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On-Site Wastewater Section

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On-Site Wastewater Management

Guidance Manual

NOTICE:	**This is a reprint of the Guidance Manual which was originally published under the Department of Environment, Health and Natural Resources. The manual text has not been revised or updated.**

Disclaimer

The contents of this publication are intended as guidance and do not replace North Carolina laws or Commission for Health Services rules.

The mention of trade names, products, or companies does not constitute an endorsement.

This manual is intended for periodic update. Sections may be changed as practices for on-site wastewater evolve.

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How to Use This Manual

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How to Use This Manual

How to Use This Manual

This publication has been designed to provide easy access to specific information needed for on-site management. It can be used as a guide to understanding specific physical requirements for on-site systems and as a reference for on-site regulations. You may find it helpful to first review the description of the overall content of this manual (below) and then to consult the table of contents to find specific discussions related to your interests.

Chapter 2 presents a short background of on-site management, including environmental impacts and the development of the science underlying on-site systems;

Chapter 3 lists the *North Carolina Laws and Rules for Sewage Treatment and Disposal Systems* and policy updates;

Chapter 4 is a detailed guide to thorough site and soil evaluation and acts as training material for environmental health specialists;

Chapter 5 presents information on the design, installation, inspection, and long-term management of conventional and modified conventional systems for small flows;

Chapter 6 is under development at the present time and will appear as a supplement. It will cover design, installation, and management aspects of large and industrial on-site wastewater systems;

Chapter 7 presents information on alternative, innovative, and experimental systems;

Chapter 8 contains information to help determine why a system has failed and suggestions to repair the system; and

Chapter 9 includes the **Appendices** and **References.** These sections are included to provide further information on topics in on-site systems and a number of references for convenience.

This manual presents the latest information available at the time of publication. As new and updated information becomes available, supplements will be added to the appropriate chapters and appendices.

Sidebar references direct the reader to the appropriate part of the North Carolina Administrative Code that deals with the subject discussed in the text near the reference. The North Carolina Administrative Code, or NCAC, is the overall body of state rules which governs all regulated activities.

In this manual, the references take the form of 15A NCAC 18A.XXXX. This means the rule appears in Title 15A of Subchapter 18A of the North Carolina Administrative Code (NCAC) and has a four digit code between .1934 and .1969. Some of the sidebar references have the form of G.S. 130A-XXX. These references direct the reader to the section of the General Statutes (G.S.) or laws covering wastewater systems. The entire *Laws and Rules for Sewage Treatment and Disposal Systems* is printed in Chapter 3 so that the reader can easily find the law or rule referred to in the sidebar.

Purpose and Goals of This Manual

Wastewater disposal can pose a threat to the environment and to public health. To protect people and the environment, wastewater must be disposed of in a manner that controls disease and prevents contamination of surface and ground water. Many residents in North Carolina who live outside urban areas must rely upon on-site systems for proper wastewater disposal. Presently, more than 50% of North Carolina housing units depend upon on-site wastewater disposal, as compared to 25% nationally.

Each year, 40,000 new on-site systems are installed for new housing, commercial, and industrial development, adding to the existing 1,440,000 on-site systems already in use in North Carolina. These systems contribute over 360 million gallons of wastewater to the environment every day. If on-site systems malfunction, the wastewater can contribute to nonpoint source water pollution, threatening the quality of the state's surface and ground water.

Properly designed and located on-site systems are a permanent means of wastewater disposal that can function reliably with minimum maintenance and cost. Most on-site systems do function satisfactorily; however, approximately 12,600 systems will be repaired this year because of failure. About 9% of the improvement permit applications will be denied, and agencies will handle some 62,000 applications for site evaluations and 136,000 consultative site visits. The total amount of money and employee time required to process the permit applications and perform the site visits are major expenditures for local and state agencies. Additionally, system failures and the installation of conventional systems on unsuitable sites create major threats to public health and significant losses of housing and business.

Because central sewage collection systems with sewage treatment plants are too costly and too difficult for many housing developments to install, on-site wastewater disposal will continue to be used. Therefore, we must learn to view on-site disposal as a permanent wastewater disposal technique, not merely as a temporary solution until a sewage collection system is installed. With proper site evaluation; proper choice of conventional, modified, innovative, or alternative systems; and proper installation, on-site systems can safely treat wastewater without endangering humans or polluting the environment.

This manual has been developed to help state and local regulatory agencies, system manufacturers, system designers, system installers, developers, homebuilders, homeowners, system operators, and the public deal with the complexities of on-site systems. The goal of this manual is to provide expert guidance on the overall management of on-site wastewater treatment and disposal in an effort to resolve many problems that now overwhelm state, county, and Extension Service personnel. Additionally, the manual may provide much-needed consistency in on-site system design, installation and maintenance which can improve the uniformity and effectiveness of on-site services to the citizens of North Carolina.

This manual provides guidance for:

- ❑ understanding the various requirements for on-site systems that may be applicable to specific locations and activities;
- ❑ understanding the basic concepts of on-site treatment and disposal;
- ❑ understanding the basic design principles for on-site systems;
- ❑ knowing the various installation and inspection techniques for on-site systems;
- ❑ learning how to determine if a system is performing as intended; and
- ❑ learning how to repair or remedy malfunctioning systems.

Please note that this manual is intended as an aid in the evaluation, construction, installation, operation, maintenance, and repair of on-site systems, but it cannot address specific problems or complex design considerations. Professional assistance should be sought for such situations.

Background

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Background

Present Impacts and History of On-Site Wastewater Systems

As defined by the Rules for Sewage Treatment and Disposal Systems,

"Sewage" means the liquid and solid human waste and liquid waste generated by water-using fixtures and appliances, including those associated with food handling.

"Effluent" means the liquid discharge of a septic tank or other sewage treatment device.

Reference
15A NCAC18A.1935(11),(39)

The large volumes of wastewater generated in the United States can be a serious threat to public health and the environment if the wastewater is disposed of improperly. People use more water than ever before due to the increasing number of labor-saving appliances and to changes in life-styles. Automatic clothes washers and dishwashers, higher standards of personal cleanliness, and automatic water supplies add great volumes of water to the average daily flow of wastewater from a home.

Those people living outside municipalities often use on-site systems for disposal of this wastewater. Because water use is increasing, on-site systems must handle ever-greater volumes of wastewater. Additionally, much of the land now being developed for suburban and rural housing is less capable of supporting on-site systems. Thus, we are facing a situation in which more on-site systems capable of handling larger volumes of wastewater are being installed, yet less-suitable sites are frequently chosen for these systems.

To help in addressing these complex problems, this chapter provides basic information about on-site wastewater systems and their management. The first section of this chapter discusses how the increasing volume of wastewater and the development of less-suitable land affect us. The second section covers some of the history of on-site wastewater management. The last section presents the basic science of on-site wastewater treatment and disposal. Information about the science of on-site treatment and disposal provides the background for the following chapters, which cover more detailed aspects of on-site systems.

Impact of On-Site Wastewater Pollution

Each year over 40,000 new on-site systems are installed in North Carolina for new housing, commercial, and industrial development, adding to the existing 1,440,000 on-site systems already in use in North Carolina. These systems contribute over 360 million gallons of wastewater to the environment every day.

Properly designed and located, on-site systems can be a permanent means of wastewater disposal that protects public health and has minimal effect on the environment. Most on-site systems function satisfactorily; however, a significant number of systems fail to perform as designed, and pressure is increasing to install on-site systems on unsuitable sites. The following statistics indicate the scope of the problem of failing on-site systems in North Carolina.

- At the time of this publication, approximately 12,600 systems in North Carolina are repaired each year because of failure. Additionally, about 11% of improvement permit applications are denied, mainly because selected sites are unsuitable.

- Public health agencies process 62,000 applications per year for site evaluations for both new systems and the repair of failing systems. Environmental health professionals perform 136,000 consultative site visits per year, often to inspect a failing on-site system.

These failing on-site systems and unsuitable sites are major concerns.

Public Health Threats

Much of today's public health knowledge regarding on-site systems was obtained during the early part of this century. Until that time, many outbreaks of contagious diseases occurred because sources of disease (drinking or coming into contact with contaminated water) were not yet known or understood. These contagious diseases are called *water-borne diseases* because they are spread by contaminated water. Other diseases were found to result when people came into contact with improperly disposed human wastes.

A basic principle learned in those early years was that to improve overall public health, sources of disease must be kept away from human contact. On-site systems use this principle by carrying human wastes deep into the soil and letting the soil absorb the wastewater so that the disease-causing organisms are in the soil, separated from humans. If on-site systems malfunction, the improperly treated and disposed wastewater becomes a potential source of disease and a genuine public health threat when humans come into contact with it.

Diseases carried in wastewater.

Improper disposal of human waste creates ideal conditions for outbreaks of many contagious diseases. Water-borne diseases include typhoid fever, cholera, dysentery, hepatitis, giardiasis, cryptosporidosis, hookworm, tapeworm, and other diseases that have plagued humankind since ancient times. Because we have developed proper means to treat and dispose of human wastes and wastewater, these previously common diseases no longer present a major problem.

How disease is spread.

From the public health point of view, there are two very dangerous types of on-site system failure. The first occurs when the wastewater does not infiltrate the ground. Instead, the wastewater *ponds,* or comes to the land's surface and forms a small pool or wet, mushy area. This unabsorbed wastewater may contain many disease-causing bacteria, viruses, and parasites.

There are three ways that humans could become sick when wastewater ponds in a treatment and disposal field.

1. Humans can come into contact with the pooled wastewater. Children are most likely to play in the pools or wet soil, but adults may have to walk through or work in the area. Once the wastewater is on the person's hands or body, the germs can spread to their mouth or nose where they are swallowed or inhaled.

2. Humans can drink contaminated water. Failing on-site systems can pollute wells, streams, rivers, and lakes, which may be used as water supplies. Wastewater from the pool can flow into a nearby stream and thereby contaminate the water bodies downstream.

3. Disease germs can be spread by insects or other animals to human food or drinking water. The animals that spread disease germs are called *vectors*. One of the best known vectors is the common housefly. It spreads disease by landing in or drinking pooled wastewater and then landing on food that humans later eat. The germs on the fly are then eaten by the humans.

A second type of on-site system failure occurs when an on-site system pollutes a well. This type of failure happens when the well is not properly constructed. In some cases, the on-site system may not be pooled wastewater on the surface, but the wastewater flows through cracks in the soil or underlying rock into the well.

If wastewater enters the well, people get sick by drinking water from the well. The on-site system or the well or both may have to be moved or rebuilt to ensure a clean supply of water.

Toxic chemicals.

Wastewater not only carries many diseases, it also contains chemicals that can cause poor health, cancer, or death. A range of information exists about the different chemicals found in the effluent from on-site systems.

Nitrate. One chemical, nitrate, has long been known to affect health, and we know a great deal about its origin and health effects. Nitrogen in wastewater is converted to nitrate by the bacteria in the septic tank and field during decomposition. The nitrate moves rapidly with the wastewater through the soil. If the wastewater gets into a drinking water well, the nitrate can be drunk by the site's residents or neighbors.

❑ Infants younger than six months are most susceptible to nitrate poisoning. Bacteria that live in the digestive tracts of newborn babies convert nitrate to nitrite. Nitrite then reacts with hemoglobin, which carries oxygen in blood, to form methemoglobin. Methemoglobin cannot carry oxygen, thus the affected baby suffers oxygen deficiency. The resulting condition is referred to as methemoglobinemia, or "blue baby syndrome." Most reported cases of blue baby syndrome due to contaminated water have ocurred with greater than 40 mg/l nitrate-nitrogen.

❑ The US EPA standard for nitrate is 10 mg/l as nitrogen in drinking water.

Artificial chemicals. Many artificial chemicals can be found in on-site wastewater effluent. Many chemicals are not "biodegradable" or broken down by bacteria in the septic tank and field. Because these chemicals are not broken down, they can flow into ground water or surface water and eventually into drinking water.

❑ Because of the wide variety of artificial chemicals, it is difficult to say what types of problems the chemicals may cause. Some chemicals are toxic or poisonous, while others may cause cancer or other diseases.

Wastewater must be absorbed into the soil and have adequate contact time in the soil so that it does not spread disease germs or toxic chemicals. When the wastewater is held in the soil, and the soil is suitable for on-site wastewater treatment, neither humans nor animals can come into contact with it and it will not pollute streams or ground water. Thus, a properly operating on-site system protects public health.

Environmental Threats

On-site wastewater disposal can pose a threat to the environment. Presently, more than 50% of North Carolina housing units, representing about 3.5 million people, depend upon on-site wastewater disposal. Based on these figures, on-site systems distribute 360 million gallons of wastewater to the environment each day.

The large volume of wastewater being discharged into the environment can cause damage to both surface and ground water. Damage is caused by the way the wastewater is discharged in the environment and the type and amount of pollutants in the water.

Nonpoint source pollution.

Pollution from on-site systems is categorized as *nonpoint source pollution.* Nonpoint source pollution comes from activities that are spread over large areas of land. *Point source pollution,* on the other hand, comes from a single point such as a pipe discharging industrial waste from a large factory.

Most nonpoint source pollution results from common activities and from land use. Examples of other nonpoint source pollution sources are:

- ❑ fertilizer and pesticides from farming;
- ❑ oil, grease and toxic metals from parking lots, roads, and automobiles;
- ❑ sediment from bare land, construction sites, and newly developed areas; and
- ❑ industrial and commercial chemicals from spills and leaks at industrial sites and commercial zones.

If on-site systems malfunction, the wastewater can contribute significant quantities of raw sewage and bacteria to surface and ground water. In addition, the wastewater from on-site systems contains certain pollutants, such as nitrate and phosphorus, which are not biodegradable in the on-site system but act as pollutants in water bodies. Thus, even systems that appear to be functioning properly can contribute to pollution of streams, lakes, marshes, or ground water.

Environmental impacts.

Pollutants in the wastewater affect animals, plants, and their habitats. Because on-site systems continually contribute huge amounts of wastewater to the environment, the long-term effects can be very serious. Some environmental impacts of wastewater are discussed below.

- ❑ Nitrate and phosphorus from on-site systems can cause *eutrophication,* an overgrowth of algae, plants, and bacteria in water bodies. Often, eutrophication appears as algae blooms in streams, rivers, estuaries, or marshes, and even sounds and bays on the ocean. Overgrowth causes fish kills and ruins the habitat for many types of plants and animals. Eutrophication occurs more often where the water moves slowly, such as in lakes, bays, and slow-moving rivers.
- ❑ In some areas, on-site systems are blamed for destroying shellfishing by releasing bacteria into the receiving water.
- ❑ Wastewater from on-site systems can cause certain parts of a stream to become *anaerobic,* which means there is no oxygen in the water. Pollutants in the on-site wastewater serve as food for bacteria and certain types of anaerobic animals. The bacteria and animals grow very rapidly and use up all the oxygen in the stream. This lack of oxygen suffocates fish, other animals, and plants.

- Toxic and synthetic chemicals from on-site systems can enter the shallow ground water. This happens most often where the soil is sandy or the water table is very high. Under these conditions, the wastewater does not receive adequate treatment to biodegrade the pollutants in the wastewater.

Because so many on-site systems discharge so much wastewater, all on-site systems must be installed so that the wastewater receives the best treatment possible to protect the environment.

History of On-Site Wastewater Management

The use of septic tanks to treat wastewater goes back to the middle of the nineteenth century. Frenchman J.L. Mouras first made a masonry tank to receive wastewater from a home in the town of Vesoul, France. After twelve years of operation, the tank was found to have only a small amount of solids in it. Mouras had expected that the tank would be very full, so he concluded that some process must be taking place that reduced the volume of solids. He and A. Moigno, a priest and scientist, experimented with the tank to learn more about processes taking place in the tank. Mouras patented the tank in 1881.

Use of septic tanks in the United States began about 1883 in Boston, Massachusetts. There, Edward S. Philbrick designed a two-chamber, round, vertical-cylindrical tank with a dosing siphon.

Although these early developments showed promise, on-site wastewater disposal remained at a crude level well into the twentieth century in both Europe and the US. During the early part of this century, city-dwellers were served by large central collection systems and had no need for on-site wastewater disposal. Rural dwellers relied on privies and other simple waste disposal means because few farms had indoor plumbing.

Since the first quarter of this century, most development work on improving on-site systems has been done in the US. By the middle of the 1920s, Henry Ryon of the New York State Department of Health began to study methods to improve on-site system performance. He realized that the most critical part of the system is the treatment and disposal field. To help ensure adequate soil absorption, he developed the percolation test. This test has been widely used to help determine the level of soil absorption possible for an on-site system, although it has been more recently shown to provide inconsistent and unrealistic information.

The next big effort to improve on-site wastewater management occurred in the late 1940s. Until that time, only the percolation test and a few guidelines were used to determine soil and site suitability for on-site system installation. Rural electrification gave farm families indoor plumbing and the opportunity to install on-site wastewater disposal systems. Soldiers returning from World War II spawned a housing boom in suburban areas where on-site systems were the only choice for wastewater disposal. However, because of the lack of knowledge of on-site system operation, failures were common. The explosion in housing growth and the growing threat to public health brought about the first study of on-site systems by the US Public Health Service in 1946.

Since that landmark study, many studies have been conducted on conventional, modified conventional, alternative, innovative, and experimental on-site systems. The research has pointed out that the most critical part of the conventional on-site system is the treatment and disposal field. We now have better ways to determine the suitability of a site for an on-site system, and we know more about improving the performance of on-site systems. The next section presents some of the findings from the research done on on-site systems.

2

Science of On-Site Wastewater Treatment and Disposal

During the early years of this century, on-site wastewater management was basically a trial-and-error process. Systems that failed were not of concern because on-site wastewater disposal was usually only used in rural areas with sparse population. There was little need for detailed knowledge; therefore, on-site wastewater treatment and disposal got little attention.

As rural electrification enabled more people to install indoor plumbing and as rural and suburban populations grew, a greater need arose for concise information about proper installation and operation of on-site systems. Almost 70 years have passed since Henry Ryon first suggested that the performance of an on-site system depended on the percolation rate of the soil. Since that time, many studies have been conducted on on-site system requirements and performance.

This section presents the important principles and guidelines learned about on-site wastewater treatment and disposal.

Principles of On-Site Wastewater Treatment and Disposal

A number of principles form the basis for on-site systems. These principles come from the many studies to determine the best ways to provide safe and reliable wastewater treatment and disposal.

Treatment and absorption of wastewater by soil.

The vast majority of on-site treatment and disposal systems depend on the soil for treatment and disposal of sewage. Although some on-site systems use surface discharge or land application to dispose of wastewater, such systems are relatively few in number.

❑ The research conducted over the last 40 years has shown that the treatment and disposal field is the most critical part of an on-site system.

❑ Devices that receive sewage upstream of the treatment and disposal field pretreat the sewage to prevent clogging of the treatment and disposal field.

The focus of on-site wastewater treatment and disposal, and the principles listed here, concentrate on the treatment and disposal field. The principles and details are listed below.

First principle. On-site systems should ensure that the effluent is absorbed by the soil and does not come to the land surface or flow directly into streams, rivers, lakes, the ocean, or the ground waters.

❑ Sewage carries many disease-causing bacteria or germs. As long as the sewage effluent stays in the soil, people are protected because the bacteria and viruses stay in the soil where there is no contact with humans. However, if the effluent comes to the ground surface, children and adults can pick up the bacteria and become ill or die. On-site systems that fail cause effluent to puddle or pool on the ground, which is dangerous to public health.

❑ On-site systems not only dispose of sewage, but also *treat* the sewage to remove bacteria, other disease-causing organisms, and pollutants. The treatment of the wastewater takes place in the soil, so the wastewater must stay in the soil for the pollutants to be removed.

Second principle. On-site systems should maximize the *aerobic treatment* of the sewage.

❑ Sewage undergoes aerobic treatment in soil layers that are not saturated with water. These soil layers are called the *unsaturated zone* or *vadose zone* because the soil is dry or damp but not completely wet. The unsaturated zone is aerobic because air and oxygen enter and help to remove bacteria and pollutants form the sewage.

❑ Aerobic treatment is the fastest and most complete treatment the effluent can receive in the soil.

❑ On-site systems should be located where the effluent must travel the farthest distance possible before getting to the water table or wet soil layers. Long travel distance helps prevent pollution of ground water.

Third principle. On-site systems should apply effluent to the soil only in a suitable and prepared *treatment and disposal field.*

❑ A treatment and disposal field is an area of land where effluent flows through pipes with holes into specially prepared trenches or beds to be absorbed by the soil. The treatment and disposal field is where the main treatment of the effluent takes place and where all the liquid effluent is absorbed.

❑ Only certain soils and certain locations should be used as treatment and disposal fields. These areas are selected by environmental health specialists to provide the safest and most reliable place to absorb liquid effluent.

❑ Septic tanks, pump tanks, or piping in areas other than the treatment and disposal field should not leak. Effluent leaks in areas outside the treatment and disposal field can and have resulted in contamination of ground water, wells, the land surface, and surface waters.

Fourth principle. Treatment and disposal field trenches should be as long and narrow as possible to maximize the effluent's contact with the soil, which increases treatment.

❑ Short and wide field trenches may have the same amount of trench bottom area as a long, narrow trench, but the long, narrow trench has much more side wall area that can absorb effluent and spread the effluent out over more land.

Fifth principle. Treatment and disposal field trenches should have level bottoms and should be level along their entire length to distribute the effluent as evenly as possible.

❑ Field trenches with slanted bottoms or trenches that slope along their length will make the effluent flow to the lowest area. All treatment and disposal of the effluent will have to take place in that one low area, which can cause early failure of the field and threaten public health if the effluent ponds on the land surface.

These five principles are the most important concepts in on-site wastewater treatment and disposal. The design and installation of all on-site systems should be guided by these principles.

Pre-treatment of sewage before soil absorption.

To protect the treatment and disposal field from clogging, some pre-treatment is necessary. The conventional on-site system uses a septic tank to pre-treat sewage before it flows to the field. Septic tanks operate on the following principles.

Septic tanks: First principle. Septic tanks remove solids suspended in sewage. The large volume of the septic tank slows the wastewater so that heavy solids can settle to the bottom and buoyant materials, such as oil and grease, can float to the top. Heavy solids form a layer of sludge on the bottom of the tank, while the oil and grease make a scum layer that floats on the wastewater. Various types of baffles, such as walls and outlet tees, are used to keep the settled and floating solids from moving out to the treatment and disposal field.

A septic tank that is working well removes about half of the pollutants in the sewage by either letting them settle out or float to the surface of the wastewater.

Septic tanks: Second principle. The second important function of the septic tank is to store solids. Because the solids are stored in the large volume of the septic tank, the tank has to be pumped out only every few years. The tank must be large enough to store the solids and still allow additional solids to settle out.

Septic tanks: Third principle. Some of the solids in the septic tank are digested by bacteria in the tank. Certain bacteria, called *anaerobes* because they live in areas where there is no oxygen, eat the sewage and produce various gases.

Considerable difference of opinion exists on how much digestion of solids takes place. Regardless of how much digestion occurs, beneficial effects of digestion are that the sludge volume and the strength of the wastewater are reduced by the bacteria. However, the gas produced by the bacteria rises through the wastewater and causes the sludge to be stirred up and possibly flow out to the treatment and disposal field. Gases produced by the bacteria are poisonous and can burn or explode, making the air inside a septic tank very dangerous. They are also highly corrosive and can deteriorate the tank and outlet tees.

Improving septic tank performance.

The following points can help make septic tanks work better.

- ❑ To get the best settling, septic tanks should be much longer than they are wide. A longer length allows the water to flow along a long path, leaving plenty of time for the solids to settle. The tank should be at least twice as long as it is wide.
- ❑ Shallow, flat tanks allow for better settling than deep and narrow tanks. Solids settle out faster in a shallow tank than in a deep tank.
- ❑ Larger septic tanks work better than small tanks because they hold the wastewater longer for better settling and have more storage volume for sludge and scum.
- ❑ Septic tanks with more compartments work better than septic tanks with one compartment, because more solids are trapped in the compartments.
- ❑ Properly designed baffle walls keep the in-flowing sewage from stirring up the sludge and carrying solids out to the treatment and disposal field.
- ❑ For best performance, the inlet and outlet of the septic tank must be separated by a long flow path for the wastewater. If the inlet and outlet are too close, the wastewater flows rapidly to the outlet before the solids can settle and the grease can separate from the water.
- ❑ Outlets work best if they have a fitting to keep the scum from flowing out into the treatment and disposal field.

For more information on these principles, see the References at the back of this manual.

Site Evaluation and Field Testing

4

Site Evaluation and Field Testing

Introduction

Finding a suitable site and soil is essential to the placement and proper functioning of any on-site system. This chapter is designed to provide information on determining the proper site and soil for the placement of on-site systems and has been written specifically for the use of environmental health specialists as a training guide.

As defined by the *Rules for Sewage Treatment and Disposal Systems,*

"Sewage" means the liquid and solid human waste and liquid waste generated by water-using fixtures and appliances, including those associated with food handling.

"Effluent" means the liquid discharge of a septic tank or other sewage treatment device.

Reference
15A NCAC 18A.1935(11),(39)

❑ Section 4.1, ***Wastewater Treatment in Soils***, describes the constituents of wastewater, the chemicals and human pathogens, and how these potentially harmful constituents are treated and absorbed by the soil.

❑ Section 4.2, ***Ground Water***, presents an overview of ground water and how ground water can be affected by improperly sited or malfunctioning on-site systems.

❑ Section 4.3, ***Soils and Geology of North Carolina***, introduces the reader to the different soils and geology of North Carolina and describes how they affect the siting and functioning of on-site systems.

❑ Section 4.4, ***Basic Soil Concepts***, presents soil and landscape position concepts necessary to conduct a site and soil evaluation. This section then relates these concepts to the placement and functioning of on-site system.

❑ Section 4.5, ***Site and Soil Evaluation Procedures***, provides details on how to make a thorough site and soil evaluation. Site evaluation factors and classifications are discussed in detail and the rules for determining the placement of an on-site system are described.

❑ Section 4.6, ***On-Site Wastewater Loading Rates***, discusses the importance of calculating the proper on-site wastewater loading rates and then instructs the reader on making the calculations for both conventional, modified, and alternative on-site systems.

❑ Section 4.7, ***Site Suitability: Matching the Site Characteristics to Appropriate Designs***, introduces the reader to the *Soil Site Evaluation for On-Site Wastewater System* form used to permit on-site systems. Six *Soil Site Evaluation for On-Site Wastewater System* forms, which have been completed, are included to help the reader understand how the forms are used to determine site and soil suitability for on-site systems.

4

4.1 WASTEWATER TREATMENT IN SOILS

The purpose of wastewater treatment is to reduce the pollutants in wastewater that can contaminate ground and surface water systems. Without proper treatment, wastewater can cause public health problems because of the potential spread of bacteria and viruses and can cause environmental degradation and contamination. Wastewater contains bacteria, viruses, nitrogen compounds, and toxic organic compounds which can cause disease in humans. Chemical constituents in wastewater that can adversely affect the environment are oxygen-demanding substances, nitrogen, phosphorus, chloride, sulfate, sodium, heavy metals, toxic organic compounds, detergent surfactants, and suspended solids.

In most on-site systems, the soil is used to treat and dispose of wastewater. Depending on a number of factors, the soil can remove or reduce these pollutants. This section describes the process of wastewater treatment in soils. The health and environmental impacts of the constituents that are released from on-site systems are also discussed in this section.

Treatment Processes in the Soil

Most of the organic solids in domestic sewage are removed by settling that takes place in the septic tank. Some of the solids will partially biodegrade in the tank. Wastewater that leaves the septic tank and enters the soil receives most of its treatment in the unsaturated aerobic regions under the treatment and disposal field.

Wastewater treatment in the soil can be broken down into three different types of processes: *physical*, *chemical*, and *biological*. Table 4.1.1 describes these processes.

❑ *Physical processes* include soil filtration, sedimentation in the soil profile, dispersion, and dilution.

❑ *Chemical processes* involve cation exchange, adsorption, organic residue complex formation, and precipitation.

❑ *Biological processes* consist of biological oxidation, nitrification, denitrification and plant uptake, inactivation, immobilization, and predation.

All of these processes may occur independently or together for any given wastewater constituent.

Aerobic Treatment

The most rapid treatment of wastewater occurs in an *aerobic* soil environment, where oxygen is present in the soil. Oxygen allows aerobic bacteria and other microorganisms to feed on the wastewater and break down the contaminants to simpler and less-harmful products. Because oxygen is a very powerful chemical, aerobic degradation proceeds much faster than similar *anaerobic* processes that occur in the absence of oxygen. The faster aerobic processes help increase the amount of treatment the wastewater receives before the wastewater enters ground or surface water.

❑ Aerobic conditions promote rapid die-off of some *pathogenic*, or disease-causing, bacteria that require anaerobic conditions to live.

❑ Additionally, oxygen in the soil favors the growth of aerobic bacteria and micro-organisms over the anaerobic organisms. In some instances, aerobic organisms may feed on the anaerobic populations, further reducing pathogen numbers.

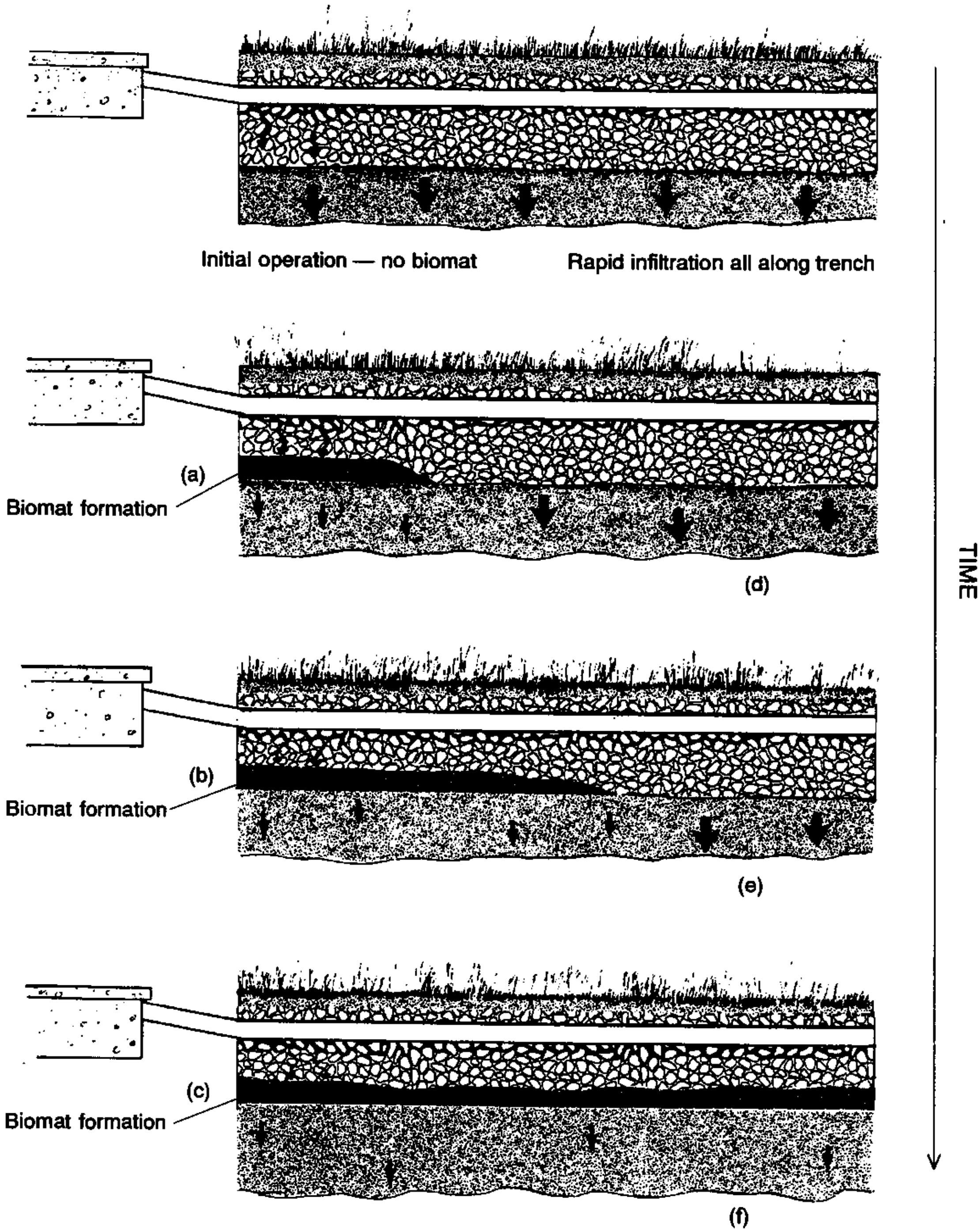
Table 4.1.1 Wastewater Treatment Processes in Soils

	Process	Effect	Conditions
PHYSICAL PROCESSES	Soil filtration	Remove organic and mineral particulate matter and pathogens (primarily bacteria) in small soil voids and biomat.	Unsaturated soil best; finer textured with moderate permeability most efficient.
	Sedimentation in soil	Remove bacteria, some viruses, and particulates by settling out on soil particles where quiescent zones exist.	More likely where flow through macropores (visible soil voids) and channels is not extensive.
	Dispersion and dilution	Reduces the concentration but not the overall mass of the pollutant.	Most important for chemicals such as NO_3-N & Cl. Affected little by other treatment processes.
CHEMICAL PROCESSES	Cation exchange	Adsorption of cations onto negatively charged exchange sites on clay minerals and organic matter. Temporary storage for later plant or microbial uptake of K^+, Na^+, NH_4^+, Ca^{++}, Mg^{++} and other metal cations.	Depends primarily on clay content, type of clay minerals, organic matter content, and pH of soil. Cations are only temporarily held.
	Adsorption	Rapid, temporary, week binding of trace metals, viruses, and organic substances to surface of soil particles.	Fine-textured soils with many fine voids show more adsorption. Unsaturated flow enhances chemical-soil contact and adsorption. Organic substances and viruses can later be eluted or "rinsed out" to ground water.
	Precipitation	Occurs when concentration of chemical elements in sewage exceeds solubility in soil, water, and ground water. Especially important for slow fixation of P as Fe, Al, or Ca-phosphates. Phosphorus permanently retained unless soil particles are physically eroded from site.	Aerobic conditions and neutral or high pH enhance formation of insoluble oxides and hydroxides. Fine texture and presence of Fe and Al oxides favor P precipitation in acid conditions. Presence of Ca-minerals enhances phosphorus precipitation in basic conditions.
	Complexation with organic residues	Chemical complexes formed from organic decomposition residues that are strongly bound to trace metals through chelation, chemical coagulation, ion exchange, surface absorption, and other reactions. Chemical complexes not part of living biomass.	Chemical complex formation enhanced by accumulation of organic residues and near neutral or slightly basic pH. Very low pH releases chelated metals into water.
BIOLOGICAL PROCESSES	Biological Oxidation (Mineralization)	Oxidation and breakdown of micro-organisms and organic compounds by other micro-organ--isms. Mineralization of organic N to NH_4^+, and release of P, S, and other nutrients. Bacteria and fungi are most important micro-organisms for biological oxidation.	Nutrients and carbon source in biomat, and aerobic conditions beneath mat enhance microbial degradation of compounds. Strongly affected by temperature. Also affected by dosing regime.
	Nitrification	A special case of biological oxidation of NH_4^+ to NO_3^- by *Nitrosomonas* and *Nitrobacter* bacteria.	Takes place only under aerobic conditions.
	Denitrification	Biological reduction of nitrate to nitrous oxide or denitrogen gas that escapes into the atmosphere.	Takes place only under anaerobic conditions with suitable carbon source.
	Immobilization	Uptake of substance from inorganic state to organic form in microbial or plant tissues rendering the substance not readily available to other organisms. Incorporation of nutrients and heavy metals into biomass.	Immobilization and mineralization resulting from biological decomposition create the cycling of N, C, P, and S in soils. Carbon to nitrogen ratio has strong effect.
	Predation	Decreases bacteria, protozoa, and helminths.	Aerobic soil conditions necessary.
	Plant Uptake	Decreases the nutrient content (N, P, K, Ca, S, and Mg) of the wastewater by plant absorption. Also removes water from the soil.	Suitable to high yields of plant biomass.
	Inactivation	Many disease-causing bacteria cannot live without the high levels of nutrients and warm temperatures inside the human digestive tract; hence they do not compete well in a soil environment. Desiccation and enzymatic destruction of bacteria and viruses are also important.	Aerobic soil conditions and long travel times that allow natural environmental and enzymatic induced die-off increase inactivation. High temperatures promote destruction of viruses.

Biomat

A significant degree of treatment occurs at the biomat in the treatment and disposal trenches. The *biomat* is a biologically active layer that covers the bottom and sides of the trenches. It is formed from complex bacterial polysaccharides and accumulated organic substances as a result of wastewater moving through the trench into the surrounding soil. A biomat is vital in obtaining a high degree of treatment of the wastewater and to preventing pollution of ground water. However, biomats slow the flow of wastewater into the soil and may even clog the soil surface so that the trench can no longer absorb any wastewater. Figure 4.1.1 shows biomat formation.

Figure 4.1.1
Biomat formation over time. Biomat forms first at beginning of trench and progresses along the entire trench over time.



The following process describes biomat formation over time.

- Initially, when the soil absorption system begins operation, there is no biomat present in the trench. The rate of wastewater flow out of the trench is determined by the soil.

- As the on-site system is used, the biomat first forms in the trenches where the wastewater enters. Over time the biomat progresses down the trench to eventually cover the entire length of the trench.

- The formation of the biomat begins immediately but takes from three to eight years to form completely. The amount of time that it takes to form the biomat depends on a number of factors, including the hydraulic loading rate of the trench, the dosing schedule, the types of substances in the wastewater, and the temperature. The upper portion of the biomat is anaerobic; the lower portion of the biomat grades from anaerobic at its top to aerobic at its bottom because the soil conditions below are aerobic.

- Once formed, the biomat physically, biologically, and chemically removes or reduces many wastewater constituents. Further, it limits the rate that water can move into the soil, helping in the purification process because the microbes have more time to treat the sewage.

- Because the biomat limits flow from the system into the soil, the amount of wastewater loaded into the system can be no greater than the amount of wastewater that can move through the biomat into the soil. When the amount of wastewater entering the system is the same or less than the amount of wastewater exiting through the biomat and into the soil, the on-site system is considered to be at equilibrium.

- A mature biomat is generally in equilibrium: the addition of organic matter to the mat occurs at the same rate as degradation of the organic matter by soil organisms.

Wastewater Movement Through the Soil

The rate of wastewater flow through the soil is critical to the ability of a soil to treat wastewater. If wastewater moves too rapidly through the soil, the chemical, physical, and biological reactions that must occur to retard, reduce, and transform the pollutants are impeded. Any soil condition that causes an increased rate of flow, such as a high water table, high hydraulic loadings, or shallow depth to seasonally high water tables, can potentially cause contamination of ground water because the wastewater has not been adequately treated.

Water moves though unsaturated soil more slowly than through saturated soil. The slower movement under unsaturated conditions provides more treatment and more protection of ground water than can be obtained in saturated soil.

Reference
15A NCAC 18A.1955(m)

In North Carolina, for soils in Groups II, III, and IV, 12 inches of unsaturated soil between the bottom of the trench and any soil wetness condition, ground water, or other unsuitable soil condition is required for proper treatment of wastewater.

- For Group I soils (sandy soils), an 18-inch separation distance is required between the trench bottom and any soil wetness conditions or the ground water. Because the rate of wastewater movement through Group I soils is faster than Group II, III, or IV soils, a greater separation distance is needed to properly treat the wastewater before it enters the ground water.

Nitrogen in On-Site Systems

Nitrogen enters domestic on-site systems mainly as organic nitrogen, which means the nitrogen is part of a large biological molecule such as a protein. Bacteria and other microbes oxidize or mineralize the organic nitrogen to ammonium forms. The ammonium can be volatilized to the atmosphere, used by bacteria and plants, or adsorbed by the biomat or soil. Ammonium can also be converted under aerobic conditions to nitrate and nitrite in soils by *Nitrosomonas* and *Nitrobacter* bacteria. The nitrate form of nitrogen can be used by bacteria or plants. Under anaerobic conditions, nitrate can be transformed to nitrogen gas, a process known as *denitrification*. Figure 4.1.2 demonstrates the nitrogen cycle: gains and losses of nitrogen in the atmosphere and soil.

❑ Because nitrate is very soluble and is not absorbed by soil, it can move through the soil into the ground water and adjoining surface waters.

❑ If there are too many on-site systems in one area, nitrate levels in ground water may exceed the U.S. Environmental Protection Agency's Maximum Contaminate Level for nitrogen of 10 milligrams/liter (mg/l). Nitrogen levels above 10 mg/l may cause sickness or death to small babies and at higher levels can be harmful to adults.

❑ Denitrification is most likely to occur in anaerobic zones, such as wet soils, or as shallow ground water moves through riparian areas next to streams. However, denitrification is limited in a properly sited system because the aerobic soil conditions will not allow denitrification to occur.

❑ Research by Bicki et al. (1985) shows that of the total nitrogen produced from on-site systems, only 20% to 40% is adsorbed or removed during flow through unsaturated soils. Therefore, dilution and denitrification are the mechanisms that must be relied upon to reduce ground water nitrate concentrations.

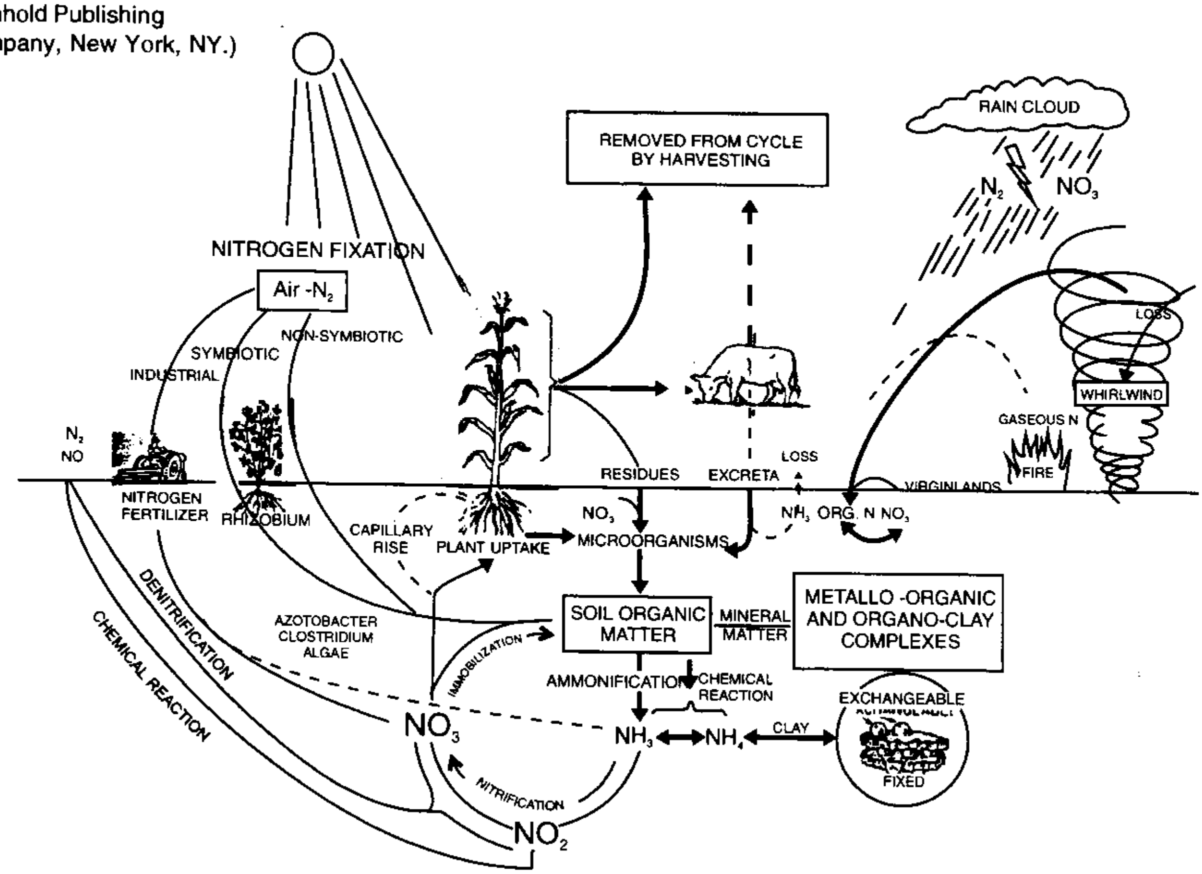


Figure 4.1.2 The Nitrogen Cycle in Soil. (Sauchelli, *Fertilizer Nitrogen —Its Chemistry and Technology, 1964.* Reprinted with permission of Van Nostrand Reinhold Publishing Company, New York, NY.)

Phosphorus in On-Site Systems

Phosphorus can enter a wastewater system in a variety of forms. Organic and synthetic phosphorus are transformed by bacteria to the simple orthophosphate form. Because excess phosphorus can stimulate *eutrophication*, the excessive growth of algae and aquatic plants in streams, rivers, and lakes, it is important that phosphorus not enter water bodies in high concentration. Fortunately, orthophosphate usually is immobilized by a number of processes in the soil.

❑ According to research by Bicki et al. (1985), if soil conditions below the on-site system treatment and disposal trenches are aerobic and unsaturated, phosphorus concentrations can be reduced by 85% to 95%.

Phosphate immobilization processes in the soil include adsorbtion to the soil particles or biomat, precipitation in the soil (Figure 4.1.3), or biological uptake.

Figure 4.1.3 Phosphorus fixation in the soil.

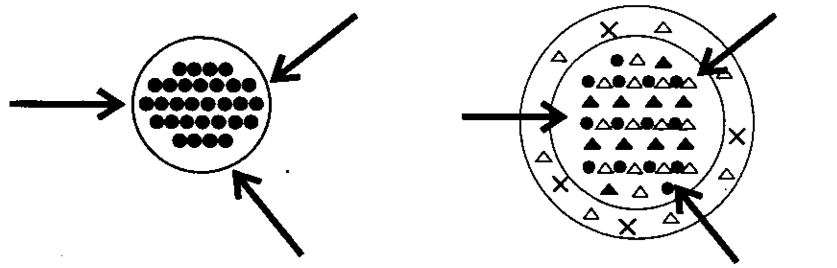
● $Ca(H_2PO_4)_2 \cdot H_2O$

▲ $CaHPO_4 \cdot 2H_2O$

△ H_3PO_4

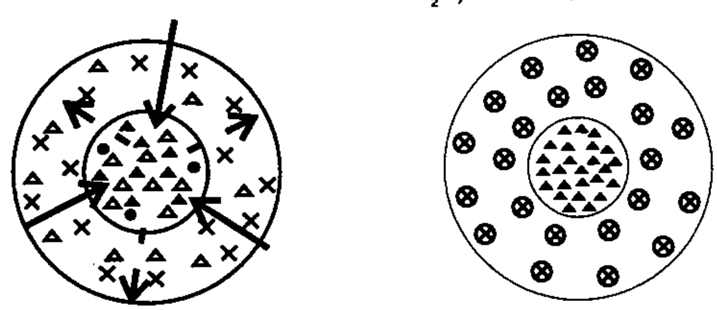
✕ Soluble Fe, Al, Mn

⊗ Insoluble Fe, Al, Mn phosphates



1. Water enters a granule of water-soluble monocalcium phosphate — $Ca(H_2PO_4)_2 \cdot H_2O$.

2. As more water is absorbed by the granule and soil, phosphate (H_3PO_4) and dicalcium phosphate ($CaHPO_4 \cdot 2H_2O$) are formed.



3. The solution of phosphate (H_3PO_4) moves into the surrounding soil. The solution displaces soil elements such as iron (Fe), aluminum (Al), or manganese (Mn).

4. The iron (Fe), aluminum (Al), or manganese (Mn) react with the phosphate to form insoluble compounds. This reaction ties up the phosphorus, making it inaccessible to plants and further movement in the soil.

Other Chemical Pollutants in On-Site Systems

Wastewater from various facilities can contain a wide variety of contaminants. Common domestic sewage has at least minor levels of the pollutants discussed below. Contaminants present in wastewater from other facilities, such as commercial and industrial establishments, vary widely depending on the type of activities taking place in the facility generating the wastewater.

❑ Chloride and sulfate occur commonly in wastewater. Both of these chemicals move readily through the soil. Soils cannot adsorb chloride and sulfate anions because these chemicals are repelled from the negative surface charge of the soils. Because chemicals such as chloride and sulfate leach into the ground water the primary mechanism for reduction is dilution. If the concentration of these chemicals in ground water is too high, then the density of on-site systems in an area may be restricted.

❑ Sodium cations are adsorbed to the soil aggregates, which are held together by organic matter and clay. If sodium levels in wastewater are too high, the sodium may disperse the organic matter and clay in the soil. Such *soil dispersion* changes the soil structure and reduces the rate of water movement through the soil, which can cause failure of an on-site system.

❑ Detergent surfactants are removed from wastewater effluent by adsorption to soil particles and by biodegradation. Aerated soil conditions enhance biodegradation and increase the treatment of surfactants. Adsorption of surfactants not only removes them from the wastewater, but it also increases the time for additional biodegradation to occur.

❑ Toxic organic compounds, such as pesticides and nonbiodegradable organic compounds, degrade slowly. Since these compounds usually are not adsorbed by the soil, they may leach and contaminate the ground water. The best way to minimize the impact of these chemicals is to keep them out of the on-site system.

❑ Heavy metals in high concentrations are usually toxic. Such metals can slow or stop the bacterial action in the septic tank and in the treatment and disposal trench. These metals should not be put into the on-site system.

Bacteria, Viruses, and Protozoa in On-Site Systems

Bacteria, viruses, and protozoa cause many human and animal diseases. Bacteria cause cholera, shigellosis, salmonella, and typhoid. Giardia and cryptosporidium are protozoa that cause dysentery. Hepatitis is caused by a viral contaminant. The comments listed below give some information about how biological contaminants are removed by on-site systems.

❑ Bacteria are removed primarily by filtration, adsorption, and natural die-off. The biomat provides a barrier to the transport of many bacteria into the soil.

- If the soil is unsaturated, bacteria are not usually transported more than three feet. If, however, saturated flow occurs, bacteria can move further.
- Saturated flow, high wastewater effluent loading rates, shallow depth to soil wetness conditions, or fractured bedrock contribute to bacterial contamination from on-site systems.

❑ Viruses, which are much smaller than bacteria, are removed by adsorption, filtration, precipitation, biological enzyme attack, and natural die-off.

- Greater clay content, low soil pH, low soil moisture content, and low effluent loading rates are important factors that decrease the possibility of viral contamination to the ground water from on-site systems.

❑ Wastewater also contains other micro-organisms, such as protozoa, which can cause disease. Unfortunately, with the exception of bacteria and viruses, little is known about the behavior of pathogens in on-site systems and in the soil. Because there have been few reported outbreaks of disease caused by microbes other than bacteria and viruses from subsurface wastewater disposal systems, it appears that these biologic agents are retained in the soil, probably because of their relatively large size.

❑ Protozoa form cysts that can survive under a wide range of conditions and are very resistant to disinfectants usually employed in drinking water treatment. Protozoan cells and cysts are generally much larger than bacteria, which may mean that they can be filtered by the soil. Filtration by the soil of protozoan cysts has been shown in the case of *Giardia lamblia* cysts, as reported by Yates in 1987.

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4.2 GROUND WATER

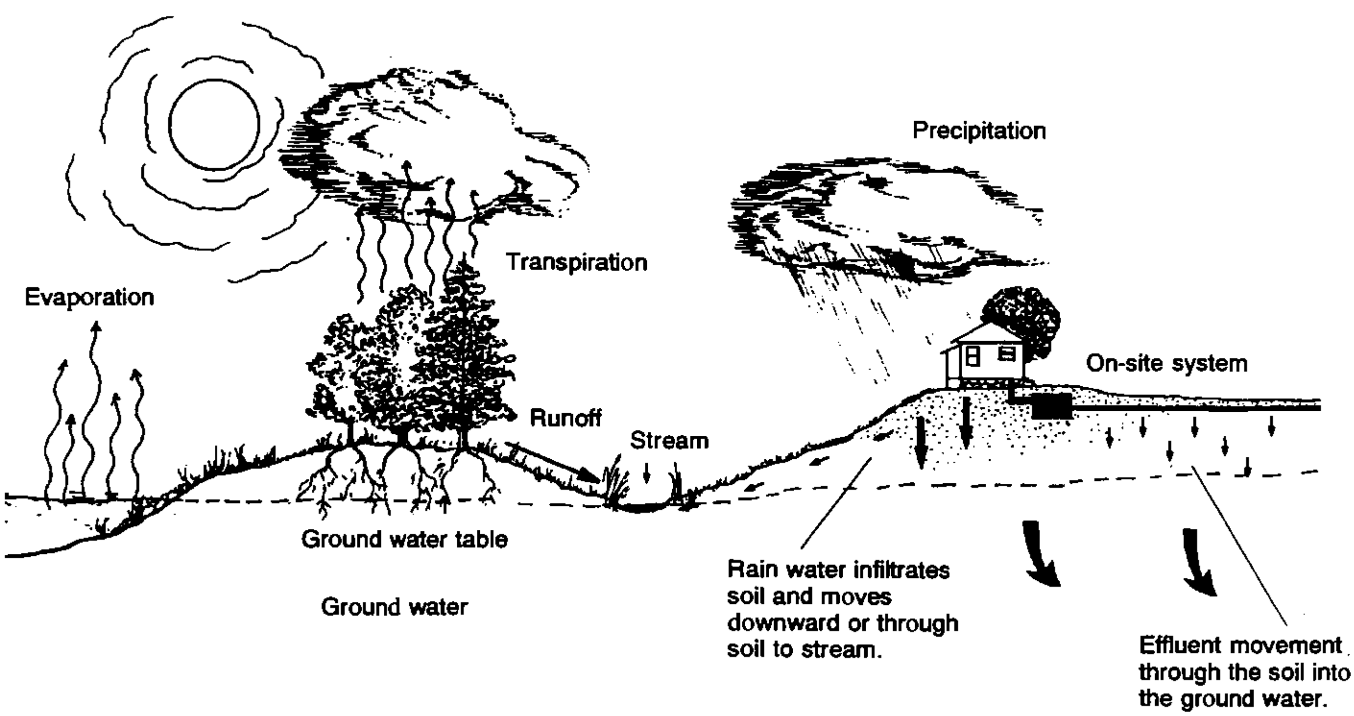
Ground water serves as the drinking water source for 52 % of North Carolina's 7 million inhabitants. Of the 3 million residents who obtain water from the ground, 63 % use ground water from individual residential wells or springs and 37 % use ground water from a community source well. Because so many North Carolinians use ground water, it is important to protect this vital natural resource.

This section presents an overview of ground water and how on-site systems affect ground water.

Introduction to Ground Water

All water on the Earth is part of the *hydrologic cycle,* a world-wide system of water movement that includes all the water in the atmosphere, on the land surface, in the earth, and in the oceans. A drawing of the hydrologic cycle is shown in Figure 4.2.1.

Figure 4.2.1 The hydrologic cycle.



Ground Water Terms and Definitions

Part of the water in the hydrologic cycle (Figure 4.2.2) is under the soil surface. This underground water is called *ground water.* As shown in the hydrologic cycle, ground water comes from rain water *infiltrating,* or flowing into and through the soil. This water can remain in the soil close to the ground surface or it can move downward into deep rock zones. The following descriptions of common terms are used in describing the ground water system.

❑ Ground water can be found in soil near the land surface, in *saprolite,* or in rock. A layer of rock, soil, or sand that contains ground water and releases it when a well in that layer is pumped is called an *aquifer.* The type of soil or rock material in

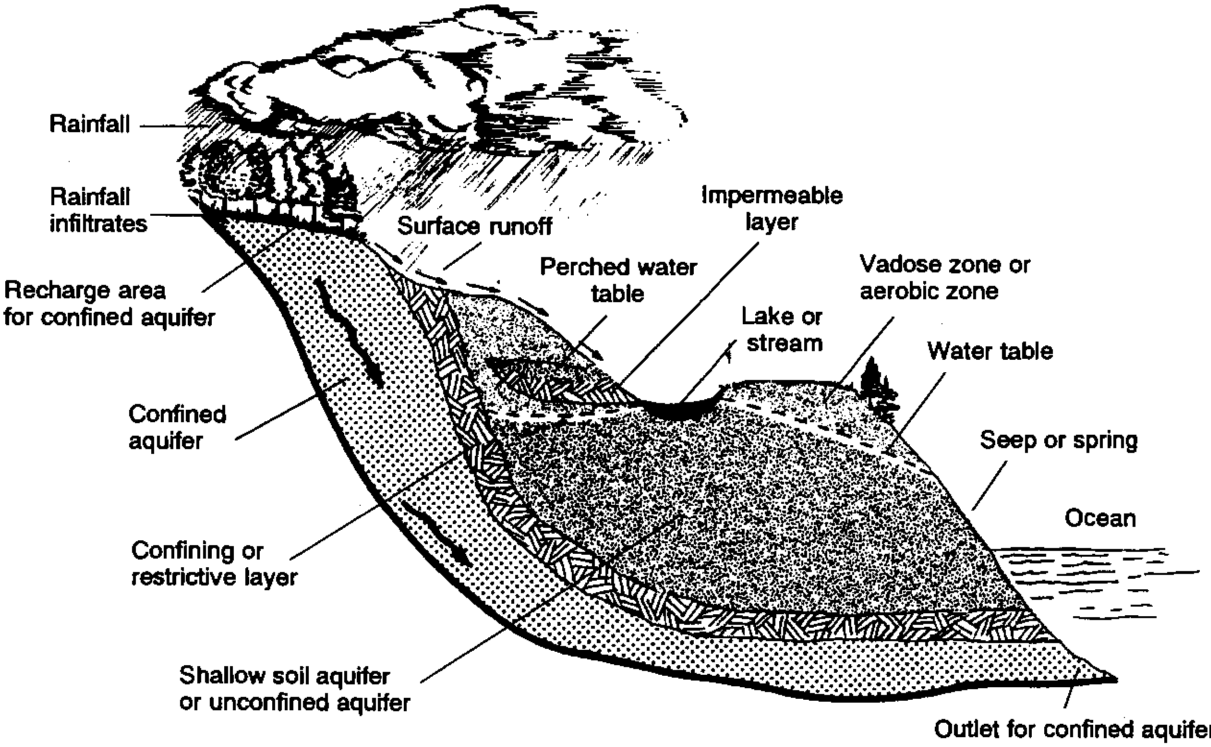


Figure 4.2.2 The hydrologic cycle and ground water flow.

the aquifer determines the amount of water that can be stored and the rate at which water can be pumped from an aquifer. For example, sandy sediments will release water more quickly than clayey sediments.

❑ If a layer of soil, rock, or sand is completely filled with ground water, it is said to be *saturated* and the part of the layer that is saturated is part of the *saturated zone*. Layers of soil, rock, or sand above the saturated zone are called *unsaturated* and are part of the *vadose zone*. The dividing line between the saturated zone and the vadose zone is the *water table*, the height of the free water surface in the soil. Figure 4.2.2 shows the location of the water table and the saturated and vadose zones.

❑ Usually shallow ground water is held in the soil layers near the ground surface like water in a bowl. This is because a *restrictive layer* or *confining layer* of clay or solid rock under the soil keeps the water from moving downward. The water table can rise and fall in response to heavy rains or dry periods, and the water can move horizontally but it does not flow downward very rapidly. Because the water table can rise or fall in response to weather conditions, the shallow soil aquifer is called an *unconfined aquifer*. The water level of a well in an unconfined aquifer will change as the water table rises and falls.

❑ In certain cases a *perched water table* will form above the normal water table due to a restrictive layer of clay or other material near the surface. A perched water table can cause wet soil conditions at shallow depths.

