IOWA
2003

ONSITE SEWAGE

DESIGN
AND
REFERENCE
MANUAL

CONTENTS

INTRODUCTION

As concerns in water quality are addressed across the state, failing onsite wastewater systems are being evaluated regarding their effect on our water quality. We are looking for better methods to evaluate and design onsite wastewater systems.

The use of this manual is not required by the State of Iowa, County, or the other organizations listed below. This manual is not a State Code. In general this manual follows the State Code, however many parts go beyond code requirements in what the work group thought was the best practice for onsite systems today.

The use of a product name is not an endorsement of that product, and is used for example purposes only.

The following organizations worked together to develop a design manual and training program for onsite wastewater systems for County Sanitarians, Contractors, and System Designers throughout Iowa:

- USDA Rural Development, (USDA RD)
- Iowa Department of Natural Resources, (IDNR)
- Iowa Environmental Health Association, (IEHA)
- Natural Resources Conservation Service, (NRCS)
- ISU Agronomy Department
- Iowa Rural Water Association, (IRWA)
- Soil Classifiers Association of Iowa
- Iowa Onsite Wastewater Association (IOWWA)
- Minnesota Extension Service
- University of Wisconsin
- EPA
- National Small Flows Clearinghouse (NSFC)

We would like to thank USDA Rural Development and Jim Carroll for all of the time that was dedicated in the preparation of the manual.

This manual was prepared with the help of the following people:

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SECTION A: WATER USE

Appendix

Introduction to Onsite Wastewater Treatment Systems

The purpose of an onsite wastewater treatment system is to adequately treat wastewater before it is discharged to the environment. Adequate treatment means removing pathogens and filtering excess nutrients from wastewater. The pathogens to be treated are viruses and fecal coliform bacteria, whereas excess nutrients to be filtered include nitrogen and phosphorus. Onsite systems are more effective at filtering phosphorus than nitrogen, however, and they may not reduce nitrogen levels below drinking water standards.

Basic Components of Onsite Systems:
An onsite system typically consists of two components for wastewater treatment: 1) a septic tank (primary treatment), which collects all wastewater and retains the solids; and 2) a secondary treatment medium, to provide wastewater treatment to remove contaminants before the wastewater is returned to the environment.

Secondary treatment media serve two separate functions: treatment and dispersal. Treatment means treating wastewater to remove pathogens and other contaminants, whereas dispersal refers to the manner in which treated wastewater is discharged. Some types of systems, such as soil absorption trenches, provide soil-based treatment and dispersal, since both treatment and dispersal take place in the soil. Other types of systems, such sand filters and mounds, provide nonsoil-based treatment, which means they use some other medium besides soil to treat wastewater. Mounds rely on soil dispersal, however, whereas sand filters rely on surface dispersal.

Basic Types of Onsite Systems:
A “conventional” onsite system refers to a septic tank followed by soil absorption trenches, which are trenches dug laterally into the soil. The various media for distributing effluent through soil absorption trenches include rock, chambers, and gravelless pipe.

An “alternative” onsite system refers to a septic tank followed by some form of secondary treatment *other than* soil absorption trenches. Some alternative systems, such as mound systems and at-grade systems, provide secondary wastewater treatment before dispersing treated wastewater <u>to the soil</u>. Other types of alternative systems provide secondary wastewater treatment, then discharge treated wastewater <u>to the surface</u>. Surface-discharging systems include sand filters, constructed wetlands, and mechanical aerobic systems. Mechanical aerobic systems rely upon a motorized aeration chamber to treat wastewater.

“Innovative” systems refer to newer systems that do not yet have a prescriptive design in Chapter 69. They may be either subsurface-discharging or surface-discharging systems, and they may be soil-based or nonsoil-based treatment systems. Current examples of innovative systems are peat filters and fixed media filters.

SOURCES OF WASTEWATER

Sewage means waste produced by toilets, bathing, laundry, cooking, washing dishes, or floor drains associated with these sources. Sewage does not include "clean" water such as swimming pool water, roof drainage, water softener recharge water, or water used to irrigate gardens. Chapter 69 does allow water softener recharge water to be discharged into an onsite wastewater system, while other "clean" water may not.

The amount of water discharged to an onsite sewage treatment system is one of the factors used in sizing that system. The other factor is determined by the texture, structure, and percolation rate of the soil.

Water use varies widely among individuals, depending on such factors as background, age and economic status. For example, an individual who was raised in a household without running water will probably be very conservative in water use even when running water is available. Teenagers are typically high water users. The use of hot tubs or water-circulating devices for therapeutic services greatly increases water use. In general water use goes up as income level increases.

A number of studies have been made throughout the country on water use habits and rates. In studies made during the 1970s, average water use per person, nationwide, was about 45 gallons per day. A 1998 study found a national water-use rate of about 80 gallons per person per day, and 69 gallons per person per day in Minnesota. A "true" average water use rate may never be known.

The estimates of flow used in Iowa to size sewage treatment systems allow for a safety factor so that systems will function properly even when serving a residence or other establishment with higher than average rates of water use. General practice is to use a value of 75 gallons per person per day as the water use rate.

Estimating Sewage Flows

Dwellings

A **dwelling** is any building or place used or intended to be used by human occupancy as a single-family or two-family residence, with no more than nine bedrooms, and producing sewage. Dwelling does not include a single-family or multifamily residence that serves both as a domicile and a place of business, if the business increases the volume of sewage above what is normal for a dwelling, or if the liquid waste generated no longer qualifies as sewage.

The estimated sewage flows presented in Figure A-1 are based on the number of bedrooms in a residence. While the *individuals* who occupy a residence use the water, the number of bedrooms is considered a good index of the potential water use.

Number of Bedrooms	Gallons per Day
2	300
3	450
4	600
5	750
6	900
7	1050
8	1200

For a residence, the estimated water use is equal to 150 gallons per day (gpd) per bedroom. This assumes an occupancy of two people per bedroom, each using 75 gpd. This is a high estimate for many residences, although it may be low for large and high-value residences.

Other Establishments

"Other establishment" is any public or private structure, other than a dwelling, that generates sewage and discharges it to an onsite system. Other establishments may have large flows and/or high-strength waste, which Chapter 69 does not address.

Cluster Systems

Any cluster system under single ownership is designed as the sum of residences served by the system. Tank size is the sum of the total tanks required for the residences in the system. Individual flows from houses are estimated as separate establishments or homes. Apartments should be the considered as if each unit were a single home**. If the design flow is more than 1500 gpd or the cluster serves more than 10 bedrooms, a public wastewater permit is required and Chapter 69 may not apply for the design of the system. Contact an engineer and the IDNR.**

Domestic sewage is generated by a dwelling; a toilet facility at an establishment open to the public; rental units, such as motels and resort cabins; shower and toilet facilities for schools or campgrounds; or any establishment that only generates bathroom, kitchen or laundry wastewater.

Non-domestic waste is generated by other sources, such as car washes and other light industrial establishments.

Figure A-2 presents flow estimates for many types of facilities that generate sewage.

Even though size of residence is used to estimate sewage flow, a sewage treatment system is designed for a certain number of gallons per day, not for a certain size residence. For example, if a system is sized for 450 gallons a day (three-bedroom home), and the home actually discharges 600 or 700 gallons per day, hydraulic failure is likely to occur. Each soil unit has a finite waste treatment capacity, which, if consistently exceeded, will lead to hydraulic overload and failure of that system.

Measuring Flow

While it is often necessary to use the values in Figure A-2 to estimate sewage flows, more accurate data should be obtained if possible. For example, if a small restaurant is to be located beyond the reach of municipal sewer, then data should be obtained from comparable facilities.

Septic systems are becoming more expensive, both to install and to repair, so one goal is to design them to treat the actual wastewater flow, rather than an estimate that may be high or low. Another goal is to get optimum use over the longest possible time from existing systems. In order to achieve these goals it's helpful to know actual flow rates, which the water meter provides. To keep track of the amount of water entering the septic system, include a water meter in the design of the system, or add one to an existing system, for example. Some eating and drinking establishments use icemakers that use large amounts of tap water to cool the ice. This water is often discharged into the sewer system. This wastewater should not be added into the septic system.

Water meters come in many different shapes and sizes. Most water meters are designed to deal with clean water, which means that they may not function properly if they are used to measure the flow of sewage. For example, many water meters have small paddles or wheels that move around to measure flow. These moving parts can be easily plugged by solids in sewage. One way to avoid this problem is to measure the flow of clean water before it is used in the house.

Clean-Water Meter

These meters should measure the water used inside the house, but not the water used outside for watering lawns and gardens, filling swimming pools, or washing cars, since this water does not enter the septic system. If it's difficult to install a water meter so that it doesn't include the water to be used outdoors, try to estimate outside use, or use only data from December to March, when there is typically no outdoor use of water.

	gallons per day per unit***	
	Avg*	**Max****
Dwelling Units		
hotel or luxury motel* **		
each guest	50	60
+ for each employee	11	13
or per square foot	0.26	0.3
motel******		
each guest	35	40
+ for each employee	11	13
or per square foot	0.22	0.46
rooming house******		
each resident	40	50
+ for each nonresident meal	2.5	4.0
daycare		
each child	25	25
Commercial/Industrial		
retail stores		
per sq. foot of sales area	0.1	0.15
or each customer	2.5	5
+ for each employee	11	15
or each toilet room	530	630
offices		
+ for each employee	15	18
or per square foot	0.1	0.25
medical office		
per square foot	0.6	1.6
industrial building		
+ for each employee	15	20
(Does not include process water or cafeteria)		
construction camp		
+ for each employee	15	20
visitor center		
each visitor	5	20
laundromat		
each machine	580	690
or each load	50	50
or per square foot	2.2	2.9
barber shop		
per chair	55	80
beauty shop		
per station	270	300
car wash		
per inside square foot	5	10
(Does not include car wash water)		

	gallons per day per unit***	
	Avg*	**Max****
Eating and Drinking Establishments		
restaurant* **		
per meal	2.5	4.0
(Does not include bar or lounge)		
or each seat	24	40
+ for each employee	11	13
dining hall* **		
per meal	2.5	4.0
coffee shop* **		
each customer	2.0	2.5
+ for each employee	11	13
cafeteria* **		
each customer	2	2.5
+ for each employee	11	13
drive-in* **		
per car stall	110	145
bar or lounge* **		
each customer	2	5.5
+ for each employee	11	13
or per seat	32	40
Institutional		
hospitals		
each medical bed	175	260
+ for each employee	10	16
mental institution******		
each bed	105	175
+ for each employee	10	16
prison or jail******		
each inmate	120	160
+ for each employee	10	16
nursing home******		
each resident	93	145
+ for each employee	10	16
Transportation		
airport, bus station or rail depot		
per passenger	2.5	4
or per square foot	3.33	6.5
or per public restroom	500	630
auto service station		
each vehicle served	11	13
+ for each employee	13	16
or per inside sq. foot	0.25	0.6
or per public restroom	500	630

	gallons per day per unit***	
	Avg*	**Max****
Recreational		
campground with hookups*		
per person	32	40
or per site	100	100
with central bath per site	50	75
add for dump station site with hookup	13	16
day camp (no meals)		
per person	13	16
YMCA/YWCA		
per member	33	33
country club		
per member	22	22
(no meals)		
per member	105	130
(meals and showers)		
per member	75	100
(in residence)		
housekeeping cabin		
per person	42	50
lodge		
per person	53	74
parks or swimming pools		
per guest	10	13
picnic parks with toilet only		
per guest	5	10
movie theater		
per guest	2.5	4
drive-in theater		
per space	3	5
skating rink or dance hall		
per customer	7	10
bowling lanes		
per lane	133	250

See SECTION C for tank sizing, page 5

	gallons per day per unit***	
	Avg*	**Max****
Schools and Churches		
day school****		
per student	10	17
(no gym, cafeteria or showers)		
per student***	16	20
(cafeteria only)		
per student***	20	30
(cafeteria, gym and showers)		
boarding school*,******		
per student	75	115
church		
per member	0.14	0.86
+ for each kitchen meal	1	1
+ per Sunday school student	0.14	0.86

*Average (Secondary Treatment Design Flow) ie laterals
**Maximum (Septic Tank Design Flow)
***High waste strength systems
****Excessive solids, particularly lint

* Figures in the “average” column designate an average daily flow and may be used for sizing the secondary treatment **unit**.

** Values in the “maximum” column are the average peak flow rates and should be used for **sizing the septic tank or tanks** so that adequate volume is available on peak flow days.

Remember, these figures are only estimates of average flow rates and each facility is different.

References:

Onsite Wastewater Treatment and Disposal Systems Design Manual, U.S. EPA, October 1980.

Forecasting Municipal Water Requirements, Vols. I and II, U.S. Department of Commerce, September 1969.

Tchobanoglous, G., and F. Burton. Wastewater Engineering: Treatment, Disposal, and Reuse, third edition, Irwin/McGraw-Hill, 1991.

Water meters measure flow in either gallons, or cubic feet. Before doing any calculations using data from the meter, check to be sure of the units of measurement. Designs for septic systems typically use gallons per day. If it measures cubic feet per second, multiply by 7.48 to convert to gallons per day.

The water meter should be installed by a plumber to make sure it's put in properly. Although it is installed directly into the water system, it won't affect water pressure.

Another type of clean water meter often found in houses is an on-demand water softener. These water softeners measure flow and recycle at certain set flow amounts. This system may also be used to calculate water flow. These calculations are not as straightforward as simply reading a meter and multiplying by a factor, but this is a valid method of measuring clean water flow.

Wastewater Measurements

Instead of measuring water use in the house, you can also measure wastewater going out to the septic system. To do this, you could try to use a water meter, but the water entering the meter would need to be free of solids.

The use of a pump as a wastewater meter is more common. All pumps run at a certain rate, so water flow can be calculated and calibrated from the pump system. This calibration is very straightforward, in that you measure the level in the tank, run the pump for a certain amount of time, measure the amount of water that has left, divide that by the amount of time that the pump was running, and come up with a pumping rate in gallons per minute. Using this rate, you can calculate how much water has been pumped, based on how long the pump has been running.

Example: A tank contains 100 gallons per foot of water depth, and the depth of wastewater is three feet. You run a pump for two minutes, and now the wastewater is two feet deep. 100 gallons have been pumped in 2 minutes, so the rate was 50 gallons per minute. Now find out how many minutes the pump runs in the course of a day. If the same pump ran for ten minutes, then during that day it pumped 10 times 50 or 500 gallons. This is a quick way to use a pump and a clock to calculate how much water is being used.

Once you know the pump's rate, check it regularly. It may slow down to the point where it is not evenly distributing wastewater to the soil treatment system, the line is plugged, there is an air lock, the impeller is worn, or it is failing for some other reason. By checking periodically, you know there is a problem it stops working.

Another way to use a pump as a measurement device is to use an event counter. An **event counter** is a meter that records every time the pump turns on. You know from the septic system design how many gallons are to be pumped each time the pump turns on, so by counting the number of times it turns on during a day you can measure the flow of wastewater going out to the system. This is not as accurate as a running time clock because the floats that turn the pump on have some variability. That is, the pump may turn on at six inches the first time and then 6-l/2 inches the second time. That can be a 15 to 20 gallon discrepancy each dose. If the event counter is turning five times a day, at a 20-gallon per time discrepancy, your calculations could be off by as much as 100 gallons of water that day.

However it is measured, flow is critical data that will allow the best design and operation of the septic system. Estimated flow is a great design tool. It allows for a safety factor and peace of mind. Measured flow is used both to design systems and to verify performance. By using both flow figures appropriately, you give the system the best chance of good long-term performance.

Calculating Design Flows

It is recommended that **average design flow be used** to calculate the secondary treatment system sizing and **maximum design flow used** to calculate septic tank sizing for "other establishments." Water meter data can be used to calculate average design flow and maximum design flow.

Measured maximum design flow is the anticipated peak daily flow. **Measured average design flow** is determined by averaging the measured daily flows for a consecutive seven-day period in which the establishment is at maximum capacity or use.

A method to calculate both the measured maximum design flow and the measured average design flow, requires two sets of data:

1) daily flow data and
2) capacity of the establishment for each day.

A minimum of two months of data is necessary, and one full year of data is recommended (the more data you have, the greater the confidence you will have in your design assumptions).

Daily flow should be in gallons per day (gpd). Some water meters give cumulative readings (so that one day the meter may measure 400 gallons, the next day 850 gallons, and the next day 1,200 gallons). If this is the case, make sure to convert the gallons into a per day unit. In this example, 400 gallons are discharged on day 1; 850 - 450 = 400 gallons for day 2; and 1200 - 850 = 350 gallons for day 3. Make sure you are using the correct units when you use the information to design a system.

Components of Wastewater

The components of wastewater may be divided into four categories:

- Pathogens
- Nutrients
- Biochemical Oxygen Demand (BOD)
- Total Suspended Solids (TSS)
- Other chemicals

Figure A-4 shows typical concentrations of these components in raw waste, septic tank effluent, and soil.

Figure A-4: Treatment Performance of Soil

parameter	raw waste	septic tank effluent	one foot below trench bottom	three feet below trench bottom
BOD_5 (mg/L)	270 - 400	140 - 220	0	0
TSS (mg/L)	300 - 400	45 - 65	0	0
fecal coliform (MPN/100ml)	1,000,000 – 100,000,000	100,000 – 100,000,000	0 – 100	0
viruses (PFU/ml)	unknown	1,000 – 1,000,000,000	0 – 1,000	0
nitrogen (mg/L)				
total	100 – 150	50 – 60	----	----
NH_4	60 – 120	30 – 60	*B – 60	*B
NO_3	<1	<1	*B – 40	*B – 40
total phosphorus (mg/L)	10 – 40	10 –30	*B – 10	*B –1

*B = background level of naturally occurring parameter in soil

Pathogens

The most critical component, in terms of what must be removed from wastewater, is pathogens. Pathogens are organisms that cause disease, including viruses, protozoan, and bacteria. Pathogens may be found in wastewater from anywhere in the house. Any human contact with water results in the potential to add pathogens to the environment. The presence of pathogens in wastewater makes its treatment a public health issue, because of the risk of spreading disease.

Fecal coliform bacteria are pathogens used as an indicator of the presence of any pathogens in wastewater. These bacteria are residents of human intestinal tracts. Fecal coliform bacteria are fairly easy to test for, and their presence is an indication that other pathogens, which are more difficult to isolate and identify, may also be present. An average value for fecal coliform bacteria in septic tank effluent is 1,000,000 organisms per 100 milliliters.

Disinfection of the wastewater is discussed in Section G.

Nutrients

Two nutrients are of primary concern in wastewater treatment: phosphorus and nitrogen. These nutrients have different chemical characteristics: phosphorus tends to bind to soil particles, while nitrogen is more mobile in the soil.

Phosphorus is a nutrient essential to the growth of plants and microorganisms. A typical value for phosphorus in septic tank effluent is 7 milligrams per liter.

The concern with phosphorus is its impact on surface waters in Iowa. Most surface water in Iowa is phosphorus-limited, meaning that any additional phosphorus will result in the growth of more plant life. Growth of algae and weeds dramatically affects lake ecosystems, and lowers their aesthetic appeal and recreational value.

Nitrogen is also an essential nutrient for the growth of plants and microorganisms. Wastewater usually contains fairly high levels of nitrogen, which appear in four different forms: organic nitrogen, ammonia, nitrate, and nitrite. As nitrogen moves through the treatment system, it changes from ammonia to nitrate. While it is possible for nitrate to change into nitrogen gas in some systems, standard trench and bed systems do not make this change, so the nitrate moves into groundwater. A typical level of nitrogen in septic tank effluent is 40 milligrams per liter.

In drinking water, which is often from groundwater, high levels of nitrogen can be toxic to infants, causing methemoglobinemia, “blue baby syndrome.” Ammonia in surface waters can be toxic to fish.

Biochemical Oxygen Demand, Dissolved Oxygen, and Total Suspended Solids

BOD is the most widely used parameter applied to the evaluation of the strength of wastewater. BOD is a measure of the dissolved oxygen required by microorganisms to oxidate or decompose the organic matter, and oxidize inorganic material such as ammonia in the wastewater . A typical BOD value for a standard system is 220 milligrams per liter. Another term often used is CBOD this is the Carbonaceous Biochemical Oxygen Demand. This is the amount of oxygen consumed, in the test period, to decompose the organic matter. Typically the test period is run for 5 days and is referred to as 5-day BOD or CBOD.

When the dissolved oxygen (DO) contained in septic tank effluent is measured, it’s usually very low; typically one milligram per liter. While DO in groundwater can be as high as 12 milligrams per liter, the microorganisms in the septic tank normally use up any available oxygen to break down organic matter. If the DO in the septic tank water is above 2 mg/l this is a sign that ground water is probably leaking into the tank. The DO in most mechanical aerobic systems is in the 8-10 mg/l range.

Total Suspended Solids (TSS) are a measure of the solids or particles that remain in the wastewater after settling has occurred in the septic tank. A typical TSS value for effluent for septic tank wastewater is 65 mg/l.

Biochemical Oxygen Demand and Total Suspended Solids together measure the strength of the wastewater. They can serve as an indicator of system performance.

For information on sampling wastewater for these components, see Appendix A-3: Monitoring Wastewater Characteristics.

Other Chemicals and Hazardous Waste

Hazardous waste should not be added to a treatment system. Nonhazardous wastes, including detergents, shampoos, antibacterial soap, and salt from water softeners, have not been shown to have detrimental effects under normal household loading. Excessive loading of any of these chemicals, however, can cause problems with the treatment process.

Of particular concern are continuous toilet cleaners and formaldehyde. Because the toilet flow represents nearly 40 percent of total wastewater, continuous use of a sanitizer can cause problems and should be avoided. Formaldehyde, typically used in chemical toilets, also causes major system problems and should be avoided.

If a residence or any other facility plans to dispose of hazardous waste into an onsite system, problems can occur. These systems would be considered **Class V- injection wells,** and are subject to Federal regulations. Photography businesses, auto repair shop, or taxidermists, for example, may generate hazardous waste. A facility that disposes of such waste should not discharge to a subsurface treatment system.

In the case of filling station wastes, oil, grease and floor washing wastes from the service bay should be discharged to a holding tank separate from the sewage system treating the toilet wastes. Any liquid waste containing petroleum products **should not** be discharged into a subsurface treatment system. A car wash area may also contain for hazardous waste, and shall also not discharge to a subsurface treatment system.

Appendix A-1: Equivalents, Equations, and Abbreviations

Equivalents and Equations:

pi (π) = 3.14

one cubic foot of water = 7.5 gallons

231 cubic inches of water = one gallon

27 cubic feet = one cubic yard

area of a rectangle or square = length x width

area of a circle = π x radius^2

volume of a box or cube = length x width x depth

volume of a cylinder = π x diameter^2 $\div$ 4 x depth

flow = volume over time (gallons per minute)

loading rate = gallons applied per day $\div$ area applied

pump capacity = gallons pumped during a cycle $\div$ run time

one foot of head = 0.43 pounds per square inch (psi)

one psi = 2.31 feet of head

one acre = 43,560 ft^2

Common Abbreviations

a = area

cfs = cubic feet per second

d = diameter

d = diameter

ft^2 or sqft = square feet

cuft = cubic feet

gal = gallons

gpm = gallons per minute

gpd = gallons per day

gpd/sqft = gallons per day per square foot

hr = hour

m = minute

in = inch

L = liter

mg = milligram

ml = milliliter

ppm = parts per million

psi = pounds per square inch

Q = flow (quantity)

π = pi (ratio of diameter of a circle to its circumference)

$>$ = greater than

$\geq$ = equal to or greater than

$<$ = less than

$\leq$ = equal to or less than

Appendix A-2: Homeowner's Responsibilities for Use of an Onsite Sewage Treatment System

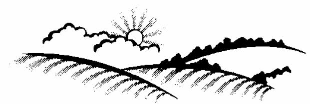
The following 2 documents are reproduced from the National Small Flows Clearing House.

They Have a good web site for information and can provide technical assistance.

http://www.nesc.wvu.edu/nsfc/nsfc_index.htm

- Check with your local regulatory agency if you have a garbage disposal unit to make sure that your septic system can accommodate this additional waste.
- Check with your local regulatory agency before allowing water softener backwash to enter your septic tank.
- Your septic system is not a trash can. Do not put grease, disposable diapers, sanitary napkins, tampons, condoms, paper towels, plastics, cat litter, latex paint, pesticides, or other hazardous chemicals into your system.
- Keep records of repairs, pumpings, inspections, permits issued, and other system maintenance activities.
- Learn the location of your septic system. Keep a sketch of it handy with your maintenance record for service visits.
- Have your septic system inspected every 1–2 years and pumped periodically (usually every 3–5 years) by a licensed inspector/contractor.
- Plant only grass over and near your septic system. Roots from nearby trees or shrubs may clog and damage the absorption field.
- Do not drive or park over any part of your septic system. This can compact the soil and crush your system.

In summary, understanding how your septic system works and adhering to these few simple rules will ensure that your septic system is a safe and economical method for treating and disposing of your wastewater onsite.



For more information regarding the care of your septic system, contact your local health department.

More information about septic systems is available from the National Small Flows Clearinghouse (NSFC) through other brochures in this series:

Groundwater protection and your septic system,
Item **#WWBRPE21**

The care and feeding of your septic system,
Item **#WWBRPE18**

For more information about this or other NSFC products, please contact us by writing to:
National Small Flows Clearinghouse
West Virginia University
P.O. Box 6064
Morgantown, WV 26506-6064
or phone:
(800) 624-8301, (304) 293-4191
or fax: (304) 293-3161
www.nsfc.wvu.edu

Helping America's small communities meet their wastewater needs

NATIONAL SMALL FLOWS CLEARINGHOUSE

NATIONAL SMALL FLOWS CLEARINGHOUSE

Helping America's small communities meet their wastewater needs

So . . . now you own a septic system

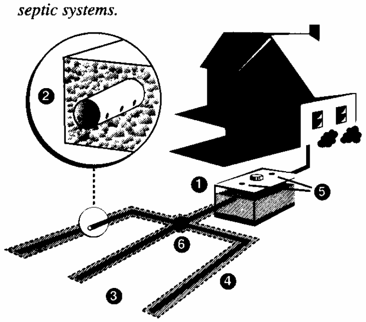
One in a series of three brochures designed to aid you in caring for your septic system.

So . . . now you own a septic system

More than 25 million homes, encompassing almost 25 percent of the U.S. population, dispose of domestic wastewater through onsite (unsewered) systems. According to the American Housing Survey for the United States, in 1993 1.5 (million) out of every 4 (million) new owner-occupied home starts relied upon a form of onsite sewage disposal.

One of the major differences between owning an unsewered versus a sewered home is that unsewered wastewater treatment and disposal systems must be maintained by the homeowner. Treatment and disposal of wastewater should be one of the primary concerns of any homeowner in an unsewered area.

The most common way to treat and dispose of wastewater in rural homes is through the use of an onsite disposal system. The majority of onsite disposal systems in the United States are septic systems.



1 septic tank
2 4" perforated pipe
3 absorption field
4 crushed rock or gravel lined trench
5 inspection ports
6 distribution box

Typical Septic System Fig. 1

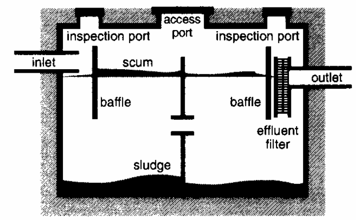
HOW IT WORKS

A typical septic system contains two major components: a septic tank and the absorption field (see Figure 1). Often, a distribution box is included as part of the system to separate the septic tank effluent evenly into a network of distribution lines that make up the absorption field. The septic tank is usually made of concrete, fiberglass, or plastic, is typically buried and should be watertight. All septic tanks have baffles (or tees) at the inlet and outlet to insure proper flow patterns (see Figure 2). Most septic tanks are single compartment; however, a number of states require two-compartment tanks or two single compartment tanks in series.

While typically designed to hold a minimum of 750–1000 gallons of sewage, the size of the tank may vary depending upon the number of bedrooms in the home and state and local regulatory requirements. The primary purpose of the septic tank is to separate the solids from the liquids and to promote partial breakdown of contaminants by microorganisms naturally present in the wastewater. The solids, known as sludge, collect on the bottom of the tank, while the scum floats on the top of the liquid. The sludge and scum remain in the tank and should be pumped out periodically (see Figure 2).

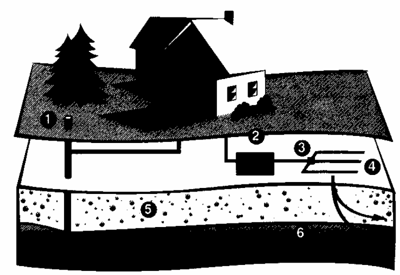
Solids that are allowed to pass from the septic tank may clog the absorption field. Keeping solids out of the absorption field not only prevents clogging, but also reduces potentially expensive repair or replacement costs and helps ensure the ability of the soil to effectively treat the septic tank effluent. Therefore, an additional safeguard in keeping solids out of the absorption field is the use of effluent filters on the outlet of the septic tank (see Figure 2).

The wastewater (effluent) coming out of the septic tank may contain many potentially disease-causing microorganisms and pollutants (i.e., nitrates, phosphates, chlorides). The effluent is passed on to the absorption field through a connecting pipe or distribution box. The absorption field is also known as the soil drainfield, the disposal field, or the leachfield. The absorption field contains a series of underground perforated pipes, as indicated in Figure 1, that are sometimes connected in a closed loop system, as illustrated on the front cover, or some other proprietary distribution system



Cross-section of a two-compartment septic tank Fig. 2

The effluent is distributed through the perforated pipes, exits through the holes in the pipes, and trickles through the rock or gravel where it is stored until absorbed by the soil. The absorption field, which is located in the unsaturated zone of the soil, treats the wastewater through physical, chemical, and biological processes. The soil also acts as a natural buffer to filter out many of the harmful bacteria, viruses, and excessive nutrients, effectively treating the wastewater as it passes through the unsaturated zone before it reaches the groundwater (see Figure 3).



1 drinking water well
2 septic tank
3 distribution box
4 absorption field
5 soil absorption (unsaturated zone)
6 groundwater (saturated zone)

Wastewater treatment and disposal in soil Fig. 3

Wastewater contains nutrients, such as nitrates and phosphates, that in excessive amounts may pollute nearby waterways and groundwater supplies. Excessive nutrients in drinking water supplies can be harmful to human health and can degrade lakes and streams by enhancing weed growth and algal blooms. However, the soil can retain many of these nutrients, which are eventually taken up by nearby vegetation.

What to Put In, What to Keep Out

- Direct all wastewater from your home into the septic tank. This includes all sink, bath, shower, toilet, washing machine and dishwasher wastewaters. Any of these waters can contain disease-causing microorganisms or environmental pollutants.

- Keep roof drains, basement sump pump drains, and other rainwater or surface water drainage systems away from the absorption field. Flooding of the absorption field with excessive water will keep the soil from naturally cleansing the wastewater, which can lead to groundwater and/or nearby surface water pollution.

- Conserve water to avoid overloading the septic system. Be sure to repair any leaky faucets or toilets. Use low-flow fixtures.

- Do not use caustic drain openers for a clogged drain. Instead, use boiling water or a drain snake to open clogs.

- Do not use septic tank additives, commercial septic tank cleansers, yeast, sugar, etc. These products are not necessary and some may be harmful to your system.

- Use commercial bathroom cleaners and laundry detergents in moderation. Many people prefer to clean their toilets, sinks, showers, and tubs with a mild detergent or baking soda.

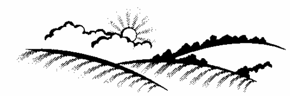
continued . . .

Septic System Health Tips

What you put into your septic system will have a direct effect on whether or not you have a healthy, long-lasting and trouble-free system. Your septic system is not a dispose-all.

- Conserve water to avoid overloading the septic system. Be sure to repair any leaky faucets or toilets. Use low-flow fixtures.
- Do not use caustic drain openers for a clogged drain. Instead, use boiling water or a drain snake to open clogs.
- Do not use septic tank additives, commercial septic tank cleansers, yeast, sugar, etc. These products are not necessary and some may be harmful to your system.
- Use commercial bathroom cleaners and laundry detergents in moderation. Many people prefer to clean their toilets, sinks, showers, and tubs with a mild detergent or baking soda.
- Check with your local regulatory agency if you have a garbage disposal to make sure that your septic system can accommodate this additional waste.
- Check with your local regulatory agency before allowing water softener backwash to enter your septic tank.
- Your septic system is not a trash can. Do not put disposable diapers, sanitary napkins, tampons, condoms, paper towels, facial tissues, plastics, cat litter, or cigarettes into your septic system. These items quickly fill your septic tank with solids, decrease the efficiency, and will require that you pump out the septic tank more frequently. They may also clog the sewer line to the septic system causing wastewater to back up into your home.
- Avoid dumping grease or fats down your kitchen drain. They solidify and the accumulation may contribute to blockages in your system.
- Keep latex paint, varnishes, thinners, waste oil, photographic solutions, pesticides, or other hazardous chemicals out of your system. Even in small amounts, these items can destroy the biological digestion taking place within your septic system.

Septic systems are a very simple way to treat household wastewater and are easy to operate and maintain. Although homeowners must take a more active role in maintaining septic systems, once they learn how their systems work, it is easy for them to appreciate the importance of a few sound operation and maintenance practices.



For more information regarding the care of your septic system, contact your local health department.

More information about septic systems is available from the National Small Flows Clearinghouse (NSFC) through other brochures in this series:

Groundwater protection and your septic system,
Item **#WWBRPE21**

So . . . now you own a septic system,
Item **#WWBRPE20**

For more information about this or other NSFC products, please contact us by writing to:
National Small Flows Clearinghouse
West Virginia University
P.O. Box 6064
Morgantown, WV 26506-6064
or phone:
(800) 624-8301, (304) 293-4191
or fax (304) 293-3161

www.nsfc.wvu.edu

Helping America's small communities meet their wastewater needs

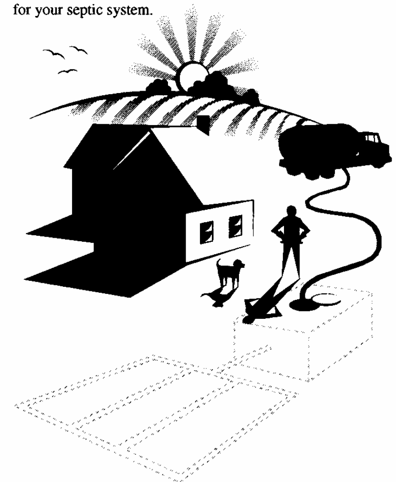
NATIONAL SMALL FLOWS CLEARINGHOUSE

NATIONAL SMALL FLOWS CLEARINGHOUSE

Helping America's small communities meet their wastewater needs

The care and feeding of your septic system

One in a series of three brochures designed to aid you in caring for your septic system.



The care and feeding of your septic system

Septic systems are very much like automobiles. They need periodic inspections and proper maintenance to continue working properly. Also, like automobiles, they must be operated properly and cannot be overtaxed without the owner suffering consequences such as repair or replacement bills.

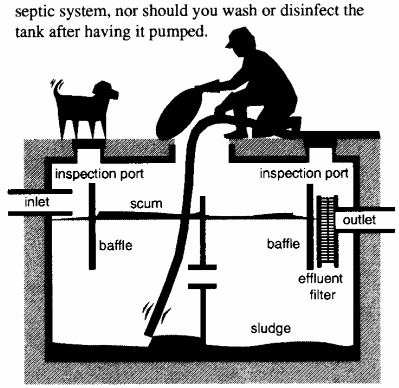
Often overlooked or neglected is the fact that a septic system should have a regular check-up to prevent problems. You should have your septic system inspected every 1-2 years by a professional and your tank pumped when necessary. The septic tank traps the solids in the wastewater and should be checked to determine whether or not it is time for it to be pumped out. The inspection port should be opened and the baffles (internal slabs or tees) should be checked to ensure that they are in good condition since the last check-up (see Figure 1). If you have a septic tank effluent filter, it should also be inspected. Effluent filters require periodic cleaning. Some filters are now equipped with alarm systems to alert the homeowner when the filter has become dirty and needs to be cleaned. Failure to keep the filter clean may result in a backup of wastewater in the home from a clogged filter. Septic systems that have mechanical parts such as a pump should be inspected at least once a year or more frequently as recommended by the manufacturer. The absorption field should be checked for sogginess or ponding, which indicates improper drainage, a clogged system, or excessive water use. The presence of damp or soggy areas or odors may indicate a leak in the system.

SEPTIC TANK

A properly designed septic system will have a septic tank with sufficient volume to accumulate solids for several years. As the level of solids rises in the tank, the wastewater has less time to settle properly and suspended solid particles flow into the absorption field. If the tank is not periodically pumped out, these solids will eventually clog the absorption field to the point where a new field will be needed.

When the tank is pumped, the contractor should pump the contents through the manhole, which is usually located in the center of the tank, rather than through the inspection ports. Pumping through one of the inspection ports could damage the baffles inside the tank (see Figure 1). Damage to the baffles could result in the wastewater flowing directly into the absorption field without the opportunity for the solids to settle.

Remember, commercial septic tank additives do not eliminate the need for periodic pumping and may be harmful to the absorption field. You should check your local health department regulations before using additives. Be sure when the septic tank is pumped that it is completely emptied. It is not necessary to retain any of the solids to restart the digestive process. You do not need biological or chemical additives for successful restart or continuous operation of your septic system, nor should you wash or disinfect the tank after having it pumped.



Cross-section of a two-compartment septic tank being pumped **Fig. 1**

When to Have Your Septic Tank Pumped

A specific determination of when it's time to pump out the solids can be made by having the depth of solids and level of scum buildup on top of the wastewater in the septic tank checked periodically. Two factors affect how often you should have your septic tank pumped. Whether you need to have your tank pumped every year, once every five years, or some other time interval is affected by these factors. The first factor is the size or capacity of the tank itself. If more people are living in the home than when the system was installed, or if new high water use appliances or technologies such as a hot tub or whirlpool bath are now in use, then the capacity may be too small. The more people using a system, the faster the solids will accumulate in the tank, and the more frequently the tank will need to be pumped. Also, the additional surge of water from hot tubs and whirlpool baths may wash solids out of the tank and into the absorption field. An inspection can determine whether the system is of adequate capacity to handle the volume of solids and flow from the number of people in the household and types of appliances used. A larger capacity system provides better treatment and requires less pumping.

The second factor is the volume of solids in the wastewater. If you have a garbage disposal, for example, you will have to pump out your system more frequently than persons disposing of their food wastes through other means. The use of a garbage disposal may increase the amount of solids in the septic tank by as much as 50 percent. Excessively soiled clothes may add solids to your septic tank. Sometimes, geographical location may also contribute to extra solids ending up in the septic tank. For example, systems in coastal areas may have an accumulation of sand in the septic tank from washing beach clothes.

Reducing the Flow of Wastewater

Generally, the more people, the more water will flow through the system. However, the use of water conservation devices such as low-flow toilets or shower fixtures greatly reduces the amount of wastewater thus prolonging the life of your septic system. For example, up to 53 gallons of water are discharged into your system with each load of laundry. If several loads are done in one day, it can put considerable stress on your system. A better practice would be to space your laundry washing throughout the week.

The new ultra low-flush toilets use between 1 and 1.6 gallons of water per flush and will provide as much as a 30 percent water savings. Low-flow faucet aerators on sink faucets and low-flow showerheads will save additional water. There are also low-flow washing machines which use much less water than standard washing machines.

ABSORPTION FIELD

An absorption field generally does not require any maintenance. However, to protect and prolong the life of the absorption field, follow these simple rules:

- Plant only grass over and near your septic system. Roots from nearby trees or shrubs may clog and damage the absorption field.
- Do not drive or park over any part of your septic system. This can compact the soil and crush your system.
- Direct all wastewater from your home into the septic tank. This includes all sink, bath, shower, toilet, washing machine and dishwasher wastewaters. Any of these wastewaters can contain disease-causing microorganisms or environmental pollutants.
- Keep roof drains, basement sump pump drains, and other rainwater or surface water drainage systems away from the absorption field. Flooding of the absorption field with excessive water will keep the soil from naturally cleansing the wastewater, which can lead to groundwater and/or nearby surface water pollution.

continued . . .

Appendix A-3: Monitoring Wastewater Characteristics

Many methods can be used to monitor an onsite wastewater treatment system's performance. They vary from something as simple as checking for sewage on the soil surface, to complicated laboratory analysis.

Costs vary from lab to lab, but estimates are given. Be sure to contact the lab prior to dropping off samples.

Certified Labs

When choosing a lab to perform analysis of wastewater characteristics, a certified lab is required, because these labs use approved standard methods and procedures. The Iowa Department of Natural Resources maintains a list of labs across Iowa that are certified. This can be found on their web site at **http://www.uhl.uiowa.edu/ClientLink/index.html** under Environmental Laboratory Certification Reports

Sampling Location

There are many locations where samples can be taken. It is best if the sample locations are determined when the system is being designed, and then built in. Effluent chambers, pump tanks and sampling ports are suggested locations for obtaining samples.

Some obvious locations where the wastewater characteristics are of interest are

- as it leaves the home
- as it leaves the tank
- at system's "end-of-pipe"
- in groundwater (lysimeter, sampling wells)
- in soil (dry gram soil/microgram fecal)

Piezometers can be used to determine the amount of separation but are not to be used to sample groundwater. Lysimeters or soil access ports can be used to determine the amount of fecal coliform bacteria under system.

Monitored Parameters

container: plastic amount: 500 mL max holding time: 24 hr

Biochemical Oxygen Demand (BOD) is a measurement of the dissolved oxygen used by microorganisms in the oxidation of organic matter in sewage in five days, and is the most widely used parameter applied to wastewater. Tests for BOD must be run within 24 hours of taking the sample because the value will change as microorganisms in the sample continue to metabolize organic matter and use up the dissolved oxygen. An average cost for a BOD test is $30. A minimum of 500 milliliters is required to run the test. A typical BOD value for septic tank effluent is 175-220 milligrams per liter.

Color is an indication of how “clean” the wastewater is. A black sample represents wastewater that is anaerobic and still needs significant treatment. A clear sample indicates that BOD and TSS have been minimized. A cloudy gray sample indicates that the septic tank is not operating properly. Properly operating aerobic treatment units will produce a chocolatey brown sample.

test on site

Dissolved oxygen (DO) is a measure to determine how much oxygen is in wastewater. The maximum level of DO in water is 12 milligrams per liter. Septic tanks usually have very low values of DO because the microorganisms in the septic tank use up all oxygen initially present. A typical value for DO in a septic tank is one milligram per liter. This can be measured with a probe or using a kit a that evaluates the DO by comparing the color of a sample after a chemical is added. The DO must be measured when the sample is taken or soon after because the level will decrease over time. DO testing kits cost about $30 and contain reagents for about 30 tests.

container: sterile bag such as “Whirl-Pak” amount: 50mL max holding time: 6 hr

Fecal coliform bacteria are an indicator organisms. Many of the pathogenic organisms present in wastewater are difficult to isolate and identify. However, the human intestinal tract contains countless coliform bacteria, which are easy to detect. The presence of fecal coliform is an indication that other pathogenic organisms are likely to be present. The number of fecal coliform bacteria will change over time; therefore a fecal coliform test must be run within six hours of taking the sample. An average cost for a fecal coliform test is $16. A 500-milliliter* sample is sufficient. An average value for septic tank effluent is 1,000,000 organisms/100 milliliters.

** The volume of sample need for the tests is determined by the testing facility. They may need more or less than this specified amount.*

container: glass amount: 1 quart max holding time: 28 days at pH < 2 and 4 degrees C

Fats, oils, and greases (FOG) are added to wastewater through the use of butter, lard, margarine, vegetable oil, and meat. A typical value for FOG from a septic tank is 20 milligrams per liter. A restaurant can produce very high values, often greater than 100 milligrams per liter. A quart or more of the effluent is required to run this test. An average cost of this test is $30. The cost is relatively high because of the chemicals required for this test.

container: plastic amount: 100 mL max holding time: 28 days at 4 degrees C

Nitrogen is a nutrient essential to the growth of plants and microorganisms. High levels can be toxic to humans. If it reaches surface water in the form of ammonia, it is toxic to fish. Wastewater naturally contains fairly high levels of nitrogen. A typical level of nitrogen in septic tank effluent is 40 milligrams per liter. A 100-milliliter sample should be sufficient for a nitrogen test. An average cost for a nitrogen test is $15.

container: plastic amount: 100 mL max holding time: 28 days at pH < 2 and 4 degrees C

Phosphorous is a nutrient essential to the growth of plants and microorganisms. This nutrient causes increased growth of aquatic vegetation in surface waters. A typical value for septic tank effluent is seven milligrams per liter of phosphorous. A sample of at least 100 millilters is needed. An average cost for a total phosphorous test is $15.

container: plastic amount: 100 mL max holding time: 7 days at 4 degrees C

Total Suspended Solids (TSS) is a measure of the organic and inorganic solids that remain in wastewater after separation occurs in the septic tank. One way to test for TSS is to measure turbidity, or the amount of light transmitted through the sample. This can be done in the field or at a lab. An average suspended solids value of septic tank effluent is 65 milligrams per liter. A 100-millilter sample is needed. An average cost for a TSS test, either a turbidity test or a different kind of analysis, is $15.

check temperature on site

Temperature of wastewater is a very important parameter because of its effect on chemical reactions. Temperature of wastewater varies from 45F to 70F depending on the season. Wastewater temperature is usually not a problem for individual residences, but very low or very high temperatures can be a problem for restaurants and infrequently-used homes. The temperature of the wastewater must be measured immediately upon taking the sample.

check for odor on site

Odor. A strong is often detected when a system is not performing properly.

check meter on site or remotely

Flow meters are used to measure the volume of wastewater going to an on-site system. They are usually located in the basement; flow can also be calculated from pump cycle or tipping bucket data.

Appendix A-4: Definitions

These definitions were taken from several sources and we wish the thank the following:

Gregg A. Eckhardt, eckhardt@txdirect.net

References definitions were adapted from

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2. Hoover, M.T., T.A. Disy, M.A. Pfeiffer, N. Dudley, R.B. Mayer, and B. Buffington. 1996. North Carolina subsurface wastewater system operators training school manual. Soil Science Department, College of Agriculture and Life Sciences, North Carolina State University, Raleigh, NC and North Carolina Department of Environment, Health, and Natural Resources, Raleigh, NC.

3. Kahn, L., B. Allen, and J. Jones. 2000. *The Septic System Owner's Manual.* Bolinas, CA: Shelter Publications .

4. Trotta, P., J. Ramsey, and S. Hoban. 2000. The basics and fundamentals of onsite wastewater treatment course. Flagstaff, AZ: Northern Arizona University.

5. Arizona Department of Environmental Quality. Aquifer Protection Permits. R18-9-101. January 1, 2001. Phoenix, AZ: ADEQ.

6. Burks, B.D. and M.M. Minnis. 1994. *Onsite Wastewater Treatment Systems*. Madison, WI: Hogarth House, Ltd.

Administrative Authority - is the local board of health as authorized by Iowa Code section 455B.172 and 567--Chapter 137.

abandoned well -a well which is no longer used. In many places, abandoned wells must be filled with approved sealing material to prevent pollution of ground water bodies.

absorb - to take in.

absorption-The process by which one substance is physically taken into and included with another substance. [3]

acute toxicity - Exposure that will result in significant response shortly after exposure (typically a response is observed within 48 or 96 hours). [1]

adhesion - the molecular attraction asserted between the surfaces of bodies in contact. Compare cohesion.

administrative authority - is the local board of health as authorized by Iowa Code Section 455B.172 and 567--Chapter 137.

adsorption - the adhesion of a substance to the surface of a solid or liquid. Adsorption is often used to extract pollutants by causing them to be attached to such adsorbents as activated carbon or silica gel.

advanced treatment -Removal of dissolved and suspended materials remaining after normal biological treatment when required for water reuse or for the control of eutrophication in receiving waters. [1]

aeration - the mixing or turbulent exposure of water to air and oxygen to stimulate breakdown in the waste stream, or to dissipate volatile contaminants and other pollutants into the air.

aerobic - Growing in the presence of oxygen, as in aerobic bacteria or aerobic treatment. [2]

aerobic treatment unit - A container of various configurations that provides for aerobic degradation or decomposition of wastewater constituents by bringing the wastewater into direct contact with air by some mechanical means. [4]

alluvium - sediments deposited by erosional processes, usually by streams.

alternative system - An onsite sewage system other than a conventional gravity system or a conventional pressure distribution system. Properly operated and maintained alternative systems provide equivalent or enhanced treatment performance as compared to conventional gravity systems. [4]

anaerobic - Growing in the absence of oxygen, as in anaerobic bacteria in a septic tank. [2]

anoxic process - The process by which nitrate-nitrogen is converted biologically to nitrogen gas in the absence of oxygen. The process is also known as anoxic denitrification. [1]

approved - A written statement of acceptability, in terms of the requirements in local and state regulations issued by the local health officer. [4]

approved list - A list of approved systems and products, developed by local health departments which may contain the following: list of proprietary devices approved by the department; list of specific systems meeting Treatment Standard 1 and Treatment Standard 2; list of experimental systems approved by the department; and list of septic tanks, pump chambers, and holding tanks approved by the department. [4]

aquifer - a geologic formation that will yield water to a well in sufficient quantities to make the production of water from this formation feasible for beneficial use; permeable layers of underground rock or sand that hold or transmit groundwater below the water table.

area drain - means a drain installed to collect surface or storm water from an open area of a building or property.

artesian aquifer - a geologic formation in which water is under sufficient hydrostatic pressure to be discharged to the surface without pumping.

artesian well - a water well drilled into a confined aquifer where enough hydraulic pressure exists for the water to flow to the surface without pumping.

attached-growth processes - Biological treatment processes in which the microorganisms responsible for the conversion of the organic matter or other constituents in the wastewater to gases and cell tissue are attached to some inert medium, such as rocks, slag, or specifically designed ceramic or plastic materials. Attached-growth treatment processes are also known as fixed-film processes. [1]

at-grade – this is an above ground pressure distribution system. This is similar to a mound without the sand.

baffles - Deflectors, vanes, guides, grids, gratings, or similar devices constructed or placed in flowing water, wastewater, or slurry systems as a check or to effect a more uniform distribution of velocities; absorb energy; divert, guide, or agitate the liquids; and check eddies. [3]

ball valve - A simple non-return valve consisting of a ball resting on a cylindrical seat within a fluid passageway. [3]

biochemical oxygen demand (BOD) - A standard test that measures the strength of wastewater by determining the quantity of oxygen that is naturally consumed by the wastewater under standard conditions. Generally it is measured in mg/L. [2]

biological filter - A bed of sand, gravel, broken stone, peat moss or other medium through which wastewater flows or trickles, which depends on biological action for effectiveness. [3]

biomat - The *biological mat* (biomat) is a black, jelly-like mat about one to two inches thick, that forms at the gravel-soil interface at the bottom and sidewalls of the drainfield trench. The biomat is composed of microorganisms (and their byproducts) that anchor themselves to soil and rock particles, and whose food is the organic matter in the septic tank effluent. Since the biomat has a low permeability, it increases contact time, so the microorganisms can break down the wastewater to provide effluent treatment. Also known as a clogging mat.[3]

biosolids - a nutrient-rich organic material resulting from the treatment of wastewater. Biosolids contain nitrogen and phosphorus along with other supplementary nutrients in smaller doses, such as potassium, sulfur, magnesium, calcium, copper and zinc. The application of biosolids to land improves soil properties and plant productivity, and reduces dependence on inorganic fertilizers.

blackwater - That portion of the wastewater stream that originates from toilets. It includes feces, urine, and associated flush waters. [4]

BOD - Biochemical Oxygen Demand. A measure of the amount of oxygen required to neutralize organic wastes, oxidize inorganic material and nitrogen.

building drain - is that part of the lowest horizontal piping of a house drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of any building and conveys the same to the building sewer.

building sewer - is that part of the horizontal piping from the building wall to its connection with the main sewer or the primary treatment portion of an on-site wastewater treatment and disposal system conveying the drainage of one building site.

buoyancy - the tendency of a body to float or rise when immersed in a fluid; the power of a fluid to exert an upward force on a body placed in it.

calcium carbonate - CACO3 - a white precipitate that forms in water lines, water heaters and boilers in hard water areas; also known as scale.

capillary zone - soil area above the water table where water can rise up slightly through the cohesive force of capillary action. See phreatophytes.

carbonates - the collective term for the natural inorganic chemical compounds related to carbon dioxide that exist in natural waterways.

cesspool - A lined or partially lined underground pit into which raw household wastewater is discharged and from which the liquid seeps into the surrounding soil. Sometimes called *leaching cesspool*. [3]

CFU - colony forming units.

chamber system - is a buried structure, typically with a domed or arched top, providing at least a six-inch height of sidewall soil exposure, creating a covered open space above a buried soil infiltrative surface.

chemical oxygen demand (COD) - A standard test that measures the amount of the organic matter in wastewater that can be oxidized (burned up) by a very strong chemical oxidant. [2]

chlorination - the adding of chlorine to water or sewage for the purpose of disinfection or other biological or chemical results.

chlorine demand - the difference between the amount of chlorine added to water, sewage, or industrial wastes and the amount of residual chlorine remaining at the end of a specific contact period. Compare residual chlorine.

chronic toxicity - Exposure that will result in sublethal response over a long term, often one-tenth of the life span or more. [1]

cistern - a tank used to collect rainwater runoff from the roof of a house or building.

clarification - Any process or combination of processes, the primary purpose of which is to reduce the concentration of suspended matter in a liquid. Term formerly used as a synonym of *settling* or *sedimentation*. In recent years, the latter terms are preferable when describing the settling process. [3]

cleanout - Any structure or device which is designed to provide access for the purpose of removing deposited or accumulated materials. [3]

clogging mat - See biomat.

cohesion - a molecular attraction by which the particles of a body are united throughout the mass whether like or unlike. Compare adhesion.

coliform – A family of bacteria. The presence of coliform bacteria is an indication of possible pathogenic bacterial contamination. *Fecal coliforms* are those coliforms found in the feces of various warm-blooded animals, whereas the term *coliform* also includes other non-pathogenic species. [2]

coliform bacteria – A family of non-pathogenic and pathogenic microorganisms.

combined sewer - a sewer system that carries both sanitary sewage and stormwater runoff. When sewers are constructed this way, wastewater treatment plants have to be sized to deal with stormwater flows and oftentimes some of the water receives little or no treatment. Compare separate sewer.

composite sample, weighted - a sample composed of two or more portions collected at specific times and added together in volumes related to the flow at time of collection. Compare grab sample.

concentration - amount of a chemical or pollutant in a particular volume or weight of air, water, soil, or other medium.

conduit - a natural or artificial channel through which fluids may be conveyed.

cone of depression - natural depression in the water table around a pumping well.

confined aquifer - an aquifer that lies between two relatively impermeable sedimentary layers.

confluent growth - in coliform testing, abundant or overflowing bacterial growth which makes accurate measurement difficult or impossible.

consolidated formation - naturally occurring geologic formations that have been lithified (turned to stone). The term is sometimes used interchangeably with the term "bedrock." Commonly, these formations will stand at the edges of a bore hole without caving.

constituents - Individual components, elements, or biological entities such as suspended solids or ammonia nitrogen. [1]

contaminants - Constituents added to the water supply through use. [1]

conventional gravity system - An onsite sewage system consisting of a septic tank and a subsurface soil absorption system with gravity distribution of the effluent [4]

creeping (progressive) failure - A condition in aging wastewater systems where the biomat becomes so intensely developed that no water can flow through it eventually causing system malfunction. Another definition is: The formation of the biomat in a gravity distribution system where the biomat becomes overdeveloped at the beginning of the trenches (through hydraulic overloading), which forces the wastewater to travel further and farther down the trenches to be dispersed. Once the biomat has overdeveloped along the entire distance, system malfunction occurs. [2]]

cubic feet per second (CFS) - the rate of discharge representing a volume of one cubic foot passing a given point during 1 second. This rate is equivalent to approximately 7.48 gallons per second, or 1.98 acre-feet per day.

current - the portion of a stream or body of water which is moving with a velocity much greater than the average of the rest of the water. The progress of the water is principally concentrated in the current. See thalweg.

denitrification - The anaerobic biological reduction of nitrate-nitrogen to nitrogen gas. Also removal of total nitrogen from a system. [3]

deposit - something dropped or left behind by moving water, as sand or mud.

design life - The estimated length of time before the system will have to be replaced or rehabilitated. [6]

detection limit - the lowest level that can be determined by a specific analytical procedure or test method.

detention time - The period of time that a water or wastewater flow is retained in a basin, tank, or reservoir for storage or completion of physical, chemical, or biological reaction. [3]

discharge - the volume of water that passes a given point within a given period of time. It is an all-inclusive outflow term, describing a variety of flows such as from a pipe to a stream, or from a stream to a lake or ocean.

discharge permit - a permit issued by the Iowa Department of Natural Resources that allows the discharge of treated effluent into waters of the State or the United States.

disinfection – the process of destroying pathogenic organisms in water and wastewater. Usually accomplished by introduction of chlorine, but more and more facilities are using exposure to ultraviolet radiation, which renders the bacteria sterile.

disinfection byproducts - halogenated organic chemicals formed when water is disinfected.

dispersion - the movement and spreading of contaminants out and down in an aquifer.

displacement - distance by which portions of the same geological layer are offset from each other by a fault.

dissolved oxygen - The concentration of oxygen (normally a gas) dissolved in water. It is a function of temperature and pressure. The colder the water, the more oxygen it will hold. In general, fish require 5.0 mg/L in a stream. [2]

distribution box - is a structure designed to accomplish the equal distribution of wastewater to two or more soil absorption trenches.

domestic wastewater - Wastewater that is generated from sanitary fixtures and appliances, food handling, etc. [2]

drain pipes - A pipe or conduit that carries untreated runoff water to nearby waterways to reduce flooding of pavements. Not to be confused with sewers which carry wastewater. [2]

drainage ditch - is any watercourse meeting the classification of a "general use segment" under rule 567--61.3(455B) which includes intermittent watercourses and those watercourses which typically flow only for short periods of time following precipitation in the immediate locality and whose channels are normally above the water table.

drip irrigation - is a form of subsurface soil absorption using shallow pressure distribution with low pressure drip emitters.

drop box - is a structure to divert wastewater flow into a soil absorption trench until the trench is filled to a set level, then allow any additional waste, which is not absorbed by that trench, to flow to the next drop box or soil absorption trench.

drywell - A well which is a bored, drilled, or driven shaft or hole whose depth is greater than its width and is designed and constructed specifically for the disposal of storm water. [5]

dwelling means any house or place used or intended to be used by humans as a place of residence.

effluent - Wastewater, partially or completely treated, flowing out of a reservoir, tank, treatment component, or disposal component. [4]

enteric viruses - a category of viruses related to human excreta.

EPA - Environmental Protection Agency

eutrophication - The process by which a waterbody becomes over-enriched with nutrients. While this is a naturally-occurring process, it can be accelerated by human activities and generally results in a less-diversified and less-desirable waterbody. [2]

facultative processes - Biological treatment processes in which the organisms can function in the presence or absence of molecular oxygen. [1]

failure - Inability of water to penetrate the soil. [6]

fecal coliform - Indicator bacteria common to the digestive systems of warm-blooded animal that is cultured in standard tests to indicate contamination from sewage or level of disinfection. Generally measured as colonies/100 mL. [2]

fill soil - means clean soil, free of debris or large organic material, which has been mechanically moved onto a site and has been in place for less than one year.

fixed-film processes - See attached-growth processes.

flocculate - To cause particles to form small lumps or masses. [3]

flow rate (or discharge or "Q") - Minimum design pumping rate required to deliver effluent to a wastewater system uniformly. [2]

foundation drain - the portion of a building drainage system provided to drain groundwater from the outside of the foundation or over or under the basement floor. It is not connected to the building drain.

free access filter (open filter) - means an intermittent sand filter constructed within the natural soil or above the ground surface with access to the distributor pipes and top of the filter media for maintenance and media replacement.

french drain - An underground passageway for water through the interstices among stones placed loosely in a trench. [3]

grab sample - a sample taken at a given place and time. Compare composite sample.

gravel - means stone screened from river sand or quarried. Concrete aggregate designated as Class II by the department of transportation is acceptable for use in wastewater systems.

gravelless pipe system - means an absorption system comprised of large diameter (8 and 10 inches) corrugated plastic pipe, perforated with holes on a 120-degree arc centered on the bottom, wrapped in a sheath of geotextile filter wrap and installed level in a trench without gravel bedding or cover.

grease interceptor (trap) - In plumbing, a receptacle designed to collect and retain grease and fatty substances normally found in kitchen or similar wastes. It is installed in the drainage system between the kitchen or other point of production of the waste and the building sewer. [3]

greywater - That portion of the wastewater stream that originates in sinks, tubs, showers, laundry; i.e., all portions of the wastewater stream excluding toilet wastes. [4]

groundwater - water within the earth that supplies wells and springs; water in the zone of saturation where all openings in rocks and soil are filled, the upper surface of which forms the water table.

hardpan - a shallow layer of earth material which has become relatively hard and impermeable.

hydraulic Failure- The user is putting more water into the treatment unit than the unit was designed to treat.

hydraulic loading rate – the rate at which the soil will accept water or wastewater.

impermeable - material that does not permit fluids to pass through.

impervious - the quality or state of being impermeable; resisting penetration by water or plant roots. Impervious ground cover like concrete and asphalt affects quantity and quality of runoff.

indicator organisms - microorganisms, such as coliforms, that indicate the presence of pollution or potentially harmful microorganisms.

indicator tests - tests for a specific contaminant, group of contaminants, or constituent which signals the presence of something else (ex., coliforms indicate the possible presence of pathogenic organisms).

individual mechanical aerobic wastewater treatment system - means an individual wastewater treatment and disposal system employing bacterial action which is maintained by the utilization of air or oxygen and includes the aeration plant and equipment and the method of final effluent disposal.

industrial wastewater - Wastewater from industrial processes or contaminated with wastewater from industrial processes. This does not fall under Chapter 69 and requires a permit from the State. [2]

infiltration - The flow or movement of water through the interstices of pores of soil or other porous medium.[3] (2) Groundwater seeping into a collection system. [2]

inflow - Direct rainflow, such as rooftop drains, into a collection system. [2]

influent - Wastewater, partially or completely treated, or in its natural state (raw wastewater) that flows into a reservoir, tank, treatment component, or disposal component. [4]

inorganic - The minerals, salts, etc. present in wastewater not attributed to carbon molecules. Examples include iron, silver, lead, sodium. [2]

intermittent sand filters - are beds of granular materials 24 to 36 inches deep underlain by graded gravel and collecting tile. Wastewater is applied intermittently to the surface of the bed through distribution pipes or troughs and the bed is underdrained to collect and discharge the final effluent. Uniform distribution is normally obtained by dosing so as to flood the entire surface of the bed. Filters may be designed to provide free access (open filters), or may be buried in the ground (buried filters or subsurface sand filters).

lagoon - a shallow pond where sunlight, bacterial action, and oxygen work to purify wastewater. Lagoons are typically used for the storage of wastewaters, sludges, or liquid wastes.

lake - means a natural or man-made impoundment of water with more than one acre of water surface area at the high water level.

leachate - water containing contaminants which leaks from a disposal site such as a landfill or dump.

limiting layer - means bedrock, seasonally high groundwater level, or any layer of soil with a stabilized percolation rate exceeding 60 minutes for the water to fall one inch, or a soil loading rate less than 0.3 gpsf.

low pressure pipe (LPP) - Lateral 1" - 2" pipe with small orifices (5/32" - 1/4") through which effluent is distributed to trench under low pressure (2 to 5 feet of head). [2]

mastic - Any of various pasty materials used as protective coatings or cements. [3]

MCL - Maximum Contaminant Level - the maximum level of a contaminant allowed in water by federal law. Based on health effects and currently available treatment methods.

mermaid- a fabled marine creature usually represented as having the head, trunk, and arms of a woman and the lower part like a tail of a fish.

micrograms per liter - Ug/L - micrograms per liter of water. Is usually used when concentration is less than 0.1 mg/L. One thousands micrograms per liter is equivalent to 1 milligram per liter. This measure is equivalent to parts per billion (ppb)

milligrams per liter - mg/L - milligrams per liter of water. This measure is equivalent to parts per million (ppm).

mound system - is an above-ground system used to treat effluents from septic tanks in cases where a limiting layer or limited land area prohibits the use of conventional subsurface absorption systems. A mound is a hybrid sand filter placed on top of the soil and after the wastewater is treated in the sand filter the water is dispersed into the soil.

municipal sewage - sewage from a community which may be composed of domestic sewage, industrial wastes or both.

nitrification - The oxidation of ammonia-nitrogen to nitrate-nitrogen in wastewater by biological or chemical reactions. [3]

nitrogen - a plant nutrient that can cause an overabundance of bacterial and algael growth, leading to a depletion of oxygen and fish kills. Several forms occur in water, including ammonia, nitrate, nitrite or elemental nitrogen. High levels of nitrogen in water are usually caused by agricultural runoff or improperly operating wastewater treatment plants. Also see phosphorous.

nonconsumptive use - using water in a way that does not reduce the supply. Examples include hunting, fishing, boating, water-skiing, swimming, and some power production. Compare consumptive use.

nonpoint source - source of pollution in which wastes are not released at one specific, identifiable point but from a number of points that are spread out and difficult to identify and control. Onsite wastewater systems are considered to be nonpoint sources of pollution. Compare point source.

nonpotable - not suitable for drinking. Compare potable.

NPDES permit - permit issued under the National Pollutant Discharge Elimination System for open discharge systems, issued by the Iowa Department of Natural resources.

nutrients - The minerals and other materials that provide food for living organisms. Traditionally, nitrogen, phosphorous, and potassium are thought of as the most important elemental nutrients for streams and lakes. [2] As a pollant, any element or compound, such as phosphorous or nitrogen, that fuels abnormally high organic aquatic ecosystems. Also see eutrophic.

on-site wastewater treatment and disposal system - means all equipment and devices necessary for proper conduction, collection, storage, treatment, and disposal of wastewater from four or fewer dwelling units or other facility serving the equivalent of 15 persons (1,500 gpd) or less. This includes domestic waste whether residential or nonresidential but does not include industrial waste of any flow rate. Included within the scope of this definition are building sewers, septic tanks, subsurface absorption systems, above-ground (mound & at-grade) systems, sand filters, constructed wetlands and individual mechanical/aerobic wastewater treatment systems.

onsite wastewater treatment facility (sewage system) - An integrated arrangement of components for a residence, building, industrial establishment, or other places not connected to a public sewer system which: conveys, stores, treats, and/or provides subsurface soil treatment and disposal on the property where it originates or upon adjacent or nearby property; and includes piping, treatment devices, other accessories, and soil underlying the disposal component of the initial and reserve areas. [4]

organic - The molecules, cells, etc. in wastewater from living organisms based on elemental carbon. [2]

organic chemicals - chemicals containing carbon.

orifice - Discharge hole in low pressure lateral or pressure manifold. [2]

outfall - the place where a wastewater treatment plant discharges treated water into the environment.

outwash - a deposit of sand and gravel formed by streams of meltwater flowing from a glacier.

parameter - A measurable factor such as temperature. [1]

pathogens - Organisms that cause disease. Examples in wastewater include Salmonella, Vibro Cholera, and Entamoeba histolytica. [2]

perched water table - groundwater standing unprotected over a confined zone.

percolation - the movement of water through the soil profile, usually continuing downward to the groundwater.

percolation test - is a falling water level procedure used to determine the ability of soils to absorb primary treated wastewater. (See Section B- Appendix B.)

permeability - the ability of a material to transmit water. It is measured by the quantity of water passing through a unit cross section, in a unit time, under 100 percent hydraulic gradient.

permeable - Having pores or openings that permit liquids or gases to pass through. [3]

pH - numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases). Technically speaking, pH is the logarithm of the reciprocal (negative log) of the hydrogen ion concentration (hydrogen ion activity) in moles per liter.

phosphorous - a plant nutrient that can cause an overabundance of bacteria and algae growth, leading to a depletion of oxygen and fish kills. High levels of phosphorous in water are usually caused by agricultural runoff or improperly operating wastewater treatment plants. Also see nitrogen.

physical weathering - breaking down of parent rock into bits and pieces by exposure to temperature and changes and the physical action of moving ice and water, growing roots, and human activities such as farming and construction. Compare chemical weathering.

phytoplankton - free-floating, mostly microscopic aquatic plants.

piezometric surface - the imaginary surface to which groundwater rises under hydrostatic pressure in wells or springs.

plankton - microscopic floating plant and animal organisms of lakes, rivers, and oceans.

plug - cement, grout, or other material used to fill and seal a hole drilled for a water well.

plume - the area taken up by contaminant(s) in an aquifer.

point source - source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant. Compare nonpoint source.

pollution - undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that can harmfully affect the health, survival, or activities of humans or other living organisms.

pond - an impoundment of water with a water surface area of one acre or less at the high water level.

porous - something which allows water to pass through it. Compare nonporous.

potable - suitable, safe, or prepared for drinking. Compare non-potable.

ppb - parts per billion - number of parts of a chemical found in one billion parts of a solid, liquid, or gaseous mixture. Equivalent to micrograms per liter (Ug/L).

ppm - parts per million - number of parts of a chemical found in one million parts of a solid, liquid, or gaseous mixture. Equivalent to milligrams per liter (mg/L).

preservative - a chemical added to a water sample to keep it stable and prevent compounds in it from changing to other forms or to prevent microorganism densities from changing prior to analysis. Controlling the temperature can also be a form of perservation.

pressure distribution - the equal distribution of effluent throughout a trench or bed by pumping of effluent through a system of pipes.

primary treatment - treatment in which solids and greases/oils are separated out and suspended solids in the sewage settle out as sludge. This is typically the septic tank. Compare secondary treatment, tertiary treatment.

professional soil analysis - a knowledgeable person evaluating the soil factors, such as color, texture, limiting layers and structure, in order to determine a wastewater loading rate for the soil and appropriate system design. Demonstrated training and experience in soil morphology (testing absorption qualities of soil by the physical examination of the soil's color, mottling, texture, structure, topography and hillslope position) shall be required to perform a professional soil analysis.

pump - a device which moves, compresses, or alters the pressure of a fluid, such as water or air, being conveyed through a natural or artificial channel.

pump chamber - A storage tank or compartment following the septic tank into which a pump and floats are installed. Effluent is pumped from the pump chamber to the disposal component of the wastewater system. In certain types of pressure distribution systems, this may also be called a "surge tank." If a siphon is used in lieu of a pump, this will be called a "siphon chamber.". [4]]

rain - water drops which fall to the earth from the air.

RCRA - Resource Conservation and Recovery Act - federal legislation requiring that hazardous waste be tracked from "cradle" (generation) to "grave" (disposal).

receiving waters - a river, ocean, stream, or other watercourse into which wastewater or treated effluent is discharged.

recharge - refers to water entering an underground aquifer through faults, fractures, or direct absorption.

reclaimed water - domestic wastewater that is under the direct control of a treatment plant owner/operator which has been treated to a quality suitable for a beneficial use.

reserve area - An area of land approved for the installation of a conforming wastewater system and dedicated for replacement of the onsite sewage system upon its failure. [4]

residual chlorine - the available chlorine which remains in solution after the demand has been satisfied. Compare chlorine demand.

restrictive layer - A stratum impeding the vertical movement of water, air, and growth of plant roots, such as hardpan, clay pan, fragipan, caliche, some compacted soils, bedrock, and unstructured clay soils. [4] [4]

reverse osmosis - a water treatment method whereby water is forced through a semipermeable membrane which filters out impurities.

roof drain - is a drain installed to receive water collecting on the surface of a roof and discharging into an area or storm drain system.

sanitary landfill - landfill that is lined with plastic or concrete or located in clay-rich soils to prevent hazardous substances from leaking into the environment.

saturation - the condition of a liquid when it has taken into solution the maximum possible quantity of a given substance at a given temperature and pressure.

scum (cake) - A layer of wastewater particles (comprised of grease/fats/oils) floating on the liquid surface in a septic tank. [3]

seal - the impermeable material, such as cement grout or bentonite placed in the annular space between the borehole wall and the casing of a water well to prevent the downhole movement of surface water or the vertical mixing of distinct aquifers.

secondary treatment system - is a system which provides biological treatment of the effluent from septic tanks or other primary treatment units to meet minimum effluent standards as required in these rules and NPDES General Permit No. 4. Examples include soil absorption systems, sand filters, above ground systems, mechanical/aerobic systems, or other systems providing equivalent treatment.

sediment - soil particles, sand, and minerals washed from the land into aquatic systems as a result of natural and human activities.

seep - a spot where water contained in the ground oozes slowly to the surface and often forms a pool; a small spring.

septage - The semi-liquid material that is pumped out of septic (or interceptor) tanks, consisting of liquid, scum, and sludge. [2]

septic tank - A water-tight primary treatment device that receives the discharge of sewage from a building sewer or sewers, designed and constructed to permit separation of settleable and floating solids from the liquid and detention and anaerobic digestion of the organic matter prior to discharge of the liquid. [4]

setback – in Iowa, setback refers to a terminology that means a minimum horizontal distance between compoents of a wastewater system and potential point of impact. [5]

settable solids - in sewage, solids that will settle when the sewage is brought to a quiet state for a reasonable length of time, usually two hours.

settleable solids - Suspended solids, in mL/L, that will settle out of suspension within a specified period of time. [1]

sewage – Untreated or partially treated wastes from toilets, baths, sinks, lavatories, laundries, and other plumbing fixtures in places of human habitation, employment, or recreation. [5]

Sewage wastewater - is the water-carried waste derived from ordinary living processes.

sewer - A pipe or conduit that carries wastewater. Not to be confused with drain pipes or other conveyances that carry water.

siltation - the deposition of finely divided soil and rock particles upon the bottom of stream and river beds and reservoirs.

sludge - solid matter that settles to the bottom of septic tanks and must be disposed of by digestion or other methods.

soil absorption capacity - In subsurface effluent disposal, the ability of the soil to absorb water. [3]

soil erosion - the processes by which soil is removed from one place by forces such as wind, water, waves, glaciers, and construction activity and eventually deposited at some new place.

spray irrigation - application of finely divided water droplets to using artificial means.

spring - an issue of water from the earth; a natural fountain; a source of a body or reservoir of water.

stream - means any watercourse listed as being a "designated use segment" which includes any watercourse which maintains flow throughout the year, or contains sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community of significance.

stream segment - refers to the surface waters of an approved planning area exhibiting common biological, chemical, hydrological, natural, and physical characteristics and processes. Segments will normally exhibit common reactions to external stress such as discharge or pollutants.

sublimation - subsidence sinking down of part of the earth's crust due to underground excavation, such as groundwater removal.

subsurface soil absorption system - A system of trenches of three feet or less in width, or beds between three and ten feet in width, containing distribution pipe within a layer of clean gravel designed and installed in original, undisturbed soil for the purpose of receiving effluent, treating it, and transmitting it into the soil. Also known as leach fields, drainfields, and absorption fields.

surface irrigation - application of water by means other than spraying such that contact between the edible portion of any food crop and the irrigation water is prevented.

surface water - water that flows in streams and rivers and in natural lakes, in wetlands, and in reservoirs constructed by humans.

suspended-growth processes - Biological treatment processes in which the microorganisms responsible for the conversion of the organic matter or other constituents in the wastewater to gases and cell tissue are maintained in suspension within the liquid. [1]

TDS - total dissolved solids - the sum or all inorganic and organic particulate material. TDS is an indicator test used for wastewater analysis and is also a measure of the mineral content of bottled water and groundwater. There is a relationship between TDS and conductivity. See specific conductance.

technology-based treatment requirements - NPDES permit requirements based on the application of pollution treatment or control technologies including BTP (best practicable technology), BCT (best conventional technology), BAT (best available technology economically achievable), and NSPS (new source performance standards).

tertiary treatment - Removal of residual suspended solids, usually by granular medium filtration after primary treatment and secondary treatment. Disinfection is also typically a part of tertiary treatment. Nutrient removal is often included in this definition. [1]

total solids - The minerals, cells, etc. left in wastewater after evaporation of the water fraction at 103°C. Usually measured in mg/L. [2]

total suspended solids (TSS) - A measurement of the 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 biochemical oxygen demand (BOD). [4]

toxicity - The adverse effect which a biologically active substance has, at some concentration, on a living entity. [3]

trace element - Any element in water or wastewater that, for reasons associated with natural distribution, industrial uses, solubility, or other factors, is present at very low concentrations. [3]

trap - (1) A device used to prevent a material flowing or carried through a conduit from reversing its direction of flow or movement or from passing a given point. (2) A device to prevent the escape of air from sewers through a plumbing fixture or catch basin. [3]

tributary - a stream that contributes its water to another stream or body of water.

turbid - thick or opaque with matter in suspension. Rivers and lakes may become turbid after a rainfall.

typical sewage - Arizona regulatory terminology that means sewage in which the total suspended solids (TSS) content does not exceed 430 mg/L, the five-day biochemical oxygen demand (BOD) does not exceed 380 mg/L, and the content of fats, oils, and greases (FOG) does not exceed 75 mg/L. [5]

unconsolidated formations - naturally occurring earth formations that have not been lithified. Alluvium, soil, gravel, clay, and overburden are some of the terms used to describe this type of formation.

USGS - United States Geological Survey

vertical separation - The depth of unsaturated, original, undisturbed soil of between the bottom of a disposal component and the highest seasonal water table, or other restrictive layer.

void - the pore space or other openings in rock or soil. The openings can be very small to cave size and are filled with water below the water table.

wastewater - water containing waste including greywater, blackwater or water contaminated by waste contact.

wastewater management district - means an entity organized in accordance with permitting legislation to perform various specific functions such as planning, financing, construction, supervision, repair, maintenance, operation and management of on-site wastewater treatment and disposal systems within a designated area.

wastewater reclamation - Processing of wastewater for reuse. [3]

water quality standards - laws or regulations, promulgated under Section 303 of the Clean Water Act, that consist of the designated use or uses of a waterbody or a segment of a waterbody and the water quality criteria that are necessary to protect the use or uses of that particular waterbody. Water quality standards also contain an antidegradation statement. Every State is required to develop water quality criteria standards applicable to the various waterbodies within the State and revise them every 3 years.

water table - level below the earth's surface at which the ground becomes saturated with water. The surface of an unconfined aquifer which fluctuates due to seasonal precipitation.

water table aquifer - an aquifer confined only by atmospheric pressure (water levels will not rise in the well above the confining bed).

Waters of the United States -

Federal regulatory terminology that means:

1. All waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters that are subject to the ebb and flow of the tide;

2. All interstate waters, including interstate wetlands;

3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any waters:

   a. That are or could be used by interstate or foreign travelers for recreational or other purposes;

   b. From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or

   c. That are used or could be used for industrial purposes by industries in interstate commerce;

4. All impoundments of waters defined as waters of the United States under this definition;

5. Tributaries of waters identified in subsections (1) through (4);

6. The territorial sea; and

7. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in subsections (1) through (6). [5]

water well - any artificial excavation constructed for the purpose of exploring for or producing ground water.

watershed - land area from which water drains toward a common watercourse in a natural basin.

weather - day to day variation in atmospheric conditions. Compare climate.

wetland - area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least part of the year, such as a bog, pond, fen, estuary, or marsh.

zero discharge -(1) Complete recycling of water. (2) Discharge of essentially pure water. (3) Discharge of a treated effluent containing no substance at a concentration higher than that found normally in the local environment. [3]

zone of aeration - a region in the Earth above the water table. Water in the zone of aeration is under atmospheric pressure and will not flow into a well.

zone of saturation - the space below the water table in which all the interstices (pore spaces) are filled with water. Water in the zone of saturation is called groundwater.

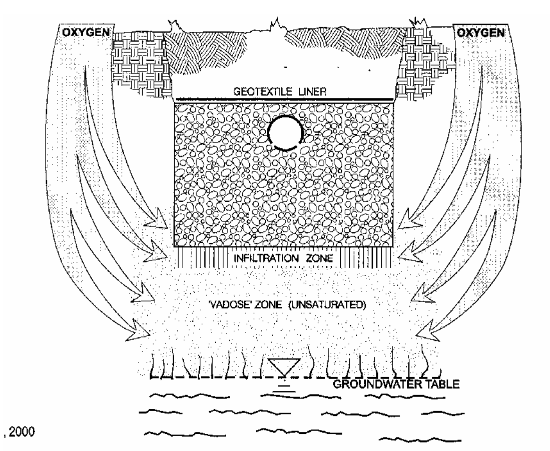
SECTION B: SOILS & SITE EVALUATIONS

PART I:
SOIL TREATMENT OF SEWAGE

The health of individuals living where public sewers are not available is of major concern in the state of Iowa. Domestic wastewaters contain many substances that are undesirable and potentially harmful such as pathogenic bacteria, infectious viruses, organic matter, toxic chemicals and excess nutrients. To protect the public as well as the environment, wastewater must be treated in a safe and effective manner. The first component in an individual sewage treatment system is usually a septic tank, which removes some organic material (BOD) and some suspended solids (TSS). TSS and BOD removal is very important because it prevents excessive clogging of the soil absorption/dispersal unit. Figure A-5 shows the levels of BOD, TSS, fecal coliform bacteria and nutrients in septic tank effluent.

Suitable soil is an effective treatment medium for sewage tank effluent. Soil contains a complex biological community. One tablespoon of soil contains over one million microscopic organisms, including bacteria, protozoa, fungi, molds and other creatures. The bacteria and other microorganisms in the soil treat the wastewater and purify it before it reaches groundwater. But the wastewater must pass through the soil slowly enough to provide adequate contact time with soil particles and microorganisms.

Soil microorganisms need the same things to live and grow as animals: a place to live, food and water to eat, oxygen to breathe, and time to grow. Soil bacteria attach themselves to soil particles using microbial slimes. The larger soil pores are filled with air containing oxygen. To provide adequate time for treatment of wastewater, it is necessary to have **at least three feet of aerated (unsaturated) soil between the point where wastewater enters the soil and the limiting layer**.



Upon leaving the septic tank, the effluent usually moves to a secondary treatment unit where it is treated using soil. Soil renovates wastewater physically, chemically and biologically before it reaches the ground water. Under some soil conditions, subsurface absorption systems may not accept the wastewater or may fail to properly treat the wastewater unless special modifications are utilized.

To do its part in wastewater disposal, suitably-textured soil must be deep enough to allow adequate filtration and treatment of the effluent before it is released into the natural environment. Usually this release is into groundwater. **The effective treatment zone needed in the soil before release into the natural environment is three feet**. Therefore, a three-foot separation distance is required from the bottom of sewage treatment trenches or beds to a limiting soil condition such as groundwater or bedrock. This three-foot treatment zone provides sufficient detention time for final bacteria breakdown and sufficient distance for filtration. Both are essential for the safe treatment of effluent. In Figure B-1, the levels of BOD, TSS, bacteria and nutrients remaining after treatment by one foot and three feet of soil are shown.

Figure B-1: Treatment Performance of Soil

parameter	raw waste	septic tank effluent	one foot below trench bottom	three feet below trench bottom
BOD_5 (mg/L)	270 – 400	140 – 220	0	0
TSS (mg/L)	300 – 400	45 – 65	0	0
fecal coliform (MPN/100ml)	1,000,000 – 100,000,000	100,000 – 100,000,000	0 – 100	0
viruses (PFU/ml)	unknown	1,000 – 1,000,000,000	0 – 1,000	0
nitrogen (mg/L)				
total	100 – 150	50 – 60	----	----
NH_4	60 – 120	30 – 60	*B – 60	*B
NO_3	<1	<1	*B – 40	*B – 40
total phosphorus (mg/L)	10 – 40	10 –30	*B – 10	*B –1
*B = background level of naturally occurring parameter in soil				

Impacts of Effluent on Groundwater

We commonly think a system is failing when effluent either ponds on the soil surface causing a wet seepy area, or when effluent backs up into the house. 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.

Groundwater represents the largest volume of fresh water on earth. Only three percent of the earth's fresh water resides in surface streams, lakes, and other surface water bodies. The other 97 percent is beneath the surface, flowing toward points of discharge such as streams, lakes, springs, and swamps. Groundwater becomes surface water at these discharge points.

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.

Soil Treatment Processes

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 drainfield 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 drainfield 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. (See Figure B-2 and B-3)

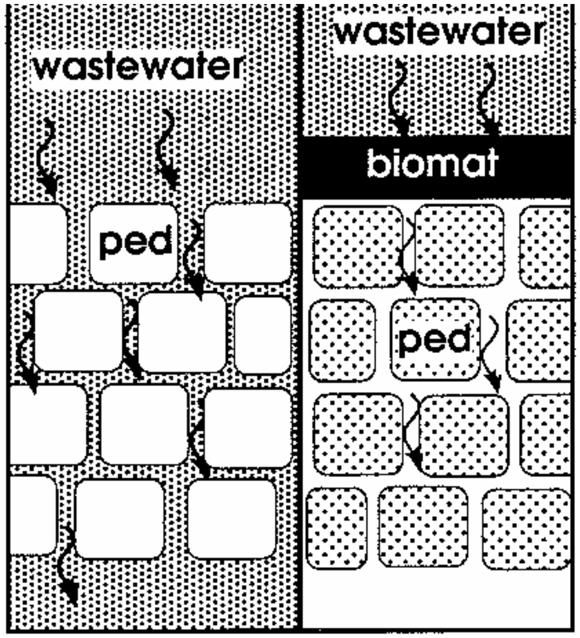


Figure B-2

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 drainfield, 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.

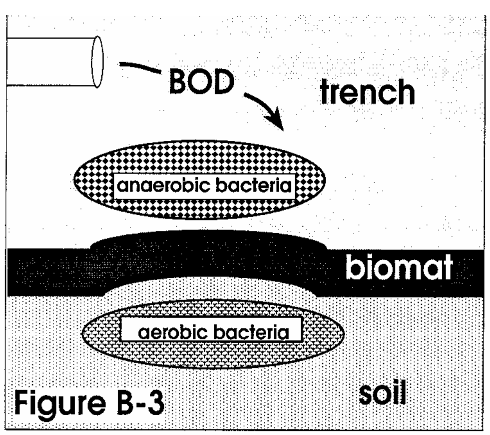


Figure B-3

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 (see Figure B-4).

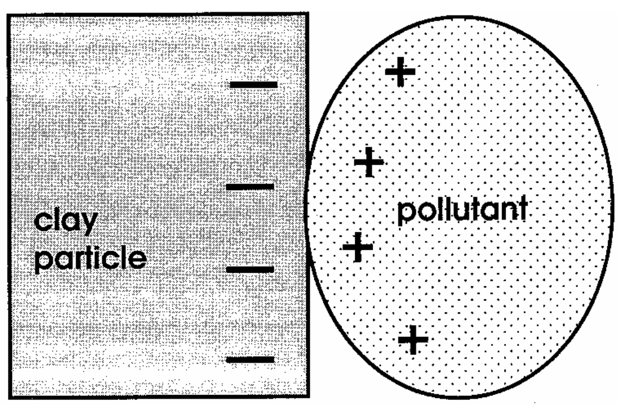


Figure B-4: Negatively-charged soil particles can attract and hold positively-charged impurities in wastewater

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 NH_4^+. 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.

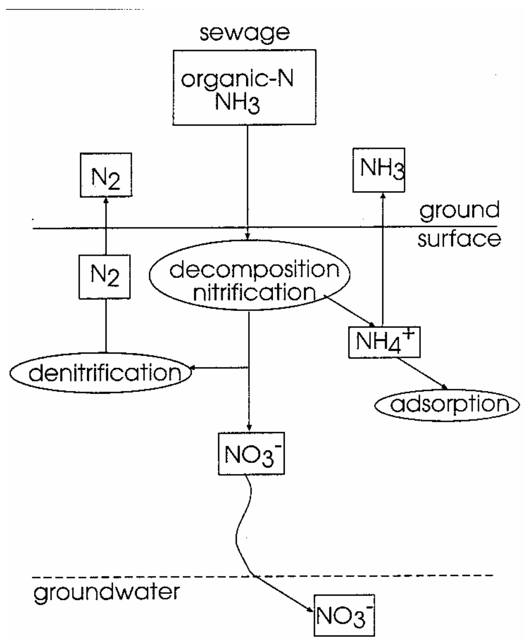


Figure B-5: Form and Fate of Nitrogen in the Subsurface Environment

Nitrates (NO_3^-) can be formed by nitrification. Nitrification ($NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$) 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 NO_3^- concentration in the effluent can be reduced. Denitrification ($NO_3^- \rightarrow N_2O \rightarrow N_2$) occurs in the absence of oxygen. For denitrification to take place, the nitrogen must usually be in the form of NO_3^-, 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 (NO_3^-) have a negative charge, they are not attracted to soils, and are very mobile.

In a study by Converse et al., 31 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 are shown below.

	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 NH_4^+ is nitrified to nitrates NO_3^- and then encounters a saturated zone, which lacks oxygen, the nitrate is converted to nitrogen gas (N_2) 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 Iowa 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 Iowa'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 in the home 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.
- Composting, incinerating, chemical, and low-flow toilets.

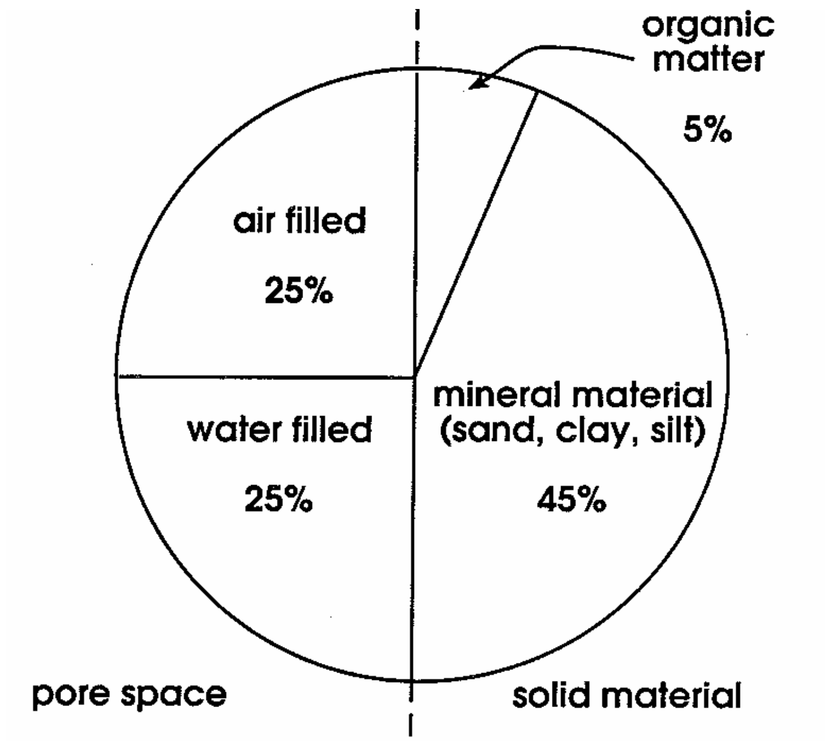
PART II: SOIL DEVELOPMENT

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 (See Figure B-6).

Figure B-6 Components of soil by volume



The following was taken from

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

The Factors of Soil Formation

The properties which characterize a soil profile are due to the influence of a particular combination of several soil forming factors. These are (1) soil parent material, (2) climate, (3) living organisms, (4) topography or relief and (5) time.

These factors work interdependently in producing a particular soil. Differences or similarities between soils are due to differences or similarities in the influence of the interrelated soil forming factors. *Each factor modifies and is modified by the other soil-forming factors*. Topography, for example, modifies the effects of rainfall—a climatic factor. The release of plant nutrients from soil minerals which originate in the soil parent material depends upon climate and time. Thus, the effect of living organisms such as growing plants is influenced by time, climate and soil parent materials. Variations in soil properties can be interpreted and explained only through consideration of the interrelated influences of the factors of soil formation.

Parent Material

The initial step in the development of a soil profile is the formation of soil parent material. The parent material provides a soil with a mineral skeleton, consisting of unconsolidated and partly decayed rocks. Some soils are formed from the weathering of bedrock in place. However, most Iowa soils formed from material that was transported from the site of the parent rock and redeposited at a new location through a transporting agency. Ice, water, wind and gravity are transporting agencies. These agencies may act independently or in combination with two or more agencies. Ice—in the form of glaciers—was particularly important in transporting and redepositing the parent materials from which Iowa soils developed.

During the Pleistocene or Ice Age, snow and ice accumulated to great depths. As pressure increased with increased depth of ice and snow, the ice sheet flowed as a plastic mass. Like a giant bulldozer it moved across the landscape. Rocks were ground into smaller particles. Hills were leveled and valleys were filled. Rocks imbedded in the bottom of the ice provided scouring action as the glacier moved.

Four glacial advances have been recognized in Iowa. The glacial periods were separated by interglacial periods with warmer climates. The first glacial period, the Nebraskan, occurred approximately 750,000 years ago. It was followed by the Aftonian interglacial period, which was followed by the Kansas glacial period, which is thought to have started about 500,000 years ago. The Yarmouth interglacial period followed the Kansan glaciation. The third glacial period, the Illinoian, occurred about 150,000 years ago and was followed by the Sangamon interglacial period. The last period of glaciation was the Wisconsin, which started about 35,000 years ago. It consisted of several substages and an important interglacial substage. The last substage was the Cary, which deposited the till in north central Iowa about 11,000 to 14,000 years ago. The Tazewell left extensive till deposits in northern Iowa. During and following the Tazewell substage (approximately 14,000 to 25,000 years ago), loess was widely deposited over Iowa.

The principal parent materials of Iowa soils are (1) glacial drift, (2) loess and (3) alluvium. Approximately 95 percent of Iowa soils formed from one of these three parent materials. The remaining 5 percent formed from colluvium; limestone, sandstone and shale residuum; and organic deposits. The distribution of the major parent materials is shown in fig. B-7.

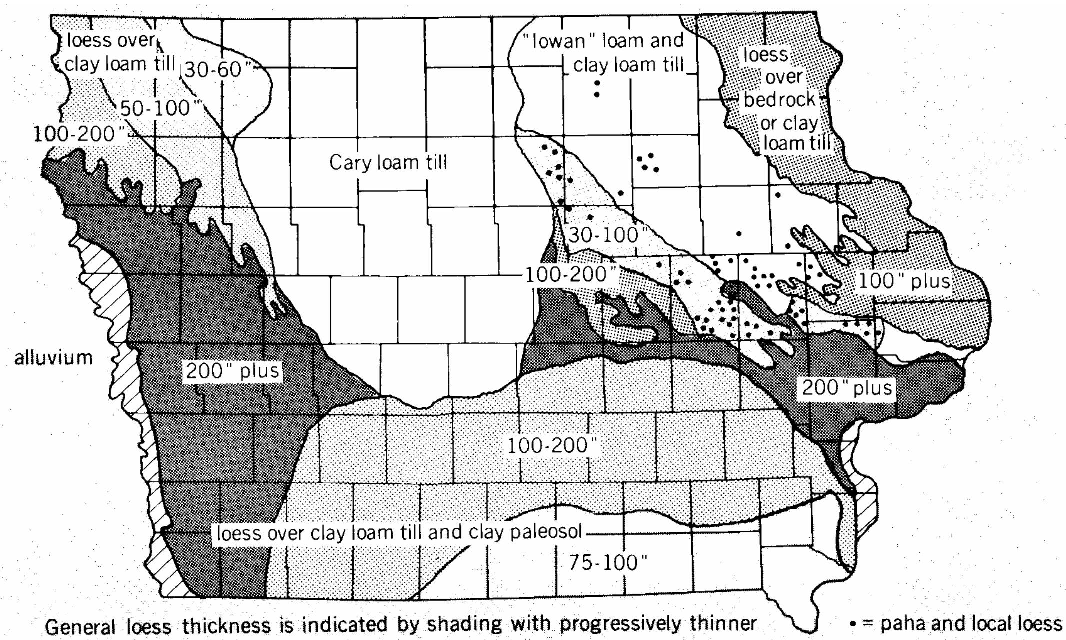


Figure B-7

Glacial drift consists of the unconsolidated mixture of gravel and partly weathered rock fragments left by glaciers. Glacial drift may consist of materials deposited directly by the ice sheet or material which has been reworked by water or other agencies as the glacier melted. Glacial drift provided parent materials for approximately 40 percent of Iowa's soils. Glacial till is the unsorted mixture of clay, silt, sand, gravel and boulders which was deposited by the ice sheet. The glacial tills from which Iowa soils were formed were generally medium to moderately fine loam and clay loam textures. Small stones, pebbles, gravel and sand are present in most glacial tills of Iowa.

Iowa soils have developed in fresh or unweathered till and also in highly weathered till. The interglacial periods between the earlier glacial periods were long enough to permit the formation of soils with well-developed profiles. These were covered by later deposition. Geologic erosion has dissected the till plain and has re-exposed the buried soils (relict soils or paleosols) through truncation or beveling. Modern soils have developed from the re-exposed material. These soils are common in southern and southeastern Iowa.

In addition to glacial till, glacial drift also includes *glacial outwash*. As the ice melted during warm seasons, melt water flowed from the margins of the ice sheet and redeposited a partly sorted mixture of gravel, sand and silt. Stratification of gravel, sand and silt layers is common, although one of the materials usually predominates. Glacial outwash occurs as pockets and fans associated with old melt-water channels. Many of these channels are now streams. They are most common in the glacial till areas of north central and northeastern Iowa.

Loess (pronounced “luss”) is a silty, wind-deposited material. Major loess deposits in Iowa are of the Wisconsin age. Loess consists almost entirely of silt but may include small amounts of very fine sand or clay. Coarse sand, gravel and boulders are not found in typical loess since these materials were too large to be moved by wind. The high percentage of silt-sized particles gives loess-derived soils a smooth, grit-free floury feel.

Loess deposits originated from materials carried away from the melting ice sheet during warm seasons. During cool seasons, the water flow ceased and the materials were deposited in broad, flat areas such as bottomlands. After drying, they were picked up by wind action and redeposited many miles from the source. For example, the loess of Wayne County is thought to come from near Onawa, a distance of almost 200 miles. Areas near the source received thicker and coarser textured deposits. The deposits thinned in the direction of the then prevailing northwesterly winds.

The major sources of loess in Iowa were (a) the Missouri River bottomlands, (b) a Wisconsin glacial drift plain north central and northeastern Iowa, (c) a Wisconsin valley drift plain in southeastern South Dakota, and (d) local sources along the Des Moines, Skunk, Iowa and Cedar rivers. Loess thicknesses are shown in fig. 5. Locally thick accumulations of loess occur in areas of northeast and east-central Iowa (paha) which are otherwise loess-free or which have thin loess caps over glacial till. The location of some of these areas, is shown in figure B-7.

Loess-derived soils may vary in characteristics from one part of the state to another. Some of the major reasons for the variation include (1) fineness, (2) thickness of the deposit, (3) rate of accumulation, (4) carbonate content at time of deposition, and (5) mineralogical composition of the loess. Climate, vegetation and topography have also caused differences. Loess-derived soils include the most productive in the state and account for almost 40 percent of Iowa soils.

Alluvium is material which was deposited by water in the floodplains along streams. Two major areas—Missouri bottomlands and Mississippi bottomlands—and numerous smaller areas along tributary streams, have soils developed from alluvium. Medium and moderately fine-textured alluvium predominates in Iowa, although coarser textured alluvium is not uncommon. Fine-textured alluvium is common in the Luton-Onawa-Salix soil association. Alluvium-derived soils are frequently stratified with layers of gravel, sand, silt and clay.

Colluvium is material deposited in footslope positions by the action of gravity, soil creep or local wash. Silty and loamy colluvial materials are most common in Iowa, although rock fragments are common below slopes with rock outcrops. Colluvial soils often occur in small, narrow areas; thus, their suitability for crop production is determined by associated soils.

Residuum, the residue from the weathering of sedimentary rocks in place, is a minor parent material in northeast Iowa and along some of the deeper stream valleys such as the Des Moines River. The sedimentary rocks include limestone, sandstone and shale. Since most of the rock outcrops occur on steep topography, soils formed from sedimentary rocks usually have AC or AR profiles. However, some soil profiles with A, B and C horizons formed from residuum are found in the state.

Organic deposits form the parent materials for peat and muck which occur in small areas, particularly in north central Iowa. Poorly drained conditions have retarded the decay of organic matter which has accumulated over time. The accumulated organic matter, with small amounts of mineral matter, serves as soil parent material.

Climate

Climate both directly and indirectly influences soil development. Direct effects include the influence of temperature and precipitation upon the weathering of rocks and minerals. High temperatures encourage rapid weathering of rocks, minerals and parent material. The speed of chemical reactions increases as temperature increases. Wind, important in soil transport, is a climatic factor that directly affects soil development. High annual rainfall influences the soil directly through its impact on erosion and leaching losses. Climatic changes played important roles in the work of glaciers as discussed in the section on soil parent materials. Climate plays an indirect role in soil formation through its effect upon plant growth and adaptation. Climatic variation between areas was important in determining the location of the broad soil areas of the world.

The climate of Iowa is relatively uniform over the state although some variation in climatic factors occurs. Climate is an important cause of crop yield variation between different sections of Iowa. Although climate probably did not play a major role in distribution of soils in Iowa, differences between soils in northwest Iowa and parts of east-central Iowa may reflect climatic variations. The soils in northwest Iowa are similar to east-central soils in most respects but are less leached, possibly because of lower annual rainfall.

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.

Most native Iowa vegetation consisted of tall prairie grasses. Forest vegetation (chiefly oak and hickory) was more prominent in eastern Iowa and along the major streams in other parts of the state.

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.

Topography

Topography refers to the lay of the land. It may be very steep or nearly level or somewhere in between. The primary influence of topography on soil development is its effect on drainage, runoff and erosion. Topography is an important factor in determining the pattern and distribution of the soils of a landscape. The aspect or direction a slope faces is an important secondary influence of topography. For example, south-facing slopes normally are warmer and drier than north-facing slopes. This can have an important effect on the kind and amount of vegetation which grows in an area.

Topography may be characterized by the gradient (degree or percent of slope), length, shape, aspect and uniformity of the slopes which make up a particular landscape. Although each of these slope characteristics is important, the topography of Iowa is most frequently expressed in terms of slope gradient or percent of slope. Seven slope gradient classes have been recognized in Iowa. These slope gradient classes and the percent of Iowa land area represented by each are presented in the following Figure B-8.

Figure B-8

Soil Groups
A = 0 – 2 %
B = 2 – 5 %
C = 5 – 9 %
D = 9 – 14 %
E = 14 – 18 %
F = 18 +

Occasionally, various slope gradient classes occur in extensive areas. More frequently, however, two or more slope gradient classes occur within one field. To show the variation in topography within the state, five major topographic areas were formed by grouping one or more of the slope gradient classes into each area. Areas with a wide range in slope gradient (5-14 percent or 9-30+ percent) generally represent a more complex topography than areas with a narrow range of gradient. In addition, the pattern of the various topographic areas in different sections of the state is an indication of complexity of the topography.

The nearly level gently sloping areas predominate in northwest, north central and northeast Iowa with extensions into east central and southeast Iowa. Southern Iowa is marked by an intricate pattern of narrow ridge tops flanked by gently sloping to strongly sloping and steep side slopes. Western Iowa has a high percentage of strongly sloping to steep topography.

Topography is important in determining the pattern of occurrences of soils within different areas of the state. This pattern is closely related to topography because of topographic influences on drainage, erosion, climate and plant growth. Soil suitability for various uses is also closely related to topography.

In addition to a geometric description of topography, soil scientists also use the concept of the hillslope profile. The high, relatively stable part of the landscape is the summit. Downslope a convexly rounded slope element is the shoulder. Below the shoulder is the backslope, many of which are linear. The backslope descends to a footslope, which is usually concave. The lower part of the profile is usually the toeslope. The shoulder and backslope are subject to erosion while the footslope and toeslope are depostional elements of the landscape. Not all the elements are present on every hillslope.

Time

Time is necessary for the various processes of soil formation to take place. The amount of time may vary from a few days for fresh alluvial deposits to thousands of years for the ”paleosols” of southern Iowa. In general, in Iowa when other factors are favorable, as soils continue to weather over a long period of time, the subsoil texture becomes finer and the soils are more leached of soluable materials. Exceptions are soils formed from materials resistant to weathering such as quartz sand. Such soils do not change much with time. Other exceptions are soils occurring on very steep topography where runoff is high and water infiltration is low. Such soils weather more slowly than soils on less steep topography. Time is an important factor in explaining soil differences among different areas of the state and also within the same area in some parts of the state.

Variations in ages of glacial and loess deposits were discussed in the section on parent materials of Iowa soils. These materials range in age from more than 500,000 years to less than 11,000 years. Many of the older deposits were covered by later sediments laid down by ice, wind or water. The landscape we see today has been and is being influenced by geologic erosion. The landforms of Iowa are shown in figure B-9. The youngest landscapes are in the alluvial areas and in the younger glacial areas of north central Iowa. Although the soils of southern areas of Iowa formed from materials which have been deposited for a long period of time or have accumulated over a long time, the modern landscape has resulted from erosional activities which accompanied the Wisconsin glacial period. Thus, the soils which occur in the modern landscape may be young even though the materials deposited may be old. However, it is not the age of the parent material that is important to understanding the time factor of soil formation. It is the age of geomorphic surface on which the soil develops that is important. A geomorphic surface is defined as a part of the earh’s surface that can be defined in space and time. It may contain many landforms and it is mappable. Some of the younger surface are in the alluvial floodplains and are recent. Landscapes covered with Wisconsin loess have summit positions that are 14,000 years old. However, associated landscape elements are much younger. Many of the upland landscapes, especially the Des Moines and Iowan surface are as young as 3,000 years.

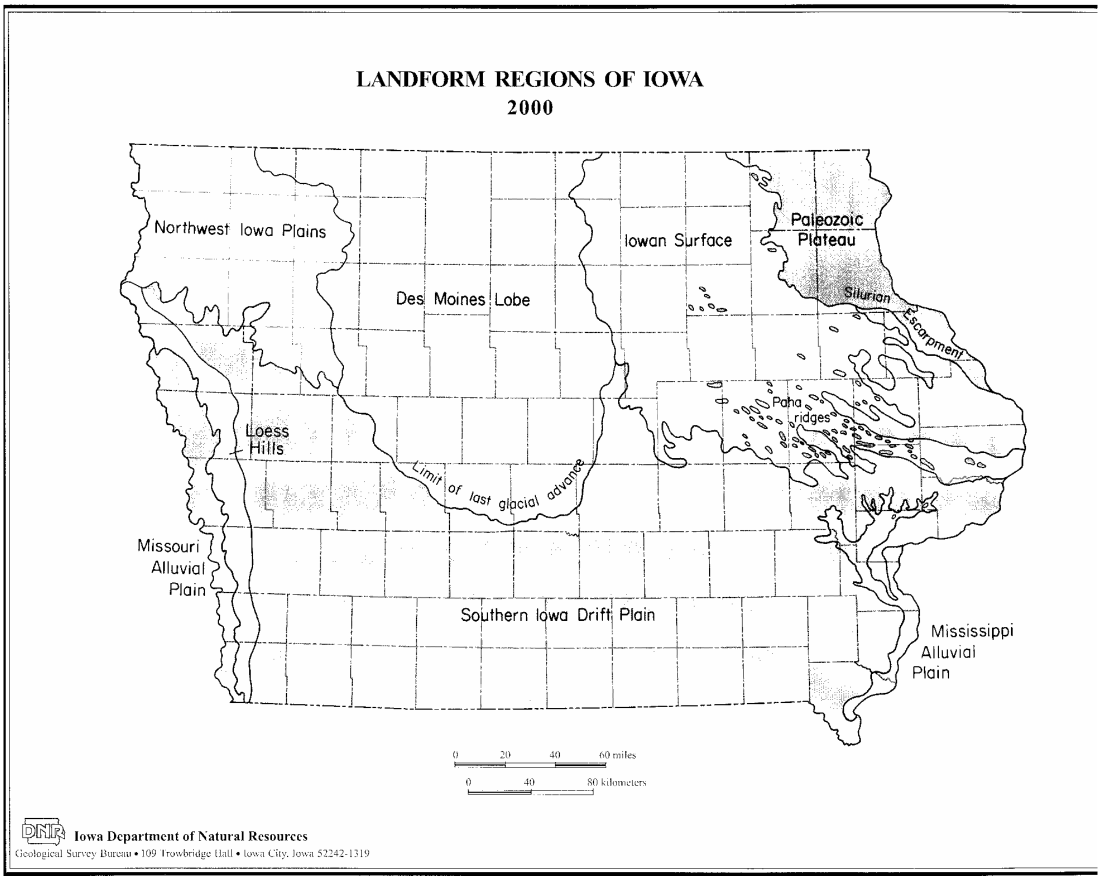


Figure B-9

Sometimes the ages of landscapes may be estimated by a process known as radiocarbon dating if organic materials are buried. If living material such as trees is covered by later deposition through the action of ice, water or wind, the radioactive carbon can serve as an estimator of the time the sediments were deposited. The age of materials less than 35,000 years old may be dated by this technique. Organic materials such as wood have been discovered in many Iowa glacial and loess deposits. These have served as sources for radiocarbon dating.

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 (See Figure B-10).

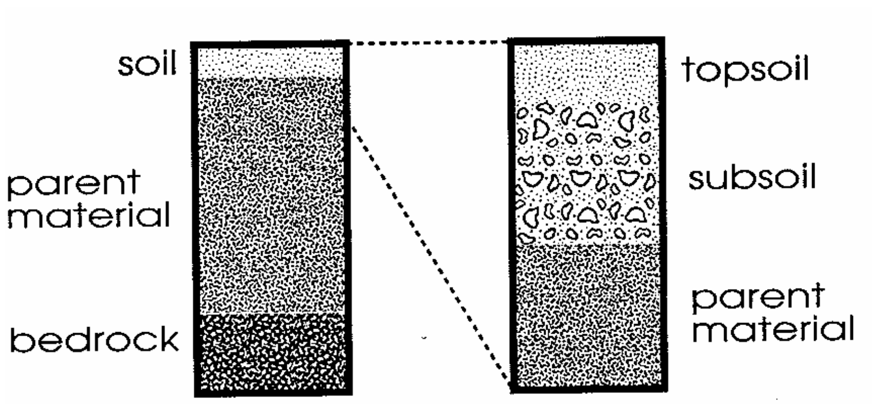


Figure B-9: Soil Profile

A fresh roadcut 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. A sample soil boring log sheet (Figure B-48) is provided on page B-70, and in **Appendix 4: Site Evaluation Forms** to aid in recording the soil description.

For example: The first soil in Figure B-10 has a clay loam subsoil over a sandy parent material. This texture change occurs abruptly less than one-inch between horizons. This soil would have problems transmitting water across the boundary. The second soil has a sandy loam subsoil over a sandy parent material. This texture change boundary occurs over a five-inch thickness. In order for water to pass across either boundary there would have to be saturation in the upper layer.

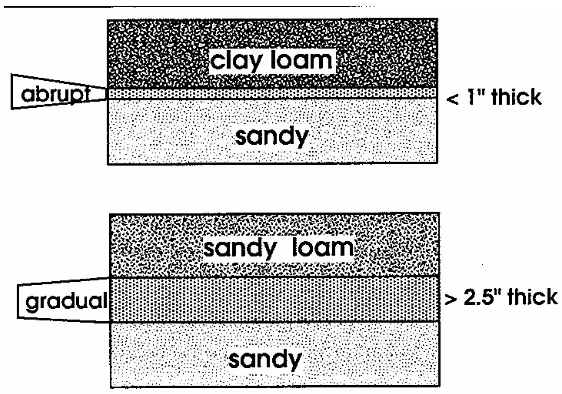


Figure B-10: Boundary Thicknesses

Determining Boundaries

Boundaries between horizons are determined by changes in soil color, soil texture, or other soil properties. **For example:** In Figure B-11, horizon 1 is 12 inches thick and is a black sandy loam. Horizon 2 is from 12 to 36 inches and is a brown sandy loam. Horizon 3 is from 36 to 72 inches and is a brown loam. 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 saturated soil conditions.

Photographs can be taken of the soil profile after the layers have been identified, but before the vertical section has been disturbed for description.

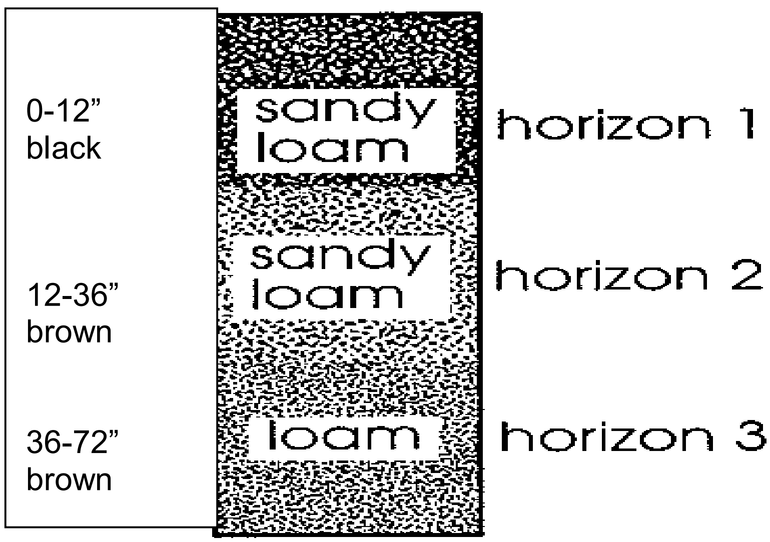


Figure B-11: Soil Profile

PART III:
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.

