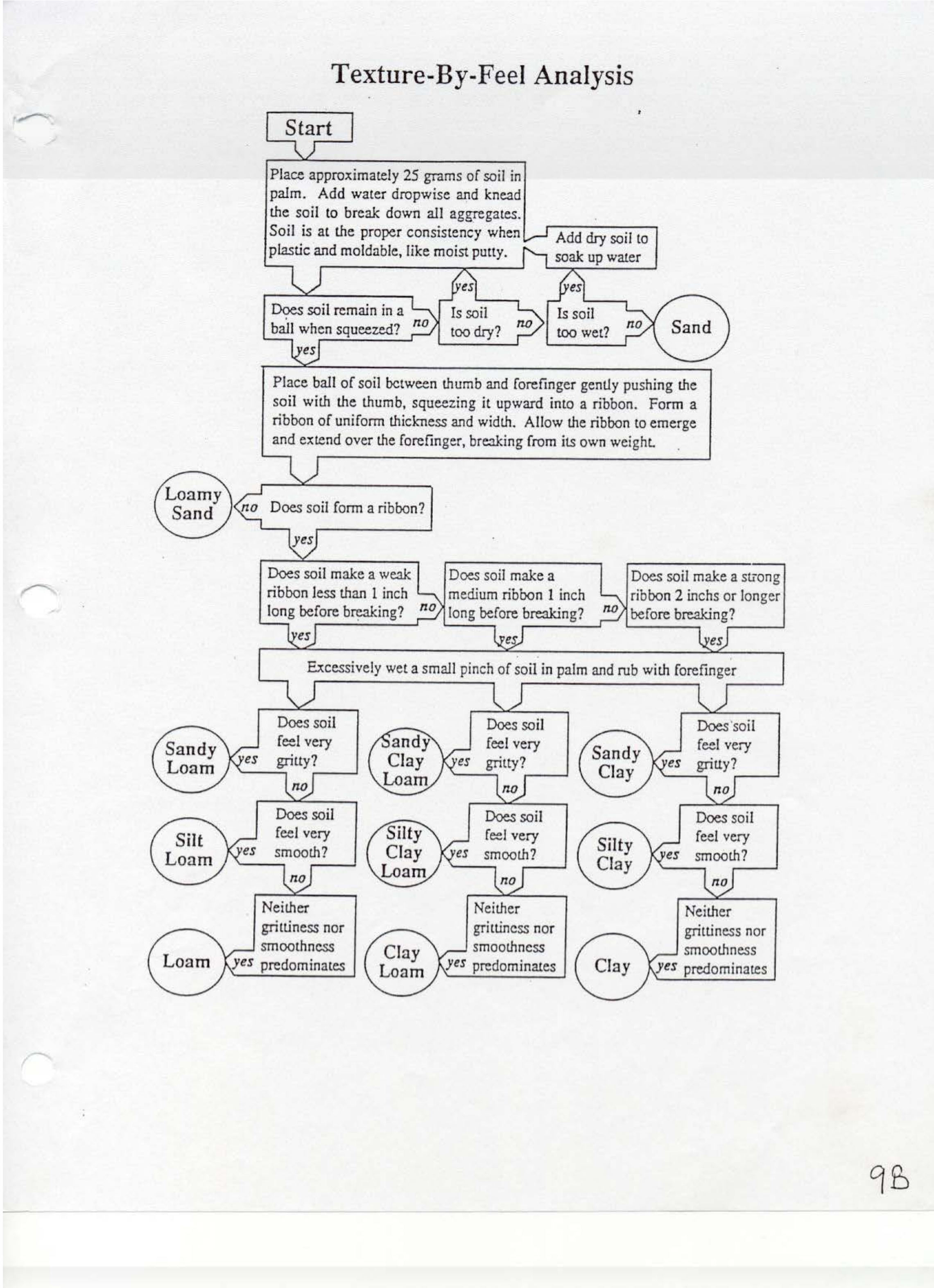
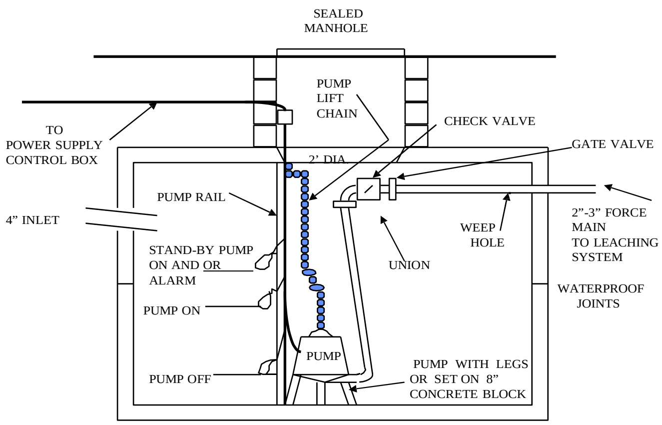


Figure 17-2. Texture by feel analysis

18. PRESSURE DISTRIBUTION

Pressure distribution is required when it is necessary to raise the elevation of wastewater for further treatment or disposal of sewage, intermittent dosing is desirable or when more than 500 ft. of absorption trench is required. A pressure distribution design example from the University of Wisconsin (Converse) is provided in Appendix H.

Figure 18-1. Typical Lift Station.



Source: Connecticut Department of Health

19. ABSORPTION TRENCH SYSTEM

Absorption (Leach) Fields

Absorption fields follow the septic tank and are designed to obtain treatment by the soil and aerobic microorganisms. Filters may be required to prolong the life of an absorption field. The most common type of field presently used is the leach field.

Location

Absorption fields shall not be located:

A) In any area which has been disturbed or re-graded unless sampled and certified as required.

B) In areas that have been or may be subject to passage, parking, or storage of heavy equipment, construction equipment, vehicles, or materials.

C) Beneath driveways, parking, or other paved areas.

D) Beneath buildings or other structures.

E) In swampy areas nor where ponding or flooding may occur.

F) Where depth to normal ground water or to rock strata is less than four (4) feet below the bottom of the trench.

G) Within 20 feet from any occupied building.

H) Within 10 to 50 feet (dependent on the soil permeability, adjacent land use, and degree of pretreatment) from a property line.

I) Within 100 ft. from existing well sites. Greater separation distances may be required with public water supply wells. Check with the Bureau of Drinking Water to determine the approved radius of public water supply wells.

Leach Fields General

A) Leach fields should be preceded by an influent drop box or distribution box for diversion of the flow to the individual lines. Fields should be divided into two equal sized sections.

B) Relatively shallow fields should be used since this increases evapo-transpiration and promotes aerobic conditions in the system. Permeability rates are usually more rapid in the upper part of the soil where pores are more common and biological action is greatest.

C) Leach lines shall be laid relatively level. Lines shall be not less than four (4) inches in diameter and laid not more than three (3) inches slope in fifty (50) feet. For sloped areas, field tiles should follow the contours and it is recommended that a drop box distribution be used so that each component is forced to pond before liquid flows to the succeeding component.

D) Maximum length of lines - 110 feet.

E) Minimum distance between centerline of trenches - 6 feet.

F) Fill material - a minimum depth of 18 inches of clean gravel or stone (3/8" to 1½") required with 12-inch depth below and 2 inches above the tile as a minimum (very shallow systems). Cover top of fill with a 2-inch layer of hay, straw, or geotextile fabric before placing earth fill to surface.

G) Conventional leaching systems may not be appropriate in soils with a seasonally high water table. Poorly drained soils often indicate other conditions which may make the site unsuitable for conventional leaching. Appropriately designed mound systems may be necessary to solve such problems.

H) Soil classification shall be shown on detail plans using USDA soil conservation service soil series, texture, effective size, and permeability limitation. On-site disposal systems should be located in areas of undisturbed soils. Sieve analysis may be required. Although not as accurate in determining soil treatment capacity, percolation tests may be utilized in lieu of the above requirements.

I) Test holes - test holes eight to ten (8-10) feet in depth should be made in the area of the proposed field and the results submitted, indicating depth to rock, seasonal ground water, normal ground water, and soil effective size.

J. Field size- for septic systems, bases on Long Term Acceptance Rate of soil below field.

K. Inspection ports, if required, should be provided at the end of each trench to observe the depth of ponding. The port shall extend from the base of the gravel and extend to final grade with a cap at ground surface. The port must be perforated within the gravel layer and either may be attached to the distribution pipe or be separate from it.

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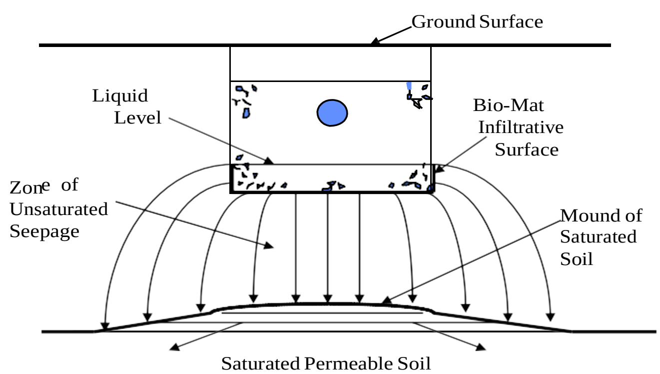
Figure 19-1. Typical leach trench



Source: Conn. Health Dept.

PREVENTING CLOGGING OF THE SOIL INFILTRATIVE SURFACE

A layer of biological slime (biomat) is formed on the interface between the soil and the leaching surface of the particular type of leaching unit being utilized (such as the rock in a leaching trench or gallery; select sand used for sand filters or the soil itself utilized in stoneless plastic leaching trenches). This soil infiltrative surface results from bacterial and biological particles being collected on the soil surface, and from the growth of certain organisms within the biomat (slime layer) itself. The thickness of the biomat is related to the sewage strength and application rate, being thicker for more heavily loaded systems. The growth of the biomat reduces the rate at which effluent passes into the soil. In so doing, it causes sewage effluent to be distributed over more infiltrative surface, thereby equalizing the distribution of sewage effluent throughout the leaching system. This, together with the reduction of BOD which occurs when the sewage effluent is filtered through the biomat, is extremely important in preventing ground water pollution. Eventually, most of the active infiltrative surface will be covered by a slime layer of more or less uniform thickness, and the rate of which the sewage effluent passes through the layer will stabilize.

Note: A leach field that is properly designed and maintained with an active biomat will generally reach an equilibrium acceptance rate of approximately 0.125gal/ft$^{2.}$ day (1,600 min/in) through the biomat.

Typically 36 inches of clean rock is placed in the bottom of the excavation; then a four-inch diameter perforated distribution pipe and covered with 2 inches of rock; a layer of permeable fabric is placed or the rock; and soil is backfill to a depth of six to 24 inches above the rock. Sewage effluent flows out through the distribution pipe and down into the rock layer into the soil. Pathogens and fine sewage solids are removed by the organisms that form the biomat, , that spreads the effluent across the soil surfaces of the trench and promotes aerobic conditions in the surrounding soil by limiting infiltration of the wastewater.
The biological layer or **biomat** is formed by anaerobic bacteria in the trench, which secrete a gluey substance to anchor themselves to the soil or rock particles. This biomat forms first along the trench bottom. As liquid begins to pond in the trench, the biomat forms along the soil surfaces on the sidewalls. When fully developed, the gray-to-black slimy biomat layer is about one inch thick.

Flow through a biomat is considerably slower than flow through natural soil, so unsaturated conditions exist in the soil beneath the drain field trench. Only the smaller soil pores contain water, while larger pores are filled with air. Unsaturated flow increases travel time of effluent through the soil, ensuring that it contacts the surfaces of soil particles. Soil must be neither too coarse nor too fine. A coarse soil may not adequately filter pathogens, and a fine soil may be too tight to allow water to pass through.

LONG TERM ACCEPTANCE RATE

This stabilized infiltration rate is sometimes called the “long term acceptance rate” of the soil. The minimum leaching area requirements in the NAC are related to the expected long term acceptance rate of the infiltrative surface within the leaching system, as indicated by percolation testing and/or soil reports. Periodically, the slime layer on the infiltrative surface will become unstable and a “breakthrough” of sewage effluent will occur. Such breakthroughs are more frequent in the more permeable soils where the biological particles are more easily detached and washed into the larger voids in the soil. Fluctuating liquid levels and loading rates accelerate slime deterioration and breakthrough. In fact, many leaching systems in highly permeable sand and gravel have functioned satisfactory for many years at loading rates well in excess of the theoretical long term acceptance rate. This may be due to the instability of the slime layer allowing frequent breakthroughs of sewage effluent.

DISPERSING LIQUID INTO THE SURROUNDING SOIL

After sewage effluent passes through the slime-covered soil infiltrative surface, it must be dispersed into the surrounding soil. In a properly functioning leaching system, this is accomplished in two ways: (a) by hydraulic flow through the voids in the soil, and (b) by capillary dispersal and evaporation. Hydraulic flow is the predominant mechanism of dispersal in the coarser grained soils, while capillary dispersal is important for the finer grained soils. Most leaching systems are constructed in moderately permeable, well graded soils where hydraulic flow and capillary dispersal occur simultaneously.

An understanding of the mechanisms of dispersal can help engineers in designing and constructing leaching systems for maximum dispersal into the surrounding soil. In a properly functioning sewage disposal system, liquid flowing from the leaching system to the ground water table will not saturate the soil under the system because the liquid will pass through the slime-covered soil infiltrative surface at a slower rate than it will pass through the soil behind it. However, it will cause a slight elevation of the ground water table under the system as the liquid is added to the ground water in this area, or will cause a “mounding” of liquid on underlying impermeable layers of ledge or hardpan.

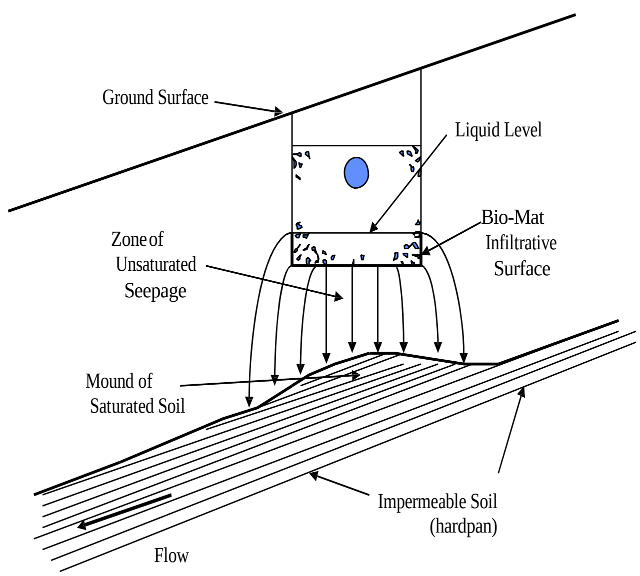
In the worst case, the mound of saturated soil could rise to the level of the leaching system, causing it to fail. Capillary dispersal and evaporation is maximized in leaching systems consisting of shallow, narrow leaching trenches. Leaching systems constructed in a relatively uniform very fine sand or silt loam have the greatest capillary dispersal and evaporation locations.

NARROW TRENCH SYSTEMS

Shallow subsurface disposal trenches, 18 to 24 inches wide, are the preferred type of leaching system in soils with slow seepage. Such systems take maximum advantage of lateral seepage into the more permeable layers in the upper few feet of soil, and promote capillary dispersal and evaporation..

When systems are located in slow soils, it is important that the loamy subsoil not be stripped from the area of the leaching system because this usually is more permeable than the underlying soil. Care should be taken to only remove the vegetative growth on the top surface and not compact the loamy subsoil with heavy equipment during construction in order to maintain the larger soil voids through which air may circulate and evaporate moisture. Rainfall will tend to saturate soils with slow seepage. Therefore, it is important that the ground surface over the leaching system is sloped to drain rapidly.

Figure 19-2. Absorption trench on a slope.



Source: Connecticut Department of Health

20. ABSORPTION BED SYSTEM

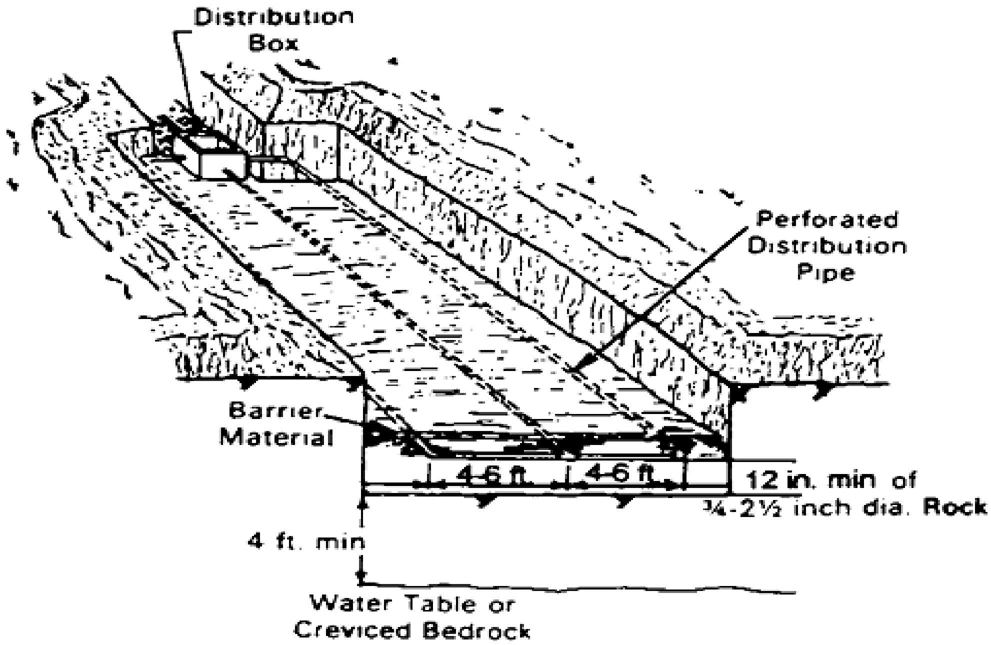
ABSORPTION BED - GENERAL

If the use of an absorption trench is not practical, an absorption bed may be used as a viable alternative to the standard disposal trench. The bottom of the absorption bed, rather than the area of the sidewall, must serve as the primary absorptive medium.

ABSORPTION BED DESIGN CRITERIA

1. The absorptive area of an absorption bed must be at least 50 percent larger than the calculated size that would be required for a standard absorption trench.
2. The percolation rate of the soils at the bottom of the absorption bed must not be slower than 60 minutes per inch.
3. The effective perimeter of the area of the sidewall beneath the distribution lines, or the depth of the aggregate, must not be less than 12 inches or more than 36 inches. The area of the sidewall may be added to the bottom of the bed when calculating the size of the total absorptive area of the Onsite Sewage Disposal System.
4. An absorption bed must not be placed on a slope if the grade of the slope is greater than 8 percent. The bottom of the absorption bed must be level.
5. The invert of the piping for the drain field must be not less than 12 inches or more than 48 inches below the finished grade. The top of the absorption bed must be at least 6 inches below the surface line of the natural soil, and a capping fill must be placed on top of the absorption bed. The capping fill must extend at least 10 feet beyond the perimeter of the leaching area of the absorption bed and must be placed at a minimum depth of 12 inches above the finished grade to allow for settling.
6. An absorption bed must have at least two distribution lines which are separated by not less than 4 feet or more than 6 feet. The distribution lines must be level and placed not less than 3 feet or more than 6 feet from the sidewall of the bed. If a gravity discharge system is used, the distribution line must not be less than 4 inches in diameter. If a pressurized distribution line is used, the line must meet the design guidelines for a pressure distribution system as set forth in NAC 445A.xx and Appendix H.
7. A distribution line must not be longer than 110 feet and must be placed on at least 12 inches of clean, graded aggregate ranging in size from 3/4 to 2 1/2 inches. At least 2 inches of aggregate must cover the top of the distribution line. Untreated building paper, straw, geotextile fabric, or any similar covering approved by the administrative authority, must cover the aggregate, and a backfill of soil must be placed over the covering.
8. The owner/operator of an Onsite Sewage Disposal System shall take such precautions as are necessary to avoid compacting the bottom of the absorption bed. Any loose or smeared soil must be raked and removed. No vehicles may travel on the area of the absorption bed after excavation is completed.
9. Dosing is required if more than 500 linear feet of distribution lines are required.
10. The following is a diagram of an absorption bed (Figure 20-1):

Figure 20-1. Typical Absorption Bed



Source: Nevada State Health Division.

Absorption bed: Inspections.

1. The construction of an Onsite Sewage Disposal System that includes an absorption bed must be inspected and verified by an engineer. The inspections must be conducted as follows:

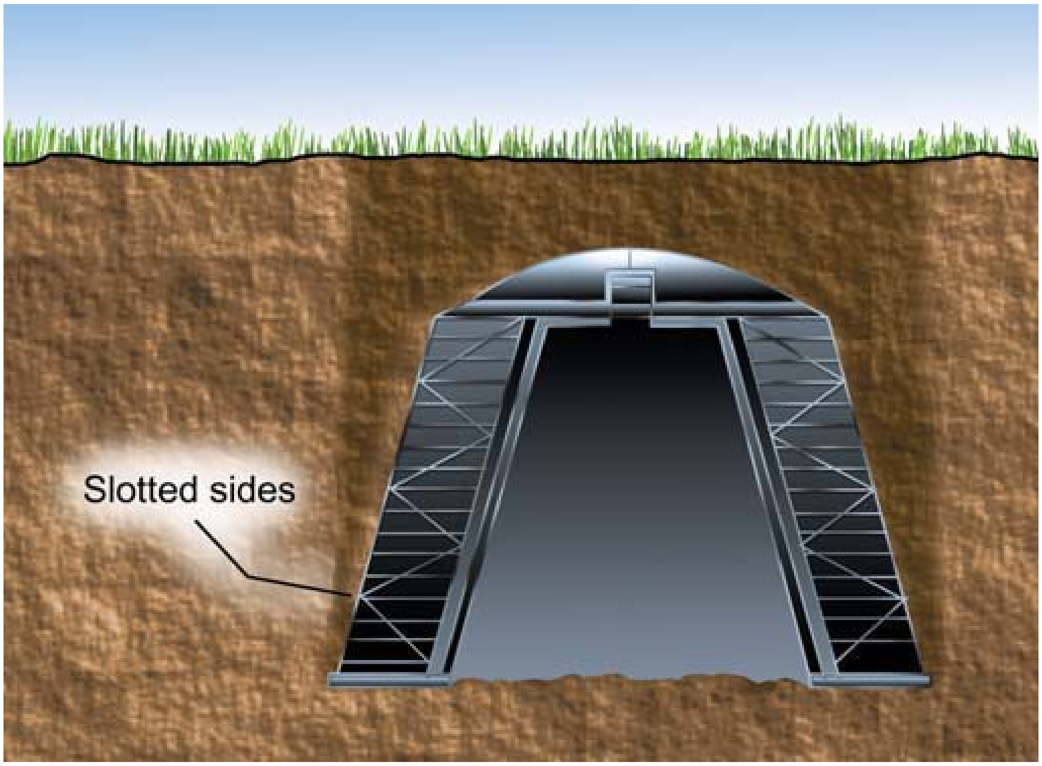
   (a) Following excavation, the bottom of the absorption bed must be examined to ensure that there is no loose soil and that no smearing conditions exist; and

   (b) Upon completion of the installation of the distribution lines in the absorption bed, the Onsite Sewage Disposal System must be inspected to ensure that the system complies with the approved design plans.

21. CHAMBER/GRAVEL-LESS SYSTEMS

Gravel-less systems are widely used. They take many forms, including open-bottomed chambers, fabric-wrapped pipe, and synthetic materials such as expanded polystyrene foam chips. Some gravel-less drain field systems use large-diameter corrugated plastic tubing covered with permeable nylon filter fabric not surrounded by gravel or rock. The area of fabric in contact with the soil provides the surface for the septic tank effluent to infiltrate the soil. The pipe is a minimum of 10 to 12 inches in diameter covered with spun bonded nylon filter fabric to distribute water around the pipe. The pipe is placed in a 12- to 24-inch wide trench. These systems can be installed in areas with steep slopes with small equipment and in hand-dug trenches where conventional gravel systems would not be possible.

Figure 21-1 Typical Chamber system



Source: Iowa Dept. of Natural Resources

Reduced sizing of the infiltration surface is often promoted as another advantage of the gravel-less system. This is based primarily on the premise that gravel-less systems do not "mask" the infiltration surface as gravel does where the gravel is in direct contact with the soil. Proponents of this theory claim that an infiltration surface area reduction of 50 percent is warranted. However, these reductions are not based on scientific evidence though they have been codified in some jurisdictions (Amerson et al., 1991; Anderson et al., 1985; Carlile and Osborne, 1982; Effert and Cashell, 1987).

Although gravel masking might occur in porous medium applications, reducing the infiltration surface area for gravel-less systems increases the BOD mass loading to the available infiltration surface. Many soils might not be able to support the higher organic loading and, as a result, more severe soil clogging and greater penetration of pollutants into the vadose zone and ground water can occur (University of Wisconsin, 1978), negating the benefits of the gravel-less surface.

A similar approach must be taken with any contaminant in the pretreatment system effluent that must be removed before it reaches ground water or nearby surface waters. A 50 percent reduction in infiltrative surface area will likely result in less removal of BOD, pathogens, and other contaminants in the vadose zone and increase the presence and concentrations of contaminants in effluent plumes. The relatively confined travel path of a plume proves fewer adsorption sites for removal of adsorbable contaminants (e.g., metal, phosphorus, toxic organics). Because any potential reductions in infiltrative surface area must be analyzed in a similar comprehensive fashion, the use of gravel-less medium should be treated similarly to potential reductions from increased pretreatment and better distribution and dosing concepts.

Despite the cautions stated above, the overall inherent value of lightweight Gravel-less systems should not be ignored, especially in areas where gravel is expensive and at sites that have soils that are susceptible to smearing or other structural damage during construction due to the impacts of heavy machinery on the site. In all applications where gravel is used, it must be properly graded and washed. Improperly washed gravel can contribute fines and other material that can plug voids in the infiltrative surface and reduce hydraulic capability. Gravel that is embedded into clay or fine soils during placement can have the same effect.

Because leaching chamber systems can be installed without heavy equipment, they are easy to install and repair. These high-capacity, open-bottom drain field systems can provide greater storage than conventional gravel systems and can be used in areas appropriate for gravel aggregate drain fields. Leaching systems can operate independently and require little day-to-day maintenance. Their maintenance requirements are comparable to those of aggregate trench systems.

The lightweight chamber segments available on the market stack together compactly for efficient transport. Some chambers interlock with ribs without fasteners, cutting installation time by more than 50 percent reused and conventional gravel/pipe systems. Such systems can be reused and relocated if the site owner decides to build on another drain field site. A key disadvantage of leaching chambers compared to gravel drain fields is that they can be more expensive if a low-cost source of gravel is readily available. Porous media should be placed along the chamber sidewall area to a minimum compacted height of 8 inches above the trench bottom. Additional backfill is placed to a minimum compacted height of 6 to 12 inches above the chamber, depending on the chamber strength. Individual chamber trench bottoms should be leveled in all directions and follow the contour of the ground surface elevation without any dams of other water stops. The manufacturer's installation instructions should be followed and systems should be installed by an authorized contractor.

Chambered systems have a number of advantages:

Light weight,
ease of installation,
open bottom.
more storage capacity for peak flows, and

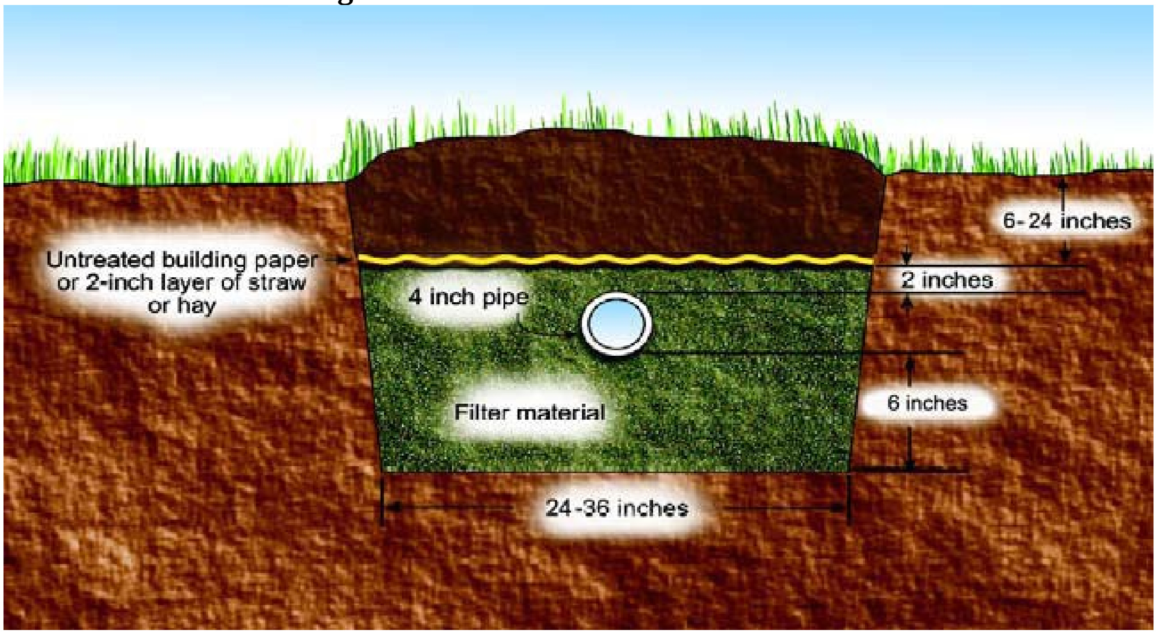
Disadvantages:

Less horizontal flexibility,
wide chambers may crush without adequate soil cover.

22. ALTERNATIVE ABSORPTION SYSTEMS

Systems that do not utilize standard trench or bed systems are considered alternative absorption systems. Alternative absorption systems include mounds, sand filters, engineered fill, etc. They are explained further in the following sections.

Figure 22-1 Trench with filter material.



Source: Iowa Dept. of Natural Resources

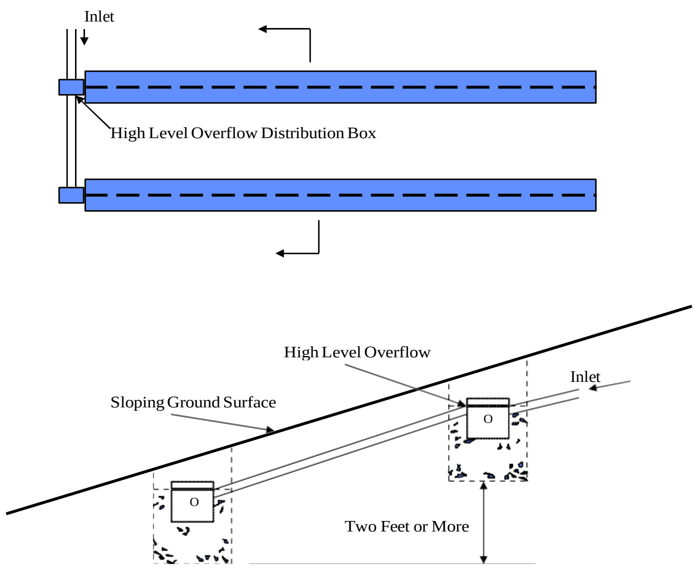
23. STEPPED NETWORK OF TRENCHES

SERIAL LEACHING SYSTEMS

In a serial leaching system, the individual leaching units are set on different elevations, and each unit is connected by a high level overflow pipe to the next lower unit. Effluent is directed to the highest leaching unit. When this unit becomes filled and is functioning at its maximum capacity, any additional effluent will overflow to the next lower unit, and subsequently to others in series.

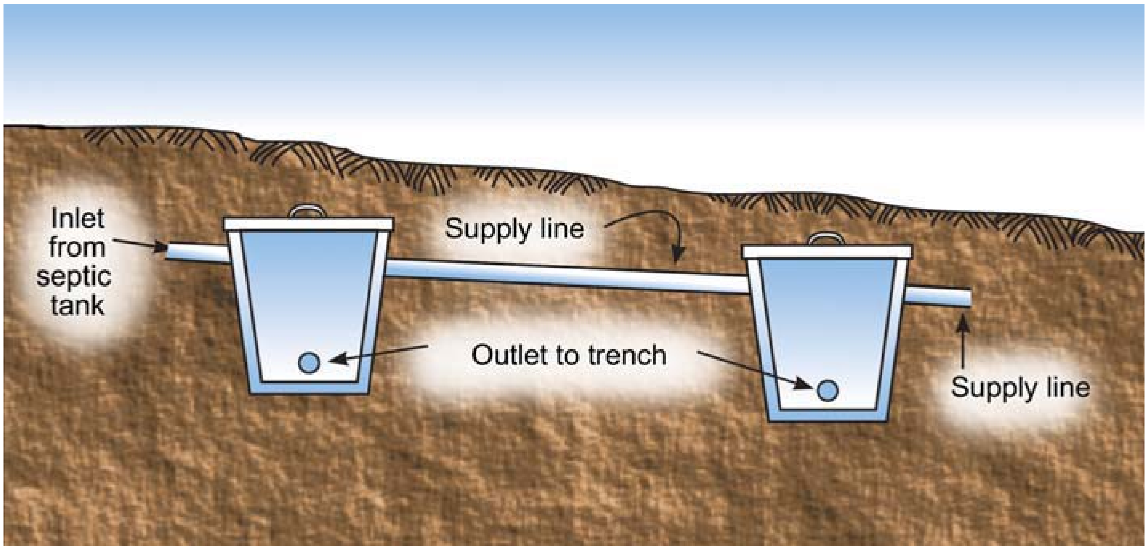
Many leaching systems installed on slopes fail because sewage effluent is not equally divided between the various leaching units. Some units receive an excessive amount which causes overload and failure. This is usually due to a carelessly installed distribution box, in which the outlets are not level.

Figure 23-1. Stepped network of trenches.



Source: Connecticut Department of Health

Figure 23-2 Stepped network of trenches (section view).



Source: Iowa Dept. of Natural Resources

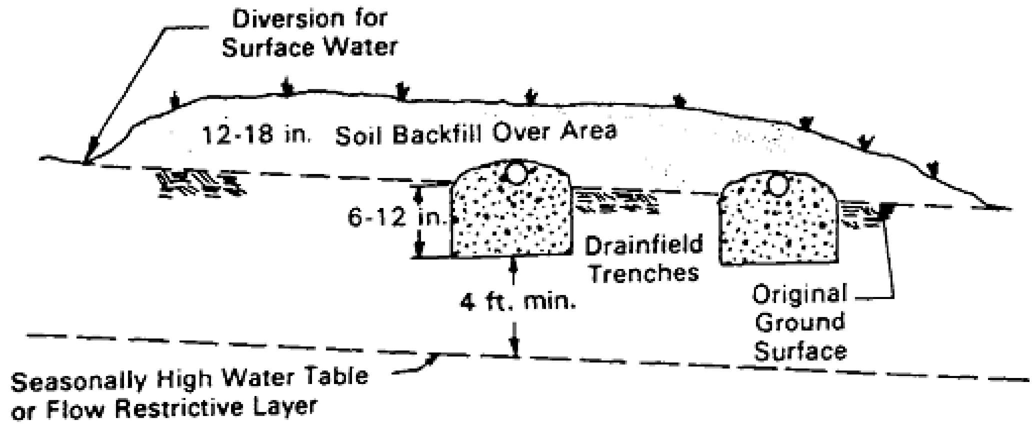
24. CAPPING FILL TRENCH

A Capping fill trench is a standard drain field trench, where the invert of the disposal drain pipe is at or slightly below the natural grade of the existing soil, which is covered by a soil cap composed of selected fill material and used to reduce the total trench depth. A capping fill trench may be used where conditions relating to high groundwater preclude the installation of a standard absorption trench.

Capping fill trench: Design criteria.

1. The soil surrounding and beneath the bottom of a capping fill trench must have a percolation rate that is greater than 2 minutes per inch, but less than or equal to 120 minutes per inch. The required area of the absorption trench must be determined by calculating the size of the effective sidewall pursuant to subsection x of NAC 445A.xxx
2. A minimum depth of 4 feet must be maintained between the bottom of the capping fill trench and the level of the seasonal high groundwater, any impermeable barrier or any other limiting features.
3. A capping fill trench must not be installed on a slope that is greater than 10 percent.
4. The invert of the disposal drain pipe must be placed not more than 12 inches below the existing grade of the native soil. At least 2 inches of aggregate must be placed above the disposal drain pipe. Untreated building paper, straw, geotextile fabric, or any other similar covering approved by the health authority, must be placed above the aggregate before the placement of the capping fill.
5. The absorption trenches must be constructed before the capping fill is constructed.
6. The capping fill must extend at least 10 feet beyond the sidewall of the absorption trench. The vegetative mat in the fill area must be disrupted by scarification or plowing. The owner of the system shall take such precautions as are necessary to prevent compaction of the scarified area. No vehicles may travel on the capping fill.
7. The native soil and the applied fill must be mixed at their point of interface. The soil to be used as fill must be of a texture similar to the native topsoil. The fill must be placed over the aggregate to a depth of not less than 12 inches or more than 18 inches.
8. The fill must be evenly graded to provide positive drainage away from the absorption trenches and toward the perimeter of the capping fill. The fill material must be placed in such a manner so as to prevent the compaction of the scarified soil at the interface of the native soil and fill. Plant vegetation must be established on the top of the fill to reduce the potential for the erosion of the capping fill.
9. A capping fill trench must not be used if the soil in which the capping fill is to be placed exhibits saturated conditions.
10. The following is a diagram of a capping fill trench (Figure 23-1):

Figure 24-1 Capping fill trench



Source: Nevada State Health Division

Capping fill trench: Inspections.

1. An engineer shall inspect the construction of a capping fill:
   (a) Upon the completion of the installation of the distribution lines in the absorption trenches.
   (b) When the fill area has been scarified. The engineer shall inspect the fill and native soils to ensure that they are not excessively moist and are of similar texture.
   (c) When the capping fill has been placed:
      (i) To ensure that there is an adequate interface of the fill and soils at the surface; and
      (ii) To verify the dimensions of the capping fill.

25. ELEVATED MOUNDS

Elevated mounds are used where there is high water table, depth to bedrock is a concern or questionable soils exist below the disposal site. The Wisconsin Mound is the most widely used mound and has had success in various states. For specific design information, refer to Appendix C for mound design and construction.

26. INTERMITTENT SAND FILTER

A sand filter system uses property grade and washed sand as a medium for wastewater treatment, after a septic tank (of septic tank effluent). Sand filters have been widely used around the United States, and the various sand filter types and their designs have been extensively tested and documented. The treatment mechanisms in a sand filter are physical filtering of solids, ion exchange (alteration of compounds by binding and releasing their components), and decomposition of organic waste by aerobic bacteria.

A properly operating sand filter should produce high-quality effluent containing less than ten milligrams per liter BOD, less than ten milligrams per liter TSS, and less than 200 ppm fecal coliform bacteria.

Sand filter systems can also be appropriate in the recovery of existing drain fields. Where drain fields have failed due to lack of maintenance or due to excessive organic loading, it is possible that an existing system can continue to be used if a sand filter is made a part of the treatment system.

HOW SAND FILTERS WORK

Sand filter systems begin with a pretreatment device, typically a septic tank that receives wastewater from the residence or other establishment. From this device, wastewater moves to the filter. Effluent from the septic tank is introduced at the top of the filter. Pressure distribution is preferred over gravity distribution to apply the wastewater to the filter surface. Pressure distribution allows even loading over the entire filter surface, and thus maximizes treatment. After treatment in the sand filter, effluent flows to a soil dispersal area or surface discharge. The most common design is a **single-pass** or **intermittent** sand filter, in which the wastewater enters the filter and exits after passing through the medium once. This is the simplest design, is generally used for residential applications and requires the largest filter.

Gravity distribution often leads to early failure of the sand filter due to clogging at the sand surface. The clogging mat develops due to overloading in certain areas of the filter, which then spreads over the entire surface of the filter. In addition, most of the wastewater is discharged on a very small area of sand and percolates through the sand very quickly not providing the time to adequately treat the effluent

SUBSURFACE SAND FILTERS

In the design of subsurface sewage disposal systems, buried sand filters may be used to produce a partially stabilized effluent for application to subsurface irrigation systems (individual permit required) or evaporation-transpiration mounds. They also may be used for oxidizing septic tank effluent before it is applied to denitrification contact beds. In a conventional subsurface sand filter, septic tank effluent is distributed through a system of perforated pipe and stone over the surface of a buried sand bed. The septic sewage is filtered and oxidized as it passes through the sand bed. Effluent is either percolated into the soil or collected below the sand bed and is discharged to a conventional or modified leaching system. In subsurface sand filters, effluent is applied intermittently by pumps or siphons to produce a relatively uniform biological growth in the filter and a better stabilized effluent. Modified subsurface sand filters may be designed for higher filtration rates, sometimes with provisions for effluent recirculation. Occasionally such filters are used for final filtration of aerated sewage effluent. High rate subsurface sand filters usually are placed in buried concrete tanks or structures with access openings to the sand surface which allow cleaning if excessive clogging occurs.

CONVENTIONAL SUBSURFACE SAND FILTERS

Septic tank effluent is discharged to the filter intermittently by means of a pump or dosing chamber. The surge produced when the pump discharges tends to surcharge the distribution pipe of small subsurface sand filters. Perforated distribution pipe are laid 6 feet on centers in a continuous, 10 to 16 inch deep layer of 1/2 to 1 inch broken rock. The top of the rock layer is protected with filter fabric to prevent dirt and silt from being washed down onto the sand surface. The filter bed itself consists of 24 to 30 inches of carefully selected sand. The sand must be relatively coarse and extremely uniform so that it will not become clogged by the buildup of fine inorganic particles which are the end product of biological decomposition.

The sand should have an effective size of between 0.3 and 0.7 millimeters and a uniformity coefficient of 3.5 or less. The effective size is the sieve size which allows 10% of the grains to pass. The uniformity coefficient is the ratio of the sieve size which passes 60% of the sand to that which passes 10% of the sand. Filter sands normally are screened and washed to meet gradation requirements. Subsurface sand filters receiving septic tank effluent usually are designed for a loading rate of about 1 gallon of effluent per day for each square foot of bed surface. Such a loading rate will allow aerobic conditions to be maintained throughout most of the filter, particularly when effluent is intermittently applied. This promotes the growth of nitrifying organisms and higher forms of protozoan which are able to reduce the BOD in the filter effluent to less than 5 milligrams per liter, and to oxidize over 80% of the nitrogen to the nitrate form. The suspended solid content of subsurface sand filter effluent normally is less than 10 milligrams per liter and the dissolved oxygen exceeds 50% of saturation. Filter effluent is either percolated to the soil underneath the sand filter or collected in a layer of 1/2 to 1-inch stone underlying the sand bed and is carried away by perforated collection type. It is important that the top of the stone layer is covered with filter fabric to prevent the filter sand from being washed away. Normally, the collection pipe is vented to ground surface to promote air circulation and help maintain aerobic conditions in the sand bed.

Recent research on single pass sand filters shows that short frequent doses to the sand filter with closely spaced orifices (4 – 6 ft^2/orifice) improves effluent quality (Darby et al., 1996). Short frequent doses require time dosing instead of demand dosing. Most mounds are demand dosed with larger areas/orifice of 15 to 20 ft^2/orifice. This results in a large quantity of effluent discharged at once and applied less uniformly on the infiltrative surface than for sand filters. This large quantity of effluent moves through the sand rapidly (assuming no ponding condition), allowing insufficient time for the biota to treat the effluent optimally. This forces fecal coliforms and pathogens further into the soil profile. Short frequent doses and more closely space orifices allows the effluent to be retained in the sand/soil for longer periods. Converse et al., (1994) suggested that the reason for some fecal coliforms found deep in the soil profile beneath mounds was due to large infrequent doses. Designers should use smaller doses and more closely spaced orifices. They should consider time dosing in distributing the effluent to the mound. Timed dosing requires that surge capacity be incorporated into the septic tank and/or pump chamber to store the peak flows until it is dosed into the mound and requires control panels which have become very user friendly.

Single-Pass Sand Filter (typically for residential use)
Effluent from the primary treatment unit, septic tank, is transmitted to a pressure distribution network within the infiltration bed of a sand filter or gravity feed system uses a distribution box and 4-inch lateral pipe. The effluent flows downward from the bed through at least two feet of filter media where it undergoes physical, chemical and biological treatment. The treated effluent is collected and either flows by gravity or is pumped to a dispersal component.

Clean sand is used in single-pass filters, often the same size as is used in mound systems. Somewhat coarser sand, such as ASTM C-33 or IDOT Concrete Sand would provide adequate treatment of the wastewater as well as better hydraulic acceptance, provided the percent of particles passing the #100 sieve are less than 4% (to prevent premature plugging and possible failure). With ASTM C-33, however, phosphorous and nitrogen would not be removed as well as with finer sand. Coarser sand permits better aeration of the wastewater, so that the bacteria in the filter never enter the anaerobic cycle in which these nutrients are removed and treated.
Single-pass pressure dosed filters are typically designed to accept about one gallon per day per square foot of filter surface. Free access sand filters may be loaded at two to five gpd/sqft. At this higher loading rate, the system will require maintenance of the medium (replacement or cleaning of the sand) is necessary because the higher loading rate will lead to surface clogging. When the loading rate is lower, the system will operate properly for longer periods without being serviced.

Recirculating Sand Filters (commercial use)
If higher loading rates are necessary to reduce the size of the filter, recirculating the waste water is an attractive alternative to the single-pass design. Recirculation means bringing the wastewater through the filter a number of times, allowing for continued filtering and increased bacterial decomposition. A recirculating sand filter system contains the following:

A recirculating tank containing a pump and related controls that distribute effluent to the sand filter and a dispersal component.
The recirculating filter, consisting of: filter media (a lid), an infiltration bed, Liner a distribution bed, an underdrain that collects filtered effluent and directs it back to the recirculating tank.

Effluent from the primary treatment of wastewater in a septic tank or other treatment component is transmitted to a recirculating/mixing tank. In the tank, effluent from the treatment component mixes with effluent that has been recirculated through the sand (gravel) filter. This mixture is applied by a pressure distribution network onto an infiltration bed of a specified media. The effluent flows downward from the bed into and through the filter media. Biological treatment occurs as the effluent passes the surfaces of the filter media. Treated effluent is collected at the bottom and is discharged by gravity or pressure back to the recirculating/mixing tank where the recirculating cycle begins again. As levels in the recirculating tank rise, treated effluent will be discharged to a dispersal component, either by gravity or pumping.

Recirculation systems require coarser media to accommodate higher loading rates; sand used for a single-pass sand filter would be too fine for a recirculating filter. For this reason, recirculating sand filters are also called gravel filters. A medium of 0.05 to 2.0 mm in diameter, such as bird grit 2, is a better choice, **3/8 inch pea gravel is to coarse and should not be used.** Advanced treatment ideas for recirculation systems include expanded shale or expanded peat media.

Recirculation systems require constantly circulating water. Designs for recirculating filters must include a timer to regulate the loading of the system. The loading rate is usually four to five gpd/sqft, and the wastewater flows through the filter four or five times before leaving the system. This allows a smaller filter surface area to produce the same high-quality effluent as a larger single-pass filter. Another advantage of recirculation systems is that as wastewater moves through the filter, it becomes oxygenated. When it's captured in the recirculation tank, it becomes anoxic (low in dissolved oxygen). During the anoxic cycle, bacteria can break down nitrates in the wastewater. This is a significant benefit in areas where nitrogen contamination of groundwater has been a problem.

Table 26-1. Specifications, mass loadings and depth for a single-pass intermittent sand filter

Design Parameter	**Typical design value**
Material	Durable, washed sand
Specifications Effective size (sand) Uniformity coefficient Percent fines (passing 200 seive)	 0.25-1.00 mm (0.3 – 0.7 mm optimal) < 4 (< 3.5 optimal) ≤ 3
Depth	2 to 3 ft.
Mass loading Hydraulic loading Organic loading	 1 gpd/ft^2 5 lb. BOD/1,000 ft^2 - d
Underdrains Slope Size	 0 – 0.1% 3 – 4 in. diameter
Dosing Frequency	 12 – 24 times per day
Dosing tank Volume	 0.5 – 1.5 times design daily flow

Source: U.S. EPA Onsite Wastewater Treatment Systems Manual, 2002.

Section 27. RECIRCULATING TEXTILE-BASED PACKED BED FILTERS

A recirculating textile-based packed bed filter is a multiple-pass, packed-bed aerobic wastewater treatment system specifically designed and engineered for long-term processing of domestic (residential strength) wastewater. The treatment media is an engineered textile, which has an extremely high void capacity, moisture-holding capacity, and surface area per unit volume. The effluent quality produced by these units is ideal for many water-reuse applications.

How Textile Filters Work

Primary treatment of raw sewage occurs in appropriately sized septic tanks where gross solids are allowed to settle. After primary treatment, effluent passes to the recirculation/blend tank. The recirculation/blend tank contains a screened pump vault with a pump that transports the wastewater to a distribution manifold in the textile filter pod. Effluent percolates down through the textile media, where it is treated by naturally-occurring microorganisms that populate the filter. After passing through the filter media, the treated effluent flows out of the filter pod through the filtrate return leading to a recirculating splitter valve. The valve automatically splits or diverts the flow between the recirculation/blend tank and the final discharge, and controls the liquid level within the tank. During extended periods of low forward flow into the system, 100% of the treated effluent is returned to the recirculation/blend tank. The recirculation/blend tank is set up so that incoming effluent from the primary septic tanks and filtrate from the textile filter pods enter at the end of the tank opposite the pump so that mixing, blending, and dilution of the effluent occurs before the blend is dosed onto the textile filter pods.

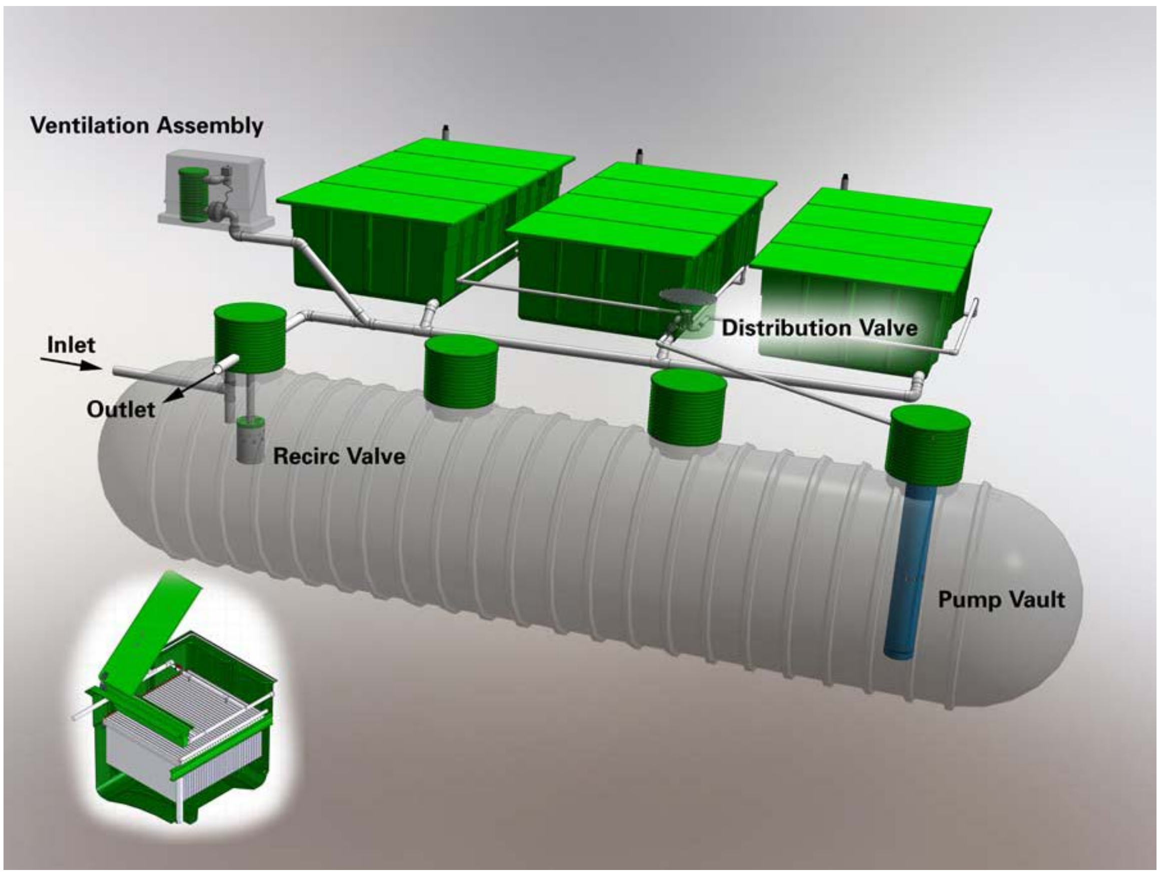
Typical Textile Filter

Excellent results with regard to $cBOD_5$ and TSS can be achieved, and in addition, total nitrogen reduction will typically exceed 60% on average, assuming sufficient alkalinity is available. If additional nitrogen reduction is desired, a specialty mode in which a portion of the filtrate is routed to recirculate through the primary tank may be considered. This option allows for improved denitrification to enhance the overall nutrient removal. There are several other factors that influence the nitrogen process, and each of these should be considered when developing a plan for achieving significant reductions in this area.

Textile pods are units that are easily installed and the system can be designed in a modular fashion to accommodate future growth as needed. Because of the unique treatment abilities of textile filters, especially their ability to reduce nitrogen, they are an alternative solution for some of Nevada’s wastewater treatment needs.

The following illustration shows the recirculation/blend tank and several modular textile filter units. Wastewater from one or more septic tanks (not shown) enters the recirculation/blend tank, where it blends with return flow from the textile filter units. A pump located at the opposite end of the tank pumps the blend to the textile filter units, where it is sprayed evenly over the textile material. After passing through the filter media, the well-aerated filtrate is routed through a splitter valve that returns part of the flow back to the recirculation/blend tank, and the remainder to final discharge, and which controls the liquid level in the tank. The inset is a cutaway view of a textile filter unit, showing the textile filter media arranged as a bank of hanging sheets, and the distribution manifold piping from which wastewater is sprayed over the textile surface.

Figure 27-1. Typical Recirculating Textile Filter Treatment System.



28. PEAT FILTERS

A peat filter is a treatment system in which septic tank effluent is applied to a approximately two-foot thick layer of sphagnum peat. Peat is an organic material made up of partially decomposed plants. It has a high water-holding capacity, large surface area, and chemical properties that make it very effective in treating wastewater. Un-sterilized peat is also home to a number of microorganisms, including bacteria and fungi. All of these characteristics work together to make peat a very reactive and effective filter.

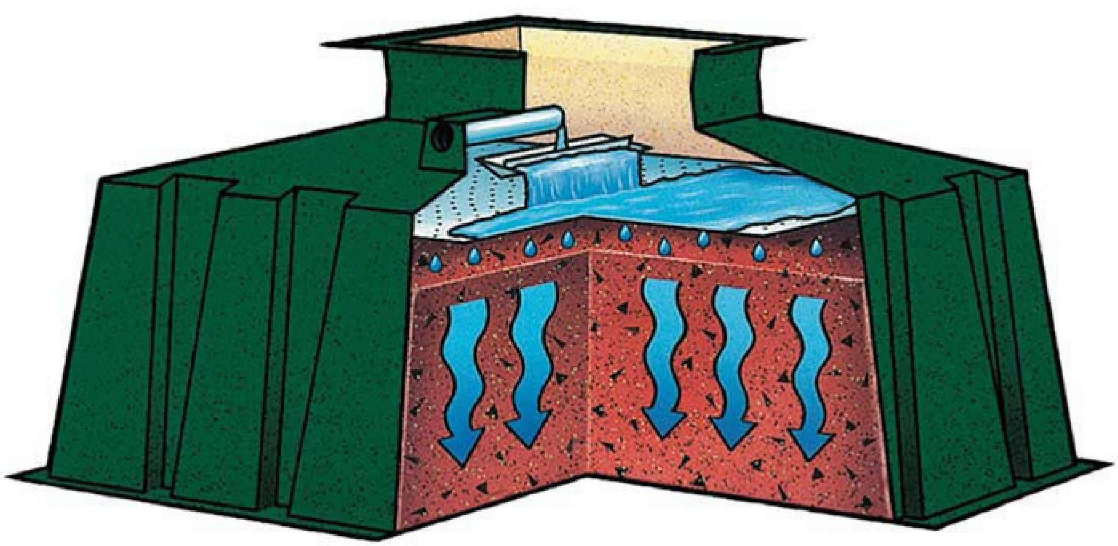
How Peat Filters Work

A peat filter has three parts: the distribution system, the peat itself, where the removal of organic matter and pathogens takes place, and the drain. There are a number of different designs from peat filter suppliers. Some designs use peat in the form of loss peat replaceable bales, and gravity distribution seems to be effective with these products. Filters using a pressure distribution system have been shown to be long lasting and provide good treatment of wastewater, however

The second part of the filter is the peat. The peat layer should be approximately two to two-and-one-half feet deep. Most of the peat used in manufactured systems comes from Canada or Ireland. It is harvested from large natural beds, then screened for the right consistency. Systems using this coarser medium also provide excellent treatment. Systems using local peat or peat from landscape firms have failed in a short period of time and are not recommended.

The third part of a peat filter is the drainage system, consisting of a liner or tank to hold the effluent inside the filter, drain field rock, and four-inch PVC pipe. The drainage system collects the effluent and delivers it to the dispersal area.

Figure 28-1. Typical peat filter



In some cases, the soil treatment system is different from those used to treat effluent from other pretreatment methods. Some companies, have developed a linerless or "bottomless" drain system, in which the effluent from the peat is allowed to drain directly into the soil below. In Nevada, the top of the soil below the peat filter system must have the three-foot separation from saturated soil, bedrock, or confining layer as required in NAC 445A.

Sizing of a soil treatment area under the peat filter has not been full researched and is left up to the manufacture. However the effluent is highly treated and loading rate increases are appropriate. Additional maintenance is required for peat filters**.** All the routine operation and maintenance practices suggested for any onsite treatment system apply to peat filters. In addition, because of the high organic content of the peat itself, maintenance includes periodically replacing the filter media. This means physically removing the layer of peat when it has begun to decompose. Life expectancy of the peat in a filter is estimated to be 8 to 15 years. The rest of the system, including pumps, distribution system, and liner, should last much longer, so system designs should facilitate easy removal and replacement of the peat.