Reference

15A NCAC 18A.1935(24)

A perched water table, as defined by the rules, is

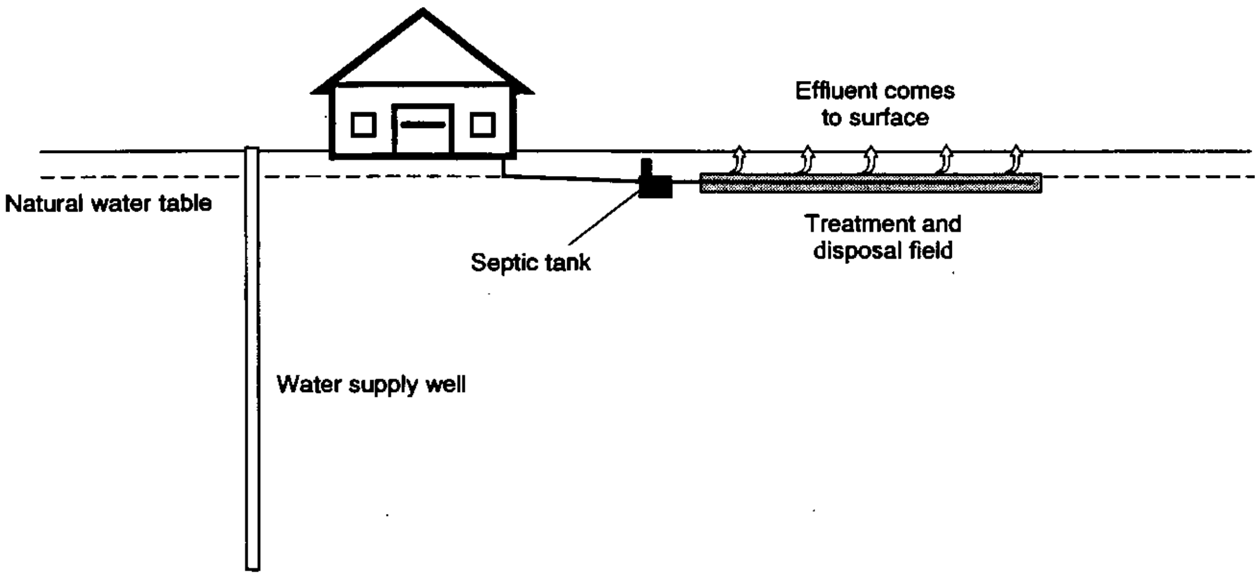
"a saturated zone, generally above the natural water table, as identified by drainage mottles caused by a restrictive horizon."

In perched water tables, the ground water is held above the normal water table by the restrictive horizon. In some areas, perched water tables cause problems for on-site systems.

- If the water table is near the surface, it is said that the area has a *high water table*. High water tables cause areas to become wetlands or can fill depressions with ground water, making a pool or swamp. It is important to note these areas when evaluating a site for an on-site system, because the high water table can reduce the soil's ability to absorb wastewater and can make aerobic conditions impossible. See Figure 4.2.3 for an illustration of how high water tables can form wet areas or pools.

- In deeper zones, a restrictive layer or confining layer above an aquifer keeps the water level from rising freely. This condition is called a *confined aquifer*. If the water in a confined aquifer builds up pressure, it can cause the water in a well to rise above the top of the aquifer, which is known as an *artesian aquifer*. With enough pressure, the water may even flow out of the well by itself, with no pumping.

Figure 4.2.3 Effluent surfacing.



Ground Water Levels in North Carolina

The ground water of most importance to on-site systems is usually shallow ground water in unconfined aquifers. The depth to the water table in an area varies according to a number of factors including annual rainfall, geologic and soil conditions, and the season of the year.

Ground Water Levels by Region in North Carolina

Ground water depths in North Carolina vary between regions and within regions because of differences in geology and soils. Seasonal variations in rainfall, temperature, and plant activity also affect ground water tables.

- In the **Piedmont**, the ground water table is typically deep. High water tables don't usually limit on-site systems. However, perched water tables are frequently found in the Triassic Basin and Slate Belt soil systems.

- The ground water table in the **Mountain** region of North Carolina will vary depending on the landscape position of the site. Sites that are located on colluvium near the bottom of the slope may be affected by high ground water levels.

❑ In the **Coastal Plain, there** are many areas with high water tables. Flat landscapes and the confining layers close to the soil surface keep the water from moving to deeper zones. The shallow ground water moves horizontally and flows into streams, lakes, sounds, and specially constructed drainage ditches.

- In many areas of the Coastal Plain, the surfaces of the streams, lakes, and sounds are at the same level as the water table. Since the ground water and surface water are so closely tied together, it is difficult to tell them apart.

Ground Water Contamination from On-Site Systems

On-site systems are often located close to water supply wells or in areas where the wastewater effluent may affect the ground water. Properly located, constructed, and maintained on-site systems protect water supply wells and the ground water. However, ground water can be polluted by on-site systems, especially incorrectly located or failing on-site systems.

To protect ground water and human safety, it is essential that a site evaluation and soil suitability analysis be performed before the installation of any on-site system and that these systems be properly maintained.

The following figures show how ground water or surface water can be contaminated by septic systems.

❑ Figure 4.2.4 demonstrates the problem of seasonally varying water tables. In the summer the depth from the bottom of the trench is sufficiently deep for wastewater effluent treatment. However, during the winter, the rising water table reduces the depth between the trench and the ground water table and eliminates the aerobic soil treatment zone, resulting in ground water contamination.

❑ In Figure 4.2.5, ground water mounding, a rise in the ground water caused by too much effluent being discharged in one area, has occurred under this community septic system. The ground water depth and direction of flow have been changed by this mounding. As a result, the drinking water supply has become contaminated.

❑ Ground water can also be contaminated from on-site systems by wastewater effluent moving to the surface, running along the surface, and then moving down the well casing and into the ground water (Figure 4.2.6).

Potential Contaminants from On-Site Systems

Ground water often contributes to surface water, especially in the Coastal Plain. If wastewater effluent contaminates ground water, and the ground water intermingles with the surface water, the surface water will also become contaminated (Figure 4.2.7).

❑ The most common contaminants of ground water that may come from on-site systems are nitrate, bacteria, and viruses; however, other contamination can occur from on-site systems. For the purpose of this manual, this discussion will focus on preventing contamination of ground water with nitrate, bacteria, and viruses.

- At levels greater than 10 milligrams per liter of nitrogen, nitrate can cause illness or death in young infants.

❑ Waterborne diseases, such as diarrhea, typhoid, and cholera are spread by various species of bacteria and viruses that come from wastewater. If there is no aerobic soil treatment zone under the drainfield, then these diseases can be transmitted to people who use ground water for their drinking water source.

Figure 4.2.4 Seasonal varying water tables.

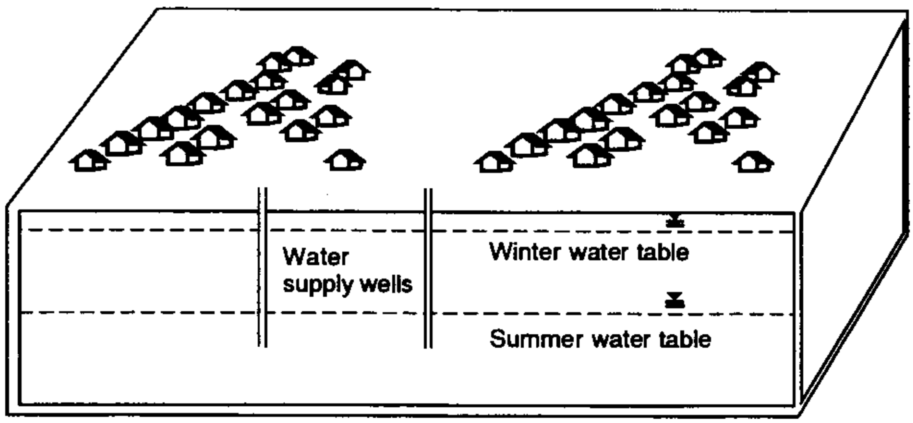


Figure 4.2.5 Ground water mounding caused by large community.

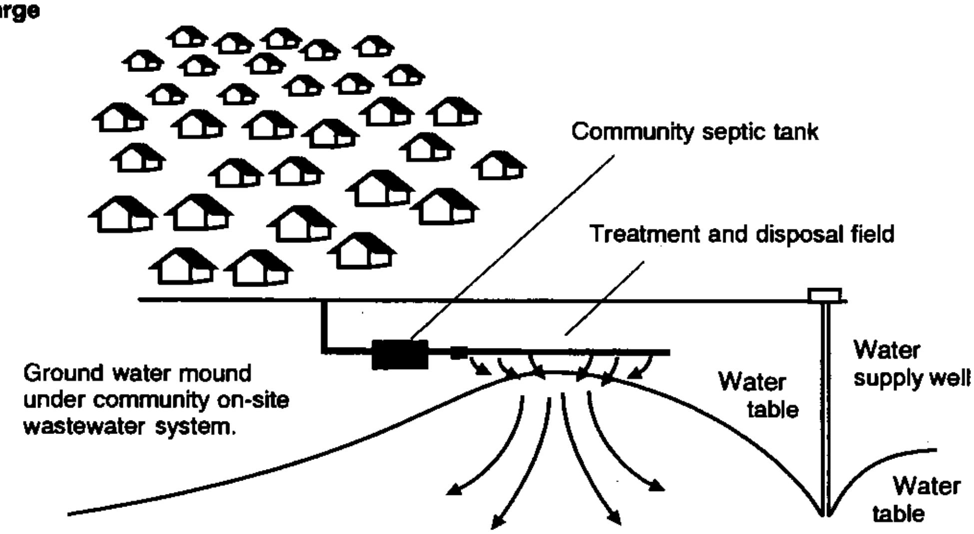


Figure 4.2.6 Surface wastewater movement and ground water contamination.

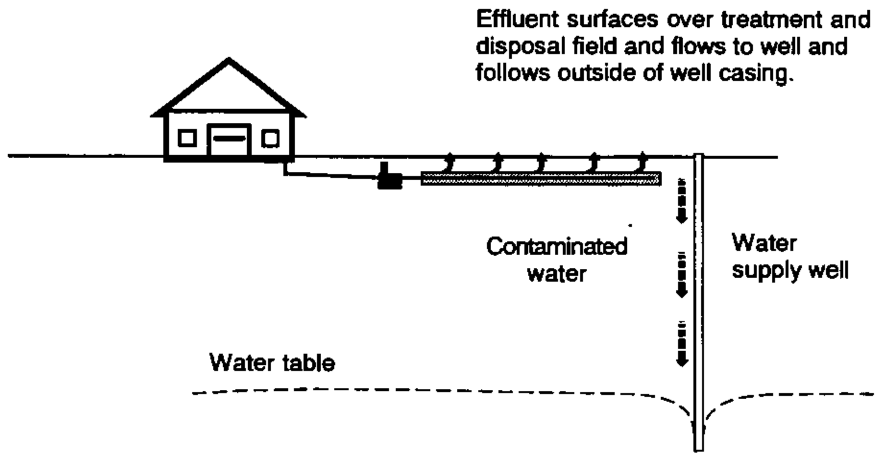
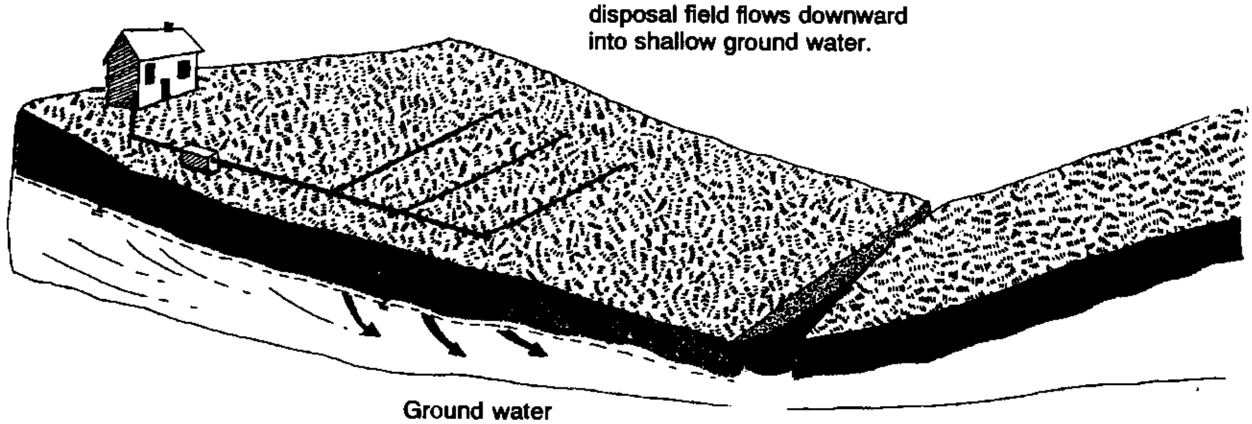


Figure 4.2.7 Intermingling between ground and surface water.



Other Sources of Ground Water Contaminants

On-site systems may contribute to ground water pollution in some cases; however, contaminants enter ground water from many other sources.

- Surface water can carry pollutants into the ground water directly through sink holes, shallow wells, or large soil pores that extend through the soil profile.
- Some contaminants, such as dissolved chemicals or chemicals from spills, flow through the soil into the ground water.
- Landfills, buried wastes, and underground storage tanks can release pollutants into the ground water.

4.3 SOILS AND GEOLOGY OF NORTH CAROLINA

North Carolina is divided into three physiographic regions: the Coastal Plain, the Piedmont, and the Mountains (Figure 4.3.1). Each region has different land forms, geology, soils, and vegetation. Large differences in soil depth, drainage, and soil mineralogy exist in soils between the different physiographic regions and within the regions. These differences in soils must be considered when locating on-site systems and in choosing what type of system to use.

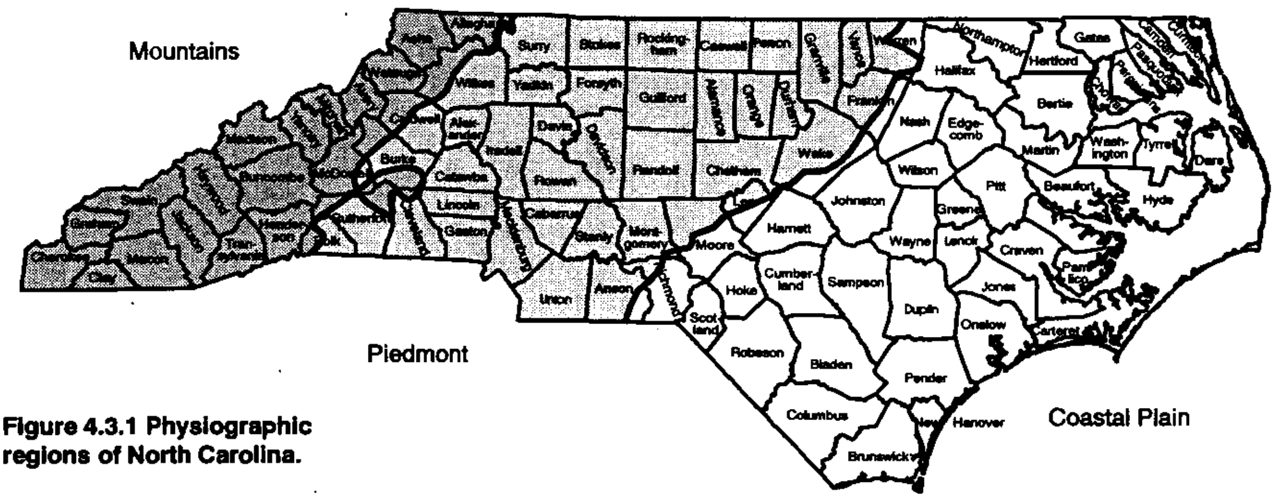


Figure 4.3.1 Physiographic regions of North Carolina.

This section discusses the geology, the types of soil, and soil locations in the different regions of the state. Additionally, information is given on the differences in soil type, depth, and drainage in the various regions that affect on-site systems.

The majority of the soils information for this section has been taken from *Soil Systems in North Carolina* (R.B. Daniels et.al, 1984). This bulletin focuses more heavily on the soil systems of the Coastal Plain because more soil survey work has been completed in this region. Currently, soil surveys are taking place in the Piedmont and Mountains, but the new soils information is not yet available.

Coastal Plain

The land area of Coastal Plain comprises 45% of the state of North Carolina. This region is rather flat in most areas, but the *topography*, or land surface, has more rolling hills as one moves westward from the ocean. Elevations in the Coastal Plain range from sea level to 660 feet or 200 meters. The soils in the Coastal Plain are relatively uniform compared to soils found in the Piedmont.

Geology of the Coastal Plain

The Coastal Plain geology is mostly marine sedimentary rocks. This rock is overlain by *fluvial* (water-borne) deposits. Sand and clay are the primary sediment types, although some limestone occurs in the southern portion of the Coastal Plain. Coastal Plain soils developed from sandy to clayey *unconsolidated marine and fluvial deposits*. These deposits are primarily sand and clay from the ocean and rivers that have been laid down over many thousands of years. They are called unconsolidated because they have not hardened into large beds of rock.

The Coastal Plain can be divided into distinct regions: the Lower Coastal Plain; the Tidewater and Barrier Island Region, which are subdivisions of the Lower Coastal Plain; the Middle Coastal Plain; and the Upper Coastal Plain. See Figure 4.3.2. The Upper Coastal Plain grades into the Piedmont just east of Raleigh.

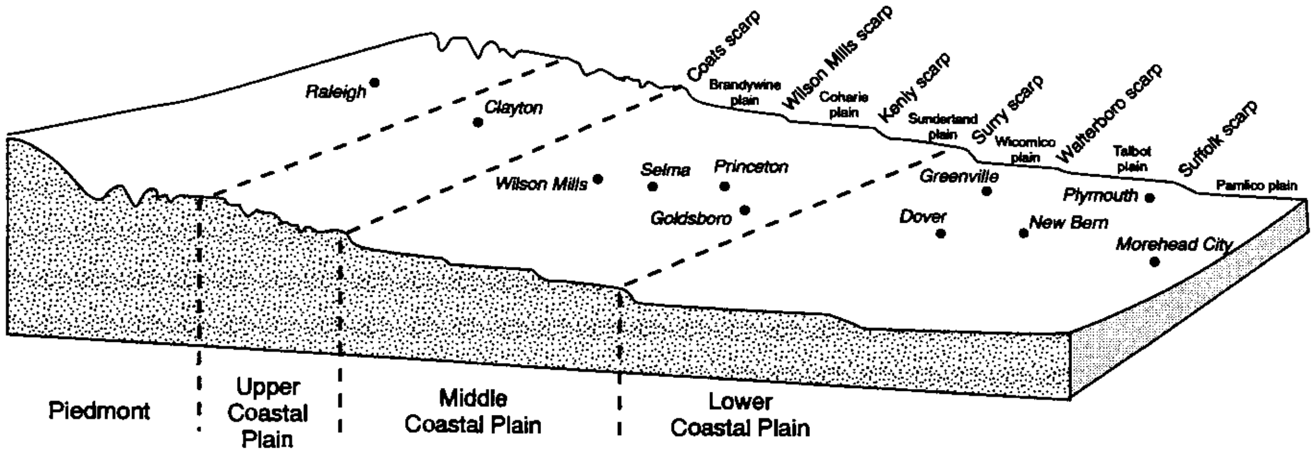


Figure 4.3.2 Coastal Plain landscape (from Daniels et al., 1984).

Lower Coastal Plain

The Lower Coastal Plain (Figure 4.3.3) is a wide, flat plain that extends from the Atlantic Ocean west to the Goldsboro area. The following characteristics of the soils of the Lower Coastal Plain are important considerations for siting on-site systems.

❑ Large areas of poorly to very poorly drained soils exist in this region. These poorly drained soils are on flood plains directly adjacent to streams and also occur far away from the stream in the middle of the interfluve areas. See Figure 4.3.4 for the relationship between landscape position and water table depth. In general, conventional on-site systems should not be located in these areas because of soil wetness.

❑ The many slow-moving streams in this area indicate that the water table is high and the soil is poorly drained. The high water table and poorly drained soil can mean that soil wetness conditions are such that many sites are UNSUITABLE for on-site systems.

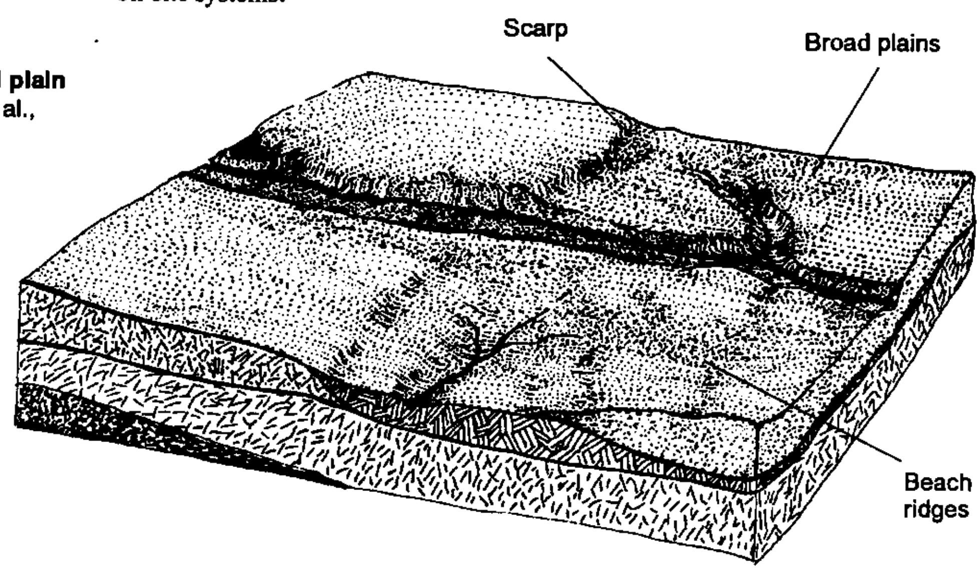
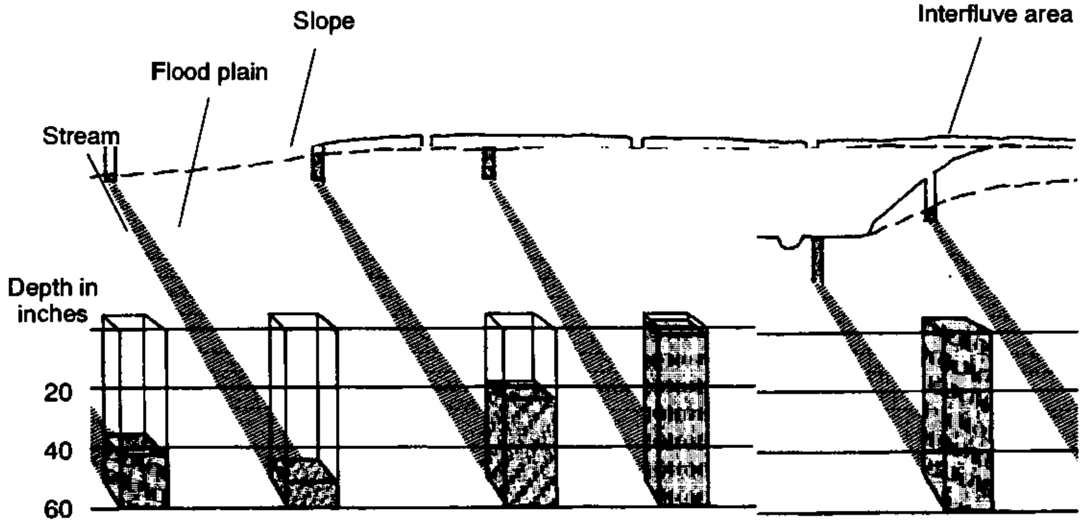


Figure 4.3.3 Lower coastal plain landscape (from Daniels et al., 1984).

Figure 4.3.4 Water table depth in relationship to stream location.



❑ Soils are often more than 5 feet thick, but many have poorly defined loamy and clayey B horizons. Soils that are thinner frequently have sandy C horizons. Many can be reclassified as PROVISIONALLY SUITABLE if drainage is successful and a modified system design is used.

Tidewater and Barrier Island Region.

The Tidewater Region lies in the northeast portion of North Carolina and is a part of the Lower Coastal Plain. The Barrier Island Region occurs along the entire coast of North Carolina. The Tidewater Region has distinctively broad, rolling plains separated by widely spaced streams and estuaries. The following characteristics of the soils of the Tidewater and Barrier Island Region are important considerations for citing on-site systems.

❑ The soils in both regions are thinner than the rest of the Lower Coastal Plain and are usually about 3 to 4 feet in depth.

❑ Tidewater Region soils tend to be poorly to very poorly drained, although well and moderately well-drained soils can be found along the dissected edges of the flats and slopes leading down to the estuaries and streams. These areas may be PROVISIONALLY SUITABLE for on-site systems. The poorly drained areas may be UNSUITABLE for on-site systems.

❑ Large wet areas are found inland between estuaries and streams in both regions. In general, the farther from the stream, the wetter the soil and the thicker the organic matter in the surface soil. Again, soil wetness in these areas may make them UNSUITABLE.

❑ Many soils in these regions are considered organic soils. Because on-site systems cannot be located in organic soils, many sites in this region are UNSUITABLE for on-site systems.

Middle Coastal Plain

The Middle Coastal Plain has smooth, gently rolling, plateau-like uplands that slope toward the ocean, and gentle-to-steep valley slopes. Figure 4.3.5 shows a typical landscape for the Middle Coastal Plain. The following characteristics of the soils of the Middle Coastal Plain are important considerations for siting on-site systems.

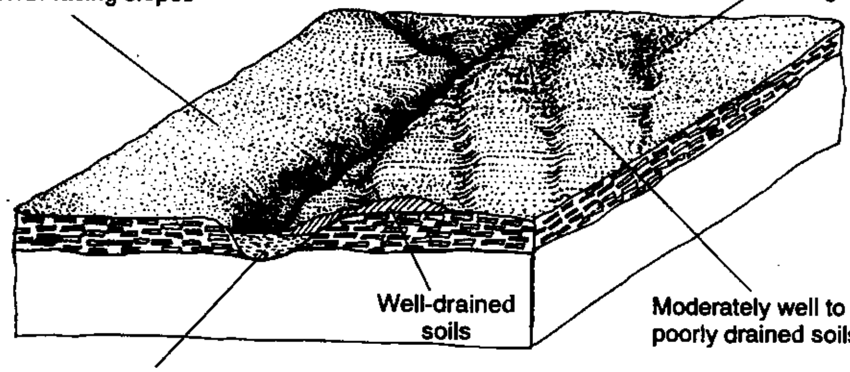
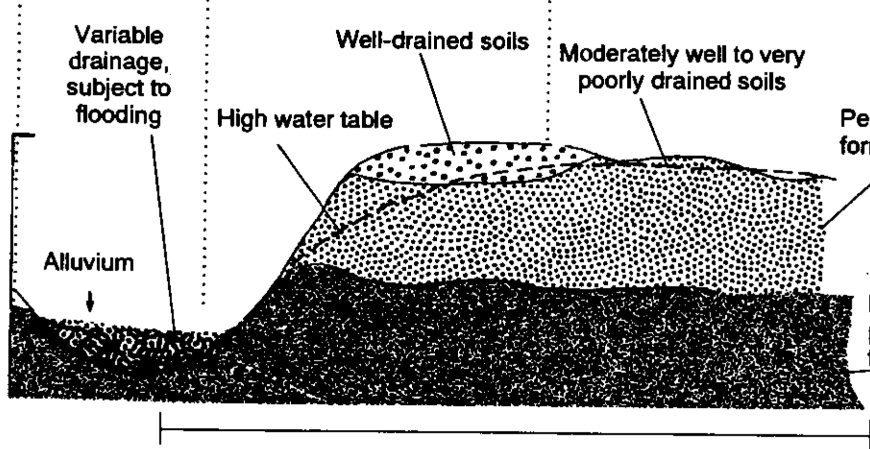


Figure 4.3.5 Landscape middle coastal plain (from Daniels et al., 1984).

- ❑ Many of the soils in this region have fine-loamy subsoils.
- ❑ Clayey soils are poorly-drained over the entire region. These soils may be UNSUITABLE due to soil wetness.
- ❑ For other soils, drainage is determined mainly by where the soil is located relative to streams and upland areas. For example, the high water tables in the middle of wide *interfluves* between streams make soils located there poorly drained, but soils located at the edge of the uplands closer to the streams are well-drained. Thus, between-stream sites may be UNSUITABLE because of soil wetness. Some of these sites can be improved by drainage and reclassified as PROVISIONALLY SUITABLE. Sites nearer to streams are usually better drained and are PROVISIONALLY SUITABLE.
- ❑ Soils in the flood plains directly adjacent to the streams have variable water tables and are prone to flooding.

Figure 4.3.6 shows the relationship between landscape position, water table depth, and soil series in the Middle Coastal Plain.

Figure 4.3.6 Relationship between landscape position, water table depth, and soil series in the middle coastal plain (from Daniels et al., 1984).



Upper Coastal Plain

The Upper Coastal Plain is a transitional zone between the Coastal Plain and the Piedmont regions. The topography varies from flat areas to small hills. The following characteristics of the soils of the Upper Coastal Plain are important considerations for citing on-site systems.

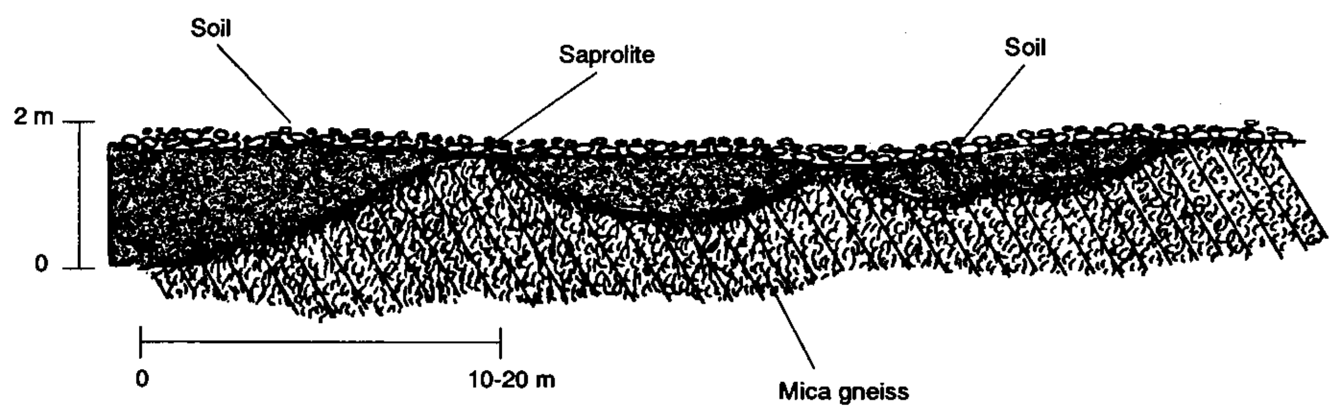
- In this region, Coastal Plain sediments lie on top of Piedmont *saprolite*. These sediments are called Coastal Plain cappings. Saprolite is decomposed rock formed in place. Saprolite is further discussed under the Piedmont Soils in the next section.

Reference
15A NCAC 18A.1935(36)

- The majority of the soils in the Upper Coastal Plain are well drained with B horizons formed in Coastal Plain cappings, merging into a 13- to 20-foot layer of saprolite.

- In places where the saprolite is exposed on the sideslopes, the soil patterns are very complicated, as shown in Figure 4.3.7. Many sites where saprolite is exposed or close to the surface may be UNSUITABLE for on-site systems. Typically the thickest Coastal Plain cappings in the Upper Coastal Plain occur on the tops of hills and in the areas with the broadest interfluves. Many of these areas are SUITABLE or PROVISIONALLY SUITABLE for on-site systems.

Figure 4.3.7 Relationship between soil and saprolite (from Daniels et al., 1984).



Piedmont

The word Piedmont means "foot of the mountain." Thus, the Piedmont region is at the foot of the mountains, between the Mountain and Coastal Plain regions. The Piedmont covers 39% of state's area and has a rolling to hilly topography. Elevations in the Piedmont range from 295 feet to 1509 feet.

Geology of the Piedmont

The geology of the Piedmont is very complex. Eight *geologic belts* (areas with similar rock types and geologic histories) exist in the Piedmont. These belts are the Inner Piedmont Belt, Kings Mountain Belt, Milton Belt, Charlotte Belt, Carolina Slate Belt, Triassic Basins, Raleigh Belt, and Eastern Slate Belt.

1. The Inner Piedmont Belt consists of intensely deformed metamorphic rocks. Gneiss and schist are intruded by granitic rocks. The age of these rocks is from 500 to 750 million years.

2. The Kings Mountain Belt consists of metamorphosed volcanic and sedimentary rocks that have been moderately deformed. These rocks are 400-500 million years old.

3. The Milton Belt contains gneiss, schist, and instrusive rocks.

4. The Charlotte Belt, which is 300-500 million years old, consists of igneous rocks such as granite, diorite, and gabbro.

5. The Carolina Slate Belt consists of volcanic and sediment rocks that have been heated and deformed.

6. The Triassic Basins are comprised of sedimentary rocks that formed approximately 200 million years ago from streams that carried mud, silt, and gravel.

7. The Raleigh Belt is composed of gneiss, schist, and granite.

8. The Eastern Slate Belt consists of slightly metamorphosed volcanic and sedimentary rocks that are partially covered with Coastal Plain sediments.

Soil Systems of the Piedmont

Soils in the region have developed from a number of different types of rock or *parent material*.

Reference
15A NCAC 18A.1935(22)

In the rules, parent material is defined as

> **"the mineral matter that is in its present position through deposition by water, wind, gravity, or by decomposition of rock and exposed at the land surface or overlain by soil or saprolite."**

Parent material is one of the *five factors of soil formation*; the other factors are time, climate, organisms, and topography. Many soil characteristics, such as texture, structure, and mineralogy, are predetermined by the parent material.

Derivation of major soil systems in the Piedmont.

There are four major soil systems in the Piedmont. Each soil system is determined by the bedrock from which the soil was formed (Table 4.3.1).

Table 4.3.1 Major Soil Systems in the Piedmont

Soil System	Bedrock
Felsic crystalline	granite, gneiss, mica gneiss, and schist.
Carolina slate belt	argillites, felsic volcanics, and mafic volcanics.
Triassic basin	Triassic mudstones, sandstones, shales, and conglomerates.
Mixed mafic and felsic	granites, diorite, gabbros.

Suitability of Piedmont soils for on-site systems.

Knowing the soil system of the site tells a great deal about its appropriateness for an on-site system.

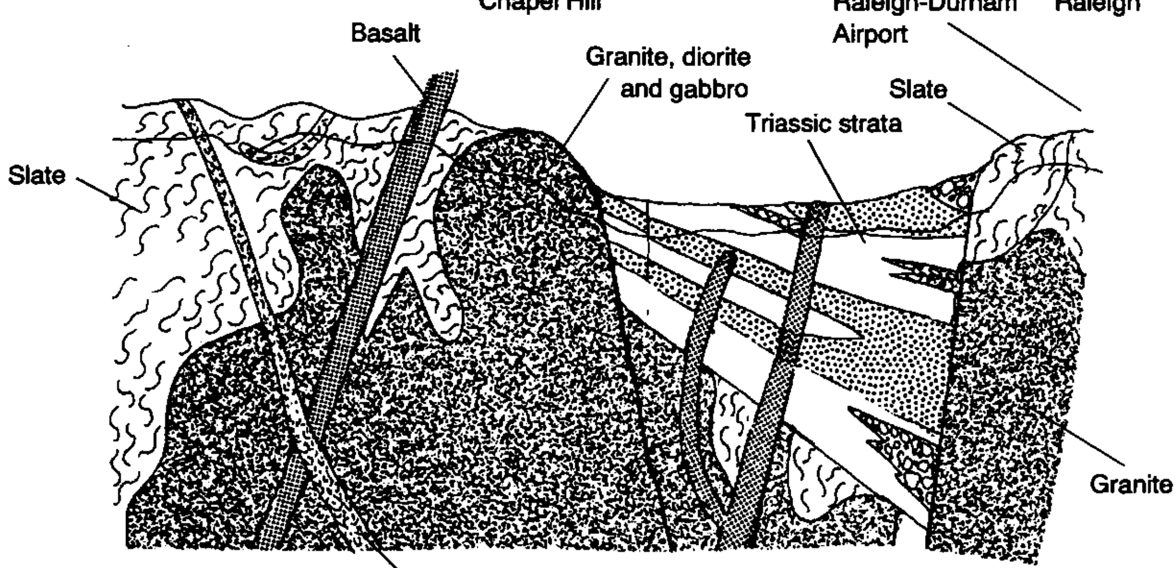
❑ Soils from the felsic crystalline soil system are generally deep and well drained and PROVISIONALLY SUITABLE for on-site systems.

❑ On-site systems usually cannot be installed easily on soils from the Carolina Slate Belt or Triassic Basin soil systems because of shallow soil depth and the occurrence of mixed mineralogy clays.

❑ Some soils from the mixed mafic and felsic soil system are appropriate for on-site systems and others are not; it depends entirely on the parent material bedrock. Soils formed from diorite and gabbros are usually UNSUITABLE because they contain mixed mineralogy clay horizons that impede wastewater flow, whereas soils formed from granites generally are PROVISIONALLY SUITABLE.

Unfortunately, the four soil systems are frequently mixed. Figure 4.3.8 shows an example of this for the very mixed bedrock zones between Chapel Hill and Raleigh. The soils formed in these zones have extremely varied properties as a result of the bedrock from which each soil was formed. Much of the soil variability is due to the type of mineralogy. Because soil can vary greatly on a single lot, each site must be carefully evaluated for its suitability for on-site systems.

Figure 4.3.8 Mineralogy from Chapel Hill to Raleigh (from Daniels et al., 1984).



Saprolite

Saprolite is frequently found in the Piedmont and Mountains and is considered by North Carolina state rules to be neither soil nor rock. Saprolite is decomposed rock that has formed in place.

Reference
15A NCAC 18A.1935(36)

Saprolite, as defined by the rules, is

> **"the body of porous material formed in place by weathering of igneous or metamorphic rocks."**

The boundaries between soil and saprolite and saprolite and rock are not clear-cut and may have gradations from one to the other.

Suitability of saprolite for on-site systems.

In some cases, soil layers are so thin that the underlying saprolite must be considered as part of the on-site treatment and disposal field. The following considerations may help when saprolite is present under thin soil.

- ❑ By its definition, saprolite does not form in sedimentary materials. The following parent materials are sedimentary: limestones, dolomites, shales, siltstone, mudstone, and claystone. Saprolites formed from mafic geologic materials often cannot be used to treat wastewater. The expansive clay minerals in saprolite formed from mafic rock cause reduced water flow.

Reference
15A NCAC 18A.1956(6)

- ❑ Most Piedmont soils over-lie saprolite. If the depth of soil above the saprolite does not meet the requirement for on-site system installation, a procedure in the rules will help to determine if the saprolite is usable for on-site wastewater disposal. See 15A NCAC 18A.1956 (6) for the procedure.

- ❑ The saprolite, as well as the soil-saprolite combination at the site, must be inspected by the use of at least one soil pit examination. Because saprolite is highly variable, more than one pit may be needed to determine site suitability.

Mountains

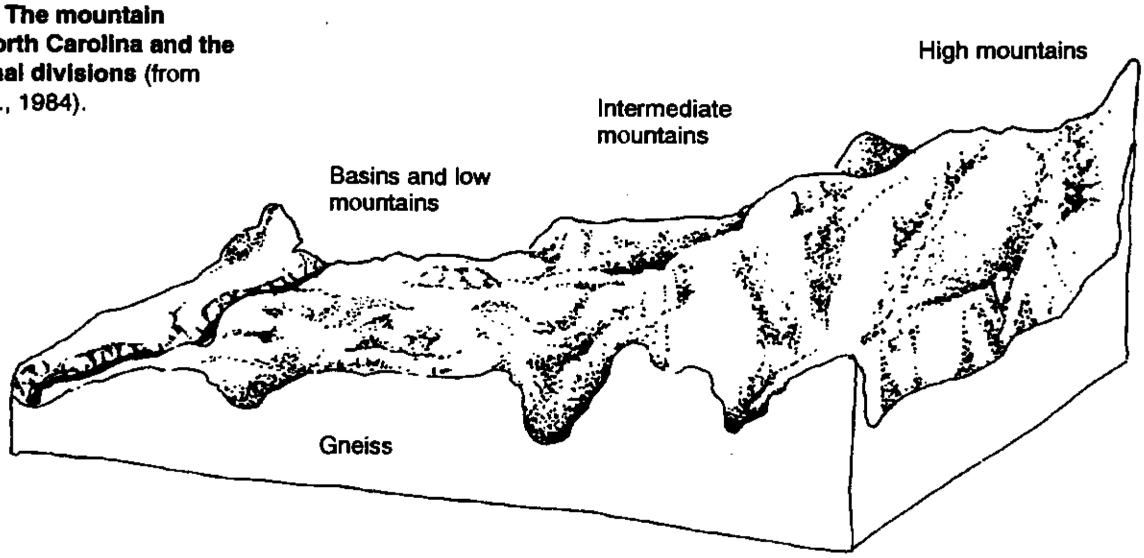
The Mountain region covers 16% of the area of North Carolina. Elevations range from 1509 feet to the tallest peak, Mt. Mitchell, at 6683 feet.

This region is part of the Blue Ridge Belt, and the geology is comprised of rocks that were formed over one to one-half billion years ago. This belt is composed of igneous, sedimentary, and metamorphic rock that have been mixed together and repeatedly squeezed, fractured, faulted, and twisted into folds. The major minerals in these rocks are feldspar, mica, quartz, and olivine.

Soil Types in the Mountains

The soils in the Mountain region can be divided into three broad classes: soils found on sharp mountain ridges and steep valley slopes; soils in broad basins with low rounded ridges, river terraces, and flood plains; and soils on high mountain peaks and ridges (Figure 4.3.9). Distinct groups of soil occupy specific landscape positions based on topography, temperature, and parent material.

Figure 4.3.9 The mountain region of North Carolina and the three regional divisions (from Daniels et.al., 1984).



Soil properties, landscape position, and parent material.

Soil properties in the mountains depend mostly on the parent material and landscape position. Thus, the type of rock the soil came from and whether the soil is on top of a hill, on the hillside, or in a bottom area will be very important in determining the suitability of the site for an on-site system.

❑ Rock and soil eroding or moving as a large mass from the upslope portions of the mountains are transported down-slope to form *colluvium,* which is erosionally-deposited material (Figure 4.3.10). Deposited colluvium changes soil depth and water flow. Particular attention must be given to these colluvial deposits: In some instances these soils make excellent locations for on-site systems, whereas in other cases, the soils are too wet.

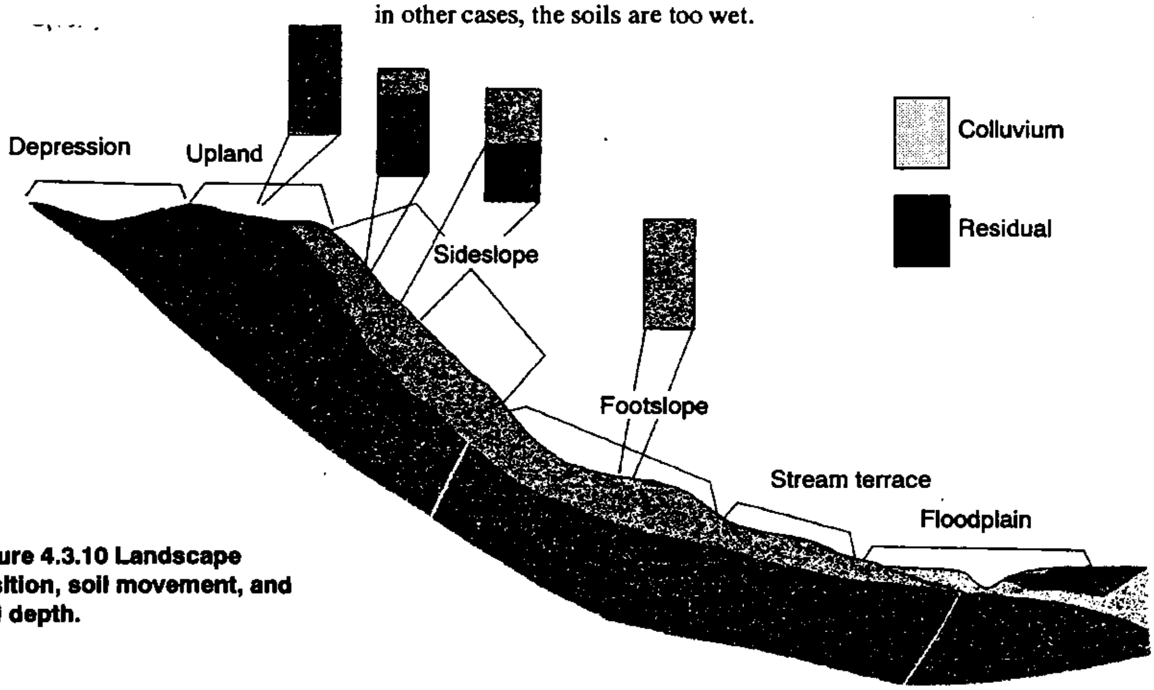


Figure 4.3.10 Landscape position, soil movement, and soil depth.

❑ Many Mountain soils have extremely thin soil layers. Because the soil layers can be very thin, saprolite may need to be included as part of the site and soil properties evaluation when installing an on-site system. If saprolite is to be included as part of the depth requirement, the saprolite must be properly evaluated. See rule 15A NCAC 18A.1956 (6) for the evaluation procedure.

Soils on Sharp Mountain Ridges and Steep Valley Slopes

The largest area of the Mountain region is occupied by the sharp ridges; steep slopes; and narrow, steep, wet valley floors. The topography is continually undulating, with elevations ranging from 1400 to 4600 feet. Representative topography consists of narrow convex ridges or interfluves and moderately to steeply sloping valley walls. Within this topography two generalized systems of soils are recognized, Intermediate Mountain soils and Low Mountain soils.

Soils formed in both the Low and Intermediate Mountain region can be composed of colluvium or *alluvium,* which is water-deposited material.

Reference
15A NCAC 18A.1935(1)

As defined in the rules, alluvial soils are

> **"stratified soils without distinct horizons, deposited by floodwaters."**

In the Low and Intermediate Mountain areas the landscape position of soils determine their depth or drainage status and thus their suitability for on-site system installation. See Table 4.3.2 for more information on Low and Intermediate Mountain soils.

Table 4.3.2 Major Soil Series in Low and Intermediate Mountains

Series	Major Slope Range %	B Horizon Texture	Comments
COLLUVIUM—depth to rock >1.5 m for all these soils			
Spivey	0	Loamy skeletal	cobbly, in coves & hollows; dark surfaces >25cm thick
Tate	5-15	Fine loamy	fans, footslopes, benches
Tusquitee	6-60	Fine loamy	coves, footslopes, benches, dark surface > 15cm thick
Haywood	2-45	Coarse loamy	coves & toe slopes above 1120m (4000 feet) dark surface >50cm thick
ALLUVIUM—in narrow steep mountain valleys			
Craigsville	0-5	Loamy skeletal	well-drained, cobbly to gravelly
French	0-2	Fine loamy	moderately well to somewhat poorly drained
Hatboro	0-2	Fine loamy	poorly drained
Iotla	0-4	Coarse loamy	somewhat poorly drained

Low Mountain soils.

Low Mountain soils are found below 3,500 feet. These soils are thicker, the B horizons are redder and contain more clay, and the A horizons are thinner than the intermediate mountain soils. Typically, most soils formed from micaceous parent materials are found in the Lower Mountain area.

Intermediate Mountain soils.

Intermediate Mountain soils are found above 3,000 feet. These soils generally have light-colored A horizons and brown to yellowish-brown B horizons that are similar to the underlying colluvium or saprolite. The texture of the A and B horizons is coarse-loamy. Soil depth is usually shallow with varying amounts of coarse fragments.

Broad Basins, River Terraces, and Flood Plain Systems

The intermountain basin soils form in broad basins, river terraces, and flood plains between large mountain chains. These broad, relatively flat basins are the location of the major industrial and agricultural regions of the Mountains. Local relief in this area of the Mountains is much less than in the other regions.

Table 4.3.3 lists the soil series and the slope position of the major soils found in the broad basins, river terraces, and flood plain system.

Table 4.3.3 Major Soils of the Broad Basins, River Terraces and Flood Plains (from Daniels et al., 1984).

Series	Major Slope Range %	Comments
UPLANDS		
Evard	15-60	Narrow ridges, steep side slopes
Fannin	10-30	Narrow ridges, steep side slopes; high mica content
Hayesville	2-5	Intermountain plateaus, low ridges, valleys, major agricultural soil
Oteen	10-45	Narrow ridges, steep side slopes, base saturation >35%, largely found in Asheville basin
Saluda	15-60	Narrow ridges, steep side slopes
TERRACES AND COLLUVIUM		
Braddock	0-35	High terraces, fans and footslopes
Bradson	2-10	High terraces, fans and footslopes
Brevard	5-35	High terraces, fans and footslopes
Dillard	2-6	Moderately well drained toe slopes and low terraces
Elsinboro	0-10	Well drained low terraces
FLOOD PLAIN		
French	0-5	Moderately well drained
Hatboro	0-2	Poorly drained
Toxaway	0-2	Very poorly drained
Colvard	0-2	Well drained
Rosman	0-3	Well-moderately-well drained
Iotla	0-3	Somewhat poorly drained
Biltmore	0-3	Well drained

Broad basin soils.

The soils in the broad basins are a mixture of those common to areas of sharp ridges and steep slopes at the lower elevations, and river terraces and flood plains. Many of these soils are used for row crop production and are morphologically, chemically, and physically similar to a common Piedmont soil, Cecil.

Terrace soils.

These soils are distinguished by landscape position as well as morphological characteristics. The soils on the high terraces resemble uplands soils, with thick, red B horizons, and those on the low terraces correspond to flood plain soils, with strong brown or yellowish-brown and less strongly expressed B horizons. Changes in parent material, elevation, and landscape position are used to distinguish terrace soils.

Flood plain soils.

The flood plain and lower terrace soils are separated by subtle elevation changes. Soils vary depending on the alluvial deposition sequence and the size of the stream.

High Mountain Soils

Although there is a wide range of ecosystems in this region above 4600 feet, only 2 soils are currently recognized: Craggey and Burton. Both have a thick A horizon but have a shallow depth to hard rock. Because of their shallow depth, these soils are UNSUITABLE for installation of on-site systems.

References

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Daniels, R.B., H.J. Kleiss, S.W. Buol, H.J. Byrd, and J.A. Phillips. 1984. *Soils Systems in North Carolina.* North Carolina Agricultural Research Service, North Carolina State University, Raleigh, NC 27695.

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4.4 BASIC SOIL CONCEPTS

Approximately three and one-half million North Carolinians use on-site systems to treat and dispose of their household wastewater, according to the 1990 U.S. Census. These systems generally rely on a wastewater receiving tank, or septic tank, and a treatment and disposal field for proper treatment and disposal of the sewage. Most of the purification of the wastewater occurs in the soil beneath the drainfield.

Using a soil absorption system for disposal and treatment of wastewater takes advantage of the physical, chemical, and biological processes in the soil. Soil can absorb and treat the wastewater and its constituents.

Not all soils and sites will adequately treat and dispose of wastewater. Soil and site evaluations are necessary in order to locate on-site systems on appropriate sites. This section presents soil concepts that are required to conduct a soil and site evaluation.

The Use of Soil for On-Site Systems

There are many methods to treat and dispose of wastewater. On-site systems usually rely on the soil because it provides an inexpensive and reliable medium for wastewater treatment and disposal. The porous nature of soil and the biological activity in the soil are key characteristics in absorbing and treating wastewater.

Because of large variations in soil characteristics, not all soils can suitably treat and dispose of the waste. The challenge for those involved with on-site systems is to design and install wastewater systems that optimize a soil's treatment potential. The following concepts should be considered when selecting sites for on-site systems.

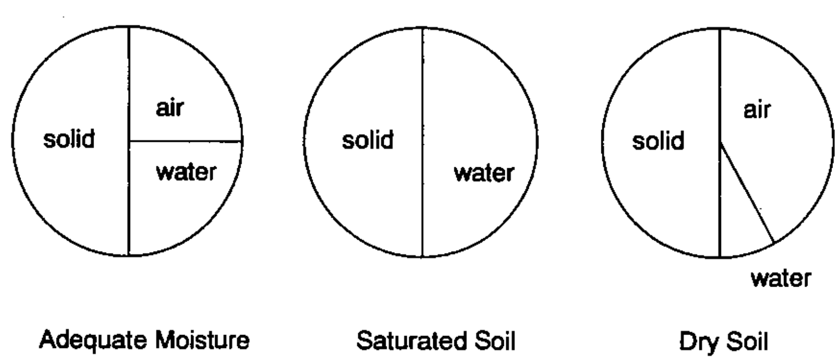
- ❑ Processes that purify wastewater include physical filtration by the soil particles, chemical treatment through ion exchange and transformation in chemical reactions, biological oxidation and decomposition by micro-organisms, and uptake of nutrients by plants.

- ❑ Soils can vary greatly over short distances, even from one side of a lot to the other. Because of their spatial variability, understanding soil becomes critical in the selection and evaluation of the sites where on-site systems will be located.

- ❑ All soils are composed of mineral matter, organic matter, and voids or spaces that can be filled with either water or air. Soil water and soil air are inversely related to each other because water and air compete for the same void space in the soils (see Figure 4.4.1).

- ❑ A winding flow path through soil voids that is neither too rapid nor too slow provides for maximum treatment of wastes by natural soil processes.

Figure 4.4.1 The relationship between soil solids, soil wetness, and void space.



Definition of Soils

Soil is defined differently by groups that use soils for varying purposes.

For the purposes of site and soil investigations for on-site systems in North Carolina, the most important definition is that contained in the *Rules for Sewage Treatment and Disposal Systems*:

Reference

15A NCAC 18A.1935(41)

> **"the naturally occurring body of porous mineral and organic materials on the land surface. Soil is composed of sand-, silt-, and clay-sized particles that are mixed with varying amounts of larger fragments and some organic material. Soil contains less than 50 percent of its volume as rock, saprolite, or coarse-earth fraction (mineral particles greater than 2.0 millimeters). The upper limit of the soil is the land surface, and its lower limit is 'rock,' 'saprolite,' or other parent materials."**

❑ Engineers define soil as "any unconsolidated material composed of discrete solid particles with gases and liquids between" (Sowers, 1979).

❑ Soil, as defined by geologists, is "that material which has been so modified and acted upon by physical, chemical, and biological agents that it will support rooted plants" (AGI, 1976).

❑ Soil, as defined by soil scientists, is a naturally occurring, three-dimensional body that has developed at the earth's surface as a result of soil-forming processes: *additions*, *losses*, *translocations*, *accumulation*, and *transformations*, as influenced by the five soil-forming factors: *parent material, relief, organisms, climate,* and *time.*

❑ Many of the criteria that are used to determine soil suitability for on-site systems come directly from soil characteristics defined by the Soil Conservation Service (SCS) in *Soil Taxonomy Handbook* (1993) and in the *Soil Survey Manual* (1994).

Soil Forming Processes and Factors

Soil forming processes include *additions* to soil bodies, such as sand blown up onto a sand dune; *losses* from soil bodies, such as soil erosion; *translocations* within a soil body, such as downward movement and *accumulation* of clay-sized particles in the subsoil; and *transformations* of material within a soil body, such as weathering of sand-sized mica particles into clay-sized kaolinite minerals.

The five soil-forming factors are *parent material, relief, organisms, climate,* and *time.*

1. *Parent material* is the rock or other matter which degrades into soil. Soils are very reflective of their parent material. For example, a soil developed from granite rock will always have a coarse texture and a relatively low pH.
2. *Relief* refers to both the slope of land and the *aspect* (the direction in relation to the sun) of the surface. The most obvious influence of relief is through slope. Slope affects losses and additions and thus causes changes in soil depth.
3. *Organisms* refer to the biological agents such as plants, fungi, and microorganisms that break down parent material into soil particles and also contribute organic matter to the soil. For example, the distribution, quantity, and type of organic matter in a soil developed under prairie vegetation is very different from a soil developed under forest vegetation.
4. *Climate* encompasses rainfall and snowfall, evaporation, and temperature. Climate controls some chemical and physical reactions and it can also affect

the type of organisms in and on a given soil. Weathering of a soil is either hastened by a hot, moist climate, or retarded by a cold, dry climate.

5. *Time* is an important soil-forming factor because it modulates the other four factors. For example, a younger soil has had less time for its parent material to be changed, and for climate, relief, and organisms to affect the soil forming processes.

Soil Horizons, Profiles, and Series

Soils are characterized by the minerals and organic matter from which they are made and by the sequence of these mineral and organic layers. The type of soil layer and the order in which the soil is layered are extremely important in on-site systems because soil layers control the movement of wastewater through the soil into the ground water.

Soil Horizons

A soil consists of a number of layers roughly parallel to the earth surface. These layers are called soil horizons.

Reference
15A NCAC 18A.1935(13)

A soil horizon, as defined by the rules,

"means a layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil forming processes."

Soil horizons are identified by different morphological characteristics: *texture, structure, color,* or *consistence*. These are discussed in greater detail on page 4.4.8.

❑ Soil scientists use a technical language in which each horizon is separated into one of *six master horizons or layers*. Master horizons are designated by the capital letters O, A, E, B, C, and R where each master horizon indicates a certain set of properties in the soil. The sequence of horizons and horizon differentiation, for any given soil, is dependent on the soil forming factors. Figure 4.4.2 describes and demonstrates the six master horizons and their properties.

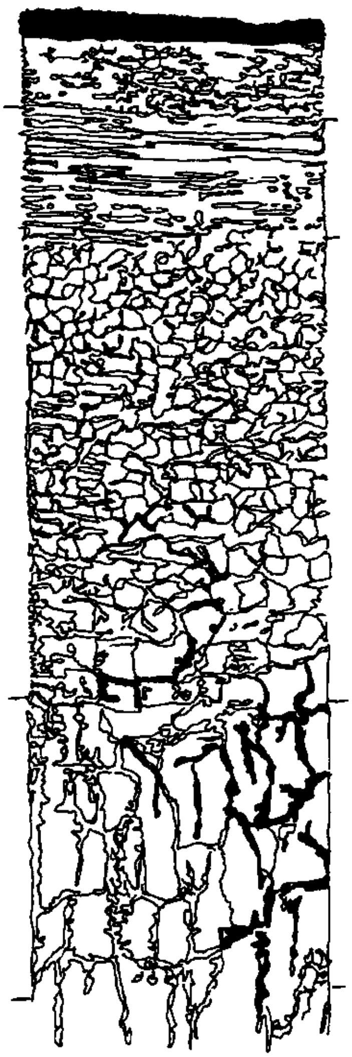
❑ Every soil contains at least one master horizon, and some soils contain all six master horizons or layers. Usually a soil contains two or three master horizons.

❑ The arrangement of horizons in the profile affects the rate of wastewater flow through the soil, the direction of flow (vertical or horizontal movement), and the amount of wastewater purification. Thus, the environmental health specialist must be able to identify the horizons present in the profile.

❑ When horizons are *transitional*, that is, they have characteristics of both the overlying and underlying horizon, two master horizon symbols are used. For example, a BC horizon would indicate a transitional horizon that grades gradually from a B into a C but is more like a B horizon than a C horizon. On the other hand, a CB horizon would be more like a C horizon than a B horizon. When the "/" symbol is used it indicates that the transitional horizon contains identifiable pieces of both types of horizons. For example, a B/C horizon is indicative of a transitional horizon where the B and C horizons are intermixed and there is more B than C material. A C/B horizon would also be an intermixed transitional horizon but with more C material than B material. **The BC or B/C horizons may be used for an on-site system if other soil factors are acceptable.**

❑ Master horizon designations can be modified by lower case letters that indicate subtle differences within a master horizon. Those symbols relevant to North Carolina soils are included in Table 4.4.1.