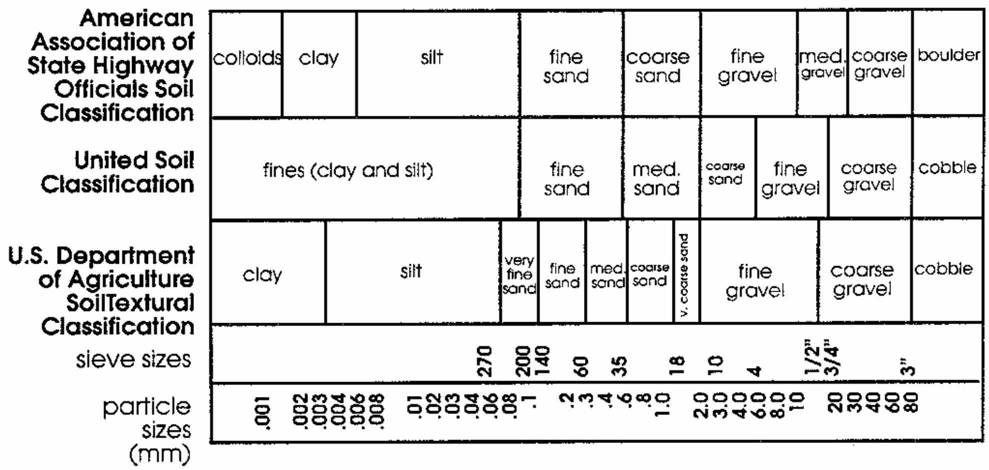
Soil texture is the relative proportion, by weight, of the soil particles finer than two millimeters. These particles are sometimes called the **fine earth fraction.** Materials larger than two millimeters are called **rock fragments.** These fragments influence moisture storage and infiltration, and 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 (see Figure B-12).

Figure B-12: A Comparison of Particle Size Limits in Three Classification Systems



Soil Separate Sizes

particle name	particle size range (mm)	sieve numbers
v. coarse sand	2.0 - 1.0	10 - 18
coarse sand	1.0 - 0.5	18 - 35
medium sand	0.5 - 0.25	35 - 60
fine sand	0.25 - 0.10	60 - 140
v. fine sand	0.10 - 0.05	140 - 270

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 B-13 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.

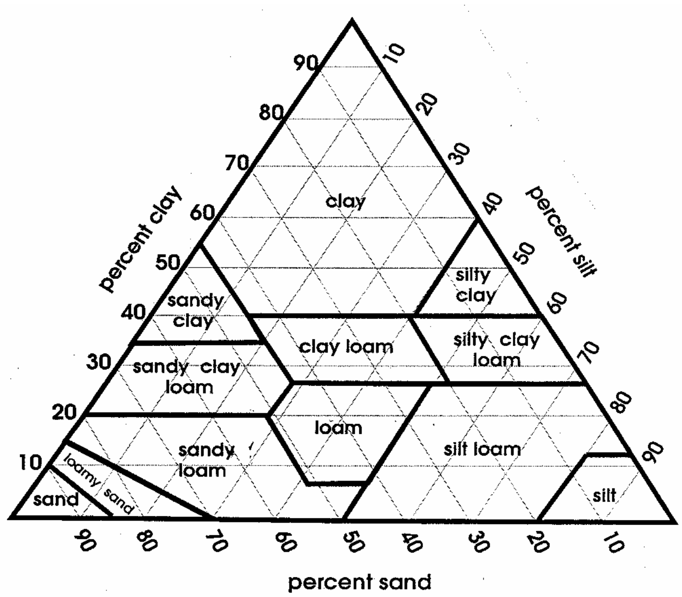


Figure B-13: USDA Soil Textural Classification

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 charcteristics 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.

Soil samples of known textural classes can be obtained from:

PSCI
Tom Fenton
Iowa State University
Agronomy Building
Ames, IA 50011
515-294-2414
http://www.agron.iastate.edu/soilsurvey/#PSCI

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.

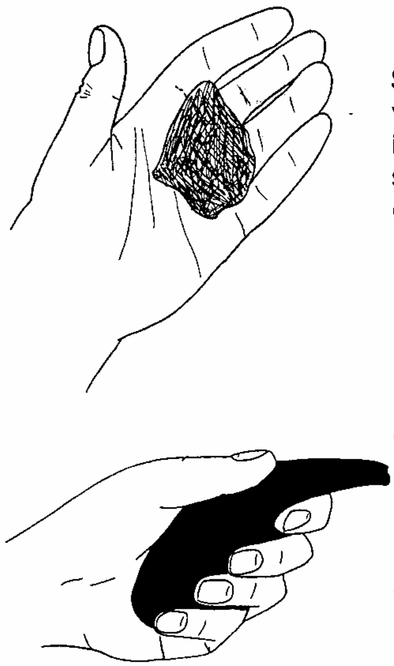
The way a wet soil "slicks out" or develops a long continuous ribbon when pressed between the thumb and fingers gives a good idea of the amount of clay present. If the soil sample forms a ribbon (loam, clay loam or clay) it may be desirable to determine if sand or silt predominate. If there is a gritty 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, see figure B-14.



Squeeze a golf ball-sized piece of moist soil in your hand, then release the pressure. If the cast is crumbly, the soil is a **sand.** If the cast retains its shape, bounce it in your hand. If the bounced cast crumbles, the soil is a **sandy loam.**

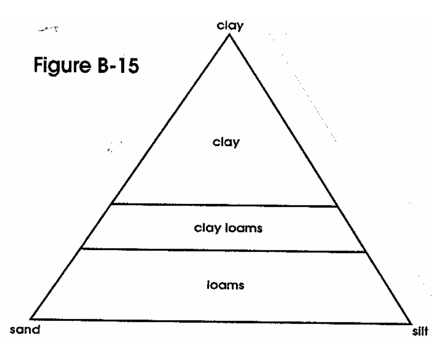
If the bounced cast retains its shape, try to form a ribbon by squeezing and pressing the soil between your thumb and forefinger. If the ribbon breaks when it is less than 1 inch long, the soil is a **loam.** A ribbon that breaks easily when 1 to 2 inches long indicates a **clay loam.** A ribbon more than 2 inches long indicates a **clay** soil.

Figure B-14: Soil Texture Determination in the Field

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**
   See Figure B-15.

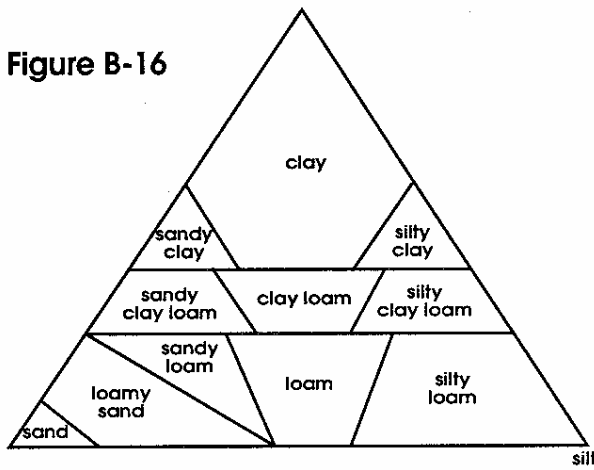
Figure B-15



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**

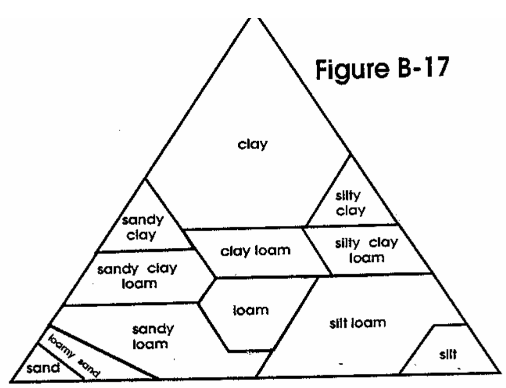
4. At this point, the lines on the triangle jog a bit, and sandy loams are distinguished. If the soil is a sandy loam, determine the amount of sand present.
    a) Very sandy (85% to 100%): **sand**
    b) Quite sandy (70% to 85%): **loamy sand**
    c) Somewhat sandy (50% to 70%): **sandy loam** See Figure B-16.

Figure B-16



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 B-17, which is the same as Figure B-13, the USDA soil texture triangle.

Figure B-17



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. Se Figure B-18

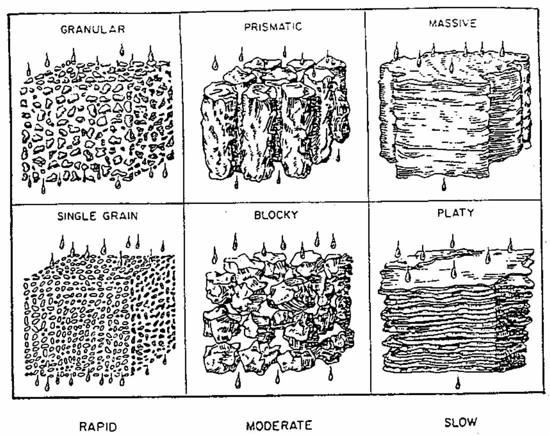


Figure 1. Types of soil structures and their influence on the rate of water movement. (Source: U.S. Department of Agriculture, 1959)

Figure B-18

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.

Clods and Soil Fragments

In Iowa, soil structure usually is developed only in the upper 3.5 to 5 or 6 feet of the soil profile. Soil structure types are distinct from one another in shape, size, grade (strength) and consistence (degree of force required to crush).

If enough force is used, any body of soil material can be broken into smaller pieces. The pieces are **peds** if their form and size are related to persistent planes of weakness. Other pieces that do not have orderly shape and size, or surfaces that indicate persistence, are *not* peds, and the layer is said to be **structureless** or **massive.** The term "massive" should not be taken to mean a hard, cemented layer. Most massive layers are relatively porous and friable to crushing. In these layers, pieces may be broken out, but they have random size and shape, and the same pieces might not form during another wetting and drying cycle. While structureless clayey soils are called massive, structureless sandy soils are called **single grain.**

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.

GRADE:
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.

Figure B-19: Soil Size Classes

	size of structure (millimeters)			
	shape			
size class	platy	prismatic or columnar	blocky	granular
very fine	< 1	< 10	< 5	< 1
fine	1 - 2	10 - 20	5 - 10	1- 2
medium	2 - 5	20 - 50	10 - 20	2 - 5
coarse	5 - 10	50 - 100	20 - 50	5 - 10
very coarse	> 10	>100	> 50	>10

Shape

Several basic shapes of peds are recognized in soils. The following terms, along with Figure B-20, describe the basic shapes and related arrangement of peds.

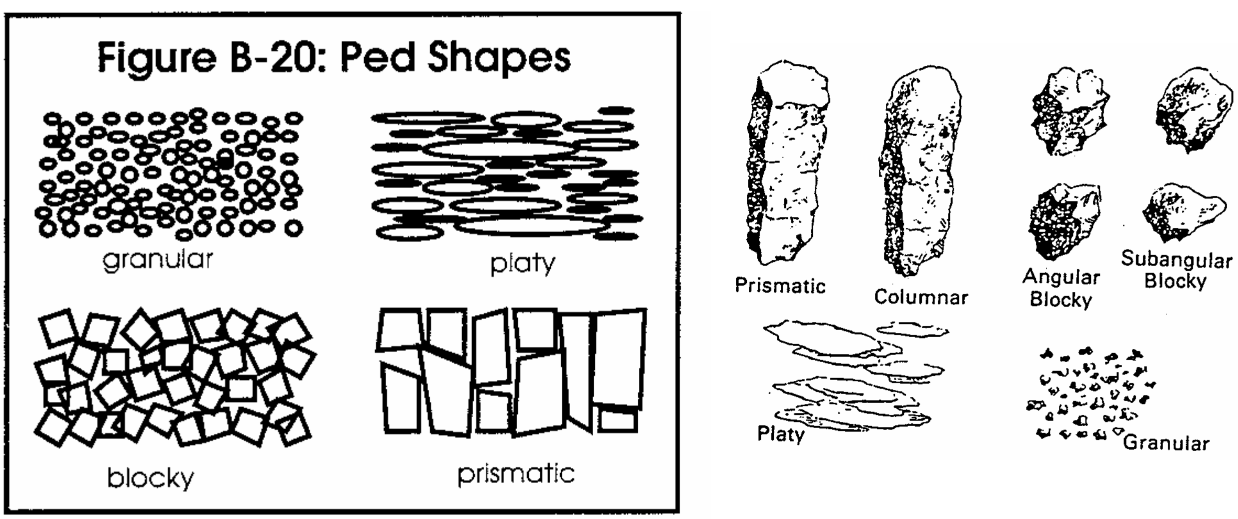


Figure B-20

- **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, figure B-21

Moist consistence class	specimen fails under
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

Figure B-21

How Structure Affects Water Movement

Between soil peds are voids or pores. Pores *between* peds are often relatively large and continuous, when compared with the voids between the soil separates *within* the peds. The type of structure determines the dominant direction of the pores and hence, water movement in the soil. Soils with strong structure have distinct pores between peds. Well structured soils with large voids between peds will transmit water more rapidly than structureless soils of the same texture, particularly if the soil has become dry before the water is added. Small structural units create more pores in the soil than large structural units, but fine textured, massive soils (soils with little structure) have very slow percolation rates. See figures B-22

Figures B-22

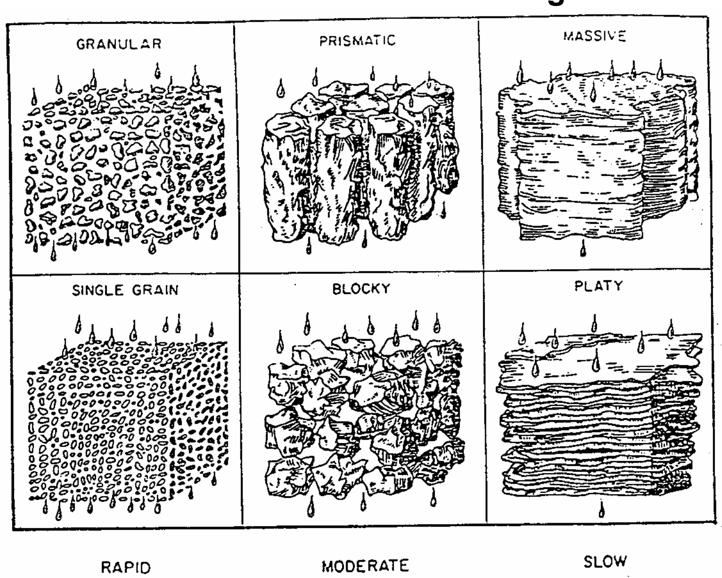


Figure 1. Types of soil structures and their influence on the rate of water movement. (Source: U.S. Department of Agriculture, 1959)

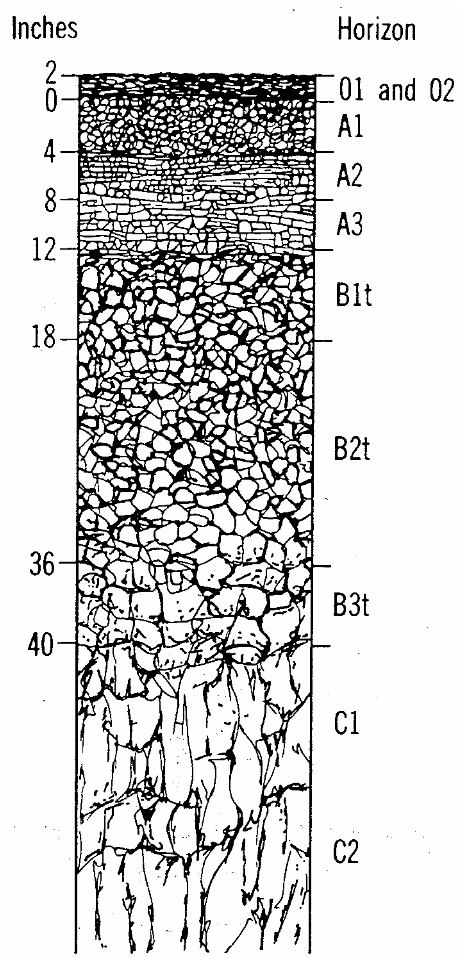


Figure 4. An example of a soil profile formed under mixed oak-hickory forest vegetation. The soil profile illustrates soil subhorizons, thickness of each subhorizon, and shape and size of soil structural units.

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.

The following tables are reprints of several state wastewater soil loading rates, and one that is used in some counties in Iowa.

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.

This manual does not recommend one table over the other. We suggest that each county evaluate what is appropriate, work with the local engineers, onsite professionals, and with the local NRCS soil scientist to determine what is best in each area.

Loading rates prepared by Louis Boeckman, Union County sanitarian, january 2003

CLASS	SOIL TEXTURE % C*1	% S*2	PARENT MATERIAL *8	NAT VEG *3	GRADE *4	SOIL STRUCTURE TYPE *5	LOADING RATES G/SQ.FT.
			WIND BLOWN	P	0	sg	1.0
CS & S	< 10	> 85	&	T	0	sg	0.9
			ALLUVIUM	F	0	sg	0.8
			WIND BLOWN	P	0	sg	0.9
LS	< 15	70-90	&	T	0	sg	0.8
			ALLUVIUM	F	0	sg	0.7
			WIND BLOWN	P	1	g,sbk,pris	0.8
SL	< 20	43-85	&	T	1	g,pl,sbk,abk,pris	0.7
			ALLUVIUM	F	2	pl,abk,pris	0.6
			TILL(WI)	P	1	g,sbk,pris	0.75
	7-27	23-52	&	T	1-2	g,pl,sbk,abk,pris	0.65
L			ALLUVIUM	F	2	pl,abk,pris	0.6
			TILL(IES)	P	1	g,sbk,pris	0.6
	18-27	20-45	TILL(IES)	T	1-2	g,pl,sbk,abk,pris	0.55
			TILL(IES)	F	2	pl,abk,pris	0.5
			LOESS	P	1	g,sbk,pris	0.7
SiL	7-27	< 20	&	T	1-2	g,pl,sbk,abk,pris	0.65
			ALLUVIUM	F	2	pl,abk,pris	0.6
			LOESS	P	1	g,sbk,pris	0.65
SiL-SiCL	20-32	< 5	&	T	2	g,pl,sbk,abk,pris	0.55
			ALLUVIUM	F	2-3	pl,abk,pris	0.5
			LOESS	P	1-2	g,sbk,pris	0.6
	32-40	< 20	&	T	2-3	g,pl,sbk,abk,pris	0.45
			ALLUVIUM	F	3	pl,abk,pris	0.4
SiCL			PEDI-	P	1	g,sbk,pris	0.45
	27-40	5-20	SEDIMENT	T	2	g,pl,sbk,abk,pris	0.4
				F	3	pl,abk,pris	0.3
			OLD	P	1-3	g,sbk,pris	0.5
CL-SICL	27-40	25-45	VALLEY	T	2-3	g,pl,sbk,abk,pris	0.4
			ALLUVIUM	F	3	pl,abk,pris	0.3
			TILL(WI)	P	1	g,sbk,pris	0.7
	27-32	20-45	&	T	1-2	g,pl,sbk,abk,pris	0.6
			ALLUVIUM	F	2	pl,abk,pris	0.5
				P	1-2	g,sbk,pris	0.4
CL	32-40	20-45	ALLUVIUM	T	2-3	g,pl,sbk,abk,pris	0.3
				F	3	pl,abk,pris	0.2
			FIRM	P	1-2	g,sbk,pris	0.2
	32-40	20-45	TILL(PRE-IL)	T	2-3	g,pl,sbk,abk,pris	0.1
				F	3	pl,abk,pris	N/S
			ALL	P	1-3	g,sbk,pris,mas	N/S
SiC-C	> 40	< 45	OTHER	T	2-3	g,sbk,abk,pris,mas	N/S
			MATERIALS	F	3	pl,abk,pris,mas	N/S

DEFINTITIONS AND EXPLANATION OF TERMS:

***1 = Percent Sand (% S)**

***2 = Percent Clay (% C)**

***3 = Native Vegetation:**

- **P** = **Prairie** formed under grass vegetation.
  Use high range of loading rate.
- **T** = **Transistion** formed under mixed grasses and tree vegetation.
  Use the mean or average of low and high loading rates.
- **F** = **Forest** formed under tree vegetation.
  Use low range of loading rate.

***4 = Structure Grade:** (General use only. May be affected by soil development or alteration of the site.)

- **1 = weak -** Poorly define individual peds.
- **2 = moderate -** Well formed peds, but not distinct in undisturbed soil.
- **3 = strong -** Durable peds, quite evident in place; will stand displacement.

***5 = Soil Structure:** (General use but may vary on specific site.)

- **sg** = **single grain** - Generally loose with no structural units.
  Associated with sandy soils.
- **g** = **granular** - Irregular and rounded faces.
  Associated with surface layers of prairies soils.
- **pl** = **platy** - Flat & tubular-like units. Associated with soils formed in tree vegetation and in depressions of prairie vegetation.
- **sbk** = **subangular bocky** - Sub-rounded and planar faces - lack sharp angles.
  Associated with subsoil horizons of prairie and transition soils.
- **abk** = **angular blocky** - Sharp anglar faces.
  Associated with subsoil horizons in soils fromed under tree vegetation.
- **pris** = **prismatic** - Vertically elongated units with flat tops.
  Associated with lower transition horizons of subsoil horizons.
- **m** = **massive** - no structural units - materials is a coherent mass.
  Associated with substratum with no development of soils.
- **cdy** = **cloddy** - Irregular blocks created by artificial disturbance by tillage or compaction.
  Associated with surface layers of soils under cultivation or compaction by livestock or equipment.

***6 = Range of Loading Rates:** (Ratings are relative values.)

(Low rating = Forest vegetation)

(High rating = Prairie vestation)

***7 = Mean or average loading Rate:**

(Average rating = Transition vegetation)

***8 = Footage calculated for 3-Bedroom Home or 450 gallons per day water usage**

Formula = GPD/Loading Rate = Linear Loading Rate/Trench Width = Total Footage.

Example: 450 gpd/.5 LR = 900 LRR/2 Ft. TW = 450 Ft. TF

Natural drainage of soils:

All ratings assume drainage of soils are excessive, somewhat excessive, well or moderately well drained.

If drainage can be improved by curtain drains, loading rates can be reduced:

- poorly drained deduct .1 from loading rate.
- somewhat poorly drained deduct .05 from loading rate.

If drainage cannot be improved, then alternative system will need to be design or use only the soil material above the seasonal high water table.

***8 = Parent Materials:**

- **Till(WI)** = Wisconsin Till
- **Till(IES)** = Iowan Erosion Surface
- **Till(Pre-IL)** = Pre-Illionian Till(Includes Kansan & Nebraskan Till)
- **Sediments** include any mantle that may overlay another parent material.
- **Alluvium** include soils formed on terraces or footslopes and toeslopes on flood plains.
- **Loess** include soils formed in uplands and on benches along major streams.
- **Pedisediment** formed in erosional sediments with loess over mantle and till is underlain. Loess and pedisediment are sometimes shallower than 5 feet to the depth of till

Table 83.44-2
MAXIMUM SOIL APPLICATION RATES
BASED UPON MORPHOLOGICAL SOIL EVALUATIONS
Wisconsin

Soil Texture	Soil Structure	Maximum Monthly Average	
		$BOD_5 > 30 \leq 220$ mg/L $TSS > 30 \leq 150$ mg/L (gals/sq ft/day)	$BOD_5 \leq 30$ mg/L $TSS \leq 30$ mg/L (gals/sq ft/day)
Coarse sand or coarser	N/A	0.7	1.6
Loamy coarse sand	N/A	0.7	1.4
Sand	N/A	0.7	1.2
Loamy sand	Weak to strong	0.7	1.2
Loamy sand	Massive	0.5	0.7
Fine sand	Moderate to strong	0.5	0.9
Fine sand	Massive to weak	0.4	0.6
Loamy fine sand	Moderate to strong	0.5	0.9
Loamy fine sand	Massive to weak	0.4	0.6
Very fine sand	N/A	0.4	0.6
Loamy very fine sand	N/A	0.4	0.6
Sandy loam	Moderate to strong	0.5	0.9
Sandy loam	Weak, weak platy	0.4	0.6
Sandy loam	Massive	0.3	0.5
Loam	Moderate to strong	0.5	0.8
Loam	Weak, weak platy	0.4	0.6
Loam	Massive	0.3	0.5
Silt loam	Moderate to strong	0.5	0.8
Silt loam	Weak, weak platy	0.2	0.3
Silt loam	Massive	0.0	0.2
Sandy clay loam	Moderate to strong	0.4	0.6
Sandy clay loam	Weak, weak platy	0.2	0.3
Sandy clay loam	Massive	0.0	0.0
Clay loam	Moderate to strong	0.4	0.6
Clay loam	Weak, weak platy	0.2	0.3
Clay loam	Massive	0.0	0.0
Silty clay loam	Moderate to strong	0.4	0.6
Silty clay loam	Weak, weak platy	0.2	0.3
Silty clay loam	Massive	0.0	0.0
Sandy clay	Moderate to strong	0.2	0.3
Sandy clay	Massive to weak	0.0	0.0
Clay	Moderate to strong	0.2	0.3
Clay	Massive to weak	0.0	0.0
Silty clay	Moderate to strong	0.2	0.3
Silty clay	Massive to weak	0.0	0.0

Note: > means greater than
$\leq$ means less than or equal to
N/A means Not Applicable

terminology faster than or slower than when referring to percolation rates rather than greater than or less than.

Minnesota

Final Sizing of Onsite Systems from Soil Characteristics

The following is a DRAFT for the purpose of generating comments on the accuracy of sizing onsite systems without a perc test. This proposal is not intended to be used on wide scale until further refinement, or without proper skills in soil texturing and soil structure identification. This procedure currently does no have approval at the county level.

Loading Rate (SQFT/GAL/DAY)

Texture	Single Grain	Massive (no structure)	Structure Granular, Blocky, or Prismatic			Platy	
			Weak	Moderate	Strong	Weak	Moderate or Strong
Co. Sand & Gravel	needs liner size at 1.67 sqft/gpd		needs liner size at 1.67 sqft/gpd			needs liner size at 1.67 sqft/gpd	
Co. & Med. Sands	pressure serial size .83 sqft/gpd		pressure serial size .83 sqft/gpd			pressure serial size .83 sqft/gpd	
Fine & V. Fine Sands	$1.67_{0.6}$		$1.67_{0.6}$			$2.0_{0.5}$	
Sandy Loam		$2.0_{0.5}$	$1.67_{0.6}$	$1.27_{0.8}$	$1.27_{0.8}$	$1.67_{0.6}$	$5.0_{0.2}$
Loam		$2.2_{0.45}$	$2.0_{0.5}$	$1.67_{0.6}$	$1.67_{0.6}$	$2.2_{0.45}$	$5.0_{0.2}$
Silt Loam		$5.0_{0.2}$	$2.2_{0.45}$	$2.0_{0.5}$	$2.0_{0.5}$	$3.3_{0.3}$	$5.0_{0.2}$
Clay Loam		kidd kiss kinn size at 5.0 sqft/gpd	kidd kiss kinn size at 4.2 sqft/gpd	kidd kiss kinn size at 2.2 sqft/gpd	kidd kiss kinn size at 2.2 sqft/gpd	$3.3_{0.3}$	kidd kiss kinn size at 5.0 sqft/gpd
Clay <45% Clay				kidd kiss kinn liner size at 4.2 sqft/gpd	kidd kiss kinn liner size at 4.2 sqft/gpd		
Clay >45% Clay							
If soil is firm when wet, or hard or cemented when dry, the horizon (layer) is not suitable.							

← 9/SF Values

= not suitable   = not found in nature

Figure B-22

Slowly Permeable Layers

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.

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 in his descriptions unless he feels the inclusion of these features clarifies that the variation in color is not caused by wetness.

B-6-1

Table 83.44-1
MAXIMUM SOIL APPLICATION RATES
BASED UPON PERCOLATION RATES
(Reports on file with county prior to July 2, 1994)
Wisconsin

Percolation Rate (minutes per inch)	Maximum Monthly Average $BOD_5 > 30$ mg/L ≤ 220 mg/L TSS > 30 mg/L ≤ 150 mg/L (gals/sq ft/day)	Maximum Monthly Average $BOD_5 \leq 30$ mg/L TSS ≤ 30 mg/L (gals/sq ft/day)
0 to less than 10	0.8	1.2
10 to less than 30	0.6	0.9
30 to less than 45	0.5	0.7
45 to less than 60	0.3	0.5
60 to 120	0.2	0.3
greater than 120	0.0	0.0

Note: > means greater than
≤ means less than or equal to

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Table IIIa
Soil Absorption System Sizing Chart
(Lineal feet of absorption trench)

BASED ON 24" wide Lateral

Min. Per Inch	Two-Bedroom 300 gal/day[1]	Three-Bedroom 450 gal/day	Four-Bedroom 600 gal/day	Five-Bedroom 750 gal/day	Six-Bedroom 900 gal/day
1-5[2]	160 .94	200 1.13	260 1.15	340 1.10	400 1.13
6-15	200 .75	300 .75	400 .75	500 .75	600 .75
16-30	300 .50	400 .56	500 .60	600 .63	700 .64
31-45	400 .38	500 .45	600 .5	800 .47	900 .5
46-60	500 .30	600 .38	700 .43	900 .42	1,100 .41

(9/SF)

TABLE 2—Design Septic Tank Effluent Loading Rates for Various Soil Textures and Structures

Kansas

Group	Soil Characteristics	Wastewater Loading (in/day)	Wastewater Loading (cm/day)	Wastewater Loading (gpd/ft^2)
I.	Gravelly coarse sand and coarser.	Not Recommended for conventional soil absorption system[5]		
II.	Coarse sands (not cemented).	1.8	4.6	1.1
III.	Medium sand with single grain structure and loose to friable consistence (not cemented).	1.5	3.7	0.9
IV.	Other sands and loamy sands with single grain or weak structure (not extremely firm or cemented consistence). Sandy loams, loams and silt loams with moderate or strong structure (except platy and loose to friable consistence).	1	2.5	0.6
V.	Sandy loams, silt loams and loams with weak structure (not of extremely firm or cemented consistence). Sandy clay loams, clay loams and silty clay loams with moderate to strong structure (not of platy, of firm, or of cemented consistence).	0.7	1.7	0.4
VI.	Sandy clay loams, clay loams and silty clay loams with weak structure (not massive, not of firm, or of cemented consistence.) Some sandy clays, clays and silty clays with moderate and strong structure (not platy, not of firm, or of cemented consistence).	0.4	1	0.25
VII.	Other soils of high clay content with weak or massive structure, extremely firm or cemented consistence or platy, clay pan, fragipan, and caliche soils.	Not Recommended for conventional soil absorption system[6]		

NOTE: The above descriptions are estimates and assume that the soil does not have large amounts of swelling clays. Soils with platy structure, massive, compacted or high density should be used with extreme caution or avoided.

[4]A trained and qualified person would include a soil scientist, such as one working for NRCS, environmental health specialist, sanitarian, or other person who has received appropriate soil training and through experience is competent.
[5]Soil is too coarse for conventional soil absorption designs, use pressure distribution dosing or other alternative system to prevent too rapid infiltration.
[6]Soils with these conditions may be acceptable for wastewater stabilization ponds or possibly other alternative systems. (See Table 6).

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. One example is the Dow soil in western Iowa. It is important to be aware of the present environment in the area being evaluated.

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.

Describing Color

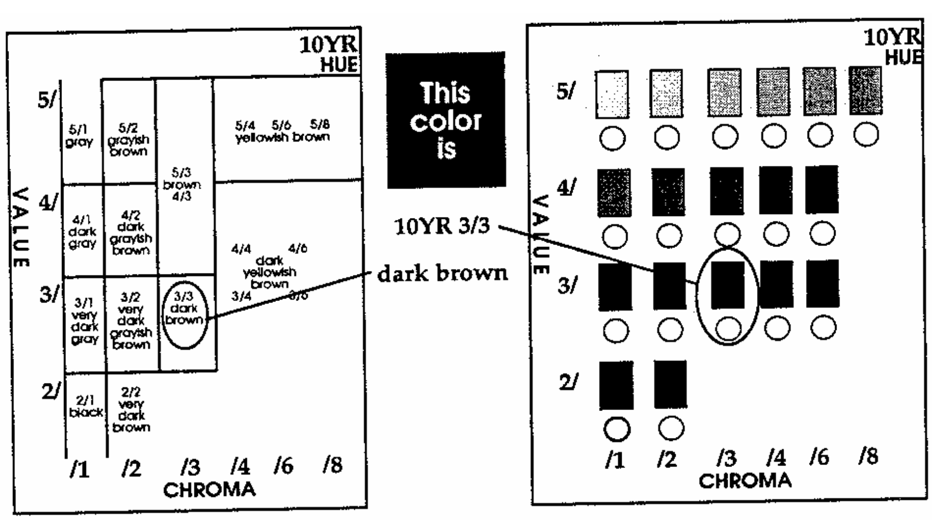
Color is composed of three variables:

- **Hue:** The dominant color, such as red, yellow, green, blue or purple.
- **Value:** The measure of the degree of darkness or lightness of color, in relation to the total amount of light reflected, such as light red or dark red.
- **Chroma:** The measure of the purity or strength of color, or its departure from a neutral of the same lightness, such as dull red or bright red.

Soil color is measured by comparison with a standard color chart. The chart used by site evaluators is the Munsell color system. The standard Munsell chart for soil color consists of about 175 different colored chips, systematically arranged on seven cards assembled into a loose-leaf notebook. Three additional cards, two for the reddest hues of soils and one for the bluish and greenish hues of grayed soils, are also available. (To order Munsell color books, refer to **Appendix B-3: Equipment and Suppliers.)**

The colors displayed on the individual color pages are of constant **hue,** designated by a symbol in the upper right-hand corner of the Munsell Color Chart. The color becomes lighter from the bottom of the card to the top by equal steps. **Chroma** increases from left to right, and grayness from right to left. Chroma notation is indicated by the horizontal scale across the bottom of the chart. The **value** notation of each chip is indicated by the vertical scale in the far left column of the chart. (See Figure B-23.) Opposite each page of color chips is a page of color symbols and corresponding English names, so that color can be expressed both by Munsell notation and color names.

Figure B-23



Read moist color of ped interiors with adequate light.

Conditions for Measuring Color

The quality and intensity of the light falling on a sample of soil affects the amount and quality of the light reflected from the sample to the eye. The moisture content of the sample and the roughness or smoothness of its surface also affect the amount and quality of the light reflected. The visual impression of color from the standard color chips is accurate only under standard conditions of light intensity and quality. As the color standards are used in the field, therefore, it is important that the light be white enough that the sample reflects its true color and that the amount of light be adequate for visual distinction between chips.

Color determination may be inaccurate early in the morning or late in the evening. When the sun is low in the sky, the light reaching the sample is somewhat red and the light reflected from the sample is redder than at midday. Even though the same kind of light reached the color standard and the sample, the reading of the sample color at these times is commonly one or more intervals of hue redder than at midday. Colors also appear different in the subdued light of a cloudy day than in bright sunlight. If artificial light is used, the light source used must be as near the white light of midday as possible. Intensity of the incident light is especially critical when matching soil to chips of low chroma and low value.

The color value of most soils becomes lower as the soil is moistened. Consequently, moisture state of the sample is given for each color determination. The soil can be moistened with water or, if wet, dried by blowing on a small ped. Changing the moisture content should continue until there is no further change in color value. Color determinations of wet soil may be in error because of the effect of light reflected from water films.

Mottling as an Indication of Zones of Soil Saturation

In Iowa, the presence of soil mottling is used as an indication of zones of soil saturation. For most soils, mottling and low chroma colors are good indicators of these 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 41F, 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 (see Figure B-24).

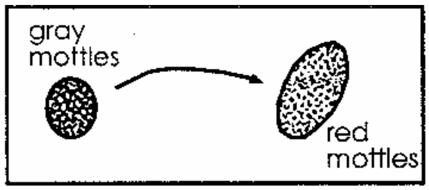


Figure B-24: Oxidation of Iron

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.

Describing Mottling or Redox Features

The color of each layer is recorded in soil descriptions. The aggregate of descriptions of each individual layer describes the color pattern of the soil.

Soil mottles are the soil colors that are in the minority if two soil colors are present (see Figure B-25). Soil mottles commonly are rusty-colored spots in the soil, but may be any color.
Color pattern within soil horizons are described for:

- matrix color (dominate color)
- mottle color (minority color)
- color of soil features (such as silt coats, clay films, organic coats)

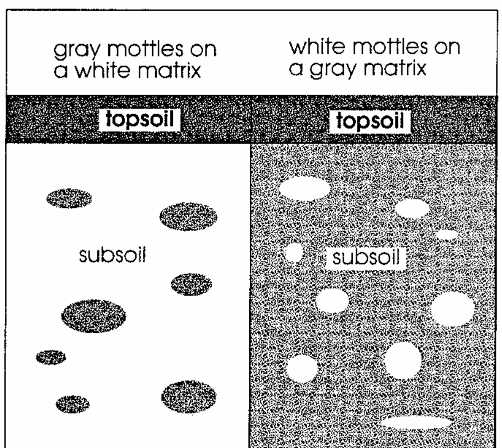


Figure B-25

When looking at a single unbroken ped, you may be viewing a coating on the ped. This coating can be organic material, silt, clay or an iron compound. Breaking or crushing (but not rubbing) will reveal the color of the ped interior, as shown in Figure B-26. If the ped interior has two or more colors, the majority color is considered the matrix color, and the minority color is the mottled color. If the ped is not coated you will be viewing the matrix and any mottle colors at the ped surface.

The ped exterior, ped interior, and mottle colors should be recorded. The physical state of the sample should be recorded as broken, crushed or cut. In mottled soils with thick ped coatings, the color and patterns of faces of peds, and those of a surface broken through the peds can be markedly different (see Figure B-26). The soil must be in a moist state when examined.

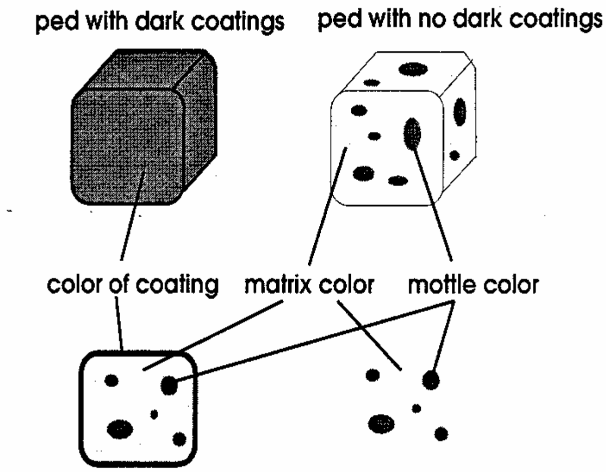


Figure B-26: Broken Peds Cross Section

Contrast refers to the degree of visual distinction that is evident between mottle and matrix colors. Contrast may be described as faint or distinct.

- **Faint:** Evident only on close examination; hue and chroma of mottles and matrix are similar.
- **Distinct:** Readily seen; soil color varies by one or more hue, more than two units of value, or more than one chroma.*

An example of distinct mottles is "pale-brown (10YR 6/3) fine sand, with many coarse, prominent, reddish-brown (5YR 5/4) mottles." Soil colors are determined by comparison with a standard set of colors as found in the Munsell color chart.

Reading the Color

1. Take a ped from the horizon to be examined. Do not crush or break the ped.
2. Adjust the water content of the ped to "moist."
3. Estimate the basic soil color (see Figure B-27), and turn to the appropriate Munsell page.

Figure 27

Estimate	Munsell Color
red	10YR to 7.5 YR
brown	10YR
olive	2.5Y or 5Y
gray	5Y

4. With the sun at your back, hold the sample behind the holes of the page. Match as closely as possible.
5. If you are not satisfied with the match, flip the page forward for browner or redder colors, backward for more olive or gray colors.
6. Record the chosen color or colors.
7. Break, cut or crush (but do not rub) the ped to see if the ped interior differs in color from the ped surface. If so, repeat steps 3 to 6 above for the ped interior.

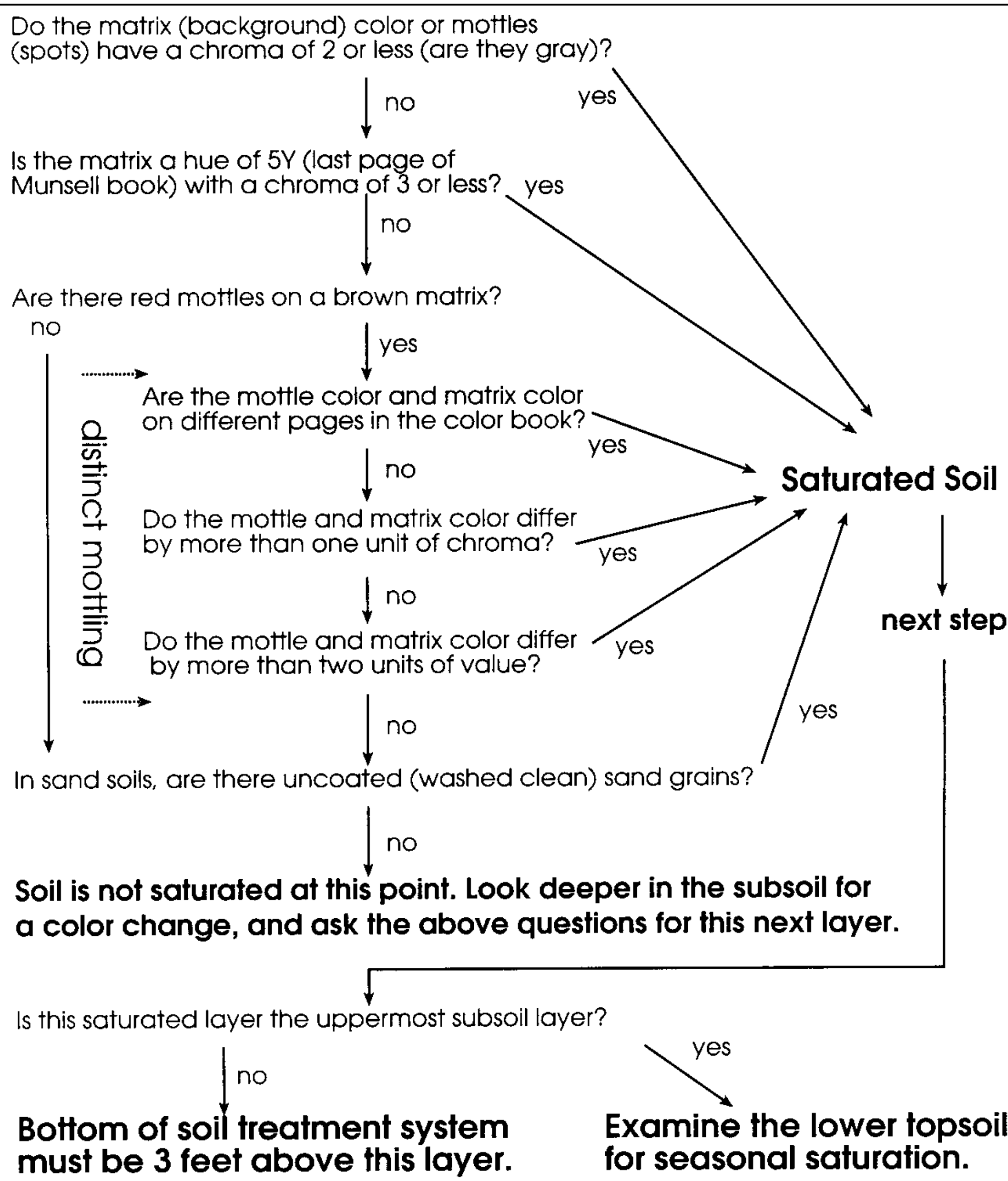
Rarely will the color of the sample be perfectly matched. Select the closest match.

Color Interpretation

Site evaluators must understand not only the mechanics of using Munsell Soil Color Charts, but also how to interpret the meaning of the colors that are described. The color and color patterns in soil are good indicators of the drainage characteristics of the soil. Soil properties, location in the landscape and climate all influence water movement in the soil. These factors cause some soils to be saturated or seasonally saturated, affecting their ability to absorb and treat wastewater. Interpretation of soil color aids in identifying these conditions. Figure B-28 illustrates the process of using color to determine soil saturation.

Figure B-28: Saturated Soil Determination

Determine the soil color using the Munsel color book.
Start with the upper subsoil. Subsoil is the first layer below an E horizon



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. Figure B-29 describes a process for determining the depth of saturated topsoil.

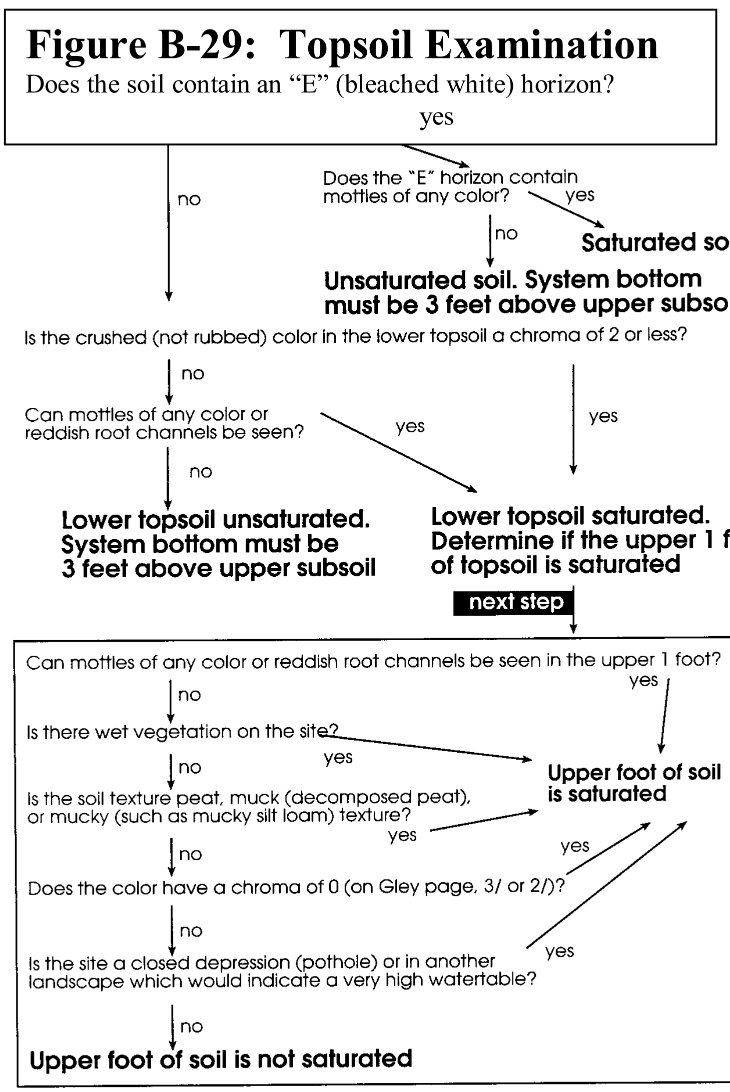


Figure B-29: Topsoil Examination

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 drainfield 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(see Figure B-30).

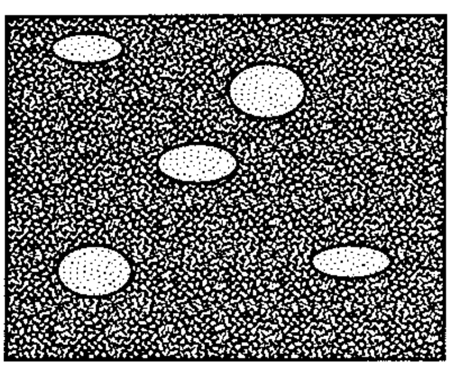


Figure B-30: Nodules

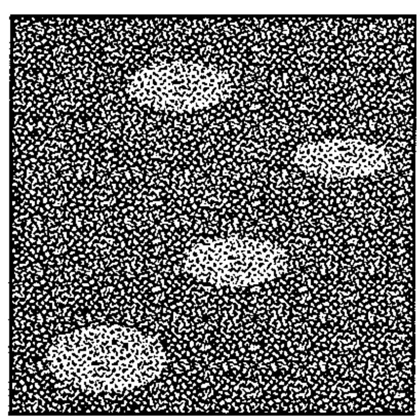


Figure B-31: Soft Accumulations

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 (see Figure B-31).

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, see Figure B-32.

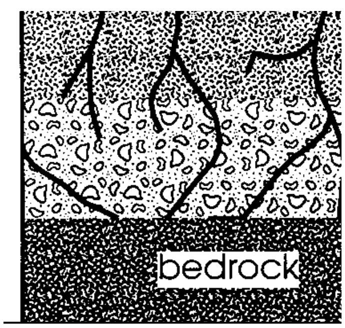


Figure B-32
Roots and Root Traces

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.

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). (See **Appendix B-1: Running a Percolation Test.)**

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

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. (See Figure B-33.)

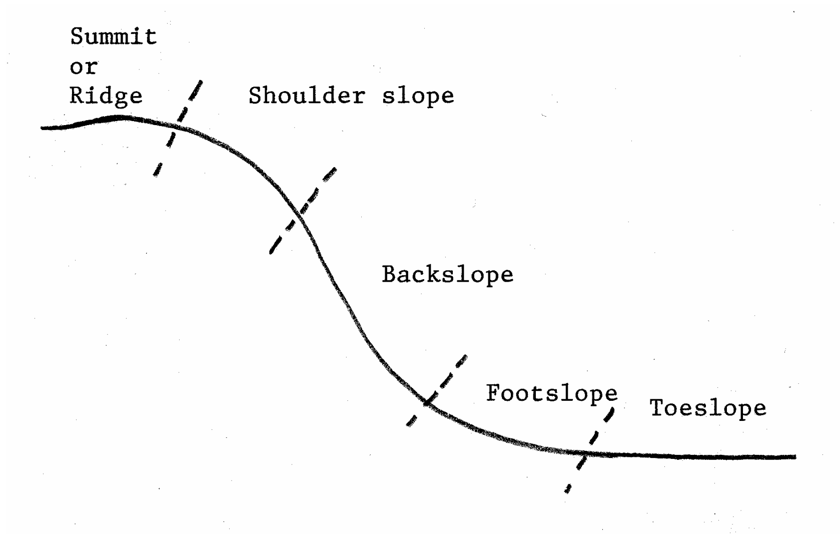
Figure B-33: Porosity and Conductivity of Soils

texture class	mean total porosity %	saturated conductivity (K_S) ft/day
sand	43.7	16.54
loamy sand	43.7	4.81
sandy loam	45.3	2.04
loam	46.3	1.04
silt loam	50.1	0.54
sandy clay loam	39.8	0.34
clay loam	46.4	0.18
silty clay loam	47.1	0.12
sandy clay	43.0	0.09
silty clay	47.9	0.07
clay	47.5	0.05

From Rawls et al., 1989. Estimating soil hydraulic properties from soil data.

Sands and gravelly soils in many landscape positions (e.g summit, shoulder, or back slope - see Figure B-34) 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.

Figure B-34



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 drainfield is evidence of this capillary movement of unsaturated flow of water. Figure B-35 shows how as a biomat develops in a trench, flow under the trench becomes entirely unsaturated.

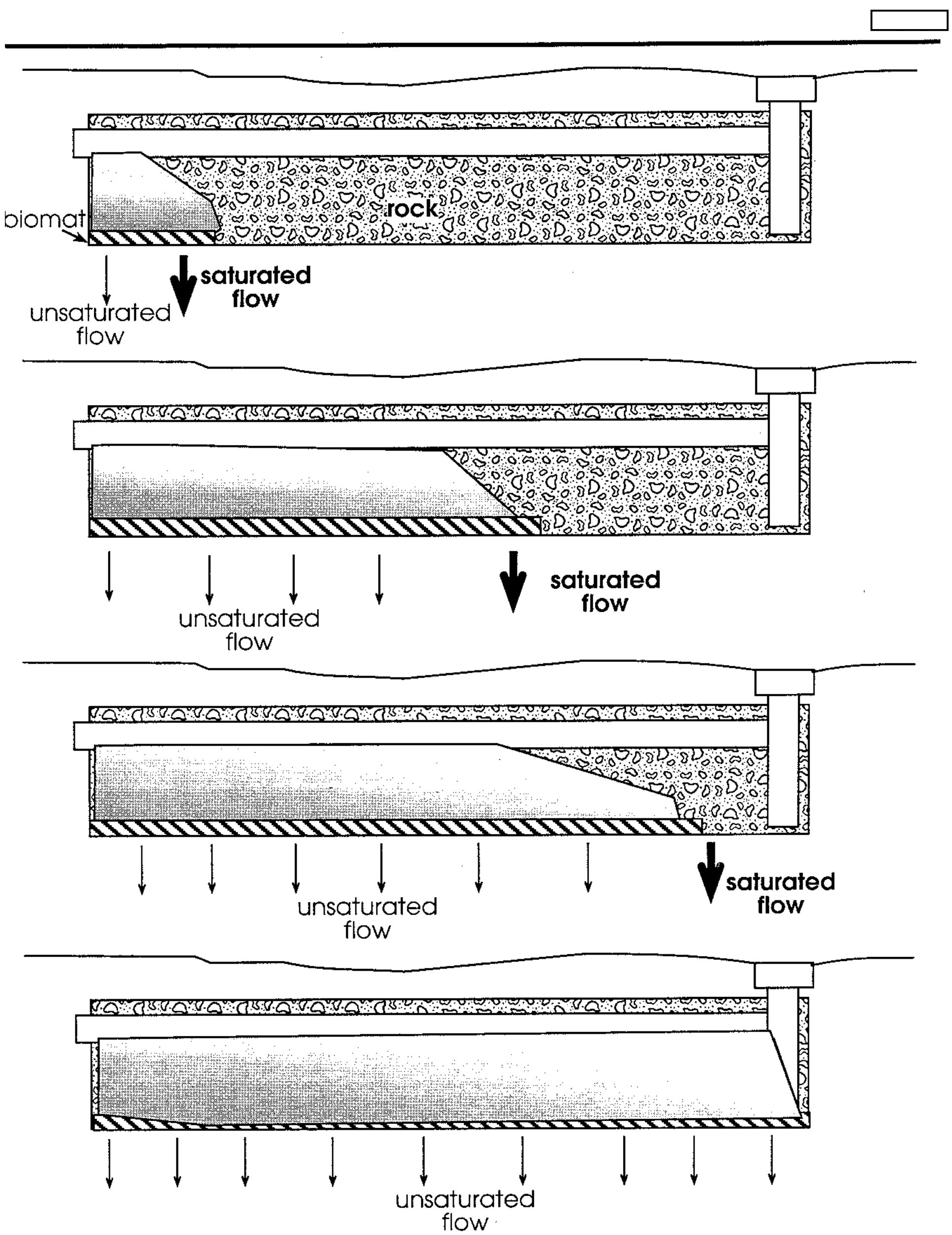


Figure B-35: Biomat Development in a Trench

Percolation Rates and Sizing Systems

Figure B-36 presents the soil sizing factors used for the various ranges of percolation rates.

NOTE: These values are approximations based on averages in soils and should only be used when there is a through knowledge of the percolation test methods and site conditions.

Figure B-36: Soil Characteristics and Required Areas for Sewage Treatment (> 3' separation)

percolation rate in minutes per inch (mpi)	common soil texture	square feet per gallon per day	gallons per day per square foot
faster than 0.1*	coarse sand	0.83	1.20
0.1 to 5	medium sand, loamy sand	0.83	1.20
0.1 to 5	fine sand**	1.67	0.60
6 to 15	sandy loam	1.27	0.79
16 to 30	loam	1.67	0.60
31 to 45	silt loam	2.00	0.50
46 to 60	clay loam, silty clay loam, sandy clay loam	2.20	0.45
over 61***	clay, silty clay, sandy clay	4.2	—

*Soil too coarse for sewage treatment; use systems for rapidly permeable soils.
**Soil having 50% or more fine sand plus very fine sand.
***Soil with too high a percentage of clay for installation of a standard in-ground system

Note that the soil sizing factor increases as the percolation rate slows down. A percolation rate of 60 means that it takes 60 minutes (one hour) for the liquid level to drop one inch in the percolation test hole. A percolation rate of 30 means that it requires 30 minutes for the one inch drop to occur. It is correct to say that 60 is a slower percolation rate than 30. Use the terminology ***faster than*** or ***slower than*** when referring to percolation rates rather than *greater than* or *less than.*

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.

Soil Drainage Classes

Seven drainage classes are recognized. The first two, **excessively drained** and **somewhat excessively drained,** describe soils that are dry longer than is typical for the dominant soils of an area. **Well drained** soils are neither unusually dry nor unusually wet. Increasing degrees of wetness limit use of **moderately well drained, somewhat poorly drained, poorly drained** and **very poorly drained soils.**

The following definitions were developed for agronomic purposes, but the basis for water movement and retention given under the definitions can be used for sewage treatment.

- **Excessively drained:** These are soils that have very high and high hydraulic conductivity, and low water-holding capacity. Water table depths are greater than six feet.
- **Somewhat excessively drained:** These soils have high hydraulic conductivity and low water-holding capacity. Water table depths are greater than six feet.
- **Well drained:** These soils have intermediate water-holding capacity. They retain optimum amounts of moisture, but they are not saturated close to the surface.
- **Moderately well drained:** These soils are wet close enough to the surface for long enough that planting or harvesting operations or yields of some field crops are slightly adversely affected. Moderately well drained soils commonly have a layer with low hydraulic conductivity, wet state relatively high in the profile, additions of water by seepage or some combination of these.
- **Somewhat poorly drained:** These soils are wet close enough to the surface or long enough that planting and harvesting operations and/or crop growth are restricted. Somewhat poorly drained soils commonly have a layer with low hydraulic conductivity, wet state high in the profile, additions of water through seepage or a combination of these.
- **Poorly drained:** These soils commonly are wet at or near the surface during a considerable part of the year so that field crops cannot be

grown under natural conditions. Poorly drained conditions are caused by a saturated zone, a layer with low hydraulic conductivity, seepage or a combination of these.

- **Very poorly drained:** These soils are wet to the surface most of the time. These soils are wet enough to prevent the growth of important crops (except rice) unless artificially drained.

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.

Water tables can be either **apparent, perched,** or **ponded.**

- **Apparent water table:** An apparent water table is the level at which water stands in a freshly dug, unlined borehole after adequate time for adjustments in the surrounding soil. (See Figure B-37.)

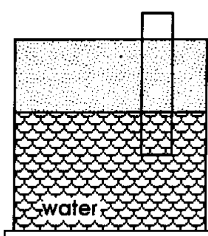


Figure B-37:
Apparent Water Table

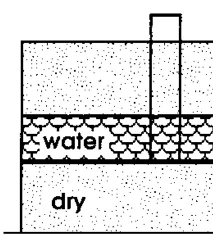


Figure B-38
Perched Water Table

- **Perched water table:** A perched water table exists in the soil above an unsaturated zone. (See Figure B-38.) A water table may be inferred to be perched on the basis of general knowledge of the water level of an area, the landscape position, the permeability of soil layers and from other evidence. To prove that a water table is perched, the water levels in boreholes must fall when the borehole is extended.

Perched and apparent water tables can be seasonal or long-term. Many soils in Iowa have a seasonally high water table

Aquifers

An aquifer is a body of groundwater which is, or can be, used for drinking water purposes. In some cases saturated soil conditions may be the upper level of an aquifer. In other cases these saturated soil conditions may be separated from a deeper aquifer by geologic materials which may impede downward groundwater movement. (See Figure B-39) In either case, there still needs to be a three-foot separation distance from the highest point of soil saturation and the bottom of the soil absorption system.

Groundwater flow rates and directions are controlled by the geologic character of an area. Recharge and discharge areas are an important concept in groundwater geology. A recharge area is usually a topographically high area from which a pressure gradient is established on the water table. From this point, the water table slopes until it intersects the surface in a stream, lake or other groundwater discharge area.

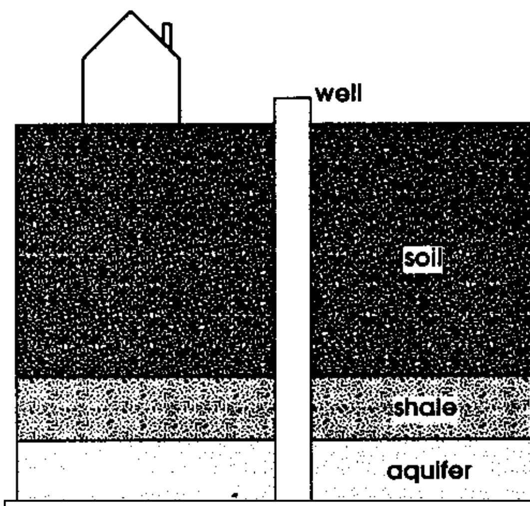


Figure B-39

PART V: 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.

Preliminary Evaluation

Determining Homeowner Preferences

Before beginning the preliminary evaluation or physical investigation of the lot, determine the needs and wants of the property owner. The major items for a site evaluator to consider in developing a lot are the following:

- Location of the house/ building improvements.
- Proposed location of the onsite sewage treatment system.
- Location of the water supply wells within 100 feet of the proposed soil absorption area and 50 feet from septic tank.
- Any lot easements or rights-of-way.

To the owner of an undeveloped lot, however, major concerns usually include the location, aspect, view, and type of house proposed. In addition, projected improvements such as a driveway, garage, patio, or swimming pool may conflict with the area most suited for onsite sewage treatment. Therefore, it is important to discuss the site evaluation for the onsite sewage treatment system at an early stage in development plans for the lot. It is a rare instance when all the desired improvements can be located exactly where the lot purchaser wants them to be.

Priorities must be established (a properly designed, sited, and installed sewage treatment system is a high priority), and trade-offs are inevitable.
Figure B-40 is a checklist that may be useful in the preliminary evaluation process.

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.

Evaluators must provide reports to the proper authorities and to the client for each site evaluation—both for sites that are suitable and for sites that are found to be unsuitable.

The individual evaluating the site is responsible for all data reported. Soil testers cannot delegate their duties to others. They may use helpers to dig holes and carry water to percolation holes, but the certified soil tester must select the sites for percolation tests and soil bore holes, make measurements, evaluate and describe soil profiles, and personally certify the reported data.

Gathering Information

Conducting a complete site evaluation requires a great deal of information—as well as knowing where to get that information. Keep in mind that a preliminary evaluation, no matter how well done, is no substitute for a field evaluation. The information needed is listed below.

- Location of noncommunity transient public water supply wells within 200 feet of the propsed system, if alternative local standards are in effect.
- Location of community or noncommunity nontranisent water supply, in a drinking water supply area, if alternative local standards are in effect.
- Location of buried pipe within 50 feet of the system.
- Location of easements.
- Location of property lines.
- Location of the ordinary high water level of public waters.
- Soil classifications and applicable characteristics at the proposed soil treatment areas. Consult the soil survey report, if available.
- Floodplain designation and flooding elevation from published data or data that is acceptable to and approved by the local unit of government or the DNR;
- All required setbacks from the system.
- Legal description and lot dimensions.
- Names of property owners.
- Inclusion of the site within an inner wellhead management zone or wellhead protection area of a public water supply.

Figure B-40

Preliminary Evaluation Checklist

Date ________ Client ______________________________

Legal Location ____________________________________

System: new replacement (circle one) Type of Establishment_______________ (e.g. single family residence, restaurant)

Is the system located in a wellhead protection area, shoreland, or does it serve a food, beverage or lodging establishment? **Y / N**

House Specifications/Flow Determination

Number of bedrooms ______

150 gpd per bedroom x __________ (# of bedrooms) = ________ gpd

Number of anticipated water-using devices ______
(automatic washer, dishwasher, water softener, garbage disposal, self cleaning humidifier, whirlpool bath.)

Description of well(s)____________________

____

Easements____________________________

____

____

Flooding Information____________________

____

Soil Survey Information:

	Soil #1	Soil #2	Soil #3
Map unit symbol			
Map unit name			
Soil features: Landscape position			
Flooding			
Slope			
Watertable depth			
Bedrock depth			

	Soil #1	Soil #2	Soil #3
Possible depth of system:			
Texture at proposed depth of system:			
Permeability at proposed system bottom (in/hr)			
60 divided by inches/hours (MPI)			
SCS suitability for onsite system			

Site Evaluation Map

Date: ________ **Site Evaluator:** ________________

Legal Location and Directions to Lot: ____

____

Any Surface Signs of Compaction: ____

Have the following been drawn on the map?

Easements: phone ____ electric ____ gas ____ **Location:** Dwelling ____ Other Improvements ____

Lot Dimensions: ____ **Location of Existing System:** ____ **Location of Replacement Area:** ____

Slope: percent ____ direction ____ **Setbacks:** Building- 10 feet ____ Property Lines - 10 feet ____

Water Well - 100 feet ____ water suction pipe - 50 feet ____ Pressure Pipe - 10 feet ____

Streams /Lakes - 25, 50, 100 feet ____ **Borings/Perc Tests:** Location ____ Elevation ____

Horizontal and Vertical Reference Point of borings ____ **Indicate North** ____ **Unsuitable Areas:** ____

Is the Proposed Location: Staked and Protected? ________ **Accessible for Pumping?** ________

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.

Two days before beginning any digging for soil investigation or system construction, you must (by state law) contact Iowa One Call at 1-800-ONE-CALL 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 three 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. Some local sanitary ordinances require locating two areas suitable for a sewage treatment system on a lot.

Vegetation

Observations of the growth of both native vegetation and cultivated crops aid in recognizing soil boundaries and provide information about soil drainage.

Native Vegetation. Generally, close relationships exist between native vegetation and kinds of soil; yet there are important exceptions. A reliable field evaluation cannot be made by studying vegetation alone, but with careful observations of both soils and vegetation, excellent correlations can be established. Cattails, alders, dogwood, willows, tamaracks and sedge grasses all indicate wet soil areas. These areas should be noted on the site evaluation map.

Cultivated Vegetation. Over an extended period of cultivation, farmers learn which crops do well and which do poorly on different kinds of soil and adjust their cropping patterns accordingly. If the differences are large—as between crop failure and reasonable performance—the absence of a given crop may reflect the suitability of that kind of soil for the crop. If the differences are small, many non-soil factors can determine the farmer's choice of fields for a given crop. Relationships observed must be interpreted with caution because of economic factors, management systems and farmer preference. But within fields of a single crop, differences of vigor, stand or color of the crop or weeds commonly mark soil differences and are valuable clues to the location of soil boundaries.

Landscape/Topography

The landscape position and slope form elements (see Figure B-42) for 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 footslopes are more likely to be poorly drained.

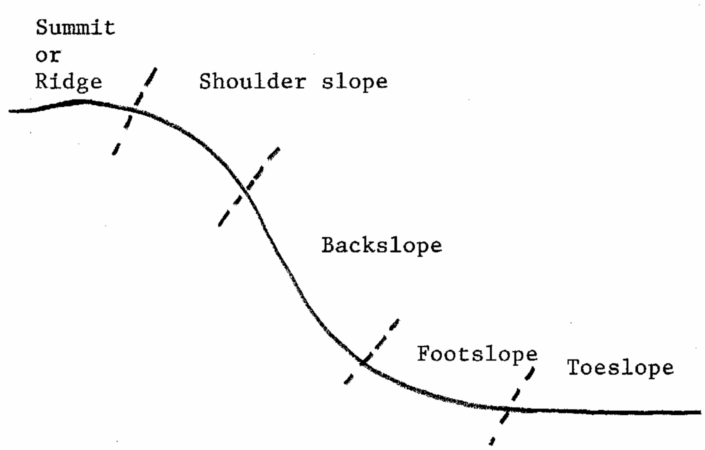


Figure B-42

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.

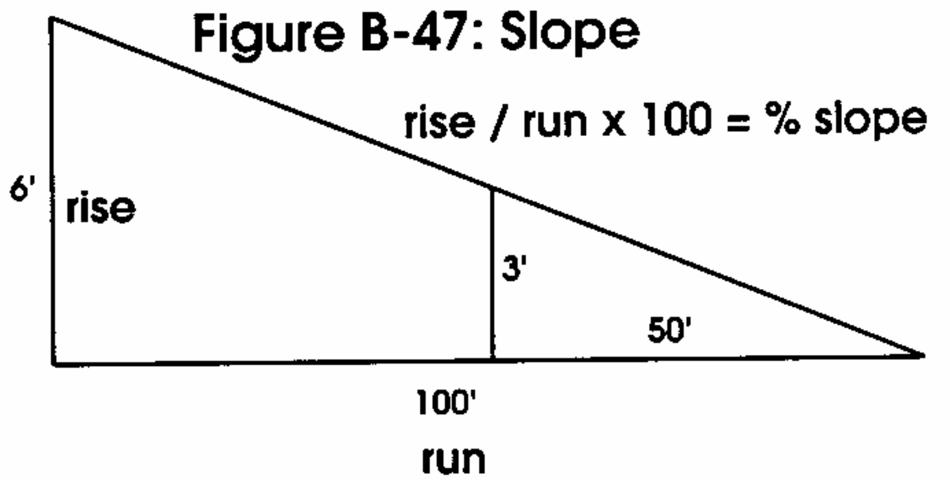
- Swamps, marshes and potholes
- Drainageways, swales or floodplains
- Sinkholes

Aid in determining the landscapes in which the soil is positioned can be gained from the Soil Survey Report.

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. One method is to use a clinometer. Slope is the ratio of vertical rise or fall to horizontal distance (see Figure B-47). It is usually expressed as a percentage.

Figure B-47: Slope



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)

In Iowa, saturated soils can be found in any landscape position, elevation and on any slope form, although in general, soil drainage is related to steepness of slope. The steeper the slope, the better the soil drainage.

The Evaluation Process

See **Appendix B-3: Equipment and Suppliers** for a list of tools to use during the site evaluation.

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 house, 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.

Because you called Iowa One Call two days before beginning your soil investigation, the locations of all buried utilities have been marked. **(Again, the Iowa One Call number is 1-800-CALL IOWA.**

Soil Investigations

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.

For example: The first boring (in the middle) is dug to six feet with no indication of bedrock, water table or gray soil coloration. The site evaluator proposes the system depth at two feet, and the remaining borings will then be dug to a five foot depth.

After the initial observation has been completed, evaluated and recorded, proposed system locations may be established.

Soil Boring Log

Figure B-48 is a soil boring log for recording data during soil investigations. 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.

Soil Boring Log

Client: ______________________________
Address: ______________________________
Legal Description: ______________________________
Date: ____________
Location: ______________________________
Soil Type: ______________________________
Disturbed/ Compacted yes no
Type of observation: Probe Pit Boring
Vegetation: Wet Dry Unknown
Parent Material: Till Outwash Loess Bedrock Alluvium
Landscape Position: ______________________________
Slope: ______ %
Drainage: Good Problems Solutions ______________________________
Floodplain: yes no

# of Bedrooms: __________
Garbage Disposal: yes no
Type: I II III IV
Flow: ______________

If yes, Elevation: ____________
Reference Point: ____________
Elevation of Boring: ________
Depth of Water: ________
Depth to Bedrock: ________
Depth of Sat. Soil: ________
Max Depth of System: ________
Soil Sizing Factor: ________
Percolate Rate: ________
Linear Loading Rate: ________
Well Type: ____________
Well Location: ____________
Depth: ____________
Casing Depth: ____________
10' of Imp. material: yes no
Bottom Elevation: ____________
Constuction Issues: ______________________________

Depth (inches)	Texture	Color (Matrix - Mottles)	Structure	Consistance
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid

Additional Notes: ______________________________

<u>Preliminary Design</u>
Trench_____ Bed_____ Atgrade ______ Mound_____ Holding Tank_____
Gravity Dist._____ Pressure Dist. _____
Sand: Serial _____ Pressure_____ Liner_____ Clay: Liner_____

Figure 48

Bedrock Determination

From your preliminary investigation, you should have a good idea if bedrock is present on or near your site. Many Iowa counties have no high bedrock conditions. If bedrock is suspected, methods to determine bedrock are as follows:

- Angular rocks on the ground surface or in the auger.
- Outcroppings on or near the site.
- Bedrock in nearby road cuts or a backhoe pit.

The depth at which the soil "stops" and the term *bedrock* is used is dependent upon the type of bedrock. The method for determining bedrock is presented in Figure B-49.

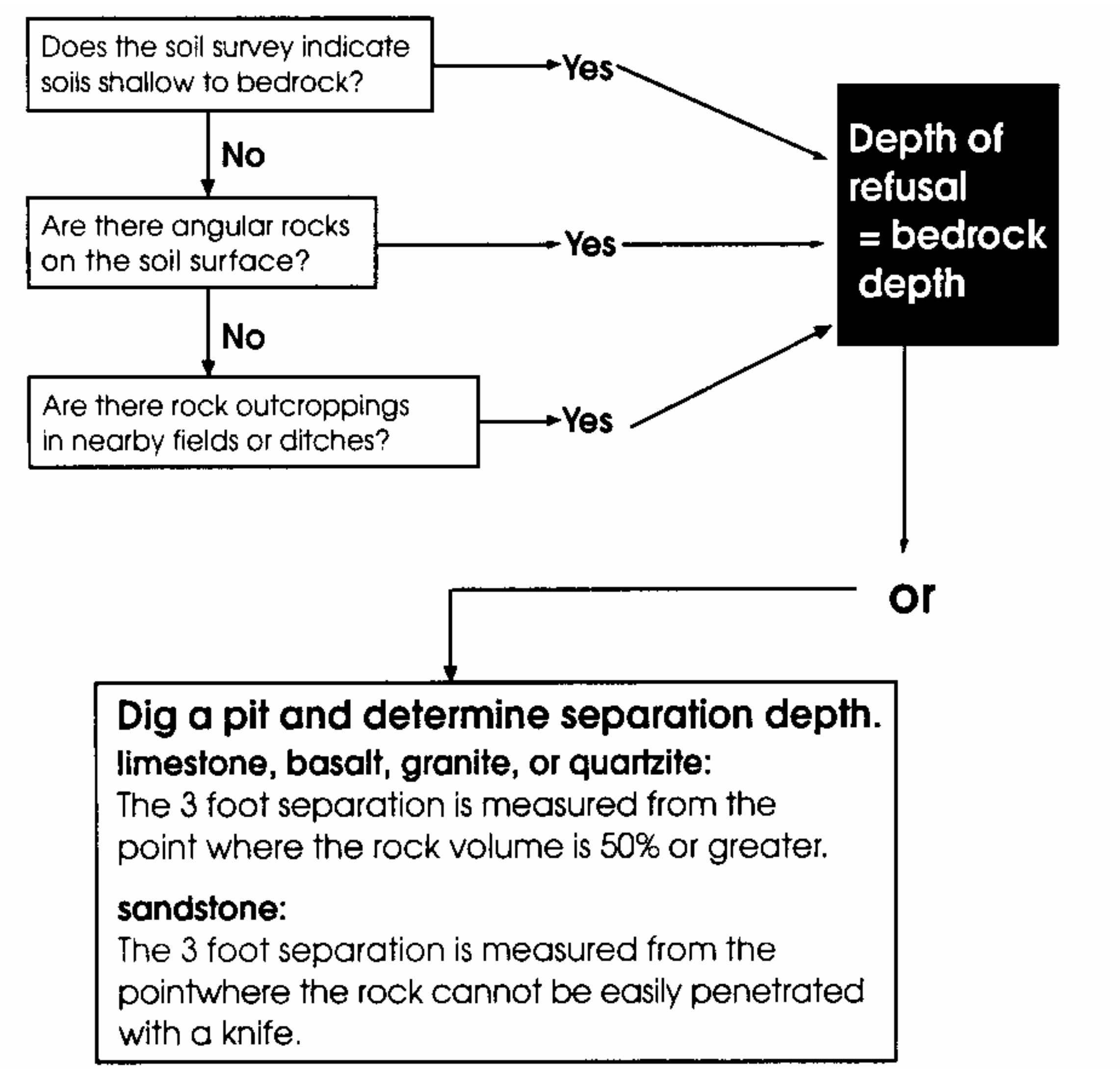


Figure B-49

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 absoprtion 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 as indicated in Figure B-50. 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.

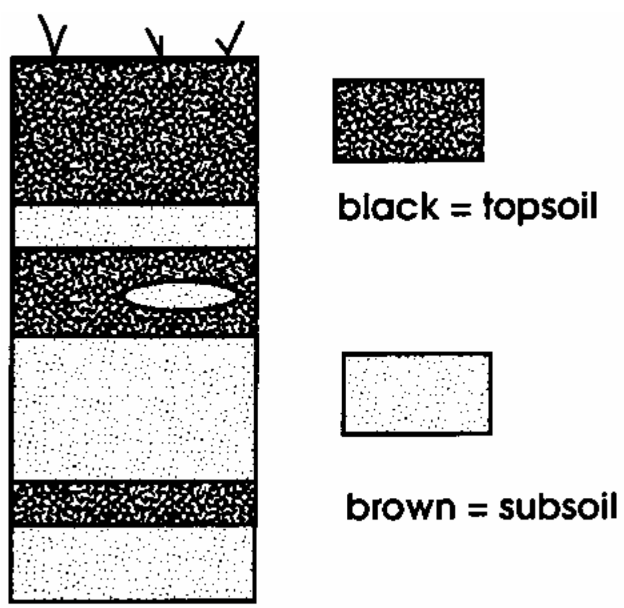


Figure B-50

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

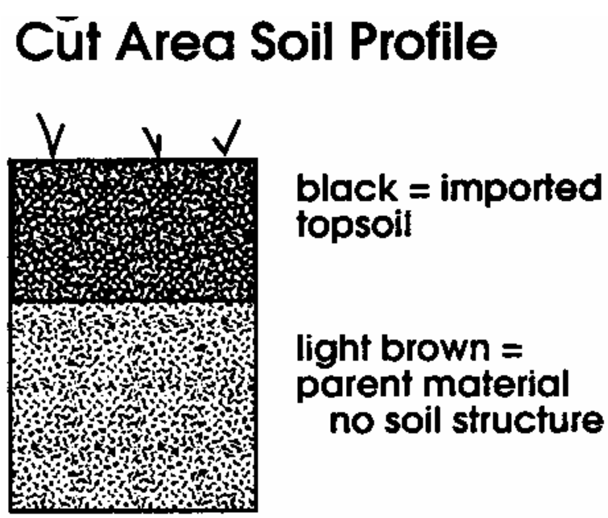
Cut areas are areas where the land surface has been lowered by removal of earthen materials. Cut areas have usually been compacted by machinery during land leveling. This compaction may be localized and spotty, or widespread, depending on wheel traffic patterns.

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, figure B-51. 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).

Figure B-51



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, as defined by the state Department of Natural Resources (DNR) 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.

Information received from the DNR or county should have revealed if the site was located in an identifiable flood plain. **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, back-swamps, 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.

The 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 fencelines.

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. The soil test report consists of four major portions:

- the preliminary evaluation report,
- the boring log,
- the map of the site, and
- the percolation test sheets.

Sometimes a property is too large to conveniently illustrate all of the required information on the grid provided on the map. In these instances, use a separate sheet to draw a plot plan diagram.

PART VI: SITE SURVEYING

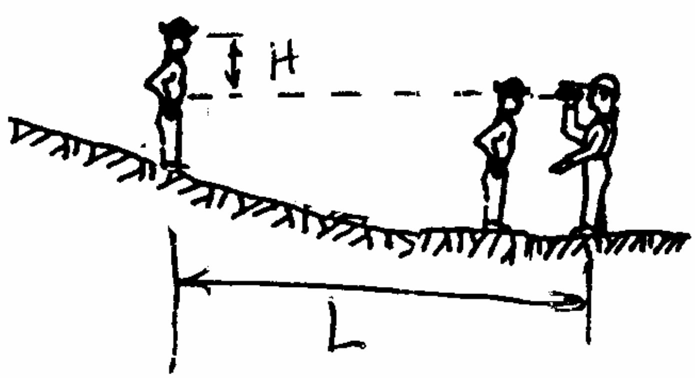
SITE and CONSTRUCTION SURVEYING

There are a number of different types of equipment available to conduct site evaluations, design layouts, and construction staking. The site topography is a critical factor in selecting the type of design and treatment system. There are three basic types of equipment hand level, engineers level often referred to as a level, and transit.

HAND LEVEL

The hand level is what it sounds like a small tube about 1-inch in diameter and 4 to 6-inches long. There is a small bubble level inside that is used to hold the hand level, level. It is the easiest to use and most inexpensive, however it is not as accurate as the others are. For initial site evaluation the hand level is sufficient to accomplish the task.

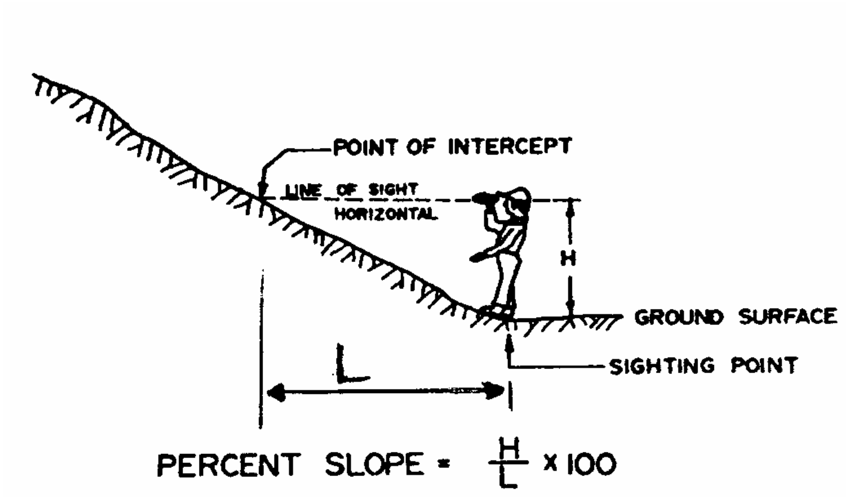
The following drawings show how to use the hand level.



On level ground site through the hand level on a person note the place where the level is level. Have the person walk to the position where you want to know the slope from where you are to there. Hold the level and note the spot on the person that you are now level on. Measure the distance between the people and then determine the approximate slope.

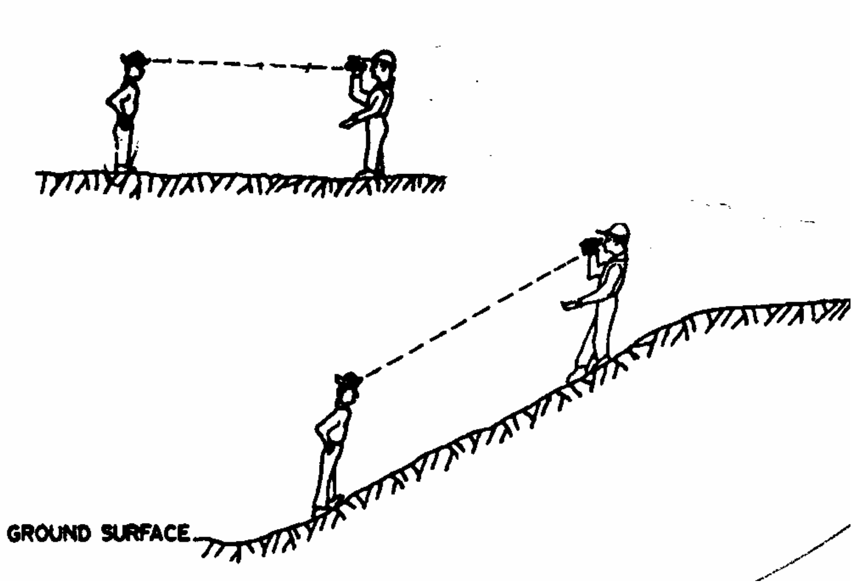
Slope = H ÷L x 100

Another way of approximating the slope is to know your eye height and sight a point that is level and measure the distance as shown below.



Also in the hand level group is the Abney Level and Clinometer. These are used to measure the slope directly, or can be used as a level.

On level ground sight a spot on a person that is level have that person stand at a location and sight the exact same spot then read the slope on the clinometer. The distance between the people is not needed with this instrument. These work for both up and down slope measurements.



ENGINEERS LEVEL

This instrument is set on a tripod and leveled. The operator looks through the eye piece and everything in the cross hairs is level with the instrument height. The distance form the level and the elevation difference is measured and the slope is calculated as follows:

$$\frac{\text{elevation difference}}{\text{distance}} \text{ X } 100 = \text{slope}$$

TRANSIT

The transit measures both horizontal and vertical angles and is capable of being used as a level. Because of the added complexity of the trigonometric method it is rarely needed for onsite construction, however it is some times used like an engineers level.

Definitions:

Benchmark (BM)

A relatively permanent object of know or assumed elevation. It may be a high point on a large boulder that will not move, a 2”x2” stake driven into the ground, a spike in a tree, or other object that will be moved during construction. Often times the benchmark is given an elevation of 100.00 for reference on the project, which has no meaning outside of the project.

Backsight (BS)

A rod reading on a point know or assumed elevation. The first reading on the benchmark would be the backsight. A backsight reading is added to the elevation of the benchmark to determine the elevation of the center cross hair of the level instrument.

Height of Instrument (HI)

The elevation of the horizontal cross hair or line of sight of the level instrument. The height of instrument is determined by adding the backsight reading to the elevation of the point being sighted upon.

Foresight (FS)

A rod reading taken on a point for which the elevation is to be determined. The elevation of that point is determined by subtracting the foresight reading from the height of the instrument.

Grade Rod

A rod reading when the bottom of the rod is held on “grade”, or the ground surface.

Turning Point (TP)

A turning point is a temporary position/setup of the level instrument to transfer a known elevation from position to another. If the benchmark is located in the front of the house and the septic system is located in the rear and there is not a clear line of sight for any point to both objects. The level instrument must the repositioned to determine the elevations needed.

NOTES

Before observations are made, focus the eyepiece on the cross hairs and ensure the no parallax is present.

Before taking any readings and in between readings check a see if that the instrument is level.

While making observations do not handle the instrument any more than necessary.

Ensure that the rod being held is vertical while readings are being taken. If the rod is waved slowly forward and back, the lowest observed reading will occur when the rod is vertical. Be familiar with the rod you are using. Some rods are marked off in tenths of feet others are in feet and inches.

With the instrument in one place the rod readings will increase as the objects being shot decrease in elevation. On septic tanks the rod readings for the outlet pipe should always be 3-inches greater than the rod reading for the inlet pipe.

ERRORS IN USING A LEVEL

Parallax occurs when the object lens is not carefully focused on the object and the observer’s eye is not focused on the plane of the instrument cross hairs. The effect is to cause the relative movement between the image of the cross hairs and the image of the object when the eye is moved up and down.

Imperfect adjustment of the instrument. If the line of sight is not parallel to the axis of the level tube, an upward or downward inclination occurs. This error is minimized by ensuring the instrument is properly adjusted, is level when each reading is made, ant that readings are approximately the same distance from the instrument.

If the rod is not held vertically, the readings will be too large. Appreciable inclinations of the rod must be avoided particularly for high rod readings. The error can be eliminated by using a rod level or by waving the rod.

When the bubble is not centered during a sighting, an error results which is greater the longer the distance between the instrument and rod. Ensure that the instrument is level on each sighting.

Improper reading of the rod. The error can be very large when numbers on the rod are confused. This mistake is not likely to occur if the observer views numbers both above and below the observed reading or when the rodman assists in spotting the observation point.

Not having the rod fully extended will cause the readings to be inaccurate.

Appendix B-1:
Running a Percolation Test

The percolation test is an important part of a site evaluation, and it is critical to the successful design of an onsite sewage treatment system. Suitable soil is the key to providing adequate onsite sewage treatment. Soil borings are used to locate a suitable area before beginning the percolation test.

The Percometer and the Hook Gauge

Figure B-52 shows a percometer, which is a device to accurately measure the drop in the liquid level in soil. A rod which is fastened to the float is read by the scale or ruler at the top of the percometer. A four-inch plastic pipe can serve as the body of the percometer. Half-inch holes should be drilled near the bottom to allow water to freely flow in and out. A plastic bottle approximately one quart in size can be used as the float. The stiff wire fastened to the top of the bottle extends through the top brace of the percometer.

A different method of measuring the drop in liquid level may be used (see Figure B-53). In this case, a hook gauge is used to determine the liquid surface and a batter board is used as a reference point. While this is an accurate method of determining the liquid level, it is not as convenient as using the percometer.

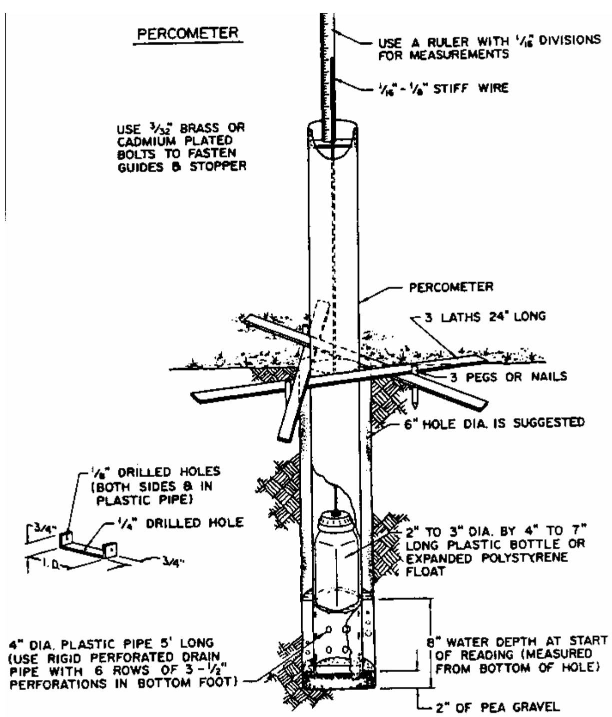


Figure 52

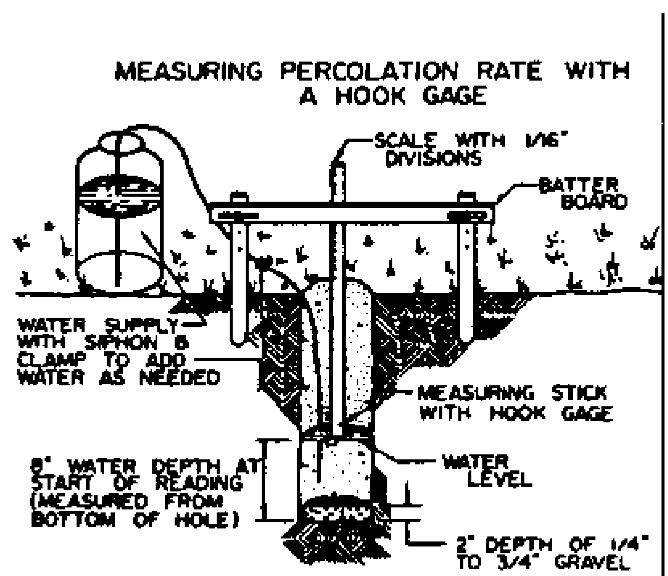


Figure 53

Percolation Test Data Sheet

A percolation test data sheet should be used.

Field ratings of the time and water level should show no erasures. If you make a mistake, cross out the reading and enter the correct value. Erasures can be made on computed values, but erasures made on field readings casts doubt on the validity of that data.

Field readings should be taken until two consecutive percolation rates vary by no more than 1/8 –inch (Chapter 69). Use the last of these thre readings to determine the percolation rate for the test hole. A percolation test should not be run where frost exists below the depth of the proposed soil treatment system.

Steps in a Percolation Test

Dig the Test Holes

The test holes should be round and at 4 to 12 inches in diameter. Dig each test hole as deep as you intend to excavate the soil treatment trench. The bottom of the percolation test hole must be at least three feet above the level of seasonally saturated soil or an impervious layer. A clamshell-type posthole digger can be used.

Prepare the Test Holes

The auger or post hole digger is likely to smear the soil along the sidewalls of the test hole. Therefore, the bottom 12 inches of the sidewalls and bottom of the hole should be scratched or scarified with a sharp, pointed instrument such as a knife. Nails driven into a 1 x 2-inch board will do a good job of scarifying the hole to provide an open, natural soil into which water may percolate. Remove all loose soil material from the bottom of the test hole. Add two inches of 1/4 to 3/4 inch gravel to protect the bottom from scouring when water is added. The gravel can be contained in a nylon mesh bag so it can be removed after the test is performed and used for additional percolation tests.

Distinguish Between Saturation and Soil Swelling

- **Saturation** means that the voids between the soil particles are full of water. This can happen in a short time.
- **Swelling** is caused by intrusion of water into individual soil particles. This is a slow process, especially in clay soils, and is why a prolonged soaking period is necessary for some soils.

Carefully fill the percolation test hole with clear water to a depth of at least 12 inches above the soil bottom of the test hole. Use a hose to prevent the water from washing down the sides of the hole or add the water directly in the percometer. A six-inch diameter hole requires about 1.5 gallons per foot of depth.

Sandy soils containing no clay do not swell. The percolation test may proceed immediately if the 12 inches of water seeps away in ten minutes or less.

For prolonged soil soaking, keep the 12-inch depth of water in the hole for at least four hours, and preferably overnight. Add water as necessary. You may use an automatic siphon or valve to maintain the 12-inch water depth (see Figures B-54 and B-55).

Figure 54

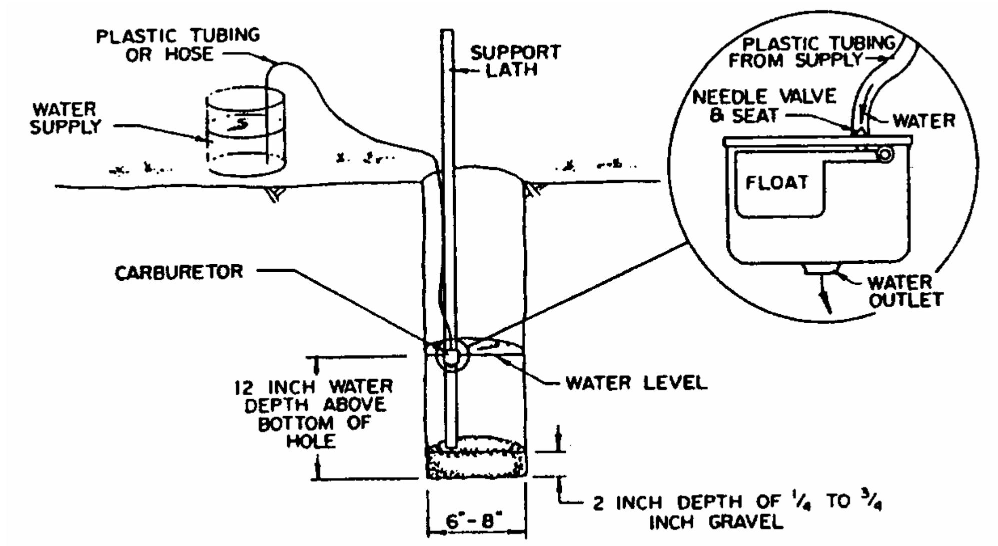
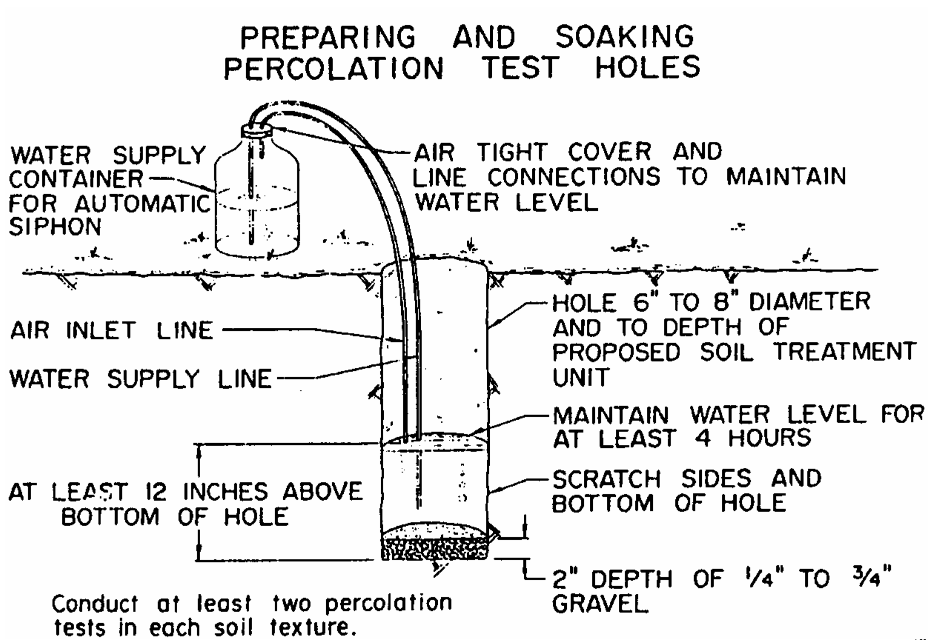


Figure 55



Measure the Percolation Rate

If more than six inches of water remain in the hole after the overnight swelling period, bail out enough water so that six inches of water remains above the gravel (eight inches if measured from the bottom of the hole). Measure the drop in the water to the nearest 1/8 inch approximately every 30 minutes. If possible, use a percometer to determine the change in water level. A batter board can also be used as a reference point together with a hook gauge to accurately locate the water surface. The hook can be made from stiff wire or an 8d nail. After each measurement, refill the water in the hole so that the liquid depth is six inches above the gravel. Continue taking measurements and filling in the percolation test data sheet until 2 consecutive percolation rates vary by a range of no more than 1/8 -inch.

If no water remains in the hole after the overnight swelling period, add six inches of clear water above the gravel. Measure the drop in the liquid level to the nearest 1/8 inch approximately every 30 minutes. After each measurement, refill the water to a depth of six inches above the gravel. Continue taking and recording the water level drop measurements until 2 consecutive percolation rates vary by no more than 1/8 – inch.

In sandy soils, or other soils in which the first six inches of water seep away in less than 30 minutes after the overnight swelling, period, allow about ten minutes between measurements. Refill the percolation test hole after each measurement to bring water to six inches above the gravel. Continue taking readings and filling in the percolation test data sheet for 1- hour and use the last reading for to calculate the percolation rate.

Calculate the Percolation Rate

Divide the time interval by the drop in water level to determine the percolation rate in minutes per inch (mpi).

- If the drop in water level is one inch in 30 minutes, the percolation rate is:

  30 minutes ÷ 1 inch = 30 mpi

- If the drop in water level is 2 1/2 inches in ten minutes, the percolation rate is:

  10 minutes ÷ 2.5 inch = 4 mpi

Calculate the percolation rate for each reading. When three consecutive percolation rates vary by no more than 10%, use the average value of these readings to determine the percolation rate for the test hole. Percolation rates determined for each test hole should be averaged in order to determine the design percolation rate. Compare the percolation rates determined for each test hole to the soil texture to verify the soil sizing factor. The percolation test data sheet showing all measurements and calculations must be submitted.

Note: A percolation test should not be run where frost exists in the soil below the depth of the proposed sewage treatment system.

APPENDIX B-2: USING SOIL SURVEYS

Soil Survey Report Descriptions

Although the Soil Survey alone cannot be used to determine the suitability of a site for an onsite treatment system, it is an excellent source of information for the preliminary evaluation of the site.

The soil descriptions in the soil survey report were prepared by soil scientists who use a technical term to label horizons. It is not critical that a site evaluator understand these labels, however the following information is provided to aid in your understanding of the soil survey report.

A horizons (commonly called **topsoil):** These are mineral horizons that formed at the surface. They are characterized by an accumulation of humidified organic matter intimately mixed with the mineral fraction.

E horizons (bleached horizons): These are mineral horizons in which the main feature is loss of clay, iron and/or aluminum leaving a concentration of sand and silt particles.

- An E horizon is usually, but not necessarily, lighter in color than an underlying B horizon. In some soils the color is that of the sand and silt particles.
- An E horizon is most commonly differentiated from an overlying A horizon by lighter color and generally has measurably less organic matter that the A horizon.
- An E horizon is commonly differentiated from an underlying B horizon by color of higher value or lower chroma, by coarser texture or by a combination of these properties.
- An E horizon is commonly near the surface below an A horizon and above a B horizon. The soil structure is commonly platy, but may be blocky or granular.

B horizons (commonly called **subsoil):** These horizons are formed below an A or E horizon and dominated by weathering of all or much of the original parent material and by concentration of clay, iron, aluminum, or carbonates, or by the removal of carbonates, and has formed granular, blocky, or prismatic structure.

C horizons (commonly called **parent material):** These horizons or layers, excluding hard bedrock, are little affected by weathering. They have no structure development except for random planes of weakness. In Iowa, the soil development “ends” at the start of the C horizon, which in most cases is less than five feet in deep.

There is no need for a site evaluator to use the *A-B-C* terminology for describing the horizons, but this terminology can be a useful tool.

Using a Soil Survey

For the soil site investigation, consult the soil map to identify the soil type and determine the following soil features:

- landscape position,
- map unit inclusions,
- slope,
- depth to groundwater,
- depth to bedrock,
- flooding potential,
- texture, and
- permeability.

Use some type of preliminary information checklist, such as Figure B-60, to record soil survey information and other information gathered in the preliminary evaluation.

Published detailed soil surveys include a series of maps on a photographic background indicating the occurrence of different soil types. These maps show the occurrence and distribution of each kind of soil.

The delineated areas on the soil map are called “map units,” which consist primarily of the soil for which the unit is named and soils with similar characteristics. In addition, there are areas within the unit consisting of soils that are different.

Soil types occupying an acre or more within the map unit are indicated by a series of map symbols. The minimum size of the map unit, however, depends on the scale of the printed map.

Therefore, while the soils map alone cannot be used to determine the suitability of a specific site, the soil survey information is still useful as background and as an indication of potential problems that may be encountered on the lot.

For counties that do not have published soil surveys, the local Soil and Water Conservation District office can often provide unpublished soils information.

client name ______________________________

legal location ______________________________

map unit symbol ____________

map unit name ______________________________

inclusions	↓	____	____		
similar soils		↓	↓	____	____
				↓	↓
soil features					
landscape position	____	____	____	____	____
flooding	____	____	____	____	____
slope	____	____	____	____	____
water table depth	____	____	____	____	____
bedrock depth	____	____	____	____	____
possible depth of system	____	____	____	____	____
texture at proposed system depth	____	____	____	____	____
permeability at proposed system bottom (in/hr)	____	____	____	____	____
60 ÷ in/hr = mpi	____	____	____	____	____
NRCS suitability for onsite system	____	____	____	____	____

preliminary design
trenches ___ bed ___ at-grade ___ mound ___ holding tank ___

system size ______________________________

Locate the site on the survey and determine what soils are there:

1. Determine the legal description of the location (i.e. section, township and range).
2. Find that location on the "Index to Map Sheets" in the survey. Map sheets are ordered numerically.
3. Refer to the specific map sheet to determine which soil map units are found at your location. Map units are denoted by symbols such as *401C*.
4. List the map unit symbols found at your location.
5. Refer to the "Index to Soil Map Units" to determine which pages have the map unit descriptions for your location. The map unit descriptions have information on limitations for a variety of uses and major soil properties. The information needed to determine suitability is most easily found in the tables just before the map sheets in the survey. The tables are all indexed by the map unit symbols.

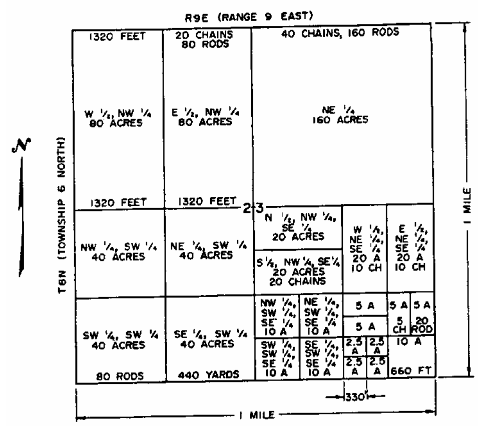
Legal Land Survey Description

Legal land surveys in Iowa are based on a township/range description, with a typical township containing 36 sections of land, each of which is one square mile, or 640 acres, in size.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Figure B-62

SECTION OF LAND WITH VARIOUS DIVISIONS
(Contains one square mile or 640 acres)



Regular-sized townships contain 36 sections of land numbered in a particular sequence starting at the northwest corner of the township. Thus section 7 is immediately below section 6, section 12 is immediately south of section 1, section 13 is south of section 12, section 18 is south of section 7, and so on. Figure B-61 shows the pattern of section numbering.

Within sections, divisions are made on a quarter basis with respect to the four directions. Figure B-62 shows a typical section with its divisions. When subdivisions are platted, individual properties are assigned block lot numbers. A complete legal description includes township and range, section number, section division, block number and lot number.

Townships also have numbers which are counted as north of baselines. The township is also given a range number measured east or west from a principal meridian. Within the section, the division is in quarters with respect to the four directions.

The southwest quarter of section 23 contains 160 acres and the southwest quarter of the southwest quarter (SW 1/4, SW 1/4) contains 40 acres and is found in the extreme southwestern portion of section 23 as is shown in Figure B-62. This designation may be used for the legal description of larger tracts of land. When subdivisions are plotted, the individual properties normally have block and lot numbers.

The zoning map should be checked to make sure the property can be used as intended. At the same time, required setbacks from buildings, property lines, road right of ways, utility easements, surface waters, wells and any other covenants on the property should be determined. A good way to keep track of these requirements is to locate them on a scale map or sketch. Graph or crosshatched paper can be used to sketch a map of a shoreland lot, as shown in Figure B-63.

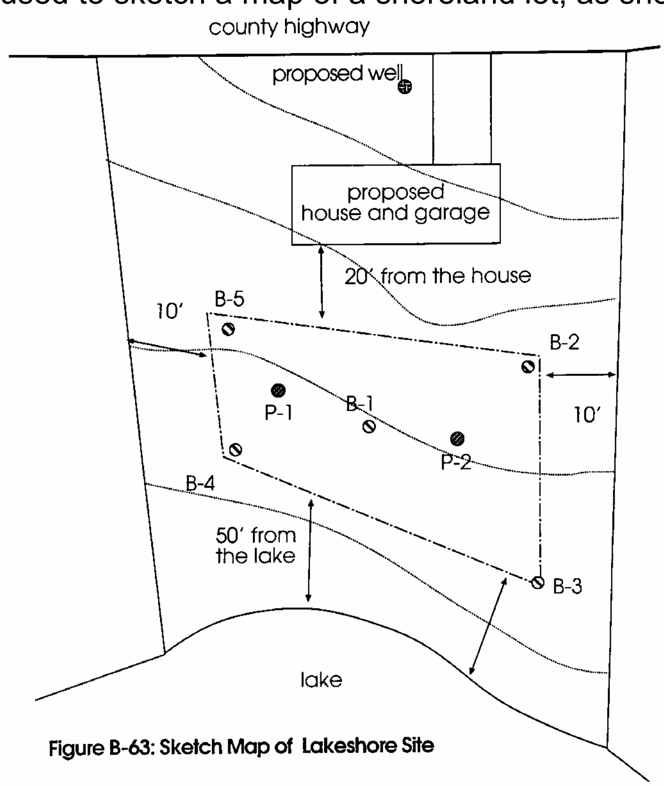


Figure B-63: Sketch Map of Lakeshore Site

The zoning map should be checked to make sure the property can be used as intended. At the same time, required setbacks from buildings, property lines, road right of ways, utility easements, surface waters, wells and any other covenants on the property should be determined. A good way to keep track of these requirements is to locate them on a scale map or sketch. Graph or crosshatched paper can be used to sketch a map of a shoreland lot, as shown in Figure B-63. On this lot, soil borings

On this lot, soil borings and percolation tests have been taken in the area proposed for the onsite sewage treatment system. The proposed house location is shown, along with the proposed well location.

This information is absolutely necessary on a permit application in order to evaluate the suitability of a site for onsite sewage treatment. The information presented by the application should always be checked against the soil survey information together with a brief site investigation before the permit is granted.

If the site is near surface waters, particularly rivers and streams, there may be a floodplain map which gives the dimensions and elevations of areas that may be flooded. This information may be available from the local zoning office. Other potential sources are the Department of Natural Resources Regional offices and local Watershed District offices. Information of required setback distances from lakes and streams are also available in these offices.

Vegetative and topographic information is available on U.S. Geological Survey (USGS) quad or topographic maps. These maps indicate areas of excessively steep slopes, depressions and surface drainage characteristics.

General Soil Survey Maps

All counties in Iowa have detailed reports available. Where this detailed information is not available there is additional published information available.

A general soils map has been published at a scale of 1:1,000,000 (one inch = 16 miles). It delineates areas of major soil groups found in the state. This map is of limited use for determining characteristics of soils for onsite waste treatment, but it provides names of soil series found in these broad areas. This provides a preliminary estimate of the types of soil materials found in the area.

Detailed Soil Survey Maps

To understand how detailed soil survey information can be used in a site evaluation, a site evaluator needs to understand how a detailed survey is made and what is represented on soils maps.

Soil surveys are a representation of how soils occur on landscapes. Soils constantly change across a landscape. The process of classifying and map soils tries to put some order into a very complex system of changes in soil characteristics. Soil characteristics, such as percent organic matter, depth of top soil, texture, depth to water table or bedrock change predictably across the landscape.

The soil scientist making a soil map uses limited and well-defined ranges in soil properties to classify soils, develop map units which describe the occurrence of the soils classified on the landscape and determine the suitability of that soil for specific uses. To accomplish this, the soil scientist walks over the landscape, looking not only at soil borings, pits and excavations, but also measuring the slopes and observing the occurrence of vegetation.

These observations not only aid in predicting where a soil occurs on the landscape, but also in determining the suitability of that soil for a specific intended use. An experienced soil scientist will map between 300 and 600 acres of soil a day. Soil borings are conducted during the process to confirm the predictions made about the occurrence of soils on the landscape.

During the survey process in a county, data is collected on the physical and chemical properties of the soils as well as on the depth to saturated soil zones and percolation rates.

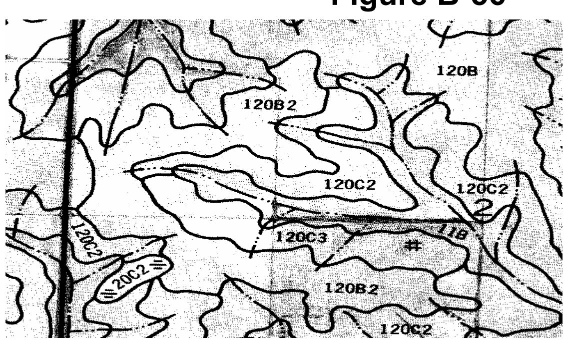
The finished product of a detailed soil survey is a series of soil maps prepared on a photographic base for an entire county. The size of the soil map unit that can be delineated on these maps is dependent on the final scale of the map. A soil map completed at a scale of 1:15,840 (one inch = 1,320 feet) will have the smallest delineation covering about 2.5-3 acres on the land surface.

An onsite waste treatment system will cover only a 1,000 to 5,000 square foot area of lawn area. Therefore, in order to use a soils map to directly determine the site suitability and system design, the map must be nearly 100% accurate to allow for total confidence that the soil mapped at the site is occurring in this 1,000 to 5,000 square foot area. Unfortunately, the only way this could be accomplished is to map out a scale of one inch = one inch, where each inch of the landscape is evaluated for soil type. Obviously, this is not possible.

Therefore, during the soil survey map process, soils different from the map unit name are included within the map unit delineation. These inclusions may at times be as much as 50% or more of the map unit. They can have similar or different soil properties that will determine their suitability for the installation of an onsite waste treatment system. The inclusions present are well-defined and characterized.

For example: The soil map symbol 120B2 appears on the soil map in Tama County, Iowa. (See Figure B-56). Referring to the soil map legend, Tama silty clay loam, 2-5 % slope, moderately eroded. The map unit may also include small areas of other soils that were too small in area to map out or to mention in the name of the unit. In other words, every square foot of the map unit area is not necessarily Tama silty clay loam.

Figure B-56



The second part of the map symbol indicates the different **slope groups** used in Iowa. They are indicated by capital letters such as **B** and defined in percent of slope as follows:

Soil Groups

A = 0 – 2 %
B = 2 – 5 %
C = 5 – 9 %
D = 9 – 14 %
E = 14 – 18 %
F = 18 +

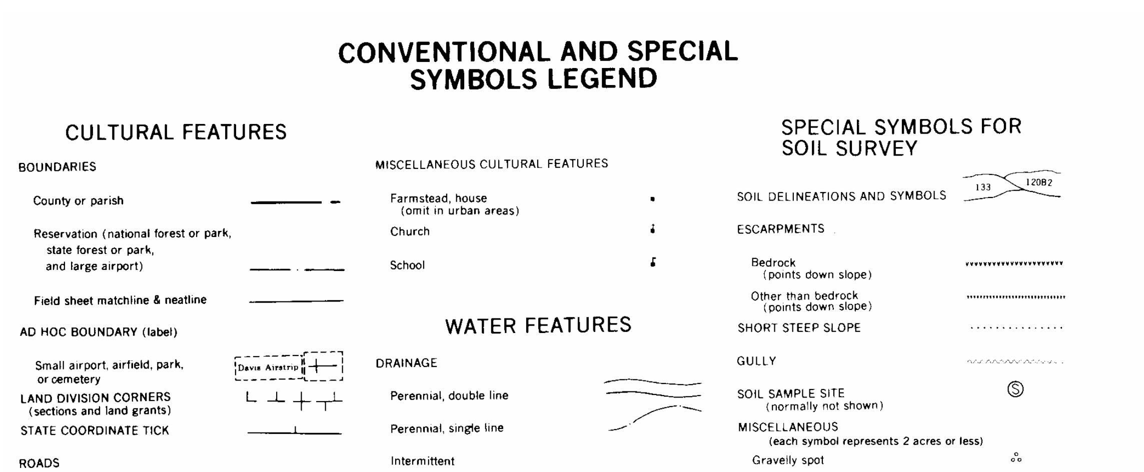
The third part of the symbol is the **erosion class.** The three major recognized erosion classes are slight, moderate, and severe.

Erosion Class

1 - slight or no erosion
2 - moderate erosion
3 - severe erosion

So the map symbol 120B2 indicates Tama silty clay loam with 2-5 percent slopes that are moderately eroded.

Besides providing information on the aerial extent and the kind of soil, the soil map shows other physical features. Since the map has an aerial photo background, it is possible to determine different land features and uses directly from the map, such as woodland, farmland, roads, cities, buildings, lakes, streams, and airports. Drainageways are shown with special map symbols, as are small wet spots, marshy areas, sandy, clayey, gravely, or stony spots. The standard symbols for these features are presented in the legend of the soil survey publication.



To demonstrate how the survey report and accompanying soil maps can be used to help determine suitability and system design, consider another typical map unit found in many Iowa counties. The map unit could be represented on the soils map by .

In either case, by looking at the soil legend in the survey report, the name of the map unit is 120B2 Tama silty clay loam, two to six percent slopes and moderate erosion. Series and map unit descriptions indicate that the Tama silty clay loam soils are well drained soil in narrow ridges in the uplands.