One development in system design is the peat "pod." These pods are modular units of peat that are easily removed and installed. Because of the unique treatment abilities of peat filters they are an alternative solution for some of Nevada's wastewater treatment needs.

29. HOLDING TANKS

A holding tank is a large, watertight tank which receives and stores liquid wastes from a building or other structure. The tank is pumped periodically and the waste removed for disposal off the site by a licensed septage hauler. Pumping such a tank can be quite expensive and for this reason, holding tanks normally should be considered only as an interim measure until a permanent method of disposal is available. Holding tanks may be used as an interim measure while public sewers are under construction or where a building is scheduled to be abandoned in the near future.

The holding tank should have sufficient liquid storage capacity to hold the volume of sewage expected to be discharged from the building over the period of a week or more. Holding tanks should never be designed to be pumped when full. Instead, the schedule of pumping should be such that the tanks are pumped when just above half full. There should be a liquid level indicator or alarm which would readily indicate when the holding tank has reached the level at which it should be pumped. This would tell the owner of the building that there is a potential for overflow and allow him to contact the pumper before this occurs. Sometimes two holding tanks are used in series with a high level alarm sounding when the first tank is full. Holding tanks should be located in secure areas which are not available to the general public. Holding tanks must have easily removal manholes extended to grade, which could represent a safety hazard.

Holding tanks should be considered potential sources of pollution and should be located so as to provide the minimum required separating distances for subsurface sewage disposal systems in the NAC. In some situations it may be necessary to reduce the required minimum separating distance in order to abate a sewage problem. If this is allowed, particular care must be given to sealing and testing the holding tank for leakage and the ground surface around the tank should be paved and graded to carry possible overflow away from wells, watercourses and residences.

The owner of the facility must agree to enter into a contract with a licensed pumper for the regular pumping of the tank. The owner of the facility may be required to furnish the division a copy of a written contract with such a pumper. The pumper must specify the final disposal area for the waste removed from the holding tank. If the volume of waste is large, a letter of acceptance may be required from the operator of the disposal area. The pumping of the holding tank and disposal of the waste should be periodically inspected.

APPLICATION

Holding tanks may only be installed where it can be conclusively shown that no other options are available and only if the local unit of government allows them to be installed. If holding tanks are approved by the local unit of government, a monitoring and disposal plan must be submitted, signed by the owner and a licensed pumper. The owner shall maintain a contract with an approved pumper for disposal and treatment of the sewage wastes.

Holding tanks should only be installed:

- in an area readily accessible to the pump truck under all weather conditions,
- where all separation distances are the same as required for septic tanks, and
- where accidental spillage during pumping will not create a nuisance.

The tank should be protected against flotation under high water table conditions by weight of tank, earth anchors or shallow bury depth. A cleanout pipe of at least 24 inches diameter shall extend to the ground surface be securely locked to prevent unauthorized entry and be provided with seals to prevent odor and to exclude insects and vermin. Holding tanks must be monitored to minimize the chance of accidental sewage overflows. A mechanical or electrical alarm must be activated when the tank has reached 75 percent capacity.

Problems with Holding Tanks

- The cost of hauling the sewage can be expensive.
- The liquid level in the holding tank needs to be continuously monitored in order to prevent an overflow. A high water alarm should be installed.

Adverse weather conditions or road restrictions may prevent hauling when necessary and require that the plumbing systems not be used until the holding tank has been pumped.

A continuous contract must be maintained to be sure that pumping service is available and that the sewage can be treated and disposed of properly.

- The high costs associated with routine pumping of a holding tank may increase the likelihood of illegal disposal of the contents.

30. CLUSTER SYSTEMS

Cluster systems are included in the NAC even though they are regulated under an individual permit. Engineers must meet the minimum requirements found in NAC 445A when designing a cluster system. Experience has shown that "large single septic tank" cluster systems are difficult to oversee because of the unpredictable flows and sewage characteristics going to the community septic tank. Further, residents are hesitant to provide equal funding for ongoing maintenance when larger populated homes are blamed for problems. In many ways, cluster systems encounter many of the same problems associated with mobile home parks.

NDEP does not have statutory or regulatory authority over individual homes. That is why a legal entity (i.e. city, county) must possess the permit, as homeowners associations are difficult to regulate and enforce. If the cluster system fails, there must be an entity with the authority to require the individual homeowners to pay for the necessary repair. Unlike a commercial building, where the business can be closed down, homeowners cannot be immediately evicted.

Engineers should be conservative in selecting a daily design flow, as the application used for community sewer considerations may not be suitable for septic tank treatment. Sludge storage and surge prevention (to prevent solids from washing out of the septic tank) must be taken into account. It is recommended that a design flow rate of 500 gallons per house per day be used for sizing the treatment and disposal system. Smaller flows may be justified, however, the local entity who the permit was issued to must be made aware of the possible problems associated with a smaller system.

The Division recognizes that managed decentralized wastewater systems are viable, long-term alternatives to centralized wastewater facilities, particularly in small communities. The above discussion on "large single septic tank" cluster systems should not dissuade the design engineer from pursuing alternatives such as Septic Tank Effluent Gravity sewers (STEG), Septic Tank Effluent Gravity Pressure sewers (STEP), Vacuum sewers, Grinder pump pressure sewers, etc.

31. OPERATION AND MAINTENANCE CHECKLIST

It cannot be stressed enough that the Operations and Maintenance Manual (O&M) must be easily readable and simple enough for the operator/owner to follow to ensure smooth operations of the system. The NDEP staff engineer performing the review of the document will be focusing on this as they perform the review.

A sample operation and maintenance checklist is included within Appendix N of this document. It should be noted that all operation and maintenance manuals are system specific and the example should only be used as a guide for the minimum required information.

32. DECOMMISSIONING OF SYSTEMS

When a permittee ceases to be covered under the general permit, they must properly abandon the septic tank. It is important to thoroughly pump the tank and either fill it with sand, gravel or other approved material to prevent a safety hazard. The tank may be excavated and removed as well, provided the void is properly filled.

<u>At no time should anybody enter the tank</u>! There could be dangerous gasses that could render a person incapable of escape. There are many cases of people dying from entering a pumped septic tank.

33. ENFORCEMENT/INVESTIGATING SEWAGE PROBLEMS

Whenever a sewage problem is reported, the appropriate administrative authority must investigate. A preliminary, fact-finding investigation should be made, and the occupants of the premises interviewed. An effort should be made to determine the nature of the problem, if one exists, the probable cause, the apparent deficiencies of the sewage disposal system, and what might be done to correct the problem. The following questions might be asked:

1. When did the problem occur? When was the system installed? - (A system which functioned properly for ten to fifteen years usually indicates that the soil in the area is satisfactory)

2. Does the problem primarily occur during the spring? - (Seasonal high ground water is likely)

3 How many occupants or users of the system are there? Are roof leaders, cellar drains, water softeners or swimming pool filters connected to the system? - (System may be loaded beyond its design capacity)

4. When was the septic tank pumped? - (There may be solids clogging the leaching system)

5. Is effluent breaking out at one point only? - (This may be due to broken pipe, poor distribution, traffic or insufficient cover)

6. Does the overflow or backup only occur after heavy rainfall? - (System may be subject to flooding)

7. Does the overflow or backup only occur during heavy use? - (System may have insufficient storage capacity)

Any possible exceptions to regulatory requirements should be discussed at this time, before proceeding with the repair.

Sewage on surface of ground

The field visit must clearly demonstrate that sewage is surfacing. If it is found that sewage is above ground, the following should occur:

1. Direct the permittee to immediately pump the septic/treatment tank. This will provide a minimum of at least one day's storage. Direct the permittee to spread out the exposed effluent for quicker drying and cover with dirt. A barricade should be erected to keep childen, pets, vectors from the area of the spill. Lime may be added to the site of the spill to provide further protection. **Caution: quicklime may burn the skin.**

2. Immediately direct the permittee in writing, to submit engineering plans for repair within two weeks. Pumping must also be maintained until such time as repairs are made. Receipts must be kept for proof of pumping.

3. Owner must notify occupants to reduce water use.

The enforcement investigator may provide written direction on an "Official Notice" pad (see example below) or return to the office and prepare certified correspondence.

CAUSES FOR OSDS FAILURE

Failure of the OSDS may occur due to one or more of the following causes:

-High water table
-Failure to pump out tanks
-Slowly permeable subsoil (clay,etc)
-Failure of dosing pump
-Overloading (hydraulic capacity exceeded)
-Excessive BOD, TSS or other constituents (oil, grease)
-Improper disposal of solvents
-Fine textured material in absorption area
-Organic material in absorption area (mound, etc)
-Inadequate setbacks

Form 33-1.

Nevada Division of Environmental Protection
Bureau of Water Pollution Control
901 S. Stewart Street
Carson City, Nevada 89701

Official Notice

To____ Date_________________________

Address____

NRS 445A.465 Injection of fluids through well or discharge of pollutant without permit prohibited; regulations.

1. Except as authorized by a permit issued by the Department pursuant to the provisions of NRS 445A.300 to 445A.730, inclusive, and regulations adopted by the Commission, it is unlawful for any person to:

(a)) Discharge from any point source any pollutant into any waters of the State or any treatment works.
(b) Inject fluids through a well into any waters of the State.
(c) Discharge from a point source a pollutant or inject fluids through a well that could be carried into the waters of the State by any means.
(d) Allow a pollutant discharged from a point source or fluids injected through a well to remain in a place where the pollutant or fluids could be carried into the waters of the State by any means.

This official notice has been issued to you for the following reason(s):

□ Sewage on the ground/failed system.
□ Failure to properly maintain system.
□ Operating without a permit
□ Sewage discharging to a watercourse.
□ Constructing/modifying system w/o approval

You are hereby directed to immediately:

Official______________________________________ Title______________________

Permittee/Representative_____________________________Title____________________

DYE TESTING

Dye testing of sewage collection and disposal systems may be done for any of the following purposes.

1. To find the source of an obvious sewage discharge when it is not apparent.
2. To establish evidence of sewage overflow or discharge in preparation for legal action.
3. To locate illegal sewage connections to storm sewers.
4. To determine if a subsurface sewage disposal system periodically overflows to ground surface or leaks into a ground or surface water drain.
5. To determine if a water discharge contains sewage.

The water soluble dyes used for these purposes are detectable in very dilute solution. Therefore, the dye is relatively easy to see in water discharges, catch basins, streams and pools of standing water. Most of these dyes are adsorbed to some degree by various minerals in the soil. For this reason, dye may be removed by percolation through even a few feet of soil and is reliable only as an indicator of direct pollution.

Fluorescein dye is normally used for testing subsurface sewage disposal systems since it is less readily absorbed by soils than most other dyes. It is usually used in the form of a sodium salt called uranine, a reddish powder rapidly soluble in water. Normally, a tablespoon of this powder is placed in the toilet bowl and flushed into the sewage disposal system in question. The dye will not stain sanitary fixtures but must be handled carefully to avoid spilling since even a few crystals will stain clothes, floors and furniture. When diluted, fluorescein has a greenish-yellow color which is fluorescent under ultraviolet light. Fluorescein can be detected in dilute concentrations invisible to the naked eye by means of a laboratory fluorometer. It also can be measured in dilute concentrations in the laboratory by acid extraction techniques.

Rhodamine dyes also may be used as sewage tracers. These come in liquid solution, are also fluorescent, and are available in several colors. The more widely used dyes of this type are Rhodamine B which is red, and Sulpho Rhodamine Pink B which has a brilliant pink color. Rhodamine dyes are generally more stable in sunlight than fluorescent and, for this reason, they are frequently used for streamflow measurement. They are more readily absorbed by soil than fluorescent and therefore are less suitable for testing subsurface sewage disposal systems. The variety of available colors allows several such systems to be tested at the same time, thereby expediting dye testing programs involving a large number of systems.

When dye testing a subsurface sewage disposal system, it should be understood that the dye may not immediately show up at the suspected point of discharge. The sewage may first pass through a septic tank or leaching system which will delay the appearance of the dye for one or two days. Therefore it is necessary to periodically reinspect such systems over several days after using the dye before it can be concluded that the system is functioning properly. Dyes are generally unaffected by chemicals normally found in domestic sewage with the possible exception of chlorine bleach. Before using dye, a brief inspection should be made of the plumbing system. It may be found that there is more than one waste line leaving the building. In such a case, each system should be tested separately with dye

34. GRANDFATER CLAUSE

The agency recognizes that existing, properly operating OSDS may not meet all new requirements and may be grandfathered. The division may require an engineer to analyze the OSDS and provide certification that the OSDS is properly functioning for the intended use, prior to inclusion under the general permit # GNEV xxxxx.

Conditions of grandfathering are:

1. System is properly operating.
2. Groundwater is not impacted by the existing system.
3. No expansion is proposed.
4. Community sewer is unavailable at the lot.
5. No threat to public health or environment.

The owner of a grandfathered system must submit an application for coverage under the general permit. Currently, there are no fees for this action.

35. EMERGENCY REPAIR

The NAC requires that all repairs to existing sewage disposal systems must be made in accordance with the prescribed requirements, unless a special exception is granted. This does not mean that every part of an existing sewage disposal system must be brought up to present standards whenever a repair is made. Rather, it means that all new construction must meet the minimum standards. For example, if the leach field shows failure, another field may be installed, provided the engineer determines the soil suitable. The owner would not have to replace the septic tank, provided is was functioning properly.

The division realizes that a timely repair is important for the protection of public health and may exercise flexibility to expedite the repair, provided minimum standards are maintained.

36. CODE EXCEPTIONS

The Nevada Administrative Code allows the division to make exceptions to many of the requirements of the regulations and Guidance Manual for repairs of existing sewage disposal systems. However, remember that there are certain exceptions which the administrative authority cannot and will not make (i.e. certain separation distances, surface discharge).

In order to obtain an exception from any regulatory requirement, either from the local director of health or the State Division of Environmental Protection, an exact description of the requested exception must be submitted. This may be in the form of a plan or sketch, or a verbal description, depending on the situation.

No exception can be allowed unless it has been determined that the repair cannot be made in compliance with regulatory requirements, and that it is unlikely that a nuisance or public health hazard will occur if the exception is granted. All exceptions must be noted on the repair permit and ultimately on the "Permit to Discharge".

As stated the above, in some cases, repairs can be made only by allowing major exceptions to the OSDS regulations. In a case where the exceptions are sufficiently great to raise a question as to the suitability of the system for certain uses, it would be advisable to state this on the "Permit to Discharge". For instance, it might be stated that the system is adequate for seasonal use only or is not sized for laundry wastes, etc.. Or it might be stated that the system was approved for use by the present business/occupants, and may not be adequate for more than fifteen persons.

GUIDELINE FOR LIMITED SYSTEM REPAIRS

The NAC requires that all repairs to existing sewage disposal systems be pursuant to the regulations and Guidance Manual. Exceptions to the code are only granted when necessary. This policy should be the basis of enforcement. When a failure occurs and a health hazard exists, abatement of that health hazard is the prime objective of the repair. Therefore before any decision can be made as to the exceptions which can be granted, it is imperative that the cause of the failure be determined. Once the investigation is completed (many times soil analysis and/or percolation testing will be required) conclusions can be reached as to what corrective action is necessary. In some cases, a "full" repair may not be deemed necessary.

SUGGESTED GENERAL GUIDELINES

1. The code requires the repair of subsurface sewage disposal systems be pursuant to Nevada Administrative Code.
2. Unless code exceptions are necessary due to existing site conditions, all portions of the repair installation shall be installed per code requirements.
3. Elements of the existing system not affected by the repair installation can remain, even if not up to current code requirements (example: old single compartment septic tanks may not have to be replaced, unless defective in some way at the time of repair).
5. The minimum repair parameters shall be based on technical data established during the repair investigation process. If an existing "failed" leaching system is situated within soil conditions which are deemed to be unfavorable for continued operation, or the system can not be salvaged, then that system shall be abandoned and the replacement system "sized" per code requirements. If the soil conditions are acceptable, the leaching system is the proper distance above maximum ground water and bedrock and the failure is attributed to leaching field clogging then a limited enlargement to the original system can be allowed. In that case, the enlargement does not necessarily have to constitute an entirely new system. This will only be allowed as an interim measure if it is anticipated that community sewer service will be serving the area in a reasonable time.

37. TREATMENT WITH CHEMICALS/FIELD RESTING

Chemicals other than hydrogen peroxide should not be used for treating clogged leaching systems since their potentially harmful effects would more than cancel out any temporary beneficial effect that may be produced. Strong acid or alkali drain cleaners are available. These may effectively open clogged sewers but can be harmful when used ahead of a septic tank and leaching system. Acid has an extremely corrosive effect on concrete and may damage septic tanks, sewers and distribution boxes. Alkali is less damaging to concrete and most household drain cleaners contain such caustic chemicals. However, both acids and alkalis will liquefy the grease which comprises the scum layer in a septic tank and coats the inside of sewers. This liquefied grease can be carried into the leaching system where it will further clog the soil.

Strong acids and alkalis also will disrupt sludge digestion. Alkali may produce excessive gas formation which will carry accumulated sludge from the septic tank into the leaching system. High concentrations of acids or caustic chemicals may even adversely affect the permeability of the soil itself by destroying its structural characteristics.

Some drain cleaners contain hazardous chemicals which can pollute ground waters. Chlorobenzene is one such chemical which was widely used in sewage treatment because of its ability to prevent grease clogging. This has been found to be a cancer causing agent which constitutes a very serious threat to ground water when applied to a leaching system. Almost all such organic grease solvents are in the same category.
Certain soil conditioning chemicals are available which are said to increase the soil percolation rate and therefore restore the capacity of clogged leaching systems. This is highly unlikely. Such chemicals may have some marginal benefit when applied to clean or dry soils in such a manner as to coat the individual soil particles. However, they are of no value when applied to clogged, flooded or saturated soils surrounding failing leaching systems. One chemical, copper sulfate has been used to destroy tree roots which are growing into sewers or leaching systems. However, copper sulfate is a groundwater contaminate and therefore it should not be utilized without DEP approval.

SELF-RENOVATION BY "RESTING"

The infiltrative capacity of most clogged leaching systems can be partially restored by taking them out of service for a year or more. This lets the system dry and allows some aerobic decomposition of the accumulated organic solids to take place. The degree of self-renovation is closely related to the soil characteristics and the period of resting. Clogged leaching systems in sands and gravels may regain some of their original infiltrative capacity if allowed to rest.

Systems in clays or silts may never recover more than a small percentage of their original infiltrative capacity no matter how long they are rested. This is probably due to chemical changes which have occurred in the soil structure itself. Self-renovation is greatly hastened if the system is dewatered by pumping when taken out of service. Leaching systems which have been clogged by grease are extremely slow to recover and in many such cases self-renovation may not be a practical consideration.

In all cases, self-renovation of clogged leaching systems by resting should be looked upon as a way of providing future system capacity rather than a method of abating an existing problem because of the long resting period which is required.

38. MOUNDING ANALYSIS

MOUNDING

When directed by the division, a study will be required of the capacity of the surrounding natural soil to absorb or disperse the expected volume of sewage effluent without mounding, overflow or breakout. This is generally used in absorption beds, filter beds etc. where the length to width does not exceed 8:1. A procedure developed by Finnemore and Hantzsche (1983), found in *Small and Decentralized Wastewater Management Systems,* Crites, Tchobanoglous, 1998, may be used:

$$h = H + Z_m/2 \qquad \text{(x – x)}$$

where h = distance from boundary to mid-point of the long term mound, ft.
H = height of stable groundwater table above impermeable boundary, ft
Z_m = long-term maximum rise of the mound, ft.

$$Z_m = (QC/A)\,(L/4)^n\,(1/Kh)^{0.5n}\,(t/S_y)^{1-0.5n} \qquad \text{(x-y)}$$

where Q = average flow, ft^3/d
A = area of disposal field, ft^2
C = constant, see table x-z
L = lengh of disposal field, ft
K = horizontal permeability of soil, ft/d
^{n} = exponent, see table x-z
S_y = specific yield of receiving soil, see table x-zz
t = time since beginning of wastewater application, d

Table 38-1

Groundwater mounding equation constants for Finnemore and Hantzsche equasion

Length-to-width ratio of disposal field	**C**	**n**
1	3.4179	1.7193
2	2.0748	1.7552
4	1.1348	1.7716
8	0.5922	1.7793

Source: Small and Decentralized Wastewater Management Systems, Crites, Tchobanoglous, 1998.

Table 38-2. Representative values of specific yield

Material	Specific yield, %
Gravel, coarse	23
Gravel, medium	24
Gravel, fine	25
Sand, coarse	27
Sand, medium	28
Sand, fine	23
Silt	8
Clay	3

Source: Small and Decentralized Wastewater Management Systems, Crites, Tchobanoglous, 1998.

Example:

Groundwater Mound Height Analysis

Determine the mound height rise for a commercial onsite sewage disposal system. The flow is 5,000 gal/d and the disposal bed is square with a length and width of 120 ft. Use a value of H of 50 ft., a value of K = 2 ft/d (60 min/in) and a Z_0 of 8 ft. The soil beneath the bed is a fine sand. A time value of 3,650 d (10 years) is to be used.

Solution:

1. From Table x-x for a length-to-width ratio of 1, select a value of C = 3.4179 and a value of n = 1.7193.

2. Convert flow units.

$$Q = (5{,}000 \text{gal/d})/(7.48 \text{ gal/ft}^3) = 668.45 \text{ ft}^{3.}$$

3. Make an initial estimate of Z_m and calculate h. Try Z_m = 9 ft.

$$h = \mathrm{H} + Z_m/2$$

$$= 50 + 9/2 = 54.5 \text{ ft.}$$

4. Select a value of 0.23 for the specific yield S_y from table x-z for fine sand.

5. Use equation xxx to calculate Z_m

$$Z_m = (QC/A)\,(L/4)^{n}\,(1/Kh)^{0.5n}\,(t/S_y)^{1-0.5n}$$

$$= (668.45 \text{ x } 3.4179/120^2)(120/4)^{1.7193}\,(1/2 \text{ x } 54.5)^{0.8597}\,(3650/0.23)^{0.1404}$$

$$= (0.1587)\,(346.4)\,(0.0177)\,(3.89) = 3.789 \text{ ft.}$$

6. Use the value of 3.789 ft. for Z_m in eqution to conduct the second iteration.

a. calculate *h:*

$$h = 50 + 3.789/2 = 51.89 \text{ ft.}$$

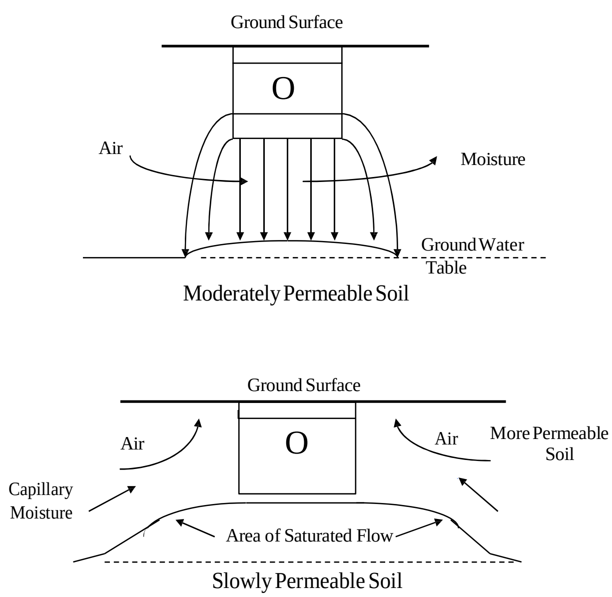
b. recalculate Z_m using h = 51.89 ft.

$$Z_m = (0.1587)\,(346.4)\,(0.185)\,(3.89) = 3.95 \text{ ft.}$$

After 10 years, the groundwater mound is estimated to rise 3.95ft and will be 4.05 ft below the surface. This design would provide the minimum separation to groundwater for adequate biological treatment. If the groundwater mounding were less than the minimum 4 ft of separation, the design would not be acceptable. The design engineer would want to consider a rectangular bed design or increase the bed size.

Note: An iterative approach to solve the equations is necessary because a value of Z_m for equation xx must be assumed to determine h so that equation xxx can be solved for Z_m. Further, the calculation in equation xxxx is sensitive to the groundwater depth when the depth is less than 20 ft.

Figure 38-1. Effluent mounding



Source: Connecticut Department of Health

39. NITROGEN/NUTRIENT LOADING

INTRODUCTION

Groundwater in Nevada is a precious resource that has been protected with the goal of preserving its value as a drinking water supply. This principle guides the Nevada Division of Environmental Protection (NDEP) by setting state drinking water standards as the discharge parameters. Nevada's groundwater standard for nitrate nitrogen is 10 mg/l. However, the division realizes that a 10 mg/l discharge standard for nitrate nitrogen may not be sufficient protection of aquifer systems. Further, NDEP recognizes that wastewater impacts on groundwater are not necessarily limited to nitrogen concerns (i.e. prescription medicine), and that the adequate treatment of all wastewater constituents is necessary to adequately protect both public health and natural resources.

DEP has implemented a Nutrient Loading Approach to achieve this purpose. Implementing an integrated wastewater management permitting approach requires incorporation of comprehensive planning concepts with conventional wastewater permitting which has traditionally focused on proper treatment at the "end of the pipe".

With the nutrient loading approach, DEP is looking at a more resource-focused approach to groundwater permitting that encourages planning to prevent pollution. The nutrient loading approach relies on varied experts from the fields of water supply, turf management and land use planning and applies planning, hydrogeologic and engineering concepts to manage wastewater. The approach also may necessitate coordination with local planning officials and regional planning agencies.

PAST POLICIES

In 1990, NDEP developed a septic tank density policy that was conservative in nature and, attempted to stop the proliferation of Individual Sewage Disposal Systems throughout Nevada. The policy was applied during subdivision reviews and allowed developers/engineers to perform a groundwater study if they did not concur with the policy.

In 2008, DEP enhanced protection of areas sensitive to nitrogen loadings by adopting its Onsite Sewage Disposal System regulations, NAC 445A, to include nitrogen limits in Nitrogen Sensitive Areas.   The 2008 regulations also limited the maximum capacity of an OSDS to 15,000 gallons per day. Discharges greater than 15,000 gallons per day must now be permitted under an Individual Permit, which will require the need for higher levels of wastewater treatment and monitoring to minimize nutrient loadings.

PROBLEMS CAUSED BY EXCESS NITROGEN

Single exposures to nitrate/nitrite exceeding federally established Maximum Contaminant Levels (MCL) may have severe health implications for specific age groups. In addition, the prevention of drinking water supply contamination due to high levels of nitrogen is critical given the expense of restoring drinking water supplies to safe MCLs. Nitrogen is one of the most difficult and expensive contaminants to remove from drinking water because it is a dissolved constituent requiring the use of ion exchange or reverse osmosis technology for removal.

EPA, pursuant to the federal Safe Drinking Water Act, has established an MCL of ten milligrams per liter (10 mg/l) for nitrate in drinking water supplies. Ingestion of drinking water with concentrations exceeding 10 mg/l nitrate may cause death related methemoglobinemia (blue baby syndrome) in infants, and has been linked to deaths diagnosed as S.I.D. syndrome, fetal and birth defects, and miscarriages. To guard against nitrate concentrations reaching these danger levels, the EPA uses 5 mg/l nitrate in public wells as a threshold requiring quadruple the level for testing for nitrate and increased reporting. Likewise, the NDEP Groundwater Protection program uses 5 mg/l as a concentration which signals degradation of water quality and requires investigation and action, as outlined in the nitrogen management areas section (xx).

OVERVIEW OF NUTRIENT LOAD APPROACH

Nutrient loading analyzes how a sensitive aquifer responds to the introduction of contaminants and what the threshold limits are (in terms of mass) before any degradation in quality is realized. Once these limits are determined, a discharge to the aquifer cannot exceed that mass. Conventional DEP permitting practice has relied on maximum concentrations as a permit limit. The conventional approach implies that regardless of flow, a standard level of treatment (i.e., a standard maximum concentration) is adequately protective of any resource. In contrast, the nutrient loading approach would be tailored to the unique characteristics of a given aquifer impacted by the wastewater discharge.

The difference in these two approaches may be illustrated by a comparison between two Onsite Sewage Disposal Systems discharging 20 mg/l total nitrogen, one at a flow of 5,000 gpd and the other at a flow of 15,000 gpd. At these flow volumes, the first plant would discharge 2.08 lb/day (assume 50 mg/l concentration) of total nitrogen and the second would discharge 6.25 lb/day of nitrogen. Assume that the OSDS are located within the watershed of a nitrogen management area where the total maximum daily load (TMDL) has been determined to be 5 lb/day of total nitrogen. With this limitation, the plant discharging 5,000 gpd would be within the TMDL, but the plant discharging 15,000 gpd would not. Note that both plants discharge the same concentration of nitrogen (20 mg/l) in full compliance with the MCL, but discharge drastically different masses of nitrogen into the aquifer. The same type of analysis may be used for other constituents in wastewater that would have potentially adverse impacts on resources.

The nutrient loading approach to regulating wastewater disposal assumes that impacts to groundwater quality and the specific sensitivity of aquifers should be the controlling factors when issuing groundwater discharge permits. Determining the sensitivity of an aquifer and applying land use planning practices to insure that cumulative nitrogen loadings do not exceed thresholds that would adversely influence the resource are an integral part of this loading approach. The approach could be a dilution model that sums all nitrogen inputs from a particular facility and site, and dilutes that nitrogen load (measured in pounds) by the volume of rainwater that percolates down to the water table annually, with consideration of the volume of the receiving aquifer.

REGULATORY FRAMEWORK

To date, DEP has required groundwater discharges permitted pursuant to NAC 445A to meet effluent limits at the point of discharge. DEP recognizes that the existing effluent limit of 10 mg/l nitrate nitrogen at the discharge point may not fully account for the resulting impacts to nitrogen sensitive aquifers or the cumulative effect of the discharge and that of other sources. The purpose of this guidance is to allow permittees the *option* of demonstrating the compliance of their discharge with the General Permit GNEVOSDS-41000 through an alternative nutrient loading approach that establishes an ambient nitrogen concentration for the overall site that cannot be exceeded at any downgradient wells located at the property boundaries. To accomplish this, NDEP would require a compliance point downgradient of the point of discharge at the property boundary. NDEP believes that this nutrient loading approach represents a protective, more comprehensive means of assessing and addressing the impacts of the discharge on the ambient groundwater quality, particularly with respect to nitrogen sensitive aquifers that also affords permittees greater flexibility in the use of wastewater treatment technologies.

40. NITROGEN LOADING ANALYSIS

When directed by the division, a study will be required of the capacity of the surrounding natural soil to assimilate or disperse the expected volume of nitrogen from the OSDS without groundwater degradation. The impact of nitrate nitrogen on the groundwater quality is dependent on the background level of nitrogen, the nitrogen loading and water balance.

In accordance with "*Small and Decentralized Wastewater Management Systems*", Crites & Tchobanoglous (1998), the following procedure is suggested to determine nitrogen loading:

1. Determine the wastewater loading rate. The regulations restrict the loading rate to a maximum of 1,000 gallons per day per acre..
2. Determine the nitrogen concentration in the applied effluent. (Use a minimum 60 mg/l unless the actual concentration has been determined).
3. Calculate the nitrogen loading. Multiply the nitrogen concentration by the wastewater loading:

$$L_n = L_w C_n F$$

Where N loading = lb/ac·d (kg/ha·d)
L_w = wastewater loading, gal/ac·d (m^3/ha·d)
C_n = nitrogen concentration, mg/L (g/m^3)
F = conversion factor, 8.34 lb/[10^6 gal·(mg/L)] (kg/10^3)

4. As an example, the nitrogen loading is

$$L_n = (1{,}000 \text{ gal/ac·d})(60 \text{ mg/L})(8.34)(10^{-6})$$

$$= 0.5 \text{ lb/acre·d}$$

Therefore, a commercial OSDS with daily flow of 5,000 gallons per day would discharge:

0.5 lb/acre·d x 5 acres = 2.5 lb nitrogen/day at the site.

2.5 lb nitrogen/day x 365 days = 912.5 lb nitrogen/year.

Assuming only 75% of the nitrogen reaches the aquifer, the load is almost 700 lb/year over a 5 acre parcel.

A qualified engineer or hydrologist should determine the impacted area of the aquifer and determine if the anticipated nitrogen load will elevate the groundwater levels to be an environmental or public health concern.

It is not in the scope of the guidance manual to lay out the analysis for such a determination. Rather the design professional must provide the information in a defensible format to the division.

41. HYDRAULIC ANALYSIS

GENERAL PRINCIPLES

Hydraulic analysis consists of applying basic hydraulic laws to the flow of sewage effluent through soil. However, there are certain differences between the way that leaching systems are assumed to function by hydraulic analysis and the way that they actually do function. For instance, hydraulic analysis assumes a constant and continuous flow of sewage effluent through saturated soil. Under normal conditions, sewage effluent is dispersed into the soil surrounding leaching systems in an unsaturated and discontinuous flow. Depending on seasonal conditions, effluent may be dispersed by atmospheric evaporation or may accumulate within the leaching system or surrounding soil. However, the continuous, saturated flow conditions assumed for hydraulic analysis probably will occur before a leaching system fails.

A mound of saturated soil will form under the leaching system where the hydraulic capacity of the surrounding soil is limited. This will rise to surround the leaching system as failure approaches. In this situation, the leaching system itself will be continuously filled with sewage effluent causing fluctuating sewage discharges from the building served to be equalized into a steady flow into the soil. Where the soil surrounding a leaching system is poor or where there is high ground water, flat slopes or underlying bedrock or hardpan, hydraulic analysis is a useful tool for estimating the maximum capacity of the leaching system to disperse effluent into the surrounding soil without breakout.

Hydraulic analysis may be required to indicate the nature and probable magnitude of the hydraulic limitations on a particular site so that the leaching system can be designed to overcome those limitations. When hydraulic analysis is used for design purposes, the accepted practice is to make an analysis based on existing site conditions, maximum ground water levels and conservative sewage flow estimates. This results in a conservative leaching system design.

DARCY'S LAW

The flow of sewage effluent and ground water through soils may be analyzed by using a hydraulic formula referred to as "Darcy's Law". This formula assumes a constant and continuous gravity flow through unconfined "channels" or areas of saturated soil. In its simplest form, Darcy's Law states that the velocity of a liquid moving through an unconfined channel under gravity conditions is proportional to the loss of hydraulic head per unit length of flow path, or:

$$V = K X (H1 - H2 / L)$$

Where:

V = Velocity of flow
K = Coefficient of permeability
H1-H2= Loss of hydraulic head
L = Length of flow channel

Darcy's Law generally is used in a modified form for hydraulic analysis of sewage and shallow ground water flow. In this analysis, the main concern is the volume of water which will flow through an area of saturated soil in a given period of time. This sometimes is called the hydraulic conductivity of the soil. The equation is usually written:

$$Q = K i A$$

Where:

Q = The hydraulic conductivity or saturated flow rate, usually expressed in cubic feet per day.

K = The coefficient of permeability of the soil through which the saturated flow takes place. This is usually expressed in feet per day.

i = The slope of the hydraulic grade. When used in hydraulic analysis of sewage or shallow ground water flow, only the horizontal length of the flow channel normally is considered since the flow channel usually follows the ground surface and is relatively flat. Therefore, i normally is expressed as a dimensionless fraction or decimal representing a vertical drop divided by a horizontal distance.

A = The cross sectional area of saturated flow, usually expressed in square feet. It is evident from the form of this equation that if either the permeability, the slope of the hydraulic grade or the cross sectional area of saturated flow is limited, the hydraulic conductivity of the soil is likewise limited.

DETERMINING SOIL PERMEABILITY

The coefficient of permeability, or simply the permeability of the soil, is a measure of how easily liquid passes through a particular soil. This depends on such things as the distribution of the particle sizes in the soil and their shape and geometrical arrangement. The permeability of naturally occurring soils can be quite variable due to stratification of different particle sizes, varying degrees of compaction and the existence of naturally occurring drainage channels formed by percolating ground water. It is not unusual for the permeability to vary by a factor of 1,000 in small samples taken from various soil layers at different locations or depths on the same site. There also may be considerable difference between the horizontal and vertical permeability in the same soil at the same location and depth. Horizontal permeabilities usually are much greater than vertical permeabilities due to the effect of layering, particle orientation and natural drainage channels. Because of this variability, considerable judgment must be used in determining the permeability of naturally occurring soils.

While the permeability is a definite physical property of a soil, it should be understood that the overall permeability of any site or any portion of the naturally occurring soil on the site can only be estimated. It cannot be measured directly. Estimates of site permeability can be based on four general types of measurements or observations.

1. Estimates based on ground water observations made on the site.
2. Estimates based on in-place testing on the site.
3. Estimates based on testing of soil samples.
4. Estimates based on soil identification and reference to available data.

The most appropriate method for estimating the permeability depends mainly on the soil and site conditions. The season or time of year also is an important consideration since most field tests or observations depend on ground water being present. In many cases, the most reliable method of estimating the overall site permeability for sewage disposal purposes is by observations of ground water levels on the site. This is particularly true where shallow or stratified soil layers are involved.

DETERMINING THE HYDRAULIG GRADE

The slope of the hydraulic grade depends on the direction and slope of the flow channel. Where layers of compact hardpan or bedrock underlie a leaching system, sewage effluent flows in a generally horizontal direction following the ground surface. In this case, the slope of the hydraulic grade is equal to the difference in elevation of the underlying impervious layer at two observation pits, divided by the distance between the pits. If only horizontal distances are considered and minor variations in depth of underlying impervious layer are disregarded, the slope of the hydraulic grade may be taken to be equal to the slope of the ground surface.

A mound of saturated soil will form under the leaching system where there are hydraulic constraints in the surrounding soil. This mound of saturated soil constitutes part of the effluent flow channel and its formation increases the slope of the hydraulic grade of the flow channel. Therefore, it is evident that constructing a leaching system in fill above the surrounding ground surface will increase the slope of the hydraulic grade and enhance the ability of the system to disperse effluent into the surrounding soil. Increasing the slope of the hydraulic grade in this manner normally is not considered when using hydraulic analysis to design a leaching system because such systems should be designed on conservative assumptions.

Where leaching systems are located over underlying impervious layers, it may be assumed that the upper end of the hydraulic grade is at the bottom of the proposed leaching system but not higher than the original grade. The lower end can be assumed to be the elevation of the impervious layer at a distance 50 feet downslope. The 50 foot distance represents the normal maximum horizontal extent of the saturation mound, as indicated by field experience. Similarly, where there is no underlying boundary layer, the lower end of the hydraulic grade may be assumed to be at the elevation of the ground water table 50 feet downslope from the leaching system.

DETERMINING THE CROSS-SECTIONIONAL AREA OF SATURATED FLOW

Where flow is in a generally horizontal direction due to underlying impervious layers, slowly permeable soil or high ground water, the cross-sectional area of saturated flow is measured in a vertical direction. The maximum cross-sectional area available to disperse sewage effluent on a hillside is equal to the depth of unsaturated soil downslope from the leaching system. Saturated flow will occur in all directions where the ground is level.

DETERMINING THE REQUIRED HYDRAULIC CONDUCTIVITY

The naturally occurring soil surrounding leaching systems should be capable of hydraulically dispersing the entire volume of sewage effluent discharged into it on a continuous basis. Ideally, it also should be capable of dispersing any ground water flowing into the area of the leaching system from higher elevation, as well as any rain falling in seasonal ground water in most hydraulic analyses made for small leaching systems.

42. EFFECTIVE LEACHING AREA

In calculating the effective leaching area of a standard (i.e. rock filled) trench, the trench sidewalls are used. Because the trench bottom rapidly develops a biomat that retards percolation, it is not considered in the leaching area formula. As an example, a leach field is constructed with 5 lines @ 100 ft. The trench depth below the bottom of the leach line is 3 ft. Therefore each trench has:

100 ft. long x (3 ft. sidewall + 3 ft. sidewall) = 600 ft^2 absorption area per trench.

600 ft^2 absorption area per trench x 5 trenches = 3,000 ft^2 absorption area.

Absorption bed effective area is based on trench bottom. Because the air pathway to the biomat is more difficult on a bed versus a narrow trench, sizing must be conservative.

43. SUBSURFACE IRRIGATION SYSTEMS

Such systems are not included in the NAC, and require special approval of state and local health authorities. NDEP will not permit subsurface irrigation systems. However, since local health authorities may allow their use, the following is offered:

Subsurface irrigation systems are systems of distribution pipe buried just below ground surface for the disposal of partially stabilized sewage effluent. Trench construction details vary, but they are normally very shallow and narrow, frequently only 12 inches wide and 12 to 18 inches deep. A relatively long length of distribution pipe is necessary to produce maximum liquid dispersal and to provide the storage volume which is lacking in the trench. Application rates are normally less than 1.0 gallons per lineal foot per day. Slotted or filter fabric wrapped plastic pipe laid in a washed sand or gravel backfill may be used, or perforated plastic pipe laid in pea stone. The sewage effluent must be partially stabilized before being applied to the leaching system in order to reduce clogging around the distribution pipe. Normally a subsurface sand filter or effluent filter is used for this purpose

44. LEACHING SYSTEMS IN HIGHLY PERMEABLE SOILS

The concern with these soils is poor distribution and little or no treatment by overloading of the trench before the biomat is formed. Soils that contain a large percentage of rocks or coarse particles (greater than two millimeters) provide poor treatment, due to the "dilution" of the soil.

SYSTEMS FOR RAPIDLY PERCOLATING SOILS

Soils in this category have low treatment capabilities and require special design considerations to design systems that will overcome this limitation. Soils with a minimum percolation rate faster than 1 inch a minute are considered to be highly permeable. Subsurface disposal systems in such soils require special design consideration in order to assure that they will not pollute wells, and ground and surface waters. In general, a determination should be made of the direction and rate of ground water movement, and a review should be made of the adequacy of the lateral separating distances between the subsurface disposal system and down-gradient wells or watercourses. If necessary, separating distances should be increased, or the design of the subsurface disposal system modified to reduce possible pollution.

PERCOLATION RATE FASTER THAN 1 MPI; COARSE SANDS AND GRAVELS

If the approach is to alter the permeability of the soil by excavating and replacing it with less permeable fill or by mixing silt or loam with the existing soil, great care must be taken. Many failures occur due to poor construction techniques.

Soil treatment systems in soils with percolation rates faster than 1 mpi, or in coarse sand and gravel, must use one of the following:

a mound system, or
a liner system.

A liner system consists of trenches with at least 12 inches of clean sand placed between the drain field rock and the coarse soil along the excavation bottom and sidewall. The treatment area is sized at 0.60 or 1.67 sqft/gal/day, or if pressure dose is 1 sqft/gal/day see pressure distribution section.

45. ENGINEERED FILLS

Engineered fill may be used, provided two conditions are met:

1. The soil conditions in the area of the proposed leaching system are suitable for sewage disposal purposes.
2. The surrounding naturally occurring soil can adequately absorb or disperse the expected volume of sewage effluent without overflow, breakout, or detrimental effect on ground or surface water.

Even though engineered fills are not optimal for wastewater treatment and disposal, there is nothing in the NAC to prohibit the placement of fill over any soil, although approvals for filling may need to be obtained from the local planning and zoning or wetland agencies. Certain sites with high water table conditions which are unsuitable for sewage disposal may be made suitable by filling. However, other sites, such as those consisting of exposed bedrock, cannot be made suitable by filling because sewage effluent eventually would pass through the fill and seep to ground surface. Therefore, no filling will be allowed where soil conditions are unsuitable. Ultimately, the acceptability of the site will depend on the results of tests made after the fill has been placed and compacted. In some cases, a special study will be required of the capacity of the surrounding naturally occurring soil to absorb or disperse sewage effluent before any approval is given. Because of these uncertainties, owners and builders are required to have a qualified professional engineer study the feasibility and cost of the necessary site improvements before placing any fill where soil conditions are classified as unsuitable for sewage disposal.

The best application for an engineered fill would be the situation where the soil is permeable, but has a high ground water table. Filling allows the system to be raised sufficiently above the observed maximum ground water level.

TYPE OF FILL MATERIAL, PLACEMENT AND INSPECTION

A clean, granular sand and gravel fill should be used in the area of leaching systems. The fill should contain no more than 5% fines, and preferably no more than 2%. Fines are clay and silt sized particles which pass the #200 sieve. Even a small amount of these particles will severely reduce the ability of the fill to transmit water, particularly when compacted. It has been determined that a significant number of leaching systems installed in select fill fail because the material brought to the site did not meet the above standard. In order to reduce the risk of fill related failures it is recommended that the following guidelines be adhered to:

1. “Select fill” shall be comprised of clean sand and gravel, free from organic matter and deleterious substances. Mixtures and layers of different classes of soil should not be used. The fill material should not contain any material larger than three (3) inches. A sieve analysis should be performed on a representative sample of the fill. Up to 45% by weight of the fill sample may be retained on the #4 sieve. The material that passes the #4 sieve is then dried and reweighed and the sieve analysis started. The sieve analysis must demonstrate that the material meets each of the following specifications:

Table 45-1.

SIEVE SIZE EFFECTIVE PARTICLE % THAT MUST SIZE PASS SIEVE

Coarse Sands	#4 - #10	± 4.75 mm - 2.0 mm	# 4	100%
Medium Sands	#10-# 40	± 2.0 mm - 0.425 mm	# 10	0% - 100%
Fine Sands	#40-100	± 0.425 mm - 0.15 mm	# 40	0% - 50%
Very Fine Sands	#100-#200	± 0.15 mm - 0.075 mm	#100	0% - 20%
Silts and Clay s	#200	< 0.075 mm	#200	0% - 5%

2. The contractor should meet with the engineer on the site to review procedures, and to agree on the fill material to be used. Inspection and testing of the fill material may be necessary unless an approved commercial sand or gravel bank is to be used which can supply material which will meet the above criteria. The location of the area to be filled should be marked by the engineer at this time.

3. The area should be cleared and rough graded. All stumps and large boulders should be removed. If necessary, top soil should be stripped and the area plowed or scarified. Prior to placement of the fill, the bottom surface of the excavation shall be scarified. Fill material should be stockpiled at the edge of the excavation until a suitable base of select material has been spread over the entire exposed area. Fill should not be placed during periods of heavy rains, snow storms or freezing temperatures. If water is present at the bottom of the excavation following a period of rain, the excavation shall be dewatered as necessary and rescarified. The excavation for and placement of “select fill” shall extend a minimum of five (5) feet laterally in all directions beyond the outer perimeter of the leaching system and to a depth to make contact with naturally occurring pervious material.

4. The engineer should inspect the prepared site and set grade stakes before “select fill” is placed.

5. “Select fill” should be placed on the edge of the site and spread over the prepared area with a bulldozer. No trucks should run over the fill until 12 inches of fill has been placed. The remainder of the fill should be placed in layers 8 to 12 inches deep and compacted by normal bulldozing or other construction equipment. Filling and compaction should be discontinued during rain storms and for 24 hours thereafter. All fill should be placed and compacted before any of the leaching system is installed.

6. If there is any question as to the characteristics of the fill material being placed, a minimum of one representative sample (made up of a composite taken from numerous locations in the fill section) may be taken from the in-place fill for a system serving a single family residence. The sample should be tested for compliance with the grain size distribution noted in Item 1, above. For larger systems, one sample may be taken for each day the filling operation is conducted.

7. Observation pits should be dug when there is any question as to the nature or depth of the fill, and percolation tests shall be conducted whenever the entire leaching structure (bottom and sides) will be situated within the fill package or when it appears that the fill may not be suitable.
An engineering compaction test is required. Inspection of the upper surface of fill can be misleading, particularly if the fill is clean and has not recently been compacted. The top few inches of a clean and or gravel fill, lacking binding material, may appear loose and insufficiently compacted. However, digging a few inches into the fill will usually show adequate density in the underlying material.

The reason clean bank-run sand or gravel makes the best fill for leaching systems is because its permeability is not greatly reduced by compaction. This is not true for most soils. Loamy soils, containing a well graded mixture of sand, silt and clay, may have a permeability in the desired range when found in their naturally compacted state. However, they can be easily compacted by standard construction equipment, and their permeability can be reduced to an unacceptable level. On the other hand, it is relatively difficult to compact a clean mixture of sand and gravel by more than 5% to 10%, and even when compacted to over 90% of optimum density, it has a sufficient permeability for leaching purposes. Native soil normally should not be used for fill in the area of the leaching system itself. However, a reasonably workable native soil could be used for cover over a leaching system or for forming the fill embankment outside the leaching area.

FILL COMPACTION

Generally, all sand or gravel fill should be mechanically compacted at the time that it is placed. Clean sand and gravel is readily compacted by the methods described above, and is unlikely to become over-compacted. Compaction tests seldom are necessary as long as this material is spread in layers during placement. Where there is a question, a modified optimum density test (ASTM D1557, Method C) may be required. A compaction of 90 to 95% of optimum usually is used as a standard for clean sand and gravel since it can be readily obtained and such material still is sufficiently permeable for leaching purposes at this density. Another important reason for mechanically compacting sand and gravel fill when it is placed is to prevent the possibility of silt migration, which can occur when this material is loosely placed and subjected to rainfall during or after placement. In its natural state, silt particles have been retained in the smaller void spaces in the sand and gravel and do not move.
However, they become loosened when the soil is disturbed during excavation and handling. If the fill is loosely placed, rainfall will cause the small silt particles to migrate, possibly forming layers within the fill or clogging the leaching system itself.

SOIL REPLACEMENT FILLING

Uneven mechanical compaction and subsequent settling can be a problem in deep fills. This frequently occurs when trucks or earth moving equipment heavily compact the embankment slope on a deep fill, but neglect the center portion of the fill. When sewage is applied to the leaching system, the center of the filled area may settle forming a "dish" or basin which retains rainfall. This can flood the leaching system and cause failure. The problem can be prevented by over filling the center portion, forming a crown which compensates for possible settlement.

Loamy soils may not have sufficient permeability if mechanically compacted to 90% of optimum density. Therefore, native soils or loamy fill should not be compacted in the same manner as sand and gravel, unless they are to be used only for covering the leaching system. Instead, they should be allowed to compact naturally over a period of 3 to 6 months, preferably during a wet season.

Rainfall and settlement will compact these soils to about 85% of optimum density, which is about the same as the density of the root zone in most naturally occurring soils. Depending on the composition of the fill, the permeability should remain within the acceptable range.

OTHER DESIGN CONSIDERATIONS

Freshly placed fill is easily eroded. Therefore, erosion control measures should be taken as soon as final grading is completed. Uphill drainage should be intercepted and diverted by means of a berm or swale. The fill should be protected with mulch, netting or other method if it is too late in the season to establish a grass cover before winter. Placement and compaction of clean sand and gravel fill on steep slopes is difficult because of the looseness of this material. In such a situation, some contractors will first form an embankment on the downhill side, either by cutting into the existing soil or by placing large boulders, top soil and stumps in the area. This is said to hold the fill in place. Such practices are extremely dangerous, since a channel of loosely compacted or permeable material can be formed which allows sewage effluent to pool.

46. USE OF TIRE CHIPS IN LIEU OF GRAVEL

Two (2) inch nominal tire chip aggregate are tire chips approved for distribution by the Division of Environmental Protection (DEP) for beneficial use in leaching systems in accordance with NAC. Two inch nominal tire chip aggregate shall be graded or sized in accordance with ASTM D 448 size number 2, 24 or 3, and shall have at least 95% by weight ranging from ½ inch to a maximum of 4 inches in any one direction. Such aggregate shall have no more than 2% by weight of fines (< #200 sieve) based on a wet sieve. Such aggregate shall also have not more than 5% by weight of tire chips containing wire protruding more than ½ inch from the sides of the tire chips.

In areas where high groundwater occurs, care must be taken to ensure buoyant forces do not heave the chips upward, resulting in a raised absorption area.

APPENDIX A

Permit Application

Nevada Division of Environmental Protection
Bureau of Water Pollution Control
NOTICE OF INTENT (NOI) FOR COVERAGE UNDER
GENERAL PERMIT GNEVOSDS-41000
FOR SUBSURFACE LAND APPLICATION SYSTEMS

NEW FACILITY

I. Name of owner/organization: ______________________________

Address: ______________________________

City: ______________ State: __________ Zip Code: __________

County: ______________ Phone: ______________

II. Name of facility with proposed subsurface disposal system: ______________

____

A. Mailing Address:

Contact Person: ______________________________

Address: ______________________________

City: ______________ State: __________ Zip Code: __________

County: ______________ Phone: ______________

B. Site Location:

Address: ______________________________

City: ______________ State: __________ Zip Code: __________

County: ______________ Phone: ______________

C. List the latitude and longitude to the nearest 15 seconds for the treatment facility:

LATITUDE			LONGITUDE		
Deg.	Min.	Sec.	Deg.	Min.	Sec.

D. Attach a map with the site location identified.

III. Description of subsurface land application system and user information: Attach a copy of the Onsite Sewage Disposal System Engineering Submittal.

A. Briefly describe the pre-treatment process (attach a process flow chart).

____
____
____

B. Briefly describe the subsurface disposal system (attach site layout).

____
____

C. Type of waste: Domestic only _____ other ______
(If other, please attach a detailed explanation of the type of wastes)

D. Briefly describe the method of sludge handling and treatment:

____
____
____

E. Design flow (average & peak daily) of facility:
Average daily___________________MGD
Peak daily ___________________MGD
Infiltrative Area____________________________________(Acres)
Reserve Area_____________________________________(Acres)

F. A copy of the following items must be attached as part of this NOI. Please check off each item to ensure it is attached. Do not submit this NOI application if you have not checked off each item.

a. [ ] Engineering Design Report (including soils investigation)
b. [ ] Maintenance and Operations Agreement (if applicable)
c. [ ] Sewer Use Agreement (if applicable)
d. [ ] Operations and Maintenance Manual
e. [ ] Onsite Sewage Disposal System Engineering Submittal

IV. Certification:

a. This section must be signed by the design engineer.

b. I certify that all requirements of the Onsite Sewage Disposal System Engineering Submittal form have been met and that the Nevada Administrative Code, Guidance Manual and other referenced guidelines will be followed in the design and construction of this system.

c. I certify that the Engineering Design Report, Maintenance and Operations Agreement, Sewer Use Agreement (if required), Operations and Maintenance Manual, and the Onsite Sewage Disposal System Engineering Submittal form are attached and complete.

d. I certify under penalty of law that this document and all attachments were prepared under direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Printed Name: ______________________________

Title: ______________________________

Representing: ______________________________

Signature: ______________________________

Seal (Signed and dated)

NOTICE OF INTENT (NOI) FOR COVERAGE UNDER
GENERAL PERMIT GNEVOSDS-41000
FOR SUBSURFACE LAND APPLICATION SYSTEMS

EXISTING FACILITY

I. Name of owner/organization: ______________________________

Address: ______________________________

City: ______________ State: __________ Zip Code: __________

County: ______________ Phone: ______________

II. Name of facility with subsurface disposal system: ______________

A. Mailing Address:

Contact Person: ______________________________

Address: ______________________________

City: ______________ State: __________ Zip Code: __________

County: ______________ Phone: ______________

B. Site Location:

Address: ______________________________

City: ______________ State: __________ Zip Code: __________

County: ______________ Phone: ______________

C. List the latitude and longitude to the nearest 15 seconds for the treatment facility:

LATITUDE			LONGITUDE		
Deg.	Min.	Sec.	Deg.	Min.	Sec.

D. Attach a map with the site location identified. Include the locations of any groundwater monitoring wells.

III. Attach a description of the subsurface land application system and user information.

A. Briefly describe the pre-treatment process (attach a process flow chart).

____
____
____

B. Briefly describe the subsurface disposal system (attach site layout).

____

C. Type of waste: Sanitary only _____ other ______
(If other, please attach a detailed explanation of the type of wastes)

D. Briefly describe the method of sludge handling and treatment:

____
____
____

E. LAS Area:
Infiltrative Area______________________________________(Acres)
Reserve Area____(Acres)

F. Give the estimated volume and strength of treated sanitary wastes that will be injected in the subsurface fluid distribution system on an average daily and peak daily basis?

ITEM	FLOW (gpd)	BOD_5	TSS	O&G	NH_3-N
Daily					
Peak					

G. Is there an underdrain collection system installed to lower the groundwater table? _______________

H. For privately owned and operated systems, a copy of the following items must be attached as part of this NOI. Please check off each item to ensure it is attached. Do not submit this NOI application if you have not checked off each item.

a. [ ] a copy of a Maintenance and Operations Agreement,

b. [ ] a copy of the construction permit (or other vehicle) for the existing system, showing the location of the existing system and the set-aside area for replacement. If such construction permit is not available, then the owner may submit a site plan showing the location of the preapplication treatment system, the subsurface fluid distribution system, the point of application, and the replacement area,

c. [ ] a copy of the Sewer Use Agreement to regulate discharges into the sewerage system,

d. [ ] A copy of the operations manual for the system that was approved by the original permitting agency is available at the plant, or if an approved operations manual is not available, I have attached a schedule for the development of an operations manual and understand that this schedule is subject to final approval from EPD and that a copy of the operations manual will be available at the plant after the final schedule date.

e. [ ] Trust Indenture: Non-governmentally owned entities must execute a trust indenture with a local government body or other trustee approved by the Division to assure continuity of operation in the event of operational or financial default by the owner. One of the following is attached:

   i. A copy of the executed trust indenture, or
   ii. A schedule for obtaining a trust indenture, which I understand, is subject to final approval from EPD. A copy of the executed trust indenture will be provided to EPD on or shortly after the final schedule execution date.

V. Certification:

a. This section must be signed by the following:

   i. For a corporation, by a responsible corporate officer. A corporate officer means:

      1. a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy o or decision-making functions for the corporation; or

      2. the manager of one or more manufacturing, production, or operating facilities, if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

   ii. for a partnership or sole proprietorship, by a general partner or the proprietor; or

   iii. for a municipality, State, Federal, or other public facility, by either a principal executive officer or a ranking elected official.

b. I certify that the Construction Permit, Maintenance and Operations Agreement, Sewer Use Ordinance, (publicly owned systems), Sewer Use Agreement (privately owned systems) and the Trust Indenture (privately owned systems) or a schedule for obtaining a Trust Indenture are attached and complete.

c. I certify under penalty of law that this document and all attachments were prepared under direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Printed Name: ______________________________

Title: ______________________________

Representing: ______________________________

Date: ______________________________

Signature: ______________________________

APPENDIX B

Basic Design Criteria

SEWER MAINS

All sanitary sewers should be designed to give a mean velocity of at least two feet per second at peak design flow based on Manning's formula with n = 0.013, or in accordance with the following table.