Figure 4.4.2 The six master horizons.



Horizons

O— Layers dominated by organic material.

A— Mineral horizons forming at the surface or below the O horizon.

E— Mineral horizon where there has been a loss of silicate clay, iron or aluminum, leaving a concentration of sand and silt particles.

B— Horizons forming below A, E, or O horizon. These horizons are changed from their original rock structure.

C— Horizons or layers that are little affected by soil weathering but are not rock.

R— Rock that takes more than hand-digging with a spade to dislodge.

❑ Some horizons allow water to flow through easily; other horizons obstruct water flow. Horizons which impede water flow are referred to as *restrictive horizons.* If a soil contains a restrictive horizon, the depth at which this horizon is located determines whether this soil is SUITABLE for an on-site system.

Reference
15A NCAC 18A.1935(33)

As defined by the rules,

> **"a restrictive horizon means a soil horizon that is capable of perching ground water or sewage effluent and that is brittle and strongly compacted or strongly cemented with iron, aluminum, silica, organic matter, or other compounds. Restrictive horizons may occur as fragipans, iron pans or organic pans, and are recognized by their resistance in excavation or in using a soil auger."**

Table 4.4.1 Subordinate Distinctions within Master Horizons (from Soil Survey Staff, 1992).

Symbol	Symbol Name	Symbol Meaning
a	Highly Decomposed Organic Matter	"a" is used with "O" to indicate the most highly decomposed organic materials in organic soils.
b	Buried Genetic Horizon	"b" designates identifiable buried genetic horizons in mineral soils. These genetic horizons had to form prior to being buried.
c	Concretions or Nodules	"c" indicates a significant accumulation of concretions and nonconcretions, if the nonconcretions are cemented with material other than silica (i.e., iron, aluminum, or manganese).
d	Physical Root Restriction	"d" is for root-restricting layers in naturally occurring or man-made unconsolidated sediments or materials.
e	Organic Material of Intermediate Decomposition	"e" is used to identify organic materials of intermediate decomposition in organic soils.
g	Strong Gleying	"g" means that the predominant color of the horizon has a chroma of 2 or less because of iron being reduced and removed due to wetness or saturation with water.
h	Illuvial Accumulation or Organic Material	"h" is used only with B master horizons. It indicates the accumulation of illuvial humus.
i	Slightly Decomposed Organic Material	"i" indicates the least decomposed of the organic materials in organic soils.
m	Cementation or Induration	"m" is used for continuous or nearly continuous cementation (>90% cemented). Root penetration is only through cracks.
p	Tillage or Other Disturbances	"p" denotes surface layer disturbances by cultivation, pasturing, or similar uses.
r	Weathered or Soft Bedrock	"r" is used with "C" to indicate layers of soft bedrock.
s	Illuvial Accumulation of Sesquioxides and Organic Matter	"s" is used in conjunction with "b" to indicate an accumulation of illuvial, amorphous, dispersible organic-matter-sesquioxide complexes if both organic matter and sesquioxide portion are significant. Also, the moist color value and chroma value must be 4 or greater. "s" is used in conjunction with "h" if the organic matter and sesquioxide components are significant. In this case, the moist color value and chroma are 3 or less.
t	Accumulation of Silicate	"t" means the accumulation of silicate clay that has either formed in the horizon or has been moved into it by illuviation.
v	Plinthite	"v" is used to indicate the presence of iron-rich, humus-poor, reddish material that is firm or very firm when moist and that hardens irreversibly when exposed to the atmosphere.
w	Development of Color or Structure	"w" denotes color or structure development in B horizons where there is not a substantial accumulation of illuvial clay.
x	Fragipan Character	"x" indicates genetically developed firmness, brittleness, or high bulk density.

Other Morphological Properties of Horizons

Soil horizons can also be described by depth, thickness, and boundary conditions, as shown in Table 4.4.2.

Table 4.4.2 Description of Horizons and Symbols

HORIZON:	Use the standard horizon nomenclature
DEPTH:	In inches from the top of A, or surface mineral horizon, except for the surface of peat or muck
THICKNESS:	Average thickness and range
BOUNDARY:	Horizon lower boundaries are described as:

1) Distinctness of boundary:

abrupt (<1" thick)	a
clear (1" - 2.5")	c
gradual (2.5" - 5")	g
diffuse (>5")	d

2) Topography of boundary:

smooth (nearly a plane)	s
wavy (pockets with width > depth)	w
irregular (pockets with depth > width)	i
broken (discontinuous)	b

Example: an abrupt, irregular boundary is noted as *ai*

Soil Profiles

Generally, a soil is composed of more than one horizon. If a hole or pit is dug in a soil, the horizons are uncovered for viewing. This vertical cross section of soil, where all horizons are revealed, is called a *soil profile.*

Soil profiles, showing typical arrangements of horizons for five representative soils in North Carolina, are presented below (Figure 4.4.3). These five soil profiles are but a few examples of the over two hundred types of soil profiles found throughout the state.

Soil Series

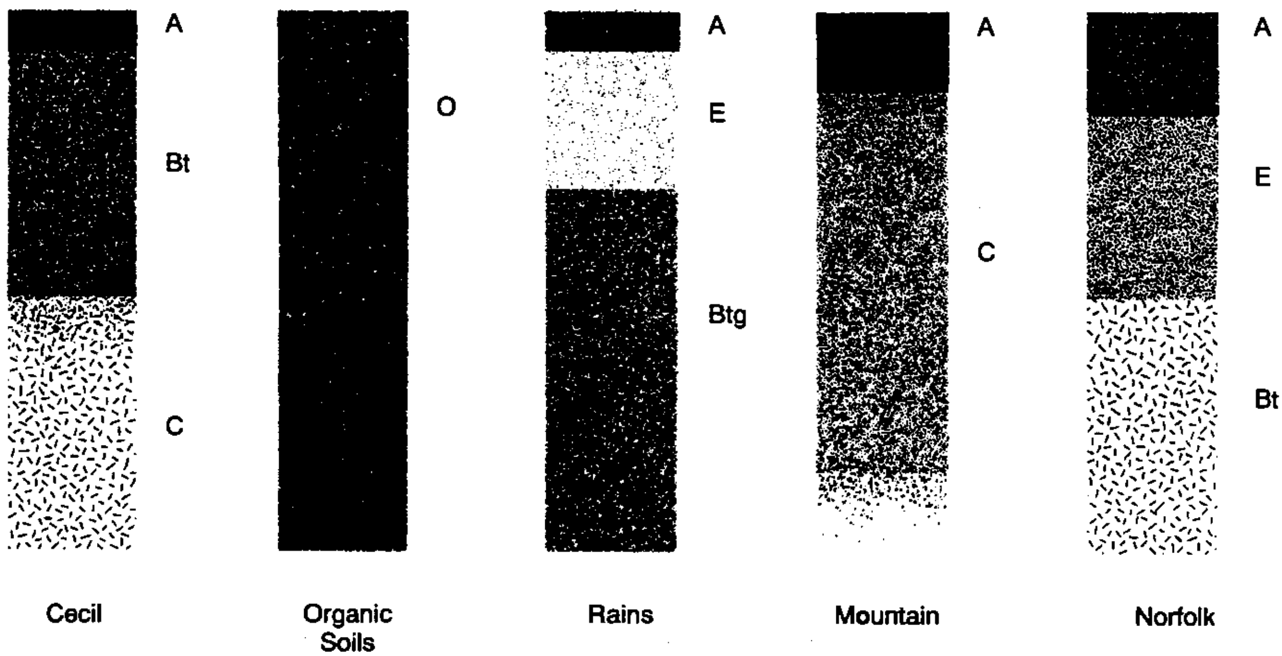
Soils can be grouped and classified based on the arrangement of soil properties within each layer in the soil profile. These properties include texture, temperature, wetness, mineralogical classes, organic matter content, and other characteristics.

Soil profiles that have a specific arrangement of horizons with specific characteristics in each horizon belong to a *soil series.* All soils in a soil series have similar profile characteristics. Each soil series will have developed from the same parent material with the same combination of weathering processes. The following concepts are helpful in understanding soil series.

- ❑ Soils within the same soil series should be more alike and behave more similarly than soils in different soil series.

- ❑ Soil series are generally named for a town or region near the location where the soil series is first described.

Figure 4.4.3 Five typical North Carolina soil profiles.



❑ Soil series are strongly associated with relief or topographic location. This is because the soil-forming processes and the other soil-forming factors (parent material, time, climate, and organisms) in a region are the same for one type of topographic location and so tend to form one or a few soil series from the same parent material. Catenas are a good example of the effects of topographic location on the landscape. A *catena* is a group of related soils in a topo-drainage sequence. A representative North Carolina Coastal Plain catena consists of five soil series: Norfolk, Goldsboro, Lynchburg, Rains, and Pantego. These soils are related by their topographic positions or relief. Relief affects drainage and thus the accumulation of organic matter. Norfolk soils are the most well drained, whereas Pantego soils are very poorly drained.

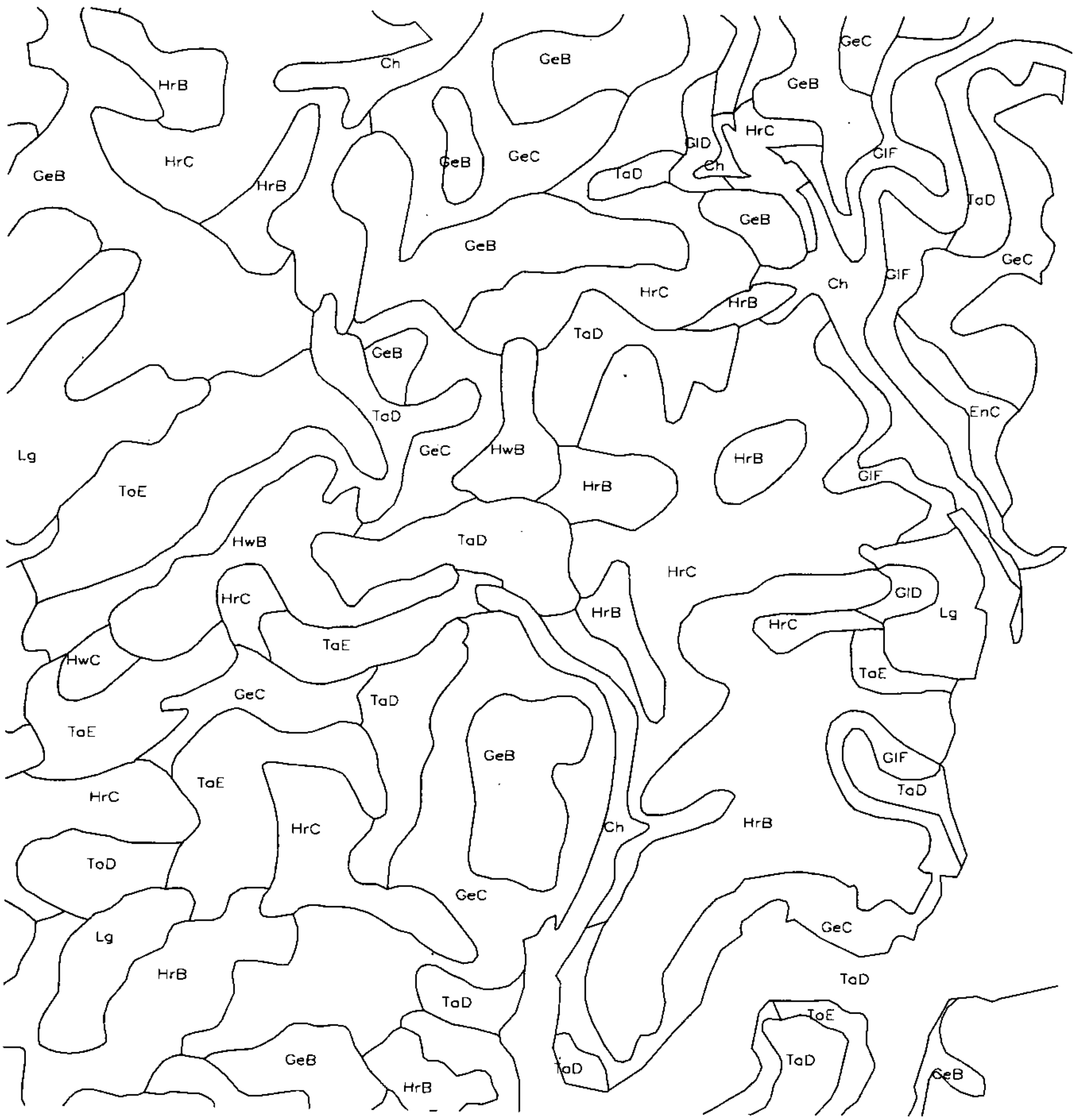
❑ Soils are mapped as soil series. Because a soil series tells us about the properties of a soil, soil maps give a great deal of information about the soil and, consequently, they give a good idea of how an on-site system will function in a location with a given soil series. In North Carolina there are over 250 mapped soil series. Figure 4.4.4 is a representative soil map from the Piedmont area of North Carolina.

❑ Because the scale of soil maps is generally greater than the area of an on-site system, soil maps should only be used in the initial survey of the area. **The only reliable method for siting an on-site system in North Carolina is a thorough site and soil evaluation done by qualified specialist at the actual site. The site and soil evaluation must include a thorough evaluation of the soil morphological properties in the soil horizons at that location.**

Reference
G.S. 130(A) - 336(b)

IN NORTH CAROLINA, EACH POTENTIAL LOCATION FOR AN ON-SITE SYSTEM IS REQUIRED, BY LAW, TO HAVE A SITE AND SOIL EVALUATION.

Figure 4.4.4 Representative soil map from the piedmont area of North Carolina.



Soil Morphological Characteristics

There are four major *morphological characteristics* that are used to differentiate soil horizons.. These characteristics are *soil texture*, *soil structure*, *color* and *consistence*. Information on the four major soil morphological characteristics is presented below.

Soil Texture

Reference

15A NCAC 18A.1935(43) (a-1)

Soil texture refers to the solid mineral part of soils. The mineral component of the soil is separated into three sizes of inorganic particles—sand, silt, and clay—which are referred to as *soil separates*.

Soil particle sizes.

Each soil separate can be categorized into a particular size class. Particle size classification is based entirely on particle size and does not consider the mineralogy. The on-site sewage disposal rules of North Carolina use the U.S. Department of Agriculture (USDA) particle-size classification system. The USDA particle size classification only considers the fine-earth fraction of the inorganic particles. The maximum particle size for the fine-earth fraction is 2 millimeters.

❑ In the USDA system, sand separates, which are the coarsest material, range in size from 2 millimeters to 0.05 millimeters diameter. Silt particles have a size range from less than 0.05 millimeters to 0.002 millimeters diameter, and is between sand and clay in size. Clay-sized particles are the smallest particles and are less than 0.002 millimeters in diameter. The relative sizes of these three particles is shown in Figure 4.4.5. See Table 4.4.3 for more details.

Figure 4.4.5 Relative particle sizes (25.4 mm = 1 inch)

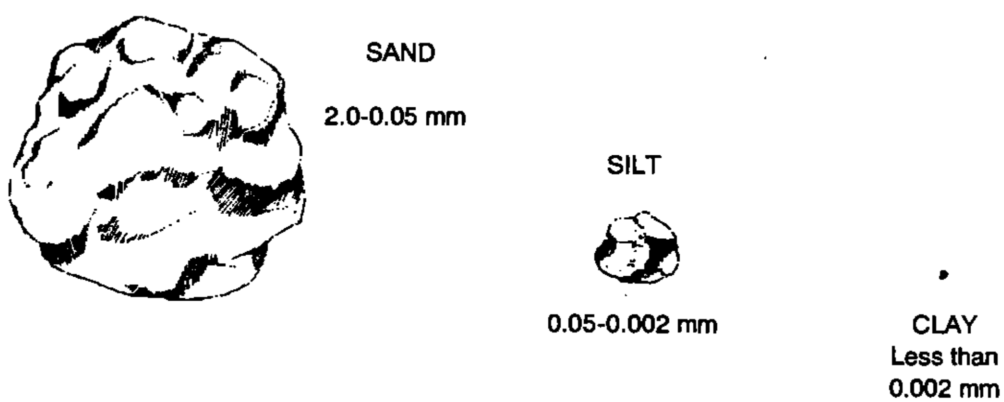


Table 4.4.3 Diameters and Characteristics of Soil Separates (from ASA, 1973).

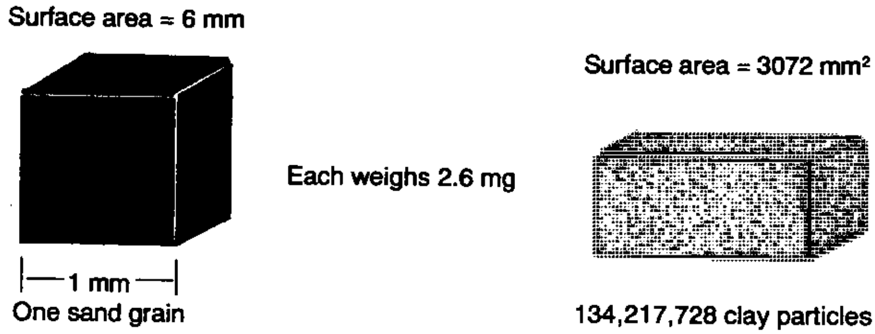
Soil Separate	Diameter of Particles	General Characteristics
Sand	2-0.05 mm	Individual particles feel gritty when the soil is rubbed between the fingers. Not plastic or sticky when moist.
Silt	.05-.002 mm	Feels smooth and powdery when rubbed between the fingers. Not plastic or sticky when moist.
Clay	less than .002 mm	Feels smooth, sticky, and plastic when moist. Forms very hard clods when dry. Particles may remain suspended in water for a very long time.

(25.4 mm = 1 inch)

❑ Because sands have a wide range of sizes, the particle-size class of sandy-textured horizons can be further subdivided into subclasses that range from very coarse sands to very fine sands. See Table 4.4.4 for more information. It is important to realize that wastewater will flow through coarse and medium sand horizons much faster than a horizon with a fine or very fine sand texture.

❑ Clay particles, because of their small size, have a much greater surface area for an equivalent weight compared to either silt or sand. The figure below shows the difference in surface area between a sand grain weighing 2.6 milligrams and a clay mass weighing the same (Figure 4.4.6). This increased surface area means that soils with clay have more potential sites for chemical and biological activity. Because of the increased surface area, soils with the right type and quantity of clay provide excellent sites for on-site systems (see sections on Soil Structure and Soil Consistence).

Figure 4.4.6 Size comparison between one grain of sand and a mass of clay.



Soil textural class.

Most soils are a mixture of the different soil separates. The texture of the soil in each soil horizon depends on the mixture of the soil separates. Every soil can be placed into one of twelve textural classes. To find the *soil textural class*, the percentages of sand, silt, and clay are plotted on a *textural triangle*. Figure 4.4.7 shows a soil textural triangle.

Figure 4.4.7 Soil textural triangle.

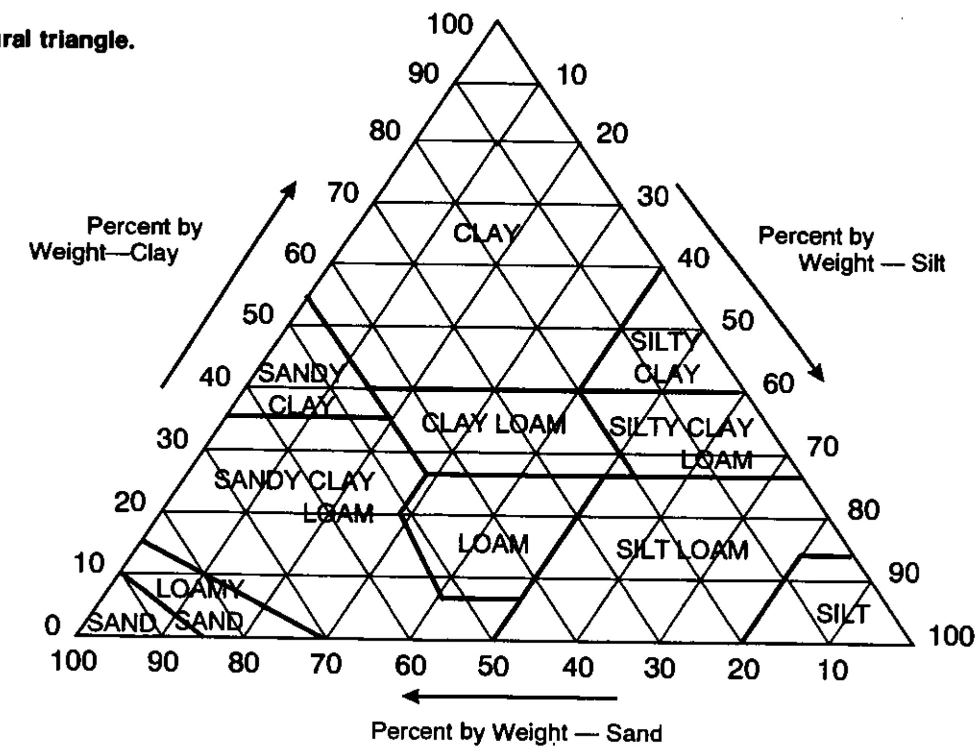


Table 4.4.4 Percentage of Sand Sizes in Subclasses of Sand, Loamy Sand, and Sandy Loam Basic Texture Classes (Source: Portland Cement Association, 1973)

		SOIL SEPARATES				
Basic soil class	Subclass	Very coarse sand, 2.0-1.0 mm	Coarse sand, 1.0-.05 mm	Medium sand, 0.5-0.25 mm	Fine sand, 0.25-0.1 mm	Very fine sand, 0.1-0.05 mm
Sands	Coarse sand	25% or more		Less than 50%	Less than 50%	Less than 50%
	Sand	25% or more			Less than 50%	Less than 50%
	Fine sand	Less than 25%		—or—	50% or more	Less than 50%
	Very fine sand					50% or more
Loamy Sands	Loamy coarse sand	25% or more		Less than 50%	Less than 50%	Less than 50%
	Loamy sand	25% or more			Less than 50%	Less than 50%
	Loamy fine sand	Less than 25%		-or-	50% or more	Less than 50%
	Loamy very fine sand					50% or more
Sandy Loams	Coarse sandy loam	25% or more		Less than 50%	Less than 50%	Less than 50%
	Sandy loam	30% or more; Less than 25%		-and-	Less than 30%	Less than 30%
	Fine sandy loam	Between 15 and 30%	—or—		30% or more	Less than 30%
	Very fine sandy loam	Less than 15%		—or—	More than 40%	30% or more

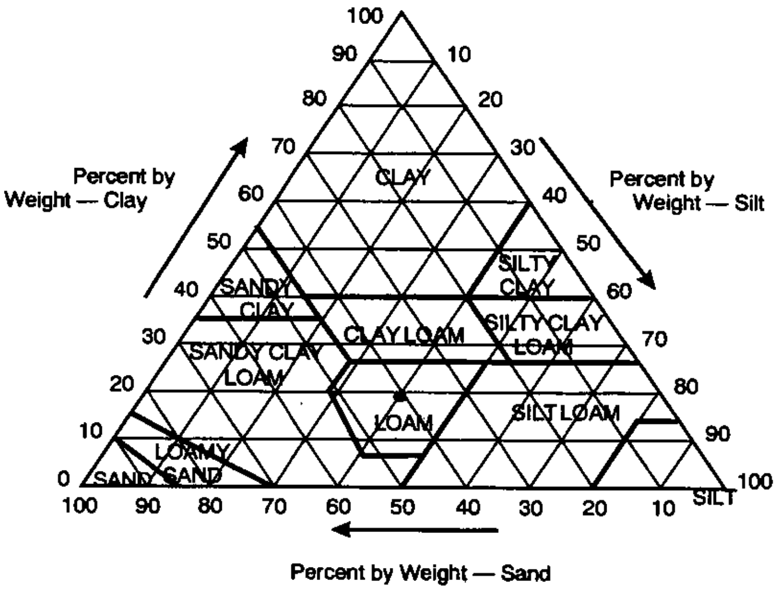
(25.4 mm = 1 inch)

Half of the content of fine sand and very fine sand must be composed of very fine sand.

The idea of grouping soils into textural classes was originally developed by the USDA to assist farmers with agronomic decisions. This textural classification system has been adapted for use in siting and sizing on-site systems because texture influences the permeability of the soil, or how fast the water moves through the soil.

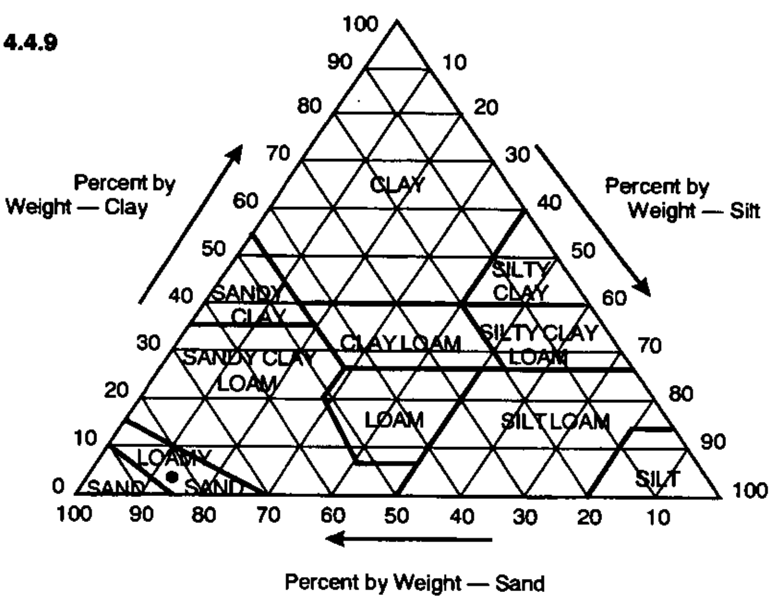
Below are several examples of texture determination.

Figure 4.4.8



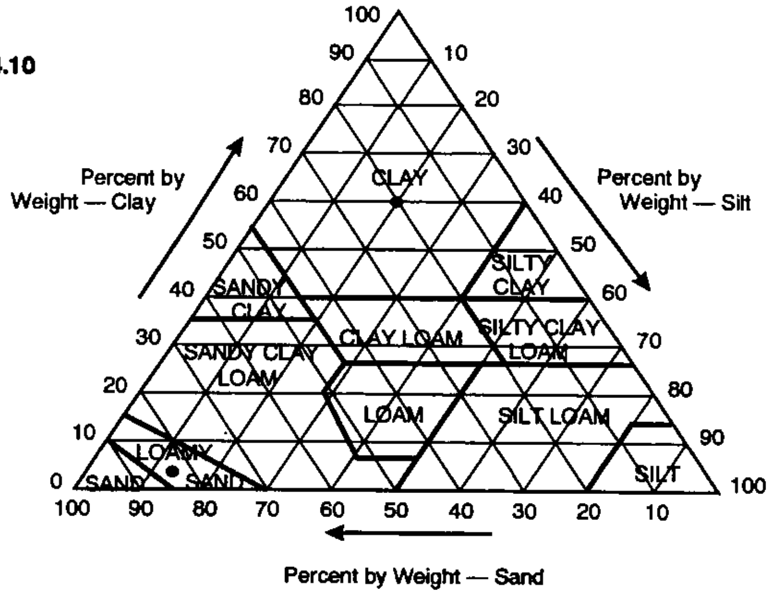
For example, soil with 40% sand, 40% silt, and 20% clay would be a loam. Look for the area in the soil textural triangle where the 40% line for sand (diagonal line that goes from right to left) intersects the 20% line for clay (horizontal line) and the 40% line for silt (diagonal line that goes from left to right) (Figure 4.4.8). This area of the triangle is where soils are classified as loams.

Figure 4.4.9



A soil with 80% sand, 15% silt, and 5% clay would be a loamy sand. Look for the area in the soil textural triangle where the 80% line for sand intersects the 5% line for clay and the 15% silt (Figure 4.4.9). This area of the triangle is where soils are classified as loamy sand.

Figure 4.4.10



A soil with 20% sand, 20% silt, and 60% clay would be a clay. Look for the area in the soil textural triangle where the 20% line for sand intersects the 60% line for clay and the 20% silt (Figure 4.4.10). This area of the triangle is where soils are classified as clay.

Soil texture is usually determined in the field by hand testing and can be confirmed by laboratory analysis. Section 4.5, Soil Texture, gives more details on testing soils.

Soil voids.

In between the particles of sand, silt, and clay are spaces called *voids*. The voids are created because the soil particles do not fit together perfectly, leaving small, irregular spaces. Every soil has a certain percentage, normally between 35 and 50%, of its volume in voids. Soil voids are important because they determine the water and air movement possible within a soil.

❑ Water and air flow into and out of a soil by moving through the void spaces. The ease with which water and air can flow through a soil is determined by the size of the voids, the number of voids in the soil, and how well the voids are connected to each other.

❑ The amount, size, and connectivity of soil voids is determined, in large part, by soil texture. Therefore, soil texture becomes a critical factor determining the rate of wastewater flow through a soil horizon.

❑ The size of the individual void spaces, in particular, has a strong influence on water movement through a soil horizon. For example, even though a clay-textured horizon will generally have more void space than a sandy-textured horizon, the movement of wastewater through a clay-textured horizon will be slower. This occurs because water can flow more quickly through the few large voids in the sand than through the many tiny voids in the clay-textured horizon. In order to account for these differences in wastewater flow, the on-site systems installed in the clay soil would require a much larger drainfield than a similar system located in a sandy soil.

Organic matter.

In addition to the soil mineral solids, soils also contain *organic matter*. Organic matter consists of decomposed leaves, twigs, animal droppings, air and water. Most soils have organic matter contents that range between 1% - 5% of the total soil weight. When the majority of the solids are mineral, soils are referred to as *mineral soils.*

Although organic matter makes up only a small portion of the soil, it is very important in determining several soil properties.

❑ Organic matter partially determines how much water can be held by the soil.

❑ Organic matter increases the surface area of a soil. Increased surface area is important in the retention of some of the wastewater constituents such as viruses, phosphorus, and ammonium.

❑ Some soils, called *organic soils*, are primarily composed of organic matter with only a small amount of mineral solids. Organically stained soils (soils stained by decomposing organic matter) should not be confused with organic soils. Organic soils must have more than 20% organic matter to be classified as an organic soil.

Reference
15A NCAC 18A.1935(21)

As defined by the rules, organic soils are

> **"those organic mucks and peats consisting of more than 20% organic matter (by dry weight) and 18 inches or greater in thickness."**

❑ Organic soils are always UNSUITABLE for on-site systems because these soils do not drain properly. Treatment and disposal fields cannot function in organic soils.

Soil Color

Soil is naturally gray to white in color when it is first formed. Over time, soil develops other colors. Soil particles become coated with inorganic substances or organic matter that is *translocated* or moved through the soil profile. For example, organic matter, such as decaying leaves and twigs, can be translocated from the soil surface downward to the A, B, and C soil horizons by rainwater moving downward through the soil. The decaying organic matter forms a brown or black coating on the soil particles so that the soil then appears to be brown or black. A coating of iron oxide on soil particles makes a red soil.

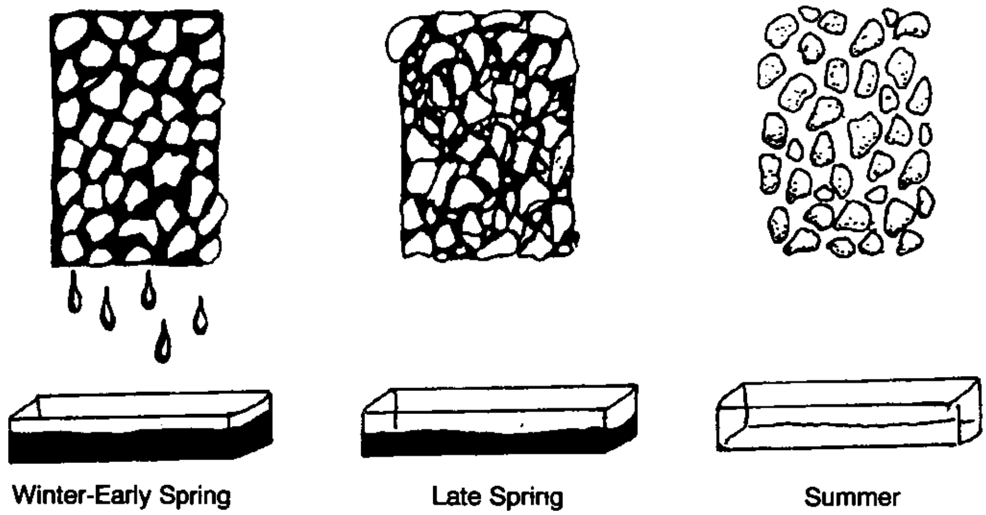
Soil color and soil wetness.

Soil color is a very useful tool for investigations of soils for on-site wastewater disposal because color can indicate the wetness of a soil. Soils that are too wet are inappropriate for siting an on-site system. While soil color cannot directly indicate the soil's suitability, soil color does indicate much about how wet the soil is throughout the year. Because of rainfall patterns and evapotranspiration, soils in North Carolina are drier during summer and fall and wetter during winter and spring. Figure 4.4.11 demonstrates the difference in water content between seasons.

❑ For on-site systems, two problems are associated with wet soils:

1. Wet soils reduce the amount of air available for bacteria to treat the wastewater.
2. The high water table causes the wastewater to flow directly into the ground water without sufficient treatment.

Figure 4.4.11 Seasonal moisture relations.



❑ When soils are well aerated (when air can move freely through the void spaces), there is enough oxygen to oxidize iron to its highest state (Fe^{+3}) and the soil has a uniform bright color. This bright orange color, due to oxidized iron, is the same color that occurs when metal rusts. In this state, the soil is aerobic and soil organisms use oxygen for their metabolism.

❑ Soils that are saturated have a different color. When a soil is saturated, water replaces the air in the void spaces, oxygen cannot move through the soil, and the soil conditions become *anaerobic*, or without oxygen. Many anaerobic bacteria use iron, aluminum, or sulfate as a substitute for oxygen in their metabolism. Therefore, when a soil is saturated, iron is reduced by bacteria to Fe^{+2} and it becomes soluble in water and can be moved or translocated out of or through the soil.

Soil that always remains saturated has a gray color since the iron is gone or is in the reduced, non-color state (Fe^{+2}). Soils that have fluctuating wetness conditions, where the soil is saturated in the winter and spring and well aerated in the summer and fall, develop a distinctive splotchy color pattern of mixed rust-orange colors and gray colors that are called *soil mottling* (described in more detail on the following page). Thus, soil color becomes a good indicator of moisture status.

Munsell color system.

Soil scientists use a very specific system — the *Munsell color system* — to standardize soil color descriptions. In the Munsell color system, each color is broken into three components: *hue, value, and chroma.*

1. *Hue* is the basic color. Hue ranges from a value of 10R, which is a red soil, to 7.5YR or 10YR, which are brown soils, to 5Y, which is a yellow soil.
2. *Value* is the lightness or darkness of the color.
3. *Chroma* is the purity or strength of the color. Natural gray starts at 0 and increases to a maximum of 8.

❑ The Munsell color book is composed of color chips with various components of hue, value, and chroma. A soil sample is compared with color chips and the appropriate color designation that matches the soil is noted and recorded.

- The matrix color is the dominant soil color of the horizon. Each matrix color can have a range of value, hue, and chroma.

- Two Munsell charts are displayed in Figure 4.4.12. The left color chart displays various combinations of value and chroma for a soil with a 7.5YR hue. The right color chart shows value and chroma combinations for a soil with a 10YR hue. Value and chroma designations are added to the hue. For example, the soil in Figure 4.4.12 could be described as 7.5YR 3/2 if it has a brown matrix color and a dark gray tinge. A soil designated as 10YR 5/1 is a gray soil.

Soil mottling.

If water cannot drain freely through the soil, then a color pattern called *soil mottling* usually develops. When a soil is repeatedly saturated for an extended period and drained, the iron compounds are biochemically reduced during saturation and then chemically oxidized when the soil drains. These conditions lead to a *mottling pattern* of bright rust- or orange-colored spots and dull gray-colored spots on the background color of the soil. Soil scientists call the bright spots *high chroma mottles* and the dull spots *low chroma mottles.*

Mottles are described in terms of their abundance or number, size, and contrast compared to the background soil color. If greater than two percent of the soil contains mottles in chroma of 2 or less, then the soil is generally considered wet (see Table 4.4.5). The abundance of mottles can be easily estimated using charts such as Figure 4.4.13.

Table 4.4.5 Mottle Abundance, Size, and Contrast.

MOTTLING: A description of mottling requires a notation of the colors and of the pattern. Colors may be noted by Munsell symbols for the matrix and color names for the mottles. Patterns may be noted in terms of:

(1) Abundance:		
few	(mottles < 2% of surface)	f
common	(mottles 2 - 20% of surface)	c
many	(mottles > 20% of surface)	m
(2) Size:		
fine	(< 5 mm.)	1
medium	(5 - 15 mm.)	2
coarse	(> 15 mm.)	3
(3) Contrast:		
faint	(Hue and chroma of matrix and mottles closely related)	f
distinct	(Matrix and mottles vary 1-2 hues and several units in chroma and value)	d
prominent	(Matrix and mottles vary several units in hue, value, and chroma)	p

Thus a gray horizon with yellow and reddish brown mottles that are common (c), coarse (3), and distinct (d) is noted as: 10YR 5/1, c3d, yellow and reddish brown mottles.

(25.4 mm. = 1 inch)

Figure 4.4.12 Munsell charts.

❑ In North Carolina, the only combination of abundance and contrast of mottles that designates a well-drained soil is few and faint. Any other combination of the mottling categories of abundance and contrast indicate potentially wet conditions.

❑ The presence of low-chroma colors, such as chroma 2 or lower, usually means that the soil is saturated part of the year. Often this happens when the water table rises during a wet season and saturates the soil.

❑ The depth to low-chroma colors in a soil can help determine the depth to the seasonal wetness and the soil drainage class. This knowledge of soil wetness can be used in assessing the suitability of a soil for siting on-site systems.

Reference
15A NCAC 18A.1942

As defined by the rules

> **"soil wetness conditions caused by a seasonal high-water table, perched water table, tidal water, seasonally saturated soils or by lateral water movement shall be determined by observation of colors of chroma 2 or less (Munsell color chart) in mottles or a solid mass."**

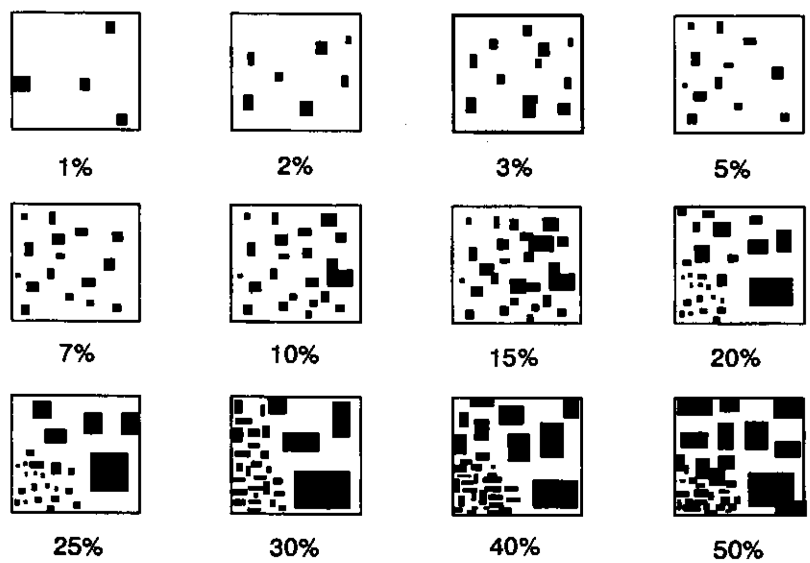


Figure 4.4.13 Mottling abundance chart.

❑ **Cautionary Note: In ascertaining soil wetness from soil color, care must be taken because in some soils, mottling can also be caused by natural variations in the parent material and not by soil wetness.**

❑ Other site characteristics can be used to indicate soil wetness. Vegetation and landscape position can both be used as an initial indicator of wet areas.

Soil Drainage Class

The SCS has established criteria for seven *soil drainage classes*. The soil drainage class is a measure of how wet the soil is during the year. Each drainage class is based on how frequently and how long the soil stays wet during a yearly cycle. See Table 4.4.6 for details on soil drainage classes.

Table 4.4.6 Criteria for Soil Drainage Classes

Excessively drained. Water is removed very rapidly. Internal free water occurrence commonly is very deep; annual duration is not specified. The soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of mottling related to wetness.

Somewhat excessively drained. Water is removed from the soil rapidly. Internal free water occurrence commonly is very deep; annual duration is not specified. The soils are usually sandy and rapidly pervious. Some are shallow. A portion of the soils are so steep that a considerable part of the precipitation received is lost as runoff. All are free of the mottling related to wetness.

Well drained. Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. Well-drained soils are commonly medium textured. They are mainly free of the mottling related to wetness.

Moderately well drained. Water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory through permanent. The soils are wet for only a short time during the growing season, but long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within the upper 1 m, periodically receive high rainfall, or both.

Somewhat poorly drained. Water is removed slowly enough that the soil is wet at shallow depth for significant periods during the growing season. Internal free water occurrence commonly is shallow and transitory or common. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. The soils commonly have one or more of the following characteristics: contain a slowly pervious layer, have a high water table, receive additional water from seepage, occur under nearly continuous rainfall, or on a flat landscape.

Poorly drained. Water is removed so slowly that the soil is wet at shallow depths periodically during the growing season, or remains wet for long periods. Internal free water occurrence is shallow or very shallow and common or persistent. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow-depth. Free water at shallow depth is usually present. This water table is commonly the result of a shallow, slowly pervious layer within the soil, of seepage, of nearly continuous rainfall, or are on flat landscapes far removed from streams.

Very poorly drained. Water is removed from the soil so slowly that free water remains at or very near the ground surface during much of the growing season. Internal free water occurrence is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soils are commonly level or depressed and frequently ponded. If rainfall is high or nearly continuous, slope gradients can be moderate or high. Often these soils are located in the center of the interfluves on flat landscapes far removed from streams.

Source: Soil Survey Staff (1991).

Redoximorphic Features

Until 1992, soil scientists used chromas of 2 or less to signify wet soils. In 1992 the definition of a wet soil was broadened to include saturation, reduction, and morphological indicators because it was believed that color alone was not a specific enough indicator of soil wetness (Vepraskas, 1992). Under the new classification, wet soils must meet specified criteria for the following characteristics: the depth of saturation, the occurrence of reduction, and the presence of *redoximorphic features*. *Redoximorphic features* are iron nodules and mottles created by the process of reduction, translocation or movement, and finally by oxidation of iron and manganese (Figure 4.4.14).

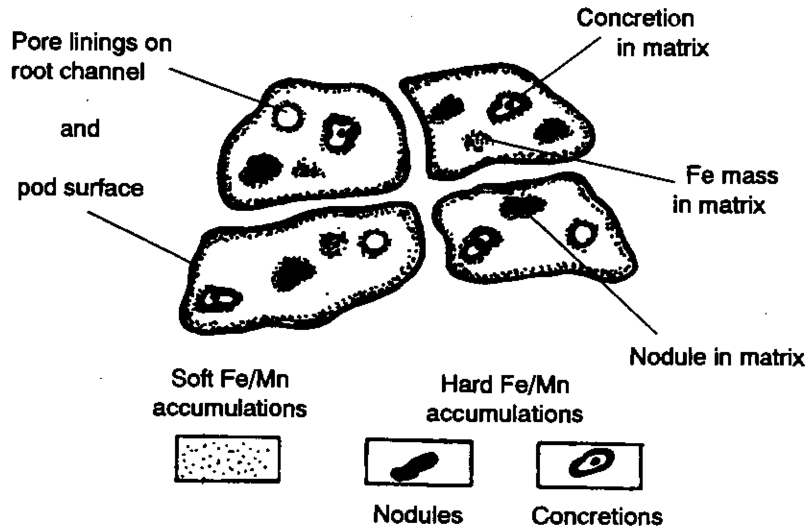


Figure 4.4.14 Redoximorphic features (from Vepraskas, 1992).

Redoximorphic features could have formed in the past and may not represent current soil wetness. For this reason, all three characteristics—saturation, reduction, and redoximorphic features—must be considered.

1. Saturation means that a soil is periodically saturated within the first two meters. This saturation may occur in the entire two-meter layer or in a portion of that layer.
2. Reduction no longer refers only to the absence of oxygen but now also includes the presence of reduced iron.
3. Redoximorphic features include only mottles and iron nodules formed by the reduction, translocation, and oxidation of iron and manganese due to wetness. Mottles are a broader category of features that includes redoximorphic features, carbonate accumulations, organic stains, and parent material color variation.

Redoximorphic features are not currently used to determine soil wetness in the North Carolina on-site wastewater rules.

Soil Structure

Soil structure is a measure of how the tiny particles in the soil group together, or *aggregate*, into units which give the soil its overall properties.

Soil structure, as defined by the rules, is

Reference
15A NCAC 18A.1935(42)

"the arrangement of primary soil particles into compound particles, peds, or clusters that are separated by natural planes of weakness from adjoining aggregates."

These soil aggregates, known as *peds,* are a mixture of all the soil components, such as sand, silt, clay, and organic matter.

Reference
15A NCAC 18A.1935(23)

A ped is defined in the rules as

"a unit of soil structure, such as an aggregate, crumb, prism, block, or granule formed by natural processes."

Ped dimensions range from fingernail to softball size.

Grades, sizes, and types of structure.

Soils have different grades, sizes, and types of structure. See Table 4.4.7 for more details.

1. The *grade* of a soil structure refers to the stability of the ped, a measure of how easily the ped breaks into smaller units or forms larger units. The structural grade is described when the soil is in a moist state.
2. The *size* of a soil structure refers to the size of the individual peds in a horizon. The sizes range from very fine to very coarse. Most horizons have a mixture of ped sizes; therefore, the predominant ped size in a horizon is described.

Table 4.4.7 Soil Structure Grades, Sizes, and Shapes.

Grade	
0 – structureless	No aggregation or orderly arrangement (massive or single grain).
1 – weak	Poorly formed, nondurable, indistinct peds that break into a mixture of a few entire and many broken peds and much unaggregated material.
2 – moderate	Well-formed, moderately durable peds, indistinct in undisturbed soil, that break into many entire and some broken peds but little unaggregated material.
3 – strong	Well-formed, durable, distinct peds, weakly attached to each other, that break almost completely into entire peds.

	Shape		
Size (Ped Diameter)	pl-platy gr-granular cr-crumb	abk-angular blocky sbk-subangular blocky	cl-columnar pr-prismatic
vf – very fine	<1 mm	<5 mm	<10 mm
f – fine	1-2 mm	5-10 mm	10-20 mm
m – medium	2-5 mm	10-20 mm	20-50 mm
c – coarse	5-10 mm	20-50 mm	50-100 mm
vc – very coarse	>10 mm	>50 mm	>100 mm

(25.4 mm = 1 inch)

3. The *type or form of a ped* (structure) refers to the shape of the ped. Parent material and organic matter can affect the shape of peds. Soils with a type of clay mineralogy, known as 1:1 mineralogy, produce sub-angular blocky peds. Soils with 2:1 mineralogy produce angular blocky peds in the summer and massive in the winter due to drying (shrinking) and wetting (swelling).

Table 4.4.8 Types of Structure, Structure Description, and Site Suitability.

<table>
<tr><th>Kind of Structure</th><th colspan="2">Description of Aggregates (Peds)</th><th>Horizon</th><th>Suitability</th></tr>
<tr><td>Crumb</td><td>Aggregates are small, porous, and weakly held together.</td><td rowspan="2">Nearly Spherical, with many irregular surfaces.</td><td rowspan="2">Usually found in surface soil or A horizon.</td><td>SUITABLE</td></tr>
<tr><td>Granular</td><td>Aggregates are small, non-porous, and are strongly held together.</td><td>SUITABLE</td></tr>
<tr><td>Platy</td><td colspan="2">Aggregates are flat or plate-like, with horizontal dimensions greater than the vertical; plates overlap, usually causing slow permeability.</td><td>Usually found in E horizons or horizons of soils formed from stratified (layered) sediments.</td><td>UNSUITABLE</td></tr>
<tr><td>Angular Blocky</td><td>Aggregates have sides that join at sharp angles, tend to overlap.</td><td rowspan="2">Nearly block-like, with 6 or more sides. All 3 dimensions about the same.</td><td rowspan="4">Usually found in subsoil or B horizon.</td><td>PROVISIONALLY SUITABLE if size is ≤ 2.5 cm. UNSUITABLE if size is >2.5 cm.</td></tr>
<tr><td>Subangular Blocky</td><td>Aggregates have sides forming obtuse angles, corners are rounded; usually more permeable than angular blocky type.</td><td>PROVISIONALLY SUITABLE if size is ≤ 2.5 cm. UNSUITABLE if size is >2.5 cm.</td></tr>
<tr><td>Prismatic</td><td>Without rounded caps on top.</td><td rowspan="2">Prism-like with the vertical axis greater than the horizontal.</td><td>UNSUITABLE</td></tr>
<tr><td>Columnar</td><td>With rounded caps on top.</td><td>UNSUITABLE</td></tr>
<tr><td>No Structure — Single Grain</td><td colspan="2">Soil material clings together in large sand and do not form aggregates.</td><td rowspan="2">Usually found in substratum or in C horizon.</td><td>SUITABLE</td></tr>
<tr><td>No structure — Massive</td><td colspan="2">Soil material clings together in large uniform masses, without peds.</td><td>UNSUITABLE</td></tr>
</table>

The effect of structure on water movement through soil.

Soil structure is an important characteristic for siting on-site systems because the structure of the soil affects the movement of water and sewage through the soil. Although the porosity is greater inside a ped, the majority of water flow is through the voids or cracks between the peds. Frequently, the only wastewater flow path in a soil that is sufficiently fast for wastewater disposal is between the peds.

❑ Well-developed, fine peds can have an acceptable amount of wastewater flow through the voids between the peds.

❑ The presence of peds is particularly important in clayey soils. If peds are too large in size (for example, greater than 1 inch or 2.5 cm), then wastewater will move too slowly (Figure 4.4.15).

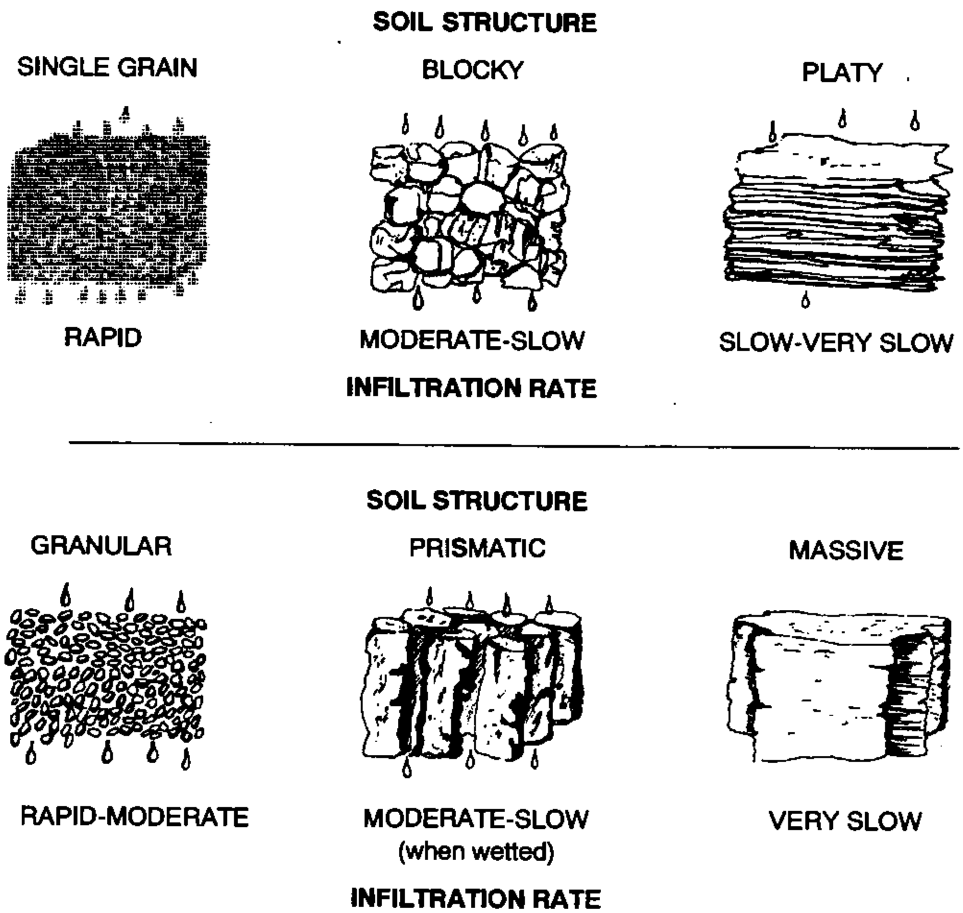


Figure 4.4.15 Infiltration rates as affected by soil structure.

❑ Because soil structure affects wastewater flow, soils with certain structures, such as platy, massive, and prismatic structure, cannot be used to treat on-site waste effluent. Platy, massive, and prismatic structured soils can impede water flow, particularly in finer-textured soils.

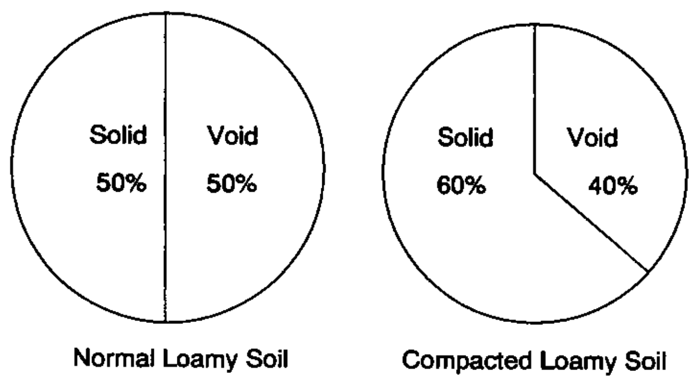
In general, the size of the structural aggregates, or peds, increases with depth through the A and B horizons. In the C horizon the soil is massive and structureless, which means there are few or no structural aggregates. Because there are no peds present, wastewater flow through the C horizon can no longer be related to peds but is through the matrix.

Changes in soil structure.

Soil structure is not static. Peds can be changed by natural or man-made conditions such as: wetting and drying; freezing and thawing; physical activity of roots and soil animals; influence of decaying organic matter and of slimes from microorganisms and other life forms; modifying effects of adsorbed cations, clay films, iron oxides, and aluminum oxides; and construction activities. Examples of changed soil structure are presented below.

1. Movement of wastewater through the soil can change soil structure. Sodium causes soil particles to disassociate from each other. Wastewater high in sodium (for instance, as a result of brine from a home water softener) can cause soil peds to disperse or break apart, which in turn will decrease void volume between the peds. Wastewater movement will then be restricted because the voids are much smaller.
2. Construction of on-site systems in clay soils that depend on the preservation of voids between the peds must occur during dry weather. If construction occurs during wet weather, excavation of trenches can result in clays being smeared across the face of the soil. This smearing blocks the voids between the peds and impedes the movement of wastewater. If construction does occur when the soil is wet, rake the sidewalls to remove the smeared clay.
3. Compaction, or compressing the soil, changes the amount of the total void space and the distribution of the void sizes. This reduces the space available for air and water in the soil. Soil compaction generally reduces the structural porosity, the spaces between the peds, more than the internal porosity. When structural porosity is reduced, the volume and the continuity of the larger voids that transport water are reduced (Figure 4.4.16).

Figure 4.4.16 Change in void space due to compaction.



Compacted soils should be avoided for on-site systems because a compacted soil may not be able to absorb enough sewage. Soils can be compacted by heavy machinery or by frequent trips of cars, trucks, or heavy earth-moving equipment over the soil.

Soil consistence is a measure of how well the soil sticks together and how resistant peds are to being ruptured or broken.

Soil Consistence

Soil consistence is used to determine clay mineralogy in the field and, from that, to judge water flow through the soil, because soil consistence is very dependent on the clay mineralogy. The type of clay in the soil affects both the consistence and the permeability of the soil.

Soil consistence is important for on-site system site evaluation because it indicates how much the soil will shrink and swell upon wetting and drying. If the soil swells when wetted by the effluent from a septic tank system, the structural voids will be filled by the expanding clay particles. The rate at which wastewater moves through the soil is greatly reduced by this loss of structural porosity, and it can cause a septic tank system to fail.

Soil consistence and moisture content.

The consistence of a soil changes with moisture content and consistence can be described when the soil is dry, moist, or wet. In North Carolina, only two moisture conditions are important, moist and wet, because dry soils are rare in North Carolina. Soil consistence is listed and the field evaluation procedure is described for these two moisture conditions in Table 4.4.9.

When the soil is wet, its consistence can be described by two characteristics, *plasticity* and *stickiness.* Plasticity, how easily the soil can be shaped by pressing or molding it, is a good indicator of the type of clay in the soil. The more plastic the soil, the higher the content of clay and the less suitable the soil is for an on-site system.

Table 4.4.9 Soil Consistency Descriptions and Abbreviations.

I. Wet consistence —moisture content at or slightly more than "field moisture capacity."	
A. Stickiness —quality of adhesion to other objects	
0. Nonsticky (wso)	Almost no natural adhesion of soil material to fingers.
1. Slightly sticky (wss)	Soil material adheres to one finger but other finger is clean.
2. Sticky (ws)	Soil material adheres to both fingers and thumb; stretches somewhat.
3. Very sticky (wvs)	Soil material strongly adheres to both thumb and finger.
B. Plasticity —capability of being molded by the hands	
0. Nonplastic (wpo)	No "wire" can be formed by rolling material between the hands.
1. Slightly plastic (wps)	Only short (<1 cm) "wires" are formed by rolling material between the hands.
2. Plastic (wp)	Long wires (>1 cm) can be formed and moderate pressure is needed to deform a block of the molded material.
3. Very plastic (wvp)	Much pressure is needed to deform a block of the molded material.
II. Moist consistence —soil moisture content between dryness and "field moisture capacity."	
0. Loose (ml)	Soil material is noncoherent. Used with single grain structureless condition.
1. Very friable (mvfr)	Aggregates crush easily between thumb and finger.
2. Friable (mfr)	Gentle thumb and finger pressure is required to crush aggregates.
3. Firm (mfi)	Moderate thumb and finger pressure is required to crush aggregates.
4. Very firm (mvfi)	Strong thumb and finger pressure is required to crush aggregates.
5. Extremely firm (mefi)	Aggregates cannot be broken by thumb and finger pressure.

* 1 cm ~ 1/2 inch

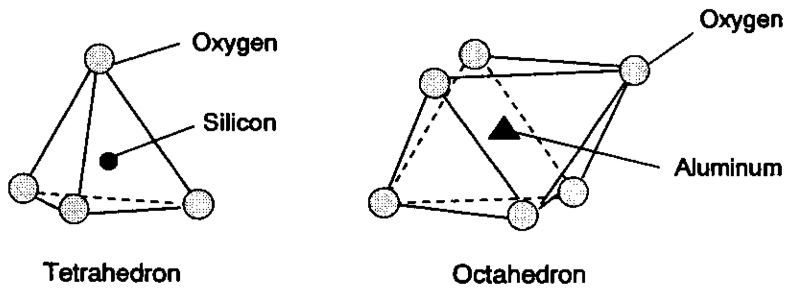
Clay Mineralogy

Clay mineralogy describes the type of clay in a soil and how the soil behaves when wet and dry. Understanding the behavior of wet soil is important in siting on-site systems.