119B	Muscatine silty clay loam, 2 to 5 percent slopes
120	Tama silty clay loam, 0 to 2 percent slopes
120B	Tama silty clay loam, 2 to 5 percent slopes
120B2	Tama silty clay loam, 2 to 5 percent slopes, moderately eroded
120C	Tama silty clay loam, 5 to 9 percent slopes
120C2	Tama silty clay loam, 5 to 9 percent slopes, moderately eroded
120C3	Tama silty clay loam, 5 to 9 percent slopes, severely eroded
120D2	Tama silty clay loam, 9 to 14 percent slopes, moderately eroded

In the physical and chemical properties table it shows that the clay content varies from 27 to 35 percent

In the sanitary facilities table it shows the soils are slight for laterals.

In the soils and water table it shows the water table greater than 6 feet.

All of these features are averages and will need to be field verified before designing a septic system.

APPENDIX B-3: EQUIPMENT AND SUPPLIERS

The field evaluation can be conducted more efficiently and accurately when the proper equipment is used.

A log sheet may be used for entering information from soil borings. (A sample copy is provided in **Section H: Forms.)** The classification system should be checked, as well as the type of sampling procedure (pit, probe or auger) which is used to collect the soil samples. It is important that a relatively undisturbed sample of soil be withdrawn from the boring hole in order to identify soil structure and the presence of mottling, which has previously been discussed.

A hand bucket auger in the 3-1/4 inch size is preferred by many site evaluators. Although more manual labor is necessary to remove the soil sample with a hand auger than with a machine, the hand auger collects a sample that represents the true characteristics of the soil. A hand auger is particularly valuable on wooded lots or other areas not accessible by power equipment.

Drainfield (*Keep Off* sign

Recording Forms:

procedure list
soil boring logs
perc test data sheet
county recording forms
design forms
graph paper
soil survey information sheet

Recording Instruments:

pencils
calculator
permanent markers
lath/flags
tacks
camera

Reference Material:

Onsite Manual

county ordinances

soil survey report

soil description

Chapter 69

Measuring Devices:

short tape measure

100' tape measure

surveying rod

Dumpy level

hydrometer

clinometer

percometer

color book
(Munsell or Globe)

water bottle for texturing

screens for sand gradation

Hole Digging:

probes with extensions

post hole digger

tile spade

augers: sand, mud, standard

Percolation Test Equipment:

pre-wetting hole device

mesh bag with gravel

hole scarifier

water jugs with water

Art's Manufacturing & Supply (AMS)
105 Harrison
American Falls, ID 83211
1-800-635-7330
(208) 226-2017
fax (28) 226-7280

Ben Meadows

PO Box 5277
Janesville, WI 53547-5277
1-800-241-6401

fax 1-800-628-2068

- soil sampling technology
- soil augers: regular, mud, dutch, sand, planer, and flighted screw
- soil sampling kits
- sludge samplers
- soil probes
- groundwater sampling technology

Forestry Suppliers, Inc.
PO Box 8397
Jackson, MS 39284-8397
1-800-647-5368
(601) 354-3565
fax 1-800-543-4203

- earth, life, and environmental science equipment
- Munsell soil color charts
- soil sampling equipment: augers, probes, and handles
- clinometers, levels

Clements Associates Inc.
1992 Hunter Avenue
Newton, IA 50208
1-800-247-6630
(515) 792-8285
fax (515) 792-1361

- soil investigation equipment

Giddings Machine Company, Inc.
401 Pine Street
PO Drawer 2024
Fort Collins, CO 80522
1-800-611-0404
(970) 482-5586
fax (970) 482-9628

- soil sampling and drilling equipment
- trailer-mounted and power-equipped soil sampling machine

Hansen Machine Works
1628 N “C” Street
Sacramento, CA 95814
(916) 443-7755
fax (916) 443-3045

- soil sampling outfit and augers

Instrumental Research, Inc.
7813 Madison Street
Minneapolis, MN 55432
(612) 571-36948

- soil augers: clay and sand, handles, and extensions
- percolation test equipment

Munsell Color Company, Inc.
2441 N Calvert Street
Baltimore, MD 21818

- Munsell color charts

Oakfield Apparatus, Inc.
PO Box 65
Oakfield, WI 53065
(414) 583-4114
fax (414) 583-4166

- soil samplers: soil safety sampler and others, accessories
- deluxe soil sampler kit

Pumpco
4141 Highway 371 N
Brainerd, MN 56401
1-800-448-7867
(218) 829-6910
fax (218) 828-9152

- Munsell color chart
- backsaver soil sampling tool
- percolation test equipment

NorthWest Lasers, Inc.
2200 University Avenue
Suite 100
St. Paul, MN 55114
(612) 645-3828
fax (612) 645-4832

Schlatter's, Inc.
PO Box 548
Francesville, IN 47946
(219) 567-9158
fax (219) 567-9459

- tile probes
- soil augers

APPENDIX B-4:
Sample Site Evaluation Forms

SOIL EVALUATION REPORT

in accordance with 77 Illinois Administrative Code, Chapter 1, Subchapter r, Section 905

Report prepared for:

NAME:______________________ INVESTIGATION NO:__________ DATE:__________

ADDRESS:______________________ PROPERTY OWNER:______________________

CITY:__________ STATE:______ ZIP:__________ COUNTY:______________________

SITE LOCATION:____

Detailed Soil Description[1] / Interpretations - Site 1

Depth (in)	Matrix Color[2]	Texture	Mottles[2]	Structure	Consistence	Coatings[2]	Notes	Permeability & Loading Rate[3] in (G/D/Ft.^{2})

Limiting Layer:______________________ Depth:__________ Slope:__________

Soil Classification:______________________ Parent Material:__________

Physiography:____

Estimated Drainage Class:__________( )observed saturation at depth (in)_____ Compaction ( )yes ( ) no (depth): ______

Remarks:____

Detailed Soil Description[1] / Interpretations - Site 2

Depth (in)	Matrix Color[2]	Texture	Mottles[2]	Structure	Consistence	Coatings[2]	Notes	Permeability & Loading Rate[3] in (G/D/Ft.^{2})

Limiting Layer:______________________ Depth:__________ Slope:__________

Soil Classification:______________________ Parent Material:__________

Physiography:____

Estimated Drainage Class:__________( )observed saturation at depth (in)_____ Compaction ( )yes ( ) no (depth): ______

Remarks:____

Detailed Soil Description[1] / Interpretations - Site 3

Depth (in)	Matrix Color[2]	Texture	Mottles[2]	Structure	Consistence	Coatings[2]	Notes	Permeability & Loading Rate[3] in (G/D/Ft.[2])

Limiting Layer:________________ Depth:________ Slope: ________

Soil Classification:________________ Parent Material: ________

Physiography: ________________

Estimated Drainage Class:__________( )observed saturation at depth (in)_____ Compaction ( )yes ( ) no (depth): ______

Remarks:________________

Site Map

Report Prepared By: (print name) ________________ Phone:________

Address: ________________

Signature:________________

[1] USDA Soil Survey Manual. Ag Handbook Nº 18. (1993)
[2] Soil color designations. Munsell Soil Color Charts. (1992).
[3] Private Sewage Disposal Licensing Act and Code. Illinois Department of Public Health. Appendix A Illustration M (1996)

SOIL BORINGS AND TRANSECT OF ON-SITE WASTEWATER TREATMENT AND DISPOSAL SYSTEM SITE

DATE: ____________ Time Started:_____ Time Completed:______ HOME OWNER: ____________________

Conducted By: ____________________ Certification:____________ ADDRESS: ____________________

CITY: ____________ ST:____ ZIP: ______

LOCATION: ____________________________________ SECTION NO.: ______ T.____ N. R.___ W. COUNTY: ____________

LANDSCAPE-LANDFORM-SLOPE TYPE: (Place "X" on Diagrams-Back of Sheet) TOWNSHIP: ____________ Lat: ____________

SOIL SYMBOL: ________ SOIL NAME: ______________________________ Long: ____________

ASPECT (°): ________ SLOPE (%): ________ SOIL PERMEABILITY: ____________ Elev (ft.): _______

DRAINAGE: ____________ DEPTH OF POTENTIAL SEASONAL HIGH WATER TABLE (ft.): _______ No. of Bedrooms: _____

SOIL BORINGS:	NO. 1	NO. 2	NO.3	NO. 4	NO. 5	NO. 6	NO. 7	NO.8	NO. 9
THICKNESS OF SURFACE SOIL (in.):	____	____	____	____	____	____	____	____	____
DEPTH TO REDOX FEATURES: Concentrations:	____	____	____	____	____	____	____	____	____
Depletions:	____	____	____	____	____	____	____	____	____
DEPTH TO GRAY MATRIX:	____	____	____	____	____	____	____	____	____
DEPTH OF LIMITING LAYERS(KD/in.):	__/__	__/__	__/__	__/__	__/__	__/__	__/__	__/__	__/__
	__/__	__/__	__/__	__/__	__/__	__/__	__/__	__/__	__/__
DEPTH TO CLAY MAXIMUM:	____	____	____	____	____	____	____	____	____
DEPTH OF ACTIVE W.T.:	____	____	____	____	____	____	____	____	____

Average Loading Rate = __

GPD = ______ R

LR = ______ nex

LLR = ______ eve

TW = _2_ = ______ ft. =

TW = _3_ = ______ ft. =

Formula:

GPD = LLR = FOOTAGE
LR TW

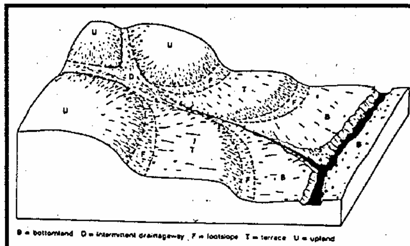
DEPTH (Inches)	HORI-ZON	SOIL TEXTURE	COLOR		COATS or CLAY FILMS	STRUC-TURE	CONSIS-TENCY	ROOTS	BOUN-DARY	MOIST STATE	COMPAC-TION	PM or REMARKS	LOADING RATE
			MATRIX	REDOX									

PM = PARENT MATERIAL--(1) Loess, (2) Glacial TillL, (3) Weathered Glacial Till, (4) Valley Fill, (5) Outwash, (6) Eolian, & (7) Alluvium

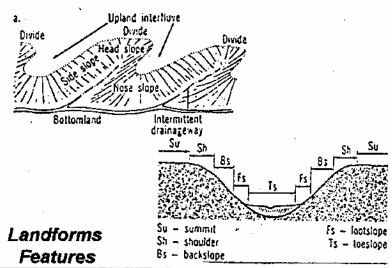
Described By: ______________

Revised by LEB

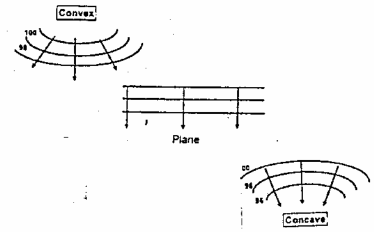
SOIL ANALYSIS 1/03



Landscape Poistion



Landforms Features



Slope Type

Drawing of Home Site Layout

Home Site Checklist:

1. Location of house
2. Location of wells
3. Location of utilities
4. Location of Soil Absorption Field.
5. Location of Street and Driveway
6. Show Direction of Slope
7. Show Orientation from North.
8. Show Owner's Name & Address
9. Show Section & Township
10. Location & Distance of Soil Borings

Cross Sectional View of Test Area

HOLE # ____

DEPTH (FT)	TEXTURE	STRUCTURE	COLOR MATRIX (MOIST)	MOTTLES	COMMENTS
1					
2					
3					
4					
5					
6					

COMMENTS

HOLE # ____

DEPTH (FT)	TEXTURE	STRUCTURE	COLOR MATRIX (MOIST)	MOTTLES	COMMENTS
1					
2					
3					
4					
5					
6					

SECTION C:
SEPTIC/SEWAGE TANKS

Septic Tank Operation

Additives

Septic Tanks

Tanks for Other Establishments

Tank Construction

Holding Tanks

Tank Maintenance

Septage Disposal

Odors From Tanks

SEPTIC/SEWAGE TANKS

The use of Sewage Tank or Septic Tank is assumed to mean the same tank in this manual.

Septic tanks are used as the primary (first) or only pretreatment step in nearly all onsite systems regardless of daily wastewater flow rate or strength. Other mechanical pretreatment units may be substituted for septic tanks, but even when these are used septic tanks often precede them. The tanks passively provide suspended solids removal, solids storage and digestion, and some peak flow attenuation.

The septic tank is the most commonly used wastewater treatment unit for onsite wastewater systems. The tank provides primary treatment by creating quiescent conditions for anaerobic bacteria inside a covered, watertight vessel, which is buried. In addition to primary treatment, the septic tank stores and its bacteria partially digest settled and floating organic solids in the sludge and scum layers. This can reduce the sludge and scum volumes by as much as 40 %, and it conditions the wastewater by decomposing organic molecules for subsequent treatment in the soil or by other unit processes (Baumann et al., 1978).

Gases generated from digestion of the organics are vented back through the house and out the plumbing stack vent pipe. The inlet tee is designed to limit short circuiting if incoming wastewater across the tank, while outlet tee is designed to retain the scum and sludge in the tank and draw effluent from the clear zone in the middle of the tank depth.

Septic Tank Operation

Sewage Wastes

All of the wastewater from the home must go into the sewage tank. Some early wastewater systems had a separate discharge for “gray water” wastewater that did not include the toilet: typically sink and washing machine water. Gray water is considered sewage water and must be treated with the other wastewaterbecause all gray water contains some amount of solids and FOGs. Do not run laundry wastes directly into a drainfield or any other type of secondary treatment, since soap, detergent scums, or clothing fibers can quickly clog the soil pores or treatment filter, causing failure.

While excessive amounts of any household chemical should not be used, normal amounts of detergents, bleaches, drain cleaners, toilet bowl deodorizers, and other household chemicals can be used and will not harm the bacterial action in the septic tank.

Non-Decomposable Materials

Do not deposit coffee grounds, wet-strength towels, disposable diapers, facial tissues, cigarette butts, feminine hygiene products, and similar non-decomposable materials into the sewage system. These materials will cause a rapid accumulation of solids in the septic tank.

Avoid dumping cooking fats or grease down the drain. These materials may plug sewer pipes or build up in the septic tank and plug the inlet or filter. Keep a separate container for waste grease and discard it separately from the sewage system..

Garbage Disposal Wastes

If a garbage disposal is used, septic tank capacity should be increased by 250 gallons, the minimum Chapter 69 requirement, over that required for dwellings or other establishments without disposals. These septic tanks fill with solids quicker and must also be pumped more frequently than for systems that do not serve garbage disposals. Also, garbage disposals grind materials into fine particles that do not settle quickly out in the septic tank and can pass through the tank into the secondary treatment system.

It is better to compost, incinerate or throw out garbage with the trash. Even though materials like lettuce, carrot tops and potato peelings are organic, they do not break down completely in the septic tank, thus adding volume to the accumulated solids in the tank.

Toilet Tissue

Toilet tissue that breaks up easily when wet should be used. To determine suitable quality tissue, place a portion in a jar half full of water and shake the jar. If the tissue breaks up easily, the product is suitable.

The color of the toilet tissue should have no effect on the septic system as long as the tissue breaks up easily when wet. High wet-strength toilet tissue often causes plugging problems. Many scented toilet tissues are of high wet-strength.

Detergents

Detergents can cause problems with septic systems by disrupting bacterial activity in the tank and treatment system. **People generally use more laundry detergent than is actually needed**. If the automatic washer discharges a large amount of suds after the washing cycle, the amount of washing products should be reduced. Bleach as a laundry additive can cause problems for the system. Bleach is toxic to the bacteria in the septic tank, so excessive use is harmful. One to three cups of bleach per week added to a residential septic system should not be a problem.

Inexpensive powder washing products may contain excessive quantities of filler or carrier, which can be extremely detrimental to the sewage system. The best solution may be to <u>use liquid laundry detergents</u>, since they are less likely to have fillers.

ADDITIVES

Septic tank additives are not recommended. Additives, which include septic tank cleaners, degraders, decomposers, deodorizers, organic digesters, and enhancers, have not proven to significantly improve tank performance. Typical residential and commercial wastewater already contains adequate numbers and types of bacteria, enzymes, yeasts, fungi, and microorganisms that additives are not necessary. . Some of these products can actually interfere with treatment processes, affect biological decomposition of wastes, contribute to system clogging, and contaminate ground water.

Types of additives and effects on treatment processes

There are three general types of commonly marketed septic system additives:

- **Inorganic compounds**, usually strong acids or alkalis, are promoted for their ability to open clogged drains. Product ingredients (e.g., sulfuric acid, lye) are similar to those used in popular commercial drain cleaners. These products can adversely affect biological decomposition processes in the treatment system and cause structural damage to the pipes, septic tanks, has been found to actually degrade soil structure and compromise long-term viability of soil treatment potential. Its use to unclog failed soil absorption fields is no longer recommended.

- **Organic solvents**, often chlorinated hydrocarbons (e.g., methylene chloride, trichloroethylene), are commonly used as degreasers and marketed for their ability to break down oils and grease. Organic solvents represent significant risks to ground water and wastewater treatment processes. These products can destroy resident populations of decomposers and other helpful microorganisms in the treatment system. Use of products containing organic solvents in onsite treatment systems is banned in many states. Introduction of organic solvents into onsite systems located in states that ban the use of these products may trigger liability issues if ground water becomes contaminated.

- **Biological additives,** like bacteria and extracellular enzymes mixed with surfactants or nutrient solutions, do not appear to significantly enhance normal biological decomposition processes in the septic tank. Some biological additives have been found to degrade or dissipate septic tank scum and sludge. However, whether this relatively minor benefit is derived without compromising long-term viability of the soil infiltration system has not been demonstrated conclusively. Some studies suggest that material degraded by additives in the tank contributes to increased loadings of BOD, TSS and other contaminants in the otherwise clarified septic tank effluent.

Other products containing formaldehyde, paraformaldehyde, quaternary ammonia, and zinc sulfate are advertised to control septic odors by killing bacteria. This objective, however, runs counter to the purpose and function of septic tanks (promoting anaerobic bacterial growth). If odor is a problem, the source should be investigated because sewage may be surfacing, a line may be plugged, or another problem might be present.

Septic Tanks

Tank Capacities

Figure C-1 shows the liquid volume of septic tanks as specified in Chapter 69. Liquid volume is calculated by using the surface area and the liquid depth as established to the bottom of the outlet pipe. **Some tank manufacturers provide two tank volumes for a tank, one to the outlet pipe (liquid capacity) and the other to the top of the tank. Care should be taken and not confuse the two values**.

Figure C-1: Septic Tank Capacities for Dwellings (gallons)			
number of bedrooms	design flow (gpd)	minimum liquid capacity	liquid capacity with garbage disposal
1-3	450	1,000	1,250
4	600	1,250	1,500
5	750	1,500	1,750
6	900	1,750	2,000
>6		2 x flow	

Chapter 69 requires that septic tanks have two compartments. The first compartment should be two-thirds to one-half of total capacity. The second compartment provides an additional zone for solids to settle out, so that the effluent is relatively clear.

Above the liquid holding capacity additional volume is required in the tank to allow for floating scum storage. The inlet and outlet tee shall be extended at least 6-inches above the liquid level, and 2-inches above the tee to the lid.

For **each** kitchen garbage unit, water softener system, or high volume water use fixture such as a large whirlpool bath, the tank shall be increased in capacity by 250 gallons.

Sewage tanks should be placed so as to be accessible for pumping in all weather conditions. The manhole for the removal of liquids and accumulated solids should be placed in a convenient location and, if buried, the exact location should be measured from permanent fixtures such as the nearest permanent building.

Tanks for Other Establishments

Septic tanks and holding tanks for other establishments (larger flows) have different volume size requirements:

- For flows less than 1,500 gallons per day, the capacity of the tank must be at least 2 times the maximum daily flow.
- For flows greater than 1,500 gallons per day, the capacity must be at least 1,125 gallons plus 75 percent of the maximum design flow. For systems with flows larger than 1,500 gpd, contact the Iowa Department of Natural Resources' Wastewater Section.
- Sufficient detention time or pretreatment must be provided to produce an effluent quality suitable for discharge to a soil treatment system (BOD less than 220 milligrams per liter, TSS less than 65 milligrams per liter, and G & O less than 30 milligrams per liter).
- Holding tanks serving an establishment should provide storage of at least 30 times the average daily design flow (to allow for monthly pumping)

Figure C-2 shows the septic tank capacities for other establishments. For example, if the maximum design flow is 4,000 gpd, use the following formula to calculate tank capacity size:

1,125 + (flow x 0.75) =

1,125 + 0.75 x 4,000 = 1,125 + 3,000 = 4,125 gallons

4,125 gallons is the value shown in Figure C-2.

Figure C-2: Tank Capacities for Other Establishments	
For flows over 1,500 gpd	capacity = (flow x 0.75) + 1,125
2,000	2,625
2,500	3,000
3,000	3,375
4,000	4,125
5,000	4,875

Special Considerations in Tank Design & Sizing

Restaurants
Restaurant wastes typically contain large amounts of cooking fats and greases. For the grease to again coagulate and separate from the liquid as part of the scum layer, both dilution and cooling must take place. High temperature dishwashers, which have internal heaters, may discharge wastewater with temperatures as high as 140 degrees F. Tanks that are in series, and thus in contact with more soil, provide better cooling. (Long, shallow tanks might also provide better cooling than deep tanks).

Septic tank capacities for restaurants should be large enough that the effluent from the tank(s) is of strength similar to that of domestic strength effluent. The BOD of the effluent should be less than 220 milligrams per liter; the TSS should be less than 65 milligrams per liter. Doubling the capacities for tanks shown in Figure C-2 may provide enough capacity; but even larger tanks may be necessary.

Laundromats
Laundromats have the problem of excessive detergent use, along with the lint that is typically discharged with the washwater. In some cases, lint traps have been used effectively to reduce the amount discharged into the septic tank system. It is recommended that septic tank capacities for laundromats be twice the values given in Figure C-2. The outlet baffle must be submerged to 50 or 60 percent of the liquid depth to retain more floating solids. Generally, very little sludge accumulates in the septic tanks of laundromat systems.

Slaughterhouses
Blood has an extremely high BOD, and is therefore very difficult to break down in a septic system. When slaughterhouses have their own onsite system, no blood should be allowed to enter the septic tank. There may be small amounts of blood entering with the cleanup water but the great majority of the blood should be collected and disposed of separately from the sewage system. An engineer should be contacted to design these systems.

Dairies, Milkhouses
Milk solids do not break down under the anaerobic digestion present in a septic tank. Consequently, subsurface disposal fields should not be used with milk wastes. There are a number of ways to dispose of milk wastes if they are kept separate from other wastes.

Filling Stations, Convenience Stores, Car Washes
The oil and grease wastes from a filling station or car wash should not be allowed to flow into a septic system. Such wastes, including floor-washing wastes from the service bay should be discharged into a holding tank, which is pumped and cleaned when full. Only the toilet wastes from a service station should flow into a septic tank and subsurface soil absorption system.

Tank Construction

Figure C-3 defines specifications and C-4 are drawings for septic tanks. Tanks must be watertight from top to bottom, and made of materials that do not corrode or decay. A good installation uses a waterproof mastic compound between the top of the tank and the tank cover and any other joint. Cleaning access extensions should be absolutely watertight, as should the connections for the inlet and outlet pipes.

Figure C-3: Septic Tank Specifications from IAC 567-Ch. 69, 69.5(3-10)

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 should be at least ½ the total tank volume, but not greater than 2/3.
- The invert of the inlet shall be at least 2" but not more than 4" higher than the invert of the pipe.
- Inlet and outlet baffles should be 4" schedule 40 sanitary tees or equivalent
  - inlet ≥ 6" above and 8" below the liquid level, but no more than 20% of depth.
  - outlet ≥ above and 10" below the liquid level but no more than 25% of depth.
  - the 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, or
  - 1 – central access ≥ 24" and inspection ports over the inlet and outlet.
- If the riser is at or above the grade it should be secured.
- Have a liquid depth of at least 40" and maximum of 78".
- Be protected against flotation under high water table conditions.
- Have a final cover that is crowned or sloped to shed surface water.

Concrete Tank Specifications

- Maximum water-to-cement ratio of 0.45
- Cement content ≥ 650 lbs/cubic yard
- Minimum compressive strength 4,000 psi at 28 days
- ASTM C150 Type II cement
- Cover reinforcement bars by at least 1”

Tank Thickness Specifications

▪ Poured concrete	6 inches thick
▪ Poured concrete, reinforced	4 inches thick
▪ Special concrete mix, vibrated and reinforced	2.5 inches thick

- Tank bottom same as walls except special cement mix ≥ 3”
- Tank top ≥ 4” with 3/8” rebar on a 6” grid or equivalant
- Cement content ≥ 650 lbs/cy

Fiberglass or plastic tanks wall thickness ≥ 1/4”

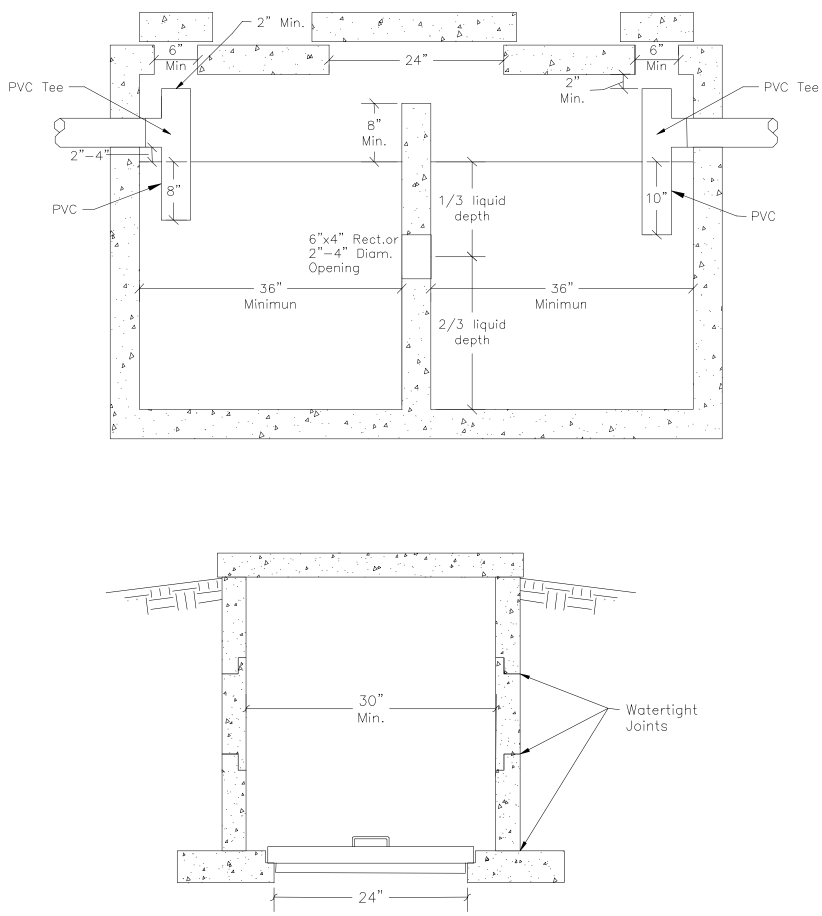


Figure C-4

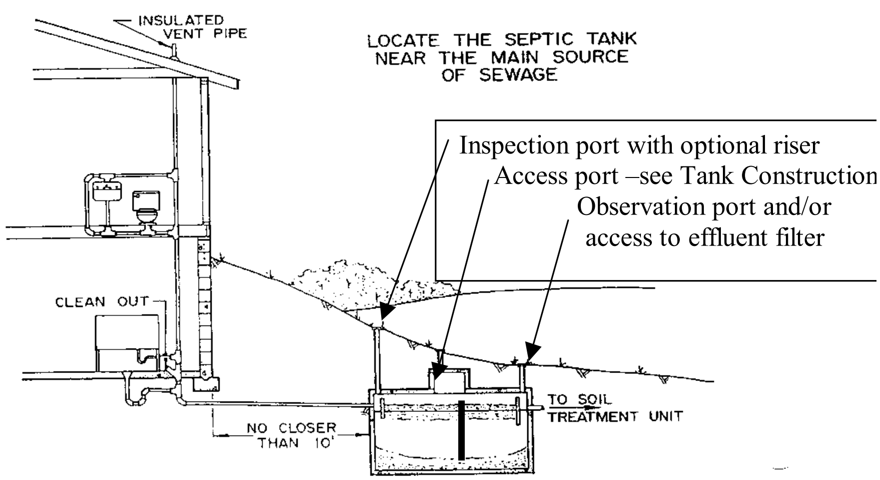
Tank Location

A septic tank should be located near the main source of sewage (usually the house) so the solids settle out with less chance of plugging the line. The tank should also be accessible for the pumper truck to reach the cleanout access hole. The tank should be placed on firm and settled soil capable of bearing the weight of the tank and its contents. Sewage tanks should not be placed in areas subject to flooding.

While a septic tank should be located near the main source of sewage, there are required setback distances for septic tanks, as listed in Figure C-5 and shown in Figure C-6.

Figure C-5: Setbacks Minimum Distance in Feet from Closed Portion of Treatment System	
Private water supply well	50
Public water supply well	200
Groundwater heat pump borehole	50
Lake or Reservoir	50
Stream or Pond	25
Edge of drainage ditch	10
Dwelling or other structure	10
Property lines (unless a mutual easement is signed and recorded)	10
Other type of subsurface treatment system	5
Waterlines continually under pressure	10
Suction waterlines	50
Foundation drains or subsurface tiles	10

Figure C-6



Effluent Screen

Effluent screens (commonly called effluent filters or septic tank filters) which can be fitted to the septic tank outlets, are commonly available (see figure C-7). 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.

Quality-assured, reliable test results have not shown conclusively that effluent screens result in effluents with significantly lower suspended solids and BOD concentrations. However, they 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. Also, as the effluent screens clog over time, slower draining and flushing of home fixtures may alert homeowners of the need for maintenance before complete blockage occurs.

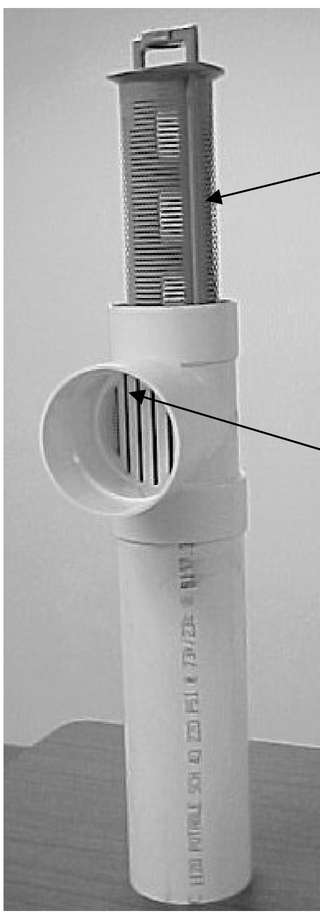


Figure C- 7
Effluent Screens or filters are basically fine plastic screens to prevent solids from passing. There are many sizes, and shapes being used. Some fit right inside the 4” sanitary tee outlet, others are more box shaped, and some have built in protection for when they are pulled out.

Filter tees are manufactured slots across the opening of the sanitary tee in the outlet baffle. This blocks large solids from leaving the tank when the filter is pulled out for cleaning.

Outlet Pipes

Schedule 40 plastic 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.

Cleaning Accesses

If the tank cover is more than 12 inches below final grade, cleaning access extensions are needed so that the cleaning access cover is no more than 12 inches below final grade. 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.

Inspection Pipes

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

Holding Tanks

Holding tanks are septic tanks with no outlets. These tanks require frequent pumping to dispose of the wastewater when the tank becomes full. Holding tanks are not recommended for typical household installations because of the cost and hassle associated with constant tank pumping. However, there are some situations where a secondary treatment system is not practical or feasible. In some instances, a holding tank may be the only alternative.

Holding tanks are constructed of the same materials and by the same procedures as septic tanks.

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 homeowner 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. Costs of pumping septic tanks are $75.00 to $300.00 for approximately 1,000 gallons. Costs may differ somewhat for holding tanks since they are usually readily accessible. A family of four is likely to generate at least 200 gallons of sewage per day. At a cost of $100 per 1,000 gallons, the annual cost to remove the sewage from a holding tank would be $7,300. Costs will vary with amount of sewage and hauling fees. Water conservation reduces sewage flow and hauling costs.
- 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 that homeowners will attempt to pump out their own tank and dispose of the contents illegally or hire a local farmer to pump out their tank using liquid manure handling equipment, which results in untreated human wastewater being spread onto farm fields illegally.

Tank Maintenance

See **Appendix A-2: A Homeowner's Responsibilities for Use of an Onsite Sewage Treatment System** for more information about monitoring and maintaining tanks.

Cleaning

Cleaning frequency of a septic tank depends upon tank capacity, the number of people using the system, and appliances such as a garbage disposal. The build-up of solids from one person will, on the average, occupy about 50 gallons of tank capacity per year.

The tank should be cleaned when solids occupy half of the initial liquid capacity (500 gallons of a 1,000-gallon tank). Some tanks may need cleaning within two years or even sooner, while others may go longer before they need cleaning.

Scum and Sludge Accumulations

Scum and sludge accumulations should be periodically evaluated. At least once every three years, the owner of the tank or a septic system professional should inspect the tank and measure the accumulation of sludge.

When to Pump a Tank

The septic tank should be cleaned whenever the top of the sludge layer is closer than 12 inches to the bottom of the outlet baffle, or whenever the bottom of the scum layer is closer than three inches to the bottom of the outlet baffle. Tank capacity and, consequently, detention time is reduced as those solids build up. A tank detention time of much less than 24 hours may result in some solids being discharged with the effluent and carried to the secondary treatment unit. To protect the secondary treatment unit, periodic removal of accumulated solids in the septic tank is necessary.

It is recommended to check the accumulated solids in a new septic tank six months to one year after the tank is put into operation. This early check of accumulation can determine whether building materials (paints, wood, compounds, dirt, etc.) were flushed into the system during construction of the new home. The measurement of the accumulated solids will help to predict the frequency of solids removal needed for system maintenance.

Sludge and Scum Testing

There are two easy methods to check the level of scum and sludge in a tank. The first is with the use of a clear plastic tube about 1 ½-inches in diameter. Open the lid or inspection port and gently insert the tube to the bottom of the tank. Place a stopper in the top and then gently remove the tube. The scum and sludge thickness can be seen through the tube and can be measured directly.

A second method of measuring the scum and sludge level is with a pole wrapped in a white cloth. Gently insert the pole to the bottom. Let the pole sit for several minutes and then gently remove the pole. The scum and sludge will stick to the cloth, so the thicknesses of the scum and sludge layers can be measured. The scum can also be measured by use of pole with a plate attached on the pole, when the plate is raised to the scum level resistance will be felt
(see figure C-8).

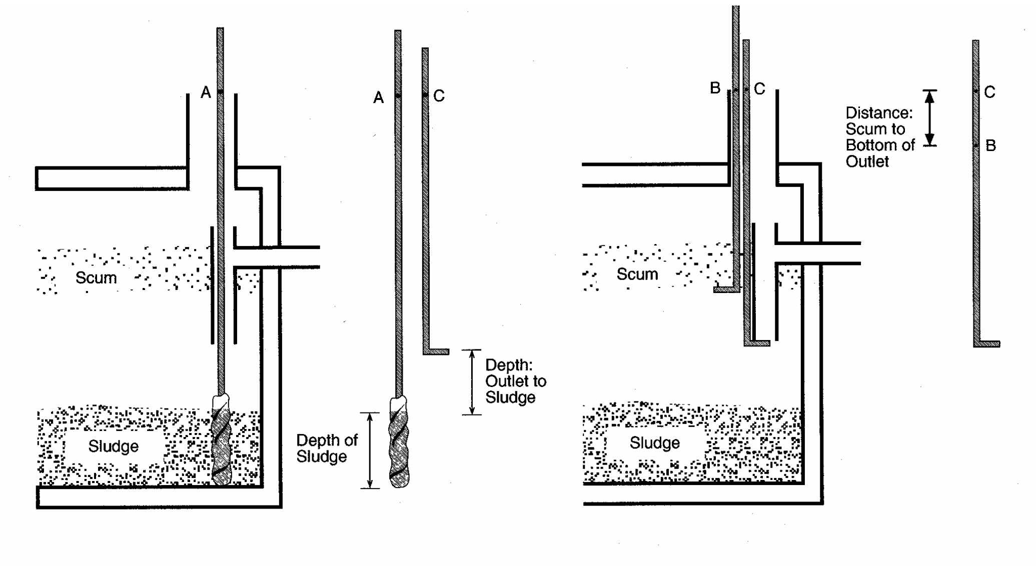


Figure C-8

Tank Cleaning Procedure

Removing all of the septic tank solids involves more than just pumping the tank. When the septic tank is cleaned the cleaning access cover or the tank cover must be removed to facilitate cleaning and to be sure that all solids have been pumped out. A septic tank cannot be cleaned adequately by pumping out liquids through only a four-inch inspection pipe, because the inspection pipe to too small to allow the hose to reach the entire tank interior. This process often results in the scum layer plugging the outlet baffle when liquid again fills the tank. Removal of all sludge, scum, and liquid *must* be done through the maintenance hole. If no maintenance hole exists, one must be installed.

Tank-cleaning can only be conducted by a professional with proper equipment. Some of the liquid is first withdrawn from the tank and then pumped back into the tank under pressure to agitate all the solids into suspension. If the scum layer is hard, it may be necessary to agitate the tank with air or to use a long-handled shovel through the cleaning access in order to break up the scum layer.

When all of the solids have been broken up and are suspended in the liquid, the mixture is pumped out of the septic tank into the truck. Unless the cleaning access is open, it will be virtually impossible to tell if all of the solids have been removed from the tank.

If someone has attempted to service a septic tank through the inspection pipes over the inlet and outlet baffles, those baffles may be broken or dislodged. When the septic tank cleaning access is open, check the condition, length, and submergence of the inlet and outlet baffles. The septic tank service personnel should replace them if they are the wrong length or in poor condition.

It is not necessary to leave solids in the septic tank to “start” it again. Sufficient bacteria remain in the tank and are continually added to the system..

How to Clean Effluent Filters

Do not remove the filter before the tank is pumped. If the filter is plugged scum or sludge may enter the laterals when the filter is removed. After the tank is pumped remove the filter and wash the filter off with the water flowing into the tank, or into a bucket. Then this wash water can be dumped into the septic tank or pumper tank. Follow the manufacturer's instructions at all times.

Septage Disposal

Septage is the term for the wastewater (solids and liquids) pumped out of septic tanks. In Iowa, disposal of septage is subject to the requirements of Iowa Administrative Code 567—Chapter 68, "Commercial Septic Tank Cleaners".

Septage must be removed from septic tanks only by an Iowa-licensed commercial septic tank cleaner or hauler. Commercial septic tank cleaners must pay a yearly license fee (currently $25) to the Iowa DNR License Bureau, 900 East Grand, Des Moines, IA 50319. Each septage hauling vehicle or tank must have the license number displayed and a copy of the current license with the vehicle. Septage haulers must dispose of septage according to Chapter 68 requirements.

There are two primary allowable methods of septage disposal: 1) discharge to a permitted wastewater treatment facility, such as a municipal treatment plant; or 2) land application, by injection or to the ground surface. Chapter 68 also allows for septage disposal to permitted sludge lagoons or sludge drying beds and to permitted sanitary landfills.

Land Application Restrictions

Land application of septage to the ground surface is subject to the following restrictions. Septage applied to the ground surface must be mixed with lime prior to application (see section below for details). The applicator must create and maintain, for 5 years, documentation including location, date, acres, vector reduction used. The maximum application rate is 30,000 gallons of septage per acre per year on cropland. Septage application is not allowed on lawns or home gardens, nor is allowed on food crops (until 38 months after application), or on land used for grazing (until 30 days after application). Septage application is also prohibited on soils classified as sand, loamy sand, silt, or on soils with a pH below 6.0, although agricultural lime may be used to increase the pH to an acceptable level. Chapter 68 places additional restrictions on septage applications on sloping ground, frozen ground, on sites near streams, lakes, sinkholes, tile line, intakes, residences, and wells.

Separation distance restrictions on land application of septage are listed below:

Separation Distances	
Residences	200 feet
Wells	500 feet
*Open Waterway	35 feet

*If septage is applied within 200 feet of a stream, lake, sinkhole or tile line surface intake located down gradient of the land application site, it shall be injected or applied to the surface and mechanically incorporated into the soil within 48 hours of application.

Prohibited sites for land application of septage are listed below:

Prohibited Sites
Soil with pH of 6.0 or less
Slopes greater than 9 percent
Frozen or snow-covered ground on slopes greater than 5 percent
Any frozen or snow-covered sites, unless special runoff precautions are taken

Mixing Lime with Septage

When septage is applied to the ground surface, it is required that it be stabilized by adding and thoroughly mixing 50 pounds of lime with each 1,000 gallons of septage, or by adding and thoroughly mixing sufficient lime to the septage to produce a mixture with a pH of 12. The mixing of lime with septage is not required if septage is injected below the surface of the land or if it is incorporated into the soil within six hours of land spreading. The purpose of these requirements is to reduce pathogens and vector attraction.

Odors from Tanks

Some homes produce noticeable septic odors from the roof vent of the home's plumbing system, and there are several methods for solving odor problems. If the plumbing vent does not extend high enough above the roofline to carry away any gases, odors may be carried downward to the ground in the house or yard area. Two common roof slopes are a four-to-12 pitch (four inches of rise per 12 horizontal inches) and a five-to-12 pitch. For a roof having a four-to-12 pitch, the plumbing vent should extend six feet two inches above the roof or two feet above the ridge.

Another possible solution is to add a filter directly to the roof vent. Filters have successfully eliminated odors from roof vents, according to reports of their use in Iowa and Minnesota.

SECTION D: SOIL ABSORPTION SYSTEMS

PART I: In-Ground Systems

Lateral Trenches
Absorption Beds
Distribution Media
Effluent Distribution Devices
Curtain Drain

PART II: Above-Ground Systems

At-Grade and Mounds
Linear Loading Rates
Wisconsin At-Grade System
Wisconsin Mound System
Minnesota Mound Design

PART III: SYSTEMS FOR SOILS WITH RAPID PERMEABILITY

PART IV: DRIP IRRIGATION

PART V: FREEZING

SECTION D: SOIL ABSORPTION SYSTEMS

A **standard system** is a technology that has proven itself over time and in many locations. Standard systems have solid research behind them and offer reasonable protection for reasonable costs. Any problems or inefficiencies of standard systems have also been clearly identified through research.

The specifications offered for standard systems are intended to provide adequate treatment of sewage with limited monitoring. Typically visual observations and evaluations of the tank are done at least once every three years.

Standard systems include **trench systems** (containing drainfield rock, gravelless pipe or chambered media), **mounds, and at-grade systems.**

Any standard system must:

- be constructed in suitable soils, see Section B
- be designed and installed with a three-foot vertical separation from high ground water, bedrock, hardpan, or other confining layer
- receive average strength septic tank effluent, defined in Section C, for high strength wastes pretreatment is required.

As-Built Drawings

After any system has been constructed, an as-built drawing should be completed by the installer and submitted to the local unit of government. See Section G pages 1 through 5.

PART I: IN-GROUND SYSTEMS

The soil treatment unit provides the final treatment and disposal of sewage tank effluent. A properly designed and installed soil treatment unit will filter out disease causing bacteria and fine solids contained in sewage tank effluent. The nutrient phosphorus will be adsorbed by (attached to) fine soil particles, and some of the nutrient nitrate-nitrogen will be converted while the remainder will move with the water.

In summer, a shallow drainfield trench supplies water (and nutrients) to grass and trees. Nitrate that remains in downward percolating water will be changed to nitrogen gas by soil bacteria or diluted by precipitation.

Lateral Trenches

As shown in Figure D-1, a lateral trench is constructed by making a level excavation 24 to 36 inches wide. The bottom of the trench must be level, as must the top of the rock in the trench.

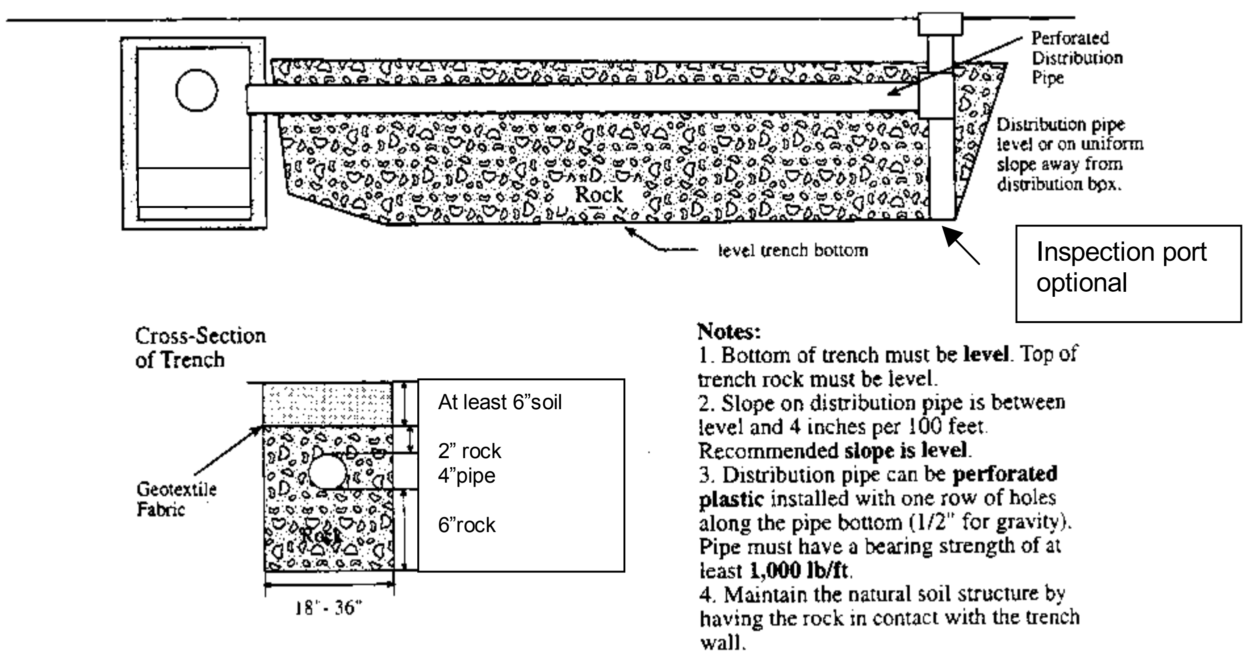


Figure D-1

Typically 6 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, a layer of bacteria and slime, 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.

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. Soils having percolation rates between 1.0 and 60 minutes per inch (mpi) or soil loading rate at or above 0.3 gpsf are suitable for treating sewage using a standard design.

Trench rock must never be placed in contact with soils having a percolation rate faster than 1.0 mpi or slower than 60 mpi. For soils with percolation rates faster than 1.0 mpi and between 61 and 120 mpi, a mound (see **Part II: Above-Ground Systems)** or a liner system, which is essentially an in-ground mound, must be used (see **Part III: Systems for Soils with Rapid Permeability).**

Standard trench systems shall not be deeper than 36-inches in depth. The final trench depth is determined by the depth of limiting layer, the bottom of the trench shall be 3-foot above the limiting layer. Studies have shown tree roots have little effect on standard systems, and that systems usually do not freeze if used on a daily basis.

System Location

Geometry, Orientation, and Configuration of the Infiltration Surface

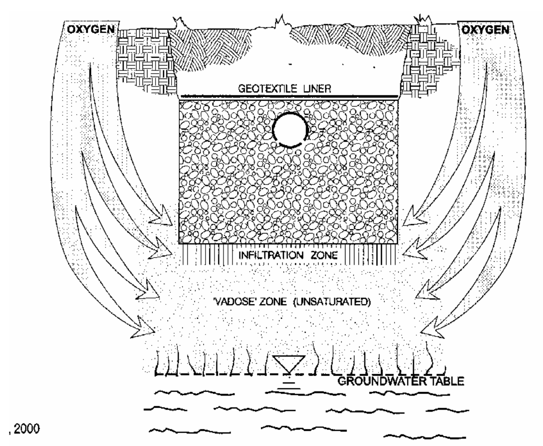
The geometry, orientation, and configuration of the infiltration surface are critical design factors that affect the performance of lateral system. They are important for promoting subsoil aeration, maintaining an acceptable separation distance from a saturated zone or restrictive horizon, and facilitating construction. The following itmes should be considered when designing a lateral system.

Geometry

The width and length of the infiltration surface are important design considerations to improve performance and limit impacts on the receiving environment. Trenches, beds, and seepage pits (or dry wells) are traditionally used geometries. Seepage pits can be effective for wastewater dispersal, but they provide little treatment because they extend deep into the soil profile, where oxygen transfer and treatment are limited and the separation distance to ground water is reduced. They are not recommended for onsite wastewater treatment and are not included as an option in this manual.

Width

Infiltration surface clogging and the resulting loss of infiltrative capacity are less where the infiltration surface is narrow. This appears to occur because reaeration of the soil below a narrow infiltration surface is more rapid. The dominant pathway for oxygen transport to the subsoil appears to be diffusion through the soil surrounding the infiltration surface, as shown below.



The saturated zone below a wide surface quickly becomes anaerobic because the rates of oxygen diffusion are too low to meet the oxygen demands of biota and organics on the infiltration surface. (Otis, 1985; Siegrist et al., 1986). Therefore, trenches perform better than beds. Typical trench widths range from 1 to 4 feet. Narrower trenches are preferred, but soil conditions and construction techniques might limit how narrow a trench can be constructed. On sloping sites, narrow trenches are a necessity because in keeping the infiltration surface level, the uphill side of the trench bottom might be excavated into a less suitable soil horizon. Wider trench infiltration surfaces have been successful in at-grades systems and mounds probably because the engineered fill material and elevation above the natural grade promote better reaeration of the fill. However, infiltration bed surface widths of greater than 10 feet are not recommended because oxygen transfer and clogging problems can occur (Converse and Tyler, 2000; Converse et al., 1990).

Length

The trench length is important where downslope linear loadings are critical, ground water quality impacts are a concern, or the potential for ground water mounding exists. In many jurisdictions, trench lengths have been limited to 100 feet. This restriction appeared in early codes written for gravity distribution systems and exists as an artifact with little or no practical basis when pressure distribution is used. Trench lengths longer than l00 feet might be necessary to minimize ground water impacts and to permit proper wastewater drainage from the site. Long trenches can be used to reduce the linear loadings on a site by spreading the wastewater loading parallel to and farther along the surface contour. With current distribution/dosing technology, materials, and construction methods, trench lengths need be limited only by what is practical or feasible on a given site. Also, use of standard trench lengths, e.g., X feet of trench/BR, is discouraged because it restricts the design options to optimize performance for a given site condition.

Height

The height of the sidewall is determined primarily by the type of porous medium used in the system, the depth of the medium needed to encase the distribution piping, and/or storage requirements for peak flows. Because the sidewall is not included as an active infiltration surface in sizing the infiltration area, the height of

the sidewall can be minimized to keep the infiltration surface high in the soil profile. A height of 6 inches is usually sufficient for most porous aggregate applications. Use of a gravelless system requires a separate analysis to determine the height based on whether it is an aggregate-free (empty chamber) design or one that substitutes a lightweight aggregate for washed gravel or crushed stone.

Orientation

Orientation of the infiltration surface(s) becomes an important consideration on sloping sites, sites with shallow soils over a restrictive horizon or saturated zone, and small or irregularly shaped lots. The long axes of trenches should be aligned parallel to the ground surface contours to reduce linear contour hydraulic loadings and ground water mounding potential. In some cases, ground water or restrictive horizon contours may differ from surface contours because of surface grading or the soil's morphological history. Where this occurs, consideration should be given to aligning the trenches with the contours of the limiting condition rather than those of the surface. Extending the trenches perpendicular to the ground water gradient reduces the mass loadings per unit area by creating a "line" source rather than a "point" source along the contour. However, the designer must recognize that the depth of the trenches and the soil horizon in which the infiltration surface is placed will vary across the system. Any adverse impacts this might have on system performance should be mitigated through design adjustments.

Configuration

The spacing of multiple trenches constructed parallel to one another is determined by the soil characteristics and the method of construction. The sidewall-to-sidewall spacing must be sufficient to enable construction without damage to the adjacent trenches. Only in very tight soils will normally used spacings be inadequate because of high soil wetness and capillary fringe effects, which can limit oxygen transfer. It is important to note that the sum of the hydraulic loadings to one or more trenches or beds per each unit of contour length (when projected downslope) must not exceed the estimated maximum contour loading for the site. Also, the finer (tighter) the soil, the greater the trench spacing should be to provide sufficient oxygen transfer. Quantitative data are lacking, but Camp (1985) reported a lateral impact of more than 2.0 meters in a clay soil.

Given the advantages of lightweight gravelless systems in terms of potentially reduced damage to the site’s hydraulic capacity, parallel trenches may physically be placed close together, but the downslope hydraulic capacity of the site and the natural oxygen diffusion capacity of the soil cannot be exceeded.

Locate the soil treatment system where a good grass cover can be established. To prevent soil compaction, do not allow automobiles or other vehicles onto the soil treatment area (lawn mowers are necessary and will not cause problems). Soil compaction causes problems both for oxygen transfer and water movement.

Locate the soil treatment system so that it is not subjected to surface water runoff. Do not allow runoff from roofs, patios, driveways or other paved areas to flow across the area over the soil treatment unit. Construct a small diversion or grassed waterway on the upslope side of the area and lead the excess surface water away from the soil treatment unit. Establish a grass cover as soon as possible after installation to prevent erosion and to promote evapotranspiration during the growing season.

Figure D-2 shows minimum depths and separation requirements for drainfield trenches. At least three feet of soil suitable for treatment must be located below the bottom of the trench. The minimum rock depth under the distribution pipe is six inches and two inches of rock must cover the distribution pipe. Minimum soil cover is six inches, so that the total distance from the seasonally saturated or impervious layer to the final grade is 4.5 feet. Note that this total could be made up of 3.5 feet of original soil and one foot of fill soil over the piping of the system.

From the USEPA Onsite wastewater Treatment Systems Manual

Table 4-4. Geometry, orientation, and configuration considerations for SWISs

Design type	Design considerations
Trench	
Geometry	
Width	Preferably less than 3 ft. Design width is affected by distribution method, constructability, and available area.
Length	Restricted by available length parallel to site contour, distribution method, and distribution network design.
Sidewall height	Sidewalls are not considered an active infiltration surface. Minimum height is that needed to encase the distribution piping or to meet peak flow storage requirements.
Orientation/ configuration	Should be constructed parallel to site contours and/or water table or restrictive layer contours. Should not exceed the site's maximum linear hydraulic loading rate per unit of length. Spacing of multiple, parallel trenches is also limited by the construction method and slow dispersion from the trenches.
Bed	
Geometry	
Width	Should be as narrow as possible. Beds wider than 10 to 15 feet should be avoided.
Length	Restricted by available length parallel to site contour, distribution method, and distribution network design.
Sidewall height	Sidewalls are not considered an active infiltration surface. Minimum height is that needed to encase the distribution piping or to meet peak flow storage requirements.
Orientation/ configuration	Should be constructed parallel to site contours and/or water table or restrictive layer contours. The loading over the total projected width should not exceed the estimated downslope maximum linear hydraulic loading.
Seepage pit	Not recommended because of limited treatment capability.

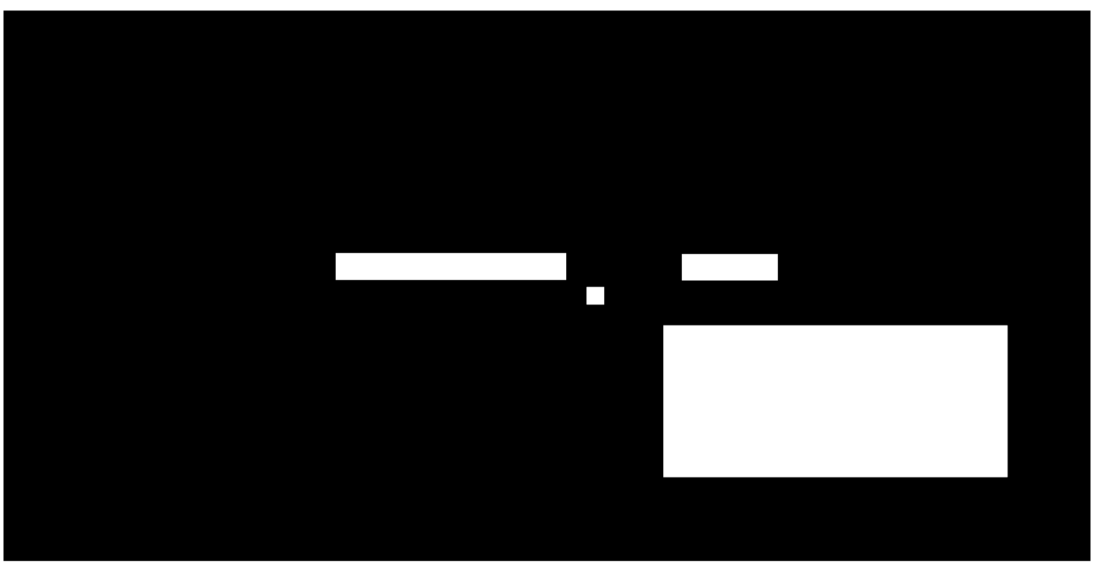
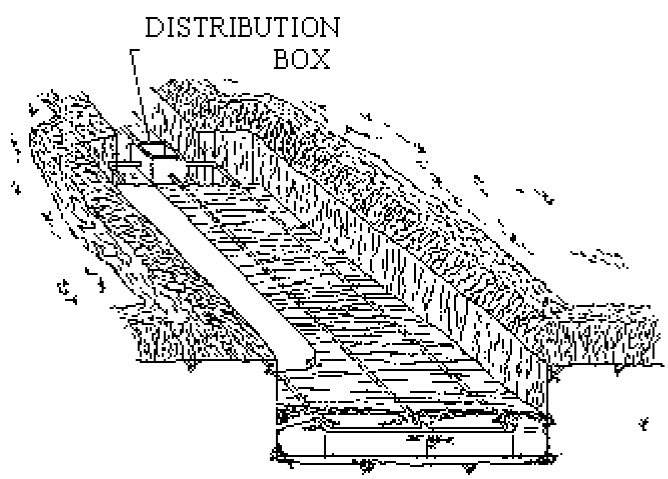


Figure D-2

Absorption Beds

A typical layout of an absorption bed is shown in Figure D-3. A trained professional should design absorption beds. Any excavation wider than three feet may considered a absorption bed. Figure D-3 shows a perspective view of absorption bed construction details.

Absorption beds should be constructed to be as narrow as possible and should be pressure dosed. Beds that are wide and gravity fed will tend to pond water , become anaerobic and proper treatment will not occur.



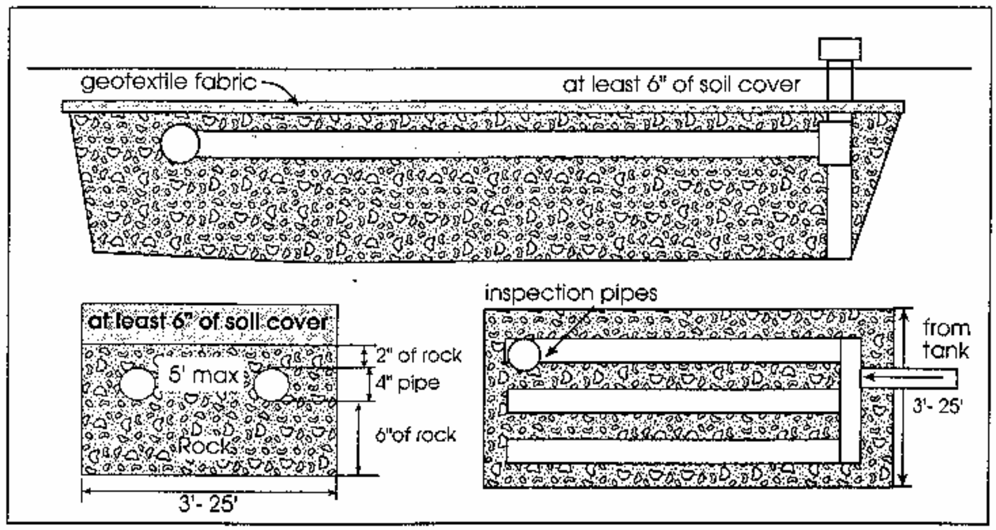


Figure D-3

Typically in a gravity system very little effluent is distributed through the distribution pipe. Effluent flows through the holes in the first length of pipe and into the clean rock, and distributes itself over the soil surface area to the extent of the biomat.

The construction of a seepage bed is essentially the same as that for a trench, except that the bed is wider.

Pressure distribution must be used for all seepage beds where the soil percolation rate is 0.1 to 5 mpi or greater than 1.0 gpsf or where the soil has a medium sand texture or coarser. If pressure distribution is used the bed may be sized as if for trenches.

Distribution Media

Drainfield Rock

Gravelless Wastewater Dispersal Systems

Gravelless systems have been widely used. They take many forms, including open-bottomed chambers, fabric-wrapped pipe, and synthetic materials such as expanded polystyrene foam chips. Some gravelless 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.

Reduced sizing of the infiltration surface is often promoted as another advantage of the gravelless system. This is based primarily on the premise that gravelless 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 gravellesss 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 gravelless surface.

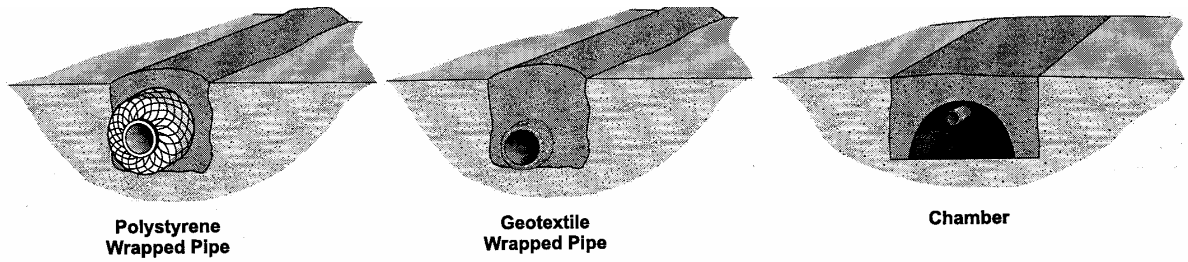
A similar approach must be taken with any contaminant in the pretreatment system effluent that must be removed before it reaches ground water or nearby surface waters. A 50 percent reduction in infiltrative surface area will likely result in less removal of BOD, pathogens, and other contaminants in the 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 gravelless 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 gravelless 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 (see *SWIS Media* in the following section), 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.

Gravelless Distribution Medium

The idea of using something other than rock to hold the trenches apart is not new: gravelless trenches have been used in Texas since 1971. The gravelless trench has since then been shown to be a good option for onsite sewage treatment in Iowa. As a result, it has been adopted as a standard system.

There are several options for gravelless systems. The first is gravelless pipe, which is corrugated pipe surrounded by a synthetic fabric. The second is a chamber made out of a nondegradable material, typically plastic, used to hold the soil apart. The third is a new product using expanded polystrene wraped around a plastic pipe.



Source: National Small Flows Clearinghouse.

USEPA Onsite Wastewater Treatment Systems Manual *4-21*

Gravelless Pipe Systems

Gravelless pipe is a corrugated pipe wrapped in synthetic fabric used in place of gravel for a trench system. This pipe typically has an inside diameter of eight to ten inches. The corrugations are usually 1/2-inch, with 3/4-inch separations.

Gravelless pipe systems are conventional because the rock that traditionally separates trenches provides little or no treatment of the effluent prior to its being dispersed into the soil. Any system that holds the soil apart and allows the wastewater to come in contact with the soil should be acceptable, as long as it has an established loading rate, or the area of soil contact can be easily determined.

Gravelless pipe systems are designed to be surrounded by soil. Do not backfill the excavation with drainfield rock. If an excavation has been filled with rock around the pipe, the biomat will not develop at the pipe-rock interface, but will instead develop at the rock-soil interface. Follow the manufacturers' recommendations for installation. (See Figure D-4.)

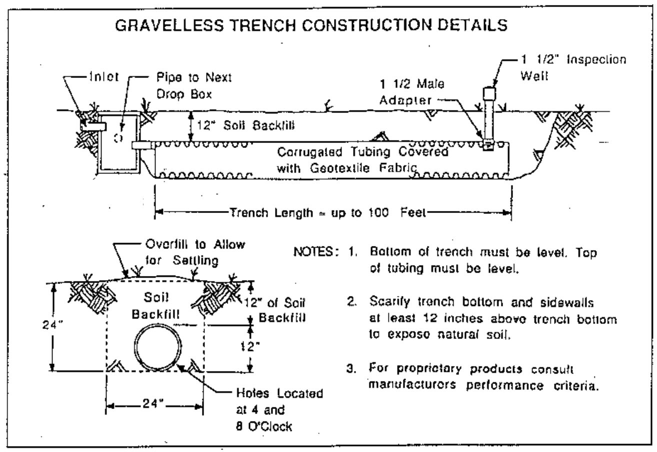


Figure D-4

Gravelless pipe systems have advantages:

- They can be relatively shallow.
- They are easy to handle, deliver, lay out, and install.
- They are lightweight and can be carried into remote, difficult-to-reach sites.
- Little cleanup is required after installation.
- They can be installed on a steep slope because of the minimal amount of equipment necessary for installation.
- Material is consistently sized.
- No rock

They also have disadvantages.

- Only 2 sizes exist, 8” & 10”.
- Problems can occur in areas of fine sand.
- Cost of materials varies; these systems can be comparatively expensive.
- Fabric plugging.

Potential Problems with Gravelless Pipe.

The utilization of gravelless pipe in fine sands have been found to develop a slower long-term acceptance rate, even though they have the same permeability and water flow characteristics as medium sand. During field reviews, this problem has been noted most often with fine sand. The key to installing gravelless pipe systems that work in fine sand is sizing them properly.

In some areas of Iowa, fabric plugging was the suspected cause of failure in soils other than fine sand, however there has been no research to document the cause of the failure.

Keep these two major construction guidelines in mind:

- **Keep it dry.** These materials will not overcome the plastic limit in soils.
- **Keep it level.** It is critical that the pipe be laid level. Most manufacturers place a stripe on the top of the pipe to allow even leveling of the product and alignment of the holes.

A gravelless pipe system must be supported all the way around during backfilling. If the pipe is too tight in the trench and space is not filled with soil during backfilling, the system will compress and failure can come very quickly. With adequate pipe support and a good base, such problems will not occur.

Chamber Systems

The chamber system is another technology that uses something other than gravel to fill the trenches. A number of chamber systems have been developed out of plastic materials, typically featuring a plastic dome with holes or slots (or both) cut in the sides. (See Figure D-5.)

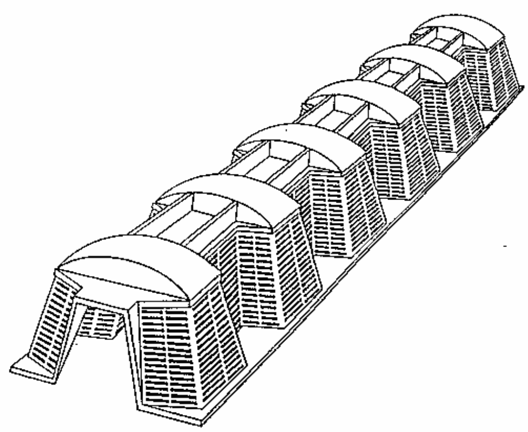


Figure D-5

A leaching chamber is a wastewater treatment system that consists of trenches or beds and one or more distribution pipes or open-bottomed plastic chambers. Leaching chambers have two key functions: to disperse the effluent from septic tanks and to distribute this effluent throughout the trenches. A typical leaching chamber consists of several high-density polyethylene injection-molded arch-shaped chamber segments. A typical chamber has an average inside width of 15 to 40 inches (38 to 102 centimeters) and an overall length of 6 to 8 feet (1.8 to 2.4 meters). The chamber segments are usually 1-foot high, with wide slotted sidewalls. Depending on the drain field size requirements, one or more chambers are typically connected to form an underground drain field network.

Typical leaching chambers are gravelless systems that have drain field chambers with no bottoms and plastic chamber sidewalls, available in a variety of shapes and sizes. Use of these systems sometimes decreases overall drain field costs and may reduce the number of trees that must be removed from the drain field lot.

About 750,000 chamber systems have been installed over the past 15 years. Currently, a high percentage of new construction applications use lightweight plastic leaching chambers for new wastewater treatment systems in states like Colorado, Idaho, North Carolina, Georgia, Florida, and Oregon. The gravel aggregate traditionally used in drain fields can have large quantities of mineral fines that also clog or block soil pores. Use of leaching chambers avoids this

problem. Recent research sponsored by manufacturers shows promising results to support reduction in sizing of drain fields through the use of leaching chambers without increased hydraulic and pollutant penetration failures (Colorado School of Mines, 201; Siegrist and Vancuyk, 2001a, 2001b). These studies should be continued to eventually yield rational guidelines for proper sizing of these systems based on the type of pretreatment effluent to be received (septic tank effluent, effluent from filters or aerobic treatment units, etc.), as well as different soil types and hydrogeological conditions. Many states offer drain field sizing reduction allowances when leaching chambers are used instead of conventional gravel drain fields.

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.

Expanded Polystyrene (EPS) drainfield systems

The following information is on a new product. At the time of this publication this product was not listed in Chapter 69, therefore each County will need to determine the suitability of this product.

EPS systems consist of one or more cylindrical bundles that are typically 12 inches in diameter. The bundles are typically produced in 5-foot or 10-foot long sections and are comprised of a four-inch corrugated polyethylene pipe surrounded by small, specifically engineered EPS pieces. The perimeter of the bundle is formed by a flexible and open netting made of polyethylene. When numerous bundles are used as part of a particular drainage product, typically only one of the bundles contains a four-inch pipe while the other bundles contain only the EPS pieces surrounded by the netting.

Two of the major concerns typically voiced concerning EPS systems surround the strength of EPS and the effects of chemicals on EPS. Independent load tests have shown that EPS systems can withstand tremendous loads such as an AASHTO rated H10 load test without compromising the structural properties of the EPS system. Much research has been performed over the past few decades concerning the effects of chemicals on EPS. It has been numerously concluded that normal household cleaners and solvents will not be detrimental to the structural properties of EPS. Deterioration of EPS will only occur if the product is subjected to large amounts of undiluted hydrocarbons such as diesel fuel or by long term exposure to direct UV.

EPS system advantages

- Lightweight and easy to install
- Extreme flexibility without any fittings
- Very cost effective

EPS system disadvantages

- Bulkier product than other alternative drainfield products
- Top of product must be covered with a barrier to eliminate soil intrusion
- Use in Iowa has been limited at the time of this publication

Effluent Distribution Devices

There are several types of “distribution” boxes: drop boxes, distribution boxes, and valve boxes.

Distribution Boxes

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. The box must be level and made of plastic or polyethylene. 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.

Because distribution boxes are designed to distribute the wastewater equally, all trenches must be the same length and should be able to treat a like amount of effluent. The outlet pipes from the distribution box should have equal slopes for five feet after leaving the box. Figure D-6 shows the layout of a trench system using a distribution box.

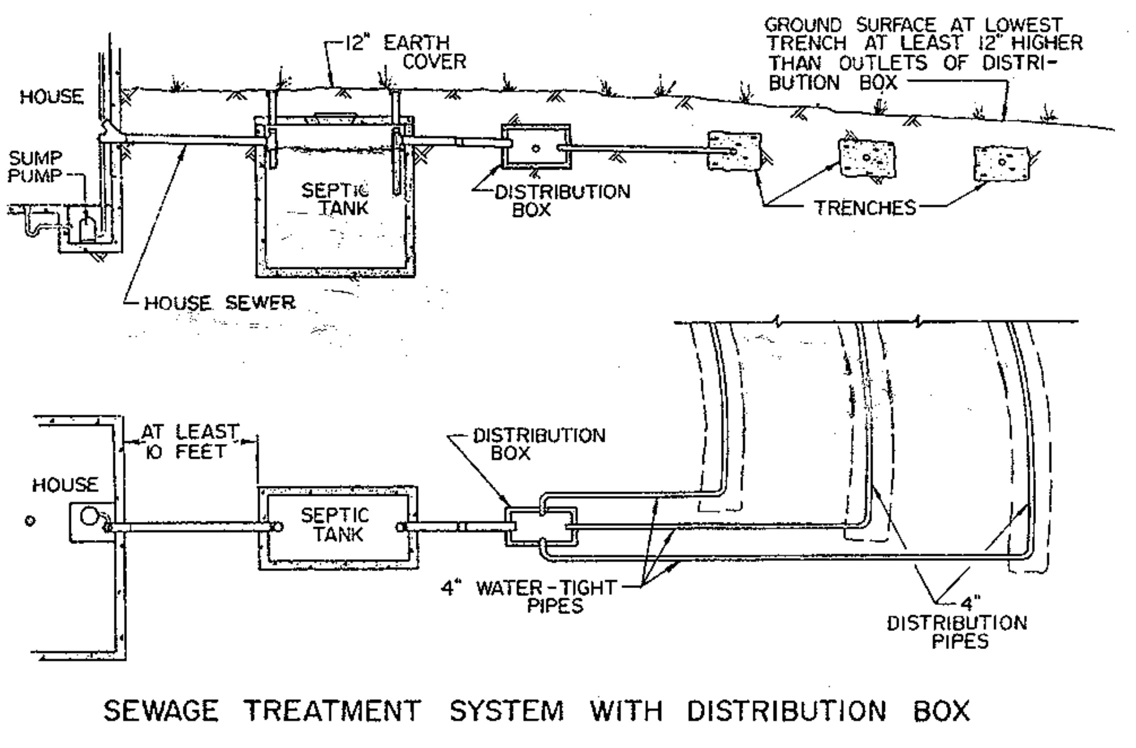


Figure D-6

Designing Laterals Using Distribution Boxes

When using distribution boxes, the trench is not filled with water and only the bottom area of the trench is used to calculate the length of lateral needed.

In conflict with what is allowed in Chapter 69, when using a distribution box there should be no reduction in bottom area for using more than 6-inches of rock under pipe. The side wall area is not exposed to the water for absorption. The only time the side wall is exposed to water is when the bottom of the trench is plugged and water is ponding in the trench. When this happens the lateral system failing. This does not hold true when using drop boxes.

When a **percolation test** is used to determine soil loading rate refer to Chapter 69 for the length required.

When using the **soil evaluation** method the soil loading rate is used to calculate the length of trench needed. Here are several examples for different types of laterals. Only the bottom surface area is used to calculate the length of trench.

Conventional 4-inch lateral pipe and 6-inches of rock.

Example: 3-bedroom home, 450-gpd flow, loamy soil, loading rate 0.6 gpsf.
24-inch wide trench with 6-inches of rock below pipe.

450 ÷ 0.6 = 750 SF (bottom area needed)
750 ÷ 2 ft wide trench = 375 feet of trench

36-inch wide trench with 6-inches of rock below pipe.

450 ÷ 0.6 = 750 SF (bottom area)
750 ÷ 3.0 ft wide trench = 250 LF pipe

Chamber System Design

The length of Chamber is based upon exposed bottom trench area, soil loading rate, and wastewater flow. No credit is given for masking affects.

Example: 3-bedroom home, 450-gpd flow, loamy soil, loading rate 0.6 gpsf.
36-inch wide Chamber:

450 ÷ 0.6 = 750 SF (bottom area)
750 ÷ 3.0 = 250 LF of Chamber pipe

If Infiltrator ® EQ-24 is used

Base width is 15-inches. This Chamber is less than ½ the width of the 36-wide Chamber:

450 ÷ 0.6 = 750 SF (bottom area)
750 ÷ (15 ÷ 12) = 600 LF of Chamber pipe EQ-24

Gravelless Pipe System Design with Distribution Boxes

There is much debate over the amount of surface area that is utilized when distribution boxes and gravelless pipe are used because the pipe is not full of water and the surface area is difficult to measure. Water may wick around the fabric to wet the entire surface of the pipe. The designer should consider this when designing these types of systems.

Chapter 69 states the 10-inch gravelless is equivalent to 24-inch wide rock system therefore the equivalent bottom area would be 24-inches.

Example: 3-bedroom home, 450-gpd flow, loamy soil, loading rate 0.6 gpsf.

450 ÷ 0.6 = 750 SF bottom trench area
750 ÷ 2 = 375 LF of pipe.

Chapter 69 states that 8-inch gravelless pipe is not equivalent to a 24-inch wide trench with 6-inches of rock and that a 20% increase in length is required.

Example: 3-bedroom home, 450-gpd flow, loamy soil, loading rate 0.6 gpsf:

450 ÷ 0.6 = 750 SF bottom trench area
750 ÷ 2 = 375 LF of pipe.
For 8-inch gravelless pipe 375 x 1.20 = 450 LF of pipe

Drop Boxes

Drop boxes are used to achieve serial distribution. Sewage is distributed by gravity flow that loads one lateral to a predetermined level before overflowing to the next lateral; each length of lateral is flooded before the next lateral is flooded.

Figures D-7, D-8 & D-9 shows the layout of a sewage treatment system using drop box distribution. Effluent flows through a watertight pipe from the septic tank to the first drop box. Outlets near the bottom of the drop box connect to the distribution pipe of the trenches. Another outlet near the top of the drop box connects to a watertight pipe leading to the drop box of the next trench.

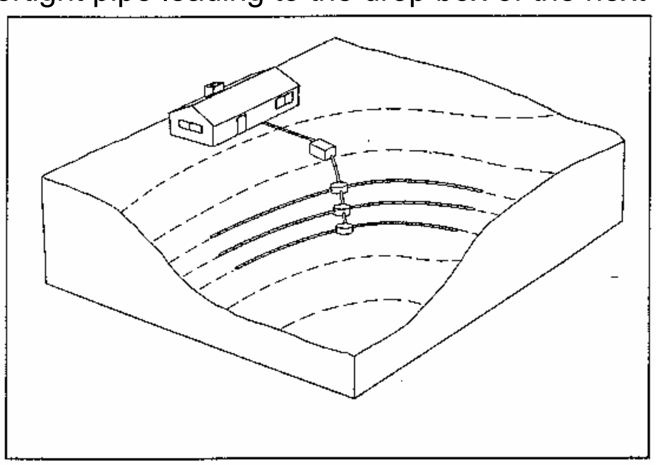


Figure D-7

The inlet pipe to the drop box should be one inch higher than the outlet pipe leading to the next drop box. When sewage tank effluent is delivered to the drop box by a pump, the inlet will be directed so the effluent flows against a side of the box that does not have an outlet. A detailed view of the drop box is shown in Figure D-8.

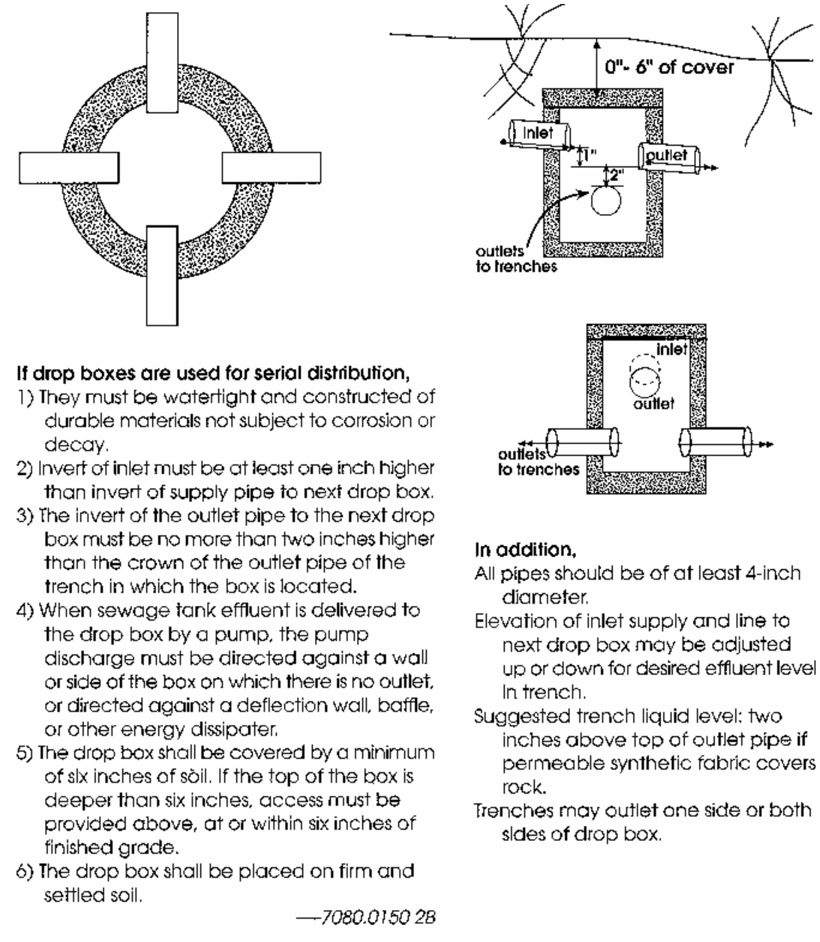


Figure D-8

Drop boxes typically are installed for each lateral line. Some systems use an overflow at the end of the lateral line to flow water into the next lateral. In addition to providing for loading of the soil absorption area, drop boxes also allow inspection of the system. Drop boxes may be constructed of fiberglass or polyethylene. Drop box strength is a factor to consider when backfilling the sewage system.

The liquid level in a trench is established by the elevation of the supply line pipe leading to the next drop box. If the elevation of the bottom of the supply pipe is approximately at the top of the rock in the trench, this liquid level will utilize the entire trench sidewall, develop the maximum hydraulic head on the bottom of the trench, and maximize evapotranspiration.

When the first trench is treating effluent at its long-term acceptance rate, any additional effluent will flow to the drop box of the second trench. Only that portion of the soil treatment unit required to treat the effluent is used. Not all trenches should be full of water. If all of the trenches are full of water then, either the system was under designed, the system is at or near failure. In either case additional laterals should be added.

The rate at which sewage is generated and the rate at which soil will absorb effluent will vary throughout the year. A change in the number of people using a system will affect the daily sewage flow. High soil moisture conditions will decrease the rate at which the soil will absorb effluent, while hot, dry weather will increase the ability of the soil to accept effluent.

Less trench bottom area will be required during summer when the soil is dry due to evapotranspiration than during winter when evapotranspiration is negligible. Thus, the trench bottom area not being used will automatically rest and dry out. This resting and drying will increase the soil's ability to absorb effluent.

The homeowner or an onsite professional can manage the drop box system. To rest the system, plug or cap the outlet pipe from the first box. The effluent will then flow into the second drop box, bypassing the first trench. The first trench will "rest:" the infiltrative surface will recover its ability to accept and treat wastewater.

If surface seepage occurs with a drop box system, typically all of the laterals are full of water and the system is being used at greater than its capacity. In this case, the seepage will occur typically at the lowest trench or weakest soil condition. To solve the problem, additional drainfield trench area will need to be constructed.

Additional trenches may be easily added to a drop box system if increased daily sewage flow requires them, provided more area of suitable soil exists. As shown in Figure D-9, a watertight pipe is connected to the last drop box of the existing system and additional drop boxes and trenches can be added without disturbing the existing sewage treatment system.

Note laterals may of different lengths but not over 100 feet.

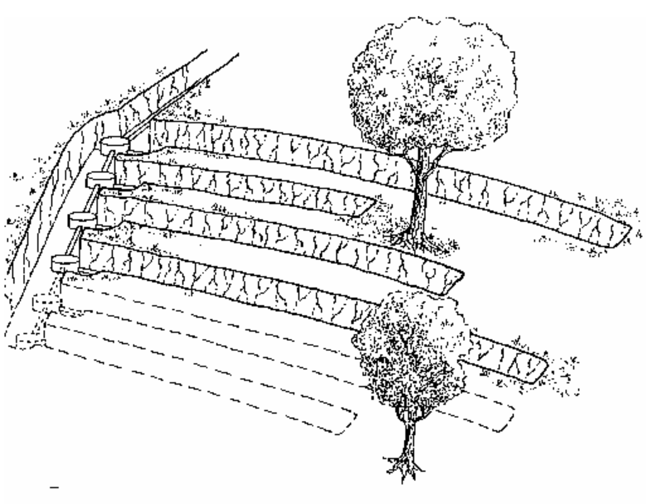


Figure D-9

The drop box provides a convenient point for inspecting the soil treatment unit. The drop box cover can be installed at the ground surface or covered with four to six inches of soil to prevent unauthorized entry. Opening the drop boxes will show how much of the drainfield trench system is being used. Some manufactures make a drop box with an inspection port.

An elevation difference of two inches between successive trenches is all that is needed for the installation of drop boxes. The first inch is for the elevation difference between the inlet pipe and the supply pipe to the next drop box, and the second inch is for the slope of the supply pipe to the next drop box. Because of this drop requirement level sites may not be appropriate for drop boxes.

Designing Laterals Using Drop Boxes

When using drop boxes, the trench is filled with water, again only the bottom area of the trench is used to calculate the square footage based on the soil loading rate and wastewater design flow, or percolation rate and Chapter 69.

If the soil is suitable and there are no confining layer conflicts, increasing the depth of rock to greater than the required 6-inches will increase the soil water soil-water contact area. In this case, the total bottom area square footage may be reduced. This reduction should only be used on confined space lots where adequate space is an issue. There is additional risk of failure by reducing the square footage of trench. For rock trenches, the total bottom square footage area may be reduced as follows:

Example: 3-bedroom home, 450-gpd flow, loamy soil, loading rate 0.6 gpsf.

24-inch wide trench with 6-inches rock below pipe. There is no reduction for 6 inches of rock.

450 ÷ 0.6 = 750 SF (bottom area)
750 ÷ 2 ft wide trench = 375 feet of trench

If confined space/lot conditions exist and reducing the lateral length is the only practical solution, then follow may alpply:

Assume above conditions and 24-inch wide trench with 12-inches rock below pipe.

Chapter 69 allows a 20% reduction in length for 12-inches of rock.
375 x 0.80 (80% of length) = 300 feet of trench

For other extra rock conditions:
for 12-inches of rock = 20% reduction
for 18-inches of rock = 34% reduction
for 24-inches of rock = 40% reduction

Chamber and Gravelless systems do not use rock and there is no reduction for use of rock with these systems.

These reductions should not be used for systems using distribution boxes.

Chamber System and Gravelless Pipe System Design with Drop Boxes

The length of a lateral is based upon the exposed bottom trench area, the soil loading rate and/or percolation test, and the daily wastewater flow.

Valve Boxes

Valve boxes, are another distribution option. Valve boxes have valves that open and close the outlets. Valve boxes are most commonly used to divert the flow from one lateral to the other by alternating the valves.

Curtain Drain

Subsurface Drainage

Soils with shallow saturated zones sometimes can be drained to allow the infiltration surface to be placed in the natural soil. Curtain drains, vertical drains, underdrains, and mechanically assisted commercial systems can be used to drain shallow water tables or perched saturated zones. Of the three, curtain drains are most often used in onsite wastewater systems to any great extent. They can be used effectively to remove water that is perched over a slowly permeable horizon on a sloping site. However, poorly drained soils often indicate other soil and site limitations that improved drainage alone will not overcome, so the use of drainage enhancements must be carefully considered. Any sloping site that is subject to frequent inundation during prolonged rainfall should be considered a candidate for upslope curtain drains to maintain unsaturated conditions in the vadose zone.

Curtain drains are installed upslope of the laterals to intercept the permanent and perched ground water flowing through the site over a restrictive horizon. Perforated pipe is laid in the bottom of upslope trenches excavated into the restrictive horizon. A durable, porous medium is placed around the piping and up to a level above the estimated seasonally high saturated zone. The porous medium intercepts the ground water and conveys it to the drainage pipe. To provide an outfall for the drain, one or both ends of the pipe are extended downslope to a point where it intercepts the ground surface. When drainage enhancements are used, the outlet and boundary conditions must be carefully evaluated to protect local water quality.

The drain should avoid capture of the lateral percolate plume and ground water infiltrating from below the lateral or near the end of the drain. A separation distance between the lateral and the drain that is sufficient to prevent percolate from the lateral from entering the drain should be maintained. The vertical distance between the bottom of the lateral and the drain and soil permeability characteristics should determine this distance. As the vertical distance increases and the permeability decreases, the necessary separation distance increases. A 10-foot separation is used for most applications. Also, if both ends of the drain

cannot be extended to the ground surface, the upslope end should be extended some distance along the surface contour beyond the end of the lateral. If not

done, ground water that seeps around the end of the drain can render the drain ineffective. Similar cautions should be observed when designing and locating outlet locations for commercial systems on flat sites. The design of a curtain drain is based on the permeability of the soil in the saturated zone, the size of the area upslope of the lateral that contributes water to the saturated zone, the gradient of the drainage pipe, and a suitable outlet configuration. If the saturated hydraulic conductivity is low and the drainage porosity (the percentage of pore space drained when the soil is at field capacity) is small, even effectively designed curtain drains might have limited effect on soil wetness conditions. Penninger at al. (1998) illustrated this at a site with a silty clay loam soil at field capacity that became completely re-saturated with as little as 1-inch of precipitation. Figure 4-6 provides a useful design chart that considers most of these parameters. For further design guidance, refer to the U. S. Department of Agriculture's *Drainage of Agricultural Land (*USDA, 1973).

A curtain drain, illustrated in Figure D-10, may be used to remove excess soil water moving laterally along a slope.

This manual recommends contacting an engineer, geologist, soil scientist, or NRCS for assistance when designing a curtain drain system.

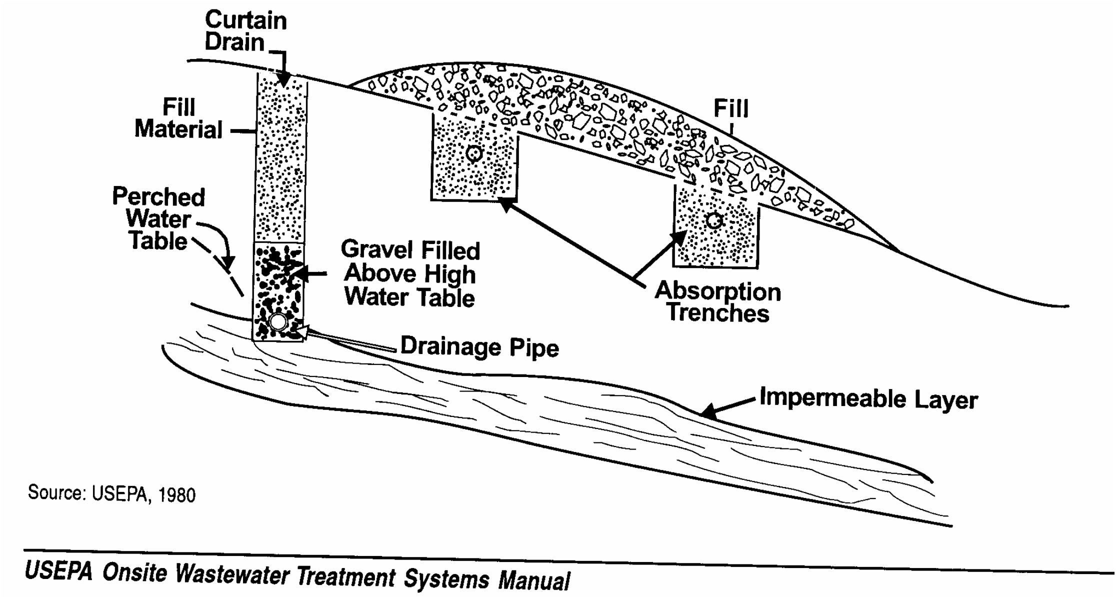


Figure D-10

Interceptor Drains or Curtain Drains

These drains may also be useful in areas of seasonally high water tables. They should be located uphill and on adjacent sides of the drainfield with at least ten feet of undisturbed soil between the sidewall of the soil treatment unit and the draintile. Within shorelands of public waters, draintile may be used, provided the groundwater table has a slope of at least two feet per 100 feet toward the public water. At least 10 feet of undisturbed soil should exist between the sidewall of the soil treatment unit and the draintile.

Backfill: The trench should be at least six inches wider than the outside diameter of the tile. An envelope of pea gravel or other approved clean pit-run gravel should be placed around the tile. The same material, or clean or washed sand, should be used to backfill the trench to within one to two feet of the top of the trench. Drain material should not be used downstream from the site in those parts of the drain that are not required to intercept groundwater.

Slope: The tile line grade should be no flatter than 1-1/4 inches per 100 feet (0.1 percent). The inside diameter of the pipe should be no smaller than four inches. Most installations will not require a size larger than four inches in diameter.

Tile Connections: The curtain drain may be connected to an existing tile drain when depth and grade permit and when approved by the local government unit. A factory-manufactured tee or Y should be used to make the connection.

Outlet: When the drain must outlet on the surface, a corrugated metal pipe at least 12 feet in length with a solid animal guard or outlet gate should be used. The outlet should be located where the water can flow away from it as fast as it is discharged. There should be at least a six-inch clearance between the bottom of the outlet pipe and the surface of the ground or water beneath it. Only one outlet should be used for the curtain drain. The water must exit onto the owner's property or onto a neighboring drainage easement.

The curtain drain should be located on the sewage system plans, which should include the following information:

- elevations of the curtain drain (bottom and final top grade) with respect to the elevations of the drainfield,
- initial and proposed finished topography of the site,
- trench widths,
- spacings,
- details of conduit and drain material placement, and
- depth of drain material and cover.

Artificial Drainage

Drawdown and mounding of the water table make it difficult to determine the appropriate depth for placement of the tile to create a three-foot unsaturated zone below the system. This drawdown is similar to the cone of depression caused by a pumping well. Drainage systems are not encouraged, because of limited success with these systems.

Agricultural Draintile

Under certain conditions, the installation of agricultural draintile may be helpful. The usual purpose of agricultural draintile is not to lower the water table in a field, but instead to create a situation where that field can be plowed within 48 hours of a two-inch rain. The movement of water off a field is much different than the overall lowering of a water table.

Typical designs for a draintile system allow for saturated soil conditions to come nearly to the soil mottles, but for a shorter duration than if the tiles were not in place. Research conducted by the University of Minnesota in a large field in southern Minnesota showed that the water table will return to the level of soil mottling during the course of a wet season but will not stay there for as long as it would if that field were not tiled.

In an onsite system, this situation is not be acceptable under current rules. When groundwater comes into a mottled soil zone, if the zone is less than three feet below the system, the system would be considered to be failing. To meet the intent of the code, a system must work for 365 days a year. Some changes in draintile installation are necessary to accomplish this goal.

When draintile is used to lower the water table, a drawdown curve or zone of influence is apparent. The steepness of this curve is determined by the soil texture or soil permeability. In sandy soils, the curve will be flatter, and the area impacted will be much greater. In heavier soils, or those containing a higher percentage of clay, the slope will be steeper and the area affected will be far less than in a sandy soil.

For soils which are typically well drained, the steepness and the area impacted by the impact curve of the zone of influence of draintiles is relatively small. A zone of impact can be increased by placing the tile deeper, which can be costly and result in construction problems.

Slowly Permeable Soils

Suitable soil permeability rates for conventional systems range from 1 to 60 mpi or greater than 0.3 gpsf, in the treatment area where the system will be placed.

Slowly permeable soils with permeability rates between 60 to 120 mpi *do* provide treatment, but problems are often encountered with the dispersal of wastewater and with construction of the system. At-grade, mound, or alternative systems should be considered

60 to 120 mpi

Solutions:

- At-Grade system
- Mound system
- Drip Distribution system

120 mpi and greater

Non-Soil Based Treatment Systems. Section F

At-Grade and Mound Systems

A sewage treatment At-grade or mound is a bed elevated to provide 3-feet of separation distance from a confining layer, such as, clay, high water conditions, or bedrock. The mound must be carefully constructed to provide adequate sewage treatment. **Mound failures are usually traced to improper design and construction practices.**

Sewage Treatment Mounds for Problem Locations

Suitable soil provides excellent treatment of sewage tank effluent, and the natural topsoil should be utilized for treatment wherever possible. However, some locations do not have soils or soil profiles suitable for treatment of sewage using lateral systems. For instance, some soils do not have the ability to accept effluent, which is necessary for the proper operation of the soil treatment system. In other soils, there are seasonal water tables at depths closer than three feet to the ground surface, such that adequate vertical separation of the soil treatment unit is not possible under "natural" conditions, or soils with a hardpan layer that restricts downward movement of the water, or with fractured or permeable bedrock, all present problems for adequate treatment and/or acceptance of septic tank effluent.

Mounds Treat Sewage Effectively

Properly designed and constructed sewage treatment mounds are an effective method of onsite sewage treatment. Mounds are basically a sandfilter system that is constructed on top of the ground.

Sufficient numbers of mounds have been installed in Minnesota, Wisconsin and elsewhere to prove that the mound treatment system is a standard technology. There are more than 8,000 single-family mounds successfully treating sewage in Minnesota, and 30,000 in Wisconsin.

Important factors in the design and successful operation of a sewage treatment mound are:

- location,
- size and shape,
- soil surface preparation,
- construction procedures,
- distribution of effluent,
- dosing quantity, and

- quality of clean sand fill.

A vertical separation of at least three feet is required between the bottom of the rock bed and any restricting layer in order to maintain aerobic conditions and treat the wastewater. When aerobic conditions exist in the clean sand, the long-term acceptance rate of the sand is typically 0.8 to 1 gallons per day per square foot. If the depth to the restricting layer is inadequate or the rock bed is too wide, anaerobic conditions may exist and cause a much slower acceptance rate. The possibility of anaerobic conditions occurring in the clean sand, and subsequent hydraulic failure, is a major design consideration when mounds wider than 15 feet –18 are used.

See Figure D-10 for a diagram of a mound. Mound construction begins with the layer of clean sand, which must be at least one-foot thick. The top of the clean sand layer must be level. Distribution pipes are placed in the clean rock. A sandy loam cap, six inches thick at the side and 12 inches thick at the center, is placed over the rock layer.

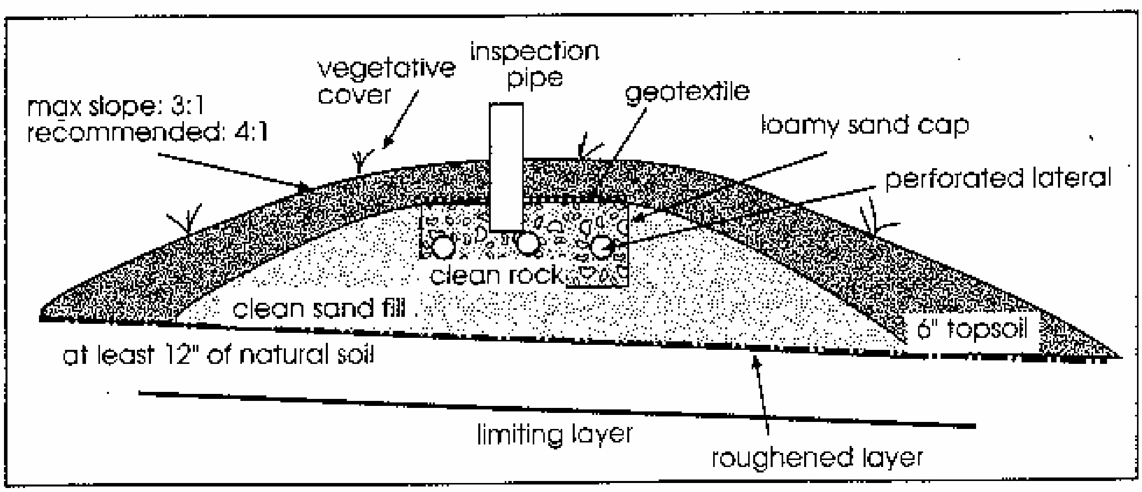


Figure D-10

Complexities of Mound Design and At-Grade Systems

The following design information is for mounds that will serve single-family residences, or daily sewage flow rates of no more than 1,200 gallons. It is not necessarily appropriate for designing systems to treat larger flows, because proper hydraulic operation of a mound depends on lateral as well as vertical seepage.

The following are design guides for Mounds and At-Grade Systems. Before an above grade system is designed, a site evaluation must be performed by a qualified evaluator. In addition, a trained designer must design the system.

The design criteria of this section cannot be simply multiplied by a scale factor to design mounds that will treat larger flows. The hydraulics of lateral and vertical movement, in the clean sand layer and in the soil under the elevated rock bed, must be carefully analyzed to ascertain that anaerobic conditions will not exist. Thus, both lateral and horizontal permeability of the underlying soil layers must be utilized to estimate the height of the saturated zone.

Where heavy clay soils with slow permeability and high seasonal saturated conditions exist over an area, it is far better to utilize mounds for one or two single-family residences than to collect the effluent from many residences and attempt to treat it and dispose of it at a single location. Flow hydraulics in clay soils will require either large depths of fill, or under-drainage, or both, to properly treat sewage. Without fill or underdrainage, anaerobic conditions under the rock layer are likely to develop.

As an example, a mound designed to treat a 3 bed room home (450 gallons per day) may function well under clay soil conditions, while a single mound serving 8 bedrooms (1200 gpd) may fail hydraulically if constructed according to the same vertical separation specifications.

Basis for Design

The design of at-grade and mound systems is based on sewage flow, as estimated for other systems, soil flow patterns as dictated by the **linear loading rate,** and the general geometry of a system built above ground.

Linear loading rate (LLR) refers to potential horizontal and vertical flow patterns in the soil. These characteristics are based on soil texture, soil structure, and any limiting layers existing in the soil. The range of the LLR is from 2 to 10 gallons per foot. The 2-gallon per foot minimum allows almost entirely horizontal flow of effluent. This minimum should be used for a system limited by impermeable bedrock or very heavy clay soils, or in any situation where horizontal movement of contaminants is a concern.

The 10 gallon per foot loading rate (the maximum) would be used when water moves down through the soil much faster than it moves sideways, as in a sandy soil profile. Design values should be somewhere between these two. For a “typical” soil horizon made up of a variety of soil textures, a linear loading rate of 3-4 gallons per foot should be used.

LINEAR LOADING RATES FOR ON-SITE SYSTEMS

By
James C. Converse
August, 1998

In sizing on-site systems, the emphasis has been placed on sizing of the bottom area in either gpd/ft^2 or in ft^2/bedroom using either a bed or trench design. This approach has worked reasonably well for in-ground trenches and beds where the limiting condition has been at least 3 ft and the soil has been relatively permeable. However, with the introduction of mounds and at-grades, the site has become more restrictive due to smaller separation distances between the ground surface and limiting condition and more slowly permeable soils, especially on sites limited to the mound. To overcome deficiencies associated with the soil loading rate, the linear loading rate concept was introduced in the 1980s.

> *The linear loading rate is defined as the amount of wastewater applied daily along the landscape contour. It is expressed in gallons per day per linear foot along the contour.*

The linear loading rate concept is a rather simple concept but one that can be hard to understand and interpret on a site by site basis. Where soil loading rates are based on soil texture, structure and consistence, linear loading rates are not as easily assigned for a given soil texture, structure and consistence as other factors such a distance from the ground surface to seasonal saturation or restrictive layers need to be considered. In essence linear loading rates have been used indirectly in the design of mound systems. Mounds in the State are not all the same length for a given daily design flow but vary in length depending on soil/site conditions. For example, in some parts of the state, the mound absorption area may be 100 ft long while in other parts of the state they may be 60 ft long. For a 3 bedroom home, the linear loading rate for the 100 ft long absorption area is 4.5 gpd/lf while for the 60 ft long absorption area it is 6.7 gpd/lf.

Assigning a linear loading rate is as much of an art as it is a science. In most situations, it has been based on judgement and experience. Thus, the following will serve as a guide for assigning linear loading rates and thus dictating the system length along the contour. Linear loading rates are not affected by effluent quality as is soil loading rates. The linear loading rate relates to getting the effluent away from the soil absorption unit and the soil loading rate is more related to clogging mat/soil interaction. Applying highly pretreated effluent (sand filter and aerobic unit effluent) will allow downsizing of the absorption area (increase soil loading rate in gpd/ft^2) but it will not affect the linear loading rate. Thus the length of the soil dispersal unit receiving highly pretreated effluent will be similar to a mound receiving septic tank effluent on similar soil profiles.

Figure 1 illustrates the concept. The left diagram represents the soil treatment /dispersal bottom area (LxW) for septic tank effluent and the arrows on the bottom represent the linear loading rates. The middle and right diagrams represent the soil treatment/dispersal bottom area assuming the site will accept 50%

downsizing (LXW)/2, resulting in soil loading rate (gpd/ft^2) twice that of the left diagram. The bottom area of the middle and right diagrams are equal but the linear loading rate on the right one is twice that for the middle one because it is half as long. The linear loading rate of the right one is 2 times the liner loading rate of the left diagram but the middle diagram has the same linear loading rate as the left diagram. The site might not be able to handle the linear loading rate assigned to the right diagram (2 times) and thus the design for the site may be inappropriate.

Figure 2 in the Wisconsin Mound Manual and the Wisconsin At-grade Manual provides excellent graphics of water movement away from mounds and at-grade units. It is similar for other soil dispersal units such as in-ground beds/trenches with restrictive layers (seasonal saturation, slowly permeable soils), especially if separation distance is only one to two feet which may be the case for highly pretreated effluent. The discussion presented in the manuals gives the designer a better understanding of what linear loading rate to assign to a given soil profile.

If the design is for a replacement system, the existing system length may be a good indicator of the linear loading rate for the site if the system failed because of longevity (clogging). If it surfaces only during high seasonal saturation then failure may be due to the fact that the effluent can not move away from the distribution cell fast enough. Thus, the linear loading rate may need to be reduced for the new system, resulting in a longer system. However, the seasonal saturation may intrude into the system because seasonal saturation may be close to, at or above the bottom of the system. On some sites, where limiting conditions may not allow for the most appropriate linear loading rate, the designer must decide the degree of risk he/she is willing to take that 1) effluent will leak out the mound toe or 2) effluent will pond in shallow in-ground trench during stress periods.

The following examples will provide some guidelines in assigning linear loading rates.

Site 1.

Soil/Site Conditions

0-6" Silt loam with moderate medium subangular blocky structure and friable consistence.

6-14" Clay loam with weak subangular blocky structure and friable consistence

14-24" Clay loam with massive structure and very firm consistence.

Seasonal saturation at 6" but may be higher as it is difficult to determine redoximorphic features in the top soil. Slope of 5%.

3

Summary

Highly pretreated effluent would enter the silt loam surface horizon relatively easy because of the structure and consistence. During the drier seasons, the effluent would move vertically downward to the clay loam horizon where it would be held up somewhat because of the texture and weaker structure. Since this profile has a slower permeability some of it would move horizontally and as it moves horizontally, gravity and capillary action would pull it downward. As it reaches the next lower horizon, the vertical flow is slowed up because of the massive structure and very firm – consistence. Depending on the degree of massiveness, some will move vertically while the majority will move horizontally. During wet seasons (saturation at 6" or so), the situation is aggravated further because there is no vertical movement. A linear loading rate of 3 gpd/lin.foot is suggested for this site. Also, during the wet season, there is a good possibility of a spongy toe and toe leakage out of the modified mound especially if the surface horizon consists of slowly permeable soils such as clay loams. For a system serving a 3 bedroom home (450 gpd), the distribution cell (aggregate) length would be 150 ft along the contour.

Site 2

Soil/Site Conditions

0-8" Silt loam with moderate medium subangular blocky structure and friable consistence.
8-17" Silt loam with weak, medium subangular blocky structure and firm consistence.
17-40" Clay loam with strong, medium angular blocky structure with firm consistence.
40-60" Clay loam with moderate, fin angular blocky structure with firm consistence.

Seasonal saturation at 17" and site slope of 8%.

Summary

Highly pretreated effluent would enter the silt loam surface horizon relatively easy because of the structure and consistence. As it approached the next horizon, it would be slowed up slightly because of the weak structure and firm consistence with some horizontal movement but mostly vertical movement. As it approaches the third horizon, it would be slowed some because of texture change but still have significant vertical flow. During the wet season there would be about 17" of vertical soil for the effluent to move horizontally away from the system. A linear loading rate of 5 gpd/lf may be appropriate for this site if the separation distance is a t least 17". For a shallow in-ground trench with the bottom at 5" below the surface a similar linear loading rate may be appropriate but the system will be somewhat stressed which may result in possible ponding occurring in the distribution cell (aggregate, chamber).

Thus the designer must be cognizant how the effluent moves away from the soil dispersal unit especially on the more restrictive sites which, for the most part, is the case when highly pretreated effluent is applied.

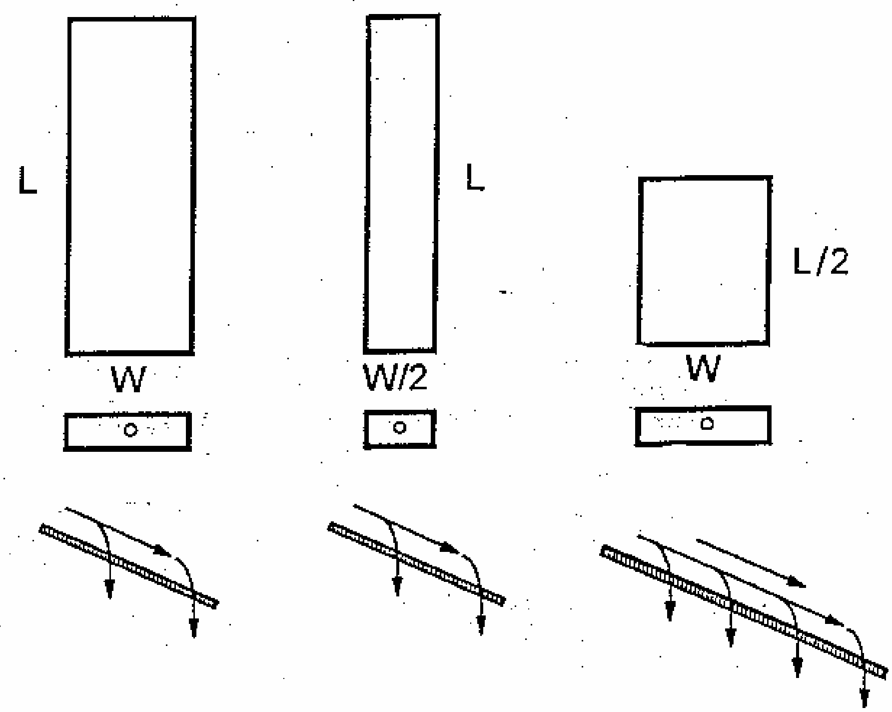


Fig. 1. These three diagrams illustrate how downsizing configuration affects linear loading rates. The left diagram represents the full size system. The middle one represents a half size system (bottom area) resulting in twice the soil loading rate and the same linear loading rate. The right one also represents a half size system (bottom area) resulting in twice the soil loading rate and but also twice the linear loading rate.

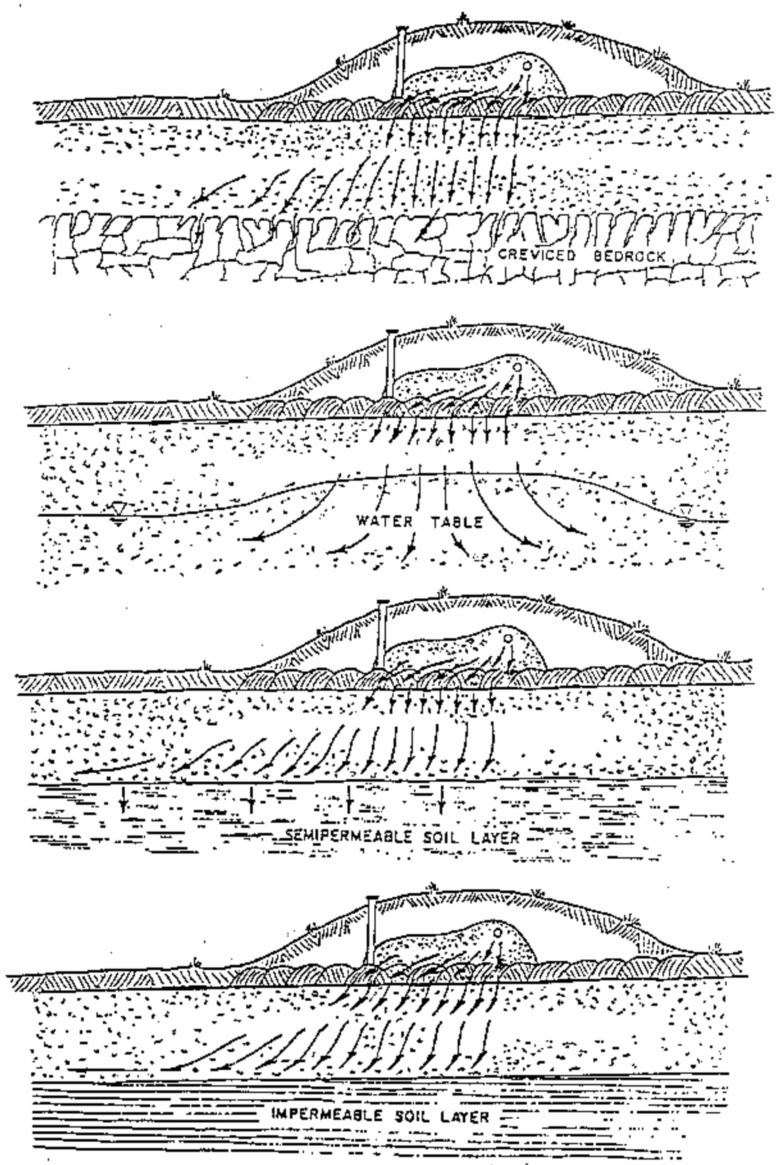


Fig. 2. This schematic represents flow away from a soil treatment unit under various soil/site conditions illustrating at-grades but suitable for mounds and other soil systems. The upper one represents permeable soil over creviced bedrock with mainly vertical flow. The other three represents more restrictive conditions resulting in lower linear loading rates.