Sewer Size	Minimum Slope feet/100 feet	Approximate Capacity at Minimum Slope (gpd)/(cfs)
4”		
6"	0.60	271,000/0.42
8"	0.40	520,000/0.80

When velocities greater than 15 feet per second are expected, provisions should be made to protect against displacement and erosion of the pipe.

In general, the minimum size of sanitary sewers shall be eight (8) inches. However, six (6) inch sanitary sewers may be used as sewers for apartments, mobile home parks, camps, schools, restaurants, and other semi-public operations, provided their hydraulic capacity is not exceeded because of short run-off periods (high peak flows).
The lateral connections shall comply with standards shown in this policy and should be made of the same material as the street sewer whenever possible to minimize infiltration from the connection between the street main and house lateral. When joint material and/or dimensions are not compatible, a commercial adaptor shall be provided.
When a smaller sewer discharges into a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing this result is to place the 0.8 depth point of both sewers at the same elevation.
When a larger sewer discharges into a smaller one, the invert of the smaller sewer should not be raised to maintain the same energy gradient.

Roof drains, foundation drains, and all other clean water connections to the sanitary sewer are prohibited.

There shall be no physical connection between a public or private potable water system and a sewer, or appurtenance thereto, which would permit the passage of any sewage or polluted water into the potable supply.

If possible, sanitary sewers and sewage force mains should be laid with at least a 10 foot horizontal separation from any water line. Sewers (or sewage force main) may be laid closer than 10 feet to a water line if it is laid in a separate trench and elevation to the crown of the sewer (or sewage force main) is at least 18 inches below the bottom of the water line. If it is impossible to maintain the 18-inch vertical separation when the sewer is laid closer than 10 feet to the water line, the sanitary sewer shall be encased in concrete or constructed of water line type materials which will withstand a 50 psi water pressure test.

If a sewage force main is laid closer than 10 feet to a water line, in no case shall the sewage force main be laid such that the crown of the sewage force main is less than 18 inches below the water line.

Whenever a sanitary sewer and water line must cross, the sewer shall be laid at such an elevation that the crown of the sewer is at least 18 inches below the bottom of the water line. If it is absolutely impossible to maintain the 18-inch vertical separation, the sanitary sewer shall be encased in concrete or constructed of water line type materials which will withstand a 50 psi pressure test. These requirements will extend for a distance of 10 feet, measured perpendicular, on both sides of the water line.

Construction of sewers in stream beds is not acceptable except for stream crossings. Whenever a sewage force main and water line must cross, the sewage force main shall be laid at such an elevation that the crown of the sewage force main is at least 18 inches below the bottom of the water line.

Manholes, if required shall be installed at the end of each line 150 feet or greater length, at all changes in grade, size, alignment, and at all pipe intersections. Manholes shall also be installed at distances not greater than 400 feet. Cleanouts may be installed at the ends of lines which are less than 150 feet in length.

Drop manholes are to be used when the sewer entering the manhole is two (2) feet or greater above the manhole invert. When the difference in elevation between the incoming sewer and the manhole invert is less than two feet, the manhole invert should be filleted to prevent solids deposition. Manholes may be either poured in place or precast concrete. Concrete construction shall conform to ASTM C-478 with joints between sections conforming to ASTM C-443.

The minimum diameter of manholes shall be 48 inches.
The flow channel through manholes should be made to conform in shape, slope, and smoothness to that of the sewers. A bench shall be provided on each side of the manhole channel. The bench should be located one (1) pipe diameter above the invert and slope no less than ½" per foot to the channel.
Manhole covers can be adjusted to grade by the use of no more than 12 inches of precast concrete adjusting collars. Watertight manhole covers should be used in street locations. In other areas, the manhole casting should be adjusted so that the top is slightly above grade to prevent the entrance of surface water. Watertight manhole covers shall be used in all locations which may be flooded by runoff or flooding.

Acceptable gravity sewer pipe materials include: acrylonitrile butadiene styrene (ABS), clay, concrete, ductile iron (DI), polyvinyl chloride (PVC), styrene rubber (SR), or any other material specified in ASTM specifications as being suitable for this use.

LOCATION OF OSDS

OSDS' should be located close enough to the building being served so as to optimize maintenance of the plant. They should be located closer to the building(s) being served than to existing or reasonably anticipated future buildings to minimize nuisance on adjacent property. Extended aeration plants should be located at least 250 feet from neighbor occupied buildings. A housed treatment plant component shall be located no less than 150 feet from existing or future residences. Housed treatment plant components or a treatment plant with oversized muffled blowers should be considered when noise may be objectionable. Topography, direction of prevailing winds, noise, and plant capacity are other factors to be considered.

GENERAL DESIGN

The treatment works structures, electrical, and mechanical equipment shall be protected from physical damage by the one hundred (100) year flood. OSDS' should remain fully operational and accessible during the twenty-five (25) year flood. This requirement applies to new construction and to existing facilities undergoing major modification. Flood plain regulations of local, state, and federal agencies shall be considered. Erosion protection and drainage of the area surrounding the plant must be provided. In order to prevent surface water from flowing into the facility, ground and surface drainage shall be diverted from the area.

Stronger wastes from food service operations and waste containing garbage or other organic matter increases both the hydraulic and BOD_5 loadings and require special consideration. Excess organic materials, such as ground vegetables produced by supermarkets, should not be tributary to this type of plant. Garbage grinders are not permitted in commercial facilities tributary to a private on-lot wastewater treatment plant.

Grease interceptors are to be provided in compliance with requirements of the local health authority.

Sludge disposal - waste sludge may be hauled away by tank truck to an approved disposal site by a registered or approved sewage tank pumper. A copy of the signed contract must be provided. An all weather access road shall be provided to allow trucks access to the sludge holding tanks. Other means of disposal will be considered only in specific cases.

PUMP SELECTION

Factors that affect pressure and are:

How high do you need to lift the water?
How fast do you need to move the water?
How much pipe and what size pipe do you plan to pump the water through?
What fittings do you have downstream of the pump?
How much pressure do you want when you get to the end of the pipe?

How high do you need to lift the water? This is the vertical distance from the water level in the tank to the discharge point. This is also called the STATIC HEAD.

How fast do you need to move the water? Do you need to pump 10 gallons per minute (gpm), 20 gpm or 100 gpm? Is there a particular rate of flow needed for the application? This is the starting place for the flow calculations.

When pumping raw wastewater, water with solids the pump must be sized large enough to push the solids through the pipe, a velocity of 2 feet per second is adequate. See the following chart for minimum flows in pipe sizes to carry the solids.

Pipe size	Minimum GPM
1 ½”	12
2”	21
2 ½”	30
3”	46

How much pipe and what size pipe do you plan to pump the water through? The pipe size and flow rate affect the Headloss. Headloss is the pressure that is used to transport the water from one point to another. The higher the flow rate the higher the headloss, so the pump needs to produce more pressure the higher the flow to maintain the same pressure at the end of the pipe.

Headloss varies with the pipe size. The smaller the pipe the higher the headloss, therefore the pump needs to produce more pressure in smaller pipes at the same flow rate to provide the same pressure at the end of the pipe for the same flow rate.

Figure B-1: Head loss Due to Friction in Plastic Pipe (c=150)

	nominal pipe diameter							
	1”	1.25”	1.5”	2”	2.5”		3”	4”
inside dia.	1.05”	1.38”	1.61”	2.067”	2.47”	3.07”	4.03	”
gal/100ft.	4.49	7.77	10.58	17.43	24.87	38.4	66.1	
Flow rate (gpm)								
1	0.8							
2	0.25							
3	0.59	0.16						
4	1.01	0.27						
5	1.53	0.40	0.19					
6	2.14	0.56	0.27					
7	2.85	0.75	0.35	0.11				
8	3.65	0.96	0.45	0.13				
9	4.53	1.19	0.56	0.17				
10	5.51	1.45	0.69	0.20	0.09			
12	7.72	2.03	0.96	0.28	0.12			
14	10.27	2.70	1.28	0.38	0.16			
16	13.14	3.46	1.63	0.48	0.20			
18		4.30	2.03	0.60	0.25			
20		5.23	2.47	0.73	0.31	0.11		
25		7.90	3.73	1.11	0.47	0.16		
30		11.07	5.23	1.55	0.65	0.23		
35		14.73	6.96	2.06	0.87	0.30		
40			8.91	2.64	1.11	0.39	0.10	
45			11.07	3.28	1.38	0.48	0.13	
50			13.46	3.99	1.68	0.58	0.16	
55				4.76	2.00	0.70	0.19	
60				5.60	2.35	0.82	0.22	
65				6.48	2.73	0.95	0.25	
70				7.44	3.13	1.09	0.29	
80				9.52	4.01	1.39	0.37	
90				11.84	4.98	1.73	0.46	
100				14.38	6.06	2.11	0.56	
125					9.15	3.18	0.85	
150					12.83	4.46	1.19	
175					17.06	5.93	1.58	
200						7.59	2.02	

What fittings do you have downstream of the pump?

Generally the pump is followed by bends, valves, check valves, or a union. Each of these fittings causes some friction loss as the water flows through it. There are charts that convert the fitting type and size to an equivalent length of pipe size. Then this equivalent length can be added to the pipe length for determine the headloss due to the pipe and fittings. Figure E-10 is used to convert the fittings.

How much pressure do you want when you get to the end of the pipe? This is the squirt height you want at the end of the pipe. If you are dumping the water into a distribution box then you a very low squirt height, less than 1 foot, if you are using a pressure distribution system then you want at least 2-3 feet. An example of putting a system all together Figure E-11:

Figure B-2: Equivalent Length of Pipe

		Nominal size of fitting and pipe (equivalent length in feet)						
type of fitting and application	**pipe and fitting material[1]**	**½"**	**¾"**	**1"**	**1 ¼"**	**1 ½"**	**2"**	**2 ½"**
insert coupling	plastic	3'	3'	3'	3'	3'	3'	3'
threaded adapter	copper	1'	1'	1'	1'	1'	1'	1'
plastic or copper to thread	plastic	3'	3'	3'	3'	3'	3'	3'
	steel	2'	3'	3'	4'	4'	5'	6'
90° standard elbow	copper	2'	3'	3'	4'	4'	5'	6'
	Plastic	4'	4'	6'	7'	8'	9'	10'
	steel	1'	2'	2'	3'	3'	4'	5'
standard tee,	copper	1'	2'	2'	3'	3'	4'	5'
straight flow thru run	plastic	4'	4'	4'	5'	6'	7'	8'
gate or ball valve[2]	steel	2'	3'	4'	5'	6'	7'	8'
swing checkvalve[2]	steel	4'	5'	7'	9'	11'	13'	16'
globe valve	steel	15'	20'	25'	35'	45'	55'	65'
30-gal vertical Water heater	----	4'	17'	56'				

1 Loss figures are based on equivalent lengths of indicated pipe material.
2 Loss figures are for screwed valves, and are based on equivalent lengths of steel pipe.
Table from MWPS-14 “Private Water Systems,” Midwest Plan Service, Iowa State University, Ames, Iowa.

PUMP CURVES

The pump performance curve shows the pumping rate (gpm) that a pump will produce against a particular head (pressure). For examples used here we are using centrifugal pumps. You can pump hard, high head low flow, or you can pump fast, high flow and low head. A pump can ONLY operate on its performance curve.

The challenge is to match the SYSTEM CURVE up to a PUMP CURVE. This is called the operating point, this is where the two intersect. Every project or system has its own needs and must be designed individually. Do not assume that this project is similar to the last one therefore the same pump will work. Identify all of the variables and design a system and pump to fit the project.

APPENDIX C

Inspection Forms

Design Engineer's Construction Inspection Form

Project____
Date/time of inspection_______________Fax to ______________
Send copy to ___________________________________
Site address   Billing address

_______________________   _______________________
_______________________   _______________________
_______________________   _______________________

Site Preparation Date ____________

1. Is the site in the right location? ❑ yes ❑ no
2. Roped off and protected from traffic? ❑ yes ❑ no
3. Small trees and brush cleared? ❑ yes ❑ no
4. Provisions for site drainage? ❑ yes ❑ no
5. Fill incorporated with underlying soil? ❑ yes ❑ no
6. Distribution field shaped to shed water? ❑ yes ❑ no
7. Lines staked out properly? ❑ yes ❑ no
8. Comments:

____
____
____
____
____
____
____
____

Construction Check Date _________

1. Tanks:

Proper size and type? ❑ yes ❑ no

Installed properly? ❑ yes ❑ no

2. Manifold and laterals: ❑ yes ❑ no

Depth of gravel suitable? ❑ yes ❑

no

Protected from debris entering system? ❑ yes ❑ no

Holes properly placed downward? ❑ yes ❑ no

Manifold and laterals connected properly? ❑ yes ❑ no

3. Water conservation devices installed in facility? ❑ yes ❑ no

4. Comments:

____
____
____
____

Operation Check

Date ______________________

1. Pump and switches operating? ❑ yes ❑ no

2. High water alarm operating? ❑ yes ❑ no

3. Electric receptacle outside pump tank? ❑ yes ❑ no

4. Wiring meets NEC? ❑ yes ❑ no

5. Pressure head in lateral lines: ❑ yes ❑ no

a. lowest:________________feet
b. highest:________________feet
6. Comments:

____
____
____
____

Final Landscaping Date ______

1. Site shaped to shed rainwater? ❑ yes ❑ no

2. Any low areas? ❑ yes ❑ no

3. Diversion drains? ❑ yes ❑ no

4. Downspout drains directed away from system? ❑ yes ❑ no

5. Seeded and mulched? ❑ yes ❑ no

6. Comments:

____
____
____
____
____

Recommendations for Checking Onsite System Failures

System failure may be caused by a single factor or a combination of several factors. Some of the causes are easily corrected and may not require extensive work to the soil absorption area. A thorough investigation is needed before repairs can be recommended. Explain to the permittee that **no** water should be used in the facility until after your inspection is completed. Even a single toilet flush can make the survey inaccurate.

Failed System Inspection Form

Owner:______________________________________Date___________________

Address:____

____

Brief description of failure:

____

____

____

____

Inspection Procedure

1. After making sure no one is using any water, check the water pressure Gauge . A recheck of this gauge after you complete your inspection will determine if any leaks are occurring that were not detected. Is there a drop in pressure? Pressure reading: ________________
Satisfactory___yes____no

2. If present, the water softener should be checked to determine if backwash recharge brine is being discharged to the seepage field. The salt solution may change the structure of some soils and hasten plugging of the soil pores. The recharge operation also adds excess water to the system. If recharge water is discharged to the ground surface, it should be directed away from the seepage field.
Satisfactory___yes____no

3. Check the furnace humidifier**.** Some humidifiers on furnaces are designed without shutoff valves. The amount of water that enters the furnace is supposed to be equivalent to the amount the warmed air will evaporate; however, any excess is discharged to the floor drain and could result in large quantities of clear water being added to the septic system. Self-cleaning humidifiers can add up to 125 gallons per day to the sewer system.
Satisfactory___yes____no

House/Trailer

The float valves in all toilet tanks should be checked. If any are sticking, they should be repaired or replaced. Sometimes, toilet manufacturers and plumbers do not take the time to ensure that the float shutoff valve is working properly or that the float ball is at the proper height. Any variation to this height could cause An adjustment should be made if the float is not working correctly.

Satisfactory___yes____no

The water elevation line in the flush tank should be approximately one inch below the top of the overflow pipe. Also, the flapper or cone at the bottom of the toilet tank should be checked: it must reseat in the hole after each flushing. A little dye or food coloring should be added to the tank to determine if all the dye stays in the tank or if it leaks into the bowl.

Satisfactory___yes____no

All faucets should be checked for dripping, and washers replaced where needed. Even a small drip adds many gallons of excess water over time.

Satisfactory yes no

Septic Tank

Many tanks are not watertight. During wet weather the septic tank should be pumped and a check made to see if any water is flowing into the tank when all water is shut off in the house. There is a possibility that foundation drains are connected to the building sewer or that water is flowing along the outside of the sewer line and infiltrating the septic tank and/or soil treatment area. Inspection ports, manhole covers and lid joints are normally not watertight, allowing infiltration if surrounding soil becomes saturated.

Satisfactory___yes____no

Is the septic tank located in a drainageway or a depression? Subsurface drainage may be needed to protect the tank from infiltration.

Satisfactory___yes____no

Is the septic tank more than eight inches below the ground surface? The inspection ports and manhole should have watertight risers to the ground surface.

Satisfactory___yes____no

The Uniform Building Code recommends laying the sewer pipe on gravel or sand, which may provide a pathway to intercept footing water and provide a direct path to the septic tank area from the house/building. If infiltration is occurring at a house with an open basement, check that any gravel that may have fallen into the house/building sewer trenches from the footing gravel has been removed. Clay should be packed around the sewer pipe, especially under the pipe, for a full five feet.

Satisfactory___yes____no

Sometimes small holes are manufactured in concrete septic tanks to eliminate suction, allowing the form to be removed. These holes must be sealed.
Satisfactory___yes____no

A hole may have been chipped in the tank to allow easier installation in high groundwater soils. If the water drops below the tank outlet, it could cause premature failure by allowing floating solids to rise on the outlet side of the baffle. Make sure the tank is watertight below the elevation of the outlet sewer pipe.
Satisfactory___yes____no

The outlet baffle should be checked to be sure it is in good condition. Corrosion of concrete baffles can cause the baffle to disintegrate above the water level and allow solids to enter the field, leading to premature failure. If this has happened, replace the baffle with a plastic outlet tee having proper submergence.
Satisfactory___yes____no

Seepage Field and Yard

Drop boxes and distribution boxes should be exposed and checked for infiltration and for the depth of water in each of them. Every drop box where the trench has been used should be full, and no water should be running into or out of the first or any other drop box when the water is off.
Satisfactory___yes____no

The roof runoff and/or downspouts should not drain toward the soil treatment unit or septic tank.
Satisfactory___yes____no

The sump pump discharge, if pumped to the ground surface, should be diverted away from the seepage field and septic tank area.
Satisfactory___yes____no

If the seepage field or septic tank area has a depressional area running through it, even a slight one, an interceptor drain or surface diversion should be installed above it to intercept this flow and divert it away from the soil treatment area or tank.
Satisfactory___yes____no

Systems that are installed too deep, even though only a portion of the system is too deep, can pick up large quantities of subsurface water. A deep trench can act like a field drain tile and feed groundwater into the system instead of percolating sewage. A subsurface drain may correct this problem.
Satisfactory___yes____no

Parking areas should not drain toward seepage fields.
Dry wells, if constructed for roof drains and sump pumps or water softeners, should be located so as to not interfere with the soil treatment area.
Satisfactory___yes____no

With serial drop box distribution, the last or lowest line trench should be where effluent surfaces first when the system is overloaded. If this has occurred, all other lines should be checked to determine that they are also full to the overflow level. If one or more is not full, distribution to the higher lines is defective and portions of the field are not working.
Satisfactory___yes____no

Landscape finish grade, especially when a slope is involved, may leave too little dirt above the stone in the trench; usually a minimum of twelve inches is needed.
Satisfactory___yes____no

Improper protection of the top of the rock layer by straw, untreated building paper or pervious nylon fabric will allow the migration and infiltration of soil particles and cause premature clogging.
Satisfactory___yes____no

Stepped netword drain field trenches must be constructed on the contour and kept level. A trench that slopes away from the serial drop box may result in effluent surfacing rather than flowing to the next trench.
Satisfactory___yes____no

Not backfilling a system before it rains or freezes, or improper backfilling, such as leaving depressions or ridges, will cause permanent damage to the system.
Satisfactory___yes____no

Poor maintenance by the owner can cause many problems.
The septic tank must be cleaned routinely; if it is not, the suspended material and/or solids will enter the field and permanently damage the system.
Satisfactory___yes____no

Excess grease will cause system plugging in a very short time. This is a problem for restaurants, and also for homes where this waste is not separated.
Satisfactory___yes____no

Systems initially designed for a certain flow may experience overloading if the building later adds flow. Most systems are not designed for the increased water use and the undersized system may be the reason for sewage surfacing.
Satisfactory___yes____no

Soils may have other problems, especially where impermeable layers are near the surface:
Satisfactory___yes____no

Where lateral movement of groundwater is necessary for the proper operation of the system, roads or driveways on a downhill side will block the lateral movement and cause the system to fail.
Satisfactory___yes____no

Water ponded by road ditches or other landscaping will slow the lateral movement of groundwater and reduce the rate at which the soil treatment unit will accept effluent.
Satisfactory___yes____no

Manmade pools or detention areas adjacent to soil treatment systems can cause problems. The level of saturated soil adjacent to a pond could be as high as or higher than the pond outlet. The soil bank from digging the pond may result in compaction of the soil pores and slowing of the normal movement of water.
Satisfactory___yes____no

Soil compaction may result from some construction procedures. Installing the system when the ground is wet results in compaction, reducing the ability of the solid to accept effluent.
Satisfactory___yes____no

Estimates of compaction:
- If no depression is created, some compaction may occur, up to 14 inches.
- If a one-inch depression is created, up to 20 inches of soil may be compacted.
- If a two-inch depression is created, up to 28 inches of soil may be compacted.

(The following individuals and equipment can cause compaction: developer, road contractor, excavator, cement truck, delivery truck, septic contractor, workers' cars, landscape contractor,and the homeowner).

ONSITE SYSTEM INSPECTION REPORT
For Septic Pumpers

Permittee:_____________________________Date: _____________________

Site address:

____
____
____

A. General Information

1. Age of Building___________years
2. Age of system____________years
3. Number of people using building___________________daily.
4. Number of permanent occupants (if applicable)_________________
5. Is OSDS currently used? ❑ yes ❑ no
6. If unoccupied, how long has it been vacant? _____________
7. Has there ever been a backup in the plumbing system? ❑ yes ❑ no
8. List any known repairs made to the system:

____
____

9. Has the system been inspected by others? ❑ yes ❑ no

If so, did it fail? ❑ yes ❑ no

10. Date tank last pumped _______________ frequency?______________

Additional Comments:____

B. System Type

1. Components of system—check all that apply

❑ Septic tank_________gals ❑ Distribution box ❑ Trenches

❑ Aerobic tank________gpd ❑ Sand filter(s) ❑ Seepage bed(s)

❑ Vault system ❑ Chlorinator ❑ Grease trap________gals

❑ Mound ❑ Other_________________________ ❑ Pump

2. Is there a garbage disposal hooked up to the system? ❑ yes ❑ no

3. Is there a greywater runoff or drainage system? ❑ yes ❑ no

If yes, location____

If yes, type of system_ ____

4. Is any part of the system below a deck, pool, or driveway? ❑ yes ❑ no

If yes, details____

C. Evaluation Procedures

1. Located, accessed, and opened the tank cover. ❑ yes ❑ no
(The inspection of the tank must be completed by looking inside the tank.)

Approximate depth of tank access below grade_____/_____ft/in
If at grade, is the cover "child proof?" ❑ yes ❑ no
(This gives a quick safety check. If the system is extremely deep, proper maintenance of the system may be difficult and may be neglected.)

2. Flush all toilets once and run all fixtures to determine that they flow into treatment tank. Introduce water into the system for 20-30 minutes. Observe the water level in the treatment tank. Does the water level change? ❑ yes ❑ no
(There should be no significant change in the water level. As water is added, it should move through the tank. If the tank shows an increase in depth, there may be a plugging problem in the system.)

3. Opened inspection port over inlet baffle to check water level in tank and that inlet baffle is clear of debris. ❑ yes ❑ no

(The baffles should be properly attached and open for flow to work properly. Piping materials should be identified; if problems exist due to poor materials, note.)

4. Pumped out primary treatment tank, listen and observed for backflow into the tank from the outlet pipe. ❑ yes ❑ no
(Backflow indicates a system that cannot handle the flow entering it. An inspection of the treatment area should follow the discovery of backflow. Potential reasons for backflow include plugged piping (materials, roots), and plugged soil system (improper use, overuse, age). *Caution!* Do not pump treatment tank if there is evidence of a malfunction in any portion of the system.)

5. Inspected the condition of the primary treatment tank for cracks, infiltration, deterioration, or damage and the integrity of the inlet and outlet baffles for deterioration or damage. ❑ yes ❑ no
(Do this using a flashlight and mirror. It should not be necessary to enter the tank. A cracked tank will not hold water in or out. This system is not operating as designed and should be noted. NEVER enter a tank unless proper confined space entry procedures are followed!)

6. Properly closed tank cover and backfilled. ❑ yes ❑ no

7. System contain a dosing or pump tank, ejector or grinder pump? ❑ yes ❑ no
If so, is the pump elevated off the bottom chamber? ❑ yes ❑ no? **(This protects the soil treatment system from excessive solids.)**
Does the pump work? ❑ yes ❑ no
(Proper operation of the pump is necessary for the system.)

8. Is there a check valve, is the purge hole present? ❑ yes ❑ no
(This may indicate a potential freezing problem.)

9. Is there a high water alarm? ❑ yes ❑

no Does the alarm work? ❑ yes ❑ no

10. Do electrical connections appear satisfactory? ❑ yes ❑ no
(The electrical connections should also be viewed for clear safety issues.)

11. Can surface water infiltrate into the tank? ❑ yes ❑ no

(Clear water entering the tank will create a significant problem for the system. Many times fixing this problem will bring back a failed system. If the system is failing, the integrity of the tanks should be checked first.)

12. Cleaned the pump tank. ❑ yes ❑ no

13. Probe drainage area to determine its location and to check for excessive moisture, odor, and/or effluent. Any indication of a previous failure? ❑ yes ❑

no Seepage visible on the lawn? ❑ yes ❑ no

Lush vegetation present? ❑ yes ❑ no

(These are clear indicators of problems. If possible, the problems should be identified. Potential reasons overuse, overloading with BOD, improper construction, plugged system due to improper use, overuse, age.)

Ponding water in the aggregate? ❑ yes ❑ no

(This could be an early sign of failure depending on the distribution method. This is a good question, but does not completely indicate a failed system)

An even distribution of effluent within the field? ❑ yes ❑ no

14. Distance between water well and system:_________feet.

Does this distance meet state regulatory requirements? ❑ yes ❑ no

(Check state regulations before verifying the setback. Also the distance does not guarantee a "good well." Be clear that this is not a well inspection.)

D. Sketch the System—use a separate sheet.

For reproducible results, show dimensions from structures that will not change, such as corners of the house. Show details such as the road in relation to the house to get the correct orientation. Show all located components**.**

E. Checklist Summary

1. Treatment in tank is: ❑ in compliance. ❑ not in compliance.

2. Absorption system is: ❑ in compliance. ❑ not in compliance.

3. If a sewage pump is utilized: ❑ in compliance. ❑ not in compliance.

F. Company Disclaimer

Based on what we were able to observe and on our experience with on-site wastewater technology, we submit this Onsite Sewage Disposal System Inspection Report based on the present condition of the onsite sewage disposal system.______________________has not been retained to warrant, guarantee, or certify the proper functioning of the system for any period of time in the future. Because of the numerous factors (usage, soil characteristics, previous failures, etc.) which may affect the proper operation of a septic system, as well as the inability of our company to supervise or monitor the use or maintenance of the system, this report shall not be construed as a warranty by our company that the system will function properly for any particular buyer.

_______________________hereby **DISCLAIMS ANY WARRANTY,** either expressed or implied, arising from the inspection of the septic system or this report. We are also not ascertaining any affect the system is having on the groundwater.

Inspecting Engineer/Company: _____
________________________ Phone___________________License No.__

I have studied the information contained herein and certify that my assessment is honest, thorough, and, to the best of my ability, correct.

Name___________________________

Title__________________________________

Date__________________________________

Source: National Association of Wastewater Transporters

APPENDIX D

Photodocumentation

PHOTOGRAPHING SITE EVALUATION AND CONSTRUCTION

A camera can be used as part of a site evaluator's field equipment. It is recommended that photographs be taken showing features of the lot before development. These photographs may be valuable in the future, in case there is a question about the proper siting or construction of the system.

When taking photographs try to include reference points such as fences, trees, buildings, or other landmarks that will remain for many years after construction or inspection. In addition include items to show scale in the picture such as people, cars, tape measures, feet or other items, and flag test holes.

NOTATING YOUR PHOTOGRAPHS

Make notes of the following:

- elevations of the outlet from the building,
- elevation going into the septic tank,
- elevation of the manhole on the septic tank,
- elevation of the D-Box,
- elevation of the trench rock cover, and
- elevations of *subsequent* drop boxes and trench rock cover. (If for some reason there is a difference in elevation, give elevations at the drop box and at the far end of the trench, to verify their similarity.)

BUILDING SEWER

First photograph the building sewer area. This should include the placement of the building sewer, the connection to the building(s), the connection to the tank, and (if possible) the type of pipe used for that portion. Photograph the building sewer and tanks in the same manner as in the previous section.

MOUND/SAND FILTER DISPOSAL SITE

Take pictures of the construction site as a whole. Begin by taking photos before construction begins, so that an overall view of the site will be available. Next, photograph the site after the vegetation has been cleared. Be sure to include any trees (before and after), highlighting that they were cut off and not grubbed.

SITE PREPARATION

Your next set of photographs should depict the site preparation. These photos should include the staking, but more importantly will show the site after the ground has been turned over by backhoeing or plowing. One of the shots of this portion of the construction should include the equipment actively engaging in work.

FINAL CONSTRUCTION

Take pictures of all components prior to covering. Carefully document the sand filter area, as it will eventually need to be uncovered for maintenance.

APPENDIX E

Site Evaluation

A good site evaluation provides sufficient information to select a suitable, cost effective treatment system, and is the first phase of the design process. A site evaluation should be a systematic process that provides information with enough detail to be useful. The evaluation must help an evaluator determine whether or not a lot contains a sufficiently large area with suitable soil to serve the proposed use of the lot. The client should be aware that soil testing will not guarantee that the lot is suitable for the intended use. An unsuitable site is not the fault of the site evaluator. A soil evaluator is not doing his/her client a favor by allowing him/her to believe that a bad site is good.

A site evaluation is much more than just “running a perc test.” The site evaluation must consider placement of the system in relation to setbacks, topography and other factors; select the proposed depth of the system, with accurate soil descriptions noting water table or bedrock depth or other limiting factor; and accurately size the system with the perc test or another appropriate method. The site evaluation consists of two parts: a preliminary investigation and a field investigation.

FIELD EVALUATION

A site investigation is the only way to accurately determine the actual conditions present on the site. A field evaluation should be done regardless of the results of the preliminary evaluation. All interested parties should be present at the time of the field evaluation so that all can see the same conditions and obvious deficiencies can be explained immediately.

Note: Before beginning any digging for soil investigation or system construction, contact the local utilities for the location of underground utilities.

A site evaluation is a comprehensive investigation and characterization of geological, hydrological, topographic, soil, and setback factors to determine the site suitability. Nearby roadcuts, railroad embankments or other exposed slopes may provide a broad view of the landscape, soil and geology of the area surrounding the site, so don’t limit your investigation to the lot itself. A site evaluation should include:

Identification of lot lines, lot improvements, required setbacks, and easements.
Description of surface features, including:
- percent and direction of the slope,
- vegetation type,
- any evidence of disturbed or compacted soil, flooding, or run-on potential, and
- landscape position.

At least one soil observation, such as a boring, conducted prior to any required percolation tests, to the depth of the seasonally saturated layer, the bedrock, or four feet below the proposed depth of the system, whichever is less.

Description of each soil observed, including:

- the depth of each soil horizon,
- the soil matrix and mottle color,
- a description of the soil texture and consistence,
- depth to the bedrock or other limiting layers,
- depth to the seasonally saturated soil,
- depth of standing water in the hole, and
- any other soil characteristic, such as hardpans or restrictive layers.

How the proposed soil treatment areas will be protected from compaction and disturbance.

INITIAL OBSERVATION

The first observations on the site should rule out areas that are obviously unsuitable. A check of the vegetation and topography will help rule out some areas of wet soil, bedrock outcropping, steep slopes, and drainageways. After lot boundaries have been established, the process of selecting locations for the various improvements can begin. Carefully evaluate topography, land forms, vegetation (including large trees the owner may want to preserve, or cattails, which indicate a high water table), drainageways, recent construction activities that may have disturbed or removed the topsoil and any other physical features affecting the site. The soil absorption system should be located in original soil, the naturally occurring, inorganic soil that has not been moved, smeared, compacted, or manipulated with construction equipment.

Both the owner and the site evaluator should have a plan on paper to test against the actual lot. Since it is much easier to remove lines on paper than to move structures such as water wells or other improvements, this is the time to determine the suitability of proposed locations. The crests of knolls and hills, as well as slightly sloping portions of hills, are likely areas for placement of onsite sewage treatment systems. Avoid depressions, drainage swales that collect runoff from the surrounding area, and excessively steep slopes. The landscape and slope forms should be observed and recorded.

Consider future landscaping plans to assure site access not only during the construction phase but also afterward, so that the septic tank can be pumped periodically. Identifying two or three potential sewage treatment sites on the lot provides additional flexibility if the primary site is found to be unsuitable. The OSDS regulations require locating two areas suitable for a sewage disposal system on a lot.

NATIVE VEGETATION

Generally, close relationships exist between native vegetation and kinds of soil; yet there are important exceptions. Careful observations of both soils and vegetation can establish excellent correlations. Cattails, alders, dogwood, willows, tamaracks (salt cedar) and sedge grasses all indicate wet soil areas. These areas should be noted on the site evaluation map.

LANDSCAPE/TOPOGRAPHY

The landscape position and slope of the area should be noted. This information is useful in estimating surface and subsurface drainage patterns. For example, sloping areas typically have good surface and subsurface drainage, while potholes, drainageways and foot slopes are more likely to be poorly drained. Landscape is an important factor which determines the surface and subsurface flow of water and should be a major consideration when locating a system. Certain landscapes cause problems for proper waste treatment and disposal.

Swamps, marshes and potholes
Drainageways, swales or floodplains
Sinkholes

SOIL SLOPE

The slope of the soil surface has several distinct properties: gradient, complexity, configuration, length and aspect. Slope influences the retention and movement of water, rate and amount of runoff, potential for soil slippage, accelerated erosion, ease with which machinery can be used and soil-water state. Slope steepness is critical in system design and must be accurately determined and recorded. Slope is the ratio of vertical rise or fall to horizontal distance It is usually expressed as a percentage. Slope plays a significant role in onsite sewage treatment as follows:

Type of system to be used (no beds on slopes of six percent or greater)
Type of gravity distribution system to be used (drop box or distribution box)
Pressure distribution system design (if all laterals are not on the same elevation)
Layout (trenches parallel to slope)

THE EVALUATION PROCESS

STAKING THE SITE

After initially evaluating the site, be sure to stake conspicuously the location of the onsite sewage treatment system, the water supply well, the building (s), and other pertinent structures. The area of the proposed onsite sewage treatment system, and the alternate site if required, must be protected from any disturbance during the other construction activities. The next task is to stake off the required setbacks and home improvements. These areas can be measured by a measuring tape or wheel, stadia hairs on a level, or a range finder. Make sure of the accessibility of the tank for pumping. The locations of all buried utilities have been marked.

Information must be reported on the thickness in inches of the different soil horizons and their suitability for treatment of sewage. It is recommended, and in some localities required, that a replacement area of equal size be investigated and identified.
To locate the onsite sewage treatment system properly, thoroughly evaluate soil texture, the presence of soil mottling, direct water table measurement and presence of bedrock. Aid in determining parent material may be gained through the Soil Survey Report. In some cases, examination of road cuts, stream embankments or building excavations will also provide useful information. Wells and well driller's logs can also be used to obtain information on groundwater and subsurface conditions.

Before a soil description can be written, the excavated soil from a boring or augering must be laid out on the ground surface with the depths of the excavated soil corresponding with the depth of the hole. A tape measure should be laid alongside the excavated soil. Rain gutters cut to six-foot lengths provide a good "home" for the soil as it is being examined. Too often, site evaluators bring up an auger full of soil, briefly examine the auger bottom, then dump the soil into a spoil pile next to the hole.

When describing the soil it is best to work in adequate natural light, and when the soil is in a moist state. Soil moisture can be altered by wetting the soil from a water bottle or blowing on a small handful to dry. The exposed soil is usually examined starting at the top and working downward to identify significant differences in any property that would distinguish between adjacent horizons. Boundaries between horizons are marked and described. Horizon depths are measured from the soil surface and recorded.

There are three methods typically used to conduct soil investigations: probings, augerings, and pits. Each method has its own advantages and disadvantages. A soil probe is a hollow tube pushed into the soil. When extracted, it displays an undisturbed column of soil for viewing. Probe diameters and lengths vary in size. Probing is probably the quickest method of looking at the soil. It also has the advantage of revealing undisturbed soil in which faint soil mottling or cemented layers may be seen.
One disadvantage of probing is the relatively small diameter of the probes and the inability to penetrate the soil in rocky areas. Extensions can be added to get deeper into the soil. Another problem is that soil can become compacted in the tube.

An auger is a hollow cylinder with teeth at the bottom which is twisted into the soil. Augering is labor-intensive and is slower than probing. Auger samples typically are larger than samples from a probe, but the disturbed, mixed and homogenized nature of the sample may not reveal faint mottles, cemented layers or structure. Augerings have advantages over probing in rocky areas, but still may be ineffective due to rocks. Extensions can be added to get deeper in the soil.

Pits are the best method to view the soil. Pits allow you to view undisturbed soil and see how the soil varies over the length of the pit, and they may be the only reliable method to determine the depth to bedrock. Soil pits should be prepared at the perimeter of the expected soil absorption area. Pits prepared within the absorption area often settle after the system has been installed and may disrupt the distribution network.

In some cases, subtle differences in color need to be recognized. Therefore, it is advantageous to prepare the soil pit so the sun will be shining on the face during the observation period. Natural light will give true color interpretations. Artificial lighting should not be used. The disadvantage of pits is the necessity of a backhoe, and the associated costs and soil disturbance. **Before entering the pit, make sure that it is safe to enter.** Be sure that it is constructed properly with a step-type configuration to allow safe entry and exit. The pit should have no sidewall slumps and show no potential for a cave-in. Be sure that no heavy piece of equipment or large objects, such as rocks or boulders are resting on the surface immediately adjacent to the pit sidewalls. Grave safety concerns exist, if the soil is sandy or if the pit is excavated below the current water table depth. Pits should be backfilled or fenced to avoid falls or unauthorized entry.

BORING PROCEDURE

After visually eliminating unsuitable areas (including setbacks) you may start the soil investigation. Soil borings and descriptions are challenging, oftentimes frustrating, but always interesting. No two sites are ever alike. The amount of soil investigation will depend upon the site variability. A typical boring is first done to the depth of five to six feet. The soil information gathered from the boring should include texture, soil horizon depth, changes in soil color and presence of bedrock. It may be helpful to lay out the cores in order as they are removed from the hole.

SOIL BORING LOG

When taking a soil boring, enter the soil texture whenever a significant change in texture occurs. For example, the top 12 inches may be a fine sandy loam; from 12 to 18 inches the texture may be loam; from 18 to 36 inches the texture may be a clay loam; and from 36 to 72 inches the texture may be clay. At the bottom of the soil boring log, the total depth of the boring hole should be entered, as well as any evidence of mottling or standing water.

Depth of water in the bore hole must be measured and recorded. However, this depth should not be used as the estimated high water table for designing a system. Most water tables fluctuate by many feet in a normal year. A single observation of water in a hole probably does not indicate its highest level. The observation of gray soil coloration or distinct mottling is the method to determine this maximum height. Data is furnished on the depth to zones of soil saturation in the soil survey reports. These reports can help the site evaluator determine whether the use of the mottling criteria is applicable in a specific area.

Lithological Discontinuity

Many soils are formed in more than one kind of parent material. For example, a soil may be formed partly in loess (silty material) and partly in loamy glacial till. This is called a lithologic contact. Lithologic discontinuity is a significant change from one horizon (or layer) to another that is related to geologic processes and not soil-forming processes.

Soil layers of varying hydraulic conductivities interfere with water movement. Abrupt changes in conductivity can cause the soil to saturate or nearly saturate above the boundary regardless of the hydraulic conductivity of the underlying layer. If the upper layer has a significantly greater hydraulic conductivity, the water ponds because the lower layer cannot transmit the water as fast as the upper layer delivers it. If the upper layer has a lower conductivity, the underlying layer cannot absorb it because the finer pores in the upper layer hold the water until the matric potential is reduced to near saturation.

Layering of soils is an important item to consider in siting onsite waste disposal systems. Abrupt textural changes can cause problems with water movement and therefore hurt system performance.

Evidence of stratification of the material—textural differences, stone lines and the like need to be noted. Many soils obviously developed from stratified parent material, others seem to have developed from uniform material like that directly beneath the soil. If layers impede water movement, a lower linear loading rate must be used in designing the soil absorption system.

Disturbed Areas

Areas that have been cut, filled, compacted or disturbed in any way frequently have difficulty in accepting wastewater from an onsite system, due to a loss of soil structure. These areas can sometimes be identified by wheel tracks, hummocks, or vegetative growth, or debris. Problems have not been reported in siting systems in agricultural fields that have undergone normal tillage practices.

Fill Soils

Fill soils are soils that have been moved from their geologic origin by mechanical means and deposited in a new location. This creates a man-made lithological discontinuity. When soils with textures other than clean sand are moved to a new location, the soil structure is destroyed, which liberates the silts and clays that migrate when water is added. This loss of pore space, migration of silts and clays and poor water movement between the different layers ultimately results in percolation problems in the soil, which may be severe. Percolation test results in a single area of loamy fill can range from seven mpi to over 200 mpi. The problem arises on which sizing factor to use.

Problems in determining the depth to the seasonally high water table are also encountered. Water tables can change when the topography is altered and soil coloration of the fill cannot be used as an indication of water table height. Its color was determined by the water table height of the area from which it was excavated, and not that of its present location. Problems can result when excavated mottled soils are placed in a well drained area. Brownish colors will gray and mottle on a wet site, but the mottled soils on a dry site will remain gray and/or mottled.

Fill soils commonly have stratified layers or different colored and textured materials. These layers have abrupt boundaries between them. Typically the thickness of subsoil material ranges from 1/8" to a few inches thick, but can vary widely. Probings or pits (not augerings) are necessary to see these layers.

Soils located in a valley or flood plain sometimes have a natural stratification of soil materials which were deposited from sediment carried by floodwaters. Each layer represents deposits from one flooding event. These layers are black to gray in color, have textures in the silt to fine sand range and lack rocks. These stratifications should not be confused with stratifications caused by fill activities.

Fill soils commonly have unnatural looking landscapes such as:

short steep slopes,
an unusually flat area in a generally rolling topography,
higher areas adjacent to wetlands or shorelands,
man made structures (such as roads or buildings) nearby,
sparse vegetation (if new fill area) or vegetation lacking vigor as compared to adjacent areas, and/or
many rocks on the soil surface.

Cut Areas

Cut areas are areas where the land surface has been lowered by removal of earthen materials. Cut areas have usually been compacted by machinery during land leveling. This compaction may be localized and spotty, or widespread, depending on wheel traffic patterns. The topsoil and subsoil have often been removed from the cut area, exposing the native parent material, which usually has little or no soil structure to aid in water percolation. There may be a layer of topsoil added on top of the cut for lawn establishment. A percolation barrier may develop at this interface, slowing the movement of water. This problem is greater if the texture of the topsoil is unlike the texture of the fill.

Altering the landscape typically alters the water table height. The depth to mottles will be less due to removing the soil surface, but may not reflect a change in the water table height due to altering the landscape. Cut areas typically have an abrupt boundary between the imported topsoil and the top of the cut surface. The parent material exposed from the cut will lack soil structure and be lighter in color (value of five or more on the Munsell color charts).

Cut areas commonly have unnatural-looking landscapes such as:

short steep slopes,
an unusually flat area in a generally rolling topography,
a level area cut out of a steep hillside, and/or
a flat crest of a hill.

Man-made structures (for example, roads or buildings) are likely to be nearby. There may be sparse vegetation as compared to adjacent areas. They may be dense, compacted and difficult to probe.

Flooding Determination

The field evaluation should determine whether the site is subject to flooding. Flooding, is the temporary covering of soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes or any combination of sources. Shallow water standing or flowing during or shortly after rain, and snowmelt, are excluded from the definition of flooding, but must be considered when designing a soil absorption system. Standing water (ponding) or water that forms a permanent covering is excluded from the definition also.

Floodplain means the area covered by a 100-year flood event along lakes, rivers, and streams as published in technical studies by local, state, and federal agencies, or, in the absence of these studies, estimates of the 100-year flood boundaries and elevations as developed pursuant to a local unit of government's floodplain or related land-use regulations.

Information from the Soil Survey Report should also have identified whether the soil is subject to localized flooding in such landscape positions as upland drainageways or intermittent streams. If flooding is suspected, the following can be used to determine the potential flooding hazard:

Landscape features: Certain landscape features have developed as the result of past and present flooding, such as former river channels, oxbows, point bars, meander scrolls, sloughs, natural levees, backswamps, sand splays, and terraces. Most of these features are easily recognizable.

Vegetation: The vegetation that grows in flood areas may furnish clues to past flooding. The survival of trees in flood-prone areas depends on the frequency, duration and time of flooding (dormant season or growing season), and also on the age of the tree and the depth of flooding. Some species are intolerant of flooding and are not found in areas that are flooded. Other species are very tolerant of flooding and even withstand partial or total submersion during the growing season. Pure stands of these species indicate frequent or long duration flooding. A biologist or forester can help relate the vegetation to flooding frequency, duration and flood period.

Soil Profile Characteristics: The soil profile provides clues to past flooding:
(1) a thin strata of material of contrasting color or texture or both;
(2) a soil layer that is darker than the layer above is an indication that the darker layer has been covered by more recent deposition; and
(3) soil layers that have abrupt boundaries to contrasting kinds of material, indicating that the materials were laid down suddenly at different times from different sources or deposited from stream flows of different velocities.

SITE EVALUATION REPORT

As site information is collected, it must be organized for easy review to determine site suitability. Providing sufficient information to the designer of the system eliminates the need for additional site visits. Percolation test and bore hole data are of little value if related test sites cannot be located on a property or if the property itself cannot be located. It is essential to relate the property location to field-identifiable reference points, and to be very specific about test hole locations relative to both fixed reference points and each test site. The best approach is to identify the distances between each test site and two reference points, such as a well and the corner of a building. Preferably, all horizontal distances should be perpendicular to, and referenced to, a north-south line and an east-west line through the horizontal reference point or other fixed reference points or identifiable baselines, such as lot lines, roads or fence lines.

A vertical reference point (also called a **benchmark)** is recommended in addition to a horizontal reference point for locating the distance to test sites—unless they are both the same point. A vertical reference point is an object of permanent elevation, the height or surface of which cannot be easily changed. The vertical reference point may be a lot line corner stake, cornerstone of an existing building, top of a well casing, a point on a centerline of a road, or a stake placed by the soil tester in a location where it will remain undisturbed for future reference.

The elevation of the vertical reference point may be arbitrarily labelled 100 feet (or any other number), as long as the elevation of the test holes are determined in relationship to the elevation of the vertical reference point.

It is the soil tester’s responsibility to clearly identify the location of test holes by both vertical and horizontal references. The elevation of the ground surface at a test site and the reported depth of test are used to compute the elevation of the bottom of the trench or bed when the system is constructed or when surface soil is removed. Quick and easy ways to measure elevations are with a builder’s level, a surveying transit, or a quality hand level. Information may be recorded on forms provided in this manual. These forms should be duplicated and distributed to the permitting office and the client, and a copy should be kept with the site evaluator.

APPENDIX F

Soils Information

SOIL TREATMENT PRCESSES

The soil treatment unit provides the final treatment and dispersal of septic tank effluent, and to varying degrees treats the wastewater by acting as a filter, exchanger, or absorber by providing a surface area on which many chemical and biochemical processes may occur. The combination of these processes, acting on the wastewater as it passes through the soil, produces clean water.

BIOMAT

In a series system as sewage tank effluent flows into a drain field trench, it moves down through the trench rock to the soil where treatment begins. A biological layer or **biomat** is formed by anaerobic bacteria in the trench, which secrete a gluey substance to anchor themselves to the soil or rock particles. This biomat forms first along the trench bottom. As liquid begins to pond in the trench, the biomat forms along the soil surfaces on the sidewalls. When fully developed, the gray-to-black slimy biomat layer is about one inch thick.

Flow through a biomat is considerably slower than flow through natural soil, so unsaturated conditions exist in the soil beneath the drain field trench. Only the smaller soil pores contain water, while larger pores are filled with air. Unsaturated flow increases travel time of effluent through the soil, ensuring that it contacts the surfaces of soil particles. Unsaturated soil has pores containing both air and water so that aerobic microorganisms living in the soil can effectively treat the wastewater through the soil system.

A developed biomat reaches equilibrium over time, in that it remains at about the same thickness and the same permeability if effluent quality is maintained. The biomat and the effluent ponded within the trench are anaerobic and the organic materials in the wastewater are food for the anaerobic microorganisms, which grow and multiply, increasing the thickness and decreasing the permeability of the biomat. On the soil side of the biomat beneath the drain field, oxygen is present so that conditions are allowing aerobic soil bacteria to feed on and continuously break down the biomat. These two processes go on at about the same rate so that the thickness and permeability of the biomat remain the same.

If the concentration of the wastewater leaving the septic tank increases because of failure to regularly pump the septic tank, more food will be present for the anaerobic bacteria, which will increase the thickness of the biomat and decrease its permeability. If seasonally saturated conditions occur in the soil outside the trench, aerobic conditions will no longer exist. Since aerobic bacteria break down the biomat, these conditions will also cause the biomat to thicken, reducing its permeability and the effectiveness of treatment.

In the unsaturated soil under a biomat, water movement is restricted. In order for the wastewater to move through the soil, it must be pulled or “sucked” through the fine pores by capillary action. This creates a thin film of wastewater around soil particles, and water movement through the finer pores.

SOIL TREATMENT

Once the effluent passes through the biomat, it enters the soil for final treatment. Soil particles, the presence of electrical charges, and the soil microbiological organisms provide treatment. Soil particles provide the surface area wastewater passes over to be purified. This purification is provided by filtering of the larger particles and by adsorption (attachment or binding). Soil particles are negatively charged, so they can attract and hold positively-charged pollutants. Soils also contain minerals that bind with some pollutants and immobilize them.

Soil contains bacteria, fungi, actinomycetes, and protozoa, all of which feed on organic material in the wastewater. Aerobic bacteria provide treatment and function only in aerated soil. If the soil is saturated and no oxygen is present, anaerobic bacteria function, but they provide insufficient treatment.

BOD is broken down by bacteria in the biomat and filtered out in the first foot below the system. Total suspended solids are also filtered out by the soil within a foot of the trench bottom.

PATHOGEN REMOVAL

Bacteria in the effluent are large enough that they are usually filtered out like BOD. In general, soil is a hostile environment to the bacteria found in sewage, due to temperature, moisture and soil predators.

Viruses are much smaller than bacteria, and are not filtered. However, some contain a positive ionic charge, and soil particles are negatively-charged, allowing them to attract and hold the positively-charged viruses. In sandy soils with limited negative charges, the main means of viral attachment to soil particles is by microbial slimes laid down by soil bacteria.

Once bacteria and viruses are caught in the soil, they eventually die because of soil conditions such as temperature or moisture levels. Some bacteria are killed by antibiotics given off naturally by soil fungi and other organisms. Others are preyed upon by soil bacteria. Studies have shown that if sandy soils are loaded at no greater than 1.2 gallons per day per square foot (gpd/sqft), virus removal will occur within two feet. The soil sizing factor for sandy soils reflects this loading rate.

NUTRIENT REMOVAL

The two principle nutrients of concern in wastewater treatment are nitrogen and phosphorus. Nitrogen is a concern because it can contaminate drinking water. Nitrogen undergoes many changes as it travels through a septic system. Septic tank effluent contains both organic nitrogen and ammonium NH4+. The predominant form entering the soil is ammonium. The transport and fate of nitrogen underneath a soil treatment system is dependent upon the forms entering and the biological conversions that take place. Figure B-5 shows the forms and fate of nitrogen in the subsurface environment. Nitrates (NO3-) can be formed by nitrification. Nitrification (NH4+ NO2- NO3-) is an aerobic reaction, so it is dependent upon the aeration of the soil.

Denitrification is another important nitrogen transformation in the soil environment below onsite systems. It is the only mechanism by which the NO3- concentration in the effluent can be reduced. Denitrification (NO3- N2O N2) occurs in the absence of oxygen. For denitrification to take place, the nitrogen must usually be in the form of NO3-, so nitrification must happen before denitrification. Mound systems facilitate this process and typically reduce nitrogen concentrations by 40 to 70 percent.
The transport of nitrate ions may involve movement with the water phase, uptake in plants or crops, or denitrification. Since nitrate ions (NO3-) have a negative charge, they are not attracted to soils, and are very mobile.
In a study by Converse et al., at-grade systems were monitored for nitrogen levels. Levels coming out of the septic tank were:

Parameter	Average value
Organic nitrogen	11 mg N/L
Ammonium	48 mg N/L

Nitrogen levels below a pressure dosed at-grade system.

Ammonium nitrate	Depth (in)	(mg N/kg dry soil) (mg N/kg dry soil)
0-6	29	28
12-18	17	16
24-30	17	13
36-42	15	10

Treatment of nitrates occurs to a limited extent by the following mechanisms.

Uptake by Plants: If trenches are shallow to the ground surface, some of the nitrate will be taken up by surface vegetation during the growing season.

Denitrification: If the ammonium NH4+ is nitrified to nitrates NO3- and then encounters a saturated zone, which lacks oxygen, the nitrate is converted to nitrogen gas (N2) and is lost to the atmosphere. Mound systems provide these nitrifying and subsequent denitrifying conditions.

Once nitrates reach the ground water, the only mitigative effect to this contamination is by dilution with the native groundwater. The effectiveness of this dilution is dependent upon the amount of nitrate entering from other sources in the area, including agricultural practices and other onsite systems, along with the hydrogeologic conditions of the groundwater system.

Lakes receiving **phosphorus** will experience an increase in aquatic vegetation. The limiting nutrient in most Nevada lakes is phosphorus, so small additions bring about a great increase in growth. Algae blooms and heavy growth of weeds not only make surface water bodies unappealing for recreation, they threaten the health of fish and other aquatic creatures. Since groundwater flows until it is ultimately discharged as surface water, the quality of Nevada's surface water is highly dependent upon the quality of its groundwater. Measures should be taken to reduce the risk that phosphorus from onsite systems will not enter lakes and rivers through the groundwater.

Phosphorus is removed from wastewater by being chemically bound by minerals and held on exchange sites on soil particles. Minerals that bind with phosphates are iron, manganese and aluminum. When the adsorption sites are filled, newly added phosphorus must travel deeper in the soil to find fresh sites. Soils higher in clay content have more of these minerals and binding sites than soils high in sand, so phosphorus movement is generally less in finer-textured soils. Laboratory studies on sands indicate that the rate of phosphorus movement is approximately eight inches per year; in clay soils it's about three inches per year. If the treatment system is functioning properly, and proper setbacks are maintained from surface waters, problems from phosphorus movement to surface water or groundwater should be minimal.

RESIDENCE TIMES

The longer contaminants remain in unsaturated soil, the greater the opportunity for treatment. One way to enhance residence times is to have less water percolating through the soil to carry contaminants into groundwater before treatment is achieved. The following methods can be used to limit the amount of water to be treated.

Water conservation: Using less water will increase contaminate residence times in the soil. Reduced flows also allow increased quiet times in septic tanks which allows the settling of solids and containment of contaminates in the tank which do no reach the soil treatment system.

Long, narrow, and shallow trenches: Trenches constructed close to the ground surface will allow the upward removal of water by evaporation and transpiration through growing plants. Shallow trenches also provide good oxygen exchange with the atmosphere for the aerobic soil bacteria to provide good treatment.

Flow-restricting water fixtures.

SOIL DEVELOPMENT

It's important to understand the characteristics of soil in order to understand soil treatment of wastewater and the proper siting of onsite systems.

Components of Soil
Soil contains about 50 percent solid material and 50 percent pore space. The solid portion typically contains five percent organic matter and 45 percent mineral material. The pore space typically contains an equal amount of water and air

"Principal Soils of Iowa, Special Report No. 42":

Living Organisms
In addition to mineral matter provided by parent material, soils also include organic matter—living organisms (plant and animals) or the remains of living organisms. Living organisms perform two chief functions in soil development. They are the source of soil organic matter, and in the case of deep-rooted plants, they help bring plant nutrients up from lower depths. The organic matter may be stored in the A horizon and will, upon decomposition, release nutrients for plant use. Soil differences caused by variations in the type of plants and their patterns of growth affect the thickness of the A horizon.

Microorganisms also play important roles in soil development. They are a source of organic matter, aid in decomposing organic matter, combine free nitrogen into forms which can be used by plants, and aid in the release of nitrogen and other organic stored nutrients for use by plants. Man, through his use of the soil, also influences soil development. Man uses soils in ways which may either improve, maintain or permanently decrease soil productivity.

Soil Profile
Weathering of the parent material forms different layers in the soil called **horizons.** Each horizon has one or more characteristics different from the layer above. The **soil profile** is all of the horizons of a soil. A fresh road cut or the wall of an excavation is a good place to study the soil profile. The soil profile is a vertical section of a soil and consists of one or more soil horizons and the unaltered material underlying the horizons. A soil horizon is a layer of soil approximately parallel to the soil surface with uniform characteristics. Soil horizons are identified by observing changes in soil properties with depth.

Soil texture, structure and color changes are some of the characteristics used to determine soil horizons. Soil descriptions are used to identify different horizons and determine if the soil has the ability to treat and dispose of the applied wastewater. Soil descriptions must be objective, complete and clear, and use standard terms, so your observations can be understood by others.
Changes in the soil that will have a significant impact on wastewater movement signal where a new horizon should be noted. This would be where changes in soil texture, color, density, permeability or bedrock occur. The importance of these contact zones, where permeability changes, cannot be overemphasized.

Soils vary widely in the degree to which horizons are expressed. Relatively fresh geologic formations, such as alluvial fans, may have no recognizable horizons, although they may have distinct layers that reflect geologic deposition. As soil formation proceeds, horizons may be detected in their early stages only by very careful examination. As age increases, horizons generally are more easily identified in the field. The term **layer**, rather than horizon, is used if all of the properties are inherited from the parent material and not from soil-forming processes.

Typically, horizon distinction lessens below three to four feet in depth, which corresponds to the depth of structure development. Horizons at this point get thicker and the boundaries between horizons are not easily seen. Technically, the loss of structure development “ends” the soil, so deeper horizons are actually parent material. Each horizon has its own set of characteristics and therefore will respond differently to applied wastewater. Also, the conditions created at the boundary between soil horizons can significantly influence wastewater flow and treatment through the soil.
The more distinct the difference between two adjacent horizons, and the more abrupt that boundary, the more problems there may be in water movement between these layers.