Clays are particles of soil less than 2 microns in diameter. Clays formed from aluminosilicate minerals in the southeastern part of the country are known as temperate region clays or silicate clays.

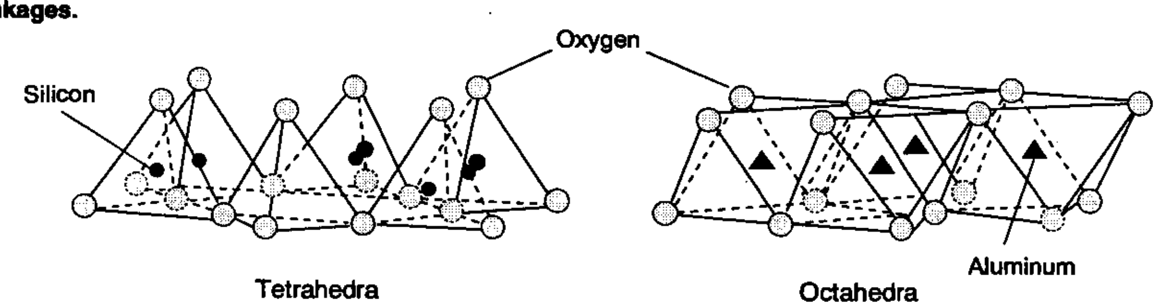
❑ Silicate clays are composed of a definite crystalline structure derived from the original rock minerals. Silicate clays have two basic structural units: a tetrahedron of four oxygen atoms surrounding a central cation, which is usually silicon (Si^{4+}); or an octahedron of six oxygen atoms surrounding a cation, usually aluminum (Al^{3+}). See Figure 4.4.17.

Figure 4.4.17 Structural units of silicate clays.



The tetrahedra or octahedra are linked together to form microscopic silica and alumina sheets, respectively (as shown in Figure 4.4.18). These alumina and silica sheets combine to form *lamellae*, a two- or three-layer stack of aluminum and silica sheets. Stacks of lamellae form clay particles.

Figure 4.4.18 Tetrahedra and octahedra linkages.



❑ The arrangement of the alumina and silica sheets determines the clay type. The lamella of a 1:1 clay mineral, such as kaolinite, is a silica sheet attached to an alumina sheet. Shared oxygen atoms link the two sheets. See Figure 4.4.19. These two-layer silica-alumina lamellae are then stacked together in a repeating fashion. Hydrogen bonds between the lamellae hold the overall crystal lattice together in a rigid fashion as shown in Figure 4.4.20.

Figure 4.4.19 Arrangements of two-layer lamella.

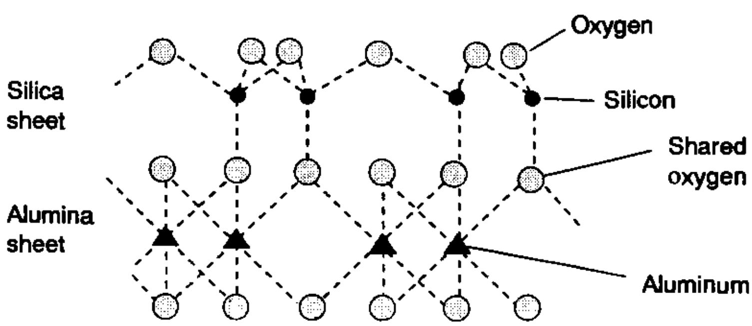
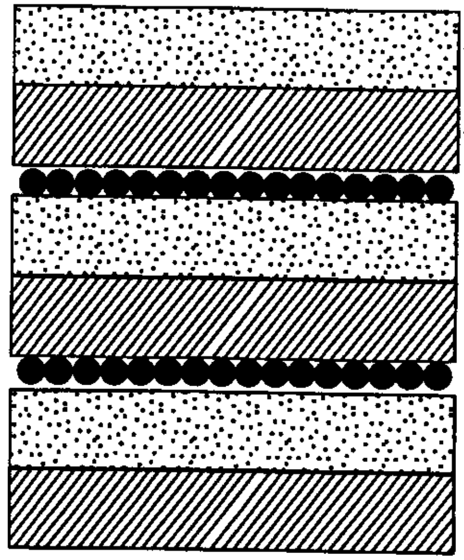
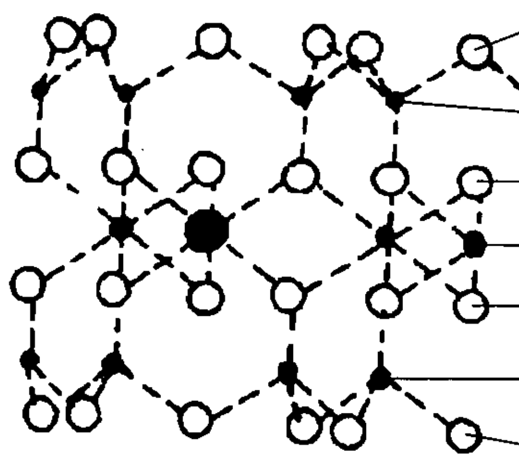


Figure 4.4.20 Repeating two-layer lamella.



❑ The lamella of 2:1 clay minerals, such as montmorillonite and bentonite, is an alumina sheet sandwiched between a silica sheet on either side and held by a shared oxygen atom, as can be seen in Figure 4.4.21. The three-layer lamellae of montmorillonite are held together loosely. This loose arrangement allows water and cations to move in and out of the clay mineral structure by moving between the lamellae. Figure 4.4.22 shows the loose lamellae of montmorillonite.

Figure 4.4.21 Arrangement of three-layer lamella.



❑ *Mixed mineralogy* clays have a mixture of both 2:1 and 1:1 clays.

❑ Soils containing the 1:1 clay types swell less upon wetting than 2:1 clays and therefore do not impede water flow when wetted as much as do the 2:1 or mixed mineralogy clays. If the percentage of clay is not too large, soils that have 1:1 clay mineralogy, such as kaolinite, have excellent potential to absorb and treat wastewater, if the drainfield is large enough. These soils generally have good structure and the increased surface area of the clay particles provides additional sites for wastewater treatment to occur.

❑ Because ions and water can move in and out between the lamellae or a layered stack made of alumina and silica, 2:1 clays shrink when dried and swell when wetted. This shrinking and swelling makes these soils UNSUITABLE for on-site

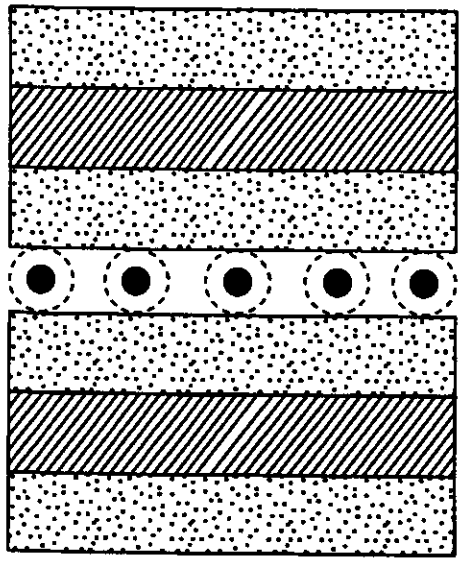


Figure 4.4.22 Repeating three-layer lamellae.

systems. When these clays are wet and swollen, little wastewater can flow through the soil. When the clay is dry, *shrinkage cracks* form and the effluent receives no treatment because it moves through the open cracks too quickly.

❑ Formation of 1:1 and 2:1 clays is primarily determined by the parent material. For example, 1:1 clays form from felsic parent material, such as granite, whereas 2:1 clays form from mafic parent material, such as diabase.

❑ Soil particles, particularly clay, have negative charges. These negative charges attract and hold nutrients and other positively charged ions or molecules.

❑ Surface area, and thus total negative charges, differs between clay types. The surface area of a 2:1 clay is 40 times greater than the 1:1 clay.

Table 4.4.10 summarizes the suitability of various clays for on-site wastewater systems

Table 4.4.10 The Influence of Clay Type on the Siting of On-Site Systems

Clay Type	Acceptable for On-Site Wastewater System Installation
1:1	Yes
Mixed Mineralogy	Maybe*
2:1	No

*See Section 4.5 (Clay Mineralogy) for more details.

Soil Hydraulic Parameters

Hydrologic parameters describe the way water moves through soil and are critical components in siting on-site systems.

Saturated Hydraulic Conductivity

Saturated hydraulic conductivity is the rate at which water moves through a saturated soil. In a saturated soil, all of the pore voids are filled with and transmitting water. The rate of flow through a soil is dependent on the sizes, number, and interconnectedness of the voids in the soil. The number of voids, their size, and spacing depend on numerous soil characteristics such as texture, mineral content, structure, biological activity, and horizon placement. Saturated hydraulic conductivity will vary between soil horizons within the same profile and from location to location.

Saturated hydraulic conductivity is important in on-site systems. This parameter can help the designer determine the volume of wastewater that the site can transmit in a given time when the soil is saturated. On-site treatment and disposal fields are not supposed to become saturated, but under some conditions, such as during wet winter months, the ground may become saturated. Thus, the saturated hydraulic conductivity can determine how a system will perform under worst-case conditions.

- The measure of water movement through a saturated soil has the units of distance/time and is given the symbol Ksat.
- Each soil horizon has its own individual Ksat, which normally varies greatly from the Ksat of other horizons in the same profile.
- Based on measurements of saturated hydraulic conductivity, soils are grouped into six classes, from very low to very high hydraulic conductivity. See Table 4.4.11 for a complete listing of saturated hydraulic conductivity classes.
- If saturated hydraulic conductivity measurements are not available, saturated hydraulic conductivity can be estimated from certain soil properties, as shown in Table 4.4.11.
- Saturated hydraulic conductivity is not typically used in North Carolina as an evaluation tool for determining wastewater flow through a soil for on-site systems with flows less than 1,500 gallons per day. To accurately measure Ksat, each horizon in a profile must be tested, four or five measurements for each horizon must be taken, and the test must be done seasonally (winter and summer). This requires more time, money, and effort than most people want to expend. Additionally, Ksat tests are conducted using clean water. Wastewater, with its particulate matter, causes water to move more slowly through a soil and thus Ksat measurements for wastewater differ. Because of these difficulties determining saturated flow, North Carolina does not use Ksat to evaluate a site's potential for an on-site treatment and disposal system; a site evaluation is performed instead. (For more information see Section 4.5).

Unsaturated Hydraulic Conductivity

Water can move through a soil even if the soil is not saturated. The unsaturated *hydraulic conductivity* is a measurement of the rate at which water moves in unsaturated soils.

Unsaturated hydraulic conductivity can help the designer determine the volume of wastewater that the site can transmit in a specific time when the soil is unsaturated. On-site treatment and disposal fields are supposed to have an unsaturated zone under the trenches to allow the wastewater to be treated aerobically.

Table 4.4.11 Estimates of Saturated Hydraulic Conductivity from Soil Properties

Class	Rate*	Soil Properties
Very High	>14.2	Rocky
		Sandy with coarse sand or sand texture, and loose consistency
		More than 0.5 percent medium or coarser vertical pores with high continuity
High	14.2-1.4	Other sandy, sandy-skeletal, or coarse-loamy soil materials that are very friable, friable, soft, or loose
		When very moist or wet has moderate or strong granular structure; or strong blocky structure of any size or prismatic structure finer than very coarse, and many surface features except stress surfaces or slickensides on vertical surfaces of structural units 0.5 to 0.2 percent medium or coarser vertical pores with high continuity
Moderate	1.4-0.14	Sandy in other consistence classes except extremely firm or cemented
		10 to 35 percent clay with moderate structure, except platy, or strong very coarse prismatic structure; and with common surface features except stress surfaces or slickensides on vertical surfaces of structural units
		0.1 to 0.2 percent medium or coarser vertical pores with high continuity
Mod. Low	0.14-0.01	Other sandy classes that are extremely firm or cemented
		18 to 35 percent clay with other structures and surface conditions except pressure or stress surfaces
		Greater than 35 percent clay and moderate structure except if platy or very coarse prismatic; and with common vertical surface features except stress surfaces or slickensides
		Medium or coarser vertical pores with high continuity, but <0.01 percent
Low	0.01-0.001	Continuous moderate or weak cementation
		Greater than 35 percent clay and meets one of the following: weak structure, weak structure with few or no vertical surface features, platy structure, common or many stress surfaces or slickensides
Very Low	<0.001	Continuously indurated or strongly cemented and with less than common roots
		Greater than 35 percent clay and massive or exhibits horizontal depositional strata and less than common roots

*Inches/hour

Source: Adapted from SCS (1983)

Under unsaturated soil conditions, voids are not completely filled with water. Unsaturated hydraulic conductivity depends on the water content of the soils as well as soil characteristics such as texture, mineral content, structure, biological activity, and horizon placement. At the same moisture status, unsaturated hydraulic conductivity, like saturated hydraulic conductivity, will vary between soil horizons within the same profile and from location to location.

❑ In an unsaturated soil, the driving force of water movement is a gradient potential that is caused by suction. Matric suction is the affinity of water molecules to other water molecules or to capillary voids. Water moves from higher to lower matric suction potentials. In other words, water moves from voids that are full to voids that are unfilled. The geometric shape and size of the voids can affect the matric potential. For example, the large voids in sandy soils empty quickly. Once the soil is desaturated, water is trapped in capillary wedges that do not contact other capillaries and water movement stops.

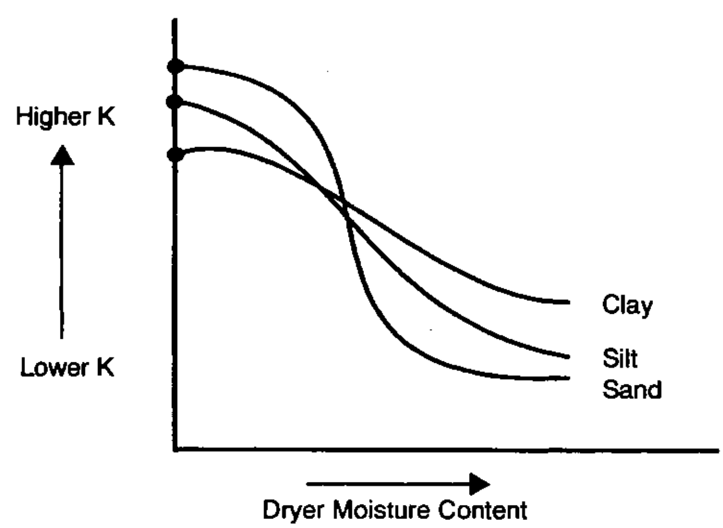
❑ Once the biomat has formed in the treatment and disposal trenches, it often becomes the limiting layer or controlling layer for water flow. In those cases, the biomat is the least conductive layer to water flow. If there is no restrictive soil layer beneath the trenches, then wastewater moves through the soil in unsaturated flow after it passes through the biomat. Since unsaturated flow is slower than saturated flow, the wastewater flows through the soil at a slower flow rate. The slower flow rates give the wastewater more contact time in the soil profile and more time to be cleansed by biochemical and chemical processes before it becomes part of the ground water. Be aware, however, that there may be soil layers under the trench that have such slow permeability that these soil layers, rather than the biomat, control the rate of wastewater flow through the soil.

❑ Recall that any site rated as a SUITABLE or PROVISIONALLY SUITABLE site must have at least 12 to 18 inches of separation between the trench bottom and soil wetness conditions or other restrictive horizons.

Two specific soil characteristics that affect unsaturated hydraulic conductivity are soil texture and depth.

❑ As soils dry from saturated conditions to lower moisture levels, the hydraulic conductivity decreases. This decrease of hydraulic conductivity varies with soil texture. In sandy soils, hydraulic conductivity decreases very quickly as the moisture content drops; in clay soils the decrease is much slower. This decline in hydraulic conductivity is shown in Figure 4.4.23.

Figure 4.4.23 Hydraulic conductivity and soil moisture by soil texture. (Note: above curves are drawn on a log-log scale. The actual hydraulic conductivities of different soils can vary greatly.)



Landscape Position and Slope

Landscape position and slope affect water movement across a site and through the soil. Thus, an understanding of slope and landscape position is critical in predicting water flow and site suitability for on-site system placement. Well-positioned on-site systems ensure that water is drained away from the site and that an adequate depth of aerated soil (12 - 18 inches) is maintained under the treatment and disposal trenches.

The Effects of Topography and Landscape Position on On-Site System Placement

Relief, which includes slope and landscape position, is one of the five soil-forming factors that, along with climate, organisms, parent material and time, affect the soil's characteristics. Relief has a pronounced effect on the soil type and depth, characteristics that are critical in determining the suitability of a site for the placement of an on-site system.

Slope and topography.

Slope refers to the inclination of the land surface whereas topography refers to the physical features of an area of land, especially the surface configuration.

❑ The topography of an area can be described as hilly, mountainous, flat, or as a coastal plain, foothills, piedmont terrain, plateau, or mountain ridges. Topography can be simple, such as in areas with smooth land surfaces, or complex, such as in areas that have abruptly irregular land surfaces. For example, contours of elevation, and the shapes of hills, mountains, valleys, ravines, streams, and rivers are shown on a topographic map.

❑ Conventional on-site systems can be installed on slope from 0-65%. The shape of the slope at a specific site is also important. For example, a site on a slope may have an outward or convex curve, which is a good placement site, or an inward or concave curve, which is a poor placement site.

Landscape position.

Landscape position is the specific position on a topographic feature. For example, an area may have a hilly topography and the landscape position of an on-site system may be at the bottom of one hill in the area. The landscape position of the treatment and disposal field is critical to the performance of an on-site system.

Slope and landscape position.

Figure 4.4.24 shows the different landscape positions: *interfluve or ridgetop, shoulder slope, side slope, foot slope,* and *toe slope.*

1. The interfluve, or ridgetop, is the flat area between streams. If the distance between the streams is large then the area is called the interfluve. Conversely, if the distance is small then the flat area is the ridgetop.
2. The shoulder slope is the landscape position adjacent to the interfluve, where the flat areas begin to break into a slope. This slope is concave and water runs off without accumulating in the soil.
3. Side slopes have nine distinct slope types: linear-linear, linear-convex, linear-concave, convex-linear, convex-convex, convex-concave, concave-linear, concave-convex, and concave-concave (Figure 4.4.25).
   - Linear slopes follow a straight line down the slope but may be flat or curve across the slope, in the horizontal direction. If the land follows a

Figure 4.4.24 Topographical location and landscape position.

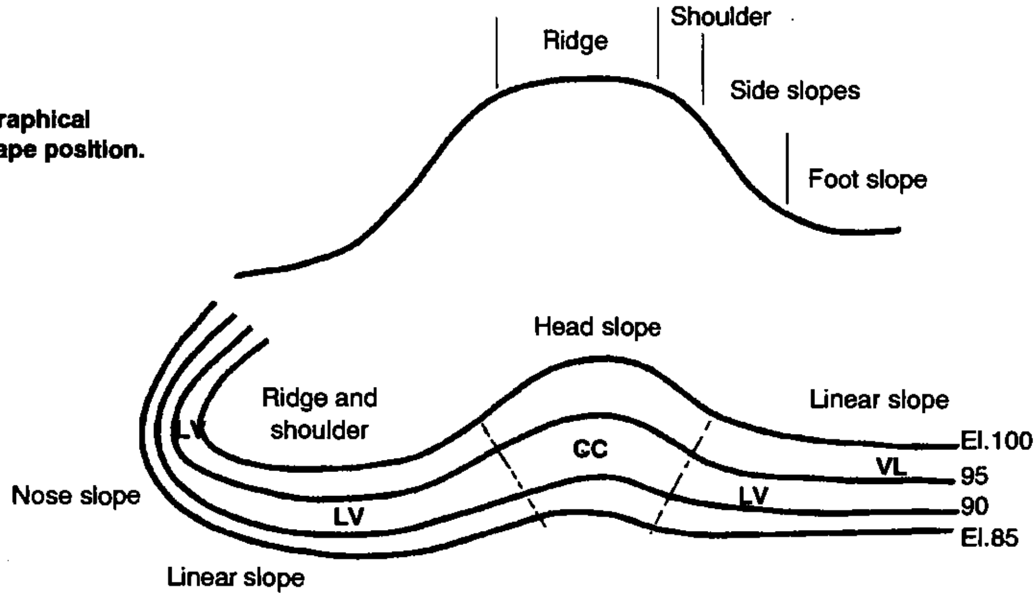
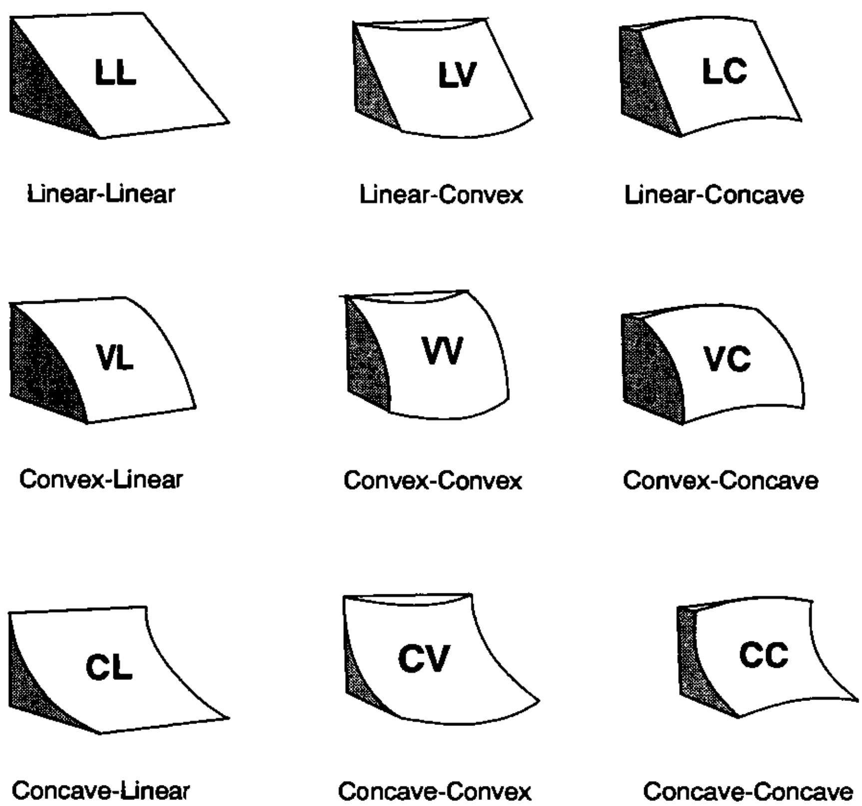


Figure 4.4.25 Types of side slopes (First word is downslope. Second word is across.).



straight line down the slope and across the slope, then it is called linear/linear. If the linear slope curves outward across the slope it is linear/convex, and if it curves inward it is linear/concave.

- More runoff flows away from the site on linear/linear and linear/convex slopes than on linear/concave slopes. This means that less water accumulates in the soil on linear/linear and linear/convex slopes than on linear/concave slopes.

4. Toward the bottom of the slope is the foot slope and the flatter toe slope. This is where *colluvium*, soils formed from debris moving down the hill, and *alluvium*, soils formed from deposits of sediment from streams, are found. The toe and foot slopes have a concave shape in the vertical direction and are often poorly drained.

Landscape position and slope in siting on-site systems.

Because slope and landscape position have pronounced effects on the soil type, soil depth, and drainage, these factors are extremely important in site evaluations for on-site systems. However, slope and landscape position must always be evaluated at each site because soil conditions and drainage differ in different regions. The following points indicate how slope and landscape positions should be used for site evaluations.

Reference
15A NCAC 18A.1940

❑ Land with a uniform slope less than 15% is considered to be SUITABLE for on-site systems.

❑ If the topography is such that the land has a uniform slope between 15 and 30%, then that land is considered PROVISIONALLY SUITABLE for on-site systems.

Reference
15A NCAC 18A.1956

❑ For land with a slope greater than 30%, the land is classified as UNSUITABLE unless an investigation shows that a modified conventional on-site system can be installed properly as under rule 15A NCAC 18A.1956.

❑ Slopes greater than 65% are always classified as UNSUITABLE.

Reference
15A NCAC 18A.1940

❑ Topography where there are complex shapes to the slopes or many gullies and ravines cutting the slopes is considered UNSUITABLE for on-site systems.

❑ Depressions, or bowl-shaped indentations in the land surface, usually are inappropriate sites for on-site systems and are classified as UNSUITABLE. Depressions collect water and are generally wetter than the surrounding soils, making them UNSUITABLE. However, if the site complies with other requirements and is approved by the local health department, the site may be considered SUITABLE.

❑ Toe slopes, foot slopes, head slopes, and depressional areas are difficult landscape positions for siting septic systems because these locations are frequently **not** sufficiently drained.

Occasionally, there is a difference in the suitability of the same landscape position in the three geographic regions in North Carolina (Table 4.4.12). This is because the same landscape position in different regions has differing drainage. For example, although the interfluve position is an excellent location for on-site systems in the Piedmont and Mountains, it is a poor site in the Coastal Plain. Because the Coastal Plain is relatively flat and also because there is a restrictive layer that causes a shallow ground water table, soils in the interfluve region of the Coastal Plain are poorly drained and are generally UNSUITABLE for on-site systems. See Figure 4.2.3 for an illustration of this characteristic.

Table 4.4.12 Landscape Position and On-Site System Siting Potential

Landscape Position	Geographic Regions		
	Piedmont	Mountains	Coastal Plain
Interfluve	excellent	excellent	poor
Shoulder	excellent	excellent	excellent
Side Slope:			
Linear/Linear	good	good	good
Linear/Convex	good	good	good
Linear/Concave	poor	poor	poor
Convex/Linear	excellent	excellent	excellent
Convex/Convex	excellent	excellent	excellent
Convex/Concave	poor	poor	poor
Concave/Linear	poor	poor	poor
Concave/Convex	poor	poor	poor
Concave/Concave	extremely poor	extremely poor	extremely poor
Foot Slope	poor	poor	poor
Toe Slope	poor	poor	poor

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4.5 SITE AND SOIL EVALUATION CONCEPTS*

The key to installing a reliable on-site system that minimizes pollution and disease is to identify suitable locations with a thorough site and soil evaluation. The evaluation determines suitability or points out site limitations. Only after a site evaluation has been completed can the proper on-site system be designed.

Reference
15A NCAC 18A.1935(40)

As defined in the rules

> **"site means the area in which the sewage treatment and disposal system is to be located and the area required to accommodate repairs and replacement of the nitrification field and permit proper functioning of the system."**

This section provides guidelines for a thorough site and soil evaluation.

Site and Soil Evaluation Principles

On-site systems must: (1) protect public health, and (2) minimize environmental impacts. To accomplish these goals, the state of North Carolina uses a site and soil evaluation to determine the suitability of a location for an on-site system and the type of system that can be installed.
This section discusses the purpose and offers guidelines for making a proper site and soil evaluation for a proposed on-site system.

Purpose of a Site and Soil Evaluation

The purpose of the site assessment is to understand the soil system and the hydrology of the site, to predict wastewater flow through the soil and into subsurface materials, and to design an on-site system to match the soil system and the hydrology of the site. The site and soil evaluation helps to predict how an on-site system will function at a site. How well the system functions depends on the soil's ability to absorb the wastewater, the probable flow paths of water from the site, and the treatment received by the wastewater.

The comprehensive site and soil evaluation used in North Carolina requires considerable expertise by the site evaluator. The site evaluator must have substantial knowledge about soil science, geology, sanitary engineering, and environmental health. Guidelines for a site evaluation are discussed below.

Guidelines for a Site Evaluation

The ten guidelines for a site evaluation can be grouped into the three components of a site evaluation:

1. collecting information before the site visit,
2. assessing the site and soil at the location, and
3. recording site evaluation data for system design and relaying the information to the designer of the system and the applicant.

**This section, Site and Soil Evaluation, was written from existing unpublished materials by Michael T. Hoover (Department of Soil Science, North Carolina State University).*

Collecting information before the site visit.

This component of site evaluation consists of preparation. Preparation includes learning about the sites and soils in the region and knowing what types of on-site wastewater systems can best fit a situation along with gathering information about the site to be evaluated.

FIRST GUIDELINE. ***Know the rules and know how to collect the needed information.*** The *Laws and Rules for Sewage Treatment and Disposal Systems* are established by the Commission for Health Services to protect public health and minimize the environmental damage from on-site systems. These rules provide performance criteria for on-site systems and consider the allowable risks to the environment and public health from constituents of the wastewater, such as bacteria, viruses, nitrate, phosphorus, and other pollutants. The rules also provide the legal support for a site and soil evaluation and set the standards for site suitability.

The standards in the rules determine the amount and level of information that will be collected for each site. An initial site assessment will determine the level of detail for the site investigation and the type of data that should be collected. For example, a site with relatively flat slope and deep, well-drained loamy soils will require less investigation than a site with a more complex slope and several different soil profiles.

SECOND GUIDELINE. ***Determine the wastewater flow rate and characteristics.*** Information on wastewater quantity and quality is used to determine the initial size and type of on-site system to be installed at a particular site. The information for determining wastewater quantity and quality can be obtained from the application for an Improvement Permit.

The type of activity and size of facility that the on-site system will serve determine the daily flow and the peak flow of wastewater, or *wastewater quantity*. Likewise, the strength of the wastewater, or *wastewater quality*, is determined by the activities in the facility and, to some degree, by the size of the facility and how and when the wastewater is created.

Wastewater quantity and quality affect the level of detail required for a site evaluation. For instance, a site proposed for treatment and disposal of wastewater from a school designed for 400 students would require a more extensive site evaluation than a system for a two-bedroom home.

THIRD GUIDELINE. ***Review preliminary site information.*** Existing, published information will help the evaluator understand the types of soils and their properties and distribution on the landscape.

- ❑ Published documents, such as soil survey reports; soil catena diagrams; and geologic, topographic and plat maps should be used for initial information about the site.

- ❑ ***Warning:*** **soil survey maps are good for planning, initial decision making, and helping you understand what to expect when you visit the site. However, they are not detailed enough to make siting recommendations. A field investigation is necessary for a proper site and soil evaluation. There is NO substitute for field investigations.**

FOURTH GUIDELINE. ***Understand the septic system design options.*** Site evaluators must understand how on-site systems function in order to assess trade-offs in design options. Additionally, the type of site investigation will also be determined by the system design options appropriate to the particular location. For instance, a different type of site investigation would be required for a modified conventional system using ground water interceptor drains than for a conventional on-site system.

❑ The on-site system must be designed to allow a sufficiently deep aerobic zone beneath the treatment and disposal field to properly treat the wastewater before it enters the ground water.

❑ Major design options include: the depth of the trench bottom or infiltrative surface; the loading rate used for sizing the system at the site; and the type of distribution system, such as gravity or pressure distribution and parallel or serial distribution.

❑ The use of pretreatment options may be needed at the site.

Assessing the site and soil at the location.

FIFTH GUIDELINE. ***View the on-site system as part of the soil system and the hydrologic cycle.*** Typically, on-site systems serving single-family homes do not add enough water to the site to substantially change the site's hydrology.

SIXTH GUIDELINE. ***Predict wastewater flow through the soil and the underlying materials.*** The soil morphological evaluation and landscape evaluation are important in predicting flow paths and rate of wastewater movement through the soil and underlying materials. These two evaluations are used for on-site systems in North Carolina because landscape position and soil morphology greatly influence wastewater flow from the site.

❑ Using the soil morphological characteristics, it can be determined whether water flow through the soil will occur primarily as vertical movement or as lateral movement in the horizontal direction.

❑ Also, the soil morphological characteristics are used to estimate the *long-term acceptance rate,* or *LTAR.* This estimate of LTAR will determine the size of the area you must investigate. For example, if the first estimate of LTAR for a site is 0.1 gallons per day per square foot (gpd/ft^2) then you will need to evaluate four times the amount of land area than if the estimated LTAR had been 0.4 gpd/ft^2. For LTAR calculations see section 4.6.

❑ Site and soil evaluations result in a more reliable prediction of wastewater movement than a percolation or *"perc" test.* The perc test estimates saturated hydraulic conductivity by filling a borehole with water and measuring how quickly the water level falls. North Carolina formerly used the perc test to evaluate sites for on-site systems, but it has been shown that the perc test technique is inaccurate and unreliable for determining wastewater flow. Therefore, North Carolina discontinued the use of the perc test for evaluating sites for on-site systems several years ago.

SEVENTH GUIDELINE. ***Determine if additional information is needed from the site.*** Site and soil conditions and the type of on-site system being considered determine whether additional evaluation is required. Some additional evaluations that may be required are: ground water mounding analysis, drainage analysis, hydrogeologic testing, linear loading rate evaluation, and hydraulic conductivity measurements.

❑ For instance, if a large system serving a school is proposed at a location with ground water within 7 to 10 feet of the soil surface, you would want to identify whether there are any horizons limiting flow. Saturated hydraulic conductivity measurements in the least permeable horizon followed by ground water mounding analyses would be beneficial. This analysis helps predict whether unsaturated, aerobic conditions will still be present beneath the treatment and disposal field after operation begins and if ground water mounding occurs beneath the system.

❑ In another example, if the soil is poorly drained, but sandy and located on a flat site, it may be possible to modify the seasonal high water table by using drainage. However, since the site is flat, additional investigations must be used to determine whether there is adequate elevation drop from the site to the proposed drainage outlet. This soil and site evaluation is necessary since drainage would not work effectively if there was not an adequate outlet available.

EIGHTH GUIDELINE. ***Assess the treatment potential of the site.*** The treatment potential of the site depends on the degree of soil aeration and the rate of flow of the wastewater through the soil. Wastewater is treated more effectively in well-aerated soils where wastewater flow is slow, which allows adequate adsorption and degradation of undesirable chemical and biological constituents. Thus, soil depth is crucial in determining the treatment potential of the site because there is a longer flow path through deeper soils. The longer flow path means more contact with the soil and soil organisms, and more time for degradation of pollutants.

❑ In North Carolina, there must be 12 inches or more of separation between the bottom of the trench and any limiting soil condition such as restrictive horizons, wetness conditions, or bedrock. This separation provides a reasonable flow path and contact time for the pollutants to be removed.

❑ The one exception is for Class I soils, which need a distance of 18 inches or more between the trench bottom and restrictive horizons, soil wetness conditions, or bedrock. These soils have a greater separation distance because wastewater flows more rapidly through them. The 18-inch separation provides more contact time for pollutant removal in these highly permeable soils.

NINTH GUIDELINE. ***Evaluate the site's environmental and public health sensitivity.*** Installing on-site systems in close proximity to community wells, near shellfish waters, in sole-source aquifer areas, or other sensitive areas may raise concerns regarding environmental and public health issues. When there are special environmental or public health concerns about a site, it may be necessary to obtain additional site information or perform certain evaluations to determine the degree of impact of the on-site system. In such cases adequate documentation must be kept to show that the site evaluation included the area of concern.

❑ For instance, concerns about public health may be raised when large on-site systems are located adjacent to community wells. Here a detailed assessment of the ground water flow system is warranted. It is essential to determine whether the plume of wastewater from the treatment and disposal field will be intercepted by the cone of depression of the community well. If the cone of depression of the well is affected, then additional pretreatment of the wastewater may be needed to minimize any chance of polluting the community well.

Recording site evaluation data for system design and relaying the information to the designer.

This component requires the site evaluator to communicate information gathered from the site evaluation to the person designing the system so that a proper design can be made.

TENTH GUIDELINE. ***Provide the system designer with soil/site descriptions and your recommendations.*** Based on the information gathered about the facility, and the actual site and soil evaluation, the last step is to suggest loading rates, highlight site and design considerations, and to point out special concerns in designing the on-site system.

❑ The site evaluator should rank each site for the type of system that can be installed and *provide specific soil and site data* that will enable selection of the most feasible design options for the site. It is not enough to just provide the recommended loading rate or design. You must provide the data upon which these decisions are based.

❑ In many cases, a single site and soil evaluation will be all that is necessary to design an appropriate system. However, on some sites, after collecting information about the site prior to and during the site visit, the evaluator may need additional information to determine the suitability of the site and the type of on-site system to be installed.

❑ The process of data collection, evaluation, and design is often an *iterative* process. This means that the whole process is repeated several times, where each time new information or a new design is tried until a design is found that will fit the site. Some sites may require many repetitions before the final selection of an appropriate on-site system is made.

Site and Soil Evaluation

Six factors must be evaluated for installation of an on-site system. These factors determine what type of on-site system best fits the site and how well the system will perform. The following section first discusses the six site and soil evaluation factors and how the site can be classified. Then each evaluation factor is presented in detail, explaining what the factor is and how to evaluate it. NOTE: This applies to design wastewater flows of 3,000 gpd or less.

Site and Soil Evaluation Factors

Reference

15A NCAC 18A.1939(a)

In the state of North Carolina six factors must be evaluated to determine the suitability of a site for on-site system installation. The six factors are:

1. slope and landscape position,
2. soil morphological characteristics,
3. soil wetness,
4. soil depth,
5. restrictive horizons, and
6. available space.

Classification of Factors

Reference

15A NCAC 18A.1939(c)

After the site and soil evaluation, the local health department will compile the information and classify each factor as SUITABLE (S), PROVISIONALLY SUITABLE (PS), or UNSUITABLE (U), for ground absorption sewage effluent treatment and disposal (Table 4.5.1).

Overall Site Suitability

Reference

15A NCAC 18A.1947

After each of the factors are classified as S, PS, or U, the overall site classification is determined by the most limiting factor that cannot be corrected by design or site modifications. For example, the soil wetness factor is U due to soil wetness at a depth of 32 inches in a loamy soil. The site may then be reclassified as PS, with the trench bottom installed no deeper than 20 inches.

Table 4.5.1. Site Classification

Suitability	Site and Soil Limitations	Special Considerations for Permitting
SUITABLE	Has no limitations. Has slight limitations.	None. Proper design and installation.
PROVISIONALLY SUITABLE	Has moderate limitations.	Modifications. Careful planning, design, and installation.
UNSUITABLE	Severe limitations. Severe limitations but special investigation indicates that a regular, modified, alternative, or innovative system can be installed and function satisfactorily.*	No permit issued unless site reclassified as PROVISIONALLY SUITABLE.

*The health department must determine that the site specific data from engineering, hydro-geologic, geologic, or soil studies indicate that a septic system can be installed such that effluent will not be:

1. pathogenic, infectious, toxic, or hazardous;
2. contaminating ground or surface water;
3. exposed on the ground surface or discharged to surface waters where it would come into contact with people, animals, or vectors.

Types of on-site systems allowed for each site classification.

Reference
15A NCAC 18A.1948

A site classified as SUITABLE receives a permit for on-site system installation with few restrictions. A permit with more restrictions is issued for a site classified as PROVISIONALLY SUITABLE. No permit is issued for UNSUITABLE sites unless the site is reclassified as PROVISIONALLY SUITABLE. The three types of site classification are described in the following list.

1. A conventional on-site system can be installed on a SUITABLE site with greater than 4 feet to any restrictions. This system could have 2 feet of backfill over the top of the crushed rock in the trench and the trench bottom would be at least 12 inches above any unsuitable soil layer. See Figure 4.5.1 for a diagram of a conventional trench.

2. A modified on-site system would have to be installed on a site permitted as PROVISIONALLY SUITABLE. For example, in a conventional modified system the distance between the soil surface and top of the crushed stone in the trench would only be 12 inches instead of 24 inches. See Figure 4.5.1 for a diagram of one type of modified conventional trench.

3. If a soil layer with unsuitable characteristics is located within 36 inches of the surface, the soil is classified as UNSUITABLE. With further investigation and if certain site modifications are made or if certain alternative on-site systems are used, the site may reclassified as PROVISIONALLY SUITABLE. Chapter 7 gives details about alternative systems.

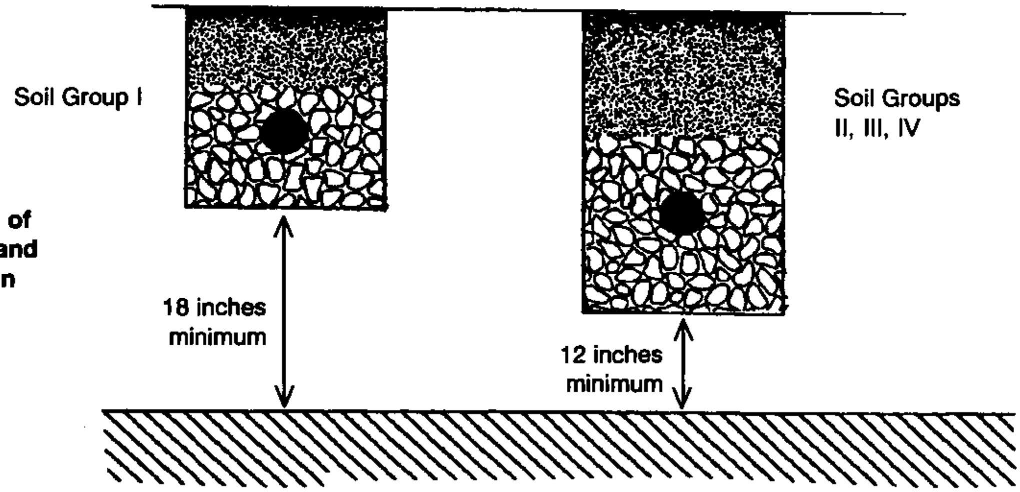


Figure 4.5.1 Placement of modified conventional and conventional trenches in the soil.

Reclassifying UNSUITABLE Sites.

Reference
15A NCAC 18A.1956(2)

Sites can be reclassified from UNSUITABLE to PROVISIONALLY SUITABLE because of soil wetness or restrictive horizons if the following conditions are met:

1. Soils are Group I or II with SUITABLE structure and clay mineralogy.
2. Restrictive horizons, if present, are less than 3 inches thick or less than 12 inches from the soil surface.
3. Site modifications can be made so that there is at least one foot of naturally occurring soil between the trench bottom and saprolite, rock, or any soil horizon unsuitable because of structure, clay mineralogy, and wetness. A low-pressure pipe system must be used if the separation between the bottom of the nitrification trench and any soil wetness condition is less than 18 inches and if more than 6 inches of this separation consists of Group I soils.

Reference
15A NCAC 18A.1955(m)

4. Easements are recorded and have adequate width for access to maintain drainage systems serving two or more lots.
5. Maintenance of the drainage system is made a condition of any permit issued for the use or operation of a sanitary sewage system.
6. Drainage can be used in other types of soil as long as the appropriate engineering, hydrogeologic, geologic, or soil studies indicate that:
   - a ground absorption system can be installed so that the effluent will be non-pathogenic, non-infectious, non-toxic, and non-hazardous;
   - the effluent will not contaminate ground water or surface water; and
   - the effluent will not be exposed on the ground surface or be discharged to surface waters where it could come in contact with people, animals, or vectors.

Evaluating Slope and Landscape Position

Two factors, *slope* and *landscape position*, determine whether water will collect at a site or flow away from the site. In general, concave or flat features accumulate water, resulting in wetter soil conditions. Convex sites tend to make water flow away from the site and are typically drier than concave or flat sites. Thus, slope and landscape position are extremely important factors in site evaluation because these factors strongly influence how wet the site is.

Slope also affects the installation of septic systems. It is impossible to operate equipment for system installation on a slope greater than 65%.

❑ When evaluating a site for landscape and slope, the environmental health specialist must locate the best position for the on-site system. To choose the best location, the environmental health specialist must evaluate the property for overall landscape position and for specific features.

- Overall topography and landscape position can be determined by walking over the property or standing at a location where the land surfaces can be seen. Those locations that have convex shapes or that have water flowing away from the location so that the soil is drier are the best locations for on-site systems. For example, it is better to install a treatment and disposal field on a ridge top than in a depressional area.
- The specific location on the lot should be evaluated for characteristics important to on-site systems. Some factors that should be investigated are:

1. What is the slope?
2. Does water flow to or away from the location?
3. Are there any depressional areas?
4. Are the soil depth and restrictive horizons deep enough to install the trench, given the slope?

❑ In evaluating the slope and landscape position, remember that laying out the system includes locating the system components in appropriate locations. For example, although the slope may not be a limiting factor, it may interfere with placement of some trenches due to the available soil depth.

Reference
15A NCAC 18A.1940

❑ Suitability for placement of conventional on-site systems, as determined by slope, is shown below.

Reference
15A NCAC 18A.1940(a-d)

Slopes < 15%	SUITABLE
Slopes 15% - 30%	PROVISIONALLY SUITABLE
Slopes > 30%	UNSUITABLE However, slopes 31% to 65% may be reclassified PROVISIONALLY SUITABLE if a modified system can be installed.
Complex slope patterns and slopes dissected by gullies and ravines	UNSUITABLE

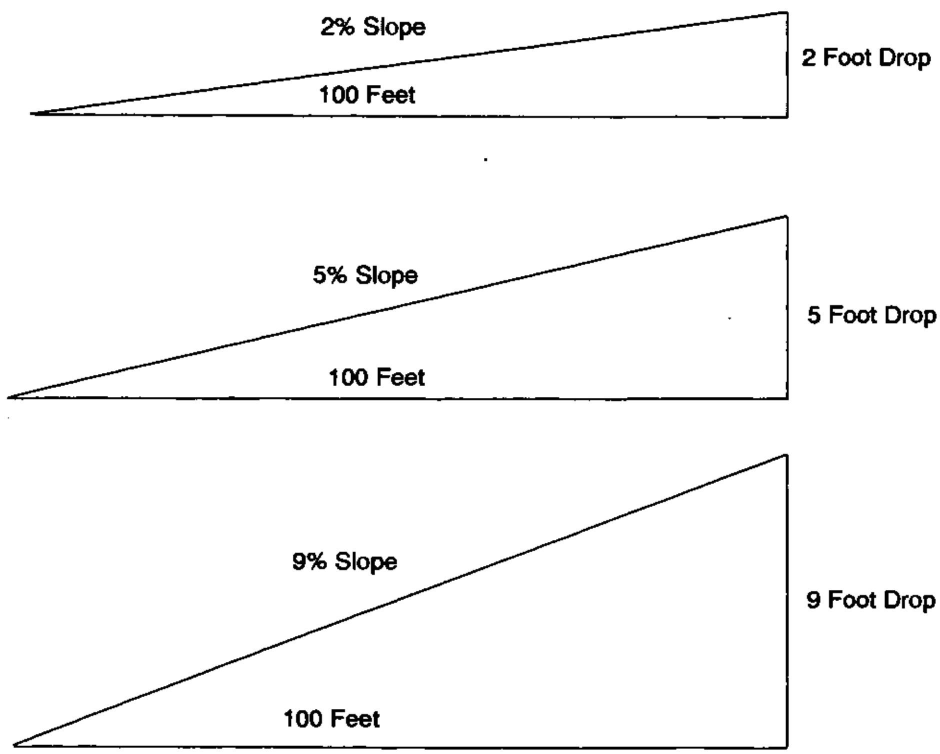
❑ For low-pressure pipe on-site systems, the slope cannot be greater than 10% unless special design procedures are approved to assure proper distribution of effluent over the treatment and disposal field.

❑ Area-fill systems cannot be installed on slopes greater than 15%.

Slope determination.

Slope is determined by measuring the change in elevation over a particular distance. Rods are held at the lowest position and the highest position. A surveyor's level is used to read the rod heights. The difference in these heights is the change in elevation. This change in elevation is then divided by the distance between the two rods. Three examples are presented below in Figure 4.5.2.

Figure 4.5.2 Slope determination.



❑ Two landscape positions that are UNSUITABLE for on-site systems are depressions and wetlands.

Reference
15A NCAC 18A.1940(e,g)

Reference
15A NCAC 18A.1937(c)

Depressions	UNSUITABLE unless the site is specifically approved by the local health department
Wetlands[1]	UNSUITABLE unless approval for on-site system installation is given in writing by the U.S. Army Corps of Engineers or the North Carolina Division of Coastal Management

[1]The applicant is responsible for notifying the local health department of any wetlands on the potential site.

Reference
15A NCAC 18A.1940(f)

❑ At sites where the landscape position and soil properties cause water to flow over or through the soil at the site of the treatment and disposal field, the local health department may direct the use of landscaping, surface diversions, or ground water interceptors to reduce the surface or subsurface water flow.

Evaluating Soil Morphological Characteristics

Reference

15A NCAC 18A.1941

Soil characteristics are critical in determining the suitability of a soil for treating wastewater. In North Carolina, the four soil characteristics evaluated are texture, structure, clay mineralogy, and organic soils. These characteristics are evaluated by using soil borings and soil pits.

Soil borings and soil pits for soil evaluation.

Four of the evaluation factors, wetness, depth, soil morphological characteristics, and restrictive horizons, require soil borings or digging a soil pit for proper evaluation. Soil borings are less expensive than soil pits and are sufficient to determine the suitability of the four soil factors for many sites. On sites that require a more detailed evaluation, a soil pit should be dug to determine site suitability. Pits provide a much better means to view and evaluate the soil than soil borings and should be used when a detailed soil description is necessary for site suitability determination.

❑ Soil borings are 2-4 inch diameter holes in the soil used to view the soil at a site. The borings or pit should be at least 48 inches deep or go down to a depth where an uncorrectable soil factor is encountered.

❑ Soil pits are holes large enough for a person to enter and view the soil closely. Backhoe-dug pits are an excellent diagnostic tool for soil depth, wetness, and restrictive horizons. Because a pit allows the evaluation of a larger cross-section than does the soil auger, the soil may be found to have different characteristics than those identified through auger sampling alone. Since the use of a backhoe-dug pit allows a more thorough soil evaluation, it may be possible to reclassify a site as PROVISIONALLY SUITABLE that would have been considered UNSUITABLE from auger borings alone prior to the pit evaluation.

- For example, a restrictive horizon at a site may be discontinuous. A soil pit analysis would probably reveal this discontinuity whereas a soil-auger test might not. By using soil pits, the site might be reclassified to reflect the restrictive layer discontinuity.
- Another situation in which pits are useful is for soils with stony or gravelly layers found in the Piedmont or Mountains. For these soils, a soil boring may lead the evaluator to think that a stony layer is impervious bedrock. A soil pit, on the other hand, may reveal that the layer is a stony or gravelly horizon that will not impede water flow.

❑ A soil pit, in conjunction with soil borings, must always be used when evaluating saprolite.

Soil texture.

Soil texture is defined as the relative proportions of the various soil separates in a soil. Texture is a soil morphological property that affects a site's suitability for treating and safely disposing of wastewater. Texture influences the hydraulic conductivity, the porosity, and the structure of a soil. Soils with poor drainage due to heavy texture, such as clay soils, may not allow wastewater to move rapidly enough through the soil to dispose of the needed volume of wastewater. Soils that are too wet or that become too wet do not provide sufficient air for the beneficial *microorganisms*, or bacteria, that are "treating" the wastewater.

Reference
15A NCAC 18A.1935(43)

According to the rules

> **"Soil textural classes means soil classification based upon size distribution of mineral particles in the fine-earth fraction less than two millimeters in diameter. The fine-earth fraction includes sand (2.0 -0.05 mm in diameter), silt (less than 0.05 mm -0.002 mm or greater in diameter), and clay (less than 0.002 mm in diameter) particles. The specific textural classes are . . . as shown in Soil Taxonomy, Appendix I, which is hereby adopted by reference in accordance with G.S. 150B-14(c) . . ."**

❑ Texture in each soil horizon can be determined by hand. Table 4.5.2 presents the criteria used to determine soil textural class by hand as described in *Soil Taxonomy* (USDA-SCS, 1975).

Reference
15A NCAC 18A.1941(a)(1)(F)

❑ If, however, laboratory analyses are used, the examination should follow the American Society for Testing and Materials D-422 procedures for soil textural testing but use the USDA particle size system for classifying textural categories. Additionally, fine loamy and clayey soils (Groups III and IV) should be soaked in a dispersing agent for 12 hours prior to the hydrometer analyses.

Reference
15A NCAC 18A.1941(a)(1)(1-D)

❑ The soil texture determinations of the fine earth fractions (< 2mm diameter) usually divide soil into 12 textural classes. In North Carolina, for the purpose of on-site wastewater evaluation, the 12 classes are combined into four textural groupings:

Group I — Sandy Texture Soils

Group II — Coarse Loamy Texture Soils

Group III — Fine Loamy Texture Soils

Group IV — Clayey Texture Soils

Table 4.5.3 shows how all 12 soil textural classes are assembled into these four groupings.

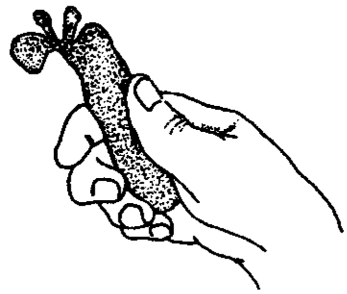
1. Soils in Group I and II are SUITABLE for on-site systems.
2. Group III and IV soils are PROVISIONALLY SUITABLE for on-site systems.

Table 4.5.2
Criteria for Soil Textural Class Determination

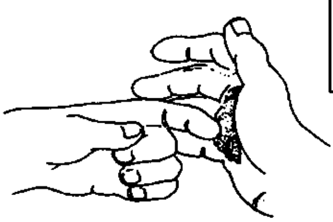
START

Place approximately 25g soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.

Does soil remain in a ball when squeezed?
- NO → Is soil too dry?
  - YES → (back to: Place approximately 25g soil in palm…)
  - NO → Is soil too wet?
    - YES → Add dry soil to soak up water → (back to: Place approximately 25g soil in palm…)
    - NO → SAND
- YES → Place a ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.



Does soil form a ribbon?
- NO → LOAMY SAND
- YES → Does soil make a weak ribbon less than 2.5 cm long before breaking?
  - NO → Does soil make a medium ribbon 2.5-5 cm long before breaking?
    - NO → Does soil make a strong ribbon 5 cm or longer before breaking?



(YES to any of the three ribbon questions) → Excessively wet a small pinch of soil in palm and rub with forefinger.

	Weak ribbon (less than 2.5 cm)	Medium ribbon (2.5-5 cm)	Strong ribbon (5 cm or longer)
Does soil feel very gritty? YES →	SANDY LOAM	SANDY CLAY LOAM	SANDY CLAY
NO → Does soil feel very smooth? YES →	SILT LOAM	SILTY CLAY LOAM	SILTY CLAY
NO → Neither grittiness nor smoothnes predominates. YES →	LOAM	CLAY LOAM	CLAY

Table 4.5.3 State of North Carolina Soil Texture Groupings for On-Site Wastewater Systems

Suitable Soils		Provisionally Suitable Soils	
Group I Sandy Soils	Sand Loamy Sand	Group III Fine Loamy Soils	Silt Loam Silt Sandy Clay Loam Silty Clay Loam Clay Loam
Group II Coarse Loamy Soils	Sandy Loam Loam	Group IV Clayey Soils	Sandy Clay Silty Clay Clay

Soil structure.

Reference
15A NCAC 18A.1941(a)(2)(A-F)

Soil structure is a way to describe how individual soil particles are arranged into larger groupings of particles called aggregates. Structure affects the rate of water movement through the soil, the amount of air that can get into the soil, and thus the soil's ability to treat wastewater. Table 4.5.4 describes soil structure categories, as designated in the rules, and assigns suitability classes to the different soil structures.

❑ Five soil structures are recognized for site evaluation purposes.

1. Crumb and granular
2. Block-like
3. Platy
4. Prismatic
5. Absence of structure: a) single grain and b) massive

❑ The presence of block-like structure is particularly important in some Piedmont and Mountain soils, since water flow around these block/peds allows these soils to be used for on-site waste management (refer back to the section on soil structure in the Basic Soil Concepts chapter for more details).

❑ For information on soil structure refer to *Soil Taxonomy*, Appendix I (USDA-SCS, 1975).

Reference
15A NCAC 18A.1941(a)(3)(A-B)

Clay mineralogy.

The type of clay mineralogy and the amount of clay in a soil influence water movement.

There are different types of clays. The two major types of clay are 2:1 and 1:1 clays. 2:1 clays expand when wet, whereas 1:1 clays expand only slightly when wet. These concepts are discussed below.

❑ Clays with a 2:1 mineralogy, such as montmorillonite, shrink when dry and swell upon wetting. When a soil swells, the soil particles expand into the structural voids, reducing the size of the openings, and reducing total porosity. The hydraulic conductivity of the soil is therefore reduced, which limits the movement of wastewater through the soil. Soils with 2:1 clay mineralogy are generally not suitable for on-site systems because the soil swells and restricts the flow of water.

Table 4.5.4 Description of Soil Structure Types and Suitability

Soil Structure Type	Description (if needed)	Suitability
Crumb and granular		SUITABLE
Block-Like	peds ≤ 2.5 cm (1 inch) diameter	PROVISIONALLY SUITABLE
	peds > 2.5 cm (1 inch) within 36 inches of the naturally occurring soil surface	UNSUITABLE
Platy	within 36 inches of the naturally occurring soil surface	UNSUITABLE
Prismatic	within 36 inches of the naturally occurring soil surface	UNSUITABLE
Absence	single grained and exhibit no structural aggregates	SUITABLE
	massive and exhibit no structural peds within 36 inches of the naturally occurring soil surface	UNSUITABLE

❑ Soils with 1:1 clays, such as kaolinite, have less shrink/swell potential. Soils with 1:1 clay mineralogy are suitable for on-site systems because these soils do not swell and restrict the water flow.

❑ If the clay fraction of the soil has between 10 and 50% 2:1 clays, *the soil has mixed mineralogy*. Some soils with mixed clay mineralogy can be used for on-site systems; some cannot. Soils with mixed mineralogy are not suitable for on-site systems if the consistence is very firm, extremely firm, very sticky, or very plastic. Each soil in this class must be evaluated to determine if it is suitable for on-site wastewater disposal.

❑ Soils with predominately 1:1 clays and less than 10% 2:1 clays are usable for on-site systems.

❑ In lieu of a laboratory analysis to determine clay mineralogy, the American Society for Testing and Materials (ASTM) procedures must be used to determine *liquid limit, plastic limit,* and *the plasticity index* of the soils.

Soil consistence.

Clay mineralogy can be determined in the field by evaluating *soil consistence.* Soil consistence is a measure of how well the soil forms shapes and how well it sticks to other objects. Consistence can be determined when the soil is dry, moist, or wet. In North Carolina, the best test for soil consistence is when the soil is moist or wet.

❑ In a moist soil, consistence is determined by looseness, friability, and firmness.

❑ In a wet soil, two consistency factors, *soil stickiness* and *plasticity*, should be determined. Stickiness, how well the soil sticks to other objects, is determined by pressing the soil between the fingers and thumb. Plasticity, how well the soil forms shapes, is determined by rolling the soil between the thumb and forefinger to determine whether a thin rod or wire of soil can be formed. See Table 4.4.9 in the section on Basic Soil Concepts for more details on how to evaluate soil consistence. Additional information on soil consistence can be found in the publication *Soil Taxonomy* (USDA-SCS,1975).

Reference
15A NCAC 18A.1941(b)

❑ If the soil is UNSUITABLE because of structure or clay mineralogy, the classification may be changed to PROVISIONALLY SUITABLE if an investigation determines that a modified or alternative septic system would function appropriately on this site. See 15A NCAC 18A.1956 or .1957 for the rules governing installation of modified or alternative septic systems.

Site suitability.

The suitability of a soil for on-site system installation, based on consistence measured at either wet or moist soil conditions, is shown in Table 4.5.5.

Table 4.5.5 Soil Consistency Criteria for Siting Septic Systems

Clay Mineralogy	Suitability	Evaluated at Moist Water Content	Evaluated at Wet Water Content
Slightly expansive (includes non-expansive)	SUITABLE	Loose, very friable, friable, or firm	Non-sticky, slightly sticky to sticky or non-plastic, slightly plastic to plastic
Expansive	UNSUITABLE	Very firm or extremely firm	Very sticky, very plastic

Organic matter.