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THE OHIO STATE UNIVERSITY

Bulletin

Extension

Mound Systems for On-site Wastewater Treatment

Siting, Design and Construction in Ohio

Bulletin 813-90

Siting

For any soil absorption system, the Ohio Household Sewage Disposal Rules require a minimum separation distance of 4 feet between the bottom of a wastewater distribution system and a limiting condition. This depth is considered necessary to treat wastewater to acceptable standards. Sufficient depth of suitable unsaturated soil exists in some areas of the state, allowing installation of a conventional soil absorption system. If the proposed site does not provide this depth naturally, suitable sand fill in a mound may make up the difference. Figure 1b is an illustration of site conditions where conventional soil absorption systems and mound systems could be used.

Before a mound system is designed, a site evaluation must be performed by a qualified soil scientist or sanitarian (soil evaluator). The most important information from a site evaluation will be an identification of limiting conditions at the site and a basic understanding of how wastewater will move away from the system.

Figure 3 shows a schematic of effluent movement within and away from mound systems for various soil profiles. Depending on limiting conditions in the profile, effluent moves away from the site vertically, horizontally, or a combination of both. Common limiting conditions are impermeable or slowly permeable subsoil layers, shallow depth to bedrock and seasonal high water table.

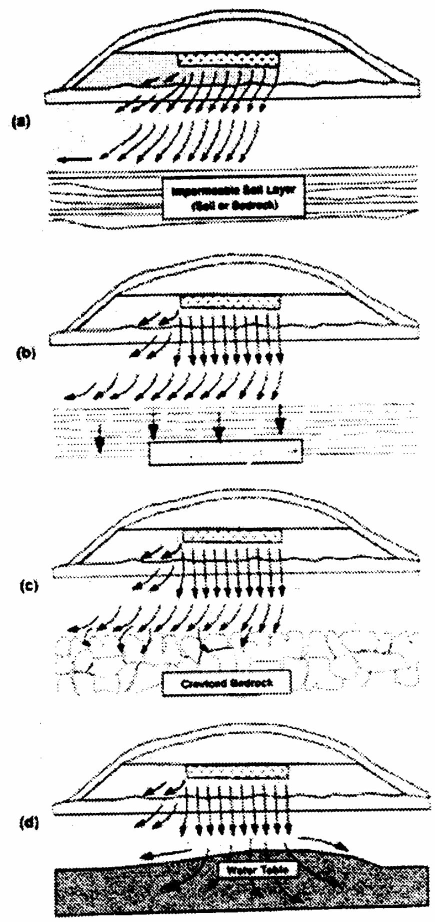
Figure 3a shows an impermeable layer beneath the mound. In this case effluent moves freely into the topsoil, but then moves horizontally away from the system upon reaching the impermeable layer.

In figure 3b effluent moves downward through the mound and into the surface horizon. Upon reaching a semipermeable soil layer, a portion of the effluent is diverted horizontally away while some effluent continues to infiltrate vertically.

Figure 3c shows effluent moving primarily downward towards and then into creviced or porous bedrock. Figure 3d illustrates effluent moving vertically to a mounded high water table, and then horizontally away within the water table.

Mound systems may be appropriate for all of these profiles, however, the situations illustrated in Figures 3a and 3d represent more restrictive sitings than those in Figures 3b and 3c. Whenever a significant portion of effluent movement away from the mound is horizontal, as in Figures 3a and 3d, the mound should be designed longer and narrower. This reduces the effluent loading rate per linear foot of the system and decreases chances of surface seepage.

Linear Loading Rate



3 - 4 gpd/lf

Impermeable Soil Layer
(Soil or Bedrock)

5 - 6 gpd/lf

Semipermeable Soil Layer

8 - 10 gpd/lf

Creviced Bedrock

3 - 4 gpd/lf

Water Table

The determination of mound dimensions will depend upon an understanding of effluent movement away from the mound. This includes both the direction of effluent movement and the rate of movement. Note that the configuration of any soil absorption system is based on these concepts. The information needed is obtained during the site evaluation. The soil evaluator should work with the designer and installers for best performance of the system.

Soil Sizing Factor for Clean Sand

The soil-sizing factor for the clean sand layer of the mound is 1 gallon per square foot of wastewater per day. Clean sand is required! Clean sand is defined in Figure D-11. Chapter 69 states that IDOT concrete sand is acceptable for sand filters and may be used for Mounds.

Figure D-11: Clean Sand		
sieve number	sieve size (mm)	percent passing
4	4.75	95 to 100
8	2.0	80 to 100
10	0.85	0 to 100
40	0.425	0 to 100
60	0.212	0 to 40
200	0.075	0 to 5

Clean sand can also easily be determined in the field by using the jar test (see Figure D-12). Place exactly two inches of sand in the bottom of a quart jar and then fill the jar three-fourths full of water. Cover the jar and shake the contents vigorously.

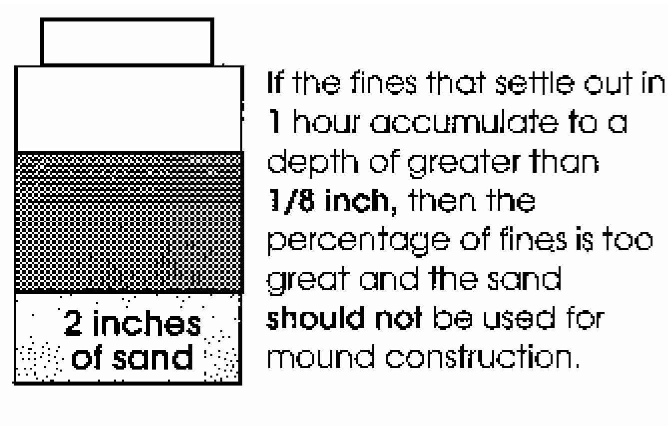


Figure D-12

Allow the jar to stand for about an hour and observe whether there is a layer of silt or clay on top of the sand. If the layer of these fine particles is more than 1/8 inch thick, the sand is probably not suitable for use in mound construction, because too many fine particles tend to cause the soil to compact during the construction process. Also, the long-term acceptance rate of this soil will be slower than the long-term acceptance rate of clean sand, which is used for sizing the rock layers.

AT-GRADE SYSTEMS FOR ON-SITE WASTEWATER TREATMENT AND DISPERSAL

James C. Converse[1]
January 1999

The Wisconsin at-grade soil absorption system was developed in the early 1980s for sites that were not suitable for in-ground trenches/bed and exceeded requirements for mounds. The "Wisconsin At-grade Soil Absorption System Siting, Design and Construction Manual, known as the at-grade manual, serves as the basic siting, design and construction manual for at-grade units (Converse et al. 1990). It has been accepted and used in a number of states. Due to its site limitations it is not as versatile as the mound or in-ground system. Fig. 1 shows a schematic of the at-grade unit. Care must be taken in making modifications to the at-grade unit so a to minimize failures. All three factors, siting, design and construction principles must be closely adhered to as to minimize the risk of system failure. The on-site professional, i.e., the soil evaluator, designer, installer and inspector must understand the principles of operation of the at-grade system before an attempt is made to site, design and install it. Operational and management must also be an integral part of the equation.

The purpose of this paper is to provide information on the siting design and construction concepts of the at-grade. **The reader should obtain a copy of the 1990 At-Grade Manual[2] for a complete discussion on siting, design and construction.**

Figure 1 shows the components of the at-grade system. The system consists of a septic tank and the at-grade unit. A pump chamber is included if pressure dosing is required. If gravity flow is used, a distribution box should be placed in the up slope portion of the unit to provide at least 3 drop points along the length of the unit.

Fig. 2 shows the landscape location of the at-grade unit in relation in-ground trenches/beds and mound systems.

PRETREATEMENT UNIT

The septic tank serves as the pretreatment unit for the at-grade unit. Converse (1999) discusses several options for septic tank/pump chamber combinations. If gravity flow is the option, then a single compartment or double compartment septic tank with an effluent filter is sufficient. If

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[2] The Wisconsin at-grade manual and related publications can be obtained from SSWMP, University of Wisconsin-Madison, 1525 Observatory Drive, Room 345. 608-265-6595. A publication list is available upon request at no cost. Three is a small charge to cover copying and mailing. It can also be ordered over the web at hppt://www.wisc.edu/sswmp.

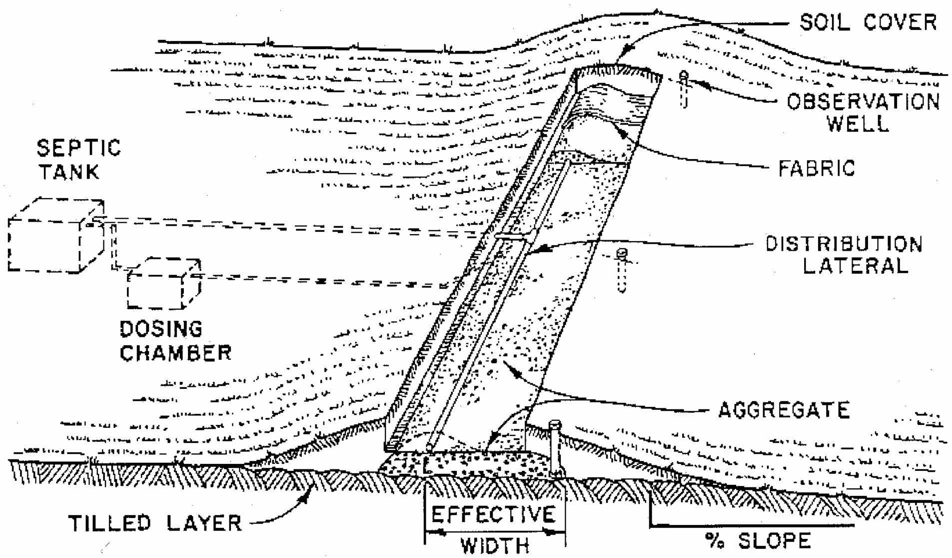

Fig 1. Schematic of the at-grade soil absorption system. Note that both pressure distribution and gravity flow distribution are shown. In actual practice, only one will be installed (Converse et al. 1990).

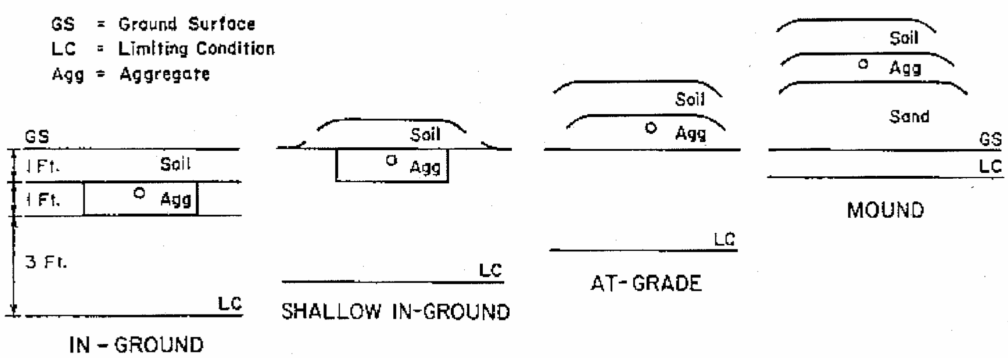

Fig. 2. Cross section of 4 soil absorption units shown in relation to ground surface and limiting conditions.

pressure distribution is the choice, then the following options may be considered.

1. A single compartment septic tank with effluent filter followed by a single compartment pump chamber.

2. A double compartment tank with the first compartment containing the 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 the second compartment, followed by a single compartment pump chamber. This may be the desired alternative as an "aerated baffle", known as the Nibbler Jr. (NCS, 1998) could be placed in the second compartment to reduce the organic matter if the at-grade unit ever fails due to breakout of effluent. The conversion would be minimal.

4. A single compartment tank with a pump vault within the septic tank. The effluent filter is incorporated in the pump vault that suspends from the outlet of the septic tank. An alternative is a double compartment tank with a hole in the center of the dividing wall to connect the two compartments together in the clear zone and the pump vault in the second compartment.

Demand dosing versus timed dosing for pressure distribution units.

Recent research on single pass sand filters shows that short frequent doses to the sand filter improves effluent quality (Darby et al., 1996). Short frequent doses require time dosing instead of demand dosing. Most at-grades are demand dosed where a large quantity of effluent is discharged into the mound. This large quantity of effluent moves through the sand rapidly (assuming no ponded condition), allowing insufficient time for the biota to totally treat the effluent. This forces fecals and pathogens further into the soil profile. Short frequent doses allows the effluent to be retained in the sand/soil for longer periods. Converse et al. (1991) showed some fecals found deep in the soil profile beneath at-grades. It may have been due to large infrequent doses. **Designers must consider using smaller doses when using demand dosing and they may want to consider timed dosing in distributing the effluent to the at-grade.** 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. Timed dosing also required control panels which have become very user friendly. Converse (1999) discusses the various options in more detail including pump vaults, effluent filters and time/demand dosing.

SITING CRITERIA

A designer must have a basic understanding of wastewater movement into and through the soil especially on more difficult sites. Typically the sites are not as difficult for at-grades as they are for mounds as there is a greater distance from the ground surface to the limiting condition such as bedrock or saturation. If the code separation distance is less than 3 ft, then the difficulty becomes greater. However, there may be other characteristics such as soil banding that may be a factor in selecting at-grades over in-ground trench/bed units. Fig. 3 shows a schematic of effluent movement away from the at-grade 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. Fig. 3a, (top figure) shows the movement primarily vertical where the soil is very permeable or crevice bedrock is present that allows for vertical movement. Fig. 3b shows a high seasonal or permanent water table. When the effluent reaches the saturated condition, it is forced horizontally as all the soil pores are full of water. Fig. 3c shows a semi-permeable condition beneath the surface. As the effluent reaches the semi-permeable area, it forces some of the effluent to move horizontally with some of it moving vertically until it reaches a point where it all moves vertically. Fig. 3d shows an impermeable layer beneath the surface. As the effluent reaches the impermeable area, it forces the effluent to move horizontally. Undoubtably, there will be some leaks in the restrictive layer with effluent moving downward. These conditions affect how the at-grade is configured. The designer must predict the direction and rate of movement or the design may be flawed resulting in treated effluent breaking out on the ground surface. The prediction is based on soil and site information obtained during site evaluation and experience.

The sizing and configuration of all soil absorption units, including at-grades, is based on how the effluent moves away from the unit and the rate at which it moves away.

Soil and Site Limitations:

Table 1 gives the soil and site criteria for Wisconsin at-grade systems used in Wisconsin. These distances may vary depending on code requirements in other areas. The separation distance for all soil based units receiving septic tank effluent is 3 ft. If the requirement were 4 ft than 4 ft would be used in Table 1.

Soil Loading Rates:

The design soil loading rate is based on the soil horizon that is in contact with the aggregate which is the surface horizon for the at-grade system (Table 2). Evaluation of the soil profile to a depth of 3 ft must be done. If a restrictive horizon is encountered, the tendency is to use the loading rate for the more restrictive horizon which results in an enlarged aggregate area. At the same time the linear loading rate must be appropriately selected otherwise toe leakage may occur. **The configuration of the at-grade must fit the soil profile with the soil loading rate and the linear loading rate matching the soil profile.**

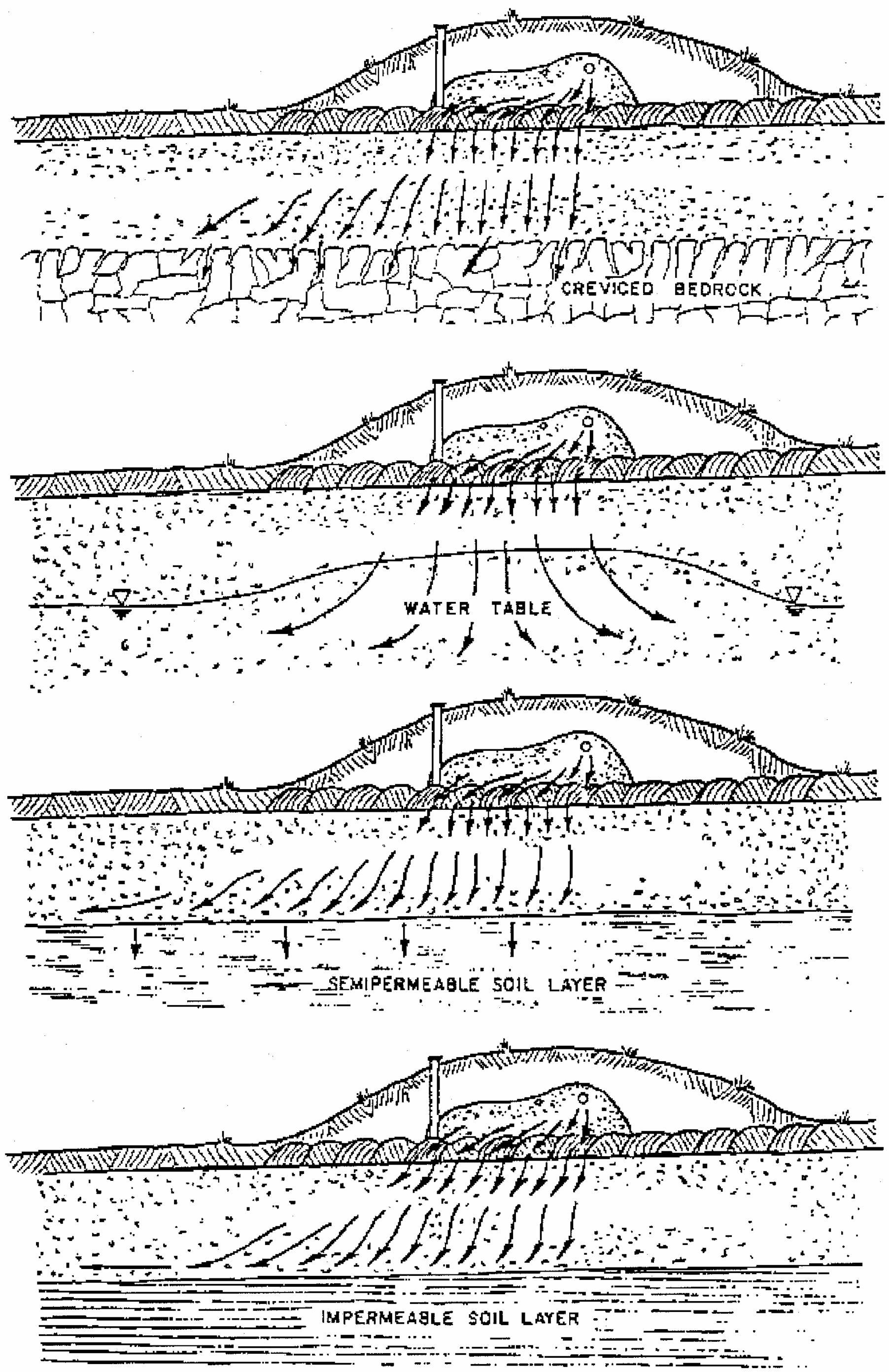

Fig. 3. Effluent movement away from the at-grade units under four different soil profile conditions (Converse et al. 1990).

Table 1. Soil and site criteria for the Wisconsin at-grade system used in Wisconsin (Converse et al. 1990).

Parameter	Limits
Depth from surface to high water[a]	3 ft
Slopes from surface to bedrock	3 ft
Surface slope[b]	<25%
Soil permeability	c
Flood Plain	No

[a] Seasonal saturation is estimated by mottles.
[b] Slopes limited due to construction. Some systems have been placed on steeper slopes. Slopes > 15% must incorporate pressure distribution.
[c] The soil permeability is estimated using soil texture, structure and consistence. Soil permeability limits for at-grades will be similar to in-ground trenches/beds.

DESIGN PRINCIPLES

System Configuration:

The system configuration must meet the soil site criteria and fit on the site. As with all soil absorption units, they should be long and narrow (Tyler and Converse, 1985; Converse and Tyler, 1986). Prior to the design, the soil evaluator/designer must use the soil profile description to 1) estimate the effluent acceptance rate of the soil and 2) determine the flow path of the effluent as it moves through the soil profile. If there is a restrict layer such as soil banding, hard pan, platy structure or high water table, the flow may be primarily horizontal and thus the design long and narrow. If there is no restrictive layer, then the flow will be vertical and the effective width of the system may be greater. It is difficult to determine the exact effective width of the system. A system that is too wide may leak at the down slope toe or either toe on level sites. Other factors such as gas transfer and exchange beneath the absorption area are also affected by the width of the system (Tyler et al. 1986). If there isn't sufficient length along the contour, but there is sufficient length along the slope, then it may be possible to stack them up the slope sufficiently apart so the up slope unit does not impact the down slope unit (Converse et al. 1990). Fig 4 shows a cross section and plan view of an at-grade unit on a sloping site.

Effect Absorption Area:

The effective absorption area is that which is available to accept effluent (Fig. 4). The effective length is the actual length of the aggregate along the contour. The effective width on sloping sites is the width from the distribution pipe to the toe of the aggregate and on level sites it is the

Table 2. Estimated wastewater design soil loading rates for the surface horizon based on soil morphological conditions for Wisconsin at-grade systems (Converse et al., 1990).

Soil condition in contact with the aggregate (Instructions: Read questions in sequence. When the conditions of your soil match the question, use that loading rate and do not go further).	If yes the Loading Rate in gpd/ft^2 Is:
A. Is the horizon gravelly coarse sand or coarser?	0.0
B. Is consistence stronger than firm or hard, or any cemented class?	0.0
C. Is texture sandy clay, clay or silty clay of high clay content and structure massive or weak, or silt loam and structure massive?	0.0
D. Is texture sandy clay loam, clay loam or silty clay loam and structure massive?	0.0
E. Is texture sandy clay, clay or silty clay of low clay content and structure moderate or strong?	0.2
F. Is texture sandy clay loam, clay loam or silty clay loam and structure weak?	0.2
G. Is texture sandy clay loam, clay loam or silty clay loam and structure weak?	0.4
H. Is texture sandy loam, loam, or silt loam and structure weak?	0.4
I. Is texture sandy loam, loam or silt loam, and structure moderate or strong?	0.6
J. Is texture fine sand, very fine sand, loamy fine sand, or loamy very fine sand?	0.6
K. Is texture coarse sand with single grain structure?	0.8

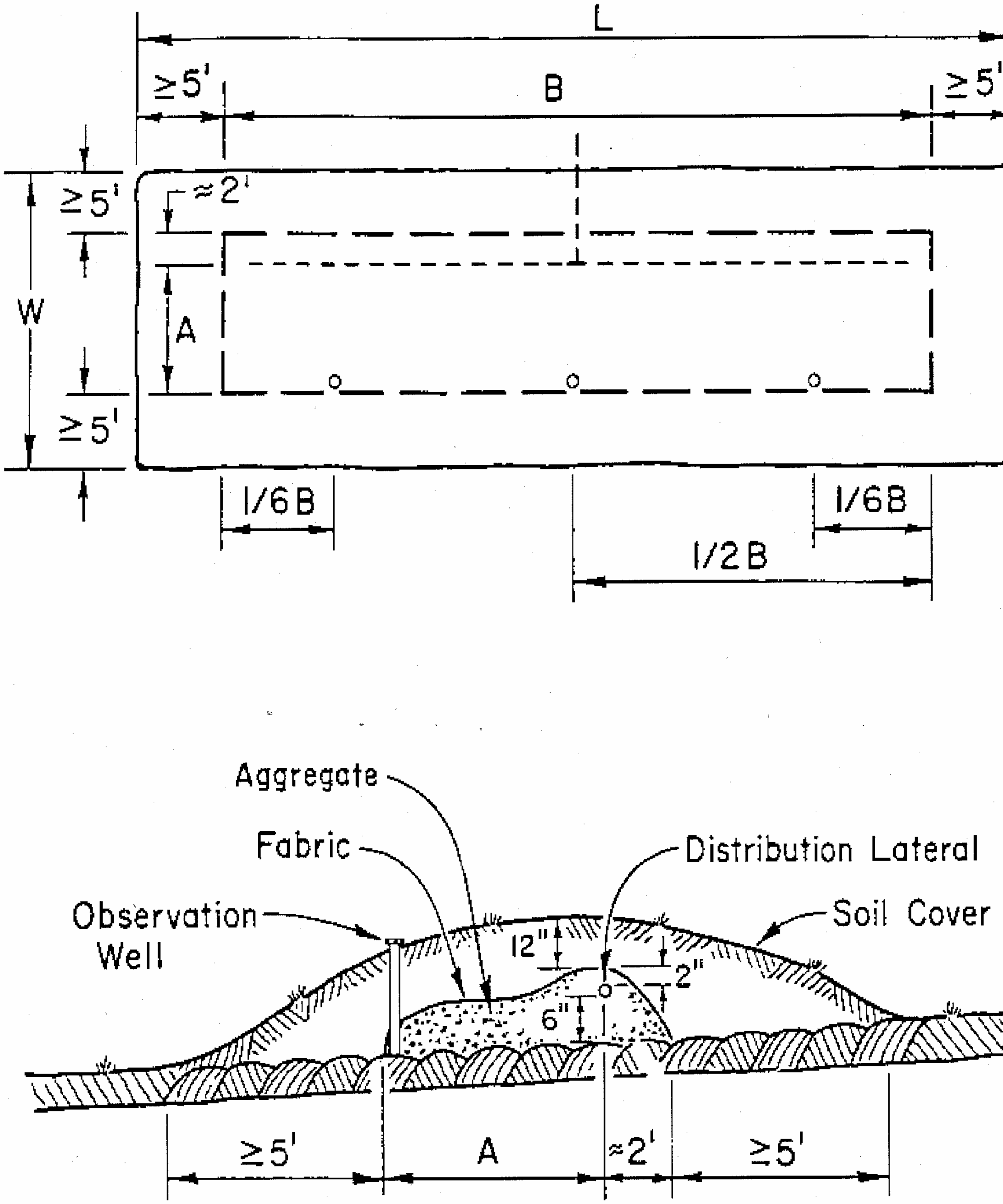

Fig. 4. Cross section and plan view of an at-grade unit on a sloping site (Converse et al, 1990)

width of the aggregate area. Table 2 is used to determine the area of the effective aggregate area and the linear loading rate determines the length and width of the effective area.

Linear Loading Rate:

The linear loading rate is defined as the amount of effluent (gallons) applied per day per linear foot of the system along the natural contour (gpd/lf). The design 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. 3). If the movement is primarily vertical (Fig. 3a), then the linear loading rate is not critical. If the movement is primarily horizontal (Fig. 3d), the linear loading rate is extremely important. Figure 5 illustrates the effect of 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 small (Tyler et al., 1986).

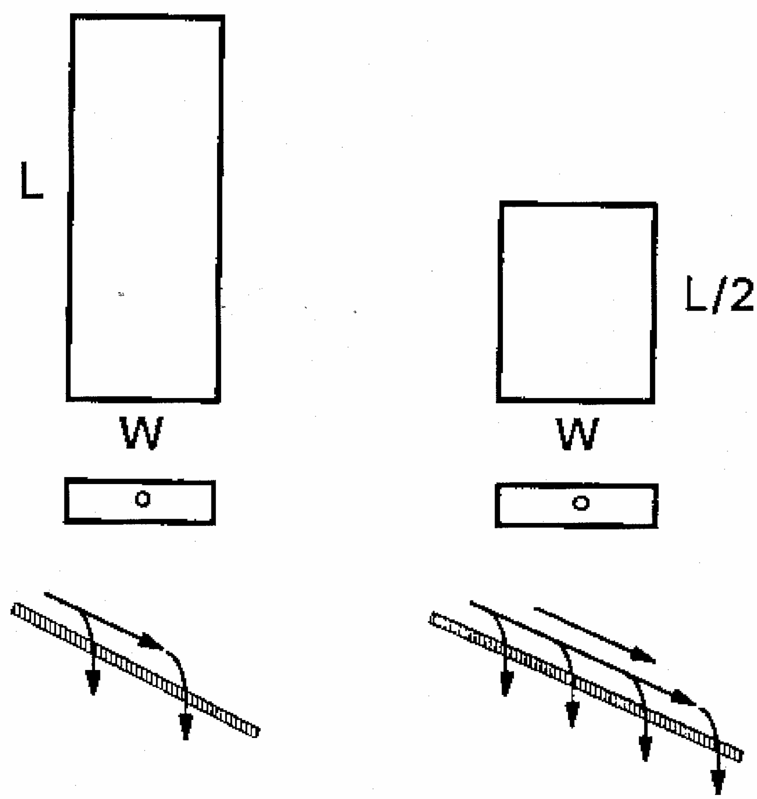

Fig. 5. The effect of linear loading rate based on system configuration on a sloping site. The sand or soil loading rates (gpd/ft^2) are the same but the linear loading rate for the right figure is twice that of the left figure. The soil may not be able to move the effluent away from the system fast enough resulting in back up and breakout at the mound toe.

It is somewhat difficult to estimate the 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. 3a), then the linear loading rate can be high but should be limited to a range of 8-10 gpd/lf otherwise the absorption area is excessively wide, especially if the soil absorption unit is the slower permeable soils such as silt loams. If the flow is primarily horizontal because of a shallow restrictive layer or limiting condition such as seasonal saturation or bedrock (Fig. 3d) then the linear loading rate should be approximately 3 gpd/lf, resulting in long and narrow systems. Converse (1998) gives a more detailed explanation and provides two examples of estimating linear loading rate.

Total Length and Width:

It is necessary to add about 5 ft to each end and sides to tie the system to the existing soil surface with the soil cover. These widths can be greater than this. Thus, the total length is sum of the aggregate length plus 10 ft and the width is the effective width, the aggregate up slope of the distribution lateral plus 10 ft (Fig.4).

Distribution Network:

The at-grade unit can be designed for either gravity or pressure distribution. Pressure distribution requires a pump tank with added costs but it does spread the effluent along the length of the unit and utilizes the total effective area of the aggregate. **Pressure distribution is the preferred and recommended method of distribution.** Fig. 6 shows the typical distribution pattern for pressure and gravity utilizing a distribution box up slope. Gravity distribution should be used in conjunction with a distribution box so the flow can be directed to at least 3 drop points along the length of the unit. Converse et al. (1990) show distribution patterns for level sites and provides a detailed discussion relative to pressure and gravity distribution.

Observation Tubes:

Observation tubes, extending from the aggregate/soil interface to or above final grade, are placed in the absorption area to provide easy access for observing ponding in the aggregate. On sloping sites the tubes are placed at the 1/4 and 3/4 points along the contour at the toe of the aggregate. The tube must be perforated along the bottom 6" of the side wall and secured using a toilet flange, tee or reinforcing rods (Converse et al., 1990).

Cover:

A geotextile synthetic fabric is placed on the aggregate. Approximately 8 – 12" of soil cover is placed over the aggregate extending at least 5 ft beyond the edge of the aggregate. The cover should support vegetation. Erosion protection must be implemented before a vegetative cover is established.

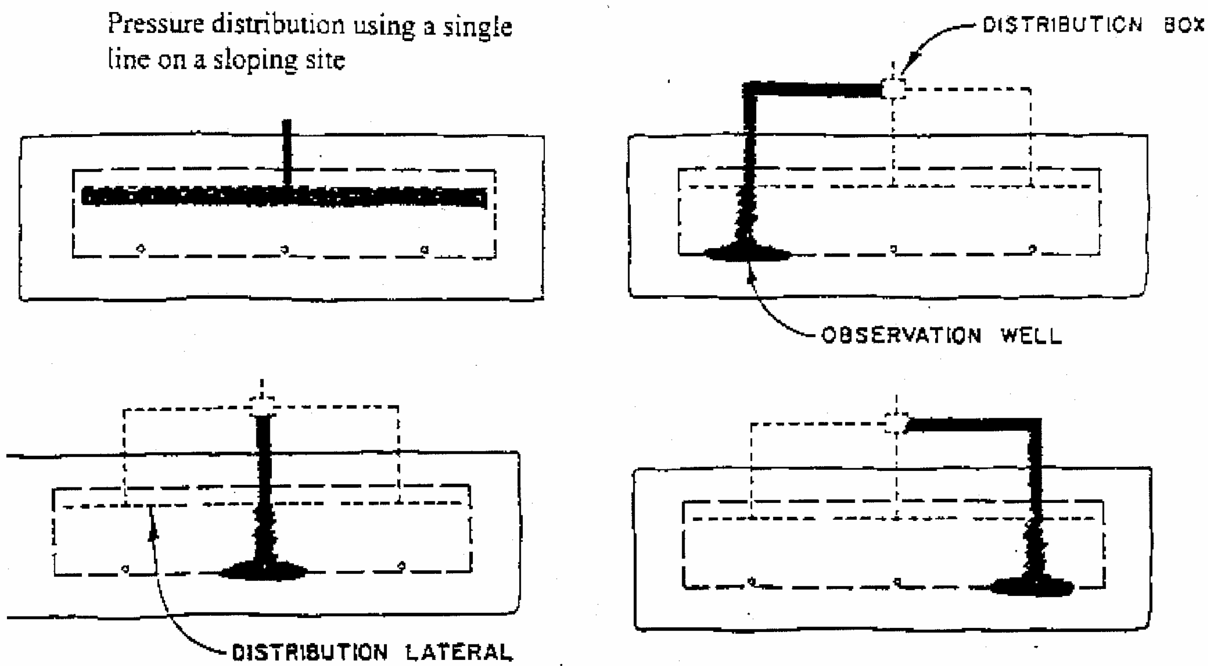

Fig. 6. Typical distribution patterns for pressure distribution (top left) and gravity flow with a distribution box with 3 drop points on sloping sites. Distribution box should sit in the upslope edge of at-grade (Converse et. Al., 1990).

DESIGN EXAMPLE

Design an on-site system based on the following soil profile description (modified from Converse et al., 1990).

Site Criteria

1. Soil profile is- Summary of 3 soil pit evaluations.

   0 – 12" Sil; 10YR 6/4&2/1; moderate, medium, subangular blocky structure; friable consistence.
   12 – 36" Sicl; 5YR 3/1; moderate, fine subangular blocky structure; firm consistence
   36+" Sic; 10YR 5/3; strong, medium, platy to massive structure; very firm consistence; many medium, prominent mottles at 3 ft.

2. Slope is 20%

3. Distance available along the contour is 170 ft and along the slope it is 30 ft.

4. Design is for a 3 bedroom house.

It appears that an at-grade system is suited for this site because the estimated saturation is at 36" the surface horizon is permeable and code setback requirements are assumed to be satisfied.

Step

1. **Determine the design flow rate (DFR).**

   Since this is a 3 bedroom home, use 150 gpd/bedroom.

   DFR = 3 br x 150 gpd/br
   = 450 gpd

2. **Estimate the soil loading rate (SLR) for the site.**

   Use table 2 for selecting the appropriate soil loading rate (SLR) that matches the soil conditions. It is based on the soil horizon that is in contact with the aggregate. Since this is a silt loam with good structure and friable consistence, use a

   SLR = 0.6 gpd/ft^2

3. **Estimate the linear loading rate (LLR) for the site.**

   Evaluate the soil profile to estimate the linear loading rate.

   The silt loam surface (A) horizon (0-12") is relatively permeable because of the texture, structure and consistence. The effluent flow will be vertically down through the aggregate, horizontally along the soil surface and vertically into the soil.

   The silty clay loam (E) horizon (12 – 36") has a moderate structure and firm consistence. Table 2 indicates that it can be loaded at 0.4 gpd/ft^2 which is less than the 0.6 gpd/ft^2 for the upper horizon. The consistence is firm which means the flow will be slightly restricted compared to friable. Thus, as the effluent moves downward through the (A) horizon, it will be slowed up because of the texture, structure and consistence change and be forced to move horizontally as effluent moves vertically.

   The silty clay loam (C) horizon (36+") has a strong medium platy to massive structure with very firm consistence. As the effluent from the (E) horizon approaches this horizon, the vertical flow of the effluent is considerably slowed. Effluent moves more slowly through silty clay. The massive nature of the soil slows up flow and the very firm consistence also slows up the flow. The platy structure directs the flow horizontally. Thus most of the flow will be going in the horizontal direction with some vertical movement. Fig. 3c depicts this site. There is approximately 30 – 36" of suitable soil for the effluent to move horizontally away from this site. Thus a linear loading rate of 5 or 6 would be appropriate for this site.

Linear Loading Rate = 5 gpd/lf.

4. Determine the effective absorption width (A) for the unit.

A = LLR / SLR

= 5 gpd/ft / 0.6 gpd/ft^2
= 8.33 ft

5. Determine the effective absorption length (B) for the unit.

B = DFR / LLR

= 450 gpd / 5 gpd/ft
= 90 ft

6. Determine the configuration of the system that best fits the site.

Once the effective width and length of the absorption area are determined, the designer must determine how it will best fit on the site. In this case there is 170 ft along the contour so this unit can be placed on the contour. A linear loading rate of 4.0 would give an an effective absorption length of 113 ft which would also fit on the site.

7. Determine the overall length (L) and the width (W) of the unit.

Add a minimum of 5 ft of soil on both ends and sides.

L = B + 2 end slopes

= 90 ft + 2(5) = 100 ft

W = A + up slope width of aggregate (C) + soil cover side widths
= 8.33' + 2' (estimated) + 2 x 5'
= 20.3' or 21 ft

To add an additional factor of safety, B could be easily increased since length along the contour is available.

8. Determine the height of the unit.

Use a minimum of 6" of aggregate beneath the distribution pipe, and about 2" above the pipe and 8-12" of soil over the aggregate. Place geotextile fabric over the aggregate. The height will be

H = 6" + 2" +2" + 10"
= ~20"

9. Design a distribution network for the site.

A pressure distribution network design includes the distribution piping, dosing chamber and pump. A design example is available through Converse et al. (1990). The following points should be considered. Otis (1981) provides a design procedure.

- Since the absorption area is relatively narrow and on a slope, a single distribution line along the length is satisfactory. It would be located 8.3 ft up slope of the aggregate toe. Another approach would be to use two lines with center feed with one line located at 4.1 ft up slope and one line located 8.3 ft up slope of the down slope toe. If a single line is used place the orifices about 12" apart since the width is about 8 ft. On the two line network, stagger the orifices with 2 ft spacing.

- Consider using 3/16" holes instead of ¼" holes with an effluent filter on the line. Data is available for 3/16" hole spacing but not in Converse et al. (1990).

- Timed dosing to the at-grade which requires surge capacity in the septic tank/pump chamber. However, most at-grades will continue to be demand dosed. In both cases the dose volume should be much less than previously recommended with not more than 5 times the void volume of the laterals. For example if the void volume of the laterals within the distribution network was 7 gallons, the dose volume would be 35 gp dose net. The total dose would be 35 gal. plus the flow back of the force main and manifold.

- **Provide easy access to flush the laterals such as turn-ups at end of laterals.**

CONSTRUCTION

Proper construction is very important. The following steps should be followed when constructing the at-grade units (Converse et al., 1990). There are variations to this approach but the principles should be followed.

Steps

1. Lay out the system with the length following the contour.

2. Cut the grass, brush and trees just above the ground surface and remove. Do not remove tree stumps. In wooded areas rake off dead vegetation if over an inch thick. Avoid heavy traffic on the site.

3. Check for proper soil moisture prior to construction. For single grain soil, the moisture content is not as critical as for structured soil. The soil is too wet to till if it takes on a wire form when rolled between the hands.

4. Determine where the force main from the pump chamber enters the at-grade unit. It will either be an end feed or an center feed. For long units, center feed is preferred. For center feed the force main can enter from the up slope center or the down slope center. If it be brought in from the down slope side, especially on slowly permeable soils where the effluent flow may be horizontal, it should be brought in perpendicular to the side of the unit 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. Oil 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. Placement of the pipe can be done after tilling but extreme care must be taken not to disturb the tilled area.

5. Till the area following the contour to a depth of 6 – 8". The tilled area should be at least the total length and width of the system. A mold board plow, chisel plow or chisel teeth mounted on a backhoe bucket are satisfactory for tillage. Chisel teeth mounded on a backhoe is the preferred method and it is easier to till around boulder and trees stumps. It also allows for deeper tilling to break up platy structure. A rototiller may be used, but not recommended, on single grain soils, such as sand. The backhoe bucket has been used but not recommended. It requires flipping the soil and much slower than chisel plowing.

   Avoid traffic on the tilled area especially beneath the aggregate area and down slope. If compaction or ruts occur in the up slope or down slope area during construction, retill the compacted or rutted area. Minimize the subsoil disturbance beneath and down slope of the absorption area.

6. Place observation tubes at 1/6, ½ and 5/6 points along the toe of the aggregate area. The tubes must be placed so that ponded effluent at the down slope edge of the aggregate may be observed in the tubes. Stabilize the tubes.

7. Place the aggregate in the designated area of the tilled area to a 6 in depth. **Work from the up slope side and avoid compaction along the down slope side especially if the effluent moves horizontally away from the unit.**

8. Place the distribution network level along the length of the unit and connect the inlet pipe from the pretreatment unit or dose chamber. Place 2 in. of aggregate on top of the network.

9. Place geotextile synthetic fabric over the aggregate. Extend it only to the edge of the aggregate.

10. Place 8-12" of soil over the fabric and taper it to a distance of at least 5 ft in all directions from the aggregate. Finish grading around the system to divert surface water away. Seed and mulch the exposed areas immediately after construction to control erosion.

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SMALL SCALE WASTE MANAGEMENT PROJECT

Wisconsin At-Grade Soil Absorption System Siting, Design, and Construction Manual

by

James C. Converse, E. Jerry Tyler, James O. Peterson

January 1990

UNIVERSITY OF WISCONSIN - MADISON
College of Agricultural & Life Sciences
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THE WISCONSIN AT-GRADE SOIL ABSORPTION SYSTEM

SITING, DESIGN, AND CONSTRUCTION MANUAL

BY

James C. Converse E. Jerry Tyler James O. Peterson*

The Wisconsin at-grade soil absorption system accepts septic tank effluent and treats and disposes of it in an environmentally acceptable manner. It serves the same function as in-ground soil absorption trenches and mound systems. Figure 1 shows a schematic of the system, which consists of a septic tank and the soil absorption unit. When pressure distribution is used, a dose chamber is required. The existing soil surface is tilled, observation tubes and the aggregate are placed, the distribution network installed, the fabric covering laid on the aggregate and soil cover placed over the fabric and on the side slopes. The hydraulics and treatment concepts are very similar to the in-ground trench or bed and the mound system.

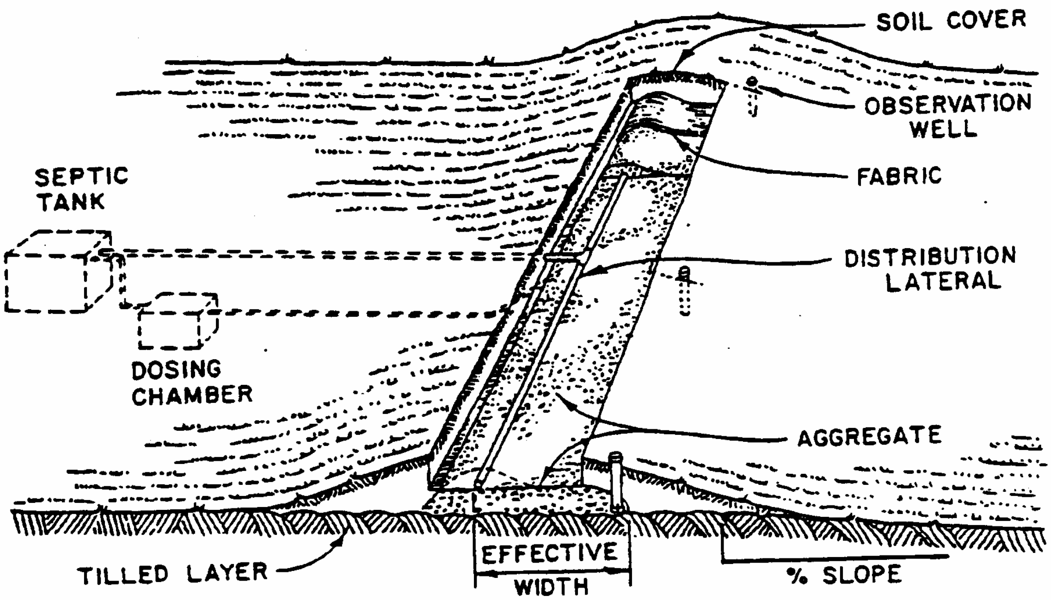

Fig. 1. Schematic of the At-grade Soil Absorption System

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PREFACE

The Wisconsin At-Grade Soil Absorption system is one of several soil absorption systems that can be used to treat and dispose of on-site wastewater through the soil. It is a relatively new system with the first system installed in 1982. Since that time a number of systems have been installed and it appears that this system has a lot of promise on sites that don't meet the criteria for in-ground soil absorption sytems but exceed the criteria for the Wisconsin Mound system.

This publication is an update and succeeds the publication entitled "WISCONSIN AT-GRADE SOIL ABSORPTION SYSTEM MANUAL SITING - DESIGN - CONSTRUCTION" which was dated May, 1989.

The at-grade system will continue to be evaluated. Additional information can be obtained through the SSWMP.

Fig. 2 shows a cross section of 4 soil absorption systems; the in-ground trench or bed, the shallow in-ground trench or bed, the at-grade, and the mound. System selection is based on the soil site criteria established by local or state codes for soil absorption systems.

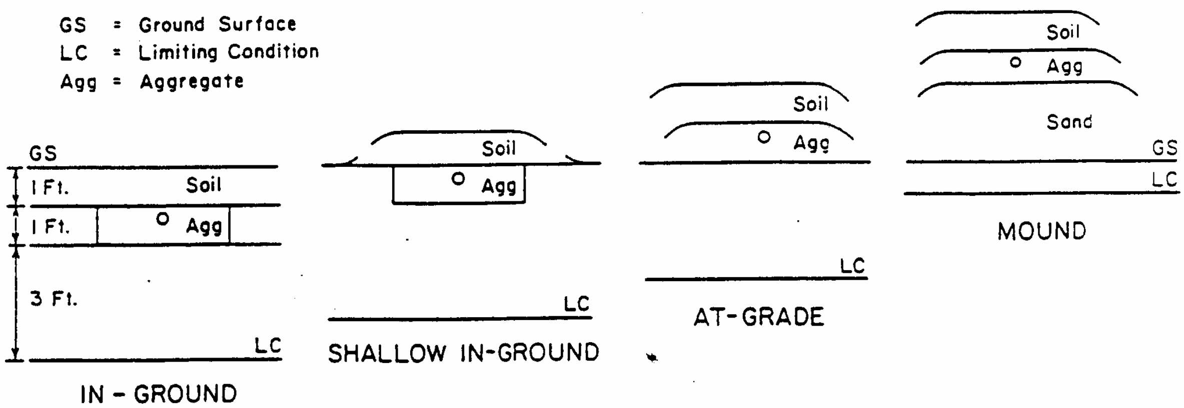


Fig. 2 Cross Section of 4 Soil Absorptions Units in Relation to Ground Surface and Limiting Conditions

The at-grade system has been evaluated in the field with 14 experimental systems which were from 1 to 5 years old and accepting domestic wastes from typical residences. All systems have been performing very well (Converse et al., 1988). As of Jan. 1990, there were over 250 units installed in Wisconsin.

SOIL AND SITE EVALUATION

Selection of the appropriate soil absorption system for a site should consider the following:

1. The landscape and topography for waterways and surface runoff. Avoid placing the system in areas where surface water accumulates or passes downslope.

2. Avoid concave slopes especially if the system will be large. Look for straight slopes, level sites, or convex slopes.

3. Avoid areas that have an excessive number of trees or rocks on the surface. Increase the size of the unit to compensate for the area of the tree stumps and rocks.

4. Evaluate several soil profiles in the area for the following:

   a. Depth to seasonal or permanent high water table for at least the depth dictated by code. It may range from 1 to 4 ft. For Wisconsin it is 3 ft beneath the proposed bottom of the system. For large systems evaluation to greater depths may be necessary.

b. Depth to bedrock for at least the required depth beneath the bottom of proposed system.

c. Texture, color, structure and consistence for at least the required depth beneath the bottom of the proposed system. Evaluate for soil banding, especially in sand textured soils. Evaluate the profile for layers that may restrict effluent flow.

d. Movement of effluent through the soil profile. Will it all move vertically downward? Will it all move horizontally away from its point of application? Will it move both vertically and horizontally and if so, can you estimate about how much will go in each direction? Figure 3 shows the effluent movement away from the at-grade unit for 4 different soil profile conditions.

e. Estimate the soil permeability based on the texture, structure and consistence. Do it for each layer of soil to the required depth beneath the proposed bottom of the system.

<u>Horizontal and Vertical Separations</u>:

Horizontal set backs from such features as wells and property lines are usually dictated by local codes and should be followed for all soil absorption systems. Most codes have required separation distances between the bottom of the aggregate and the high water table or bedrock. Table 1 gives the required distance of 3 ft for Wisconsin. Some codes may require only one foot of separation while some may require four feet of separation. The at-grade unit should follow the same separation distances as required for other soil absorption units.

<u>Slopes</u>:

Table 1 gives the slope limitation for at-grade systems. Limited experience is available for the steeper slopes. On the steeper slopes care must be taken to maintain safe construction practices as well as design.

<u>Design Soil Loading Rate</u>:

The design soil loading rate is based on the soil horizon that is in contact with the aggregate, which is the surface horizon for the at-grade system. Table 2 gives the recommended loading rates for various combinations of soil texture, structure, and consistence. These are estimates based on experience. Codes may dictate loading rates or area per bedroom based on the percolation rate. If percolation rates are required, then the rate should be determined for the most limiting horizon beneath the bottom of the system up to a distance of 3 ft (or code requirement) beneath the bottom of the system. Care should be used in sizing system absorption area based on percolation rates. If used, other criteria should also be used to make sure that the percolation rate is giving a reasonable absorption area. Table 3 gives sizing of absorption areas based on percolation rates.

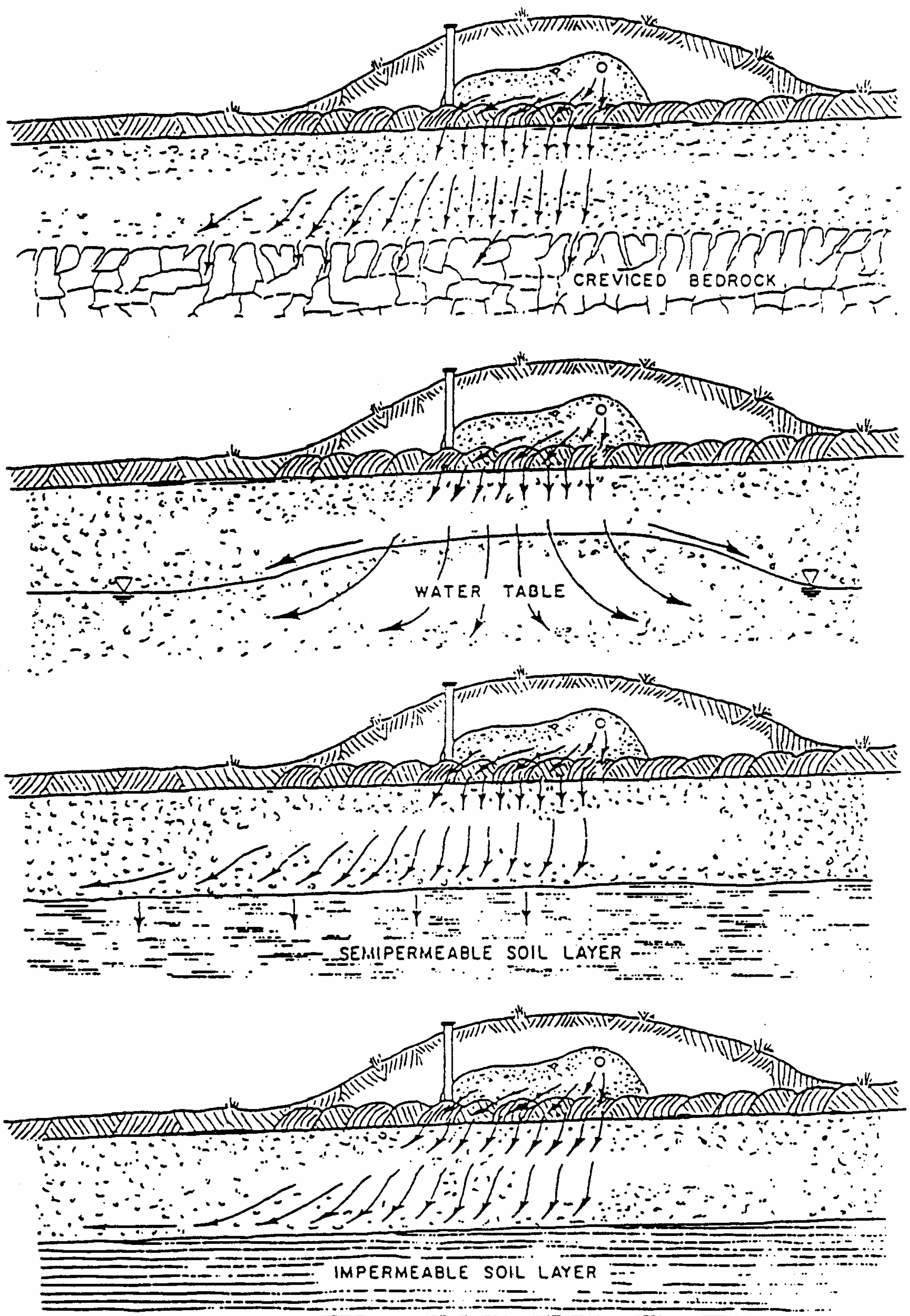


Fig. 3. Effluent Movement Away From the At-grade Unit Under Four Different Soil Profile Conditions

Table 1. Soil and Site Criteria for the Wisconsin At-Grade System Used in Wisconsin

Parameter	Limits
Depth from surface to high water[a]	> 3 ft
Depth from surface to bedrock	> 3 ft
Surface slope[b]	< 25 %
Permeability of soil (0-3 ft)	c
Flood plain	no

[a] May be seasonal which would be estimated by mottles. Wisconsin code sets 3 ft separation distance to limiting condition. Other codes may require other distances.

[b] Limited experience on 25% slope. Recent systems, not reported by Converse et al. (1988), have been placed on 25-30% slopes.

[c] The standard percolation test was not performed on the sites during the experimental phase (Converse et al., 1988). The estimated percolation rates for the surface horizon are between 0 and 60 mpi with the majority of the sites having rates of 30 mpi or faster.

DESIGN PRINCIPLES

System Configuration:

The system configuration must meet the soil site criteria and also fit on the site. As with other soil absorption systems, they should be designed long and narrow (Tyler and Converse, 1985; Converse and Tyler, 1986). Necessary design configuration may not fit on some sites thus requiring other alternatives. Prior to the design, the soil evaluator/designer must use the soil profile description to 1) estimate the effluent acceptance rate of the soil and 2) determine the flow path of the effluent as it moves through the soil profile and away from the system. For example, if there is a restrictive layer such as soil banding, hardpan, platy structure or high water table, the flow may be primarily horizontal and thus the design must be long and narrow (Fig. 3). If the platy structure is in the surface horizon or just below it, tilling will reorient the structure and should allow for vertical flow. If there is no restrictive layer, then the flow will be vertical and the effective width of the system may be greater. Unfortunately, it is very difficult to determine the exact effective width that the system should be. A system that is too wide may leak at the downslope toe or either toe on level sites. Other factors such as gas transfer and exchange beneath the absorption area (aggregate/soil interface) are also affected by the width of the system (Tyler et al., 1986). If there isn't sufficient length along the contour, but there is sufficient distance along the slope, configuration 3 and 4 in Fig. 4 may be appropriate for the site but only for at-grades using a pressure distribution network.

Effective Absorption Area:

The effective absorption area is that which is available to accept effluent. The effective length of the absorption area is the actual length of the aggregate along the contour. The effective width on sloping sites is the distance from the distribution pipe to the toe of the aggregate and on level

Table 2. Estimated Wastewater Design Soil Loading Rates for the Surface Horizon Based on Soil Morphological Conditions for Wisconsin At-grade Systems

	Soil Condition of Horizon in Contact with Aggregate (Instructions: Read questions in sequence. When the conditions of your soil match the question, use that loading rate and do not go further).	If Yes The Loading Rate In gpd/ft^2 Is:
A.	Is the horizon gravelly coarse sand or coarser?	0.0
B.	Is consistence stronger than firm or hard, or any cemented class?	0.0
C.	Is texture sandy clay, clay or silty clay of high clay content and structure massive or weak, or silt loam and structure massive?	0.0
D.	Is texture sandy clay loam, clay loam or silty clay loam and structure massive?	0.0
E.	Is texture sandy clay, clay or silty clay of low clay content and structure moderate or strong?	0.2
F.	Is texture sandy clay loam, clay loam or silty clay loam and structure weak?	0.2
G.	Is texture sandy clay loam, clay loam or silty clay loam and structure moderate or strong?	0.4
H.	Is texture sandy loam, loam, or silt loam and structure weak?	0.4
I.	Is texture sandy loam, loam or silt loam, and structure moderate or strong?	0.6
J.	Is texture fine sand, very fine sand, loamy fine sand, or loamy very fine sand?	0.6
K.	Is texture coarse sand with single grain structure?	0.8

sites it is the width of the aggregate (Figs. 1, 4 and 8).

Depending on the soil texture and other characteristics, the required absorption area can be determined using Table 2. The width is based on the linear loading rate acceptable to the site. The linear loading rate, which is defined as the loading rate per linear foot of system (gallons per day per linear foot along the contour (gpd/lf)), can be greater for deep permeable soils than for a shallow zone of permeable soil over a less permeable soil. Unfortunately it is difficult to estimate the linear loading rate for many soil

Table 3. Sizing of the Effective Area Based on Percolation Rates*

Soil Class (mpi)	Sizing (sq. ft / bedroom)
Class 1 (0 - 10)	165
Class 2 (10 - 30)	250
Class 3 (30 - 45)	300
Class 4 (45 -60)	330

*Taken from Wisc. Adm. Code (1985) on sizing using trench bottom area. The recommended approach to sizing is to use Table 2.

conditions but "good estimates" are suggested based on experience and judgement by the authors. If the flow away from the system is primarily vertical (Fig 4a), then the linear loading rate can be high but the recommended rate is below 10 gpd/linear ft otherwise the absorption area becomes excessively wide, especially on the slower permeable soils such as the silt loams to silty clay loams. However, if the more permeable soils are shallow and flow is primarily horizontal (Fig. 3d) then the linear loading rate should be constrained to 3-4 gpd/linear ft. This approach will normally result in systems that are narrow and therefore long.

<u>Total Length and Width</u>:

Once the effective length and width of aggregate/soil contact area are determined, it is necessary to add about 5 ft on each side and end of the aggregate to tie the system into the existing soil surface with the cover soil. Greater widths are satisfactory if additional landscaping is desired. However, use of heavy machinery on the downslope toe should be avoided especially if there is any horizontal movement of effluent caused by a slowly permeable horizon or high water table.

<u>Distribution Network</u>:

The at-grade system can be designed for either gravity or pressure distribution. The pressure distribution network requires a dose chamber while the gravity network does not as long as the pretreatment tank outlet is at a higher elevation than the distribution network. Because of the limited experience with gravity units, pressure distribution networks are being installed in all gravity units with the manifold being stubbed just outside the unit. If gravity distribution should not function properly, or if continued research shows they do not provide a reasonable length of service, the unit can be converted to pressure distribution easily. <u>At this time pressure distribution is preferred and recommended for at-grade systems</u>.

<u>Gravity Distribution</u>: Figure 5 shows the typical distribution pattern for both pressure and gravity flow. Typically in gravity flow, the effluent leaves the distribution pipe at one or two locations, moves vertically down

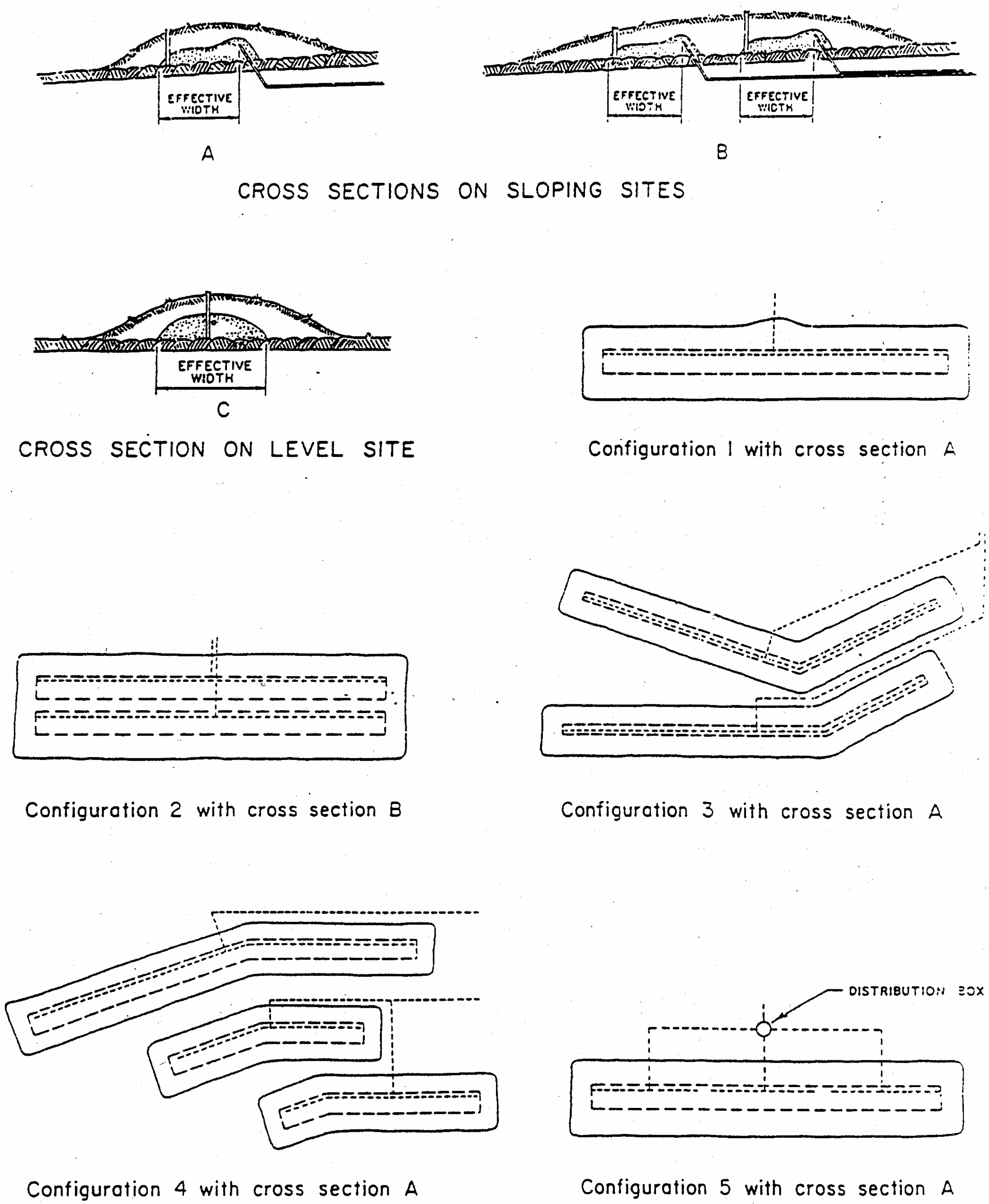
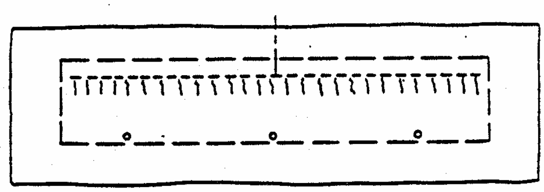
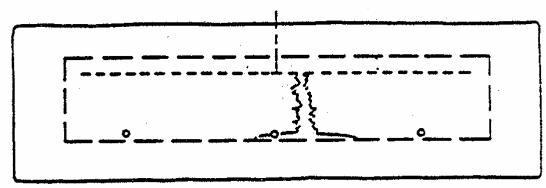


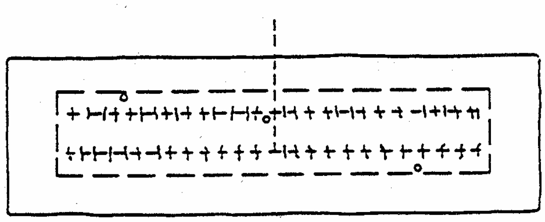
Fig. 4. Typical Configurations of At-Grade Units That Have Been Installed



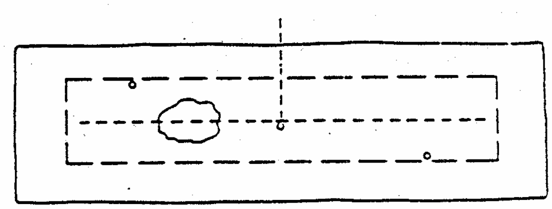
Pressure Distribution Using a Single Line on Sloping Site



Gravity Distribution Using a Single Line on Sloping Site



Pressure Distribution Using 2 lines On a Level Site



Gravity Distribution Using a Single Line on a Level Site

Fig. 5. Typical Distribution Patterns for Pressure and Gravity Distribution Networks

through the aggregate and then moves horizontally along the soil/aggregate interface until it infiltrates into the soil (Converse, 1974). As the clogging mat develops, the effluent will move further down the slope until it infiltrates. Eventually it will reach the toe of the aggregate and then it will move horizontally along the toe until it infiltrates. This phenomenon is called creeping clogging. Ponding will occur along the toe of the aggregate and may be observed in the observation tubes if the tubes are located downslope of where the effluent left the distribution pipe. If not, ponding will eventually appear in the observation tubes as the ponded effluent creeps along the toe of the aggregate. As noted in Fig 5, a large part of the effective infiltration area may not be used with gravity distribution on sloping sites.

On level sites, the effluent will spread out over the whole area just as it does in in-ground trenches or beds. Thus on some sites it may be appropriate to make the bottom of the absorption area level provided an acceptable separation distance between the bottom of the aggregate and the bedrock or high water table is maintained (Table 1). The system is then approaching a shallow in-ground system (Fig. 2) for which there is limited experience. Care must be taken not to reduce the infiltration rates in the soil due to construction practices. The effective infiltrative area must be quite level or the effluent will not flow to high areas until lower areas are excessively ponded. Sites that appear to be level may actually have a slight slope. In that case up to one half the absorption area may be ineffective if the system is designed as a level site.

If gravity flow is used, it must be restricted to the single absorption area configuration (Fig 4, configuration 1 and 5) as the effluent will enter one or the other absorption area unless provisions are made so the flow can be directed to either trench through a distribution box or drop box arrangement. In which case, all of the flow will be directed to one area until it is switched to the other area.

As the effluent ponds at the toe of the aggregate, seepage to the surface may occur resulting in raw effluent on the surface which must be avoided. This seepage will continue to occur until corrective action is taken. Corrective action includes converting the system to pressure distribution by connecting the pressure distribution network to a dose chamber (Fig 1) or by providing some means of diverting the flow from area to area in the system. This can be done by providing a distribution box up-slope of the at-grade unit (Fig 4, configuration 5) or providing diverting tees and risers where the pipe from the septic tank connects to the perforated distribution pipe (Fig 6). Figure 6 also shows the distribution of effluent as it is distributed to different parts of the system. The disadvantage of this approach, is that someone has to divert the flow occasionally. When done it will allow part of the system to rest.

<u>Pressure Distribution</u>: Pressure distribution is the recommended method of distribution of the septic tank effluent in the at-grade unit. Fig. 5 shows how the effluent is spread along the contour. The effluent leaves the lateral through the small diameter hole and moves vertically downward through the aggregate where it infiltrates into the soil. As it comes in contact with the soil, it will move laterally away (downslope on sloping sites and laterally in all directions on level sites) and infiltrates into the soil.

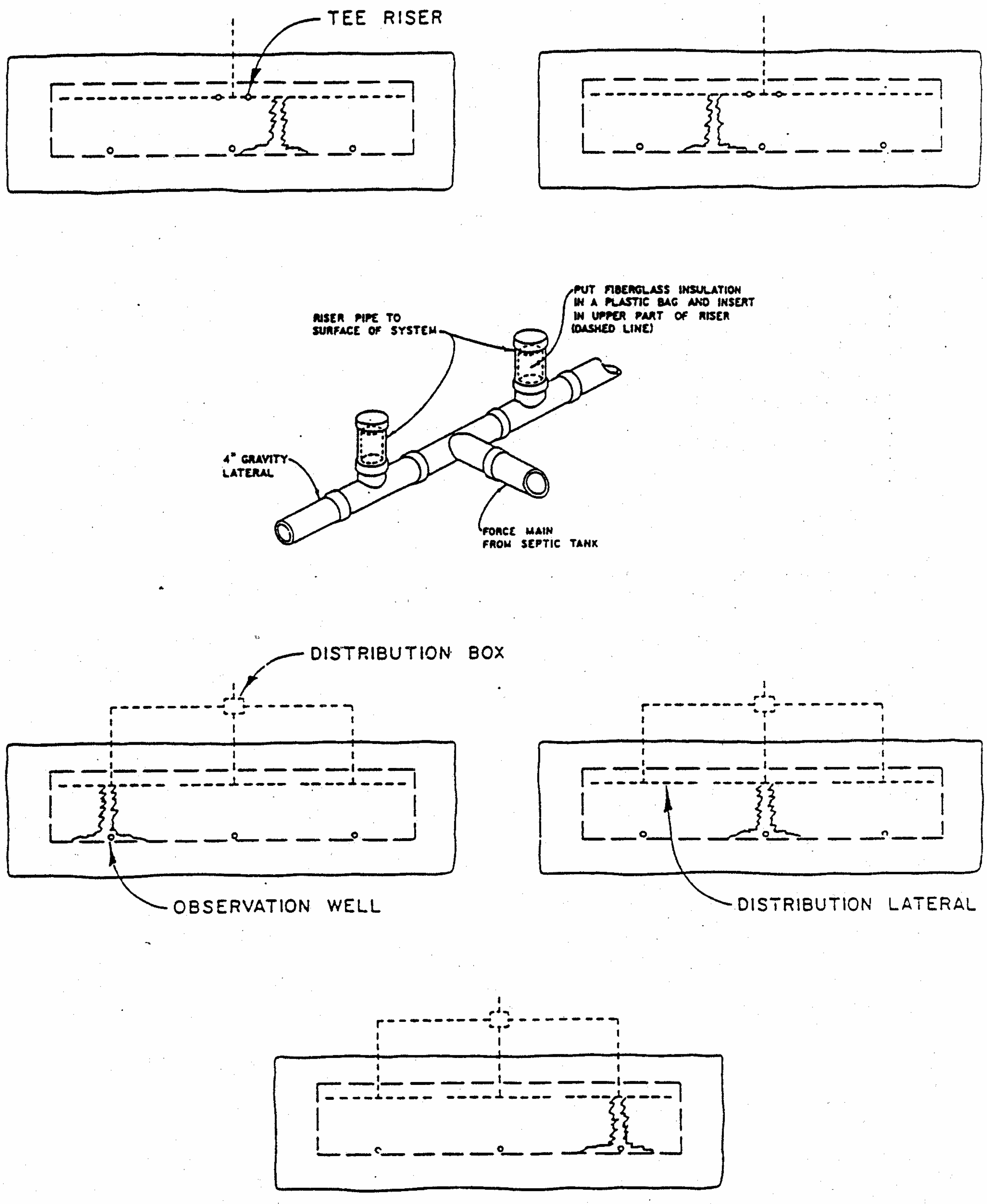


Fig. 6. Typical Distribution Patterns for Gravity Using Tees and Distribution Boxes

This approach should minimize the severe progressive clogging that typically occurs in gravity systems, but a clogging mat can occur in pressure systems.

The pressure distribution network configuration will vary depending upon the size and dimensions of the absorption area. For level sites with narrow absorption areas, a single lateral in the center along the length of the absorption area will suffice (Fig. 5). For wider absorption areas, it may be appropriate to use parallel laterals, fed by a manifold, and spaced equal distance apart so that the distance from the edge of the aggregate to the lateral is one half the distance of the spacing between the laterals and using a center manifold especially on longer units (Fig. 5).

On sloping sites for all systems, the distribution network consists of a single perforated pipe on the upslope edge of the aggregate with a center feed preferred (Fig. 5). For wider absorption areas on sloping sites, some contractors have installed parallel laterals with one lateral near the upslope edge and a parallel lateral midway down the slope. This approach has some validity in that it spreads the effluent over a wider area. If this approach is used and the slope is minimal, it is best to install the pipes level by placing more aggregate beneath the lower laterals. Designing pressure distribution networks for sloping sites is risky and provisions such as valves to equalize the flow to each lateral are recommended. Otis (1981) describes a procedure for designing a system for a sloping site.

The design of the pressure distribution network consists of 1) selecting the perforation diameter and spacing, 2) sizing the lateral length and diameter 3) selecting the number of laterals, 4) calculating the flow rate and dose volume, 6) sizing the force main, 6) sizing the pump based on head and flow rate, and 7) sizing the dose chamber. The design steps along with a design example are given in the appendix.

Observation Tubes:

Capped observation tubes, extending from the aggregate/soil interface to or above final grade, are placed in the absorption area provide easy access for observing ponding in the aggregate. Seepage at the toe of the unit, the result of excessive ponding, is the most probable cause of failure. On sloping sites the observation tubes must be placed just upslope of the downslope edge of the aggregate with the downslope edge of the tube at the edge of the aggregate. These observation tubes, consisting of 4 in. dia. PVC pipe with slots in the lower portion of the tube, must be stabilized so that they don't pull out when removing the cap. Fig. 7 shows three examples of stabilizing the observation tubes. The tubes can be cut off at final grade and recessed slightly to avoid being damaged by lawn mowers. Screw-type or slip caps are commonly used for the cover.

Cover:

After the aggregate, distribution pipe and observation tubes have been installed, a geotextile synthetic fabric is placed on the aggregate. Hay, straw or other material is not to be used in place of the fabric. Approximately one foot of soil cover is placed on the fabric and extended and tapered to a distance of at least five feet beyond the aggregate edge. The surface is seeded to vegetation to reduce erosion.

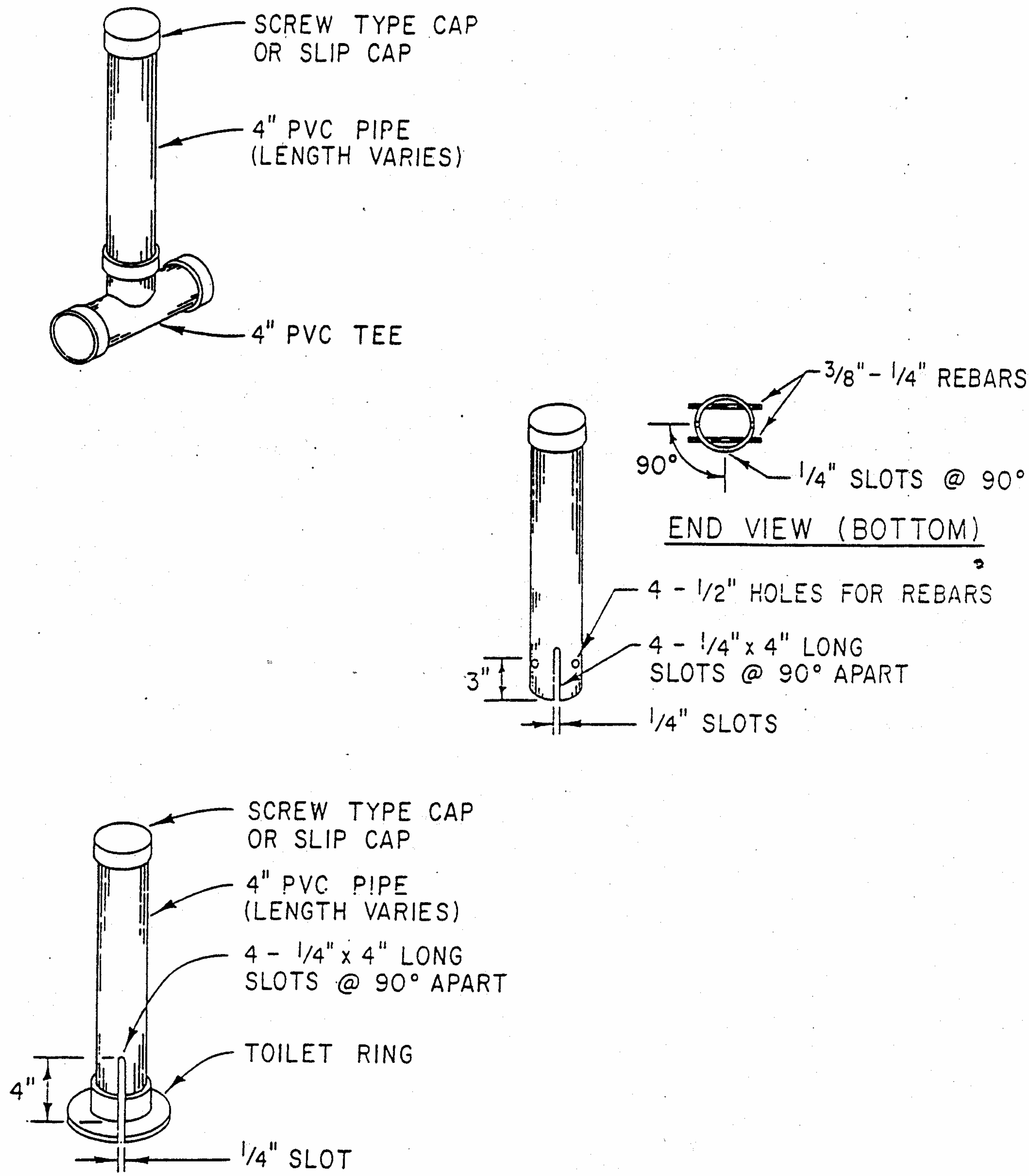


Fig. 7. Three Methods of Stabilizing Observation Tubes

DESIGN AND CONSTRUCTION EXAMPLE

Design:

When working with on-site wastewater treatment systems, the evaluator/designer must evaluate the soil site conditions and then select the best system for the site that meets the owner's needs and causes the least impact on the environment. When evaluating the site the following should be done (Refer to previous section on soil and site criteria for more detail):

1. Evaluate the landscape for surface water movement. Measure elevations and distances on the site so that slope, contours and available areas can be determined.

2. Describe several soil profiles where the system will be located. Determine the limiting conditions such as bedrock, high water table, and soil permeability.

The designer uses the information to design a system that will fit the site. Not all sites meet the criteria for on-site soil absorption systems and an alternative to soil absorption may be necessary.

Assume for the example the following site factors:

1. Soil profile is:

   0 - 12 in. sil; 10YR 6/4&2/1; moderate, medium, subangular blocky structure; friable consistence.
   12 - 24 in. sicl; 5YR 3/1; moderate, fine, subangular blocky structure; firm consistence.
   24 - 36 in. sic; 10YR 5/3; strong, medium, platy to massive structure; very firm consistence; many, medium, prominent mottles at 3 ft.

2. Slope is 20%.

3. Distance available along the contour is 175 ft and along the slope it is 30 ft.

4. Design for a 3 bedroom house.

Based on the above information, it appears that an at-grade system is suited for this site because estimated high water is at 36 in., the surface soil horizon is permeable, and code setback requirements are assumed to be satisfied.

Steps:

1. Determine the design flow rate (DFR).

   Since this is a 3 bedroom house, use 150 gallons per bedroom or a design flow rate of 450 gpd.

2. Estimate the soil loading rate (SLR) for the site.

   Use table 2 for selecting the appropriate soil loading rate (SLR) that matches the soil conditions. It is based on the soil horizon that is in contact with the aggregate. Since this is a silt loam with good structure and friable consistence, use a

$$SLR = 0.6 \text{ gpd/ft}^2$$

   Note: In table 2 there is no mention of platy structure which will have a tendency do impede vertical flow. If the platy structure is in the surface horizon or slightly below and it can be tilled, the reorientation should allow the flow to move vertically through the horizon.

3. Estimate the linear loading rate (LLR) for the site.

   Evaluate the soil profile to estimate a linear loading rate. Since this profile consists of a permeable soil over a slowly permeable soil with massive structure, the flow will be primarily horizontal with some vertical flow (see Fig. 3c). Also, since the slope is fairly steep, a narrow system is appropriate. Based on experience and the discussion in the Design Principles section, an appropriate linear loading rate is:

$$LLR = 4.0 \text{ gpd/lf}$$

4. Determine the effective absorption width (A) of the unit.

   Since the estimated linear loading rate is 4 gpd/ft and the soil loading rate is 0.6 gpd/ft^2 then:

$$A = LLR \,/\, SLR$$

$$= 4 \text{ gpd/ft} \,/\, 0.6 \text{ gpd/ft}^2$$

$$= 6.7 \text{ ft}$$

   This is the effective width of the aggregate. If this was on a non-sloping site, then the total aggregate width would be 6.7 ft. Since this is on a sloping site, the total aggregate width will be about 8.0 - 9.0 ft as approximately 1.5 to 2 ft of aggregate must be placed upslope of the distribution pipe to support the distribution network and satisfy the angle of repose of the aggregate (Fig. 1 and 8).

5. Determine the absorption length (B) of the unit.

   The length of the absorption area (B) is dependent on the design flow rate (DFR) and the linear loading rate (LLR) then:

B = DFR / LLR

= 450 gpd / 4 gpd/lf

= 112 ft

Thus the effective absorption area is 112 ft by 6.7 ft or 750 ft^2.

6. Determine the configuration of the system that best fits the site.

   Once the effective width and length of the absorption area are determined, the designer must determine how it will best fit on the site. On some sites it may be necessary to divide the absorption area into several units if there isn't sufficient length along the contour. Fig. 4 show various configurations that have been used. The most common is the single unit that is placed on the contour. On some sites it may be necessary to build several parallel units using alternating pumps to dose each unit or design a pressure distribution system for a sloping site.

7. Determine the overall length (L) and width (W) of the unit.

   It is necessary to tie the aggregate into the surrounding soil surface by placing soil about 5 ft wide around the perimeter of the aggregate (Fig. 1 and 8). Greater widths for landscaping purposes are satisfactory.

   L = absorption length (B) + soil cover end lengths

   = 112 ft + 5 ft + 5 ft

   = 122 ft

   W = absorption width (A) + upslope width of aggregate (C) + soil cover side widths

   = 6.7 ft + 2 ft + 5 ft + 5 ft

   = 19 ft

8. Determine the height of the unit.

   Design for a minimum of 6 in. of aggregate beneath the distribution pipe and about 2 in. above the pipe. As shown in Fig. 8a, the aggregate will taper off at the edges. Place synthetic fabric over the aggregate and approximately 1 ft of soil cover over the fabric. Thus the height of the unit above the original grade will be approximately 2 ft at the distribution lateral and tapering to the edges.

9. Design a distribution system for the unit.

   Since the absorption area is relatively narrow and on a slope, a single distribution line along the length is satisfactory. It would be located 6.7 ft upslope of the aggregate toe. If the site was level, the distribution pipe would be located in the center of the aggregate. The distribution can either be gravity or pressure but pressure distribution is recommended.

Gravity: If gravity is used, provisions should be made so the flow can be diverted to at least 2 locations within the unit either using two vertical risers near the center inlet tee or use a distribution box as shown in Fig. 6. The gravity laterals consist of 4" perforated PVC drain pipe preferably with a center inlet. One distribution lateral along the length of the absorption area for gravity is sufficient regardless of the width of the absorption area. A pressure distribution line should be installed next to the gravity distribution line because gravity distribution in these systems has not been proven with time. If several absorption areas are installed (Fig. 4, configuration 2, 3 or 4) gravity distribution is not recommended.

Pressure: Design the pressure network as per procedure outlined in the appendix. Normally the network consists of a single lateral along the length of the absorption area. On wider absorption areas, some have installed several parallel laterals (Fig. 5) but only on relatively low slopes. Care must be taken to get equal distribution in the laterals if they are not at the same elevation.

Construction:

As with all soil absorption systems, proper construction is very important. The following steps should be followed when constructing the at-grade unit. There are variations to this approach, but the principles should be followed closely.

Steps:

1. Lay out the system with the length following the contour.

2. Cut all grass, brush and trees just above ground surface and remove. Do not remove tree stumps. In wooded areas rake off dead vegetation if over an inch thick. Avoid heavy vehicle traffic on the site.

3. Check for proper soil moisture prior to construction. For single grain soil, such as sand, the moisture content is not as critical as for structured soil. The soil is too wet to till if it takes on a wire form when rolled between the hands.

4. Till the area following the contour to a depth of 6 to 8 in. The tilled area should be at least the total length and width of the system. A mold board plow, chisel plow, or chisel teeth mounted on a backhoe bucket are satisfactory for tillage. The normal teeth on a backhoe are not satisfactory and must not be used. Chisel teeth, mounted on a backhoe, is the preferred method as it is easier to till around boulders and tree stumps. It also allows for deeper tilling to break up platy structure. A rototiller may be used (but not recommended) for single grain soils, such as sand, but not for

structured soils. Care must be taken not to compact and smear the soil during the tillage operation. Driving on the tilled area can rut and compact the soil and is not recommended.

5. Install the inlet pipe from the pretreatment unit or dose chamber from the upslope side either prior to plowing or after plowing. If it enters from the downslope edge or if the site is level, place the pipe <u>prior</u> to tilling with minimum disturbance of the downslope edge of the system. Bring the force main in at right angles to the absorption area and connect to the upslope end (preferably) of the manifold and not the center of the manifold if a manifold is used.
   Do not bring the force main in from the end of the absorption area to the center of the system as this would destroy the soil structure beneath the absorption area. If required to come in from the end, use either an end feed or bring the force main in on the upslope side of the absorption area.

   Avoid traffic on the tilled area especially beneath the aggregate area and downslope. If compaction or ruts occur in the upslope or downslope area during construction, retill the compacted or rutted area. Minimize the subsoil disturbance beneath and downslope of the absorption area.

6. Place the three observation tubes at 1/6, 1/2, and 5/6 of the absorption length and <u>exactly at the toe of the aggregate</u>. The tubes must be constructed and placed so that ponded effluent at the downslope edge of the aggregate may be observed in the tubes. Stabilize the observation tubes (Fig. 7).

7. Place the aggregate in the designated area of the tilled area to a depth of 6 in. Work from the upslope edge of the system.

8. Place the distribution network level along the length of the unit and connect it to the inlet pipe from the pretreatment unit or dose chamber. Place 2 in. of aggregate on top of the network.

9. Place non-biodegradable geotextile synthetic fabric (not building paper, burlap, hay or straw) over the aggregate. Extend it only to the edge of the aggregate.

10. Place approximately 12 in. of soil over the fabric and taper it to a distance of at least 5 ft in all directions from the aggregate. Finish grading round the system to divert surface water away. Seed and mulch the exposed areas immediately after construction to control erosion.

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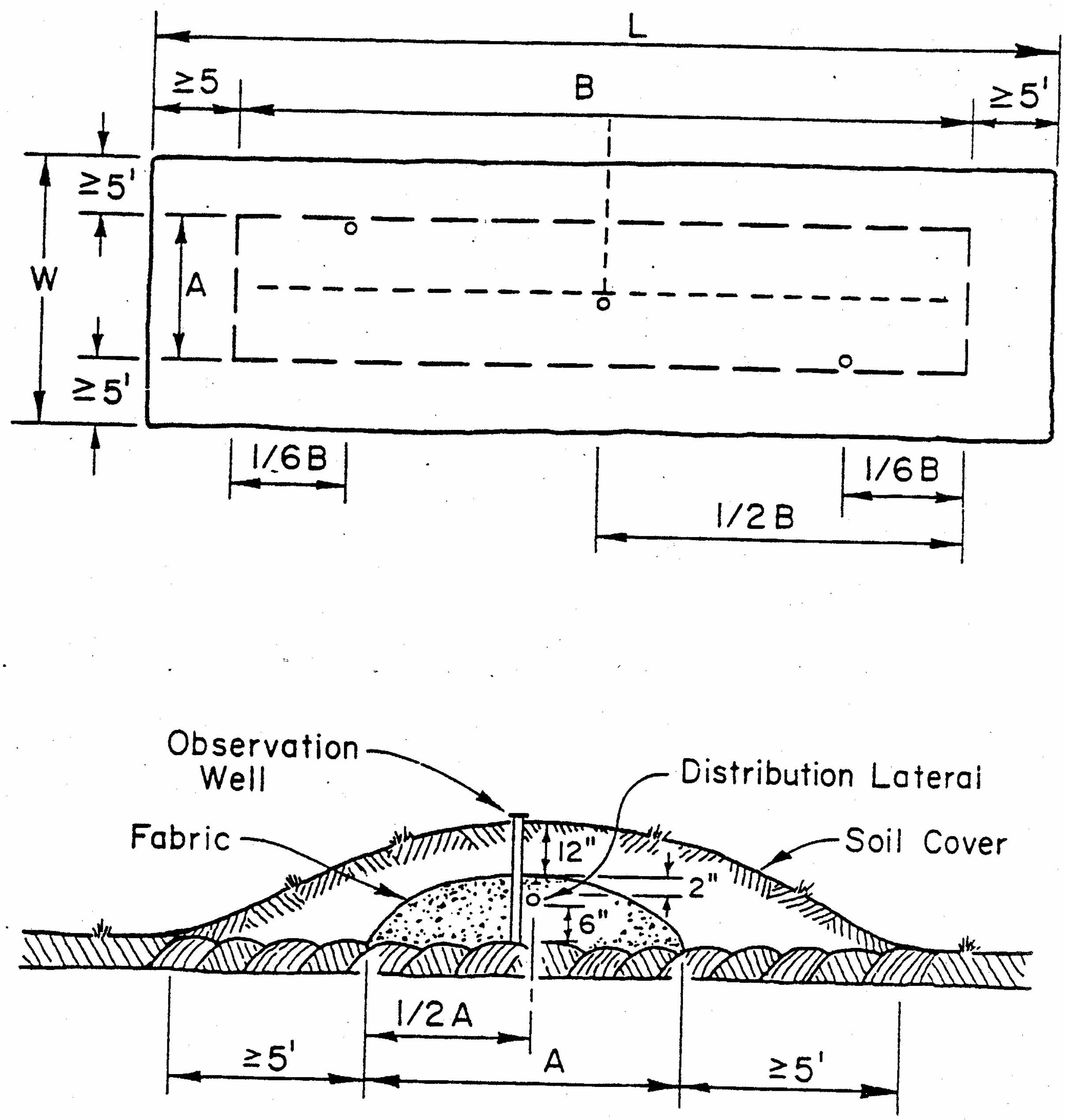
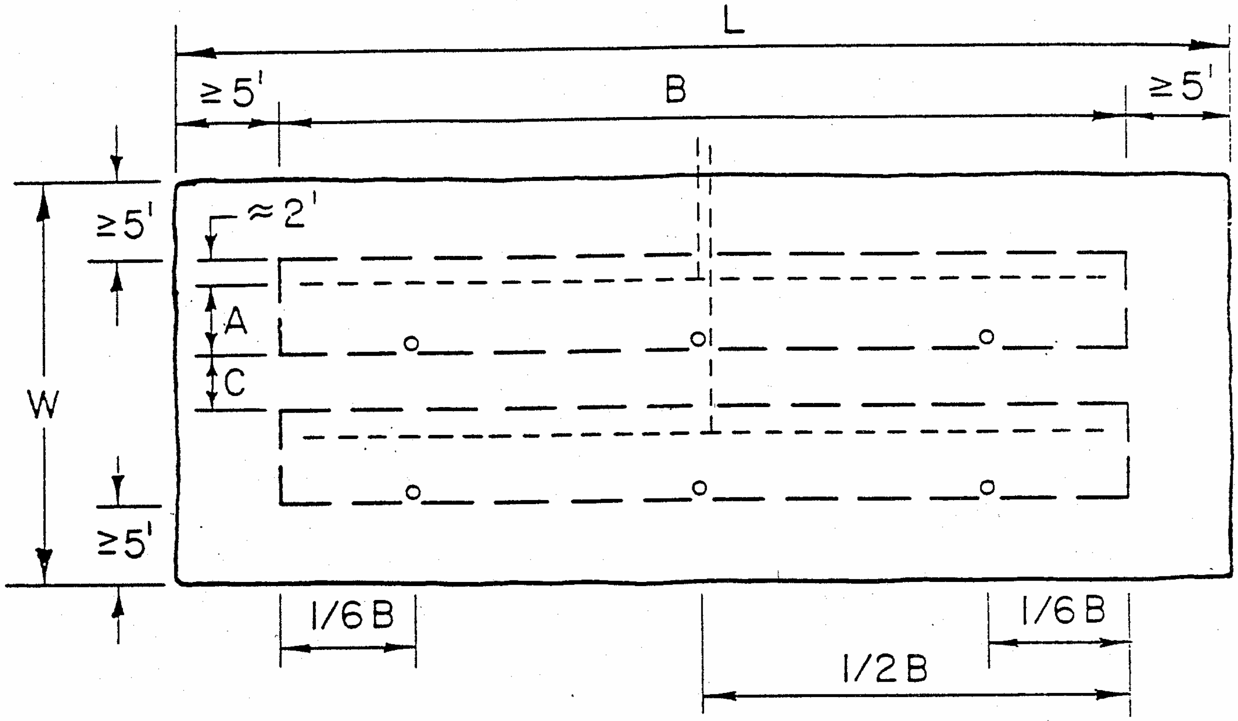


Fig. 8b. Plan View and Cross Section of a Wisconsin At-grade Unit with an Single Soil Absorption Area on a Level Site



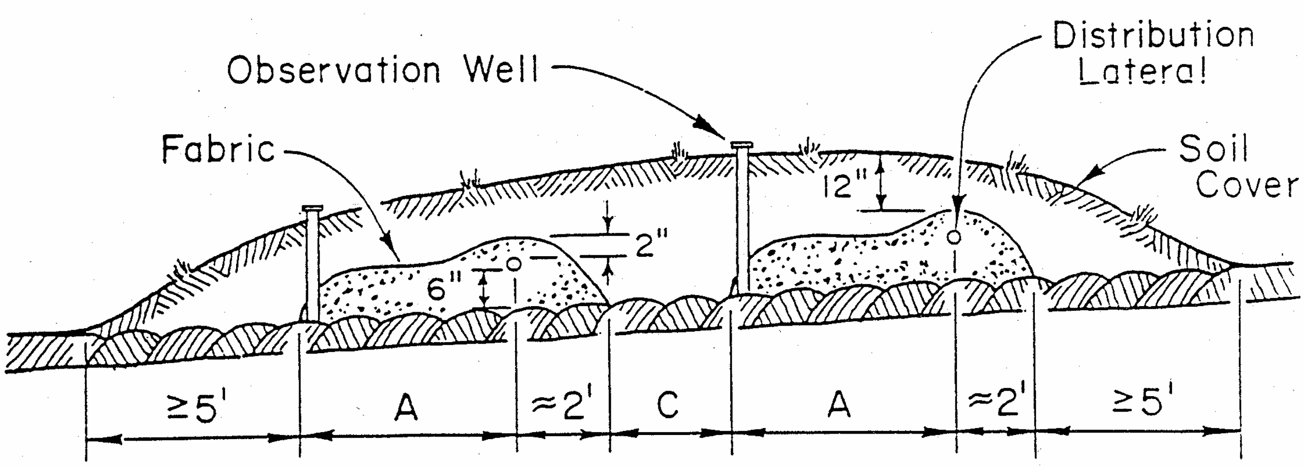


Fig. 8c. Plan View and Cross Section of a Wisconsin At-grade Unit with Two Absorption Areas With in a Single Unit on a Sloping Site

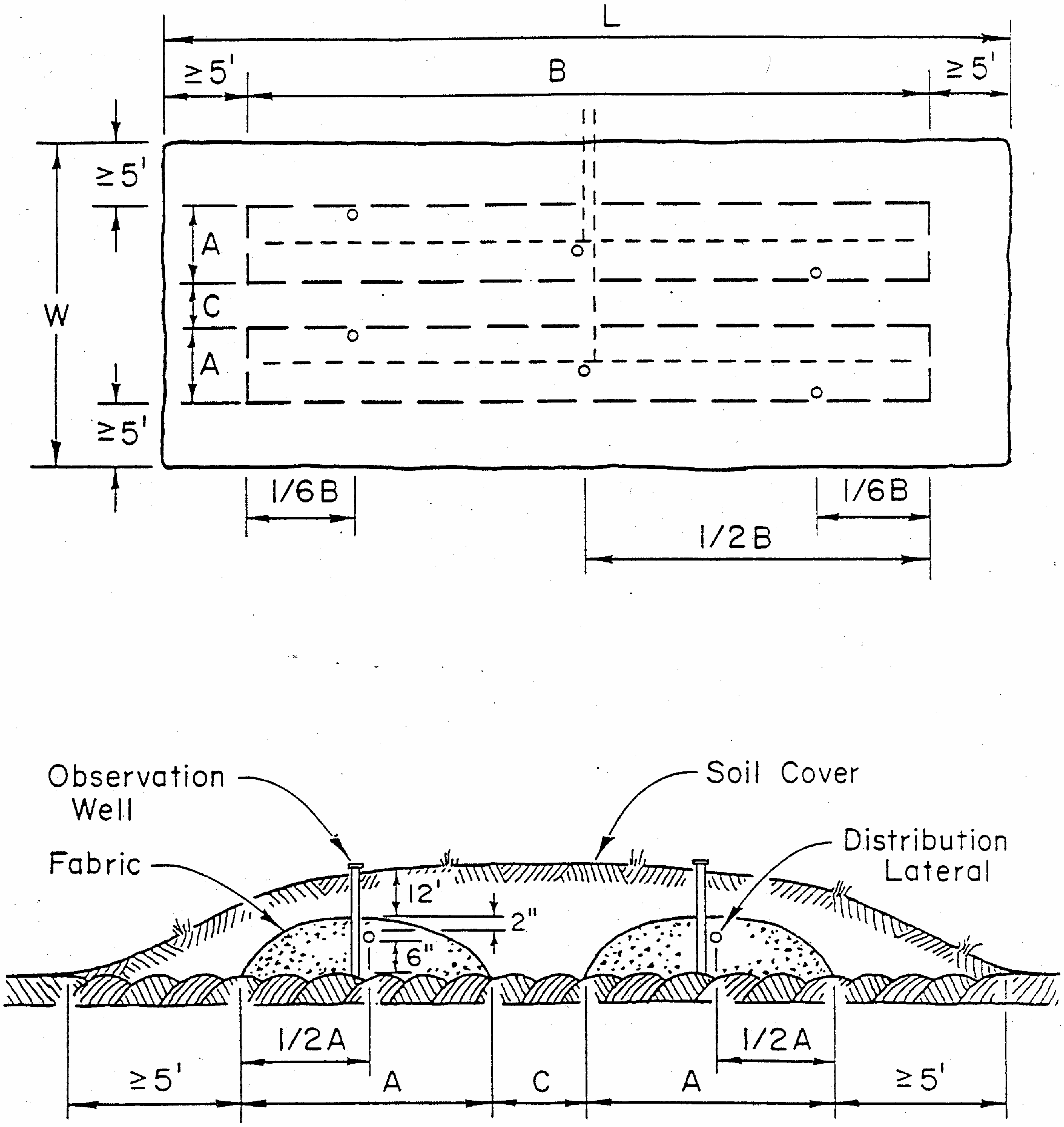


Fig. 8d. Plan View and Cross Section of a Wisconsin At-grade Unit with Two Absorption Areas Within a Single Unit on a Level Site

WISCONSIN MOUND SOIL ABSORPTION SYSTEM:

SITING, DESIGN AND CONSTRUCTION MANUAL

BY

James C. Converse 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. The

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[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 an endorsement, explicitly or implicitly.

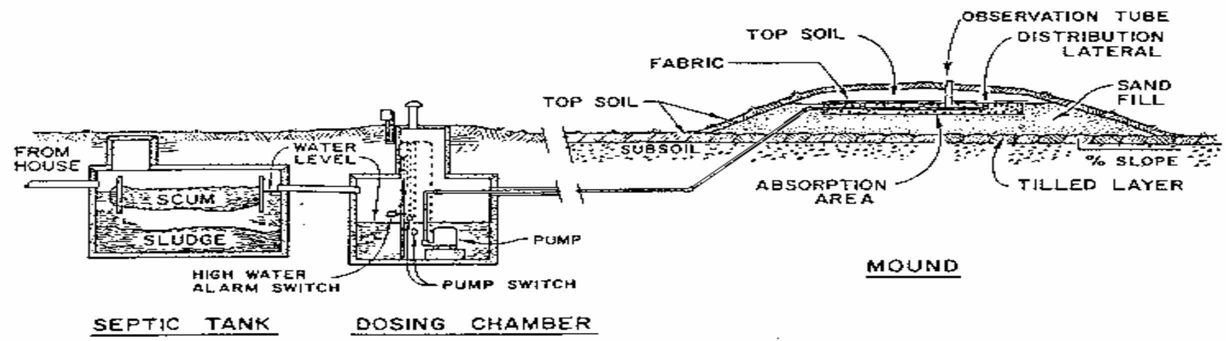

Fig. 1. Schematic of the Wisconsin mound system showing septic tank, dosing and mound.

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 wastewater which has been pretreated by passing the wastewater 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 wastewater, 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 wastewater, 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 wastewater. 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 or 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 with 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 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 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 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 sore 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 understands 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 feet of separation is required. This figure can be used for other separation distances, which may vary from 1–4 feet 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 feet 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

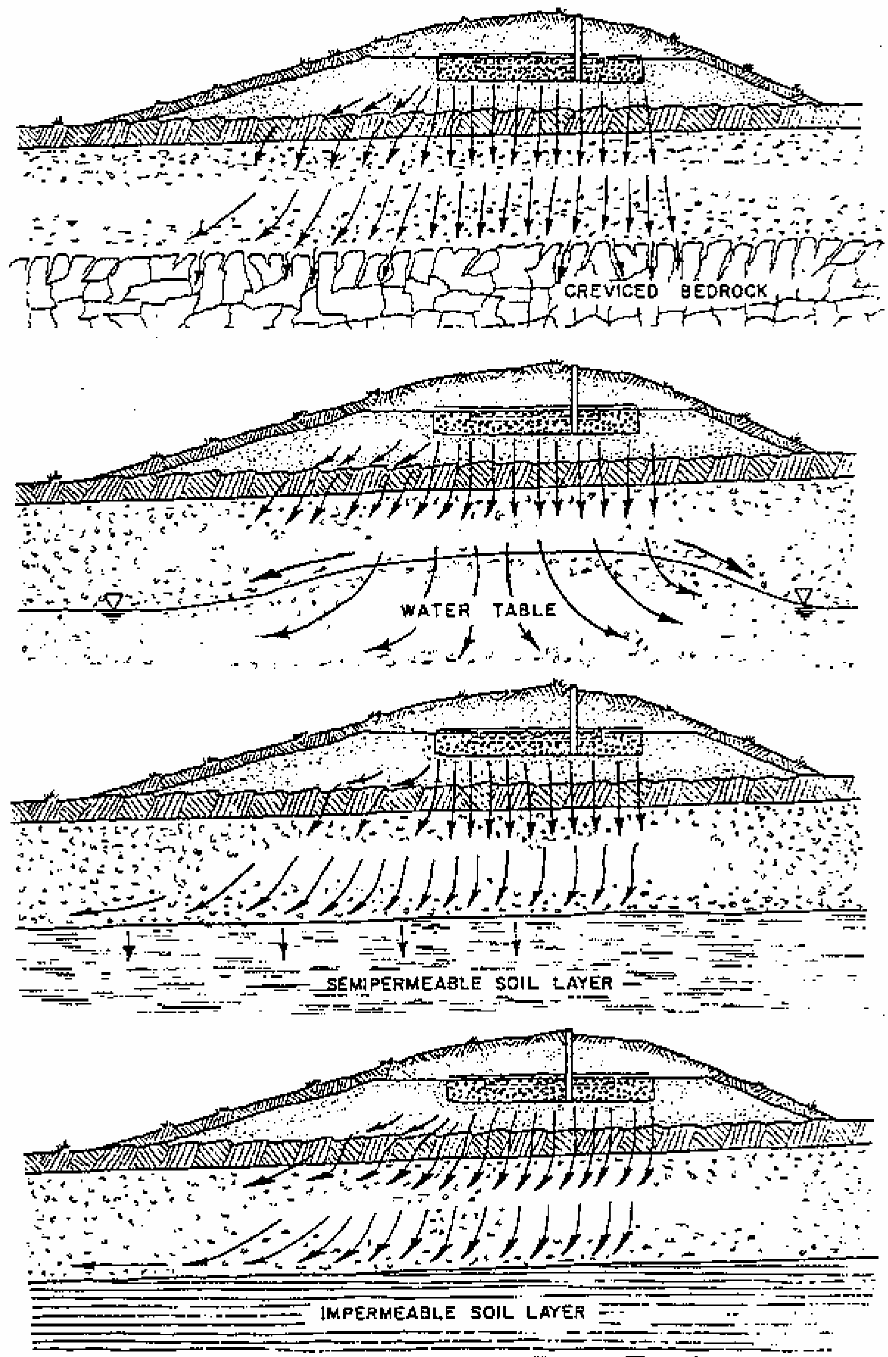

Fig. 2. Effluent movement within and away from the Wisconsin mound for four different types of soil profiles.

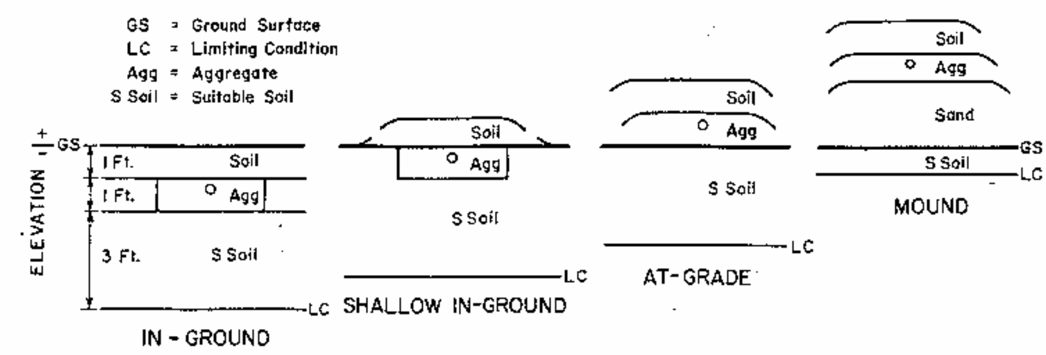

Fig. 3. Cross section of four soil absorption units in relation to ground surface and limiting conditions.

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.

Seasonal saturation is determined by 1) redoxmorphoric features (soil color, grays 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 topsoil, 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 topsoil. 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 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	24in.[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 of 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 pretreated 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 2 % 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, a greater down slope horizontal separation distance may be appropriate to avoid weeping into a ditch 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 has 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 (Figure 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. Figure 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 wastewater. 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.

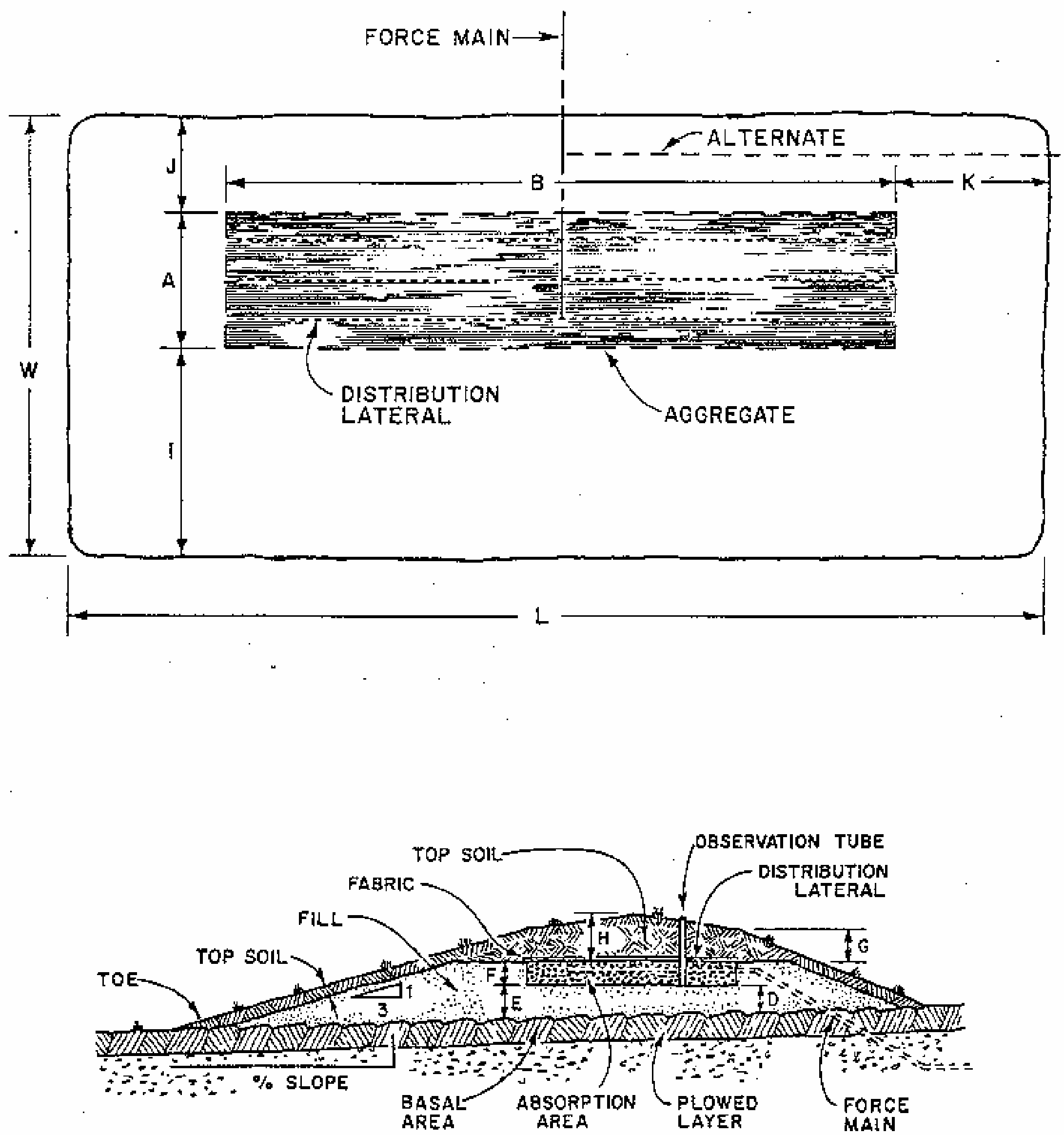

Fig. 4. Cross section and plain view of a mound system on a sloping site.

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 that 20% (by wt) material that is greater than 2 mm in diameter (course 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 (<0.53 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 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 rate 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 wastewater 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.

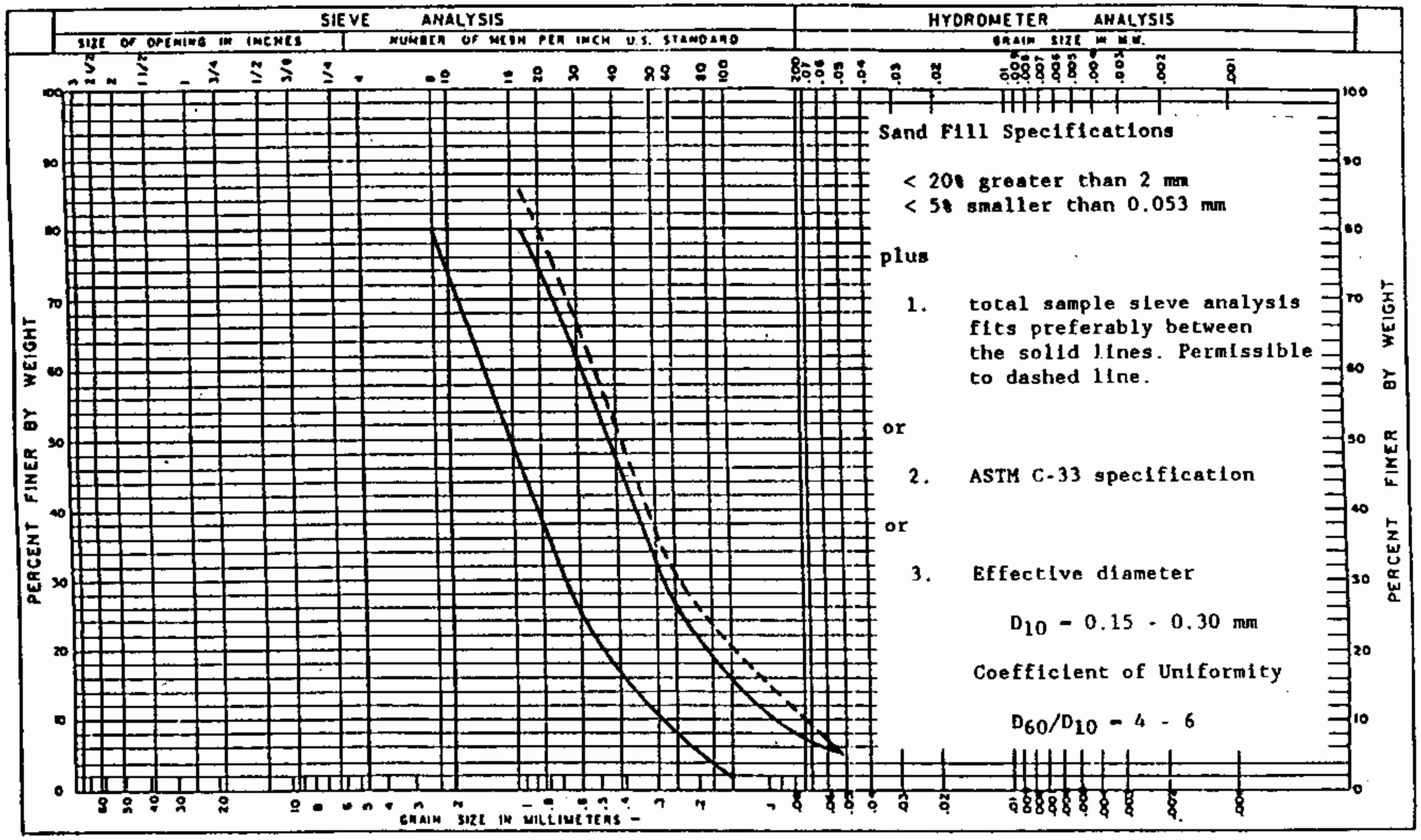

Figure 5. A guideline for the selection of the sand fill for Wisconsin Mounds. The total sample sieve analysis contains 20% or less material larger than 2.0 mm and contains 5% or less material finer than 0.053 mm plus one of the three additional specifications listed in figure. The fraction greater than 2 mm can have stones and cobbles.