Horizons are described and differentiated from one another on the basis of the following characteristics:

texture
matrix color
mottling (redoximorphic features)
structure
consistence
presence or absence of roots

The depth at which one or more of these characteristics appreciably changes will be described and recorded.

PHYSICAL PROPERTIES OF SOIL

Soil Texture
Soil texture can be used to estimate the percolation rate, which is then used to estimate the size of the treatment area that needs to be investigated. While soil texture is not an absolute indicator of the percolation rate, it can provide helpful preliminary information. Soil texture is the quantity of various inorganic particle sizes present (sand, silt and clay). The sand-, silt-, and clay-sized particles are called **soil separates.** You can think about texture as the “feel” of the soil.
Soil texture is the relative proportion, by weight, of the soil particles finer than two millimeters. These particles are sometimes called the **fine earth fraction.** Materials larger than two millimeters are called **rock fragments.** These fragments influence moisture storage and infiltration, and they dilute the volume of soil material that can provide treatment of the effluent.

While most people have a good idea of what a sand particle looks and feels like, it's impossible to see a single clay particle with the naked eye, and it's difficult to imagine 0.002 millimeters. If a sand particle were magnified to a size ten inches in diameter, a silt particle in comparison would be about one inch in diameter and a clay particle about the size of a grain of sugar.

Soil texture classes are defined according to the distribution of the soil separates. The basic texture classes, in order of increasing proportions of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. The sand, loamy sand and sandy loam classes may be further subdivided into coarse, fine or very fine.

Textural classification systems include the U. S. Department of Agriculture (USDA) textural classes, the United Soil Classification, and the American Association of State Highway Officials (AASHO) Classification.

The USDA textural classification was developed to reflect water movement in soils and is the system used in sizing onsite systems. USDA texture classes are given as percentages of sand, silt and clay. Figure 17-1 is a diagram commonly called the soil textural triangle, which is used to identify the soil texture based upon the percent of sand, silt and clay. Be careful to enter the triangle along the proper lines for the three particle sizes. At any point on the soil triangle, the sum of the percentages of sand, silt and clay should total 100 percent.

For example: Locate the point for a soil having 10 % clay, 40 % silt, and 40 % sand. A soil with this combination of particles is classified as a loam. Note that a clay loam can have as much as 45 % sand and still have the characteristic and percolation rate of a clay loam.

The Twelve Soil Textural Classes

Clay is a fine-textured soil material. When wet, clay is quite plastic and can be very sticky. When the moist soil material is squeezed, it forms a long, flexible ribbon; when moist and smeared, it is shiny. A clay soil material leaves a slick surface when rubbed with a long stroke and firm pressure. Due to its stickiness, clay tends to hold the thumb and forefingers together.

Silty Clay has characteristics similar to clay. It contains approximately equal amounts of silt and clay. It is both sticky and smooth-feeling.

Sandy Clay also has characteristics similar to clay. It has nearly equal parts sand and clay, and very little silt. It has a sticky feel. Individual sand particles may also be felt.

Clay Loam is a fine-textured soil. The moist soil material is plastic and will form a cast that will bear much handling; when formed into a long ribbon, it breaks readily. When kneaded in the hand it does not crumble readily but tends to work into a heavy compact mass.

Silty Clay Loam is a fine-textured soil similar to clay loam. It generally contains more silt than clay, and can have up to 20 percent sand. It has a slightly sticky feel, and is rather stiff. It also feels smooth or floury.

Sandy Clay Loam is composed primarily of sand with small, nearly equal, amounts of clay and silt and has characteristics similar to clay loam. It is slightly to fairly sticky-feeling. Individual sand grains may be felt.

Silt is too fine to be gritty to the touch, but its smooth, slick, or greasy feel lacks any stickiness.

Silt Loam is a soil material having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called "silt." When pulverized, it feels soft and floury. When moist, the soil readily runs together and puddles. It cannot be formed into a ribbon.

Loam is a relatively even mixture of sand, silt and clay. A loam feels somewhat gritty, yet fairly smooth and highly plastic. The term "loam" is not related to the term "topsoil." Loam textures refer to the mineral fraction of the texture and not with how much organic matter (blackness) the soil has.

Sandy loam is similar to loam, but contains a higher percentage of sand, with enough silt and clay to make it somewhat sticky. Individual sand grains can be seen readily and felt.

Loamy Sand is a soft, easily squeezed soil that is only slightly sticky. Individual sand particles can be felt.

Sand is commonly loose and single-grained, but it may be cemented together. Individual grains can be readily seen or felt. Squeezed in the hand when dry, it falls apart when pressure is released and does not form a ribbon. Squeezed when moist, it forms a cast that crumbles when pressure is released or when touched. For adequate sizing of onsite systems in sand, the size of the sand grains must be determined.

Soil Texture Determination

While analysis of soil texture is done routinely by many laboratories, field texturing can provide the necessary accuracy. Therefore, expenditures of time and money for laboratory analyses are not necessary. Field estimates of textures are commonly within plus or minus one-half of the actual textural class. This uncertainty is even less when highly skilled individuals perform the field estimation.

Laboratory Analysis
Texture can be measured in the laboratory by determining the proportion of the various sizes of particles in a soil sample. The analytical procedure is called **particle-size analysis** or **mechanical analysis.** Stone, gravel and other materials greater than two millimeters are sieved out of the sample and do not enter into the analysis of the sample. The amounts are measured separately. Of the material smaller than two millimeters, the amount of the various sizes of sand is determined by sieving. The amount of silt and clay is determined by differential rate of settling in water. Organic matter and dissolved mineral matter are removed in the pipette procedure but not in the hydrometer procedure. The two procedures are generally very close but a few samples exhibit wide discrepancies, especially those with high organic matter or high soluble salts. Detailed procedures are found in *Soil Survey Investigations Report No. 1., Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples*, 1972, by USDA-SCS. The Amounts of sand, silt and clay derived from this method are plotted on the textural triangle to determine the soil texture.

Field Determination of Soil Texture
The determination of soil texture is made in the field mainly by feeling the soil with the fingers, and sometimes by examination under a hand lens. This requires skill and experience, but good accuracy can be obtained if the site evaluator frequently checks his or her estimation against laboratory results.

To determine the soil texture, moisten a sample of soil one to two inches in diameter. There should be just enough moisture so that the consistency is like putty. Too much moisture results in a sticky material, which is hard to work. Press and squeeze the sample between thumb and forefinger. Press the thumb forward to try to form a ribbon from the soil. The amount of sand in the sample can be determined by "washing off" the silt and clay, and feeling for sand particles. Sand particles can be seen individually with the naked eye and have a gritty feel to the fingers. Many sandy soils are loose, but some are not. Silt particles cannot be seen individually without magnification; they have a smooth feel to the fingers when dry or wet.

Clay soils are sticky. The way a wet soil "slicks out" or develops a long continuous ribbon when pressed between the thumb and fingers gives a good idea of the amount of clay present. If the soil sample forms a ribbon (loam, clay loam or clay) it may be desirable to determine if sand or silt predominate. If there is a gritty feel and lack of smooth talc-like feel, then sand very likely predominates.
If there is not a predominance of either the smooth or gritty feel, then the sample should not be called anything other than a clay, clay loam or loam. If a sample feels quite smooth with little or no grit in it, and will not form a ribbon, the sample would be called silt loam.

The content of particles coarser than two millimeters cannot be evaluated by feel. The content of the coarser particles is determined by estimating the proportion of the soil volume that they occupy.

An experienced site evaluator can determine the texture of soil quite accurately using both feel and sight. A good estimate of the textural class can be made using the following procedure. Final sizing of systems without the aid of a percolation test should only be attempted by an experienced site evaluator with adequate training or by a soil scientist who can accurately determine the soil texture and structure.

Procedure

1. Moisten a sample of soil the size of a golf ball, but don't get it very wet. Work it until it is uniformly moist, then squeeze it out between your thumb and forefinger to try to form a ribbon.
2. Second decision. If the moist soil is
a) extremely sticky and stiff: one of the **clays**
b) sticky and stiff to squeeze: one of the **clay loams**
c) soft, easy to squeeze, only slightly sticky: one of the **loams**
3. Third decision. Try to add an adjective to refine the description.
a) The soil feels very smooth: **silt** or **silty**
b) The soil feels somewhat gritty: no adjective
c) The soil feels very, very gritty: **sandy**
4. At this point, the lines on the triangle jog a bit, and sandy loams are distinguished. If the soil is a sandy loam, determine the amount of sand present.
a) Very sandy (85% to 100%): **sand**
b) Quite sandy (70% to 85%): **loamy sand**
c) Somewhat sandy (50% to 70%): **sandy loam**
5. To distinguish between silt loam and silt, consider how slick or floury the soil feels.
a) very slick: **silt**
b) somewhat slick: **silt loam**

Soil Structure

Soil structure has a significant influence on the soil's acceptance and transmission of water. Soil structure refers to the aggregation of the soil separates (sand, silt and clay) into clusters called **peds.** These peds are separated by surfaces of weakness. Some soil horizons contain simple structures, in which each ped is a single entity, without smaller peds contained inside. In many soil horizons, one or more sets of small peds are held together to form discrete bodies recognizable as larger peds.

If a percolation test is not to be conducted for final system sizing, a detailed analysis of the soil structure is necessary. A soil pit or large-diameter probe will be necessary to adequately examine the structure. The sidewall of a soil pit should be carefully examined, using a pick or similar device, to expose the natural cleavage and planes of weakness. Cracks in the face of the soil profile are indications of breaks between soil peds. If cracks are not visible, a sample of soil should be carefully picked out and, by hand, carefully separated into the structural units until any further breakdown can only be achieved by fracturing. Since the structure can significantly alter the water transmission of soils, more detailed descriptions of soil structure are sometimes desirable. Size of the structural units provide useful information to estimate hydraulic conductivities.

Soil Structure Determination

In soils that have structure, the size, consistence, shape, and grade (distinctness) of the peds are described**.** Field terminology for soil structure consists of separate sets of terms designating each of these properties. The four terms for soil structure are combined in the order:

grade
size
shape
consistence

For example, "strong fine granular structure" describes a soil that separates almost entirely into discrete peds, with a range in size from five to ten millimeters that are loosely packed and roughly spherical.

Grade

Grade describes the distinctness of peds. Determining grade in the field depends on the ease with which the soil separates into discrete peds and also on the proportion of peds that hold together when the soil is handled.

Massive- No observable aggregation, or no orderly arrangement of natural lines of weakness.

Weak**-** Poorly formed, indistinct peds, barley observable in place.

Moderate**-** Well formed, distinct peds, moderately durable and evident, but not distinct in undisturbed soil.

Strong**-** Durable peds that are quite evident in undisturbed soil, adhere weakly to one another, withstand displacement when soil is disturbed.

Size

There are five size classes: very fine, fine, medium, coarse, and very coarse. The size limits of these classes refer to the smallest dimension of plates, prisms, and columns, and vary according to the shape of the units. If units are more than twice the minimum size of "very coarse," actual size of units is specified. Figure B-19 gives the limits for the size classes for four shapes of soil units.

Shape

Several basic shapes of peds are recognized in soils. The following terms describe the basic shapes and related arrangement of peds.

Granular: The peds are approximately spherical or polyhedral and are found in topsoils. These are the small, rounded peds that hang onto roots when soil is turned over.

Platy: The peds are flat and platelike. They are generally oriented horizontally and are usually overlapping. Platy structure is commonly found in timbered areas just below the leaf litter or shallow topsoil.

Blocky: The peds are block-like or polyhedral, and are bounded by flat or slightly rounded surfaces that are casts of the faces of surrounding peds. Blocky peds are nearly equidimensional but grade to prisms, which are longer vertically, and to plates, which are longer horizontally. The structure is described as angular blocky if the faces intersect at relatively sharp angles, and as sub-angular blocky if the faces are a mixture of rounded and plane faces, and the angles are mostly rounded. Blocky structure is commonly found in the lower topsoil and subsoil.

Prismatic: The individual peds are bounded by flat or slightly rounded vertical faces. Peds are distinctly longer vertically, and the faces are typically casts or molds of adjoining peds. Prismatic structure is commonly found in the lower subsoil.

Consistence

Soil consistence in the general sense refers to “attributes of soil material as expressed in degree of cohesion and adhesion or in resistance to deformation on rupture. In the field, resistance of soil material to rupture is used. Consistence is highly dependent upon on the soil-water state and should be consistent. Therefore, it is recommended that moist or wet samples be used. To determine the consistence place a one-inch, block-like specimen between thumb and forefinger. Stress applied in the hand should be over a one-second period.

Loose- (Intact specimen not available)

Friable- slight force between fingers

Firm- moderate force between fingers

extremely firm- moderate force between hands or foot pressure rigid foot pressure

Research has shown that percolation rates are correlated with grade and shape of subsoil structure. Faster percolation rates can be expected where soil structure is present. Better soil structure can compensate for higher clay content in some cases. However, soils with well developed structure, such as soils formed under forest vegetation, generally have clay coating which swell when moisten. Their presence reduces the rate of water movement. Small peds and single-grained structures will have rapid percolation rates. Soils with granular, blocky, prismatic or columnar structures enhance flow both horizontally and vertically. Platy structures restrict downward movement of water because the ped faces are oriented horizontally. Platy structures are often associated with lateral (sideways) movement of water.

Structure is one soil characteristic that is easily altered or destroyed. Structure is very dynamic, changing in response to moisture content, chemical composition of soil solution, biological activity and management practices. Soils containing minerals that shrink and swell appreciably, such as montmorillonite clays, show particularly dramatic changes. When the soil peds swell upon wetting, the large pores become smaller and water movement through the soil is reduced.

Therefore, when determining the hydraulic properties of a soil for wastewater disposal, soil moisture contents should be similar to that expected in the soil surrounding a soil disposal system.

In general, finer-textured soils cannot accept as much effluent as coarser textured soils. Soils with more developed structures can accept more effluent than massive or weak-structured soils. These values should be reviewed by the designer and modified to fit site specific conditions. There may be other site specific conditions that warrant adjusting the values.

Soil Color

Soil color is an indicator of natural drainage conditions that were present at some time during soil formation. However, in some areas, soil color may be a relict condition related to past climatic and landscape conditions and not related to present natural drainage.

Significance of Color - The color of the surface layer may be used to judge the organic matter content of the soil. Color may be a mark of the effects of past vegetation or human use or misuse of the soil. Some soils exhibit color directly inherited from the parent rock. These and other relationships are clues for identifying soils and appraising their properties.

There are primarily two coloring agents in the soil: organic matter and iron. Most people recognize the dark surface soil as being humus-enriched. The varying shades or red, yellow and gray of soils are usually due to the quantity and form of iron present. Red means that the iron is oxidized and not hydrated with water. Yellow indicates hydration and sometimes less oxidation. Gray indicates chemical reduction due to wetness and lack of oxygen. **Soil color is an indicator of natural drainage conditions.**

Soil horizons may contain many different colors. The colors are derived from either the native parent material or the soil-forming process. These processes may result in the formation of clay films, silts coats, organic stains, nodules, and oxides, all of different colors. One important soil-forming process that needs special attention is when the soil color indicates a saturated soil condition.

The presence of soil redoximorphic features (“**mottling**”) is used to estimate saturated soil conditions throughout the world, and identification of these features help determine the depth of the seasonally high water table.

These features identify soil subject to periodic saturation even when the soil is dry. Organic matter content in a soil is commonly indicated by color, especially in temperate climates such as in Iowa. Dark-colored soils are generally high in organic matter. Soil colors usually range from pale brown to very dark brown or black as organic matter increases, if the horizon is not seasonally saturated. The depth of the dark color depends on the amount and distribution of organic matter. Alternate saturation and drying of the soil horizon results in various shades of gray, brown and yellow, called **mottling.** Red color in soils is generally due to the natural material in which the soil has developed.

Sands are generally yellow due to iron oxides and small amounts of organic matter. When sands are periodically saturated, the colors are either gray or mottled or both.

Mottling as an Indication of Zones of Soil Saturation
For most soils, mottling and low chroma colors are good indicators of saturation zones. Mottling that indicates periodic saturation is now called “redoximorphic features”. Whatever these soil features are called, they are formed in saturated soil by the processes of reduction, translocation, and oxidation of iron and manganese compounds. In saturated soil with a temperature above 41ºF, bacteria soon deplete the available free oxygen needed to digest organic matter. Anaerobic bacteria remove oxygen from the iron and manganese compounds. Removing oxygen changes the iron and manganese compounds, making them water-soluble. These soluble compounds move with the soil water until an oxygen-rich zone is encountered.

Once they encounter the oxygen, the compounds precipitate from solution, accumulating as coatings of reddish or yellowish iron oxide or black manganese oxide on the faces of the peds, walls of pores, or channels, or as accumulations inside of peds. Mottles often form *inside* soil peds in well-structured, medium-textured soils.
Precipitated iron or manganese oxides also accumulate in pores or voids containing trapped air as cemented concretions or as three-dimensional concretions called **nodules.**

The area from which the iron and manganese oxides are removed becomes a light gray color, known as **gley.** When other properties are equal, the percentage of gley in the saturated zone is proportional to duration of saturation. In depressions, soils waterlogged with stagnant water have not been flushed of dissolved iron oxide. This results in bluish gray or greenish colors, implying that the soil is saturated for long periods.
Periodic saturation of soil cannot always be identified by mottles. Some soils can become saturated without the formation of mottles, because one of the conditions needed for mottle formation is not present. Some soils are wet for significant periods, but the water contains sufficient oxygen to maintain bright, unmottled soil colors. Some soils are wet only during winter when soil temperatures are so low that soil bacteria have a very slow rate of respiration, and chemical reactions virtually stop. These soils are wet only when the processes that would cause mottles and gray colors do not operate.

Mottles will not form during soil saturation under the following conditions:

the water contains sufficient oxygen to serve the biological needs for organic matter digestion and

soil or water temperatures are below 41F during the period when a soil zone is saturated, preventing the bacterial activity needed to form mottles.

Experience and knowledge of moisture regimes related to landscape position and other soil characteristics are necessary to make proper interpretations in these situations.

Data furnished on the depth to zones of soil saturation within the soil survey reports can help the site evaluator determine whether the use of the mottling criteria is applicable in a specific area. There are some soils that show mottling characteristics that do not have zones of soil saturation. For instance, once gray coloration or soil mottles are formed, they will remain intact even if the geologic climate changes or if the soil is artificially drained. However, these are a small minority of cases, so that the use of mottling to indicate saturation is generally a good procedure.

Uniform reddish or brownish soil colors will indicate horizons that are well drained and consistently provide adequate oxygen to provide treatment of effluent. Typically as you go deeper into the soil, it becomes duller in color and mottled. As the abundance and contrast in soil mottles increases, the soil is having difficulty removing the natural precipitation at the site. Gray, olive or bluish colors, with or without mottles, are associated with poor drainage and lack of oxygen.

Topsoil Color
Topsoil is a natural soil layer with a color value less than 3.5, where subsoil has a layer with color greater than or equal to 3.5. Commonly, dark colors suggest more organic matter than light colors. Humified organic material is commonly dark, however, raw organic material, such as peat, is not necessarily dark. Some soils are nearly black because of organic coatings on peds, but when the peds are crushed, the soil appears significantly lighter. In other soils, the organic matter is disseminated throughout the peds. Usually soils with poorer drainage have deeper, thicker topsoil than well-drained soils in adjacent areas.

Other Soil Features
The site evaluator should be aware that there are other features in the soil which have not been previously described. They are important because the site evaluation may confuse some of these features with soil mottling caused by wetness. The site evaluator need not include these descriptions unless he feels the inclusion of these features clarifies that the variation in color is not caused by wetness.
The presence of iron and/or manganese nodules, particularly in a pale-colored soil matrix, often indicates periodic saturation. Although nodules are not a color, they are often associated with soil colors indicating wetness. Nodules or concretions may be indicative of slow percolation rates, restrictive horizons and/or a seasonal water table.

The case for rejecting a proposed drain field site solely on the presence of nodules is not strong, but nodules are a good indicator of soil/site moisture conditions.
The features discussed here are identifiable bodies embedded in the soil. Some of these bodies are thin and sheetlike; some are spherical; others have irregular shapes. They may contrast sharply with the surrounding material in strength, composition or internal organization.

Nodules and Concretions

Nodules and concretions are discrete bodies. They are commonly cemented. They may also be uncemented but coherent units that separate from the surrounding soil along clearly defined boundaries. They range in composition from material dominantly like that of the soil to concentrations of nearly pure chemical compounds.

Soft Accumulations

Soft accumulations contrast with the surrounding soil in color and composition but are not easily separated as discrete bodies, although some have clearly defined boundaries. Most soft accumulations consist of calcium carbonate, iron and manganese

Soft Rock Fragments

Soft rock fragments have rock structure, but break down easily.

Surface Features

The surfaces of individual peds may have coats of a variety of substances unlike the adjacent soil material and covering part or all of the surfaces. Descriptions of surface features may include kind, location, amount, continuity, distinctness, and thickness of the features. In addition, color, texture and other characteristics that apply may be described, especially if they contrast with the characteristics of the adjacent material.

Roots and Root Traces

The presence of roots in each layer is recorded in soil descriptions. The absence of roots or the orientation of roots may indicate hardpan, saturated soil, or bedrock.

Part IV: Soil Drainage

The flow of water in soil depends on the soil's ability to transmit the water and the presence of a force to drive the water. An understanding of how water moves into and through soil is necessary to predict the potential of soil for wastewater absorption and treatment.

Roots and Root Traces

The movement of water through the soil is controlled by landscape, internal soil properties, and environmental factors. Soil properties influencing water movement include cracks, coarse fragments, soil structure, total porosity, size, continuity of pores, and water content of the soil. Environmental factors include form and intensity of precipitation, evapotranspiration, and temperature.

Terms Used to Describe Drainage

Bulk density is an indicator of the total porosity of the soil. It is calculated as the weight of a given volume of soil which includes pore spaces. An average bulk density is 1.3 grams per cubic centimeter. Coarse-textured soils will usually have a higher bulk density because they have less pore space than fine-textured soils. **Porosity,** or the amount of void space between soil particles, ranges from 40 to 50 percent. In disturbed soils or hardpans, porosity can be much less. Texture, structure, and organic matter are all important in determining soil porosity. Coarser-textured soils have larger pores, but less pore space than finer-textured soils.

Lower horizons in the soil profile tend to have higher bulk densities than upper layers. Subsoils are generally more compacted because of the overlying weight of the upper soil. They usually contain less organic matter, and thus a less open structure. Often subsoils accumulate clays and iron oxides that have washed down from the upper horizons. These clay particles become trapped in larger pores, reducing the overall pore space.

Percolation rate or **perc rate** is the length of time it takes for a depth of water to be absorbed by the soil. It’s measured in minutes per inch (mpi).

Permeability is a measure of the ease of fluid flow through porous media, and is proportional to the porosity of the media. Permeability is measured in inches per hour. To convert from permeability units to percolation units, divide the permeability value into the number 60. For example:

> 60 in./hr. ÷ 0.2 = 300 minutes per inch (mpi).

To convert from percolation rate units to permeability units, divide the percolation rate into 60. For example:

> 30 mpi = 60 ÷ 30 = 2 inches per hour (in/h).

Soil texture is used as an indirect indicator of soil permeability. Generally, the higher the percent clay in a soil horizon, the slower the percolation rate. But texture alone cannot be used to determine the final sizing of systems. For instance, a sandy loam soil is *likely* to have a percolation rate in the six to 15 mpi range, however, it is entirely *possible* that a sandy loam soil could have a percolation rate much slower, if the soil had been compacted or cemented by natural processes or human activity.

Hydraulic conductivity is the rate of water movement within the soil. It is a measure of the ease with which water moves through the soil, and is measured in centimeters per hour or feet per day. Soils higher in clay contain more pore space than soils high in sand, but the individual pore spaces are smaller. As the clay content of soils increases, hydraulic conductivity decreases.

Sands and gravelly soils in many landscape positions (e.g. summit, shoulder, or back slope) can transmit water downward so readily that the soil or layer remains moist for no more than a few hours after a thorough wetting. These soils have large connected voids.

Sandy loam, loam, and loamy sand commonly remain moist for no more than a few days after thorough wetting. These soils commonly have weak to moderate structure. These soils are often considered favorable for rooting and for supplying water to plants. Clayey soils commonly transmit water downward so slowly that they remains moist for a week or more after a thorough wetting. Other soils with low hydraulic conductivity may be structureless or have only fine and discontinuous pores (as in some clays, fragipans or cemented layers).

Layers may be massive or platy. There may be few connecting pores that could conduct water when the soil is wet. Hydraulic conductivity does not necessarily describe the ability of soils, in their natural setting, to dispose of water internally. A soil may have very high conductivity, yet contain free water because there are restricting layers below the soil, or because the soil is in a depression where water from surrounding areas accumulates faster than it can pass through the soil. Therefore, the water may actually move very slowly despite the soil's high conductivity. Actual rate of water movement is a product of the hydraulic conductivity and the **hydraulic gradient.** The hydraulic gradient at any point is determined by the elevation of that point relative to some reference level.

Thus, the higher the water above this reference, the greater its gravitational potential. Hydraulic conductivity is highly variable. Measured values for a particular soil series can vary by 100-fold or more. Hydraulic conductivity can be given for the soil as a whole or for a particular layer or combination of layers. The layer with the lowest value determines the hydraulic conductivity classification of the soil.

The above discussion relates to water movement in soils that are saturated with water. However, distinction needs to be made between saturated hydraulic conductivity and unsaturated hydraulic conductivity.

Saturated Flow

Saturated hydraulic conductivity is the greatest rate at which water can move through the soil. Saturated flow occurs when the soil is saturated or nearly saturated. When all the pores are filled with water, most of the water flows by gravity through the large pores. Saturated hydraulic conductivity is a function of such soil properties as pore size distribution, pore geometry, total porosity (water-filled porosity at saturation), and clay mineralogy. Water moves much more easily through large pores than through small ones. The size and continuity of pores in a soil largely determines the rate of internal water movement.

Cracks, structure, coarse fragments and porosity determine the cross-sectional area available for water movement through a soil. Decreasing the cross-sectional area available for flow decreases the rate and amount of water movement through the soil.

Sands have the smallest number of pores, yet sands have the fastest percolation rates. This is due to the large pores in sands. Pores in sand are also fairly continuous. While porosity in clayey soils is large, the majority of the pores are very small. Trapped air decreases flow if the soil has free water or water at very low tension, because the air bubbles act like coarse fragments and block water flow.

Unsaturated Flow
Water flow is unsaturated when the soil water is under tension (negative pressure). Unsaturated hydraulic conductivity is a function of the same soil properties as saturated hydraulic conductivity and also of the soil water content. Unsaturated flow is always slower than saturated flow.

The ability of the soil to draw or pull water into its pores is referred to as its **matric potential.** The matric potential is produced by the affinity of water molecules to each other and to solid surfaces. Molecules within the body of water are attracted to other molecules by cohesive forces, while water molecules in contact with solid surfaces are more strongly attracted to the solid surfaces by adhesive forces. The result of these forces acting together draws water into the pores of the soil. The water tries to wet the solid surfaces of the pores due to adhesive forces and pulls other molecules with it due to cohesive forces.
The driving force behind unsaturated flow is not gravity, but a soil tension force (sometimes called “capillary attraction,” “wicking action” or “sucking power”).
Under unsaturated conditions, the largest pores drain first since they are able to exert the least tension or sucking power. Water is pulled or sucked through the smaller pores. Since clays have smaller pores, they can actually transmit water faster under unsaturated conditions than sands.

Water moving by unsaturated flow is moving due to tension, not gravity, so it does not have to go down, but can move sideways or even up, to wherever the soil is the driest. The presence of lush, green grass over the drain field is evidence of this capillary movement of unsaturated flow of water.

Permeability
Permeability is the rate of water movement through a saturated soil in inches per hour. The percolation test measures only the rate of the drop of water in a test hole of a specific diameter and does not measure the rate of movement of water through the soil. However, the relative values for permeabilities will give some index of the ability of soil to transmit water. A very slow permeability also indicates a soil which is relatively high in fine material such as silt and clay and thus, may need extreme care during the installation of the soil treatment system. Slowly permeable layers occur in soils due to many geologic or soil-forming events. They may be layers cemented by translocation and deposition of iron, calcium or clay. Dense layers (low porosity) are formed by the weight of glacial ice over soil parent material or by heavy construction equipment.

Water Tables
Saturated soil conditions are also known as **groundwater** and **the water table.** The relationship between soil and water is critical in evaluating the use suitability for a soil. Soil wetness should be characterized by identifying the depth to the uppermost zone of saturation and the approximate duration of that saturation. Saturated soil conditions are detrimental to onsite soil absorption systems. Failures occur both in the movement of effluent into the soil and in its treatment. Premature system failure due to saturated soil conditions can be because of:

- soil flowing at saturation and clogging the gravel beds or the distribution piping,

- accelerated clogging of the system area by bacteria that operate during saturated or wet soil conditions, *or*

- slow or no movement of effluent out of the system because the soil is already filled with water and is unable to accept additional liquid.

All of the preceding situations lead to effluent either surfacing on the ground or backing up into the home.

Treatment of effluent is not effectively achieved in saturated soil. Contamination of drinking water wells can occur when untreated effluent enters groundwater. Knowledge of the times and depths at which a soil is wet is important to determine if the soil is suited for onsite sewage treatment. Free water exerts a strong influence on the physical, biological and chemical processes that are necessary for sewage treatment and disposal.

Soil wetness is influenced by climate, slope and landscape position as well as by permeability characteristics of the soil. Precipitation, runoff, amount of moisture entering the soil and rate of water movement through the soil along with evaporations, affect the degree and duration of wetness. Different areas of the same soil may differ in wetness because of landscape position. A soil in a higher position may be deeper to the water table or have a shorter duration of wetness than the same soil downslope. In determining where onsite systems can be located, saturated soil is considered the highest elevation in the soil where redoximorphic features (mottling) is present.

Zones of soil saturation change from day to day, season to season and year to year. Following periods of brief heavy rains, soil moisture contents at any depth may change rapidly as the water percolates through the profile. This may result in horizons being saturated for a very short time (a matter of hours), not long enough for the formation of gray colors or distinct mottles. During extended dry or wet periods, changes in soil moisture contents will be so slow as to appear almost constant.

If a portion of the soil profile is saturated, the depth to saturation can be determined by observing the depth to the water surface in a bore hole. This may be of value during wet periods; however, soil color and mottling are most often used to estimate depth to saturated conditions. Interpretation and identification of soil horizons that are periodically saturated depend on the identification and description of soil mottles.

A seasonal high water table is a zone of saturation in the soil at the highest average depth during the wettest season. It is at least six inches thick, persists in the soil for more than a few weeks and is within six feet of the soil surface. Soils with a seasonal high water table are classified according to water table depth, type, and time of year when the water table is highest.

Appendix G

Assessing Aerobic treatment

ASSESSING PERFORMANCE OF ON-SITE TREATMENT UNITS THAT TREAT THE WASTEWATER AEROBICALLY

James C. Converse1

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How does one assess if the on-site wastewater treatment unit, utilizing aerobic principles is performing adequately? These units include aerobic units, single pass sand filters, recirculating sand filters, peat filters, constructed wetlands, biofilters and other units that treat the wastewater aerobically. In order to assess if a unit is performing satisfactory and to its design potential, the evaluator must understand the goals of the unit. For example, is the goal of the unit to treat the effluent to a high degree (BOD and TSS < 25 mg/L and Fecals to <10,000 col/100 mL) or is it to reduce the organic load to the downstream unit and not necessarily reduce the BOD to < 25 mg/L etc.

A. Sampling: In order to assess the performance , one needs to sample the effluent. There are basically two types of sample which are:

1. Grab sample - sample taken from the unit which will provide information on performance at the time the sample was taken. Sample taken from the end of the pipe are typically grab samples.

2. Composite sample - sample taken at intervals over a period of time, normally 24 hours. The various sub-samples are mixed together to form a "composite" sample. Size of individual sub-samples are normally proportional to flow quantity. This process requires installation of a special instrument called "composite sampler" or similar name. It usually requires preserving the sample during the collection process.

3. Pump chamber sample - the pump chamber serves as a "compositor" of the effluent. Taking a grab sample from the pump chamber provides a composite sample.

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When reporting results, the sampling location and type of sample should be reported.

B. Analysis/Evaluation: Performance analysis is done at the site and samples sent to the laboratory.

1. On-site analysis: This will include examining the physical performance of the actual unit and the effluent sample.

a. Physical performance - Examine if the following items are functioning:

1. Air blowers or pumps, connections and filters
2. Pumps
3. Alarms
4. Filters

5. Mixed liquor sample for aerobic units (suspended growth). This is done by taking a grab sample of the contents, putting it in a graduated cylinder and observing the level of solids. If setteable solids occupies 45-50% it may be time to have the unit pumped. Observe color - Should be Chocolate Brown.
6. Observe if anything appears to be unusual.

b. On-site effluent analysis
1. Sniff the sample for any odor. Sample should not have any "septic smell" if the goal of the unit is to produce a very high quality effluent (low BOD, TSS) and operating properly. If the goal of the unit is to reduce the BOD/TSS substantially, but not necessarily to < 30 mg/L, then there may be slight septic smell.
2. Observe the clarity of the sample. Sample should be relatively clear if the goal is to treat it to BOD/TSS <30 mg/L. If not, there may be some lack of clarity.
3. Check the pH with a small hand held pH meter. It should read between 6.5 and 7.5.
4. Check the dissolved oxygen level. This should be done with minimal agitation to avoid mixing air with the sample. Oxygen levels will vary but levels should be between 1 and 8 mg/L. Higher levels indicates the unit is performing well and low levels <1 mg/L indicates the unit is not performing adequately. This may be the result of hydraulic/organic overloading, inadequate air supply or poor transfer of oxygen to the water. Those units that aren't expected to treat the effluent to low BOD/TSS levels may have reduced oxygen levels.
5. Temperature of sample. Temperature should be taken immediately.

2. Off-Site analysis:
Further information can be obtained by sending a representative sample to a certified laboratory. This can be somewhat costly and is not necessary for every performance evaluation. It must be done if it appears that the system is not functioning properly based on on-site evaluation.

a. Biochemical oxygen demand. - 5 day test to measure level of oxygen demanding material. BOD should be < 30 mg/L for systems expected to have low BOD.

b. Total suspended solids - TSS should be <30 mg/L for systems expected to have low TSS.

c. Nitrogen - TKN, ammonia and nitrate. TKN measures organic and ammonia nitrogen. The TKN and ammonia should be low and nitrates high. During the winters the TKN and ammonia may be a little higher and nitrates a little lower than summer time. TKN and ammonia values should be < 5 and nitrates typically in range of 25-50 mg/L depending on the source of effluent. Nitrates will be lower if unit is a recirculating filter. T

d. Fecal coliforms: measures the level of pathogen reduction via fecal coliform indicators. Numbers will vary depending on type of unit. Single pass sand filter and peat filter effluent will typically have numbers < 1000 col./100 mL. Aerobic units will typically have values that range from < 1000 - 100,000 col./100 mL depending on a number of factors such as degree of treatment, disinfection etc. Recirculating filters will have numbers in range of 1,000 to 100,000 col./100 mL depending on a number of variables. Typical septic tank effluent will have numbers in range of 100,000 to millions col./100 mL.

e. Alkalinity: This is a measure of the buffering capacity of the effluent. Sufficient alkalinity must be present for nitrification to occur. Alkalinity is measured as mg/L of $CaCO_3$ (Calcium Carbonate). Typical values for on-site systems range from 250 – 450 mg/L as $CaCO_3$.

Note: It should be noted that ammonia, nitrates and alkalinity are typically evaluated off-site. However, test kits are available for on-site evaluation of these parameters.

C: Testing Equipment/Kits

1. **Dissolved Oxygen Instruments/Kits:**
The following are instruments used for measuring dissolved oxygen:

a. Hach Company, P.O. Box 608, Loveland Colorado. 1-800-227-4224. Cat. No. 1469-00 - Cost $48. This unit measures oxygen via adding the contents of 3 samples to the sample and using drop count titration and calculating the DO. Takes a few minutes to perform.

b.. Fisher Scientific - 1-800-766-7000. Cat. No. 13-299-200 Chemets Self Filling Ampules. 0-10mg/L $49 for 30 tests. This kit measures dissolved oxygen within two minutes. Compare the solution color to a color chart. Takes less time to perform than Hach.

Cat. No. 13-299-415 Single Analyte Meters (SAMs) - Cost $195. This unit measures oxygen via adding the contents of one ample to the sample and read the results on photo detector. Takes less time to perform than Hach.

Cat. No 13-298-56 - YSI Model 55 Hand held dissolved oxygen meter. - $700. This unit measures both dissolved oxygen and temperature by inserting the probe into the sample or the pump chamber. It has a long cable connecting the probe to the unit. Probe needs to be calibrated and membrane changed periodically. There are other models and more expensive models available.

Note: Dissolved oxygen testing equipment is available through some of the other suppliers listed below.

2. Ammonia, nitrate, pH, settleable solids, alkalinity test kits.
Testing kits and equipment are available from a number of manufacturers: Listed are several sources for obtaining test kits and equipment. Not all sources handle all the materials.

Chemetrics Dissolved oxygen chemet tubes. www/chemetrics.com
800 356-3072 Route 28, Calverton, VA 20138

Cole-Parmer. www.coleparmer.com 800 323-4340, 625 E. Bunker Ct., Vernon Hills, IL 60061

Fisher Scientific. www.fishersci.com 800 955-6666, 4500 Turnberry Drive, Hanover Park, IL 60103

Hach Test strips for ammonia, nitrate, pH, www.hach.com Alkalinity 800 227-4224, PO Box 389, Loveland, CO 80539

LaMotte. www.lamotte.com 800 344-3100, PO Box 329, Chestertown, MD 21620

APPENDIX H

Pressure Distribution Design

PRESSURE DISTRIBUTION NETWORK DESIGN

By

James C. Converse[1]

January, 2000

Septic tank effluent or other pretreated effluent can be distributed in a soil treatment/dispersal unit either by trickle, dosing or uniform distribution. **Trickle flow**, known as gravity flow, occurs each time wastewater enters the system through 4" perforated pipe. The pipe does not distribute the effluent uniformly but concentrates it in several areas of the absorption unit.

Dosing is defined as pumping or siphoning a large quantity of effluent into the 4" inch perforated pipe for distribution within the soil absorption area. It does not give uniform distribution but does spread the effluent over a larger area than does gravity flow. Uniform distribution, known as pressure distribution, **distributes the effluent somewhat uniformly throughout the absorption area.** This is accomplished by pressurizing relatively small diameter pipes containing small diameter perforations spaced uniformly throughout the network and matching a pump or siphon to the network.
This material has been extracted and modified from a paper entitled "Design of Pressure Distribution Networks for Septic Tank- Soil Absorption Systems" by Otis, 1981. It also includes material from the "Pressure Distribution Component Manual for Private Onsite Wastewater Treatment Systems" by the State of Wisconsin, Department of Commerce, 1999.

Design Procedure

The design procedure is divided into two sections. The first part consists of sizing the distribution network which distributes the effluent in the aggregate and consists of the laterals, perforations and manifold. The second part consists of sizing the force main, pressurization unit and dose chamber and selecting controls.

A.**Design of the Distribution Network:**

Steps

1. Configuration of the network.

The configuration and size of the soil treatment/dispersal unit must meet the soil site criteria. Once that has been established, the distribution network can be designed.

2. Determine the length of the laterals.

Lateral lengths are defined as the distance length from the manifold to the end of the lateral. For a center manifold it is approximately than one half the length of the absorption area. For end manifolds it is approximately the length of the absorption area. The lateral end about 6" to 12" from the end of the absorption units.

3. Determine the perforation size, spacing, and position.

The size of the perforation or orifices, spacing of the orifices and the number of orifices must be matched with the flow rate to the network.

Size: The typical perforation diameter has been 1/4" but, with the advent of the effluent filters, placed in septic tanks to eliminate carry-over of large particles, smaller diameter orifices can be used. Orifices as small as 1/8" are commonly used in sand filter design utilizing orifice shields to protect the orifice from being covered with aggregate. There are also concerns about using the 1/8" orifices as to how well they drain when located downward especially if they have been drilled in the field. Shop drilling the orifices under tight specifications reduces the concern. As a compromise, one might consider using 3/16" diameter orifices which will allow for more orifices than if 1/4" diameter orifices were used. This example will use 3/16" diameter orifices. **A sharp drill bit will drill a much more uniform orifice than a dull drill. Replace drills often. Remove all burrs and filing from pipe before assembling it.**

Spacing: It is important to distribute the effluent as uniformly as possible over the surface to increase effluent/soil contact time to maximize treatment efficiency. Typical spacing has been 30-36" but some designers have set spacing further apart to reduce pipe and pump sizes. Typical spacing for sand filters has been 6 ft^2/orifice. This spacing is being adopted in the Wisconsin Code (1999) for all pressure distribution applications. This example will use the 6 ft^2/orifice.

Positioning: In cold climates, it is essential that the laterals drain after each dose event to prevent freezing. In sand filters, the orifices have been placed upward with the orifice protected with an orifice shield. The laterals are sloped back to the force main for drainage after each dose. Because of the longer laterals normally encountered in mounds the orifices are typically placed downward for draining as it is much more difficult to slope the lateral to the manifold/force main because of their greater length than found in sand filters. However it can be done. The designer/installer may want to consider sloping the pipe back to the manifold, placing the orifices upward with orifice shields or placing a 3 or 4" half pipe over the entire length of the lateral. Another alternative is placing the lateral inside a 4" perforated pipe with orifices downward or with orifices upward and pipe sloped to the manifold.

4. Determine the lateral pipe diameter.
Based on the selected perforation size and spacing, Fig. A-1 through A-3 will be used to select the lateral diameter.

5. Determine the number of perforations per lateral.
Use N = (p/x) + 0.5 for center feed/center manifold or N = (p/x) + 1 for end fed/end manifold where N = number of perforations, p= lateral length in feet and x= perforation spacing in feet. Round number off to the nearest whole number.

6. Determine the lateral discharge rate.
Based on the distal pressure selected, Table A-1 gives the perforation discharge rate. Recommended distal pressures are 2.5 ft for 1/4" orifices, 3.5 ft for 3/16" orifices and 5 ft for 1.8" orifices. The head that the system operates under is controlled where the system curve interacts with the pump curve (Fig. A-4). For this example use 3.5 ft of head.

7. Determine the number of laterals and the spacing between laterals.
Since the criteria of 6 ft^2/orifice is the guideline, the orifice spacing and laterals spacing are interrelated. For absorption area widths of 3 ft, one distribution pipe along the length requires an orifice spacing of 2 ft. For a 6 ft wide absorption area with the same configuration it would require orifice spacing of 1 ft. **Ideally, the best option is to position the perforations to serve a square such as a 2.5 by 2.5 area** but that may be difficult to do but a 2 by 3 is much better than a 6 by 1 area.

8. Calculate the manifold size and length.
The manifold length is the same as the spacing between the outer laterals if the force main comes into the manifold end. For smaller units assume the manifold size is the same as the force main diameter since the manifold is an extension of the force main. There are procedures for determining the manifold size for larger systems (Otis, 1981).

9. Determine the network discharge rate.
This value is used to size the pump or siphon. Take the lateral discharge rate and multiply it by the number of laterals or take the perforation discharge rate and multiply it by the number of perforations.
4
10. Provide for Flushing of Laterals.
Provisions must be made to flush the laterals periodically, preferably annually. Easy access to lateral ends is essential otherwise, the flushing will not be done. Turn-ups, as used in sand filter technology, is one approach.

B.**Design of the Force Main, Pressurization Unit (Pump or Siphon), Dose Chamber and Controls.**

Steps

1. Develop a system performance curve.
The system performance curve predicts how the distribution system performs under various flow rates and heads. The flow rate is a function of the total head that the pump works against. As the head becomes larger, the flow rate decreases but the flow rate determines the network pressure and thus the relative uniformity of discharge throughout the distribution network. The best way to select the pump is to evaluate the system performance curve and the pump performance curve. Where the two curves cross, is where the system operates relative to flow rate and head.
The total dynamic head that the pump must work against is the:

1. System network head (1.3 x distal pressure with minimum 2.5 ft.).
2. Elevation difference between the off-float and the highest point in the network.

3. Friction loss in the force main. The system network head is the pressure maintained in the system during operation to assure relatively uniform flow through the orifices. The 1.3 multiplier relates to the friction loss in the manifold and laterals which assumes that the laterals and manifold are sized correctly. The elevation difference is between the pump off switch and the distribution network in feet (the pump industry uses the bottom of the pump to the net work). The friction loss in the force main between the dose chamber and the inlet to the network is determined by using Table A-2. Equivalent length for fittings should be included but have typically been ignored. They are included in the example problem with equivalent lengths found in Table A-3.

2. Determine the force main diameter.
The force main diameter is determined in Step 1, part B.

3. Select the pressurization unit.
Pumps
The effluent pumps used for pressurizing the distribution networks are either centrifugal effluent pumps or turbine effluent pumps. The turbine effluent pump, which is a sightly modified well pump, is relatively new to the on-site industry. Relatively speaking the centrifugal pump is a higher capacity/ lower head pump with a relatively flat performance curve and the turbine pump is a lower capacity/higher head pump with a relatively steep performance curve. Turbine pumps probably have a longer life. They may be the preferred choice for time dosing because of their longevity relative to stop/starts.
Using pump performance curves, select the pump that best matches the required flow rate at the operating head. Plot the pump performance curve on the system curve. Then determine if the pump will produce the flow rate at the required head. Do not undersize the pump. It can be oversized but will be more costly.

Siphons
Care must be taken in sizing siphons. The head that the network operates against has to be developed in the force main by backing effluent up in the pipe. If the discharge rate out the perforations is greater than the siphon flow rate, the distal pressure in the network will not be sufficient. Some manufacturers recommend that the force main be one size larger than the siphon diameter to allow the air in the force main to escape. However, this will reduce the distal pressure in the network which may be below the design distal pressure. Falkowski and Converse, 1988, discuss siphon performance and design.

4. Determine the dose volume required.
The lateral pipe volume determines the minimum dose volume. The recommended dose volume has been 5 - 10 times the lateral volume. Also, it was recommended that the system be dosed 4 times daily based on the design flow which would be about 113 gpdose (450 gpd/ 4). At this rate, some mounds would only be dosed once a day. With the advent of timed dosing where effluent is applied a number of times per day, smaller doses need to be applied. However, sufficient volume needs to be applied to distribute the effluent uniformly across the network.

Thus, net dose volume size is 5 times the lateral pipe volume with not over 20% of the design volume/dose. The floats are set based on the net dose volume plus the flow back. Table A-4 gives the void volume for various size pipes.

5. Size the dose chamber.

The dose chamber (Fig. A-5) must be large enough to provide:

a. The dose volume.

b. The dead space resulting from placement of the pump on a concrete block.

c. A few inches of head space for floats

d. Reserve capacity based on 100 gallons per bedroom.

If time dosing is selected, the pump chamber or septic tank/pump chamber must have sufficient surge capacity. The reserve capacity normally would be sufficient to handle it in a pump chamber. However, if a turbine pump is used, there may not be enough surge capacity if the pump must be submerged as turbine pumps are relatively tall. If the liquid level needs to be above the pump, sufficient dead space reduces the working volume of the tank. That is not the case for centrifugal pumps.

6. Select controls and alarms.

Select quality controls and alarms. Follow electrical code for electrical connections. Some have to be made outside the dose tank. There are excellent friendly user control panels for timed dosed systems.

DESIGN EXAMPLE

Design a pressure distribution network for the mound as described in the Wisconsin Mound Soil Absorption System Siting, Design and Construction (Converse and Tyler, 2000). The absorption area is 113 ft long by 4 ft wide. The force main is 125 ft long and the elevation difference is 9 ft with three 90^o elbows.

A. Design of the distribution network.

Steps:

1. Configuration of the network.

This is a narrow absorption unit on a sloping site.

2. Determine the lateral length.

Use a center feed, the lateral length is:

Lateral Length = (B / 2) - 0.5 ft Where: B = absorption length.

= (113 / 2) - 0.5 ft = 56 ft

3. Determine the perforation spacing and size.

Perforation spacing - Each perforation covers a maximum area of 6 ft^2. The absorption area is 4 ft wide.

Option 1: Two laterals on each side of the center feed
Spacing = (area/orifice x no. of laterals / (absorption area width)
= (6 ft^2 x 2) / (4 ft) = 3 ft.

Option 2: One lateral down the center on each side of the center feed:
Spacing = area per orifice / width of absorption area = 6 ft^2 / 4 ft = 1.5 ft

Best option: Ideally, the best option is to position the perforations to serve a square but that may be difficult to do. In Option 1, each perforation serves a 2' by 3' rectangular area while in option 2, each perforation serves a 1.5 by 4 area. With an absorption area of 6 ft wide with one lateral down the center, perforation spacing would be 1 ft apart and the perforation would serve an area of 6 by 1 ft **which would be undesirable**. The proposed Comm. 83 code (Wisc Adm. Code, 1999) states that laterals have to be within 2.0 ft of the edge of the absorption area to eliminate designs laterals with close spacings.

Perforation size -
Select from 1/8, 3/16 or 1/4". Use 3/16" as per discussion in section "Design Procedure Item A-3.

4. Determine the lateral diameter.
Using **Fig. A-2 (3/16")**:

Option 1: For **two laterals** on each side of the center feed and lateral length of 56 ft and 3.0 ft spacing, the **lateral diameter = 1.5"**

Option 2: For one lateral on each side of center feed and lateral length of 56 ft and 1.5 ft spacing, **the lateral diameter = 2".**

5. Determine number of perforations per lateral and number of perforations.

Option 1: Using 3.0 ft spacing in 56 ft yields:
N = (p/x) +0.5 = (56 / 3.0) +0.5 = 19 perforations/lateral
Number of perforations = 4 lateral x 19 perforations/lateral = 76

Option 2: Using 1.5 ft spacing in 56 ft yields:
N = (p/x) + 0.5 = (56/ 1.5) + 0.5 = 38 perforations/ lateral
Number of perforations = 2 laterals x 38 perforations/lateral = 76
Check - Maximum of 6 ft^2 / perforation =
Number of perforations = 113 ft x 4 ft / 6 ft^2 = 75 so ok.

6. Determine lateral discharge rate (LDR).
Using network pressure (distal) pressure of 3.5 ft and 3/16" diameter perforations, Table A-1 gives a discharge rate of 0.78 gpm regardless of the number of laterals.

Option 1: LDR = 0.78 gpm/ perforation x 19 perforations = 14.8 gpm

Option 2: LDR = 0.78 gpm/ perforation x 38 perforation = 29.6 gpm

7. Determine the number of laterals.
This was determined in Step 3 and 4.

Option 1: Two laterals on each side of center feed = 4 laterals spaced 2 ft apart.

Option 2: One lateral on each side of center feed = 2 laterals down center of absorption area.

8. Calculate the manifold size.

Option 1. The manifold is same size as force main as it is an extension of the force main or it could be one size smaller. For larger systems, there is a table available by Otis, 1981 and Wisc. Adm. Code.

Option 2. There is no manifold.

9. Determine network discharge rate (NDR)

Option 1. NDR = 4 laterals x 14.8 gpm/lateral = 59.2 or 60 gpm

Option 2. NDR = 2 laterals x 29.6 gpm/lateral = 59.2 or 60 gpm
Pump has to discharge a minimum of 60 gpm against a total dynamic head yet to be determined.

10. Total dynamic head.
Sum of the following:
System head = 1.3 x distal head (ft)
= 1.3 x 3.5 ft = 4.5 ft
Elevation head = 9.0 ft (Pump shut off to network elevation)
Head Loss in Force Main = Table A-2 and A-3 for 60 gallons and 125 ft of force main and 3 elbows.
Equivalent length of pipe for fittings - Table A-3

Option A: 2" diameter force main = 3 elbows @ 9.0 ft each = 27 ft of pipe equivalent.

Option B: 3" diameter force main = 3 elbows @ 12.0 ft each = 36 ft
Head Loss = Table A-2

Option A: 2" diameter force main = 7.0 (125 ft + 27 ft)/100 = = 10.6 ft
10
Option B: 3" diameter force main = 0.97(125 ft + 36 ft) 100 = = 1.6 ft

Total Dynamic Head (TDH)

Option A: TDH = 4.5 + 9 + 10.6 = 24.1 ft (2" force main)

Option B: TDH = 4.5 + 9 + 1.6 = 15.1 ft (3" force main)

11. Pump Summary

Option A: Pump must discharge 60 gpm against a head of 24.1 with 2" force main.

Option B: Pump must discharge 60 gpm against a head of 15.1 ft with 3" force main.

These are the calculated flow and head values. The actual flow and head will be determined by the pump selected. A system performance curve plotted against the pump performance curve will give a better estimate of the flow rate and total dynamic head the system will operate under. The next section gives an example.

Design of the Force Main, Pressurization Unit, Dose Chamber and Controls

Steps

1. Calculate the system performance curve.
Use the following table to develop a system performance curve. Follow procedures (a) through (g) which is listed below the table. Orifice is synonymous to perforation. **This example uses Option A. Option B can be calculated similarly.**

Total Flow	Orifice Flow	Elevation Difference	Force Main	Network Head	Total Head
-------(gpm)-----------		-----------------------(ft)-------------------------------------			
40	0.526	9	5.0	2.1	16.1
50	0.658	9	7.6	3.3	19.9
60	0.789	9	10.6	4.7	24.3
70	0.921	9	14.2	6.4	29.6
80	1.053	9	18.1	8.4	35.5

Procedure:
a. Select 5 flow rates above and below the network discharge rate of 60 gpm.
b. Calculate the orifice (perforation) flow rate for each of the flows. This is done by dividing the flow rate by the number of orifices in the network. For the 30 gpm and 76 orifices, the orifice flow rate is 0.395 gpm.
c. The elevation head is the height that the effluent is lifted.
d. The force main head is the head loss in the force main for the given flow rate. Table A-2 gives the friction loss. Need to select a force main diameter.

For this example use 2" force main. For the 60 gpm the friction loss is 7.0 ft x 1.52 for head of 10.6 ft.

e. The network head is calculated by $H = 1.3(Q/(11.79d^2))^2$. H is head in ft, Q is orifice flow rate in gpm, and d is orifice diameter in inches. The 1.3 is an adjustment factor for friction loss in laterals. For 3/16" diameter orifice the equation is $H = 1.3(Q/0.4145)^2$.

f. The total head is the sum of the elevation, force main and network heads.

2. Determine the force main diameter.

Force main diameter:

Option A: = 2" (determined in Step 1 of Section B).

Option B: = 3"

3. Select the pressurization unit.

Plot the performance curves of several effluent pumps and the system performance curve (Fig. A-8). For the system curve plot the flow rates vs. he total head. On the system curve, using an X where the flow rate intersects the curve (in this case 60 gpm). Select the pump, represented by the pump performance curve, located next along the system performance curve just after 60 gpm (Pump B) as that is where the pump will operate. Pump C could be selected but it is over sized for the unit.

4. Determine the dose volume.

More recent thinking is that the dose volume should be reduced from the larger doses recommended earlier.

Use 5 times the lateral void volume.

Use void volume from Table A-4.

Option 1: Option 2:

Lateral diameter = 1.5" 2.0"

Lateral Length = 56' 56'

No. of laterals = 4 2

Void volume = 0.092 gal/ft 0.163

Net dose volume

Option 1: = 5 x 56 x 4 x 0.092 = 103 gal./dose

Option 2: = 5 x 56 x 2 x 0.163 = 91.3 gal/dose

Flow back from force main

Option A: 2" force main @ 125 ft @ 0.163 gal./ft = 20.4 gal/dose

Option B: 3" force main@ 125 ft@ 0.0.367 gal/ft = 45.9 gal/dose

Set the floats to dose the combination selected:

Dose volume with Option 1 and Option A = 103 + 20 = 123 gpdose

Dose volume with Option 1 and Option B = 103 + 46 = 146

Dose volume with Option 2 and Option A = 91 + 20 = 111

Dose volume with Option 2 and Option B = 91 + 46 = 137

The net dose volume to the mound will be 91 or 103 gpd with either 20 or 46 gallons flowing back into pump chamber. No check valve is used to prevent flow back in cold climates due to freezing potential. If the dose is limited to 20% of the design flow, Option 1 with net dose of 91.3 is very close to 90 gpdose (450 gpd x 20%). Option 2 does not meet the 20% criteria.

5. Size the dose chamber.
Based on the dose volume, storage volume and room for a block beneath the pump and control space, 500 to 750 gallon chamber will suffice. If timed dosing is implemented, then a larger tank will be required to provide surge storage. Use 2/3 daily design flow for surge capacity.

6. Select controls and alarm.
Demand Dosing: Controls include on-off float and alarm float. An event recorder and running time meter would be appropriate to install. If the pump is calibrated and dose depth recorded, these two counters can be used to monitor flow to the soil unit.
Time Dosing: The advantage of time dosing provides more frequent doses and levels out peak flows to the soil treatment/dispersal unit. In mounds with longer laterals and larger orifices, compared to shorter laterals and smaller orifices in sand filters, time dosing may not be as appropriate as it is in sand filters.

7. Select Effluent Filters.
Filters must be installed on the septic tank to minimize solids carry-over to the pump chamber. A second filter, located on the pump outlet, will keep any solids falling into the pump chamber from being carried over. Converse (1999) provides information relative to filters.

CONSTRUCTION AND MAINTENANCE
Good common sense should prevail when constructing and maintaining these systems. Good quality components should be used. There is no lack of good components today. Water tight construction practices must be employed for all tanks. Surface runoff must be diverted away from the system. Any settling around the tanks must be filled with the soil brought to grade or slightly above to divert surface waters. Provisions must be incorporated into the lateral design, such as turn-ups, to provide for easy flushing of the laterals as solids will build up and clog the orifices. **DO NOT ENTER THE TANKS WITHOUT PROPER SAFETY EQUIPMENT**.

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Table A-1. Discharge rates from orifices.