Reference
15A NCAC 18A.1941(a)(4)

Organic soils, soils with 20% or more organic matter by weight to a depth of 18 inches or greater, are always UNSUITABLE as locations for on-site systems. These soils remain wet throughout most of the year because they drain too slowly. Organic soils may also burn or subside causing the on-site system to be destroyed.

Soil Wetness

Reference
15A NCAC 18A.1941(a)(4)

Adequate treatment of wastewater can only occur in well-aerated soils. Because wet soils do not allow adequate treatment of wastewater, on-site systems must not be installed in wet soils.

Soil color is used to indicate soil wetness. Once the soil colors and the depth of these colors have been determined, the soil can be classified for suitability of on-site system installation based on wetness.

❑ *Chroma* is the relative strength, purity, or saturation of the color of the soil. Chromas of 2 or less on the Munsell color chart, either in mottles or as a solid soil mass, often indicate a wet soil. The wetness could be caused by a seasonal high-water table, perched water table, tidal water, soils that are saturated during the rainy season, or movement of ground water into and through the soil. The relationships between the depth to the soil with chroma 2 or less color and the site suitability for installation of an on-site system are presented in Table 4.5.6.

Reference
15A NCAC 18A.1942(a)

Table 4.5.6 Soil Wetness and Site Suitability

Soil Wetness Depth (from Soil Surface)	Suitability
> 48"	SUITABLE
36 - 48"	PROVISIONALLY SUITABLE
< 36"	UNSUITABLE

❑ Sometimes soil color is an artifact of the original parent material and is not indicative of soil wetness. If the soil color is due to the original parent material, then color shall not be used to judge the suitability of this soil for the installation of an on-site system.

❑ Other site characteristics can be used to indicate soil wetness. Vegetation and landscape position can both be used as an initial indicator of wet areas.

❑ If the site has been drained, the soil must be evaluated for soil wetness by monitoring the site with monitoring wells from December through March to determine the water table depth.

❑ In the Piedmont, interceptor drains may be used for lowering perched water tables. In the mountains, these drains can divert laterally moving water in colluvial soils. In the Coastal Plain, ground-water-lowering devices, such as subsurface tiles, ditches, or pumped drainage, are frequently used.

Reference
15A NCAC 18A.1942(b)

❑ If the soil is UNSUITABLE because of wetness, the classification may be changed to PROVISIONALLY SUITABLE if an investigation determines that a modified or alternative septic system would function appropriately on this site. See 15A NCAC 18A.1956 or .1957 for the rules governing installation of modified or alternative septic systems.

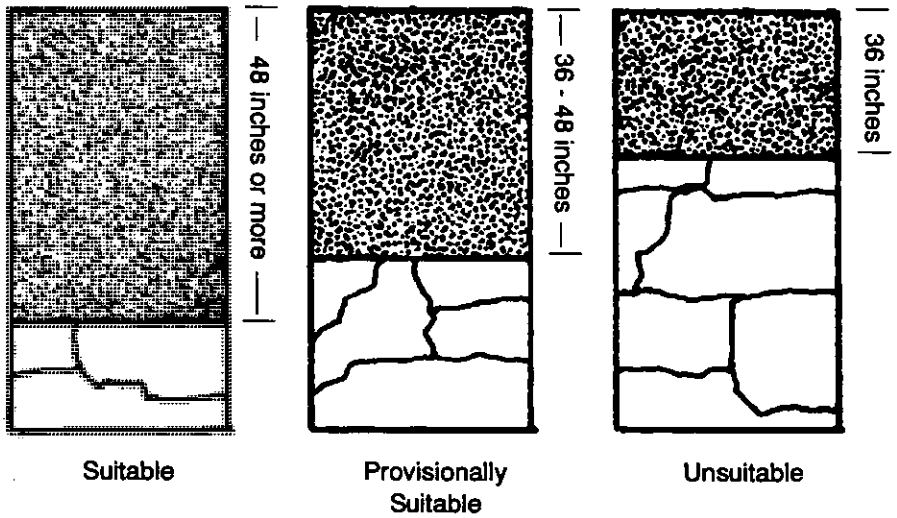
Soil Depth

Reference

15A NCAC 18A.1943(a)

Soils must have enough depth so that wastewater is properly treated. Soil depth from the soil surface to the saprolite, rock, or parent material is a major factor in determining the suitability of the site for on-site systems. See Figure 4.5.3 for a drawing showing soil depth requirements, as stated in the rules.

Figure 4.5.3 Soil depth and site suitability.



❑ Twelve inches or more of aerated soil is generally required beneath the trenches to adequately treat the wastewater. However, a total of 48 inches of acceptable soil is necessary for conventional on-site system installation. If the total soil depth is between 36 inches and 48 inches, a modified on-site system can be installed, requiring 12-24 inches of soil above the trench, a 12-inch trench, and 12 inches below the trench.

Reference

15A NCAC 18A.1943(b)

Reference

15A NCAC 18A.1957(a)(2)(B)

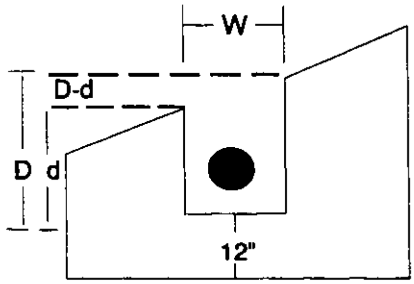
❑ The only exception to the soil depth requirement is for sites with less than 36 inches of soil where the site evaluation has determined that a modified or alternative system can be installed. For instance, site suitability for low-pressure pipe systems must be based on the first 24 inches of soil beneath the naturally occurring soil and surface. See 15A NCAC 18A.1956 or .1957 for the rules governing installation of modified or alternative septic systems.

Soil depth and slope.

On steep slopes, the depth of soil required for installation of trenches may be greater than the depth called for in the rules. This extra soil depth is needed to keep the bottom of the trench level and at the proper depth on the sloping site. For example, if a treatment and disposal field has a slope of 60% and a modified conventional system with a trench depth of 24 inches is to be installed, then the minimum soil depth at the lowest elevation must be 57.6 inches. This depth is required because on a 60% slope with a 36-inch wide trench, there is a difference of 21.6 inches between the uphill and downhill sides of the trench. To keep the downhill side of the trench 24 inches deep and to have 12 inches of soil under the trench bottom, there must be 57.6 inches (21.6 + 24 + 12) of total soil depth.

See Figure 4.5.4 for another explanation of the extra depth of soil required to install trenches on slopes. Table 4.5.7 lists the differences in the uphill and downhill sides of a trench for trenches of various widths on various slopes.

Figure 4.5.4 Difference in depth in inches between uphill and downhill side of trench.



Example: For a trench width (W) of 36 inches and a slope of 40%, the difference between the uphill and downhill side of the trench (D-d) is 14.4 inches. For a trench depth (d) of 18 inches and a minimum separation from trench bottom of 12 inches, the required minimum soil depth is 18+12+14.4 = 44.4 inches.

Soil depth and the use of saprolite.

Reference
15A NCAC 18A.1956(6)

If soils are not deep enough to install an on-site system but are underlain by saprolite, the site may be reclassified as PROVISIONALLY SUITABLE under certain conditions. A trench or pit investigation of the saprolite must be conducted in order to determine if the following physical properties and characteristics are met:

1. Saprolite must have weathered from igneous or metamorphic rocks.
2. Saprolite texture must be sand, loamy sand, sandy loam, loam, or silt loam.
3. Clay mineralogy must be SUITABLE (non or slightly expansive).
4. Moist saprolite consistence must be loose, friable to very friable or firm for more than 2/3 of the material.
5. Wet saprolite consistence must be nonsticky or slightly sticky and nonplastic or slightly plastic.
6. The saprolite must have no open and continuous joints, quartz veins, or fractures relic of parent material to a depth of 2 feet below the proposed trench bottom.

Saprolite depth. When saprolite is used rather than soil to treat wastewater, a separation distance of 24 inches is necessary between the bottom of the trench and any weathered rock or bedrock (Figure 4.5.5). If the trench is placed partially in soil and partially in saprolite, then the separation distance is 24 inches – x, where x is the depth of the soil in inches (Figure 4.5.5). For example, if a 12-inch trench was composed of 9 inches of soil and 3 inches of saprolite, then the total depth of saprolite necessary to treat the wastewater would be 15 inches (24 inches – 9 inches = 15 inches).

Figure 4.5.5 Trench placement in saprolite soil and a mixed soil/saprolite.

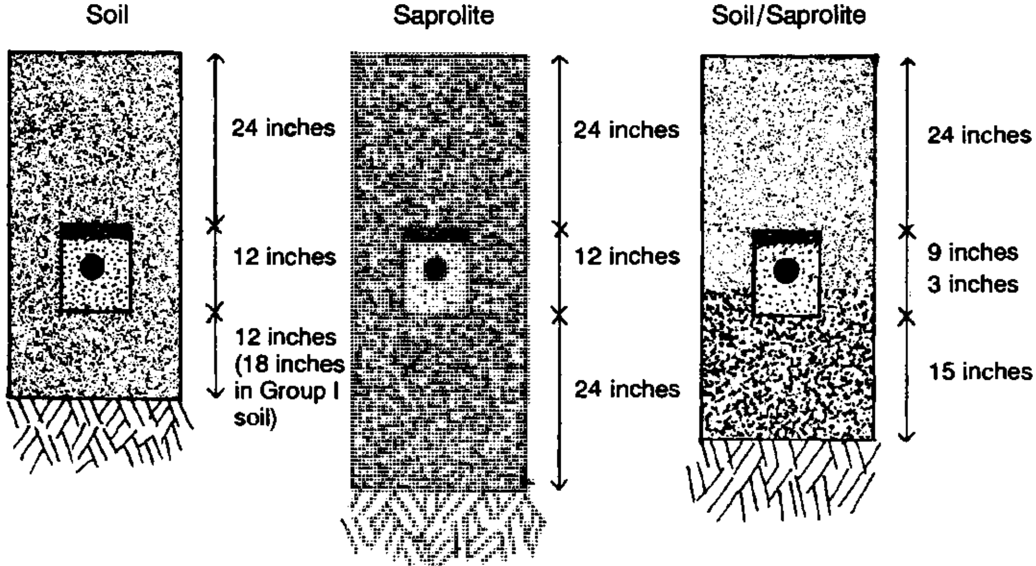


Table 4.5.7 Difference in Uphill and Downhill Sides of Trenches in Inches by Slope and Trench Widths

Slope	Trench Width (inches)							
(%)	12	15	18	21	24	27	30	36
2.0	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7
4.0	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.4
6.0	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.2
8.0	1.0	1.2	1.4	1.7	1.9	2.2	2.4	2.9
10.0	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.6
12.0	1.4	1.8	2.2	2.5	2.9	3.2	3.6	4.3
14.0	1.7	2.1	2.5	2.9	3.4	3.8	4.2	5.0
16.0	1.9	2.4	2.9	3.4	3.8	4.3	4.8	5.8
18.0	2.2	2.7	3.2	3.8	4.3	4.9	5.4	6.5
20.0	2.4	3.0	3.6	4.2	4.8	5.4	6.0	7.2
22.0	2.6	3.3	4.0	4.6	5.3	5.9	6.6	7.9
24.0	2.9	3.6	4.3	5.0	5.8	6.5	7.2	8.6
26.0	3.1	3.9	4.7	5.5	6.2	7.0	7.8	9.4
28.0	3.4	4.2	5.0	5.9	6.7	7.6	8.4	10.1
30.0	3.6	4.5	5.4	6.3	7.2	8.1	9.0	10.8
32.0	3.8	4.8	5.8	6.7	7.7	8.6	9.6	11.5
34.0	4.1	5.1	6.1	7.1	8.2	9.2	10.2	12.2
36.0	4.3	5.4	6.5	7.6	8.6	9.7	10.8	13.0
38.0	4.6	5.7	6.8	8.0	9.1	10.3	11.4	13.7
40.0	4.8	6.0	7.2	8.4	9.6	10.8	12.0	14.4
42.0	5.0	6.3	7.6	8.8	10.1	11.3	12.6	15.1
44.0	5.3	6.6	7.9	9.2	10.6	11.9	13.2	15.8
46.0	5.5	6.9	8.3	9.7	11.0	12.4	13.8	16.6
48.0	5.8	7.2	8.6	10.1	11.5	13.0	14.4	17.3
50.0	6.0	7.5	9.0	10.5	12.0	13.5	15.0	18.0
52.0	6.2	7.8	9.4	10.9	12.5	14.0	15.6	18.7
54.0	6.5	8.1	9.7	11.3	13.0	14.6	16.2	19.4
56.0	6.7	8.4	10.1	11.8	13.4	15.1	16.8	20.2
58.0	7.0	8.7	10.4	12.2	13.9	15.7	17.4	20.9
60.0	7.2	9.0	10.8	12.6	14.4	16.2	18.0	21.6

Restrictive Horizons

The depth where restrictive horizons are located is important when determining the suitability of a site. Because restrictive horizons retard or stop water or wastewater flow, the presence of these horizons, if they are too close to the soil surface, can disqualify a site for on-site system installation.

Reference
15A NCAC 18A.1944(a)

As defined in the rules, *restrictive horizon* means

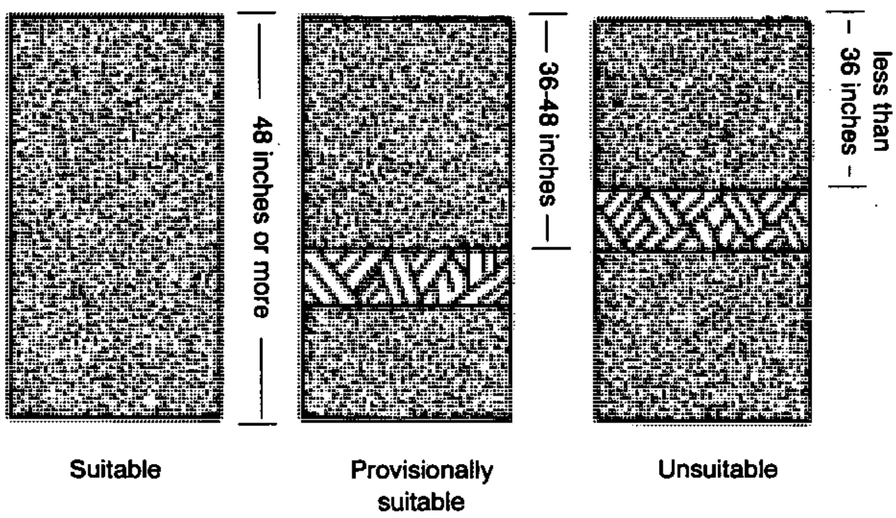
> **"a soil horizon that is capable of perching ground water or sewage effluent and that is brittle and strongly compacted or strongly cemented with iron, aluminum, silica, organic matter, or other compounds. Restrictive horizons may occur as fragipans, iron pans, or organic pans, and are recognized by their resistance in excavation or in using a soil auger."**

❑ For purposes of site evaluation, restrictive horizons are defined as layers of material that are at least three inches thick that effectively prevent water from flowing through. See Figure 4.5.6, which shows the relationship between restrictive horizon depth and suitability for on-site system installation.

Reference
15A NCAC 18A.1944(b)

❑ The only exception to the restrictive horizon depth requirement is for sites where the restrictive horizon is less than 36 inches from the surface and where the site evaluation has determined that a modified or alternative system can be installed. See 15A NCAC 18A.1956 or .1957 for the rules governing installation of modified or alternative septic systems.

Figure 4.5.6 Soil restrictive layers and site suitability.



Available Space

Available space for on-site systems depends on both the area of acceptable soil and site conditions and the required separation distances between the on-site system and buildings, water supplies, and other structures.

On-site space needed.

Reference
15A NCAC 18A.1945(a)

Sites for on-site systems must be large enough to allow installation and proper functioning of the systems. There must be enough area for the treatment and disposal field so that the system has long-term reliability. (See Section 4.6 for information on long-term acceptance rates of septic wastewater.)

Reference
15A NCAC 18A.1945(b)

❑ In addition to the area needed for the treatment and disposal field, sites must be large enough area for a *repair* or replacement system that is set aside. The repair area would be used to install another treatment and disposal field if the original treatment and disposal field fails.

Reference
15A NCAC 18A.1935(31)

In the rules, the definition of the *repair area* is

> **"an area, either in its natural state or which is capable of being modified, consistent with these rules, which is reserved for the installation of additional nitrification fields and is not covered with structures or impervious materials."**

❑ The size of repair areas must conform to the rules for the design criteria of conventional sewage systems (15A NCAC 18A.1955), modifications to septic tank systems (15A NCAC 18A.1956), or for design of alternative sewage systems (15A NCAC 18A.1957). For example, the initial system may be a conventional septic system with 4 trenches, 9 feet on center, and 80 feet long; and the replacement may be a pressure distribution system with 10 trenches, 5 feet on center, and 80 feet long. The repair area must also conform to the necessary setbacks. The Improvement Permit must designate the original system layout, repair area, and type of replacement system.

Reference
15A NCAC 18A.1945(c)

❑ There are exceptions to the repair area criteria described above. If a site or tract of land meets all of the following criteria then it is exempt from the repair area space requirement:

- The lot or tract of land was on record with the Register of Deeds at the court house on January 1, 1983.
- The lot is of insufficient size to satisfy the repair area requirement.
- A system of no more than 480 gallons is to be installed.

Reference
15A NCAC 18A.1945(d)

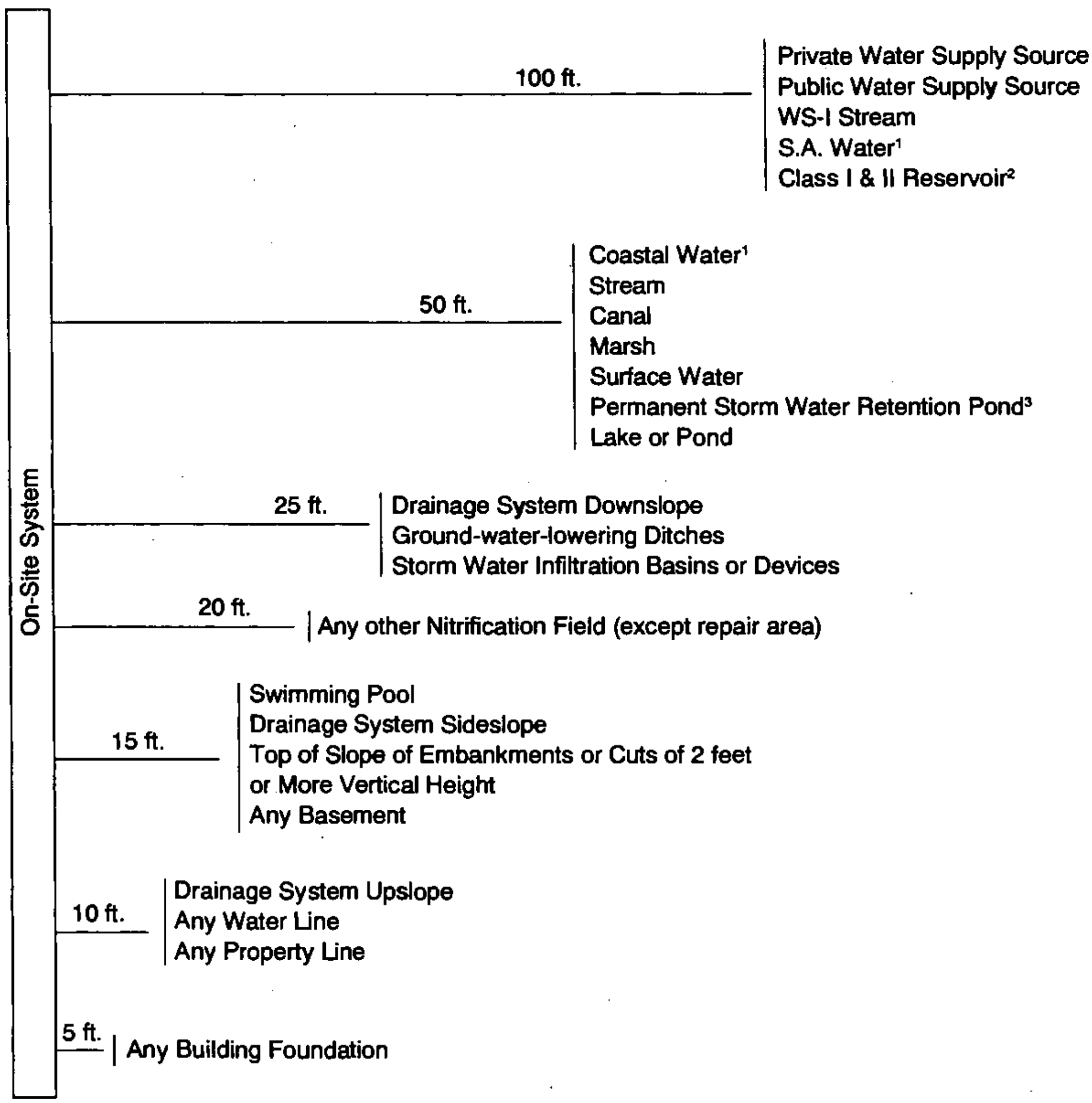
❑ Lots exempt from the replacement system area requirement must still reserve the maximum feasible area for repairs or expansion of the initial system.

Horizontal distance placement requirements.

A site must have enough space to install the on-site system and to keep a separation between the system and certain features or structures. On-site systems must be set back certain distances from water supply sources, streams, lakes, drains, buildings, property lines, and other features. These minimum setback distances are to protect water wells, streams, and homes from pollution by the on-site system, allow for area to install the system, and space for the treatment and disposal of wastewater.

Placement distances for conventional and modified on-site systems are presented in Figures 4.5.7-9 on the following pages.

Figure 4.5.7 On-site treatment and disposal system component placement distances for flows less than 3,000 gallons/day



NOTES:

[1] From "mean high water mark"— see definition in 15A NCAC 18A. 1935(15).

[2] From "normal pool elevation"

[3] From "flood pool elevation"

Figure 4.5.8 On-site disposal system placement distances for flows greater than 3,000 gallons per day with one or more treatment and disposal fields receiving more than 1,500 gallons per day.

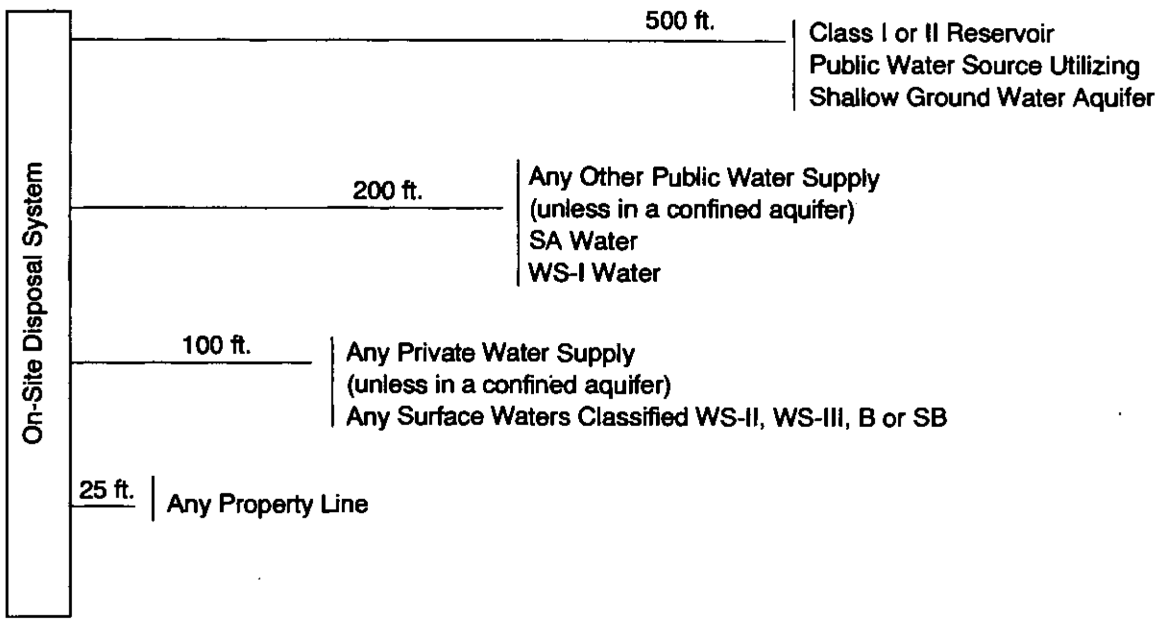
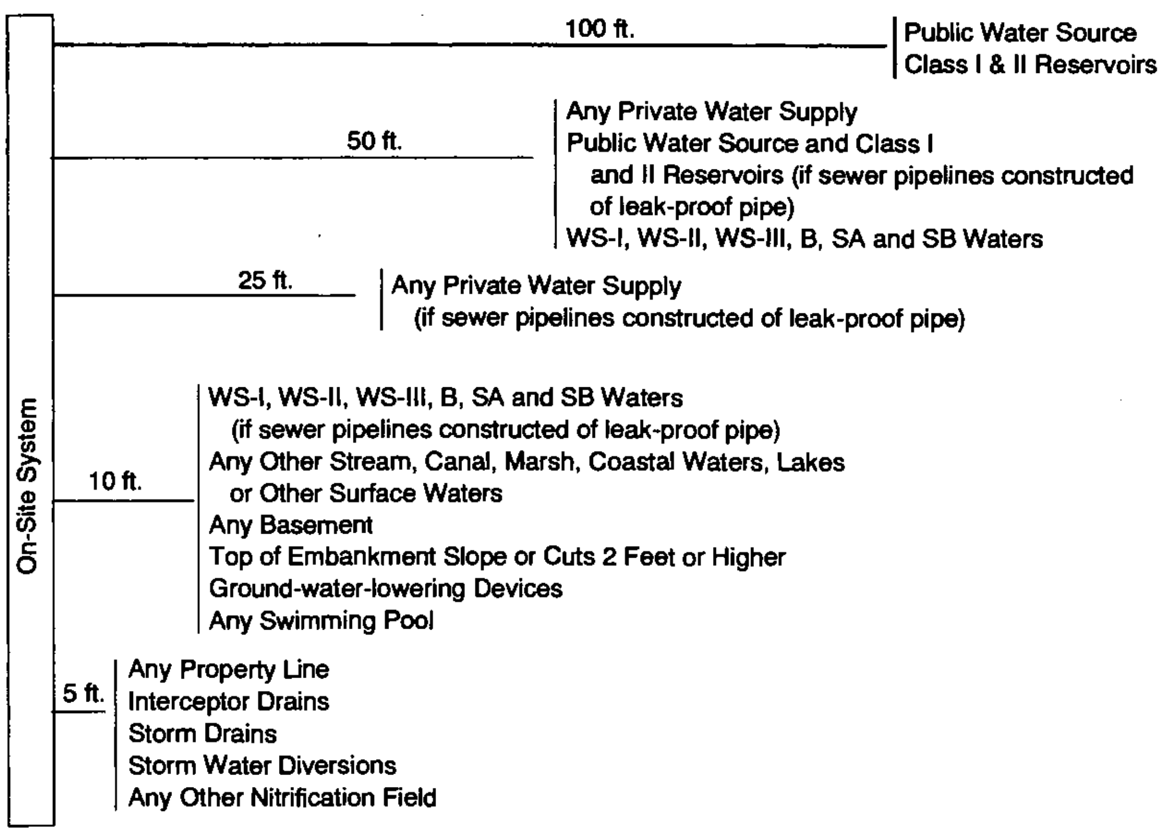


Figure 4.5.9 On-site system placement distances for collection sewers, force mains, and supply lines.



Reference

15A NCAC 18A.1950(f,g,h)

Rules for the placement of sewer lines crossing a water line, a storm drain, and a stream are presented in Table 4.5.8.

Table 4.5.8 Location of Sewer Lines

	Separation Distance/ Sewer Line Location	Required Construction
Water lines	Sewer lines may cross a water line if 18 inches of clear separation distance is maintained, with the sewer line passing under the water line.	If conditions prevent 18-inch separation from being maintained or whenever it is necessary for the water line to cross under the sewer, the sewer line shall be constructed of ductile iron pipe or its equivalent and the water line shall be constructed of ferrous materials equivalent to water main standards for a distance of at least 10 feet on each side of the point of crossing, with full sections of pipe centered at the point of crossing.
Storm drains	Sewer lines may cross a storm drain if 12 inches of clear separation distance is maintained.	Sewer lines may also cross a storm drain if the sewer is of ductile iron pipe or encased in concrete or ductile iron pipe for at least five feet on either side of the crossing.
Streams	Sewer lines may cross a stream if at least three feet of stable cover can be maintained.	Sewer lines may also cross a stream if the sewer line is of ductile iron pipe or encased in concrete or ductile iron pipe for at least 10 feet on either side of the crossing and protected against the normal range of high and low water conditions, including the 100-year flood/wave action. Aerial crossings shall be by ductile iron pipe with mechanical joints or steel pipe. Pipes shall be anchored for at least 10 feet on either side of the crossing.

Source: *Laws and Rules for Sewage Treatment and Disposal Systems.* 1992. North Carolina Department of Environment, Health, and Natural Resources, Division of Environmental Health On-Site Wastewater Section.

Some exceptions to the rules and general provisions for separation distances are listed in Table 4.5.9.

Reference
15A NCAC 18A.1950(b)

Reference
15A NCAC 18A.1950(c)

Reference
15A NCAC 18A.1955(e)

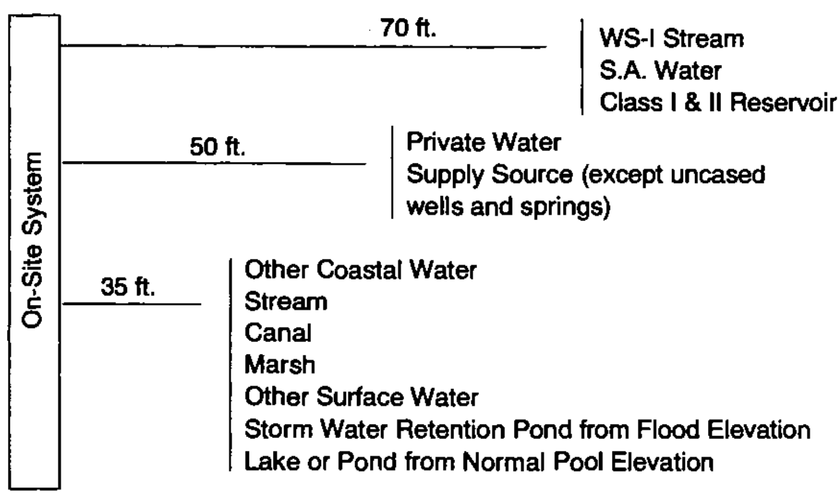
Reference
15A NCAC 18A.1950(i)

Table 4.5.9 Additional Rules for Locating On-Site Systems

Wastewater System Component	Location and Construction Requirement
Ground absorption sewage treatment and disposal system and repair areas.	May be located closer than 100 feet from private water supply but no closer than 50 feet. Springs or uncased wells that are down slope and used as a drinking water source require 100 foot separation.
Treatment and disposal fields and repair areas.	These fields cannot be located under paved areas or areas that have vehicle traffic. If pipe runs under vehicle traffic areas, then the conveyance pipe must be made of ductile iron or an equivalent pipe, or a Schedule 40 PVC, PE or ABS pipe must be installed with a minimum of 30 inches of compacted soil over the pipe.
Septic tanks, lift stations, wastewater treatment plants, sand filters, and other pretreatment systems.	These structures cannot be located in areas of frequent flooding (more often than the 10-year event) unless they are watertight and can operate during a 10-year storm. All mechanical and electrical equipment must be placed above the 100-year flood level or protected against a 100-year flood.

There are a few exceptions from the standard rules to the placement distances for individual aerobic sewage treatment units (ATUs). These distances are presented below (Figure 4.5.10).

Figure 4.5.10 On-site system placement distances for individual aerobic sewage treatment units.



Additional Evaluation Factors

Reference

15A NCAC 18A.1946

There are a number of situations where other factors, in addition to the above six site factors, must be considered.

Reference

15A NCAC 18A.1946(1)

High-capacity wells.

All pumping wells create a cone of influence, an area around the well where the ground water level is lowered by the withdrawal through the well. High-capacity wells, such as community, municipal, and industrial water supply wells, pump more water and have much larger cones of influence than household wells. These large cones of influence must be considered when locating on-site systems. Thus, on-site systems may need to be located much farther away from large wells than the required 100 feet, as shown in Figure 4.5.7.

Reference

15A NCAC 18A.1946(2)

Large on-site systems.

For on-site systems discharging more than 3,000 gallons per day, certain information must be collected to predict the height of the water table mound below the treatment and disposal field and the flow rate of the wastewater from the treatment and disposal field trenches. Soil borings to depths greater than 48 inches, permeability and hydraulic conductivity measurements, and water level readings must typically be collected. If these measurements indicate that the water table will not remain two or more feet below the treatment and disposal field or that the wastewater will rise to the surface, the site must be classified as UNSUITABLE. More detail on conducting site evaluations for large systems can be found in Section 4.6.

Reference

15A NCAC 18A.1946(4)

Hydraulic conductivity measurement techniques and other tests in relationship to some soil morphological characteristics. Hydraulic conductivity is the measure of the rate water moves through the soil. The rate of water movement through a soil is influenced by the texture, structure, and mineralogy, because these soil morphological characteristics determine the size and the connectivity of the pores, which in turn determines the speed of water movement.

❑ Hydraulic conductivity measurements for determining site suitability for on-site wastewater systems are used in two specific situations in North Carolina:

- For large systems where the flow to a single nitrification field is more than 1500 gallons per day and
- For the design of artificial drainage systems used to modify sites for on-site systems.

❑ In most situations, the usual site evaluation is enough to determine the suitability of the site or lot for on-site systems. For sites located on *benchmark soils* (soils that are typical to North Carolina), additional information on hydraulic conductivity is available.

Hydraulic conductivity tests. Determining hydraulic conductivity requires a proper test method. Many hydraulic conductivity tests have been devised and are in use in different areas. A good source for information on hydraulic conductivity tests is the article by Amoozegar and Warrick, 1985, in Appendix B.

The two methods most commonly used in North Carolina when soil hydraulic conductivity measurements are necessary are the *constant-head permeameter test* and the *auger-hole pump out test.*

- *Constant-head permeameter test.* The constant-head permeameter, also called the shallow well pump-in method, is a common technique used to measure saturated hydraulic conductivity. This test works best where the water table is relatively deep. A source of water is required to saturate the soil for this test. See the publication by Amoozegar and Warrick, 1985, or Appendix 2, for more information on constant-head permeameter tests.
  - To run the test, a hole is bored to a desired depth and enough water is poured into the hole to maintain a certain depth of water in the hole, usually 6 inches (for a 2.5-inch diameter hole). After a while, the flow rate of the water out of the hole through the soil will be constant. This flow rate should be measured, along with the diameter of the hole, the depth of the water in the auger hole, and the distance between the bottom of the hole and any restrictive layers. Equations provided in Appendix B should be used to calculate saturated hydraulic conductivity.
- *Auger-hole pump-out test.* The auger-hole pump-out method, or auger-hole method, is the most commonly used test to measure saturated hydraulic conductivity where the water table is near the surface. More details on this test can be found in the article by Amoozegar and Warrick, 1985, in Appendix B.
  - In this test, a hole is dug below the water table, using a soil auger to minimize soil disturbance. The hole needs to fill with water and be pumped out several times before the actual test. When the test begins, the ground water is allowed to rise in the hole to the level of the water table. Then, the water is pumped out of the hole and the rate at which the water rises in the hole is measured.
  - To calculate the saturated hydraulic conductivity, the depth of the water in the hole , the diameter of the hole, and the distance between the restrictive layer below the hole and the bottom of the hole must be determined. Several different calculation techniques can be used. See Appendix B for more information on this test.
- *Other methods.* As mentioned above, there are a number of methods for determining hydraulic conductivity. In *Methods of Soil Analysis*, Amoozegar and Warrick have separated shallow water table methods from deep water table methods. The methods described by Amoozegar and Warrick are listed below. More information can be found in Appendix B.
  - Shallow water table methods include the auger-hole pump-out method, the piezometer method, and other techniques.
  - Deep water table methods are the double-tube, the shallow well pump-in, the cylindrical permeameter, the infiltration-gradient, and the air-entry permeameter methods.

Compilation of Site Information

Reference

15A NCAC 18A.1947

Reference

15A NCAC 18A.1947

Because North Carolina uses site evaluation to determine site suitability, it is essential to evaluate all six factors—slope and landscape position, soil morphological characteristics, soil wetness, soil depth, restrictive horizons, and available space—and to compile them into a suitability rating.

- If the ratings are the same for all six evaluation factors, then that rating is the site's classification. For example, on a site where each individual factor is designated as SUITABLE, the site should receive a SUITABLE classification.

- ❑ If some of the site evaluation factors are different, then the most limiting factor that cannot be corrected determines the overall site suitability classification. If, for example, one of the six factors is deemed UNSUITABLE and cannot be corrected, then the site will be classified as UNSUITABLE. Several examples of uncorrectable limiting factors are listed below:
  - The setbacks from existing wells on the property or on adjacent property are not far enough away (as specified in the rules) from the proposed on-site system.
  - A dissected toe slope or depression is part of the site's landscape position.
  - The slope is greater than 65%.
  - Rock or plinthite is found at a depth less than 36 inches.
  - The clay mineralogy is 2:1.

References

Amoozegar, A. and A.W. Warrick. 1986. Hydraulic Conductivity of Saturated Soils: Field Methods. In *Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods,* (eds). Agronomy Monograph no. 9, 2nd edition. American Society of Agronomy - Soil Science Society of America, Madison, WI.

Hoover, M.T. Unpublished mimeo. Principles of Site Evaluation. Soil Science Department, North Carolina State University, Raleigh, NC.

Kleiss, H.J. and M.T. Hoover. 1986. Soil and Site Criteria for On-Site Systems. In *Utilization, Treatment, and Disposal of Waste on Land.* Soil Science Society of America, Madison, WI.

USDA-SCS. 1975. *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys.* U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Staff, Agriculture Handbook No. 436. Washington, DC.

4.6 ON-SITE WASTEWATER LOADING RATES

The volume of wastewater that can be treated and disposed of by an on-site system is extremely important to the system user and to environmental health specialists. An on-site system that fails because too much wastewater is applied is not only a problem for the user and environmental health specialist, but is also a danger to the public health. On the other hand, oversized on-site systems are expensive and may not be the best use of land.

Estimating System Loading Rates

The *loading rate* of an on-site system is the amount of wastewater applied to a square foot of soil per day. This rate depends on a number of factors, including the long-term acceptance rate of the soil at the infiltrative surface, the type of on-site system, and the contents of the wastewater.

Detailed knowledge of the site is necessary to keep the system loading in a safe range. This section presents ideas for determining the loading rate for an on-site system.

Long-Term Acceptance Rate of a Soil

The *long-term acceptance rate* (LTAR) is the amount of wastewater that can be applied each day over an indefinite period of time to a square foot of soil such that the effluent from the on-site system is absorbed and properly treated. In the rules, LTAR and loading rate are the same.

The LTAR is determined by a number of factors. Certainly, the rate effluent can move through the most hydraulically limiting soil horizon has a great effect on the LTAR. However, the type of biomat that forms at the infiltrative surface and the type of system also affects the LTAR. A specific LTAR is based on the total evaluation of the soil and site.

❑ Table 4.6.1 illustrates how soil texture affects the range of values for LTAR for conventional systems. The loading rate of Group I soils can be as much as 10 times that of Group IV soils.

❑ An example of how the LTAR range is changed for some modified wastewater systems can be seen by comparing Table 4.6.1 and 4.6.2. For the same texture, the LTAR range for wastewater effluent application is always greater for a conventional on-site system installed in the soil *solum* (A, E, or B horizon) than for a system installed in saprolite. The reason for this difference is that saprolite materials usually have lower hydraulic conductivity than solum horizons of a comparable texture (Amoozegar et al., 1993).

❑ For conventional systems or modified conventional systems, the LTAR is the rate per day that wastewater can be absorbed *through the bottom of the infiltration trenches and underlying horizons.* For low-pressure pipe (LPP) systems, the LTAR is the rate per day that wastewater can be absorbed *through the entire drainfield area* (trenches plus the area between the trenches).

Conventional On-Site Systems Loading Rates

Reference

15A NCAC 18A.1955(b)

For conventional on-site systems the LTAR is based upon the most hydraulically limiting soil horizon within 3 feet of the soil surface or one foot below the trench bottom, whichever is deeper. Long-term acceptance rates for conventional on-site systems are presented in Table 4.6.1 for the four soil groups.

Table 4.6.1 Long-Term Acceptance Rate for Conventional On-Site Systems

Soil Group	Soil Texture Classes*	Long-Term Acceptance Rate gpd/ft²
I	Sands	1.2 - 0.8
	Sand	
	Loamy Sand	
II	Coarse Loams	0.8 - 0.6
	Sandy Loam	
	Loam	
III	Fine Loams	0.6 - 0.3
	Sandy Clay Loam	
	Silt Loam	
	Clay Loam	
	Silty Clay Loam	
	Silt	
IV	Clays	0.4 - 0.1
	Sandy Clay	
	Silty Clay	
	Clay	

*Soil Texture Class for soils that have SUITABLE or PROVISIONALLY SUITABLE structure and clay mineralogy. (USDA Classification)

❑ If grease accumulation will be a problem, then the LTAR for any soil group cannot exceed the mean rate of application. For example, if a food service or meat market facility was planned for a site with a clay loam textured soil, then the maximum wastewater loading rate possible for the site would be 0.45 gpd/ft^2.

❑ For facilities where there is data from comparable facilities that indicate the grease and oil content of the effluent will be less than 30 mg/l and the chemical oxygen demand is less than 500 mg/l, an LTAR up to the maximum for the applicable soil's textural group can be used. Otherwise, if a significant pretreatment system will be used at a business or place of public assembly that can assure consistent reduction of the wastewater strength to that of a typical single family home, then a loading rate greater than the mean for that soil group could logically be considered for that site. However, this would require a special application under rule 15A NCAC 18A.1948(d) by the owner to the Health Department.

Using long-term acceptance rates to calculate the treatment and disposal field size. The following calculation of treatment and disposal field area is for a conventional system.

The amount of effluent that is expected to enter a septic tank each day is based on the type of facility, as stated in 15A NCAC 18A.1952(b)(1). In this example, a three-bedroom house will be built on the site. The daily flow rate

Reference

15A NCAC 18A.1952(b)(1)

into the septic tank is designed to be 360 gallons per day for the whole house, or 120 gallons per bedroom per day.

The on-site system is to be sited on a soil whose most restrictive textural horizon within a foot of the trench bottom (or 3 feet from the ground surface) is Group IV. The LTAR for this soil texture ranges from 0.4 - 0.1 gpd/ft^2. For the purposes of this example we will select a LTAR of 0.4 gpd/ft^2.

The daily flow is divided by the LTAR to determine the trench bottom area: 360 gpd divided by 0.4 gpd/ft^2 equals a trench bottom area of 900 ft^2.

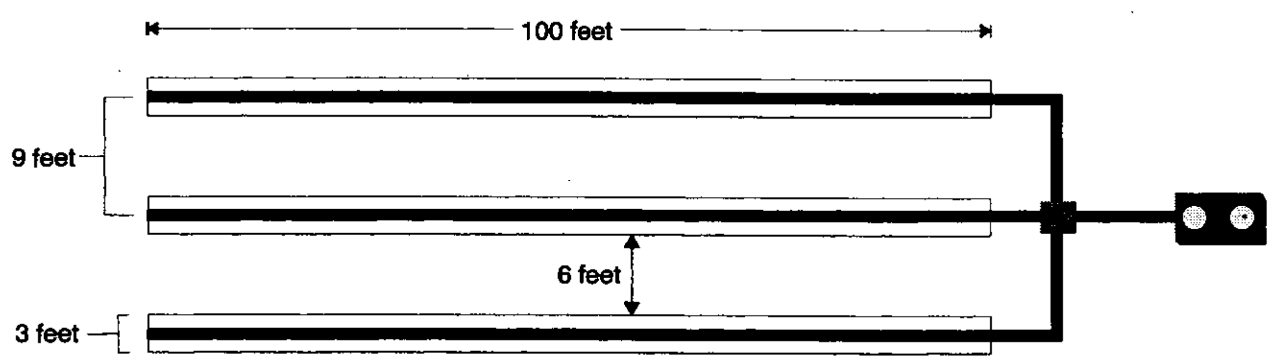
In order to determine the length of trench from the trench bottom area, the trench bottom area is divided by the trench width: 900 ft^2 divided by a 3 ft trench width equals 300 linear feet of trench.

Reference

15A NCAC 18A.1955(c)

If the slope is uniform and there are to be three trenches, then each trench would be 100 feet long. The trenches must be on 9 foot centers since the trenches are 3 feet wide. (Note: the center to center spacing equals 3 times the design trench width.) Therefore, the minimum total area for installation of the nitrification area is 2100 ft^2: the sum of 1.5 ft + 9 ft + 9 ft + 1.5 ft times 100 ft long which equals 2100 ft^2 (Figure 4.6.1).

Figure 4.6.1 Total drainfield area for a conventional system.



If the slope is not uniform, then the total installation area will have to be larger. In the above example, if the slope was not uniform, then trenches might have to be further apart than 9 foot centers so that each trench follows the contour of the slope.

Modified Conventional On-Site Systems

Reference

15A NCAC 18A.1956(1)

For sites where the distance between the soil surface and a limiting soil condition of soil depth or soil wetness is less than 36 inches, the site can be reclassified to PROVISIONALLY SUITABLE for the installation of a modified conventional system. Using shallow placement of the treatment and disposal field trenches, the most hydraulically limiting soil, rock, or saprolitic horizon within at least 24 inches from the soil surface or 12 inches below the trench bottom, whichever is deeper, is used to determine the LTAR.

On-Site Systems Installed in Saprolite

Reference

15A NCAC 18A.1956(6)(b)

Long-term acceptance rates have also been determined for saprolite that has been deemed acceptable for on-site system installation as stated in rules 15A NCAC 18A.1956(6).

For on-site systems installed in saprolite, the LTAR for the site is the LTAR of the most hydraulically limiting saprolite within a depth of 2 feet below the trench bottom. See Table 4.6.2 for values of LTAR for saprolite.

❑ Like conventional on-site systems, the LTAR for saprolite is related to the textural class of the saprolite. However, with saprolite, only two textural groups

Reference

15A NCAC 18A.1956(b) Table III

Table 4.6.2 Long-Term Acceptance Rate for Saprolite

Saprolite Group	Saprolite Textural Classes	Long-Term Acceptance Rate (gpd/ft²)
I	Sands	
	Sand	0.8 - 0.6
	Loamy Sand	0.7 - 0.5
II	Loams	
	Sandy Loam	0.6 - 0.4
	Loam	0.4 - 0.2
	Silt Loam	0.3 - 0.1

are acceptable, Class I and Class II saprolites, which are subclassified as sands, loamy sands, sandy loams, and loams.

- Total daily flow for on-site systems installed in saprolite cannot exceed 1,000 gallons.

Using long-term acceptance rates to calculate the treatment and disposal field size.

Calculations for the treatment and disposal field area are the same for saprolite as they are for a conventional system, except the loading rates are lower. Use the appropriate long-term acceptance rates for Class I and Class II texture saprolite in Table 4.6.2.

Gravelless Trench Systems

Reference

15A NCAC 18A.1956(3)

For gravelless trenches, including prefabricated, permeable block panel on-site systems and large diameter pipe systems, the LTAR is determined from the appropriate table (Table 4.6.1 or 4.6.2), but is restricted to never being greater than 0.8 gallons per day per square foot.

Low-Pressure Pipe On-Site Systems

Reference

15A NCAC 18A.1957(a)(3)

If a low-pressure pipe on-site system is used at a particular site, then the wastewater loading rate for that site must be matched to the LTAR for this type of system. The LTAR selected is based on the most limiting soil horizon that occurs within 2 feet of the soil surface or one foot below the trench bottom, whichever is deeper. The LTARs for low-pressure pipe on-site systems are presented in Table 4.6.3 for the four soil groups.

- If grease accumulation will be a problem then the LTAR for any soil group cannot exceed the mean rate of application. For example, a food service or meat market facility could not install an on-site system on a loamy sand soil using a wastewater loading rate exceeding 0.5 gpd/ft^2.

- For facilities where there is data from comparable facilities that indicate the grease and oil content of the effluent will be less than 30 mg/l and the chemical oxygen demand is less than 500 mg/l, an LTAR up to the maximum for the applicable soil's textural group can be used. Otherwise, if a significant pretreatment system will be used that can assure consistent reduction of the wastewater strength to that of domestic sewage, then a loading rate greater than the mean for that soil group could logically be considered for that site.

Table 4.6.3 Long-Term Acceptance Rate for Low-Pressure Pipe Systems

Soil Group	Soil Texture Classes (USDA Classification)	Acceptance Rate (gpd/ft^2)
I	Sands	0.6 - 0.4
	Sand	
	Loamy Sand	
II	Coarse Loams	0.4 - 0.3
	Sandy Loam	
	Loam	
III	Fine Loams	0.3 - 0.15
	Sandy Clay Loam	
	Silt Loam	
	Clay Loam	
	Silty Clay Loam	
	Silt	
IV	Clays	0.2 - 0.05
	Sandy Clay	
	Silty Clay	
	Clay	

*Soil Texture Class for soils that have SUITABLE or PROVISIONALLY SUITABLE structure and clay mineralogy. (USDA Classification)

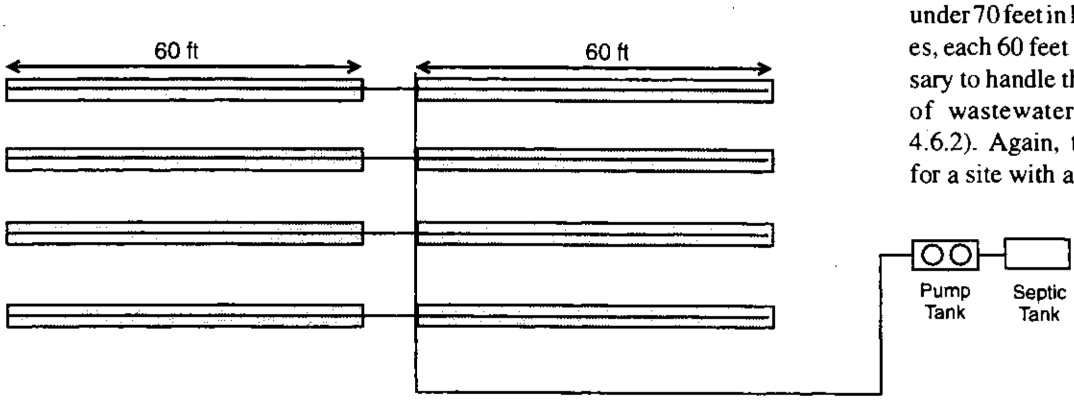
Using long-term acceptance rates to calculate the treatment and disposal field size.

Unlike conventional systems where the loading rate is based on the trench bottom area, the loading rate for a low-pressure pipe system is based on the total area of the treatment and disposal field.

The following calculation of treatment and disposal field area is for a low-pressure pipe system.

> The estimated LTAR is 0.15 gpd/ft^2 for this site where a low-pressure pipe on-site system is to be installed. 360 gpd of wastewater effluent will flow daily to the treatment and disposal field. The amount of treatment and disposal field area needed is calculated as 360 gpd divided by 0.15 gpd/ft^2 which equals a total of 2400 ft^2. If the trenches for the drainfield are spaced a distance of 5 feet from each other then the total trench length needed is 480 feet, or 2400 ft^2 divided by 5 feet equals 480 feet. Thus, keeping the trenches under 70 feet in length, 8 trenches, each 60 feet long, are necessary to handle the daily amount of wastewater flow (Figure 4.6.2). Again, this example is for a site with a uniform slope.

Figure 4.6.2 Total drainfield area for a low-pressure pipe system.



Area-Fill On-Site Systems

Reference

15A NCAC 18A.1957(b)(1)(D)

For area-fill systems that meet the requirements of 15A NCAC 18A.1957(b)(1)(A), the lowest LTAR for the applicable soil group of the most hydraulically limiting soil horizon within 18 inches of the naturally occurring soil surface or to a depth of one foot below the trench bottom, whichever is deeper, must be used to design the system.

❑ The LTAR values for Group I soil area-fill systems are reduced to spread the flow of the effluent over a larger area over these very permeable soils so that the effluent receives adequate treatment. There are two exceptions to the LTAR shown for Group I soils (Table 4.6.1) when using fill systems:

- The LTAR cannot be greater than 1.0 gallon per day per square foot for gravity distribution, or
- The LTAR cannot be greater than 0.5 gallons per day per square foot for low-pressure pipe systems installed on sites with at least 18 inches of Group I soils below the naturally occurring soil surface or to a depth of one foot below the trench bottom, whichever is deeper.

Individual Aerobic Sewage Treatment Units (ATUs)

Reference

15A NCAC 18A.1957(c)(5)(C)

The LTAR for ATUs may be increased 25% for Group I or II soils. For example, the LTAR of Group I soils ranges from 1.2 - 0.8 gpd/ft^2 for a conventional on-site system. If an ATU system was planned for Group I soils, the LTAR range would be 1.5-1.0 gpd/ft^2 — a 25% increase.

Large On-Site Systems

Large on-site systems require a more-detailed site evaluation to more accurately determine the LTAR. A standard description of what a site and soil evaluation would be for a large system is not possible. Rather, this section describes a typical scenario that can aid in understanding the correct approach to large system site investigations.

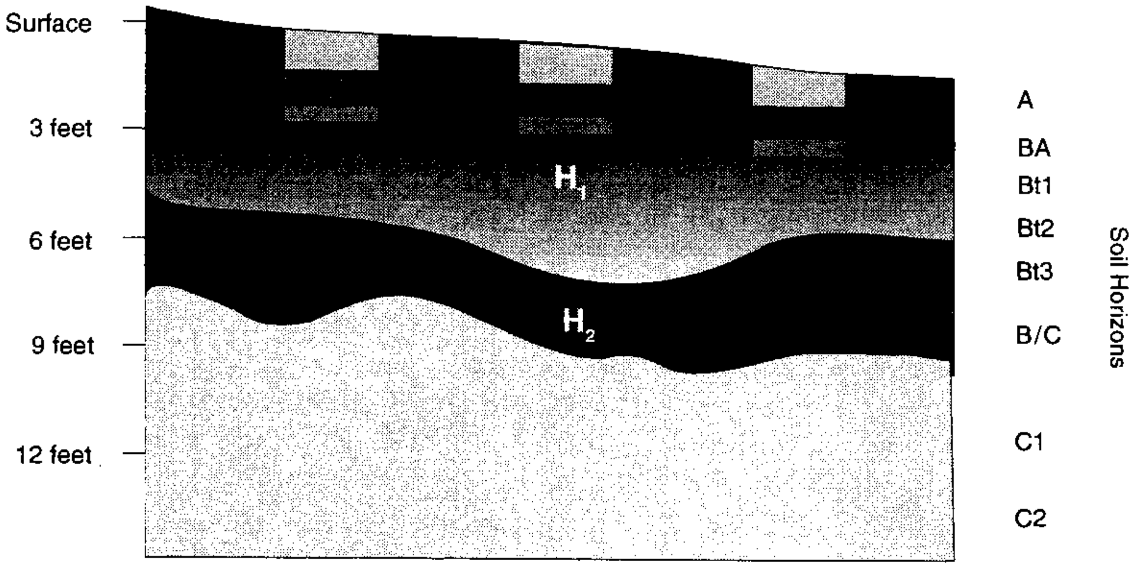
The site and soil investigation must include more detailed descriptions and assessments of soil morphology and measurements of the saturated hydraulic conductivity (Ksat) of one or more soil horizons at that site. The location and number of Ksat measurements will vary with each site, depending upon the site conditions and the water flow regime at the site. See Section 4.5 under *Additional evaluation factors — Large on-site systems* for more details on using either the constant-head permeameter test or the auger-hole pump-out test to measure Ksat. Other tests may also be appropriate, such as aquifer pump tests, for large systems in coastal areas. The first part of Section 4.5, *Guidelines for a site evaluation*, provides guidance for performing a site evaluation for a large system.

Figure 4.6.3 illustrates a typical site in the Piedmont or Mountain region where a large on-site system is proposed. The soil here is deep and well drained. It has eight soil horizons down to a depth of 12 feet below the ground surface. The landscape position is an interfluve with a 4% slope of the ground surface.

❑ A large, modified conventional system with trenches 2 to 3 feet deep is proposed for the site. A much deeper than usual assessment of soil properties is required — down to 12 feet — than is necessary for small, single family systems (usually only to 4 feet).

❑ The horizons should be grouped on the basis of the similarity of their characteristics. For this example, there would be three major horizon groupings: horizon H_1 (the Ap, BA, Bt1, and Bt2 horizons), horizon H_2 (includes the Bt3 and B/C horizons) and horizon H_3 (includes the C1 and C2 horizons).

Figure 4.6.3 Schematic illustrating depth of proposed trenches relative to soil horizons at a site being evaluated for a large drainfield.



❑ Three factors that could control the direction and quantity of flow of effluent from the proposed system were identified at this site.

- The first factor is the rate of sewage effluent that can leave the trenches through the biomat at the infiltrative surface. This rate is determined by the LTAR of the biomat that forms in the BA and Bt1 horizons. The LTAR can be estimated from Tables 4.6.1, 4.6.2, or 4.6.3, or it can be estimated by measuring the Ksat of the horizons at the infiltrative surface (the BA and Bt1 horizons) and by assuming a percentage reduction in Ksat due to the biomat. Biomats typically reduce flow rates to 1-10% of the saturated hydraulic conductivity, although the percentage reduction can be even greater on some rapidly permeable sands. The amount of infiltrative surface (in this case, the amount of trench bottom area) needed to accommodate the maximum design flow from the proposed facility after a biomat forms should be determined. If pretreatment (such as with a pressure-dosed sand filter) is used to reduce BOD and suspended solids, the biomat will not form as extensively and the LTAR can be increased for the infiltrative surface. Likewise, if waste strength will exceed that of typical domestic wastewater, such as at food service facilities, the LTAR should be decreased.

- Next, the most slowly permeable horizon in the soil should be identified because this horizon will potentially control the flow of wastewater through the site. In this example, the bottom of the Bt horizon and the transitional B/C horizon were identified as the horizons most restrictive to vertical water movement. Therefore, Ksat measurements should be made in these horizons. Since the soil is well drained and these horizons are well above the water table, the constant-head permeameter test would be an appropriate method to measure Ksat. The number of Ksat measurements needed will depend upon the degree of variability of the soil horizons of interest (in this case, the Bt3 and B/C). If there is only a small amount of soil variability, then one to two Ksat measurements **for each** 1,000 ft^2 of total drainfield area (not trench bottom area) may be sufficient. This is, however, just an estimate of the number of measurements needed for a site where a large system is proposed. Each site will be different.

- The measured Ksat values in the most slowly permeable horizon (H_2 in this example) should be compared to the estimated LTAR of the horizon where the infiltrative surface will be placed (H_1 in this example). If the LTAR of H_1 is more than two or three times greater than the Ksat of H_2 then the ultimate rate of flow through the soil would be controlled by saturated flow through H_2, not wastewater infiltration into H_1. Therefore, the system size should be increased beyond the size indicated by the LTAR of H_1. On the other hand, if the LTAR of H_1 is nearly equivalent to or less than the Ksat of H_2, then the ultimate rate of flow through the soil would be controlled by saturated flow through the biomat at the infiltrative surface, and all vertical flow through H_2 and H_3 beneath the infiltrative surface would occur as unsaturated down to the ground water table. In this case, the system size would be determined by the LTAR of H_1.
- The third factor that may be identified as potentially controlling flow at this site is the rate of lateral flow through H_1 in the downslope direction. Perching of water on a slowly permeable horizon and flow over that horizon is more likely to occur as the Ksat of H_2 becomes smaller in comparison to the Ksat of H_1. Usually a 10-fold reduction in Ksat over a short vertical distance will cause some water to perch within and on the more slowly permeable layer. A 100-fold or greater reduction in Ksat will lead to more substantial perching of water. Both the slope of the slowly-permeable horizon and the amount of effluent proposed for disposal on a common slope must be considered, in addition to the horizon's LTAR rates, while evaluating the site's suitability for the system.