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 dimensions (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 liner 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).

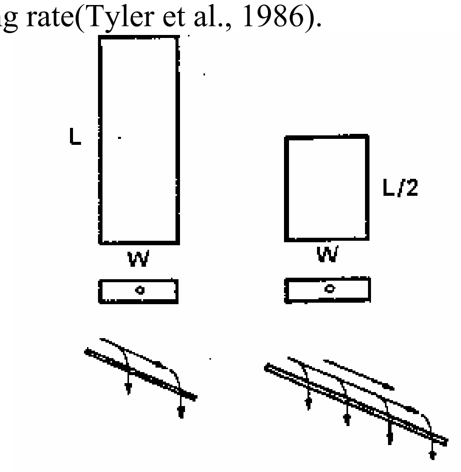

Fig. 6. The effect of linear loading rate based on system configuration on a sloping site. The sand or soil loading rates (gpd/ft2) are the same but the linear loading rate for the right figure is twice that of the left figure. The soil may not be able to move the effluent away from the system fast enough 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/ft2)
= 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/ft2 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 (Table2).

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 consideration. Typical dimensions are 8-12 ft.

Depth D: The 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 runoff 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.**

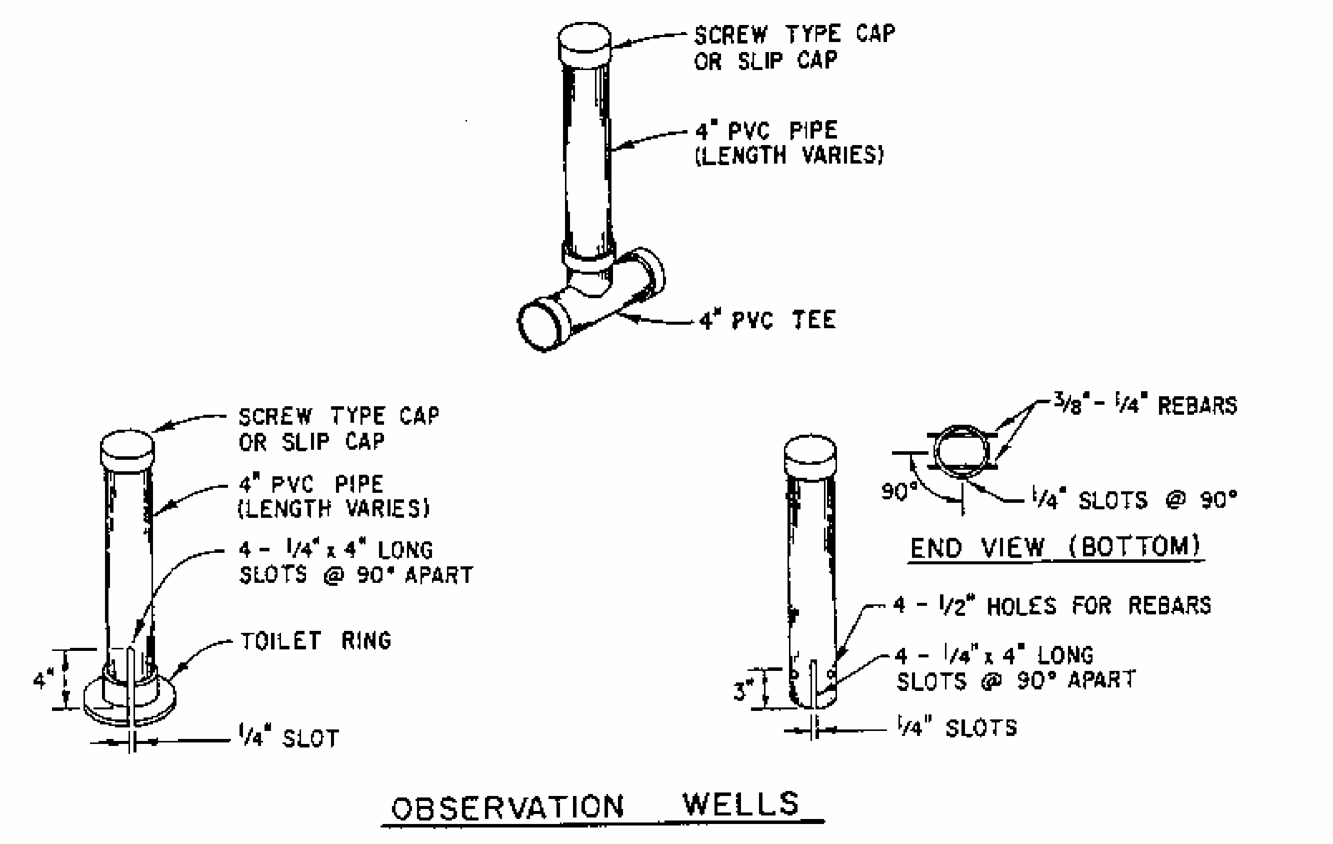

Fig. 7. Three methods of securing observation tubes.

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”) have a platy structure and firm consistence. The consistence will slow the flow and the platy structure will impede vertical flow and cause the flow to move horizontally. If this layer it 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.** It 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 form 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 recommend 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 be 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	1.0
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
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. 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 removed, 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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Here are some details of At-Grade systems and construction instructions for both At-Grade and Mound systems.

MOUND and AT-GRADE CONSTRUCTION INSTRUCTIONS

Only construct the system when the soil moisture is satisfactory. The satisfactory moisture range, to a depth of 7-8", is defined as where the soil will crumble and not form a wire when rolled between the palms

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 fitter, 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 topsoil.

3. Determine where the force main from the pump chamber enters the mound. It will either be an end feed or an center feed. For center feed the force main can enter from the up slope center, 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, depending if it is a mound or at-grade. If it must be brought in from the down slope side, 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 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 ripped only when the soil moisture in within a satisfactory range. The satisfactory moisture range, to a depth of 7-8", 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 topsoil. 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, second choice is a chisel plow pulled behind a tractor, third choice is a mold board plow. Tilling along the contour is required.
Till around the stumps without exposing an excessive amount of roots. Chisel teeth mounted 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.

5. AD work should 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.

(Numbers 6 & 7 do not apply to at-grade systems)

6. 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 or placed with a blade and track type tractor. A wheeled tractor will rut up the surface. All work should 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.

7. 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 handwork.

8. Place clean washed river gravel to the desired depth.

9. Place the pressure distribution network with holes located downward and cover it with 2 inches of aggregate. Connect the force main to the distribution network. If chambers are used, the pressure distribution laterals shall have holes pointing 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.

10. Cover the aggregate with a geotextile synthetic fabric.

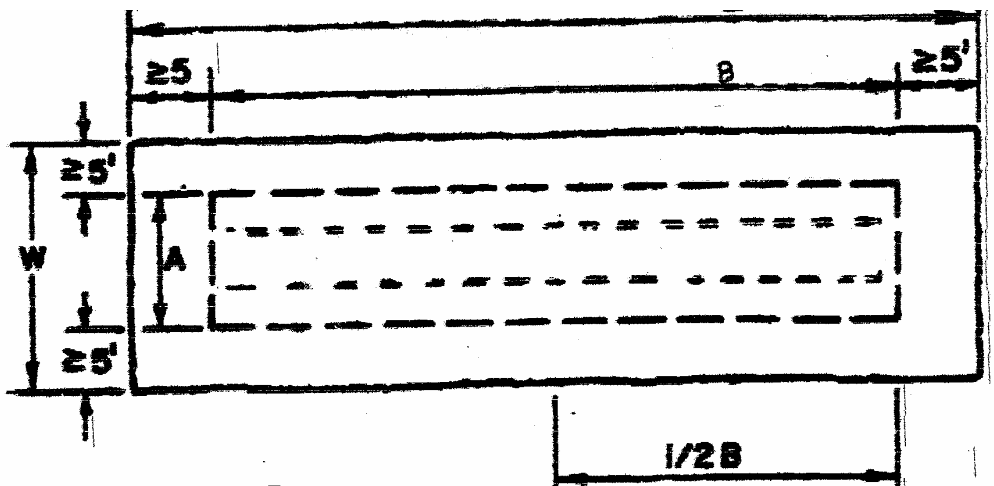
11. Place suitable soil cover on the mound. There should be 6" on the sides and shoulder (G) and 12" on the top center (H). The soil cover should support vegetation. If not provisions must be made to control erosion.

12. Final grade the mound and area so surface water moves away from the mound and does not accumulate on the up slope side of the mound. Use lightweight equipment.

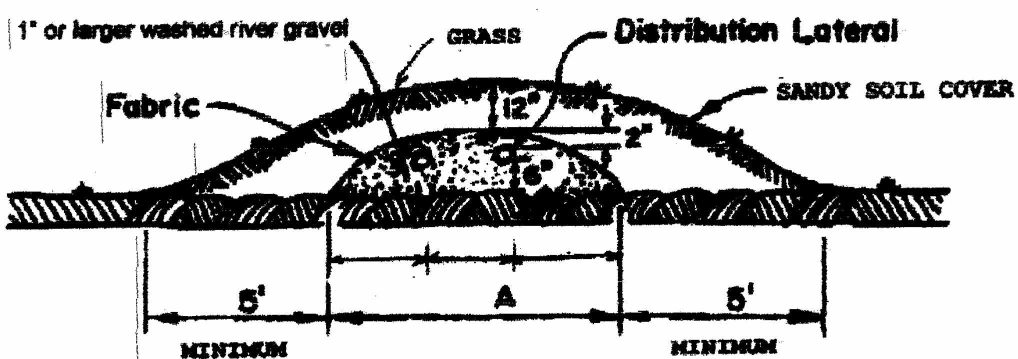
13. Seed and mulch the entire exposed area to avoid erosion. Advise the homeowner on proper landscaping. The top of the mound becomes dry during the summer and the down slope toe may be wet during the wet seasons. Avoid deep-rooted vegetation on the top of the mound to minimize root penetration into the distribution network.

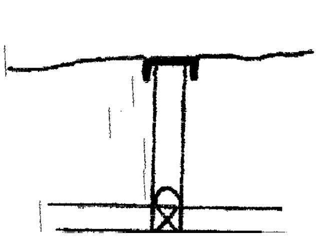
14. It is important to complete the mound system before it rains.

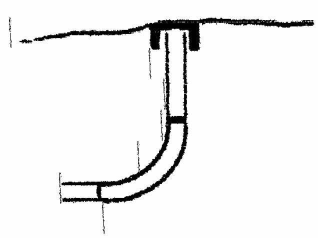
15. Inform homeowner about the type of system, maintenance requirements and do's and donts associated with on-site soil based systems.

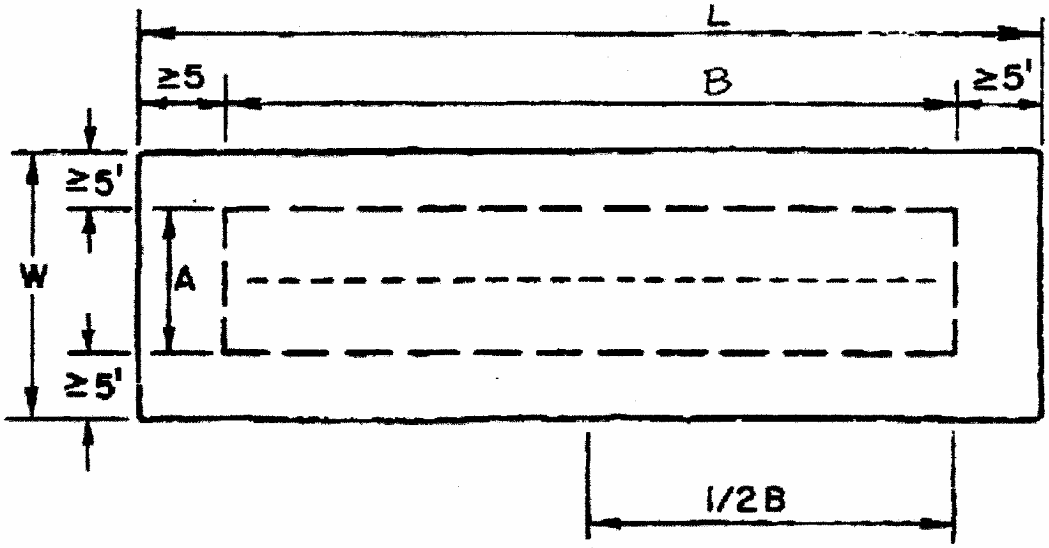


FORCE MAIN PIPE SIZE _____
DISTRIBUTION PIPE SIZE _____
WITH _______ INCH HOLES AT _______ INCHES ON-CENTER.
POINT HOLES DOWN, EXCEPT ONE HOLE POINTING UP
TO RELEASE AIR IN THE LINE.

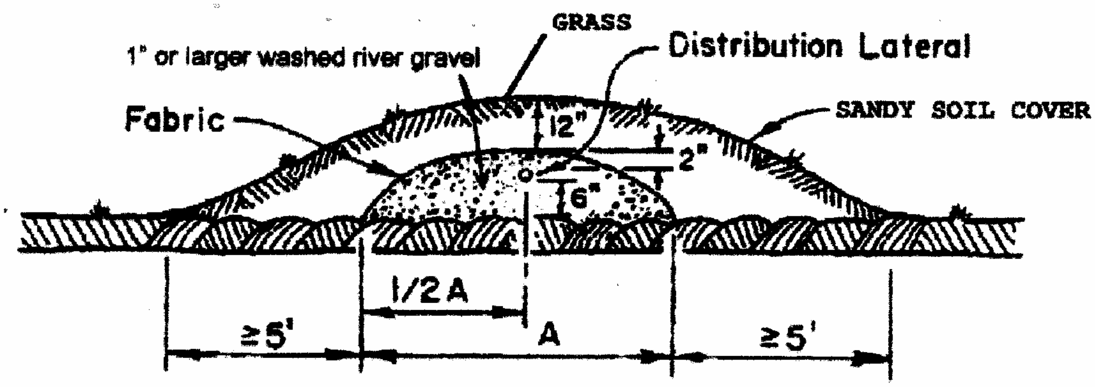


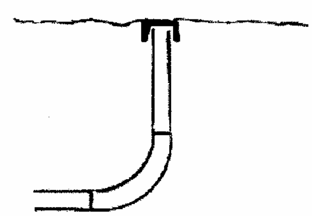






FORCE MAIN PIPE SIZE _____
DISTRIBUTION PIPE SIZE _____
WITH _______INCH HOLES AT _______ INCHES ON-CENTER.
POINT HOLES DOWN, EXCEPT ONE HOLE POINTING UP
TO RELEASE AIR IN THE LINE.





SECTION E:
Above-Grade Systems

Contents

Figures

SECTION E: Above-Grade Systems

Part 1: At-Grade Systems

The at-grade system is an alternative to consider when you have exactly 3 feet to the water table, or when you have soils that you do not want to excavate (typically heavier soils).

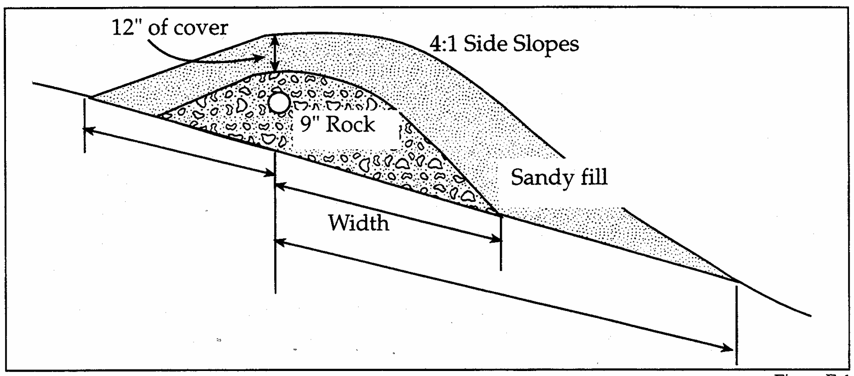


Figure E-1

This system cannot be used if the distance to the water table is less than 3 feet.

System Advantages

One of the advantages of using an at-grade system is the potential savings in material. The material used to cover the rock bed should be a sandy material, but it does not need to be the same clean sand used in the construction of a mound.

The other advantage of this system is that spreading it out across the slope (long and narrow) offers better potential treatment of nutrients and other contaminants found in the effluent. By maintaining a 3-foot separation to the water table, treatment and removal of the potential contaminants is all but guaranteed.

Basis for Design

The design of the at-grade system is based on flow, soil flow patterns as dictated by the linear loading rate (LLR) and the general geometry of a system built above ground. The flow is the same as that used in other design systems based on the necessary flow for a particular sized house.

Linear loading rate refers to potential horizontal and vertical flow patterns in the soil. These characteristics are based on soil texture, soil structure and limiting layers existing in the soil.

The range of the linear loading rate is from 2 to 8 gallons per foot. The 2-gallon-per-foot minimum dictates a near 100% horizontal flow of effluent. This minimum would be used for a system limited by impermeable bedrock or very heavy clay soils, or in any situation where horizontal movement of contaminants is a concern.

The 8-gallon-per-foot loading rate (the maximum) would be used when water moves down through the soil much faster than it moves sideways, as would be indicated by a consistent sandy soil profile.

A typical design number should be somewhere between these two. For a typical soil horizon made up of a variety of soil textures, a linear loading rate of 4 gallons per foot should be used.

MPI	**Soil Texture**	Other characteristics in the intail 48"	Linear Loading Rate (gpd/ft)
Faster than 0.1	Coarse Sand	For the entire depth	6
0.1 to 5	Sand	No Banding Layers with no Mottles Layers with Mottles	8 4 2
0.1 to 5 6 to 15	Fine Sand* Sandy Loam	No change in texture Layers of other textures	6 4
16 to 30 31 to 45 46 to 60	Loam Silt Loam Clay Loam	No change in texture Layers of other textures	4 3
60 to 120 Slower than 120	Clay Clay Bedrock	For the entire depth or encountered in boring	2

*Soils having 50% or more fine sand plus very fine sand

Figure E-2

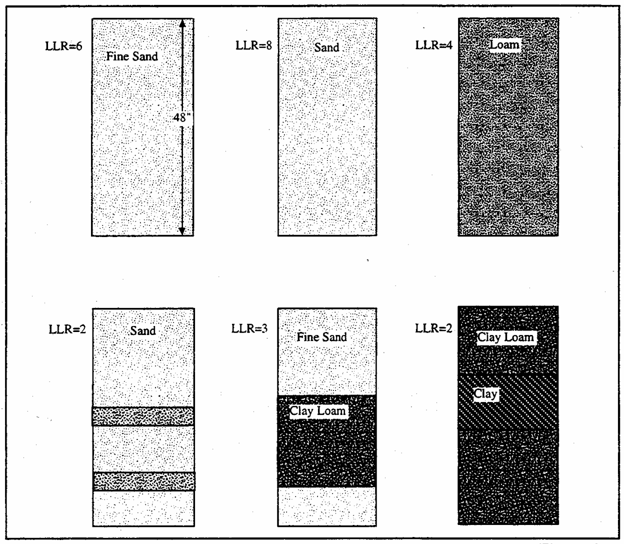


Figure E-3

Linear Loading Rate examples

Calculating System Size

Required system length is calculated by dividing daily flow by the linear loading rate. The linear loading rate is also used to size the width of the system. Since the width of the rock should encompass the absorption width of this system, multiply the linear loading rate by the soil absorption ratio to determine the proper size of the system. (This calculation is very similar to the absorption width calculation for a mound system.)

LLR used to calculate rock width & length

For example: For a 4-bedroom house over loam soil on an 8% slope, use a linear loading rate of 4.

❒ The length of the rock bed would be the flow (600) divided by the linear loading rate (5), or 120 feet.

❒ The width would be the linear loading rate (5) multiplied by the soil sizing factor (1.67), which equals 8 feet (8.35').

Thus, the rock bed would be 8 feet by 120 feet.

The final calculation is the requirement for the downslope width and the upslope width. This is done using a height of 2 feet and the slope multipliers given in Figure E-4.

BERM SLOPE MULTIPLIERS

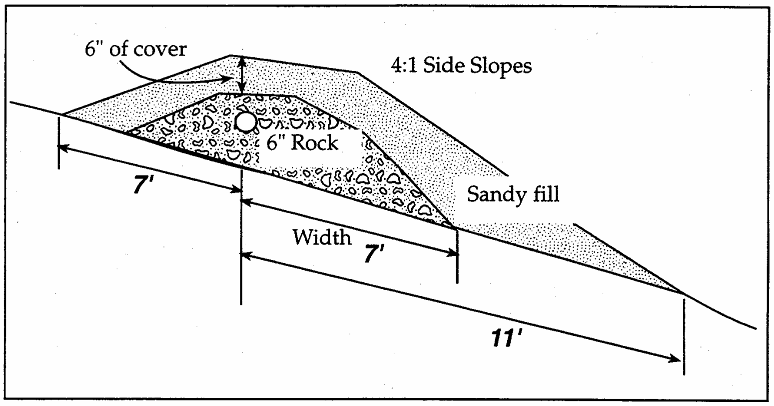
Land Slope, in %	DOWNSLOPE berm multipliers for various berm slope ratios					UPSLOPE berm multipliers for various berm slope ratios					
	3:1	4:1	5:1	6:1	7:1	3:1	4:1	5:1	6:1	7:1	8:1
0	3.0	4.0	5.0	6.0	7.0	3.0	4.0	5.0	6.0	7.0	8.0
1	3.09	4.17	5.26	6.38	7.53	2.91	3.85	4.76	5.66	6.54	7.41
2	3.19	4.35	5.56	6.82	8.14	2.83	3.70	4.54	5.36	6.14	6.90
3	3.30	4.54	5.88	7.32	8.86	2.75	3.57	4.35	5.08	5.79	6.45
4	3.41	4.76	6.25	7.89	9.72	2.68	3.45	4.17	4.84	5.46	6.06
5	3.53	5.00	6.67	8.57	10.77	2.61	3.33	4.00	4.62	5.19	5.71
6	3.66	5.26	7.14	9.38	12.07	2.54	3.23	3.85	4.41	4.93	5.41
7	3.80	5.56	7.69	10.34	13.73	2.48	3.12	3.70	4.23	4.70	5.13
8	3.95	5.88	8.33	11.54	15.91	2.42	3.03	3.57	4.05	4.49	4.88
9	4.11	6.25	9.09	13.04	18.92	2.36	2.94	3.45	3.90	4.30	4.65
10	4.29	6.67	10.00	15.00	23.33	2.31	2.86	3.33	3.75	4.12	4.44
11	4.48	7.14	11.11	17.65	30.43	2.26	2.78	3.23	3.61	3.95	4.26
12	4.69	7.69	12.50	21.43	43.75	2.21	2.70	3.12	3.49	3.80	4.08

Note: The product of the multiplier and the height results in the horizontal distance to where the berm meets the original land slope. Example: Height at upper edge of rock layer is 3.0 feet, rock layer is 10 feet wide, land slope is 6% and berm slope ratio is 4:1. Upslope berm width is 3.23 x 3.0 = 9.7 ft; height at lower edge of rock layer is 3.0 + 10 x 0.6 = 3.6 ft and downslope berm width is 5.26 x 3.6 = 18.9 ft.

Figure E-4

❒ Assuming a slope of 8 and a 4:1 slope, the upslope dimension would be the height (2) times the upslope multiplier (3.03), which would be an upslope berm of 7 feet.

❒ The downslope would be the height (2) times the downslope multiplier (5.33), which is a downslope of approximately 11'.
or
The rockbed plus 5' (8'+5'=13') whichever is greater. The downslopde width would be 13'.



Finished At-Grade System example

Figure E-5

Construction Procedures

Construction procedures for at-grade systems are similar to those for a mound system, with roughening of the soil followed by placement of the material. Extreme care should be taken in the area that has been roughened to minimize any effects to the soil.

Check out Mound Construction

At-grade systems should be constructed using pressure distribution. During testing of these systems, the only system failures that did occur happened when gravity distribution was used instead of pressure distribution.

If the necessary length cannot be found on the slope in one continuous section, this system can be broken into smaller pieces using the same dimensions. Care should be given in the design of the pressure distribution system, since, if the laterals are at different elevations, the separation of the holes would have to be designed differently.

Be careful when breaking to fit for a small lot

Part 2: Mound Systems

Mounds must be carefully constructed

A sewage treatment mound is a seepage bed elevated by clean sand fill to provide an adequate separation distance between the rock layer in the mound and the barrier layer such as saturated soil conditions or bedrock. The mound must be carefully constructed to provide adequate sewage treatment.

Mound failures have usually been traced to improper construction practices.

Important Design Factors

Important factors in the design and successful operation of a sewage treatment mound are:

- ❒ Location
- ❒ Size and shape
- ❒ Soil surface preparation
- ❒ Construction procedures
- ❒ Distribution of effluent
- ❒ Dosing quantity
- ❒ Quality of clean sand fill

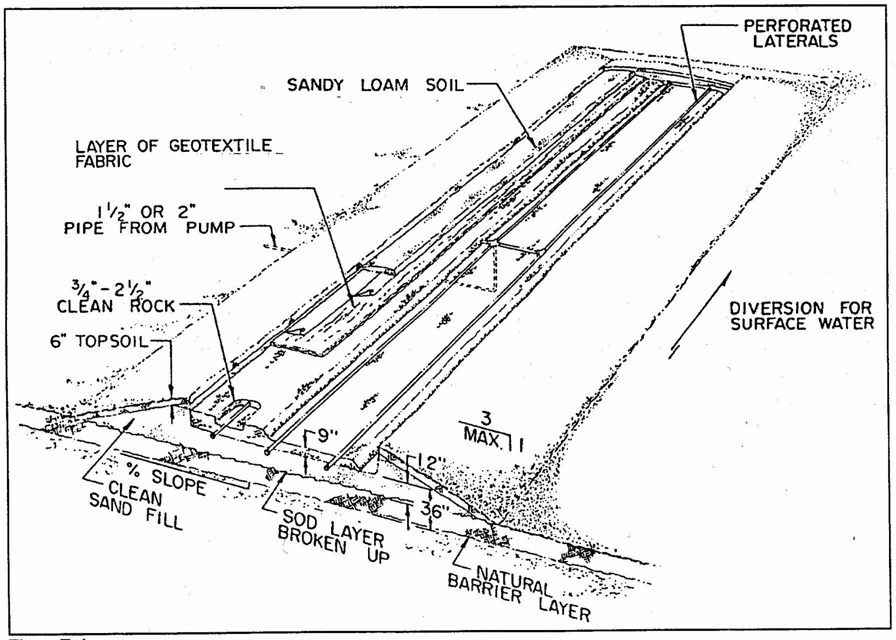


Figure E-6

Sewage Treatment Mounds for Problem Soils

Suitable soil provides excellent treatment of sewage tank effluent. The natural topsoil should be utilized for treatment wherever possible. The surface layer of a clay soil usually has a more rapid percolation rate than the underlying subsoil. Sandy soils have more organic matter in the top soil layer than in deeper layers. Soils with adequate organic matter and calcium carbonate (limestone) are good absorbers of the nutrient phosphorus found in sewage tank effluent.

Some soils do not have a percolation rate in the range of 0.1 to 60 minutes per inch (mpi), which is necessary for the proper operation of the soil treatment system. In other soils, there is seasonal saturation at depths closer than 3 feet to the ground surface, such that adequate vertical separation of the soil treatment unit is not possible under "natural" conditions. Soils with a "pan" layer, that restricts downward movement of liquid, or with fractured or permeable bedrock have problems for adequate treatment and acceptance of septic tank effluent.

Mounds Are Effective Sewage Treatment Methods

Properly designed and constructed sewage treatment mounds are an effective method of onsite sewage treatment. Research at the Small-Scale Waste Management Project indicates that residential mounds utilizing pressure distribution will have 44% fewer nitrates percolating downward than a standard subsurface trench system.

Nitrate removal up to 44%

Sufficient numbers of mounds have been installed in Minnesota and elsewhere to prove that the mound treatment system should be an accepted technology. There are more than 8,000 single-family mounds successfully treating sewage in Minnesota.

Minnesota has found that properly designed and constructed mounds are an effective method of sewage treatment and accept them as a standard system. Sewage treatment mounds should not be considered alternative treatment systems but rather preferred treatment systems, in many instances.

What Mounds Look Like

Figures E-6, E-7 and E-8 show three different perspectives of mound design. FigureE-7 is a cross-sectional view and E-8 is a plan view of a mound system. Mound construction begins with the layer of clean

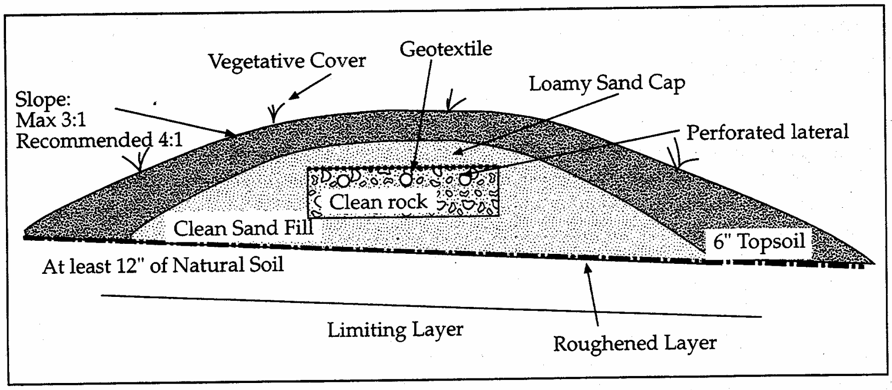


Figure E-7

sand which must be at least 1-foot thick. The top of the clean sand layer must be level as must the rock layer which is placed upon the clean sand layer. Distribution pipes are placed in the clean rock. A sandy loam cap that is 6 inches thick at the side and 12 inches thick at the center is placed over the rock layer.

The purpose of the sandy cap is to avoid undue soil compaction so that the pore spaces are maintained, and soil air and moisture can move freely. The entire mound area is covered with a 6-inch layer of topsoil, upon which a grass cover should be established as soon as possible.

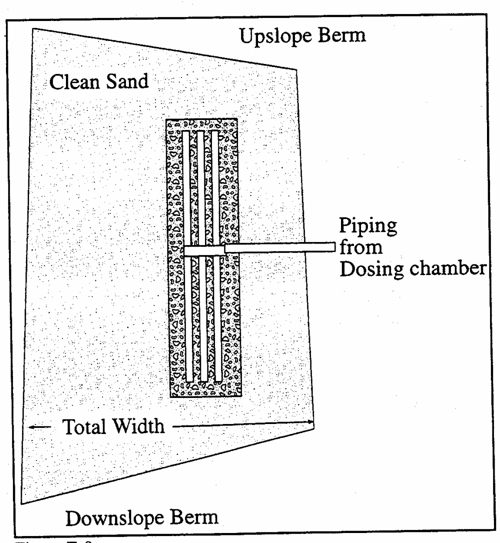


Figure E-8

Design Criteria Based on Analysis

The design material presented in this section suggests a possible approach. It is intended to deal primarily with mounds or "berms" for single-family residences, or daily sewage flow rates of no more than 1200 gallons. A flow of 1200 gallons per day can be treated with a rock bed 10 feet wide by 100 feet long in a properly constructed mound or berm. The proper hydraulic operation of a mound depends on lateral as well as vertical seepage.

Design Criteria: More Than Just Multiplying by a Scale Factor

The design criteria of this section cannot be simply multiplied by a scale factor and expected to properly treat larger flows. The hydraulics of lateral and vertical movement in the clean sand layer and the soil under the elevated rock bed must be carefully analyzed to ascertain that anaerobic conditions will not exist. Thus, both lateral and horizontal permeabilities of the underlying soil layers must be utilized to analyze the flow regime to estimate the height of the saturated zone.

Where heavy clay soils with slow permeabilities and high seasonal saturated conditions exist over an area, it is far better to utilize mounds for one or two single-family residences than to collect the effluent from many residences and attempt to dispose and treat it at a single location. The flow hydraulics in clay soils will require either large depths of fill, or underdrainage, or both, to design a proper sewage treatment system to prevent anaerobic conditions under the rock layer.

As an example, a mound designed to treat 450 gallons per day may function very well under certain clay soil conditions, while a single mound serving 5 or 10 residences may fail hydraulically if constructed according to the same vertical separation specifications.

Location and Ground Slope

Increased slope may mean faster percolation rate

Mounds should be located on slopes whenever possible. The present standards for locating mounds on slopes are found in Minnesota Rules, part 7080. These standards suggest that, as slope increases, the percolation rate of the topsoil increases allowing for the best site of the mounds.

Determining Specifications

Soil Sizing Factor

The soil sizing factor for the clean sand layer of the mound is 0.83 square feet per gallon of waste per day.

Area of Rock Layer

Rock Area = Flow x 0.83

To determine the area of rock layer required for a 4-bedroom, type I home,the estimated sewage flow rate of 600 gpd. Multiplying 600 gpd times 0.83 sq ft/gpd results in a rock layer area of 500 sq ft. The rock layer in a mound should be no wider than 10 feet, unless special design considerations are made. Thus, the shape of the rock layer required for a daily sewage flow of 600 gallons is 10 feet wide by 50 feet long.

Clean Sand Is Required

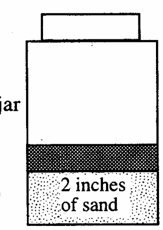
C-33 is Clean Sand

25% Coarse
< 40% Fine Sand
< 10% Fines

Sand is defined as a soil texture composed by weight of at least 25% of very coarse sand, and medium sand varying in size from 2.0 to 0.25 mm, less than 50% of fine or very fine sand ranging in size between 0.25 and 0.05 mm, and no more than 10% of particles smaller than 0.05 mm. Figure E-9 presents the jar test as a method for testing for clean sand.

Jar Test For
Clean Sand For Mounds

Use a 1 Quart Mason jar



If the fines that settle out in 1 hour are greater than **1/8 inch** then the percentage of fines is too great and the sand **should not** be used for mound construction

Figure E-9

System Design

A vertical separation of at least 3 feet is required between the bottom of the rock bed and any restricting layer in order to maintain aerobic conditions and treat the waste water. (See Figure E-10)

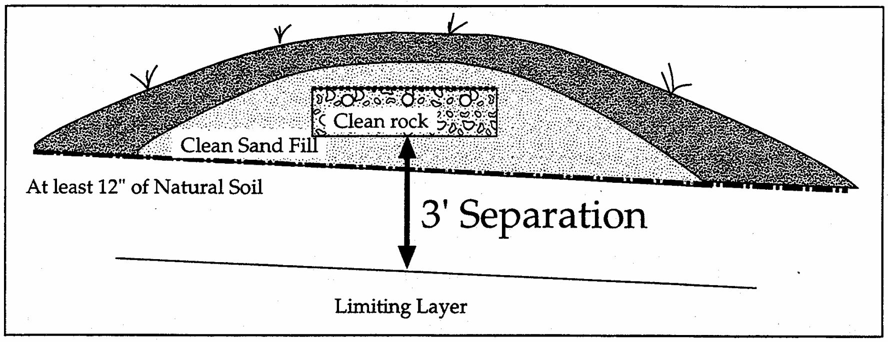


Figure E-10

When aerobic conditions exist in the clean sand, the long-term acceptance rate will be 1.2 gallons per day per square foot. If the depth to the restricting layer is inadequate or the rock bed is too wide, anaerobic conditions may exist and cause a much slower acceptance rate. The possibility of anaerobic conditions occurring in the clean sand and subsequent hydraulic failure is a major design consideration when mounds larger than those required for single-family residences are required.

A depth of at least 9 inches of drainfield rock should be placed on the sand layer prior to installing the distribution pipe. Drainfield rock is defined as clean rock, crushed igneous rock or similar insoluble, durable and decay-resistant material free from dust, sand, silt or clay. The size should range from 3/4 inch diameter to 2 1/2 inch diameter.

Rock Depth = 9 Inches

Size and Shape

❒ The bottom area of the drainfield rock shall be sized on the basis of 0.83 square feet per gallon of waste per day.

❒ In no case shall the width of the filter (rock) in a single bed exceed 10 feet.

Bed width < 10'

❒ A maximum of two 10-foot-wide rock beds may be installed side by side in a single mound if the soil percolation rate is between 5 and 60 mpi to a depth of at least 24 inches below the sand layer. The rock beds should be separated by at least 4 feet of sand.

Single rock beds are best

❒ Total area required by the mound depends on dimensions of the rock mound height and berm sideslopes.

What Is Absorption Width?

The absorption width of a mound is that width of soil under the sand layer that receives effluent. The width of the soil receiving effluent must have the capability to absorb this effluent; otherwise, berm toe surfacing will occur. (See Figure E-11)

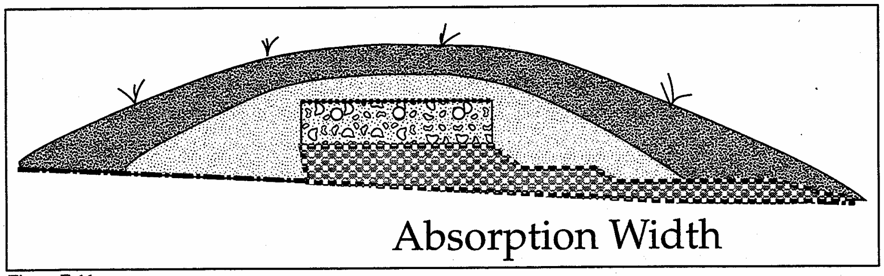


Figure E-11

Recent research and analysis have shown that the absorption width concept is the proper way to design a mound. If sufficient soil area is available for the downward percolating liquid to soak into the soil, then the relationship of slope and percolation rate is relatively unimportant. The percolation rate in the top foot of soil is used to determine the acceptance rate of the soil. As long as sufficient mound width is available so that all of the liquid is accepted into the soil and pressure distribution is used, berm toe surfacing should not occur. One of the major reasons for berm toe surfacing has been inadequate downslope berm widths. (See Figure E-12)

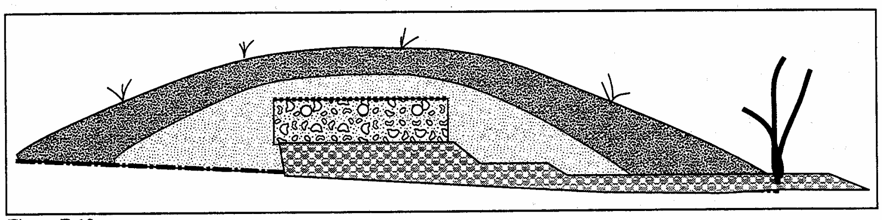


Figure E-12

On original soil with slopes of less than 1%, absorption width is equal to the sum of the upslope berm width, the rock layer width and the downslope berm width. Using the symbols in Figure E-15, absorption width equals $d_2 + W + d_1$. On ground sloping more than 1%, all of the effluent is assumed to move downslope and absorption width equals $d_2 + W$.

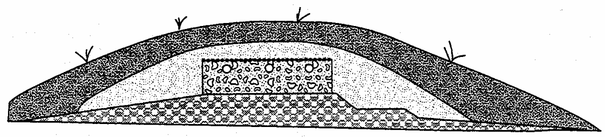


Figure E-13

Total absorption area is the product of the length of the rock layer and the absorption width. The berms located at the end of the rock layer are necessary for mound construction but the soil area under these berms is not considered part of the total absorption area.

How Much Absorption Width Is Required?

Adequate absorption width is essential to the successful operation of an onsite sewage treatment mound. The required absorption width depends upon the allowable loading rate of the soil under the clean sand layer of the mound. The allowable loading rate depends upon the percolation rate of the 1-foot layer of soil in contact with the clean sand layer of the mound. Allowable soil loading rates for various soil percolation rates are presented in Figure E-14.

Absorption Width Sizing Table

Percolation Rate in Minutes per Inch (MPI)	Soil Texture	Gallons per day per square foot	Ratio of Absorption width to Rock Layer Width
Faster than 0.1	Coarse Sand	1.20	1.00
0.1 to 5	Sand	1.20	1.00
0.1 to 5	Fine Sand	0.60	2.00
6 to 15	Sandy Loam	0.79	1.52
16 to 30	Loam	0.60	2.00
31 to 45	Silt Loam	0.50	2.40
46 to 60	Clay Loam	0.45	2.67
60 to 120	Clay	0.24	5.00
Slower than 120	Clay	0.20	6.00

Figure E-14

The downward percolation rate of original soil profiles in Minnesota have been measured on many slowly permeable soils. None of these original profiles has been found to have a vertical movement slower than 1 cm per day. This is a loading rate of 0.24 gpd/sq.ft.

Thus, if 1.20 gallons per day is the loading rate on a square foot of the clean sand, but the soil under the sand can absorb only 0.24 gallons per day per square foot, then 5.0 times as much absorption area must be available as sand areas in contact with the rock layer. Since only the side berms are used in the determination of absorption area, the term absorption width is preferred. Very little liquid will move out into the end berms of the mound.

Another way to express the absorption width requirement is to use the absorption width ratio, which is defined as the area of soil required to absorb the effluent percolating downward from one square foot of the rock layer.

Since the rock layer is sized on the basis of 0.83 square feet per gallon of wastewater per day, the loading rate is 1.2 gallons per day per square foot of area. If the soil under the clean sand layer does not have this absorption capability, then the effluent must be spread out over additional soil area.

For example, a soil having a percolation rate in the range of 61-120 mpi has an allowable loading rate of 0.24 gpd/ft^2 as shown in Figure E-14. Dividing the loading rate of the rock layer of 1.20 gpd/ft^2 results in a ratio of soil area to rock layer area of 5.00. This is the absorption width ratio for a soil having a percolation rate in the top foot of 61-120 mpi. As can be noted from Figure E-14, soils having faster percolation rates have greater allowable loading rates and consequently smaller absorption width ratios.

The width of a rock layer in a mound shall be no greater than 10 feet. A maximum of two 10-foot wide rock layers may be installed side by side in a single mound only if the soil percolation rate is between 5 and 60 mpi to a depth of at least 24 inches below the sand layer. The two rock layers shall be separated by 4 feet of clean sand. The reason for this requirement is to provide adequate absorption width and a sufficient depth of permeable soil to allow the liquid to move laterally.

A slide slope ratio of 4:0 (4 feet horizontal, 1 foot vertical) is the steepest berm slope allowed for mounds constructed on soils having a percolation rate of 61-120 mpi. The absorption width ratio may require even flatter side slopes in order to expose sufficient soil to effluent.

For mounds constructed on soils having percolation rates between 5 and 60 mpi, a berm slope ratio of 3 to 1 is the steepest allowed. A 4 to 1 berm slope ratio or flatter, however, is desirable for landscaping and maintenance.

Multipliers

Figure E-4 presents multipliers that are used to determine upslope and downslope berm widths. It will also allow calculation of downslope berm width for rock bed widths narrower than 10 feet.

Examples of Absorption Width Design

To achieve sufficient absorption width, it is occasionally necessary to use a narrower and longer rock layer. For the mound which was designed, a 10 x 50 foot rock layer was selected. On a slowly permeable soil, however, an 8-ft wide by 62.5-foot long rock layer would function better hydraulically.

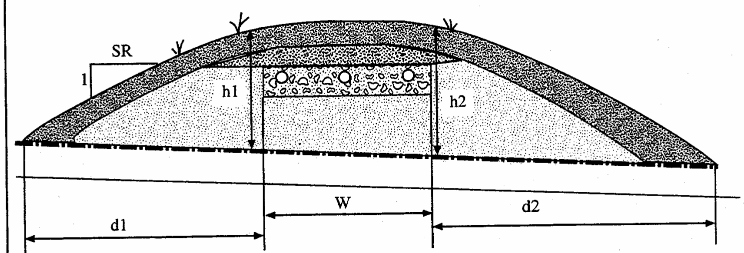
If this mound is located on an 8% slope, the downslope mound height, h_2, will be 3.0 + 0.08 x 8.0 or 3.64 feet. From Figure E-4, for a slope ratio of 4:1, the berm multiplier is 5.88. This value multiplied by the downslope berm height of 3.64 gives the value of 21.4 feet for d_2. The upslope berm multiplier is 3.03 for a slope ratio of 4:1. Since the upslope mound height is 3.0, the upslope berm width is 3.0 x 3.03 or 9.1 feet.

For example: The soil has a percolation rate of 50 mpi in the top foot and the site has a 6% slope. Mottled soil is located at the 2-foot depth. From Figure E-14, the absorption area loading rate is 0.45 gpd/ ft^2 and the absorption width ratio is 2.67. If a 10-foot wide rock layer is used, the required absorption width is 26.7 feet (10 feet x 2.67).

Since the landslope is greater than 3%, only the width of the rock layer and the downslope berm are included in determining absorption widths. Thus, the width of the downslope berm included in determining absorption widths. Thus, the width of the downslope berm must be 16.7 feet (26.7-10.0).

To check the downslope berm dimensions for 3:1 and 4:1 berm slope rations, refer to Figure E-4. The downslope berm multiplier for a 3:1 slope is 3.65, which when multiplied by the mound height of 3.6 feet results in a downslope berm dimension of 13.2 feet. Since this is less than the required 16.7 feet, the berm slope ration must be flatter than 3:1.

The downslope berm multiplier for a 4:1 slope ratio is 5.26, which when multiplied by the mound height of 3.6 feet results in a downslope berm width of 18.9 feet. Since this dimension is greater than the required 16.7 feet, a berm slope ratio of 4:1 could be used.



SR = Slope ratio of horizontal distance per 1.0 foot vertical
S = Landslope in percent
h1 = Depth of mound on upslope edge of rock bed
h2 = Depth of mound on downslope edge of rock bed
W = Width of rock bed
d1 = Upslope dike width
d2 = Downslope dike width

Formulas:

$$d1 = \frac{h1\ SR}{1 + S/100\ SR} \qquad d2 = \frac{h2\ SR}{1 - S/100\ SR} \qquad h2 = h1 + W(S/100)$$

Figure E-15

Mound Width

The total width of the mound from berm to berm toe is shown on Figure E-15.

❒ Dimension d_1 is the upslope berm width, and dimension d_2 is the downslope berm width. The width of the rock layer is designated as W.

❒ The height of the mound above the original soil at the upper edge of the rock layer is designated as h_1 and the height at the downslope edge of the rock layer is designated as h_2.

❒ The slope of the berm is designated with a slope ratio (SR), which is the ratio of the horizontal distance to the vertical distance.

Mound Width Examples

For example: An SR of 3 indicated 3 feet horizontal to 1 foot vertical and would be equivalent to a slope of 33%. An SR of 4 is a flatter slope and is equivalent to a 25% slope. A table of those values is also presented for convenience.

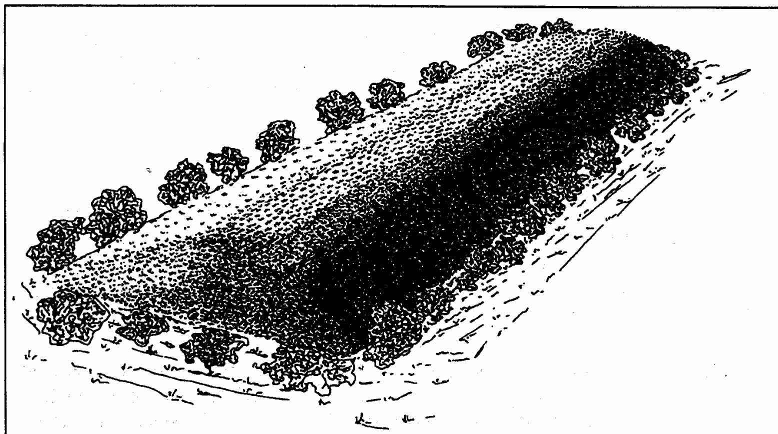
On level ground, d_1 equals d_2. On sloping ground, d_2 becomes longer than d_1 when the slope ratio is the same for both berms.

The dimension h_1 is usually 3.0 feet, consisting of 1.0 foot of clean sand, 1.0 foot of rock layer, and 1.0 foot of soil cover over the rock. On level ground h_2 equals h_1, but on sloping ground h_2 is greater than h_1 because the top of the sand layer and the bottom of the rock layer must be level.

Mound Length

The length of the mound varies depending upon where it is measured. As can be seen from Figure E-8 in the plan view, the mound shape is trapezoidal. If the length is measured along the center of the rock layer, then the height of the mound at the end of the rock is 3.3 feet. If the berm slope ratio is 4:1, the berm will extend out 4.0 x 3.3 or 13.2 feet. The total length of the mound measured at the centerline of the rock layer will be 13.2 feet. The total length of the mound measured at the centerline of the rock layer will be 13.2 + 50 + 13.2 or 76.4 feet. The mound will be slightly longer near the base of the downslope berm and slightly shorter near the base of the upslope berm.

Several mound shapes are shown in Figures E-16 and E-17. The rectangular mound is most commonly used, since it is the easiest to construct. While the mound location depends upon soil suitability, every effort should be made to fit the mound into the landscape plan. Mounds can be used as privacy berms or to highlight a certain portion of the outdoor living area. While the mound must be functional for sewage treatment, the location and shape should also be functional in the landscape plan.



RECTANGULAR SEWAGE TREATMENT MOUND

Figure E-16

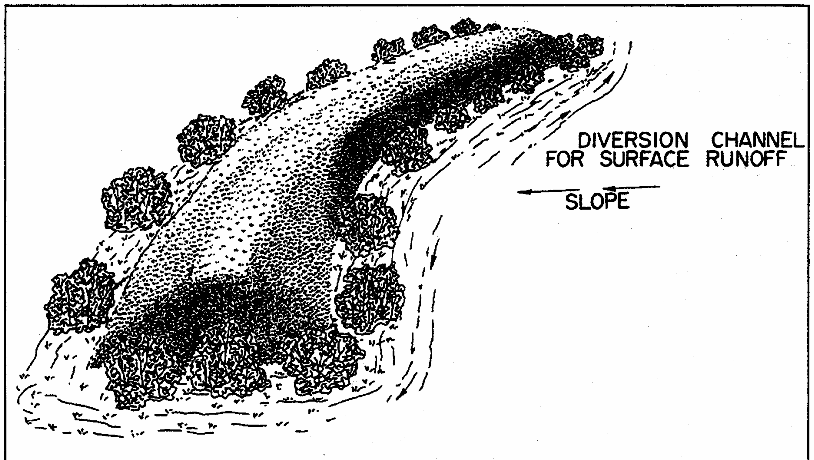


Figure E-17

Pump and Collection Tank

Install Alarm Device

A pump should be used to deliver effluent to the mound. A siphon will not be allowed as a closing device to deliver effluent to a pressure distribution system. An alarm device should be installed to warn of pump failure.

Adequate Treatment = Series of Small Doses

The quantity of effluent delivered to the mound each pump cycle should be no more than 25% of one day's sewage flow. The reason for this limit is to provide adequate treatment by having a series of small doses. The more doses, the better.

Pressure Distribution

Pressure distribution must be used for all mound systems. Effluent should be distributed over the rockbed by 1-inch to 1 1/2-inch diameter perforated pipe under pressure. Perforation holes shall be 3/16 to 1/4 inch in diameter drilled in a straight line along the length of the pipe.

< 10% loss in the System

The number of perforations and perforation spacings must not exceed 10% of the average pressure head on the perforations. Holes should be used and any burrs in the inside of the pipe should be removed. The perforated pipe laterals should be installed level with the perforations downward.

Pressure Fittings are Important

Distribution pipes used for pressure distribution must be constructed of sound and durable material not subject to corrosion, decay, or loss of strength under continuously wet conditions. All pipes and associated fittings used for pressure distribution must be properly joined together. The pipe and connections must be able to withstand a pressure of at least 40 pounds per square inch.

2" diameter manifold for all mounds

The perforated pipe laterals should be connected to a 2-inch diameter manifold pipe and should have ends capped. The laterals should be spaced no further than 40 inches on center and no further than 20 inches from the edge of the rock.

The manifold pipe should be connected to the supply pipe from the pump and should be sloped toward the supply pipe from the pump. At least 2 inches of rock should be placed over the distribution pipes.

Perforated Laterals

Figure E-18 shows a layout of perforated laterals to provide pressure distribution of effluent over the rock layer of a mound. The length of the perforated lateral is measured from the point where the effluent enters to the end cap. All connections in the pressure distribution system must be tight in order to prevent leakage and to withstand pressure.

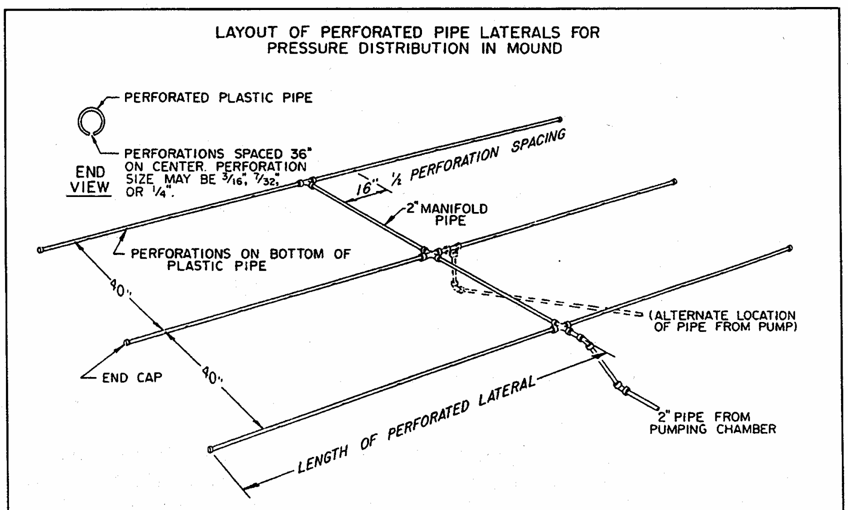


Figure E-18

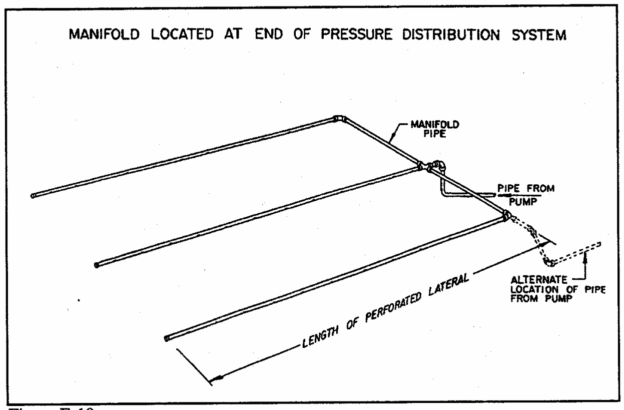


Figure E-19

The pipe from the pump can enter at the center of the manifold system (Figure E-18) or at the end (Figure E-19). The laterals can be connected to the manifold as shown in Figure E-18 or with a tee-to-tee lateral construction as shown in Figures E-20 and E-21.

Also as shown on Figure E-20, there should be a perforation drilled horizontally into the end cap of the perforated lateral near the top or crown.

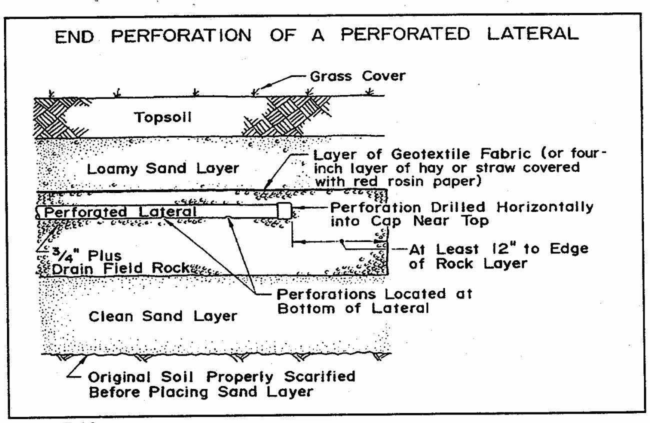


Figure E-20

For example: With 1/4-inch perforations spaced 36 inches apart, the maximum length that a 1-inch perforated lateral could extend would be 27 feet, the maximum length of a 1-1/4 inch lateral would be 42 feet, and the maximum length of a 1-1/2 inch lateral would be 54 feet. (See

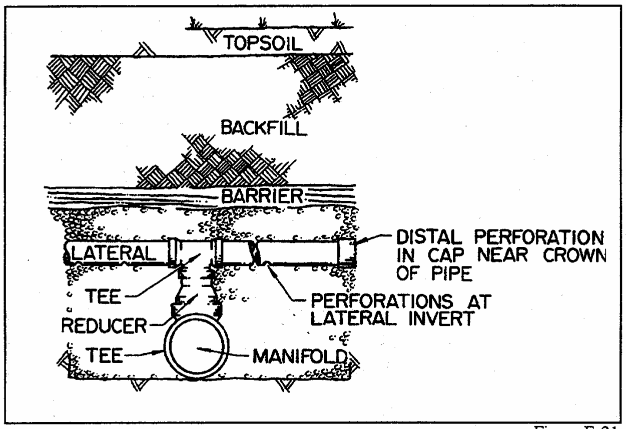


Figure E-21

Figure E-15) Using 1 inch or 1-1/4 inch diameter pipe would require that the manifold be located in the center of the rock layer. With the 1-1/2 inch size for the perforated laterals, the manifold could be located on one end as shown in Figure E-19.

As the lateral diameter increases, the maximum allowable length increases. Also, as the perforation size gets smaller, the maximum allowable length increases. The required pumping capacity is greater for a perforation spacing of 30 inches than 36 inches because there are more perforations. Also the required pumping capacity increases as the perforation diameter increases.

Another technique for determining the pumping capacity required for the perforated lateral system is to determine the number of perforations and multiply by the discharge per perforation. Assuming a 36-inch perforation spacing and a rock layer that is 50 feet long, a total of 17 perforations will be required for each perforated lateral.

The last perforation should be placed in the end cap of each lateral and should be at least one foot from the edge of the rock layer. There will be 3 laterals and a total of 51 perforations.

For a residential system, the head on the perforation should be at least 1.0 foot. The table of perforation discharges in Figure E-22 shows that 0.74 gpm will be discharged by a 1/4 inch perforation at a head of 1.0 foot. Multiplying 51 perforations by 0.74 gpm/perforation results in a total required flow rate of 37.7 gpm.

Perforation Discharges in GPM

Head	Perforation diameter (inches)	
	7/32	1/4
1.0a	0.56	0.74
1.5	0.69	0.90
2.0b	0.80	1.04
2.5	0.89	1.17
3.0	0.98	1.28
4.0	1.13	1.47
5.0	1.26	1.65

a Use 1.0 foot of head for residential systems.
b Use 2.0 feet of head for other esablishments.

Figure E-22

Friction Factors

Figure F-23 contains friction factors that can be used to calculate the friction loss in a perforated lateral. To use these "F" factors, the friction loss is first calculated as if the entire flow were moving through the entire length of the pipe.

In the previous example, each lateral would have a flow of 37.7/3 = 12.6 gpm. The friction loss for 12.6 gpm should be calculated for 48 lineal feet of the pipe diameter under consideration. This total friction loss is then multiplied by an "F" factor which is 0.374 for a pipe having 17 outlets.

Friction Loss Should Be No More Than 2% of Average Operating Pressure

The friction loss in the pipe with multiple outlets should not be greater than 2% of the average operating pressure; in this case, 1.0 foot. Thus the maximum allowable friction loss would be 0.20 foot, and the difference in discharge between the first and last perforation along the perforated lateral will be less than 10%.

"F" Factors for a Pipe with Multiple Outlets

Number of Perforations	"F" Factor
6	0.432
8	0.409
10	0.396
12	0.387
14	0.380
16	0.376
18	0.372
20	0.370
30	0.360

Figure E-23

By using the “F” factor in Figure E-23 and the friction loss for plastic pipe presented in Figure F-14, the maximum allowable number of various size perforations that are allowed on various diameter laterals were calculated and are presented in Figure E-24. This table is suitable only for the perforations listed. Similar tables may be developed for other perforation diameters.

Maximum allowable number of quarter inch perforations per lateral to guarantee <10% Discharge variation

perforation spacing (feet)	1.25 inch	1.5 inch	2.0 inch
2.5	14	18	28
3.0	13	17	26
3.3	12	16	25
4.0	11	15	23
5.0	10	14	22

Figure E-24

Three Layers in Mound Construction

The contractor is primarily responsible for proper mound construction. There are three layers that, if not treated properly, can create problems with the hydraulic performance of the mound.

Natural Soil

First Layer = Natural Soil

The first layer is the natural soil on which the mound is to be constructed. If this soil is wetter than the plastic limit, or if considerable construction activity has caused compaction, then the ability of the soil to transmit liquid will have been seriously reduced.

For proper hydraulic performance, there should be at least 3 feet of natural or clean sand above the limiting soil condition. This could be 3 feet of natural soil above a saturated layer, it could be 2 feet of natural soil plus 1 foot of clean sand, or it could be 2 feet of clean sand. Unless the soil under the mound has the ability to transmit liquid both vertically and horizontally, the mound will not function properly.

Soil Surface

Second Layer = Soil Surface

Another critical layer that is essential to proper mound performance is the soil surface on which the clean sand layer is placed. Soil surface preparation should be carefully studied. Once the clean sand layer is in place, it will be extremely difficult for the inspector to determine how the soil surface was prepared prior to sand placement.

A soil surface that has been smeared, compacted or otherwise made unsuitable for the movement of liquid through it will not recover that capacity after a period of time. Liquid will likely seep out of the mound at the toe of the berm or at the edge of the rock layer.

Soil Surface Preparation

The discharge pipe from the pump to the mound area should be installed prior to soil surface preparation. The trench excavated to install the discharge pipe should be carefully backfilled and compacted to prevent seepage of effluent.

All vegetation in excess of 4 inches in length and dead organic debris must be removed from the surface of the total area under the mound. (See Figure E-25)

The total area selected for the mound, including that under the berms, should be roughened to thoroughly break up any existing sod layers and to provide a suitable transition zone between the original soil and the plastic limit.

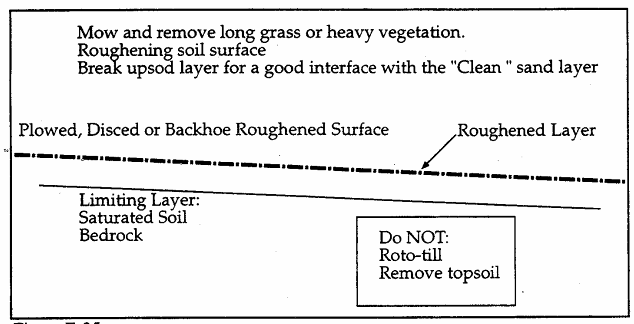


Figure E-25

Plastic Limit

Plastic limit is the soil moisture content below which the soil may be manipulated for purposes of installing a soil treatment system, and above which manipulation will cause compaction and puddling.

Plastic Limit = 1/8 inch Soil Wire

If a fragment of soil can easily be rolled into a wire 1/8 inch in diameter, the moisture content is above plastic limit.

If the soil is dry enough to be friable and falls apart when rolling it into wire, the moisture content is below the limit and soil may be manipulated.

The standard method of determining the plastic limit is specified in the American Association of State Highway Officials (AASHO) Designation: T 90-61.

Roughening

Surface preparation or roughening may be performed with a mold board plow, a disk plow or a backbone using only the teeth. Mold board plow furrows shall be at least 8 inches deep, should be thrown upslope and should run perpendicular to the slope. There should be no dead furrow under the mound. Never use a rototiller to prepare the surface.

No Rototilling

Disking may be used to roughen the soil surface and break up the sod layer. Care must be taken so as not to compact or puddle deeper soil layers. In no case should any surface soil be excavated and moved more than one foot from its original location.

Mound construction should proceed immediately after surface preparation is completed. Every effort should be taken to prevent rain from falling on the prepared soil surface.

Protec t soil surface from rain

Construction Equipment

A rubber-tired tractor may be used for plowing or disking to prepare the soil surface, but in no case should a rubber-tired tractor be used after the surface preparation is completed. A crawler or track-type tractor should be used for mound construction, where the soil percolation rate is slower than 15 minutes per inch. A minimum 6-inch layer of sand must be kept below the equipment during construction.

Clean Sand Layer

The other layer over which the contractor has responsibility, but which can easily be checked by the inspector, is the texture of the clean sand layer. Clean sand, described on the basis of a sieve analysis, is a soil texture composed by weight of at least 25% of very coarse, coarse and medium sand varying in size from 2.0 to 0.25 mm, less than 50% of fine or very fine sand ranging in size between 0.25 and 0.05 mm, and no more than 10% of particles smaller than 0.05 mm.

Third Layer = Clean Sand

Clean sand can also easily be determined by using the fruit jar test. This is the same test that was mentioned in Figure E-9. Place exactly 2 inches of sand in the bottom of a quart fruit jar and then fill the jar three-fourths full of water. Place the cover on the jar and shake the contents vigorously.

Allow the jar to stand for about an hour and observe whether there is a layer of silt or clay on top of the sand. If the layer of these fine particles is more than 1/8 inch thick, the sand is likely not suitable for use in mound construction, because too many fine particles tend to cause the soil to compact during the construction process. Also, the long-term acceptance rate of this soil will be slower than the long-term acceptance rate of clean sand, which is used for sizing the rock layers.

Construction Materials and Procedures

A minimum of 12" of soil defined as sand should be placed where the drainfield rock is to be located. A crawler tractor with a blade or bucket shall be used to move the sand in to place. At least 6 inches of sand should be kept under the tracks to minimize compaction of the plowed layer. When placing sand with a backhoe that has rubber tires, the tractor must not drive over the drainfield rock or mound berms. The sand layer upon which the drainfield rock is placed should be level. (See Figure E-26)

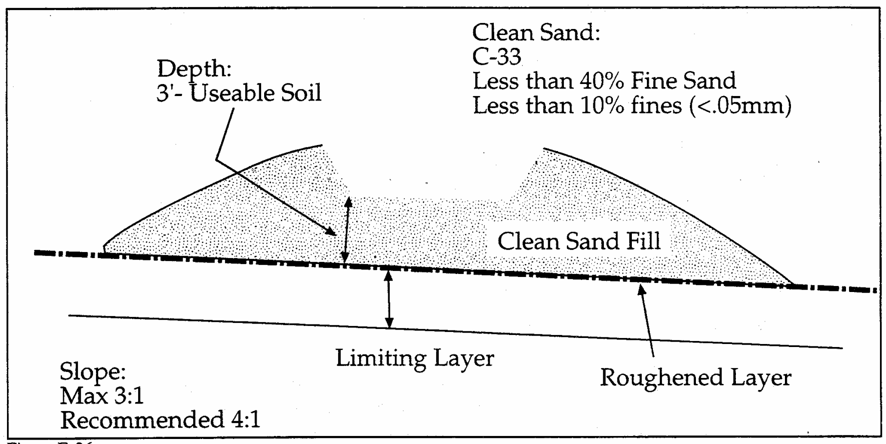


Figure E-26

Cover Material

Geotextile must be used over the rock bed. This fabric should allow air and water to move through, but catch all fine materials. Construction vehicles should not be allowed on the rock until backfill is placed.

Sandy soil should be placed on the rock to a depth of 12 inches in the center of the mound and to a depth of 6 inches at the sides.

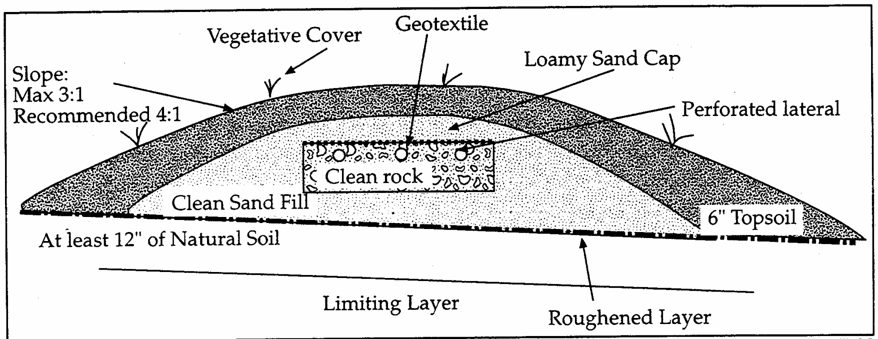


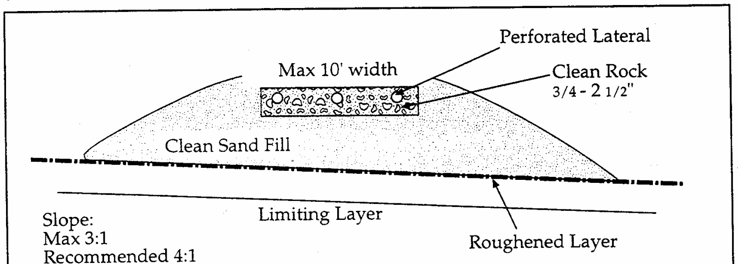
Figure E-27

When the two beds are installed side by side, the sandy loam fill at the center of the mound should be 18 inches deep and 6 inches deep at the sides.

Six inches of topsoil should be placed on the rock over the entire area of the mound. A grass cover should be established over the entire area of the mound. No shrubs should be planted on the top of the mound. Shrubs may be placed at the foot and side slopes of the mound. Be sure that the planted shrubs can handle the wet environment.

Side slopes of 4 feet horizontal to 1 foot vertical (4:1) are suggested for the berms of the mound. This gentle slope will allow easy mowing of the grass cover. If area is limited, steeper side slopes of 3:1 can be used. In no case, however, should the berm slope be steeper than 3:1.

Whenever mounds are located on slopes a diversion shall be constructed immediately upslope from the mound to intercept and divert runoff.



12" layer of clean rock and pressure pipe in place.
Bottom and top of rock layer must be level.
Rock must be clean and free of fine material and debris.
Size of the rock is 3/4 inch tp 2 1/2 inch.
9" of rock must be placed under the pressure pipe and 2" above.

Figure E-28

Mound Dimensions

Slope	Upslope Berm (feet)	Rockbed	Downslope Berm <60 MPI	60 MPI - 120MPI
0%	16	10'	17	30
1%	15.4	10'	17	40
2%	14.8	10'	18.3	40
3%	14.3	10'	19.4	40
4%	13.8	10'	21	40
5%	13.3	10'	22.5	40
6%	12.9	10'	24.4	40
7%	12.5	10'	26	40
8%	12.1	10'	28.3	40
9%	11.8	10'	30.6	40
10%	11.4	10'	33.4	40
11%	11.2	10'	36.4	40
12%	10.8	10'	40	40

The system length is the flow ÷ the bed width plus the upslope berm twice.

Length = (_____ ÷10) + ______ + ______

Figure E-29

The setback for mound systems is based on the absorption area on the downslope side. This chart is a quick reference for these dimensions.

Percolation Rate in Minutes per Inch (MPI)	Soil Texture	Downslope setback to Rock Layer
Faster than 0.1	Coarse Sand	5
0.1 to 5	Sand	5
0.1 to 5	Fine Sand	10
6 to 15	Sandy Loam	5
16 to 30	Loam	10
31 to 45	Silt Loam	14
46 to 60	Clay Loam	17
60 to 120	Clay	40
Slower than 120	Clay	50

Figure E-31

Location of Soil Treatment System

Item	Setback Distance
Water supply well less than 50 feet of casing and not encountering 10 feet of impervious material	100
Any water supply well or buried water suction pipe	50
Building	20
Streams, Lakes or other bodies of water (Shoreland Management Act)	50,75,150
Property lines or buried pipe distributing water under pressure	10

Figure E-30

PART III: SYSTEMS FOR SOILS WITH RAPID PERMEABILITY

Systems for Rapidly Permeable Soils

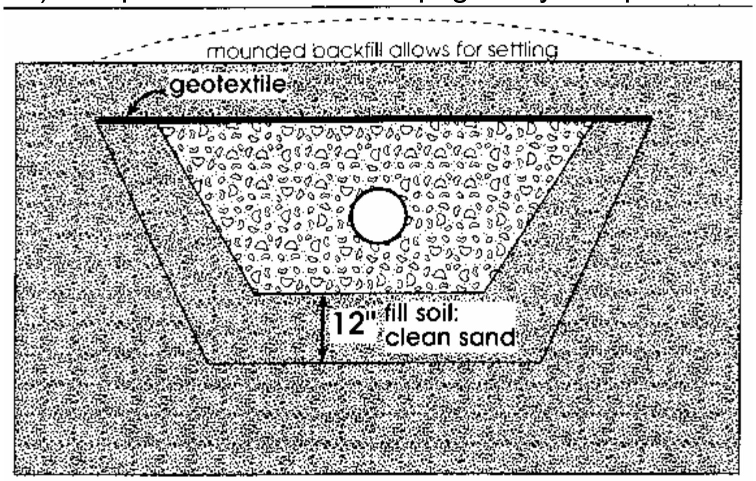
Soils in this category have low treatment capabilities and require special design considerations to design systems that will overcome this limitation.

Perc Rates Faster than 1 mpi: Coarse Sands and Gravels

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 drainfield 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 (see Figure D-54) or if pressure dose is 1 sqft/gal/day see pressure distribution section.



Perc Rates Less than 1 mpi: Sands and Gravels

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.

PART IV: DRIP IRRIGATION

This has been reprinted from the USEPA Onsite Wastewater Treatment Systems Manual.

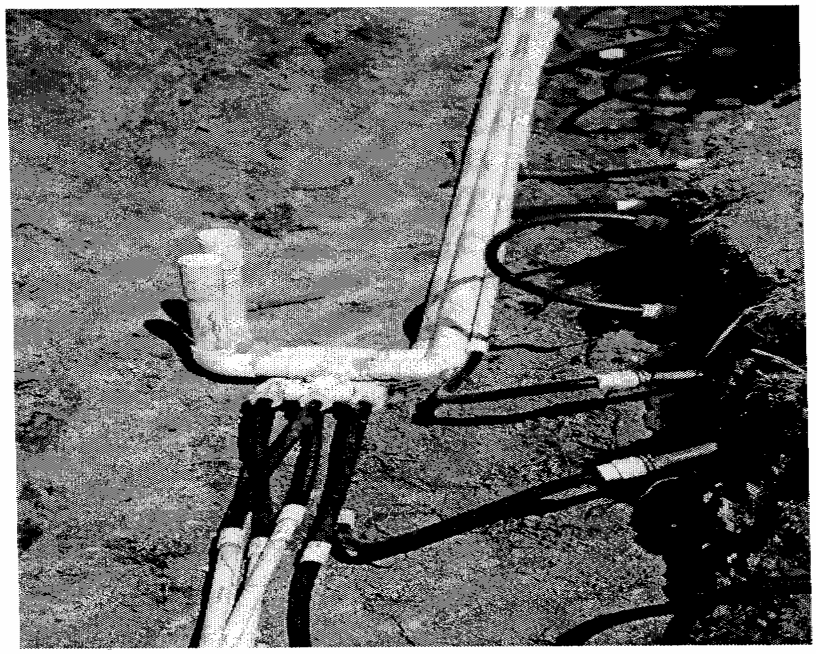
Dripline pressure network

Drip distribution, which was derived from drip irrigation technology, was recently introduced as a method of wastewater distribution. It is a method of pressure distribution capable of delivering small, precise volumes of wastewater effluent to the infiltration surface. It is the most efficient of the distribution methods and is well suited for all types of lateral applications. A dripline pressure network Consists of several components:

- Dose tank
- Pump
- Prefilter
- Supply manifold
- Pressure regulator (when turbulent, flow emitters are used)
- Dripline
- Emitters
- Vacuum release valve
- Return manifold
- Flush valve
- Controller

The pump draws wastewater effluent from the dose tank, preferably on a timed cycle, to dose the distribution system. Before entering the network, the effluent must be prefiltered through mechanical or granular medium filters. The former are used primarily for large lateral systems. The backflush water generated from a self-cleaning filter should be returned to the headworks of the treatment system. The effluent enters the supply manifold that feeds each dripline (figure 4-17). If turbulent flow emitters are used, the filtered wastewater must first pass through a pressure regulator to control the maximum pressure in the dripline. Usually, the dripline is installed in shallow, narrow trenches 1 to 2 feet apart and only as wide as necessary to insert the dripline using a trenching machine or vibratory plow. The trench is backfilled without any porous medium so that the emitter orifices are in direct contact with the soil. The distal ends of each dripline are connected to a return manifold. The return manifold is used to regularly flush the dripline. To flush, a valve on the manifold is opened and the effluent is flushed through the driplines and returned to the treatment system headworks.

Figure 4-17. Pressure manifold and flexible drip lines prior to trench filling



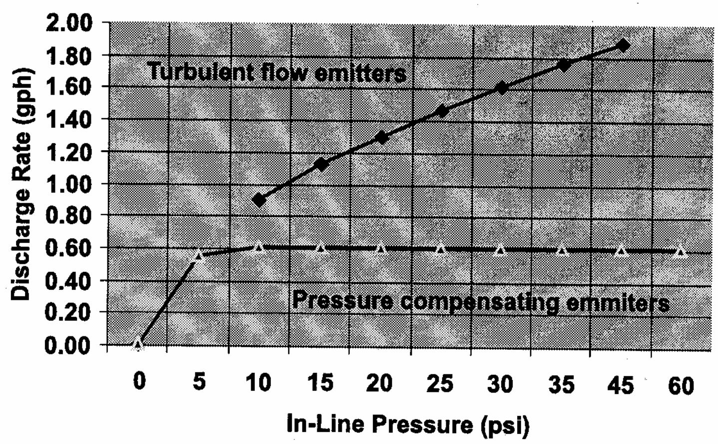
Source: Ayres Associates.

Because of the unique construction of drip distribution systems, they cause less site disruption during installation, are adaptable to irregularly shaped lots or other difficult site constraints, and use more of the soil mantle for treatment because of the shallow depth of placement. Also, because the installed cost per linear foot of dripline is usually less than the cost of conventional trench construction, dripline can be added to decrease mass loadings to the infiltration surface at lower costs than other distribution methods. Because of the equipment required, however, drip distribution tends to be more costly to construct and requires regular operation and maintenance by knowledgeable individuals. Therefore, it should be considered for use only where operation and maintenance support is ensured.

The dripline is normally a ½-inch-diameter flexible polyethylene tube with emitters attached to the inside wall spaced 1 to 2 feet apart along its length. Because the emitter passageways are small, friction losses are large and the rate of discharge is low (typically from 0.5 to nearly 2 gallons per hour).

Two types of emitters are used. One is a “turbulentflow” emitter, which has a very long labyrinth. Flow through the labyrinth reduces the discharge pressure nearly to atmospheric rates. With increasing in-line pressure, more wastewater can be forced through the labyrinth. Thus, the discharges from turbulent flow emitters are greater at higher pressures (figure 4-18). To more accurately control the rate of discharge, a pressure regulator is installed in the supply manifold upstream of the dripline. Inlet pressures from a minimum of 10 psi to a maximum of 45 psi are recommended. The second emitter type is the pressure-compensating emitter. This emitter discharges at nearly a constant rate over a wide range of in-line pressures (figure 4-18).

Figure 4-18. Turbulent-flow and pressure-compensating emitter discharge rates versus in-line pressure



Head losses through driplines are high because of the small diameter of the tubing and its in-line emitters, and therefore dripline lengths must be limited. Manufacturers limit lengths at various emitter spacing. With turbulent flow emitters, the discharge from each successive emitter diminishes in response to pressure loss created by friction or by elevation changes along the length of the dripline. With pressure-compensating emitters, the in-line pressure should not drop below 7 to 10 psi at the final emitter. The designer is urged to work with manufacturers to ensure that the system meets their requirements.

Pressure-compensating emitters are somewhat more expensive but offer some important advantages over turbulent-flow emitters for use in onsite wastewater systems. Pressure-compensating dripline is better suited for sloping sites or sites with rolling topography where the dripline cannot be laid on contour. Turbulent-flow emitters discharge more liquid at lower elevations than the same emitters at higher elevations. The designer should limit the difference in discharge rates between emitters to no more than 10 percent. Also, because the discharge rates are equal when under pressure, monitoring flow rates during dosing of a pressure-compensating dripline network can provide an effective way to determine whether leaks or obstructions are present in the network or emitters. Early detection is important so that simple and effective corrective actions can be taken. Usually, injection of a mild bleach solution into the dripline is effective in restoring emitter performance if clogging is due to biofilms. If this action proves to be unsuccessful, other corrective actions are more difficult and costly. An additional advantage of pressure-compensating emitters is that pressure regulators are not required. Finally, when operating in their normal pressure range, pressurecompensating emitters are not affected by soil water pressure in structured soils, which can cause turbulent-flow emitters to suffer reduced dosing volumes.

Controlling clogging in drip systems

With small orifices, emitters are susceptible to clogging. Particulate materials in the wastewater, soil particulates drawn into an emitter when the dripline drains following a dose, and biological slimes that grow within the dripline pose potential clogging problems. Also, the moisture and nutrients discharged from the emitters may invite root intrusion through the emitter. Solutions to these problems lie in both the design of the dripline and the design of the distribution network. Emitter hydrodynamic design and biocide impregnation of the dripline and emitters help to minimize some of these problems. Careful network design is also necessary to provide adequate safeguards. Monitoring allows the operator to identify other problems such as destruction from burrowing animals.

To control emitter clogging, appropriate engineering controls must be provided. These include prefiltration of the wastewater, regular dripline flushing, and vacuum release valves on the network. Prefiltration of the effluent through granular or mechanical filters is necessary. These filters should be capable of removing all particulates that could plug the emitter orifices. Dripline manufacturers recommend that self-cleaning filters be designed to remove particles larger than 100 to 115 microns. Despite this disparate experience, pretreatment with filters is recommended in light of the potential cost of replacing plugged emitters. Regular cleaning of the filters is necessary to maintain satisfactory performance. The backflush water should be returned to the head of the treatment works.

The dripline must be flushed on a regular schedule to keep it scoured of solids. Flushing is accomplished by opening the flush valve on the return manifold and increasing the pumping rate to achieve scouring velocity. Each supplier recommends a velocity and procedure for this process. The flushing rate and volume must include water losses (discharge) through the emitters during the flushing event. Both continuous flushing and timed flushing are used. However, flushing can add a significant hydraulic load to the treatment system and must be considered in the design. If intermittent flushing is practiced, flushing should be performed at least monthly.

Aspiration of soil particles is another potential emitter clogging hazard. Draining of the network following a dosing cycle can create a vacuum in the network. The vacuum can cause soil particles to be aspirated into the emitter orifices. To prevent this from occurring, vacuum relief valves are used. It is best to install these at the high points of both the supply and return manifolds.

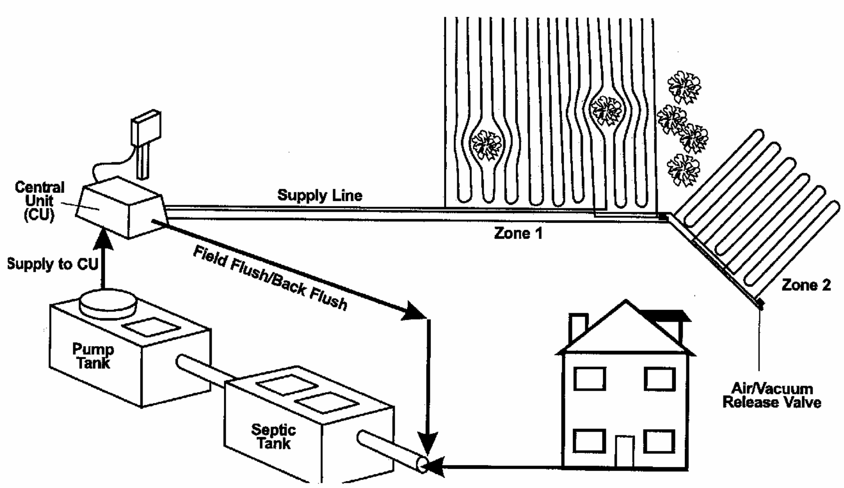
Placement and layout of drip systems

When drip distribution was introduced, the approach to sizing drips using this distribution method was substantially different from that for laterals using other distribution methods. Manufacturer-recommended hydraulic loading rates were expressed in terms of gallons per day per square foot of drip distribution footprint area. Typically, the recommended rates were based on 2-foot emitter and dripline spacing. Therefore, each emitter would serve 4 square feet of footprint area. Because the dripline is commonly plowed into the soil without surrounding it with porous medium, the soil around the dripline becomes the actual infiltration surface. The amount of infiltration surface provided is approximately 2/3 to 1 square foot per 5 linear feet of dripline. As a result, the wastewater loading rate is considerably greater than the hydraulic loadings recommended for traditional laterals. Experience has shown however, that the hydraulic loading on this surface can be as much as seven times higher than that of traditional lateral designs (Ayres Associates, 1994). This is probably due to the very narrow geometry, higher levels of pretreatment, shallow placement, and intermittent loadings of the trenches, all of which help to enhance reaeration of the infiltration surface.

The designer must be aware of the differences between the recommended hydraulic loadings for drip distribution and those customarily used for traditional laterals. The recommended drip distribution loadings are a function of the soil, dripline spacing, and applied effluent quality. It is necessary to express the hydraulic loading in terms of the footprint area because the individual dripline trenches are not isolated infiltration surfaces. If the emitter and/or dripline spacing is reduced, the wetting fronts emanating from each emitter could overlap and significantly reduce hydraulic performance. Therefore, reducing the emitter and/or dripline spacing should not reduce the overall required system footprint. Reducing the spacing might be beneficial for irrigating small areas of turf grass, but the maximum daily emitter discharge must be reduced proportionately by adding more dripline to maintain the same footprint size. Using higher hydraulic loading rates must be carefully considered in light of secondary boundary loadings, which could result in excessive ground water mounding (see chapter 5). Further, the instantaneous hydraulic loading during a dose must be controlled because storage is not provided in the dripline trench. If the dose volume is too high, the wastewater can erupt at the ground surface.

Layout of the drip distribution network must be considered carefully. Two important consequences of the network layout are the impacts on dose pump sizing necessary to achieve adequate flushing flows and the extent of localized overloading due to internal dripline drainage. Flushing flow rates are a function of the number of manifold/dripline connections: More connections create a need for greater flushing flows, which require a larger pump. To minimize the flushing flow rate, the length of each dripline should be made as long as possible in accordance with the manufacturer's recommendations. To fit the landscape, the dripline can be looped between the supply and return manifolds (figure 4-19). Consideration should also be given to dividing the network into more than one cell to reduce the number of connections in an individual network. A computer program has been developed to evaluate and optimize the hydraulic design for adequate flushing flows of dripline networks that use pressure-compensating emitters (Berkowitz and Harman, 1994).

Figure 4-19. Dripline layout on a site with trees



Source: Adapted from American Manufacturing, 2001.

Internal drainage that occurs following each dose or when the soils around the dripline are saturated can cause significant hydraulic overloading to lower portions of the system. Following a dose cycle, the dripline drains through the emitters. On sloping sites, the upper driplines drain to the lower driplines, where hydraulic overloading can occur. Any free water around the dripline can enterthrough an emitter and drain to the lowest elevation. Each of these events needs to be avoided as much as possible through design. The designer can minimize internal drainage problems by isolating the driplines from each other in a cell, by aligning the supply and return manifolds with the site's contours. A further safeguard is to limit the number of doses per day while keeping the instantaneous hydraulic loadings to a minimum so the dripline trench is not flooded following a dose. This tradeoff is best addressed by determining the maximum hydraulic loading and adjusting the number of doses to fit this dosing volume.

Freezing of dripline networks has occurred in severe winter climates. Limited experience indicates that shallow burial depths together with a lack of uncompacted snow cover or other insulating materials might lead to freezing. In severe winter climates, the burial depth of dripline should be increased appropriately and a good turf grass established over the network. Mulching the area the winter after construction or every winter should be considered. Also, it is good practice to install the vacuum release valves below grade and insulate the air space around them. Although experience with drip distribution in cold climates is limited, these safeguards should provide adequate protection.

PART V: FREEZING

The following paper was copied from University of Minnesota and some of the references are to contact Minnesota. We recommend contacting the county sanitarian or the IDNR if you have questions.

UNIVERSITY OF MINNESOTA
ONSITE SEWAGE TREATMENT PROGRAM

Freezing Problems with Onsite Sewage Treatment Systems

Sara Christopherson and Ken Olson

Why Might an Onsite System Freeze?

According to many onsite professionals this has been a very hard year for onsite septic systems due to the lack of snow cover combined with cold temperatures. Even in a normal Minnesota winter, freezing can occasionally be a problem. Identifying and correcting a potential freezing problem is far easier than dealing with a frozen system. Here are a few common causes of onsite system freeze-ups.

Lack of Snow Cover: Snow serves as an insulating blanket over the septic tank(s) and soil treatment area (trenches, drainfield or mound). Snow helps keep the heat of the sewage and the heat created by the treatment of the sewage in the soil. Lack of snow allows frost to go deeper into the ground, potentially freezing the system.

Compacted Snow: Compacted snow will not insulate as well as uncompacted snow. Driving any type of equipment over the system compacts snow and sends the frost down deeper. Automobiles, snowmobiles, ATV's, people, and large livestock should stay off the system all year long but especially in the winter. Anytime traffic over a sewer pipe, septic tank, or soil treatment area is anticipated, insulated pipe should be used.

Compacted Soils: Areas that have compacted soils, such as driveways, paths or livestock enclosures, tend to freeze deeper, affecting septic system components that may be in the area.

Lack of Plant Cover: This often occurs in new systems installed late in the fall where a vegetative cover could not be established before winter. The vegetative cover insulates the system and helps hold snow.

Irregular Use of System: When homes or cabins are unoccupied for long weekends or extended periods of time, no sewage is entering the system to keep it warm. This can also occur when very low volumes of sewage are being generated. In cases when only one or two people are living in a home, they may use only a small percentage of the designed flow rate of 150 gallons per bedroom. Low usage may not be sufficient to keep the system from freezing. Frequent use, warm water temperatures and total volume of sewage are all important in cold temperature stress situations.

Leaking Plumbing Fixtures: When a fixture such as a toilet or shower leaks, it sends a very small trickle of sewage to the system. This trickle can freeze within the pipe and eventually cause the pipe to freeze solid. Appliances such as high efficiency furnaces and humidifiers can also cause water to freeze in the pipes due to the small amount of discharge.

Pipes Not Draining Properly: A common cause of freeze-ups are sewer pipes and pump lines that are not installed with proper fall (change of elevation) or pipes that settle after installation. Anytime a dip or low spot occurs in a pipe, sewage can collect and freeze. Pump lines can develop a dip right next to or above the septic tank as a result of backfilled soil settling from the excavation during the tank installation. It is important that all sewage drains out of the pipe from a pump line.

Cold Air Entering the System: Open and uncapped riser or inspection pipes and manhole covers allow cold air into the system and can cause the system to freeze.

Water Logged System: If a system was hydraulically failing (e.g. water coming to surface or seeping out the side of a mound) in the fall, it is a prime candidate to freeze. This effluent will freeze and prevent further effluent from entering the soil.

What Should You Do If Your Onsite System Freezes?

If your septic system is frozen, your first step is to call an onsite professional. If you have a pump and hear water constantly running in a pump tank (a possible indication of a frozen system) disconnect your pump and call an onsite professional. This will likely be a pumper or an installer who can help determine the cause of the problem and offer solutions. The U of M Onsite Program web site is one place to go to locate a professional - http://septic.coafes.umn.edu/homeowner/index.html. Many pumpers and installers have devices called steamers and high-pressure jetters to try to unfreeze system piping. Unless the cause of freezing is corrected the piping will refreeze. Other methods used to help fix a freezing problem include adding heat tape and tank heaters. Cameras can be sent down the pipes to determine where the freezing is occurring and if repairs are needed. If the treatment area is full of ice, or there is evidence of leaking, there is no need to thaw the lines leading to the treatment area, as it cannot accept liquid until the area is thawed in spring.

If it is not feasible to correct the problem or equipment is not available in your area, the only other option is to use the septic tank(s) in the system as a holding tank until the system thaws naturally. You will need to contact a pumper who will empty out the tanks when they are full on a regular basis. This can be very costly, especially with normal volumes of water use (50 to 75 gallons per person per day). Reduce water use by limiting the number of toilet flushes, taking short showers, using the dishwasher at full capacity, limiting running water to get hot or cold and doing laundry at a laundromat. It is smart to find the cause of the freezing problem so that it can be addressed in the spring, preventing future freeze-ups.

There are many misconceptions about how to deal with a frozen onsite system.

- Do NOT add antifreeze, salt or a septic system additive into the system.
- Do NOT pump sewage onto the ground surface.
- Do NOT start a fire over the system to attempt to thaw it out.
- Do NOT run water continually to try to unfreeze system.

What Can You Do to Prevent Your Onsite System From Freezing in the Future?

Depending on your system, location, and water use, you may never have a freezing problem. However, there are several steps that you can take if you are concerned about your onsite system freezing. Here are some precautions if you have had a past problem or are concerned about having a future problem. It is not necessary to do all of these, but you may pick and choose based on your situation:

1. Place a layer of mulch (8-12 inches) over the pipes, tank and soil treatment system to provide extra insulation. This mulch could be straw, leaves, hay or any other loose material that will not compact and stay in place. This is particularly important if you have had a new system installed late in the year and no vegetative cover has been established. If your system is currently frozen ignore this step, as it will delay thawing come spring.
2. Let the grass in your lawn get a little longer in the late summer/fall over the tank and soil treatment area. This will provide extra insulation and help hold any snow that may fall.
3. Use water; the warmer the better! The Onsite Sewage Treatment Program is usually an advocate of water conservation, but if freezing is a concern, increasing low use to a normal water use can help the system. This includes spreading out your laundry schedule to possibly doing one warm/hot load per day, using your dishwasher and maybe even taking a hot bath. DO NOT leave water running all the time, as this will hydraulically overload the system.
4. If you know you are going to be gone for an extended period, plan accordingly. This could include having someone use sufficient quantities of water in the home regularly or pumping out your tank before leaving. If you live in an area with a high water table, you should only pump out the tank if the tank was designed for high water table conditions. If a tank is left full for several winter months, the sewage will get very cold in shallow tanks and can even freeze. If you then return home before temperatures start to rise, the effluent leaving the tank will be cold. By starting with an empty tank, you can then start fresh with warm effluent. If you use a cabin on a limited basis during the winter months, this may be a good idea as well.
5. Fix any leaky plumbing fixtures or appliances in your home. This will help prevent freezing problems and help your system work better year round. If you have appliances that generate very low flows such as high efficiency furnaces, you can put a heat tape in the pipe, and while on vacation have someone come by and run warm water for a while. Alternately, you could install a small condensate pump that holds and discharges 2 gallons per cycle.
6. Keep all types of vehicles and high traffic people activities off of the system. This is a good rule to follow year round.
7. Make sure all risers; inspections pipes and manholes have covers on them. Sealing them and adding insulation is a good idea. Insulation may be added during construction particularly if the top of the septic tank is within 2 feet or the surface.
8. Keep an eye on your system. If any seeping or ponding occurs contact an onsite professional to help determine the cause and remedy.
9. If these steps fail to solve a freezing problem, you may need to dig up the area where the system is freezing to determine if there is a problem with the slope of the pipe.

For More Information

Please see our website at: http://septic.coafes.umn.edu/homeowner/index.html for more information about proper operation of septic systems. Otherwise give us a call at (800) 322-8642.

SECTION E: PRESSURE DISTRIBUTION AND PUMPING SYSTEMS

Part I: Pumping Systems

Part II: Pressure Distribution Systems

Part III: Dosing Siphons

PART II: PUMPING SYSTEMS

Pumping Situations

Whether it handles sewage or effluent, a pumping station consists of two parts: a dosing chamber and a pump. Never install a pump directly in the septic tank to pump to soil treatment units. The sewage solids will plug either the pump or the soil, causing the either the pump or the soil treatment unit to fail. Install a compartment in the septic tank for the pump or use a separate watertight tank beyond the septic tank to separate solids in the septic tank.   Effluent pumps are designed to handle only sewage effluent, which is a relatively clear liquid.

Figure E-1 shows two different pumping situations. The first is a pump located in a separate tank beyond the septic tank. This arrangement is often used in a repair situation where there is an existing septic tank. All sewage wastes are delivered by pump to the drainfield trench system. In the event of pump failure, water use would need to be restricted until the pump can be repaired or replaced.

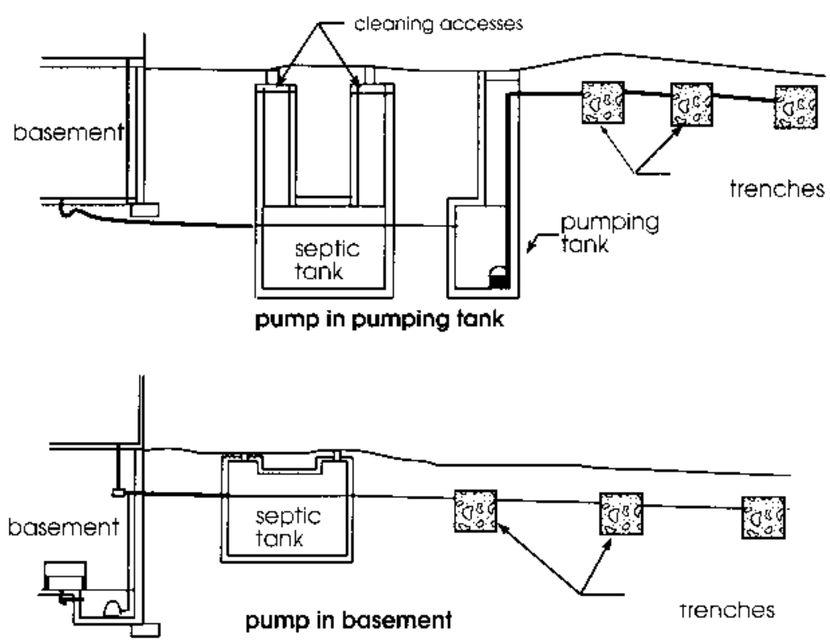


Figure E-1

The cover of the pumping tank, the cover of the septic tank and all cleaning access extensions must be made absolutely watertight to prevent any groundwater from infiltrating the system. Pipe connections to the tanks also must be sealed to be absolutely watertight.

The second situation is a pump located in the basement that delivers laundry tub wastes to the house sewer, from which point the wastes flow by gravity into the septic tank and onto the drainfield trench system. If there is a basement toilet, a sewage ejector or solids handling pump should be used. If sewage solids are pumped, a compartmented tank or two tanks in series should be installed to provide for adequate solids separation. Even though only a portion of the sewage wastes are pumped, there will still be considerable turbulence in the first septic tank when the pump operates. In the event of pump failure, only the basement plumbing could not be used.

The second example also shows that the septic tank is shallow and readily available for cleaning. A tank with a short cleaning access is much easier to clean than a tank with a long cleaning access, such as the one in the first situation. A shallow septic tank is also much less susceptible to groundwater infiltration. It is often less expensive to install a new septic tank at a higher elevation and raise the house sewer line than it is to repair a deep septic tank.

Pumping Effluent

Figure E-2 shows a typical pumping situation where the sewage source is at an elevation lower than where the soil is suitable for sewage treatment. A logical question is why the house was not located at an elevation high enough so that sewage could flow by gravity into the soil treatment unit.

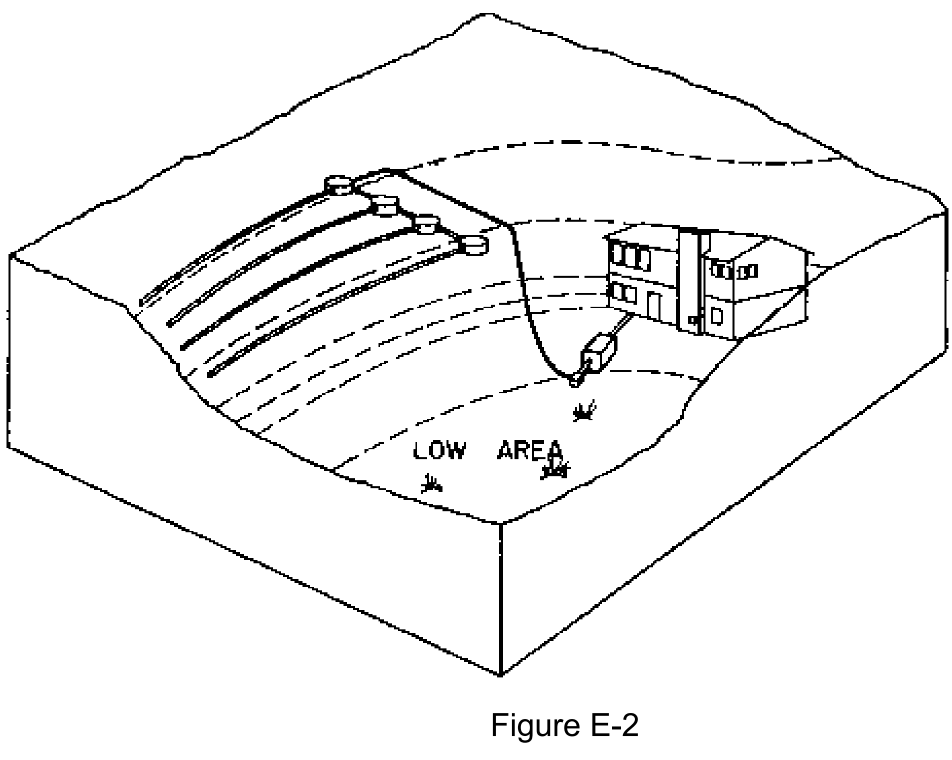


Figure E-2

In some instances, the property owner may want the house at a certain elevation. In other instances, proper planning was not done with respect to the relative location of the house and the sewage treatment system. In the past, many people have incorrectly thought that low areas were suitable for sewage treatment, even though they were too wet for any other purpose.

Note that the pump delivers effluent to a series of trenches using drop box distribution. Figure E-3 shows the first drop box in this system, which accepts the effluent from the pumping station. The bottom of the discharge piping from the pump must be at least two inches higher than the supply line to the next drop box, to avoid any liquid drainback to the pumping station, other than that contained in the pipe from the pump.

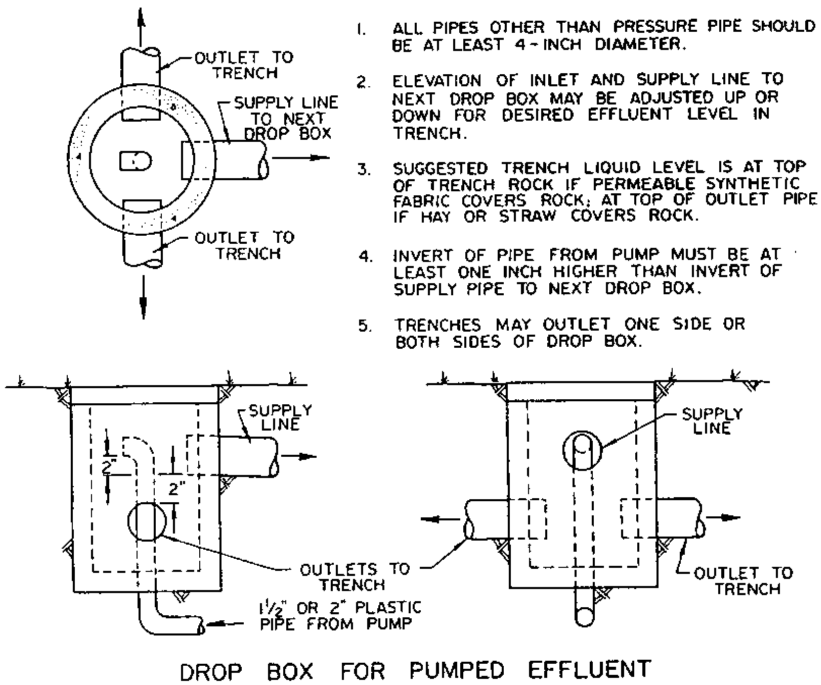


Figure E-3

The discharge line from the pump must be directed to flow against a wall of the drop box where there is no outlet. This placement is necessary to assure that the effluent does not all flow out a single pipe but is instead first distributed to the initial trench, with the remainder then flowing through the supply line to the next drop box

Pumping Raw Sewage

Occasionally it is necessary to pump raw sewage. For example, if a septic tank located next to the source of sewage would be inaccessible for maintenance, which requires the removal of accumulated scum and sludge, it may be more appropriate to pump all sewage solids to a septic tank system in a more accessible location.

Pumps for Raw Sewage

Whenever sewage solids are pumped, a sewage ejector or solids-handling pump must be used. The diameter of the discharge piping must be of the same diameter as the discharge size of the pump. The sewage must flow through the pipe at a velocity of at least two feet per second to transport the 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

Ejector Pumps

Solids-handling or **ejector pumps** are commonly installed in basements to pump sewage solids up to a gravity sewer line. The volume of the pump tank must be large enough to accommodate any drainback from the piping, and to effectively dose the system. Whenever such a pump is used to deliver toilet waste to a septic tank, dose volume must be limited to minimize the impact on the tank.

Grinder Pumps

Grinder pumps can are designed for raw sewage. A rotating blade shears or grinds sewage into smaller particles before pumping it. Grinder pumps have a high starting torque and must use a particular type of starting mechanism on the electric motor. In addition, grinder pumps require relatively high maintenance, such as sharpening and replacing bearings. Since all sewage must pass through the grinding mechanism, a grinder pump may experience blockage as the grinding mechanism becomes dull.

Dosing Tank Specifications

The dosing tank is placed between the sewage tank and the lateral system to accumulate effluent. A pump is turned on when the designed dose amount of effluent has collected in the dosing tank, and shuts off when the dose has been delivered. Float switches suspended in the tank usually control the pump. A third switch is used to trigger an alarm when the effluent collected in the dosing tank reaches the emergency level. Proper dosing tank construction, placement and sizing must be considered to ensure reliable system operation.

The dosing tank construction requirements are the same as for sewage tanks. The tank must be durable and watertight and must withstand the soil loads, which push in on the walls. The environment in the tanks is corrosive, so no metal parts or fittings can be used. The major difference between a septic tank and a dosing tank is that the dosing tank will be emptied on a daily basis. **Since the tank will be emptied every day, anchoring it against flotation is critical in areas with a high seasonal or permanent water table.**

Figure E-16: Dosing Tank Recommendations
▪ Pump tanks must meet or exceed the requirements for sewage tanks see Chapter 69 and be vented. ▪ At least one maintenance hole, 20 inches in least dimension, must be located directly above the pump, and must extend through the cover to final grade, and be constructed to prevent unauthorized entry. ▪ The tank must have either an alternating two-pump system or a minimum capacity of 500 gallons or 100% of the average design flow, whichever is greater. ▪ The pump must have an alarm to warn of failure. ▪ Pump intakes must be at least four inches from the bottom of the dosing chamber or protected in some other manner to prevent the pump from drawing excessive settled solids. ▪ There must be access to the pump, pump controls, and pump discharge line without entering the tank. ▪ Electrical installations must comply with all laws and ordinances, including the latest codes, rules, and regulations of public authorities having jurisdiction, and with the National Electrical Code.

Ensuring that the dosing tank is watertight is also critical. In areas with a high seasonal or permanent water table, groundwater may leak into the dosing tank and overload the system. The seals around the pipes that enter and exit the dosing tank are especially vulnerable to leaks. If the pump is running more than the few minutes a day it takes to pump out the accumulated septic tank effluent, groundwater may be leaking into the septic tank or dosing tank.

Dosing tanks can be round or rectangular. A four-inch to eight-inch concrete block makes a good pedestal for the pump.

Never enter a dosing tank. Any work to replace pumps, switches or connections should be performed from the outside, and the pump, pump controls, and pump discharge line *must* be removable from the surface. The sewage gases produced in the tank can kill a person in a matter of minutes. When working on a tank, make sure the area is well ventilated and someone is standing by. *Never* go into a dosing tank t without a self-contained breathing apparatus to retrieve someone who has accidentally fallen in. While waiting for help, the best thing to do is to put a fan at the top of the tank to blow in fresh air. (See **Section C: Sewage Tanks** for a discussion of safety precautions and practices for working with sewage tanks.)

A complete pumping station with a tank, pump and controls is shown in Figures E-4 and E-5.

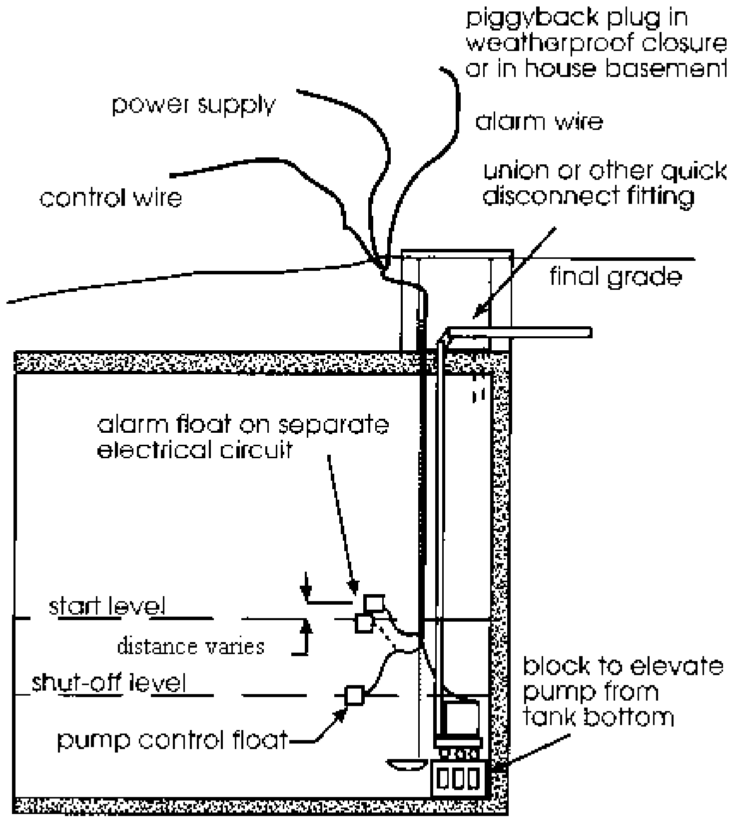


Figure E-4

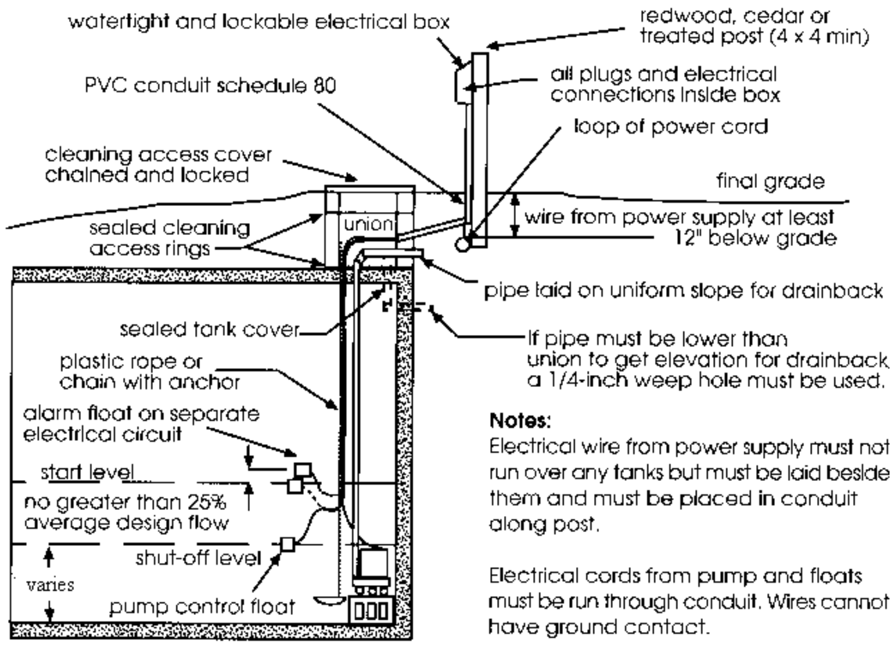


Figure E-5

Cleaning Access Dimensions

The cleaning access's smallest dimension must be at least 20 inches, and preferably 24 inches, for easy access. The cleaning access extension should be 24 inches in diameter. A precast septic tank is often selected for use as the pumping tank. The inlet to this tank can be higher than the normal septic tank inlet, thus providing for additional reserve capacity in the event of pump failure.

Buoyancy

If the pumping tank is installed where the water table is high, consider the problem of tank buoyancy. Be sure the weight of the tank will be adequate to prevent flotation when the tank is nearly empty (which it will be much of the time). Otherwise, anchors may be needed to prevent tank flotation.

Flotation usually is not a problem with a concrete tank but may be with a tank constructed of fiberglass or polyethylene. Such tanks are very likely to need anchoring according to manufacturer's specifications if they are used as a pumping tank in a site with a high water table.

A compartmented tank can help to reduce the buoyancy problem. When a compartmented tank is used, the strength of the inside wall is critical. Since the constant water pressure will be on one side of the wall, the design should be reviewed to avoid failure.

Control Switches for Pumps

Control switches sense the water level in the dosing tank and signal the pump or alarm system. A failure of the control switches can cause sewage to back up into the home or come out the top of the dosing tank. Some switches handle power to the pump directly, while others require a relay. Figure E-6 shows three types of pump controls.