Orifice diameter (in.)					
Pressure	1/8	3/16	1/4	5/16	3/8
-(ft)-	**(gpm)**				
2.5	0.29	0.66	1.17	1.82	2.62
3.0	0.32	0.72	1.28	1.00	2.87
3.5	0.34	0.78	1.38	2.15	3.10
4.0	0.37	0.83	1.47	2.30	3.32
4.5	0.39	0.88	1.56	2.44	3.52
5.0	0.41	0.93	1.65	2.57	3.71
5.5	0.43	0.97	1.73	2.70	3.89
6.0	0.45	1.02	1.80	2.82	4.06
6.5	0.47	1.06	1.88	2.94	4.23
7.0	0.49	1.10	1.95	3.05	4.39
7.5	0.50	1.14	2.02	3.15	4.54
8.0	0.52	1.17	2.08	3.26	4.69
8.5	0.54	1.21	2.15	3.36	4.83
9.0	0.55	1.24	2.21	3.45	4.97
9.5	0.57	1.28	2.27	3.55	5.11
10.0	0.58	1.31	2.33	3.64	5.24

Values calculated as: gpm = 11.79 x d2 x h1/2 where d = orifice dia. in inches, h = head feet.

Table A-2. Friction loss in plastic pipe.

Flow	Nominal Pipe Size					
(**gpm**)	3/4	1	1-1/4	1-1/2	2	3	4
				(Feet/100 ft of pipe)			
2							
3	3.24						
4	5.52						
5	8.34						
6	11.68	2.88		Velocities in this area are below 2 fps.			
7	15.53	3.83					
8	19.89	4.91					
9	24.73	6.10					
10	30.05	7.41	2.50				
11	35.84	8.84	2.99				
12	42.10	10.39	3.51				
13	48.82	12.04	4.07				
14	56.00	13.81	4.66	1.92			
15	63.63	15.69	5.30	2.18			
16	71.69	17.68	5.97	2.46			
17	80.20	19.78	6.68	2.75			
18		21.99	7.42	3.06			
19		24.30	8.21	3.38			
20		26.72	9.02	3.72			
25		40.38	13.63	5.62	1.39		
30		56.57	19.10	7.87	1.94		
35			25.41	10.46	2.58		
40			32.53	13.40	3.30		
45			40.45	16.66	4.11		
50			49.15	20.24	4.99		
60				28.36	7.00	0.97	
70				37.72	9.31	1.29	
80	Velocities in theses areas				11.91	1.66	
90	exceed 10 fps, which is too great				14.81	2.06	
100	for various flows and pipe diameters				18.00	2.50	0.62
125					27.20	3.78	0.93
150						5.30	1.31
175						7.05	1.74

Note: Table is based on - Hazen-Williams formula: $h = 0.002082L \times (100/C)_{1.85} \times (gpm_{1.85}/d_{4.8655})$ where: h = feet of head, L = length in feet, C= Friction factor from Hazen-Williams (145 for plastic pipe), gpm = gallons per minute, d= nominal pipe size.

Table A-3. Friction losses through plastic fittings in terms of equivalent lengths of pipe.
(Sump and Sewage Pump Manufacturers, 1998)

Type of Fitting	Nominal size fitting and pipe: 1-1/4	1-1/2	2	2-1/2	3	4
90o STD Elbow	7.0	8.0	9.0	10.0	12.0	14.0
45o Elbow	3.0	3.0	4.0	4.0	6.0	8.0
STD. Tee (Diversion)	7.0	9.0	11.0	14.0	17.0	22.0
Check Valve	11.0	13.0	17.0	21.0	26.0	33.0
Coupling/ Quick Disconnect	1.0	1.0	2.0	3.0	4.0	5.0
Gate Valve	0.9	1.1	1.4	1.7	2.0	2.3

Table A-4. Void volume for various diameter pipes.

Nominal Pipe Size (In.)	Void Volume (gal./ft)
3/4	0.023
1	0.041
1-1/4	0.064
1-1/2	0.092
2	0.163
3	0.367
4	0.650
6	1.469

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Fig. A -1a. Minimum lateral diameter based on orifice spacing for 1/8 in. diameter Orifices.

APPENDIX I

Mound system design

WISCONSIN MOUND SOIL ABSORPTION SYSTEM:
SITING, DESIGN AND CONSTRUCTION MANUAL

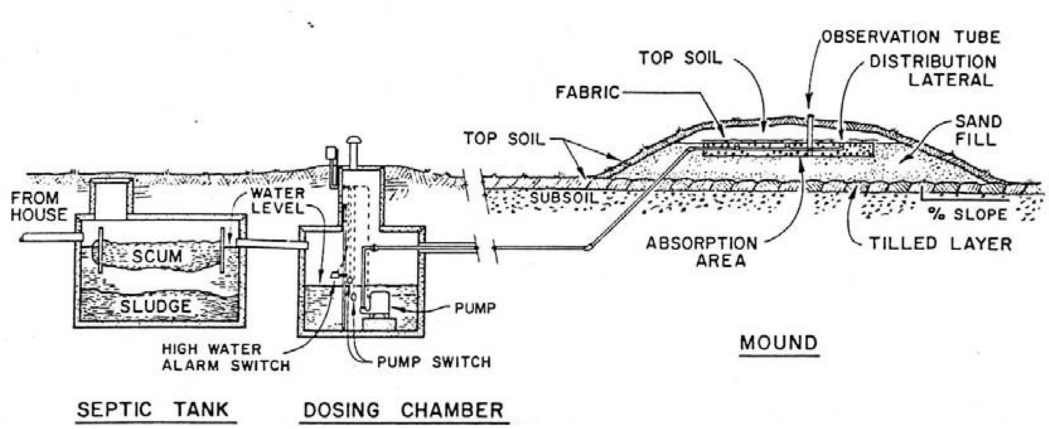
BY
James C. Converse and E. Jerry Tyler[1]
January , 2000[2]

The Wisconsin mound wastewater soil treatment system was developed in the 1970s to overcome some limitations of in-ground trench and bed units and the Nodak system (Witz,1974). The objective of the mound, as with other soil-based units, is to treat and disperse domestic and commercial wastewater on-site via subsurface in an environmentally acceptable manner and to protect the public health.
The Wisconsin mound has been widely accepted and incorporated in many state and local regulations. In 1980 it was incorporated into the Wisconsin Administrative code. Mound technology was successfully implemented in Wisconsin partially because of an extensive educational program offered during the introduction of the mound concept. For the mounds to continue as a viable "tool" in treating and dispersing on-site wastewater, the soil evaluator, designer, installer, regulator and manager must understand the principles of operation, design, installation and management of the system.

Mounds in some areas have not been as successful as in Wisconsin, primarily because of the lack of trained professionals and/or unproven design modifications. Education of all parties involved is essential and care must be taken when making modifications.

Figure 1 shows the components of a Wisconsin mound system. It consists of a septic tank, a dosing chamber and the mound. The septic tank removes solids by settling and floatation with some of the solids transformed into soluble material which pass to the dosing chamber.

Figure 1. Schematic of the Wisconsin mound system showing septic tank, dosing and mound.



The dosing chamber contains a pump or siphon, which transfers effluent, under pressure, to a distribution network of small diameter pipes with small perforations which distributes the effluent uniformly over the absorption area of the mound. The effluent infiltrates into and percolates through the mound sand and native soil, the pathogens are removed, the organic matter is assimilated, nitrogen is transformed to nitrate and phosphorus is retained in the native soil and may slowly migrate depending on the soil properties..

Originally, the Wisconsin mound was designed for specific soil and site limitations for wastewater flows of less than 750 gpd (Converse et al., 1975 a, b, c; Converse, 1978). Based on further research and evaluation, the mound technology was expanded to larger systems and more difficult soil and site conditions (Converse and Tyler, 1986a and b; Tyler and Converse, 1985; and Converse and Tyler, 1987). The new criteria were incorporated into a siting, design and construction manual (Converse and Tyler, 1990).

Many changes have taken place in on-site technology recently especially in sand filter technology. Since the mound is a combination of a single pass sand filter and dispersal unit, many of the sand filter research findings should be implemented into mound technology. **Thus, the purpose of this publication is to incorporate new findings into the siting, design and construction of mounds receiving septic tank effluent.**

WASTEWATER SOURCE

The wastewater quality and quantity is extremely important to ascertain before designing a soil based on-site wastewater treatment system. The design and performance of the mound system, as well as other soil based treatment systems, is based on typical domestic waste water which has been pretreated by passing the waste water through a septic tank. Typical domestic effluent will have a biochemical oxygen demand (BOD) in the range of 150 - 250 mg/L and total suspended solids (TSS) in range of 50 - 100 mg/L. Fats oils and greases (FOG) are typically below 15 mg/L. These numbers will vary somewhat depending on household activity, water conservation activities and the biological activity in the septic tank. The mound is suitable for final treatment and dispersal of highly pretreated effluent from such units as aerobic units, sand filters, peat filters and biofilters which typically produce effluent with BOD and TSS less than 25 mg/L. For this quality of waste water, the sand loading rate can be increased over that used for septic tank effluent and the separation distance can be reduced depending on code requirements. Current thinking is to double the loading rate and reduce the separation distance by 12" (Wisc. Adm. Code, 2000).

High strength wastewastes, such as from restaurants, must either 1) be pretreated to similar BOD, TSS and FOG strengths of septic tank effluent from domestic wastewater before it is applied to the mound or 2) the loading rate to the sand must be reduced significantly so that the organic loading rate to the mound is at or less than that from domestic wastewaster. Extreme care must be exercised when working with non- domestic wastewater.

The design loading rates are based on 150 gpd/bedroom resulting in 450 gpd for a 3 bedroom home. If the mound, as well as other soil based units, is loaded at 450 gpd on a regular basis, it will likely fail. The daily average flow is expected to be no more than about 60% of design or 270 gpd. If water meter readings are used in the design process, the design flow rate must be adjusted upward by at least the same percentage or typically 1.5 - 2 times the meter reading.

The focus of this publication is on domestic septic tank effluent. Adjustments can be made to the design for the highly pretreated effluent and high strength wastes as previously stated.

PRETREATMENT

The septic tank serves as a pretreatment unit for all soil absorption units, including the mound, and its primary function is to remove solids via settling and floatation. New technologies can be incorporated into the septic tank with the most common being effluent filters and pump vaults. Converse (1999) provides information relative to effluent filters and other components related to septic tanks. The dosing chamber/vault is also an essential component to the mound system. It provides a home for the pump and controls, stores effluent and can provide extra storage during down time. With new technology, pump vaults can be incorporated within a septic tank, thus eliminating a tank. The following are several options available for consideration (Converse, 1999):

1. A single compartment septic tank with an effluent filter followed by a single compartment pump chamber.
2. A double compartment tank with the first compartment containing an effluent filter serving as the septic tank and the second compartment serving as the pump chamber.
3. A double compartment tank with both compartments serving as a septic tank with an effluent filter at the outlet of second compartment, followed by single compartment pump chamber. This may be the desired alternative as a modified aerobic unit, such as a Nibbler Jr. (NCS, 1998) or similar product, could be placed in the second compartment to reduce the organic load to the mound if the mound should ever develop a clogging mat, pond and breakout. The conversion would cause minimal disturbance as a tank is already available. Converse et al., (1998) discuss renovation of clogged soil absorption units utilizing aeration.
4. A single compartment tank with a pump vault within the septic tank. The effluent filter is incorporated into the pump vault that suspends from the outlet of the septic tank. An alternative is a double compartment septic tank with a hole in the center of the middle wall to connect the two compartments together in the clear zone and the pump vault in the second compartment. This unit will not provide extra storage capacity as will the individual tank.

Recent research on single pass sand filters shows that short frequent doses to the sand filter with closely spaced orifices (4 - 6 ft^2/orifice) improves effluent quality (Darby et al., 1996).

Short frequent doses requires time dosing instead of demand dosing. Most mounds are demand dosed with larger areas/orifice of 15 to 20 ft^2/orifice. This results in a large quantity of effluent discharged at once and applied less uniformly on the infiltrative surface than for sand filters. This large quantity of effluent moves through the sand rapidly (assuming no ponded condition), allowing insufficient time for the biota to cleanse the effluent totally. This forces fecal coliforms and pathogens further into the soil profile. Short frequent doses and more closely spaced orifices allows the effluent to be retained in the sand/soil for longer periods. Converse et al. (1994) suggested that the reason for some fecal coliforms found deep in the soil profile beneath mounds was due to large infrequent doses. **Designers should use smaller doses and more closely spaced orifices. They should consider time dosing in distributing the effluent to the mound.**

Timed dosing requires that surge capacity be incorporated into the septic tank and/or pump chamber to store the peak flows until it is dosed into the mound and requires control panels which have become very user friendly. Converse (1999) discusses the various options including pump vaults, effluent filters and time/demand dosing. Pressure distribution and dose volumes are discussed in detail by Converse (2000).

SITING CRITERIA

A designer of on-site wastewater treatment and dispersal systems must have a basic understanding of wastewater movement into and through the soil. The designer should work closely with the site evaluator to make sure he/she understand how effluent will move into the soil and away from the system. This understanding is based on information collected during the site evaluation.

Figure 2 shows a schematic of effluent movement within and away from mound systems under various soil profiles. Depending on the type of profile, the effluent moves away from the unit vertically, horizontally or a combination of both. These concepts are true for all on-site systems. The siting and design concepts presented here and elsewhere results in soil treatment/dispersal units that are long and narrow (Converse et al., 1989; Tyler et.al., 1986). The more restrictive the soil profile, the narrower and longer the soil treatment/dispersal unit will be. If these concepts are not followed, then the system may not perform as expected. **The sizing and configuration of all soil absorption units , including the mound, is based on how the effluent moves away from the unit and the rate at which it moves away. Not all of these concepts will apply to all soil and site conditions as soil treatment/dispersal units are not compatible to all sites and should not be used on such sites.**

Separation distances:

Codes, regulating on-site systems, require a depth of soil or soil and sand fill to treat effluent before it reaches a limiting condition such as bedrock or high water table or other restrictive layers. Figure 3 shows the relationship between the type of system best suited for the site and the location of the limiting condition beneath the ground surface where 3 ft of separation is required. This figure can be used for other separation distances which may vary from 1-4 ft depending on the code requirement.

For the mound unit, this separation distance consists of the distance from the ground surface to the limiting condition below the ground surface plus the depth of sand between the ground surface and the infiltrative surface within the mound (sand/aggregate interface or the exposed surface of chamber units. For example, if the code requires 3 ft of suitable soil and the limiting condition is 20" beneath the ground surface, the sand fill depth between the ground surface and the infiltrative surface is 16" for mounds receiving septic tank effluent.

Distance to Water Table:
A distinction should be made between permanent water table and seasonal saturation. Seasonal saturation is the depth at which the soil is saturated for a period of time (days to weeks) primarily during the spring months. This may occur at other times during wet periods and at other locations. Permanent water table relates to a water table that is present all the time. The level may vary depending on precipitation and other factors. All research relating to mounds has been done on seasonally saturated sites. This is important to understand as mounds may perform differently when placed on sites with permanent water table than on sites with shallow seasonal saturation. For example, stress at the toe will be more continuous with a shallow permanent high water table than with seasonal saturation.

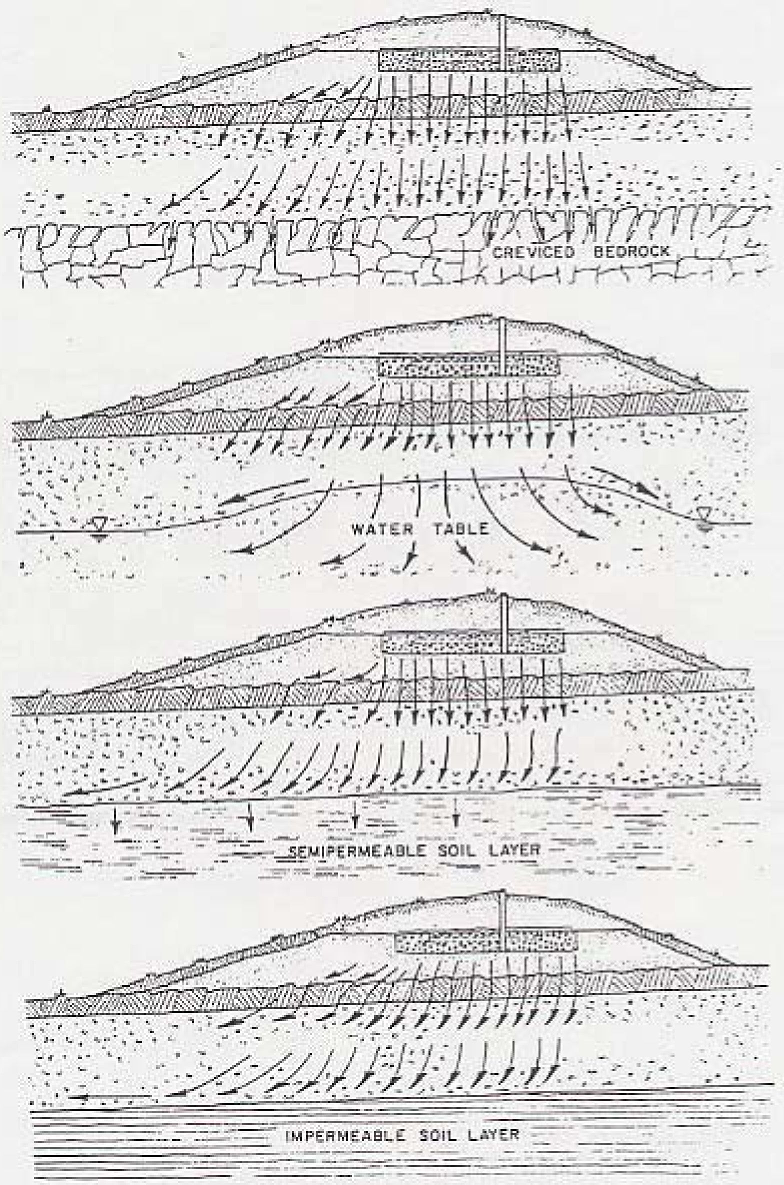
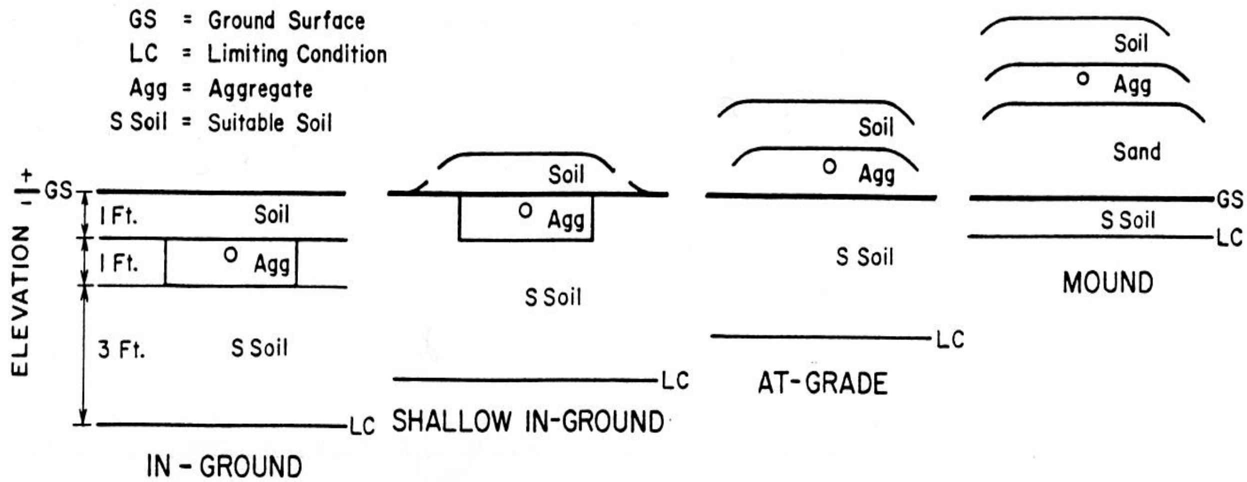


Fig. 2. Effluent movement within and away from the Wisconsin mound for four different types of soil profiles.

Fig. 3. Cross section of four soil absorption units in relation to ground surface and limiting conditions.



Seasonal saturation is determined by 1) redoxmorphoric features (soil color, greys and reds, previously known as mottles) or 2) direct observation via a soil boring or observation wells. Landscape features and native vegetation type also give an indication of soil moisture conditions. If the redoxmorphoric features extend into the top soil, it is difficult to estimate the distance of seasonal saturation beneath the ground surface as it is impossible to detect redoxmorphoric features because of the predominate blackish color in the top soil. In these situations direct observation is the best method but the window of opportunity is very limited.

During seasonal saturation the mound is under stress and there is the possibility of toe leakage. Leakage will be a function of the saturation depth, soil permeability, soil loading rate and linear loading rate. In Wisconsin, very few mounds have had toe leakage because mounds are long and narrow on sites with a high potential for toe leakage. The recommended depth to seasonal saturation is 10 in. beneath the ground surface (Table 1).

It is extremely important to note that as the depth to seasonal saturation decreases (< 10 in.), the chance of toe leakage during seasonal saturation increases greatly. To minimize toe leakage under these conditions, the linear loading rate (to be discussed later) must be decreased resulting in longer mounds. The mound will also be taller to compensate for the reduced soil separation distance.

Table 1. Recommended soil and site criteria for the Wisconsin mound system.

Parameter	
Depth to high water table	10 in.
Depth to crevice bedrock	24 in.[a]
Depth to non-crevice bedrock	10 in.
Permeability of top horizon	0.3 gpd/ft^2
Site Slope	Note[b]
Filled site	Yes[c]
Over old system	Yes[d]
Flood Plain	No

[a] Depth recommended if the crevices are open. If the crevices are filled with soil, may consider reducing depth to 18".
[b] Note: Slope is not a factor in the performance of mound. Slope may be limited due to safe construction techniques.
[c] Suitable according to soil criteria (texture, structure, consistence).
[d] The area and back fill must be treated as fill as it is a disturbed site.

Depth to Bedrock:
Bedrock should be classified as crevice, non-crevice semi-permeable or non-crevice impermeable. Bedrock has been defined where at least 50% of the material by volume is rock (Wisc. Adm. Code, 1983). Once the effluent reaches the bedrock, treatment may or may not take place depending on the bedrock characteristics. In crevice bedrock where the crevices are filled with soil the flow is concentrated in the crevices which may reduce treatment effectiveness but it will be more effective than bedrock with open crevices. Therefore, some credit should be given to filled crevices (see footnote a in Table 1).

Soil Permeability:
Table 2 gives the recommended soil loading rate based on soil texture and structure for the mound basal area. This table assumes that the soil consistence is loose, friable or firm and not very firm. In very firm conditions, water movement is very slow and the site is not recommended for mound placement. Since the basal area receives effluent low in BOD and TSS, the loading rate can be increased compared to soils receiving septic tank effluent. In the past effluent quality has not been taken into consideration when sizing the basal area and the soil loading rates have been the same as for septic tank effluent. This change will reduce the basal area required but will be more in line with loading rates of highly preteated effluent. In most cases the mound footprint will not change because of the recommended 3:1 side slopes. The 3:1 slope was selected for mowing safety.

Slopes:
Site slopes are not a limitation for on-site soil units. Slope limitations are primarily for construction safety concern. Systems on steep slopes with slowly permeable soils should be long and narrow to reduce the possibility of toe leakage. A 25% limit is recommended which is based on construction concerns (Table 1) and not soil and hydraulic properties.

Filled areas:
Fill is defined as the soil placed to raise the elevation of the site. Textures range from sand to clay or a mixture of textures. Structure is often massive (structureless) or platy. Under these circumstances the permeability of the soil is reduced and variable. A more intensive soil evaluation must be done because of the increased variability encountered in filled sites over naturally occurring sites. Many more observations are generally needed for filled sites compared to non-filled sites and the site evaluator must be knowledgeable of the ramifications of fill.

Flood Plains:
It is not recommended to install any soil absorption system in a flood plain, drainage ways or depressions unless flood protection is provided.

Horizontal Separation Distances:
The same separation distances used for other soil based dispersal units should be used for the mound unit. On sloping sites the up slope and end distances should be measured from the up slope edge or ends of the aggregate to the respective features and the down slope distance should be measured from the down slope toe of the mound to the respective features. As with all soil based dispersal units on sloping sites where the flow away from the unit is primarily horizontal, agreater down slope horizontal separation distance may be appropriate to avoid weeping into aditch or basement that may be located down slope.

Sites with Trees and Large Boulders:
Generally, sites with large trees, numerous smaller trees or large boulders are less desirable for mound systems because of the difficulty in preparing the site. If a more desirable site is not available, the trees must be cut at ground level leaving the stumps in place. Boulders should not be removed. If the tree stumps and/or boulders occupy a significant amount of the surface area, (in most cases they do not) the size of the mound basal area should be increased to provide sufficient soil to accept the effluent. The site evaluator should provide location and size information about trees and boulders.

Table 2. Design basal loading rates for mound systems for soil horizons with loose, very friable, friable and firm consistence. These values assume wastewater has been highly pretreated with BOD and TSS < 25 mg/L and based on 150 gpd/bedroom.

	Structure					
	0		pl		bk, pr or gr	
Texture	**sg**	**m**	**1**	**2 & 3**	**1**	**2 & 3**
	- - - - - - - - - - - - - - - - **gpd/ft^2** - - - - - - - - - - - - - - - -					
cos	1.6	-	-	-	-	-
s	1.2	-	-	-	-	-
fs	0.9	-	-	-	-	-
vfs	0.6	-	-	-	-	-
lcos	1.4	-	-	-	-	-
ls	1.0	-	-	-	-	-
lfs	0.9	-	-	-	-	-
lvfs	0.6	-	-	-	-	-
cosl	-	0.6	0.5	0.0	0.7	1.0
sl	-	0.5	0.4	0.0	0.6	0.9
fsl	-	0.5	0.4	0.0	0.6	0.8
vfsl	-	0.4	0.3	0.0	0.6	0.8
l	-	0.5	0.5	0.0	0.6	0.8
sil	-	0.2	0.3	0.0	0.3	0.8
si	-	0.0	0.0	0.0	0.3	0.6
scl	-	0.0	0.0	0.0	0.3	0.6
cl	-	0.0	0.0	0.0	0.3	0.6
sicl	-	0.0	0.0	0.0	0.3	0.6
sc	-	0.0	0.0	0.0	0.0	0.3
sic	-	0.0	0.0	0.0	0.0	0.3
c	-	0.0	0.0	0.0	0.0	0.3

MOUND DESIGN CONCEPTS

As with all soil based treatment/dispersal units, a mound system must be sized and configured to match the soil and site conditions and the volume and quality of wastewater applied to it. It is imperative that the designer have sufficient information about the quality and quantity of effluent, soil and site features and understands the mound operating principles and movement of effluent away from the system. The designer, in cooperation with the soil scientist or site evaluator, must accurately estimate the design basal loading rate (Table 2), determine the direction of flow away from the system (Fig. 2) and estimate the linear loading rate, before the mound can be designed. The design consists of estimating the 1) sand media loading rate, 2) basal (soil) loading rate and 3) linear loading rate for the site. Once these three design rates are determined, the mound can be sized for the site. Fig. 4 shows a cross section and plan view of the mound on a sloping site and shows dimensions that must be determined.

Sand Media Loading Rate:
The design sand loading rate for the absorption area (aggregate/sand interface or chamber bottom/sand interface) is dependent upon the quality of the effluent applied and the type and quality of the fill material. This design assumes that the effluent quality is septic tank effluent from domestic waste water. If high strength wastes from commercial establishments is the source, such as from restaurants, the loading rates must be adjusted based on wastewater strength with comparable organic loading rates (BOD, TSS, FOG) (Siegrist et al., 1985) resulting in lower loading rates or the wastewater pretreated equal to or less than typical domestic septic tank effluent quality. If highly pretreated effluent (BOD and TSS < 25 mg/L and very low FOG) is used, the loading rate of 2.0 gpd/ft^2 is reasonable. Separation distances may be reduced depending upon the fecal coliform count of the effluent (Converse and Tyler, 1998).

The purpose of the sand fill, along with the native soil, is to treat the effluent to an acceptable level. A very coarse sand will not provide adequate treatment and it may not be practical to use a median to fine sand because of the very low loading rate required to minimize clogging. Thus, the sand must be selected that provides satisfactory treatment and allows for a reasonable loading rate.

During the initial development of the mound, medium sand (USDA classification) was considered suitable for mound fill but it was soon shown that premature clogging resulted for sand fill that was on the fine side of medium. Bank run sand, which was classified as medium sand, was also found unsuitable, in most cases, as it was usually poorly sorted (high uniformity coefficient) and contained a lot of fines. Currently**, the recommendation is to use a coarse sand with a minimum amount of fines (< 5%)** which appears to give acceptable treatment at an acceptable loading rate and reasonable cost. Standard classifications, such as USDA, are not suitable as they are very broad. For example, a sand classified as coarse sand may or may not be acceptable while a sand classified as medium sand may be as it depends upon a combination of various sand fractions.

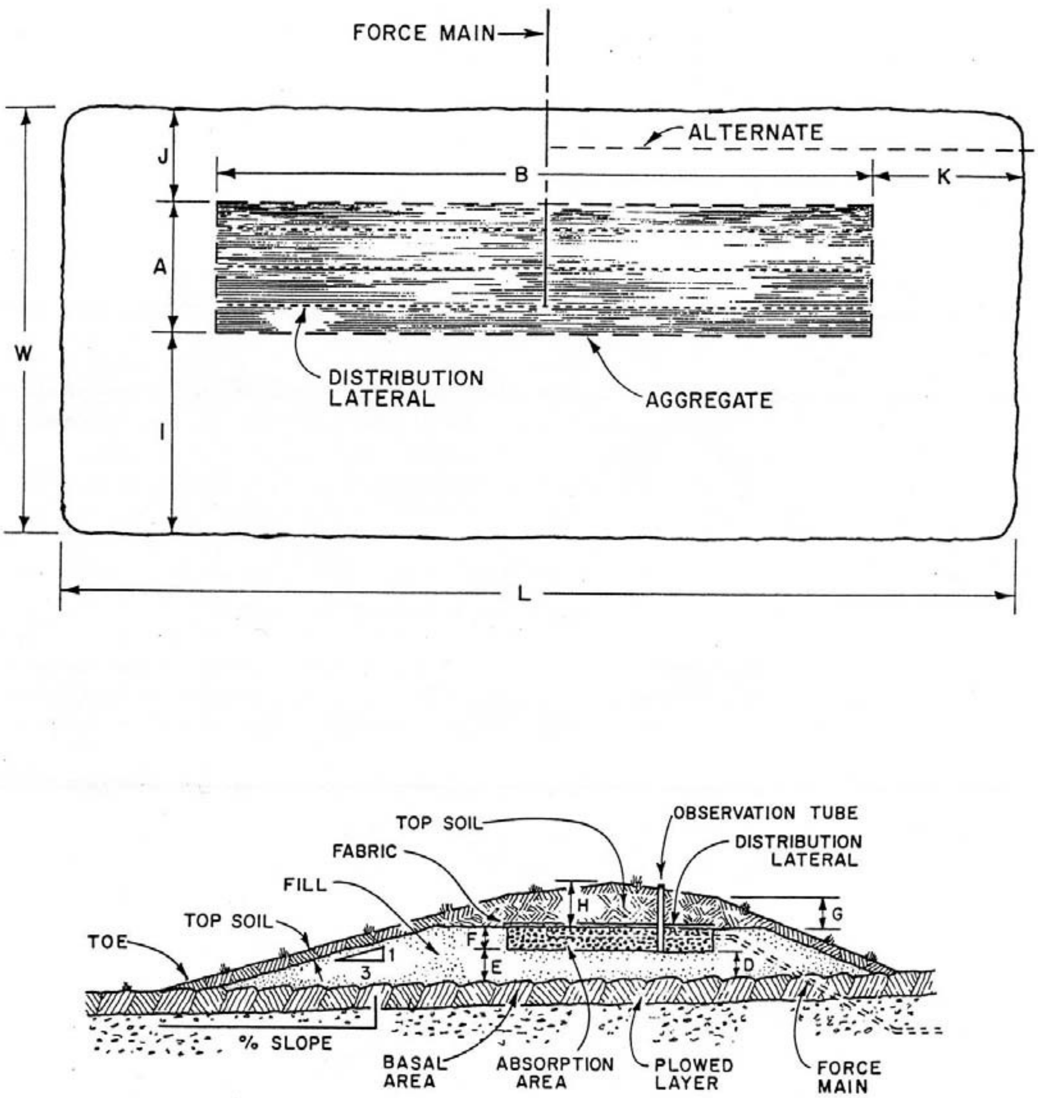


Fig. 4. Cross section and plan view of a mound system on a sloping site.

Figure 5 can be used as a guide for selecting a suitable mound sand fill. Based on a sieve analysis of the total sample, the sand fill specification should fit between the ranges given in Fig. 5. In addition, the sand fill must not have more than 20% (by wt) material that is greater than 2 mm in diameter (coarse fragments) which includes stone, cobbles and gravel. Also, there must not be more than 5% silt and clay (<0.53 mm, 270 mesh sieve) in the fill. **Less would be better.**

C-33 specification (ASTM, 1984) for fine aggregate does fit within this guideline but the coarser (>2 mm) and finer (<0.053 mm) fractions must be evaluated to make sure they meet the limits. A sand with an effective diameter (D_{10}) of 0.15 - 0.30 mm and uniformity coefficient (D_{60}/D_{10}) between 4 and 6 fit within these guidelines provided the coarser (>2 mm) and finer (0.053 mm) fractions meet the guideline. **Although these guidelines give a range, it is best to stay on the coarse side (left curve with effective diameter close to 0.30 mm and uniformity coefficient of 4.0) than to be on the fine side (near the right curve).**

The single pass sand filter recommends a coarser sand with less fine material with effective diameter of 0.30 mm and uniformity coefficient of <4.0 and 0-2% passing the 100 mesh sieve and 0-1% passing the 200 mesh sieve (Orenco, 1998). Since the mound is a sand filter, the material recommended for sand filters would be suitable. The recommended sand filter loading rate is slightly higher than for mounds.
The sand filter utilizes timed dosing with small frequent doses and less area/orifice, which enhances treatment quality, instead of demand dosing with large infrequent dosing.

The recommended design loading rate for a sand fill that meets the mound sand fill specification (Fig. 5) is 1.0 gpd/ft^2 for typical domestic septic tank effluent. Some designers may feel more comfortable using a design loading rate of 0.8 gpd/ft^2. Experience has shown that a clogging mat may form at this interface and lead to back up or breakout of septic tank effluent requiring corrective action. Based on many years of experience, some mounds have failed via clogging. Initial design called for a loading rates of 1.2 gpd/ft^2. Reducing the sand loading rate does not substantially increase construction costs. **The 1.0 gpd/ft^2 loading rate assumes that there is a safety factor**. It assumes, for design purposes, that a home generates 75 gpcd with two people per bedroom or 150 gallons per bedroom per day with the actual flow in the range of 50 to 60% of design. Converse and Tyler (1987) found, based on water meter readings in the home, that the waste water generated averaged 47% of design with a range of 29 to 82%.

However, some designers like to use the flow generated based on water meter readings or use the number of people per house times the estimated average of 50 gpd/c for design purposes. **If this approach is used, then a factor of safety of 1.5 to 2 must be incorporated or the design loading rate in gpd/ft^2 reduced accordingly.** Similar procedures should be followed for commercial establishments including lower loading rates due to the higher strengths effluents as discussed previously.

Figure 5.

14

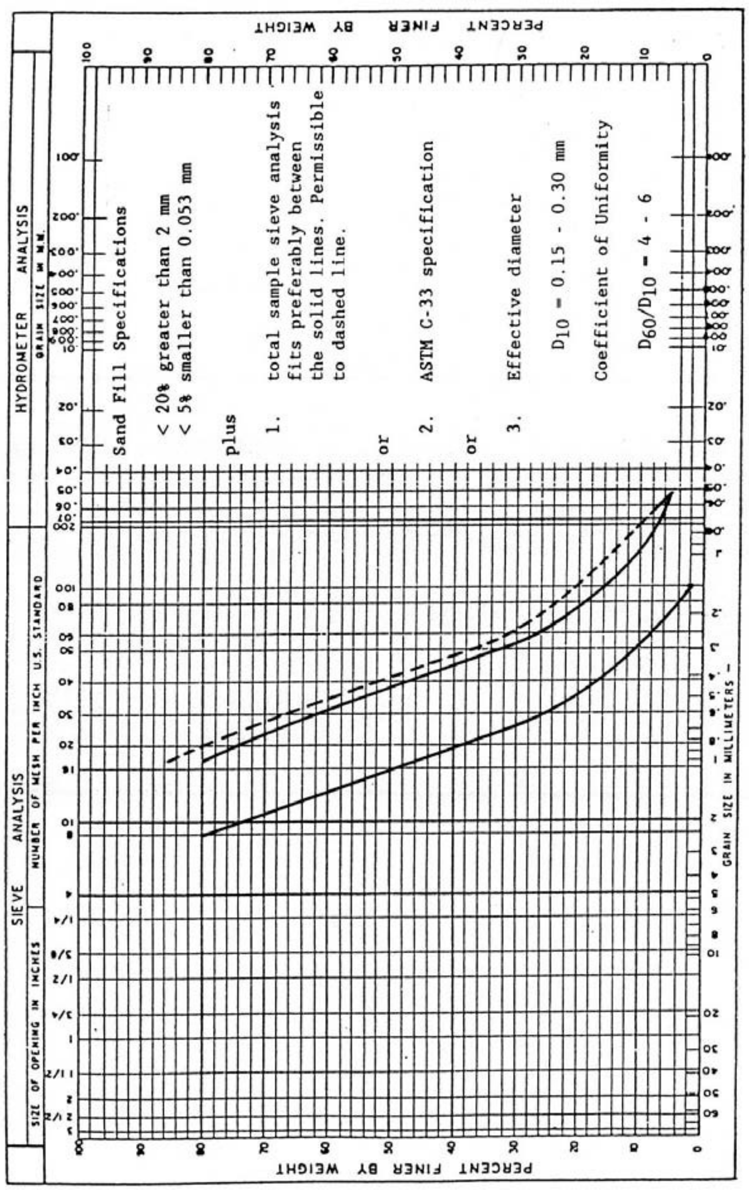


Figure 5. A guideline for the selection of the sand fill for Wisconsin Mounds. The total sample sieve analysis contains 20% or less material larger than 2.0 mm and contains 5% or less material finer than 0.053 mm plus one of the three additional specifications listed in figure. The fraction greater than 2 mm can have stones and cobbles.

[1] James C. Converse, Professor, Biological Systems Engineering and E.Jerry Tyler, Professor, Soil Science Department, University of Wisconsin-Madison. Member and Director, respectively, of Small Scale Waste Management Project. Research supported by the College of Agricultural and Life Sciences.

[2] This is an updated version of the 1990 mound manual with the same name. It should be used in place of earlier versions.

Note: Names of products and equipment mentioned in this publication are for illustrative purposes and do not constitute and endorsement, explicitly or implicitly.

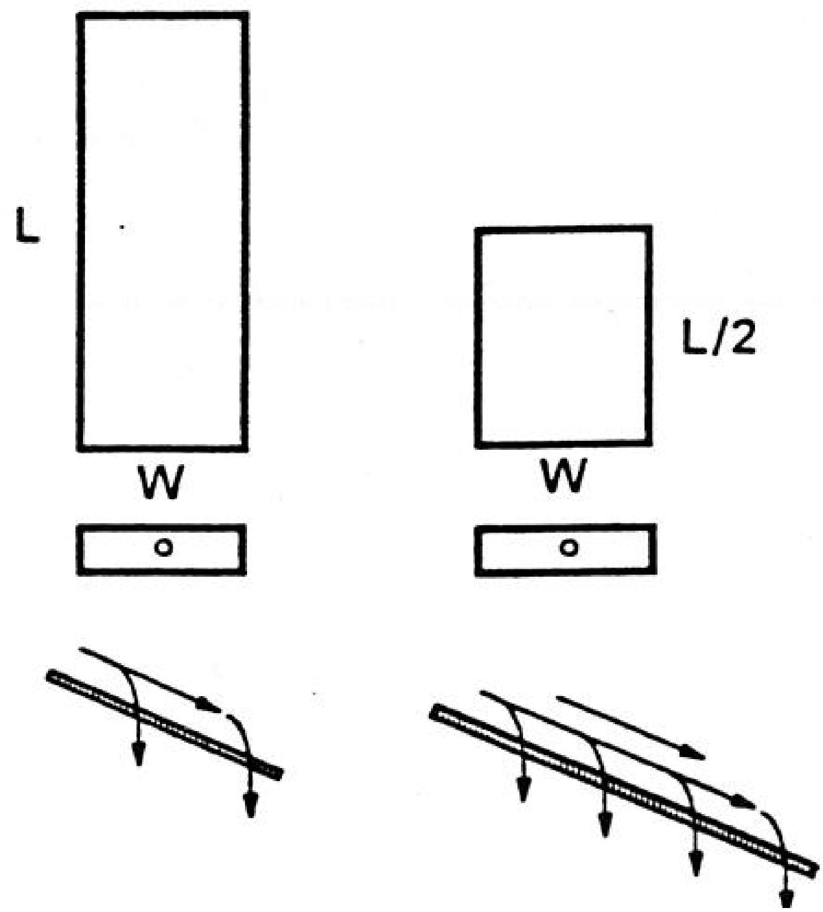
Basal Loading Rate:

The basal area (sand/soil interface in Fig. 4) is the area enclosed by B(A+I) for sloping sites and B(A+I+J) for level sites where J = I for level sites. In the past basal loading rates assumed a clogging mat would form. Experience has shown that the clogging mat will not form at this interface because most of the organic matter (BOD and TSS) have been removed as it passes through the sand. Thus, the basal loading rate (gpd/ft^2) be higher than for septic tank effluent. Table 2 provides basal loading rates for septic tank effluent after having passed through the mound sand. These values assigned to the basal loading rate (BOD and TSS < 30 mg/L) should be used with some caution because there is limited experience. Also, the basal dimension (I) calculated by these numbers is usually less than the value calculated for the side slope (3:1) except in very slowly permeable soils.

Hydraulic Linear Loading Rate:

The hydraulic linear loading rate is the volume of effluent (gallons) applied per day per linear foot of the system along the natural contour (gpd/ft). The design hydraulic linear loading rate is a function of effluent movement rate away from the system and the direction of movement away from the system (horizontal, vertical or combination, Fig. 2). If the movement is primarily vertical (Fig. 2a), then the hydraulic linear loading rate is not critical. If the movement is primarily horizontal (Fig. 2d), the hydraulic linear loading rate is extremely important. Figure 6 illustrates the effect of hydraulic linear loading rate on the configuration selected. Other factors such as gas transfer beneath the absorption area suggest that the absorption area width be relatively narrow regardless of the hydraulic linear loading rate (Tyler et al., 1986).

Fig. 6. The effect of linear loading rate based on system configuration on a sloping site



The sand or soil loading rates (gpd/ft2) are the same but the linear loading rate for the right figure is twice that of the left figure. The soil may not be able to move the effluent away from the system fast enough resulting in back up and breakout at the mound toe. This is more critical as mounds are placed on more difficult sites (shallow seasonal saturation and slowly permeable soils). It is somewhat difficult to estimate the hydraulic linear loading rate for a variety of soil and flow conditions but based on the authors' experience "good estimates" can be given. If the flow is primarily vertical (Fig. 2a), then the hydraulic linear loading rate can be high but the gaseous linear loading rate (oxygen transfer to meet the oxygen demand) should be limited to 8-10 gpd/ft of typical domestic septic tank effluent. The slower the gas transport or the higher the wastewater BOD, the narrow the absorption area needed in order to meet the oxygen demand beneath the absorption area. If the flow is primarily horizontal, because of a shallow restrictive layer or limiting condition such as seasonal saturation or bedrock (Fig. 2d), then the linear loading rate should be in the range of 3-4 gpd/ft, resulting in long and narrow systems. Converse (1998) gives a more detailed explanation and provides two examples of estimating linear loading rate.

Sizing the Mound:

Figure 4 shows the cross section and plan view of the mound for sloping site. The dimensions are based on the site conditions and loading rates which are site specific. Prior to designing, the designer needs to determine the following loading rates:

Design Flow Rate - gpd
Sand loading rate - gpd/ft^2
Basal loading rate - gpd/ft^2
Hydraulic linear loading rate - gpd/ft

Absorption Area Width (A): The width of the absorption area is a function of the hydraulic linear loading rate and the design sand loading rate.

A = (Hydraulic Linear Loading Rate / Sand Loading Rate) = (gpd/ft)/ (gpd/ft^2) = ft

Note: If the designer doesn't feel comfortable with using linear loading rate, he/she can select a width. It is recommended that width be less than 10 ft which may be to wide for some sites. Selecting a width, in essence, is selecting a linear loading rate. If the sand loading rate is 1.0 gpd/ft^2 then the linear loading rate and width values are the same.

Absorption Area Length (B): The length of the absorption area, along the natural surface contour, is a function of the design flow rate (gpd) and the linear loading rate (gpd/lf).

B= (Design Flow Rate / Hydraulic Linear Loading Rate) = (gpd)/ (gpd/ft) = ft

Basal Length (B) and Width (I, A and J): The basal length is (B) and the basal width for sloping sites is (I + A) and for level sites it is (I + A +J). The width is based on the linear loading rate and the basal loading rate for highly pretreated effluent (Table 2).

For sloping sites:

I +A = (Hydraulic Linear Loading Rate / Basal Loading Rate) = (gpd/ft)/(gpd/ft^2) = ft

For level sites:

I+A+J = (Hydraulic Linear Loading Rate / Basal Loading Rate) = (gpd/ft)/(gpd/ft^2) = ft

Slope Widths (I and J) : For sloping sites the down slope width (I) is a function of the mound depth at the down slope edge of the absorption area, desired side slope, normally 3:1 and the down slope correction factor. Up slope width (J) is a function of the mound depth at the up slope edge of the absorption area, the desired side slope, normally 3:1 and up slope correction factor.

For level sites the slope widths (I) and (J) are equal and a function of the mound depth at the edge of the absorption area and the desired side slope, normally 3:1.

Slope Length (K): The slope length (K) is a function of the mound depth at the center of the absorption area and the desired mound end slope, normally 3:1. Steep end and side slopes are not recommended if the mound is to be mowed due to safety considerations. Typical dimensions are 8 - 12 ft.

Depth D: This depth of the sand fill is a function of the suitable soil separation depth required by code and the depth of the limiting condition from the soil surface. If the required separation distance from the absorption surface to the limiting condition, such as bedrock or seasonal saturation, is 3 ft and the limiting condition is 1 ft beneath the ground surface, then (D) must be a minimum of 2 ft which is measured at the up slope edge of the absorption area.

Depth E: This depth is a function of the surface slope and width of the absorption area (A) as the absorption area must be level.

Depth F: This depth is at least 9 in. with a minimum of 6 in. of aggregate beneath the distribution pipes, approximately 2" for the distribution pipe and 1" of aggregate over the pipe.

Depth G and H: The recommended depth for (G) and (H) for the soil cover is 6" and 12",respectively. The (H) depth is greater than the (G) depth to provide a crown to promote run off from the mound top. For narrow absorption areas, 6" of difference is not required. Depths in earlier mound versions were 12 and 18" for cold climates. **Shallower depths are being recommended to allow for more oxygen diffusion to the absorption area.**

Mound Cover: The purpose of the mound soil cover is to provide a medium for a vegetative cover and protection. Any soil cover that will support a suitable vegetative cover and allow the mound to breathe is satisfactory. **It is important that the mound be able to breathe to allow oxygen to diffuse into and below the absorption area.** Clay loam, silty clay loam and clay soils restricts oxygen diffusion. Thicker soil covers also reduce oxygen transfer. The recommended mound cover consists of the sandy loam, loamy sands and silt loams. These coarser soils will not shed the precipitation as well as heavier soils and will not hold as much moisture during the summer dry periods but the benefits of breathing is probably superior to the negatives. If the soil cover does not support good vegetative cover, other means, such as decorative stone, must be implemented to avoid surface erosion.

Observation Tubes: It is essential that all soil absorption systems, including mounds, have observation tubes extending from the infiltrative surface (aggregate/sand interface for mounds) to or above the ground surface to observe ponding at the infiltrative surface. Tubes should be placed at approximately 1/4 and 3/4 points along the length of the absorption area. Fig. 7 illustrates three methods of anchoring the observation tubes.

The bottom 4" must have perforations in the sides to allow ponded effluent to enter and exit the pipes. Ponded effluent will not enter from the bottom of the pipe.

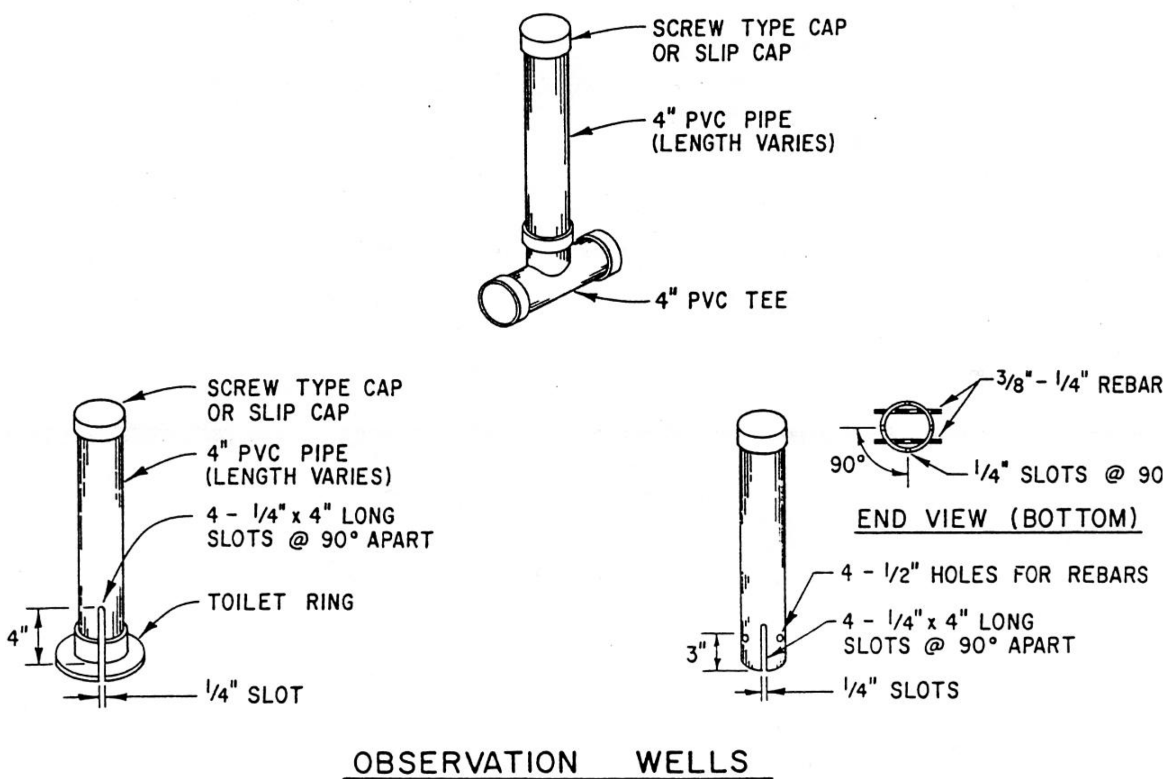


Fig. 7. Three methods of securing observation tubes.

Effluent Distribution Network: Pressure distribution network is essential for distributing the septic tank effluent. Gravity flow is unacceptable as it will not distribute the effluent uniformly over the infiltrative surface or along the length of the mound (Converse, 1974, Machmeier and Anderson, 1988). Otis (1981) provides design criteria and examples for pressure distribution. Converse (2000) discusses pressure distribution and provides a design example for the new criteria.

DESIGN EXAMPLE

Design an on-site system based on the following soil profile description.
Site Criteria

1. Soil Profile - Summary of 3 soil pits evaluations.

    A. 0 - 6 in. 10YR6/4&2/1; silt loam (Sil); strong, moderate, angular blocky structure; friable consistence.

E. 6 -11 in. 10YR5/3; silt loam (Sil); moderate, fine platy structure; firm consistence.

B. 11-20 in. 10YR6/3; silty clay loam (Sicl); moderate, fine, subangular blocky structure; firm consistence; few, medium, distinct mottles starting at 11".

C. 20-36 in. 10YR5/3; silty clay (sic); massive structure; very firm consistence; many, medium, prominent mottles.

2. Slope 20%

3. The area available consists of 170 ft along the contour and 50 ft along the slope. There are 3 medium size trees in the area.

4. The establishment generates 300 gallons of wastewater of domestic septic tank effluent per day based on water meter readings.

Step 1. Evaluate the quantity and quality of the wastewater generated.
For all on-site systems a careful evaluation must be done on the quantity of wastewater generated. As indicated earlier, most code values have a factor of safety built into the flows generated daily. These are the values that are typically used for design. It is appropriate for the designer to assess if the code value is appropriate for the given facility and if not, work with the regulators on a suitable number. If metered values are used, a suitable factor of safety must be added to the daily average flow such as 50 to 100%. The average flow should be based on a realistic period of time and not be, for example, an average of six months of very low daily flow rates and 6 months of very high flow rates in which case then the high flow rates should be used for design plus the factor of safety. **It is best to over design rather than under design even though the cost is greater but system performance and longevity should be greater.**

Effluent quality must also be assessed. If it is typical domestic septic tank effluent, these sizing criteria may be used. If it is commercial septic tank effluent, lower loading rates (gpd/ft^2) must be used (Siegrist, et al., 1985) or the effluent pretreated to acceptable BOD and TSS. Use a factor of safety of 150%.

Design Flow Rate = 300 gpd X 1.5 = 450 gpd.

Typical design flows are 150 gpd/bedroom.
(Experience has shown that some mounds designed at 150 gpd/bedroom have ponded even though the actual flow was probably well below the design).

Step 2. Evaluate the soil profile and site description for design linear loading rate and soil loading rate.

For this example and convenience the one soil profile description is representative of the site. A minimum of 3 evaluations must be done on the site. More may be required depending on the variability of the soil. The soil evaluator must do as many borings as required to assure that the evaluation is representative of the site. Soil pits are better than borings but a combination are satisfactory. In evaluating this soil profile, the following comments can be made:

The silt loam (A) horizon (0 - 6") is relatively permeable because of its texture, structure and consistence. The effluent flow through this horizon should be primarily vertical.

The silt loam (E) horizon (6 - 11") has a platy structure and firm consistence. The consistence will slow the flow and the platy structure will imped vertical flow and cause the flow to move horizontally. If this layer is tilled, the platy structure will be rearranged and the flow will be primarily vertical. **Thus, tillage must be done at least 11 in. deep on this site to rearrange the platy structure.** If the structure in this horizon was not platy, then tillage would be limited to 5-6" in-depth.

The silty clay loam (B) horizon (11-20 in.) is slowly permeable because of the texture and firm consistence. The flow will be a combination of vertical and horizontal flow in the upper portion and primarily horizontal flow in the lower portion of the horizon due to the nature of the next lower horizon. During wet weather the “B” horizon may be saturated with all flow moving horizontally.

The silty clay (C) horizon (20 - 36 in.) will accept some vertical flow as the effluent moves horizontally down slope in the upper horizons. The flow through this profile will be similar to the cross section shown in Fig. 2c and during seasonal saturation as shown in Fig. 2b.

Based on experience a properly designed mound system should function on this site. It meets the minimum site recommendations found in Table 1.
Linear loading rates range from about 1 - 10 gpd/lf. Since this site has a very shallow seasonal saturation and a very slowly permeable horizon at about 20", and seasonal saturation at 11", the linear loading value for this site should be 3-4 gpd/lf.

Linear Loading Rate = 4 gpd/lf

Note: LLR = 3 could be used for a more conservative design and less risk of toe leakage especially during seasonal saturation.
A basal loading rate for the soil horizon in contact with the sand (basal area) is selected based on the surface horizon (A). Use table 2 to determine the design basal loading rate.

Basal Loading Rate = 0.8 gpd/ft^2

Step 3. Select the sand fill loading rate.

The section entitled "Sand Fill Loading Rate" and Fig. 6 give guidelines for selecting a suitable sand fill for the mound. Other fills may be used but caution should be used as performance data is very limited with the other fills.

Sand Loading Rate = 1.0 gpd/ft^2

No absorption area credit is given for use of chambers in mounds.

Step 4. Determine the absorption area width (A).

A = Linear Loading Rate / Sand Loading Rate
= 4 gpd/ft / 1.0 gpd/ft^2
= 4 ft (Since this appears to be the weak point in the mound, consider making It 6 ft wide. A 6 ft wide absorption area would give a sand loading rate of 0.67 gpd/gpd/ft^2.. The linear loading rate will remain at 4 gpd/lf .

However, increasing the area will require more orifices in the pressure distribution network).

Step 5. Determine the absorption area length (B).

B = Design Flow Rate / Linear Loading Rate
= 450 gpd / 4 gpd/lf
= 113 ft.

Step 6. Determine the basal width (A + I).

The basal area required to absorb the effluent into the natural soil is based on the soil at the sand/soil interface and not on the lower horizons in the profile. An assessment of the lower horizons was done in Step 2 when the linear loading rate was estimated.

A + I = Linear Loading Rate / Basal Loading Rate
= 4 gpd/ft / 0.8 gpd/ft^2
= 5.0 ft (The effluent should be absorbed into the native soil, within a 5 ft.)

Since A = 4 ft
I = 5.0' - 4.0' = 1 ft. ("I" will also be calculated based on side slope)

Step 7. Determine the mound fill depth (D).

Assuming the code requires 3 ft of suitable soil and soil profile indicates 11 in. of suitable soil then:

D =36" - 11" = 25 in.

Step 8. Determine mound fill depth (E).

For a 20% slope with the bottom of the absorption area level then:

E = D + 0.20(A)
= 25" + 0.20 (48")
= 35 in.

Step 9. Determine mound depths (F), (G) and (H)

F = 9 in. (6 in. of aggregate, 2 in. for pipe and 1 in. for aggregate cover over pipe)

G = 6 in.

H = 12 in.

These depths have changed from 12 and 18" so as to allow more oxygen to diffuse into and beneath the absorption area. Sand filters have only 6" of cover and freezing is not a problem as long as the distribution network drains after each dose. Granted most sand filters are below grade which may be a factor.

Step 10. Determine the up slope width (J)

Using the recommended mound side slope of 3:1 then:

J = 3 (D + F+ G) (Slope Correction Factor from Table 3)

= 3(25" + 9"+ 6") (0.625)

= 6.25 ft or 6 ft

Step 11. Determine the end slope length (K).

Using the recommended mound end slope of 3:1 then:

K = 3((D + E)/2 + F + H)

= 3 ((25" + 35")/2 + 9" + 12")

= 12.75 ft or 13 ft

Step 12. Determine the down slope width (I)

Using the recommended mound side slope of 3:1 then:

I = 3(E + F + G) (Slope Correction Factor from Table 3)

= 3(35" + 9" + 6")(2.5)

= 37.5 ft.