❑ At this site the soil evaluation revealed that an approximate 10-fold reduction or less would be expected in the Ksat of H_2 when compared to H_1. However, close examination of the soil horizon boundaries in a backhoe pit indicated that no significant perching was currently occurring under natural rainfall conditions. While some perching on the H_2 horizon could occur at low loading rates, it would be temporary and inconsequential since an adequate aerobic vertical separation would persist beneath the infiltrative surface. However, at high loading rates, one would expect more substantial perching to occur. In this case, the horizontal Ksat of H_1 would need to be measured to allow calculation of the height of the perched water mound over H_2 and the transmissivity of H_1.

In summary, measured Ksat values of the most slowly permeable horizon should be compared to estimated LTAR at the infiltrative surface. The lowest of the two values should then be used to determine the site loading rate. Examples are presented below.

Example 1. The most slowly permeable horizon of the soil being evaluated is the lower B horizon, which has a clay texture. The estimated LTAR at the infiltrative surface in Table 4.6.1 is 0.1 gpd/ft². However, the average Ksat value of the most slowly permeable horizon is measured to be 0.024 gpd/ft² (0.1 cm/day). Because the Ksat value is considerably lower than the LTAR value, this site would be unsuitable for siting an on-site system using the LTAR from Table 4.6.1. The lower B horizon, although not a restrictive horizon, transmits water too slowly for an on-site system to function suitably in this soil at a loading rate of 0.1 gpd/ft².

Example 2. At another site, which is similar to the site in Example 1, the average Ksat value for the lower B horizon is 0.24 gpd/ft² or 10 cm/day. The LTAR for this site is estimated as 0.1 gpd/ft². Because the Ksat of the lower B horizon is greater than the LTAR, an on-site system could be installed at this site, assuming all other site evaluation factors are suitable. The estimated loading rate would be 0.1 gpd/ft².

The Importance of Correctly Estimating the Loading Rate

Most of the on-site systems have a range of LTARs, depending on the most limiting soil textural grouping. Estimating the LTAR can be difficult because not only must the texture of the most limiting horizon be classified correctly, but "the right rate" must be estimated from a range of rates. Experience with a number of sites and numerous soils will aid in determining a proper value for LTAR. By misclassifying the limiting soil textural horizon or by estimating the wrong LTAR, the entire calculation for treatment and disposal field area can be altered.

Problems with Overestimation or Underestimation of LTAR

The LTAR must be estimated correctly so that the size of the treatment and disposal field is correct.

❑ If the LTAR is overestimated, the size of the treatment and disposal field will be too small, which can invite early failure of the on-site system.

❑ If the LTAR is underestimated, the treatment and disposal field will be too large, thus wasting resources because the on-site system will be underutilized and the construction cost of the site will have been more than necessary.

❑ If available space is limiting system installation, underestimation of the LTAR means that a larger treatment and disposal field will be required. This may erroneously produce an UNSUITABLE classification due to space limitations that would preclude the siting of an on-site system. The site might be able to accommodate an on-site system with a smaller treatment and disposal field.

Using Site Evaluation Factors to Choose a Proper Value for LTAR

The range of LTAR values listed in the tables reflects the influence that other site evaluation factors can have on the LTAR. By considering the other site characteristics, higher or lower values of LTAR can be selected to help fit the on-site system to the site.

❑ Soil texture is the major soil characteristic that determines the LTAR for any given soil or saprolite. Estimates of LTAR from the LTAR range for a given **soil textural class** should then be based on site characteristics such as soil depth, structure, color, consistence, landscape position, and the type of wastewater effluent.

❑ The following factors influence the value assigned to LTAR for **small wasteflows**.

Table 4.6.4 Site and Soil Evaluation Factors That Influence Assigned LTAR

Site Evaluation	Higher LTAR	Average LTAR	Lower LTAR
Landscape position	Ridges or interfluve, shoulder and nose or convex slopes	Linear side slopes	Head, foot and toe slopes, or concave slopes
Soil structure	Crumb and granular, single-grained soils		Block-like structure
Clay mineralogy	No clay or little 1:1 clay	1:1 clay	Mixed clay or 2:1 clay
Organic matter	0%	2-5%	High organic matter indicates persistent wetness
Soil wetness	>48 inches deep	36-48 inches deep	36-24 inches
Soil depth	>48 inches deep	36-48 inches deep	36-24 inches
Restrictive horizons	>48 inches deep	36-48 inches deep	<36 inches deep if they are discontinuous

An example of using the different soil and landscape characteristics to estimate LTAR is presented in Table 4.6.5 and the explanation following table.

Table 4.6.5 Comparison of Two Similar Sites and the Effects of Soil Morphological Characteristics and Landscape Position on LTAR

Soil A	Horizon	Soil B
Landscape position = ridge		Landscape position = lower side slope
Texture = sandy loam Structure = granular Consistence = friable	AE	Texture = sandy loam Structure = granular Consistence = friable
Texture = clay (non-expansive) Structure = strong, fine angular blocky Consistence = friable	B	Texture = clay (non-expansive with a slight influence of mixed mineralogy) Structure = moderate, medium angular blocky Consistence = firm
Texture = sandy loam Structure = moderate, medium subangular blocky Consistence = firm	BC	Texture = sandy clay loam Structure = weak, coarse subangular blocky Consistence = firm
Texture = loamy sand Structure = massive Consistence = friable	C	Texture = loam Structure = massive Consistence = very firm

These two soils are very similar. The most limiting horizon for both soils is the B horizon (clay texture). The LTAR range for soils with a clay horizon using a conventional on-site system is 0.4 - 0.1 gpd/ft^2.

- Soil A has the more strongly developed structure in the B and C horizons, better landscape position on the ridge as opposed to on the side slope, and a lack of any mixed mineralogy influence. These factors indicate that Soil A is better suited for more rapid infiltration of wastewater than Soil B and thus should receive a higher LTAR value. Conversely, the weaker structure, mixed mineralogy, and poorer landscape position cause Soil B to receive an LTAR low in the range.

For this example, the LTAR of Soil A is estimated to be 0.4 gpd/ft^2, while the LTAR of Soil B is estimated at 0.1 gpd/ft^2.

References

Amoozegar, A., M.T. Hoover, H. J. Kleiss, W.R. Guertal, and J.E. Surbrugg. 1993. *Evaluation of Saprolite for On-Site Wastewater Disposal.* (Water Resources Research Institute, The University of North Carolina. UNC-WRRI-93-279.)

4.7 SITE SUITABILITY: MATCHING SITE CHARACTERISTICS TO APPROPRIATE DESIGNS

Few sites in North Carolina receive a SUITABLE classification for on-site system installation. Since the majority of sites receive either PROVISIONALLY SUITABLE or UNSUITABLE classifications, either a site or system modification or an alternative system must be used to allow installation of an on-site system. This section discusses which limiting site factors can be overcome and which cannot.

Choosing an appropriate system design for a site requires expertise. Each site must be matched by its characteristics to an appropriate on-site system. The first step in this process is to obtain the required information on a Soil Site Evaluation for On-Site Wastewater System form.

Soil Site Evaluation Form

The *Soil Site Evaluation for On-Site Wastewater System* is a form used by environmental health specialists to quantify site and soil characteristics and determine the suitability classification of a site. It contains information that ranges from the location of the proposed facility to the soil profile description at that site (Figure 4.7.1).

This form is an essential tool in both determining the appropriateness of an on-site system and maintaining a record of how the decision was made. Proper completion of the form protects both the environmental health specialist as well as the public.

- The front side of the form contains the detailed site and soil profile evaluation. The back side of the form states the abbreviations used on the front side and also provides space for the environmental health specialist to draw a layout of the lot with the house and other structures. *It is very important to make this drawing.* Be sure to include the soil profile locations as well as the proposed house site and all other pertinent structures such as wells, buildings, roads, driveways, and drainage channels.

- At least three soil profiles should be described on the form. Each soil profile should include: landscape position and slope; soil morphological characteristics including texture, structure, mineralogy/consistence, soil matrix color, and soil mottle color; and other profile characteristics such as wetness condition, soil depth, presence of saprolite, profile classification, and profile LTAR.

- The LTAR and type of on-site system are specified by the specialist.

- Any modifications to the on-site system must be listed.

- Each *Soil Site Evaluation for On-Site Wastewater System* form should be completely filled out. The information contained on the form will be invaluable for legal documentation (should a legal action occur).

After the profile descriptions have been completed, the environmental health specialist assigns suitability ratings for all evaluation factors. The overall site suitability is then determined from the individual suitability ratings.

On-Site Systems that Can Be Installed with a Given Site Classification

A PROVISIONALLY SUITABLE or UNSUITABLE classification means that a conventional on-site system cannot be installed on that site. To allow landowners to use these sites, procedures have been established to match certain modified conventional or alternative on-site systems to sites with less than SUITABLE ratings. Here the environmental health specialist can be of great help in matching the capability of site to various alternative on-site systems.

SUITABLE sites. If a site is deemed SUITABLE, then a conventional system can be installed. However, in North Carolina only a small percentage of sites receive a SUITABLE rating.

PROVISIONALLY SUITABLE sites. More sites receive a PROVISIONALLY SUITABLE classification than SUITABLE or UNSUITABLE classifications.

- ❑ Sites classified PROVISIONALLY SUITABLE require modified conventional or alternative on-site systems. The system or site modifications must overcome the limiting soil and site characteristics and still ensure the proper treatment of the wastewater effluent in order to protect public health and minimize the environmental impact of the on-site system.
- ❑ Many of the UNSUITABLE sites can be reclassified as PROVISIONALLY SUITABLE if an appropriate site modification or on-site system can be designed for the site.

Shallow-placement and fill systems.

On-site systems that use shallow-placed trenches or fill over the treatment and disposal field can be used in some situations to overcome site limitations.

- ❑ In general, when depth is limited because of wetness, restrictive horizons, and depth to rock or saprolite, shallow-placement conventional systems or area-fill systems can be used to overcome the limitation.

UNSUITABLE sites.

Ten percent of all sites that receive an UNSUITABLE classification cannot be reclassified. No type of on-site system can be installed at these locations.

Site limitations that cannot be overcome.

Certain site evaluation factors are so limiting for on-site systems that there are no techniques to overcome the limitation.

- ❑ Certain types of soil structure, or lack of structure, and expansive clay mineralogy cannot be modified, thus limiting siting of on-site systems.
- ❑ Topography where the slope is greater than 65% cannot be overcome.

DEPARTMENT OF ENVIRONMENT,
HEALTH, & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

SHEET___OF____
PROPERTY I.D.#:________________
DATE: ________________
COUNTY:________________

SOIL/SITE EVALUATION
FOR
ON-SITE WASTEWATER SYSTEM

OWNER:____________________APPLICANT:____________________
APPLICATION DATE:______DATE EVALUATED:____________________PROPOSED FACILITY:_______
________PROPOSED DESIGN FLOW (.1949):_______PROPERTY SIZE:________LOCATION OF SITE:____________________
____________________WATER SUPPLY: Private___Public__
Well___Spring___Other______ EVAL. METHOD: Auger Boring__Pit__Cut___

PROFILE #	.1940 LANDSCP POS./ SLOPE %	HORIZON DEPTH (IN.)	SOIL MORPHOLOGY .1941 (a)(1) TEXTURE	(a)(2) STRUCTURE	(a)(3) MINERALOGY CONSISTENCE	SOIL MATRIX COLOR	SOIL MOTTLE COLOR	OTHER PROFILE FACTORS
1								.1942 WETNESS CONDITION
								.1943 SOIL DEPTH/ .1956 SAPROLITE
								.1944 RESTRICTIVE HORIZON
								.1947 PROFILE CLASSIF
								PROFILE LTAR
2								.1942 WETNESS CONDITION
								.1943 SOIL DEPTH/ .1956 SAPROLITE
								.1944 RESTRICTIVE HORIZON
								.1947 PROFILE CLASSIF
								PROFILE LTAR
3								.1942 WETNESS CONDITION
								.1943 SOIL DEPTH/ .1956 SAPROLITE
								.1944 RESTRICTIVE HORIZON
								.1947 PROFILE CLASSIF
								PROFILE LTAR
4								.1942 WETNESS CONDITION
								.1943 SOIL DEPTH/ .1956 SAPROLITE
								.1944 RESTRICTIVE HORIZON
								.1947 PROFILE CLASSIF
								PROFILE LTAR

AVAILABLE SPACE (.1945)________OTHER FACTORS (.1946)________SITE CLASSIFICATION____________SYSTEM TYPE(S)________SITE
LONG-TERM ACCEPTANCE RATE(S)________________EVALUATED BY:__________OTHER(S) PRESENT:__________
____

COMMENTS:________________________________

Figure 4.7.1 Soil site evaluation for on-site wastewater system form.

LEGEND

USE THE FOLLOWING STANDARD ABBREVIATIONS

LANDSCAPE POSITION	GROUP	TEXTURE	[illegible]	[illegible] MINERALOGY CONSISTENCE	STRUCTURE
CC - CONCAVE SLOPE	I	S - SAND	1.2 - 0.8		G - SINGLE GRAIN
CV - CONVEX SLOPE		LS - LOAMY SAND		NEXP - NON-EXPANSIVE	M - MASSIVE
D - DRAINAGE WAY				SEXP - SLIGHTLY EXPANSIVE	CR - CRUMB
DS - DEBRIS SLUMP	II	SL - SANDY LOAM 0.8 - 0.6		EXP - EXPANSIVE	GR - GRANULAR
FP - FLOOD PLAIN		L - LOAM			SBK - SUBANGULAR BLOCKY
FS - FOOT SLOPE					ABK - ANGULAR BLOCKY
H - HEAD SLOPE	III	SI - SILT	0.6 - 0.3		PL - PLATY
L - LINEAR SLOPE		SICL - SILTY CLAY LOAM			PR - PRISMATIC
N - NOSE SLOPE		CL - CLAY LOAM			
R - RIDGE		SCL - SANDY CLAY LOAM			
S - SHOULDER SLOPE		SLC - SILT LOAM CLAY			
T - TERRACE					
	IV	SC - SANDY CLAY 0.4 - 0.1			
		SIC - SILTY CLAY			
		O - ORGANIC	NONE		

MOIST	WET
VFR - VERY FRIABLE	NS - NON-STICKY
FR - FRIABLE	SS - SLIGHTLY STICKY
FI - FIRM	S - STICKY
VFI - VERY FIRM	VS - VERY STICKY
EFI - EXTREMELY FIRM	NP - NON-PLASTIC
	SP - SLIGHTLY PLASTIC
	P - PLASTIC
	VP - VERY PLASTIC

NOTES:

HORIZON DEPTH IN INCHES BELOW NATURAL SOIL SURFACE

DEPTH OF FILL IN INCHES FROM LAND SURFACE

RESTRICTIVE HORIZON— THICKNESS AND DEPTH FROM LAND SURFACE

SAPROLITE S (SUITABLE) OR U (UNSUITABLE)

SOIL WETNESS - INCHES FROM LAND SURFACE TO FREE WATER OR INCHES FROM LAND SURFACE TO SOIL COLORS WITH CHROMA 2 OR LESS - RECORD MUNSELL COLOR CHIP DESIGNATION. CLASSIFICATION - S (SUITABLE), PS (PROVISIONALLY SUITABLE), OR U (UNSUITABLE)

EVALUATION OF SAPROLITE SHALL BE BY PITS.

LONG-TERM ACCEPTANCE RATE: GAL/DAY/FT²

Figure 4.7.1 Soil site evaluation for on-site wastewater system form (page 2).

Examples of Matching On-Site Systems with Sites

The following examples demonstrate how information in the SOIL SITE EVALUATION FOR ON-SITE WASTEWATER SYSTEM forms is used to match on-site systems to sites. Six site evaluations are discussed below.

Site Evaluation # 1 (Form 1).

This site in Chatham County reveals shallow soil depth and soil wetness problems. The site, however, was reclassified as PROVISIONALLY SUITABLE for a shallow-placement conventional system for the areas where Profiles 1 and 2 were taken.

- Profiles 1 and 2 indicate limited soil depth. However, the soil is deep enough so that a shallow-placement system can be installed.

- The angular blocky structure in the clayey third horizon indicates that there is some slight influence of mixed mineralogy clays here. Although the clay mineralogy of the soil is classified as slightly expansive, it is at the high end of the range. For this reason, the permeability of this clayey layer will be less than other slightly expansive clays. Therefore, the LTAR selected for this soil is 0.2 gpd/ft^2, which is near the low end of the range given for Group IV soils in Table 4.6.1.

- At the locations of Profiles 3 and 4, which are downslope from the system area in the repair area, there is a soil wetness condition close to the surface. Profiles 3 and 4 indicate soil wetness at approximately a 28-inch depth.

- In order to correct the soil wetness at Profiles 3 and 4, a subsurface interceptor drain could be installed to remove excess water, and a shallow LPP could be installed.

- The LPP system is used because of the relatively shallow wetness conditions. Note that the LPP long term acceptance rate of 0.1 gpd/ft^2 from Table 4.6.3 indicates that the treatment and disposal field size is determined differently than for modified conventional systems.

Site Evaluation # 2 (Form 2).

The county environmental health specialist, after evaluating a lot in Robeson county classified the site as PROVISIONALLY SUITABLE. The following points were considered in making the determination.

- The soil at this location is deep enough for a conventional system. Trench bottoms can be placed 24 to 36 inches deep.

- The most limiting soil horizon is a Group III soil with an LTAR of 0.3—0.6 gallons per day per square foot (gpd/ft^2).

- The other site and soil characteristics that help determine the loading rate, such as landscape position, structure, and consistence, are adequate for an LTAR in the middle of the range for a Group III soil.

- An LTAR of 0.5 gpd/ft^2 was selected for the site.

Site Evaluation # 3 (Form 3).

This site was originally classified as UNSUITABLE, but further study deemed that with the appropriately designed on-site system, a PROVISIONALLY SUITABLE classification was allowable. Located in Wayne County, the soil did not meet the soil wetness criteria because of soil wetness conditions encountered at 25 inches. These points were part of the reasoning to reclassify the site.

- The mottle color recorded was 10YR6/1 in the 25—45 inch horizon, indicating soil wetness or redoxymorphic features.

- To overcome the limiting soil wetness at the 25-inch depth, a shallow-placement conventional system was designed for the site. Alternatively, a low-pressure pipe system could also be used.

- Placing the trench bottoms at a depth of 13 inches from the top of the soil surface would allow a 12-inch separation distance between the bottom of the trenches and the top of the wet soil horizon.

- In order to obtain 6 inches of cover over the top of the trench, a minimum of five inches of loam or sandy loam fill must be used over the trenches.

- An LTAR near the bottom of the range for Group III soils was used, since the site is wet and a capillary fringe will be present.

Site Evaluation # 4 (Form 4).

The situation for site evaluation # 4, located in Wake County, is similar to that just described in Wayne County: soil wetness is the limiting soil morphological characteristic. However, this site has more severe problems since the limiting soil horizon is 20 inches below the soil surface. To classify this soil from UNSUITABLE to PROVISIONALLY SUITABLE, an on-site system that utilizes 10 inches of fill on top of the natural soil surface has been specified. Because the slope is nearly level, a fill system is reasonable for this site.

- A minimum of a 10-inch layer of fill is placed over the location of the proposed trenches

- In order to obtain the 12-inch separation distance between the bottom of the trench and the top of the limiting horizon, the trench bottom is placed 8 inches below the original soil surface, which is 18 inches below the top of the fill.

- The lower 8 inches of the trench is in natural soil and the upper 4 inches of the trench is in fill material.

- Six inches of fill are over the top of the trench.

Site Evaluation # 5 (Form 5).

Because of a soil depth less than 36 inches, this site in Buncombe County was classified as UNSUITABLE. By using a shallow-placement conventional system with a carefully placed trench, this site can be reclassified as PROVISIONALLY SUITABLE.

- A sandy loam saprolite material begins at 34 inches.

- Care must be taken to lay out a system that ensures that the trench bottom is never closer than 12 inches from the saprolite. Hand digging of the trenches may be recommended if excavation equipment cannot operate safely on this site without excavating a trench for the equipment into the hillside.

- Narrow trenches are easier to install so that no part of the trench bottom is closer than 12 inches from the saprolite and so the trench bottom is level across its width.

- 12-inch wide trenches must be used, with 6 inches of cover over the trench to maintain the required 12 inches of vertical separation below the entire trench bottom to the saprolite. (Figure 4.5.4 and Table 4.5.6). A 12-inch wide trench could be placed on a soil as shallow as 33.4 inches (6+12+12+3.4) to saprolite on this 28% slope site. However, a 36-inch wide trench would require a soil that is 41.1 inches (6+12+12+10.1) deep on this slope.

- The trenches must be installed on the contours of the slope to keep the trenches level along their length.

- Alternatively, the saprolite material in the fourth horizon could be evaluated from a backhoe-dug pit to assess its suitability for placement of deeper trenches.

Site Evaluation # 6 (Form 6).

This site is UNSUITABLE for installation of an on-site system and cannot be reclassified. This site has the following uncorrectable limiting factors.

- The subsoil mineralogy is expansive beginning at the 10 inch depth.
- The soil structure is prismatic.
- There is soil wetness within 22 inches of the surface and a clayey texture.
- A sandy loam saprolite material begins at 38 inches.
- The saprolite material can be evaluated from a deep backhoe-dug pit to determine its potential for deep placement of trenches. However, hard augering of the saprolite indicates it is extremely firm. The percentage of sites that have saprolite that is found to be usable is very low when the saprolite is extremely firm.

DEPARTMENT OF ENVIRONMENT, HEALTH, & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

SHEET 1 OF 1
PROPERTY I.D.#:
DATE: 9-1-94
COUNTY: Chatham

SOIL/SITE EVALUATION
FOR
ON-SITE WASTEWATER SYSTEM

OWNER: I.O. Public APPLICANT: Same
APPLICATION DATE: 9/1/94 DATE EVALUATED: 9/1/94
PROPOSED FACILITY: 3 bedroom home PROPOSED DESIGN FLOW (.1949): 360 gpd PROPERTY SIZE: unlimited acreage
LOCATION OF SITE: Pittsboro Field Demonstration Site
WATER SUPPLY: Private x Public ___ Well x Spring ___ Other ___ EVAL. METHOD: Auger Boring x Pit ___ Cut ___

PROFILE #	.1940 LANDSCP POS./ SLOPE %	HORIZON DEPTH (IN.)	SOIL MORPHOLOGY .1941 (a)(1) TEXTURE	(a)(2) STRUCTURE	(a)(3) MINERALOGY CONSISTENCE	SOIL MATRIX COLOR	SOIL MOTTLE COLOR	OTHER PROFILE FACTORS	
1	L 12	0-4	l	gr	fr, ss, sexp	7.5YR4/2	none	.1942 WETNESS CONDITION	none
		4-22	cl	sbk	fi, s, sexp	7.5YR5/6	none	.1943 SOIL DEPTH/ .1956 SAPROLITE	38"
		22-38	c	sbk	fi, s, sexp	7.5YR5/6	none	.1944 RESTRICTIVE HORIZON	none
		38-44	scl (sap)	m	fi, s, sexp	7.5YR6/8	2.5YR7/4	.1947 PROFILE CLASSIF	P.S.
		40-50+	wrock	-	vfi	N/A	N/A	PROFILE LTAR	0.2
2	L 10	0-4	l	gr	fr, ss, sexp	7.5YR4/2	none	.1942 WETNESS CONDITION	none
		4-24	cl	sbk	fi, s, sexp	7.5YR5/4	none	.1943 SOIL DEPTH/ .1956 SAPROLITE	40"
		24-40	c	sbk	fi, s, sexp	7.5YR5/6	none	.1944 RESTRICTIVE HORIZON	none
		40-50+	scl (sap)	pl-m	fr, s, sexp	7.5YR6/8	10YR8/3	.1947 PROFILE CLASSIF	P.S.
								PROFILE LTAR	0.2
3	L 11	0-5	l	gr	fr, ss, sexp	7.5YR3/2	none	.1942 WETNESS CONDITION	38"
		5-28	cl	sbk	fr, s, sexp	10YR5/4	none	.1943 SOIL DEPTH/ .1956 SAPROLITE	44"
		28-38	c	sbk	fi, s, sexp	10YR5/4	10YR7/4	.1944 RESTRICTIVE HORIZON	none
		38-44	c	sbk	fi, s, sexp	10YR6/4	10YR6/2	.1947 PROFILE CLASSIF	P.S.
		44-50+	scl (sap)	m	fi, s, sexp	10YR7/2	10YR4/8	PROFILE LTAR	0.1 LPP
4	L 13	0-6	l	gr	fr, ss, sexp	10YR4/2	none	.1942 WETNESS CONDITION	28"
		6-28	cl	sbk	fi, s, sexp	10YR5/4	none	.1943 SOIL DEPTH/ .1956 SAPROLITE	42"
		28-36	cl	sbk	fi, s, sexp	10YR5/3	10YR6/2	.1944 RESTRICTIVE HORIZON	none
		36-42	c	sbk	fi, s, sexp	10YR5/4	10YR6/2	.1947 PROFILE CLASSIF	U
		42-50+	scl (sap)	m	fr, s, sexp	10YR6/1	10YR5/8	PROFILE LTAR	0.1 LPP

AVAILABLE SPACE (.1945) S OTHER FACTORS (.1946) S SITE CLASSIFICATION P.S.
SYSTEM TYPE(S) shallow conv. SITE LONG-TERM ACCEPTANCE RATE(S) 0.2
EVALUATED BY: AB. Specialist OTHER(S) PRESENT: I.O. Public
COMMENTS: Repair area will need subsurface interceptor drain and a shallow low pressure pipe system to allow reclassification from UNSUITABLE to PROVISIONALLY SUITABLE. The LPP-LTAR is 0.1.

DEPARTMENT OF ENVIRONMENT,
HEALTH, & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

SHEET 1 OF 1
PROPERTY I.D.#: ________
DATE: 9-1-94
COUNTY: Robeson

SOIL/SITE EVALUATION
FOR
ON-SITE WASTEWATER SYSTEM

OWNER: J.Q. Public APPLICANT: Same
APPLICATION DATE: 9/1/94 DATE EVALUATED: 9/1/94
PROPOSED FACILITY: 3 bedroom home PROPOSED DESIGN FLOW (.1949): 360 gpd PROPERTY SIZE: unlimited acreage
LOCATION OF SITE: Norfolk Series
WATER SUPPLY: Private___ Public x Well___ Spring___ Other___ EVAL. METHOD: Auger Boring x Pit___ Cut___

PROFILE #	.1940 LANDSCP POS./ SLOPE %	HORIZON DEPTH (IN.)	SOIL MORPHOLOGY .1941 (a)(1) TEXTURE	(a)(2) STRUCTURE	(a)(3) MINERALOGY CONSISTENCE	SOIL MATRIX COLOR	SOIL MOTTLE COLOR	OTHER PROFILE FACTORS	
	S	0-9	ls	1.gr	vfr. sexp	10YR5/2		.1942 WETNESS CONDITION	>48
1	0-10	9-14	ls	1.gr	vfr. sexp	10YR6/4		.1943 SOIL DEPTH/ .1956 SAPROLITE	>48
		14-17	sl	1.sbk	fr. sexp	10YR5/6		.1944 RESTRICTIVE HORIZON	>48
		17-48	scl	1.sbk	fr. sexp	10YR5/6		.1947 PROFILE CLASSIF	PS
								PROFILE LTAR	0.3-0.6
								.1942 WETNESS CONDITION	>48
2			same as profile #1					.1943 SOIL DEPTH/ .1956 SAPROLITE	>48
								.1944 RESTRICTIVE HORIZON	>48
								.1947 PROFILE CLASSIF	PS
								PROFILE LTAR	0.3-0.6
								.1942 WETNESS CONDITION	>48
3			same as profile #1					.1943 SOIL DEPTH/ .1956 SAPROLITE	>48
								.1944 RESTRICTIVE HORIZON	>48
								.1947 PROFILE CLASSIF	PS
								PROFILE LTAR	0.3-0.6
								.1942 WETNESS CONDITION	>48
4			same as profile #1 except sl horizon extends to a 24" depth					.1943 SOIL DEPTH/ .1956 SAPROLITE	>48
								.1944 RESTRICTIVE HORIZON	>48
								.1947 PROFILE CLASSIF	PS
								PROFILE LTAR	0.3-0.6

AVAILABLE SPACE (.1945) S OTHER FACTORS (.1946)______ SITE CLASSIFICATION PROVISIONALLY SUITABLE
SYSTEM TYPE(S) conventional SITE LONG-TERM ACCEPTANCE RATE(S) 0.5
EVALUATED BY: AB. Specialist OTHER(S) PRESENT: J.Q. Public
COMMENTS: The recommended trench bottom depth is 24" below the soil surface. The maximum depth allowable is 36 inches (.1955 (g)).

FORM #3

DEPARTMENT OF ENVIRONMENT,
HEALTH, & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

SHEET 1 OF 1
PROPERTY I.D.#: ____
DATE: 9-1-94
COUNTY: Wayne

SOIL/SITE EVALUATION
FOR
ON-SITE WASTEWATER SYSTEM

OWNER: J.O. Public APPLICANT: Same
APPLICATION DATE: 9/1/94 DATE EVALUATED: 9/1/94
PROPOSED FACILITY: 3 bedroom home PROPOSED DESIGN FLOW (.1949): 360 gpd PROPERTY SIZE: unlimited acreage
LOCATION OF SITE: Goldsboro Series
WATER SUPPLY: Private ___ Public x Well ___ Spring ___ Other ___ EVAL. METHOD: Auger Boring x Pit ___ Cut ___

PROFILE #	.1940 LANDSCP POS./ SLOPE %	HORIZON DEPTH (IN.)	SOIL MORPHOLOGY .1941 (a)(1) TEXTURE	(a)(2) STRUCTURE	(a)(3) MINERALOGY CONSISTENCE	SOIL MATRIX COLOR	SOIL MOTTLE COLOR	OTHER PROFILE FACTORS	
1	I	0-8	ls	l. gr	vfr. sexp	10YR5/2		.1942 WETNESS CONDITION	25
	0-5	8-12	ls	l. gr	vfr. sexp	10YR6/3		.1943 SOIL DEPTH/ .1956 SAPROLITE	>45
		12-15	sl	l. sbk	fr. ss. sexp	10YR6/6		.1944 RESTRICTIVE HORIZON	>45
		15-25	scl	l. sbk	fr. ss. sp. sexp	10YR5/6		.1947 PROFILE CLASSIF	U
		25-45	scl	l. sbk	fr. ss. sp. sexp	10YR6/3	10YR6/1	PROFILE LTAR	0.3-0.6
2								.1942 WETNESS CONDITION	25
				Same as profile #1.				.1943 SOIL DEPTH/ .1956 SAPROLITE	>45
								.1944 RESTRICTIVE HORIZON	>45
								.1947 PROFILE CLASSIF	U
								PROFILE LTAR	0.3-0.6
3								.1942 WETNESS CONDITION	
								.1943 SOIL DEPTH/ .1956 SAPROLITE	
								.1944 RESTRICTIVE HORIZON	
								.1947 PROFILE CLASSIF	
								PROFILE LTAR	
4								.1942 WETNESS CONDITION	
								.1943 SOIL DEPTH/ .1956 SAPROLITE	
								.1944 RESTRICTIVE HORIZON	
								.1947 PROFILE CLASSIF	
								PROFILE LTAR	

AVAILABLE SPACE (.1945) 5 OTHER FACTORS (.1946) ____ SITE CLASSIFICATION PS - .1956 (1)
SYSTEM TYPE(S) Shallow placed conv. SITE LONG-TERM ACCEPTANCE RATE(S) 0.4
EVALUATED BY: AB. Specialist OTHER(S) PRESENT: J.O. Public
COMMENTS: A shallow placed conventional system can be used to reclassify the site as provisionally suitable (.1956(1)). The trench bottoms must be no deeper than 13 inches from the soil surface and a minimum of 5 inches of loam or sandy loam fill should be used to achieve a 6 inch cover (.1955 m and e).

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HEALTH, & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

SHEET 1 OF 1
PROPERTY I.D.#:
DATE: 9-1-94
COUNTY: Wake

SOIL/SITE EVALUATION
FOR
ON-SITE WASTEWATER SYSTEM

OWNER: I.O. Public APPLICANT: Same
APPLICATION DATE: 9/1/94 DATE EVALUATED: 9/1/94
PROPOSED FACILITY: 3 bedroom home PROPOSED DESIGN FLOW (.1949): 360 gpd PROPERTY SIZE: unlimited acreage
LOCATION OF SITE: Altavista
WATER SUPPLY: Private___ Public x Well___ Spring___ Other______ EVAL. METHOD: Auger Boring x Pit___ Cut___

PROFILE #	.1940 LANDSCP POS./ SLOPE %	HORIZON DEPTH (IN.)	SOIL MORPHOLOGY .1941 (a)(1) TEXTURE	(a)(2) STRUCTURE	(a)(3) MINERALOGY CONSISTENCE	SOIL MATRIX COLOR	SOIL MOTTLE COLOR	OTHER PROFILE FACTORS	
1	T	0-8	fsl	1. gr	vfr. sexp	10YR5/2		.1942 WETNESS CONDITION	20
	0-6	8-12	fsl	1. gr	vfr. sexp	10YR6/3		.1943 SOIL DEPTH/ .1956 SAPROLITE	>48
		12-15	scl	1. sbk	fr. sexp	10YR6/6		.1944 RESTRICTIVE HORIZON	>48
		15-20	cl	1. sbk	fr. sexp	10YR5/6	5YR5/8	.1947 PROFILE CLASSIF	U
		20-48	scl	1. sbk	fr. sexp	10YR5/8	10YR6/2	PROFILE LTAR	0.3-0.6
2								.1942 WETNESS CONDITION	22
								.1943 SOIL DEPTH/ .1956 SAPROLITE	>48
								.1944 RESTRICTIVE HORIZON	>48
			Similar to profile # 1 except 5th horizon with low chroma mottles begins at 22 inches.					.1947 PROFILE CLASSIF	U
								PROFILE LTAR	0.3-0.6
3								.1942 WETNESS CONDITION	20
								.1943 SOIL DEPTH/ .1956 SAPROLITE	>48
								.1944 RESTRICTIVE HORIZON	>48
			Similar to profile #1 except textures of 3rd and 5th horizons are clay loam.					.1947 PROFILE CLASSIF	U
								PROFILE LTAR	0.3-0.6
4								.1942 WETNESS CONDITION	
								.1943 SOIL DEPTH/ .1956 SAPROLITE	
								.1944 RESTRICTIVE HORIZON	
								.1947 PROFILE CLASSIF.	
								PROFILE LTAR	

AVAILABLE SPACE (.1945)______ OTHER FACTORS (.1946)______ SITE CLASSIFICATION PS - .1957 (b)(1)
SYSTEM TYPE(S) Fill system SITE LONG-TERM ACCEPTANCE RATE(S) 0.3
EVALUATED BY: AB. Specialist OTHER(S) PRESENT: I.O. Public
COMMENTS: A minimum of 10 inches of suitable fill must be placed on the lot to reclassify the site as provisionally suitable for a fill system (.1957(b)(1)) with a low pressure pipe system. Otherwise a minimum of 16 inches of fill would be required with gravity distribution.

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DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

SHEET 1 OF 1
PROPERTY I.D.#: ____
DATE: 9-1-94
COUNTY: Buncombe

SOIL/SITE EVALUATION
FOR
ON-SITE WASTEWATER SYSTEM

OWNER: J.O. Public APPLICANT: Same
APPLICATION DATE: 9/1/94 DATE EVALUATED: 9/1/94
PROPOSED FACILITY: 3 bedroom home PROPOSED DESIGN FLOW (.1949): 360 gpd PROPERTY SIZE: unlimited acreage
LOCATION OF SITE: Evard Series
WATER SUPPLY: Private___ Public_x_ Well___ Spring___ Other___ EVAL. METHOD: Auger Boring_x_ Pit___ Cut___

PROFILE #	.1940 LANDSCP POS./ SLOPE %	HORIZON DEPTH (IN.)	SOIL MORPHOLOGY .1941 (a)(1) TEXTURE	(a)(2) STRUCTURE	(a)(3) MINERALOGY CONSISTENCE	SOIL MATRIX COLOR	SOIL MOTTLE COLOR	OTHER PROFILE FACTORS	
	L	0-5	sl	2. gr	vfr. sexp	10YR3/3		.1942 WETNESS CONDITION	>55
1	20	5-23	scl	2. sbk	fi. sexp	10YR4/6		.1943 SOIL DEPTH/ .1956 SAPROLITE	34
		23-34	scl	2. sbk	fr. sexp	10YR4/6		.1944 RESTRICTIVE HORIZON	>55
		34-55+	sl (sap)	rock con.	vfr. sexp	5YR4/6	10YR6/2	.1947 PROFILE CLASSIF	U
								PROFILE LTAR	0.3-0.6
	L							.1942 WETNESS CONDITION	>55
2	22							.1943 SOIL DEPTH/ .1956 SAPROLITE	36
			Similar to profile # 1 except slope is 22%.					.1944 RESTRICTIVE HORIZON	>55
								.1947 PROFILE CLASSIF	PS
								PROFILE LTAR	0.3-0.6
	L							.1942 WETNESS CONDITION	>55
3	28							.1943 SOIL DEPTH/ .1956 SAPROLITE	34
			Similar to profile # 1 except slope is 28%.					.1944 RESTRICTIVE HORIZON	>55
								.1947 PROFILE CLASSIF	U
								PROFILE LTAR	0.3-0.6
4								.1942 WETNESS CONDITION	
								.1943 SOIL DEPTH/ .1956 SAPROLITE	
								.1944 RESTRICTIVE HORIZON	
								.1947 PROFILE CLASSIF	
								PROFILE LTAR	

AVAILABLE SPACE (.1945)____ OTHER FACTORS (.1946)____ SITE CLASSIFICATION PS - .1956 (1)
SYSTEM TYPE(S) Shallow placed conv. SITE LONG-TERM ACCEPTANCE RATE(S) 0.4
EVALUATED BY: AB, Specialist OTHER(S) PRESENT: J.O. Public
COMMENTS: The site can be reclassified provisionally suitable by using a shallow placed conventional system with a maximum trench depth of 22 inches (.1956(1) and.1955(m)).
Alternatively, a site evaluation from backhoe excavated pits could be conducted to determine the suitability of the saprolite (4th horizon) for deeper placement of the trenches (.1956(6)).

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HEALTH, & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

SHEET 1 OF 1
PROPERTY I.D.#: ______
DATE: 9-1-94
COUNTY: Durham

SOIL/SITE EVALUATION
FOR
ON-SITE WASTEWATER SYSTEM

OWNER: I.O. Public APPLICANT: Same
APPLICATION DATE: 9/1/94 DATE EVALUATED: 9/1/94
PROPOSED FACILITY: 3 bedroom home PROPOSED DESIGN FLOW (.1949): 360 gpd PROPERTY SIZE: unlimited acreage
LOCATION OF SITE: White Store Series
WATER SUPPLY: Private___ Public_x_ Well___ Spring___ Other______ EVAL. METHOD: Auger Boring_x_ Pit___ Cut____

PROFILE #	.1940 LANDSCP POS./ SLOPE %	HORIZON DEPTH (IN.)	SOIL MORPHOLOGY .1941 (a)(1) TEXTURE	(a)(2) STRUCTURE	(a)(3) MINERALOGY CONSISTENCE	SOIL MATRIX COLOR	SOIL MOTTLE COLOR	OTHER PROFILE FACTORS	
	L	0-6	fsl	1. gr	vfr. sexp	10YR5/3		.1942 WETNESS CONDITION	22
1	2-15	6-10	cl	1. sbk	fi. sexp	7.5YR5/6		.1943 SOIL DEPTH/ .1956 SAPROLITE	38
		10-22	c	pr to 1.abk	vfi. vs. vp. exp	5YR5/6	2.5YR4/4	.1944 RESTRICTIVE HORIZON	>38
		22-38	c	2. sbk	vfi. vs. vp. exp	5YR4/6	10YR6/2	.1947 PROFILE CLASSIF	U
		38+	sl	0. m	extfi. ss. sp. sexp	2.5 YR 3/4	10YR6/1	PROFILE LTAR	
								.1942 WETNESS CONDITION	24
2								.1943 SOIL DEPTH/ .1956 SAPROLITE	36
		Similar to profile #1 except clayey, expansive horizon begins at 14 inches.						.1944 RESTRICTIVE HORIZON	>38
								.1947 PROFILE CLASSIF	U
								PROFILE LTAR	
								.1942 WETNESS CONDITION	26
3								.1943 SOIL DEPTH/ .1956 SAPROLITE	38
		Similar to profile # 1 except clayey expansive horizon begins at 18 inches.						.1944 RESTRICTIVE HORIZON	>38
								.1947 PROFILE CLASSIF	U
								PROFILE LTAR	
								.1942 WETNESS CONDITION	18
4								.1943 SOIL DEPTH/ .1956 SAPROLITE	36
		Similar to profile # 1 except 2nd horizon is missing and clayey expansive horizon begins at 6 inches.						.1944 RESTRICTIVE HORIZON	>38
								.1947 PROFILE CLASSIF	U
								PROFILE LTAR	

AVAILABLE SPACE (.1945) U OTHER FACTORS (.1946)______ SITE CLASSIFICATION unsuitable
SYSTEM TYPE(S) none SITE LONG-TERM ACCEPTANCE RATE(S)______
EVALUATED BY: AB. Specialist OTHER(S) PRESENT: I.O. Public
COMMENTS: The site is unsuitable for a septic tank system due to a clay subsoil with prismatic structure and expansive mineralogy (.1941), and soil wetness within 22 inches of the soil surface (.1942).

Conventional and Modified Conventional On-Site Systems

5

Conventional and Modified Conventional On-Site Systems

As defined by the *Rules for Sewage Treatment and Disposal Systems,*

"Sewage" means the liquid and solid human waste and liquid waste generated by water-using fixtures and appliances, including those associated with food handling.

"Effluent" means the liquid discharge of a septic tank or other sewage treatment device.

Reference

15A NCAC 18A.1935(11),(39)

Conventional on-site systems are the most common and the simplest on-site wastewater disposal systems. Installed properly, conventional systems are very reliable and require minimal maintenance.

Sometimes conventional systems must be modified to work properly in areas with thin soil layers, steep slopes, or high water tables. There are a number of standard modifications to the conventional system that can make on-site systems function well in these difficult conditions.

This chapter will explain the design, installation, inspection, and maintenance of conventional systems and modified conventional systems. Each section is designed as a complete guide. The initial section of the chapter shows how to determine the expected daily flow of wastewater for a system. The following sections contain information on: system design and layout; details about system components such as tanks, distribution devices, and treatment and disposal fields; modifications to conventional systems; installation and construction of systems; and field inspection of systems.

5.1 WASTEWATER FLOWS AND CHARACTERISTICS

Reference

15A NCAC 18A.1949

The amount of sewage that flows from a house depends on a number of factors, such as the number and age of the occupants, water-using habits, time spent at home, the size of the house, condition and age of the plumbing fixtures, and the income level of the occupants. Sewage flows from restaurants, businesses, and commercial buildings vary widely with the type of business and activity in the building. The amount of sewage that an on-site system must handle is important to the design, construction, and installation of an on-site system because the amount of sewage determines the size of the septic tank, pipelines, and the size of the treatment and disposal field. This section discusses how to estimate how much flow an on-site system can receive.

Design Unit Method

A *design unit* is used to determine the amount of sewage that will flow from a house, business or other facility.

Reference
15A NCAC 18A.1935(a)

The rules define a design unit as

one or more dwelling units, places of business, or places of public assembly on:

a. a single lot or tract of land;

b. multiple lots or tracts of land served by a common ground absorption sewage treatment and disposal system; or

c. a single lot or tract of land or multiple lots or tracts of land where the dwelling units, places of business or places of public assembly are under multiple ownership (e.g. condominiums) and are served by a ground absorption system or multiple ground absorption systems which are under common or joint ownership or control.

The design unit method is used in the North Carolina *Laws and Rules for Sewage Treatment and Disposal Systems.* (See 15A NCAC 18A.1949 for the complete rule.)

For example, the dwelling unit for a house is a bedroom. The number of bedrooms determines how many people may live in the house (design unit). It is assumed that there will be two people living in the house for each bedroom and that each person will use 60 gallons of water per day, so each bedroom contributes 120 gallons per day to the sewage flow from a house. More bedrooms means that there are more people using water and that there is more flow to the on-site system. A 3-bedroom house would have 3 bedrooms at 120 gallons per day or a 360 gallon-per-day flow.

Reference
15A NCAC 18A.1949

Under the rules, the minimum flow from a house, for design purposes, is 240 gallons per day, whether the house has one or two bedrooms. This minimum flow is used so that the on-site system will be adequately sized to account for water used by the basic fixtures expected to be present in all houses, regardless of size (e.g. bathroom sink, toilet, and shower; kitchen sink and dishwasher; and a laundry machine).

In the same way, sewage flows from businesses can be determined by how many design units the business has. For example, the design unit for a restaurant is 40 gallons of sewage per day for each customer seat. So, a 100-seat restaurant would need an on-site system designed to handle 4,000 gallons of sewage per day (40 gallons per seat per day x 100 seats = 4,000 gallons per day). Motels generate 120 gallons per day for each room and day schools produce 10-15 gallons of sewage per day for each student.

The following points show how to use design units to determine sewage flow.

- ❑ The minimum flow from a house is 240 gallons per day.
- ❑ Each bedroom more than two bedrooms adds 120 gallons per day.
- ❑ If there are more than two people per bedroom, then the sewage flow is 60 gallons per day for each person living in the house.
- ❑ For businesses and other buildings see Table 5.1.1 for the flow per design unit.
- ❑ Design of sewage treatment and disposal systems for facilities not identified in this table shall be determined using available flow data, water-using fixtures, occupancy or operation patterns, and other measured data.

Table 5.1.1 Daily Sewage Flow for Establishments

Type of Establishment	Daily Flow for Design
AIRPORTS	5 gal/passenger
Railroad Stations (does not include food service facilities)	
Bus Terminals (does not include food service facilities)	
BARBER SHOPS	50 gal/chair
BARS, COCKTAIL LOUNGES (does not include food service)	20 gal/seat
BEAUTY SHOPS OR STYLE SHOPS	125 gal/seat
BOWLING LANES	50 gal/lane
BUSINESSES (other than those listed elsewhere in this table)	25 gal/employee
CAMPS	
Construction or Work Camps (with flush toilets)	60 gal/person
(with chemical toilets)	40 gal/person
Summer Camps	60 gal/person
Campgrounds with Comfort Station (without water and sewer hookups)	100 gal/campsite
Travel Trailer/Recreational Vehicle Park (with water and sewer hookups)	120 gal/space
CHURCHES (does not include a kitchen, food service facility, day care center, or camp)	5 gal/seat
COUNTRY CLUBS	20 gal/member
FACTORIES (exclusive of industrial waste)	25 gal/person/shift
Add for showers	10 gal/person/shift
FOOD SERVICE FACILITIES	
Restaurants	40 gal/seat or 40 gal/15 ft² of dining area, whichever is greater
24-hour Restaurant	75 gal/seat
Food Stands	
(1) Per 100 square feet of food stand floor space	50 gal
(2) Add per food employee	25 gal
Other Food Service Facilities	5 gal/meal
HOSPITALS	300 gal/bed
MARINAS	10 gal/boat slip
With bathhouse	30 gal/boat slip
MEAT MARKETS	
(1) Per 100 square feet of market floor space	50 gal
(2) Add per-market employee	25 gal
MOTELS/HOTELS	120 gal/room
With cooking facilities	175 gal/room
OFFICES (per shift)	25 gal/person
RESIDENTIAL CARE FACILITIES, REST HOMES, NURSING HOMES	60 gal/bed
With laundry	120 gal/bed
DAY SCHOOLS	
With cafeteria, gym, and showers	15 gal/student
With cafeteria only	12 gal/student
With neither cafeteria nor showers	10 gal/student
BOARDING SCHOOLS	60 gal/person
SERVICE STATIONS	250 gal/water closet or urinal
24-hour Service Stations	325 gal/water closet
STORES, SHOPPING CENTERS, AND MALLS (Exclusive of food service and meat markets)	120 gal/1000 ft² of retail sales area
STADIUMS, AUDITORIUMS, THEATERS, DRIVE-INS	5 gal/seat or space
SWIMMING POOLS, SPAS, AND BATHHOUSES	10 gal/person

Adjusted Daily Flows

The actual flow of sewage from certain places may vary considerably from the flow rate listed in Table 5.1.1. For instance, if a business installs fixtures that use only small amounts of water, such as ultra-low flow toilets and ultra-low flow showerheads, then the daily sewage flows will be lower than listed in Table 5.1.1. This means that the treatment and disposal field for an on-site system can be made smaller under the rules. A smaller system requires less land area and is less expensive to construct.

❑ Adjustments are not allowed for single-family houses or most other homes. Only places listed in Table 5.1.1 can request to adjust the daily flow of sewage so that they can install smaller treatment and disposal fields.

❑ Establishments that request adjustments of flow may be required to install a flow equalization tank to smooth out the bursts of sewage that may flow at certain times of high usage. For example, a restaurant that serves only evening meals may have high peak flows for only a few hours a day and nothing during the rest of the day. Here, a grease trap and flow equalization tank that releases the sewage slowly to the septic tank and treatment and disposal field will be very helpful. The grease trap and flow equalization tank can keep grease and oil from being carried through the septic tank to the treatment and disposal field.

❑ It is important to study the characteristics of the sewage to determine the strength of the wastewater. Restaurants and other food service facilities usually need to determine the amount of grease and oil and the strength of the waste before a smaller treatment and disposal field can be approved. Other establishments may need to test for other characteristics.

Reference
15A NCAC 18A.1949(c)

If an establishment wishes to apply for an adjustment to the daily flow of sewage, it must show that the daily flows are lower than the amount of sewage usually expected from a similar establishment. Two ways to show that the daily sewage flows are lower than Table 5.1.1 are given below.

Method 1

The facility may keep records of the water used each month for 12 months in a row, and for the water used each day for 30 days of use. Frequently, records of water use can be obtained from water bills or from the public water utility company. To get a good estimate of the water used each day, the 30-day record should be taken when the water use is heavy. Next, the highest monthly reading is divided by the sum of the 30 days' water usage to get a *peaking factor*. The peaking factor shows how much difference there is between the normal daily flow during the peak flow month and taken to normal daily flow for the 30-day daily flow monitoring period. Then the highest three readings of the 30 days' records are averaged and multiplied by the peaking factor. The final result is an adjusted daily flow to use for design of an on-site system.

Keeping daily records of water usage is necessary because it is very difficult to determine a daily flow from yearly or monthly water usage. A daily flow calculated from a yearly or monthly usage will not show high peak flows. An example is given below.

> ***Example.*** Suppose a 24-hour restaurant with 30 seats begins using disposable dinnerware, which greatly reduces flows from dishwashing, and a specially designed advanced pretreatment unit which assures waste-water characteristics do not exceed domestic strength. The restaurant manager requests a permit for an on-site system that is smaller than called for in Table 5.1.1. They agree to keep records of their water use for 12 months in a row and for a 30-day straight period to show that a smaller on-site system will be adequate. Of the 12 monthly records, the highest

monthly water usage is 52,721 gallons. The 30-day record occurred during the month of June, which is a time when water usage is expected to be higher than normal. The sum of the 30 days' water usage records is 49,842 gallons and the three highest daily flows recorded are 1,468 gallons, 1,537 gallons, and 1,562 gallons.

The peaking factor is the first number needed. It can be found by dividing the highest monthly water usage by the sum of the 30 days' water usage. In this example, the highest monthly water usage is 52,721 gallons and the sum of the 30 days' water usage is 49,842 gallons. Dividing 52,721 by 49,842 equals a peaking factor of 1.06. Next, the three highest daily flows from the 30 days' water records are averaged. In the example, the three highest daily flows are 1,468 gallons, 1,537 gallons, and 1,562 gallons. The average is the sum of the three daily flows divided by 3, which gives an average daily flow of 1,522 gallons per day. To find the adjusted daily flow, multiply the average daily flow by the peaking factor, or 1,522 gallons per day times 1.06 equals an adjusted daily flow of 1,613 gallons per day. A shorter version of the calculations is presented below.

The peaking factor is 52,721 gallons divided by 49,842 gallons = 1.06.

The average daily flow of the top three is 1,468 + 1,537 + 1,562 gallons = 4,567 gallons ÷ 3 days = 1,522 gallons per day.

The adjusted daily flow is 1,522 gallons per day × 1.06 peaking factor = 1,613 gallons per day.

From Table 5.1.1, the daily flow for a 24-hour restaurant with 30 seats is 2,250 gallons. As you can see, the adjusted daily flow, 1,613 gallons, is less than the flow listed in Table 5.1.1, which means that a much smaller treatment and disposal field can be used.

Method 2

With this method, the treatment and disposal field can be made smaller because the establishment uses water-conserving devices in all of its operations. To obtain an adjusted daily flow less than shown in Table 5.1.1, the facility must install plumbing fixtures that use very little water and must have documents that show how much less water will be flowing to the wastewater system. Examples of ultra-low-flow fixtures are toilets that use 0.5 gallons per flush or less, self-closing faucets with flow rates restricted to 1 gallon per minute or less, and showerheads with flow rates of 1.5 gallons per minute or less. Reduced daily flows can be used in designing a smaller on-site system except for pretreatment devices such as septic tanks. Pretreatment devices must be sized as shown in Table 5.1.1. An example is given below.

Example. A wholesale-retail meat distributor with 1,000 square feet of retail area and 10 employees must install a new on-site system. To conserve water, the distributor installs low-flow toilets that use 1.6 gallons per flush and self-closing faucets that restrict the water flow to 1 gallon per minute. Handwashing fountains are operated by hip bars so that the water flow turns off between uses. Showers are used only occasionally by employees but are equipped with low-flow shower heads with on-off toggles as part of the water conservation program. Information provided with the plumbing devices indicates that the water use could be reduced by up to 60%. Flows from the meat preparation area are not reduced by the water conservation effort and remain at 1,000 gallons per day.

After considering the devices installed, the type of work, and the water use by employees, the local health department, in agreement with the On-Site Wastewater Section, grants the business an adjusted daily flow of 1,450 gallons per day. The treatment and disposal field can be sized for the 1,450-gallon-per-day flow. The grease trap and septic tank, however, must be sized for the flows from the meat preparation area, and must have a minimum size of 1,000 gallons to remove grease before it enters the septic tank.

Wastewater Characteristics

In addition to the volume of sewage, it is important to know the characteristics of the wastewaters that are handled by on-site systems. The characteristics of the wastewater help determine the size and type of the on-site system. In some cases, additional septic tanks, filters, aerobic units, or large treatment and disposal fields may be required, especially where very strong wastewater must be treated. Table 5.1.2 lists a number of wastewater characteristics that can be important in designing on-site systems.

Sewage from most households has a common range of values for many of the characteristics listed in Table 5.1.2. These typical values are listed in Table 5.1.3, Typical Characteristics of Household Wastewater.

Sewage from restaurants, commercial buildings, and industries can vary widely from site to site. Because the strength of the wastewater can be very different, it is best to have the applicant test the wastewater for selected characteristics to help determine the type and size of the on-site system needed.

Types of Household Wastewater

In recent years, much effort has been made to treat, recycle, or even reuse different types of wastewater from normal home use. The following definitions describe wastewater from homes.

- *Black water* is the wastewater from toilets, urinals, and other devices that receive human or animal wastes. This sewage is very dangerous because it is polluted with high concentrations of bacteria and solids.

- *Gray water* is wastewater from bathroom sinks, showers, baths, laundries, dishwashers, and kitchen sinks. This wastewater contains some pollutants and moderate concentrations of bacteria. The solids content can be high, especially in water from laundries, which contains lint. Gray water must be treated and disposed in an approved on-site system.

- Some homes and facilities that must conserve water use systems that reuse gray water for flushing toilets. Thus, the gray water is used twice before it is discharged to the on-site system, saving water.

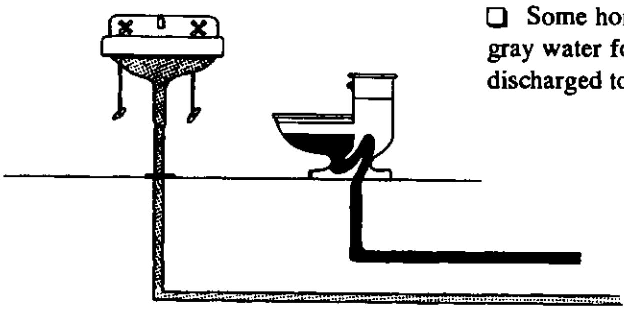


Table 5.1.2 Wastewater Characteristics.

Characteristic	Symbol	Explanation
Total solids	TS	A measure of the total amount of substances in the wastewater, both dissolved and suspended as particles.
Volatile solids	VS	The amount of matter in a wastewater that can be easily oxidized. This is a rough measure of the organic substances in the water.
Total suspended solids	TSS	The amount of particles suspended, rather than being dissolved, in the water. TSS includes mineral matter such as soil particles, nonliving organic matter, and living microbes such as bacteria.
Volatile suspended solids	VSS	The easily oxidized suspended matter in water. VSS includes only organic particles, bacteria, and living microbes.
Biochemical oxygen demand	BOD	A measure of the "strength" of the wastewater, this test determines the amount of oxygen used by bacteria to degrade the substances in the water.
Chemical oxygen demand	COD	Another measure of the strength of the wastewater. This test deter mines the oxygen required to degrade all organic matter in the water, even substances that bacteria cannot degrade.
Total organic carbon	TOC	A measure of the total amount of organic carbon substances in water. This analysis can be useful for testing industrial wastewater because all organic substances are included in this quantity, including substances that cannot be degraded biologically.
Total nitrogen	N	The total amount of nitrogen compounds in the water. Nitrogen compounds are important because they contribute to eutrophication in water bodies.
Total Kjeldahl nitrogen	TKN	The total amount of organic nitrogen and ammonia. TKN nitrogen is generally converted to nitrate and nitrite by sewage treatment.
Ammonia	NH_3	One form of nitrogen usually found in raw sewage.
Nitrate	NO_3	A form of nitrogen usually found in aerobically treated effluent. Nitrate is very soluble in water and moves easily through the soil.
Nitrite	NO_2	A form of nitrogen usually found in aerobically treated effluent. Nitrite is easily converted to nitrate by certain bacteria in the presence of oxygen.
Total phosphorus	TP	The total amount of phosphorus compounds in water. Phosphorus compounds are important because they contribute to eutrophication in water bodies.
Phosphate	PO_4	A form of phosphorus found in the dissolved form in treated effluent.
Total coliform	TC	The total amount of all types of coliform bacteria.
Fecal coliform	FC	The amount of those types of coliform bacteria that live in the intestines of warmblooded animals and found in fecal matter.
E. Coli.	EC	The amount of *Escherichia Coli*, a type of fecal coliform bacteria, found in the water. This bacterium is used as an indicator of pollution caused by human waste.
Fecal Streptococci	FS	Fecal Streptococci are another type of bacteria found in the intestines of warm-blooded animals. This type of bacteria is an indicator of the disease-causing potential of a polluted water.

The information listed in Table 5.1.3 is for characteristics of domestic wastewater. Industrial and commercial wastewater can have many other characteristics.