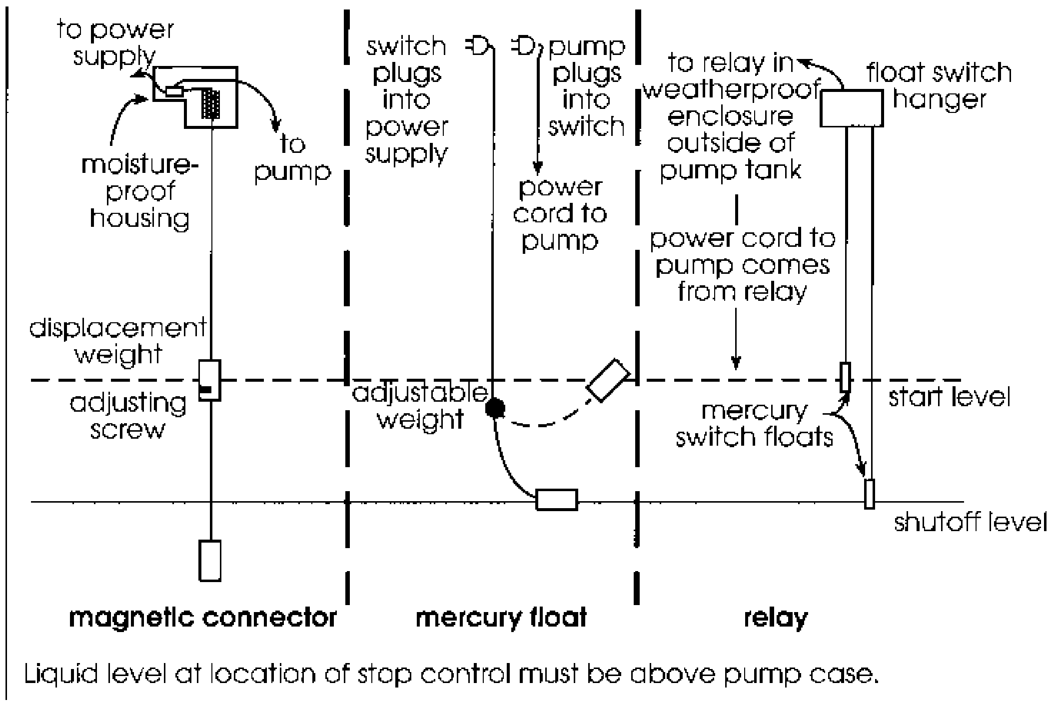


Figure E-6

Mercury switches encased in a plastic or neoprene float are recommended. They are simple and reliable. One switch turns the pump on and a second switch is placed below it to turn the pump off. A third switch is used to activate an alarm if the effluent level exceeds two days storage. The alarm system must be powered in such a way that if the pump circuit fails, the alarm will still operate. Provide a means to turn off the alarm without losing power to the pump.

The distance needed between the on and off switches for a given dose volume depends on the size and shape of the dose tank.

Converting Dose Volume to Distance Between Floats

Cylindrical Tanks

The gallons per inch in a cylindrical tank can be determined by:

$3.14 \times (\text{diameter})^2 \div 4 \times 7.5 \div 12$

If a circular tank of four feet in diameter is used as the pumping tank, the calculation is: $3.14 \times 4^2 \div 4 \times 7.5 \div 12 = 7.85$ gallons per inch

If 150 gallons are to be pumped, float separation is calculated as:

$150 \div 7.85 = 19$ inches

The start control must be set 19 inches higher than the stop control in order to pump out 150 gallons per pump cycle.

Rectangular Tanks

The gallons per inch of depth in a rectangular tank can be determined by:

width x length x $7.5 \div 12$

If a rectangular pumping tank has inside dimensions of four feet by five feet, the volume per depth is:

$5 \times 4 \times 7.5 \div 12 = 12.5$ gallons per inch

To pump 150 gallons, calculate:

$150 \div 12.5 = 12$ inches

The pump start level should be set one foot above the pump stop level.

Drainback

In most domestic applications, the pipe from the pumping station is buried only deep enough to prevent physical damage. It is sloped to drain back to the tank or the distribution system after each pump operation.

Sizing of the pump tank is very important.

For example: a 1.5-foot diameter tank contains 1.08 gallons per inch of depth. Thus, in a ten-inch depth, the volume is 10 x 1.08 = 10.8 gallons, less the actual volume of the pump, which is 2.8 gallons. Eight gallons of wastewater will be pumped out with each pump cycle. And if the pipe is allowed to drain back into the tank when the pump is shut off the actual volume of water that reaches the disposal system is less the pipe volume.

A pumping tank of this size should not be installed in a situation where any drainback occurs. For example, if 50 feet of 2-inch force main are used to the distribution the drain back would be 50 x 0.174 = 8.7 gallons. This amount of water would signal the pump to start again the pump would continue to recycle continuously until it eventually burned out.

Shutoff Level

The shutoff level should be above the body of the pump case, to allow the pump to run while completely submerged for more effective cooling than if the pump body were exposed to air. This placement is particularly important in a pumping tank with a large surface area. Also, there may be a small amount of scum on the surface that would tend to stick to the body of the pump if it were periodically exposed.

Care should be taken that the float switch cannot come to rest on top of the pump, thus preventing the pump from shutting off. In such a situation, the pump would continue to run and be damaged from operating dry

Alarm Float

An alarm float should be located on an electrical circuit separate from the pump to alert the homeowner in case of electrical failure in the pump circuit. The alarm float should be set to activate approximately three inches higher than the pump start level. The alarm mechanism should be both visible and audible, and located where it can be easily seen and heard.

The reserve capacity of the tank is the remaining volume after the alarm sounds.

Electromechanical Devices

There should be no electromechanical devices or connections located in the pumping tank or in the dosing chamber cleaning access because of the risk of corrosion at the connections. The electrical plug-ins should be located in a weatherproof enclosure near the pumping tank or located in a nearby building.

It’s a good idea to attach the control wires to a separate pipe or to a plastic rope or chain with an anchor, so that the control wires can be removed without removing the pump. If the pump has failed, it can be removed without disturbing the control wires.

Provide an outlet for the wires through the side of the cleaning access. Consider installing a section of six-inch plastic pipe with a cap alongside the cleaning access to contain the pumping station wires.

All electrical installations must comply with the National Electric Code.

Wiring Pumping Systems

All wastewater distribution systems that utilize a pump require electrical power and control systems. Proper wiring materials and installation procedures are critical to the safety of the installer, the sewage system users, and all individuals involved in future repairs and maintenance. Adequate wiring ensures reliable pump and system performance. Follow a few basic guidelines to ensure safe and reliable operation at a reasonable cost. In all cases, installation procedures must follow the specifications of the U.S. National Electric Code (NEC). Contact local electrical inspection authorities for permits and inspection requirements. A qualified electrical installer should do the work.

Make no electrical connections inside the dosing tank. This includes plug-ins, screw-type, twisted wire, boxes, relays, or any other type of connection that requires movement to connect or operate. If connections or splices must be made, they should be located in a watertight, corrosion-resistant junction box with watertight, corrosion-resistant fittings and a cover sealed by a gasket.

Materials for Outdoor Wiring

Electrically, there is no difference between wiring inside or outside a building. However, the materials and installation procedures are considerably different. Outdoor wiring must be able to withstand exposure to water, weather, and corrosive environments. This is certainly the case for wiring septic system dosing chambers.

Boxes and Panels

Outdoor equipment used in residential wiring must be weatherproof. The two most common types of weatherproof equipment are driptight and watertight, such as NEMA 2,3, or3R. Driptight equipment seals against water falling vertically. Driptight boxes are usually made of painted sheet metal and have shrouds or shields that deflect rain falling from above. These boxes are not waterproof and should not be used where water can spray or splash on the unit. Driptight boxes are usually used for control or circuit breaker panels.

Watertight boxes seal against water coming from any direction. Individual junction boxes, switch boxes and receptacle boxes will usually be of the watertight type. Watertight boxes are designed to withstand temporary immersion or spray streams from any direction. They are commonly made of cast aluminum, zinc-dipped iron, bronze or heavy plastic and have threaded entries for watertight fittings and covers sealed by gaskets.

Wiring Methods

Two methods, or a combination of the two, are common in outdoor wiring. One method is to place electrical wires inside a conduit. The other is to use cable. In either case, protection from physical damage, water, and corrosion must be provided.

Running wires through sealed conduit provides physical, water, and corrosion protection. Several kinds of conduit are acceptable for outdoor use. Rigid metal conduit made from aluminum or steel provides equivalent wire protection. However, aluminum conduit is not recommended for installation where it is directly in contact with soil. Rigid PVC conduit can be used above ground. High-density polyethylene conduit is suitable for underground installation. Do not use thinwall conduit electrical metallic tubing (EMT) for underground or outdoor installations.

An underground feeder cable can be buried without conduit protection, but physical protection for underground cable is highly recommended to reduce the risk of spading through the cable at a later time. A redwood or treated wood board buried just above the cable is highly recommended to provide physical protection. Do not use nonmetallic cable for underground installations. While it is an excellent material for interior wiring, it will not withstand the moisture conditions in the soil.

Combining the conduit and cable wiring methods is also an option. Conduit can be used around cable for physical protection. Conduit is particularly useful to protect cables where they enter and exit the soil. If conduit and cable are used in combination, appropriate connectors and bushings are needed for transitions from one system to the other. Minimum burial requirements apply to wire in conduit and cables. The size of the wire is determined from the electrical need (the motor size) and the length of wire. Figure E-7 gives wire specifications for various lengths and motor ratings.

Pump and Alarm Control Center

The cables that connect to the pump control switch, alarm switch and pump all originate from the pump and alarm control center. The center should either be placed inside a nearby building or inside a weatherproof box on a post near the entrance port to the dosing tank. Never place the control system inside the dosing tank or riser. The moisture in the dosing tank will cause the system to corrode and fail.

The preferred location for the control and alarm center is indoors, such as in a basement or garage. Conventional indoor wiring material may be used. Order pump and controls with extra-long cables.

When a nearby building is not available, locate the control center in a weatherproof enclosure mounted to a treated wood or steel post near the entrance to the dosing tank. In both cases, it is important to use wire, connectors and weatherproof enclosures appropriate for outdoor use.

A pump motor relay with built-in motor overcurrent protection can be used. The pump motor start and stop switches control the relay coil current. Conduit is used for physical protection of the conductors and cables entering and leaving the box.

A pump motor controlled by the mercury switches and relay built into a plug-in type unit is another option. Overcurrent protection for the motor is supplied by the ground-fault circuit interrupter (GFCI)/circuit breaker combination in a weatherproof enclosure. National Electric Code requirements state that all outdoor outlets of a residence must be GFCI-protected. The GFCI-protected receptacle for the pump power and control circuit should be enclosed in a watertight box. Another alternative is to use a receptacle with built-in GFCI protection and a standard circuit breaker. In either configuration, the alarm system is powered from a separate circuit breaker to prevent tripping the alarm circuit when the pump circuit is tripped.

Figure E-7: Wire Lengths for Pump Motor Ratings

Motor Rating		AWG Copper Wire Size					
volts	**hp**	**14**	**12**	**10**	**8**	**6**	**4**
115	1/3	130	210	340	540	840	1300
	1/2	100	160	250	390	620	960
230	1/3	550	880	1390	2190	3400	5250
	1/2	400	650	1020	1610	2510	3880
	3/4	300	480	760	1200	1870	2890
	1	250	400	630	990	1540	2380
	1-1/2	190	310	480	770	1200	1870
	2	150	250	390	620	970	1530
	3	120*	190	300	470	750	1190
	5	0	0	180	280	450	710
	7-1/2	0	0	0	200*	310	490
	10	0	0	0	160*	250*	390
	15	0	0	0	0	170*	270*

2- or 3-wire cable, maximum length in feet, service entrance to motor

*Lengths meet U.S. National Electric Code (NEC) ampacity only for individual conductor 60C cable in free air or water, not in conduit. If cable rated other than 60C is used, lengths remain unchanged, but minimum size acceptable for each rating must be based on the NEC table column for that temperature cable.

Lengths without asterisks meet NEC ampacity for individual conductors and jacketed 60C cable. Flat molded cable is considered jacketed cable.

Maximum lengths shown maintain motor voltage at 95% service entrance voltage, running at maximum nameplate amperes. If service entrance voltage will be at least motor nameplate voltage under normal load conditions, 50% additional length is permissible for all sizes.

Table based on copper wire. If aluminum wire is used, it must be two sizes larger. If table calls for #12 copper, for example #10 aluminum would be required.

Wiring from the Pump and Alarm Controls to the Pump and Switches

The power cable to the pump and float switch cables running from the control center into the tank should be run in conduit (metal or PVC) where physical protection is needed. The area around the conduit entering the tank should be sealed to prevent surface water from entering the tank through the conduit. If the conduit provides a continuous connection between the control center box and the tank, the conduit entrance to the box should be plugged with electrical putty to prevent the movement of moisture and corrosive gases into the control box.

Power cables used in these installations, such as Types SE, SJ or SOW, must be suitable for moist and corrosive environments. The power cable to the pump must have a grounding conductor (usually a green insulated wire) to ground the pump motor frame. Metallic conduit should not be used for equipment grounding to or within the tank. Since the pump is considered a motor load, it must have appropriate disconnecting means. The disconnect for units of one horsepower or greater (circuit breaker or switch) must be clearly marked and either in sight of the pump location or lockable. This prevents inadvertent reactivation of the circuit during servicing of the unit. Below one hp, receptacles and plugs listed for motor loads (hp listed) may be used.

Power Supply to the Pump and Alarm System Control Center

Power to the pump and alarm system control center, when located outside a building, will most frequently be supplied by an underground branch circuit from a nearby service entrance or sub-panel. Follow electrical code specifications for materials and burial depths as described earlier. Avoid routing buried wiring through existing or anticipated gardens or landscaping areas to minimize the chances of damage due to spading.

Power to the control center should be from a single individual branch circuit with no other loads. The circuit breaker or fuse supplying this circuit should be clearly marked at the service entrance location.

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. See Figure E-8.

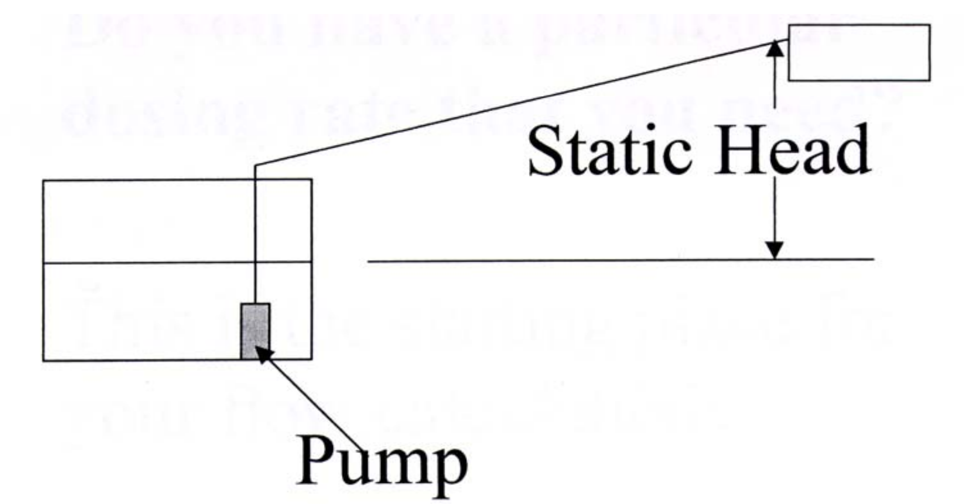


Figure E-8

- 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.

Examples:

15 gpm, 100 ft of 2” pipe Headloss (HL) = 0.48 ft

25 gpm, 100 ft of 2” pipe HL = 1.11 ft

25 gpm, 100 ft of 3” pipe HL = 0.16 ft

In addition the longer the pipe the greater the Headloss.

Examples:

25 gpm, 100 ft of 2” pipe HL = 1.11 ft

25 gpm, 350 ft of 2” pipe HL = 3.88 ft
(this is obtained by multiplying 1.11 x 3.5 = 3.88)

These values come from Figure E-9. There are many types of pipes and schedules of pipe be sure to use the correct chart for the type of pipe used.

Figure E-9: Head Loss Due to Friction in Plastic Pipe (c=150)							
flow rate (gpm)	nominal pipe diameter						
	1”	1.25”	1.5”	2”	2.5”	3”	4”
inside dia. gals/100ft.	1.05” 4.49	1.38” 7.77	1.61” 10.58	2.067” 17.43	2.47” 24.87	3.07” 38.4	4.03” 66.1
1	0.08						
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 fitings. Figure E-10 is used to convert the fittings.

Example: 2" plastic coupling = 3 ft of 2" pipe
2" plastic 90 bend = 9 ft of 2" pipe

Figure E-10: Equivalent Length of Pipe

type of fitting and application	pipe and fitting material[1]	Nominal size of fitting and pipe (equivalent length in feet) 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'
90° standard elbow	steel	2'	3'	3'	4'	4'	5'	6'
	copper	2'	3'	3'	4'	4'	5'	6'
	plastic	4'	4'	6'	7'	8'	9'	10'
standard tee, straight flow thru run	steel	1'	2'	2'	3'	3'	4'	5'
	copper	1'	2'	2'	3'	3'	4'	5'
	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.

- 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:

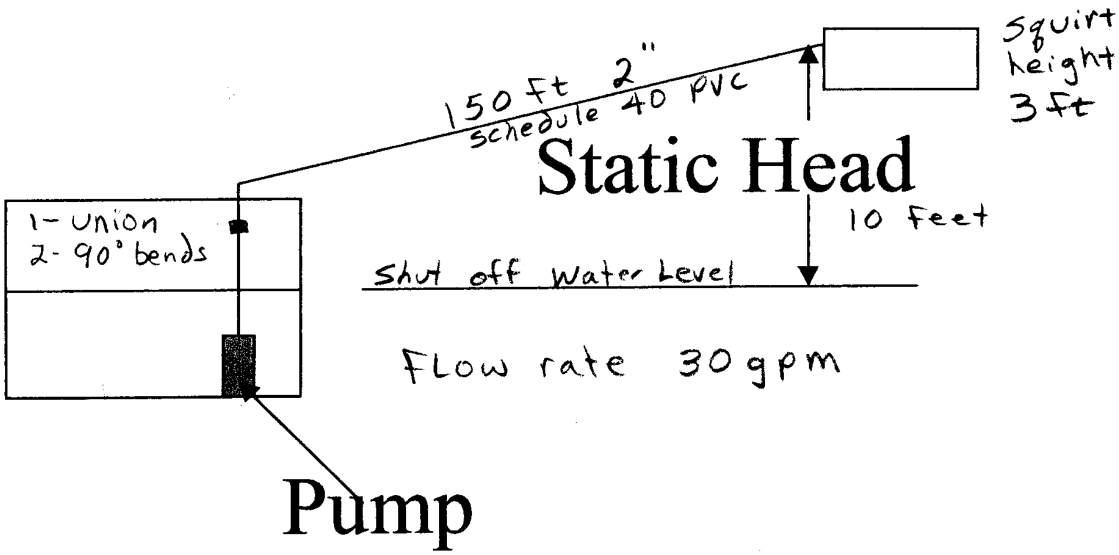


Figure E-11

Flow rate required 30 gpm

Static head		=10 ft
Squirt height		= 3 ft
1-2"coupling	= 2x3	= 6 ft ft
2-2" bends	= 2x9	= 18 ft
		= 150 ft pipe
Total pipe equivalent length		= 174 ft.

From Figure E-9 30 gpm in 2"pipe HL is 1.55 ft per 100 feet
Headloss due to pipe and fittings is 1.55 x 1.74 = 2.70 ft
Therefore the total head that the pump needs to produce is

Elevation difference	= 10 ft
Squirt height	= 3 ft
Pipe losses	= 2.7 ft

Total Dynamic Head = 15.7 ft at 30 gpm
At different flow rates there will be different head losses. When these are calculated and plotted on a graph this is called a **system curve**. This is the flow vs headloss for a given pipe system.

From the example above the system curve is

At 20 gpm 14.2 ft	At 30 gpm 15.7 ft
At 40 gpm 17.6 ft	At 50 gpm 20 ft
At 60 gpm 22.7 ft	

A system of pipes, fittings, static head, squirt height can ONLY operate on its system curve.

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. See Figure E-12.

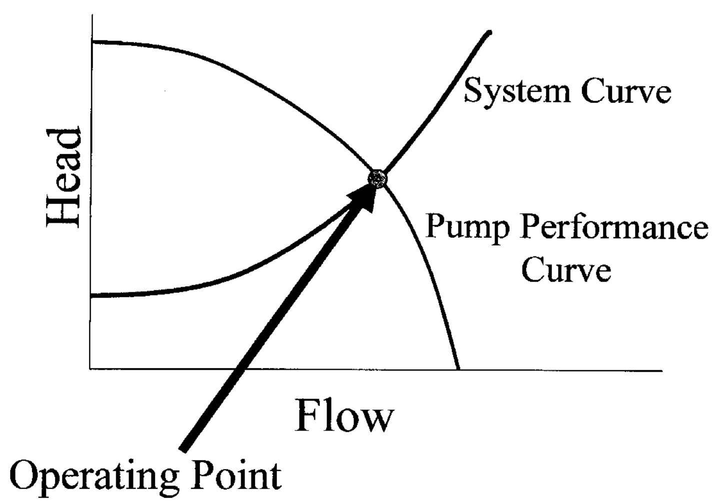


Figure E-12

The pump curve can not be below the operating point that you want the system to operate at. Pick a pump and pump curve that is as close to the operating point but above the point as possible.

Plotting each of these on pump curves reveals the following in Figure E-13. If these were the only pumps available then a decision must be made on which pump to use.

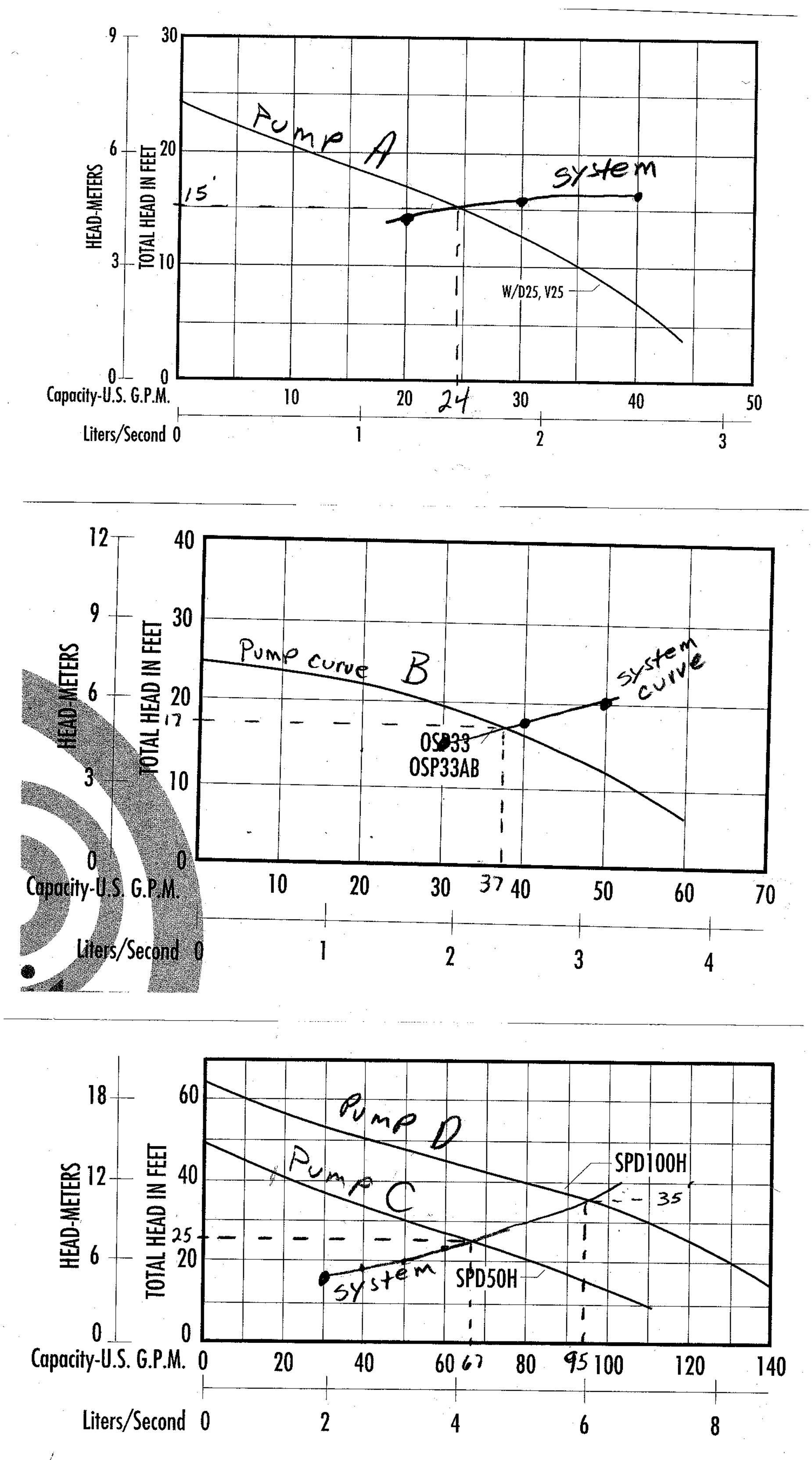
Pump A only produces 15 feet of at 24 gpm which is below the required. This pump should be rejected.

Pump B will provide 17 feet at 37 gpm. This will exceed the minimum by a small amount and will work.

Pump C will provide 25 feet at 67 gpm. This far exceeds the needs of the system, and is rejected

Pump D will provide 35 feet at 95 gpm. This far exceeds the needs of the system, and is rejected.

Pump B should be selected for the job.



Pump A
system
15'
W/D25, V25
HEAD-METERS
TOTAL HEAD IN FEET
Capacity-U.S. G.P.M.
Liters/Second
24
Pump curve B
system curve
17
37
OSP33
OSP33AB
Pump D
Pump C
SPD100H
35'
25
system
SPD50H
67
95

Figure E-13

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. Ask the dealer or the manufacture for assistance in designing the system they are more than glad to help.

Look for booklets on sizing and trouble shooting pump systems they are very helpful.

A good example is the

THE PROBLEM SOLVER, By STA-RITE call 800-525-6090

PART II: PRESSURE DISTRIBUTION SYSTEMS

This section examines the dosing chamber and distribution system that conveys the septic tank effluent to the secondary treatment system for treatment and disposal. The discussions on design and construction are intended to enable health officials and contractors to design, construct, and inspect pressure distribution systems.

Use pressure distribution for all mounds, at-grade systems, recommended for sand filters.

Uniform Distribution

Septic tank effluent is distributed through a series of perforated pipes. **Uniform distribution** of the septic tank effluent in the above-mentioned situations is very important. Uneven distribution of effluent can result in localized overloading and the system may fail.

Uniform distribution is achieved using a pressure distribution system. Pressure distribution systems are carefully designed so that the volume of septic tank effluent flowing out of each hole of the distribution pipe is **nearly identical**. The pipe diameters and hole diameters must be carefully sized to achieve uniform distribution.

Pressure distribution systems consist of five components:

- lateral pipes with holes drilled into the pipe,
- manifold and main connected to the laterals,
- dosing tank to collect septic tank effluent to be pumped to the treatment system,
- pump or dosing siphon to pressurize the system, and
- controls and power supply to operate the pump.

Steps to design and construct these components will be presented in this section. The following is a paper by Jim Converse on how to design a pressure distribution system.

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.

---

[1]James C. Converse, Professor, Biological Systems Engineering, University of Wisconsin-Madison. Member of Small Scale Waste Management Project.

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.

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° 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)

$= (6\ ft^2 \times 2) / (4\ ft)$
$= 3$ 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

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)	(gpm)	(ft)	(ft)	(ft)	(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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Sump and Sewage Pump Manufacturers Association. 1998. Recommended guidelines for sizing effluent pumps. P.O. Box 647 Northbrook, Il 600065-0647.

Wisconsin Administrative Code. 1999. Pressure distribution component manual for private onsite wastewater treatment systems. Department of Commerce, Safety and Building Division, Madison, WI.

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 were calculated as: gpm = 11.79 x d^2 x $h^{1/2}$ 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					
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					11.91	1.66	
90					14.81	2.06	
100					18.00	2.50	0.62
125					27.20	3.78	0.93
150						5.30	1.31
175						7.05	1.74

Velocities in this area are below 2 fps.

Velocities in theses areas exceed 10 fps, which is too great for various flows and pipe diameters

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
90° STD Elbow	7.0	8.0	9.0	10.0	12.0	14.0
45° 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

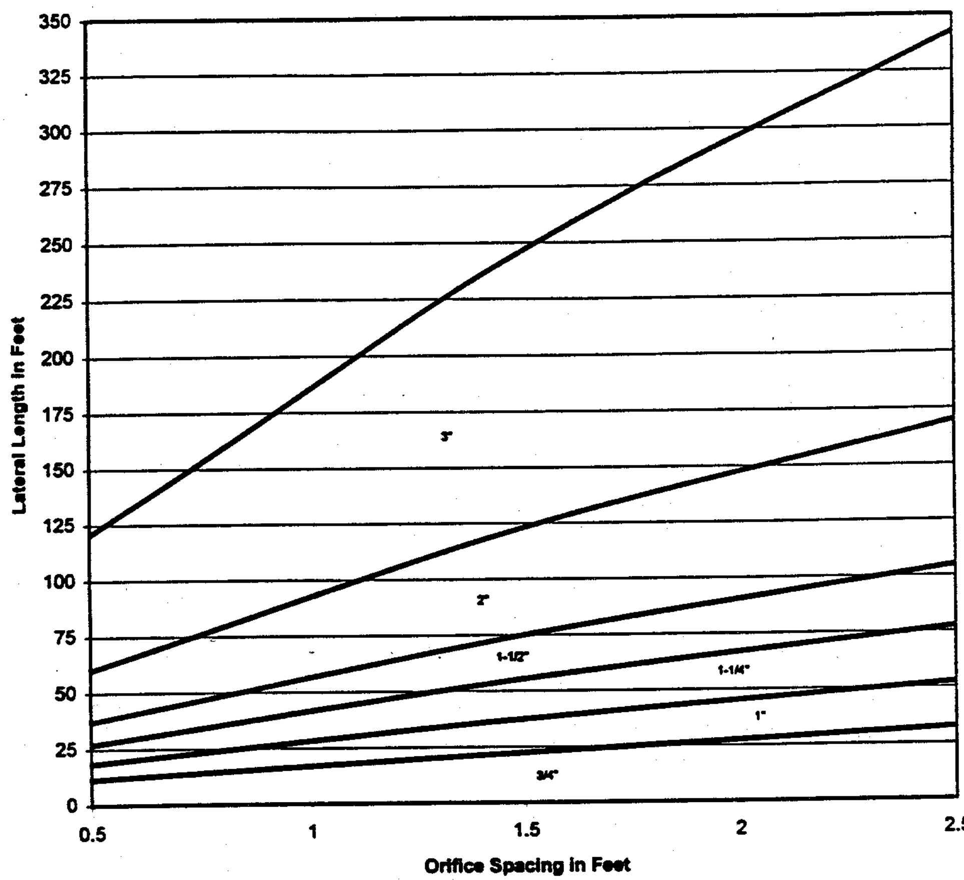

Fig. A -1a. Minimum lateral diameter based on orifice spacing for 1/8 in. diameter orifices (Wisc. Dept. Of Commerce, 1999b).

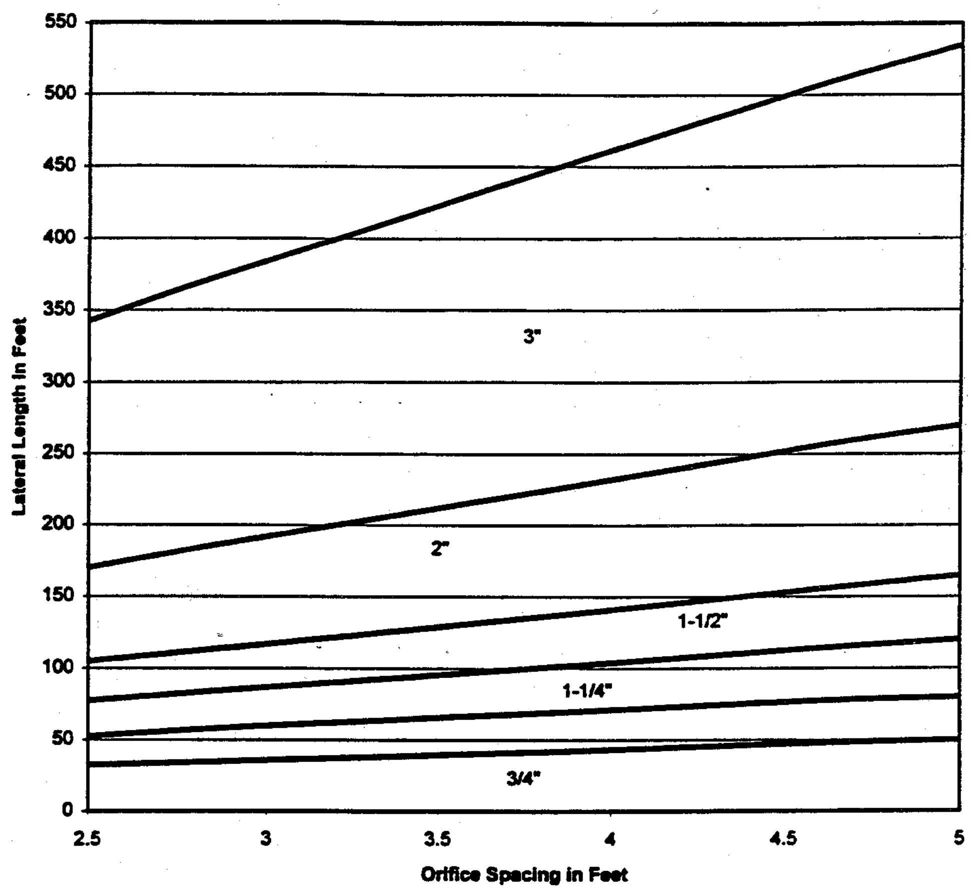

Fig. A -1b. Minimum lateral diameter based on orifice spacing for 1/8 in. diameter orifices (Wisc. Dept. Of Commerce, 1999b).

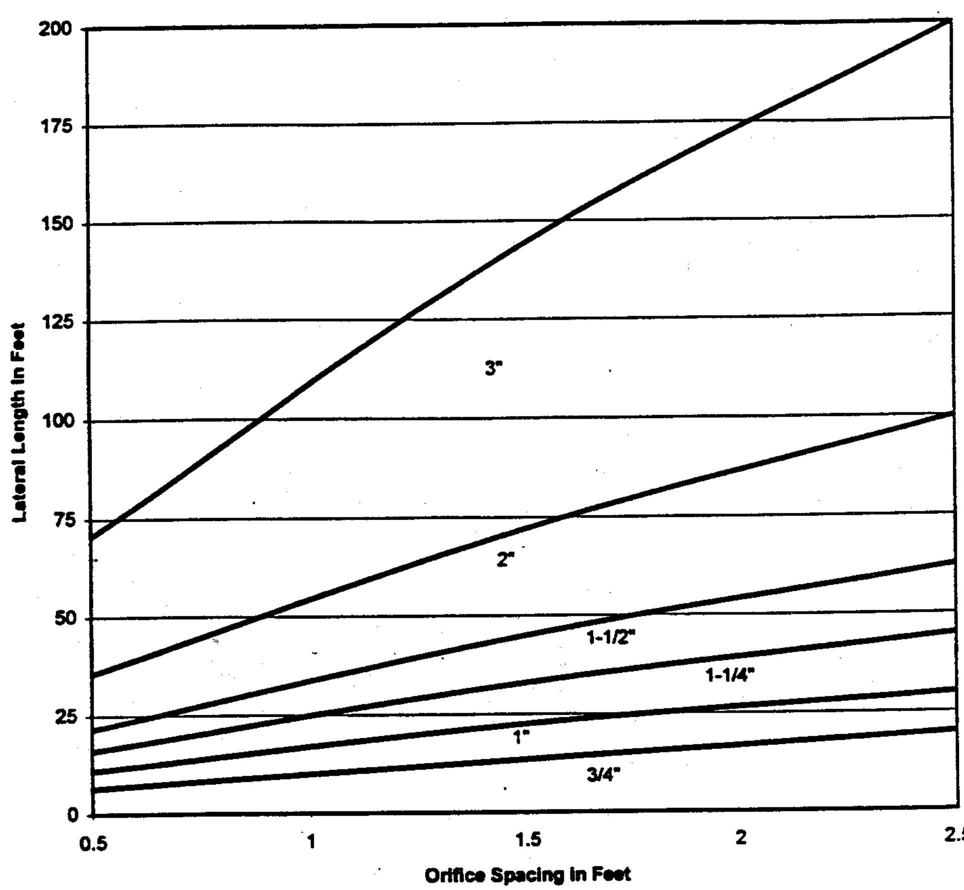

Fig. A -2a. Minimum lateral diameter based on orifice spacing for 3/16 in. diameter orifices (Wisc. Dept. Of Commerce, 1999b).

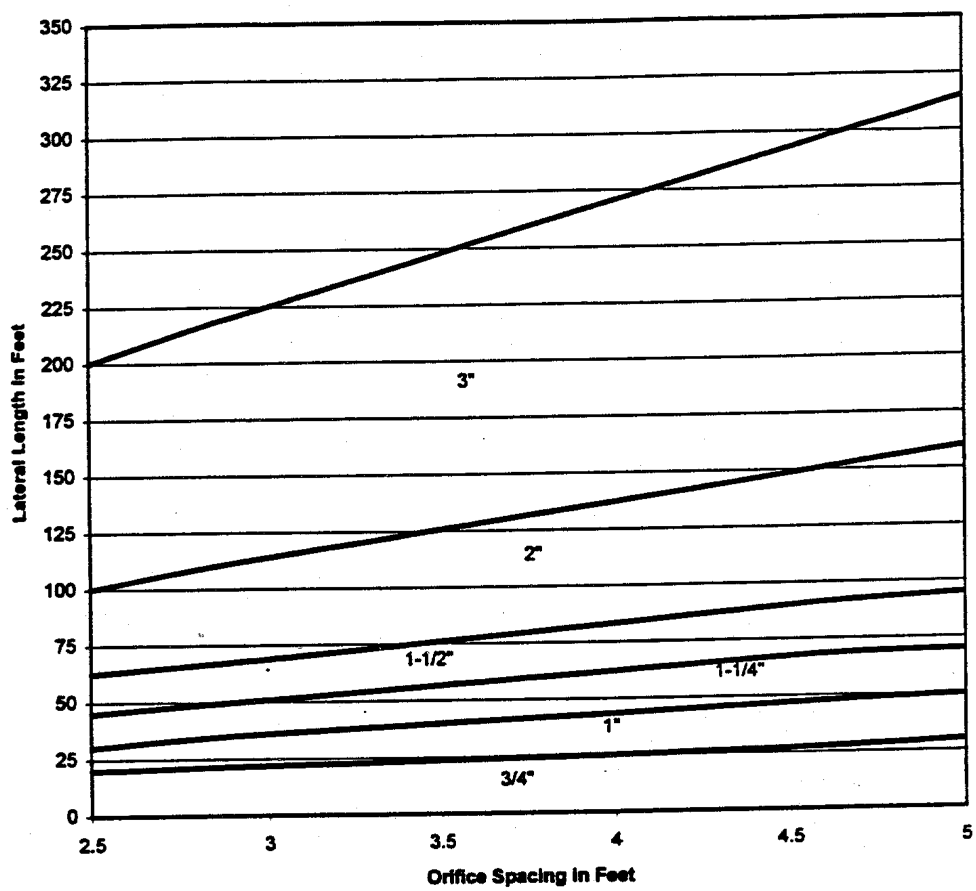

Fig. A -2b. Minimum lateral diameter based on orifice spacing for 3/16 in. diameter orifices (Wisc. Dept. Of Commerce, 1999b).

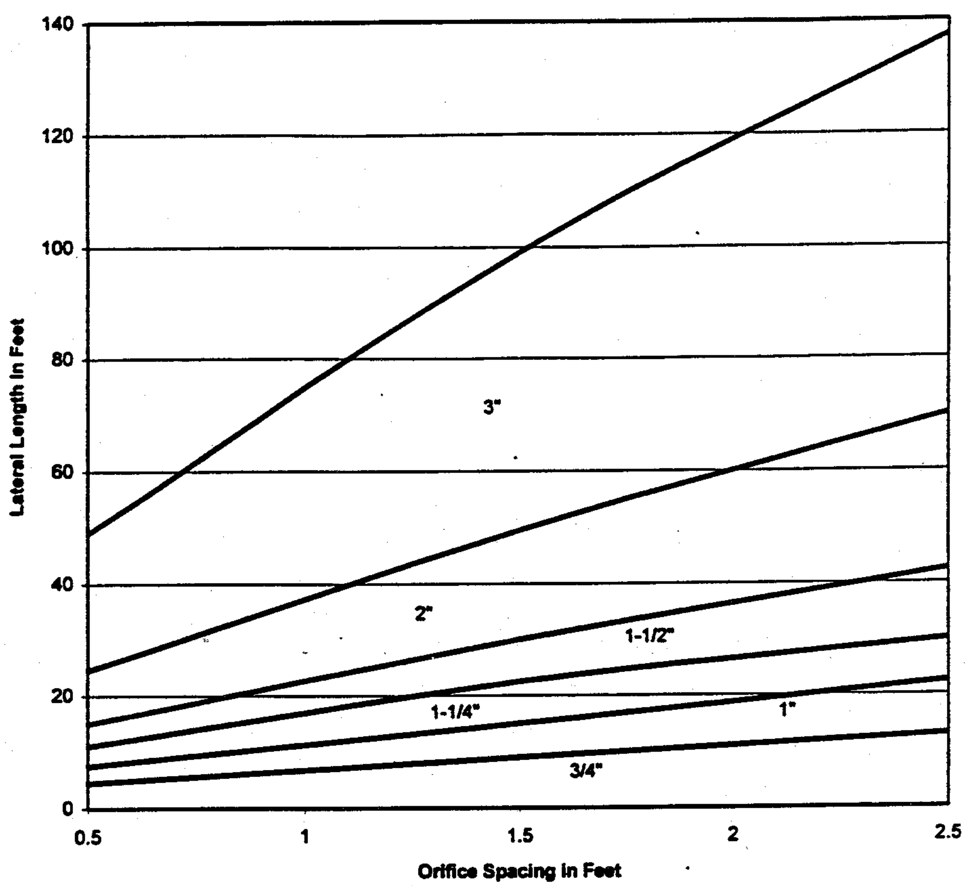

Fig. A -3a. Minimum lateral diameter based on orifice spacing for 1/4 in. diameter orifices (Wisc. Dept. Of Commerce, 1999b).

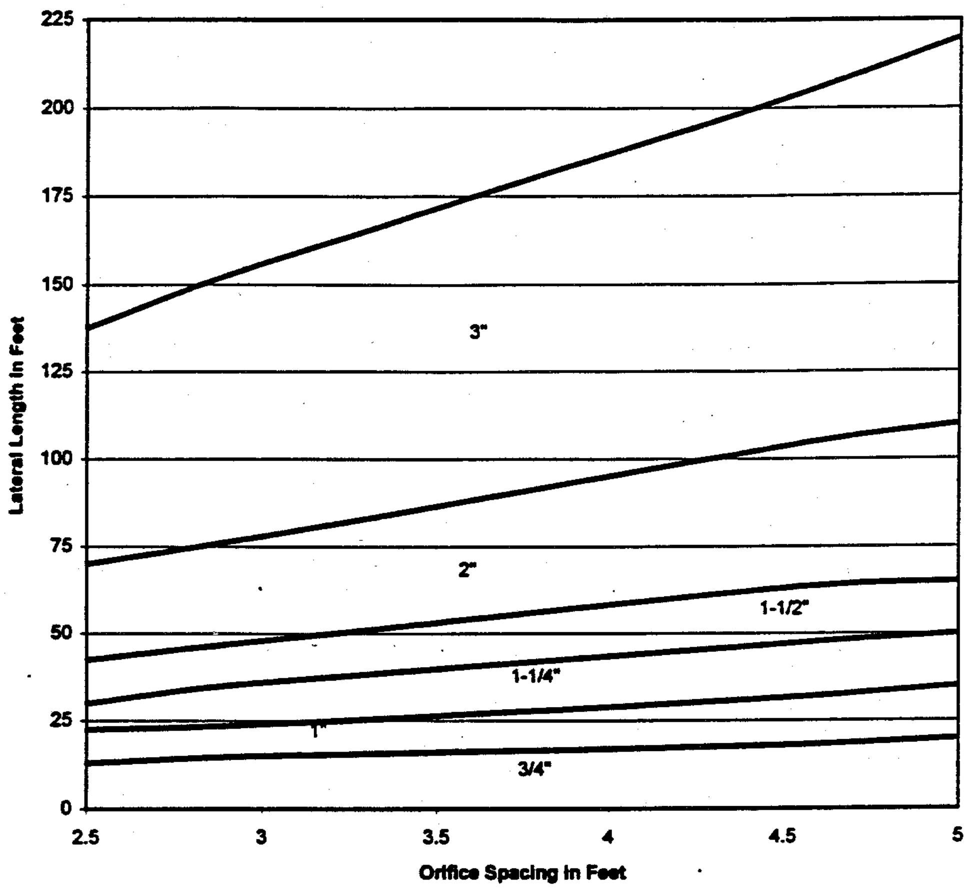

Fig. A -3b. Minimum lateral diameter based on orifice spacing for 1/4 in. diameter orifices (Wisc. Dept. Of Commerce, 1999b).

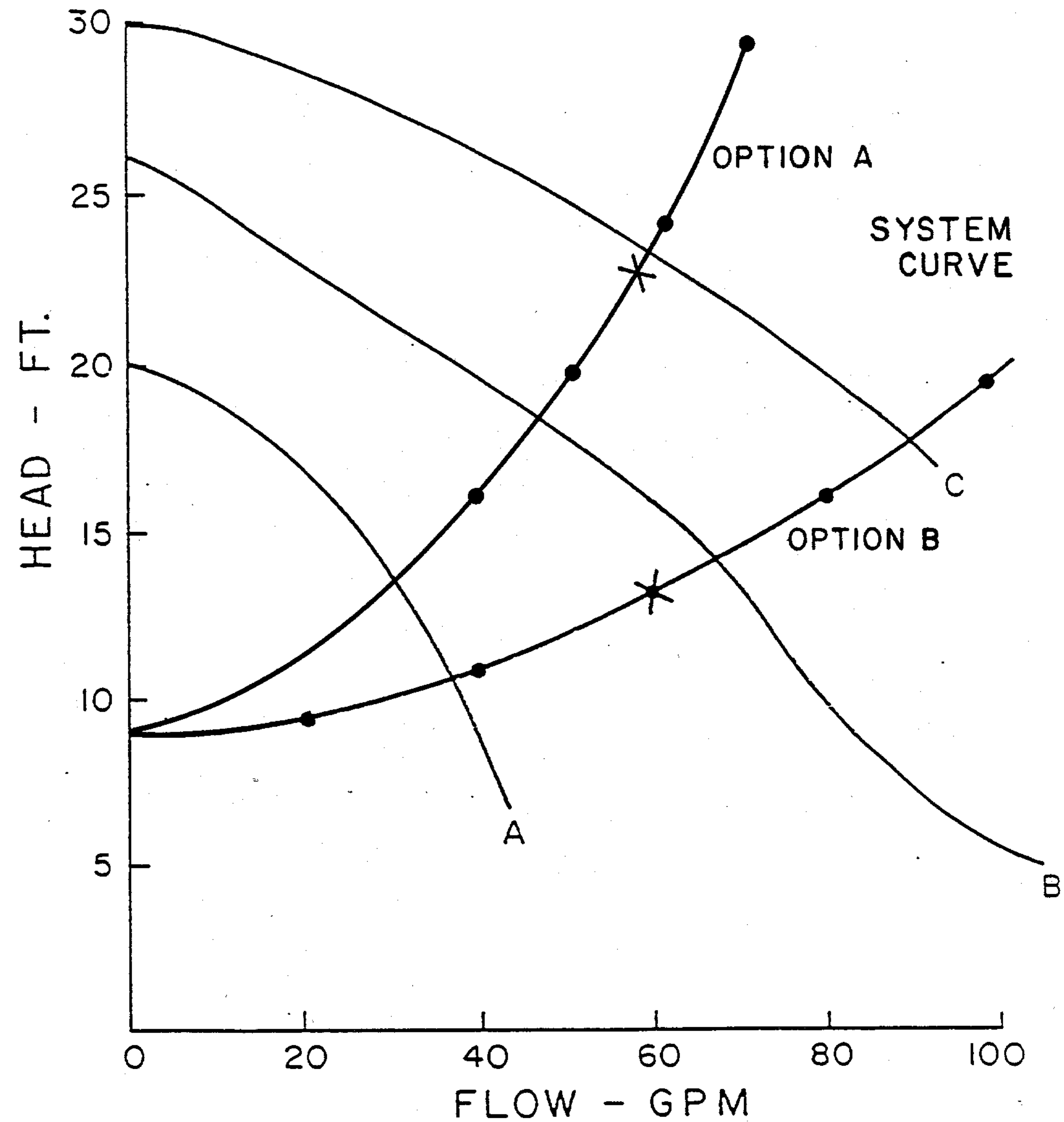

Fig. A-4 System performance curve and several pump performance curves for the example problem. For this example, the pump must provide a flow of at least 60 gpm (represented by X on the system performance curve. Pump A, represented by performance curve A, will not provide it. Pump C exceeds the requuirmements considerably and the curves interesect near the end of the pump curve. Pump B is the correct pump to select as it is just slighly above the desired point (X) and it is toard the middle of the pump curve.

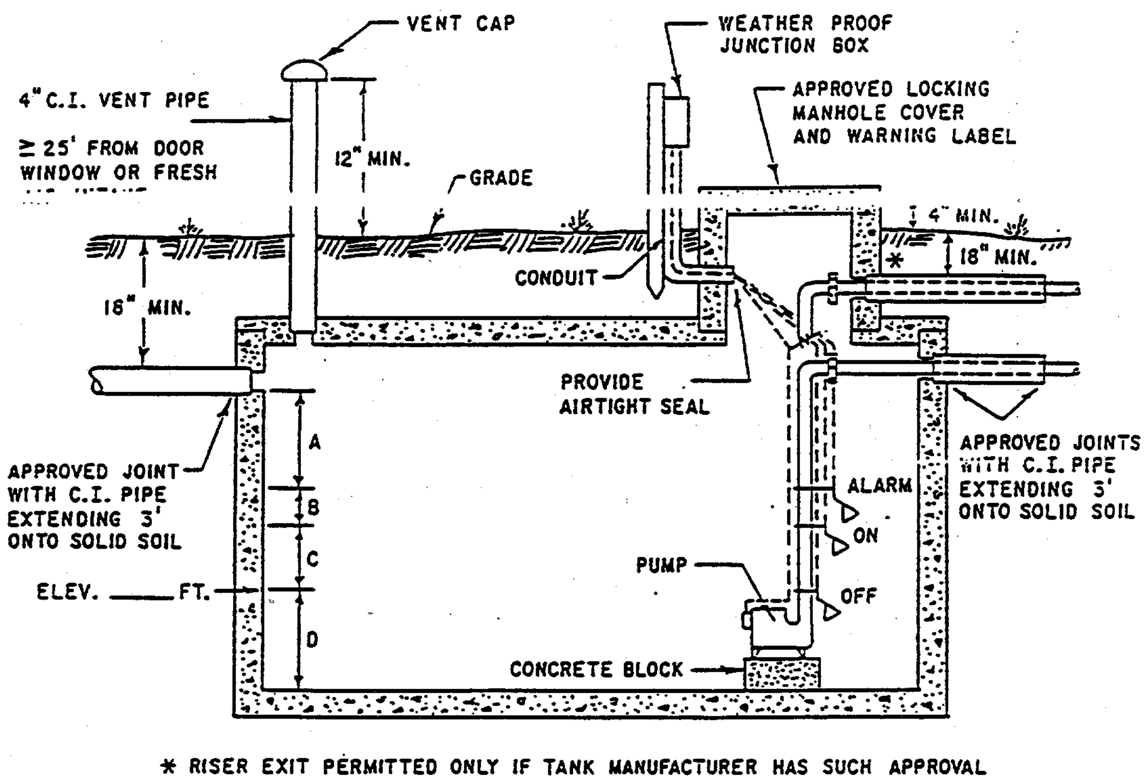

Fig. A-5. Cross section of a dose chamber with pump and floats. There are other examples available. Make sure it meets code.

PART III: DOSING SIPHONS

Another method of pressurizing the distribution system is by using a dosing siphon. The following paper by Eric S. Ball, P.E., discusses the design, use, and installation of dosing siphons.

Design, Use and Installation of Dosing Siphons for On-site Wastewater Treatment Systems

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Introduction

Automatic dosing siphons are nothing new. They've been used for 100 years or more to flush livestock yards, in sewage treatment plants to dose trickling filters, and to dose recirculating sand filters. What is new is that as increases in suburban and rural populations have spurred development of innovative and alternative wastewater management methods, dosing siphons have become commonplace in single family and small community systems where they are used to dose gravity and pressurized drainfields as well as sand filters.

Dosing siphons are useful devices for dosing fixed, finite volumes of liquid at flow rates ranging from a few gallons per minute to several hundred gallons per minute. In on-site wastewater systems, siphons are especially useful in converting small, continuous flows into large intermittent dosing flows. Modern siphons are made of corrosion resistant materials, have no moving parts, require no power source, are easy to install, and require very little maintenance. They are a cost-effective alternative to pumps in many situations, especially in remote areas and other sites where electricity is difficult to obtain.

One criterion must be met in any siphon system: the area to be dosed must be downhill from the dosing tank. A siphon will discharge only to a lower elevation.

Basic Siphon Operation

Nomenclature

An automatic dosing siphon has two main components—the bell and the trap (Figure 1). The bell includes the bell housing itself, a vertical inlet pipe, an intrusion pipe, and a snifter pipe. The trap includes a long leg, a short leg, and a discharge fitting with an air vent. Depending on the siphon drawdown, the trap may be outfitted with an external trigger trap. The bell and trap are connected with threaded fittings.

Revised 8/9/96

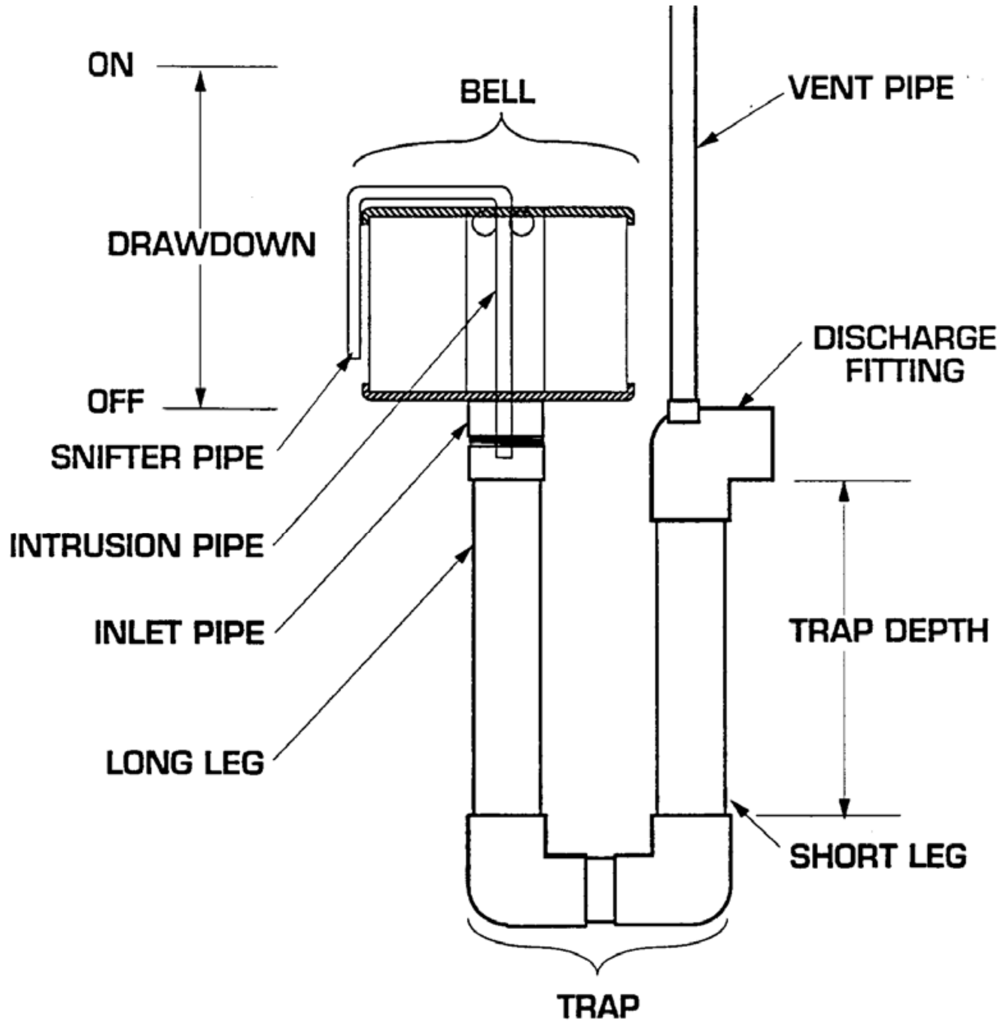
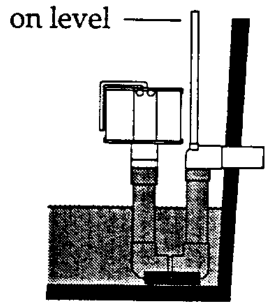


Figure 1: Siphon Nomenclature

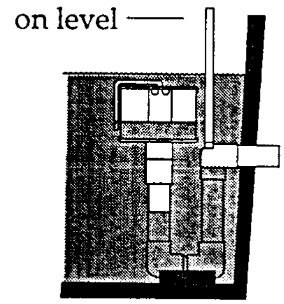
Single Siphon Operation

Following installation in a tank, a siphon must have its trap(s) filled with water. When fluid rises above the open end of the snifter pipe, air is sealed in the bell and long leg of the siphon. As the fluid in the tank rises further, the pressure on the confined air increases and forces water out of the long leg of the trap. Once the pressure is great enough to force all the water out of the long leg, the trapped air escapes through the short leg to the air release vent pipe. At this point, the siphon has been "tripped" and fluid is discharged from the siphon until the liquid level in tank drops tó the bottom of the bell. Air is then drawn under the bell which "breaks" the siphoning action and the process begins again. Figure 2 shows one complete cycle of a single siphon. At the end of a dosing cycle, incoming flow may seal off the bottom of the bell before the bell is fully recharged with air. The snifter pipe, with its open end an inch or more above the bottom of the bell, allows a full recharge of air beneath the bell at the end of each cycle. Because the end of the snifter pipe is the elevation at which air becomes trapped under the bell, shortening or lengthening the snifter pipe is an effective way to increase or decrease the "on"

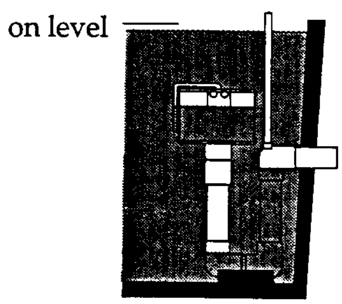
or "trip" level of the siphon. There are limits, however, to the amount of adjustment allowable. Installers should consult the siphon manufacturer before altering the length of the snifter pipe.



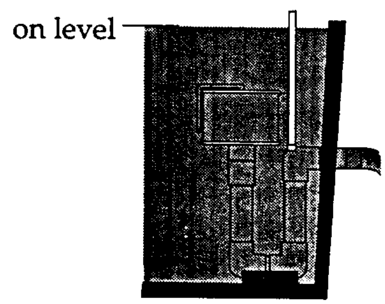
2a. Trap must be primed (filled with water) prior to raising liquid level above bottom of snifter pipe.



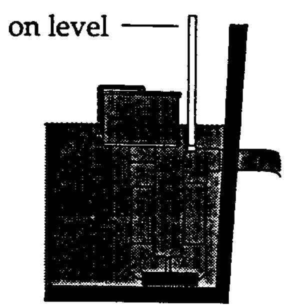
2b. Water is discharged from long leg as water level rises above snifter pipe.



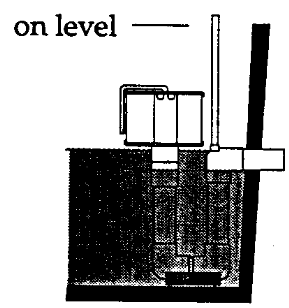
2c. Just before triggering, water level in long leg is near bottom of trap.



2d. Siphon is triggered when air is vented through vent pipe.



2e. Siphon continues to dose until water level drops to bottom of bell.



2f. Air under bell "breaks" the siphon. Snifter pipe ensures full recharge of air under bell.

Figure 2

Some siphons require an additional mechanism called a trigger trap to exhaust all of the air from under the bell at the beginning of the cycle. Whether or not a siphon requires a trigger trap depends on several variables: bell diameter, bell height, trap diameter, and the height over the bell at which the siphon activates. For a given bell configuration, it is determined mathematically and experimentally whether a trigger trap is necessary. The trigger trap actually starts the siphon cycle.

Siphons needing trigger traps typically have relatively short drawdowns as compared to the siphon diameter and thus have lower available driving head to exhaust air. Without a trigger trap, the full volume of trapped air fails to exhaust and the siphon goes into what is called a drooling, or trickling mode. In this mode—with some air still trapped under the bell—the water level has risen inside the bell above the intake of the inlet pipe and liquid is exiting the siphon at a fraction of the full siphon discharge rate. Absent a true siphoning effect, the water level in the tank will not drop below the level of the inlet pipe's intake. Since this intake is above the bottom of the snifter pipe, the siphon cannot be recharged with air and will continue to operate indefinitely in a trickling mode.

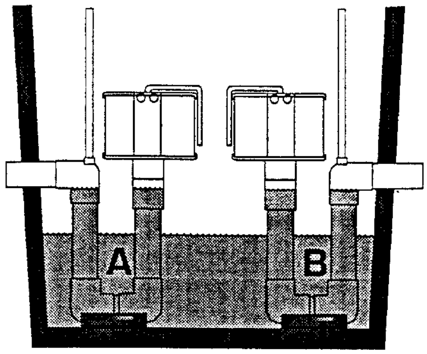
It is possible to force a siphon that should have a trigger trap (but doesn't) into seemingly working properly by filling the tank very quickly. This rapid filling provides extra driving head to force all the air out of the bell. However, most tanks with an installed siphon fill much slower than this rapid rate. A recent study has shown poorly designed siphons (needing trigger traps) to be a primary cause of failures in the field. Coincidentally, the same circumstance—filling the tank too rapidly at the end of a dosing cycle—can also cause a properly designed siphon to go into a trickling mode. In this case, water is entering the tank so fast that the snifter pipe is sealed before the bell is fully recharged with air.

Alternating Siphons

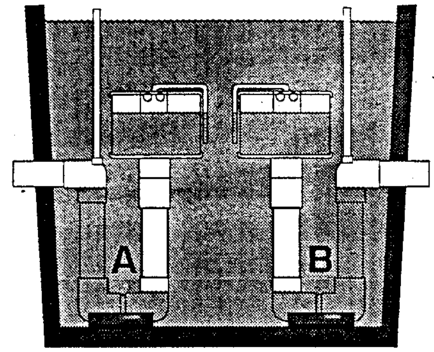
Two identical siphons, installed in a single chamber at the same elevation (Figure 3), will alternate automatically. Because of slight variations in dimension and/or slight variations in the elevation of the two bells, one of the two siphons will trigger first. The siphon that triggered first will end the first dosing cycle with its trap full. The siphon that didn't trigger will have lost much of the water in its trap at the end of the first dosing cycle. When the tank fills up a second time, the second siphon will trip first since its trap is only partially full and requires less pressure to trip. The third time the tank fills up, the first siphon, with its trap only partially full, will trip first. This alternating process will repeat itself indefinitely. In Figure 3, the on level of the first cycle will be a distance H' above the bell. All subsequent cycles will operate at height H, since all cycles after the first are triggered from a partially full trap. For most siphons, H is approximately one inch lower than H'.

Multiple Sequencing Siphons

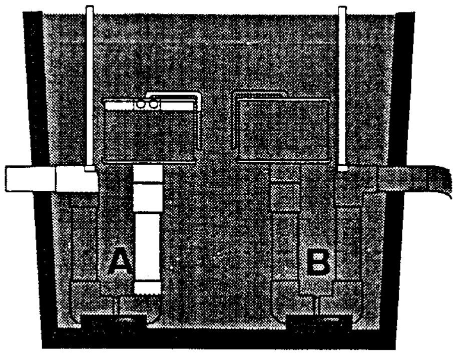
Near the turn of the century, several methods were designed to alternate three, four, or more siphons to dose sewage. These include various types of sequencing starting bells and other mechanical devices. Now, electrical or air operated solenoid valves are also used. However, troubleshooting and maintenance of multiple sequencing siphon systems can be difficult. There are simpler, more reliable ways to design systems that avoid multiple sequencing siphons. These include flow splitting devices prior to any number of single or alternating dosing siphons.



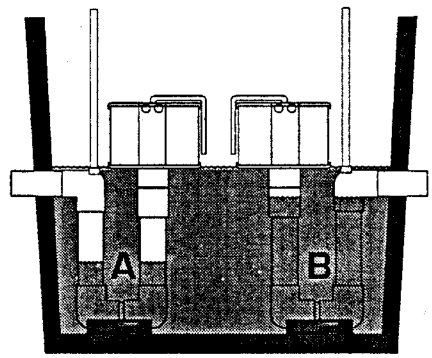
3a. Alternating siphons with traps primed prior to first cycle.



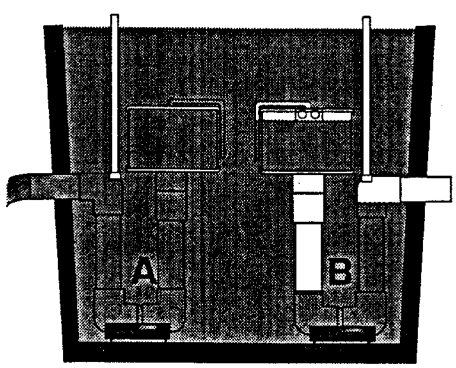
3b. Water is discharged out of the long leg of both siphons as the water level rises in the tank above the snifter pipe.



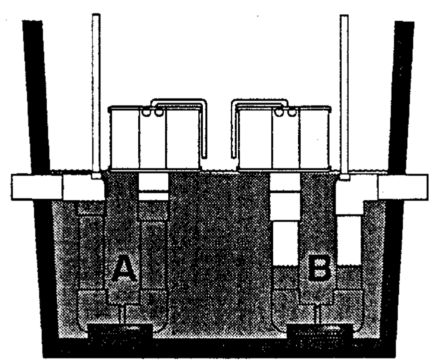
3c. Because of slight variations in the two siphons, one (siphon B in this example) triggers before the other.



3d. End of first cycle - siphon that didn't trigger (A) has partially full trap.



3e. Siphon A, needing less pressure on its partially full trap, triggers the second cycle.



3f. End of second cycle - siphon B now has partially full trap and will trigger next.

Figure 3

Siphon Sizes

The size of a siphon refers to the diameter of its trap. Siphons are most commonly

available in diameters from two inches to eight inches. Common drawdowns may range from four to 48 inches. Most manufacturers use three digit model numbers. The first digit refers to the siphon's diameter and the last two digits indicate the drawdown. A model 324, for example, designates a three inch diameter siphon with a 24 inch drawdown. Custom siphons can be built with virtually any diameter and drawdown.

Siphon discharge flow rates are normally given in gallons per minute (gpm) in one or all of the following forms: maximum flow rate, minimum flow rate, and average flow rate. These flow rates are measured at open discharge and thus do not include transport pipe friction losses or head losses due to trapped air. As discussed later, pressurized systems are usually designed using a flow rate somewhat below the average flow rate of the siphon.

Installation Configurations

Siphons can be installed in virtually any type of tank, basin, or reservoir that holds a fluid. In wastewater systems, siphons are installed most often in concrete or fiberglass dosing septic tanks ranging in size from 500 to several thousand gallons. They also may be installed in smaller basins ranging in size from about 50 gallons to a few hundred gallons. Basins are commonly constructed of concrete, fiberglass, PVC, or polyethylene.

For small flow rate systems (30 gpm or less), the most cost-effective installation is a two inch siphon mounted in a screened vault which is placed directly in a single compartment septic tank (Figure 4), so that a second dosing tank or chamber is not required. Two inch vault-mounted siphons may also be installed in compartmented septic tanks or separate dosing tanks. This type of siphon suspends from the top of the tank and is easily removed for cleaning and maintenance of both the

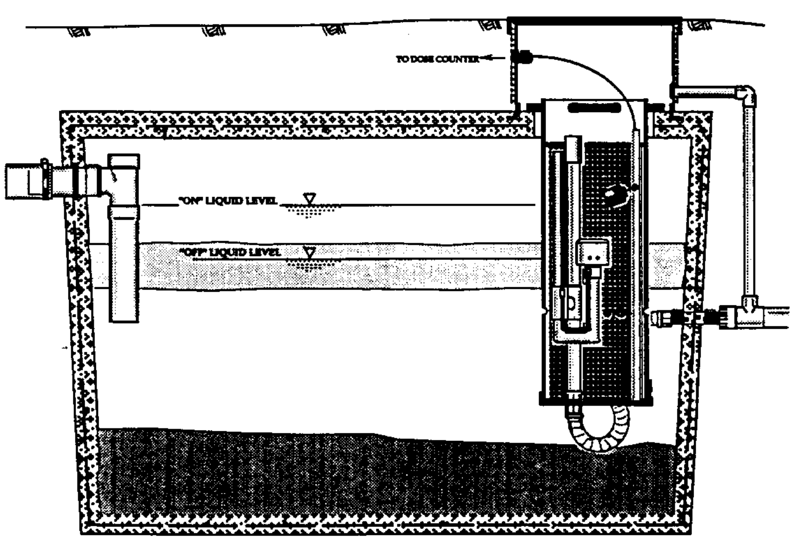


Figure 4: Single Compartment Dosing Tank

siphon and the tank.

Systems that are designed for flow rates greater than 30 gpm require a three inch or larger siphon installed in a compartmented septic tank or separate dosing tank (Figures 5 & 6). Three inch and larger siphons are located in the tank with the bottom of the trap positioned in one of three places: above the bottom, on the bottom, or through the bottom of the tank (Figures 6,7, & 8). Placement depends on the dimensions of the tank and siphon and the desired trip level. The two most common methods of installation are bolt-in-place and cast-in-place. If the trap of the siphon does not need to extend beneath the bottom of the tank, either method may be used. A fiberglass bolt-in bracket is simplest, quickest, and most cost effective in this situation (Figures 5 & 6). If the trap of the siphon needs to extend below the bottom of the tank (Figure 7), the cast-in method must be used. Installations through the tank floor are more difficult and time consuming than other methods.

Filtering

Regardless of the type of siphon or method of installation, filtering the effluent before it reaches the siphon is required. A filter helps protect the performance of the siphon, the distribution network, and the disposal area. A key benefit of filtering is keeping the siphon's snifter pipe clear. If blockage, even momentary, of the

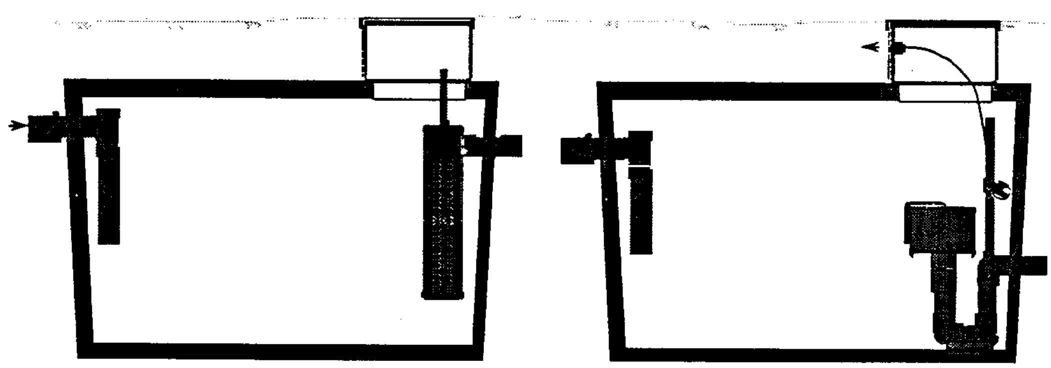


Figure 5: Bolt-In method of installation in a single compartment dosing tank

snifter pipe occurs during the end of the discharge cycle, the siphon may cease to operate and fail in a trickling mode. Momentary blockage may be caused by floating debris that subsequently floats away or disintegrates, with the result that the siphon ceases to function <u>for no apparent reason</u>. Three methods of filtering are used: a screened vault (two inch siphons only), an outlet filter installed in a tank or chamber prior to the siphon chamber (Figure 5), or a screen that surrounds the siphon itself (Figure 6). For siphons three inch and larger, the preferred method of

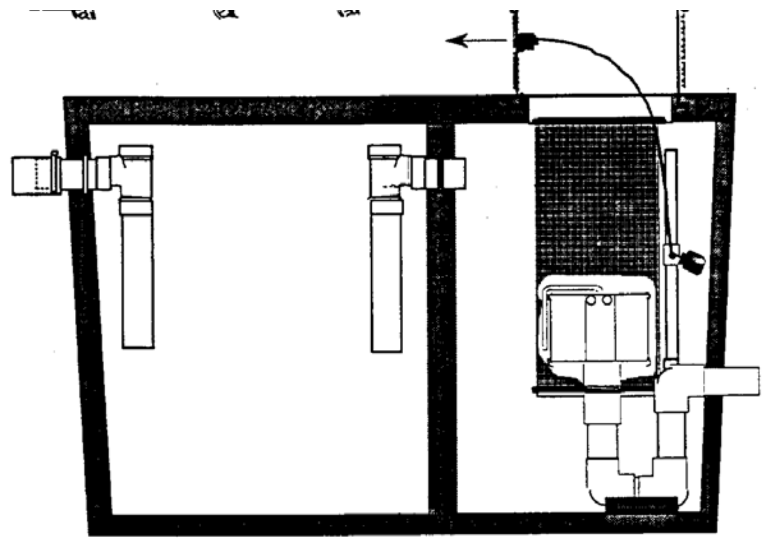


Figure 6: Bolt-In method of installation in a two compartment dosing tank

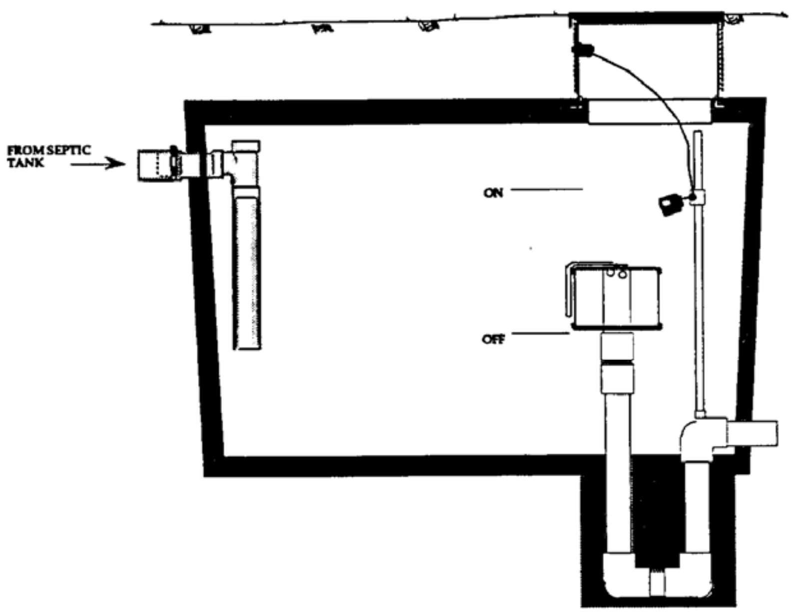


Figure 7: Cast-In method of installation (through tank floor)

filtering is the outlet filter.

Siphon Applications

In on-site treatment systems, siphons commonly discharge to gravity or pressurized drainfields. Distribution to gravity drainfields is done most effectively by directing the siphon discharge to a Hydrosplitter. Pressurized by the siphon, a Hydrosplitter distributes flow evenly to each individual trench. Flow can be split unevenly (with the use of flow control orifices in the Hydrosplitter) to accommodate differing trench lengths. A siphon can also discharge into common drop and distribution boxes. The flow rate of the siphon is usually not as critical when discharging to a gravity box as it is when discharging to a Hydrosplitter. On a system using a

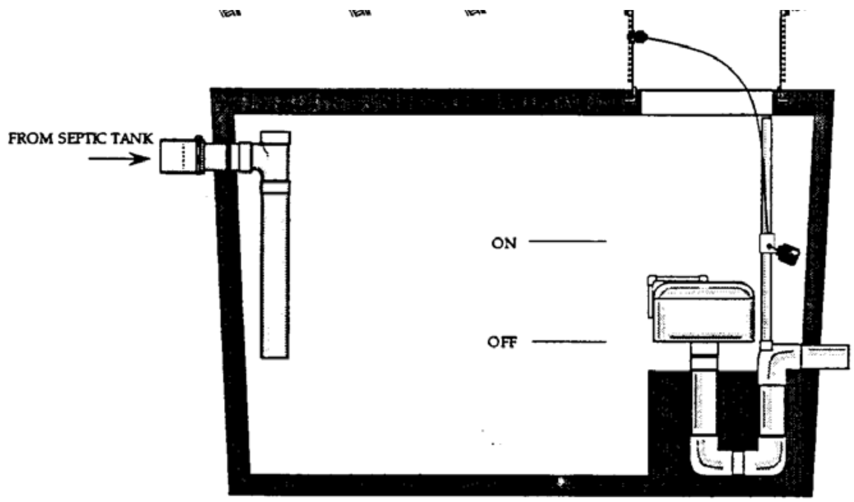


Figure 8: Cast-In method of installation (above tank floor)

Hydrosplitter, the flow rate of the siphon must be matched with the flow control orifices so that when the siphon discharges, the transport line will backfill to a height to provide pressure at the Hydrosplitter.

Sizing siphons for pressurized drainfields is similar to sizing those with Hydrosplitters in that the discharge rate of the siphon must be large enough to cause the transport line to backfill. The pressure at the orifices (squirt height) is created by the vertical elevation (static head) of the backfilled portion of the transport line as shown in Figure 9.

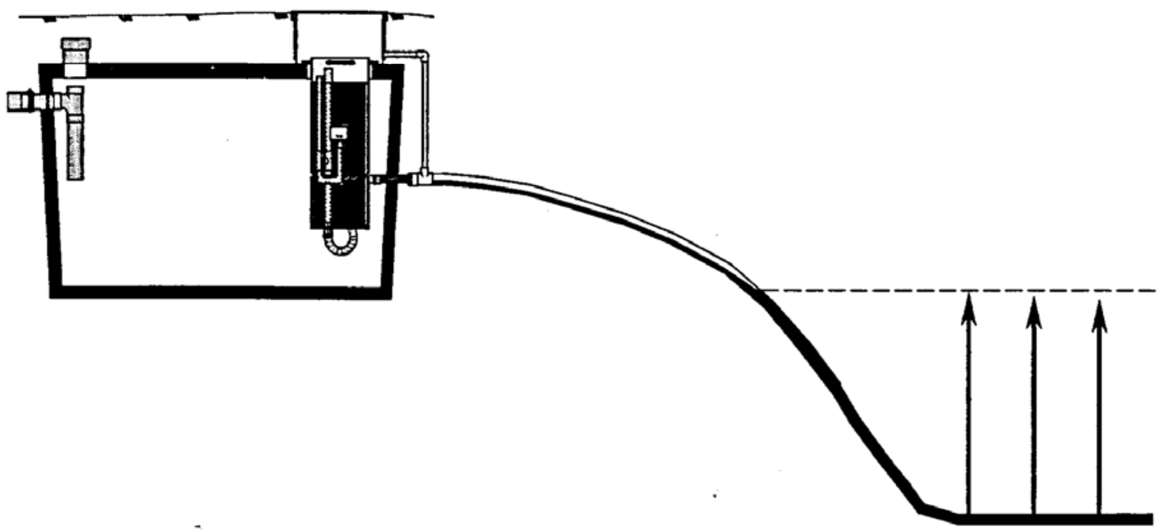


Figure 9: Squirt height relationship to transport line

Siphons are regularly used in septic tanks to dose intermittent sand filters. A two inch siphon may also be installed in a sand filter collection basin. If siphons are used for both functions, a complete sand filter system with pressure dosed drainfield can be installed with no power required. Of course, this is limited to a fairly

well sloped site since there must be fall from the septic tank to the top of the sand filter and from the bottom of the sand filter to the disposal field.

A siphon may be discharged to a flow splitter basin to divide large flows. Similar to Hydrosplitters, flow splitter basins are adapted to higher flow rates and are more versatile for field adjustments and maintenance. A siphon discharging to a flow splitter basin that feeds several tanks with alternating dosing siphons is a method that can be used to avoid multiple sequencing siphons for large disposal fields.

Effluent pumps may be used effectively in conjunction with dosing siphons. For example, a disposal field requires a high flow rate to pressurize it, but it's at a higher elevation than the dose tank. Instead of a large horsepower pump in the dose chamber, a small, easy to maintain effluent pump might be used to transport effluent to a second higher-elevation dosing tank containing a high flow-rate siphon. Pump/siphon combinations are also useful for disposal fields that are far from the collection point. A small effluent pump can be used to pump the effluent in a small diameter PVC line to a tank with a dosing siphon. This eliminates the need for large diameter transport lines capable of handling the dosing flow rate.

Siphon System Design

To gravity drainfields (without Hydrosplitters), the flow rate is usually not critical. Therefore, the following discussion refers mainly to pressurized systems. The details involved in achieving ideal transport line conditions, however, are applicable for all siphon and pump systems.

Accurate information on the topography of the site is essential for laying out a siphon system. The transport line length and profile are critical in determining how or if the system will operate. It is important to allow open channel flow along the length of the transport line so that the air that is displaced can vent to an air vent located at the start of the transport line. If open channel flow cannot be maintained, additional air venting will be necessary. Manning's equation can be used to determine if the slope is steep enough to maintain open channel flow. The designer must, however, be aware of the limitations of theoretical calculations.

The ideal transport line is one pipe diameter size larger than the siphon and is as short as possible with a constant slope from the outlet of the siphon to the disposal field (Figure 10). Unfortunately, many sites fall short of ideal. Long transport lines with changes in slope are often unavoidable. Nevertheless, steps can be taken to head off potential problems. The most common problem in transport lines is air binding caused by significant changes in slope (Figure 11). In the example shown in Figure 11, the problem is that the initial slope out of the siphon is less than the friction head loss of the pipe flowing full. Thus, the pipe may be flowing full at the change to a steeper slope and the air in the lower portion of transport line cannot

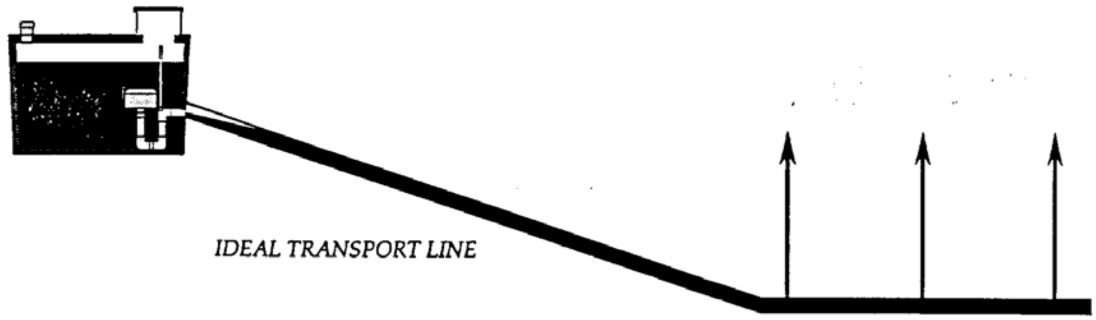


Figure 10: Transport line with constant slope

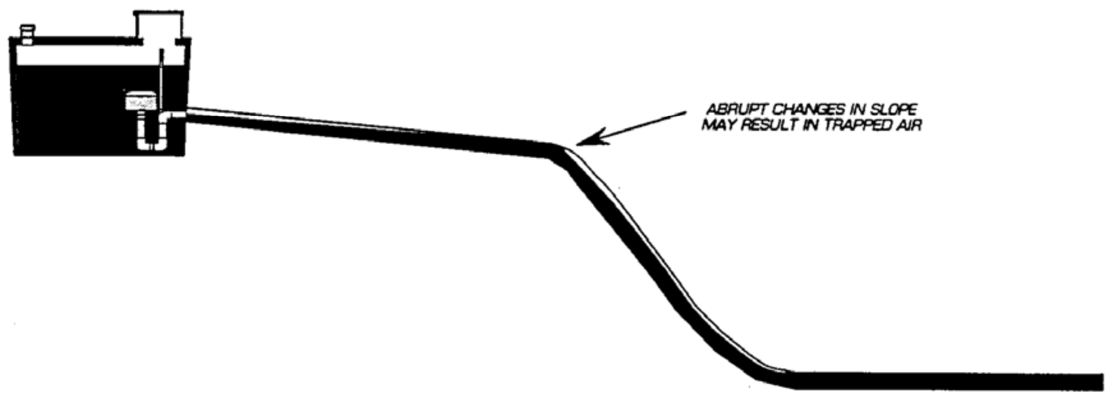


Figure 11: Transport line with significant change in slope

exit the air vent near the tank. Additionally, the flow just out of the siphon is unsteady and turbulent, which could cause additional air binding problems. An air release device positioned just below the change in slope normally will remove air accumulations. The single easiest way to avoid air binding problems is to use a transport line one size larger than the siphon itself. Note: for large siphons same size may be ok. Even on a very steep slope, using a transport line the same diameter as the siphon is not advisable, since turbulent, unsteady flow may be encountered. Air binding also occurs when a transport line has a "belly", i.e., a section of pipe that is always full of liquid. Some type of venting is necessary following a "belly." In a transport line where a long section of the bottom of the transport line is flat, a belly may be inevitable. To avoid having to fill this section of pipe each cycle, the system designer may purposely make this section of pipe lower than the discharge point. However, this situation should be avoided whenever possible.

The first step in specifying a siphon for a pressurized system is to verify that the elevation difference, or fall, is adequate to provide the desired pressure at the disposal location. Second, the flow rate required by the distribution network or splitter is determined. In general, the siphon selected should have an average discharge rate higher than the flow rate necessary to pressurize the system. Next, the transport line size is selected, generally one pipe size larger than the siphon size. Depending on the length and slope of the transport line, siphons of six inch diameter and larger may not need a larger transport line size. Again, Manning's equation may be used to help in this determination. The transport line volume and any dis-

tribution network volume that is necessary to provide the desired pressure is then calculated. This piping volume is important in determining the dose volume needed to achieve the desired system pressurization. It is possible, using calculus, to roughly approximate the minimum dose volume required to reach the system design pressure. Using generalizations or "rules of thumb" for the required dose volume is not good practice. Calculations should be performed for each system. A method for performing these calculations is presented in a separate paper. Finally, using the dose volume and the dimensions of the siphon chamber, the drawdown depth is calculated.

Venting

There are three common methods of venting siphon systems. An open standpipe is the most frequently used. Air release valves—with carbon filters for odor control—can be installed on transport lines where an open standpipe is not acceptable. A transport line that has trapped air may also be vented back to itself at a higher position. Most siphons are manufactured with an integral air vent, for venting the air trapped beneath the bell. A vent should always be installed just outside the siphon chamber, usually where the pipe size is increased.

When a system is installed, the transport line should not be buried until proper operation has been verified. Access to the pipe is essential if additional venting becomes necessary. If low flow rates suggest that air entrapment is occurring, a portable drill with a 1/8th inch bit is useful for finding the locations of the air pockets. If a hole is drilled and air is not released, the hole is easily plugged with a stainless steel tapping screw.

Monitoring Devices

Monitoring of a single siphon is usually done with a float switch connected to a battery operated digital counter. The float, installed in the dosing chamber, is positioned to activate near the on level of the siphon. If the siphon fails to cycle (trickles), the liquid level in the tank will not reach the on position and no cycles will be recorded. Alternating siphons can be monitored using the same counter described above, with the addition of another counter in one of the drainfields. The float for the drainfield counter is contained in a small canister that is connected to a drainfield lateral. When the drainfield is dosed, the canister fills with liquid, raising the float and activating the counter. In a properly operating alternating system, the dose counter in the tank records twice as many doses as the counter at the drainfield. Siphon monitors are a quick, easy method of checking siphon performance and are recommended for all siphon systems. High water alarms are not useful since siphon failure does not result in a high water condition.

Maintenance

Maintenance of siphons is limited mainly to checking for proper operation. Dose counters are recommended on all siphons for this purpose. Counters should be checked monthly and a written record kept. Siphons that lapse into a trickling mode can usually be put back into operation by blowing air under the bell or by lowering the liquid level in the tank below the bottom of the bell. Two inch vault-mounted siphons need only be lifted enough to expose the bottom of the bell. Note that as the siphon chamber is filling, liquid is forced out of the siphon trap into the discharge pipe. This flow should not be confused with trickling mode.

If filters or screens are installed, they should be inspected periodically and cleaned as necessary.

FLOUT

Flout stands for "Floating Outlet".

It's a new way to flood septic system effluent into the leach field. It floods the distribution box with water well above the invert of the leach pipes, and insures an equal, fast flow of water down all legs of the leach field.

What does it do?

It holds back the water coming from the septic tank until enough is collected to flood the leach field. When the discharge cycle starts, all the stored water is fed to the D-box and flows out every leg of the leach field. After discharging is completed, the septic tank water is held back until another full charge of water is collected. This gives the leach field time to rest and absorb the water that has flooded it. The flooding action insures the entire leach field sees water every time the tank discharges utilizing more surface area of the soil to treat the septic effluent than that of a standard trickling leaching system. If you have a 300-gal charge, 200' of 24" wide leach field, each square foot of trench bottom will average only .66 gallons of water per discharge.

How does it work?

Gravity powers the system so no pumps are required. The Flout body acts like a boat hull and floats up on the surface of the water as the dousing tank fills. It is attached to the tank discharge pipes by a flexible coupling, allowing the Flout to lift off the tank floor in an arc as the water level rises in the dousing tank. The rising of the Flout prevents any water from flowing out to the leach field. When the water level is high enough, it over flows into the Flout body, causing the Flout to loose buoyancy and sink to the bottom of the tank. This action opens a direct path for the water to flow out of the tank and into the leach field. The flow of water fills the leach field pipes at a rate of 65 gallons per minute (per 3" outlet). When the water level falls below the edge of the Flout body, the water remaining inside empties (selfbails) by draining into the leach field, allowing the Flout to regain buoyancy and float up off the floor of the tank, once again blocking water from flowing out. The cycle now restarts as water trickles in from the septic tank and is held back from the leach field as the Flout floats up.

HOW IT WORKS
As effluent from the septic tank fills the chamber, the Float is empty and buoyant and floats on the surface. Flexible connectors allow the Float to rise. When the effluent reaches the maximum level in the chamber, ii spills into a hole in the top of the float. This causes the float to sink. The effluent in the chamber discharges through the pipe(s) which exit the Float, dosing the septic field while providing equal distribution through each outlet, the chamber continues to empty down to the top of the Float. Then the Float empties and resumes floating to repeat another cycle.

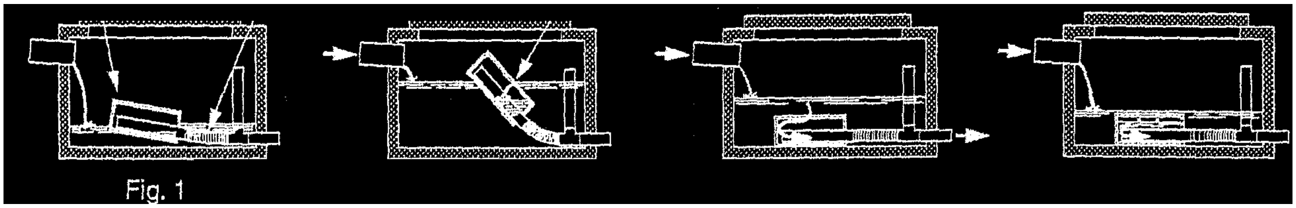
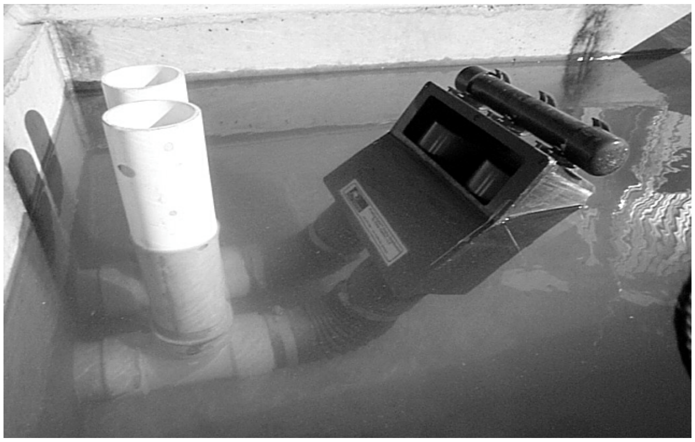


Fig. 1



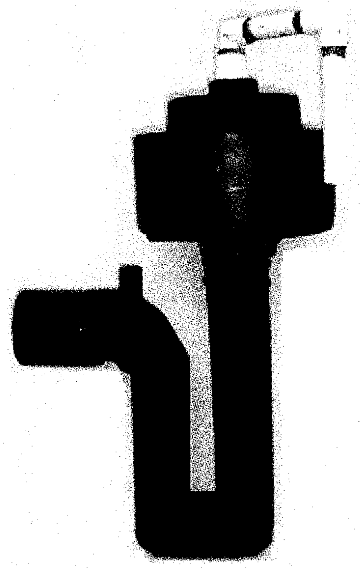
What makes the flout different than a Bell Siphon?

It's easier and faster to install than a bell siphon and requires no special forms to build. Handling and onsite installation is accomplished using the same equipment required to set a septic tank and all work done at the same time the septic tank is delivered. The Flout tank can be leveled quickly and accurately. Any precast septic tank supplier can easily modify tank forms they already own, build a few and then return to building the regular products, on short notice. A contractor can install the flout tank in about an hour and wastes no time leveling the outlets of a d-box. The flout is glued in place inside of the dousing tank (at the precast plant) and delivered on site, ready to install in the ground. The excavated hole for the tank requires a simple flat bottom. 3" or 4" adapter connection pipes can be cast into the tank wall, as per your customer requirements and connection to the D-box is by the installation contractor. No more "grouting in" bell siphons on the job site. No priming water ever needs to be added to the flout for correct operation. Connection to the D-box is just as easy as gluing PVC pipes together. For those big jobs, any number of outlets may be installed in the tank, even or odd number as required. For large dousing applications, additional holding tanks can be paralleled to the dousing tank increasing water, volume per discharge.

For more information call 1-800-479-6335

Web site www.sunnycrest.com/flout

AMERICAN AUTOMATIC SIPHONS

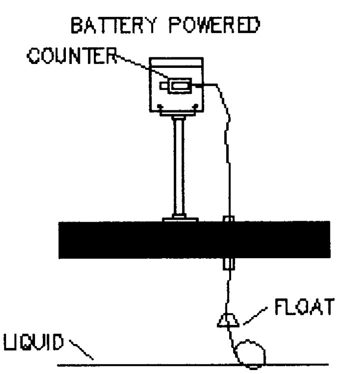


SIMPLEX (ONE)
An inexpensive trouble-free method of providing dosing and resting is through the use of an automatic siphon. There is an automatic dosing siphon available for a wide variety of dosing tank and drawdown depths.

DUPLEX (TWO)
Longer periods of rest can be provided by installing two siphons in the dosing tank and alternately discharging the tank into one-half of the field at a time. The american siphon is hydraulically designed to automatically alternate when two siphons are installed. This is accomplished with no moving parts as it relies upon the hydraulic design of the siphon.

OPERATION OF AUTOMATIC SIPHON

When the liquid rises in the tank above the open end of the vent pipe affects an air seal. As the liquid continues to rise air trapped in the dome and the long leg of the main trap forces water out of the trap. When the head of the liquid in the tank forces all of the long leg of the trap a quantity of air will be forced around the lower bend. Liquid in the short leg of the trap will be rapidly forced out of the short leg by the up rush of air and will start the siphon action. The liquid is drawn out of the tank until air reaches the bottom of the dome which stops the siphon action.



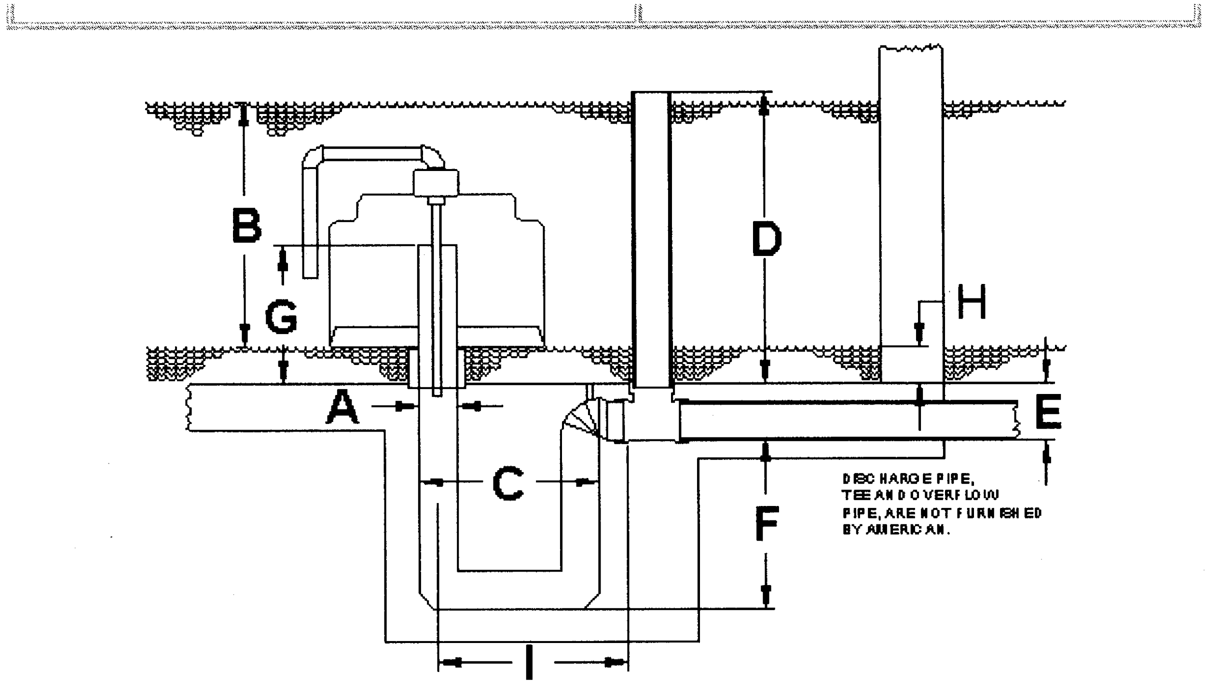
SIMPLEX SIPHON CYCLE COUNTER

<u>Part No.</u>
<u>Description</u>

SSCF-GL
SIMPLEX SIPHON CYCLE COUNTER

DSFS-GL
DUPLEX SIPHON CYCLE COUNTER

The Battery operated siphon counter has a 5 year battery life design. The counter comes in a NEMA 4X enclosure with a non-mercury differential float switch. Dual siphon counters are provided with two counters and two flow switches.



APPROX. DIMENSIONS IN INCHES

SIPHON MODEL NUMBER		**207**	**313**	**413**	**417**	**423**	**523**	**630**	**836**
SIPHON DIA.	A	2	3	4	4	4	5	6	8
DRAWDOWN	B	7	13	13	17	23	23	30	36
WIDTH OF TRAP	C	6.6	8	10.5	10.5	11	13.3	16	20
HIGH WATER ABOVE FLOOR	D	9	16	20	20	26	26	33	39
FLOOR TO DISCHARGE	E	3.4	4.5	5	5	5	7.8	10	8.5
TRAP DEPTH	F	6.4	11.5	12	15	15	20	30	30
HEIGHT ABOVE FLOOR	G	5	12	9	11	16	12	15.1	25.5
BOTTOM BELL TO FLOOR	H	2	3	3	3	3	3	3	3
TRAP TO DISCHARGE	I	N/A	10.5	16.5	16.5	16.5	19.5	22	26.5
AVG. DISCHARGE G.P.M.		30	72	140	150	160	325	450	900
MIN. DISCHARGE G.P.M.		25	48	100	100	100	230	350	450
APPROX. WEIGHT (LBS)		**6**	**7**	**12**	**13**	**14**	**17**	**31**	**57**

AMERICAN MANUFACTURING COMPANY, INC.

Last revised: Oct-14-2002, Comments to: info@americanonsite.com

Orenco Systems, Inc.

Web site www.orenco.com

3 in. and 4 in. Dosing Siphons

Orenco's Dosing Siphons can be used as an alternative to pumps when dosing downhill. Flow rates can range from just a few gallons per minute to several hundred gallons per minute, depending on siphon size. Dosing siphons use no moving parts. Counters are used to monitor siphon operation.

SECTION F: Non-Soil Based Treatment Systems

Part I: Introduction
Choosing Technology for Onsite Systems

Part II: Sand Filters

Part III: Peat Filters

Part IV: Constructed Wetlands

Part V: Mechanical Aerobic and Other Systems

Part VI: Alternative Toilets

Part VII: Disinfection

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 at least three feet of soil separating the system from bedrock or saturated soil) does an excellent job of removing all of those problems.

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 3-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. 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, coastline and source water protection areas. It may require periodic sampling before the effluent is discharged.

A final important aspect of management is replacement. As an onsite system wears out, it must be fixed. In a conventional system, replacement is the responsibility of the homeowner and 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 three 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. *Management strategies must be specific to the treatment system.*

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. Under the old management schedule, the holding tank was pumped every two years—not nearly often enough. A holding tank may fill in two weeks! The management needs of the holding tank were higher than the level of management available. The holding tank, which was a fine technology, became 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 all of the 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 plotted before running water and electricity was available. These new life-style choices were not considered when these lots were plotted, and now the current owners are paying 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

PART II: SAND FILTERS

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 drainfields. Where drainfields 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, 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.

Single-Pass Sand Filter

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. 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

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 <u>shall not</u> 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.

Designing Sand Filter Systems

To determine the size of the filter, determine the volume of wastewater flow from the residence, and multiply it by the loading rate. The choice of the loading rate will affect the management of the system: at loading rates approaching three to four gpd/sqft, a single-pass filter will need regular cleaning of the sand surface (every two to three months), or clogging will prevent the system from operating.

The infiltrative surface of a single-pass pressured sand filter is typically sized using a loading rate of .80 to 1.0 gpd/sqft for pressure dosed systems. For gravity feed systems Chapter 69 allows 0.63 gpsf as a loading rate. This loading rate assumes a biomat has formed at the infiltrative surface and that a long-term application rate will occur. High strength wastes (see Chapter A) will require pretreat or lower loading rates. Figure F-4 shows different loading rates for different filters.

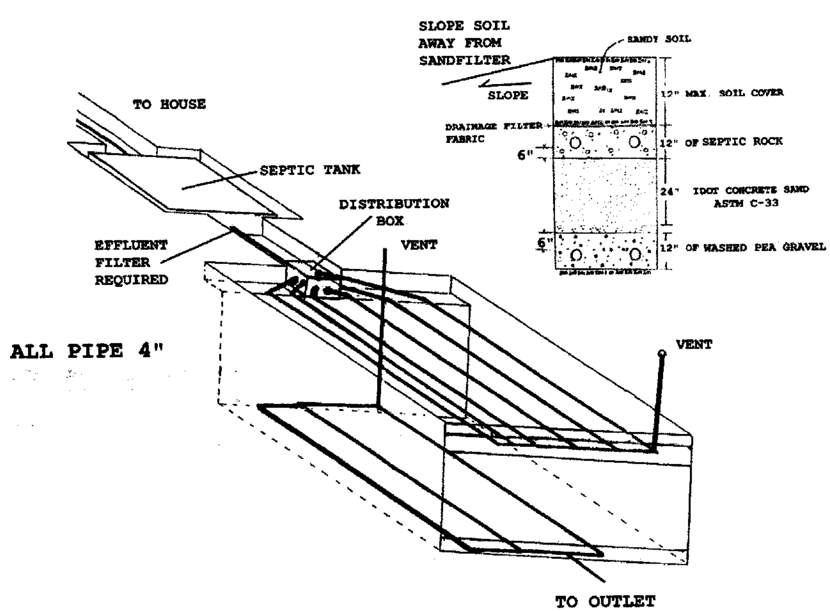
Figure F-4: Typical Design Values for Sand Filters			
Design Factor	**low-rate**	**high-rate**	**recirculating**
Hydraulic Loading (based on forward flow)	< 1.0 gpd/sqft	2-5 gpd/sqft	3-5 gpd/sqft
Organic Loading	$< 5 \times 10^{-3}$ lbs. BOD/day/sqft		
Pretreatment	must include setting and removal of solids		
Media			
material	washed, durable granular material		
effective size	0.3 – 1 mm	0.3 – 1 mm	0.8 – 3 mm
uniformity coefficient	< 4.0	< 4.0	< 4.0
depth	24 inches	24 inches	24 inches
Dosing Frequency	> 6 – 12 per day	> 6 – 12 per day	5 – 10 per 30 min
Recirculation Ratio	NA	NA	5:1

The layout of the filter, in terms of length to width ratios, is not as critical as a good system of dosing, or applying wastewater to the filter surface. Ideally, the filter will receive wastewater evenly over its surface and at even time intervals. Timed dosing and a two-foot spacing of inlet pipes are recommended in many states using this system.

Single-Pass Sand Filters

Daily Flow

The recommended daily design flow for dwellings is the number of bedrooms times 150 gallons per day. For other establishments, estimate the average daily design flows using other sources. If the design flow is measured rather than estimated, you should also add a safety factor of at least 150% when sizing the system. You may want to include flow-measuring equipment in designs, including elapsed time meters and event counters.



Media for Intermittent Sand Filters

The filter media must meet the criteria specified in Figure F-5. Clean sand must be free of organic impurities and contain less than three-percent deleterious (harmful) substances. A good alternative in Iowa is the use of IDOT Concrete sand, or ASTM C-33 sand.

The minimum and optimum depth of the filter media is 24 inches. The pea gravel depth is always three inches, and the underdrain gravel depth should be a minimum of six inches.

Figure F-5: Clean Sand

sieve number	sieve size (mm)	percent missing
4	4.75	95 to 100
8	2.0	80 to 100
10	0.85	0 to 100
40	0.425	0 to 100
60	0.212	0 to 40
200	0.075	0 to 5

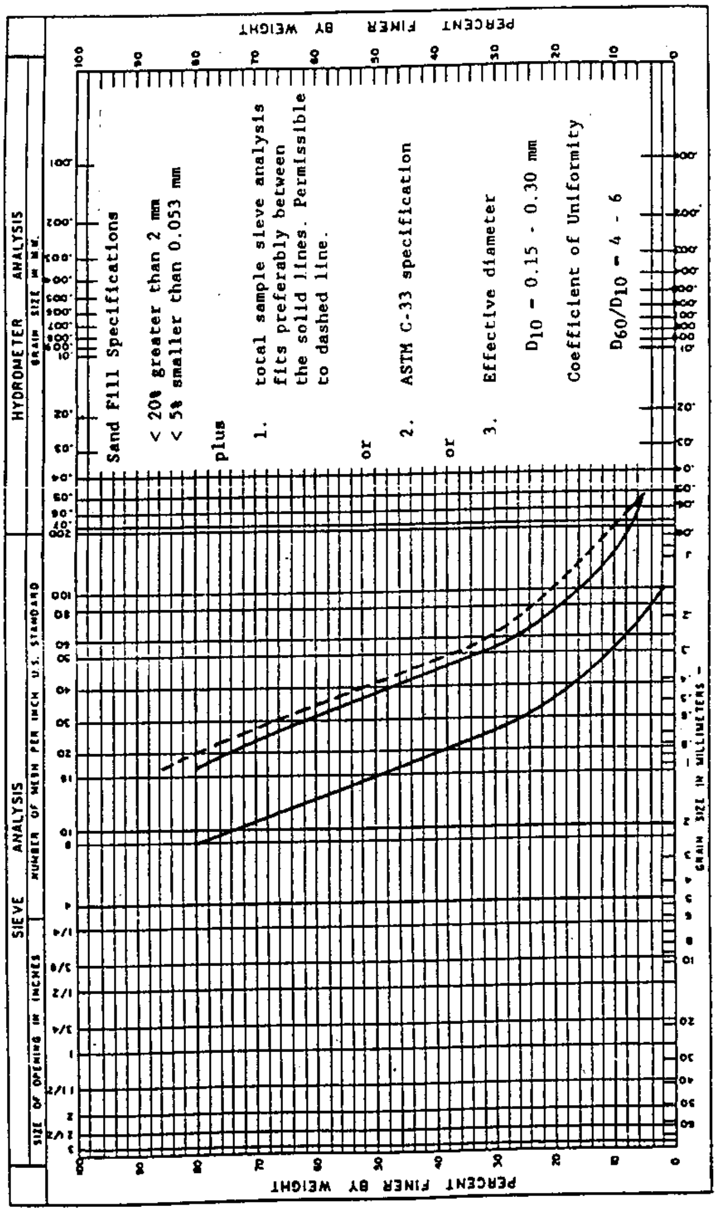
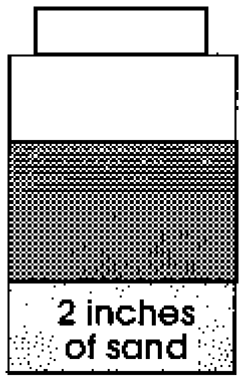


Figure 5. A guideline for the selection of the sand fill for Wisconsin Mounds. The total sample sieve analysis contains 20% or less material larger than 2.0 mm and contains 5% or less material finer than 0.053 mm plus one of the three additional specifications listed in figure. The fraction greater than 2 mm can have stones and cobbles.

This graph shows the range of sand size that is acceptable. Do not accept any sand on the fine side, error on the side of larger particle size.

Clean sand can also easily be field checked by using the jar test. Place exactly two inches of sand in the bottom of a quart jar and then fill the jar three-fourths full of water. Cover the jar and shake the contents vigorously. Allow the jar to stand for about 1 hour and observe whether there is a layer of silt or clay on top of the sand. If the layer of these fine particles is more than 1/8 inch thick, the sand is probably not suitable for use in mound construction, because too many fine particles tend to cause the soil to compact during the construction process. Also, the long-term acceptance rate of this soil will be slower than the long-term acceptance rate of clean sand, which is used for sizing the rock layers.



If the fines that settle out in 1 hour accumulate to a depth of greater than **1/8 inch,** then the percentage of fines is too great and the sand **should not** be used for mound construction.

Place an underdrain pipe in the underdrain gravel at the same level or an inch or two above the main floor of the sand filter. This pipe should be slotted or perforated four-inch SCH 40 pipe or stronger. It should not be directly against the bottom; they should be facing 4 & 8 o'clock or, if facing six o'clock, have a few inches of gravel under the pipe.

A four-inch pipe surrounded by rock provides outflow from the filter. The depth flowline of the outflow pipe should be from one foot to 18 inches below the bottom of the sand. It is critical that the effluent drain freely out of the sand, since saturated conditions in the filter would greatly reduce its effectiveness.

Liner material specifications if needed:

- 20-30 millimeter thickness
- Manufactured per National Sanitation Foundation Standard 54.
- One-piece construction, without holes. (If a boot and a gravity-flow underdrain will be used, see Figure F-6.)

Figure F-6: Using a Boot	
If a synthetic membrane liner is used, a boot will be required.	
-	The boot outlet is to be bedded in sand.
-	The boot is to be sized to accommodate a 4” underdrain outlet pipe.
-	The boot is to be secured to the 4” outlet pipe with two stainless steel bands and screws and sealant strips as recommended by the manufacturer.
-	An inspection port shall be installed at the outlet of the underdrain pipe from the sand filter to the drainfield to facilitate checking if leakage is occurring and injecting air if needed.
-	The trench from the filter to the drainfield shall be backfilled with a minimum 5 lineal feet clay dam to prevent the trench from acting as a conduit for groundwater movement towards the drainfield.
-	Test the sand filter and boot for leakage: 1. Block the outlet pipe. 2. Fill the underdrain gravel with water. 3. Measure the elevation of the water through the inspection port. 4. Let the water stand for a minimum of 24 hours. 5. Measure the elevation of the water through the inspection port. **There must not have been any drop in the water level.**

Underdrain and Inspection Ports

Select the underdrain method, and how the effluent will be transmitted to the disposal component. In the simplest designs, effluent flows by gravity from the sand filter to the lift tank, the soil dispersal area, or surface discharge point. There are a variety of ways to design the underdrain, typically, three inches of pea gravel is placed over a six-inch layer of gravel containing the underdrain collection pipe.

If effluent is pumped directly from the sand filter to soil dispersal area, the filtrate is collected in a gravel bed underlying the filter media and is discharged into a pump basin. Provide a basin in which pump will sit, lower than the sand filter bottom so filtrate flows toward pump. This basin will usually be eight to 18 inches deeper than the bottom of filter. If a synthetic membrane is used, the pump basin must be adequately supported with a base on both sides of the synthetic membrane. The pump basin must allow the pump to stay submerged at all times.