Since the I dimension becomes quite large on steeper slopes, it may be desirable to make the down slope steeper such as 2:1 and not mow the mound. If the natural slope is 6% instead of 20% the mound width would be 28 ft (9 + 4 + 15).

Step 13. Overall length and width (L + W)

L = B + 2K

= 113 + 2(13)

= 139 ft

W = I + A + J

= 31 + 4 + 6

= 41 ft

Step 14. Design a Pressure Distribution Network

A pressure distribution network, including the distribution piping, dosing chamber and pump, must be designed. A design example is presented by Converse, 2000. Items to consider when designing the pressure distribution network.

- Using 3/16" holes instead of 1/4" holes with an effluent filter in the tank.

- Using 6 ft^2/orifice instead of the typical 15 - 20 ft^2/orifice that has been used.

- Provide easy access to flush the laterals such as turn-ups at end of laterals.

- Dose volume at 5 times the lateral pipe volume and not to exceed 20% of the design flow and not dose at the previously recommended 1/4 the design flow or 10 times the lateral void volume.

- Timed dosing which requires surge capacity in the septic tank/pump chamber. With the configuration of the mound (long and narrow), the dose volume is larger than for sand filter and time dosing may not be appropriate if larger dose volumes are required due to 5 times the lateral volume.

MOUND PERFORMANCE

The first Wisconsin mound system of the current design was installed in 1973. In Wisconsin there are over 30,000 mounds based on estimates by state regulators. Many other states have adopted the technology. Proper siting of all soils absorption units, including the mound, is essential otherwise the system will not function as planned.

In Wisconsin the mound system has a success rate of over 95% based on a survey by Converse and Tyler (1986b). This success rate is due in part to a very strong educational program relating to siting, design and construction.

A mound can fail either at the 1) aggregate or chamber/sand interface due to a clogging mat, 2) at the sand/soil interface due to the inability of the soil to accept the influent or 3) plugging of the pressure distribution network. Converse and Tyler (1989) discuss the mechanism that may cause failure and methods to rectify the problem. Another alternative (not discussed in that publication) to renovate mounds, that have severe ponding, is to introduce highly pretreated

Table 4. Down slope and up slope correction factors

Slope %	Down Slope Correction Factor	Up Slope Correction Factor
0	1.00	1.00
1	1.03	0.97
2	1.06	0.94
3	1.10	0.92
4	1.14	0.89
5	1.18	0.88
6	1.22	0.85
7	1.27	0.83
8	1.32	0.80
9	1.38	0.79
10	1.44	0.77
11	1.51	0.75
12	1.57	0.73
13	1.64	0.72
14	1.72	0.71
15	1.82	0.69
16	1.92	0.68
17	2.04	0.66

Table 4. Down slope and up slope correction factors (con.t)

Slope %	Down Slope Correction Factor	Up Slope Correction Factor
18	2.17	0.65
19	2.33	0.64
20	2.50	0.62
21	2.70	0.61
22	2.94	0.60
23	3.23	0.59
24	3.57	0.58
25	4.00	0.57

effluent to the mound by installing an aerobic unit, Nibbler Jr (NCS, 1998) or equivalent between the septic tank and pump chamber (Converse et al., 1998).
Converse et al., (1994) evaluated 13 mound systems for performance based on fecal coliform movement, nitrogen and chloride movement beneath the mound. Some fecals were found outside the 3 ft treatment zone beneath the system. The cause, though not definitive, may be related to the large infrequent doses of septic tank effluent to the mound which is typical of demand dosing and the large orifice spacing (15 to 20 ft^2).

MOUND CONSTRUCTION

A construction plan for any on-site system is essential. A clear understanding between the site evaluator, the designer, contractor and inspector is critical if a successful system is installed. It is important that the contractor and inspector understand the principles of operation of the mound system before construction commences otherwise the system will not function as intended. It is also important to anticipate and plan for the weather. It is best to be able to complete the mound before it rains on it. The tilled area (basal area) and the absorption area must be protected from rain by placing sand on the tilled area and aggregate on the absorption area prior to precipitation.

There are several different ways to construct a mound as long as the basic principles and concepts are not violated. The following are suggested construction steps:

1. The mound must be placed on the contour. Measure the average ground surface elevation prior to tillage along the up slope edge of the absorption area. This contour will serve as the base line for determining the elevation of the bottom of the absorption area.

2. Grass, shrubs and trees must be cut close to the ground surface and removed from the site. In wooded areas with excess litter, it is recommended to rake the majority of it from the site. Do not pull out the stumps and do not remove the sod or the top soil or boulders.

3. Determine where the force main from the pump chamber enters the mound. It will either be center feed or end feed. For long mounds, center feed is preferred and all end feeds can be made into center feed. For center feed the force main can enter from the up slope center (preferred), the down slope center or exit the native soil at the end and be placed horizontally on a slight slope in the sand beneath the aggregate or just up slope of the aggregate. If it must be brought in from the down slope side, especially on slowly permeable soils with high seasonal saturation where the effluent flow may be horizontal, it should be brought in perpendicular to the side of the mound with minimal disturbance to the down slope area. All vehicular traffic must be kept in a very narrow corridor. Minimal damage is done if the soil is dry. Soil should be packed around the pipe and anti- seep collars should be installed to minimize effluent and water following the pipe. Entering from the down slope center should be the last choice on sites that are slowly permeable with shallow seasonal saturation.

4. The footprint of the mound must be tilled only when the soil moisture is within a satisfactory range. The satisfactory moisture range, to a depth of 6-7", is defined as where the soil will crumble and not form a wire when rolled between the palms. The purpose of tillage is to roughen the surface to allow better infiltration into the top soil. It also provides more contact between the sand and the soil. Excessive tillage will destroy soil structure and reduce infiltration. The preferred method is using chisel teeth mounted on a backhoe which can be easily remove, followed by a chisel plow pulled behind a tractor, followed by the backhoe bucket with short teeth which requires flipping the soil.
Normally it takes much longer to use the backhoe bucket than a chisel teeth mounted on the backhoe with the added cost quickly recovered. Moldboard plows have been used successfully but are the least preferred.

Rototillers are prohibited on structured soils but may be used on unstructured soils such as sand to break up the vegetation. However, they are not recommended. All tilling must be done following the contour. If a platy structure is present in the upper horizons, the tillage depth should be deep enough to try to break it up without bringing an excessive amount of subsoil to the surface. Deep tilling for the sake of deep tilling is not recommended. Till around the stumps without exposing an excessive amount of roots. Chisel teeth, mounded on a backhoe, is the preferred and an easier method for tilling around stumps. Stumps are not to be removed but some small ones may be inadvertently pulled out during tilling. If so, remove them from the site. If there are an excessive number of stumps and large boulders, the basal area should be enlarged or another site selected but that is the rare occasion.

5. Once the site has been tilled, a layer of sand must be placed before it rains. Driving on the exposed tilled soil is prohibited so as not to compact it or rut it up. Sand should be placed with a backhoe (preferred) or placed with a blade and track type tractor. A wheeled tractor will rut up the surface. **All work is to be done from the up slope side so as not to compact the down slope area especially if the effluent flow is horizontally away from the mound.**

6. Place the proper depth of sand, then form the absorption area with the bottom area raked level. The sand should be reasonably compacted in the trench area to minimize settling. A good backhoe operator can form the trench with minimal hand work.

7. Place a clean sound aggregate to the desired depth. **Limestone is not recommended.** If chambers are used, proper procedures must be performed to keep the chambers from settling into the sand. Procedures are available from the manufacturers that include compacting the sand to a certain specification and placing a coarse netting on the compacted surface prior to chamber placement.

8. Place the pressure distribution network with holes located downward and cover it with 1 in. of aggregate. Connect the force main to the distribution network. If chambers are used, the pressure distribution laterals must be suspended from the chambers with holes upward. Provisions must be made to allow the laterals to drain after dosing. This is accomplished by having several holes located downward or sloping the pipe in the chamber toward the force main. The laterals and force main must drain after each dose.

9. Cover the aggregate with a geotextile synthetic fabric.

10. Place suitable soil cover on the mound. There should be 6" on the sides and shoulder (G) and 12" on the top center (H) after settling. The soil cover should support vegetation. If not, provisions must be made to control erosion.

11. Final grade the mound and area so surface water moves away from and does not accumulate on the up slope side of the mound. Use lightweight equipment.

12. Seed and mulch the entire exposed area to avoid erosion. Advise the homeowner on proper landscaping. The top of the mound becomes dry during the summer and the down slope toe may be wet during the wet seasons. Avoid deep rooted vegetation on the top of the mound to minimize root penetration into the distribution network (Schutt, K., et al. 1981)

13. Inform homeowner about the type of system, maintenance requirements and do’s and don’ts associated with on-site soil based systems.

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Steps in Constructing a Mound (Bed-Type) Septic System

Don D. Jones, Agricultural Engineering Department; Joseph E. Yahner, Agronomy Department; and Edward R. Miller, Indiana State Board of Health

ID-163

Cooperative Extension Service
Purdue University
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On-site disposal of residential wastewater is not permissible unless certain disposal area restrictions, such as, slowly permeable soils, shallow permeable soils over a limiting layer, or permeable soils with high water tables, can be overcome. One possible way of overcoming these problems is to construct an elevated soil absorption bed called a mound.

Mounds require more care than conventional systems in site selection, design, and construction. This partly is because the soil and site characteristics are marginal, and contractors are apt to be less experienced with mound construction techniques. *The proper location and soil preparation are essential for a properly functioning mound.*

This publication describes the correct procedure for the installation of a mound following the final design approval by the health department. It discusses the construction steps involved in preparing the site properly, placing the fill, laying and covering the pressure distribution network, and installing the septic tank and pump chamber.

The publication also should aid you in applying the design information suggested by a Fast Agricultural Communications Terminal System (FACTS) computer program entitled RWASTEII FX-89. This program is available at Cooperative Extension Service offices to help you determine the type of on-site septic system best suited to a particular set of site and soil conditions. If a mound is recommended for your site, the program will provide alternative layouts with dimensions that best fit the shape and size of the disposal area. The program also will estimate the volume of sand, gravel, and soil required for construction and size the pumping and piping needs of the pressure distribution bed. The design recommendation must then be reviewed and altered to fit the actual features of the site.

Constructing a Mound

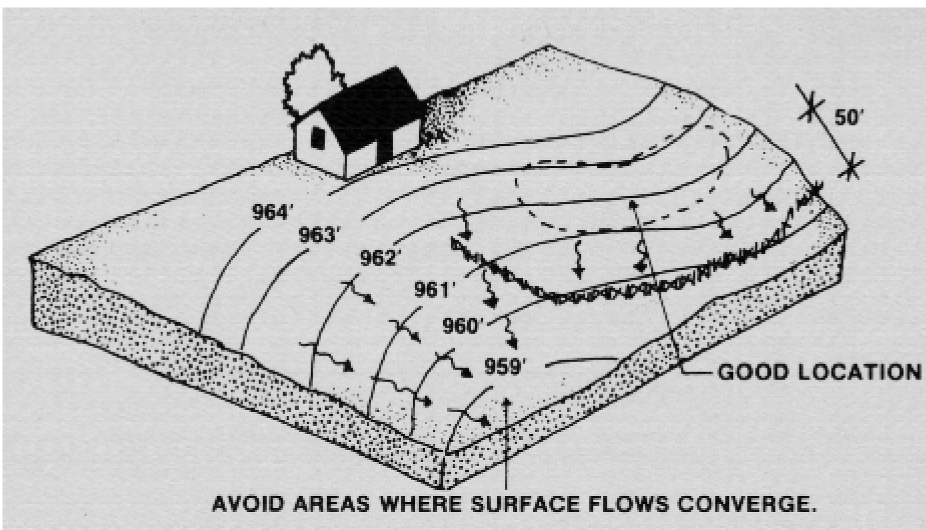
To adequately treat wastewater, mounds should be as long and narrow as the site permits, regardless of flat or sloping topography. A long, narrow slope will minimize the "mounding" of the groundwater table under the absorption bed. Treatment is further enhanced by using a pressure distribution system to uniformly apply ("dose") the septic tank effluent over the mound bed several times per day.

Because of their higher cost, mounds are installed only on sites where conventional absorption systems are not suitable. Since mounds usually are constructed on sites with very limiting soil and site conditions, good construction techniques are essential if a mound is to function properly and provide many years of trouble-free operation. The following procedure should be considered when constructing a properly designed mound.

A. Site Layout

Step 1: Select a site that sheds water. The long axis of the mound must be oriented parallel to the contour of the slope (i.e., along lines of equal elevation), not up and down the slope or on a slope where wastewater movement will converge (Figure 1). A contour or topographic map is needed to properly locate and orient the mound.

Figure 1. Proper orientation of mound system on a complex slope



Step 2: Using a transit, stake out the mound perimeter and bed in the proper orientation using the dimensions provided by the FACTS program (Figure 2). Reference stakes set 10-20 feet from the mound perimeter also should be used in case the corner stakes are removed during construction. Lay out and stake the locations of the feedline trench, septic tank, and pump chamber. Their exact locations may be dictated by minimum distance requirements from water supplies, structures, property lines, and bodies of water as outlined by the Indiana State Board of Health. These setback distances also are part of the FACTS program.

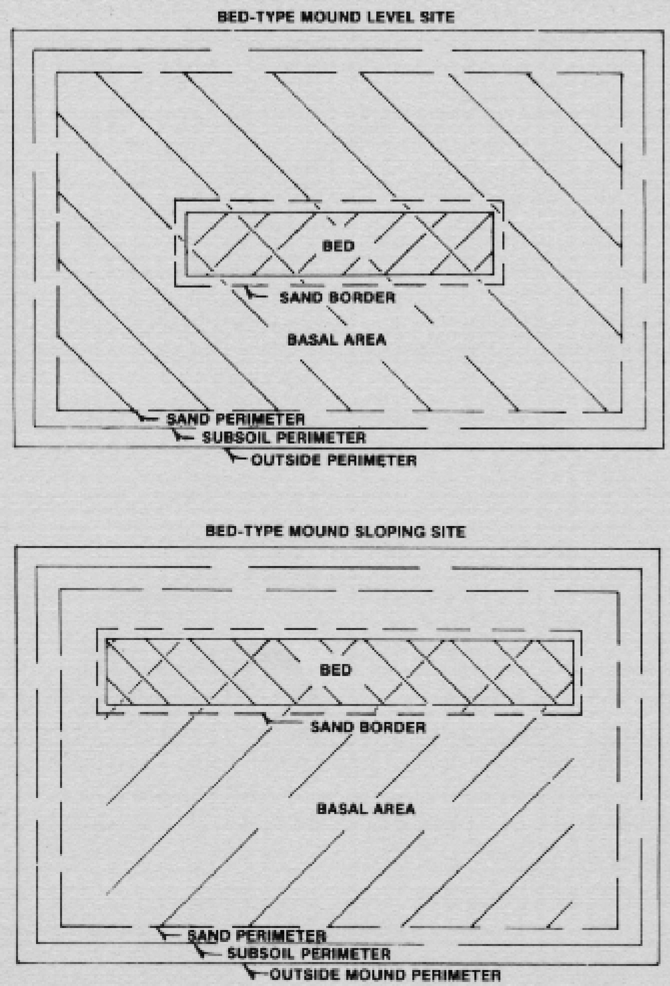


Figure 2. Plane view of mound

Step 3: The area required for the mound, and an additional 50 feet downslope from the site, should be fenced. This will prevent disturbance, scalping, or compaction of the mound site by construction equipment. All vehicular traffic should be prohibited from the area before, during, and after the construction of the home and installation of the septic system.

Step 4: Install a diversion ditch and/or subsurface curtain drain (backfill with gravel) upslope from the system to keep runoff and seepage water away. This is generally necessary to help control the water table below the mound. Keep subsurface drains at the distance specified by the health department from the upslope edge of the mound.

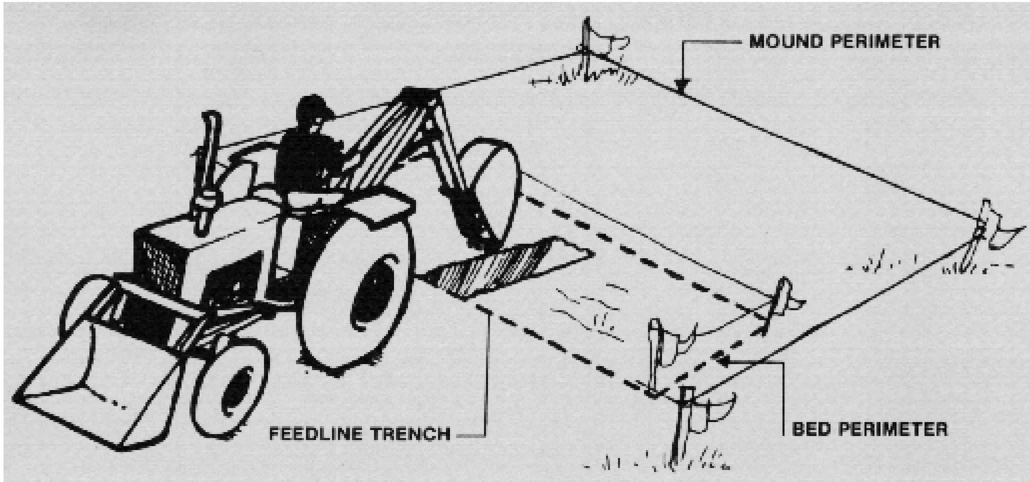
B. Site Preparation

Step 1: Mow and remove any excessive vegetation. Any trees should be cut at ground level and the stumps left in place.

Step 2: Before the surface soil is tilled, the following determinations must be made. Referring to a point of known elevation established in the previous topographical survey of the site, determine the highest elevation of the soil surface within the perimeter of the bed's location. Then, calculate the bottom elevation of the bed by adding the depth value of the sand fill under the gravel bed (see the FACTS program output) to the elevation measurement above. The bottom elevation will be used in a later step of the construction procedure.

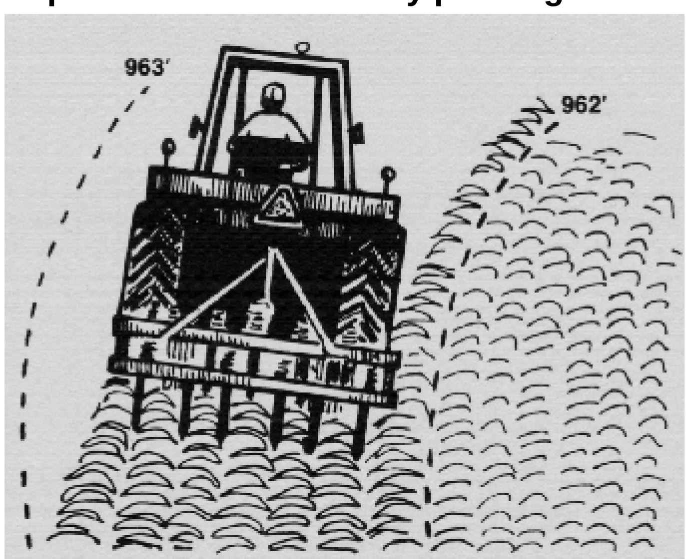
Step 3: Install the feedline pipe from the dosing chamber to where the manifold will be located on the upslope edge of the mound bed as recommended by the FACTS program (Figure 3). Trench, so the feedline pipe will lay either below the frost line (about 40 inches in most of Indiana) or slope uniformly back to the dosing chamber so it will drain after each dose. Backfill and compact the soil around the pipe to minimize seepage along the pipe. This step should be done before plowing to avoid compaction of the soil surface due to the pipe laying operation.

Figure 3. Stake out the mound and install feedline.



Step 4: Plow the area within the mound perimeter 7-8 inches deep, and parallel to the contour of the slope using a moldboard or chisel plow (Figure 4). (Do not use a single-bottom moldboard plow because the trace wheel will compact the soil at the bottom of each furrow). Each furrow slice should be thrown upslope. If a chisel plow is used, make two passes. On sites that cannot be plowed (e.g., wooded areas with stumps) roughen the surface to a depth of 7-8 inches with the backhoe teeth. Rototilling unplowed areas is not usually recommended because of potential damage to the soil structure, but it may be used in granular soils such as sands.

Figure 4. Prepare the mound site by plowing across the slope



The soil is too wet to plow if a soil sample taken from the plow depth forms a ribbon (e.g., 1/8 inch diameter) when rolled between the palms (Figure 5). If it crumbles, plowing may proceed. This pretillage investigation is essential to prevent possible system failure.

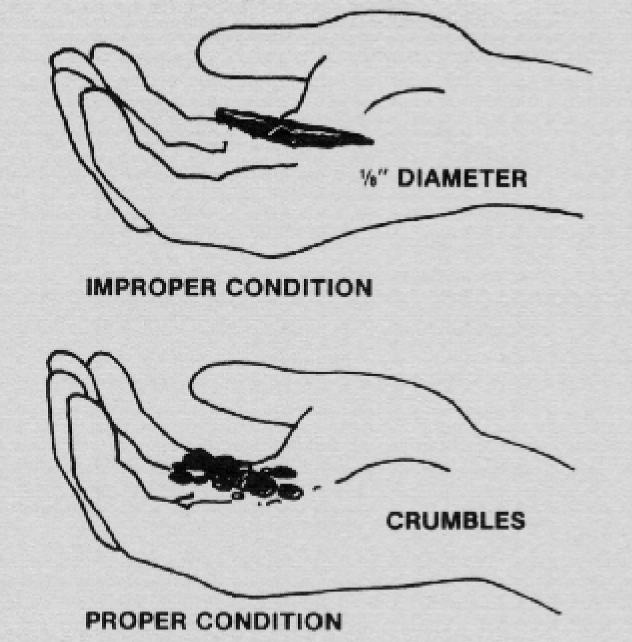


Figure 5. Construction *must* not take place if soil is too wet.

Proper surface preparation is very important in mound construction. Seepage may occur between the mound and the soil surface if surface preparation is done poorly or if the soil is too wet during the tillage operation.

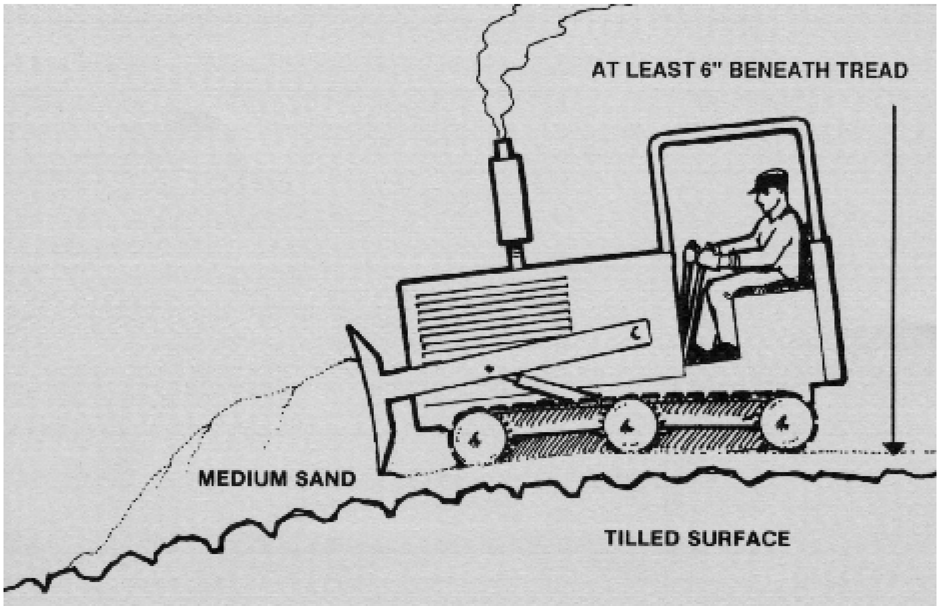
Step 5: If mound construction must be temporarily discontinued, cover the plowed area with at least 8 inches of sand-fill material or a temporary removable cover (Figure 6) 50 that the plowed area is not exposed to rainfall. This prevents compaction and sealing. If left uncovered during a rainfall another pass with the plow after the soil dries will be necessary.

C. Fill Placement

Step 1: At the upslope edge of the proposed mound bed, extend the end of the effluent feedline pipe above the existing grade to the correct elevation of the distribution network. Use the information from the FACTS program.

Step 2: On the upslope edges of the plowed area, use a medium sand that meets Indiana State Highway Specification (Spec) #23 requirements as a replacement for the old (Spec) #14-1. Keep all traffic off the plowed area and the downslope side of the planned mound to avoid compaction (Figure 6). The use of medium sand, the specification given above, is important. Substitutes probably will not be acceptable.

Figure 6. Cover plowed surface with sand as soon as possible, working from the upslope side and ends to prevent compaction of downslope side.



Step 3: Move the fill material into place using a small track-type tractor with a blade. Always keep at least 6 inches of material beneath the tracks of the tractor to minimize compaction of the natural soil. Continue to work the fill material in this manner until the height of the fill is the same elevation as the top of the absorption bed, and is shaped according to the dimensions specified in the FACTS program.

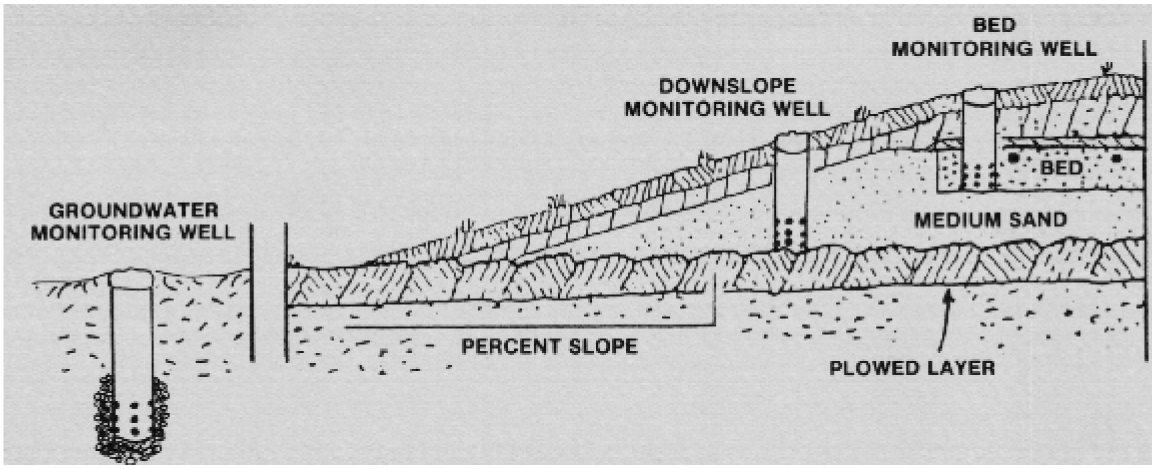
Step 4: Shape the absorption bed within the mound to the proper depth, either by hand or with the blade of the tractor. Hand level the bottom of the bed, checking the bottom elevation against the reference elevation calculated in Step 2 of Part B with a transit or engineer's level. Shape the upslope and sideslopes of the fill material to a three to one slope.

Step 5: Monitoring wells, which allow evaluation of the performance of the mound once it is in operation, should be installed at this point in the construction process. These wells are usually 4-inch diameter plastic PVC pipe. Each monitoring pipe should be perforated with ½ inch holes over the lower 6-inch length. The well opening at the soil surface is covered with a friction fit or screw cap.

A monitoring well should be installed in the mound bed, extending vertically from the bottom of the gravel absorption bed to the final surface grade of the mound. Another well should be installed downslope of the bed. Extend it from the sand fill and soil interface through the sand fill to the final surface grade on the downslope side of the mound (Figure 7). This provides a means of evaluating any evidence of ponding in the bed or mounding of the groundwater table in the sand fill.

Monitoring wells also can be installed upslope and downslope, but outside of the mound perimeter (Figure 7). These wells will provide a means for evaluating the seasonal groundwater level which can affect the performance of the system. The wells should extend to a depth of 40 inches below the surface of the soil.

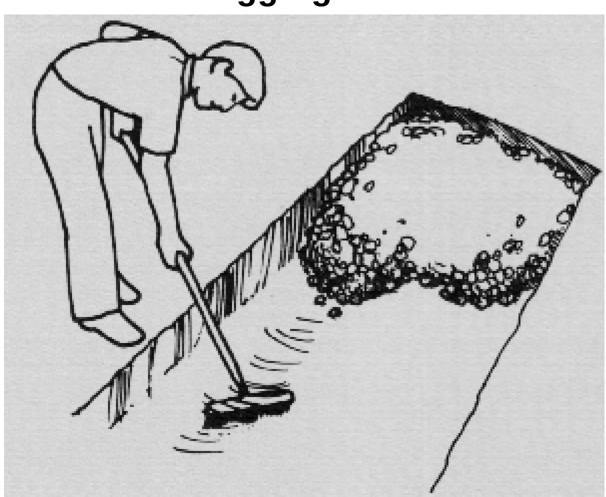
Figure 7. Placement of monitoring wells.



D. Pressure Distribution Network Placement

Step 1: Carefully place washed Spec #5 stone or aggregate, approved by the local health department, over the bottom of the bed to a minimum depth of 6 inches. If ruts are formed in the bed bottom, loosen and relevel the sand before covering with aggregate (Figure 8). Finally, level the aggregate.

Figure 8.Remove any ruts in the bed bottom before spreading aggregate.



Step 2: Install the manifold pipe for connection to the laterals, either at one end or in the center of the bed, depending on the layout recommendation by the FACTS program. All pressure distribution piping and fittings should be schedule 40 PVC plastic (ASTM-D-1785). The manifold must be placed so that it will drain between doses to prevent

plugging or freezing. It should drain into the lateral distribution pipes (Figure 9) or back into the pump chamber if connected to the lateral distribution pipes from below (Figure 10).

Figure 9. Sanitary cross connections. Drill ¼" hole on underside of manifold end with feedline drainage to pump chamber.

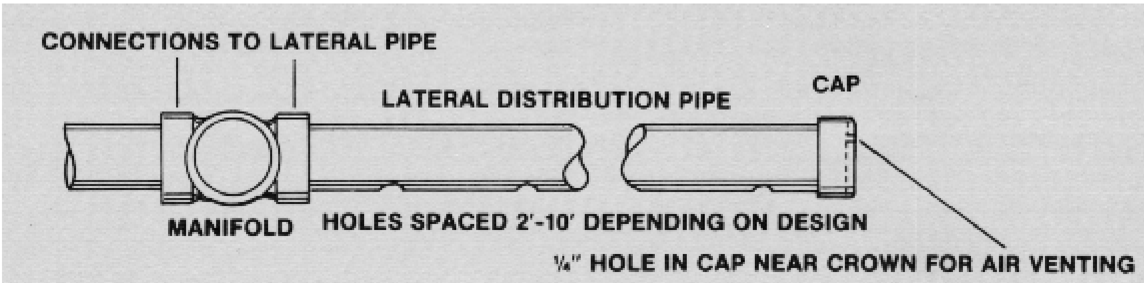
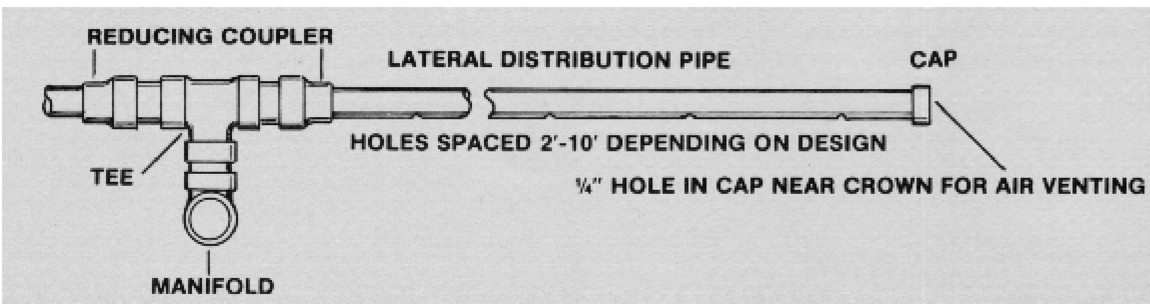


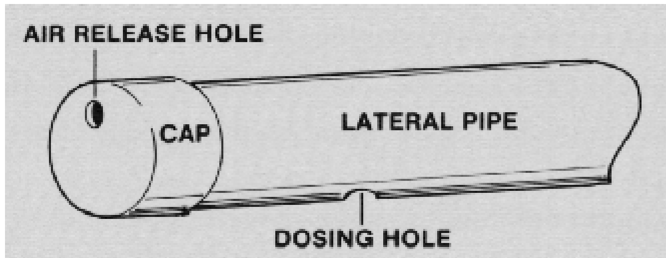
Figure 10. Tee-to-tee connection. Feedline and manifold must drain back to the pump chamber.



Step 3: The length and diameter of the distribution lateral pipes are provided by the FACTS program. First, lay out the piping network. Clean all glue joints with a solvent. Apply glue to both male and female sections of a joint, then join. Twist slightly to create a leak-proof connection. Glue a cap to the end of the lateral pipe that is away from the manifold.

Step 4: Starting from the uncapped end of the lateral, the first hole is drilled at half the hole spacing distance. The following holes are then drilled at the specified hole spacing distance until the end is reached. These holes should be drilled in a line along the length of the lateral pipe. When finished, all holes should face the same direction. On the top side of the end cap, opposite the row of dosing holes, drill a ¼ -inch air release hole to ensure that all wastewater drains from the lateral pipe after each dose (Figure 11).

Figure 11. An air release hole ensures that all wastewater drains from the lateral pipe after each dose.



Remove all burrs around the dosing holes both inside and outside the pipe, taking care not to enlarge any hole beyond its design diameter. Be sure to remove any loose chips from the inside of the lateral pipes to prevent possible clogging of the dosing holes. If the parts of the network have been carefully identified, the hole drilling and capping can be done in a shop and taken to the site for assembly.

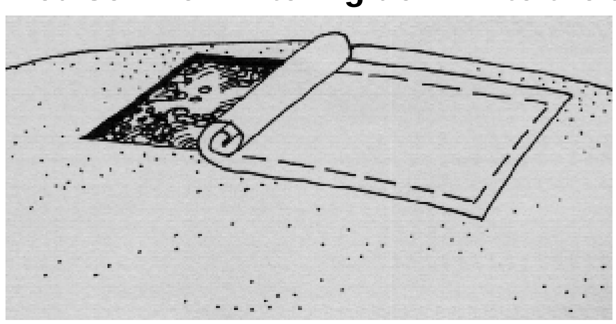
Step 5: Assemble the network on top of the aggregate. Make sure the dosing holes of each lateral are facing downward (the invert side of the pipe) before connecting the laterals to the manifold. Also, make sure the laterals are level over the entire bed by using a carpenter's or engineer's level.

E. Covering

Step 1: Carefully cover the pipe network with additional washed Spec #5 gravel or approved aggregate to a depth of 2 inches above the crown of the pipe.

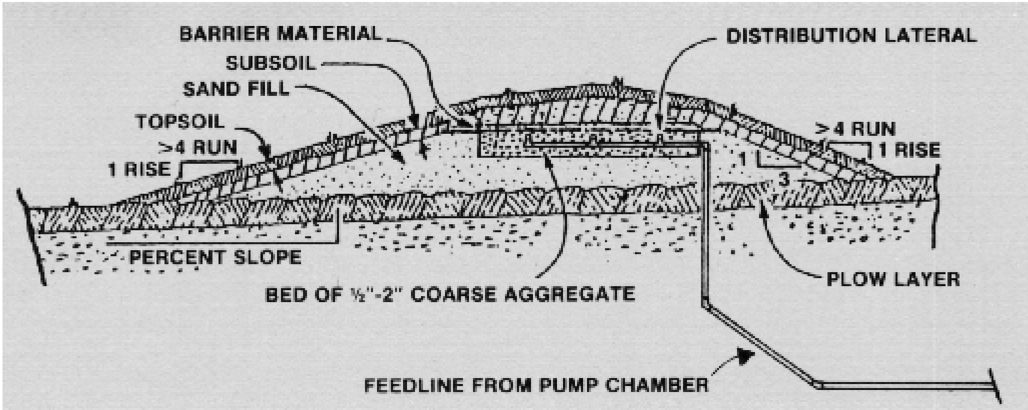
Step 2: Next, place a barrier material over the coarse aggregate (Figure 12). Suitable materials can be synthetic filter fabric, 4-6 inches of marsh hay or straw, or untreated building paper.

Figure 12. The aggregate must be covered with permeable material to keep backfilled soil from filtering down into the aggregate.



Step 3: Cover the bed and sand fill with at least 6 inches of a fine textured subsoil of clay or silt loam (Figure 13). The cover over the bed should be further mounded so that the soil depth, at the longitudinal centerline of the bed, is one foot to promote drainage from the top of the mound.

Figure 13. Cross sectional view of mound



Step 4: Finally, place 6 inches of good quality topsoil over the entire mound surface to provide a good medium for grass and to enhance surface drainage away from the mound. Figure 13, a cross-section of a completed mound, shows the vanous covering layers.

Step 5: Sow grass or lay sod over the mound using grasses adapted to the area. Shrubs can be planted around the base and up the sideslopes. Those planted on the downslope side should be somewhat moisture tolerant since this area may be rather moist during early spring and late fall. Plantings on top of the mound, on the other hand, should be drought tolerant since the upper portion of the mound can become quite dry during the summer.

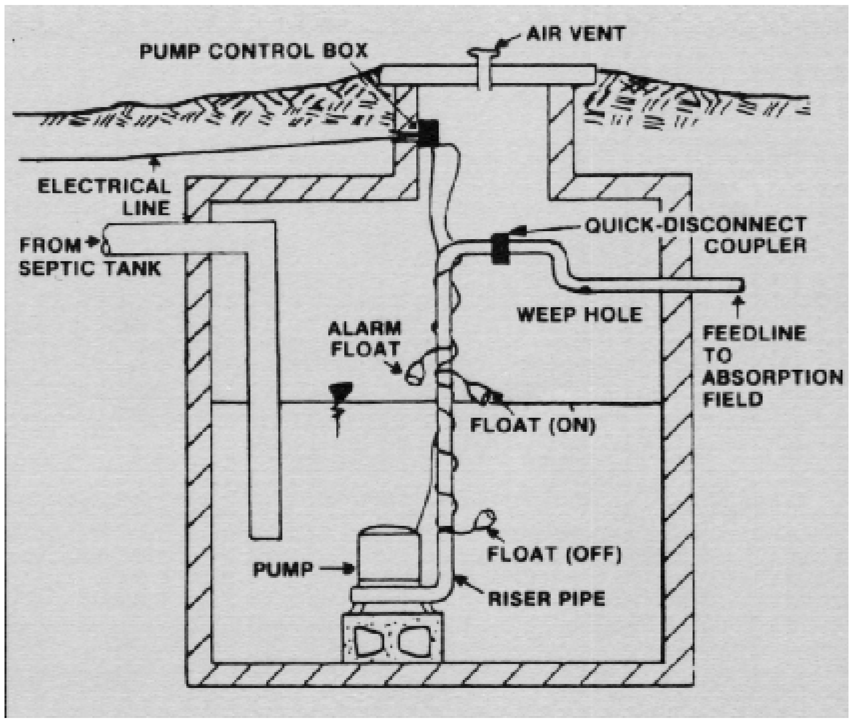
F. Septic Tank and Pump Chamber Installation

Step 1: Excavation depths for the septic tank and pump chamber are determined largely by what is necessary to obtain gravity flow in the sewer from the point where it leaves the house. A two percent slope is required for the house sewer to the septic tank, while a one percent slope is sufficient for a pipe carrying septic tank effluent to the pump chamber. Make sure both tanks are tightly sealed against groundwater seepage before installation. The pump chamber should be the same size or larger than the septic tank, allowing for at least one day of reserve storage of effluent after the high water alarm is activated due to a pump or float failure.

Step 2: Carefully level both the septic and pump tanks for proper operation after installation. Access must be provided to all parts of both tanks to allow inspection and maintenance. Use 4-inch diameter PVC sewer pipes (ASTM-D-2665, 3033, or 3034) with watertight connections between the house and the septic tank, and between the septic tank and pump chamber. Make sure inlet and outlet connections of both tanks are tightly sealed so groundwater cannot seep into the system (otherwise the mound may be overloaded). Footing and roof drains must not be connected to the septic system. Crown backfill to a height of 6 inches over the tanks to allow for settling and to divert surface runoff.

Step 3: Install a submersible sewage effluent pump or siphon that has the head and discharge characteristics recommended by the FACTS program. (The program is designed to balance pump characteristics against the hydraulic requirements of the piping network.) The proper pump or siphon, when properly installed, should give even discharge from all dosing holes in the absorption bed. Set the pump 6-8 inches above the tank floor on a large platform of cement blocks to prevent settled sludge from interfering with the operation of the pump and the piping network (Figure 14).

Figure 14. Cross sectional layout of pump chamber and associated components.



Step 4: Plumb the pump to the feedline with a riser pipe and quick-disconnect coupler so the pump can be easily removed for inspection and maintenance (Figure 14). The quick-disconnect coupler should be located near the access of the pump chamber to reduce the difficulty of disconnecting the pump. Common couplers (rubber or hose) are anchored to the pipe ends by hose clamps or plastic PVC unions. A coupling that allows a quick disconnection or connection is the cam-lock type connector used on fire hoses (Figure 15). Where practical, connectors should be made of plastic instead of metal because the tank environment is corrosive. If an effluent pump is used, a ½ - inch weep hole should be drilled on the underside of the feedline to allow drainage of the distribution system after each dose.

Step 5: Make the electrical connections from the pump to the control circuitry. The pump operation should be controlled by external mercury float switches (allowing easy adjustment of the dose volume) rather than a diaphragm controller built into the pump body. Install a high water alarm float, about 3 inches above the high water control float, on an independently fused A.C. circuit to alert the owner of a malfunction. All electrical leads should be long enough to allow the pump and floats to be removed from the chamber without electrical disconnection. Use nonmetallic, tamper- proof, and weatherproof electrical boxes for all electrical connections. The connection box may either be mounted in the basement or near the access to the pump chamber. Be sure that the electrical circuitry is grounded properly for safe operation of electrical equipment in a wet environment according to the National Electrical Code.

G. Maintaining the System

Traffic and construction must be avoided over and immediately downslope from the mound location to prevent compaction and to minimize frost penetration. You also should maintain a good grass or vegetative cover over the area to maximize the uptake of water and to prevent surface erosion. Provide the homeowner with a layout diagram of the septic system, referenced to the home and lot boundaries. This will enable location of the tanks and absorption field for future maintenance.

Sludge should be removed from the septic tank and pump chamber every 3-5 years. This clean-out schedule is even more important with mound systems than with standard gravity fed systems to avoid carryover of solids to the mound which can plug the pressure distribution pipe openings in the bed. Homeowners should be encouraged to monitor the performance of the septic system by routinely check- ing for the presence and depth of water in the monitoring wells during spring, summer, and fall. Any progressive increase in ponding depth within the mound bed or sand fill over time may be indicative of a future problem.

Water conservation measures in the home help insure that the mound will not be overloaded. It would be wise to install water conserving devices like faucet aerators, low-flow fixtures, and appliances when possible.

Operating and Maintaining the Home Septic System (ID-142) is a helpful Cooperative Extension publication that is written for the homeowner. This publication and the above recommendations should help the homeowner better understand the operation and maintenance of their on-site septic system for many years of trouble-free operation.

Additional Assistance

In addition to the FACTS computer program located at each Indiana County Cooperative Extension office, assistance in selecting and designing an on-site system is available from your local county health department and your local Soil Conservation Service (SCS) office. Some assistance also may be available for design of innovative systems.

Don D. Jones, Agricultural Engineering Department, (317) 494-1175 or
Joseph E. Yahner, Agronomy Department, (317) 4945049.

REV 4/90

Waste Disposal Project

Cooperative Extension Work in Agriculture and Home Economics, State of Indiana, Purdue University and U.S. Department of Agriculture Cooperating. H.A. Wadsworth, Director West Lafayette, IN. Issued in furtherance of the Acts of May 8 and June 30, 1914. It is the policy of the Cooperative Extension Service of Purdue University that all persons shall have equal opportunity and access to our programs and facilities.

APPENDIX J

Sand Filter Design
U.S. EPA & Rhode Island

Subsurface filters should not be used where a discharge to surface waters is proposed. Wastes containing large amounts of greases or detergents from food establishments cannot be treated in this type filter.

Two references for the design of sand filters are given below (US EPA and the state of Rhode Island):

United States Environmental Protection Agency
Office of Water
Washington, D.C.
EPA 832-F-99-067
September 1999

Wastewater Technology Fact Sheet

Intermittent Sand Filters

DESCRIPTION

Intermittent Sand Filters (ISFs) have 24-inch deep filter beds of carefully graded media. Sand is a commonly used medium, but anthracite, mineral tailings, bottom ash, etc., have also been used. The surface of the bed is intermittently dosed with effluent that percolates in a single pass through the sand to the bottom of the filter. After being collected in the underdrain, the treated effluent is transported to a line for further treatment or disposal. The two basic components of an ISF system are a primary treatment unit(s) (a septic tank or other sedimentation system) and a sand filter.

ISFs remove contaminants in wastewater through physical, chemical, and biological treatment processes. Although the physical and chemical processes play an important role in the removal of many particles, the biological processes play the most important role in sand filters.

ISFs are typically built below grade in excavations 3 to 4 feet deep and lined with an impermeable membrane where required. The underdrain is surrounded by a layer of graded gravel and crushed rock with the upstream end brought to the surface and vented. Pea gravel is placed on top of the graded gravel, and sand is laid on top of the pea gravel. Another layer of graded gravel is laid down, with the distribution pipes running through it. A flushing valve is located at the end of each distribution lateral. Lightweight filter fabric is placed over the final course of rock to keep silt from moving into the sand while allowing air and water to pass through. The top of the filter is then backfilled with loamy sand that may be planted with grass. Buried ISFs are usually designed for single homes.

Some common types of these sand filters are listed below.

Gravity Discharge ISFs
The gravity discharge ISF is usually located on a hillside with the long axis perpendicular to the slope to minimize the excavation required. Because the effluent leaving the sand filter flows out by gravity, the bottom of the sand filter must be several feet higher than the drain field area. To achieve that difference in elevations, a sand filter may be constructed partially above ground.

Pumped Discharge ISFs
The pumped discharge sand filter is usually sited on level ground. Its location in relation to the drain field is not critical since a pump located within the sand filter bed allows effluent to be pumped to a drain field at any location or elevation. Discharge piping goes over—not through—the sand filter liner, so the integrity of the liner is protected.

Bottomless ISFs
The bottomless ISF has no impermeable liner and does not discharge to a drain field, but rather directly to the soil below the sand. Table 1 shows the typical design values for ISFs. These values are based on past experience and current practices and are not necessarily optimum values for a given application.

ADVANTAGES AND DISADVANTAGES
Some advantages and disadvantages of ISFs are listed below:

Advantages
- ISFs produce a high quality effluent that can be used for drip irrigation or can be surface discharged after disinfection.
- Drain fields can be small and shallow.
- ISFs have low energy requirements.
- ISFs are easily accessible for monitoring and do not require skilled personnel to operate.
- No chemicals are required.
- If sand is not feasible, other suitable media can be substituted and may be found locally.
- Construction costs for ISFs are moderately low, and the labor is mostly manual.
- The treatment capacity can be expanded through modular design.
- ISFs can be installed to blend into the surrounding landscape.

Disadvantages
- The land area required may be a limiting factor.
- Regular (but minimal) maintenance is required.
- Odor problems could result from open filter configurations and may require buffer zones from inhabited areas.
- If appropriate filter media are not available locally, costs could be higher.
- Clogging of the filter media is possible.
- ISFs could be sensitive to extremely cold temperatures.
- ISFs may require a National Pollutant Discharge Elimination System (NPDES) Permit when the effluent is surface discharged.

TABLE 1. TYPICAL DESIGN CRITERIA FOR ISFs

Item Design Criteria
Pretreatment Minimum level: septic tank or equivalent
Filter medium: Material Washed durable granular material
Effective size: 0.25-0.75 mm
Uniformity coefficient: < 4.0
Depth: 18 - 36 in
Underdrains: Type Slotted or perforated pipe
Slope: 0-0.1%
Size: 3-4 in
Hydraulic loading: 2-5 gal/ft2/day
Organic loading: 0.0005-0.002 lb/ft2/day
Pressure distribution Pipe size: 1-2 in
Orifice size: 1/8-1/4 in
Head on orifice: 3-6 ft
Lateral spacing: 1-4 ft
Orifice spacing: 1-4 ft
Dosing Frequency: 12-48 times/day
Volume/orifice: 0.15-0.30 gal/orifice/dose
Dosing tank volume: 0.5-1.5 flow/day
Source: Adapted from: U.S. EPA, 1980 and Crites, et.al.

PERFORMANCE
Sand filters produce a high quality effluent with typical concentrations of 5 mg/L or less of biochemical oxygen demand (BOD) and suspended solids (SS), as well as nitrification of 80% or more of the applied ammonia. Phosphorus removals are limited, but significant fecal coliform bacteria reductions can be achieved.

The performance of an ISF depends on the type and biodegradability of the wastewater, the environmental factors within the filter, and the design characteristics of the filter. The most important environmental factors that determine the effectiveness of treatment are media reaeration and temperature. Reaeration makes oxygen available for the aerobic decomposition of the wastewater.

Temperature directly affects the rate of microbial growth, chemical reactions, and other factors that contribute to the stabilization of wastewater within the ISF. Filter performance is typically higher in areas where the climate is warmer compared to areas that have colder climates. Discussed below are several process design parameters that affect the operation and performance of ISFs.

The Degree of Pretreatment
An adequately sized, structurally sound, watertight septic tank will ensure adequate pretreatment of typical domestic wastewater.

Media Size
The effectiveness of the granular material as filter media is dependent on the size, uniformity, and composition of the grains. The size of the granular media correlates with the surface area available to support the microorganisms that treat the wastewater. This consequently affects the quality of the filtered effluent.

Media Depth
Adequate sand depth must be maintained in order for the zone of capillarity to not infringe on the upper zone required for treatment.

Hydraulic Loading Rate
In general, the higher the hydraulic load, the lower the effluent quality for a given medium. High hydraulic loading rates are typically used for filters with a larger media size or systems that receive higher quality wastewater.

Organic Loading Rate
The application of organic material in the filter bed is a factor that affects the performance of ISFs. Hydraulic loading rates should be set to accommodate the varying organic load that can be expected in the applied wastewater. As with hydraulic loading, an increase in the organic loading rate results in reduced effluent quality.

Dosing Techniques and Frequency
It is essential that a dosing system provide uniform distribution (time and volume) of wastewater across the filter. The system must also allow sufficient time between doses for reaeration of the pore space. Reliable dosing is achieved by pressure-dosed manifold distribution systems.

OPERATION AND MAINTENANCE
The daily operation and maintenance (O&M) of large filter systems is generally minimal when the ISF is properly sized. Buried sand filters used for residential application can perform for extended periods of time. Primary O&M tasks require minimal time and include monitoring the influent and effluent, inspecting the dosing equipment, maintaining the filter surface, checking the discharge head on the orifices, and flushing the distribution manifold annually. In addition, the pumps should be installed with quick disconnect couplings for easy removal.

The septic tank should be checked for sludge and scum buildup and pumped as needed. In extremely cold temperatures, adequate precautions must be taken to prevent freezing of the filter system by using removable covers. Table 2 lists the typical O&M tasks for ISFs.

APPLICABILITY
An assessment conducted in 1985 by the U.S. Environmental Protection Agency of ISF systems revealed that sand filters are a low-cost, mechanically simple alternative. More recently, sand filter systems have been serving subdivisions, mobile home parks, rural schools, small communities, and other generators of small wastewater flows.

Sand filters are a viable addition/alternative to conventional methods when site conditions are not conducive for proper treatment and disposal of wastewater through percolative beds/trenches. Sand filters can be used on sites that have shallow soil cover, inadequate permeability, high groundwater, and limited land area.

Placer County, California

Placer County, California, in the last 20 years has had to develop their land with on-site systems due to the popularity of their rural homes at elevations of 100 to 4,000 feet. The county extends along the western slope of the Sierra Nevada Mountains from Lake Tahoe through the foothills and into the Great Central Valley. Large areas of the county have marginal soil quality, shallow soil depth, and shallow perched groundwater levels.

In 1990, a program was initiated to permit the use of the Oregon-type ISF system on an experimental basis to evaluate their performance and other related factors. The ISF system used in this study had the following components: a conventional septic tank followed by a separate pump vault; a plywood structure with a 30 mm PVC liner for the filter and appurtenances; 24 inches deep of carefully graded and clean sand; a gravel over-layer and under-layer containing the pressurized piping manifold to distribute the septic tank effluent over the bed; and a collection manifold to collect the wastewater. The dimensions of the filter (for both three- and four- bedroom homes) were 19 feet x 19 feet at a design loading rate of 1.23 gal/ft^2/day. Summarized below in Table 3 are the results obtained from 30 ISF systems serving single-family homes during warm and cold weather.

The results of this study indicate that ISF systems showed a marked improvement in their effluent quality over septic tanks. Although the systems performed well, nitrogen and bacteria were not totally removed, which indicates that ISF systems should be used only where soil types and separations from the groundwater are adequate.

TABLE 2. RECOMMENDED O&M FOR ISFs

Item O&M Requirement

Pretreatment Depends on process; remove solids from septic tank or other pretreatment unit

Dosing chamber

Pumps and controls Check every 3 months

Timer sequence Check and adjust every 3 months

Appurtenances Check every 3 months

Filter media

Raking As needed

Replacement Skim sand when heavy incrustations occur;

replace sand to maintain design depth

Other Weed as needed

Monitor/calibrate distribution device as needed

Prevent ice sheeting

Other findings show that early involvement of stakeholders is vital to the program's success; effective system maintenance is essential; and the local learning curve allows errors that adversely affect system performance.

Boone County, Missouri

A pressure-dosed ISF was installed and monitored on the site of a three-bedroom single-family residence in Boone County, Missouri. The sand filter, followed by a shallow drain field, replaced a lagoon and was installed to serve as a demonstration site for the county. The soil condition at this site is normally acceptable for septic tank effluent, but the top 30 to 35 cm had been removed to construct the original sewage lagoon.

The existing septic tank was found to be acceptable and was retrofitted with a pump vault and a high-head submersible pump for pressure dosing the sand filter. The sand filter effluent drained into the pump vault in the center of the sand filter, which then pressure dosed two shallow soil trenches constructed with chambers. The system was installed in October 1995, and the performance was monitored for 15 months.

The sand filter used in this study consistently produced a high quality effluent with low BOD, SS, and ammonia nitrogen (NH_4-N). Table 4 lists the various parameters studied. The aerobic environment in the sand filter is evident from the conversion rate of NH_4-N to nitrate nitrogen (NO_3-N) that also resulted in no odor problems. The fecal coliform numbers were consistently reduced by four log units. The average electricity use by this system was 9.4 kWh/month, and the cost of operating two pumps in the system has been less than 70 cents per month.

The high quality effluent produced by the sand filter also reduced the size of the absorption area. The cost of an ISF system depends on the labor, materials, site, capacity of the system, and characteristics of the wastewater. The main factors that determine construction costs are land and media, which are very site-specific. Table 5 is an example of a cost estimate for a single-family residence.

Energy costs are mostly associated with the pumping of wastewater onto the filter. The energy costs typically range between 3 to 6 cents per day. Consequently, the energy costs of sand filters are lower than most small community wastewater processes, except for lagoons.

TABLE 3. COMPARISON OF EFFLUENTS FROM SINGLE-FAMILY, RESIDENTIAL SEPTIC TANKS AND ISFs FOR 30 SYSTEMS IN PLACER COUNTY

Effluent Characteristic	Septic Tank Effluent	ISF Effluent	% Change
CBOD5	160.2 (15)*	2.17 (44)*	98
TSS	72.9 (15)*	16.2 (44)*	78
NO3-N	0.1 (15)*	31.1 (44)*	99
NH3-N	47.8 (15)*	4.6 (44)*	90
TKN	61.8 (15)*	5.9 (44)*	90
TN	61.8 (15)*	37.4 (44)*	40
TC	6.82 x 105 (13)*	7.30 x 102 (45)*	99 (3 logs)
FC	1.14 x 105 (13)*	1.11 x 102 (43)*	99 (3 logs)

*Number of samples
$CBOD_5$, TSS, and nitrogen expressed as mg/L; arithmetic mean. Fecal and total coliform expressed as geometric mean of
MPN/100 ml.
Source: Cagle and Johnson (1994), used with permission from the American Society of Agricultural Engineers.

TABLE 4 EFFLUENT CHARACTERISTICS OF THE ISF IN BOONE COUNTY, MO.

Parameter	Septic Tank	Sand Filter	% Change
BOD (mg/L)	297	3	99.0
TSS (mg/L)	44	3	93.2
NH_4-N (mg/L)	37	0.48	98.7
NO_3-N (mmlL)	0.07	27	384.71
Fecal coliform (#/100 mL)	4.56E+05	7.28E+01	99.9

Source: Sievers; used with permission from the American Society of Agricultural Engineers, 1998.

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TABLE 5 COST ESTIMATES FOR SINGLE FAMILY RESIDENCE
Item Cost ($)
Capital Costs
Construction costs, 1,500-gallon single compartment septic/pump tank @ 57 cents/gallon $ 850
ISF complete equipment package (includes dual simplex panel, pump pkg., tank risers, lids, liner, lateral kit, orifice shields, etc.) $ 3,200
Non-component costs $750
Engineering (includes soils evaluation, siting, design submittal, and construction inspections) $2,000
Contingencies (includes permit fees) $1,000
Land May vary

Total Capital Costs $10,800
Annual O&M Costs
Labor @ $65/hr. (2 hrs./yr.) $130/yr.
Power @10 cents/kWh May vary
Sludge disposal *25/yr.
*Septic tank pumping interval based on 7 years with five occupants.

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Rhode Island Department of Environmental Management
Guidelines for the Design and Use of Sand Filters in Critical Resource Areas
April 2000

Guidelines for the Design and Use of Sand Filters in Critical Resource Areas

Introduction

Different types of sand filters have different design criteria, sand media specifications, and corresponding hydraulic loading rates. The sand media used in the filters, and the microorganisms that colonize and reside in them, are responsible for much of the wastewater treatment. Sand filter media quality is crucial to the operation and longevity of the filter. To assure good wastewater treatment, sand media free of fine particles, with the proper sand uniformity and effective size must be used with the appropriate sand filter type and hydraulic loading rate.