Table 5.1.3 Typical Characteristics of Household Water

Characteristic	Symbol	Range of concentration in milligrams per liter	Mass loading in grams per person per day
Total solids	TS	680 - 1000	115 -170
Volatile solids	VS	380 -500	65 -85
Total suspended solids	TSS	200 -290	35 -50
Volatile suspended solids	VSS	150 -240	25 -40
Biochemical oxygen demand	BOD	200 -290	35 -50
Chemical oxygen demand	COD	680 -730	115 -125
Total nitrogen	N	35 -100	6 -17
Ammonia	NH_3	6 -18	1 -3
Nitrate and nitrite	NO_3 and NO_2	less than 1	less than 1
Total phosphorus	TP	18 -29	3 -5
Phosphate	PO_4	6 -24	1 -4
Total coliform	TC	10^{10} -10^{12} cells per liter	
Fecal coliform	FC	10^{8} -10^{10} cells per liter	

5.2 ON-SITE WASTEWATER SYSTEM DESIGN

Basic Principles of On-Site Systems

Reference

15A NCAC 18A.1938

The design of an on-site system requires knowledge of the basic principles of on-site wastewater disposal, the site, and the various systems that can be installed. This section presents the information required to design a proper on-site system.

In order for on-site systems to be safe and reliable, several principles must be observed when designing, installing, or inspecting on-site systems.

First Principle

All on-site systems should be designed so that the sewage is treated and disposed of to minimize the pollutants and prevent contamination of ground water and surface water.

❑ Sewage carries many disease-causing germs and pollutants. To protect humans and the environment, on-site systems should be designed to:

- Protect humans from contact with sewage;
- Keep animals, insects, and rodents from contact with sewage;
- Prevent direct discharge of sewage to the ground water; and
- Prevent direct discharge of sewage to surface water.

❑ Public health is threatened when on-site systems fail to operate properly. These system failures usually result in sewage *ponding* or forming pools on the ground surface because the sewage is not absorbed by the soil. In these instances of system failure, people can come in contact with the pooled sewage that can then spread disease.

Second Principle

On-site systems should be designed and installed to maximize the *aerobic treatment* of the sewage. Aerobic treatment is explained below.

❑ Treatment of sewage means that the sewage is "treated" or processed to remove germs and pollutants. In on-site systems, the sewage is treated by the organisms that live in the soil and by the soil itself.

❑ Aerobic treatment means that air and oxygen are present when the treatment occurs. Effluent undergoes aerobic treatment in soil layers that are not saturated with water. These soil layers are called the *unsaturated zone* because the soil is either dry or damp but never completely wet. Air and oxygen enter the soil in the unsaturated zone and help to remove bacteria and pollutants from the effluent.

❑ Aerobic treatment is the fastest and most complete treatment the effluent can receive in the soil. In addition, some disease-causing germs cannot survive in aerobic conditions because oxygen kills them.

❑ On-site systems should be located where the effluent must travel the farthest distance possible before entering the water table or wet soil layers. This long travel distance helps prevent pollution of ground water by allowing for a longer treatment time, which reduces the chance of untreated effluent reaching ground water supplies.

Third Principle

Effluent should be applied to the soil only in appropriate sites and in a constructed *treatment and disposal field.*

❑ A treatment and disposal field is an area of land where effluent flows into specially prepared trenches or beds to be absorbed by the soil. The treatment and disposal field is where the main treatment of the effluent takes place and where all the effluent is absorbed.

❑ Only certain soils and certain locations should be used as treatment and disposal fields. These areas are selected by environmental health specialists to provide the safest and most reliable place to treat and dispose of effluent.

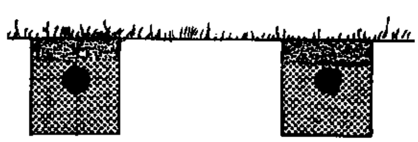
❑ There should be no leakage of sewage from septic tanks, pump tanks, or piping in areas other than the treatment and disposal field. Sewage leaks in areas outside the treatment and disposal field can result in the contamination of ground water and wells.

Fourth principle

Treatment and disposal field trenches should be as long and narrow as possible to maximize soil contact and disposal area.

❑ Short and wide treatment and disposal field trenches may have the same amount of trench bottom area as a long, narrow trench, but the long, narrow trench has much more side wall area that can absorb effluent. The following is an example that illustrates the increase in sidewall area when narrow trenches are used.

The narrow trenches above have more sidewall area for absorption of effluent than wide trenches with the same bottom area shown below.



Example. A three-bedroom home with a daily flow of 360 gallons per day on a site with 3 feet of Group III soil above rock and a Long Term Acceptance Rate of 0.4 gallons per day will require 900 square feet of trench bottom area. To make the calculations simple, assume that the effluent will fill the trench to the top of the crushed stone, a depth of 1 foot. Using the standard 36-inch wide trench, there would be 300 linear feet of trench required which gives 600 square feet of trench sidewall area. If a narrow trench is used, for example a 24-inch wide trench, then 450 linear feet of trench will be needed to meet the requirement of 900 square feet of trench bottom area. However, the narrow trench will have 900 square feet of sidewall area compared to only 600 square feet of sidewall area for the 36-inch trench. The increased sidewall area can help the treatment and disposal field last longer and reduce the tendency of the effluent to pool on the surface.

Fifth principle

Treatment and disposal field trenches should be level across the bottom and be level along their entire length to distribute the effluent as evenly as possible.

❑ Treatment and disposal field trenches with slanted bottoms or trenches that slope along their length will cause the effluent to flow to the lowest area. Thus, all absorption of the effluent will have to take place in that one low area, which can cause early failure of the treatment and disposal field and threaten public health if the effluent ponds on the land surface.

❑ On sloping sites, treatment and disposal field trenches should be installed along the contours of the slope so that the trenches are level along their length.

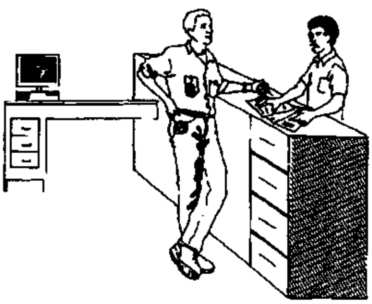
These five principles should guide the design and installation of all on-site systems in order for each system to be as safe and reliable as possible. The following sections present the steps required to design, install, and approve an on-site system.

Designing an On-Site System

The following procedure lays out the steps necessary to obtain approval for an on-site system.

System design, step one: applying for an improvement permit.

Reference
15A NCAC 18A.1937



Filling out an application for an improvement permit.

❑ Much information is needed to complete an application for an *Improvement Permit,* the permit required for the installation or repair of on-site systems, and to proceed with a system design. Listed below are most of the items required for an Improvement Permit application.

- Name of the landowner or system owner.
- Mailing address of the landowner.
- Location of the property, including the city or town, county, subdivision name and lot number, and street name and number.
- A survey plat of the property showing important boundaries, the tax office identification number, and the map and page number of the tax map.
- A description of the type of residence, building, or facility that is planned for the lot including whether there will be a basement.
- Plans for expansion or additions.
- Plans for a pool, sauna, or hot tub.
- The number of bedrooms for a residence so that the sewage flow can be estimated.
- The type of water supply serving the residence, building, or facility, such as a private well or a public water supply.
- The location of designated wetlands on the property.
- For other facilities such as small businesses, strip shopping centers, and townhouses, the type of business and expected water usages.
- Signature of the landowner or authorized agent on the improvement permit application.

❑ The following information can be helpful to identify the specific property in the application.

- The Property Identification Number.
- The date the lot was created.

System design, step two: working with a plat of the property.

A survey plat should contain the following items:

❑ The location of all wells and existing on-site systems on the property and on adjacent properties. The location of the wells and existing systems is critical when determining placement and size limits for the proposed on-site system.

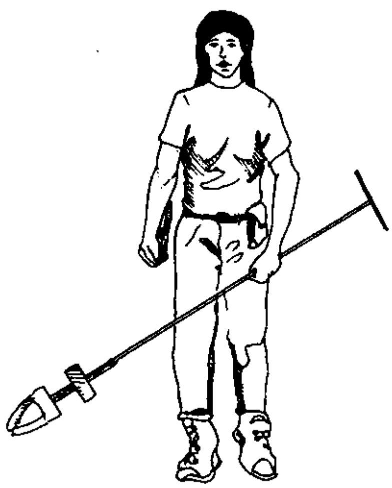
❑ The outline or footprint of the house, and all other structures to be built on the lot. Other structures include: driveways; utilities such as electrical lines, telephone lines, cable television lines, gas pipelines, and water pipelines, especially if the utilities are installed underground; swimming pools; gazebos; outbuildings; and any other structure or device which may interfere with the design or layout of the on-site system.

- ❑ The location of a surveying benchmark and its elevation, if available, to make horizontal and vertical measurements.
- ❑ Other information as needed for special cases.

System design, step three: preparing for a soil and site evaluation.

In addition to the information that can be collected in the office, a new system or a system repair will require a trip to the property to gather information about the soils and site conditions of the lot.

The objective of a site evaluation is to make the on-site system as safe and reliable as possible by finding the best soil and location for the treatment and disposal field. The following list contains information in making a site and soil evaluation. Note that the owner is required to clear the underbrush from the lot prior to the site evaluation.



Environmental health specialist with tools for a site and soil evaluation.

The following list contains suggested items for making a site and soil evaluation.

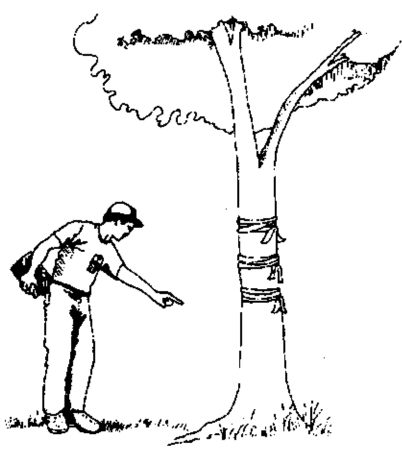
- ❑ For completing the site evaluation form:
  - Permit application and any other necessary forms.
  - Clipboard with paper and pencil, pens for notes and calculations.
  - Plat of the property.
  - Calculator.
- ❑ For evaluating the site:
  - Measuring tapes: 100-200 foot fiberglass tape in an open reel; 6-10 foot steel tape in a closed reel.
  - Engineer's level or a laser level with a target rod to find distances and locations.
  - Clinometer or Abney hand level — to check the slope of the land surface.
  - Magnetic compass — to locate North for a reference.
  - Surveying markers: wire flags, tape, and marking paint to mark locations of house, septic tank, drainage field.
- ❑ For investigating the soil:
  - Soil augers. There are several types of soil augers. Closed-bucket augers work better in sands and light soils, while open-bucket augers can be used in light clay. Flighted augers may work well in very heavy clay.
  - Trenching shovel (sharp shooter).
  - Munsell color book — to classify soil color.
  - Knife or geologist's hammer for digging or scraping soil in large pits dug to view the soil profile.
  - Tape for measuring depths in the soil profile.
  - Water bottle to moisten soil to determine consistence.

❑ A backhoe or other power digging equipment may be needed to dig observation pits to identify the soil profile and evaluate the soil for absorption capability or where saprolite is to be evaluated.

System design, step four: finding the lot boundaries.

Reference
15A NCAC 18A.1938(g)

Lot boundaries must be located to ensure that the entire septic system is installed on the right property and that the site investigation has been done for the right lot. The owner should locate and mark the property corners and boundaries so the investigator will know where to do the site evaluation. Property side lines should be clearly marked if visibility is blocked from corner to corner or if there is a long distance between corners.

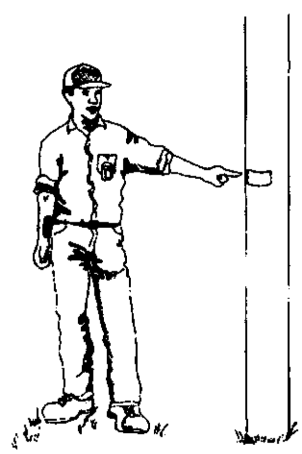


Finding property boundaries.

❑ New lots will probably have surveying stakes from the property survey. On existing lots, look for permanent markers such as metal stakes in the ground, pins in a road, or property monuments identified on the property deed. These are the best markers for determining lot boundaries. Power and telephone poles are often located on property lines and can also be used to determine boundaries.

System design, step five: establishing a benchmark at the site.

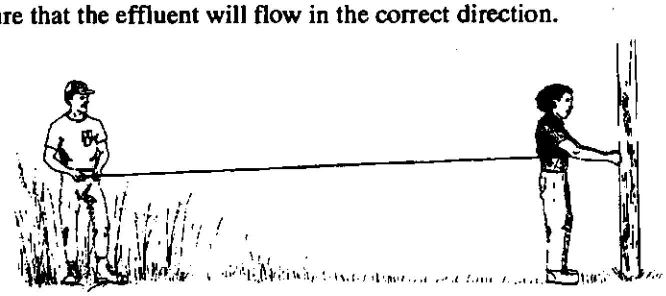
Establishing a *benchmark* at each site is necessary to provide a position and elevation reference for future surveying activities. A benchmark is a permanent object or location on the property that will not move or be changed during construction or at least until system installation is complete. A mark on the corner of an existing building foundation, a large rock, or a surveying hub can all serve as benchmarks for on-site system design.



Locating a benchmark.

❑ The benchmark will be used as a reference for the layout of the on-site system. Horizontal and vertical distances should be measured from the benchmark to locate system components and to determine which parts are higher or lower than the others.

❑ Use the benchmark to set and check slope on pipelines, and check elevation of the septic tank, distribution box, and treatment and disposal field. Since most on-site systems operate by gravity flow, all piping must be installed with a slope to ensure that the effluent will flow in the correct direction.



Measuring from benchmark to locate the on-site wastewater system.

System design, step six: determining the location of the treatment and disposal field.

Reference
15A NCAC 18A.1945(a)

To locate and lay out the on-site system, you must know the location of soil suitable for the treatment and disposal field and the location of other items that require *setbacks* or separations from the treatment and disposal field.

❑ It is critical to know where the water lines, water wells, and water supplies are located on the property and adjacent properties.

❑ The location, size, and shape of the house, building, or facility are needed to determine what land is available to install the pipes, septic tank, and the treatment and disposal field.

System design, step seven: conducting a soil and site evaluation.

Reference
15A NCAC 18A.1939-1948

A soil and site evaluation is critical to the performance of an on-site system. Such factors as the size of the lot and natural conditions — slope, landscape position, and soil characteristics — must be thoroughly evaluated and classified before the site can be approved. (See Chapter 4 for details on soil and site evaluation.)

The results of the soil and site evaluation will be one of the following three classifications.

1. SUITABLE — This site is favorable for a septic system.

2. PROVISIONALLY SUITABLE — This site has moderate limitations. A septic system installed on this site will require modifications and careful design, planning, and installation.

3. UNSUITABLE — This site cannot be used unless the site can be reclassified as Provisionally Suitable. A site can be reclassified if there is written documentation that includes information on the site's soils, engineering properties, geology, and *hydrogeology*. Hydrogeology is the study of ground water and its flow through the earth.

❑ The site evaluation should include evaluating the general landscape of the surrounding area as well as the landscape features of the specific lot for the proposed system.

Table 5.2.1 lists in a short form important factors in a site and soil evaluation. The following sections discuss in more detail the factors involved in a site and soil evaluation.

Topography and landscape position. The *topography*, the slope and smoothness of the site, is important to the design and installation of an on-site system. It is very difficult to install proper treatment and disposal fields and ensure that the effluent will stay in the soil if the land has an extreme slope. Other landscape features such as gullies, ravines, wet areas, and low areas may prevent or limit the type of system that can be installed. The following points should be used in the evaluation of a site for an on-site system.

Reference
15A NCAC 18A.1940

❑ Uniform slopes less than 15% are SUITABLE.

❑ Uniform slopes 15% to 30% are PROVISIONALLY SUITABLE.

❑ Uniform slopes greater than 30% are UNSUITABLE for conventional systems — a modified system may allow the lot to be reclassified as PROVISIONALLY SUITABLE.

❑ Slopes over 65% are UNSUITABLE.

❑ Designated wetlands are UNSUITABLE. A designated wetland is a wetland that the U.S. Army Corps of Engineers or other government agency certifies as meeting their requirements for a wetland.

Table 5.2.1 Important Factors in a Site and Soil Investigation*

Factor	Importance
On-site system located on correct property	There are many legal problems if treatment and disposal fields are constructed on the wrong property.
Topography and landscape position	These factors affect how the land and soil will treat and absorb the effluent. Topography is the slope, hills, valleys, ravines, and gullies on the property. Landscape position is the shape of the ground surface and location.
Soil characteristics	Soil characteristics affect the treatment and absorption of the effluent. Soil characteristics include texture, structure, clay mineralogy, and organic content.
Soil wetness	Soil wetness can reduce the absorption of effluent and can lead to ground water pollution. Soil wetness can be caused by a high water table, perched water table, tidal water, seasonal saturation, or by ground water movement.
Soil depth	Soil depth is extremely important in ensuring adequate capacity to absorb and treat the daily flow of effluent.
Restrictive horizons	Restrictive horizons in soils can severely limit the absorptive capacity of the soil. Soil borings must locate all restrictive horizons within 48 inches of the surface.
Available space	All sites must have enough space to install a treatment and disposal field of the proper size. Additionally, sites must have space for a replacement system. For all sites, it is best if there is enough space for a replacement field, even though an exemption may exist.
Water wells on adjacent property	Required setback distances must be maintained for all wells near the proposed on-site wastewater system.
Large-capacity water wells	On-site systems may need to be installed farther away from a large-capacity well than the usual separation distance for wells because of a larger drawdown cone around the large-capacity well.
Massive failures of multiple-residence systems	One should consider the potential health hazard of a massive failure of an on-site system that serves a large number of residences.
Water table mounding	On-site systems that handle more than 3000 gallons per day must predict the height of the water table mound that will develop under the treatment and disposal field from the flow of effluent into the soil.

**Reference*

15A NCAC 18A.1939-1946(4)

❑ Depressions are UNSUITABLE. Low areas may flood after rains and it can be hard to find proper soil for the treatment and disposal field in depressions.

❑ Landscapes with complex slope patterns and slopes dissected by gullies and ravines are UNSUITABLE. Lots that are not smooth and flat make it much harder to install a proper treatment and disposal field.

Areas that catch water from rain should be landscaped to provide good drainage. Also, areas with a perched water table or with ground water movement in the shallow soil zones should have subsurface drains or interceptor ditches installed to prevent the soil in the treatment and disposal field from becoming saturated.

Reference
15A NCAC 18A.1941

Soil investigation. The type of soil on the lot is critical to the performance of the on-site system. Usually, soils with finer textures, such as clay, have less capacity to absorb effluent while soils with sandy textures have little trouble in absorbing effluent. Use the following procedure to determine the soil and its suitability for on-site wastewater disposal.

Making soil boring with a hand auger.

Reference
15A NCAC 18A.1941 (2)

Soil texture. Soil texture can be determined either by hand or through a laboratory analysis. In Chapter 4, Figure 4.5.2 gives a procedure for determining soil texture by hand. Laboratory testing must follow the American Society for Testing and Materials procedure D-422 for sieve and hydrometer analysis of soils. See 15A NCAC 18A.1941(F) for the details.

❑ Sandy textured soils are SUITABLE.

❑ Coarse loamy textured soils are SUITABLE.

❑ Fine loamy textured soils are PROVISIONALLY SUITABLE.

❑ Clayey textured soils are PROVISIONALLY SUITABLE.

❑ Organic soils are UNSUITABLE.

Soil structure. Soil structure determines how well water moves through some types of soil and is more difficult to determine than soil texture. Refer to Chapter 4 for details on how to determine soil structure.

Reference
15A NCAC 18A.1942

Soil wetness. Areas that have high water tables or tend to hold water are not good sites for on-site systems. A site investigation should determine the depth of the water table and whether the site is regularly flooded or the soil is saturated with water.

❑ Soils are SUITABLE when soil wetness is below 48 inches.

❑ Soils are PROVISIONALLY SUITABLE when soil wetness is between 36 and 48 inches.

❑ Soils are UNSUITABLE if the soil wetness is less than 36 inches, although the site may be reclassified as PROVISIONALLY SUITABLE if a modified or alternative system can be designed for the site.

Reference
15A NCAC 18A.1943

Soil depth. An on-site system must have enough soil beneath the treatment and disposal field to properly treat the effluent or the ground water or nearby streams may be polluted.

❑ Soils are SUITABLE when soil depth is 48 inches or more.

❑ Soils are PROVISIONALLY SUITABLE when soil depth is between 36 and 48 inches.

❑ Soils are UNSUITABLE if the soil depth is less than 36 inches, although the site may be reclassified as PROVISIONALLY SUITABLE if a modified or alternative system can be designed for the site.

Restrictive horizons. *Restrictive horizons* are layers of soil 3 inches or more thick that do not absorb water and do not allow water to pass through. These layers can cause sewage to pond if the layers are too close to the ground surface.

Reference
15A NCAC 18A.1944

❑ Soils are SUITABLE when the restrictive layer is 48 inches or more deep.

❑ Soils are PROVISIONALLY SUITABLE when the restrictive layer is between 36 and 48 inches deep.

❑ Soils are UNSUITABLE when the restrictive layer is less than 36 inches deep, although the site may be reclassified as PROVISIONALLY SUITABLE if a modified or alternative system can be designed for the site.

Available space. On-site systems require sufficient space for proper installation. Additional allowance must be made for setbacks from various objects and areas near an on-site system. A site evaluation includes checking the points listed below to ensure that there is enough space to meet the requirements.

References
15A NCAC 18A.1945
15A NCAC 18A.1950
15A NCAC 18A.1955 (c)
15A NCAC 18A.1945(b)
15A NCAC 18A.1945(d)

❑ All lots must have enough space to install a properly sized treatment and disposal field. The field must have the required bottom area calculated by dividing the expected daily effluent flow by the long-term acceptance rate for the type of soil at the site and for the type of system to be installed.

❑ Systems with effluent flows above 480 gallons per day must have enough space to set aside a *repair area.* The repair area is an area that can be used for another treatment and disposal field if the first field should fail. The replacement system, both type and location, must be designated.

❑ If the lot does not require a repair area, it is good practice to design the system so that the most space possible is left for a repair area in case a replacement field is needed.

Vegetation survey. Evaluate vegetation to determine both desirable and undesirable species. Refer to Chapter 4 for details on the types and locations of vegetation that may render a site SUITABLE or UNSUITABLE.

Other factors. A good site and soil evaluation includes checking and evaluating a number of factors that can seriously affect public health. Consider these factors for each site.

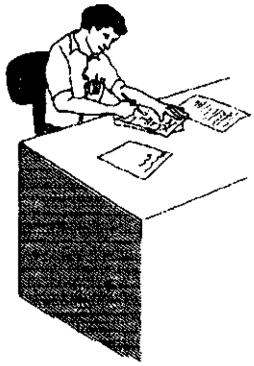
Reference
15A NCAC 18A.1946

❑ Large-capacity wells can develop a *cone of influence,* which may overlap the area of the treatment and disposal field. A cone of influence is an area in the ground where the normal ground water flow has been changed by a pumping well so that the ground water within the cone of influence now flows into the well. An on-site system in the cone of influence of a large well may cause contamination of the well. Careful consideration is required in these cases to protect the public.

Reference
15A NCAC 18A.1946(1)

❑ Very large systems, with flows over 3000 gallons per day, may need to do special soil investigation and borings to be certain that the wastewater will not create a problem with a high water table or surface pooling of effluent.

❑ Another factor to consider is what can happen if the proposed on-site system fails. On-site systems that fail can threaten public health, especially in cases where large numbers of people are dependent on the system; when children could be exposed to pooled effluent; and when wells that supply drinking water to homes, businesses, churches, and schools could possibly be contaminated.



Determining site classification.

System design, step eight: determining the usable area.

Information gathered from the site and soil evaluation should indicate where the usable areas are on a lot.

❑ Locate and measure off the usable area considering the overall area needed for soil absorption. Stake out the usable area on the lot with surveying stakes and draw it on the lot plan. Laying out the usable area can help determine where to put each part of the system and where the nondisturbance areas are.

❑ Check the size and shape of the usable area to be sure that a conventional on-site system will fit.

System design, step nine: determining the site classification for a conventional system.

Reference
15A NCAC 18A.1948

The results of the site and soil evaluation should provide enough information to make a decision about the site's suitability. Site suitability must be determined before beginning a design of the system and only classifications of SUITABLE and PROVISIONALLY SUITABLE are acceptable for system installation.

Reference
15A NCAC 18A.1947

❑ If the topography, landscape, soil type, soil wetness, soil depth restrictive horizons and space are all PROVISIONALLY SUITABLE, for example, then the site should receive a PROVISIONALLY SUITABLE classification.

❑ If the factors in the site and soil evaluation have different classifications, then the site should be classified according to that factor which limits the site. For example, the evaluations of the factors result in SUITABLE classifications for all factors except soil depth and landscape position, which are classified as PROVISIONALLY SUITABLE. The site should be classified as PROVISIONALLY SUITABLE because the soil depth is more limiting than the landscape position.

System design, step ten: selecting a system type.

Select a type of on-site system that fits the lot size and is compatible with all soil and site factors evaluated. Conventional, modified, and alternative systems each have certain advantages and disadvantages. Try to find a system that fits all the factors and will be the most reliable at the least cost, keeping in mind that the options are limited by the rules.

The depth of the soil and the depth to restrictive horizons or other limiting conditions are very important in choosing a system type. Be especially aware of the maximum depth for treatment and disposal trenches.

The different types of systems require different amounts of treatment and disposal trench area. After the type of system has been chosen, choose a trench width and then calculate the length of trench needed for the treatment and disposal field. Recall that long, narrow trenches have more soil contact area and may make a more reliable treatment and disposal field.

Reference

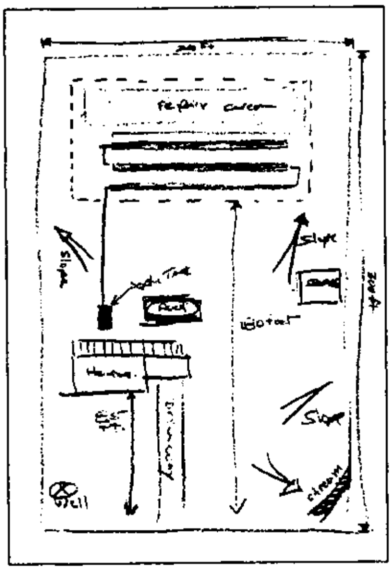
15A NCAC 18A.1948(d)

Site reclassification. A site classified as UNSUITABLE may be used for a ground absorption sewage treatment and disposal system specifically identified in rules .1955, .1956, or .1957 of this section or a system approved under Rule .1969 if written documentation, including engineering, hydrogeologic, geologic, or soil studies, indicates to the local health department that the proposed system can be expected to function satisfactorily. Such sites shall be reclassified as PROVISIONALLY SUITABLE if the local health department determines that the substantiating data indicate that:

- A ground absorption system can be installed so that the effluent will be non-pathogenic, non-infectious, non-toxic, and non-hazardous;
- The effluent will not contaminate ground water or surface water; and
- The effluent will not be exposed on the ground surface or be discharged to surface waters where it could come in contact with people, animals, or vectors.

The state shall review the substantiating data if requested by the local health department.

System design, step eleven: laying out the system.



Rough sketch of lot showing house, pool, driveway, and proposed on-site system.

After completing the site and soil evaluation and selecting the type of system, the designer should follow these steps. See Figure 5.2.1 for a drawing of a proposed property layout.

- Consult with the property owner to check for unseen obstructions, such as buried utilities and stumps cut off below ground.
- Mark the proposed septic tank location on the lot and on the drawing. Remember the setbacks required and try to locate the septic tank outside of the usable area to leave as much usable area as possible for a repair area.
- Pick a starting point in the usable area and, using surveying tools, find its position from the benchmark.
- Find the ground elevation at the starting point and at the proposed septic tank location. The septic tank inlet must be higher than the outlet for effluent to flow out of the tank. For gravity systems, the septic tank outlet must be higher than the treatment and disposal field inlet to allow the effluent to flow into the trenches.
- Using the benchmark as a reference, lay out each treatment and disposal field trench or bed on a convenient contour of elevation in the usable area of the lot.
- Be sure that the benchmark has not been moved since the initial site and soil survey.
- Use long and narrow trenches along the contours so that the trenches have the most soil contact possible.
- When using a distribution box for a treatment and disposal field, the trenches should be of equal lengths. Trenches should be 9 feet on center for the usual 36-inch wide trench. Narrower trenches must be separated, center to center, by three times the trench width with a minimum separation width of 5 feet.
- When a serial distribution treatment and disposal field is to be used, the treatment and disposal field trenches should be 9 feet apart on center for a 36-inch wide trench. The 9-foot separation should be measured horizontally, not on the slope of the land. Narrower trenches must be separated by three times the trench width, center to center.

❑ Restaurants, meat markets, and other facilities that generate sewage with a high content of grease require special steps in on-site system design. All on-site systems designed for these facilities must use a long-term acceptance rate for the site that is no greater than the mean value of the range of values given for the soil on the site. An alternative is to use a pretreatment step to remove grease from the sewage. Both of these steps help keep the treatment and disposal field from being clogged by grease.

❑ Always keep the repair area in mind. Lay out a repair area within the usable area that could be used as a treatment and disposal field in the event the currently proposed field becomes unusable.

❑ Watch the nondisturbance area. Mark areas within the usable area that cannot be used as part of the treatment and disposal field because of other considerations.

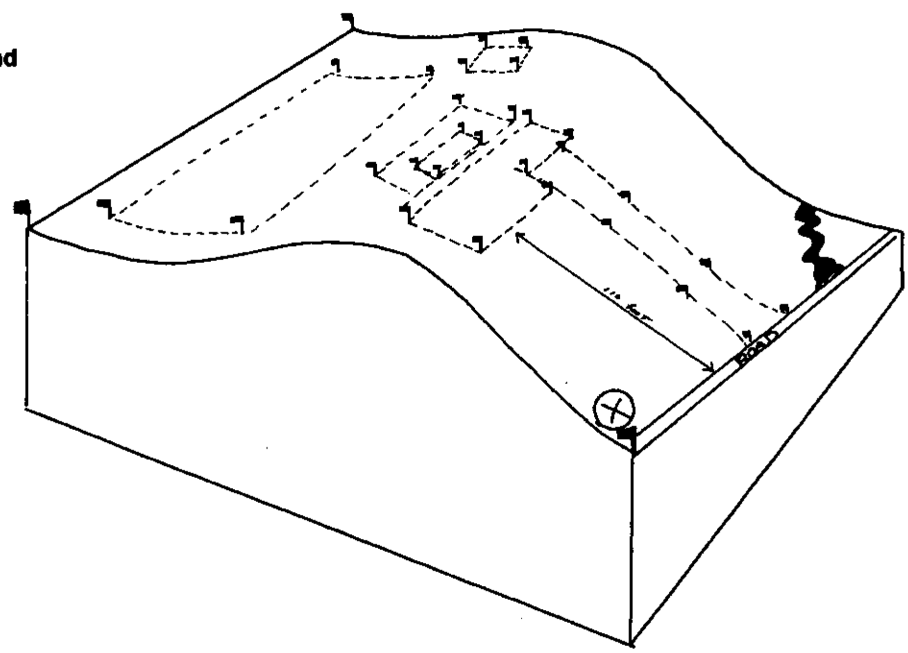


Figure 5.2.1. Property and proposed features surveyed and staked out. Features include house, driveway, pool, and on-site system.

System design, step twelve: determining whether to use a pump.

Most systems use gravity flow to convey effluent to the treatment and disposal field. In some cases, a pump for the on-site system may be needed if the field is higher than the sewer outlet from the house or septic tank, or if the effluent must flow over a rise or through a depression to the field. The following points should be considered when using pumps in on-site systems.

❑ Check the elevation of the conveyance pipe from the house or business. If the pipe is below the elevation of the treatment and disposal field, then the effluent must be pumped to the field. Pump systems must always use a pump tank and pump controls for the system to work properly.

❑ If a pump is needed, it should be located where it can pump effluent from the pump tank that follows a septic tank rather than a sewage lift station. Pumping raw sewage requires special pumps and higher maintenance.

❑ In some situations, such as homes on lakefront property, raw sewage must be pumped to an on-site system located some distance from the lake. In these cases, special grinder pumps can be used to pump the raw sewage to the on-site system.

☐ Look for high spots between the sewage coming from the house and the treatment and disposal field. If the high spot is small, the solid conveyance pipe may be installed by simply digging a deep trench, and making sure that the pipe slopes down toward the treatment and disposal field. It is difficult to safely install the conveyance pipe more than 6 feet deep. Also, if the pipe is too deep, repairs are difficult.

Reference

18A NCAC 15A 1937(b)

System design, step thirteen: granting the improvement permit.

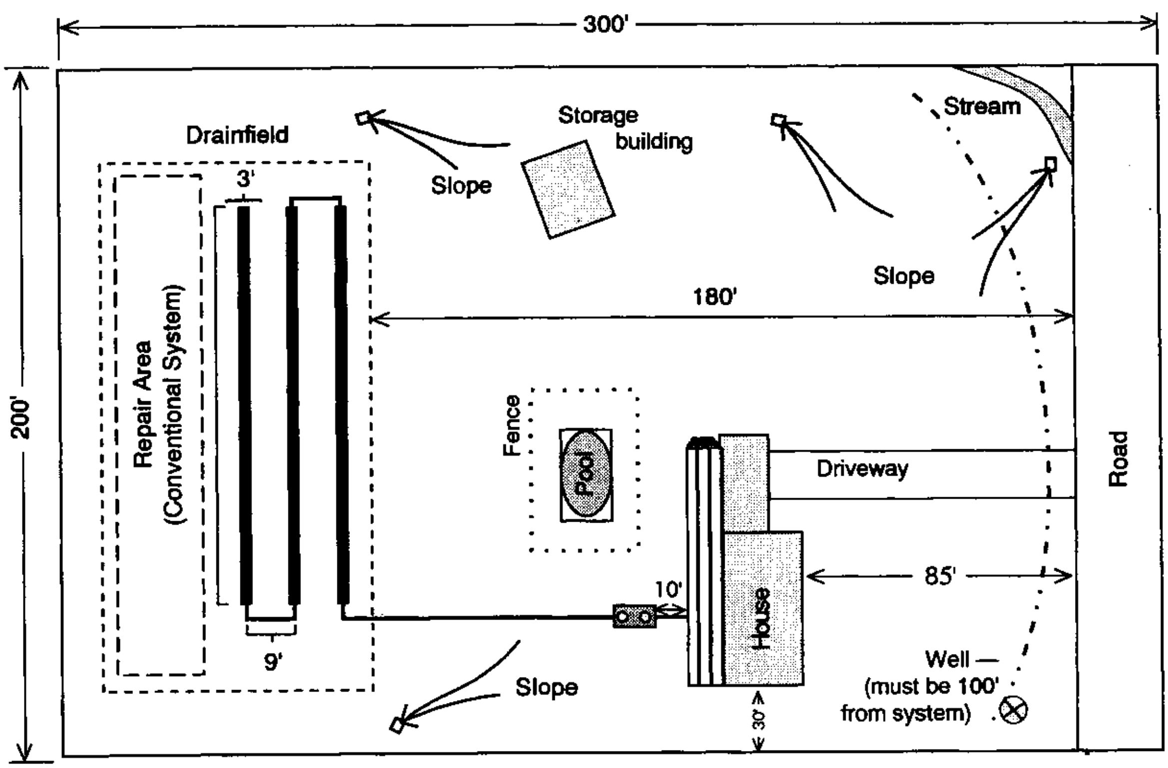
After the site has been evaluated and different system designs have been proposed, a permit must be granted or denied.

☐ If the permit is denied, the Environmental Health Specialist must state the reasons for the denial. Denial must be based on the *Laws and Rules for Sewage Treatment and Disposal Systems,* 18A NCAC 15A.1901-.1969.

☐ If the permit is granted, be sure to include a scale drawing of the system layout with important features such as wells, boundaries, and location of buildings. See Figure 5.2.2.

☐ The permit shall include all system specifications such as type and size of pipe, size of tanks, size and length of treatment and disposal field trenches, the expected daily effluent flow, the repair area, and the depth of the pipes.

Figure 5.2.2. Final scaled drawing of lot showing important features such as house, pool, driveway, slope, well, and on-site system.



5.3 REQUIREMENTS FOR CONVENTIONAL AND MODIFIED CONVENTIONAL ON-SITE SYSTEMS

Many components of on-site systems, such as tanks and conveyance piping, have the same requirements for all types of systems. Some components, such as treatment and disposal trenches, have different requirements depending on the type of system to be installed.

Design of Tanks for On-Site Systems

Tanks are used for a number of purposes in on-site systems. Many on-site systems use only a septic tank, but some systems may use tanks for storage to pump effluent to a drainfield and other systems may use tanks as grease traps to remove grease and oils from wastewater. This section tells what characteristics are required and how to find the proper size for on-site system tanks.

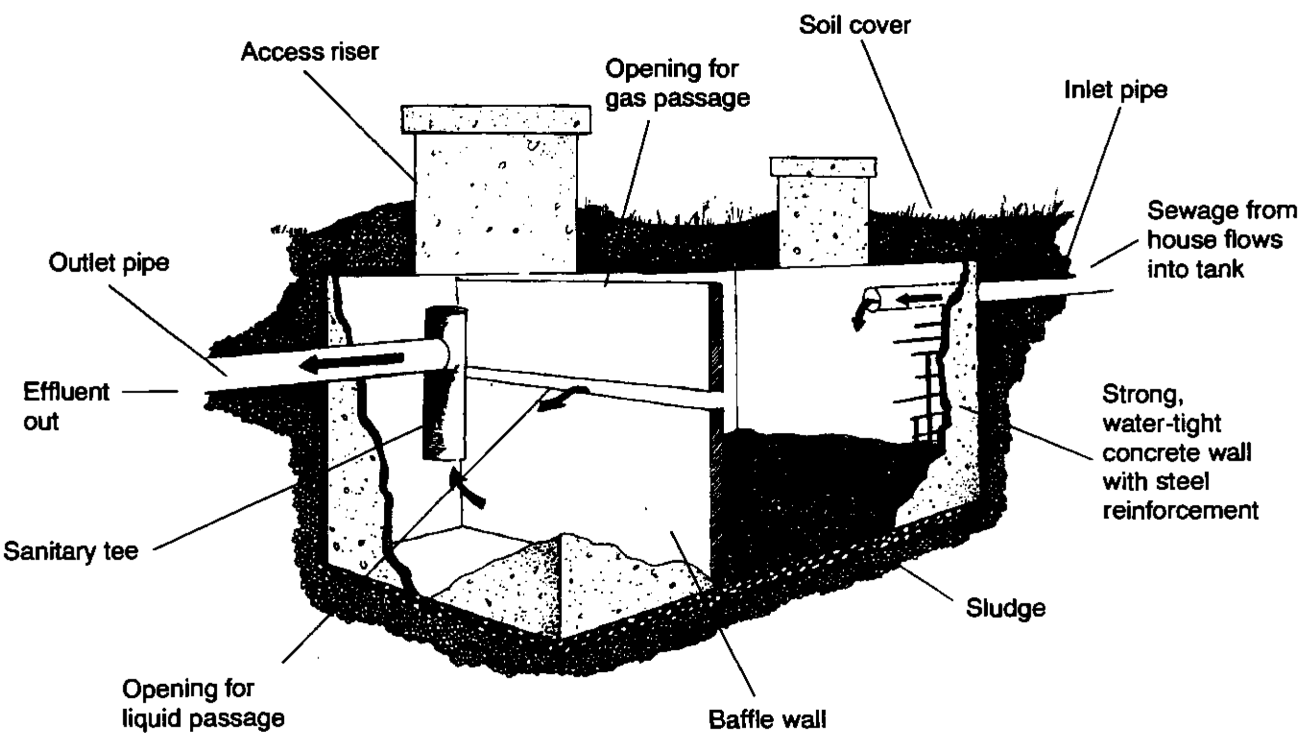
Septic Tanks

Reference

15A NCAC 18A.1952

A septic tank must be able to withstand corrosion, the heavy weight of the soil covering it, and the weight of the large volume of sewage inside without leaking. All septic tanks must have two compartments to allow the solids to settle and to separate the floating scum from the liquid. The baffle wall and the sanitary tee help separate the solids and the scum from the effluent so that the effluent is as clear as possible. Clear effluent keeps the treatment and disposal field from clogging. All tanks must meet the following criteria. Figure 5.3.1 shows a septic tank and its components in operation.

Figure 5.3.1. Cut-away view of septic tank.



Watertight. Septic tanks must be watertight to prevent sewage from entering the ground outside the drainfield. The soil where the tank is located may not be suitable for sewage application and leaking sewage may cause contamination of wells, streams, or other adjacent property.

❑ Septic tanks must also be watertight to prevent surface or ground water from entering the on-site system. If large volumes of surface or ground water seep into the tank, the system can fail.

❑ All connections to a septic tank should be watertight so that no effluent leaks outside the drainfield and no ground water seeps into the tank and the system. All sealants should be approved before use.

Strength. Tanks must be structurally strong to avoid being crushed by the weight of the soil. A collapsed tank could cause major pollution and safety problems, along with inconvenience and cost to the owner.

❑ Materials used in tanks must be corrosion-resistant to prevent the tank from being worn down by the sewage or by ground water, causing leaks. Only certain materials such as pre-cast concrete, fiberglass, and polyethylene plastic can be used for septic tanks. Built-in-place tanks can be made of concrete or concrete blocks with mortar lining.

Reference
15A NCAC 18A.1952(b)(1-3)

Volume. There are several ways to determine the volume of a septic tank for a system to be installed, depending on whether the system is for a small- to medium-sized house, for a large house, or for a place of business or assembly.

❑ Tanks for *small- to medium-sized* houses are sized from the following chart:

Table 5.3.1 Tank Sizes for Small-Medium Houses

Number of Bedrooms	Minimum Liquid Capacity (gallons)	Equivalent Liquid Capacity per Bedroom (gallons)
3 or fewer	900	300
4	1000	250
5	1250	250

❑ *Large houses*, with more than five bedrooms, or multi-family residences, or on-site systems serving two or more residences, or businesses with sewage flows between 600 and 1500 gallons per day must determine the volume of a septic tank using the following formula.

$$V = 1.17Q + 500 \text{ gallons}$$

where:

V = The volume of the septic tank, in gallons.

Q = The daily flow of sewage from the large house, multi-family residence, all residences connected to the system or business, in gallons.

Note that the minimum volume of a septic tank where the system serves two or more residences is 1500 gallons.

❑ Septic tanks for *small businesses* or other public *places*, such as fairgrounds, auditoriums, stadiums, churches, campgrounds, theaters, schools and the like with a design sewage flow of 600 gallons per day or less, must have a tank with a volume determined by the following formula.

$$V = 2Q$$

where:

V = Volume, or liquid capacity of the septic tank, in gallons.

Q = Daily flow of sewage from the business or place of public assembly, in gallons.

❑ On-site systems with *flows of 1500 to 4500 gallons per day* require a septic tank with a volume calculated by the following formula.

$$V = 0.75Q + 1125 \text{ gallons}$$

where:

V = The volume of the septic tank, in gallons.

Q = The daily flow of sewage from the establishment.

❑ *Large establishments* where the sewage flow is more than 4500 gallons per day must use the following formula to determine the volume of a septic tank.

$$V = Q$$

where:

V = The volume of the septic tank in gallons.

Q = The daily flow of sewage from the establishment.

Study Figure 5.3.1 to see the parts inside and connected to the tank.

Pump Tanks

Reference

15A NCAC 18A.1954(b)

Some on-site systems require the use of a pump in the system to pump the effluent to a drainfield that is higher than the septic tank or to pump to a pressure distribution system. Design and sizing of these types of tanks is presented below. See Figure 5.3.2 for the components of a pump tank.

❑ There must be only one compartment in a pump tank. If a 2-compartment tank is to be used, then the partition in the tank must have at least two 4-inch holes in the partition no higher than 12 inches from the tank bottom to allow free flow of the effluent from one compartment to the other. Other openings of different shapes are allowed as long as the openings are as large as the two 4-inch holes.

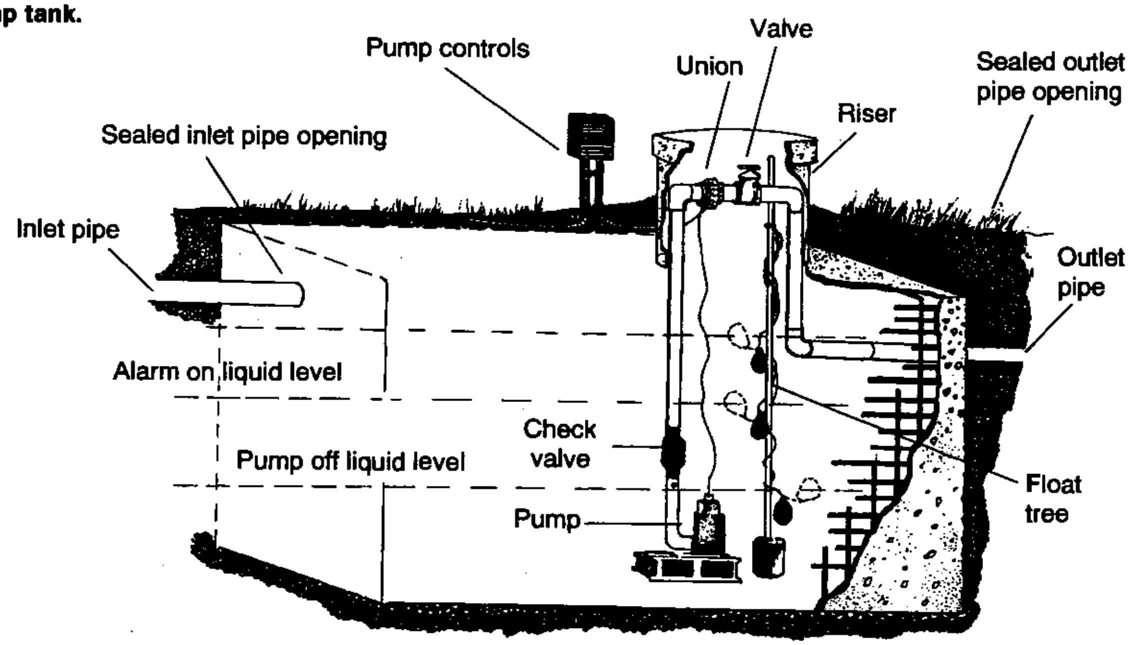
❑ Pump tanks must be watertight to prevent surface or ground water from leaking in and adding large volumes of water that will be pumped to the treatment and disposal field. Water-test all pump tanks for leaks just before the tanks are put into use.

Reference

15A NCAC 18A.1952(c)(1) and .1941

❑ The minimum size for a pump tank is 750 gallons. Pump tanks are often required to be larger than the minimum size as determined by the type of soil in the drainfield.

Figure 5.3.2. Cut-away view of pump tank.



❑ For on-site systems with treatment and disposal fields in Group I, II, or III soils, the pump tank size must be at least 2/3 of the volume of the septic tank.

❑ Pump tanks for systems with treatment and disposal fields in Group IV soils are required to have at least the same volume as the septic tank.

❑ Another method used to size a pump tank is to meet the minimum pump submergence requirement, minimum dosing requirement, and minimum emergency storage requirement. Determining the volume of a pump tank to meet these criteria is complicated and not practical for most small wastewater systems.

Grease Traps

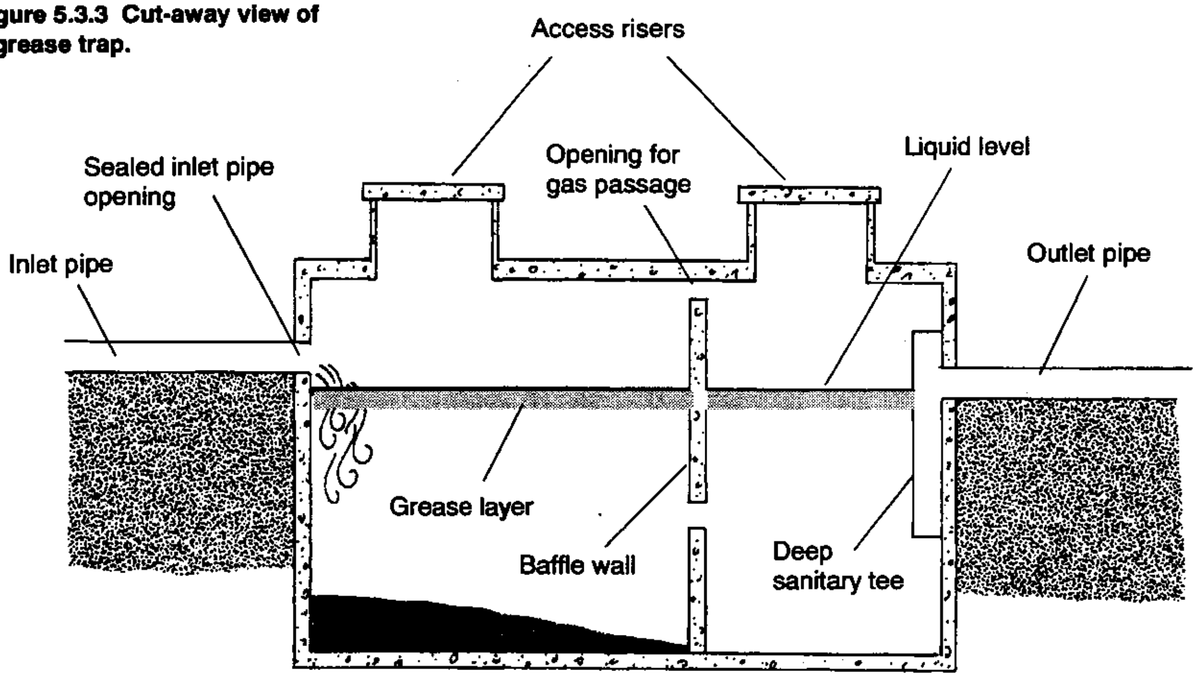
Grease traps are used to prevent grease, fat and oil from clogging the soil in on-site drainfields. Usually, a grease trap is a pre-cast concrete tank with two or more chambers. The liquid wastewater flows into the grease trap chamber where the grease floats to the surface. Openings between the chambers, located at least halfway toward the tank bottom, allow only wastewater to flow on to the septic tank, keeping the grease in the grease trap. Figure 5.3.3 shows a cut-away view of a grease trap tank.

Reference

15A NCAC 18A.1955(k)

Grease traps are required for on-site systems for restaurants, food service facilities, meat markets, and wherever food and meat preparation would generate large amounts of grease and oils in the wastewater. Grease traps can also be helpful for residential systems where a garbage disposal is used. Here, the trap captures finely ground food particles that may need more time to settle than sanitary solids, preventing the fine particles from being carried to the drainfield.

Figure 5.3.3 Cut-away view of a grease trap.



Additional information on grease traps is presented in the following list.

- ❑ Only kitchen wastes should be piped to a grease trap. All sanitary wastes should be routed around the grease trap to the septic tank.
- ❑ Grease traps should be located far enough from the building to allow the sewage to cool and the grease to congeal and float to the surface; otherwise the grease will flow into the septic tank.
- ❑ Sizes for grease traps can be determined by the following methods:
  - The volume of the tank should be large enough to provide 5 gallons of storage for every meal served.
  - The volume should equal 2/3 of the capacity of the septic tank.
  - The volume can be calculated by the following formula:

$$V = D*GL*ST*(HR/2)*LF$$

where:

V	=	The volume of the grease trap, in gallons.
D	=	The number of seats in the dining area.
GL	=	The amount of wastewater per meal served: use 1.5 gallons per meal where single-service dinnerware is used; use 2.5 gallons per meal where multiple-use dinnerware is used.
ST	=	A storage capacity factor equal to 2.5.
HR	=	The number of hours the facility is open for business.
LF	=	A loading factor, use 1.25 for facilities located on interstate highways, use 1.0 for facilities located on other highways and in recreational areas, and use 0.8 for facilities located on secondary roads.

Source: EPA Design Manual, 1980.

❑ The length of a tank used for a grease trap should be at least twice as long as the width to get better grease removal.

❑ Grease traps must have at least two chambers. Each chamber must have a 24-inch manhole for access and a manhole to cover the outlet sanitary tee. All manholes should have risers that extend to the ground surface and have watertight covers to keep out surface water. The manhole covers must be easy to remove so that the grease traps can be inspected easily and cleaned frequently.

❑ The openings in the partitions and the outlet to the sanitary tee should be no higher than 1/2 the liquid depth to remove water as far below the grease as possible.

❑ A series of tanks can be used as a grease trap, similar to a tank with multiple partitions. Specially designed grease separators may be installed, if approved, so that the size of the tank may be reduced.

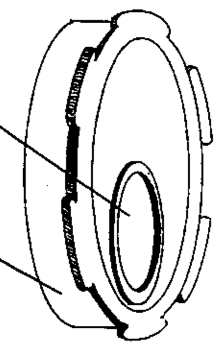
Design of Distribution Devices for Conventional Systems

Reference
15A NCAC 18A. 1955(g)
Reference
15A NCAC 18A.1955(l)

Reference
15A NCAC 18A.1955(j)

After the sewage flows through the septic tank it must be directed to the treatment and disposal field. Most on-site systems have a treatment and disposal field that has a number of parallel trenches. Because each trench should receive the same amount of effluent, a *distribution device* is used to evenly spread the effluent to each trench. This section contains information on distribution devices and where to use the different types available. The following points discuss distribution devices.

- The device must be installed so that at least 2 feet of undisturbed earth separates the distribution device from the septic tank and the treatment and disposal trenches. This separation by undisturbed earth helps reduce leaking of sewage into unsuitable areas outside the treatment and disposal field.
- Distribution devices must be level to operate properly. They should be installed on a concrete pad or bench of undisturbed soil to keep the device level as the soil settles after the system is installed. If the devices are not level, more effluent flows to one treatment and disposal trench than to another, causing an overload in that trench.
- Concrete pads for distribution devices should be at least 2 1/2 inches thick and 6 inches larger on each side than the distribution device.
- A riser installed over the distribution device allows easy access and adjustment of flow after the system is installed.
- Adjustments to ensure even flows to all trenches should be made during installation of distribution devices. All outlets from a distribution device must be at the same level so that the same amount of effluent flows out of each outlet. A number of devices are available to make rapid adjustments to the outlets of distribution devices so that all outlets have the same flow. These flow-adjusting devices work well and can speed installation. See the drawing at left for one type of adjustable outlet device.

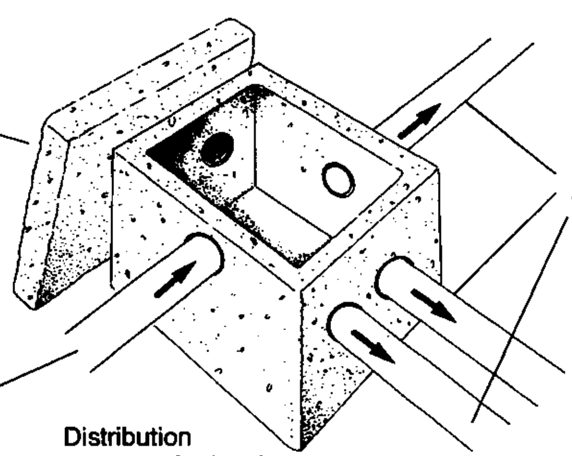


Speed Leveler™. The flow to a trench is adjusted by rotating this pipe-end insert to raise or lower the outlet hole.

Distribution Boxes

The most common distribution device is a distribution box or D-box. As the name suggests, the purpose of the distribution box is to evenly distribute the sewage effluent flow to the parallel trenches in the treatment and disposal field. Figure 5.3.4 shows an installed distribution box with its lid removed for inspection.

Figure 5.3.4. Concrete distribution box.



Reference

15A NCAC 18A.1955(j)

❑ Distribution boxes should be watertight, corrosion-resistant, and strong enough to withstand the weight of the soil over them. The box should be set on a firm base of undisturbed earth or a concrete pad to prevent uneven settling.

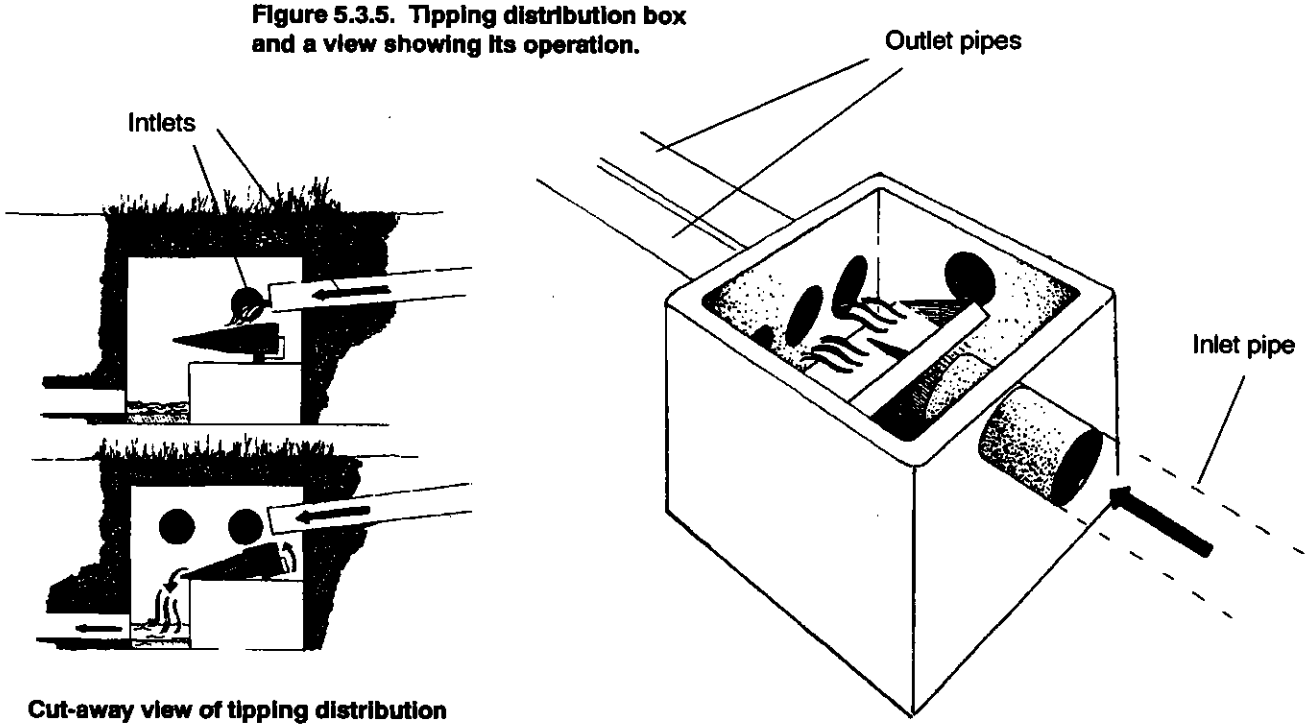
- These boxes should not leak in order to keep sewage effluent from entering the soil outside the treatment and disposal field and to keep ground water out of the system.

❑ Distribution boxes can be made of concrete or polyethylene plastic; either material works well if installed properly.

Tipping Distribution Box

Another type of flow divider is the tipping distribution box or tipping D-box. This commercially manufactured device uses a specially shaped pan or bucket to send effluent to the treatment and disposal field trenches in small flows, or slugs, of about 1.5 gallons. When the bucket is filled it tips, sending the slug of effluent to the treatment and disposal trenches. The drawing in Figure 5.3.5 show the inside of a tipping distribution box, and the cut-away view shows how it works.

Figure 5.3.5. Tipping distribution box and a view showing its operation.



Cut-away view of tipping distribution box showing operation. Above: bucket filling. Below: bucket tips and empties.

Advantages of the tipping distribution box are that the slugs of effluent will be split up more uniformly between the outlet lines, and will allow for a more even distribution along the trench length. Each burst of effluent flows farther along the trench using more of the trench length to absorb the effluent. The usual distribution box allows small trickles of effluent to flow into the treatment and disposal trench. These small trickles are absorbed by the first part of the trench while the other parts of the trench have no effluent in them.