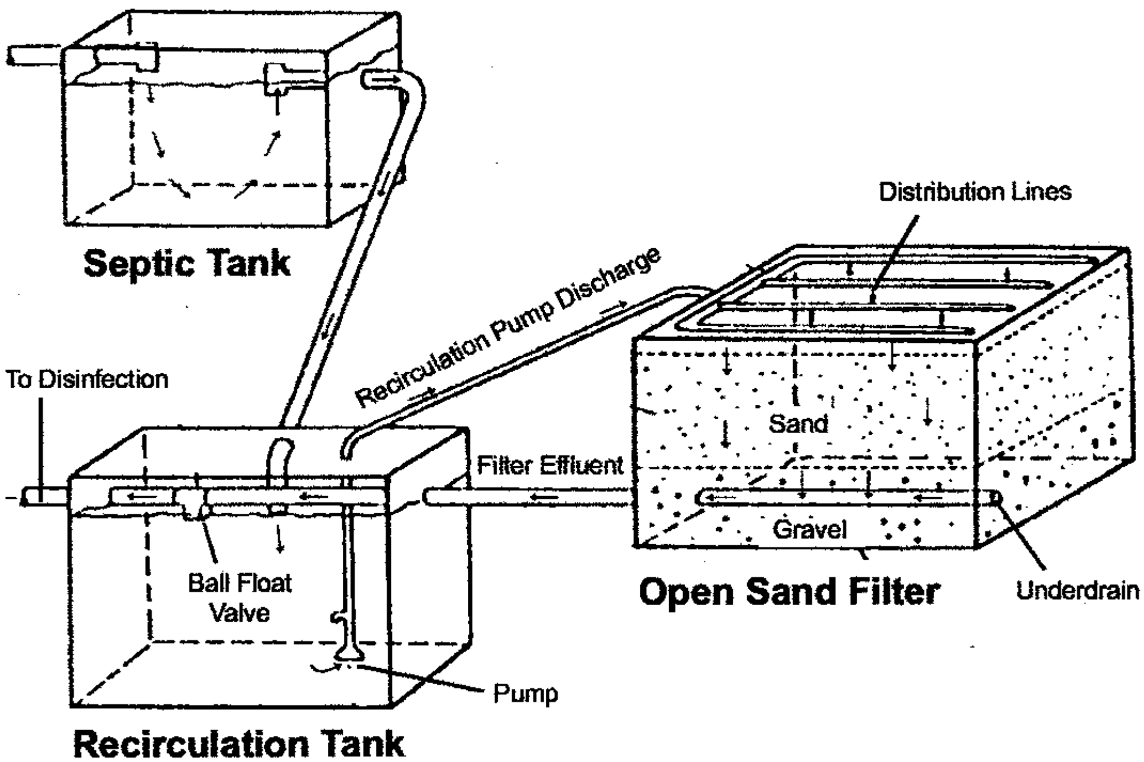
Design the Distribution Network

Pressure distribution is preferred. The required number of doses per day is between six and 12. (See **Section E: Pressure Distribution and Pumping Systems.)**

Recirculating Sand Filters

Determine Daily Flow

Recommended daily design flow for dwellings is the number of bedrooms times 150 gpd. For other establishments, estimate the daily flows using other sources. Designers are strongly encouraged to include flow-measuring equipment in designs, including elapsed time meters and event counters.



A plastic liner is required for all recirculating sand filters. To remove the impact of ground water.

Sizing

Select the filter media. It must meet these criteria:

- Particle size distribution complies with Figure F-7.
- Effective particle size: three to five mm

- Uniformity coefficient: ≤ 2
- Filter media must be washed.

Figure F-7: Particle Size Distribution for Recirculating Sand Filter Media		
sieve size	**particle size (mm)**	**percent missing**
3/8 inch	9.50	100
No. 4	4.75	0 – 95
No. 8	2.35	0 – 2
No. 30	0.60	0 – 0.1

The uniformity coefficient is defined as the ratio of D60 (grain diameter for which sixty percent the sample by weight is finer) to D10, the effective grain size (grain diameter for which ten percent of the sample by weight is finer).

Determine the required infiltrative surface area (the interface between gravel and sand). The loading rate is calculated on the basis of the BOD of the septic tank effluent. While the maximum septic tank influent BOD for onsite sewage systems is 220 milligrams per liter, Washington State guidelines suggest that recirculating sand filters may satisfactorily treat sewage with a BOD as high as 720 milligram per liter.

Calculate the loading rate (gallons per day per square foot) by dividing 1,150 by the BOD of the tank effluent. For residential applications the maximum loading rate is five gpd/sqft. If the BOD is suspected to be greater than 220 milligrams per liter, the loading rate will be lower. For repairs, alterations or expansions to existing systems or where BOD is suspected to exceed 220 milligrams per liter, composite sampling of the septic tank is recommended to generate good information. For new development, especially for nonresidential development, BOD should be estimated on the basis of the best available comparative information from similar facilities.

Determine the required surface area for the sand filter bed by dividing the average daily flow by the loading rate.

The depth of the bed will depend on whether gravel or a gravelless alternative is used. If gravel is used, the depth will be a minimum of nine inches if a one-inch diameter lateral is used. The bottom of the bed should be level. The minimum and optimum depth of the filter media is 24 inches. The bottom of the filter media should be level. Pea gravel depth is three inches. The underdrain gravel depth is a minimum of six inches with gravity underdrain, and sufficient depth to provide adequate storage volume when using a pump well/vault to pump sand filter filtrate to the next component. The gravel depths may be greater to provide additional storage volume if filtrate will be pumped form the sand filter to the next system component.

Place an underdrain pipe in the underdrain gravel at the same level or an inch or two above the main floor of the sand filter. This pipe should be slotted four-inch ASTM 3034 pipe or stronger. The slots should not be directly against the liner. They should either be facing 12 o'clock or, if facing six o'clock, have a few inches of gravel under the pipe and slots.

Select the type of containment vessel to be used. This will affect whether the sand filter is above or below ground. See the above discussion of single-pass sand filters for more detailed information.

Select the underdrain methodology and how the effluent will be transmitted back to the recirculating/mixing tank. This will usually be done via a gravity flow from the filter, which means it is critical that the elevations of the filter drain and the recirculation tank are evaluated.

Distribution Network

When pressure distribution is needed. The recommended number of doses per day is 48. **(See Section E: Pressure Distribution and Pumping Systems.)**

Recirculating Tank

For residential systems, the minimum volume of the recirculating/mixing tank should be 100 percent to 150 percent of the estimated average daily flow. For other establishments, tank volume should be 100 percent of the estimated average daily flow.

Doses are primarily controlled by a timer. Floats are wired in parallel with the timer to control the pump during periods of excessive wastewater flow and/or in the event of timer malfunction. A timer should control the recirculating pump in continuous cycles of five minutes on and 25 minutes off. Each unit of effluent is designed to flow through the sand filter about five times before it flows to the disposal component. This results in a recirculation rate of 5:1 (read as "five to one".)

Based on the 5:1 recirculation rate, determine the through-filter flow: the actual volume of effluent going through the filter each day:

daily design flow (gpd) x 5.

Next, determine the dose, in gallons per cycle:

through-filter flow (gpd) ÷ 48 cycles/day.

Once you know the dose, you can determine the pumping rate in gallons per minute:

gal/cycle ÷ 5 minutes/cycle.

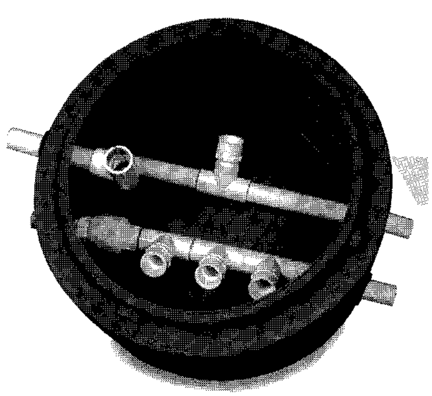
(See Section F: Pumping Systems for more information about selecting pumps.)

The recirculating pump should be located at the opposite end of the tank from both the inflow from the septic tank (or other pretreatment process) and the return from the filter. The pipe from the filter back into the recirculating/mixing tank is typically four inches in diameter. For larger flows, larger diameter pipe may be needed.

Recirculating Device

A buoyant-ball check valve. The elevation of this valve (typically 80 percent of the liquid depth) will control whether sand filter effluent flows back into the recirculating/mixing tank or out to the drainfield/discharge point. The ball must be sufficiently buoyant that it makes a good seal. The Valve requires the final discharge to be determined by the elevation of the pump station. The filter is dosed periodically by a timer. The periodic dose is continuous so filter resting is less, and maintenance events may increase but the quality potential is enhanced due to the filter being continuously active. The following picture was furnished by American Manufacturing.

Another type of splitter device is a distribution box or something similar like this Zabel basin assembly. Water flows in and fills the box. There are 3 openings in the return pipe to the recirculating tank and 1 opening to the discharge point. This allows 75 % of the flow to be returned to the tank and discharges 25% at all times. On this type of system there needs to be a shut off switch in the recirculating tank otherwise the pump tank will run out of water. The filter rests



during low flow so filter runs may be longer but the quality may be detracted from during restart after long rest periods.

There are other types of splitters on the market in addition to these shown above.

Placement

Flexibility in terms of siting is probably the single biggest advantage of a sand filter system. Because the filter is watertight and uses a medium for treatment, the soil on which or in which it is constructed is not critical. What is critical is the ability of the system to transfer oxygen, because without adequate oxygen, bacterial action will be seriously compromised. Wisconsin recommends using landscaping rock from the sand filter surface to the soil surface to maximize gas exchange. The location is entiled to avoid any excessive surface runoff being introduced into the system.

Soil and site conditions for sand filters are usually not critical. The primary consideration is that the site where the filter will be located needs to be stable. Additionally, care must be exercised to insure that seasonal high water tables or surface water does not enter the top of the sand filter. Soil and site conditions are critical for the disposal component following the sand filter.

Final Dispersal of Wastewater

This system will discharge very clean effluent, but the effluent must still be disposed of. Surface discharge is permitted in Iowa and is most commonly used. If the treated wastewater is disposed of into the soil then pressure distribution to the soil system is necessary, rather than gravity distribution, since the effluent from sand filters contains very little organic matter. Because the effluent is so “clean,” a biomat layer does not form as it does in soil treatment systems receiving effluent from septic tanks. A biomat layer makes the soil less permeable to water, so effluent flows through the length of the trench. Without a biomat, effluent tends to percolate through the soil only at the beginning of the trench, unless pressure distribution is used to apply effluent evenly throughout the soil treatment system.

Maximize the ability of the design and site to disperse wastewater and take in a minimum of groundwater and surface runoff:

- Making the soil dispersal area for a sand filter as long and narrow as possible.
- Minimizing the number of laterals down slope from each other.
- Running the laterals of the soil dispersal area so they are parallel with the slope contours.

The problem of dispersal becomes more difficult as the soil becomes shallower and finer-textured, and as the design flows become greater.

A crested site where subsurface flow can occur in multiple directions is desirable for soil dispersal areas. Look for areas with convex slopes, rather then concave slopes. Try to locate soil dispersal area on the upper part of a slope, rather than at the bottom of a slope. Stay away from drainageways, depressions or areas subject to flooding.

Strictly observing setback requirements and paying special attention to downslope geologic or soil conditions and land use activities will help mitigate problems with using systems on small lots. As the density of onsite sewage systems increases, especially on sites with shallow soils (frequently the case with intermittent sand filter systems) and where they are placed down-gradient from each other, concerns become greater. Especially on small lots, site evaluation should include assessment of the impacts that surrounding lot developments may have on the design and performance of a system.

Dispersal of Effluent from a Single-Pass Filter

Effluent from a single-pass sand filter may be surface discharged, flow to a drainfield or a mound. If a drainfield is used, a minimum vertical separation of 24 inches is recommended. You should design with additional separation to allow for groundwater mounding after the soil has begun to receive effluent.

Dispersal of Effluent from a Recirculating Filter

The receiving soil treatment system is designed using normal design methods and loading rates. No increase in loading rates is permitted with recirculating sand filter effluent. For either gravity or pressure distribution drainfields, it is recommended that the receiving drainfield must have a minimum vertical separation of 24 inches.

Advantages & Disadvantages of Mounds and Sand Filters

As the design professional decides which system and system components are the most appropriate for a given site, it may be helpful to quickly compare the different systems and components discussed in this course. Information on mound systems is included to help design and regulatory professionals understand the similarities and differences of mound and sand filter systems.

Mound

- Mounds may take up less area than a system of trenches.
- There is a continuous unsaturated flow from sand into original soil.
- Mounds use the upper horizons of soil, which are typically more permeable and contain more organic material.

but

- Mounds can create aesthetic problems and concerns.

- They can be seriously affected if multiple systems are downslope from each other.
- Site preparation and installation are critical.
- Materials may be costly.

Single-Pass Sand Filter

- Takes up relatively little area compared to mounds.
- Works well in conjunction with mounds to provide additional treatment on sensitive sites.

but

- Concrete or synthetic membrane liners can be costly.
- Repair or replacement work for a system with a liner must be done by hand.
- Two pumps are required: one to dose the sand filter, one to dose the soil dispersal area.

Recirculating Sand Filter

- Suitable for light commercial applications, treating tank effluent with a BOD of 230 to 720 milligrams per liter.
- Generally smaller in size than intermittent sand filters.

but

- Surface must remain open to encourage oxygenation.
- Requires more pumps and controls than intermittent sand filters.
- Concrete or synthetic membrane liners can be costly.
- Repair or replacement work for a system with a liner must be done by hand.

Management, Operation and Maintenance of Sand Filters

The local health agency has the authority to require that an acceptable maintenance agreement be established, and supporting documents be developed and approved by the local health official, prior to the issuance of approvals for a proposed sand filter sewage system.

Construction Plan

An important part of the design package is the construction plan. It contains specific instruction to the installer to help assure a quality installation. In addition to the step-by-step installation instruction, it should include the following:

- Routes for construction vehicles.
- Identification of reserve area and instructions to stay away from it.
- Instructions as to when the system can be constructed (time of year, moisture content).
- Instructions for proper grading, diking, ditching, and subsurface drainage.
- Instruction for fencing the disposal component and reserve areas if they are located in areas where vehicular, livestock, or pedestrian traffic could cause problems.
- Instruction for cleaning.

Maintenance

For the onsite treatment and disposal system to operate properly, its various components need periodic inspection and maintenance. The maintenance is the responsibility of the homeowner, but may be best performed by experienced and qualified service providers. Provide the owner with a description of maintenance concerns.

1. Type of use: describe the organic waste strength concerns and testing protocols.
2. Age of system: describe concerns about pump calibration and parts that may need replacement due to wear.
3. Nuisance factors: describe possible factors, such as odors or user complaints.
4. Septic tank: inspect yearly for structural integrity, proper baffling, screen, ground water intrusion, and proper sizing. Inspect and clean effluent baffle screen and also pump tank as needed.
5. Dosing and recirculating/mixing tanks: rinse the effluent screen (spray with hose), inspect and clean the pump switches and floats yearly. Pump the accumulated sludge from the bottom of the chambers,

whenever the septic tank is pumped, or every three years, which ever is sooner.

6. Pumpwell: inspect for infiltration, structural problems, and improper sizing. Check for pump or siphon malfunctions, including problems related to dosing volume, pressurization, breakdown, clogging, burnout, or cycling. Pump the accumulated sludge from the bottom of the pumpwell, whenever the septic tank is pumped, or every three years, whichever is sooner.
7. Check monitoring ports for ponding.
8. Inspect and test yearly for malfunction of electrical equipment such as timers, counters, control boxes, pump switches, floats, alarm system or other electrical components, and repair as needed. System checks should include improper setting or failure, of electrical, mechanical, or manual switches.
9. Pump and pump screen: inspect yearly and clean as needed.
10. Mechanical malfunctions (other than those affecting sewage pumps) including problems with valves, or other mechanical plumbing components.
11. Malfunction of electrical equipment (other than pump switches) such as timers, counters, control boxes, or other electrical components.
12. Material fatigue, failure, corrosion problems, or use of improper materials, as related to construction or structural design.
13. Neglect or improper use, such as loading beyond the design rate, poor maintenance, or excessive weed growth.
14. Installation problems, such as improper location or failure to follow design.
15. Septic tank maintenance, including pumping frequency, structural integrity, improper baffling, ground water intrusion, or improper sizing.
16. Overflow or backup problems where sewage is involved.
17. Exposed-surface filter bed: weed and remove debris from the bed surface, quarterly.
18. Specific chemical/biological indicators, such as BOD, TSS, and/or fecal coliform bacteria sampling and testing, may be required by the local health authority.

Owner's Manual

The design package will also include the owner's operation manual, which should include specific instructions to the system owner or their monitoring person. The owner's manual should contain:

- Diagrams of the system components and their location.
- Explanation of general system function, operational expectations, and owner responsibilities.
- Specifications of all electrical and mechanical components installed (occasionally components other than those specified on the plans are used).
- Names and telephone numbers of the system designer, local health authority, component manufacturer, supplier/installer, and the management entity to be contacted in the event of a failure.
- Information on the periodic maintenance requirements of the sewage system: septic tank, dosing and recirculating/mixing tanks, sand filter unit, pumps, switches, alarms, and disposal unit.
- Information on troubleshooting operational problems. This information should be detailed and complete to assist the system owner in making accurate decisions about when and how to attempt corrections of operational problems, and when to call for professional assistance.
- Information on the final landscaping of the site, including limitation about future plantings, and identification of activities that can't occur around the system and reserve area.
- Maintenance, monitoring and sampling requirements / recommendations. This includes inspecting monitoring ports, looking for leaking plumbing fixtures and tanks, and evidence of site protection. This should include forms and methodologies to be used.
- Description of the quantity and quality loading limitations of the system.
- For proprietary sand filter devices, a complete maintenance and operation document should be developed and provided by the manufacturer and made available to the system owner. A copy of this document should also be provided to the local health authority, prior to the issuance of the local installation permit.

PART III: PEAT FILTERS

The following information is on a new product, peat filters. At the time of this publication this product was not listed in Chapter 69, therefore each County will need to determine the suitability of this product.

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. Unsterilized 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.

In some studies, peat filters have removed high concentrations of nutrients, BOD, suspended solids, and fecal coliform bacteria. In Minnesota, research peat filters have consistently done an excellent job of treating a wide range of waste strengths and waste types.

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. Bord na Mona[1] brand filters use a peat from Ireland that is somewhat coarser. 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, drainfield rock, and four-inch PVC pipe. The drainage system collects the effluent and delivers it to the dispersal area.

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 Iowa, 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 Chapter 69. 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 Iowa’s wastewater treatment needs.

The following fact sheets are supplied by peat filter manufactures and are included for informational purposes only. This manual makes no recommendation on any manufactures product.

The Ecoflo® Biofilter

The unit consist of a small fiberglass shell containing a patented sphagnum peat moss filtering media (Fig.1).

Wastewater from the septic tank flows into the Ecoflo® Biofilter and is evenly distributed over the surface of the peat using a unique distribution system with no electrical requirements.

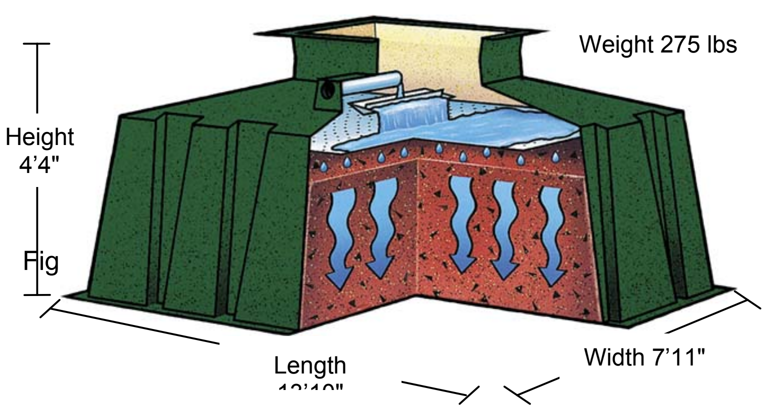
The wastewater is treated as it percolates down through the peat, and the effluent is then disposed for infiltration into the native soil or discharged to a watercourse in accordance with existing local regulations.

Treatment Efficiency

Parameters	Percentage of treatment by the Ecoflo® Biofilter	Septic Tank Effluent	Ecoflo® ST-650 Biofilter Effluent
Biochemical Oxygen Demand **(BOD_5)**	95%	≤ 250 mg/L	≤ 10 mg/L
Total Suspended Solids **(TSS)**	90%	≤ 75 mg/L	≤ 10 mg/L
Fecal Coliforms **(CFU/100 ml)**	99%	≤ 2 000 000 CFU/100 ml*	≤ 25 000 CFU/100 ml*

* Geometric means correspond to ≤ 750 000 CFU/100 ml at septic tank outlet and to 2 000 CFU/100 ml at Ecoflo® Biofilter outlet.

The Ecoflo® Biofilter Treatment



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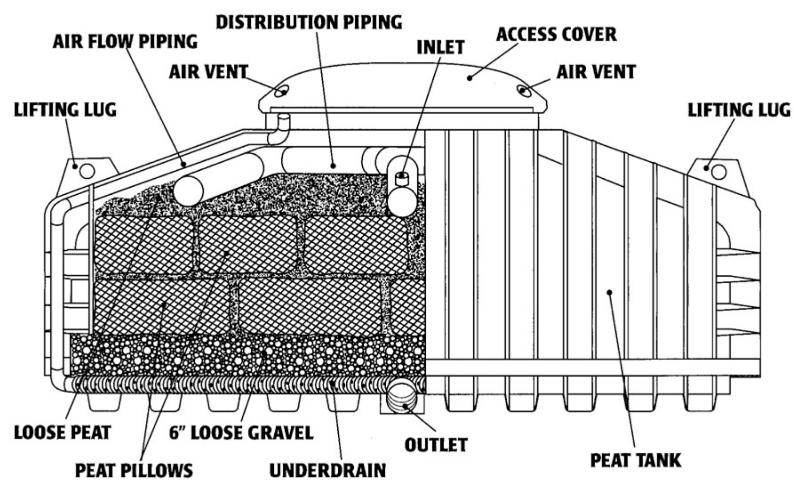
Tel.: (205) 408-9691 Fax: (205) 408-8783
E-mail: ecoflo@premiertech.com
Website: premiertech.com
Toll Free Number: 1-877-295-5763

ECO-PURE WASTEWATER SYSTEM

- A passive secondary advanced treatment system.
- Influent enters the system from the septic tank and moves into the distribution piping.
- Effluent is distributed through the peat to the bottom of the tank where it enters into the underdrain.
- The effluent exits through the outlet and moves to the absorption area.
- A 5-year maintenance agreement is included with each system.
- An annual inspection under the maintenance agreement consists of: cleaning the septic tank filter and inspecting the peat filter, hose out the distribution piping and rake peat if necessary.

ECO~PURE PEAT BIOFILTER

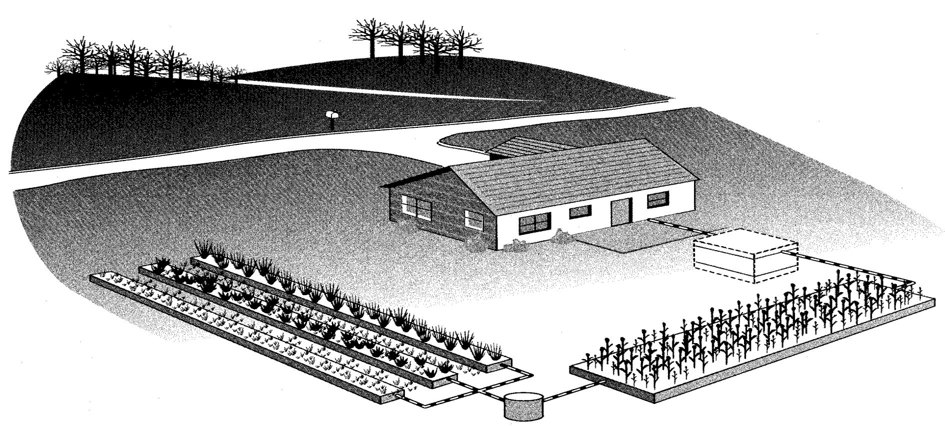


PART IV: CONSTRUCTED WETLANDS

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. **Subsurface flow systems** are the type required by Chapter 69 for use in Iowa. 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.

A new 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 are the type recommended for use in Iowa. 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. Chapter 69 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. Chapter 69 recommends 33:1, based on the recent EPA manual this may be 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. Chapter 69 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, see section C.

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.

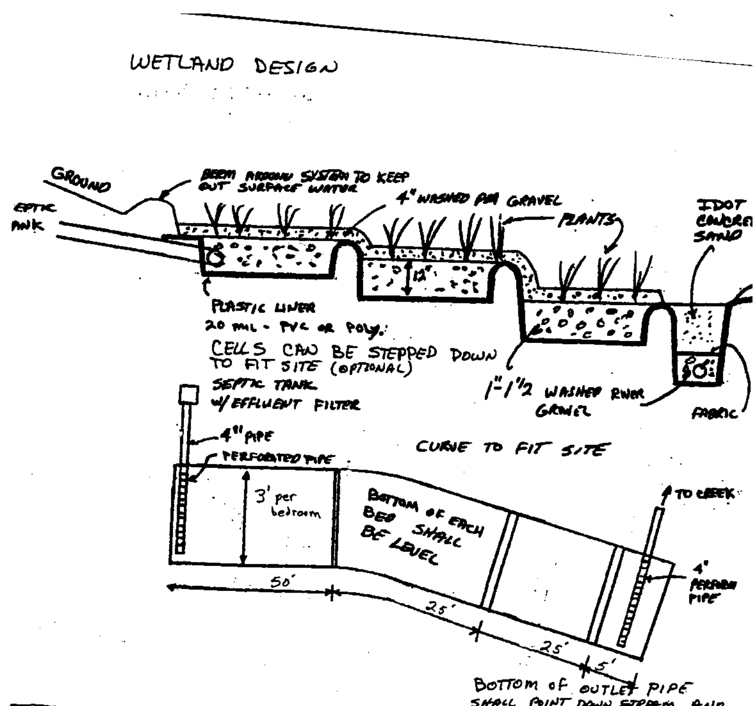
Typical System Design and Layout

Subsurface flow system, assume 1-bedroom system, this can be increased for number of bedrooms.

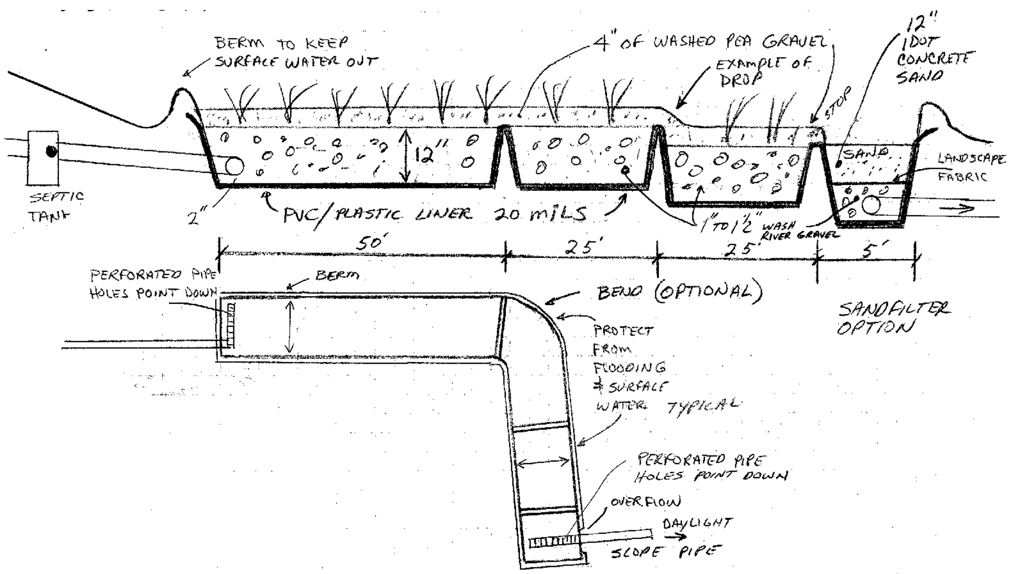
Flow 150 gallons per day

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



NOTES:
1. Layout is for concept, fit to site.
2. Bottom of each bed shall be level.
3. Minimum bed sizes shown.
4. Provide berm around entire wetland to keep surface water out.
5. Plants: collect plants in the area, leave mud ball on roots.
   Use common cattail, narrow leaf cattail, bulrush, and reeds.
   Plant at – foot on center.
   Cut plants down each fall, to insulate bed in winter, remove in spring.
6. Check sand often, and rake clean.



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.

PART V: MECHANICAL AEROBIC AND OTHER SYSTEMS

The following paper was reprinted with permission from James C. Converse.

IOWWA thanks James for all of the support and information provided.

AERATION TREATMENT OF DOMESTIC WASTEWATER FOR ON-SITE TREATMENT OF DOMESTIC WASTES

AEROBIC UNITS AND PACKED BED FILTERS

James C. Converse[1]

January, 1997

Revised, January 1999

Revised, February 2000

On-site waste treatment and management utilizes anaerobic and/or aerobic processes for the treatment of domestic waste. A number of units are commercially available and can be categorized as either **aerobic units (ATUs) or packed bed filters (PBFs)**. Aerobic units are submerged units in which air (oxygen) is introduced into the mixed liquor with oxygen diffusing into the liquid. Pumps and blowers provide the air. Packed bed filters are unsaturated units in which the air diffuses in and through the voids created between the media. Air diffuses in from the atmosphere. Some units will have a small fan to increase circulation of the air.

This publication is divided into two main categories: aerobic units and packed bed filters. All units approved in Wisconsin as of January, 2000 will be described. It will also contain other units. **This presentation is not inclusive and does not imply endorsement of one product over another and it will continually be updated to include more units.**

TESTING PROTOCOL

To establish quality control in aerobic units (ATUs) and protect the public from poor quality and low performance units, NSF, International, in cooperation with the industry and the regulatory community, developed a testing performance standard (Standard Number 40), (NSF, 1996). For a fee, NSF, International will test aeration units using domestic waste under a controlled pilot plant (field) environment measuring influent and effluent quality and performance under various loading regimes. The standard has Class I and Class II levels based on performance standards as follows:

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[1] James C. Converse, P.E., Professor. Department of Biological Systems Engineering, College of Agricultural and Life Sciences, University of Wisconsin-Madison. Member of the Small Scale Waste Management Project.

Note: Names of products and equipment mentioned in this publication are for illustrative purposes and do not constitute an endorsement, explicitly or implicitly. It does not include all units available on the market and the presence or absence of a product does not imply acceptance or rejection of a particular product.

Class I Effluent

Plants providing a Class I effluent shall be shown to meet EPA Secondary Treatment Guidelines (Federal Register, 1987) for BOD_5, SS, and pH. These are as follows:

$CBOD_5$:

- The 30-day average of $CBOD_5$ concentration of effluent samples shall not exceed 25 mg/L.
- The 7-day average of $CBOD_5$ concentration of effluent samples shall not exceed 40 mg/L

TSS:

- The 30-day average of TSS concentrations of effluent samples shall not exceed 30 mg/L.
- The 7-day average of TSS concentrations of effluent samples shall not exceed 45 mg/L.

pH:

- The pH of individual effluent samples shall be between 6.0 and 9.0.

Other:

- Color - 15 units
- Threshold Odor - non-offensive
- Oily Film - nonvisible evidence other than air bubbles
- Foam - None

Class II Effluent

Not more than 10% of the effluent $CBOD_5$ values shall exceed 60 mg/L. Not more than 10% of the effluent TSS values shall exceed 100 mg/L.

As noted, NSF, International primarily evaluates a unit for BOD and suspended solids effluent concentration. With the increased interest in nitrogen removal and pathogen removal, all aeration units should be evaluated for nitrogen and pathogen removal. For soil based treatment/dispersal, pathogen and nitrogen removal are as important if not more important than BOD and suspended solids removal. BOD and suspended solids removal have been and will continue to be important parameters, especially for surface water discharge and are used by the industry for secondary treatment performance. **Phosphorus and virus removal are also important emerging concerns.** To date no packed bed filters have been NSF tested. The fact that they have not been NSF tested should not imply that they are inferior or incapable of receiving NSF classification. In fact some aerobic units have not been NSF rated. Many reasons may dictate why a company has not had their unit evaluated. **Standard 40 was developed to evaluate aerobic units (ATUs).** Since then a number of packed bed units have emerged.

AEROBIC UNITS (ATUs)

Aeration technology, known as activated sludge, extended aeration and similar other names, is used extensively in large municipal systems for treating wastewater. Industry has developed "miniature" plants adapted for small clusters and for individual home use. This discussion will be limited to the concepts and performance of small units known as individual home wastewater treatment plants, aerobic units or ATUs and other units that utilize aeration for treating the wastewater that come as "prepackaged units". **These units can be categorized as either: 1) suspended growth , 2) attached growth (submerged fixed media) or 3) combination of both. Aeration is achieved by mechanically delivering air bubbles to a liquid (water) media where the oxygen diffuses into the liquid so it can be utilized by the bacteria.**

ATUs have been marketed for many years in some parts of the country but are now being introduced in other parts of the country. Many improvements have been and are continuing to be made and new systems are being introduced.

System Characteristics

- Systems can be either batch or flow-through (known as intermittent flow).
- Most systems have a septic tank/trash tank, external or internal, to settle out the large solids and scum. Some systems may pump the effluent from the septic tank to the aerobic unit utilizing a timer for more uniform loading. The septic tank must be water tight.
- All system have a method of incorporating air into the wastewater to maintain dissolved oxygen in the wastewater either continuously or intermittently.
- All systems incorporate some method of solids separation such as settling, filtering through a fabric or through a plate filter.
- All systems require sludge removal or destruction.
- Systems operate in an extended aeration mode to reduce solids accumulation except for periods when they are loaded heavily.
- Most units are quite sensitive and can be easily upset by the addition of toxic chemicals

and some medications. Rapid and large changes in organic and hydraulic loading can upset these units. During these times the units may foam and froth with increased BOD and SS effluent concentrations. Seeding the unit at start-up and after upsets will usually bring the system to stability earlier.

- Excess solids may on occasion exit the unit either around the cover or through the effluent pipe (bulking) depending on system configuration. Bulking takes place when the solids do not settle out and as a result exit the unit through the outlet pipe.

- All systems have sensors and high water alarms to alert the owner to problems.

- Most units state power rating in horsepower or amps and volts and state the cfm and pounds of BOD_5/day that the unit is capable of processing. They also state flow rate in gpd they are capable of handling.

- All systems require periodic maintenance by a professional at 6 month intervals. Telemetry may reduce the frequency of site visits.

Suspended-growth Units

In suspended growth systems, microorganisms are kept in suspension in an aeration tank where air is mixed with the wastewater. The following systems primarily use suspended-growth as the method of converting organic matter into bacterial cells, carbon dioxide and water.

a. Multi-Flo Waste Treatment Unit

The unit is constructed of fiberglass and comes factory assembled (Fig. 1). This unit is NFS Class 1 rated. The unit comes in a variety of sizes with the smallest unit of 500 gallons capable of treating the effluent from a 3 bedroom home. Larger units, up to 1500 gallons, are available.

A trash tank, proceeding the unit, may or may not be recommended for removal of settleable solids. The wastewater (or trash tank effluent) enters the inlet and drops into the basin (activated sludge or mixed liquor portion). Flow is by gravity. Some systems are installed with a pump located in the trash tank with a timer which doses a small amount of wastewater frequently during the day to provide a more uniform flow into the unit (Fig. 2). Surge capacity is designed into the trash tank. Small. frequent doses are desired.

An aerator, located in the bottom of the tank, pulls in air and disperses fine bubbles which work their way to the top with oxygen dissolving into the effluent.

As wastewater enters, an equal amount of effluent moves through the filter fabric, upward inside the filters (cylinder) and over the weir, exiting through the outlet. The filter fabric retains the solids (primarily bacterial cells) within the basin. The filter surface acts as a fixed media for bacteria growth. The surge bowl allows for some foaming and surge capacity. Liquid sensors are located to detect high water and pump failure.

This unit removes some nitrogen but it does not incorporate a discrete nitrification/ denitrification phase as part of the treatment process. Access to the unit is through the cover and lifting out the surge bowl.

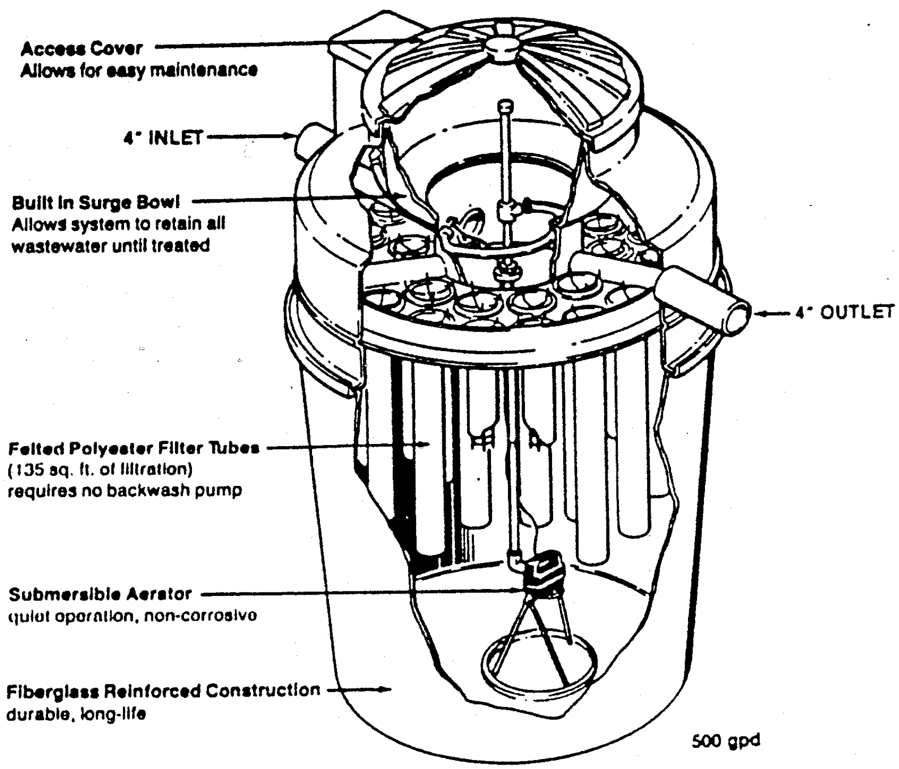

Fig. 1. A cut-away view of the Multi-Flo unit. (Consolidated)

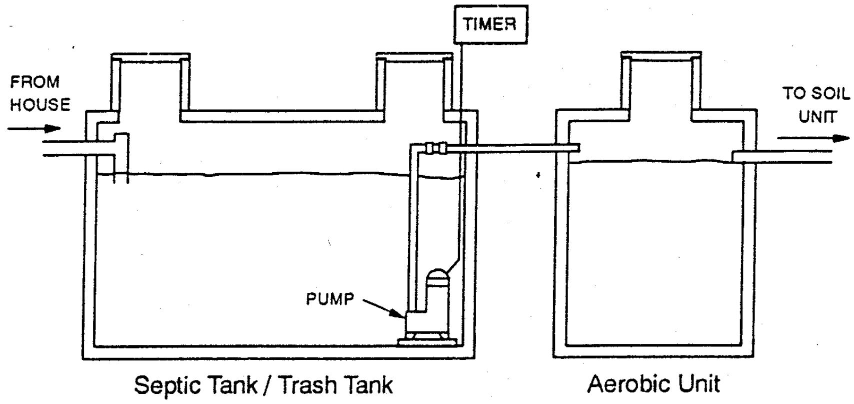

Fig. 2. Illustration of a trash/septic tank with pump and timer pumping effluent to the aeration unit minimizing surge flow.

b. Norweco Singulair Wastewater Treatment Plant

The unit consists of a concrete tank divided into 3 compartments (Fig. 3). The tanks are locally manufactured and outfitted with factory-made pumps, filters and controls. This unit is NSF Class 1 rated. The unit comes in several sizes with the smallest being a 500 gpd unit serving a 3 bedroom home.

The wastewater from the home enters a pretreatment chamber where the larger solids settle out. The liquid volume of the pretreatment chamber is approximately 440 gallons in the 500 gpd unit.

The effluent enters the extended aeration chamber through a submerged port where the suspended and dissolved solids are converted to bacterial cells, water and carbon dioxide. The contents of this chamber are typically called mixed liquor. The liquid volume of this chamber is 590 gallons for the 500 gpd unit.

A top-mounted motor rotates a shaft with a hub with several openings. Air is drawn through the hollow shaft and through the holes in the hub with bubbles dispersing into the mixed liquor. The rotating hub and air bubbles keep the contents mixed. Oxygen is diffused into the mixed liquor as the air bubbles move in the liquid.

Mixed liquor moves to the clarifier through a port located in the bottom of the unit. The solids settle to the bottom of the clarifier. The sloping walls of the clarifier assists the movement of solids back into the aeration chamber.

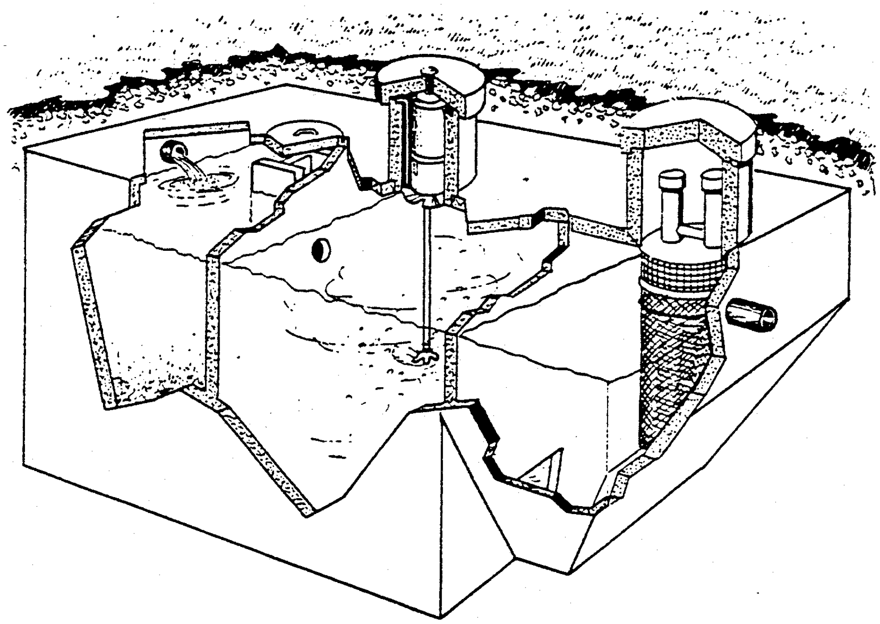

Fig. 3. Cut-away view of the Norweco Singulair unit (Norweco).

The effluent moves into the Bio-Kinetic filter unit which consists of a series of plates that promote quiescent settling. The remaining solids settle out and a relatively clear effluent exits the tank through the outlet. This unit removes some nitrogen but it does not incorporate a discrete nitrification/ denitrification phase as part of the treatment process.

Access to the system is through the inspection port (pretreatment chamber), the aerator port (aerator lifts out) and the Bio-Kinetic port (clarifier).

c. Cromoglass

The unit consists of a 3 compartment fiberglass tank (Fig. 4). This unit is classified as an sequence batch reactor (SBR) as it is a fill and draw (batch) unit. It comes in several sizes with the smallest unit serving a 3 bedroom home.

The wastewater from the home enters the solids retention section where the large solids settle out. Effluent enters the aeration chamber through a screen located in the wall, near the bottom, dividing the solids retention and aeration chamber.

The pump in the aeration section circulates mixed liquor in the aeration chamber and forces mixed liquor through the screen into the solids retention section breaking up the solids and also pumps it into the contact clarifier. The mixed liquor flows back into the aeration chamber via an opening in the wall near the top.

As the pump moves mixed liquor through the overhead pipe, air is pulled in through the air intake allowing oxygen to dissolve into the mixed liquor. The pump operates continuously mixing and aerating the mixed liquor.

At a preset time or when the mixed liquor reaches a certain level, the pump shuts off allowing the solids to settle in the clarifier for a 60 minute period. After settling, the effluent is pumped out of the clarifier. The timer is normally set for six aeration/settle/discharge cycles per day. The discharge pump will not operate when the liquid level in the aeration chamber is below the low water float level. Thus, the number of discharges will depend on the flow to the system.

Some nitrogen is removed during the process. However, a denitrification option is available. This option requires the installation of the next larger size unit, a timer and controls to disengage the circulating pump, stopping aeration. The oxygen is rapidly depleted producing an anoxic condition in the aeration and clarifier sections resulting in the denitrification of the nitrates. After a prescribed time, the timer starts up the pump which provides oxygen to the unit.

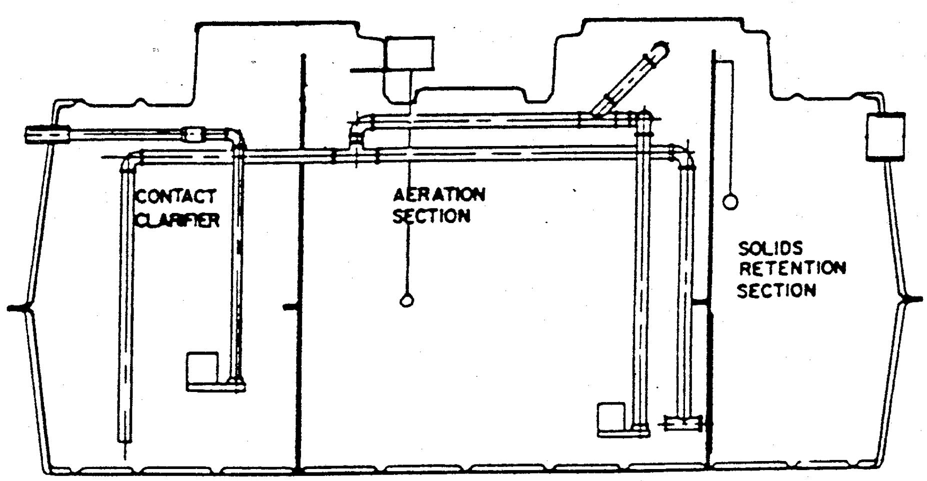

Fig. 4. Cross section of a Cromoglass unit (Cromoglass).

d. **Clearstream Wastewater Unit**

The unit consists of a single tank with a Imhoff cone in the center (Fig. 5). Unit sizes range from 500 to 1500 gallon capacity. This unit is NSF Class 1 rated. The household wastewater enters an external trash trap with a volume of 50 to 100% of the gallon per day rating of the Clearstream unit.

A remote blower supplies air to a diffuser located along the outside wall near the bottom of the tank. Influent enters the tank near the outer edge and moves down around the outside of the Imhoff cone where it comes in contact with the mixed liquor. Effluent moves up through the bottom of the Imhoff cone which provides a quiescent settling area for solids to fall back into the mixed liquor portion of the tank.

The effluent exits through a tertiary filter (optional) attached to the outlet pipe. Solids need to be removed from the tank periodically. This unit removes some nitrogen but it does not incorporate a discrete nitrification/ denitrification phase as part of the treatment process.

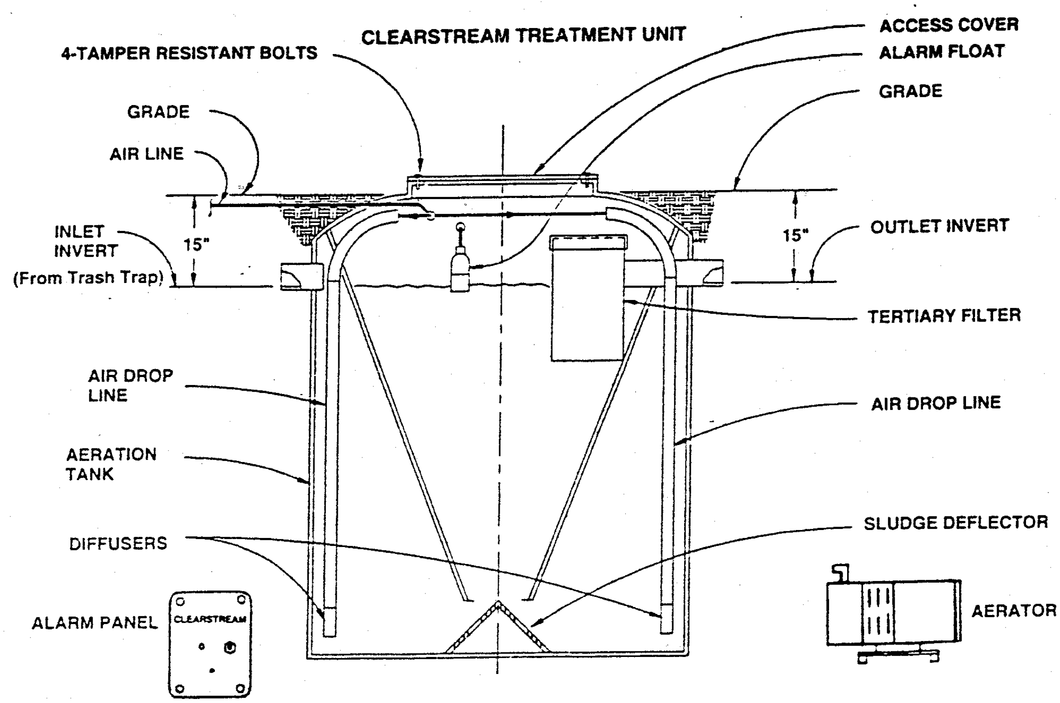

Fig. 5. Cross section of a Clearstream unit (Clearstream).

e. Delta Whitewater

The unit consists of a single tank with a Imhoff cone in the center (Fig. 6) in sizes ranging from 400 gpd to 1500 gpd. This unit is NSF Class 1 rated.

The household wastewater may or may not enter an external trash trap (optional).

A remote blower (65 watts) supplies air to several diffusers located along the outside wall near the bottom of the tank. A minimum of 2100 cf of aeration is provided per each pound of BOD_5. The 400 gpd unit has a treatment capacity of 1.0 lb BOD_5.

Influent enters the tank near the outer edge and moves down around the outside of the Imhoff cone where it comes in contact with the mixed liquor. Effluent moves up through the bottom of the Imhoff cone which provides a quiescent settling area for solids to fall back into the mixed liquor portion of the tank.

The effluent exits through the outlet pipe. Solids are removed from the tank periodically. This unit removes some nitrogen but it does not incorporate a discrete nitrification/ denitrification phase as part of the treatment process.

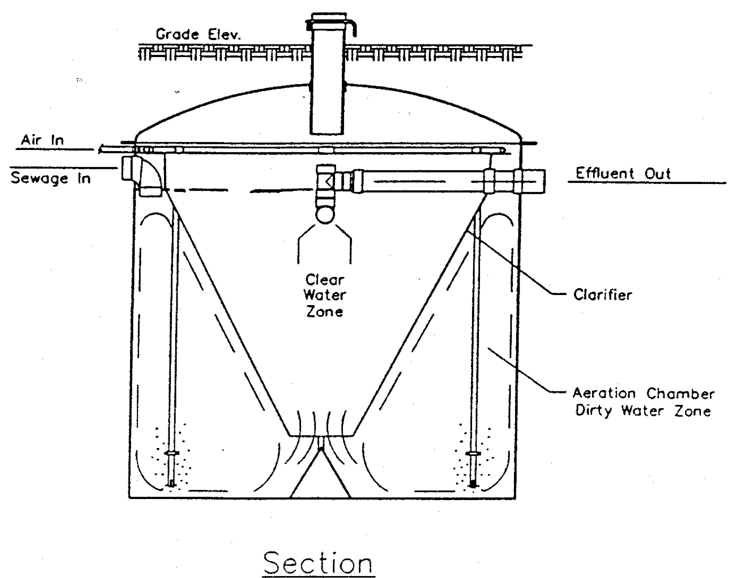

Fig. 6. Cross section of a Delta Whitewater unit (Delta).

f. Nayadic

This unit consists of a two concentric cone shaped tank with one compartment inside the other. Fig. 7 shows a cut-away view of the tank with sizes ranging from 500 to 1500 gpd capacity. This unit is NSF Class I rated.

The tank normally receives effluent directly from the source with a trash tank up front optional. However, for best performance time dosing with small frequent doses is recommended (Fig. 2) with a trash tank serving as a surge tank.

The raw wastewater enters the inner compartment. A blower discharges air to a diffuser in the open bottom of a draft tube in the center of the inner tank. The air lifts the mixed liquor upward with the solids settling down around the outside of the draft tube. The cycle continues with the aeration and mixed liquor confined to the inner tank.

As wastewater enters the tank, effluent from the inner tank moves downward through the solids laden mixed liquor in the bottom and upward in the outer tank. As the effluent rises, the solids settle downward to the center below the draft tube and are drawn up into

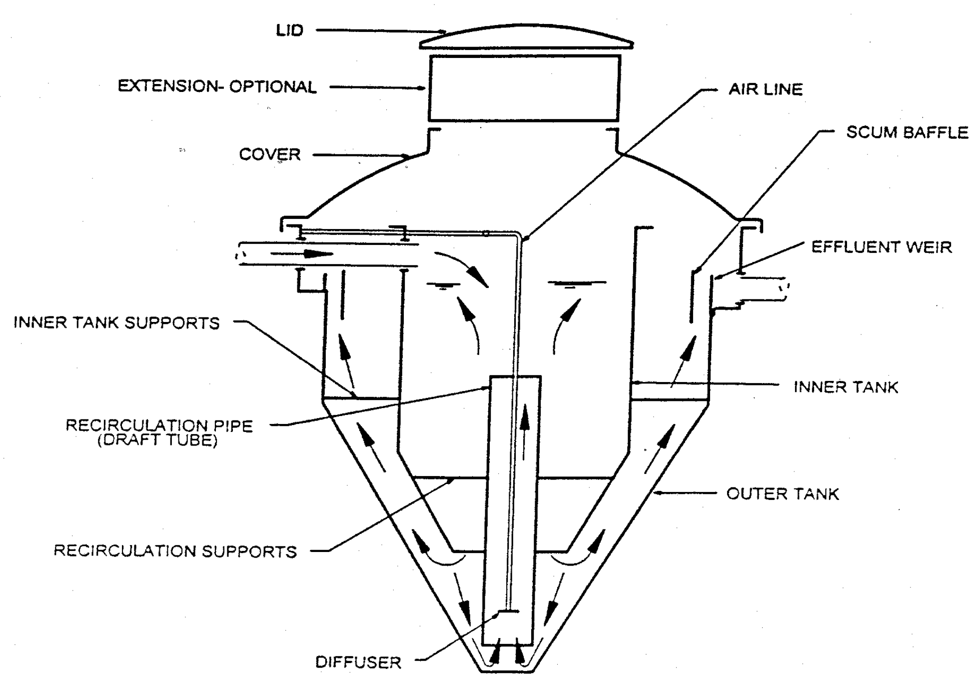

Fig. 7. A cut-away view of the Nayadic wastewater treatment unit (Consolidated).

the mixed liquor. Clear effluent flows over the 360° weir and out the exit pipe. A scum baffle located inside the overflow weir keeps floating solids from passing over the weir.

This unit removes some nitrogen but it does not incorporate a discrete nitrification/ denitrification phase as part of the treatment process. However, as the nitrified effluent moves downward into and through the solids laden bottom where the oxygen levels are probably very limited some nitrogen removal, via nitrification/denitrification, takes place.

Attached-growth Units

Attached-growth aerobic units incorporate a large surface area for bacteria to attach themselves. These surface areas may be fixed or they may be floating cylinders/spheres that move around in the mixed liquor.

a. Jet Treatment Plant

The J-353 model contains the "Jet Bat Process Media" in the aeration section (Fig. 8). This unit is primarily a submerged attached-growth media unit with the lower portion operating as suspended-growth phase. This unit is NSF Class 1 rated. It comes in several sizes.

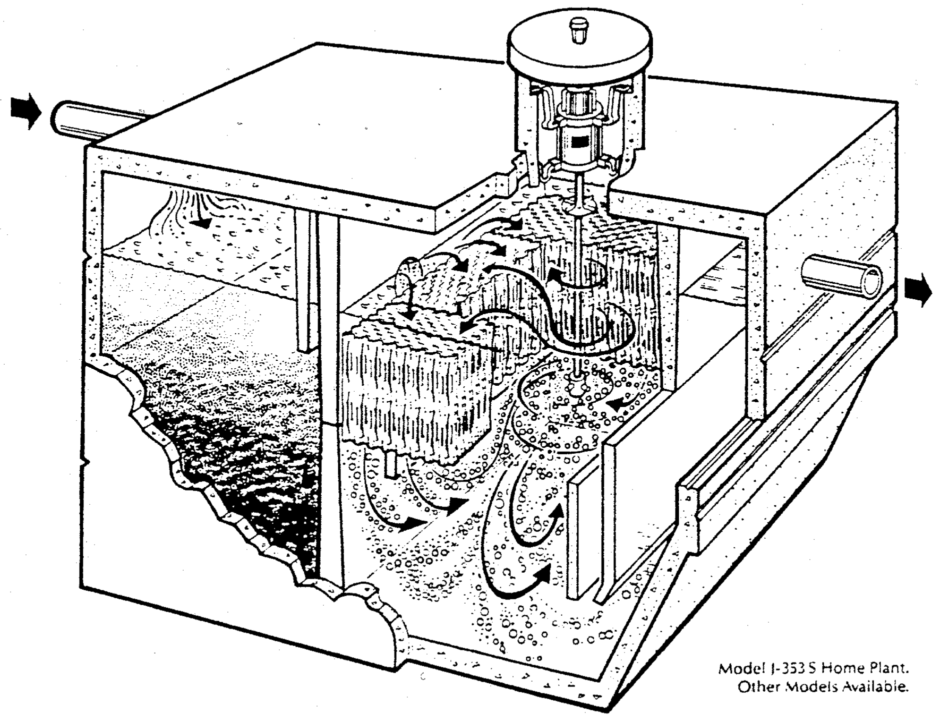

Fig. 8. A cut-away view of the J-353 Model Jet aeration plant for home use (Jet).

The wastewater from the home enters the pretreatment tank where the solids settle out. The chamber is sized at 475 gallons for a 3 bedroom size home. The effluent enters the extended aeration chamber through a submerged port where the suspended and dissolved solids are converted to bacterial cells, water and carbon dioxide. This compartment is sized at 600 gallons. Bacteria are attached to the fixed media in the upper portion of the compartment.

A top mounted motor rotates a shaft with a hub containing several openings. Air is drawn through the hollow shaft and through the hub with bubbles dispersing into the mixed liquor surrounding the shaft. Oxygen is diffused into the mixed liquor as the air bubbles move in the liquid. The rotating hub and air bubbles circulates mixed liquor throughout the fixed media. The mixed liquor moves through the porous media supplying dissolved oxygen and food (Fig. 8). Solids slough off the fixed media settling to the bottom of the compartment.

The mixed liquor moves out the bottom of the aeration chamber into and up through the clarifier section where the solids settle out. Some of the solids move back into the aeration chamber with the assistance of the sloping wall. This compartment is sized at 125 gallons. An optional tube settler is available for this compartment. The effluent flows out through the outlet pipe.

b. Bio-Microbics - FAST

This unit consists of a two compartment tank (Fig. 9). The tanks are locally manufactured and outfitted with a media chamber, external blower and controls. It has a NSF Class 1 rating.

Solids settle out in the first compartment with effluent flowing into the second compartment through a hole located near the top of the wall.

The FAST media chamber, inserted into the top of the second compartment, provides large surface area for bacteria attachment. The bottom of the chamber is open. An air lift tube (tube within a tube) is located in the center of the fixed media. Air, from an external blower is forced downward in the inner tube. As it exits the inner tube, it flows upward between the larger and smaller tubes. The air bubbles lift mixed liquor upward dispersing it over the top of the media where the mixed liquor and dissolved oxygen move downward through the media. Bacteria extract the organic matter, converting it to carbon dioxide, water and new cells. Organic nitrogen and ammonia are converted to nitrates. Solids slough off the fixed media and accumulate in the bottom portion of the second chamber.

A small trough located on top of the media (not shown) diverts some of the mixed liquor through the chamber sidewall into the second compartment outside the aeration chamber, where anoxic conditions exist. The nitrate is denitrified to nitrogen gas.

As wastewater moves into the second compartment, liquid moves out the discharge pipe which is connected to the inner chamber. Access to each compartment is through risers (not shown). Solids are pumped from both chambers, periodically. A nitrification/ denitrification process is designed into this system.

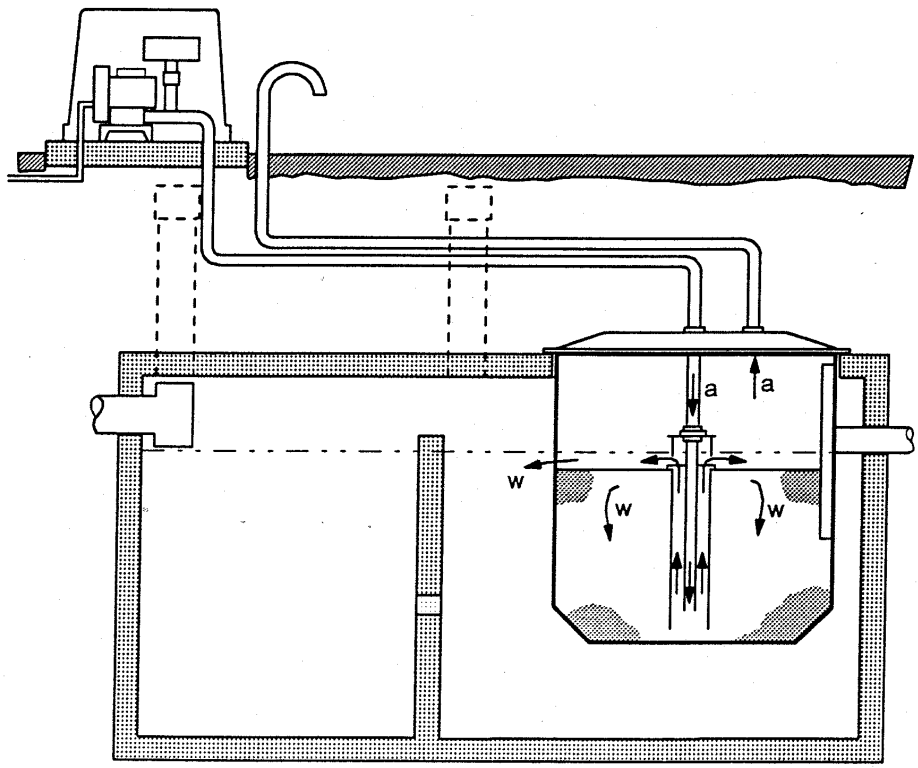

Fig. 9. Cross section of a Bio-Microbics FAST unit (Bio-Microbics).

c. MicrosepTec EnviroServer

The unit consists of a 5 compartment tank along with a thermal processor, blower(s), chlorinator and computer. This unit has an NSF Class 1 rating. It has been evaluated by the University of California - Riverside and has several accreditations by ANSI , SCC and RvD. Fig. 10 shows a cut-away view of the unit. The units come in 600, 1200 and 1500 gpd size.

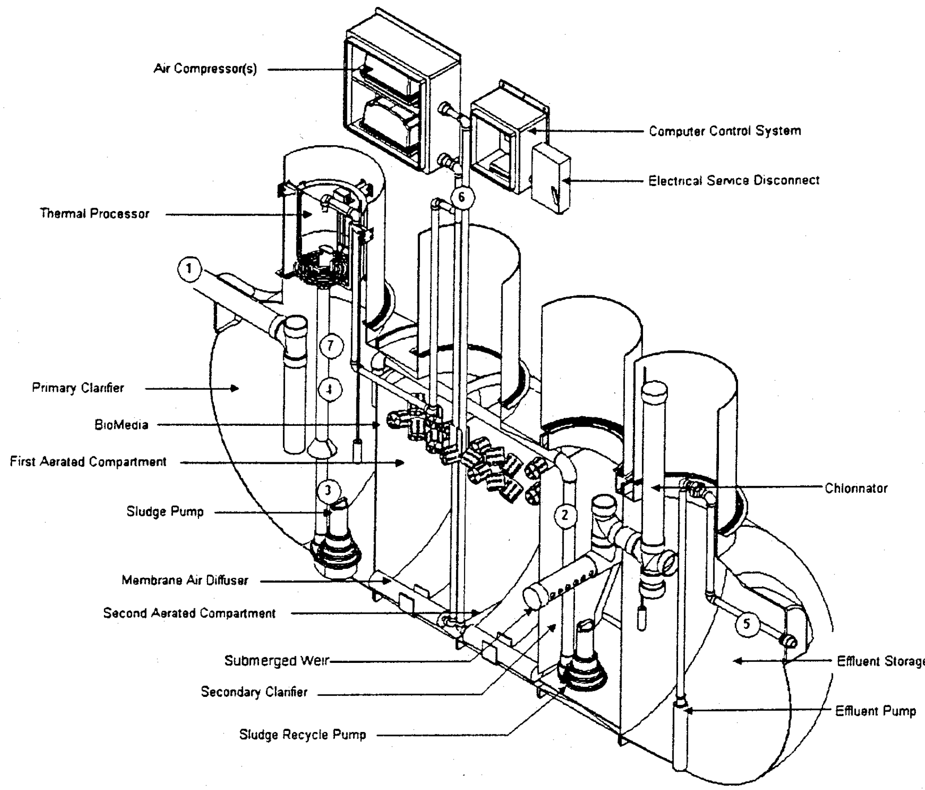

Fig. 10. Cut-away view of the EnvironServer Wastewater Treatment Unit (MicrosepTec).

The wastewater enters the primary clarifier where solids settle and the effluent and scum flow to the first aerated compartment with effluent movement into the second aeration compartment. Both of these compartments have floating media consisting of small cylinders with fins which serve as attachment sites for the bacteria. Air is delivered via a compressor and membrane air diffuser dedicated to each compartment. The small cylinders move around in the mixed liquor. There is about 15 cu. ft. of biomedia in each compartment for the 600 gpd unit. A single blower serves both compartments in the 600 gpd unit. The organic matter and suspended solids are reduced and the ammonia is converted to nitrate.

The mixed liquor flows through a submerged weir to the secondary clarifier chamber (compartment 4) where solids are settled out. A pump recycles the settled solids and effluent back to the primary clarifier where the nitrates are denitrified. In the 600 gpd unit approximately 50 gph is recycled to the primary chamber with the pump controlled by a timer.

Effluent flows from the secondary clarifier through a chlorinator into the effluent storage unit where a pump discharges it from the unit.

A sludge pump, located in the primary clarifier and controlled by a timer, discharges accumulated solids, controlled by a timer, to a thermal processor where the effluent flows via gravity through a screen (1/16" opening) back into the primary clarifier. The screen retains solids. When the solids accumulate to a prescribed depth, the thermal processor reduces the solids to ash and gas using a 220 volt electric burner. The ash falls into the primary clarifier and the gas is scrubbed as it exits the processor.

A computer monitors the process and is connected to the Microseptec headquarters for 24 hr monitoring. Monitoring includes primary and secondary alarms, high water level, air compressor (pressure switch), disinfection (ORP sensor), thermal decomposition cycle (thermocouples) and sludge pump (temperature change). Regulators, via password, can access the monitoring.

c. The Nibbler and Nibbler Jr.

Nibbler: The Nibbler was developed to reduce the high strength wastes (restaurant and other) to BOD levels of typical residential septic tank effluent (Fig. 11). The high strength wastewater (grey water, not black waters) enters a septic tank/ grease trap before entering the Nibbler.

The Nibbler consists of a concrete tank with pods of buoyant media in the upper portion of the tank. The media serve as attachment surfaces for the bacteria. A settling zone exists in the lower portion of the tank. Air is introduced in the lower portion of the pods with the mixed liquor circulated through the media. A small blower located adjacent to the unit supplies the air.

The upper portion of the mixed liquor is aerobic while the lower portion is anaerobic. Facultative bacteria, operating under either aerobic or anaerobic conditions, exist in an intermediate zone. Treated effluent with lower BOD, TSS and FOG (fats, oils and greases) exits the unit.

Nibbler Jr.: The Nibbler Jr. was developed for residential use (Fig. 12) to renovate failing soil absorption units by significantly reducing the organic load to the failing system. The unit is designed to remove BOD and suspended solids but not to the same extent as expected of Class 1 units. The unit is placed in the second compartment of a double compartment tank. It is desired to have the opening in the clear zone between the tanks for the first compartment can provide surge capacity. The liquid level in both tanks moves up and down through out the day as wastewater enters the first compartment and the effluent is slowly discharged from the system. The unit can be placed in a second tank but must have sufficient surge capacity.

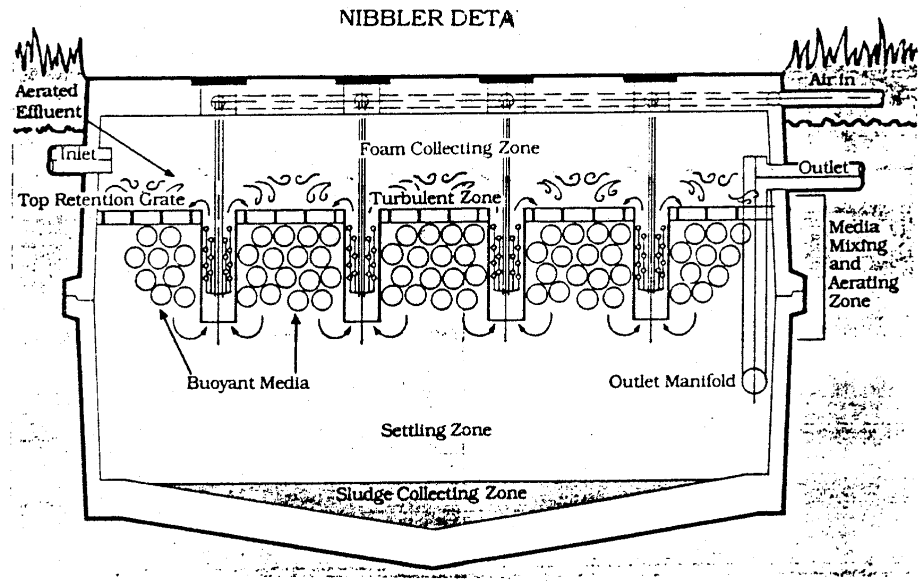

Fig. 11. The Nibbler for high strength wastes. (NCS)

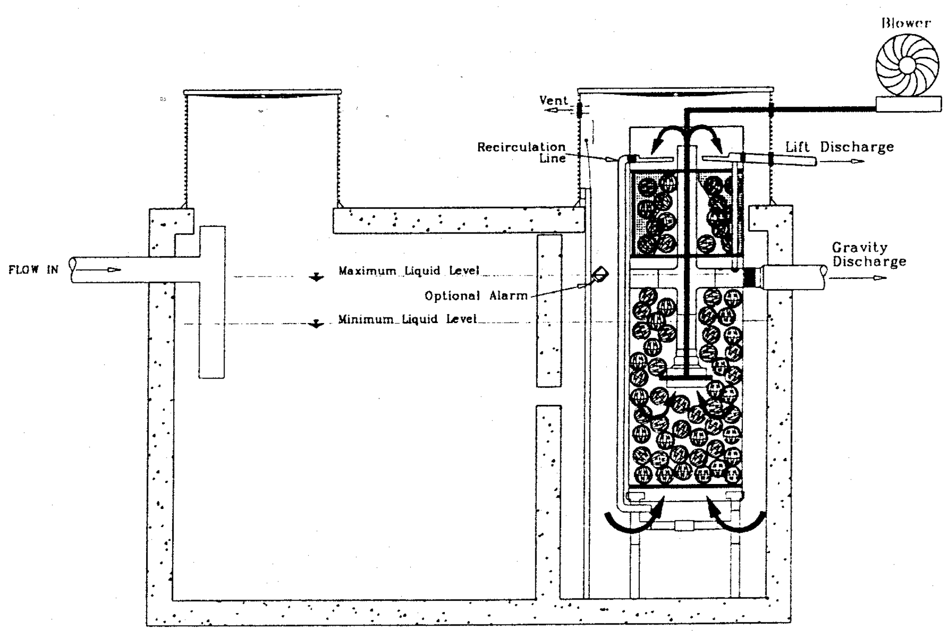

Fig. 12. Nibbler Jr. is placed in the second compartment of a two compartment tank. Effluent can discharge by gravity or be lifted (NCS).

Air is introduced near the bottom of the unit via an air lift tube using a regenerative blower located adjacent to the unit. The air lifts the wastewater upward between the inner and outer tube with a portion of the wastewater recycled to the bottom of the unit and a portion exiting the tank. The portion recycled and exiting the unit can be adjusted by changing the collection surface area, located in the splash zone.

This unit removes some nitrogen. Nitrogen reduction is enhanced by recycling a portion of the effluent to the bottom of the unit provided nitrates are present. This unit was not designed to specifically remove nitrogen.

d. Rotating Biological Contactor

A septic tank upstream removes the settleable solids. Effluent enters through the submerged inlet from an upstream septic tank (Fig. 13).

The disks rotate slowly with a portion of the disk submerged in the septic tank effluent. The biological growth is attached to the disks. During the submerged portion of the cycle, the bacteria come in contact with the organic matter in the effluent and during the air exposed portion of the cycle, oxygen diffuses into the biological mat maintaining aerobic conditions.

Biological growth slough off the disks into the unit with solids recycled to the septic tank or removed from the unit. Pumping of solids is required periodically. Some nitrification/denitrification is likely in this process.

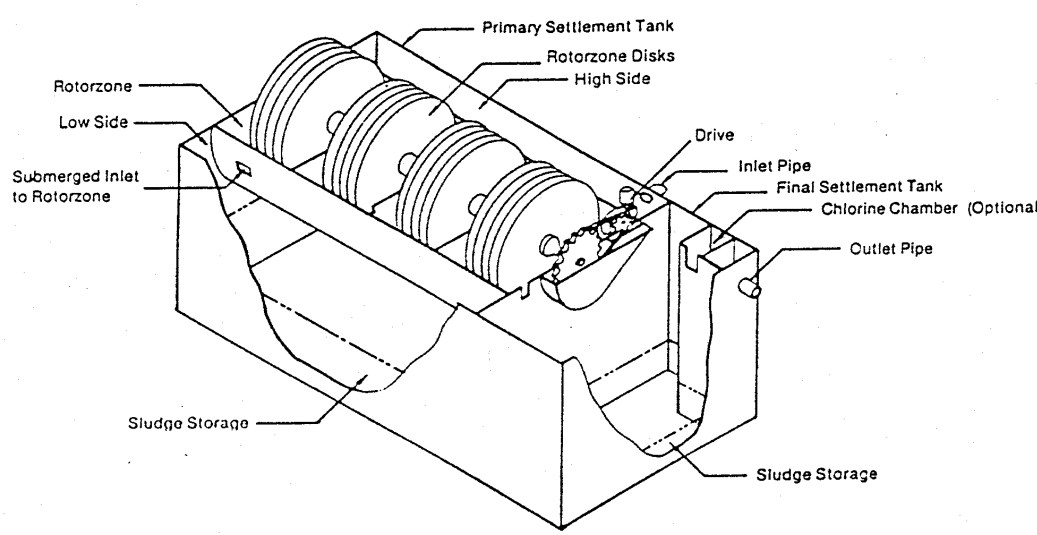

Fig. 13. Schematic of a rotating biological contactor (CSM Rotodisk Inc.)

PACKED BED FILTERS (PBFs)

Packed bed filters, are also known as fixed film media units and trickling filters. The most popular packed bed filter, known primarily as an intermittent sand filter, dates back to the late 1800s where it was used to treat wastewater. Single pass sand filters and recirculating sand/gravel filters have been used for many years. More recently, peat filters and synthetic media filters have been developed. These units can operate as single pass filters (sand and peat) or as multiple pass (recirculating) filters. Aeration is achieved by air diffusing through the open voids in the media with oxygen diffusing into the cell mass attached to the media. Some units will use a small fan to assist air movement in and around the media. Bacteria and other microflora attach themselves to the media. As the wastewater trickles downward over the media, the bacteria extract the organic matter and utilize the dissolved oxygen from the wastewater.

System Characteristics

- Systems are either single or multiple pass (recirculation).

- All systems have a septic tank to settle out the large solids and scum.

- Oxygen is supplied via atmospheric diffusion into the voids between the media. Some units use a small fan to assist aeration.

- Bacteria attach themselves to the media.

- Physical, chemical and biological reactions take place as the effluent moves over the media and through some of the media (foam and textile). Solids are filtered out, organic matter is converted to carbon dioxide and water with new bacterial cells being generated but not to the same extent as in some aerobic units. Nitrogen is converted to nitrate.

- For the most part, packed bed filters are more tolerant, some more so than others, to upsets by overloading and toxic materials entering the units. However, they can be upset if some care is not exercised.

- Most systems are operated with timed dosing which requires some controls and surge capacity in the septic tank/pump chamber. Some systems allow gravity flow to the unit.

- All systems should have sensor and alarms especially if pumps are part of the system.

- The septic tank needs to be monitored for solids and scum accumulation and pumped when appropriate. Solids accumulation in the packed beds generally does not accumulate as rapidly as in aerobic units. Units, loaded very heavily, will accumulate solids more so than units less heavily loaded.

- In single pass filters, nitrogen is converted to nitrates with some denitrification taking place on micro sites that are anoxic. In recirculating filters, all or a portion of the filter effluent is recycled to a recirculating tank that receives septic tank effluent or back through the septic tank. Some type of flow splitter diverts part of the effluent downstream for further processing or dispersal. Denitrification takes place in the recirculating tank if the anoxic conditions exist. Denitrification is enhanced if the filter effluent is recycled to the septic tank.

- These units need periodic maintenance by a professional. Some units may need monitoring every 6 months while others may require monitoring annually. Telemetry may reduce the number of site visits and will provide continuous monitoring.

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c. Waterloo Biofilter

The Waterloo Biofilter is a fixed media aeration unit consisting of a septic tank, pump chamber and biofilter placed in a wooden building above ground or in a concrete container with cover below grade (Fig. 22).

Media consists of 2" foam plastic cubes (same material as used in seat cushions) placed at random in a pod. The pod consists of a cylinder basket made of semi-rigid netting material that is about 2 ft in diameter by 2 ft high. The pods are stacked two high. A spray nozzle is located directly above each set of pods with effluent time dosed to the nozzle. A fine mist is applied over the entire top of the pod. Bacteria grow on the surface and inside the foam cubes. As the effluent moves downward, the effluent flows over the foam and into the foam cubes.

Air moves through and around the cubes to provide oxygen to the bacteria. A fan is mounted in the side of the unit to assist in air movement. The effluent exiting the unit flows to flow splitter where a portion of the effluent flows to the soil dispersal unit with the remainder flowing back to the septic tank or the pump chamber where denitrification takes place.

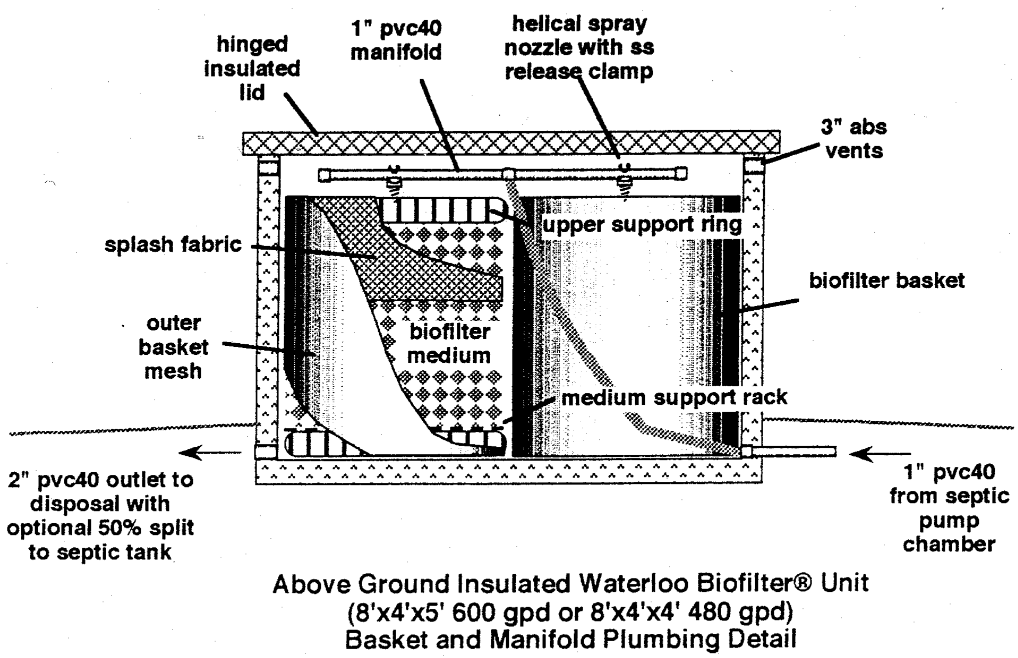

Fig. 22. Waterloo biofilter for on-site treating of wastewater. The system can also be installed below ground surface (Waterloo Biofilter Systems Inc.).

d. Aerocell Advanced Modular Treatment System

The Aerocell Advanced Modular Treatment System consists of a septic tank, pump chamber, aerocell treatment modules and a flow splitter (Fig. 23). It utilizes open-cell plastic foam as the treatment medium which is the same media as used in the Waterloo Biofilter. The unit comes in modules consisting of a plastic tank approximately 30" in diameter and 30" high. Four and 6 modules in parallel are required for a 3 and 4 bedroom homes, respectively. The filtered septic tank effluent is pumped to each pod where the effluent is sprayed on the surface.

The effluent passes over and through the media where the bacteria consume the organic matter and the nitrogen is converted to nitrate. The filter effluent passes to a flow splitter where a portion is recycled to the septic tank for denitrification and the remaining portion flows to a pump chamber or drain field.

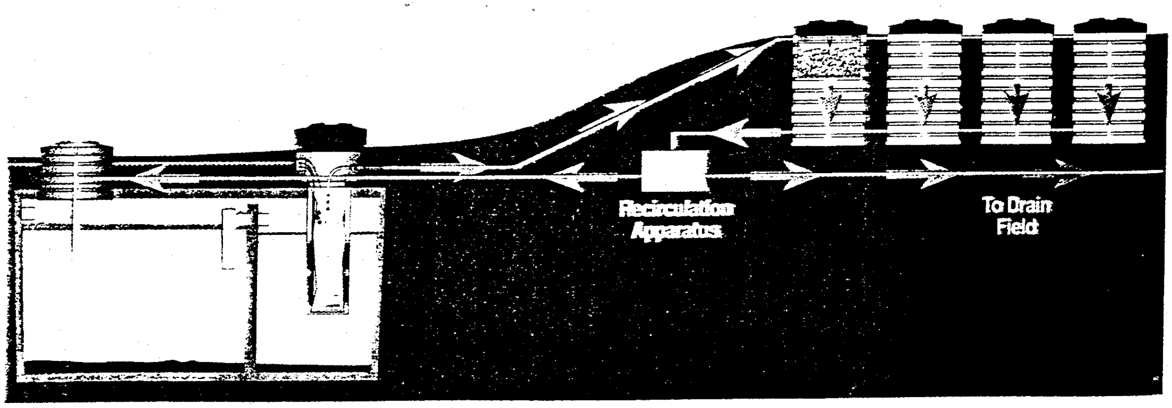

Fig. 23. View of a Aerocell advanced modular treatment unit (Zabel).

e. Bioclere System

This system incorporates a septic tank upstream of the Bioclere unit (Fig. 24). This unit is NSF Class 1 rated and comes in 500 gpd capacity and larger units.

The septic tank effluent passes into the baffled zone in the sump of the unit. The effluent is pumped at timed intervals to the top of the trickling filter where it is distributed over the filter media. The media consists of randomly packed plastic media serving as attachment sites for the bacteria. As the wastewater passes over the media, the bacteria remove the organic material and convert the nitrogen to nitrates. Air diffuses into the media void area to provide aerobic conditions in the filter. A fan assists in the air movement.

The effluent reenters the sump where it is mixes with the sump contents. A portion of the effluent is recycled through the trickling filter, depending on the amount of septic effluent entering the unit. The solids that slough off the trickling filter settle out in the bottom of the sump. The nitrate is denitrified. Clarified effluent exits the unit through the discharge pipe.

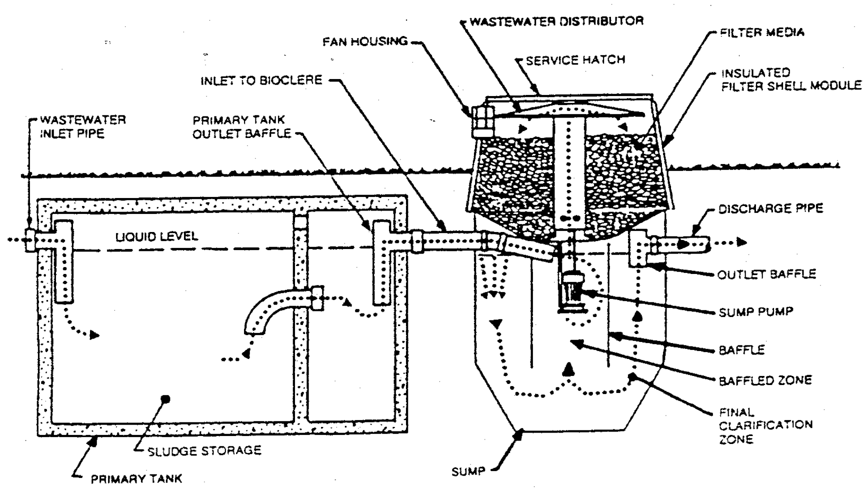

Fig. 24. Cross section of a typical residential Bioclere system (Ekofinn Limited).

e. Others

There are many other aeration type devices on the market that serve in the same capacity as those listed above. It is not the intent of the author to discriminate against any one by not including their unit. More units will be added as time permits.

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Clearstream Wastewater Systems, Inc. P.O. Box 705, Silsbee, TX 77656 (409-385-1395)

Consolidated Treatment Systems Inc. 1501 Commerce Center Drive, Franklin, OH. 45005 513-746-2727.

Crest Precast Inc. 609 Kistler Drive, LaCrescent, MN 55947. 1-877-843-4231. www.RIGHTSystem.com

Cromaglass Corporation, P.O. Box 3215, Williamsport, PA 17701, (717-326-3396)

CMS Rotodisk Inc. 5266 General Rd. Unit 12, Mississauga, Ont. Canada L4W 1Z7.

Delta Environmental Products Inc. 8275 Florida Blvd, Denham Springs, LA 70727. (800-219-9183)

Ekofinn Limited, 33639 Ninth Ave. So. Federal Way, WA 98003 (206-661-6128)

Jet Inc., 750 Alpha Drive, Cleveland, OH 44143 (216-461-2000)

NCS, 16207 Meridian, P.O. Box 73399, Puyallup, WA (206-838-2359)

Norweco, Inc. 220 Republic Street, Norwalk, OH 44857-1196 (419-668-4471)

Orenco Systems Inc. 814 Airway Avenue, Sutherlin, Oregon. 97479-9012. (1-800-348-9843). Www.orenco.com

Waterloo Biofilter Systems Inc. 2 Taggart Court, Unit # 4 Guelph, Ontario, N1H 6H8, Canada. (519-836-3380)

Zabel Environmental Technology, 10409 Watterson Tr. Louisville, KY40299-3701. (1-800-221-5742). Http://www.zabel.com.

ASSESSING PERFORMANCE OF ON-SITE TREATMENT UNITS THAT TREAT THE WASTEWATER AEROBICALLY

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January, 2000
Revised: Sept., 2000
Revised: Feb., 2001

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 www/chemetrics.com 800 356-3072 Route 28 Calverton, VA 20138	Dissolved oxygen chemet tubes
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 www.hach.com 800 227-4224 PO Box 389 Loveland, CO 80539	Test strips for ammonia, nitrate, pH, Alkalinity
LaMotte www.lamotte.com 800 344-3100 PO Box 329 Chestertown, MD 21620	

PART VI

Alternative Toilets

Outdoor Toilets

The provisions of Chapter 69.13 allow the use of outdoor toilets. The pit should be liquid-tight, with the wastes periodically removed by someone who services septic tanks. The privy should be securely attached to the ground or to the tank used for the pit.

An outdoor toilet can be kept relatively odor-free and can be constructed for year-round use. But while an outdoor toilet is the least costly alternative to a flush toilet, it may be the least desirable alternative for a residence in a northern climate.

An improperly constructed and maintained privy can be an abomination to both eyes and nose. Several methods can be used to minimize the sanitary privy odor problem caused by decomposition of the organic matter in the pit.

- Chemical additives can change the bacterial action so that less odor is generated.
- Both the pit and the upper part of the structure must be vented.
- There should be tight fitting covers on the seat openings.
- Finally, the inside of the structure should be painted with a polyurethane-type paint to minimize the penetration of odors into the wood.

Additives

A number of products on the market claim to minimize odors in a sanitary privy. One that is reasonably effective is hydrated lime. Associated compounds containing the same chemical are slaked lime, quicklime, hot lime, chloride of lime, and pebbled lime.

Approximately one cup of hydrated lime sprinkled over the solids in the pit will minimize odors and aid in decomposition. As the odors again become objectionable another cup of lime should be added. Excess amounts of hydrated lime will retard decomposition, however, rather than promote it, although the generation of odors will be inhibited. Caution should be used to keep the hydrated lime dust out of eyes and nostrils.

Commercial compounds are available and may be tried by the individual owner in order to determine their effectiveness. Some of them are odor suppressants while others change the bacterial environment within the pit.

Ventilation

To minimize odors in the upper part of the privy, vent the pit. Insect-proof openings should be placed in the walls below the seat. A vent should extend from the underside of the seat board through the roof or up to a horizontal vent open to the sides of the toilet. All vent openings to the outside should be properly screened to keep out insects.

The vent must be flush with the underside of the seat board and must not extend down into the pit. Gases which cause odors are lighter than air, and if the vent extends down below the seat board, these gasses will collect under the seat board to be released upward into the privy when the seat cover is opened.

The opening in the seat board must have a tight-fitting cover. The type of seat and cover used on a flush toilet is *not* satisfactory unless weather stripping is added. The cover should be kept in place when the privy is not in use, and can be hinged to close automatically.

At the top of the privy there should be a screened opening on each side or, preferably, all the way around the top to allow air to pass through and carry away any odors which may seep into the upper part of the structure.

A tight-fitting door, preferably with a self-closing feature, such as a spring, should be used to minimize the number of insects that get into the privy. (A crescent-shaped window, also screened, may be cut into the door so that the utility of the structure will be recognized.)

Keeping Wood Odor-Free

Any odors, which in the past have risen into the structure of an old privy, have probably become entrapped in the pores of the wood. To remove these odors, make a solution of disinfectant and trisodium phosphate, and scrub the inside walls and all other inside surfaces of the privy. This solution will remove odors from the pores of the wood. After the wood has dried, paint the inside of the privy with a polyurethane compound to prevent any additional odors from penetrating the wood.

These techniques should minimize the odor that collects in the structure of a sanitary privy. Proper air circulation can be very helpful in carrying away any odors, so proper venting of the structure is absolutely essential.

Even though bacteria are decomposing the organic waste, there will be some residue remaining. This residue will gradually build up until it must either be removed or the structure moved to a new location. Usually a septic tank pumper or someone can remove the solids with equipment to perform the task in a sanitary manner. The frequency of solids removal will depend upon the size of the pit and the amount of use.

Gas Incinerator Toilets

The function of an electric incinerator toilet is essentially the same, except that electrical energy is used for the incineration process.

Incinerator toilets can completely eliminate liquid and solid toilet wastes from the sewage treatment system. The initial cost may vary from $800 to $1,500, including electric wiring and a fireproof vent for the waste gases. Check with your local building official to determine the type of fireproof vent that is required for the installation of an incinerator toilet.

In addition to the initial expense, there may be some replacement costs of component parts for an incinerator toilet. Average energy use is 1.5 pounds of gas or 1.0 kWh for each toilet cycle (flush). Current energy costs can be used to determine the actual use cost.

Because an incinerator toilet requires a cool-down period after each incineration cycle, it may not be a particularly desirable device for a large family where demands on the toilet may come in short spans of time. An incinerator toilet is not particularly effective for situations where there is a considerable amount of liquid waste. Liquid is difficult to burn.

The waste gases from an incinerator toilet have some odor and, under certain atmospheric conditions, may settle to the ground and be objectionable to occupants or neighbors. There have been reports along lakeshore areas, where temperature inversions are common, of incinerator toilets causing serious odor problems. The firepot requires regular cleaning to remove ashes and other residue and will need to be periodically replaced, depending upon the amount of use.

Chemical Toilets

Figure F-1 shows a schematic diagram of a chemical toilet, which is available in many models. In most chemical toilets, a charge of chemical is added to a small amount of water. After use, the liquid is recirculated by an electric- or hand-operated pump to flush the wastes into the holding chamber.

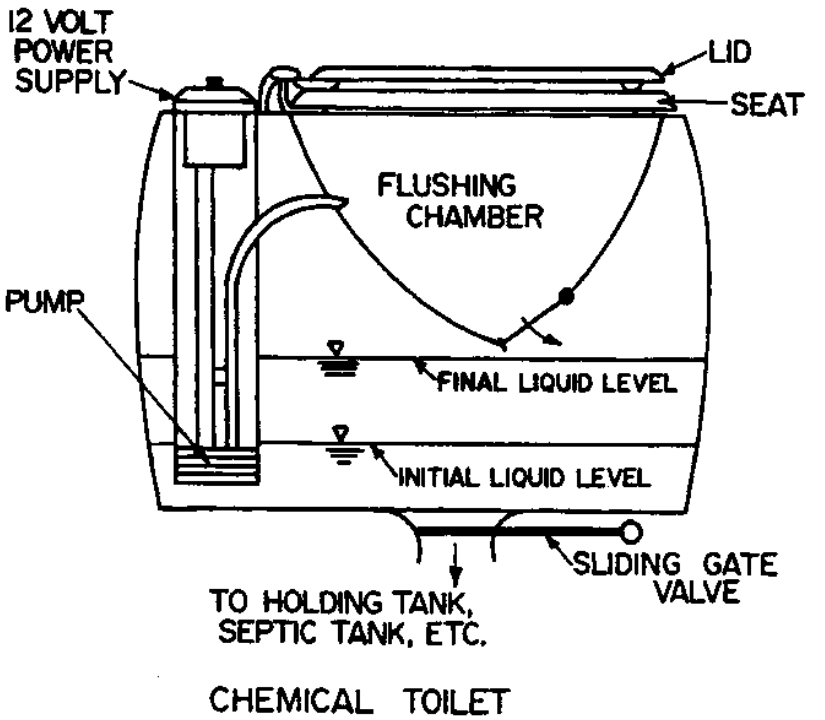


Figure F-1

The initial charge of chemical is adequate for 40 to 160 uses, depending upon the model. When the holding chamber is full, a valve can be opened to discharge wastes into the septic tank. On some chemical toilets, the holding chamber can be removed for disposal of wastes. Wastes are reduced to about two percent of those from a conventional flush toilet.

The initial cost of chemical toilets varies greatly depending on model and size, but it will likely range from $200 to $700 plus installation. The cost of the chemical may be from two to three cents per toilet use. Because most chemical toilets are plastic, they should not corrode. Maintenance costs should be minor.

Composting Toilets

The composting toilet shown in Figure F-2 requires an adjoining room or a cellar for the composting unit. It is also available, however, in a smaller room-sized model as shown in Figure F-3.

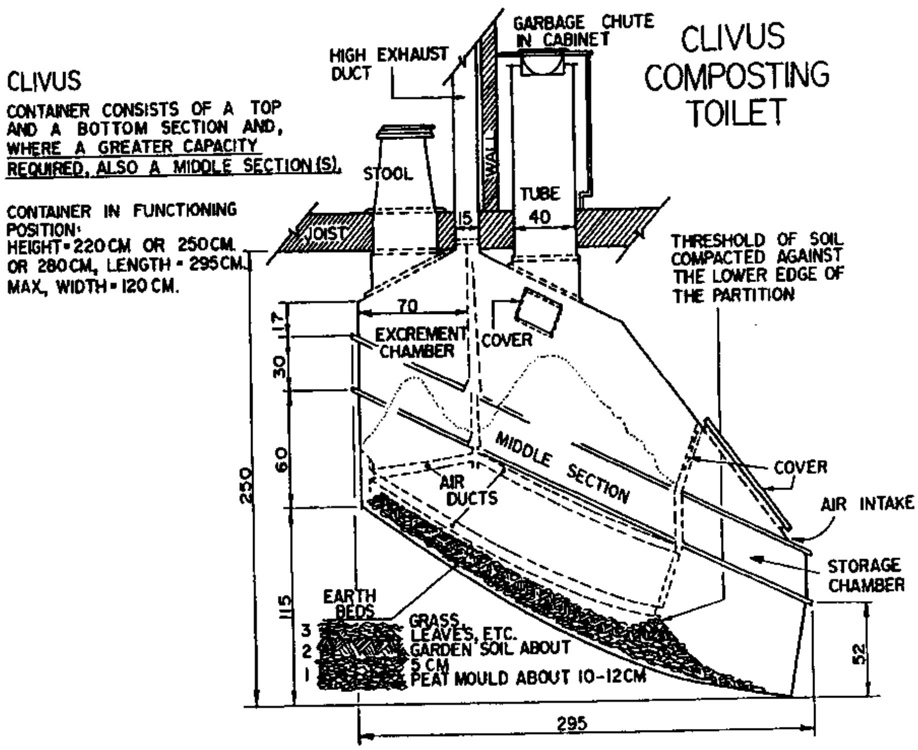
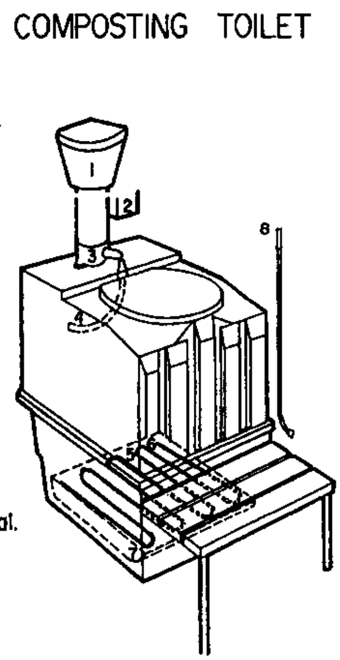


Figure F-2



1. Ventilator Cover with fine-mesh net to prevent flies and insects from entering.
2. Transformer with switch.
3. Fan to evacuate all odor.
4. Distributor to spread input.
5. Heating Coil to warm and evaporate liquid.
6. Thermostat placed inside the heating coil to control the heat level.
7. Collecting Tray to hold decomposed material.
8. Scraper for use when emptying

Figure F-3

Composting toilets are more appropriately called **biological toilets** and have two basic principles of operation:

- liquid is evaporated, and
- solid wastes are biologically decomposed into compost.

The biological toilet uses no water and requires no connection to house plumbing.

Every biological toilet has a capacity limit, which depends on its ability to evaporate moisture. To increase the capacity, most room-sized biological toilets use heating elements and fans, together with mixers for the organic material. All biological toilets designed for year-round use must have electricity to run the fan and the heating element. Large-volume biological toilets may be used in seasonal residences without having electricity available, but care must be taken that excess liquid is not discharged into them.

All biological toilets must have the compost removed periodically. The frequency—which depends upon the type of toilet and the number of people using it—might vary from every three weeks to once per year. A biological toilet requires frequent examination and care so that it will continue to function in a satisfactory manner. Care and maintenance requirements vary with the different brands of toilets.

It is advisable to obtain an accurate cost estimate from the supplier of the model you are interested in, as well as information about energy consumption, installation, maintenance and replacement. Energy costs may be appreciable for the year-round use of a composting toilet. The prices of composting toilets may range from $750 to $3,000, plus installation.

Part VII Disinfection:

Attached are 3 articles on disinfection. For more information check out the web.

Onsite Wastewater Treatment Systems Technology Fact Sheet 4

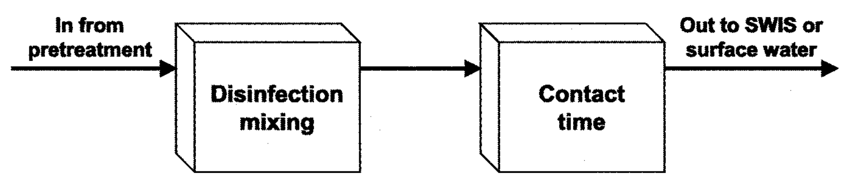
Effluent Disinfection Processes

Description

The process of disinfection destroys pathogenic and other microorganisms in wastewater. A number of important waterborne pathogens are found in the United States, including some bacteria species, protozoan cysts, and viruses. All pretreatment processes used in onsite wastewater management remove some pathogens, but data are scant on the magnitude of this destruction. The two methods described in this section, chlorination and ultraviolet irradiation, are the most commonly used (figure 1). Currently, the effectiveness of disinfection is measured by the use of indicator bacteria, usually fecal coliform. These organisms are excreted by all warm-blooded animals, are present in wastewater in high numbers, tend to survive in the natural environment as long as or longer than many pathogenic bacteria, and are easy to detect and quantify.

A number of methods can be used to disinfect wastewater. These include chemical agents, physical agents, and irradiation. For onsite applications, only a few of these methods have proven to be practical (i.e., simple, safe, reliable, and cost-effective). Although ozone and iodine can be and have been used for disinfection, they are less likely to be employed because of economic and engineering difficulties.

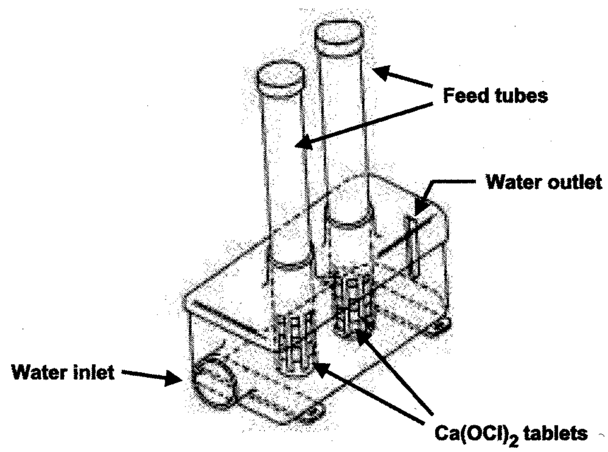
Figure 1. Generic disinfection diagram



Chlorine

Chlorine is a powerful oxidizing agent and has been used as an effective disinfectant in water and wastewater treatment for a century. Chlorine may be added to water as a gas (Cl_2) or as a liquid or solid in the form of sodium or calcium hypochlorite, respectively. Because the gas can present a significant safety hazard and is highly corrosive, it is not recommended for onsite applications. Currently, the solid form (calcium hypochlorite) is most favored for onsite applications. When added to water, calcium hypochlorite forms hypochlorous acid (HOCl) and calcium hydroxide (hydrated lime, $Ca(OH)_2$). The resulting pH increase promotes the formation of the anion, OCl^-, which is a free form of chlorine. Because of its reactive nature, free chlorine will react with a number of reduced compounds in wastewater, including sulfide, ferrous iron, organic matter, and ammonia. These nonspecific side reactions result in the formation of combined chlorine (chloramines), chloro-organics, and chloride, the last two of which are not effective as disinfectants. Chloramines are weaker than free chlorine but are more stable. The difference between the chlorine residual in the wastewater after some time interval (free and combined chlorine) and the initial dose of chlorine is referred to as chlorine demand. The 15-minute chlorine demand of septic tank effluent may range from 30 to 45 mg/L as Cl; for biological treatment effluents, such as systems in Technology Fact Sheets 1, 2, and 3, it may range from 10 to 25 mg/L; and for sand filtered effluent, it may be 1 to 5 mg/L (Technology Fact Sheets 10 and 11).

Figure 2. Example of a stack-feed chlorinator



Calcium hypochlorite is typically dosed to wastewater in an onsite treatment system using a simple tablet feeder device (figure 2). Wastewater passes through the feeder and then flows to a contact tank for the appropriate reaction. The product of the contact time and disinfectant residual concentration (Ct) is often used as a parameter for design of the system. The contact basin should be baffled to ensure that short-circuiting does not occur. Chlorine and combined chlorine residuals are highly toxic to living organisms in the receiving water. Because overdosing (ecological risk) and underdosing (human health risk) are quite common with the use of tablets, long swales/ditches are recommended prior to direct discharge to sensitive waters.

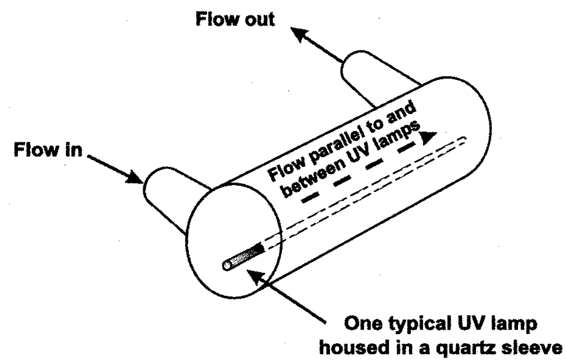
Use of simple liquid sodium hypochlorite (bleach) feeders is more reliable but requires more frequent site visits by operators. These systems employ aspirator or suction feeders that can be part of the pressurization of the wastewater, causing both the pump and the feeder to require inspection and calibration. These operational needs should be met by centralized management or contracted professional management.

Ultraviolet irradiation

The germicidal properties of ultraviolet (UV) irradiation have been recognized for many years. UV is germicidal in the wavelength range of 250 to 270 nm. The radiation penetrates the cell wall of the organism and is absorbed by cellular materials, which either prevents replication or causes the death of the cell. Because the only UV radiation effective in destroying the organism is that which reaches it, the water must be relatively free of turbidity. Because the distance over which UV light is effective is very limited, the most effective disinfection occurs when a thin film of the water to be treated is exposed to the radiation. The quantity of UV irradiation required for a given application is measured as the radiation intensity in microWatt-seconds per square centimeter (mW-s/cm^2). For each application, wastewater transmittance, organisms present, bulb and sleeve condition, and a variety of other factors will have an impact on the mW-s/cm^2 required to attain a specific effluent microorganism count per 100 mL. The most useful variable that can be readily controlled and monitored is Total Suspended Solids. TSS has a direct impact on UV disinfection, which is related to the level of pretreatment provided.

Many commercial UV disinfection systems (figure 3) are available in the marketplace. Each has its own approach to how the wastewater contacts UV irradiation, such as the type of bulb (medium or low pressure; medium, low, or high intensity), the type of contact chamber configuration (horizontal or vertical), or the sleeve material separating the bulb from the liquid (quartz or teflon). All can be effective, and the choice will usually be driven by economics.

Figure 3. Wastewater flow in a quartz UV unit



Typical applications

Disinfection is generally required in three onsite-system circumstances. The first is after any process that is to be surface discharged. The second is before a SWIS where there is inadequate soil (depth to ground water or structure too porous) to meet ground water quality standards. The third is prior to some other immediate reuse (onsite recycling) of effluent that stipulates some specific pathogen requirement (e.g., toilet flushing or vegetation watering).

Design assumptions

Chlorination units must ensure that sufficient chlorine release occurs (depending on pretreatment) from the tablet chlorinator. These units have a history of erratic dosage, so frequent attention is required. Performance is dependent on pretreatment, which the designer must consider. At the point of chlorine addition, mixing is highly desirable and a contact chamber is necessary to ensure maximum disinfection. Working with chlorinator suppliers, designers should try to ensure consistent dosage capability, maximize mixing usually by chamber or head loss, and provide some type of pipe of sufficient length to attain effective contact time before release. Tablets are usually suspended in open tubes that are housed in a plastic assembly designed to increase flow depth (and tablet exposure) in proportion to effluent flow. Without specific external mixing capability, the contact pipe (large-diameter Schedule 40 PVC) is the primary means of accomplishing disinfection. Contact time in these pipes (often with added baffles) is on the order of 4 to 10 hours, while dosage levels are in excess of those stated in table 1 for different pretreatment qualities and pH values. The commercial chlorination unit is generally located in a concrete vault with access hatch to the surface. The contact pipe usually runs from the vault toward the next step in the process or discharge location. Surface discharges to open swales or ditches will also allow for dechlorination prior to release to a sensitive receiving water.

Table 1. Chlorine disinfection dose (in mg/L) design guidelines for onsite applications

Calcium hypochlorite	Septic tank effluent	Biological treatment effluent	Sand filter effluent
pH 6	35–50	15–30	2–10
pH 7	40–55	20–35	10–20
pH 8	50–65	30–45	20–35

Note: Contact time = 1 hour at average flow and temperature 20 °C. Increase contact time to 2 hours at 10 °C and 8 hours at 5 °C for comparable efficiency. Dose = mg/L as Cl. Doses assume typical chlorine demand and are conservative estimates based on fecal coliform data.

The effectiveness of UV disinfection is dependent upon UV power (table 2), contact time, liquid film thickness, wastewater absorbance, wastewater turbidity, system configuration, and temperature. Empirical relationships are used to relate UV power (intensity at the organism boundary) and contact time. Table 2 gives a general indication of the dose requirements for selected pathogens. Since effective disinfection is dependent on wastewater quality as measured by turbidity, it is important that pretreatment provide a high degree of suspended and colloidal solids removal.

Table 2. Typical ultraviolet (UV) system design parameters

Design parameter	Typical design value
UV dosage	20–140 mW-s/cm^2
Contact time	6–40 seconds
UV intensity	3–12 mW-s/cm^2
Wastewater UV transmittance	50–70%
Wastewater velocity	2–15 inches per second

Commercially available UV units that permit internal contact times of 30 seconds at peak design flows for the onsite system can be located in insulated outdoor structures or in heated spaces of the structure served, both of which must protect the unit from dust, excessive heat, freezing, and vandals. Ideally, the unit should also provide the necessary UV intensity (e.g., 35,000 to 70,000 mW-s/cm^2) for achieving fecal coliform concentrations of about 200 CFU/100 mL. The actual dosage that reaches the microbes will be reduced by the transmittance of the wastewater (e.g., continuous-flow suspended-growth aerobic systems [CFSGAS] or fixed-film systems [FFS] transmittance of 60 to 65 percent). Practically, septic tank effluents cannot be effectively disinfected by UV, whereas biological treatment effluents can meet a standard of 200 cfu/100 mL with UV. High-quality reuse standards will require more effective pretreatment to be met by UV disinfection. No additional contact time is required. Continuous UV bulb operation is recommended for maximum bulb service life. Frequent on/off sequences in response to flow variability will shorten bulb life. Other typical design parameters are presented in table 2.

Performance

There are few field studies of tablet chlorinators, but those that exist for post-sand-filter applications show fecal coliform reductions of 2 to 3 logs/100 mL. Another field study of tablet chlorinators following biological treatment units exceeded a standard of 200 FC/100 mL
93 percent of the time. No chlorine residual was present in 68 percent of the samples. Newer units managed by the biological unit manufacturer fared only slightly better. Problems were related to TSS accumulation in the chlorinator, tablet caking, failure of the tablet to drop into the sleeve, and failure to maintain the tablet supply. Sodium hypochlorite liquid feed systems can provide consistent disinfection of sand filter effluents (and biological system effluents) if the systems are managed by a utility.

Data for UV disinfection for onsite systems are also inadequate to perform a proper analysis. However, typical units treating sand filter effluents have provided more than 3 logs of FC removal and more than 4 logs of poliovirus removal. Since this level of pretreatment results in a very low final FC concentration (<100 CFU/100 mL), removals depend more on the influent concentration than inherent removal capability. This is consistent with several large-scale water reuse studies that show that filtered effluent can reach essentially FC-free levels (<1 CFU/100 mL) with UV dosage of about 100 mW-s/cm^2, while higher (but attainable) effluent FC levels require less dosage to filtered effluent (about 48 mW-s/cm^2) than is required by aerobic unit effluent (about 60 mW-s/cm^2). This can be attributed to TSS, turbidity, and transmittance (table 3). Average quartz tube transmittance is about 75 to 80 percent.

Table 3. Typical (UV) transmittance values for water

Wastewater treatment level	Percent transmittance
Primary	45–67
Secondary	60–74
Tertiary	67–82

Source: USEPA, 1986.

Management needs

Chlorine addition by tablet feeders is likely to be the most practical method for chlorine addition for onsite applications. Tablet feeders are constructed of durable, corrosion-free plastics and are designed for in-line installation. Tablet chlorinators come as a unit similar to figure 2. If liquid bleach chlorinators are used, they would be similarly constructed. That unit is placed inside a vault that exits to the contact basin. The contact basin may be plastic, fiberglass, or a length of concrete pipe placed vertically and outfitted with a concrete base. Baffles should be provided to prevent short-circuiting of the flow. The contact basin should be covered to protect against the elements, but it should be readily accessible for maintenance and inspection.

The disinfection system should be designed to minimize operation and maintenance requirements, yet ensure reliable treatment. For chlorination systems, routine operation and maintenance would include servicing the tablet or solution feeder equipment, adding tablets or premixed solution, adjusting flow rates, cleaning the contact tank, and collecting and analyzing effluent samples for chlorine residuals. Caking of tablet feeders may occur and will require appropriate maintenance. Bleach feeders must be periodically refilled and checked for performance. Semiskilled technical support should be sufficient, and estimates of time are about 6 to 10 hours per year. There are no power requirements for gravity-fed systems. Chemical requirements are estimated to be about 5 to 15 pounds of available chlorine per year for a family of four. During the four or more inspections required per year, the contact basin may need cleaning if no filter is located ahead of the unit. Energy requirements for a gravity-fed system are nil. If positively fed by aspirator/suction with pumping, the disinfection unit and alarms for pump malfunctions will use energy and require inspection. Essentially unskilled (but trained) labor may be employed. Safety issues are minimal and include wearing of proper gloves and clothing during inspection and tablet/feeder work.

Commercially available package UV units are available for onsite applications. Most are self-contained and provide low-pressure mercury arc lamps encased by quartz glass tubes. The unit should be installed downstream of the final treatment process and protected from the elements. UV units must be located near a power source and should be readily accessible for maintenance and inspection. Appropriate controls for the unit must be corrosion-resistant and enclosed in accordance with electrical codes.

Routine operation and maintenance for UV systems involves semiskilled technician support. Tasks include cleaning and replacing the UV lamps and sleeves, checking and maintaining mechanical equipment and controls, and monitoring the UV intensity. Monitoring would require routine indicator organism analysis. Lamp replacement (usually annually) will depend upon the equipment selected, but lamp life may range from 7,500 to 13,000 hours. Based on limited operational experience, it is estimated that 10 to 12 hours per year would be required for routine operation and maintenance. Power requirements may be approximately 1 to 1.5 kWh/d. Quartz sleeves will require alcohol or other mildly acidic solution at each (usually four per year) inspection.

Whenever disinfection is required, careful attention to system operation and maintenance is necessary. Long-term management, through homeowner-service contracts or local management programs, is an important component of the operation and maintenance program. Homeowners do not possess the skills needed to perform proper servicing of these units, and homeowner neglect, ignorance, or interference may contribute to malfunctions.

Risk management issues

With proper management, the disinfection processes cited above are reliable and should pose little risk to the homeowner. As mentioned above, a potentially toxic chlorine residual may have an important environmental impact if it persists at high concentrations in surface waters. By-products of chlorine reactions with wastewater constituents may also be toxic to aquatic species. If dechlorination is required prior to surface discharge, reactors containing sulfur dioxide, sodium bisulfate, sodium metabisulfate, or activated carbon can be employed. If the disinfection processes described above are improperly managed, the processes may not deliver the level of pathogen destruction that is anticipated and may result in some risk to downstream users of the receiving waters. The systems described are compact and require modest attention. Chlorination does not inherently require energy input; UV irradiation and dosage pumps do consume some energy

(>1kWh/day). Both processes will require skilled technical support for the monitoring of indicator organisms in the process effluents.