Sand filters will not reach complete removal of all the nutrients and pathogens in domestic wastewater. Shallow - narrow drain fields when combined with a sand filter may help produce a treatment train that is cost effective and more efficient. The installation of narrow (12 inches wide) and shallowly placed (within 12 inches of the ground surface) low pressure drain fields directly in native soils, without trench stone, have been used successfully in Rhode Island on several State demonstration projects.

Although to date, little research information exists on the nutrient and pathogen removal efficiency of shallow - narrow drain fields, their design parameters would encourage enhanced treatment of wastewater.

Types of Sand Filters Covered by this Guidance
This guidance is intended for the design of sand filters receiving residential strength wastewater which should not exceed the following parameters: biochemical oxygen demand (BOD_5) of 230 mg/l; total suspended solids (TSS) of 125 mg/l; fat, oil, and grease (FOG) of 25 mg/l; and total Kjeldahl nitrogen (TKN) of 75 mg/l.

Recirculating Sand Filters (RSF) -Multiple pass sand filter (Figure 1).
Sized at a maximum of 5.0 gallons/ square foot /day. With a recirculation rate of 2-4, the actual wastewater loading rate on the sand filter is 3-5 times the forward flow from the dwelling.

R.S.F. Treatment Process Summary - Wastewater, having received primary treatment in a septic tank or equivalent unit, flows by gravity to a recirculation (mixing) tank. In doses controlled by both a programmable timer and float switch, the mixed fresh wastewater and partially treated filter effluent is applied to a bed of sand media (actually of small gravel sized particles). This mixed wastewater is dispersed over the filter surface in a PVC distribution network surrounded in pea stone. Wastewater trickles down through the sand media, where biological treatment occurs.

The treated R.S.F. effluent is collected in an under drain at the bottom of the filter and discharged back to the recirculation tank. There most of it mixes with incoming wastewater, a small amount gets discharged to the drain field, and the cycle begins again. Typically, a buoyant-ball check valve is used to control discharge and recirculation. Treated wastewater is discharged to a drain field for additional treatment.

Single Pass Sand Filter (SPSF)

1. Low Rate single pass filter loaded at a maximum of 1.25 gallons/square foot/day.
2. High Rate single pass filter loaded at a maximum of 2.0 gallons/square foot/day.

SPSF Treatment Process Summary - Wastewater, having received primary treatment in a septic tank or equivalent unit, is pressure dosed to a bed of specified sand media. Wastewater applications to the filter surface are controlled by both a programmable timer and float switch. Wastewater is dispersed over the sand filter surface in a PVC pipe distribution network surrounded in pea stone. Wastewater trickles down in unsaturated thin film-flow through the sand media, where biological treatment occurs. The treated wastewater (sand filter effluent) is collected in an under drain at the bottom of the filter and discharged by pressure to an shallow - narrow drain field, where additional treatment occurs.

Selecting the Best Sand Filter for a Site

Because of size and space considerations, most single pass sand filters are designed for flows of less than 1,000 gallons per day. Recirculating sand filters, because of the higher hydraulic loading rates, utilize larger sized sand media, but have a smaller size footprint and tend to be more economical for larger flows. With the addition of an anaerobic zone provided by the recirculation tank, nitrogen removal will be greater in the recirculating sand filter than in a single pass sand filter.

Conversely, pathogen removal efficiency is better in single pass sand filters. This is due primarily to the finer sand media particles used in a single pass filter that physically screen out larger septic microbes. In addition, the lower hydraulic loading rates in single pass sand filters create longer retention times in the filter for treatment processes to occur. These treatment characteristics should be considered when siting sand filters in critical resource areas.

High rate SPSFs are recommended for sites where space considerations are a primary concern. These filters will produce a high quality effluent, low in BOD_5 and TSS (concentrations of both usually less than 5 mg/L). Pathogen reductions in high rate filters are considerably better than what is possible in many other advanced treatment systems. However, high rate SPSF effluent will still contain residual pathogenic organisms and are not the preferred sand filter design for use in shallow groundwater areas or in areas with "dug" drinking water wells. Under tight lot conditions in these types of locations, a treatment train consisting of a high rate SPSF followed by an ultraviolet disinfection unit and pressurized shallow narrow drain fields may produce high treatment levels.

Low rate SPSFs are recommended for sites where maximum removal of pathogenic organisms is desired. Applicable locations are: critical resource areas such as drinking water reservoir watersheds, pathogen sensitive poorly-flushed coastal ponds, shallow water table soil locations where shallow dug wells provide potable water, sites in close proximity to shellfishing grounds, and areas where recreational water contact issues are a concern.

Tank Specifications

All tanks and containers used in a sand filter system **must be watertight**, otherwise the sand filter systems will not function properly. Leaks will allow groundwater to infiltrate into tanks and be pumped onto filters, subsequently overloading them. Similarly, under deep groundwater conditions, wastewater leaking out of a septic tank will not be dosed to the sand filter and treatment will be short circuited.

All septic, recirculation and pump tanks should be either vacuum tested or water tested with their access risers in place before use. It is recommended that any tank used in a sand filter system be guaranteed watertight by the tank manufacturer, the installer, or the designer doing construction oversight. All tanks shall have a watertight riser to grade at both the inlet and outlet end for servicing. All seams or joints in, and between, the septic tank and riser shall be watertight. The risers should be mechanically bonded to the tank in a way that provides both structural integrity and watertightness. All inlet and outlet pipes to the tank shall also have strong mechanical bonds that are watertight.
To water test a tank, seal the tank inlet and outlet. Next, fill the tank with tap water to 2 to 4 inches above the joint between the riser and tank and let stand for 24 hours. If there is a water loss, refill, mark the water level and let stand for two more hours. There should be no additional water loss.

Vacuum testing of tanks should be done by a qualified contractor or tank manufacturer experienced in performing this procedure. It is recommended that the tanks be constructed, installed and tested in accordance with American Society for Testing and Materials (ASTM) Standard C-1227-97A.

To help achieve the maximum level of **primary treatment**, two compartment septic tanks (divided in a 2/3 and 1/3 configuration) shall be used with all sand filter systems

Wastewater from kitchen and food processing facilities must first pass through a grease tank with at least a 3 day, and preferably a 5 day hydraulic retention time, before mixing with the main blackwater stream. A three day hydraulic retention time may be adequate to trap fats, oil and grease. However, peak flows, wash water temperature, and detergents can influence fat, oil, and grease removal efficiency. In high risk installations, tankage volume should be increased appropriately to allow for maximum fat, oil and grease removal.

Filter Enclosure

A. It is essential that the enclosure containing the sand media is watertight to prevent groundwater from flooding the system and to prevent untreated effluent from leaking out of the filter. The enclosure shall be a monolithic concrete slab and walls or a 30 mil PVC liner with all boots, patches, repairs and seams having the same physical properties as the parent material. If using PVC liners all seams shall be factory welded or secured with the appropriate resilient sealant.
B. Any penetrations in concrete enclosures must be formed with the appropriate precast knockout. To assure a watertight connection it is recommended that an appropriatelysized PVC coupling or watertight rubber boot be cast into the concrete wall and the underdrain pipe be glued or clamped into the coupling/boot. An alternate method would be to utilize a core and flexible rubber expansion seal. Likewise, all transport pipes delivering wastewater to the filter should also be glued. Gasketed PVC pipe may be used to minimize thermal expansion and contraction problems on long pipe runs of over 300 feet.
C. Any penetration through the PVC liner wall shall be done with a PVC boot attachment glued to the liner with the appropriate resilient sealer. Two (2) inches of fine sand shall be placed beneath the bottom of the liner to bed and protect it against sharp objects.
D. When using a PVC liner, the support walls shall be rigid and made of plywood (or equivalent) and 2x4 construction to hold the liner in place during installation. The points of all screws and fasteners used in construction shall face away from the liner. Alternately, if the soil on site will support vertical walls of an excavation, wooden support walls may not be needed. However, a wooden top frame structure (such as landscape timbers) is still needed to hang and hold the liner while sand is placed in the filter. Care is needed not to stretch the liner during the filling procedure.
E. The outside of the liner walls shall be backfilled evenly as the filter sand is placed into the enclosure. This will prevent the walls from bowing outward as the filter is filled with sand media. When backfilling the enclosure, avoid fill material with sharp stones which can penetrate the PVC liner after the plywood rots away. Overdigging the hole should be avoided; minimal backfilling on bottom and sides provides a more stable enclosure.

Installation of Sand Filter Media
A. Sand media shall be selected for the appropriate application based on the enclosed sand filter media guidelines.
B. No filter fabric of any kind shall be placed around the filter underdrain pipe(s) or between the 3/8” pea stone covering the filter base and the overlying sand media.
C. Sand should be a minimum of twenty-four (24) inches deep and be thoroughly washed and as free of fines as possible.
D. It is recommended that the sand media be placed in level eight (8) inch lifts in the filter and wetted slightly during installation to promote even settling. It is important not to wet the sand too much because particle stratification may occur.
E. As the filter is filled with sand, the edges of the filter should be “walked down” by installer to make sure sand is tight along filter perimeter, and no voids exist. The installer should watch that the liner is not stretched during the filling process.
F. After the required amount of filter sand has been added to the filter, place three (3) inches of 3/8” washed pea stone over the filter sand. After the distribution laterals have been installed atop the pea stone and pressure tested, install shields on each orifice on the distribution laterals, add two (2) more inches of pea stone to cover the distribution laterals. No filter fabric of any kind should be placed between the sand and overlying pea stone layers.

Cover Material
A. For **buried single pass sand filters**, a light-duty non-woven filter fabric shall be placed on top of the uppermost layer of pea stone, between the pea stone and the topsoil cover material. This will eliminate fine soil particles from clogging the pea stone. Do not use heavy weight filter fabrics because they can limit gas/oxygen movement into and out of the sand filter.
B. A maximum of eight (8) inches around the center pump basin and six (6) inches on the filter edges of loamy sand or sandy loam topsoil and a grass cover are recommended to complete the **buried single pass filter** installation. The finished grade for any sand filter should be slightly higher than the surrounding grade and crowned, if possible, to prevent surface water from flowing onto the filter.
C. When using a **recirculating sand filter**, cover the filter with pea stone to two (2) to four (4) inches over the top of the lateral end ball valve. **Recirculating sand filters have a pea stone surface and do not get covered with topsoil.**

Precautionary Notes:
D. **Sand filters should not be placed in a depressional area on a property, where stormwater is likely to collect during rainfall events.**
E. **Care should be taken to not bury the filter too deeply or cover the filter top with soil material that could compact excessively (especially when moist). This could limit the gas/oxygen diffusion through the filter surface and cause filter hydraulic failure.**
F. **Avoid placing buried single pass sand filters in a traffic area where they would receive excessive foot traffic.**
G. **A minimum buffer of ten (10) feet should be maintained between sand filters and neighboring trees and shrubs. Water-loving trees and shrubs shall not be placed adjacent to sand filters, because their root systems can cause system damage.**

H. **Under no circumstances should heavy equipment, vehicles, or impermeable surfaces/materials be allowed over a finished sand filter. At a minimum, this would result in poor treatment. More likely system failure, broken components, and financial expense to the homeowner will result.**
I. **Under wet site conditions, it is recommended that the sand filter elevation be raised to avoid having the filter enclosure sitting directly in groundwater. A raised filter can be crowned at the surface and blended into the surrounding surface grades, which will help keep the filter isolated from surface water runoff also.**

Sand Filter Media
It is important to remember that using good quality sand media is essential. Not all sand and gravel operations will have the ability to produce sand with these specifications.
A sieve analysis of the sand media to be used should be conducted to assure that its effective size and uniformity coefficient are appropriate for the intended use. When sampling the stock piled sand media, samples should be taken from several locations within the pile to assure a representative sample for analysis. The standard method to be used for performing particle size analysis should comply with one of the following:
1. The sieve method specified in ASTM D-136 and ASTM C-117.
2. The method specified in Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples, Soil Survey Investigation Report #1, U.S. Department of Agriculture, 1984.

Important Note: To prevent clogging in the filter, all sand media must be well washed and as free of fine particles and dust as possible.

Requirements for All Sand Filters:
1. A programmable timer, to control and adjust the number of doses per day, length of dose time, and the duration of time between doses.
2. A high water alarm, pump, and float switch(s) set to override the programmable timer in the event of timer malfunctions or temporary excessive water use.
3. A pump control panel with an elapsed time run meter and a dosing event counter (pump impulse counter) for each pump in the system.
4. An impulse counter on the timer override or high water alarm float (whichever is most applicable to the expected daily flow. This counter would indicate how often the system is working in override or high water situations.
5. A routine hydraulic surge storage capacity in the tank from which effluent is pumped onto the sand filter. This surge storage capacity shall be a minimum of 10% of the tank volume capacity, and shall be positioned between the elevation of the timer operating float switch and the high water alarm/timer override float switch.
6. An emergency storage capacity in the tank from which effluent is pumped onto the sand filter. This zone shall be positioned above the elevation of the high water alarm/timer override float switch and below the tank inlet invert. This storage volume shall be a minimum of 10% of the tank volume capacity.

Requirements for Recirculating Sand Filters:

1. A separate recirculation tank with a hydraulic capacity (in gallons) as noted in Table 1.
2. A recirculation buoyant-ball check valve (or other approved flow splitting device) to split the return flow from the sand filter. The ball when seated should maintain the liquid level in the recirculation tank at 80% of tank liquid capacity. The liquid capacity is determined by the elevation of the timer operating float switch.
3. A recirculation ratio from 3:1 to 5:1. Note that a 4:1 recirculation ratio returns 3 parts (3/4) of the sand filter effluent back to the recirculation tank, while discharging 1 part (1/4) of the sand filter effluent to the drain field.

Operation and Maintenance Requirements for Sand Filter Systems

WARNING - Before doing any work on either the wiring to the level control floats and pumps in the vault, tanks, or on the control panel, pull the fuse and switch the circuit breakers in the control panel to the OFF position. Do not enter a confined space without using proper equipment and following standard confined space safety precautions.

A. Immediately after any sand filter system has been installed, the head or “squirt height” of the distribution laterals needs to be determined, recorded in the maintenance record and left on site (usually in the system electrical control box). Measuring the head is done by attaching a graduated length of clear PVC pipe to the end of the sweep elbow accessed by removing the inspection port cover (in a recirculating sand filter, the straight end of the lateral can be accessed by pushing aside the pea stone, and attaching a 90 degree elbow). The pump is turned on, the sweep end opened, and the wastewater height in the clear pipe is measured and recorded.
B. A minimum of five (5) feet of distal head pressure is recommended to discourage orifice clogging.
C. Orifice blockage will occur in all systems. A bottle brush (appropriately sized for the lateral) attached to a plumbers snake is pushed down each lateral to unplug the orifices.
D. With the bottle brush removed, the pump should be manually engaged and each lateral line can be flushed out through the lateral end onto the sand filter.
E. Alternatively, a pressure power washer with appropriately sized tubing can be sent down each lateral to flush accumulated solids.
F. Usually a sand filter in continuous use will require lateral flushing / bottle brush treatment once a year. Sand filters operating above their daily design flow or systems in need of a septic tank pumpout, may require more frequent lateral flushing; the frequency based upon the results of the distal lateral head pressure test. Seasonallyused sand filters may not need yearly lateral flushing, but their lateral head (pressure) should be checked once per year, and maintenance performed as needed.

G. The lateral “squirt height” (which approximates, but is somewhat less than, the head) in recirculating sand filters can be determined by spreading aside the pea stone surface covering one of the distribution laterals, removing an orifice shield, and measuring the squirt height with a tape measure placed next to the stream. Alternately, a 90 degree elbow can be attached to the lateral end and head visually measured in an attached clear pipe.

H. The surface of all sand filters should be kept free of debris. If the sand filter is an “open” filter covered with pea stone instead of turf, the sand filter surface should be kept free of weeds and grasses. This surface can be lightly raked to remove leaves, etc. and weeds and grasses should be removed when they first appear.

I. Once a year all electrical components should be checked for function. All float switches should be activated and timers should be checked against the desired setting. All float switches should be hosed down to prevent scum accumulation. All wiring should be neatly bundled and placed out of the operating path of the float switches.

J. The septic tank and pump tanks should be measured for sludge and scum accumulation. This should occur every 1-3 years, the frequency depending on household usage and occupancy. More actively-used systems should be placed on the more frequent sludge/scum measurement schedule. This can easily be done as part of the annual maintenance. If sludge and scum levels warrant, have those tanks pumped.

IMPORTANT! If fiberglass or polyethylene tanks are used, it is important to monitor ground water levels before pumping septage or to schedule pumping of tanks for late Summer or early Fall to avoid tanks floating (this time period may differ depending upon weather conditions). Pumping concrete tanks during periods of high groundwater may also cause tank floatation problems. The yearly inspection process will facilitate the scheduling of tank pumping to avoid emergency pumping situations. All tanks should be filled with tap water immediately after septage pumping is completed.

K. The effluent filter in the septic tank should be hosed off on a yearly basis, and whenever the septic tank is pumped. Systems operating above their design flows may require more frequent effluent filter cleaning.

L. **Effluent filters located in a recirculation tank should be checked a minimum of every six months for accumulation of slime growth.** If the pump is located in a pump vault, this slime growth may necessitate the removal and cleaning of the vault, pump and the effluent filter, if so equipped. If inspections determine that slime growth is not a problem, then this particular inspection item schedule may be reassessed.

M. If the pump vault is removed, the cleaned vault should be filled with clean water from a garden hose as it is being lowered back into the septic tank. This will prevent the screen from being fouled with solids in the tank and will also make it easier to submerge.

N. All slime material hosed off of filters, pumps and vaults should be placed into the **inlet end of the septic tank**, accessible through the tank inlet access riser / manhole**.**

O. All tanks should be visually inspected for watertightness and structural soundness when maintenance is performed.

In the event of an audible alarm, the alarm can be silenced by pushing the red button on the outside of the control panel. In most cases the alarm will be due to a temporary high water situation caused by too much water entering the system at a particular time. This will be self-correcting in most cases. If the alarm keeps coming on or if the red light on the outside of the panel stays on for a prolonged period of time after the alarm is silenced there may be a more serious problem such as a clogged effluent filter, “full” septic tank, or mechanical malfunction.
Q. The high water alarm will come on if the volume of water used at a particular time is more than what is accommodated for discharge in the usual dosing process. An alarm may go on if the occupancy or water use of the house or facility is more than typical. These are referred to as “nuisance alarms” and do not mean there is a system problem. If the nuisance alarm persists, the dosing schedule and amounts can be changed to help correct the problem. In some cases, persistent alarms may indicate a more serious problem that needs to be addressed.
R. At each visit, readings from elapsed run time meters, event counters, and water meters should be recorded on the data cards (usually stored in the electrical control panel).
S. At each site visit, a sample of the sand filter effluent should be collected to visually check for effluent clarity. This sample should be clear and odor-free.

Sizing Drain fields Receiving Sand Filter Effluent
Because all three sand filter designs in this guide are capable of reducing waste strength to well below secondary treatment levels (i.e. BOD and TSS well below 30 mg/l), they may be allowed a reduction in conventional drain field size. To gain additional reductions of nutrients and pathogenic organisms in critical resource areas, shallow narrow drain fields shall be used in conjunction with the sand filters illustrated in this guide. Loading rates for soils receiving sand filter effluent shall follow the criteria shown below.

[1]**Drainfield loading rates shall be based upon texture, structure, and consistence of most restrictive horizon.**
[2]**Sand lined shallow narrow pressure dosed trenches shall be used in these soil types.**

Pressurized Shallow - Narrow Drain fields
Remember to follow these basic rules when designing and installing shallow - narrow drain fields:
1) keep the drain field base shallow (8-12 inches below existing and finish grades);
2) keep the bottoms of the individual trenches level;
3) do not over-dig the width or depth of the drain field trenches;
4) keep the elevation of all the drain field trenches the same;
5) provide for lateral pipe drainage and maintenance access;
6) avoid working soils that are moist or wet because they can easily smear and compact;
7) scarify the drain field base well before installing components.

When first reviewing a construction site and developing a design, it is best to position shallow - narrow drain fields parallel to ground surface contours. This will help make it easier to keep drain field base elevations uniform.

Designing perpendicular to a surface contour will mean that the down gradient end of the drain field trench will be shallow placed, whereas the up gradient end will be much deeper.

Small frequent doses of sand filter effluent to a drain field surface are preferred over fewer larger doses. Drain field pump basins/chambers should be designed with float switches controlling high water alarm, pump on/off, and low water alarm / redundant off. An impulse counter and elapsed time run meter shall also be used on the drain field

Trenches at Different Elevations and Zoned Drain fields
Site conditions may not facilitate installing drain field trenches at the same elevation. In these situations orifice plates may be used to provide uniform wastewater distribution. These plates should be installed in PVC unions to facilitate cleaning and changing, if necessary. In addition, gate valves should be used to help equalize flow to trenches that are not at the same elevation. Access ports should be installed at the locations of orifice plate unions and gate valves.

Smaller sized pumps can be used on larger drain fields and still maintain distal head pressure by utilizing simple non-electric automatic distributing valves. These valves sequentially redirect flow to separate zones within the drain field.

Maintenance
Because sand filter effluent is low in BOD and TSS, accumulation of biosolids or slime material in drain field lateral pipes is fairly minimal. Over time, however, biosolids will accumulate, blocking orifices and creating uneven wastewater distribution along the trench.

To unclog the orifices locate the trench access port and open the lateral sweep end. Open each lateral end, manually engage the pump and purge any loose solids out the lateral end into the access port. A bottle brush (appropriately sized for the lateral) attached to a plumbers snake is then pushed down each lateral to unplug the orifices. With the bottle brush removed, the pump should be manually engaged and each lateral line can be flushed out through the lateral end onto the drain field surface. This minimal amount of biosolids will usually decompose within two days. Alternatively, a pressure power washer with appropriately sized tubing can be sent down each lateral to flush accumulated solids.

Usually a shallow - narrow drain field following a sand filter in continuous use will require lateral flushing / bottle brush treatment once a year or every two years. Systems operating above their daily design flow may require more frequent lateral flushing; the frequency based upon the results of the distal lateral head pressure test. Seasonally-used systems may not need yearly lateral flushing, but their lateral head (pressure) should be checked once per year, and maintenance performed as needed.

Precautions
The landscape immediately above and adjacent to any septic drain field should be protected from heavy vehicle traffic and excessive weight loads, before, during and post-construction. This is especially important when using shallow drain fields row drain fields, because they are located close to the ground surface and especially susceptible to damage after construction. It is recommended that the proposed drain field location be staked and flagged/fenced to prevent encroachment during home construction. If vehicle encroachment is expected to be a problem after construction, some structure such as garden timbers, fences, or walls should be used to protect the drain field area.

The drain field area should be kept debris free and planted to grass. Impermeable materials should not be installed or stored over the shallow - narrow drain field. Trees and shrubs should be kept a minimum distance of ten (10) feet from the drain field. Roots from nearby moisture-loving trees such as willows, black locust, and red maple may cause problems with root clogging drain field lateral orifices. Greater setback distances are recommended from these tree species.

APPENDIX K

Denitrification
U.S. EPA Fact Sheet

EPA 625/R-00/008

Onsite Wastewater Treatment Systems Technology Fact Sheet 9

Enhanced Nutrient Removal--Nitrogen

Description

Nitrogen is a pollutant of concern for a number of reasons. Nitrogen in the ammonia form is toxic to certain aquatic organisms. In the environment, ammonia is oxidized rapidly to nitrate, creating an oxygen demand and low dissolved oxygen in surface waters. Organic and inorganic forms of nitrogen may cause eutrophication (i.e., high productivity of algae) problems in nitrogen-limited freshwater lakes and in estuarine and coastal waters. Finally, high concentrations of nitrate can harm young children when ingested.

Ammonia oxidation (nitrification) occurs in some of the processes described in previous fact sheets, and is dependent upon oxygen availability, organic biochemical oxygen demand (BOD), and hydraulic loading rates. Nitrogen removal by means of volatilization, sedimentation, and denitrification may also occur in some of the systems and system components. The amount of nitrogen removed (figure 1) is dependent upon process design and operation. Processes that remove 25 to 50 percent of the total nitrogen include aerobic biological systems and media filters, especially recirculating filters (Technology Fact Sheet 11).

Enhanced nitrogen removal systems can be categorized by their mode of removal. Wastewater separation systems, which remove toilet wastes and garbage grinding, are capable of 80 to 90 percent nitrogen removal. Physical-chemical systems such as ion exchange, volatilization, and membrane processes, are capable of similar removal rates.

Ion exchange resins remove NH_4-N or NO_3- N. Membrane processes employ a variety of membranes and pressures that all have a significant reject flow rate. Volatilization is generally significant only in facultative lagoon systems where ammonia volatilization can be significant. The vast majority of practical nitrogen-removal systems employ nitrification and denitrification biological reactions. Most notable of these are recirculating sand filters (RSFs) with enhanced anoxic modifications, sequencing batch reactors (SBR), and an array of aerobic nitrification processes combined with an anoxic/anaerobic process to perform denitrification. Some of the combinations are proprietary.

Any fixed-film or suspended-growth aerobic reactor can perform the aerobic nitrification when properly loaded and oxygenated. A variety of upflow (AUF), downflow, and horizontal-flow anaerobic reactors can perform denitrification if oxygen is absent, a degradable carbon source (heterotrophic) is provided, and other conditions (e.g., temperature, pH, etc.) are acceptable.

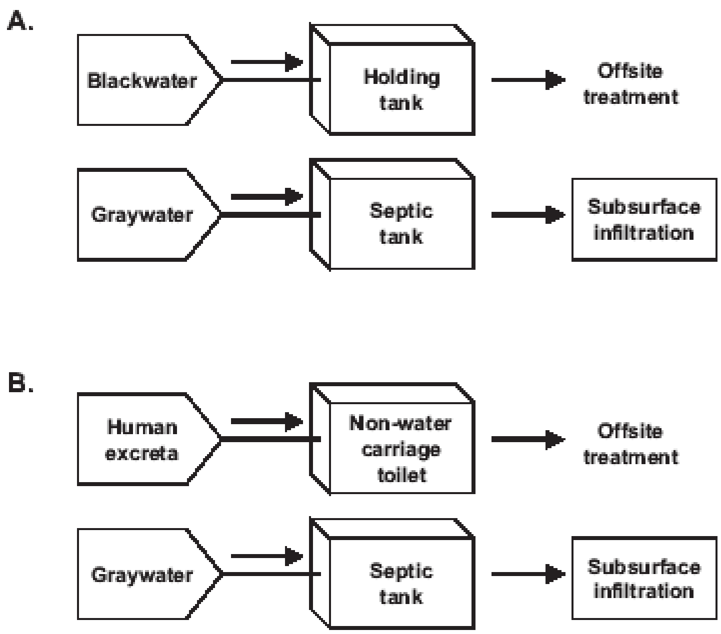
Figure 1. Nitrogen removal systems

The most commonly applied and effective nitrogen-removal systems are biological toilets or segregated plumbing options and/or nitrification-denitrification process combinations. A more complete list is described below, along with accompanying schematic diagrams.

Source separation systems

Source separation relies on isolating toilet wastes or blackwater from wastewater. This requires separate interior collection systems. Two source separation systems were identified: blackwater holding tank with low-volume-discharge toilets and graywater septic tank system, and non-water-carriage toilets and graywater septic tank system (figure 2). These types of toilets are discussed in chapter 3.

Figure 2. Source separation systems: A. blackwater holding tank with tank with low-volume discharge toilets and graywater septic tank system B. non-water-carriage toilet and graywater septic tank system



Blackwater holding tank with low-volume-discharge toilets and graywater septic tank system

Blackwater discharged directly to a holding tank requires periodic removal for offsite treatment. Graywater wastes can be discharged to a conventional septic tank or subsurface infiltration system.

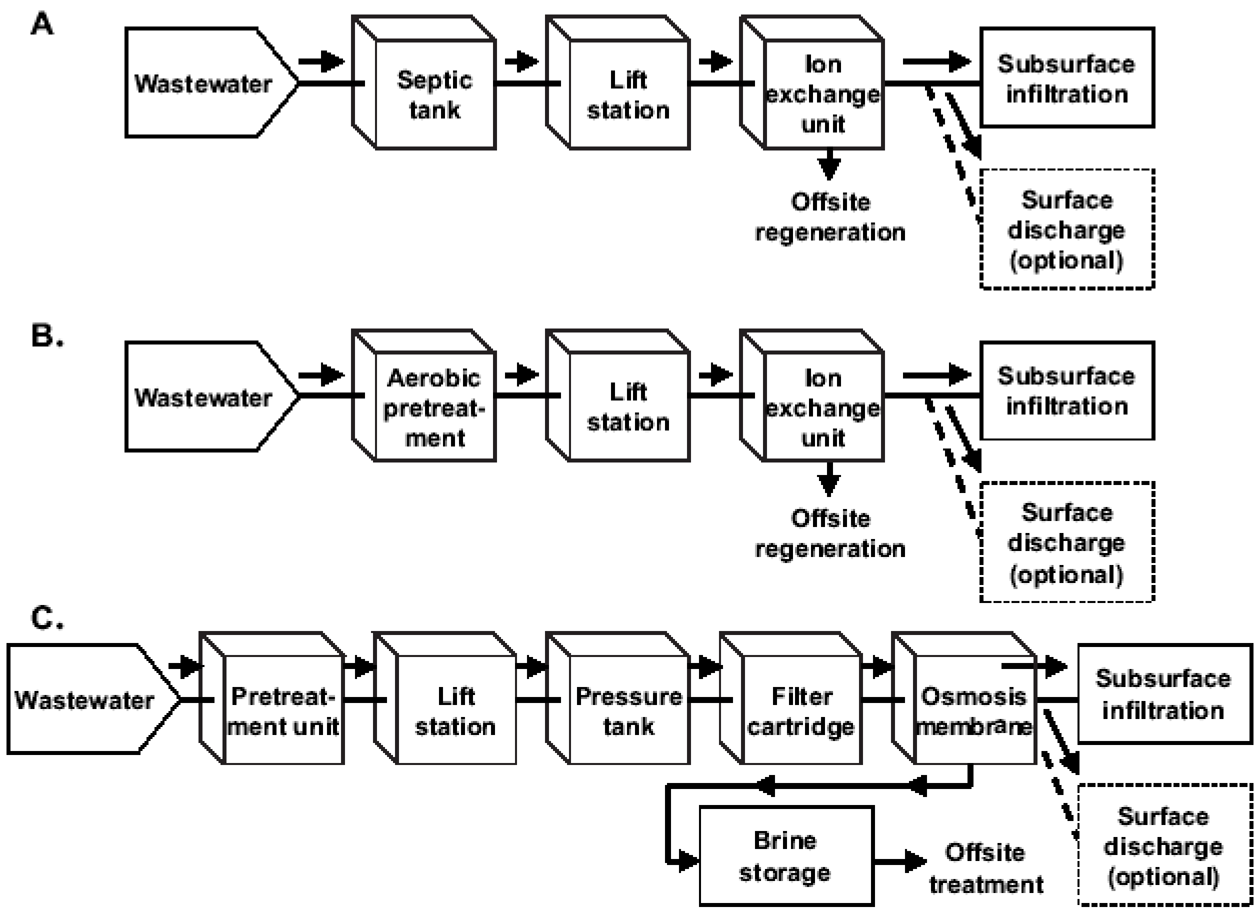
Non-water-carriage toilets and graywater septic tank system

Excreta is discharged to non-water-carriage toilets to promote bulk reduction and decomposition. Biological and incineration toilets are the most common methods of accomplishing this. Non-water-carriage toilets that use these processes are commercially available. The remaining graywater wastes can be discharged to a conventional septic tank subsurface infiltration system.

Physical/chemical treatment systems

Two types of physical/chemical treatment systems, ion exchange and reverse osmosis, appear to have some promise for single home use, although neither is in use at present (figure 9-3).

Figure 3. Physical chemical systems: A. cation (NH_4^+) exchange; B. anion (NO_3^-) exchange; C. reverse osmosis



Ion exchange

Two types of systems may be employed: cationic or anionic exchange systems. In the cationic system, the ammonium in septic tank effluent is removed. Clinoptilolite, a naturally occurring zeolite that has excellent selectivity for ammonium over most other cations in wastewater, can be used as an exchange medium. In the anionic system, septic tank effluent must be nitrified prior to passage through the exchange unit. Strong-base anion resins can be employed as an exchange medium for nitrate. Both systems require resin regeneration offsite.

Reverse osmosis

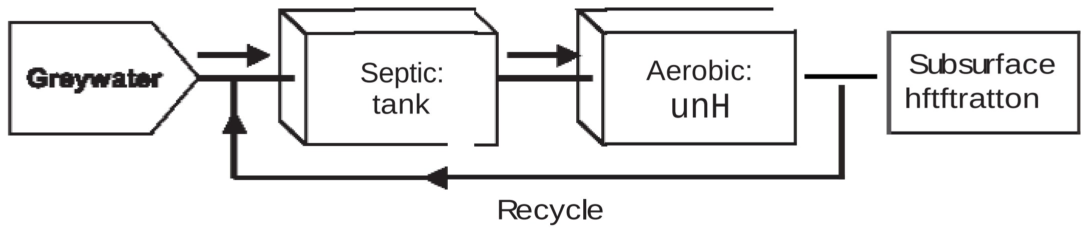
This system requires pretreatment to remove much of the organic and inorganic suspended solids in wastewater. Pretreated wastewater stored under pressure is fed to a chamber containing a semipermeable membrane that allows separation of ions and molecules before disposal. Large volumes of waste brine are generated and must be periodically removed for offsite treatment.

Biological treatment systems

A number of onsite treatment systems use biological denitrification for removal of nitrogen from wastewater. These systems have received the most scrutiny with respect to development and performance monitoring. However, more development and performance monitoring will be necessary to refine the performance consistency and improve understanding of operation processes and mechanisms (see figure 4).

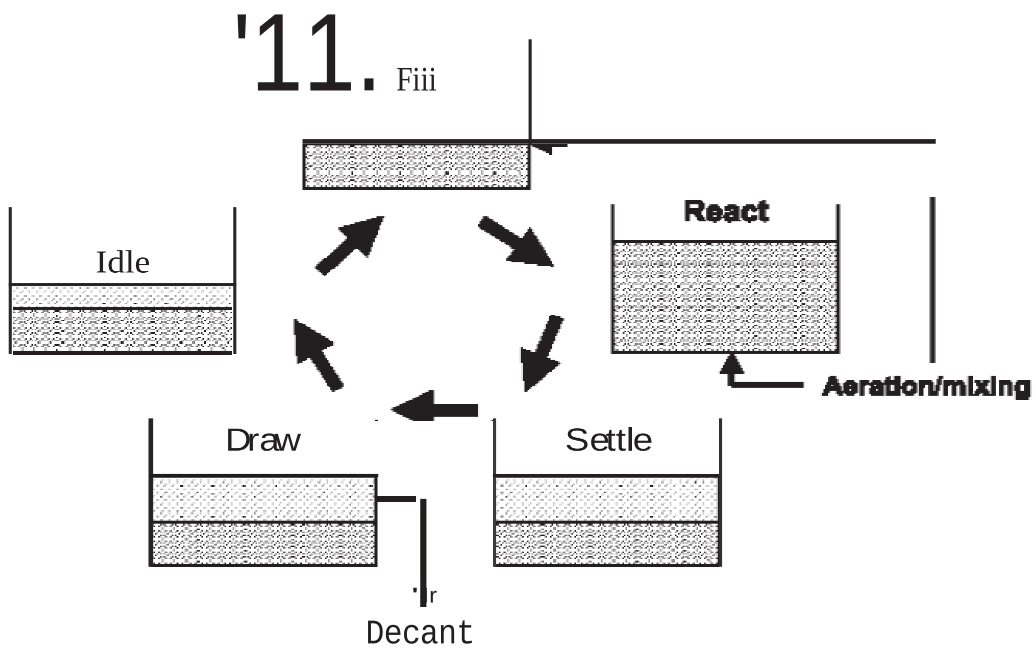
Figure 4. Biological systems: A. anaerobic/anaerobic trickling filter package plant, B. sequencing batch reactor (SBR) design principle; C. ISF with AUF; D. source separation, treatment, recombination; E. recirculating sand filter with septic tank options; F. recirculating sand filter with anaerobic filter and carbon source

A.



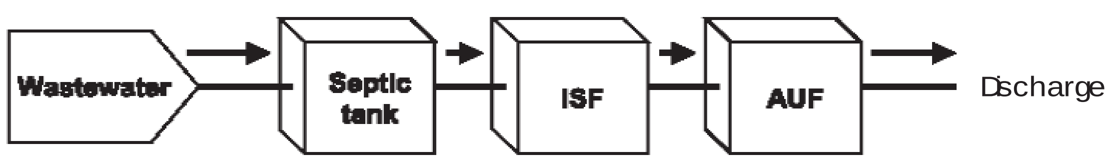
Greywater
Septic: tank
Aerobic: unH
Subsurface hftftratton
Recycle

B.



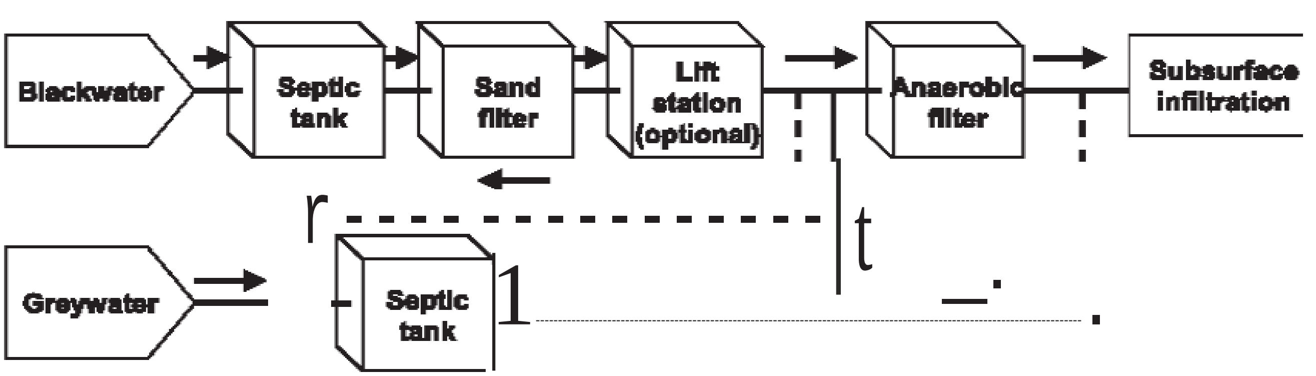
Fiii
Idle
React
Aeration/mixing
Draw
Settle
Decant

C.



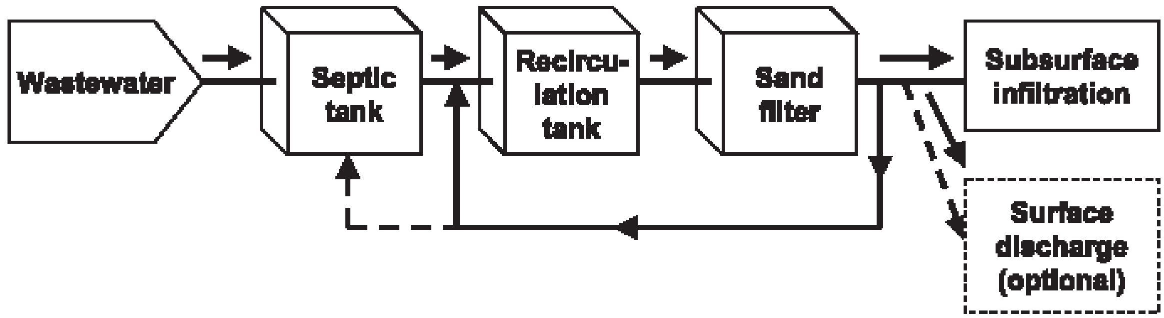
Wastewater
Septic tank
ISF
AUF
Dscharge

D.

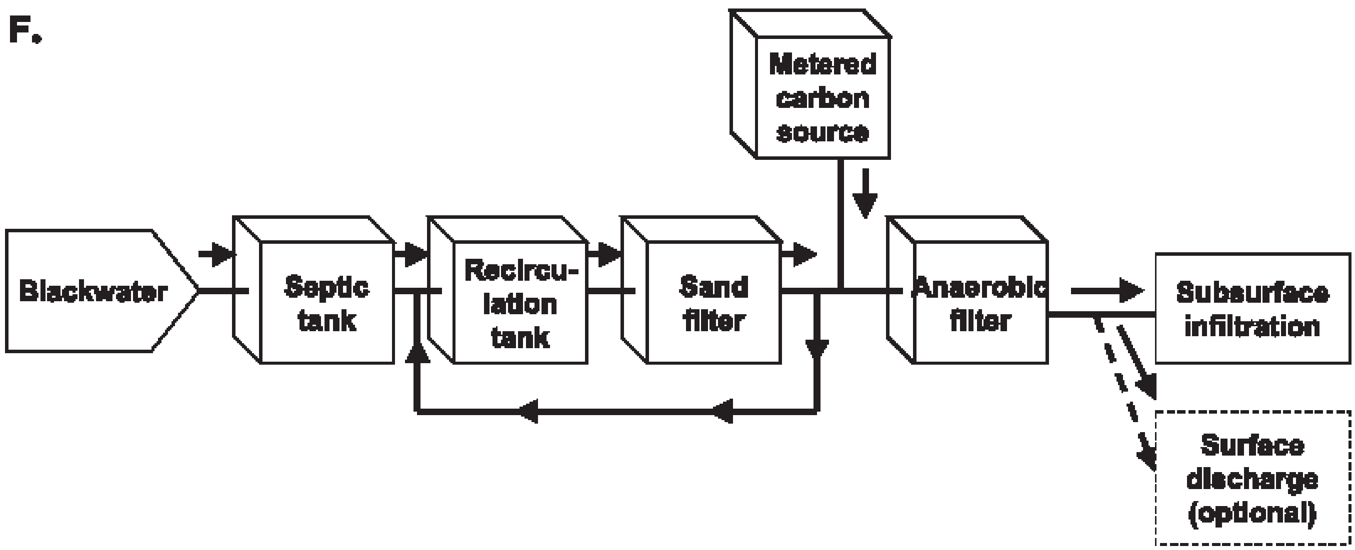


Blackwater
Septic tank
Sand filter
Lift station (optional)
Anaerobic filter
Subsurface infiltration
Greywater
Septic tank

E.



F.



Aerobic/anaerobic trickling filter package plant

These commercial systems use synthetic media trickling filters that receive wastewater from overlying sprayheads for aerobic treatment and nitrification. Filtrate returns to the anaerobic zone to mix with either septic tank contents or incoming septic tank effluent and undergoes denitrification. A portion of the filtered effluent (equal to the influent flow) is discharged for disposal or further treatment.

Sequencing batch reactor (SBR)

If sufficient hydraulic retention time (HRT) is provided to permit nitrification during the "react" phase of the SBR cycle and if the fill stage is anoxic for a sufficient HRT, the system can remove significant amounts of nitrogen and phosphorus. The SBR design is essentially the same as is described in the SBR fact sheet, while operationally the conditions noted above must be maintained.

Intermittent sand filters with anaerobic filters

Nitrification is provided in the ISF, while denitrification is provided in either the preceding septic tank with recirculation or a separate anaerobic filter. A vegetated submerged bed (VSB) ("subsurface flow wetland") may be substituted for the anaerobic filter.

Source separation, treatment, and recombination

One commercial system employs this sequence where blackwater (toilet wastewater), after settling in a separate tank, is aerobically treated with an ISF to nitrify the majority of the nitrogen before it is recombined with settled greywater in an anaerobic upflow filter (AUF) for denitrification.

Recirculating sand filters combined with anaerobic/anoxic filters

RSF systems normally remove 40 to 50 percent of influent nitrogen. To enhance this capability, they can be combined with a greater supply of carbon, time, and mixing than is normally available from the conventional recirculation tank. The anaerobic/anoxic options include recycling to the septic tank, better mixing, and longer HRT in a separate UF or VSB, or adding supplemental carbon (e.g., methanol, ethanol) to enhance the potential of the denitrification step.

Typical applications

Nitrogen removal is increasingly being required when onsite systems are on or near coastal waters or over sensitive, unconfined aquifers used for drinking water. Nitrogen removal systems generally are located last in the treatment train prior to SWIS disposal and may be followed by disinfection when the system must discharge to surface waters. Usually, the minimum total nitrogen standard that can be regularly met is about 10 mg/L. Aerobic biological systems should not be employed at seasonal facilities.

Design assumptions

A myriad of potential systems exist for enhanced nitrogen removal, and all of the major unit processes of such systems are described elsewhere. Also, since waste stream modification is covered in chapter 3, only the most promising, developed options are discussed in this fact sheet. Of the options discussed, granular media filters or aerobic biological systems (usually combined with an anaerobic upflow filter or the original septic tank process) are discussed in more detail.

Some salient design considerations that are not covered in other fact sheets or text include the following:

- Autotrophic denitrification in packed-bed sulfur reactors (variation on AUF) has been successfully demonstrated, but the need for additional alkalinity and the production of a high sulfate effluent have thus far limited the process.
- Denitrification improves with increased HRT in the recirculation tank, better mixing, and a pH between 7 and 8.
- Use of greywater as the degradable carbon source for denitrification limits the degree of denitrification attainable owing to reduced nitrogen content and low carbon-to-nitrogen ratio. The latter should exceed 5:1 for good denitrification.
- Use of synthetic anionic exchange resins appears impractical at this time. Cationic exchange of NH4-N with clinoptilolite is feasible but very expensive because of the regeneration management costs. Both may be subject to fouling and clogging problems.
- Membranes present a major problem given the volume of the reject stream, which must be collected and frequently trucked to a site that will accept it for disposal.
- The use of beds of carbon-rich materials below SWIS leach lines could be a promising concept if the hydraulic matching problems are solved and the bed service life can be extended for 10 years or more.
- Accessibility, size of the holding tank, and availability of residual management facilities are significant design considerations in blackwater separation systems.
- Recycling to the septic tank may affect solids and grease removal in the tank and cause poor mixing of the nitrified stream with the septic tank contents. This could raise the oxidation-reduction potential (ORP) of the mixture above the normal range for an anoxic zone that accomplishes denitrification. Recycling to the second compartment of a multicompartment tank is suggested at a ratio of less than 2.5 to 1 with a contact time of greater than 2 days.
- An AUF used for enhanced denitrification should be loaded with between 0.06 and 0.3 1b COD/ft^3 per day and have an HRT of at least 24 hours (preferably 36 or more hours). It can be filled with large (> 2 inches) rocks or synthetic media. A vegetated submerged bed (VSB) can be substituted for an AUF and may contribute some labile carbon to aid the process.
- SBR design for nitrogen and phosphorus removal is essentially similar, but the amount of labile carbon required is greater (6 to 8 mg/LCOD/ mg/L of TKN to be denitrified).
- Modern microprocessor controls make very complex process combinations possible to remove nitrogen, but overall simplicity is still desirable and requires less O/M sophistication.
- To attain full (>85 percent) nitrification, fixed-film systems cannot be loaded above 3 to 6 g BOD/m^3 per day or 6 to 12 g BOD/m^3 per day for rock and plastic media, respectively.

Performance

Some expected sustainable performance ranges for the most likely combinations of nitrogen removal processes are given in table 1. Some of the nitrogen-removal systems could be combined with source separation and product substitution (low-phosphate detergents) for a maximum reduction in nitrogen where extreme measures might be required. However, the removals would not be additive owing to the changes in wastewater characteristics.

Table 1. Typical N-removal ranges for managed systems

Process	Percent TN removal
RSF	40 - 50
RSF (with recycle to ST or AUF)	70 - 80
ST - FFS (with recycle to ST or AUF)[a]	65 - 75
SBR[a]	50 - 80
SS and removal	60 - 80
(SS - TT R)[a]	40 - 60
ISF - AUF	55 - 75

a Commercially available systems.
Note: RSF = recirculating sand filters; AUF = anaerobic upflow filter; ST = septic tank; FFS = fixed-film system; SBR = sequencing batch reactor; SS = source separation; TT = treatment applied to both systems; R = recombined; ISF = intermittent sand filter.

Management needs

Management needs for most unit processes are covered in other fact sheets. Source separation is feasible only for new homes, as it would be prohibitively expensive for existing homes. AUF systems are different from the fact sheet in that they must have HRTs greater than 2 days to enable anaerobic biological denitrification to be effective. This will add to O/ M tasks by requiring regular flushing of excess biological growth.

Some separation and removal would require regular inspection and maintenance of non-water-carriage toilets and periodic removal and proper disposal of excess solids from these units and from holding tanks.

Risk management issues

Of the most likely systems shown in the table, few are extremely susceptible to upset by hydraulic loading variations. However, soluble toxic shocks could affect any AUF, SBR, or fixed-film nitrification system. Extreme cold will also have an impact on these systems. However, the ISF, RSF, and AUF systems have been the most resilient unit processes (excluding source separation) when properly housed and insulated. Power outages will affect all of the treatment systems. Reliability would be greatest for those that incorporate filters and less for the SBR and fixed-film systems.

Costs

The capital and total costs of most of the nitrogen removal systems are very site specific, but non-water-carriage toilet source separation (assuming new homes) is the least expensive (low-water-use fixtures and holding tanks would add about $4,000 to $6,000). The biological combinations would be more expensive, and the physical/chemical systems would likely be the most expensive. Multiple units will generally increase costs, while the use of gravity transfer between processes will reduce them.

The additional O/M associated with an AUF involves flushing and disposal of excess flushed solids. If methanol is employed to enhance denitrification, additional O/M is required for the feeding system.

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APPENDIX L

Nitrogen Loading Analysis
Massachusetts Model

The following is the Massachusetts Model for Nitrogen Loading Analysis. It was developed because of the impact of Onsite Sewage Disposal Systems to the waters of Cape Cod. It is provided as an example of how other states determine the potential impact from OSDS regarding groundwater degradation**.** The link may be found at :
http://www.mass.gov/dep/water/priorities/techtool.htm

(Another guide for the engineer may be found at the State of Michigan's web site http://www.deq.state.mi.us/documents/deq-wd-gwguidance.pdf)

Note: NDEP does not endorse one modeling method over another, nor does referencing these sites imply they are the only methods available.. The design engineer is encouraged to review all data and, if necessary, develop their own process.

Nutrient Loading Approach

The nutrient loading approach is best understood as a two step process. **Step One** requires a demonstration that a project utilizing a nutrient loading approach will not cause nitrogen concentrations from the site overall to exceed 5 mg/l nitrogen. **Step Two** describes an approach to monitoring the groundwater effected by the project at the downgradient property boundary, and ascertaining whether a concentration less than 5 mg/l nitrogen in monitoring wells can be achieved.

1. Step One: Calculate the nitrogen load generated at the site.

There are presumably several sources of nitrogen at most sites. These may include but are not limited to sanitary wastewater, fertilizer, runoff, feed lot or stable wastes and nitrogen in precipitation. The nutrient loading approach requires calculating the total number of pounds of nitrogen discharges on a site over a one-year period and dividing that total by the volume of recharge from precipitation that leaches to replenish the groundwater table. The simple formula that describes this concept is:

$$\frac{\text{L (load of nitrogen)}}{\text{V (volume of dilutional recharge)}} = \text{concentration (in groundwater)}$$

Load. Load means the nitrogen that percolates downward to the groundwater table, and may derive from several site-specific sources. The number of pounds contributed by each source must be determined and added together to establish a **total load**. For example, when determining the nitrogen load from people at a residential facility, the most current local census data for population should be used to estimate anthropogenic nitrogen load. Similarly, the portion of the total load contributed by fertilizer is calculated using fertilizer units based on the size of the lawn requiring maintenance and the volume of fertilizer applied. Nitrogen inputs from runoff are dependent on the percentage of impermeable surface and the mechanisms for recharge.

A site with a large percentage of impermeable surface with leaching catch basins providing an effective mechanisms for avoiding loss through evaporation or transpiration may demonstrate higher recharge values than a permeable area that supports trees, shrubs or grass and normally sacrifices approximately one half of the precipitation that falls to evapotranspiration.

Examples of the Nutrient Loading Approach

A. New Development

Example 1. Comparison of on-site system loadings with sewered site loadings.

A condominium developer wants to put 100 3-bedroom condominiums on 25 acres of land, clustering the majority. Twenty percent of the development is covered by impervious material (roof tops, roads, sidewalks, driveways, recreational areas), but leaching catch basins collect all runoff and rooftops drain to dry wells. Out of the total area, 3 acres are artificially fertilized. The wastewater flows may be included in the dilutional recharge and does not have a public water supply. What would the resultant ambient groundwater concentration be if (a) On-site systems are employed? (b) a treatment plant treating to 10 mg/l nitrogen is employed?

Assumptions[1]

Nitrogen Loads

- On-site Systems. Local census data indicates on-average 3 persons per dwelling @ 5.9 lbs/nitrogen/person/yr for 100 condominiums. This results in 1770 lbs/year/nitrogen total.

- Treatment Plant. Local census data indicates 3 persons per dwelling @ 55 gpd x 10 mg/l nitrogen x 365 day/yr = 1.67 lbs/nitrogen/person/yr.

  3 persons x 1.67 lbs/nitrogen/person/yr x 100 dwellings = 501 lbs/yr/nitrogen total.

- Fertilizer.
  3 acres of lawn @ 33 lbs/yr/acre leaching to the water table = 99 lbs

- Runoff
  - nitrogen concentration in runoff is assumed to be 1.5 mg/l.
  - impermeable acres runoff (5.7 million gallons/yr) @ 1.5 mg/l = 32.4 million mg/yr **or** 71 lbs/yr.

[1] See Appendix A.

Volume of Recharge

- wastewater recharge = 3 persons/dwelling x 55 gpd x 100 dwellings x 365 day/yr = 6 million gallons/year

- 18"/yr of rainfall recharges the water table which equates to .49 million gallons/acre/yr for 20 pervious acres = 9.8 million gallons/year;

- 20% of 25 acres (5 impervious acres) recharges the full volume of rainfall (42"/yr) which equals 1.14 million gallons/acre, or 5.7 million gallons/yr.

Step One: Calculate the nitrogen load generated at the site.

On-site Systems

$$\frac{\text{Load}}{\text{Volume}} = \frac{1770 \text{ lbs} + 99 \text{ lbs} + 71 \text{ lbs}}{9.8 \text{ million gal} + 5.7 \text{ million gal} + 6 \text{ million gal}} = \frac{880 \text{ million mg}}{81 \text{ million liters}} = 11 \text{ mg/liter}$$

Treatment Plant treating to 10 mg/l nitrogen

Load = wastewater + fertilizer + runoff

$$\frac{\text{Load}}{\text{Volume}} = \frac{501 \text{ lbs} + 99 \text{ lbs} + 71 \text{ lbs}}{9.8 \text{ mil gal} + 5.7 \text{ mil gal} + 6 \text{ million gal}} = \frac{305 \text{ million mg}}{81 \text{ million liters}} = 3.8 \text{ mg/liter}$$

Step 2: Determine how to monitor the groundwater concentration at the site.

Monitoring this site would require the installation of monitoring wells at downgradient property boundaries to monitor the permitted treatment plant discharge and the quality of groundwater leaving the site. The location of discharge should be based on the property line compliance concentration and should be located at the upgradient end of the site.

Alternatively, the developer could locate monitoring wells to evaluate separate discharges from individual denitrifying systems, with a goal of evaluating the cross-section of groundwater leaving the site.

Discussion. This site cannot sustain the proposed loadings and meet the necessary site loading concentration of 10 mg/l using strictly on-site systems. The options open to the developer are to sewer the entire parcel and treat effluent to 10 mg/l nitrogen (3.8 mg/l) at a treatment plant, or to employ denitrifying systems to reduce all discharges from on-site systems to lower nitrogen concentrations.

Example 2. Golf Course, Wastewater Treatment Plant and On-site Systems

A golf course/condominium developer owns 200 acres of land, and would like to build a 50 acre golf course and construct 200 homes on the fringes of the course, each with 5000 ft^2 of lawn. It is a very permeable geologic local which recharges 24"/yr to the water table. There is 15% impervious cover that is quickly collected by leaching catch basins.

Assumptions

Acceptable site: 24"/year x 200 acres = 5420 lbs = 5 mg/l nitrogen

Proposed Nitrogen Loads

- On-site Systems. Local census data indicates on-average 2.5 persons per dwelling @ 5.9 lbs/nitrogen/person/yr for 200 homes. This results in 2950 lbs/year/nitrogen total.

- Treatment Plant. Local census data indicates 2.5 persons per dwelling @ 55 gpd x 10 mg/l nitrogen x 365 day/yr = 1.67 lbs/nitrogen/person/yr.

  3 persons x 1.67 lbs/nitrogen/person/yr x 200 homes = 835 lbs/yr/nitrogen total.

- Fertilizer.
  Lawn fertilizer: 200 homes x 5000 ft2/lawn = 33 lbs/acres nitrogen = 757 lbs nitrogen
  Golf course fertilizer = 50 acres[2] x 38 lbs/acre = 1900 lbs

- Runoff
  15% of 200 acres = 30 acres
  nitrogen concentration in runoff is assumed to be 1.5 mg/l
  @ 42"/year x 1.5 mg/l nitrogen = 427 lbs/year

Volume of Recharge

- impervious surfaces – 42 "/yr for 30 acres = 34.2 million gal/yr or 129.4 million liters/yr
- pervious surfaces – 24 "/yr for 170 acres = 110 million gal/yr or 419 liters/yr

[2] See Appendix A.

Step One: Calculate the nitrogen load generated at the site.

On-site Systems

$$\frac{\text{Load}}{\text{Volume}} = \frac{2450\text{ lbs} + 757\text{ lbs} + 1900\text{ lbs} + 427\text{ lbs}}{419\text{ million liters} + 129\text{ million liters}} = \frac{6034\text{ lbs}}{548\text{ mil liters}} = 5\text{ mg/l nitrogen}$$

Treatment Plant (10 mg/l)

$$\frac{\text{Load}}{\text{Volume}} = \frac{835\text{ lbs} + 757\text{ lbs} + 1900\text{ lbs} + 427\text{ lbs}}{419\text{ million liters} + 129\text{ million liters}} = \frac{3919\text{ lbs}}{548\text{ mil liters}} = 3.24\text{ mg/l nitrogen}$$

Step Two: Determine how to monitor the groundwater concentration at the site.

Monitoring the quality of groundwater leaving the site is dependent on the geologic subsurface materials. The size of the site might allow for subdivided into quadrants and monitoring the densest population of systems in a groundwater stream to do. The full breath of the site must be considered. Multilevel well clusters may be required depending on opera for depth and/or subsurface stratigraphy. Site monitoring should be discussed with DEP hydrogeologists.