Chlorination systems respond to flow variability if the tablets are feeding correctly. UV does not do so and is designed for the highest flow scenario, thus overdosing at lower flows since there is no danger in doing so. Toxic loads are unlikely to affect either system, but TSS can affect both. Inspections must include all pretreatment steps. UV is more sensitive to extreme temperatures than chlorination, and must be housed appropriate to the climate. In extremely cold climates, the UV system can be housed inside the home with minimal danger to the inhabitants. Power outages will terminate UV disinfection and pressurized pumps for both systems, while causing few problems for gravity-fed chlorination units. There should be no odor problems during these outages.

Costs

Installed costs of a complete tablet chlorination unit are about $400 to $500 for the commercial chlorinator unit and associated materials and $800 to $1,200 for installation and housing. Operation and maintenance would consist of tablets ($30 to $50 per year), labor ($75 to $100 per year), and miscellaneous repairs and replacements ($15 to $25 per year), in addition to any analytical support required.

Installed costs of UV units and associated facilities are $1,000 to $2,000. O/M costs include power ($35 to $40 per year), semiskilled labor ($50 to $100 per year), and lamp replacement ($70 to $80 per year), plus any analytical support.

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On-site wastewater treatment systems

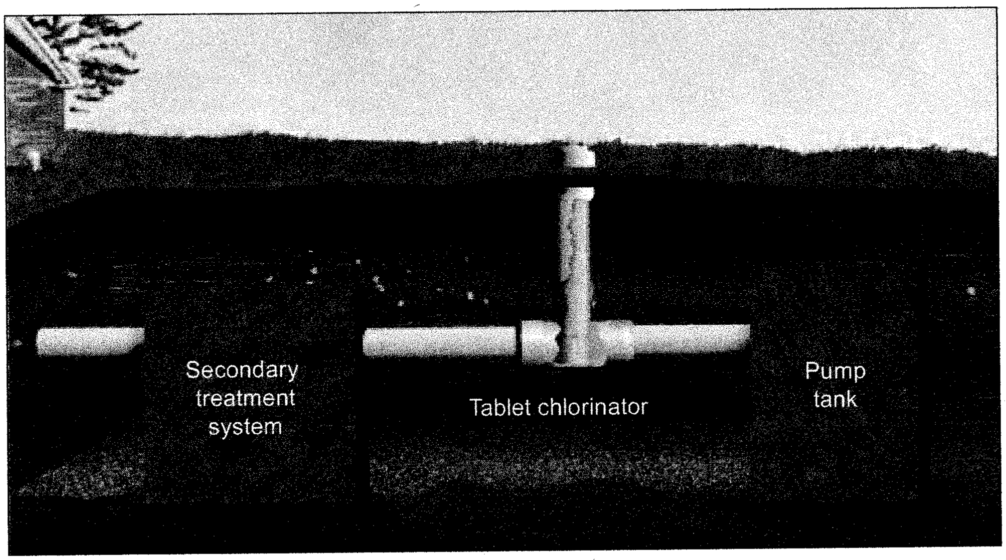

Figure 1: The most common form of disinfection for on-site systems is tablet chlorination.

Tablet chlorination

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Wastewater that is sprayed onto lawns must first be disinfected to prevent odors and remove disease-causing microorganisms. Wastewater can be disinfected with chlorine, ozone and ultraviolet light. For on-site wastewater treatment systems, the most common form of disinfection is tablet chlorination.

Tablet chlorinators generally have four components:

- ✓ Chlorine tablets.
- ✓ A tube that holds the tablets.
- ✓ A contact device, which puts the chlorine tablets into contact with the wastewater.
- ✓ A storage reservoir, usually a pump tank, where the wastewater is stored before it is distributed.

Before being chlorinated, wastewater from a home is treated by a secondary treatment device, usually in an aerobic treatment unit or sand filter. The wastewater moves from the treatment device through a pipe to the contact device.

The contact device usually contains a basin, where the tube containing a stack of chlorine tablets is placed. The bottom tablet in the tube is in contact with the wastewater flowing through the basin. As that tablet dissolves and/or erodes, the tablet above it falls by gravity to replace it.

A tablet can dissolve quickly or slowly, depending on the amount of wastewater coming into contact with

Use only chlorine tablets that are approved for wastewater

it and the length of time it is in contact. A balance must be struck regarding the contact time in the chlorinator basin: Too much contact time causes the wastewater to be over-chlorinated and the tablets to be consumed rapidly; too little contact time, and the wastewater is not chlorinated enough.

Use only chlorine tablets that are approved for use in wastewater. They are made of calcium hypochlorite, a common household bleach. These tablets dissolve in the wastewater, releasing the hypochlorite, which then becomes hypochlorous acid, the primary disinfectant.

Do not use swimming pool chlorine tablets. They are often made from trichloroisocyanuric acid, which is not approved for use in wastewater treatment systems. These tablets make the chlorine available too slowly for it to be effective. If wetted repeatedly, they also can produce nitrogen chloride, which can explode.

Do not combine tablets of trichloroisocyanuric acid with calcium hypochlorite, because the combination will form the explosive compound nitrogen chloride. Read the list of active ingredients on the tablet label to make sure you are using calcium hypochlorite.

Because chlorine tablets are caustic, handle them with care. Wear gloves to protect your skin from direct contact with the tablets. Moist tablets are the most caustic; handle them with special care.

Also, because chlorine gas collects in the tablet container, open the container in a well-ventilated area. Chlorine gas can escape from the tablets and container, reducing the effectiveness of the tablets and possibly corroding metal products stored near the container.

After being chlorinated, the wastewater enters the pump tank, where the disinfection process is completed. At this point the wastewater is called reclaimed water. Texas regulations require that reclaimed water contain at least 0.2 milligrams of chlorine per liter of wastewater or have no more than 200 fecal coliforms (bacteria from human wastes) per 100 milliliters of wastewater.

An easy way to determine the chlorine concentration in your reclaimed water is by using chlorine test kits. They are available in stores that sell swimming pool supplies.

The most satisfactory kits require that you mix a small amount of reclaimed water in a solution and compare the mixture's color with those shown in the kit. The kits using paper strips may be less satisfactory because they do not determine the actual concentration of chlorine in the water.

Usually, if a test detects any chlorine, the wastewater will contain less than 200 fecal coliforms per 100 milliliters. But this does not guarantee that it is free of disease-causing organisms. To reduce the risk of having any disease-causing organisms, the wastewater should have at least 0.2 milligrams of chlorine per liter.

How to keep it working

You can either buy a chlorinator commercially or have one built by an installer. Please follow the manufacturer's recommendations for maintaining the system. Other guidelines:

- ✓ Make sure the chlorinator contains chlorine tablets at all times. Inspect it weekly to ensure that tablets are present and in

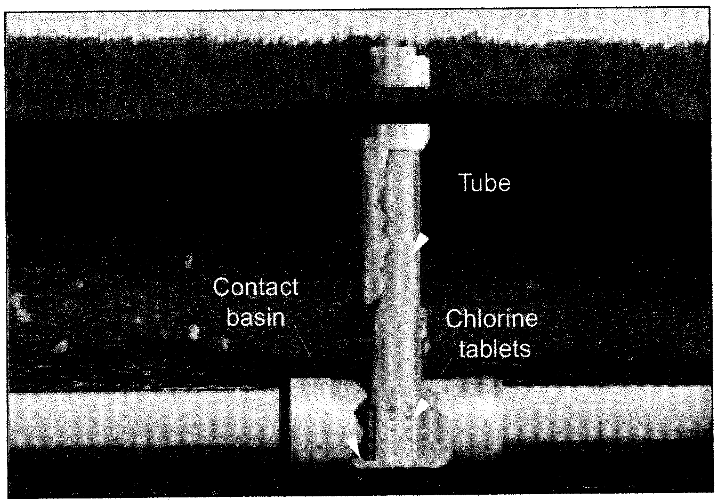

Figure 2: Wastewater disinfection begins in the contact basin.

contact with the wastewater. Add chlorine tablets as necessary. Just as cars do not operate without gasoline, tablet chlorinators do not operate without chlorine tablets.

✓ If you use a spray distribution system, Texas regulations require that you keep a maintenance contract in effect with a licensed maintenance provider. Most such contracts stipulate that the homeowner replace the chlorine tablets.

✓ Tablets can become compacted in the tube. To reduce the chances of compaction, place two to five tablets in the tube at a time.

✓ If the tablets do become compacted in the tube, or if a portion of the bottom tablet has not dissolved and is holding up the rest of the stack, remove the tube and wash out the blockage with a stream of water from a garden hose.

✓ Use only tablets that have been certified for use in domestic wastewater systems. State regulations do not allow tablets for swimming pools and other applications to be used to treat wastewater.

✓ Use a chlorine test kit to determine the chlorine concentration in the pump tank.

✓ If you smell septic odors when the reclaimed water is being sprayed, check to make sure that the chlorinator contains chlorine tablets. If it does, contact your maintenance provider to check the system.

Tablet chlorinators do not operate without chlorine tablets

Fact Sheet

Ultraviolet Disinfection

Project funded by the U.S. Environmental Protection Agency under Assistance Agreement No. CX824652

What is disinfection?

Human exposure to wastewater discharged into the environment has increased in the last 15 to 20 years with the rise in population and the greater demand for water resources for recreation and other purposes. Wastewater is disinfected to prevent the transmission of infectious diseases and to ensure that water is safe for human contact and the environment. There is no perfect disinfectant. However, there are certain characteristics to look for when choosing the most suitable disinfectant:

- ability to penetrate and destroy infectious agents under normal operating conditions;
- lack of characteristics that could be harmful to people and the environment;
- safe and easy handling, shipping, and storage;
- absence of toxic residuals, such as cancer-causing compounds, after disinfection; and
- affordable capital and operation and maintenance (O&M) costs.

What is UV disinfection?

One way to disinfect wastewater is through ultraviolet (UV) radiation, which inactivates disease-causing bacteria by electromagnetic radiation. Wastewater flows through or around a tube with UV light penetrating it from all directions. Radiation is transferred to the cell walls of the bacteria, rendering the organisms sterile.

A UV disinfection system consists of mercury arc lamps, a reactor, and ballasts. The lamps are the source of UV radiation, the ballasts provide power to the system, and wastewater flows through tubes in the reactor. Two types of mercury lamps can be used: low pressure or medium pressure.

There are two types of UV disinfection reactor configurations: contact and noncontact. In both of these types, wastewater can flow either perpendicular or parallel to the lamps. Figure 1 (see page 2) shows two UV contact reactors with submerged lamps placed parallel and perpendicular to the direction of the wastewater flow. In the noncontact reactor, the UV lamps are suspended outside of a clear conduit. Flap gates or weirs are used to control the level of the wastewater.

What are the advantages and disadvantages of using UV disinfection?

Advantages

- UV disinfection is effective at inactivating most viruses, spores, and cysts.
- UV disinfection is a physical process rather than a chemical disinfectant; thus eliminating the need to generate, handle, transport, or store toxic/hazardous or corrosive chemicals.
- There are no toxic residuals that could be harmful to humans or aquatic life.
- UV is user-friendly for operators.
- The wastewater needs to be in contact with UV light for only a short time to be adequately disinfected (approximately 20 to 30 seconds with low-pressure lamps).
- UV disinfection equipment requires less space than other methods.

Disadvantages

- Low dosages may not effectively inactivate some viruses, spores, and cysts.
- Organisms can sometimes repair themselves and "undo" the effects of UV disinfection. This phenomenon is known as *photoreactivation*.
- The tubes used to carry the wastewater can develop a buildup of slime, or fouling, which may require regular cleaning for preventive maintenance.
- It is more difficult to penetrate microorganisms in wastewater that is not clear (containing high amount of solids in suspension).
- In some cases, UV can be more expensive than other disinfection methods.
- There is no measurable residual to indicate the effectiveness of UV disinfection.

What determines the performance of UV disinfection systems?

A UV disinfection system must be designed to reach the most bacteria with the

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This fact sheet was developed by Clement Solomon, Peter Casey, Colleen Mackne, and Andrew Lake.

ETI
Environmental Technology Initiative

A General Overview

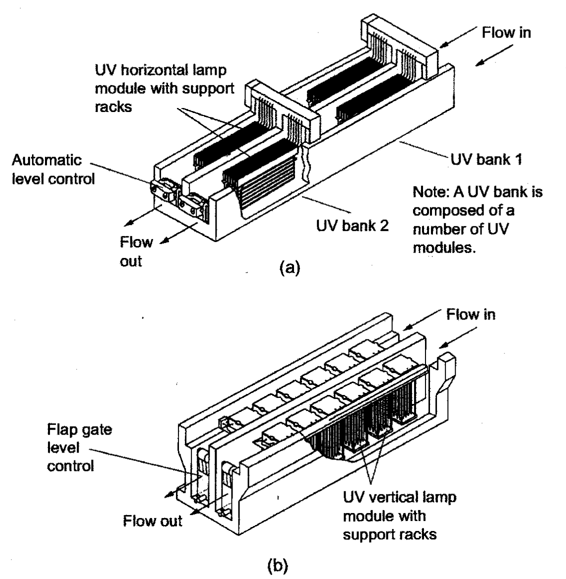

Figure 1:
Isometric cut-away views of typical UV disinfection systems with cover grating removed: (a) horizontal lamp system parallel to flow (adapted from Trojan Technologies, Inc.) and (b) vertical lamp system perpendicular to flow (adapted from Infilco Degremont, Inc.)

Source: Crites and Tchobanoglous (1998), used with permission from The McGraw-Hill Companies

strongest UV dose for the longest time possible. The success of UV disinfection depends on the amount of time the wastewater is exposed to UV radiation, the intensity of UV radiation, and the characteristics of the particular wastewater at the time of disinfection. The amount and type of microorganisms vary with different wastewater. The concentration of total suspended solids and of particle-associated microorganisms determines how much UV radiation ultimately reaches the target organisms. The higher these concentrations are, the lower the UV radiation absorbed by the organisms, and thus, the less effective disinfection can be.

Are UV disinfection systems easy to operate and maintain?

Proper O&M is needed to keep a UV system functioning at maximum performance. This requires that all surfaces between the UV radiation and the target organisms be kept clean—mainly the tubes, lamps, and reactor. Inadequate cleaning is one of the most common causes for a UV system's failure to perform.

O&M also involves replacing the tubes, lamps, or quartz sleeves regularly, according to manufacturer's instructions. Lamps are generally replaced after 12,000 hours of use, quartz sleeves after 5 to 8 years, and ballasts every 10 to 15 years.

What is the cost of UV disinfection?

The cost of UV disinfection systems depends on the manufacturer, the site, the capacity of the plant, and the characteristics of the wastewater to be disinfected. The main operating costs are power consumption, equipment replacement and repairs, cleaning supplies, and personnel costs.

Typical (total) O&M costs per year for each low-pressure lamp range from $85 to $98, which includes these items: power; replacement of lamps, ballasts, and sleeves; cleaning chemicals and supplies; staffing requirements; and miscellaneous equipment repairs.

How do I stay informed about UV technology?

For more information on UV disinfection or a list of other fact sheets, contact the National Small Flows Clearinghouse (NSFC) at West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064. Phone: (800) 624-8301 or (304) 293-4191. Fax: (304) 293-3161. World Wide Web site: *http://www.nsfc.wvu.edu.*

The NSFC provides free and low-cost informational services and products to help homeowners and small communities address their wastewater needs. Also, information about manufacturers, consultants, regulations, and facilities can be obtained from the NSFC's databases.

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SECTION G: Inspection and Evaluation

Appendix

SECTION G: INSPECTION AND EVALUATION

Inspection Result: A Rating

The outcome of the compliance inspection is a record of the system's condition, a rating of either **in compliance** ("acceptable") or **not in compliance ("not acceptable").**

The acceptable rating documents that the existing system is not failing and is not an imminent threat to public health. It does not address the life expectancy of the system or the meeting of all standards set by state or local codes. More comprehensive inspections are often done, but these are not compliance inspections.

A system is considered in compliance if:

- **it is not an imminent threat to public health,**
- **it is not failing to treat wastewater, and**
- **it meets performance expectations of any applicable monitoring plan.**

Determining whether or not a system is failing requires you to know when it was constructed and what kind of establishment it serves.

If the system is a performance system, the site must be inspected as a standard system would be to insure proper operation, and the operating permit for the system should also be evaluated.

The unacceptable rating is the bad news, and many systems fall into this category. Some systems are not compliant in such a way that they present an **imminent public health threat,** while many systems are unacceptable, or **failing to treat wastewater,** for other reasons.

Imminent Threat to Public Health or Safety

The most serious failures are imminent threats to public health.

These systems are a direct threat to public health, including the health of the systems' owners, primarily because they may be contaminating public drinking water supplies, and they should be brought into compliance, or "updated," quickly. The grace period may be set by local units of government. In many areas these systems are identified as a "nuisance" condition, and then must be dealt with in less than ten days. Many local units of government require pumping to remove the sewage and then require replacement of the system within ten months. The proper method for updating each problem will be site-specific.

Failing To Treat Wastewater

At a minimum, the compliance inspection must identify if the system is failing, even if it does not present an imminent threat to public health.

Onsite systems should be considered failing if they do not or may not fully treat sewage before it enters the groundwater. Failure to treat sewage adequately can cause serious problems in surface waters and groundwater, including our valuable sources of drinking water. These water resources must be protected.

Not all failures are visible as sewage flowing into ditches or streams. Failure of a tank, or failure to maintain the tank, may also lead to early failure of the soil treatment system. If an onsite system has a cesspool, seepage pit, leaching pit or drywell, untreated sewage is likely to be entering groundwater, and such a system is considered to be failing. Similarly, if the soil treatment portion of the onsite system is sited so that there is insufficient separation of the system from saturated soil or bedrock, untreated sewage is likely to be entering the groundwater.

Cesspool, Seepage Pit, Leaching Pit, Drywell

Cesspools and seepage pits are defined as unacceptable because they were not designed or constructed to treat waste, only to dispose of it. Treatment of sewage requires oxygen, unsaturated flow, and adequate distance from groundwater. Typically, cesspools were not constructed to fulfill these criteria.

Limiting Layer

Three feet of separation from a limiting layer such as groundwater or bedrock allows for the waste-treatment performance of soil. In many different sites and soils, three feet is still sufficient separation for adequate treatment. Even in systems treating high-strength sewage, this standard separation distance ensures the protection of human health and of the environment.

"Exceptions"

Some kinds of water may be discharged to the soil surface, to surface water bodies, or into groundwater without constituting failure of the onsite system. This is because the standards deal only with **sewage.**

Other types of water, including footing and roof drainage, and chemically treated hot-tub or pool water, should be dealt with other than through the onsite system. Greywater, including wastewater from bathing and washing dishes and clothes, *is sewage,* and all sewage must be properly treated.

Non-Code System

A number of other things could be inspected, including setback distances of system from wells and other structures or property lines, materials used in construction of the system, and the system size. All of these are criteria for new systems but are *not* a part of an existing system inspection unless required by the local unit of government or your customer. An existing system cannot be considered failing only because it does not meet the criteria for new systems.

A system may not be “up to code,” but it is not necessarily failing.

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 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 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.

Make sure you know the standards set by the local unit of government. They may be more or less restrictive units of government will provide you with a written list of the differences.

The inspection is likely to 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 property transfer and 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 require 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 bedrooms in the building. **Compare the number of bedrooms with the number of current residents, and consider patterns of water use.** 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 that same house 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 in the house 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 a residence or any other facility disposes of hazardous waste into an onsite system, the County Sanitarian 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.

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 house. The sewer service coming out of the house 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 (see Figure G-1). 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.

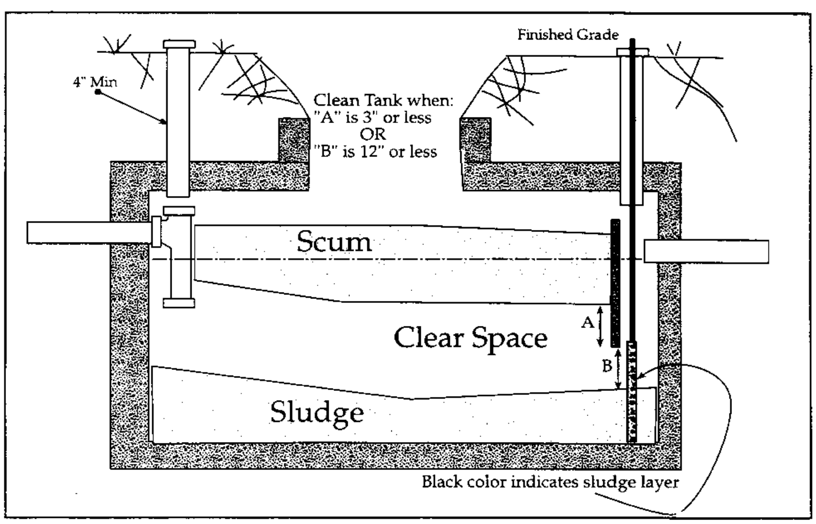


Figure G-1

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	**Excessive Scum**
Water softener	Detergent use
No baffle	Grease & oil
Turbulence	

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 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

Current Chapter 69 requires that the baffles are PVC tees, however many of the older tanks have different types of 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

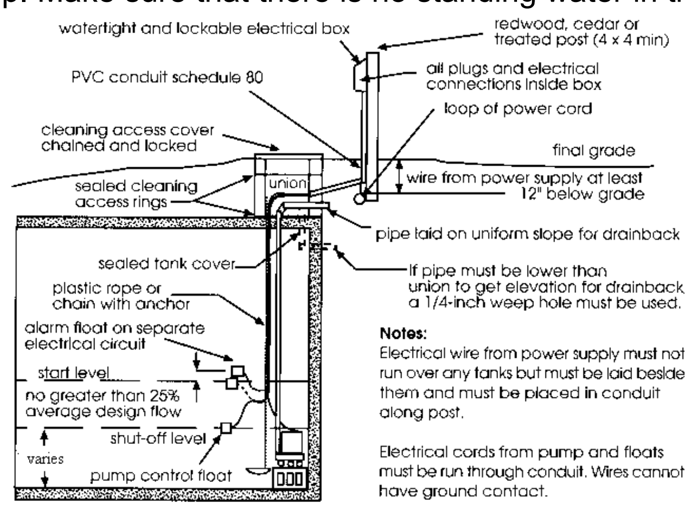
Is there any odor in the vicinity of the tank? Odors typically indicate a venting problem, but may indicate system failure. Odors should be vented out through the system, not back through the house.

Evaluating the Lift Station

Inspect how the water is moved out to the soil treatment system, beginning with the lift station, see Figure G-2. 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

We recommend 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 properlydesigned 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 drainageway, 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. Appendices G-1 through G-6 are sample inspection forms. 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 G-1: Construction Inspection Form

Date ordered ____________ Ordered by ______________________

Date/time of inspection _______________ Fax to ______________

Send copy to ____________________________________

Site address | Billing address

________________________ ________________________

________________________ ________________________

________________________ ________________________

Site Preparation Date _________________

1. Is the site in the right location? ___________
2. Roped off and protected from traffic? ___________
3. Small trees and brush cleared? ___________
4. Provisions for site drainage? ___________
5. Fill incorporated with underlying soil? ___________
6. Distribution field shaped to shed water?__________
7. Lines staked out properly? ___________
8. Comments:

____

____

____

____

____

____

____

____

Construction Check

Date _________

1. Tanks:
   Proper size and type? ___________

   Installed properly? ___________

2. Manifold and laterals:
   Depth of gravel suitable? ___________

   Protected from stones entering system? ___________
   Holes drilled properly, placed downward? ___________
   Manifold and laterals connected properly? ___________
3. Water conservation devices installed in house? ___________
4. Comments:

____
____
____
____

Operation Check

Date _____

1. Pump and switches operating? ___________

2. High water alarm operating? ___________

3. Electric receptacle outside pump tank? ___________

4. Wiring meets NEC? ___________

5. Pressure head in lateral lines:

   a. lowest: _______________ feet

   b. highest: _______________feet

6. Comments:

____
____
____
____

Final Landscaping

Date ______

1. Site shaped to shed rainwater? ____________

2. Any low areas? ____________

3. Diversion drains? ____________

4. Downspout drains directed away from system? ____________
5. Seeded and mulched? ____________

6. Comments:
____
____
____
____
____

Appendix G-2: Recommendations for Checking Homes with 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.

When introducing yourself to the homeowner, explain that **no** water should be used in the house until after your inspection is completed. Even a single toilet flush can make the survey inaccurate. It's best to do the investigation after a heavy rain.

The following form lists the items that should be checked out and verified to eliminate contributing causes of septic field failures.

Failed System Inspection Form

Owner ____

____

____

Legal Description
subdivision ____

____

_______1/4 section _______T ________ R

Type and Location of Failure

____

____

____

Inspection Procedure

1. After making sure no one is using any water, check the **water pressure gauge** in the basement. 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. The **footing drain sump pump pit** must be checked to see that the water is not being pumped into the septic tank. Many older homes had a by-pass valve with only one sump and pump. The valve was to be turned one way when doing the laundry and back when the wash was completed. Laundry wastewater was to be pumped to the septic tank while washing clothes, and rain water from footing drains would be pumped to the ground surface or to the road ditch at all other times. If the valve was not returned after doing the laundry, rainwater would be pumped to the system and failure would result due to excess water.

Recommend the installation of a separate sealed sump and pump that discharges to the septic system to handle laundry waste exclusively. Sometimes the washing machine pump will be able to pump into the sanitary sewer line.

Satisfactory ___ yes ___no

The **laundry and/or sewer ejector sump pit** should be checked. It should have a sealed sump pit. The bottom should be intact and water-tight. Sometimes footing drain water enters the laundry sump pit through cracks or around the four-inch pipe from floor drain or laundry pipes and is pumped to the septic tank. This is especially true when the two sumps are adjacent to each other.

Satisfactory ___ yes ___no

Problems that may be found when checking sump pits and pumps:

One sump pump for both laundry and footing drains. _______

By-pass valve on one sump pump. _______

Leaky sewer injection on laundry sumps. _______

Bottomless laundry sumps. _______

Leaky joints in cast iron below floor. _______

Recommended ways of checking one and two sump pumps:

Check location of discharge. If it is to the sewer, pull the plug on the pump and fill with water to the top of the pit or floor drain. Check for any drop after approximately five to ten minutes. The water level should remain constant at all times.

Satisfactory ___ yes ___no

If the clearwater discharge is being pumped toward the field area, even if it is underground, put dye into the sump and run enough water that the pump turns on. This will determine whether clear water is infiltrating into the tank and seepage lines.

Be sure to replace plug.

Satisfactory ___ yes ___no

4.The water softener should be checked to determine if backwash recharge brine is being discharged to the seepage field. The salt solution usually does not hurt the septic tank; however, it 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.

Do not recommend the elimination of the water softener because soft water requires less water for washing.

Satisfactory ___ yes ___no

5. Check the 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

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 created by a lot that slopes up in the rear? 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. This is especially important in soils that have seasonally high water tables.

Satisfactory ___ yes ___no

Many complaints on hillside houses, especially those with walk-out basements, have led to the discovery that it is common for the sewer line to pass under the footing tile. Although direct connections are no longer being made, the trench cut for sewer line to the tank provides a direct passageway for water to seep from the foundation footing to the septic tank area. Is the tank top deeper than the basement floor?

Satisfactory ___ yes ___no

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

In humid areas, a depression over seepage lines can add many gallons of water to the field. A one-inch depression over a three-foot-wide trench 100 feet long will store 186 gallons of water what will infiltrate into the field. A three-inch depression over 100 feet will add more than 558 gallons of water to the field. Add enough tile over seepage lines during initial construction so that depressions do not occur.

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 drop box distribution, the last or lowest line trench should be where 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

The interceptor drain outlet pipe may be covered over and plugged; if so, it must be opened up to permit drainage. A plugged curtain drain could be worse than no curtain drain.

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 six to eight inches is needed.

Satisfactory ___ yes ___no

Many people do not realize that agricultural field tiles are almost always installed 36 to 45 inches deep to drain from fields. These tiles may be under the seepage trenches and not be found during construction. There is usually no map of farm drain tiles. These tiles may flood out a system or permit sewage in the trench to flow out untreated.

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 clay particles and cause premature clogging.

Satisfactory ___ yes ___no

Drainfield trenches must be constructed on the contour and kept level. A trench that slopes away from the 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

Check to see that no underground utility has been placed in the soil treatment area, as it could damage the septic system and cause effluent to surface. Installation of an underground sprinkler system could damage thesoil treatment system or result in overloading of the system.

Satisfactory ___ yes ___no

Poor maintenance by the homeowner 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 two-bedroom home may experience overloading if the home is later converted to three or four bedrooms and occupied by a large family. Additional sources of excess water use include water-using appliances and entertaining regularly. 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.

Appendix G-3: Maintenance Inspection Checklist

Date ordered ____________ Ordered by ______________________

Date/time of inspection _______________ Fax to ______________

Send copy to ____________________________________

Site address | Billing address

_______________________ ________________________

_______________________ ________________________

_______________________ ________________________

Inspection Date ______________

System Type _____ ____________________________________

Visual Site Examination

1. Any rainfall in last three days? ________________

2. Effluent ponded on surface? ________________

3. Indications of recent ponding? ________________

4. Ground above system damp and mushy
   compared to surrounding area? ________________

5. Noticeable odor of sewage? ________________

6. Other __________________________________ ________________

If any "yes" answers, sketch location and extent on last page.

Site Maintenance

1. Condition of vegetative cover ____
2. Site drainage (roof water, ditches, etc.) _____ ______________________

____

3. Riser and lid ____

4. Turn-ups present and accessible? ❑ yes ❑ no

5. Erosion ____

Pump Examination

1. Pump and switch properly plugged in? ❑ yes ❑ no
2. Pump operating? ❑ yes ❑ no

3. Switch operating? ❑ yes ❑ no

4. Good seat where supply line leaves tank? ❑ yes ❑ no
5. Quality of effluent
   Greasy? ❑ yes ❑ no
   Sludge accumulation? ❑ yes ❑ no

6. Measure pressure head and adjust.

   Initial head: ______________ feet________________

   Adjusted head: ___________ feet________________

7. Comments on problems noted above:

____
____
____
____

Homeowner Comments

____
____
____
____
____

Additional Observations

____
____
____

Sketch of Problem Location(s), Extent

APPENDIX G-4:
NAWT INSPECTION REPORT (EXPANDED VERSION)

Date ordered ____________ Ordered by ______________________

Date/time of inspection _______________ Fax to_______________

Send copy to ____________________________________
Site address Billing address

_______________________ ________________________

_______________________ ________________________

_______________________ ________________________

This information may be critical later in the event of problems.

A. General Information—obtain as much as possible when ordered.

1. Age of dwelling _____ years 2. Age of system _______ years

May give insight into type of system, typical maintenance or permit requirements.

3. Number of people occupying dwelling
   sellers____ anticipated ____
4. Number of bedrooms in dwelling ______

May give insight into flow, use of system or if the system has been overused.

5. Is dwelling currently occupied? Yes No Unknown
6. If dwelling is unoccupied, how long has it been vacant? ______

May give insight into last use. If the system is not in use, it may give a false reading of "acceptable." Some companies will not complete an inspection unless the building is occupied.

7. Has there ever been a backup in the house? Yes No Unknown

First direct question on system performance. A "Yes" points to problems. If the correction was flow reduction, new owners may have problems right away. If problems are seasonal, there may be saturated soil conditions in the soil treatment area. A properly designed system should work year-round.

8. List any known repairs made to the system

Check any permanent records available on the system.
Verify that the work was appropriate for the system.

9. Has the system been inspected by others? Yes No
   If so, did it fail? Yes No

This should help you avoid professional pain. Consistency in inspections is important.

10. Date tank last pumped _________ At what frequency? ______

Additional Comments

B. System Type

1. Components of Sanitary Sewage Disposal System—
check all that apply

❑ Septic tank _______gals	❑ Distribution box	❑ Trenches
❑ Aerobic tank ______gpd	❑ Sand filter(s) bed(s)	❑ Seepage
❑ Cesspool _________gals	❑ Vault system	❑ Chlorinator
❑ Mound	❑ Spray irrigation _____gals	❑ Grease trap
❑ Stream discharge	❑ Other__________	❑ Pump

This will give a space to identify the type of system located at the site. If the system type is not on the list, make a note.

2. Is there a garbage disposal hooked up to the system?
   Yes No Unknown

3. Is there a greywater runoff or drainage system? Yes No
   If yes, give location ________________________________
   If yes, what type of system ___________________________

4. Is any part of the system below a deck, pool, or driveway?
Yes No If yes, give details______________________________

May give insight into the use and long term performance of the system. A garbage disposal indicates a need for increased maintenance. Greywater may npt drain to surface. Check local ordinances for information about systems under structures.

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 at the rate of 3-4 gpm (this is the flow of one spigot fully opened) 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 this.

4. Pumped out primary treatment tank, listened 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 the tank cover and backfilled. Yes No

7. Does the 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 the drainage area to determine its location and to check for excessive moisture, odor, and/or effluent. Is there—

Any indication of a pxrevious 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 may be an early sign of failure. Distribution methods to the system may affect the final outcome. This is a good question, but a failed system it does not make.

An even distribution of effluent within the field?
Yes No

14. Distance between water well and system: _____ feet.

Does this distance meet local code requirements?
Yes No

This is an excellent check but local codes vary. Check before verifying the setback. Also the distance does not guarantee a "good well." Be clear that this is not a well inspection

15. Explain answers as necessary

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 ❑ in compliance.
❑ not in compliance.

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

The final statement of the system is necessary for the system inspection to be complete. A judgment on the acceptability is what you were hired for, so come to a conclusion.

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 Treatment System Inspection Report based on the present condition of the onsite sewage disposal system. ____(company name)__________ 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.

_____(company name)_____ 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.

It is important that the client understand that this inspection does not guarantee that the system will perform for any period of time.

Inspecting 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_______________________

APPENDIX G-5: NAWT ONSITE SYSTEM INSPECTION REPORT

Date ordered ____________ Ordered by ______________________

Date/time of inspection _______________ Fax to ______________

Send copy to ____________________________________
Site address Billing address

_______________________ ________________________
_______________________ ________________________
_______________________ ________________________

A. General Information

1. Age of dwelling______ years

2. Age of system_________ years

3. Number of people occupying dwelling
sellers____ anticipated ____

4. Number of bedrooms in dwelling_________

5. Is dwelling currently occupied? Yes No Unknown

6. If dwelling is unoccupied, how long has it been vacant? ______

7. Has there ever been a backup in the house?
Yes No Unknown

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 __________

At what 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)

❑ Cesspool _________gals ❑ Vault system ❑ Chlorinator

❑ Grease trap _______gals ❑ Spray irrigation ❑ Mound

❑ Stream discharge ❑ Other__________ ❑ Pump

2. Is there a garbage disposal hooked up to the system?
Yes No Unknown

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
Depth of tank access below grade____/____ft/in
If at grade, is the cover child-proof? Yes No

2. Flush all toilets once and run all fixtures to determine that they flow into treatment tank. Introduce water into the system at the rate of 3-4 gpm (this is the flow of one spigot fully opened) for 20-30 minutes. Observe the water level in the treatment tank. Does the water level change?
Yes No

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

4. Pumped out primary treatment tank, listened and observed for backflow into the tank from the outlet pipe. Yes No

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

6. Properly closed the tank cover and backfilled. Yes No

7. Does the system contain a dosing or pump tank, ejector or grinder pump?
Yes No

Is the pump elevated off the bottom chamber? Yes No

Does the pump work? Yes No

8. Is there a check valve, is the purge hole present? Yes No

9. Is there a high water alarm? Yes No

Does the alarm work? Yes No

10. Do electrical connections appear satisfactory? Yes No

11. Can surface water infiltrate into the tank? Yes No

12. Cleaned the pump tank. Yes No

13. Probe the drainage area to determine its location and to check for excessive moisture, odor, and/or effluent. Is there—

Any indication of a previous failure? Yes No

Seepage visible on the lawn? Yes No

Lush vegetation present? Yes No

Ponding water in the aggregate? Yes No

Even distribution of effluent within the field? Yes No

14. Distance between water well and system: _____ feet.
Does this distance meet local code requirements? Yes No

15. Explain answers as necessary

D. Sketch of System—separate sheet.

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, the pump is
   ❑ 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 Treatment 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 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_____________________

Appendix G-6: 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 house,
- 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 house, 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 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 back-hoeing or plowing. One of the shots of this portion of the construction should include the equipment actively engaging in work.

SECTION H: SAFETY

SECTION H: SAFETY

Personal Protective Equipment

Too many workers think personal protective equipment is a nuisance. They think it gets in the way, is inconvenient, is uncomfortable, and that it is not necessary anyway. There are even some workers who worry about how they will look if they wear safety goggles or ear plugs.

There are limits to how much protection you can get from personal protective equipment. It stands to reason that safety equipment is useless if you leave it hanging in a closet or take it off while you still need it. Even if you use protective equipment, and wear it when you need it, it cannot work magic. You still must use common sense and work safely.

Protective equipment does not give you super powers. Use it within the limits of the warning label, because that is when it safeguards you.

About one in ten disabling injuries to workers is to the feet and toes. These injuries can be reduced, or eliminated, by wearing safety shoes. Strap-on metal leg guards will protect your insteps, shins, and lower legs.

Work Site Protection

Traffic must be warned of your presence when near a street. “WORKERS AHEAD” and CAUTION, CONSTRUCTION WORK” signs are effective. Signs with flags or flashers and vehicles with rotating flashing lights are used to warn other motorists. Use flaggers to alert drivers and to direct traffic around the work site. Warning signs and flaggers must be located far enough in advance of the work area to allow motorists time to realize they must slow down, be alert for activity, and safely change lanes or follow a detour. Exact distances and nature of advance warning depend on traffic speed, congestion, roadway conditions, and local regulations.

EXCAVATING AND TRENCHING

Cave-ins are Killers

Trench and excavation cave-ins account for a growing number of fatalities and serious injuries in construction. In 1972 alone, more than 100 workers were suffocated or crushed in such cave-ins. Too many contractors and the workers they employ fail to realize the hazard of working in unprotected or poorly protected excavations. With little or no warning, an unsupported, improperly shored or sloped trench or excavation wall can collapse, trapping the workers below in seconds.

Inadequate shoring in an attempt to cut costs or save time, misjudgment of soil conditions, defective shoring materials, failure to evaluate changing weather conditions or heavy loads in the area—these are among the common causes of trench and excavation cave-ins.

According to the OSHA construction safety and health standards, a trench is referred to as a narrow excavation in which the depth is greater than the width. Although, the width is not greater than 15 feet. An excavation is any man-made cavity or depression in the earth's surface. This can include excavations for anything from cellars to highways.

OSHA requires that all excavations over five feet deep be sloped, shored, or otherwise supported. When soil conditions are unstable, excavations shallower than five feet also must be sloped, supported, or shored.

Causes of Cave-Ins

- Failure to shore, possibly because of a deliberate short-cut to save time or expense.
- Inadequate shoring because of lack of knowledge or misjudgment of soil stability.
- Failure of shoring because of unsuspected bank loading caused by traffic or machinery vibration.
- Inadequate shoring maintenance or replacement after changes occur in the soils surrounding an excavation as a result of construction work or heavy rains.
- Failure of shoring material.
- Placement of spoil too near the trench edge.
- Trench wall undercutting.

Preventing Cave-Ins

One method of ensuring the safety and health of workers in a trench or excavation is to slope the sides of the cut to the "angle of repose." This is the angle closest to the perpendicular at which the soil will remain at rest. The angle of repose varies with different kinds of soil and must be determined on each individual project. When an excavation has water conditions, silty material, or loose boulders, or when it is being dug in areas where erosion, deep frost, or slide planes are apparent, the angle of repose must be flattened.

A second method of support is shoring-sheeting. This method involves tightly-placed timber shores, bracing, trench jacks, piles, or other materials installed in a manner strong enough to resist the pressures surrounding the excavation.

Contractors also may use a trench box, a prefabricated moveable trench shield composed of steel plates welded to a heavy steel frame. OSHA standards permit the use of trench box as long as the protection it provides is equal to or greater than the protection that would be provided by the appropriate shoring system.

Biological Hazards

Infection and Infectious Diseases

Although workers are certainly not expected to stay clean at all times, practicing personal cleanliness greatly reduces the risk of infections and infectious diseases. Both water and wastewater may expose workers to biological hazards.

The on-site installer has occasional exposure to these hazards.

Although most studies of routine exposures to wastewater reveal only slight risk of disease, a number of studies continue to show some evidence of the risk of infections. These reports usually stem from investigations prompted by apparent outbreaks of disease among wastewater workers. The finding of increased rates of gastrointestinal illness among inexperienced workers points to the importance of efforts to minimize contact with wastewater and to continue to promote basic hygienic principles.

Basic Hygiene Principles

For the sake of your health and the health of your family, when working around wastewater or septage:

- Never eat your lunch or put anything into your mouth without first washing your hands.
- Always wear your rubber boots when working in tanks, sewer lines, or septage.
- Always wear rubber or plastic coated gloves when cleaning out pumps, handling hoses, or when working around wastewater.
- Do not wash work clothes with the family wash.

Summary

Wastewater and water workers are exposed to many disease-producing microorganisms. Microorganisms are routinely discharged in sewers from hospitals and throughout the community from persons with illnesses. Although most studies indicate that infections with specific agents are not common, wastewater-exposed workers, especially during their first few years of employment, experience increased rates of gastrointestinal illness. These are generally thought to be related to biological exposures. Two studies indicated a risk of hepatitis A among sewer workers and those involved in primary sludge treatment. Recent studies have shown sewer workers to be at increased risk for parasitic infection but improved work practices seem to reduce the risk. Appropriate work practices including using facilities for daily showers and separating clothing used on the job and after work are essential. Use of personal protective equipment and practices recommended for health care workers to prevent infection from the virus causing AIDS (HIV) is advised. As much as feasible, it is also advised for those exposed to wastewater, such as in and near hospitals.

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 (CH_4)
- Carbon dioxide (CO_2)
- Hydrogen sulfide (H_2S)

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

Over 50% of the workers who die in confined spaces are attempting to rescue other workers. 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 a double fatality. They could even result in multiple fatalities if there is more than one would-be rescuer.

REMEMBER: AN UNPLANNED RESCUE WILL PROBABLY BE YOUR LAST.

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.

SECTION I:

Iowa Administrative Code 567,

Chapter 69

CHAPTER 69
ON-SITE WASTEWATER TREATMENT AND DISPOSAL SYSTEMS

567--69.1(455B) General.

69.1(1) Applications. These rules are applicable only to on-site wastewater treatment and disposal systems.

69.1(2) Definitions.

"Administrative authority" is the local board of health as authorized by Iowa Code section 455B.172 and 567--Chapter 137.

"Approved" means accepted or acceptable under an applicable specification stated or cited in these rules, or accepted as suitable for the proposed use by the administrative authority.

"Area drain" means a drain installed to collect surface or storm water from an open area of a building or property.

"Building drain" is that part of the lowest horizontal piping of a house drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of any building and conveys the same to the building sewer.

"Building sewer" is that part of the horizontal piping from the building wall to its connection with the main sewer or the primary treatment portion of an on-site wastewater treatment and disposal system conveying the drainage of one building site.

“Chamber system” is a buried structure, typically with a domed or arched top, providing at least a six-inch height of sidewall soil exposure, creating a covered open space above a buried soil infiltrative surface.

“Conventional” when used in reference to sewage treatment means a soil absorption system involving a series of two foot wide trenches filled with gravel one foot deep, containing a four inch diameter rigid pipe to convey the sewage effluent.

"Distribution box" is a structure designed to accomplish the equal distribution of wastewater to two or more soil absorption trenches.

“Drainage ditch” is any watercourse meeting the classification of a “general use segment” under rule 567--61.3(455B) which includes intermittent watercourses and those watercourses which typically flow only for short periods of time following precipitation in the immediate locality and whose channels are normally above the water table.

“Drip irrigation” is a form of subsurface soil absorption using shallow pressure distribution with low pressure drip emitters.

“Drop box” is a structure to divert wastewater flow into a soil absorption trench until the trench is filled to a set level, then allow any additional waste, which is not absorbed by that trench, to flow to the next drop box or soil absorption trench.

"Dwelling" means any house or place used or intended to be used by humans as a place of residence.

“Fill soil” means clean soil, free of debris or large organic material, which has been mechanically moved onto a site and has been in place for less than one year.

"Foundation drain" means that portion of a building drainage system provided to drain groundwater from the outside of the foundation or over or under the basement floor not including any wastewater and not connected to the building drain.

"Free access filter (open filter)" means an intermittent sand filter constructed within the natural soil or above the ground surface with access to the distributor pipes and top of the filter media for maintenance and media replacement.

"Gravel" means stone screened from river sand or quarried. Concrete aggregate designated as Class II by the department of transportation is acceptable.

"Gravelless pipe system" means an absorption system comprised of large diameter (8 and 10 inches) corrugated plastic pipe, perforated with holes on a 120-degree arc centered on the bottom, wrapped in a sheath of geotextile filter wrap and installed level in a trench without gravel bedding or cover.

"Individual mechanical aerobic wastewater treatment system" means an individual wastewater treatment and disposal system employing bacterial action which is maintained by the utilization of air or oxygen and includes the aeration plant and equipment and the method of final effluent disposal.

"Intermittent sand filters" are beds of granular materials 24 to 36 inches deep underlain by graded gravel and collecting tile. Wastewater is applied intermittently to the surface of the bed through distribution pipes or troughs and the bed is underdrained to collect and discharge the final effluent. Uniform distribution is normally obtained by dosing so as to flood the entire surface of the bed. Filters may be designed to provide free access (open filters), or may be buried in the ground (buried filters or subsurface sand filters).

"Lake" means a natural or man-made impoundment of water with more than one acre of water surface area at the high water level.

"Limiting layer" means bedrock, seasonally high groundwater level, or any layer of soil with a stabilized percolation rate exceeding 60 minutes for the water to fall one inch.

"Mound system" is an alternative above-ground system used to absorb effluents from septic tanks in cases where either seasonally high water table, high bedrock conditions, slowly permeable soils or limited land areas prevent conventional subsurface absorption systems.

"On-site wastewater treatment and disposal system" means all equipment and devices necessary for proper conduction, collection, storage, treatment, and disposal of wastewater from four or fewer dwelling units or other facility serving the equivalent of 15 persons (1,500 gpd) or less. This includes domestic waste whether residential or nonresidential but does not include industrial waste of any flow rate. Included within the scope of this definition are building sewers, septic tanks, subsurface absorption systems, mound systems, sand filters, constructed wetlands and individual mechanical/aerobic wastewater treatment systems.

"Percolation test" is a falling water level procedure used to determine the ability of soils to absorb primary treated wastewater. (See Appendix B.)

"Pond" means a man-made impoundment of water with a water surface area of one acre or less at the high water level.

"Primary treatment" is a unit or system to separate the floating and settleable solids from the wastewater before the partially treated effluent is discharged for secondary treatment.

"Professional soil analysis" is an alternative to the percolation test which depends upon a knowledgeable person evaluating the soil factors, such as color, texture, and structure, in order to determine an equivalent percolation rate. Demonstrated training and experience in soil morphology (testing absorption qualities of soil by the physical examination of the soil's color, mottling, texture, structure, topography and hillslope position) shall be required to perform a professional soil analysis.

"Roof drain" is a drain installed to receive water collecting on the surface of a roof and discharging into an area or storm drain system.

"Secondary treatment system" is a system which provides biological treatment of the effluent from septic tanks or other primary treatment units to meet minimum effluent standards as required in these rules and NPDES General Permit No. 4. Examples include soil absorption systems, sand filters, mechanical/aerobic systems, or other systems providing equivalent treatment.

"Septage" means the liquid contents (including sludge and scum) of a septic tank normally pumped out periodically and transported to another site for disposal.

"Septic tank" is a watertight structure into which wastewater is discharged for solids separation and digestion, referred to as part of the closed portion of the treatment system.

"Sewage wastewater" is the water-carried waste derived from ordinary living processes.

"Sludge" means the digested or partially digested solid material accumulated in a wastewater treatment facility.

"Stream" means any watercourse listed as being a "designated use segment" in rule 567--61.3(455B) which includes any watercourse which maintains flow throughout the year, or contains sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community of significance.

"Subsurface absorption system" is a system of perforated conduits connected to a distribution system, forming a series of subsurface, water-carrying channels into which the primary treated effluent is discharged for direct absorption into the soil (referred to as part of the open portion of the treatment system).

"Subsurface sand filter" is a system in which the effluent from the primary treatment unit is discharged into perforated pipes, filtered through a layer of sand, and collected by lower perforated pipes for discharge to the surface or to a subsurface absorption system. A subsurface sand filter is an intermittent sand filter which is placed within the ground and provided with a natural topsoil cover over the crown of the distribution pipes.

"Wastewater management district" means an entity organized in accordance with permitting legislation to perform various specific functions such as planning, financing, construction, supervision, repair, maintenance, operation and management of on-site wastewater treatment and disposal systems within a designated area.

69.1(3) General regulations.

a. Connections to approved sewer system.

(1) No on-site wastewater treatment and disposal system shall be installed, repaired, or rehabilitated where a public sanitary sewer is available or where a local ordinance requires connection to a public system. The public sewer may be considered as not available when such public sewer or any building or any exterior drainage facility connected thereto, is located more than two hundred feet from any proposed building or

exterior drainage facility on any lot or premises which abuts and is served by such public sewer. Final dermination of availability shall be made by the administrative authority.

(2) When a public sanitary sewer becomes available within two hundred feet, any building then served by an on-site wastewater treatment and disposal system shall connect to said public sanitary sewer within a time frame or under conditions set by the administrative authority.

(3) When a public sanitary sewer is not available, every building wherein persons reside, congregate or are employed shall be provided with an approved on-site wastewater treatment and disposal system.

(4) If a building is to be connected to an existing on-site wastewater treatment and disposal system, that existing system shall meet the standards of these rules and be appropriately sized.

b. Discharge restrictions. It is prohibited to discharge any wastewater from on-site wastewater treatment and disposal systems (except under an NPDES permit) to any ditch, stream, pond, lake, natural or artificial waterway, county drain tile, surface water drain tile, land drain tile or to the surface of the ground. Under no conditions shall effluent from on-site wastewater treatment and disposal systems be discharged to any abandoned well, agricultural drainage well or sinkhole. Existing discharges to any of the above-listed locations or structures shall be eliminated by constructing a system which is in compliance with the requirements of these rules.

c. Construction or alteration. All on-site wastewater treatment and disposal systems constructed or altered after the effective date of these rules shall comply with these requirements. Alteration includes any changes that effect the treatment or disposal of the waste. Repair of existing components that does not change the treatment or disposal would be exempt. However, the discharge restrictions in "b" above would always apply.

69.1(4) Permit required. No on-site wastewater treatment and disposal system shall be installed or altered as described in 69.1(3)"c," until an application for a permit has been submitted and a permit has been issued by the administrative authority. The installation shall be in accordance with these rules.

69.1(5) Site analysis.

a. Site evaluation. A site evaluation shall be conducted prior to issuance of a construction permit. Consideration shall be given, but not be limited to, the impact of the following: topography; drainageways; terraces; floodplain; percent of land slope; location of property lines; location of easements; buried utilities; existing and proposed tile lines; existing, proposed and abandoned water wells; amount of available area for the installation of the system; evidence of unstable ground; alteration (cutting, filling, compacting) of existing soil profile; and soil factors determined from a soil analysis, percolation tests and soil survey maps if available.

b. Soil survey reports. During a site analysis and investigation, maximum use should be made of soil survey reports which are available from USDA Natural Resources Conservation Service. A general identification of the percolation potential can be made from soil map units in Iowa. Verification of the soil permeability on the specific site must be performed.

69.1(6) Minimum distances. All on-site wastewater treatment and disposal systems shall be located in accordance with the minimum distances shown in Table I.

TABLE I

Minimum Distance in Feet From	Closed Portion of Treatment System (1)	Open Portion of Treatment System (2)
Private water supply well	50	100
Public water supply well	200	200
Groundwater heat pump borehole	50	100
Lake or reservoir	50	100
Stream or pond	25	25
Edge of drainage ditch	10	10
Dwelling or other structure	10	10
Property lines (unless a mutual easement is signed and recorded)	10	10
Other type subsurface treatment system	5	10
Water lines continually under pressure	10	10
Suction water lines	50	100
Foundation drains or subsurface tiles	10	10

(1) Includes septic tanks, mechanical aeration tanks and impervious vault toilets.
(2) Includes subsurface absorption systems, mound systems**,** intermittent sand filters, constructed wetlands or waste stabilization ponds.

567--69.2(455B) Requirements when discharged into surface water. All discharges from on-site wastewater treatment and disposal systems which are discharged into any surface water shall be treated in a manner that will conform with the requirements of NPDES General Permit No. 4 issued by the department of natural resources, as referenced in 567--Chapter 64. Prior to the installation of any system discharging to waters of the state, a notice of intent to be covered by NPDES General Permit No. 4 shall be submitted to the department. Systems covered by this permit must meet all applicable requirements listed in the NPDES permit.

567--69.3(455B) Requirements when discharged into the soil. No septage or wastewater shall be discharged into the soil except in compliance with the requirements contained in these rules.

567--69.4(455B) Building sewers.

69.4(1) Location and construction. The types of construction and distances as shown in Table II shall be maintained for the protection of water supplies. The distances shall be considered minimum and increased where possible to provide better protection.

TABLE II

Sewer Construction	Distance from Well Water Supply	
	Private	Public
1. Schedule 40 plastic pipe (or SDR 26 or stronger) with	10	25

approved type joints or cast-iron soil pipe (extra heavy or centrifugally cast) with joints of preformed gaskets.		
2. Sewer pipe installed to remain watertight and root-proof.	50	75

Under no circumstances shall a well suction line pass under a building sewer line.

69.4(2) Requirements for building sewers.

a. Type. Building sewers used to conduct wastewater from a building to the primary treatment unit of an on-site wastewater treatment and disposal system shall be constructed of Schedule 40 plastic pipe (or SDR 26 or stronger) with solvent-weld or bell-and-gasket type joints, or cast iron with integral bell-and-gasket type joints.

b. Size. Such building sewers shall not be less than 4 inches in diameter.

c. Grade. Such building sewers shall be laid to the following minimum grades:

4-inch sewer	12 inches per 100 feet
6-inch sewer	8 inches per 100 feet

69.4(3) Cleanouts.

a. Spacing. A cleanout shall be provided where the building sewer leaves the house and at least every 100 feet allowing rodding downstream.

b. Change of direction. An accessible cleanout shall be provided at each change in direction or grade, if the change exceeds 45 degrees.

567--69.5(455B) Primary treatment--septic tanks.

69.5(1) General requirements.

a. Septic tank required. Every on-site wastewater treatment and disposal system, except mechanical-aerobic systems, shall have as a primary treatment unit a septic tank as described in this rule. All wastewater from the facility serviced shall discharge into the septic tank (except as noted in "d" below).

b. Easements. No septic tank shall be located upon property under ownership different from the ownership of that property or lot upon which the wastewater originates unless easements to that effect are legally recorded and approved by the proper administrative authority.

c. Effluent discharge requirements. All septic tank effluent shall discharge into a secondary treatment system in compliance with this rule or other system approved by the administrative authority according to rule 69.18(455B).

d. Prohibited wastes. Septic tanks shall not be used for the disposal of chemical wastes or grease in quantities which might be detrimental to the bacterial action in the tank or for the disposal of drainage from roof drains, foundation drains, or area drains.

69.5(2) Capacity.

a. Minimum capacity. The minimum liquid holding capacity shall be as specified in the following table (capacity may be obtained by using one or more tanks):

up to and including 3-bedroom homes	1,000 gal.
4-bedroom homes	1,250 gal.
5-bedroom homes	1,500 gal.
6-bedroom homes	1,750 gal.

Two hundred fifty gallons of capacity shall be added to each of these tank volumes if a kitchen garbage disposal unit, water softener, or a high volume water use fixture such as a whirlpool bath is to be used.

b. Other domestic waste systems. In the event that any installation serves more than a 6-bedroom home or its equivalent, or serves a facility other than a house and serves the equivalent of 15 persons or less (1,500 gal/day), approval of septic tank capacity and design must be obtained from the administrative authority. Minimum septic tank liquid holding volume shall be two times the estimated daily sewage flow.

c. For wastewater flow rates for nonresidential and commercial domestic waste applications under 1,500 gal/day, refer to Appendix A.

d. Minimum depth. Minimum liquid holding depth in any compartment shall be 40 inches.

e. Maximum depth. Maximum liquid holding depth for calculating capacity of the tank shall not exceed 6½ feet.

f. Dimensions. The interior length of a septic tank should not be less than 5 feet and shall be at least 1½ times the width (larger length-to-width ratios are preferred). No tank or compartment shall have an inside width of less than 2 feet. The minimum inside diameter of a vertical cylindrical septic tank shall be 5 feet.

69.5(3) Construction details.

a. Fill soil. Any septic tank placed in fill soil shall be placed upon a level, stable base that will not settle.

b. Compartmentalization. Every septic tank shall be divided into two compartments as follows (compartmentalization may be obtained by using more than one tank):

(1) The capacity of the influent compartment shall not be less than one-half nor more than two-thirds of the total tank capacity.

(2) The capacity of the effluent compartment shall not be less than one-third nor more than one-half of the total tank capacity.

c. Inlet/outlet. The invert of the inlet pipe shall be a minimum of 2 inches and a maximum of 4 inches higher than the invert of the outlet pipe.

d. Baffles. Four-inch diameter schedule 40 plastic pipe tees shall be used as inlet and outlet baffles. Inlet tees shall extend at least 6 inches above and 8 inches below the liquid level of the tank. The inlet tee shall extend below the liquid level no more than 20 percent of the liquid depth. The outlet tee shall extend above the liquid level a distance of at least 6 inches and below the liquid level a distance of at least 10 inches but no more than 25 percent of the liquid depth. A minimum clearance between the top of the inlet and outlet tees and the bottom of the tank lid of 2 inches shall be provided. A horizontal separation of at least 36 inches shall be provided between the inlet baffle and the outlet baffle in each compartment.

A horizontal slot 4 inches by 6 inches, or two suitably spaced 4-inch diameter holes in the tank partition, may be used instead of a tee or baffle, the top of the slot or holes to be located below the water level a distance of one-third the liquid depth. A ventilation hole or slot shall be provided in the partition, at least 8 inches above the liquid level.

e. Access. Access must be provided to all parts of septic tanks necessary for adequate inspection, operation, and maintenance.

An access opening shall be provided at each end of the tank over the inlet and outlet. These openings shall be at least 18 inches in the smallest dimension if the tank has no other openings. Alternatively, a single opening at least 24 inches in diameter may be provided at the center of the tank allowing access to both compartments, with two smaller openings at least 6 inches in diameter over both inlet and outlet.

If the top of the tank is to be greater than 12 inches below the finished ground surface, a riser at least 24 inches in diameter must be installed over each manhole of 18 inches in diameter or more to bring the top of the manhole lid to within 6 inches of the finished ground surface.

69.5(4) Construction.

a. Materials. Tanks shall be constructed of poured concrete or plastic resistant to corrosion or decay and designed so that they will not collapse or rupture when subjected to anticipated earth and hydrostatic pressures when the tanks are either full or empty. Metal tanks are prohibited.

b. Dividers. Tank divider walls and divider wall supports shall be constructed of heavy, durable plastic, fiberglass, concrete or other similar corrosion-resistant materials approved by the administrative authority.

c. Inlet and outlet ports. Inlet and outlet ports of pipe shall be constructed of heavy, durable schedule 40 PVC plastic sanitary tees or other similar approved corrosion-resistant material.

69.5(5) Wall thickness. Minimum wall thickness for tanks shall conform to the following specifications:

Poured concrete	6 inches thick
Poured concrete, reinforced	4 inches thick
Special concrete mix, vibrated and reinforced	2.5 inches thick
Fiberglass or plastic	.25 inches thick

69.5(6) Concrete specifications. Concrete used in precast septic tank construction shall have a maximum water-to-cement ratio of 0.45. Cement content shall be at least 650 pounds per cubic yard. Minimum compressive strength (f'c) shall be 4,000 psi (28 Mpa) at 28 days of age. The use of ASTM C150 Type II cement or the addition of silica fume or Class F fly ash is recommended.

69.5(7) Tank bottoms. Septic tank bottoms shall conform to the specifications set forth for septic tank walls except special mix concrete shall be at least 3 inches thick.

69.5(8) Tank tops. Concrete or masonry septic tank tops shall be a minimum of 4 inches in thickness and reinforced with 3/8-inch reinforcing rods in a 6-inch grid or equivalent. Fiberglass or plastic tank tops shall be a minimum of 1/4 inch in thickness and shall have reinforcing and be of ribbed construction.

69.5(9) Reinforcing steel placement. The concrete cover for reinforcing bars, mats, or fabric shall not be less than 1 inch.

69.5(10) Bedding. Fiberglass or plastic tanks shall be bedded according to manufacturer's specifications. Provisions should be made to prevent flotation when the tanks are empty.

69.5(11) Connecting pipes.

a. Minimum diameter. The pipes connecting septic tanks installed in series and at least the first 5 feet on the effluent side of the last tank shall be a minimum of 4-inch diameter schedule 40 plastic.

b. Tank connections. All inlet and outlet connections at the septic tanks shall be made by self-sealing gaskets cast into the concrete or formed into the plastic or fiberglass.

c. Joints. All joints in connecting schedule 40 plastic pipe shall be approved plastic pipe connections such as solvent welded or compression-type gaskets.

d. Pipe in unstable ground. Schedule 40 plastic pipe shall be used extending across excavations or unstable ground to at least 2 feet beyond the point where the original ground has not been disturbed in septic tank installations. If the excavation spanned is more than 2 feet, it must be filled with sand or compacted fill to provide a firm bed for the pipe. The first 12 inches of backfill over the pipe shall be applied in thin layers using material free from stones, boulders, large frozen chunks of earth or any similar material that would damage or break the pipe.

567--69.6(455B) Secondary treatment--subsurface absorption systems. Soil absorption systems are the best available treatment technology and shall always be used where possible.

69.6(1) General requirements.

a. Locations. All subsurface absorption systems shall be located on the property to maximize the vertical separation distance from the bottom of the absorption trench to the seasonal high groundwater level, bedrock, hardpan or other confining layer, but under no circumstances shall this vertical separation be less than 3 feet.

b. Soil evaluation. A percolation test or professional soil analysis is required before any soil absorption system is installed.

(1) Percolation test. The percolation test procedure is outlined in Appendix B.

(2) Alternative analysis. If a professional soil analysis is performed, soil factors such as soil content, color, texture, and structure shall be used to determine a percolation rate.

(3) Acceptable percolation rate. An area is deemed suitable for conventional soil absorption if the average percolation test rate is 60 minutes per inch or less and greater than 1 minute per inch. However, if an alternative type system is proposed (e.g., mound), then the percolation test should be extended to determine whether a percolation rate of 120 minutes per inch is achieved.

(4) Confining layer determination. An additional test hole 6 feet in depth or to rock, whichever occurs first, shall be provided in the center of the proposed absorption area to determine the location of groundwater, rock formations or other confining layers. This 6-foot test hole may be augered the same size as the percolation test holes or may be made with a soil probe.

c. Groundwater. If seasonal high groundwater level is present within 3 feet of the trench bottom final grade and cannot be successfully lowered by subsurface tile drainage, the area shall be classified as unsuitable for the installation of a standard subsurface absorption system. Consult the administrative authority for an acceptable alternative method of wastewater treatment.

d. Site limitations. In situations where specific location or site characteristics would appear to prohibit normal installation of a soil absorption system, design modifications may be approved by the administrative authority which could overcome such limitations. Examples of such modifications could be the installation of subsurface drainage, use of shallow or at-grade trenches, use of dual soil treatment areas, mound system or water conservation plans.

e. Prohibited drainage. Roof, foundation and storm drains shall not discharge into or upon subsurface absorption systems. Nothing shall enter the subsurface absorption system which does not first pass through the septic tank.

f. Prohibited construction. There shall be no construction of any kind, including driveways, covering the septic tank, distribution box or absorption field of an on-site wastewater treatment and disposal system. Vehicle access should be infrequent, primarily limited to vegetation maintenance.

g. Driveway crossings. Connecting lines under driveways shall be constructed of schedule 40 plastic pipe or equivalent, and shall be protected from freezing.

h. Easements. No wastewater shall be discharged upon any property under ownership different from the ownership of the property or lot upon which it originates unless easements to that effect are legally recorded and approved by the administrative authority.

69.6(2) Trench length requirements.

a. Percolation charts. Table IIIa specifies lineal feet of lateral trenches required in accordance with the results of the standard percolation tests. Tables IIIb and IIIc list optional methods for determining length of lateral trenches or sizing of absorption beds. The alternative option for increased rock usage (Table IIIb) shall be used only when the size of lots limits the use of trench lengths prescribed in Table IIIa. Absorption beds (Table IIIc) shall not be used except when the lot size limitations preclude the installation of a lateral trench system. Further details concerning limitations of these two alternatives should be obtained from the administrative authority prior to requesting authorization for installation.

b. Unsuitable absorption. Conventional subsurface soil absorption trenches shall not be installed in soils that have a percolation rate less than 1 minute per inch or greater than 60 minutes per inch. Plans for an alternative method of wastewater treatment shall be submitted to the administrative authority for approval prior to construction.

Table IIIa
Soil Absorption System Sizing Chart
(Lineal feet of absorption trench)

Min. Per Inch	Two-Bedroom 300 gal/day[1]	Three-Bedroom 450 gal/day	Four-Bedroom 600 gal/day	Five-Bedroom 750 gal/day	Six-Bedroom 900 gal/day
1-5[2]	160	200	260	340	400
6-15	200	300	400	500	600
16-30	300	400	500	600	700
31-45	400	500	600	800	900
46-60	500	600	700	900	1,100

[1]For domestic, nonhousehold wastewater flow rates refer, to Appendix A.

[2]For soils having more than 50 percent of very fine sand by weight, plus fine sand having a particle size range of 0.05 millimeters (sieve size 270) to 0.25 millimeters (sieve size 60), the 16-30 min. per inch values shall be used when gravelless pipe is installed.

Table IIIb
Alternative Option for Increased Rock Usage
(Only if necessary)

Depth of gravel [1] below distribution line	Reduction in trench lengths as taken from Table IIIa
12"	20%
18"	33%
24"	40%

[1]Total depth of trench must not exceed 36". Soil profile must be consistent with the percolation rate throughout the depth used. Separation from groundwater and confining layers must be maintained.

Table IIIc
Alternative Option for Use of Absorption Bed[1]

Percolation Rate Min./Inch	Absorption Area/Bedroom Sq. Ft.	Loading Rate/Day Gal./Sq. Ft.
1-5	300	.5
6-15	400	.375
16-30	600	.25

[1]Absorption beds may only be used when site space restrictions require and shall not be used when the soil percolation rate exceeds 30 min./inch.

69.6(3) Construction details. *(*All soil absorption trenches.)

a. Depth. Lateral trenches shall not exceed 36 inches in depth unless authorized by the administrative authority, but a more shallow trench bottom depth of 18 to 24 inches is recommended**.** Not less than 6 inches of porous soil shall be provided over the laterals. Minimum separation between trench bottom and groundwater, rock formation or other confining layers shall be 36 inches even if extra rock is used under the pipe.

b. Length. No lateral absorption trench shall be greater than 100 feet long.

c. Separation distance. At least 6 feet of undisturbed soil shall be left between each trench edge on level sites. The steeper the slope of the ground, the greater the separation distance should be. Two feet of separation distance should be added for each 5 percent increase in slope from level.

d. Grade. Trench bottom should be constructed level from end to end. On sloping ground, the trench shall follow a uniform land contour to maintain a minimum soil cover of 6 inches while ensuring a level trench bottom .

e. Compaction. There shall be minimum use or traffic of heavy equipment on the area proposed for soil absorption. In addition, it is prohibited to use heavy equipment on the bottom of the trenches in the absorption area.

f. Fill soil. Soil absorption systems shall not be installed in fill soil. Disturbed soils which have stabilized for at least one year would require a recent percolation test.

g. Bearing strength. Soil absorption systems shall be designed to carry loadings to meet AASHTO H-10 standards.

h. Soil smearing. Soils with significant clay content should not be worked when wet. If soil moisture causes sidewall smearing, the trench bottom and sidewalls shall be scarified.

69.6(4) Gravel systems.

a. Gravel. A minimum of 6 inches of clean, washed river gravel, free of clay and clay coatings, shall be laid below the distribution pipe, and enough gravel shall be used to cover the pipe. This gravel shall be of such a size that 100 percent will pass a 2½-inch screen and 100 percent will be retained on a ¾-inch screen. Limestone or crushed rock is not recommended for soil absorption systems. If used it shall meet the following criteria:

(1) Abrasion loss. The percent wear, as determined in accordance with the AASHTO T 96, Grading C, shall not exceed 40 percent.

(2) Freeze and thaw loss. When subjected to the freezing and thawing test, Iowa DOT Materials Laboratory Test Method 211, Method A, the percentage loss shall not exceed 10 percent.

(3) Absorption. The percent absorption, determined in accordance with Iowa DOT Materials Laboratory Test Method 202, shall not exceed 3 percent.

(4) Gradation. The aggregate shall have not more than 1.5 percent by weight pass a No. 16 sieve.

b. Trench width. Lateral trenches for gravel systems shall be a minimum of 24 inches and a maximum of 36 inches in width at the bottom of the trench.

c. Grade. The distribution pipes shall be laid with a minimum grade of 2 inches per 100 feet of run and a maximum grade of 6 inches per 100 feet of run, with a preference given to the lesser slope.

d. Pipe. Distribution pipe shall be PVC rigid plastic meeting ASTM Standard 2729, or other suitable material approved by the administrative authority. The inside diameter shall be not less than 4 inches, with perforations at least ½ inch and no more than ¾ inch in diameter spaced no more than 40 inches apart. Two rows of perforations shall be provided located 120 degrees apart along the bottom half of the tubing (each 60 degrees up from the bottom centerline). The end of the pipe in each trench shall be sealed with a watertight cap unless, on a level site, a footer is installed connecting the trenches together. Coiled perforated plastic pipe shall not be used when installing absorption systems.

e. Gravel cover. Unbacked, rolled, 3½-inch-thick fiberglass insulation, untreated building paper, synthetic drainage fabric, or other approved material shall be laid so as to separate the gravel from the soil backfill.

69.6(5) Gravelless pipe systems.

a. Application. Gravelless subsurface absorption systems may be used as an alternative to conventional 4-inch pipe placed in gravel-filled trenches. However, they cannot be used in areas where conventional systems would not be allowed due to poor permeability, high groundwater, or insufficient depth to bedrock.

b. Installation. Manufacturer's specifications and installation procedures shall be adhered to.

c. Material. The 8- and 10-inch I.D. corrugated polyethylene tubing used in gravelless systems shall meet the requirements of ASTM F667, Standard Specification for Large Diameter Corrugated Polyethylene Tubing.

d. Perforations. Two rows of perforations shall be located 120 degrees apart along the bottom half of the tubing (each 60 degrees up from the bottom centerline). Perforations shall be cleanly cut into each inner corrugation along the length of the tubing and should be staggered so that there is only one hole in each corrugation.

e. Top marking. The tubing should be visibly marked to indicate the top of the pipe.

f. Filter wrap. All gravelless drainfield pipe shall be encased, at the point of manufacture, with a geotextile filter wrap specific to this purpose.

g. Trench width. If dug with a backhoe, the minimum trench width for the gravelless system shall be 18 inches in sandy loam soil to ensure proper backfill around the bottom half of the pipe. In clay soils, the minimum trench width shall be 24 inches. If the pipe is laid in with a wheel trencher leaving a curved trench bottom, the trench width may be just 2 inches wider than the outside diameter of the pipe.

h. Length of trench. The total length of absorption trench for a 10-inch gravelless tubing installation shall be the same as given in Table IIIa for a conventional absorption trench, except for fine sandy soils as noted in Table IIIa footnote. An increase of at least 20 percent in total trench length shall be required if 8-inch tubing is used rather than 10-inch.

69.6(6) Chamber systems.

a. Application. Chamber systems may be used as an alternative to conventional 4-inch pipe placed in gravel-filled trenches. However, they cannot be used in areas where conventional systems would not be allowed due to poor permeability, high groundwater, or insufficient depth to bedrock.

b. Installation. Manufacturer's specifications and installation procedures shall be closely adhered to.

c. Length of trench. The total length of absorption trench for chambers 24 inches or less in bottom width shall be the same as given in Table IIIa for a conventional absorption trench. For chambers greater than 33 inches in width a reduction of 25 percent from the lengths given in Table IIIa may be used.

d. Sidewall. The chambers shall have at least 6 inches of sidewall effluent soil exposure height.

69.6(7) Gravity distribution. Dosing is always recommended and preferred to improve distribution, improve treatment and extend the life of the system.

a. On a hillside, septic tank effluent may be serially loaded to the soil absorption trenches by drop boxes or overflow piping (rigid sewer pipe). Otherwise, effluent shall be distributed evenly to all trenches by use of a distribution box or commercial distribution regulator approved by the administrative authority.

b. Design. When a distribution box is used, it shall be of proper design and installed with separate watertight headers leading from the distribution box to each lateral. Header pipes shall be rigid PVC plactic pipe meeting ASTM Standard 2729 or equivalent.

c. Outlets height. The distribution box shall have outlets at the same level at least 4 inches above the bottom of the box to provide a minimum of 4 inches of water retention in the box.

d. Baffles. There shall be a pipe tee or baffle at the inlet to break the water flow.

e. Unused outlets. All unused outlet holes in the box shall be securely closed.

f. Interior coating. All distribution boxes shall be constructed of corrosion-resistant rigid plastic materials, or other corrosion-resistant material approved by the administrative authority.

g. Outlets level. All outlets of the distribution box shall be made level**.** A 4-inch cap with an offset hole approximately 2½ inches in diameter shall be installed on each outlet pipe. These caps shall be rotated until all outlets discharge at the same elevation. Equivalent leveling devices may be approved by the local authority.

h. Equal length required. The soil absorption area serviced by each outlet of the distribution box shall be equal.

69.6(8) Dosing systems.

a. Pump systems.

(1) Pump and pit requirements. In the event the effluent from the septic tank outlet cannot be discharged by gravity and still maintain proper lateral depths, the effluent shall discharge into a watertight vented pump pit with an inside diameter of not less than 24 inches, equipped with a tight-fitting manhole cover at grade level. The sump vent shall extend a minimum of 6 inches above grade level and shall be a minimum size of 1¼ inches fitted with a return bend. The pump shall be of a submersible type of corrosion-resistant material.

(2) Pump setting. The pump shall be installed in the pump pit in a manner that ensures ease of service and protection from frost and settled sludge. The pump shall be set to provide a dosing frequency of approximately twice a day based on the maximum design flow. No on-site electrical connections shall be made in the pump pit. These connections shall be made in an exterior weatherproof box.

(3) Pressure line size. The pressure line from the pump to the point of discharge shall not be smaller than the outlet of the pump it serves.

(4) Drainage. Pressure lines shall be installed to provide total drainage between dosings to prevent freezing or be buried below frost level up to the distribution box.

(5) High water alarm. Pump pits shall be equipped with a sensor set to detect if the water level rises above the design high water level when the pump fails. This sensor shall activate an auditory or visual alarm to alert the homeowner that repairs are required.

(6) Discharge point. The effluent shall discharge under pressure into a distribution box or may be distributed by small diameter pipes throughout the entire absorption field.

b. Dosing siphons. Dosing siphons may also be used. Manufacturer's specifications shall be adhered to for installation. Similar dosing volumes and frequencies are recommended. Dosing siphons require periodic cleaning to ensure their continued proper operation.

567--69.7(455B) Mound system.

69.7(1) General requirements.

a. Mound systems shall be permitted only after a thorough site evaluation has been made and landscaping, dwelling placement, effect on surface drainage and general topography have been considered.

b. Mound systems shall not be utilized on sites which are subject to flooding with a ten-year or greater frequency.

c. Mound systems shall not be utilized on soils where the high groundwater level, impermeable bedrock or soil strata having a percolation rate exceeding 120 minutes per inch occur within 12 inches of natural grade, or where creviced bedrock occurs within 20 inches of natural grade.

d. Mound systems shall be constructed only upon undisturbed naturally occurring soils.

e. Mound systems shall be located in accordance with the distances specified in Table I as measured from the outer edge of the mound.

f. No buildings, driveways or other surface or subsurface obstructions shall be permitted within 50 feet on the down gradient side of the mound when the mound is constructed on a slope greater than 5 percent. No future construction shall be permitted in this effluent disposal area as long as the mound is in use.

g. Specifications given in these rules for mounds are minimal and may not be sufficient for all applications. Technical specifications are changing with experience and research. Other design information beyond the scope of these rules may be necessary to properly design a mound system.

69.7(2) Material for mound fill.

a. The mound shall be constructed using clean, medium-textured sand, sometimes referred to as concrete sand. The sand size shall be such that at least 25 percent by weight shall have a diameter between 2.0 and 0.25mm, less than 35 percent with a diameter between 0.25 and 0.05mm and less than 5 percent with a diameter between 0.002 and 0.05mm.

b. Rock fragments larger than 1/16 inch (2.0mm) shall not exceed 15 percent by weight of the material used for sandy fill.

69.7(3) Construction details.

a. There shall be a minimum of 3 feet of fill material and undisturbed naturally occurring soils between the bottom of the washed gravel and the highest elevation of the limiting conditions defined in 69.7(1)"c."

b. Gravel shall be washed and shall range in size from 3/4 inch to 2½ inches.

c. From 1 to 2 feet of medium-textured sand (depending upon the underlying soil depth, see 69.7(3)"a") must be placed between the bottom of the gravel and the top of the plowed surface of the naturally occurring soil.

d. Mound systems shall utilize absorption bed distribution piping design. The bed shall be installed with the long dimension parallel to the land contour. Systems on steep slopes with slowly permeable soils should be narrow to reduce the possibility of toe seepage.

e. Minimum spacing between distribution pipes shall be 4 feet, and a minimum of 3 feet shall be maintained between any trench and the sidewall of the mound.

f. No soil under or up to 50 feet down gradient of the mound may be removed or disturbed except as specified herein.

g. Construction equipment which would cause undesirable compaction of the soil shall be kept off the base area. Construction or plowing shall not be initiated when the soil moisture content is high. If a sample of soil from approximately 9 inches below the surface can be easily rolled into a 1/8- to 1/4-inch diameter wire, the soil moisture content is too high for construction purposes.

h. Aboveground vegetation shall be closely cut and removed from the ground surface throughout the area to be utilized for the placement of the fill material.

i. The area shall be plowed to a depth of 7 to 8 inches, parallel to the land contour with the plow throwing the soil up slope to provide a proper interface between the fill and the natural soil. Tree stumps should be cut flush with the surface of the ground, and roots should not be pulled.

j. The base area of the mound is to be calculated on the results of percolation rate as indicated in Table IV. The base area of the mound below and downslope from the trenches, excluding the area under the end slopes, must be large enough for the natural soil to absorb the estimated daily wastewater flow.

k. Table IV

Percolation Rate Min/Inch	Application Rate Gal/Square Foot/Day
Less than 1	Not Suitable
1 - 5	1.25
6 - 15	1.00
16 - 30	.75
31 - 45	.50
46 - 60	.40
61- 90	.20
91 - 120	.10
Over 120	Not Suitable

l. The area of the fill material shall be sufficient to extend 3 feet beyond the edge of the gravel area before the sides are shaped to at least a 4:1 slope (preferably 5:1).

m. Distribution system.

(1) The distribution pipe shall be rigid plastic pipe, schedule 40 or 80 with 1-inch nominal diameter.

(2) The distribution pipe shall be provided with a single row of 1/4-inch perforations in a straight line 30 inches on center along the length of the pipe or an equivalent design that ensures uniform distribution. All joints and connections shall be solvent-cemented.

(3) The distribution pipe shall be placed in the clean, washed gravel (or crushed limestone as described in 69.6(4)"a") with holes downward. The gravel shall be a minimum of 9 inches in depth below and 3 inches in depth above the pipe.

(4) No perforations shall be permitted within 3 inches of the outer ends of any distribution pipes.

(5) The outer ends of all pressure distribution lines shall be securely capped.

(6) The central pressure manifold should consist of 1½-inch or 2-inch solid plastic pipe using a tee or cross for connecting the distribution lines.

n. Construction should be initiated immediately after preparation of the soil interface by placing all of the sandy fill material needed for the mound (to the top of the trench) to a minimum depth of 21 inches above the plowed surface. This depth will permit excavation of the trenches to accommodate the 9 inches of washed gravel or crushed stone necessary for the distribution piping.

o. The absorption trench or trenches shall be hand excavated to a depth of 9 inches, the bottoms of the trenches made certain to be level.

p. Twelve inches of gravel shall be placed in the trench and hand leveled, and then remove 3 inches of the gravel removed with a shovel in the location where the distribution pipe will be placed. After the distribution pipe is placed the pipe shall be covered with 2 inches of gravel.

q. The top of the gravel shall be covered with synthetic drainage fabric. Unbacked, rolled 3½-inch-thick fiberglass insulation, untreated building paper, or other suitable material may be used with approval of the administrative authority. Plastic or treated building paper shall not be used.

r. After installation of the distribution system, gravel and material over the gravel, the entire mound is to be covered with topsoil native to the site or of similar characteristics to support vegetation found in the area. The entire mound shall be crowned by providing 12 inches of topsoil on the side slopes with a minimum of 18 inches over the center of the mound. The entire mound shall be seeded, sodded or otherwise provided with a grass cover to ensure stability of the installation.

s. The area surrounding the mound shall be graded to provide for diversion of surface runoff water.

69.7(4) Dosing.

a. Dosing shall be required for mound systems.

b. The dosing volume shall be five to ten times the distribution piping network volume.

c. The size of the dosing pump or siphon shall be capable of maintaining an approximate pressure of one psi at the outer ends of the distribution lines.

567--69.8(455B) Drip irrigation.

69.8(1) General design.

a. Pretreatment required. These systems must be preceded by a secondary treatment system discharging a treated, filtered effluent with BOD and TSS values less than 20 mg/l.

b. Separation from groundwater. Drip irrigation systems shall have a minimum vertical separation distance to high groundwater level or bedrock of 20 inches.

c. Maximum hillside slope. Drip irrigation systems shall not be installed on slopes of more than 25 percent.

d. Specifications given in these rules for drip irrigation are minimal and may not be sufficient for all applications. Technical specifications are changing with experience and research. Other design information beyond the scope of these rules may be necessary to properly design a drip irrigation system.

69.8(2) Emitter layout.

a. Discharge rate. Systems shall be designed so that emitters discharge approximately 1 gpm at 12 psi or other rates suggested by the manufacturer and approved by the administrative authority.

b. Grid size. Drip lines shall be run in parallel lines 2 feet apart. Emitters shall be placed in the drip lines on 2-foot intervals with emitters offset 1 foot between adjacent lines. Each emitter shall cover 4 square feet of absorption area.

c. Field size. The field shall be sized according to the application rate given in Table V.

d. Depth of drip lines. Drip lines shall be laid on the contour 6 to 12 inches deep with a maximum line length of 100 feet. Lines may be of unequal length.

e. Interconnection. Drip lines shall all be connected to supply and return headers such that the entire system will automatically drain back to the dosing tank or pump pit upon completion of the pumping cycle . Vacuum breakers shall be positioned at the high point of the supply and return headers.

The dosing tank shall have a high water audio/visual alarm.

Table V. Length of Drip Line Required Per Bedroom

Perc. Rate min./in.	Design Hyd. Loading gpd/sq.ft.	Length of Drip Line feet/bedroom
1 - 5	2.0	40
6 - 15	1.3	60
16 - 30	0.9	90
31 - 45	0.6	150
46 - 60	0.4	200
61 - 90	0.2	400
91 - 120	0.1	800

567--69.9(455B) Intermittent sand filters.

69.9(1) General requirements.

a. Use. Intermittent sand filters may be used when the administrative authority determines the site is unacceptable for a full-sized soil absorption system.

b. Location. Intermittent sand filters shall be located in accordance with the distances specified in Table I.

c. Sampling. A sampling port shall be available at the discharge point of the filter or shall be installed in the discharge line. Monitoring and effluent sampling of intermittent sand filters must meet the requirements of the NPDES permit as specified in rule 69.2(455B). Such sampling shall be performed annually or as directed by the administrative authority. The maximum carbonaceous BOD_5, total suspended solids and fecal coliform count requirements are as follows: (fecal coliform tests shall only be required where waste discharge is into a watershed within one mile upstream of a “Class A” water)

Effluents Discharging To	Fecal Coliform/100 ml	$CBOD_5$	TSS
Class "A" waters:			
Primary contact water use*	200	25	25
All other water use classifications	no limit	25	25

*A separation distance of 750 feet shall be maintained between any point of discharge and a primary recreational area as specified in the "Recommended Standards for Bathing Beaches" of the Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers.

d. Prohibited construction. There shall be no construction, such as buildings or concrete driveways, covering any part of an intermittent sand filter.

69.9(2) Construction.

a. Number. An intermittent sand filter shall consist of one filtering bed or two or more filtering beds connected in series and separated by a minimum of 6 feet of undisturbed earth.

b. Pipelines. Each bed shall contain a horizontal set of collector lines. The collector lines shall be equivalent to SDR 35 PVC pipe, 8 inch diameter gravelless drainpipe or other suitable materials.

(1) One collector line shall be provided for each 6 feet of width or fraction thereof. A minimum of two collector lines shall be provided.

(2) The collector lines shall be laid to a grade of 1 inch in 10 feet (or 0.5 to 1.0 percent).

(3) Each collector line shall be vented or connected to a common vent. Vents shall extend at least 12 inches above the ground surface with the outlet screened, or provided with a perforated cap.

(4) Gravelless drainfield pipe with fiber wrap may be used for the collector lines. If so, no gravel or pea gravel is required covering the collector lines. The pipe shall be bedded in filter sand.

(5) If 4-inch plastic pipe with perforations is used for the collector lines, they shall be covered as follows:

1. Gravel 3/4 inch to 2½ inches in size shall be placed around and over the lower collector lines until there is a minimum of 4 inches of gravel over the pipes.

2. The gravel shall be overlain with a minimum of 3 inches of washed pea gravel 1/8-inch to 3/8-inch size interfacing with the filter media. A layer of fabric filter may be used in place of the pea gravel. Fabric filters must be 30 by 50 mesh with a percolation rate of at least 5 gal/sq.ft.

(6) A minimum of 24 inches of coarse washed sand shall be placed over the pea gravel or above the gravelless drainfield pipe. The sand shall meet the Iowa DOT standards for concrete sand: 100 percent shall pass a 9.5 mm screen, 90 to 100 percent shall pass a 4.75 mm screen, 70 to 100 percent shall pass a 2.36 mm screen, 10 to 60 percent shall pass a 600Tm screen, and 0 to 1.5 percent shall pass a 75Tm screen.

69.9(3) Subsurface sand filters.

a. Distribution system and cover.

(1) Gravel base. Six inches of gravel ¾ inch to 2½ inches in size shall be placed upon the sand in the bed.

(2) Distribution lines. Distribution lines shall be level and shall be horizontally spaced a maximum of 3 feet apart, center to center. Distribution lines shall be rigid perforated PVC pipe.

(3) Venting. Venting shall be placed on the downstream end of the distribution lines with each distribution line being vented or connected to a common vent. Vents shall extend at least 12 inches above the ground surface with the outlet screened, or provided with a perforated cap.

(4) Gravel cover. Enough gravel shall be carefully placed to cover the distributors.

(5) Separation layer. A layer of material such as unbacked, rolled 3½-inch-thick fiberglass insulation, untreated building paper of 40- to 60-pound weight, synthetic drainage fabric or 4 to 6 inches of marsh hay or straw shall be placed upon the top of the upper layer of gravel.

(6) Soil cover. A minimum of 12 inches of soil backfill shall be provided over the beds.

(7) Distribution boxes. A distribution box shall be provided for each filter bed where gravity distribution is used. The distribution boxes shall be placed upon undisturbed earth outside the filter bed. Separate watertight lines shall be provided leading from the distribution boxes to each of the distributor lines in the beds.

b. Sizing of subsurface sand filters.

(1) Gravity flow**.**

1. For residential systems, single bed subsurface sand filters shall be sized at a rate of 240 square feet of surface area per bedroom.

2. Dual subsurface sand filters, constructed in series, shall be sized at the rate of 160 square feet of surface per bedroom in the first filter and 80 square feet of surface area per bedroom in the second filter in the series.

(2) Pressure dosed.

1. For residential systems, single bed subsurface sand filters dosed by a pump or dosing siphon may be sized at a rate of 180 square feet of surface area per bedroom.

2. Dual subsurface sand filters, constructed in series, may be sized at the rate of 120 square feet of surface per bedroom in the first filter and 60 square feet of surface area per bedroom in the second filter in series.

(3) Nonhousehold. Effluent application rates for commercial systems treating domestic waste shall not exceed the following:

1. 1.5 gallon/square feet/day for double bed sand filters.

2. 1.0 gallon/square feet/day for single bed sand filters.

3. Total surface area for any subsurface sand filter system shall not be less than 200 square feet.

69.9(4) Free access sand filters.

a. Description. Media characteristics and underdrain systems for free access filters are similar to those for subsurface filters. Dosing of the filter should provide for flooding the bed to a depth of approximately 2 inches. Dosing frequency is usually greater than two times per day. For coarser media (greater than 0.5mm) a dosing frequency greater than four times per day is desirable. Higher acceptable loadings on these filters as compared to subsurface filters relate primarily to the accessibility of the filter surface for maintenance. Gravel is not used on top of the sand media, and the distribution pipes are exposed above the surface.

b. Distribution. Distribution to the filter may be by means of troughs laid on the surface, pipelines discharging to splash plates located at the center or corners of the filter, or spray distributors. Care must be taken to ensure that lines discharging directly to the filter surface do not erode the sand surface. The use of curbs around the splash plates or large stones placed around the periphery of the plates will reduce the scour. A layer of washed pea gravel placed over the filter media may also be employed to avoid surface erosion. This practice will create maintenance difficulties, however, when it is time to rake or remove a portion of the media surface.

c. Covers. Free access filters may be covered to protect against severe weather conditions and to avoid encroachment of weeds or animals. The cover also serves to reduce odor conditions. Covers may be constructed of treated wooden planks, galvanized metal, or other suitable material. Screens or hardware cloth mounted on wooden frames may also serve to protect filter surfaces. Where weather conditions dictate, covers should be insulated. A space of 12 to 24 inches should be allowed between the insulated cover and sand surface. Free access filters may not be buried by soil or sod.

d. Loading. The hydraulic loading for free access sand filters should be from 2.0 to 5.0 gpd/sq.ft.

e. Number of filters. Dual filters each sized for the design flow are recommended for loading rates in excess of 3½ gpd/sq.ft. treating septic tank effluent.

69.9(5) Dosing. Dosing for sand filters is strongly advised. Without dosing, the entire area of the sand filter is never effectively used. Dosing not only improves treatment effectiveness but also decreases the chance of premature failure.

a. Pumps. A pump shall be installed when adequate elevation is not available for the system to operate by gravity.

(1) The pump shall be of corrosion-resistant material.

(2) The pump shall be installed in a watertight pit.

(3) The dosing system shall be designed to flood the entire filter during the dosing cycle. A dosing frequency of greater than two times per day is recommended.

(4) A high water alarm shall be installed.

b. Dosing siphons. When a dosing siphon is used where elevations permit, such siphon shall be installed as follows:

(1) Dosing siphons shall be installed between the septic tank and the first filter bed.

(2) Dosing siphons shall be installed with strict adherence to the manufacturer's instructions.

c. Dosing tanks. The dosing tank shall be of such size that the siphon will flood the entire filter during the dosing cycle. A dosing frequency of greater than two times per day is recommended.

567--69.10(455B) Individual mechanical aerobic wastewater treatment systems. General requirements for individual mechanical aerobic wastewater treatment systems are as follows:

69.10(1) Use. Mechanical/aerobic systems may be used only when the administrative authority determines that the site is unacceptable for a full-sized soil absorption system. Because of the higher maintenance requirements of mechanical/aerobic systems, preference should be given to sand filters, where conditions allow.

69.10(2) Certification. All individual mechanical aerobic wastewater treatment plants shall be certified by an ANSI-accredited third-party certifier to meet National Sanitation Foundation Standard 40, Class I, including appendices (May 1996).

69.10(3) Installation and operation. All individual mechanical aerobic wastewater treatment plants shall be installed, operated and maintained in accordance with the manufacturer's instructions and the requirements of the administrative authority. The aerobic plants shall have a minimum treatment capacity of 150 gallons per bedroom per day or 500 gallons, whichever is greater.

69.10(4) Effluent treatment. The effluent from individual mechanical aerobic wastewater treatment plants shall receive additional treatment through the use of intermittent sand filters, mound systems or subsurface absorption systems of a magnitude of half that prescribed in rules 69.6(455B), 69.7(455B) or 69.9(455B) or by discharge to a drip irrigation system as sized in 69.8(455B).

69.10(5) Maintenance contract. A maintenance contract with a manufacturer-certified technician shall be maintained at all times. Maintenance agreements and responsibility waivers shall be recorded with the county recorder and in the abstract of title for the premises on which mechanical aerobic treatment systems are installed. Mechanical aerobic units shall be inspected for proper operation at least twice a year on six month intervals.

69.10(6) Effluent sampling. Any open discharge from systems involving mechanical aeration shall have the effluent sampled at each inspection. Tests shall be run for $CBOD_5$, TSS and coloform bacteria as noted in 69.9(1).

567---69.11(455B) Constructed wetlands.

69.11(1) General site design.

a. Application. Constructed wetlands shall only be used where soil percolation rates at the site exceed 120 minutes per inch. Because of the higher maintenance requirements of constructed wetland systems, preference should be given to sand filters, where conditions allow.

b. Effluent treatment. The effluent from a constructed wetland shall receive additional treatment through the use of intermittent sand filters of a magnitude of half that prescribed in rule 69.9(455B).

c Effluent sampling. Effluent sampling of constructed wetlands shall be performed twice a year or as directed by the administrative authority. Tests shall be run on all parameters as required in 69.9(1).

d. Specifications given in these rules for constructed wetlands are minimal and may not be sufficient for all applications. Technical specifications are changing with experience and research. Other design information beyond the scope of these rules may be necessary to properly design a constructed wetland system.

69.11(2) Wetland design.

a. Depth. The wetland shall be of a subsurface flow construction with a rock depth of 18 inches and a liquid depth of 12 inches.

b. Materials. Substrate shall be washed river gravel with a diameter of 3/4 inch to 2½ inches. If crushed quarried stone is used, it must meet the criteria listed in 69.6(4)"a."

c. Sizing and configuration. Detention time shall be a minimum of seven days.

(1) Dimensions. This may be accomplished with trenches 16 to 18 inches deep (12 inches of liquid), 3 feet wide with 100 feet of length per bedroom. This may also be done with beds 16 to 18 inches deep with at least 300 square feet of surface area per bedroom. The bottom of each trench or bed must be level within ±½ inch.

(2) Configuration. Multiple trenches or beds in series should be used. Beds or trenches in series may be stepped down in elevation to fit a hillside application. If the system is on one elevation, it should still be divided into units by earthen berms at about 50 and 75 percent of the total length.

(3) Unit connections. Each subunit shall be connected to the next with an overflow pipe (rigid sewer pipe) that maintains the water level in the first section. Protection from freezing may be necessary.

d. Liner. Wetlands shall be lined with a synthetic PVC or PE plastic liner 20 to 30 mils thick.

e. Inlet pipe. Effluent shall enter the wetland by a 4-inch pipe sealed into the liner. With beds, a header pipe shall be installed along the inlet side to distribute the waste.

f. Protective berms. Wetland system sites shall be bermed to prevent surface water from entering the trenches or beds.

69.11(3) Vegetation.

a. Setting plants. Vegetation shall be established on the wetlands at time of construction. Twelve inches of rock is placed in each unit, the plants are set, then the final 4 to 6 inches of rock is placed.

b. Plant species. Only indigenous plant species shall be used, preferably collected within a 100-mile radius of the site. Multiple species in each system are recommended. Preferred species include, but are not limited to:

(1) Typha Latifolia - Common cattail

(2) Typha Angustifolia - Narrow leaf cattail

(3) Scirpus spp. - Bullrush

(4) Phragmites communis - Reed

c. Plant establishment. Transplantation is the recommended method of vegetation establishment. For transplanting, the propagule should be transplanted, at a minimum, on a 2-foot grid. The transplants should be fertilized, preferably with a controlled release fertilizer such as Osmocote 18-5-11 for fall and winter planting, 18-6-12 for spring planting, and 19-6-12 for summer planting. Trenches or beds should be filled with fresh water immediately.

d. Plant management. In the late fall the vegetation shall be mown and the detritus left on the wetland surface as a temperature mulch. In the early spring the mulch shall be removed and disposed of to allow for adequate bed aeration.

567--69.12(455B) Waste stabilization ponds.

69.12(1) General requirements. Waste stabilization ponds may be used if designed and constructed in accordance with the following criteria and provided the effluent is discharged in accordance with the requirements of the general NPDES permit listed in rule 69.2(455B). A septic tank sized according to rule 69.5(455B) shall precede a waste stabilization pond.

69.12(2) Location. Waste stabilization ponds must meet the following separation distances:

a. 1,000 feet from the nearest inhabitable residence, commercial building, or other inhabitable structure. If the inhabitable or commercial building is the property of the owner of the proposed treatment facility, or there is written agreement with the owner of the building, this separation criterion shall not apply. Any such written agreement shall be filed with the county recorder and recorded for abstract of title purposes, and a copy submitted to the department.

b. 1,000 feet from public shallow wells.

c. 400 feet from public deep wells.

d. 400 feet from private wells.

e. 400 feet from lakes and public impoundments.

f. 25 feet from property lines and rights-of-way.

69.12(3) Size.

a. Dimensions. Ponds shall have a length not exceeding three times the width.

b. Capacity. When domestic sewage from a septic tank is to be discharged to a waste stabilization pond, the capacity of the pond shall be equivalent to 180 times the average daily design flow.

c. Depth. The wastewater depth for a waste stabilization pond shall be uniform and 3 feet to 5 feet.

d. Freeboard. A minimum freeboard of 2 feet shall be maintained at all times.

69.12(4) Embankments.

a. Seal. Embankments shall be constructed of impermeable materials and shall be compacted. The bottom of the waste stabilization pond shall be cleared and leveled to the required elevation and shall be lined with an impermeable natural or man-made material. Seepage loss through the sides and bottom shall be less than 1/16 inch per day.

b. Slopes. Inside embankment slopes shall be 3 horizontal to 1 vertical. Outside embankments shall be at least 3:1.

c. Berm top. Berm tops shall be at least 4 feet wide.

d. Cover. Embankments shall be seeded from the outside toe to the inside high water line. From the high water line down the embankment diagonally about 5 feet shall be rip-rapped for erosion and vegetation control.

69.12(5) Inlet and outlet structures.

a. Inlet. The inlet shall be placed no higher than 12 inches above the bottom of the pond. It shall discharge near the middle of the pond at a point opposite the overflow structure and onto a concrete spash plate at least 2 feet square.

b. Outlet. The outlet pipe shall withdraw water from a submerged depth of at least 1 foot. The intake for the outlet pipe shall be 3 to 5 feet from the embankment.

c. Separation. The inlet and outlet should be separated to the maximum extent possible, ideally by a berm or baffle constructed in the lagoon to prevent short-circuiting.

69.12(6) Drainage. All surface water shall be diverted away from the waste stabilization pond.

69.12(7) Discharge.

a. Controlled discharge. If the pond is designed for open discharged, it must be discharged under controlled conditions. The effluent must be tested before discharge, and effluent quality must be less than 25 mg/l of $CBOD_5$ and less than 25 mg/l of TSS. Another test must be taken during discharge with the same results. Pond discharge is permitted only in spring and fall when stream flows are highest.

b. Continuous discharge. If the pond is to have an unlimited continuous discharge, the effluent shall receive additional treatment through the use of intermittent sand filters, mound systems or subsurface absorption systems of a magnitude of half that prescribed in rules 69.6(455B), 69.7(455B) and 69.9(455B). Under continuous discharge, effluent sampling shall be as required for constructed wetlands as outlined in 69.11(1)"c."

69.12(8) Maintenance.

a. Fencing. All waste stabilization ponds are to be fenced adequately to prevent entrance of livestock and to discourage entrance by people into the area. Signs shall be posted warning of possible health and safety hazards.

b. Vegetation. Vegetation on the top and sides of the berm shall be kept mown. No trees shall be allowed to become established.

567--69.13(455B) Requirements for impervious vault toilets. All impervious vault toilets hereafter constructed or required by the administrative authority to be reconstructed shall comply with the following requirements:

69.13(1) Location. Impervious vault toilets shall be located in accordance with the distances given in Table I, rule 69.3(455B) for the closed portion of the treatment system.

69.13(2) Construction. The vault shall be constructed of reinforced, impervious concrete at least 4 inches thick. The superstructure including floor slab, seat, seat cover, riser and building shall comply with good design and construction practices to provide permanent safe, sanitary facilities. The vault shall be provided with a cleanout opening fitted with a fly-tight cover.

69.13(3) Disposal. Wastewater from impervious vault toilets shall be disposed of at a public sewage treatment facility.

567--69.14(455B) Requirements for portable toilets. All portable toilets shall be designed to receive and retain the wastes deposited in them and shall be located and maintained in a manner that will prevent the creation of any nuisance condition. Disposal of waste from portable toilets shall be at a public sewage treatment facility.

567--69.15(455B) Requirements for chemical toilets. All chemical toilets shall comply with the following requirements:

69.15(1) Tank. Chemical toilets for use in isolated residences shall have a receptacle of smooth, impervious material that is resistant to chemicals and easily cleanable.

69.15(2) Vent. When vents are required for chemical toilets, they shall be of durable corrosion-resistant material installed in a professional manner.

69.15(3) Mixing and chemical charge. The fixture shall be equipped with a mixing device and shall be charged with the proper concentration of bactericidal chemical or chemicals. Chemical recharges shall be added and mixed with the contents when necessary to maintain sufficient solution strength and to suppress odors.

69.15(4) Toilet rooms. Chemical toilets shall be located in toilet rooms which are well lighted, ventilated and maintained in a nuisance-free condition.

69.15(5) Final disposal of receptacle contents. The receptacle contents shall be disposed of in accordance with the requirements of 567--Chapter 68. The recommended method of disposal is discharging to a municipal sewage treatment facility.

567--69.16(455B) Other methods of wastewater disposal. Other methods or types of private wastewater treatment and disposal systems shall be installed only after plans and specifications for each project have been approved by the administrative authority.

567--69.17(455B) Disposal of septage from on-site wastewater treatment and disposal systems. The collection, storage, transportation and disposal of all septage shall be carried out in accordance with the requirements in 567--Chapter 68.

69.17(1) Methods of septage disposal.

a. Discharge (with owner approval) to a municipal or other permitted wastewater treatment system.

b. Discharge (with owner approval) to permitted sludge lagoons or sludge drying beds.

c. Land application in accordance with the following requirements:

(1) The maximum application rate is 30,000 gallons of septage per 365-day period per acre of cropland.

(2) The following site restrictions shall be met when septage is applied to land.

1. Septage shall not be applied to a lawn or a home garden.

2. The septage shall be applied only to soils classified as acceptable throughout the top five feet of soil profile. The septage shall not be applied to soils classified as sand, loamy sand and silt. The acceptability of a soil shall be determined using the USDA soil classifications.

3. Land application sites shall have soil pH maintained above 6.0, unless crops prefer soils with lower pH conditions. If the soil pH is below 6.0, it is acceptable to use agricultural lime to increase the pH to an acceptable level.

4. If the septage is applied to land on which the soil loss exceeds the soil loss limits established by the county soil conservation district, the septage shall be injected on the contour or shall be applied to the surface and mechanically incorporated into soil

within 48 hours of application. The septage shall not be applied to ground having greater than 9 percent slope.

5. Septage application on frozen or snow-covered ground should be avoided, unless special precautions are taken to avoid runoff. If application on frozen or snow-covered ground is necessary, it shall be limited to land areas of less than 5 percent slope.

6. Septage shall not be applied to land that is 35 feet or less from an open waterway. If septage is applied within 200 feet of a stream, lake, sinkhole or tile line surface intake located down gradient of the land application site, it shall be injected or applied to the surface and mechanically incorporated into the soil within 48 hours of application.

7. If the septage is applied to land subject to flooding more frequently than once in ten years, the septage shall be injected or shall be applied to the surface and mechanically incorporated into the soil within 48 hours. Information on which land is subject to flooding more frequently than once in ten years is available from the department.

8. Septage shall not be applied within 200 feet of an occupied residence or within 500 feet of a well.

9. Food crops shall not be harvested for 38 months after application of septage.

10. Animals shall not be allowed to graze on the land for 30 days after application of septage.

(3) One of the following vector attraction reduction and pathogen reduction requirements shall be met when septage is applied to land.

1. Septage shall be injected below the surface of the land. No significant amount of the septage shall be present on the land surface within one hour after the septage is injected.

2. Septage applied to the land surface shall be incorporated into the soil within six hours after application to or placement on the land.

3. The septage shall be stabilized by adding and thoroughly mixing sufficient lime to produce a mixture with a pH of 12. Provide a minimum of two hours of contact time after mixing the lime with the septage prior to applying to land. Each container of septage shall be monitored for compliance.

4. The septage shall be stabilized by adding and thoroughly mixing 50 pounds of lime with each 1,000 gallons of septage.

(4) When septage is applied to land, the person who applies the septage shall develop the following information and shall retain the information for five years:

1. The location, by either street address or latitude and longitude, of each site on which septage is applied.

2. The number of acres in each site on which septage is applied.

3. The date and time septage is applied to each site.

4. The rate, in gallons per acre per 365-day period, at which septage is applied to each site.

5. A description of how the vector attraction reduction requirements are met.

6. The following certification statement shall be provided with the records when the records are requested by the department:

"I certify, under penalty of law, that the pathogen requirements and the vector attraction reduction requirements have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment."

(5) Other methods of stabilization may be acceptable if shown to be equivalent to 69.17(1)"c"(3)"3."

d. Discharge (with owner approval) to a permitted sanitary landfill in accordance with 567--Chapters 102 and 103 and the following requirements:

(1) Stabilize the septage by adding and thoroughly mixing sufficient lime to produce a mixture with a pH of 12.

(2) Provide a minimum of two hours of contact time after mixing the lime with the septage prior to applying to the landfill.

(3) Dewater the septage.

(4) Obtain a special waste authorization permit from the department.

69.17(2) Commercial septic tank cleaners. Individual administrative authorities shall enforce the licensing program for commercial septic tank cleaners in accordance with the requirements of 567--Chapter 68.

567--69.18(455B) Alternative or innovative on-site wastewater treatment and disposal systems.

69.18(1) Design requirements. Alternative or innovative systems are to be designed and operated in accordance with approved standards and operating procedures established by individual administrative authorities.

a. Plans and specifications, meeting all applicable rule requirements, should be prepared and submitted to the administrative authorities by a licensed professional engineer. Included with the engineering submittal should be adequate supporting data relating to the effectiveness of the proposed system.

b. For systems designed to discharge treated effluent into waters of the state, it will be necessary to obtain a Notice of Intent to fall under the requirements of NPDES General Permit No. 4. The administrative authority is responsible for determining that the requirements of the permit are met including the monitoring program.

c. Administrative authorities should prepare for signature an enforceable agreement to be placed on record which would require that present and future system owners meet all applicable rule requirements. In the event of noncompliance, the administrative authority shall require that adequate steps be taken by the system owner to bring the system into compliance.

d. Wastewater management districts may be formed for the purpose of providing specialized control of on-site wastewater treatment and disposal systems located in certain problem areas or in intensive development areas. Formation of such wastewater management districts shall be coordinated under the guidance of the administrative authority and shall meet all applicable rule requirements.

69.18(2) Reserved.

567--69.19(455B) Variances. Variances to these rules may be granted by the department of natural resources or the administrative authority provided sufficient information is submitted to substantiate the need and propriety for such action. Applications for variances and justification shall be in writing and copies filed with the department.

These rules are intended to implement Iowa Code chapter 455B, division III, part 1.

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Date

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Larry J. Wilson, Director

Appendix A
Estimates of NonHousehold Domestic Sewage Flow Rates

Source of use for sewage unit	(units)	Gallons per day per unit: Average (Secondary treatment unit sizing)	Maximum (Septic tank)
Dwelling units			
Hotels or luxury motels	(Each guest)	50	60
	(Add per employee)	11	13
or	(Per square foot)	0.26	0.3
Discount motels	(Each guest)	30	40
	(Add per employee)	11	13
or	(Per square foot)	0.22	0.46
Rooming house	(Each resident)	40	50
	(Add per nonresident meal)	2.5	4.0
Commercial/Industrial			
Retail stores	(Per square foot of sales area)	0.1	0.15
or	(Each customer)	2.5	5
	(Plus each employee)	11	15
or	(Each toilet room)	530	630
Offices	(Each employee)	15	18
or	(Per square foot)	0.1	0.25
Medical offices	(Per square foot)	0.6	1.6
Industrial buildings	(Each employee)	15	20
	(Does not include process ware or cafeteria)		
Construction camp	(Each employee)	15	20
Visitor center	(Each visitor)	5	20
Laundromat	(Each machine)	580	690
or	(Each load)	50	50
or	(Per square foot)	2.2	2.9
Barber shops	(Per chair)	55	80
Beauty shops	(Per station)	270	300
Car washes	(Per inside square foot)	5	10

(Does not include car wash water)

<u>Eating and Drinking Establishments</u>			
Restaurant	(Per meal)	2.5	4.0
	(Does not include bar or lounge)		
or	(Each seat)	24	40
	(Plus add for each employee)	11	13
Dining hall	(Per meal)	2.5	4.0
Coffee shop	(Each customer)	2.0	2.5
	(Add per employee)	11	13
Cafeteria	(Each customer)	2	2.5
	(Add per employee)	11	13
Drive-in	(Per car stall)	110	145
Bar or lounge	(Each customer)	2	5.5
	(Add per employee)	13	16
or	(Per seat)	32	40
Country clubs (no meals)	(Per member)	22	22
or	(Per member) (Meals and showers)	105	130
or	(Per member in residence)	75	100
<u>Resorts</u>			
Housekeeping cabin	(Per person)	42	50
Lodge	(Per person)	53	74
Parks/swimming pools	(Per guest)	10	13
Picnic parks with toilet only	(Per guest)	5	10
Movie theaters	(Per guest)	2.5	4
Drive-in theaters	(Per space)	3	5
Skating rink/dance hall	(Per customer)	7	10
Bowling lanes	(Per lane)	133	200
<u>Transportation</u>			
Airport, bus or rail depot	(Per passenger)	2.5	4
or	(Per square foot)	3.33	6.5

or	(Per public restroom)	500	630
Auto service station	(Each vehicle served)	11	13
	(Add per employee)	13	16
or	(Per inside square foot)	0.25	0.6
or	(Per public restroom)	500	630
<u>Institutional</u>			
Hospitals	(Each medical bed)	175	250
	(Add per employee)	10	16
Mental institution	(Each bed)	105	175
	(Add per employee)	10	16
Prison or jail	(Each inmate)	120	160
	(Add per employee)	10	16
Nursing home	(Each resident)	93	145
	(Add per employee)	10	16
<u>Schools and churches</u>			
School	(Per student) (No gym, cafeteria or showers)	10	17
	(Per student) (Cafeteria only)	16	17
	(Per student) (Cafeteria, gym & showers)	20	30
Boarding school	(Per student)	75	115
Churches	(Per member)	0.14	0.86
	(Add for each kitchen meal)	1	1
	(Add per Sunday School student)	0.14	0.86
<u>Recreational</u>			
Campground/with hookups	(Per person)	32	40
or	(Per site with central bath)	100	100
	(Per site)	50	75
	(Add for dump station w/hookup)	13	16
Day camp (no meals)	(Per person)	13	16
Weekly overnight camp	(Per member)	33	33

Appendix B
Percolation Test Procedure

(1) A minimum of three test holes distributed evenly over the proposed lateral field is required.

(2) Percolation test holes shall be 4 to 12 inches in diameter and to the same depth as the proposed absorption trenches (not to exceed 36 inches in depth).

(3) Sides and bottoms of the test holes shall be scratched or roughened to provide a natural surface. All loose material shall be removed from each hole.

(4) The bottoms of the test holes shall be covered with approximately 2 inches of rock to protect the bottom from scouring action when the water is added.

(5) The hole shall be filled with at least 12 inches of clean water and this depth shall be maintained for at least 4 hours and preferably overnight if clay soils are present. It is important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained.

(6) In sandy soils with little or no clay, soaking is not necessary. If, after filling the hole twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

(7) Except for sandy soils, percolation rate measurements should be made at least 4 hours but no more than 24 hours after the soaking period began. Any soil that sloughed into the hole during the soaking period is removed and the water level is adjusted to 6 inches above the gravel (or 8 inches above the bottom of the hole). At no time during the test is the water level allowed to rise more than 6 inches above the gravel.

(8) Immediately after adjustment, the water level is measured from a fixed reference point to the nearest 1/8 inch at 30-minute intervals. The test is continued until two successive water level drops do not vary by more than 1/8 inch. At least three measurements are made.

(9) After each measurement, the water level is readjusted to the 6-inch level. The last water level drop is used to calculate the percolation rate.

(10) In sandy soils or soils in which the first 6 inches of water added after the soaking period seeps away in less than 30 minutes, water level measurements are made at 10-minute intervals for a 1-hour period. The last water level drop is used to calculate percolation rate.

(11) The percolation rate is calculated for each test hole by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in terms of minutes per inch. To determine the percolation rate for the area, the rates obtained from each hole are averaged. (If tests in the area vary by more than 20 minutes per inch, variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.) EXAMPLE: If the last measured drop in water level after 30 minutes is 5/8 inch, the percolation rate = (30 minutes)/(5/8 inch) = 48 minutes/inch.