Discussion. In this example, the developer runs the DEP Zone II loading model for a build out scenario and concludes that the site will not elevate nitrogen concentration in the public water supply to an unacceptable degree. The local planning board concurs. In this case, the very high recharge rate (24 "/yr) accommodates a higher site loading which is enhanced to an even greater degree by rapidly recharging 30 acres worth of the runoff through a stormwater recharge system.

Any additional construction would trigger the need for enhanced treatment on existing systems because the 200 units are at 5.00 mg/l. All planning assumptions and land uses must be "locked in" through deed restrictions, bylaws or comparable enforceable documents.

Example 3. A Mixed Use of Treatment Technologies in a Zone II

A developer proposes a mix of treatment technologies for a 90 acre parcel on which he/she proposes to cluster 250 homes. The recharge rate is 18"/yr, 15% of the site is impervious, but only 10% utilizes leaching catch basins. There are ten acres of manicured lawn. The occupancy rate based on current census data is a 2.75 average. The site is within a Zone II and cannot include wastewater flows in recharge calculations.

Step One: Calculate the nitrogen load generated at the site

Acceptable Site Load
Assuming uniform recharge of 18”/yr x 90 acres = 1834 lbs = 5 mg/l

Proposed Nitrogen Load

- On-site systems. 250 homes x 2.75 people/home x 5.9 lbs nitrogen/person/yr = 4056 lbs
- Lawn Fertilizer. 10 acres x 33 lbs/acre/yr = 330 lbs/yr
- Runoff. 9 acres x 1.14 million gallons/yr/acre x 1.5 mg/l nitrogen = 58 million mg or 26 lbs/yr

Volume

- ***Pervious recharge. 81 acres x 18"/yr = 39.6 million gallons/yr***
- Impervious recharge. 9 acres x 42"/yr = 10.3 million gallons./yr

Load = 4056 lbs + 330 lbs + 26 = 2003 mil mg = 10 mg/l

Volume 39.6 + 10.3 (million gal) 199 mil liters

Step 2: ***Determine how to monitor the groundwater concentration at the site.***

Monitoring the site must address the mixed-use of wastewater disposal technologies. Again, because of the parcel's size in the use of on-site systems, said dividing the site into quadrants in my train the heaviest density of systems in any stream to might be appropriate. The use of clustered wells and composited samples would be depending on the site hydraulics and subsurface geologic conditions.

Discussion. All 250 homes utilizing septic systems far exceeds the 5 mg/l standard. Sewering all the homes and treating the wastewater to 10 mg/l results in a concentration of 3.68 mg/l. A mix of 200 sewered homes and 50 on-site septic systems results in a concentration of approximately 5 mg/l.

Example 4. I/A Systems for Nitrogen Reduction

What type of nitrogen reducing technology would be required to allow for the siting of a 80-unit condominium on 20 acres of land. The recharge rate is 18"/yr, the % impervious surface is 12%, and there are two acres of manicured lawn. Because the site is not within the Zone II of the well that provides it with water, the wastewater volume may be included in the dilution calculations.

Step One: Calculate the nitrogen load generated at the site

Acceptable Site Load

• 18”/yr x 20 acres = 407 lbs/yr

Load

- • On-site systems. 2.5 occupancy x 80 units x 5.9 lbs nitrogen/person/yr = 1180 lbs/yr
-
- • Lawn Fertilizer. 2 acres x 33 lbs nitrogen/acre/yr = 66 lbs/yr
-
- • Runoff. 2.4 acres x 42"/yr/acre x 1.5 mg/l nitrogen = 15.5 million mg = 7 lbs

Volume

• Wastewater recharge. 2.5 occupants x 80 homes x 55 gpd x 365 = 4.02 mil gal/yr

• Pervious recharge. 17.6 acres x 18"/yr recharge = 8.66 million gallons/yr

• Impervious recharge. 2.4 acres x 42"/yr recharge = 2.7 million gallons./yr

$$\frac{\text{Load}}{\text{Volume}} = \frac{1180 \text{ lbs} + 66 \text{ lbs} + 7}{8.6 + 2.7 \text{ (million gal)}} = \frac{568 \text{ mil mg}}{58 \text{ mil liters}} = 9.7 \text{ mg/l nitrogen}$$

Discussion. Because the site is within a Zone II, the 5 mg/l standard applies. Utilizing on-site systems produces a background concentration that is double the acceptable concentration. Utilizing wastewater treatment technologies that treat nitrogen to the listed concentrations for all homes results in the following ambient concentrations:

Nitrogen Concentration Treated to	Resulting Site Concentration Nitrogen
10 mg/l	3.2 mg/l
19 mg/l	5.5 mg/l
25 mg/l	7.15 mg/l

The developer must treat to an overall standard of 5 mg/l. Several treatment options exist utilizing a mix of technologies that will result in a loading in pounds each gradient to an ambient 5 mg/l concentration.

B. Existing Development

Example 5. Title 5 systems on a large parcel in a Zone II

A community of 120 seasonal residential dwellings lie on 85 acres of a land in a Zone II. Forty of the 120 homes are used year-round, 80 are used for six months of each year. Forty of the 85 acres have a diminished recharge rate of 12'/yr, the balance 18"/yr. All dwellings are sewered by Title 5 systems. How should this existing, large facility be treated? It has been in existence for 70 years.

<u>Site Capacity</u>

40 acres @ 12"/yr	=	13,033,152 gal
45 acres @ 18"/yr	=	1,993,444 gal

	=	132.5 mill mg

The site can sustain a nitrogen load of 1459 lbs/yr and stay within the 5 mg/l nitrogen Zone II goal.

<u>Step One: Calculate the nitrogen load generated at the site.</u>

<u>Site Loadings</u>

40 year-round homes	3 x 5.9 lbs/yr x 40	=	708 lbs/yr
3 occupants/dwelling	lawn @ 33 lbs	=	33 lbs/yr
1,000 ft^2 lawn/dwelling	total:		741 lbs/yr
80 seasonal homes	3 x 2.9 lbs/yr x 80	=	696 lbs/yr
3 occupants/dwelling	lawn	=	60 lbs/yr
1,000 ft^2 lawn/dwelling	total:	=	756 lbs/yr
	--		
	TOTAL:		1497

<u>Discussion</u>: The site loading rate of 1497 exceeds the 5 mg/l goal of 1459 lbs/yr and equates to 5.6 mg/l. Based on historic data, the public water supply well has shown no indication of water quality degradation, with no increasing nitrogen concentration. Given that this land use has existed for 70 years without a demonstrated negative impact on the well, DEP is comfortable allowing this discharge to continue at this loading rate under a permit requiring ongoing monitoring and reporting.

Furthermore, DEP recommends a groundwater discharge permit that requires reporting of all planning assumptions, deed restricts homes to remaining seasonal, maintains pervious surfaces, requires regular inspections, maintenance and pump outs, establishes enforceable oversight entity for enforcement and establishes appropriately sized escrow accounts. A monitoring program should be established to review planning assumptions and property line groundwater quality.

Step Two: Determine how to monitor the groundwater concentration at the site.

Monitoring wells should be located and constructed to evaluate the entire length of downgradient property line. Again, because of the site's size, dividing it into groundwater quadrants and monitoring the area downgradient of the site's most dense on-site locations might provide a representative sampling approach.

Example 6. Relatively Large Title 5 Systems in Zone II

An existing condominium group located in a Zone II on 25 acres of land has three 5,000 gallon per day discharges to on-site systems. There are five acres of fertilized lawn and three acres of well drained impervious surface. The public water supply well shows gradually increasing nitrogen concentrations over time, going from an average nitrogen concentration of 0.5 mg/l in 1985 to an average of 2.0 mg/l in 1995. How should this facility be handled?

Site Capacity

22 acres @ 18"/yr	= 40.7 million mg/yr
3 acres @ 42"/yr	= 12.9 million mg/yr
Total:	= 53.6 million mg/yr

The acceptable load on this 25 acre parcel is 590 lbs/yr nitrogen to maintain the Zone II 5 mg/l nitrogen standard.

Step One: Calculate the nitrogen load generated at the site.

Site Loadings

3 5,000 gallon/day x 35 mg/l	= 1597 lbs
5 acres fertilized lawn (5 x 33 lbs/acre/yr)	= 165 lbs
Total (yr)	***= 1762 lbs***

Discussion. With continued use of on-site systems, the loading at this site is unacceptably high and contributes to the degradation of the public water supply. Building a treatment plant and treating all of the wastewater to 10 mg/l nitrogen would decrease the site's load from 1762 lbs to a more acceptable 620 lbs/yr. Even though this loading rate slightly higher than the goal of 590 lbs/yr to achieve 5 mg/l, it is acceptable because the 30 pound differential in load is unlikely to have a measurable effect on the water quality in the well.

V. Upcoming Regulatory Revisions

For the purposes of this Policy, the nutrient loading approach represents an option for applicants and an assessment tool for DEP. DEP intends to evaluate and refine this Policy as it is implemented through the issuance and oversight of groundwater permits, with a goal of incorporating a final nutrient loading approach in amendments to 314 CMR 5.00 in the near future. Comments or questions concerning this Policy should be directed to Alan Slater or Mike Rapacz.

Appendix 112233

Conversions and Assumptions

Note: The calculations in this Policy rely on the following standard assumptions. Proponents may use these assumptions unless, in accordance with current literature suggesting different nitrogen concentrations for various land uses, DEP requires alternative nitrogen concentrations to be used in nitrogen load calculations.

Load

1 lb = 454,000 milligrams

lbs nitrogen/person/yr = 55 gal/person/day x 35 mg/l nitrogen x 365 days = 5.9 lbs/person/yr

lawn fertilizer = 31 lbs/1000 square feet x 43,560 x 0.25 leachability = 33 lbs/acre/yr

golf course fertilizer = 3.5 lbs/1000 square feet x 43,560 x 0.25 leachability = 38 lbs/acre/yr

Volume

1 cubic foot = 7.48 gallons

1 acre = 43560 square feet

1 acre foot = 325,828 gallons

Appendix 11222

Nutrient Loading Models

The following nutrient loading models are available for use in undertaking projects described in this Policy.

Site Specific Nutrient Loading

- This Policy describes site specific requirements for development requiring groundwater discharge permits. It applies to both nutrient sensitive and non-Nutrient Sensitive Areas.

- Technical Bulletin 91-001, Cape Cod Commission, Nitrogen Loading - this document articulates the nutrient loading approach required by the Cape Cod Commission for projects under their jurisdiction. It generally applies site by site but includes assumptions that are transferable to watersheds.

DEP Zone II Nitrogen Loading Model

This model is available on the DEP website ***www.state.ma.us/dep***. It describes an approach to predicting nitrogen concentration in public drinking water wells based on a current zoning build out reflecting the existing and potential land use development within an approved Zone II. It is a computerized land use model with assumptions and threshold values transferable to watershed loading assumptions.

Embayment Flushing Models

The Cape Cod Commission has different flushing models to address dilution and flushing in embayments with differing physical characteristics. These calibrated two-dimensional models reflect different tidal cycles and residence times. The Commission will discuss the appropriate model and its use.

Appendix 1111

Examples of Nitrogen Trading Options

The following examples are conceptual situations

The following two examples portray applying the nutrient loading approach to existing facilities.

Nitrogen Trading in a Zone II

A hotel builder proposes to build a hotel on 1.5 acres of land in a Zone II. The estimated flows from the hotel are 4,500 gallons per day. The recharge rate is 42"/year because the entire 1.5 acres is paved and drains immediately to leaching catch basins.

Allowable loading on 1.5 acres @ 42" recharge:

Load	= 32,373,126 mg	= 5mg/l	=	71 lbs/year
Volume	= 6,474,625 liters			

Proposed Discharge Loading 4500 gal/day @10 mg nitrogen	= 137 lbs/year

The hotel developer has three options:

1. They may run the DEP Zone II Nitrogen Loading Model and, dependent on the result, be allowed the 71 lbs. allocation for the site. If the hotel owner employs Best Available Technology and removes nitrogen to a standard of 5 mg/l and immediately recharges all of the precipitation that falls on the 1.5 acre site, they will discharge approximately 68 lbs/yr and have the appropriate dilution to dilute to below 5 mg/l nitrogen.

OR

2. II Nitrogen Loading Model and, dependent on the result, be allowed the 71 lbs/year allocation for the site and remove the balance of nitrogen (137 - 71 = 66 lbs/year) from elsewhere in the Zone II. This may be accomplished by building an advanced treatment plant, treating hotel wastewater and that of neighbors or abutters through sewering. A reduction of 66 lbs/year would require sewering five 3-occupant homes and treating hotel and residential wastewater to a standard of 10 mg/l nitrogen

OR

3. The hotel developer may opt to build a treatment plant and sewer not only the hotel, but sufficient residential or commercial land use to offset the hotel design flows and effectively add no nitrogen to the Zone II. This would require treating hotel flows and ten 3-occupant residences to a standard of 10 mg/l nitrogen.

Nitrogen Loading in a Built out Zone II

A developer proposes to build a retirement/assisted care facility on 25 acres in a Zone II. Upon running the DEP Zone II model, it is apparent that, based on current zoning, the well will be over 5 mg/l nitrogen. The developer decides to build an advanced wastewater treatment plant and sewer areas abutting his own so that the nitrogen from the retirement facility will be completely offset. He proposed to house 100 people, has five acres of manicured lawn, and 3 acres of well drained pavement. What does he need to do to offset his site loadings?

Site Acceptability (maintain 5 mg/l nitrogen Zone II standard)

22 acres @ 18"/year recharge = 40.7 mill mg/yr.
3 acres @ 42"/year recharge = 12.9 mill mg/yr.
Total = 53.6 mill mg/yr.

The acceptable load on this 25 acre parcel is 590 lbs./year nitrogen.

Proposed Site Loading

- 5 acres fertilized lawn (5 acres x 33 lbs./acre) = 165 lbs.
- 100 clients/staff @ 1.67 lbs/person/year = 167 lbs.

Total = 332 lbs.

The developer proposed loadings are well within the 5 mg/l - 590 pound limit. They must therefore remove 348 pounds from elsewhere in the Zone II to negate his site's impacts. Since his treatment plant treats to 10 mg/l from the 35 mg/l associated with residential wastewater, he would have to sewer 25-3 occupant residences to offset or negate his own sites loading.

Nitrogen Trading In An Overloaded Nitrogen Sensitive Embayment

A developer proposes to construct a condominium development and golf course on 85 acres in a coastal watershed that drains to a sensitive estuary already suffering from eutrophication problems. The proposed development includes 50 acres of golf course, 100 3-bedroom condominiums, 5 acres of well drained impervious surface, and 5 acres of manicured residential lawn. What approach should be undertaken to develop this parcel?

Step 1: The developer must determine the sensitivity of the embayment and the potential nitrogen load from this proposed site.

Answer: The sensitivity of the embayment is determined by completing an estuarine flushing model and by determining the annual loading from the watershed contributing groundwater to the estuary (Appendix B).

The proposed loadings to the site are:

50 acres of fertilized golf course @ 38 lbs/acre/year		= 501 lbs/year
5 acres lawn @ 33 lbs/acre/year		= 165 lbs/year
100 dwellings @ 3 people/unit x 1.67 lbs/year		= 501 lbs/year
(assumes a nitrogen treatment level of 10 mg/l)	Total	= 2566 lbs/year

Step 2: Determine the sites loading allocation.
The estuary is already overloaded. The developer must negate any nutrient loadings at the site by removing a commensurate load (2566 lbs.) from elsewhere in the watershed.

Step 3: Nutrient trading
In order to remove 2566 pounds nitrogen from the watershed to offset site inputs, the developer may construct an advanced treatment plant on the condominium site and sewer neighboring areas, construct a second treatment plant elsewhere and sewer or may fund the construction/maintenance of I/A systems in the watershed capable of removing 2566 pounds from several systems.

Some examples of commensurate load reductions:

2566 lbs. nitrogen removal/year

- 136 3-occupant residences (Title 5 systems)
- 251 3-occupant residences utilizing I/A systems - nitrogen @ 19 mg/l
- 1 9000 gallons/day strip mall and 86 3-occupant residences

Step 4: Hydrogeologic evaluations would be required to evaluate the hydraulic and ground and surface water quality implications of any of these proposed options. The removal of nitrogen from elsewhere in the watershed through the employment of treatment plants or I/A systems and the site specific hydrogeologic evaluation should allow for limited site development in areas thought to be overly developed.

APPENDIX M

Constructed Wetlands

Note: Constructed wetlands will not be permitted under the general permit. However, this section is provided as a guide for applications that may be covered under an Individual permit.

A constructed wetland system treats wastewater by filtering, settling and bacterial decomposition in a large natural-looking marsh. As wastewater moves through the constructed wetland system, the solids are removed through physical filtering and settling. The organic matter is broken down by bacteria, both aerobically, with the oxygen supplied by the plants growing in the wetland, and anaerobically, whenever there is little or no dissolved oxygen in the water. These systems have been used in the U.S. and elsewhere with mixed results.

The constructed wetland system is made up of three parts: the liner, the distribution medium, and the plants. The liner keeps the wastewater in the system and excludes groundwater. Although the liner can be made from a number of materials, 30 mil PVC is the most common and probably the most reliable. Clay liners, which have recently been the subject of interest, can crack, allowing the wastewater to move into the soil and contaminate groundwater. For this reason, clay liners are not recommended.

The distribution medium at the inlet is usually pea gravel. This first part of the distribution system feeds the wastewater to the wetland, spreading wastewater across its width. Both gravity and pressure distribution can achieve even spreading of the wastewater over the system, allowing the water to flow evenly through the length of the system. The next portion of the distribution system is the rock media where the plants, usually cattails, but sometimes including sedges, grow. The last part is the polishing filter/sand filter before discharging the water into the environment.

System Designs

Three wetland designs are common: open water, hydroponic, and subsurface flow:

Open water systems look like ponds. Wetland plants grow from the bottom and the water moves through the system at the surface. Because the water is fairly deep, the surface area required for this design is the smallest. Water evaporates off the surface and oxygen from the air gets dissolved in the water, so bacteria can break down the waste aerobically. Unwanted plants and animals, including insects, can take up residence in an open-water constructed wetland.

The EPA manual "Constructed Wetlands Treatment of Municipal Wastewaters" EPA/625/R-99/010 may provide more detailed information. Check the EPA web site at www.epa.gov.

Subsurface flow systems. They are constructed so all effluent moves through a medium (rock) with the plants growing in the medium. All the wastewater flow occurs below the surface of the media and does not pond on the surface. Because there is no free water surface, there is no danger of the system freezing in winter.

These systems typically require more space than open water systems, but less space than hydroponic systems.

Treatment processes are both aerobic, with oxygen being supplied by plant root systems, and anaerobic at microsites within the pea rock media where there is no dissolved oxygen. The anaerobic decomposition reduces nitrogen levels in the discharge. This double action also allows for excellent removal of bacteria and phosphorus, if adequate time is provided for wastewater to move through the system. Roughly 6 days of detention time is recommended to adequately treat waste with the typical strength from a residence.

Hydroponic systems are shallow, with most of the water flowing in the root zone of the plants. In these systems, as in open water systems, water evaporates off the surface and there's plenty of oxygen available, in addition to what the plants produce. The plants tend to take up nutrients from the water more efficiently than in open water systems. These systems are very shallow, however, so they have to be much larger than open water designs, and they are more likely to freeze in winter. Fencing to prevent human contact with wastewater is essential in these systems as well.

Sizing

The size of the system is typically based on the wastewater remaining in the wetland for 6 days. For subsurface flow systems, the space occupied by the rock medium must be included in calculations for the system size; a 40 percent porosity ratio takes the rock volume into account, increasing the system volume necessary for adequate retention time. Typical design requires 300 square feet per bedroom when using common septic rock. The shape is not critical except that it should prevent wastewater from flowing too quickly through the system. The typical shape is rectangular with a length-to-width ratio of 10:1 to 20:1 is recommended. The EPA manual recommends 33:1, which is long. The other system components are sized using typical engineering practices and pipe flow characteristics.

Placement

The system is designed to run level, so the system should be located on the contour. Surface water inflow can cause overloading problems, so drainage should be directed away from the system. A barrier to soil erosion into the wetland, such as rock landscaping or sod, is needed to minimize sediment problems. Berm around the wetland keep surface water out. Variations in shape may be used to fit site.

Final Dispersal of Wastewater

Wastewater from the constructed wetland system may be discharged on the surface. The individual permit requires a polishing filter before discharge to the surface.

Operation and Maintenance

Water levels must be maintained. The proper functioning of the constructed wetland system is dependent on water being in it at all times. Periods without flow may allow the system to dry up, killing the plants and bacteria that treat the waste. During vacation periods make sure the system has adequate water supplies in the summer and winter.

Plant and bacterial life processes are critical to the operation of the system. Large flows may also lead to inadequate treatment, by washing pathogens and nutrients right through. These large flows may be caused by excessive wastewater flows or by natural events such as torrential rains. These can lead to a long-term reduction in the ability of the system to provide treatment.

Influent quality can affect the system. Toxic chemicals can harm or kill plants and bacteria in the wetland. In commercial applications, plugging of the media with excess solids, undercomposed organic matter, or grease may be a concern; however, this problem has not been researched.

The septic tank must be routinely inspected and pumped. Inspect the plants for signs of stress, excessive dead material, yellowing and insects. Check the water level. Check with a local garden center for help in identifying the problem and solution. Keep the water level 3 to 4 inches below the surface at all times.

Winter Operation
In the late fall cut the plants and cover the rock and sand filter with 3 to 4 inches. If there is not enough plant material use hay or straw. Do not use plastic sheeting this may reduce the oxygen flow and allow the system to go septic. In the spring remove the dead material from the rock.

Typical System Design and Layout
Subsurface flow system, assume 1-bedroom system, this can be increased for number of bedrooms.

Flow 150 gallons per day
Length = 50 feet Alternate Length = 100 feet
Width = 6 feet Alternate Width = 3 feet
Number of cells = 3 3 cells
#1 = 25 feet #1 = 50 feet
#2 = 15 feet #2 = 25 feet
#3 = 15 feet #3 = 25 feet
Depth of water and 1-inch rock = 12-inches
Depth of cover rock, pea gravel = 4-inches
Plants at 12-inches on-center

Plants
The plants are the visual indicator of the wastewater treatment system and should include several different kinds to add interest to the system. The best time to plant is in the spring of the year but they may be planted up to August. Plants need time to establish their root system to survive the winter. Water must also be available to the plants. Plants must be adapted to the climate conditions of the system therefore it is recommended that the plants be collected locally for best results.

Four common types of plants are:

Common Cattail - Typha Latifolia
Narrow Leaf Cattail - Typha Angustifolia
Bullrush - Scirpus Americanus
Reed - Phragmites Communis

There are many other types of species available including flowering plants such as irises and lilies which may add variety and color to the treatment system, however, do not grow food for consumption in the wastewater system. If the plants are collected locally, a small amount of soil should be left on the root ball to help establish the plant. The plants should be spaced no more than 12-inches on center. Fertilizer is not needed if the system is to be used immediately.

APPENDIX N

Sample O & M Check List

Frequency	Maintenance Task	Date Maintenance Task Performed (check when task is completed)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pump / Pump Chamber													
Monthly	Visual Inspection												
Biannually	Check / Clean Screen(s)												
Biannually	Test Run Pumps												
Biannually	Check Float Switch Operation												
Pump Controls / Electrical Panel													
Weekly	Record Elapsed Time Meter Readings												
Weekly	Record Dose Counters												
Monthly	Calculate Average Daily Flows												
Biannually	Manually Operate Controls												
Biannually	Check for Moisture & Corrosion												
Biannually	Test Alarm(s)												
Distribution System / Drain fields													
Monthly	Inspect Monitor Ports												
Monthly	Inspect Drain fields for Ponding												
Biannually	Inspect and Exercise Valves												
Biannually	Rotate Fields												
Septic Tanks / Pump Chambers													
Biannually	Check Sludge Levels												
Biannually	Check Floating Solids (Scum) Level												
Biannually	Check / Clean Effluent Filters												
Biannually	Check Inlets / Outlets												
Operating Permit Requirements													
5 years	Renew Permit												
Annually	Annual Report												

County ____________________ Operator ____________________

System Name ____________________ Title ____________________

Approved Max. Flow ____________________ Phone No. ____________________

Contact Person ____________________

Information Provided By:

Legal Owner ____________________

Owner Address ____________________ Name ____________________

Title ____________________

Phone / Fax No ____________________ Date ____________________

APPENDIX O

Inspections of Existing OSDS

Preparation and Record Review

The first step of the compliance inspection is the research phase. Gather all available data about the system. This may include local permits, the county soil survey, a review of any other data, and a permit holder/homeowner interview. This interview is a particularly good idea if no records exist. Begin by determining the age of the system. The older the system, the more likely problems are to occur. Also, older systems may have been using significantly different technologies than are currently in use. In particular, they may be significantly smaller and their ability to handle increased water use may be less. At some sites, an older system may mean no system at all, because many of the older systems were connected to county ditches, cesspools or drainage systems.

Along with finding out the age of the system, review records of previous inspections. Older systems may not have been reviewed, or may not have any records available. On the other hand, newer systems may have complete records that make it easier to review and identify problems. The inspection may require some digging, so you must know the locations of buried pipes and cables. The Distribution Box should be exposed on all inspections. Prepare forms and equipment for the field inspection.

The Inspection

The inspection is likely to focus on a failure or the use of the system by a new owner. The inspection will be broken into three pieces: the current use of the system and the effects of that use, the condition and performance of the tank, and the condition and performance of the soil treatment system. The order in which you inspect the parts of the onsite system may be dictated by the site, but the following is a typical flow for completion. You are not required to address all the defects of the system, but a thorough inspection can be useful in the decision-making process.

System Use

Check the flow of wastewater going to the system. Flow can be estimated based on the number of offices, restrooms, bedrooms, trailer spaces, etc. in the building or business. If the residents are older, they may be very good at limiting water use, whereas the new residents might not be as efficient at using water. On the other hand, if the people moving in are employed full time and are not at home during the day, shower at a health club and eat out regularly, they will add very little water to the system, and a small system may be more than adequate.

An enormous difference in the flow from trailers is possible if a family with children is living in it, not just in terms of the total wastewater flow, but also in the duration of the high flows. In particular, if there are a number of teenagers, the amount of bathing and laundry can increase dramatically. All families go through high and low wastewater flow periods as kids are growing up. All the current soil-treatment system sizing information is based on three feet of unsaturated soil. With less than the standard separation, the size of the soil treatment system cannot be calculated.

Separation from **bedrock** is a key to proper system performance because only adequate separation can ensure proper treatment and prevent the contamination of wells. In shallow-to-bedrock situations, drinking water wells are all related to the cracks in the bedrock. If untreated sewage enters the bedrock, it will flow in the same cracks. Wells can be contaminated very quickly. Multiple families in homes or duplexes also can affect wastewater flow. Two or more families sharing an onsite system typically use more water than a single large family, because there are more meals prepared, dishwasher loads, and more loads of laundry.

The final water-use issue is leaky fixtures. Make sure that all of the water using devices operate properly. If they do not, they should be fixed. Repair or replacement of leaky fixtures is a highly effective, low-cost improvement to the system.

Hazardous Wastes

Systems serving businesses may be disposing of hazardous waste. If any facility disposes of hazardous waste into an onsite system, NDEP or the local health authority must be contacted. A car wash is an example of a business whose wastewater would be considered hazardous waste.

In-Home Businesses

A number of in-home businesses can also affect the use of the system. The most common in-home business is childcare. Daycare facilities, because of the constant use and number of persons in the house, can put pressure on the system. Review the system design to make sure that the tank capacity is large enough to deal with the high flows, as well as that the soil treatment system can handle the total average flow. An effluent screen is often a good addition to a system to help it deal with this pattern of use.

Taxidermy is another in-home business that can affect an onsite system. The chemicals used during the process this can impair system function. Check the tank for these chemicals. In-home lawn-care businesses can also cause problems. Again, the issue is improper disposal of chemicals, in this case insecticides, fungicides, and herbicides, which can cause trouble by harming the bacteria in the tank and in the soil.

Painting businesses run out of the home can add toxic chemicals to the onsite system, too. There may also be excessive hydraulic loading from washing brushes used to apply water- based paints, and the paints themselves can be a problem, when particles of pigment do not settle effectively in the tank and then plug the pores in the soil system.

Photo labs, too, can cause significant problems in septic systems because of the chemicals used. These chemicals, in particular the fixer, are toxic and do not settle out in the tank.

Home beauty shops can cause two different problems for the onsite system. The first is the excess hair entering the tank. If the establishment is only a barber shop, that is, the only services are washing and cutting hair, increased tank capacity and the use of an effluent screen should be sufficient to handle this in-home business.

On the other hand, a beauty shop that uses chemicals such as bleach, dye and permanent solutions may be causing significant problems to the tank. Check the tank for evidence of chemicals.

The Bathroom

In any house, the number one place where water is used is the bathroom, where many water-using fixtures are located. If possible check all bathroom fixtures for leaks and drips. The primary water-user in the bathroom is the toilet. Check to determine that it isn't leaking or using extra water during flushing. It may use extra water because it isn't flushing effectively and is often flushed twice, or it may stick "on" so that water continues to run into the toilet tank even after it's full. On the other hand, the toilet may be a low-water-use model.

Finally, check for toilet cleaners that are automatically added with each flush. These chemicals can cause problems in the tank. The bathtub should be noted, in terms of its use and size. Excessive numbers of large bathtubs may be a problem. An example of this would be in a bed-and-breakfast where there are multiple bathrooms that contain large tubs. A number of these larger tubs could overload a tank, but one in a household would not put it into a problem category.

The Kitchen

In the kitchen, too, there are a number of opportunities to use water and to otherwise affect the onsite system. Interestingly, the choice of food and of manner of preparation can have a significant impact on the tank and soil treatment area. In particular, large amounts of cooking oil or undigested food added to the system can cause significant problems, as can cooking frequent large meals for special events or as part of a home catering business. Much of this undigested food is added through the garbage disposal. Use of the garbage disposal can cause problems, particularly if the onsite system is not maintained regularly. The issues associated with garbage disposals are that undigested food takes the bacteria longer to break down, that small pieces of undigested food are slow to settle, and that the use of the garbage disposal adds extra water to the system. Tanks serving homes with garbage disposals may need to be pumped out twice as often.

Another potential source of problems from the kitchen is the dishwasher, because of the high temperature of the water it uses. Hot water will keep oils from congealing and rising to the top of the tank, so that the oils move out into the soil treatment area. Use of phosphate soap may also cause problems in the system.

Other Water-Using Devices

The next water-user in the house is the laundry. The major impact here is the schedule of when laundry is done, whether a single load is washed every few days, or many loads are done one day a week. The better schedule is to spread the use of the washer out over the week, so that the tank isn't overloaded with water on a weekly laundry day. The soap that is used in the laundry may be critical if cast iron piping is a part of the system. Powdered detergents create crusting in iron pipes, leading to problems in the system.

Otherwise, the use of laundry soap to manufacturers' recommendations is typically not a significant issue. Concentrated soaps are more likely to be overused.

Water treatment, such as a drinking water filter or an iron filter, should be reviewed. Some drinking water treatments add large amounts of water to the system. Verify that the system is operating properly and not increasing too much the use of water in the house. (The users of the system should check that filters are replaced regularly; they can actually be *adding* contaminants if they are not changed often enough.)

Another water-treatment device is the water softener. The major issue here is the addition of water to the system. If the water softener is operating properly, it's usually not a significant problem. On the other hand, many older water softeners sometimes stick "on" and can significantly overload a system. Older water softener products, particularly sodium-based salts, may be more harmful to the onsite system than some of the newer products.

High-efficiency furnaces are not a significant problem for the system, but may be a problem for the piping, because of the high acidity of the water coming from the furnace. It's been known to eat through pipes, particularly inexpensive plastic pipes. Furnace wastewater can also be a problem because it's added in very small amounts, so that as it flows through the pipes it can get cold enough to freeze. High-efficiency furnace discharge should be piped so that it is regularly flushed out either by the dishwasher, the shower, or the laundry.

Commercial Kitchen

Commercial kitchens generate grease and must have a properly sized grease trap (UPC) to prevent problems with line clogging, tank and distribution field plugging. Check to make sure a grease trap is present and is pumped on a routine basis. Commercial kitchen waste stream is generally very strong, resulting in a high BOD load to the OSDS. If not properly sized, the OSDS will be overloaded and fail.

Trailer Park

Existing trailer parks may not have proper sizing for the number of tenants, creating a hydraulic overload to the system. Excessive laundry use may also cause premature failure. Many times, disposable diapers are flushed and create clogs in the line and take up space in the septic tank.

Park residents should be made aware that the only things allowed in the toilet and sink are flush/rinse water and toilet paper. Paper towels, cigarette butts, floss, diapers, rags, etc. will not decompose in the septic tank and take up valuable storage space.

RV Park

RV parks are intended to be utilized by short term RV’s. Many times a park will allow trailers with laundry capability for extended stays. This will also cause hydraulic failure. Further, dump stations may receive sanitizer solution (formaldehyde) from holding tanks that will inhibit microbial activity in the treatment tank.

Medical Conditions

The use of many medicines can affect the system. Antibiotics, for instance, can kill the bacteria in the system. The use of these drugs should be documented in case of problems in the system. Other medical conditions that could have an impact on the system would include bulimia, because of the increased addition of undigested food.

Non-Sewage Water

Other water-management practices that could be affecting the system. A swimming pool would be a problem if pool water was discharged through the system. That water, because of the use of chlorine, does not need to enter the onsite system and should be routed around it instead.

Roof or site drainage, any clean water that enters the site by rain or runoff, should not be directed towards the system at all and should be routed around it. This clean water includes groundwater on the site. If there is tile drain around the house, pumped by a sump pump, that pump should never discharge into the system.

Evaluating Sewage Tank Performance

The tank holds a wealth of information about the operation and performance of the whole onsite system. Some states use the tank as the single point of information about an entire system. Although your inspection will include examinations of other system components, start by opening the tank and looking into it. For many tanks that means opening the 20-inch manhole.

For other tanks it means taking a section of the lid off. You have to be able to see the inside of the tank, so opening the four-inch inspection pipe will not be sufficient. Finding the tank can be difficult. Water flows downhill, so usually the tank is downhill from the building. The sewer service coming out of the structure will give you a general direction, and then look for clues: an inspection pipe, a low spot, dead grass, early snow melt, or other landscaping.

Flow, Settling and Bacterial Action

First, get a general overview of the tank and its contents. If there’s a lot of floating material that doesn’t belong in there, such as plastic products or undigested food, you know that the users of the system may be causing some problems. The tank should be developing three layers, a scum layer on top, clear water in the middle, and a sludge layer on the bottom. If these three separate layers are not present, then the system is not operating the way it should, and you need to find out why.

When wastewater doesn’t form these layers, it’s often because some chemical has been added that has killed the bacteria, or because one of the baffles in the tank is missing. Sometimes the layers will form but then become mixed due to turbulence in the water, in particular if there is a pump in the basement introducing too much water into the system.

Evaluate the scum layer. It should not be excessively thick, and should always be less than three inches from the bottom of the outlet baffle to ensure that excessive scum is not leaving the tank. The scum layer should also not be higher than the outlet baffle, or overflowing the baffle and flowing into the outlet.

No scum

No scum may indicate the use of water softeners, detergent use, no oil & grease baffle or excessive turbulence in the septic tank. When this occurs, scum may be transferred to the absorption field where premature clogging of the soil matrix can occur.

Excessive scum

Excessive scum in the tank may mean that the tank needs to be cleaned out, or it may mean that the wastewater has high levels of soap or grease. Users of the system may be able to reduce the amount of soap or grease in the water, or they may have to have the tank cleaned on a more frequent basis. For systems serving commercial establishments, such as restaurants, it may be a good idea to extend the outlet baffles, so that the first of two or three tanks becomes a grease trap. Another component of scum is undigested food. If a particularly thick scum layer contains a large proportion of undigested food, there is usually a problem in the house, either excessive garbage disposal use or a medical problem such as bulimia. The users of the system should deal with these issues.

Other problem materials to check for include feminine hygiene products, such as tampons and pads, and barrier-method birth control products, such as condoms. These products should not be in the tank! They will neither sink nor float; instead, they will tend to flow through the tank and into the soil system, where they can plug both the outlet line and the soil system. Users of the system should understand that these products must not become part of the sewage flow. For systems serving restaurants or other commercial establishments, an effluent screen to prevent these materials from leaving the tank may be necessary.

Evaluate the sludge layer. It should not be within 12 inches of the bottom of the outlet. Allow time for the sludge to settle before measuring this distance. Verify that the sludge is settling well and that there is not excessive movement of sludge out of the tank. Sludge will not settle properly if the water in the tank is turbulent. Turbulent conditions could be from a pump in the basement adding high volumes of water, “stirring up” the wastewater. Or there may simply be too much water entering the tank. If sewage flow from the house to the tank has increased since the tank was designed and constructed, the tank may not be large enough to handle the amount of wastewater entering it. Users of the system may be able to reduce their water use to improve the performance of the system.

If there is an excess of material that cannot be broken down by the bacteria in the tank, such as coffee grounds, soil, or soap, both the scum and the sludge layers can quickly become too thick. The only way to get these materials out of the tank is by pumping.
If the tank is over-full (if the water level is higher than the outlet invert), the system is not operating as it should. An over-full tank is not conducive to settling, so sludge and other solids may reach the soil treatment area. There may be plugging in the line, or the soil treatment system at the other end of the line may be plugged.

If a lift station is part of the system, the pumps may have had problems, causing the tank to overfill. If, after pumping out the tank, there is excessive runback (water entering the tank from the outlet side) into the tank, there is certainly plugging of the soil treatment area.

Effluent Quality
The performance of the onsite system can be determined by laboratory testing of the effluent. Septic tanks should produce effluent with a BOD of less than 220 milligrams per liter, TSS less than 65 milligrams per liter and G & O less than 30 milligrams per liter. When effluent has higher values than these, soil treatment systems typically develop overloading problems.

Watertightness
The inspector must determine if a tank is watertight. Without inspecting the tank for soundness, the inspector cannot issue a certificate of compliance. Any tank that is not watertight is, in essence, a cesspool. If the tank is watertight, then it meets the minimum requirement. Watertight means that water is not allowed to flow in or out of the tank other than through the design penetrations (inlet and outlet pipes). Watertightness is critical to tank performance.

Excess water entering the tank from surface runoff can result in inadequately-treated effluent entering the soil treatment system, causing premature failure of the soil system. Untreated wastewater entering the soil from a leaky tank presents health risks to humans and can have grave environmental consequences.

The licensed pumper can help determine if the tank is watertight, and may be a useful resource about the system. General experience has been that most tanks without a maintenance access are not watertight. Verify that the concrete walls are watertight. Pay particular attention to seams in the walls. Tanks with mid-wall seams have a high probability of breaking through and not being watertight. These walls should include some type of tongue and groove; check this joint.

Inspection of the walls includes checking the corners where the cover and the walls meet. These joints also should have a tongue-and-groove connection and some type of a mastic sealer in and on them. The other watertight surface is the tank bottom. This may seem pretty straightforward, but many tank floors were not properly constructed and are not watertight.

Next, check all the penetrations, including inlet, outlet, manhole riser, lid of the manhole, and inspection pipes. All of these should be watertight. A very good hint that they are not is the intrusion of roots. The presence of roots indicates a problem that has been in existence for a long time.

Another indication of a problem is a trickle of water entering the tank. Surface water must not be allowed to enter the system. One place it might is through the manhole, which can be buried to minimize some of the surface. If it is not buried, it should be elevated at least one inch above the finished grade to guarantee that you do not have excessive flow into the tank. Sealing this lid may seem like a good option, but sometimes a sealed manhole lid becomes permanently sealed and cannot be opened for maintenance. A number of local units of government require that the maintenance access be brought to the surface. This is a good idea, but if access is not brought to the surface, the system can still be in compliance.

Inspection pipes must be watertight at the surface of the tank. More importantly, they must have a cover on them. *A coffee can is not a cover.* The cover should be a tight-fitting plastic pipe. The best cover would be a threaded cap, to allow repeated opening without affecting the fit of the cover. There should be self-sealing gaskets wherever penetrations meet the tank walls or lid. A number of the newer septic tanks have gaskets that require some type of a masonry support to work. The riser itself needs to be watertight at all joints; plastic and concrete materials are available to achieve this. The typical length of the riser is ten to 12 inches, so using concrete means more pieces are necessary to bring it to the surface, and every connection must be watertight. With large-diameter smooth-wall plastic pipe, it is critical that a seal be made where the pipe is connected to the tank. Simply setting the pipe on top of the tank does not make a watertight connection.

Another consideration is the location of the tank in the landscape. It should be located where a minimum amount of water will run off over it. Be particularly aware of hard surfaces, from which the most water will run off; ideally, the tank would be upslope from these.

Baffles.

Check the baffles in the tank. The baffles begin the settling process by forcing the flow down, keep the scum inside the tank and ensure that effluent leaving the tank comes from the clear liquid layer. If there are problems with the baffles, the system cannot work properly. One way to correct the problem of too many solids leaving the tank is to install effluent screens.

There are two general types of baffles: plastic pipe (sanitary tees) and wall baffles. The advantage of wall baffles is that they are built in. They have a larger space to allow larger solids to enter the tank. The downside of the wall baffles is that if the tank is not properly constructed the baffles will be significantly impaired. It’s also difficult to add effluent screens to a tank with wall baffles. But either type of baffle will work adequately as long as it’s in place.

Baffles must be properly connected. A wall baffle or a large pipe baffle should be connected in such a way that it will not corrode. All baffles must be securely attached, so they remain in place over the life of the tank, and they must be inspectable. Baffles made of PVC sanitary tees must be properly glued and affixed onto the system. During the inspection you also want to verify that nothing is plugging the baffles. It's a good idea to verify that there is enough free space between the inlet pipe and the baffle to allow the free flow of both water and the solids in the water. There should be two to four inches between pipe and baffle. Note the depths of the baffles: the inlet baffle should be at least six inches deep. The outlet baffle should be drawing from the clear portion of the tank, typically about 40% of the depth. If the tank's function is to handle excessive suds or grease, the depth of the outlet baffle may be lowered so that the tank functions as a grease trap.

Tank Construction and Installation

Check the structural integrity of the tank. The lid should be strong enough to support the weight of a man (say, 200 pounds.). If the lid is at the soil surface strength is critical. Some concrete tank lids have two different thicknesses to hold them in place, which is a good idea, but if the top lid is too thin there can be problems. Walls must be strong enough to maintain seven feet of saturated soil overburden. Refer back to the original design of the tank to check this. If the tank is deeper than seven feet there should be special design considerations so that its performance will be adequate in those conditions.

Check for settling of soil around the tank. Depressions in the soil at the edges of the tank can lead to ponding of rainwater, followed by infiltration. The pipe going out of the tank should also be constructed and installed to minimize soil settling. Note the presence of cast iron pipe, which can react with soap products, causing corrosion and eventual flow problems. Cast iron pipe should be avoided or replaced if at all possible.

Odor

Is there any odor in the vicinity of the tank? Odors typically indicate a venting problem, but may indicate system failure. Odors should be vented out through the system, not back through the house.

Evaluating the Lift Station

Inspect how the water is moved out to the soil treatment system, beginning with the lift station. You should be able to access the pump without having to enter the tank. The manhole should be brought to the surface, all electrical connections should be such that there is no sparking, and there should be a remote shut-off for the pump.

There should be no sludge moving into the lift station. If there's excessive sludge in the lift station or the first section of the trenches, there are probably turbulent conditions in the tank, resulting in poor settling. As discussed above, users of the system can often make changes to alleviate the turbulence.

Check the lift station to see that it's watertight, and inspect its structural integrity just as you inspected the sewage tank. Verify that the pump has adequate capacity, taking into consideration friction loss. There should be a quick disconnect set-up. Make sure that there is no standing water in the piping.

Evaluating Soil System Performance

Drop Boxes and Distribution Boxes

NDEP recommends digging up the Distribution Box and sometimes a lateral line. Inspect the distribution system that brings effluent to the soil treatment area, either drop boxes, valve boxes, or distribution boxes. (These are also good places to check the performance of the tank.) Verify that drop boxes have solid walls and bottoms. Although drop boxes need not be absolutely watertight, they should be constructed in such a way as to minimize outflow. They should have minimal side seepage, so the presence of roots may indicate a problem. The penetration should be solid and free.

Check distribution boxes for structural soundness and watertightness. Root infiltration is a definite indication of a problem. Inspect piping for bows, drops or ponding water, which indicate possible settling of the soil. If the distribution system is over-full, it's an early sign of problems, possibly due to lack of maintenance or sludge flow-through. There may be sludge in the maintenance box or plugging in the soil system itself.

Piping

Examine the piping materials. As mentioned above, cast iron can be a problem because of reactivity with some detergents. Problems with clay and orangeburg pipes are also common, as both these materials are likely to crack, and cracking leads to troubles with roots. If there's excessive root infiltration in the piping, either the soil is too wet, or else the soil is fine, but the piping isn't watertight.

Soil

Verify the soil type, its texture and structure. Usually this is based on the perc rate of the soil. Use this information to estimate the proper soil sizing factor for the system. More important than soil type in terms of performance is the depth of the system. Check the distance from the bottom of the system to the limiting layer (bedrock or saturated soil). The system should have been designed and constructed with a "design depth" of at least three feet of soil between the system and the limiting layer. Based on current research, three feet of separation will result in excellent treatment.

Once the system has been constructed and has begun accepting effluent, the depth to saturated soil will change. The new separation is called the "operating depth": the actual depth of the water table under the working system. Operating depth is always less than design depth. How much less depends on a number of factors, including surface water drainage and system application rates. But if a system is properly designed with three feet of separation, the operating depth should be sufficient to maintain treatment. That is, from the limiting layer to the bottom of the system, there will be some non-saturated soil.

Take a boring of soil and use the Munsell color book to classify the soil. This boring should be located *near* but not *in* the system, because the system can change the soil colors, giving a false reading on the separation depth. If the boring shows wet soils all the way up to the bottom of the system, that system has **zero** operating separation and is not treating the wastewater, which is flowing into the groundwater and causing problems. There has been a lot of discussion and debate about the proper operating separation. So far, there is no accepted figure for this separation, except that it must be greater than zero. It is also important that the system not be **too deep**. "Too deep" means three feet of cover or four feet to the bottom of the system. Soil treatment systems should be relatively shallow to maximize oxygen transfer to the bottom of the system. Although shallower systems perform better, a deep system is not necessarily failing.

Surface Water

Look at the impact of surface water on the system. Inspection pipes allow visual observation of how much of the system is used, and are therefore an important component of the soil treatment system. But they must be watertight and have watertight lids to minimize the addition of water to the system.

Another issue in terms of surface water is the location of the system in the landscape. Trenches should be located along contours. They should not be located in drainage areas such as the bottom of a drainage way, or in the middle of or transecting a drainage swale.

Surfacing Effluent

If the soil treatment system is over-full, effluent will come to the soil surface. If effluent is surfacing, the system is failing and is an imminent public health threat. People are creative at hiding sewage! Odor is a great indicator of surfacing effluent. Spongy ground over the top of the system is another indicator. Check for cattails or other landscaping that may hide surfacing effluent.

Dye testing is one way to identify failures, but it will miss some failing systems, so it cannot be used as the only criterion. There are a number of new dyes that are available for use. They include the use of optical brighteners for the identification of sewage. The process for using brighteners includes collecting a sample on a cotton swab and having the cotton analyzed. This method is still being researched.

It is important to identify the cause of the failure. It may be due to plugging of soil pores, sewage flows in excess of the soil's ability to accept effluent, soil compaction, or malfunction or plugging of the distribution system. You may already have found the cause of the problems in your inspection of the tank or lift station.

Setbacks

Check setback distances. The most critical, in terms of possible contamination, are the setbacks from the well. The setback from the well to the system is based on the construction of both well and system. The distance should be calculated from the absorption area of the well, and based on the type of well and the type of soil treatment system. If the well is shallow, the setback is more critical than for a deep well because of the potential connection between the two systems. Setback distances from buildings or property lines, may be dictated by local ordinances.

System Sizing
Note the percentage of the soil treatment system being used, and make a record of it. The users of the system should understand that proper maintenance of their tank and protection of their soil treatment site in terms of drainage, mowing, and avoiding compaction is very important. The texture of the soil determines the size of the soil treatment area. If mistakes are made in design, the system will have a hard time performing properly. The configuration of the system—its layout with respect to the contour of the land—is the second consideration in sizing a soil treatment system.

Reports
The final step in the inspection is completing the reports. The keys are that your report identify the type of system, address the criteria for a rating of “failing,” and identify that you cannot guarantee performance.

APPENDIX P

Staff Check List for Review

Nevada Division of Environmental Protection

OSDS PROJECT REVIEW CHECKLIST

Project Name:			
Owner Name:		Telephone: ( )	
Owner Address:	City:	State:	Zip:
Engineer:		County:	

ENGINEERING REPORT

	NAC 445A *List section in violation*	Item	Yes	No	N/A	Comments
		Engineer's Seal				
		General Information outlining scope of project, and;				
		Analysis of the disposal area's capability to adequately treat and dispose of the proposed quality and quantities of sewage.				

		General Information				
		Owner				
		Engineer				
		Project Description				
		Project Location				
		Description of Existing System(s)				
		Source of Domestic Water				
		Activity or Land Use of Area-Present and Anticipated				
		Anticipated Sewage Volume				
		Availability of Public Sewers				
		Growth Patterns				
		Possible Use of Alternative Systems and Designs				

		Soils				
		Soils and Areas of Special Concern-(Designs shall meet land area requirements in NAC 445A and any more stringent local regulations)				
		Site evaluation and soils analyzed by qualified PE or soil scientist to include soil type and depth, hydraulic loading rate, topography, drainage characteristics, designated flood plains, structurally deficient soils, existing encumbrances				
		Slope Acceptable				
		Four Feet Vertical Separation				

(Continued On Page 2)

		Maps				
		Detailed Area Map-Include entire proposed development, adjacent areas and all acreage under development				
		Development Plan Map-(To scale-include total development, not just disposal area) Include:				

		Primary, Reserve Areas and Other Components Surface				
		Waters and/or Wells Within 500 feet of Disposal Area				
		Classified (Jurisdictional) Wetland Within 1,000 Feet of Disposal Area				
		Structures, Roads, Parking Areas Adjacent to Disposal Area				
		Any On-Site Storm water Systems, Retention Basins, or Drainage Areas for Project				
		All Water and Sewer Lines Within 500 feet of Disposal Area				
		Location of 100 Year Flood Boundaries				
		Location of Scouring Channel of Stream or River				
		Drainage Basins and Drainage Patterns Throughout the Development Site				

		Geology and Groundwater				
		Discussion of geology and its relationship to existing groundwater and soil conditions				
		Topography, geology and ground cover				
		Depth to Groundwater				
		If an unconfined aquifer exists that is usable for potable purposes, then water quality information on aquifer should be obtained, if not already available				
		Direction of flow of the aquifer, if known				
		Locations, capacities and well logs, if available, of all wells and springs within 1,000 feet of disposal area				
		Public health impact on ground and surface water quality				
		If the location of the drain field is within an area of special, a statement of compliance with any special design or site requirements				

(Continued on page 3)

		Input Balance-(generally required for areas with high rainfall and shallow and/or slowly permeable soils but may be required at any time by the reviewing agency)				
		Nitrate Balance-(may be required in areas where the quantities, qualities, and directions of ground water flow are known)				
		Climatic Conditions				

		Inspections				
		Schedule of inspections to confirm installation conforms to the plans and specifications				

		Minimum Land Area				
		Minimum Land Area (If the disposal field is located in a different area with variable soil conditions, the minimum land area shall be based on 1 gal/ft^2				
		CALCULATION AREA:				

		Compliance with Other Local and State Regulations				
		SEPA Compliance (need one of the following):				
		Signed Declaration of Non-Significance				
		Letter from Lead Agency stating Final EIS is Acceptable				
		Letter from Lead Agency stating Total Development is Exempt from SEPA				
		Lake and river shorelines area-If all or part of a project is in a shorelines area, a statement that the total project is in conformance with shoreline master plans, coastal zone management plans, and flood control zone requirements				
		Compliance with local zoning, platting, and building requirements as they relate to sewer utilities				

		Construction Schedule				
		Schedule of Construction and for Phase Development				

Continued on page 4)

		Operation and Maintenance/Management				
		Discuss options available for management of the system. Explain the preferred option				
		Management Plan discussing the following:				
		Public Entity (required for subdivisions or systems where parcels/lots are individually owned)				
		Private Entity				
		Duties of the management entity				
		Controls to ensure continuity and permanency of proper operation and maintenance				
		Methods and frequency of monitoring, recordkeeping, and reporting to the department				
		Rights and responsibilities of management				
		Rights and responsibilities of persons purchasing connections to the LOSS				
		Draft Operation and Maintenance Manual				

PLANS AND SPECIFICATIONS

		Engineer's Seal				
		Two Copies				

		General Layout				
		Water Source Shown				
		Setbacks Met				
		Test Holes Shown				
		Trench Separation Adequate (min. 6.0')				
		(				
		20' Separation between drain field beds				
		15' Separation between drain field trench areas				
		Replacement Area Shown				
		3-50% Drain field Areas				
		Drainage Checked				
		Monitor Ports				
		Slope Acceptable				
		Flow Control Devices Needed				
		(If "yes", orifice sizes checked)				
		Lateral Elevation vs. Contours				
		Beds/Trenches level				
		Trench/Bed Width (3' Trench/10' Bed Max)				
		Lateral Invert in Native Soil				

		6-24” Cover/36” Max to trench bottom				
		Wtr/Swr crossings & details				
		Cleanouts on Laterals Extended to Grade				
		Pressure Distribution				
		Loading Rate Verified				
		Soils Data				
		Sand Specification				
		High Strength Waste				
		3’ Vertical Separation Maintained				

		Tank(s)				
		Septic Tank-Outlet at 40% Depth				
		Septic Tank-Effluent Filter(s)				
		PVC Sanitary Tees Verified				
		Septic Tank Volume				
		6’ Max Credited Liquid Depth				
		20% Scum Storage				
		Verified Volume in Dosing Tank				
		Access Risers to Grade w/Gas Tight Lids				
		Tanks need to be traffic rated?				
		Tanks on “Approved List”				

		Dosing/Pumping Equipment & Controls				
		Explosion Proof Pumps				
		Check Valve @ Pumps				
		Quick Disconnects for pump removal				
		Non-Corrosive Slide Rails				
		Programmable Timers				
		Audible/Visual Alarms				
		Dose Counters & Hour Meters				
		Pump Curve(s)				
		Siphon Data				

		Calculations				
		Friction Loss Verified				
		Manifold Size Verified				
		Void Volume Verified				
		Elevations Checked				

(Continued on page 6)

		Specifications				
		Pipe Material Specified				
		Drainrock Specified				
		Certified Installer				
		Filter Fabric Specified				
		Testing Specification				
		Tanks leak tested				
		Pressure testing sewer lines				
		Provisions for DOH Final Inspection				

		Collection System				
		Gravity Sewer				
		Meet DEP Criteria (min. 2 ft./sec)				
		Gravity Effluent Sewers				
		Comprehensive Sewer Planning Area				
		Cleanouts/Manholes				
		STEP Sewer				
		Calculations Submitted				
		Pump Curves				
		Typical Details				
		Air Relief Valves				
		Provisions for cleaning lines				

		Other				
		Sent copies to Local Health Department				
		LHD Permits needed				
		Waivers				
		Easements				

Reviewed By: Date:

Comments:

Nevada Division of Environmental Protection
Bureau of Water Pollution Control

APPENDIX Q

Safety

Confined Space Safety

The deaths of workers in confined spaces constitute a recurring occupational tragedy. Approximately 60% of these fatalities have involved would-be rescuers.
If you are required to work in a:

- Sewer
- Septic tank
- Pumping/lift station
- Pit

or similar type of structure or enclosure, you are working in a CONFINED SPACE.

Causes of Fatalities
Based on the information derived from these case studies, NIOSH concluded that these fatalities occurred as a result of encountering one or more of the following potential hazards:

- lack of natural ventilation
- oxygen-deficient atmosphere
- flammable/explosive atmosphere
- unexpected release of hazardous energy
- limited entry and exit
- dangerous concentrations of air contaminants
- physical barriers or limitations to movement
- instability of stored product

Confined Space Identification
A confined space is a space which has all of the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Limited openings for entry and exit.
- Not designed for continuous worker occupancy.

Confined Space Hazards
As mentioned, the atmosphere in a confined space may be extremely hazardous because of the lack of natural air movement.

- Oxygen-deficient atmospheres.
- Flammable atmospheres.
- Toxic atmospheres.

Symptoms of Asphyxiation Include:

Headache
Dizziness
Drowsiness
Nausea

Prolonged exposure can cause convulsions and death. **Never trust your senses to determine if the air in a confined space is safe! You can NOT see or smell many toxic gases and vapors, nor can you determine the level of oxygen present.**

Methane (CH4)
Carbon dioxide (CO2)
Hydrogen sulfide (H2S)

Working in a Confined Space…

Keep alert! At the first sign of trouble—dizziness, difficulty breathing, anything—leave immediately or call for help. Report the problem to your supervisor. **Never** enter a confined space without a buddy waiting outside to help you. He should have the same type of protective gear you have. Your buddy should also:

Have a lifeline or parachute harness attached to you which he could use to pull you out if necessary.
Have you signal him periodically so he knows you're okay.
Remain outside at all times. A third person should be within hailing distance to help if necessary.

Rescue Attempts
Rescuers must be trained in and follow established emergency procedures. They must use appropriate equipment and techniques (lifelines, respiratory protection, standby persons, etc.). Unplanned rescues, such as when someone instinctively rushes in to help a downed co-worker, can easily result in

Electrical Safety
Typically most people would expect electrical work to be performed by a competent, licensed electrician. However, there is a lot of leeway as to when a contractor must employ a licensed electrician to do electrical installation work. For example, Iowa does not mandate the use of licensed electricians on a statewide basis. The only specific requirements are those enforced by municipalities, as part of their city's ordinances. City ordinances vary between municipalities. Thus, any contractor that is working within the city limits of a municipality must be aware of and follow that city's requirements.

Anyone who allows untrained and unqualified persons to install electrical components on a project is creating a significant legal risk for himself or herself. In the event that there is an injury causing accident, explosion, fire, etc., the installer will be liable for damages. Legal judgments may be even higher if the installer did not use reasonable and prudent care when installing the system.

Typically, the use of untrained, unqualified persons to install electrical wiring and equipment would not be viewed as reasonable and prudent care. Therefore, it is recommended that installers always utilize competent, licensed electricians who are knowledgeable of the National Electrical Code for all of the electrical installation work associated with OSSF systems