Another advantage of the tipping D-box is that the slugs of effluent may be more evenly distributed.

Flow Splitter

The flow splitter (Figure 5.3.6) is a specially designed pipe fitting that allows effluent to enter from a higher pipe and be split into two lower pipes. Flow splitters can be used effectively to divide the flow between two equal-length treatment and disposal trenches.

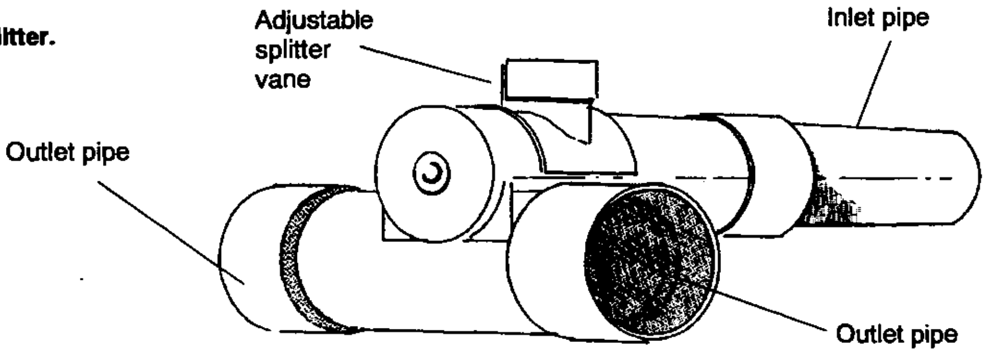


Figure 5.3.6. Flow splitter.

Flow splitters must be installed exactly level to work properly. They should be placed on undisturbed soil so that the soil will not settle and tilt the splitter.

Design of Treatment and Disposal Trenches

The most important part of any on-site system is the *treatment and disposal field.* Septic tanks help remove solids and grease from the wastewater, but the field treats and disposes of the wastewater. The field distributes the wastewater so that biological and chemical actions in the trenches and in the soil can remove bacteria and pollutants and so that the soil can absorb the water. It is critical to public health that the wastewater discharged to an on-site system flows into the soil and stays in the soil until properly treated. Well designed and installed trenches can ensure that the effluent will not come to back to the surface.

Reference

15A NCAC 18A.1955(g)

It is extremely important that all treatment and disposal trenches be constructed level across their width and along their length. On sloping lots this means that the trenches must be constructed on the contours that run across the face of the slope. Only when the trenches are level will the effluent be evenly distributed over the entire trench bottom. If the trench is not level, either across the width or along the length, then the effluent will flow to the lowest area and only that area will receive effluent. Figure 5.3.7 shows trenches installed on the contours of a slope.

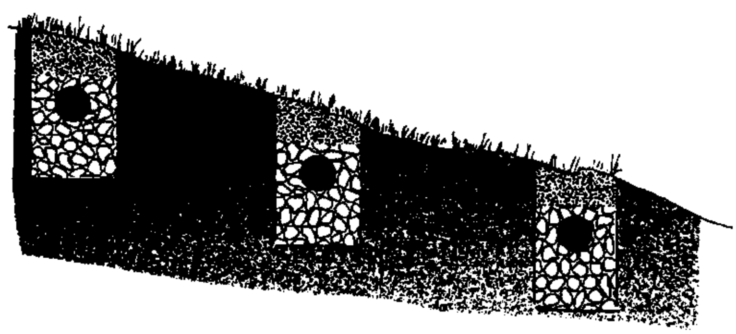


Figure 5.3.7. End view of trenches on a slope showing that trench bottoms are level across their width and that trenches are placed on contours so that the trench is level across the face of the slope.

A typical treatment and disposal field for a flat lot consists of a number of parallel trenches of equal length installed in SUITABLE or PROVISIONALLY SUITABLE soils. The trench bottoms are level across their width and along their length and each trench receives the same amount of effluent. A distribution device such as a distribution box divides the effluent flow equally among all the treatment and disposal trenches. Further information on trenches is discussed as follows.

Size of Trenches

Reference
15A NCAC 18A.1955(h)

Long and narrow trenches provide more soil absorption area and better hydraulic contact with the soil than short, wide trenches. A system with trenches as long and narrow as possible is best for the required treatment and disposal area. Figure 5.3.8 shows a typical field using a distribution box and parallel trenches.

Reference
15A NCAC 18A.1955(c)

❑ A trench should be wide enough so that enough gravel is around the pipe. The crushed stone provides temporary storage for the wastewater before it flows into the soil and also protects the pipe from being crushed.

❑ Make the distance between the center of the trenches three times the width of the trenches. For example, 36 inch-wide trenches would be spaced 9 feet apart, center to center.

❑ The maximum width of a trench is 36 inches. Even if the trench is made wider than 36 inches, the field is designed and sized as though the trenches were 36 inches wide.

Reference
15A NCAC 18A.1955(c)

❑ To find the length of trench needed, you must first know the long-term acceptance rate or LTAR of the soil. The LTAR of the soil is the volume of water the soil will absorb per square foot of soil over a long period of time. See the following Table 5.3.1 for ranges of long-term acceptance rates.

❑ A layer of bacteria and other biological matter, called a *biomat,* will form on the surface of the soil in the trench. This layer is where the majority of the pollutants break down, making it extremely important to the process. The biomat tends to slow the flow of effluent into the soil but it does not stop the flow altogether. This slowing of the effluent flow into the soil affects the long-term acceptance rate or LTAR.

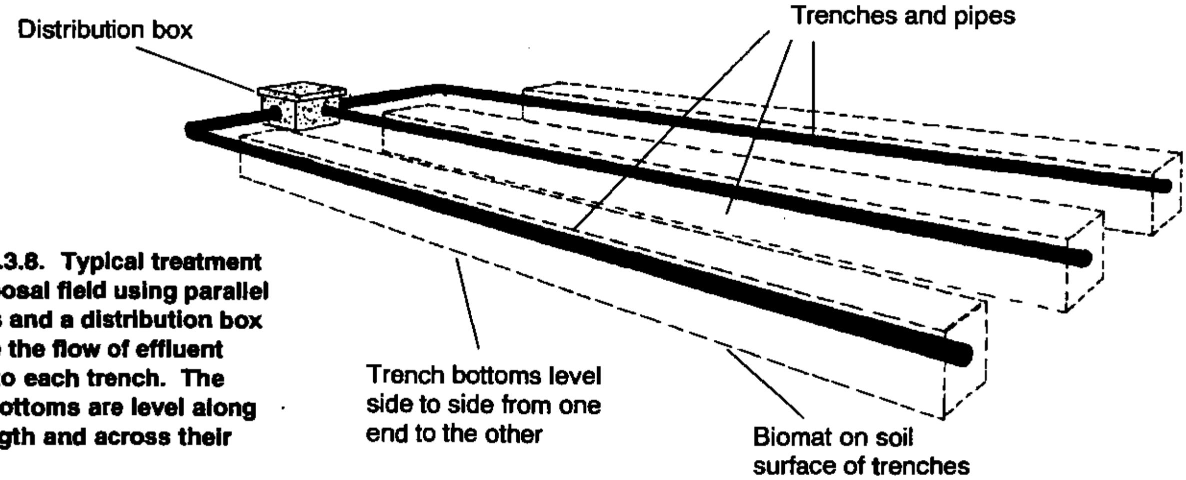


Figure 5.3.8. Typical treatment and disposal field using parallel trenches and a distribution box to divide the flow of effluent equally to each trench. The trench bottoms are level along their length and across their width.

Once the long-term acceptance rate of the soil in the field is known, divide the daily flow of sewage by the long-term acceptance rate of the soil. The result is the total area of trench bottom required for the treatment and disposal field. Divide the total area of trench bottom by the trench width to get the total trench length.

Reference
15A NCAC 18A.1955(c)

1. Daily sewage flow ÷ long-term acceptance rate = the total area of trench bottom required.

2. Total area of trench bottom required ÷ trench width = the total length of trenches required.

Table 5.3.2 Long-term Acceptance Rates of Soils by Soil Classification (From 15A NCAC 18A.1955(b)*

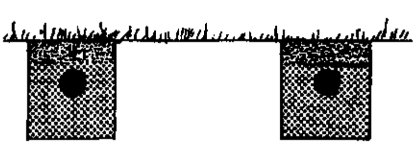
Soil Group	Soil Texture Classes (USDA Classification)	Soils in Texture Class	Long-term Acceptance Rate (gallons/day/square foot)
I	Sands	Sand Loamy Sand	1.2 - 0.8
II	Coarse Loams	Sandy Loam Loam	0.8 - 0.6
III	Fine Loams	Sandy Clay Loam Silt Loam Clay Loam Silty Clay Loam Silt	0.6 - 0.3
IV	Clays	Sandy Clay Silty Clay Clay	0.4 - 0.1

*All soils must have SUITABLE or PROVISIONALLY SUITABLE structure and clay mineralogy.

Note: For on-site systems where there is a lot of grease in the wastewater, the long-term acceptance rate or LTAR cannot be higher than the average LTAR for the Soil Group. For example, for Soil Group II, the LTAR for a greasy wastewater cannot be higher than 0.7 gallons per day per square foot. The LTAR is set low so that the treatment and disposal field is not plugged with grease.

Reference
15A NCAC 18A.1955(b)

The narrow trenches above have more sidewall area for absorption of effluent than wide trenches with the same bottom area shown below.



Example. An owner wants to install a conventional on-site system on a lot that contains soil of Soil Group III with a long-term acceptance rate of 0.5 gallons per day per square foot. The flow of sewage from the four-bedroom house to be built on the lot will be 480 gallons per day. Trench width will be the usual 36 inches wide. To find the necessary total trench length for the on-site system, use the following equation:

480 gallons / day ÷ 0.5 gallons / day /square foot = 960 square feet

960 square feet ÷ 3 feet = 320 feet of total trench length

If the designer for the system described above decided to use 2 foot-wide trenches instead of 3 foot-wide trenches, then he would use the following equation to find the total trench length required.

960 square feet ÷ 2 feet = 480 feet of total trench length

The narrow trench is longer and provides much more soil contact on the side walls, which should improve absorption of the daily effluent flow volume. Because the narrow trenches are longer, it may be more difficult to fit the treatment and disposal field in the lot boundaries, but the narrow trenches can improve the long-term reliability of the system. See the drawing in the sidebar for a comparison of narrow and wide trenches.

Use of Crushed Rock in Trenches

Reference

15A NCAC 18A.1955(h)

Treatment and disposal field trenches must have 6 inches of crushed stone under the pipe and at least 2 inches of level, uniform stone on top of the pipe, for a total depth of 12 inches of crushed stone in a trench when 4-inch pipe is used. The pipe must be centered in the trench with crushed stone surrounding it on all sides.

❑ Washed stone must be used so that the soil in the trenches is not plugged by fine particles from the crushed rock.

❑ The sizes of crushed rock can be numbers 3, 4, 5, 57, or 6 of the ASTM D-448, Standard Sizes of Coarse Aggregate. The same number designations are used by the state Department of Transportation and most gravel quarries. Numbers 3, 4, 5, 57, and 6 crushed stone have been washed to remove the fine particles and dust so that it will not clog the soil in the trench.

Use of Pipes in Trenches

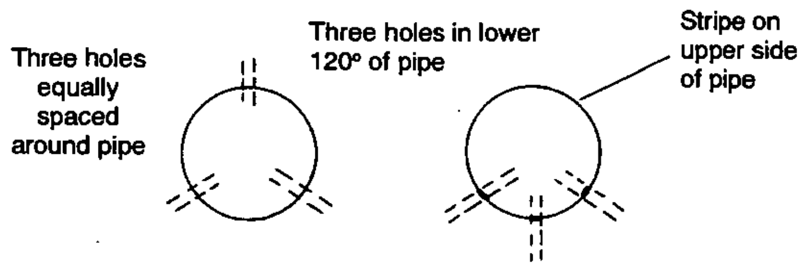
Reference

15A NCAC 18A.1955(f)

Generally, 4-inch corrugated plastic tubing is used for the pipe in trenches. All pipe used in the trenches must meet ASTM F 405 Standard Specification for Corrugated Polyethylene (PE) Tubing and Fittings or have a suitable hole size and spacing and be as strong as pipe that meets ASTM F 405. Holes in the pipe should be between ½ and ¾ inch in diameter and spaced every 4 inches along the pipe in three rows. See Figure 5.3.9 for typical hole patterns.

❑ The pipe must always be installed in the center of the trench and be surrounded by crushed stone on all sides to give the pipe support against being crushed.

Figure 5.3.9 End view of treatment and disposal field pipes showing different hole patterns.



Depth of Trenches

Reference

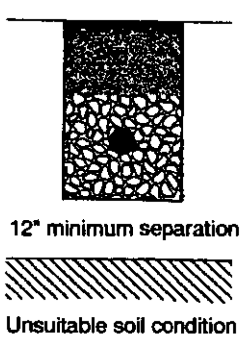
15A NCAC 18A.1955(g)

Reference

15A NCAC 18A.1955(m)

Trenches cannot be deeper than 3 feet, even in deeper, well-drained soils. In adequate soil with a deep water table, the trench will be 3 feet deep, with 12 inches of crushed stone and 2 feet of cover soil over the crushed stone.

❑ Trenches must not be too deep for a number of reasons. Trenches less than 3 feet deep have more unsaturated soil zone under them, which means that more oxygen is present to help treat the effluent. Also, there is more biological activity in the first 3 feet of soil because more organisms are present, which help to remove pollutants from the effluent.



❑ *There must be at least 1 foot of separation between the bottom of the treatment and disposal trench and the top of* any *unsuitable soil condition,* as shown in the drawing to the left. Unsuitable soil conditions are soil layers that do not absorb water well such as rock, some *saprolite,* and clay layers. Saprolite is the soft rock or very sandy material that is formed as the bedrock breaks into small particles, eventually forming soil.

Reference

15A NCAC 18A.1935(36)

As defined by the rules, Saprolite means,

> **"the body of porous material found in place by weathering of igneous or metamorphic rocks. Saprolite has a massive, rock-controlled structure, and retains the fabric (arrangement of minerals) of its parent rock in at least 50 percent of its volume. Saprolite can be dug with hand tools. The term saprolite does not include sedimentary parent materials."**

Rock, some types of saprolite, and expansive clay do not allow the effluent to be absorbed and can cause the sewage effluent to pond on the soil surface.

❑ One foot of separation allows the effluent to be treated by bacteria and other organisms as it moves downward through the soil. If there is less distance between the trench bottom and the unsuitable layer, the effluent may not receive adequate treatment.

Reference
15A NCAC 18A.1955(g)

Soil wetness. Another unsuitable condition is soil wetness, which can be caused by a seasonal high water table, a perched water table, tidal water, seasonally saturated soils, or lateral movement of water through the soil. When soil wetness is near the ground surface, there is little aerobic treatment of the effluent as it is absorbed into the soil. Also, soil wetness can rise due to heavy rainfall and force the effluent upwards to the ground surface.

❑ To prevent problems with soil wetness, there must be 12 inches between the bottom of the treatment and disposal trench and the top of the wet layer.

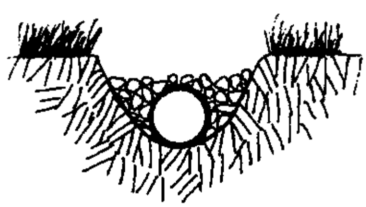
Reference
15A NCAC 18A.1955 (m)

- If the soil wetness layer is less than 18 inches below the bottom of the treatment and disposal trench, and there are more than 6 inches of Group I soil between the trench bottom and the wet layer, then a low-pressure pipe system must be used to obtain the proper aerobic treatment of the effluent.

Design of Conveyance Piping

Reference
15A NCAC 18A.1955(e)

The pipes used between the septic tank and the treatment and disposal field are called *conveyance piping* because these pipes carry the effluent to the next part of the on-site system. Conveyance pipes must have watertight joints to prevent leaking and the pipe must be strong enough to resist being crushed when it is in the soil. Requirements for conveyance piping are given as follows.



Cut-away view of PE tubing used as convayance pipe showing proper bedding in crushed stone.

❑ The usual pipe is 3-inch, Schedule 40 PVC (polyvinyl chloride) pipe. Other materials may be used, such as Schedule 40 PE (polyethylene) or Schedule 40 ABS (acrylonitrile butadiene styrene), as long as they are strong enough to resist being crushed by soil weight.

❑ All conveyance piping should have a minimum slope or fall of 1/8 inch per foot so that the effluent flows freely through the pipe.

❑ The joints in the pipe should be made according to the manufacturer's instructions to be sure that the joint does not leak and is strong enough to not break apart in the soil.

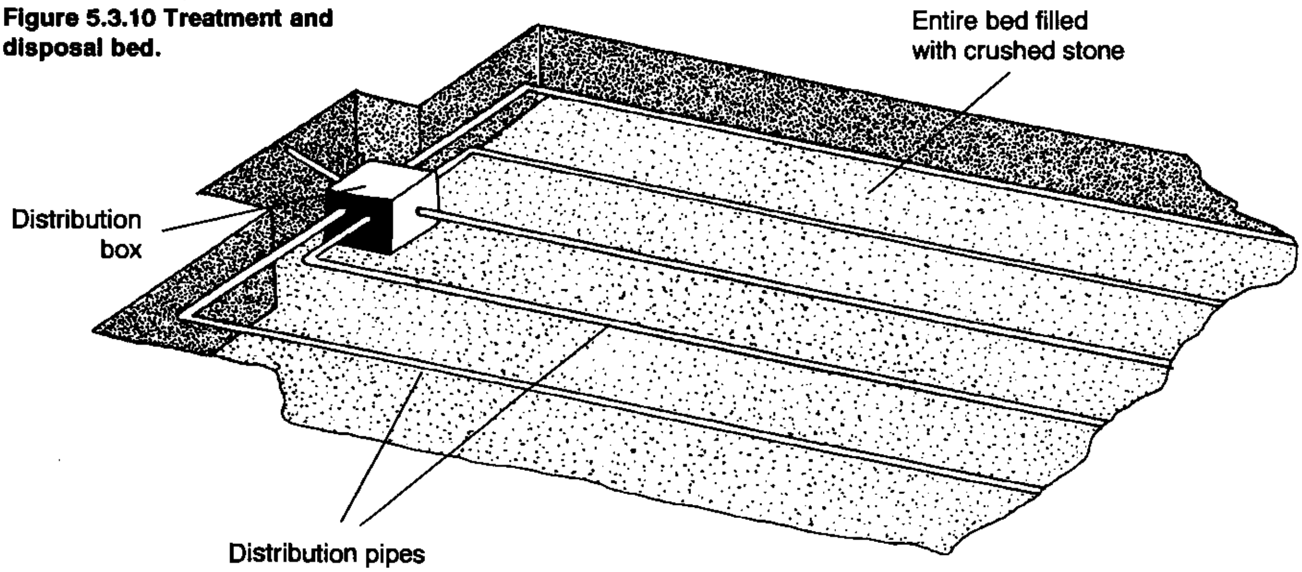
❑ Corrugated PE (polyethylene) tubing may be used as conveyance piping if a number of conditions are met. See 15A NCAC 18A.1955(e) for details on using corrugated PE tubing.

Design of Treatment and Disposal Field Beds

Reference
15A NCAC 18A.1955(d)

There may not be enough space on some lots to design the usual trench treatment and disposal field. In this case, the designer may consider a *treatment and disposal bed.* A bed is simply a large area filled with gravel and pipes that has been prepared to receive effluent, much like a disposal trench. In the bed system, conveyance pipes carry effluent from the septic tank to the bed where the effluent flows into pipes buried in the bed. The buried pipes help spread the effluent evenly over the entire bed bottom but, unlike trenches, the sidewalls are not used. The following guidelines should be used when designing a treatment and disposal bed. Figure 5.3.10 shows a cut-away view of a treatment and disposal bed.

Figure 5.3.10 Treatment and disposal bed.



❑ Treatment and disposal field beds can only be used where the soil is classified as belonging to Soil Groups I, II, or III. These are sandy soils that contain little or no clay such as sands, and loamy soils. These soils have the high permeability needed for proper operation of a treatment and disposal bed.

❑ The area of the bed must be 50% larger than the area required by a treatment and disposal field trench system. This large area is needed for beds because effluent is mainly absorbed through the bottom of the bed, unlike trenches, where much of the absorption takes place through the trench sidewalls.

❑ To ensure an even flow of effluent to all pipes in the bed, use a distribution device such as a distribution box or a tipping distribution box.

❑ Bed systems cannot be used where the sewage flow is more than 600 gallons per day.

❑ The sewage pipes in the bed must be at least 18 inches from the edge of the bed and be located on 3-foot centers in the bed.

Reference

15A NCAC 18A.1955(d)

❑ The bed should be dug from the sides so that the heavy equipment will not compact the soil on the bed bottom.

❑ Beds should not be used on sites with slopes greater than six percent and should only be used where the site is classified as SUITABLE or PROVISIONALLY SUITABLE.

❑ The example problem that follows shows how to calculate the size of a bed system for the same conditions in the following example.

Reference

15A NCAC 18A.1955(b)

Example. This example is the same as given in the section on treatment and disposal trenches, page 5.3.11, so you can compare the areas required for trenches and beds.

An owner wants to install a conventional on-site system on a lot that contains soil of Soil Group III with a long-term acceptance rate of 0.5 gallons per day per square foot. The daily flow of sewage from the four-bedroom house to be built on the lot is 480 gallons per day. The necessary total bottom area of a treatment and disposal field bed for this on-site system can be calculated, as follows:

480 gallons / day ÷ 0.5 gallons /day /square foot = 960 square feet of trench bottom area

For an absorption bed system, the size of the bed bottom area is 50% greater than the trench bottom area. This can be expressed as bed bottom area = 150% of the trench bottom area, or

960 square feet of trench bottom area x 150% = 960 square feet of trench bottom area x 1.5 = 1440 square feet of bed bottom area required.

Serial Distribution Treatment and Disposal Fields

On lots with sloping land, it may be difficult to install the treatment and disposal field in one area with parallel trenches. Instead of parallel trenches, a *serial distribution treatment and disposal field* can be used. The serial distribution treatment and disposal field refers to a field where effluent flows from the highest trench segment to the next lower trench segment, and to the next, and so on, in series. The highest trench segment receives a full volume of effluent before the next lower trench segment receives any flow at all. This differs from the usual treatment and disposal field where effluent flows into all trenches at once.

A serial distribution field consists of a single trench divided into trench segments that are located along contour lines or lines of equal elevation on the lot. The trench segments are installed along contours to ensure that the trench is level along its length and therefore the entire trench is used to absorb the effluent.

A serial distribution treatment and disposal field can be installed as an end-feed field or as a center-feed field. The end-feed field delivers effluent to one end of each trench segment. The center-feed field brings the effluent flow to the center of each disposal trench rather than to the end. The drawing in Figure 5.3.11 shows a serial distribution system using the stepdowns to feed each trench segment from the end.

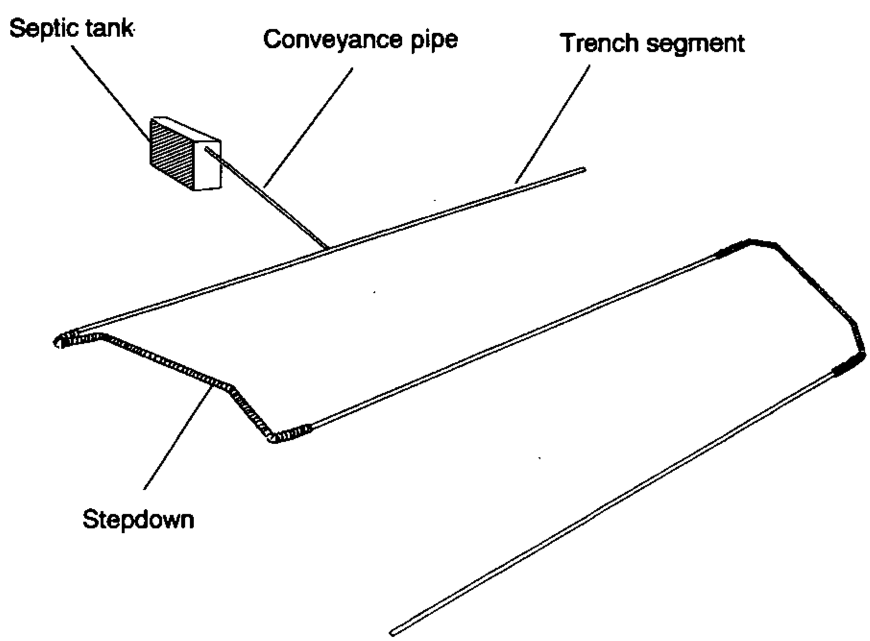


Figure 5.3.11 Serial distribution system.

Location of Trenches

Use serial distribution fields on sloping lots where distribution boxes are not effective. Slopes should be in the range of 6% to 30%.

- Install treatment and disposal trenches along elevation contours. The disposal trenches should be level and as long as possible. The trenches should be constructed like a usual trench: perforated pipe centered in the trench, 6 inches of crushed stone under the pipe, 2 inches of stone over the pipe, and the trench should be no deeper than 36 inches on the deep side when cutting into a hillside. Measure on the uphill sidewall.

- Each 36-inch wide trench segment centerline must be at least 9 feet from the other trench segment centerlines. As the trench segment follows the contour, there may be more distance between trench segments, but the separation cannot be less than 9 feet.

- The first disposal trench segment in the series is located on the highest contour. Place the second trench segment on an elevation contour below the first contour that is a minimum of 9 feet from the center of the first trench. The third trench segment should be a few feet lower than and at least 9 feet away from the second segment, and so forth until all the required length of trench is installed. Measure the 9-foot separation distance between the trench segments from center to center.

- Start laying out the trench segments on the steeper portion of the slope so that the trench is installed on the contour and so it ends on the less steep part of the slope. This method ensures that the trench segments will have at least the minimum separation at the end of the trench segments because the trench segments follow the contours and the contours are farther apart on the less steep area. If the trench segments are started on the less steep area, then the trench segments may be too close to each other in the steep area.

Reference
15A NCAC 18A.1955(1)

- Each treatment and disposal trench on a contour must be connected to the next trench down the slope. The connections between each trench must convey the sewage to the lower trench with no erosion and no leakage.

Stepdowns

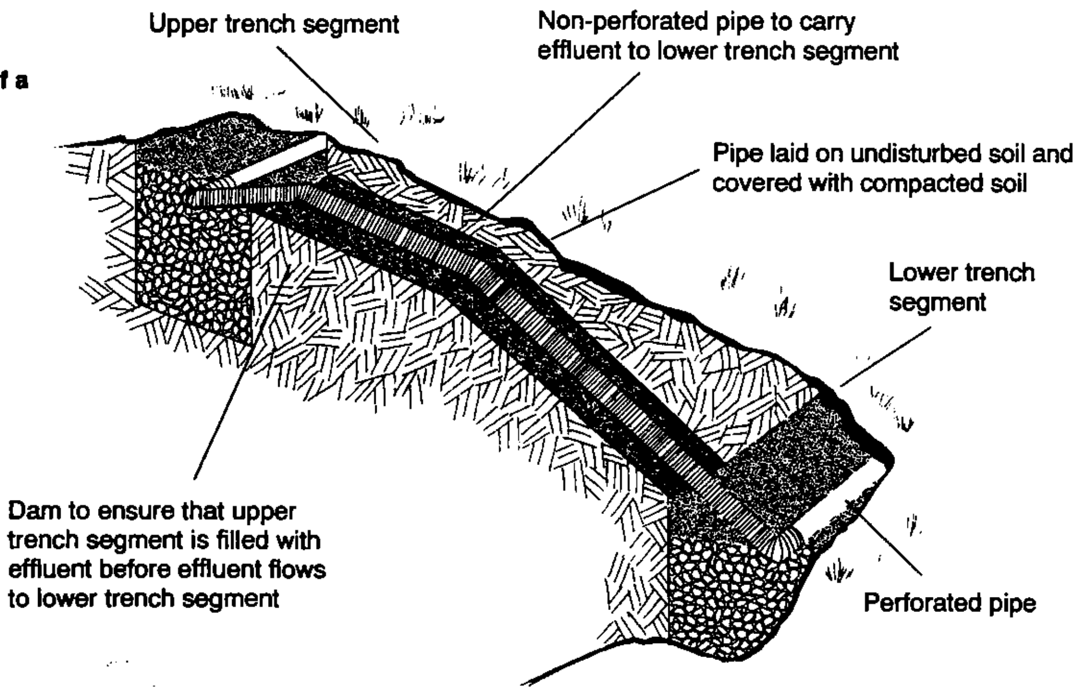
Reference
15A NCAC 18A.1955(1)

Stepdowns are used for connecting the higher trench segment to the lower trench segment. Stepdowns work by making the higher trench segment fill with effluent before it can flow to the next lower trench segment down the slope (Figure 5.3.12).

- A stepdown is constructed by leaving a dam of undisturbed soil 2 feet long and as high as the top of the crushed stone in the treatment and disposal trench. A solid pipe is connected to the perforated pipe in the higher trench and is run over the dam and down to the next lower trench and connected to the perforated pipe there. The soil surrounding the solid pipe must be compacted around and over the pipe to prevent effluent leaking along the pipe. The solid pipe should be 3-inch Schedule 40 PVC pipe so that the pipe will not collapse where it goes over the dam and has less soil cover to protect it.

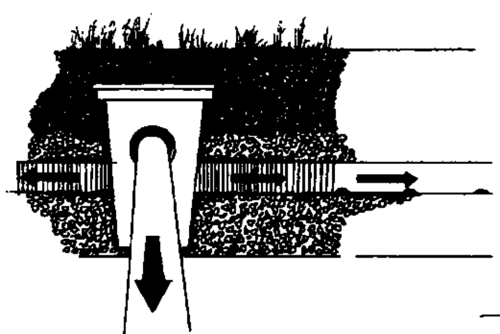
- A stepdown can be made using corrugated, nonperforated PE tubing, but using solid Schedule 40 PVC pipe is better because it is much stronger.

Figure 5.3.12
Cut-away view of a stepdown.



Drop Boxes

Another method used to connect a higher trench segment to the next lower trench is a *drop box*. A drop box is made of precast concrete or polyethylene plastic with one inlet opening and several outlet openings. The inlet brings the effluent to the drop box where it flows out one or two outlets to the treatment and disposal trench on that elevation contour. Another outlet allows effluent to flow to the next lower trench segment. A view of installed drop boxes is shown in Figure 5.3.13.



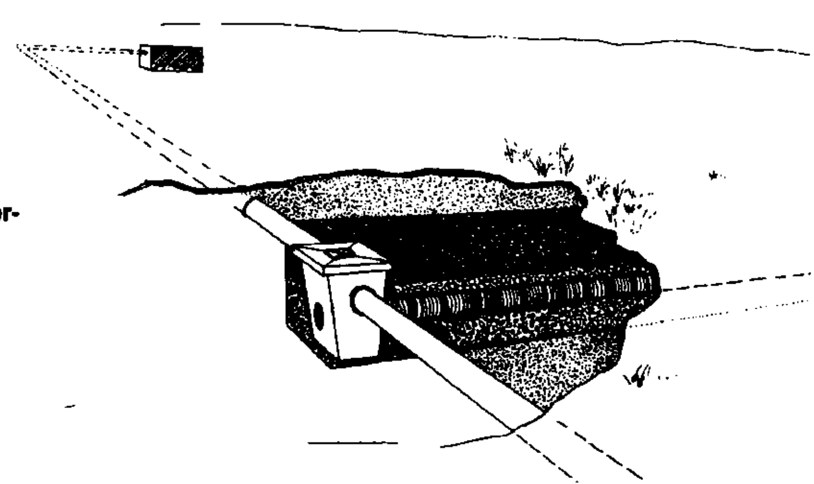


Figure 5.3.13 Drop boxes for end-feed serial distribution system and for center-feed distribution system.

❑ In a drop box, the bottom of the inlet opening must be 1 inch above the bottom of the outlet opening going to the next trench down the slope. The top of the openings feeding the trench segment must be 2 inches below the bottom of the outlet opening. Because the openings to the trench segments are lower than the outlet to the next lower trench, the trench segment fills with effluent first and then it flows to the next trench segment further down the slope.

Reference

15A NCAC 18A.1955(1)

❑ For end-feed trenches, a stepdown or a drop box may be used to connect separate treatment and disposal trenches on different elevation contours. Drop boxes used for end-feed serial distribution treatment and disposal fields have only one outlet to the trench on the same contour as the drop box.

❑ In center-feed trenches, only drop boxes can be used and each drop box will have two outlets, one going to each half of the treatment and disposal trench.

❑ The area of disposal trenches taken up by stepdowns or by drop boxes does not count as part of the required length of treatment and disposal trench.

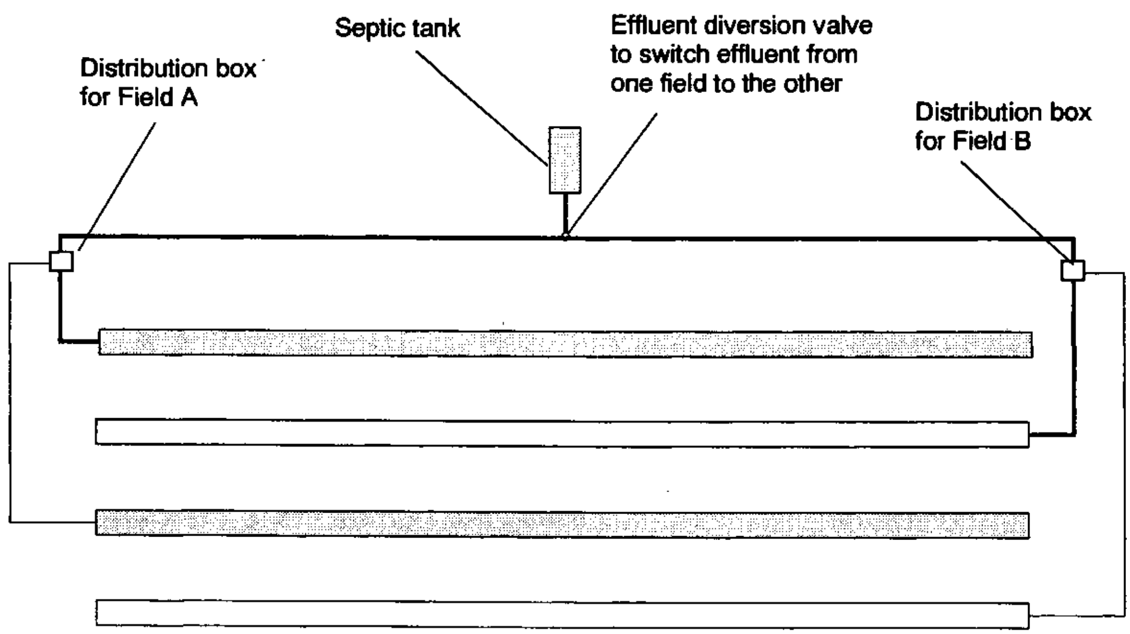
Design of Dual Alternating Treatment and Disposal Fields

Reference

15A NCAC 18A.1955(1)

In situations where the soil on a lot is likely to clog after a period of operation of the on-site system, a dual-alternating treatment and disposal field should be used. This type of field has two separate treatment and disposal fields, each sized to be 75% of the size needed for a single field. An *effluent diversion valve* is installed in the conveyance pipe from the septic tank and the conveyance pipes then go to each treatment and disposal field. The system owner turns the effluent diversion valve so that the effluent flows from the septic tank to one of the fields for a set period of time, usually from six to twelve months. At the end of the time period, the owner turns the valve so that the effluent now flows to the other field for the same set period of time. In this way, half of the treatment and disposal area has a period of time to rest and dry out, which may reduce the chances of clogging. See Figure 5.3.14 for a plan view of a dual alternating treatment and disposal field system. A drawing of an effluent diversion valve appears on the next page.

Figure 5.3.14 Diagram of dual alternating treatment and disposal fields.



❑ Dual alternating treatment and disposal fields are typically used in Groups III and IV soils and are highly effective in clayey soils. They can be used anywhere conventional systems are used.

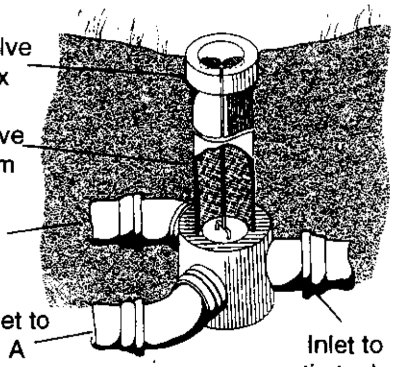
Reference
15A NCAC 18A.1955(1)

❑ Effluent diversion valves should be made of strong material that will not crush or corrode. The best diversion valves are made of PVC.

❑ Diversion valves should be installed in a valve box so that the owner has easy access to the valve and can operate the valve from the ground surface.

❑ A good reminder for homeowners is "When you change clocks in the spring and fall, turn the valve to switch the fields."

❑ The following example problem shows how to calculate the size of a dual alternating fields system for the same conditions in the example on page 5.3.11.



Effluent diversion valve.

Example. This example is the same as that given in the section on treatment and disposal trenches, page 5.3.11, so you can compare the areas required for a single treatment and disposal field and for the dual alternating fields. An owner wants to install a conventional on-site system on a lot that contains soil of Soil Group III with a long-term acceptance rate of 0.5 gallons per day per square foot. The daily flow of effluent from the four-bedroom house to be built on the lot is 480 gallons per day. The necessary total bottom area of a treatment and disposal field can be determined using the calculations below.

480 gallons / day ÷ 0.5 gallons / day /square foot = 960 square feet of trench bottom area.

For the dual alternating treatment and disposal fields, each field should be 75% of the area of a single treatment and disposal field. So,

960 square feet x 75% = 720 square feet of trench bottom area for each of the alternating fields.

If the overall area required for the single and dual alternating fields are compared we get the following result.

A single treatment and disposal field system with 36-inch wide trenches will need 960 square feet ÷ 36 inches = 320 feet of trench length. To keep each trench under 100 feet long, divide the total trench length by four to get four 80-foot long trenches. Since these trenches are 36 inches wide, each trench must be 9 feet from the next, center-to-center. This means that there are three 9-foot wide strips between the trenches and two 1.5 foot-wide strips on the sides of the field, and each strip is 80 feet long. Thus, the total area of the treatment and disposal field is found by the following equations:

3 x 9 feet x 80 feet = 2160 square feet plus
2 x 1.5 feet x 80 feet = 240 square feet,
which equals a total of 2400 square feet for the single treatment and disposal field.

For the dual alternating fields, the total trench bottom area is 720 square feet for each field, which means that for 36-inch wide trenches, 720 square feet ÷ 36 inches = 240 feet of trench length is needed. Breaking this total trench length into three equal-length trenches, each trench will be 240 feet ÷ 3 = 80 feet long. The trenches must be spaced 9 feet center-to-center, so there will be two strips 9 feet wide between the trenches and two strips 1.5 feet wide on the sides of each field. So, the total area for each field is:

2 x 9 feet x 80 feet = 1440 square feet, and
2 x 1.5 feet x 80 feet = 240 square feet for a
total area of 1680 square feet for each alternating field, or a
total area of 2 x 1680 square feet = 3360 square feet for
the entire dual alternating field system.

The total field area for a single treatment and disposal field is 2400 square feet and for dual alternating fields is 3360 square feet. Dual alternating fields require 40% more area, but it may provide much better long-term operation and a longer lifetime than the single treatment and disposal field.

5.4 MODIFIED CONVENTIONAL SYSTEMS

In many situations, a conventional on-site system must be modified to accommodate certain limitations at the site. The term "modified conventional systems" refers to a number of changes in the usual installation to make up for a lack of soil depth, steep slopes, ground water flows or high water tables, and usable areas that are higher than the septic tank.

Some modifications change the site; some modifications change the treatment and disposal field installation. This section presents information on modifications used:

Reference
15A NCAC 18A.1956

1. To improve a site for a conventional treatment and disposal field;
2. To install a modified treatment and disposal field on steep slopes or on saprolite;
3. To install treatment and disposal trenches on shallow soils or very steep slopes; and
4. To install treatment and disposal fields at higher elevations than the septic tank.

Site Modifications

Site modifications change the site to improve its characteristics for on-site disposal. Two types of site modifications are presented here that can help lower high ground water tables or drain away ground water flowing through the site. Both site modifications do not change the treatment and disposal field; the field is installed as usual.

Soil wetness or elevated ground water.

Reference
15A NCAC 18A.1956(2)

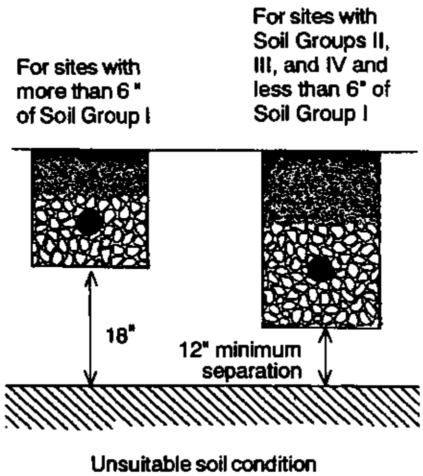
Because rain water flows into and is stored in the soil, there is some depth where the soil is saturated with water. The top of the saturated soil is called the *water table.*

For on-site systems, the various conditions which cause the soil to be saturated with water for extended periods are called *soil wetness conditions.* These conditions include seasonal high water tables, perched water tables, tidal water, seasonally saturated soils, or lateral movement of water through the soil. Each of these conditions can move the level of saturated soil closer to the ground surface or deeper into the soil. If the level of saturated soil is too close to the soil surface, then, on some sites, site modifications can be made to allow the use of the site for an on-site system.

Reference 15A NCAC 18A.1956(2)
Reference 15A NCAC 18A.1955(m)

Soil wetness conditions that cause the soil to be saturated will produce certain types of colors in the soil. These colors have a chroma of two or less and may be seen as *mottles* or as the overall matrix color of the soil. Mottling is seen as streaks, patches, or spots of darker color in a soil layer. Mottling is an indicator of the position or depth of the highest level of the water table. Any device or system used to lower the level of this soil wetness condition must extend below the highest level of the water table.

Saturated conditions are not always at the same depth. Water table depth fluctuates seasonally and yearly. It changes with the amount of rainfall, the amount of water used by plants, and the level of water in nearby streams, rivers, and lakes. In North



Carolina, the winter months are often when the water table is highest because of increased rainfall and low water consumption by plants.

The following points discuss site modification. Table 5.4.1 presents a decision tree for determining if a site can be modified.

❑ In areas where the soil wetness is within 12 to 36 inches of the soil surface, techniques may be used to lower the soil wetness condition. The soil should be classed as Soil Group I or II with SUITABLE structure and clay mineralogy. At least 12 inches must separate the water table and the trench bottom for soils classed as Soil Group II. For soil classed as Soil Group I, 18 inches must separate the trench bottom and the water table. See the drawing on the left.

❑ Soils where wetness conditions are within 12 inches of the ground surface, such as wetlands, cannot be drained.

Table 5.4.1 Decision Tree for Site Modifications

Soil wetness position	Site classification	Proper action
Is soil wetness between 0 to 12 inches deep?	UNSUITABLE	Cannot drain site, probably classed as wetland. Site cannot be used.
Is soil wetness between 12 to 36 inches deep?	UNSUITABLE	Can use shallow placement system or site modifications. Reclassify as PROVISIONALLY SUITABLE
Is soil wetness between 36 and 48 inches deep?	PROVISIONALLY SUITABLE	Use shallow placement or site modifications if needed.
Is soil wetness more than 48 inches deep?	SUITABLE	Use conventional placement.

Reference

15A NCAC 18A.1956(4)

❑ Seasonal soil wetness conditions may be modified in sandy and coarse loam soils that are used for on-site systems. Here, *ground-water-lowering techniques* can be used to modify soil wetness. The most common technique is to install open channels or ditches to drain the ground water from the upper 3 feet of the ground. See Figure 5.4.1 for a diagram of a ground-water-lowering system.

❑ Open channels allow the ground water to drain from the soil into the channel and flow to an *outlet*. An outlet is the place where the ground water flows away from the site and into a large drainage ditch or stream. Usually outlets have some form of structure to control the height of the water in the open channels of the ground-water-lowering system. The height of the outlet controls the height of the lowered water table. The system user should change the outlet height as needed to prevent failure of the on-site system. Figure 5.4.2 shows two views of outlets.

❑ Because a ground-water-lowering system is controlled by the outlet, the outlet must be protected to ensure that the system works as it was designed. Outlets must extend into the receiving stream and be protected from burrowing animals or other things that block free flow of the water into the receiving stream.

Figure 5.4.1 Diagram of a ground-water-lowering system.

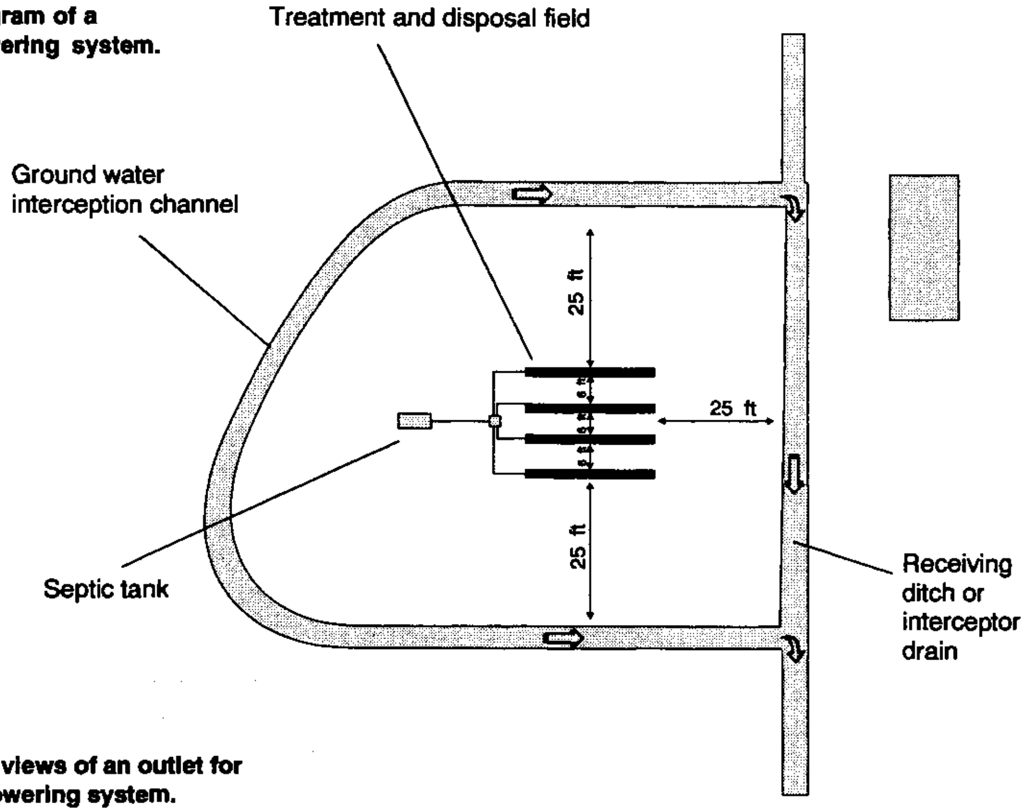
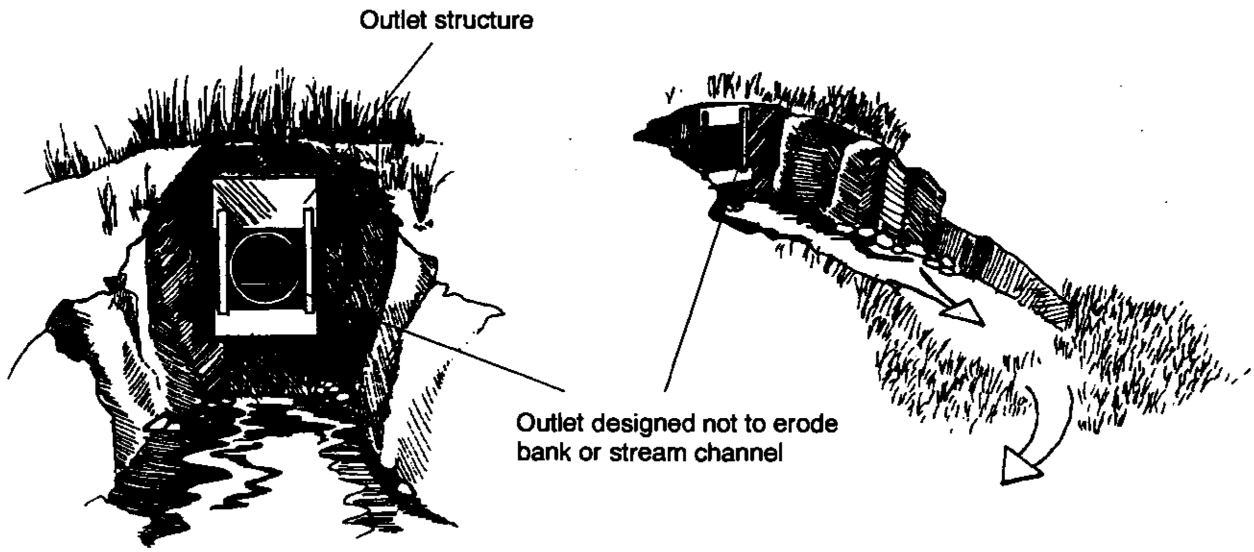


Figure 5.4.2 Two views of an outlet for a ground-water-lowering system.

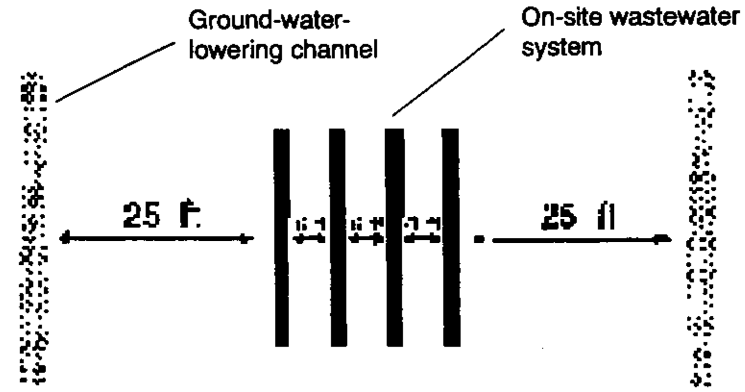


Design requirements.

Reference
15A NCAC 18A 1950(15)(A)

❑ When open channels are used to lower the water table, the system designer must provide a plan indicating the separation distances of the treatment and disposal trenches and the drainage channels and indicate the approximate shape of the lowered water table. Ground-water-lowering channels must be at least 25 feet from any portion of the on-site system (Figure 5.4.3). The system designer also must provide detailed drawings and specifications to ensure that the outlet is protected properly.

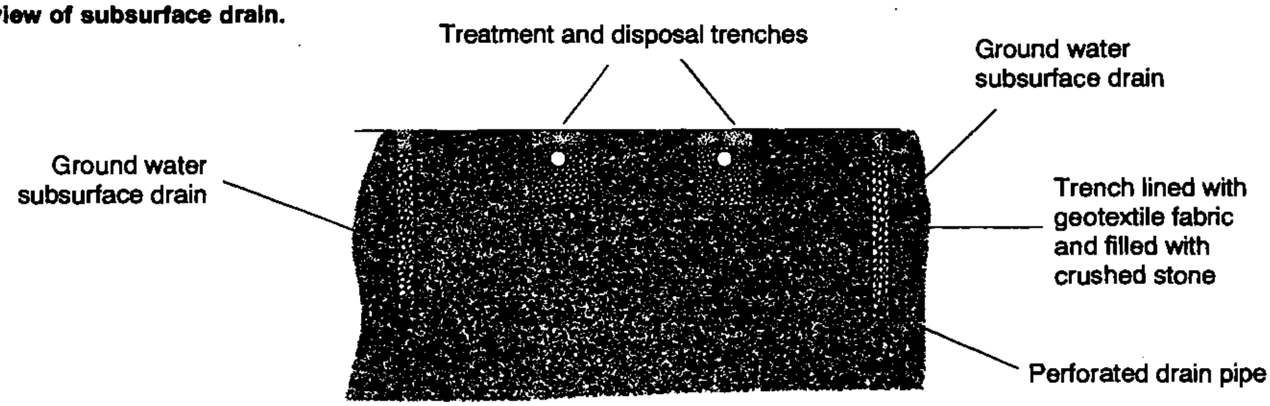
Figure 5.4.3 Ground-water-lowering channels located 25 feet from treatment and disposal field.



❑ When multiple lots in a development are drained, a detailed plan drawn by an engineer must be provided for the entire development. The lot drainage system must be maintained and frequently a *drainage district*, a legally-formed governing body, is required to accomplish this. The designer of the drainage system must specify the elevations of the outlet and the receiving stream or ditch. The receiving ditch should have stable side slopes, generally not greater than 3:1, and should be protected against erosion with a fiber mat and/or a permanent vegetative cover.

❑ Ground water can be lowered using subsurface drains or buried pipes. A pipe is installed 3 to 4 feet deep and surrounded by washed gravel. The pipe must be installed with a positive slope so that the ground water drains from the pipe to the outlet. Figure 5.4.4 shows an end view of a subsurface drain system.

Figure 5.4.4 Cut-away end view of subsurface drain.



❑ The outlet for a subsurface drain system can be a buried pipe that is surrounded by compacted soil for the length of one section of pipe to prevent the ground water from flowing along the outside of the pipe and washing it out. The outlet must empty into a water way above the normal water level and the outlet should be screened to keep out animals. If the subsurface drain carries high volumes of water or the water flows at high velocities, the water way at the outlet should be protected against erosion and scour.

Pumped drainage systems.

Reference
15A NCAC 18A.1956(2)

❑ In areas where the elevation of the water in the receiving ditch is sometimes or always above the ground water elevation required, a pumped ground-water-lowering or drainage system may be required. The pump lifts the water over the

Reference

15A NCAC 18A.1956(2)(e)

outlet and discharges into the receiving ditch. In this way, the pumped drainage system can lower the water table below the level of the water in the receiving ditch. A pumped drainage system must be designed to discharge the required volume of drainage water to the receiving stream.

Reference

15A NCAC 18A.1950

❑ The pump drainage system pump tank must comply with the same setback requirements as the subsurface drains. The design engineer must demonstrate that appropriate setbacks and buffers are maintained. Inspectors must check to see that the water in the receiving ditch is not polluted by the discharge of shallow ground water, particularly in areas where fresh water can degrade saltwater nursery areas.

❑ Pumped drainage can be required for individual lots or for large developments. Whenever pumps are used in a drainage design, a maintenance program must be established so that the pump and the outlets are properly maintained and serviced. This maintenance is usually done by a county or a drainage district management program.

System Modifications

System modifications change the way an on-site system is installed. These modifications overcome problems with steep slopes, shallow soil, or places where the usable area is higher than the septic tank. A decision tree to determine the use of interceptor drains is contained in Table 5.4.2.

Interceptor Drains

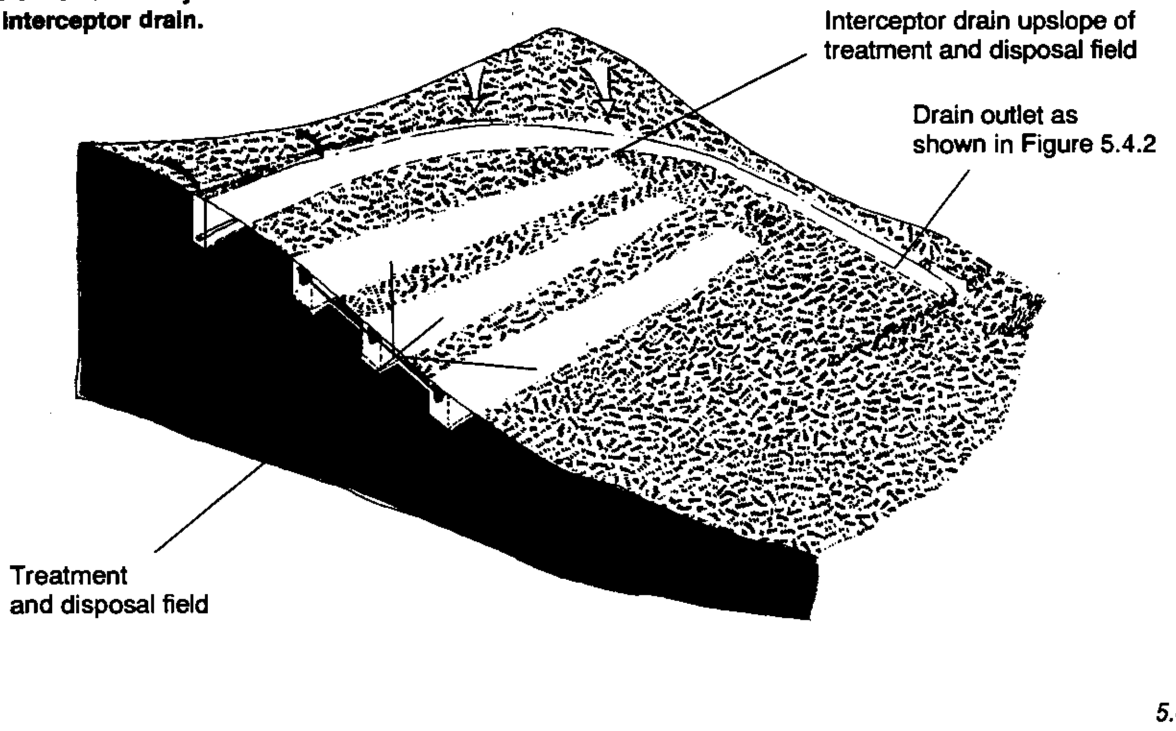
Some locations, especially sloping lots with large drainage areas above, may have a perched water table where water moves through the soil into the usable areas of the lot. This *shallow subsurface flow* can reduce the capability of an on-site wastewater treatment system to absorb and adequately treat wastewater because the water is trapped on an impermeable soil layer.

Reference

15A NCAC 18A.1956(4)

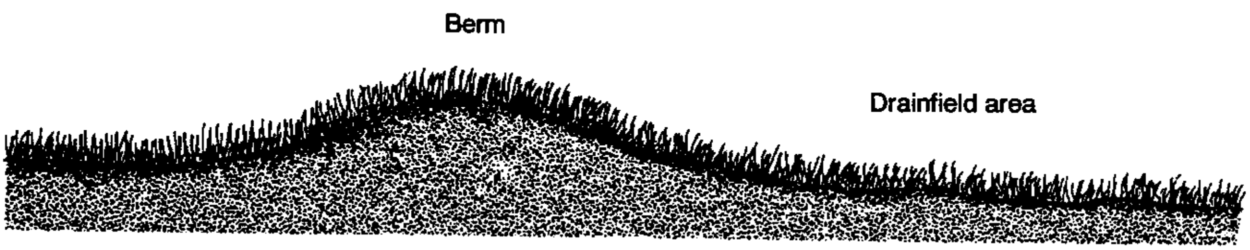
❑ *Interceptor drains* can be installed above the treatment and disposal field to catch and divert this shallow subsurface ground water. An interceptor drain, or a subsurface drain, is a trench filled with crushed rock to collect ground water or intercept the ground water as it flows through the soil. A pipe at the bottom of the trench carries the collected ground water to an outlet where the water is discharged. See Figure 5.4.5 for details of an interceptor drain.

Figure 5.4.5 Cut-away end view of an interceptor drain.



❑ *Surface water diversions* are usually used with interceptor drains to divert surface water from the usable areas. Surface water diversions consist of a shallow channel and berm to direct the surface water away from the usable area. See Figure 5.4.6, taken from the North Carolina Erosion and Sediment Control Planning and Design Manual (Smolen et. al, 1988), for details of surface water diversions.

Figure 5.4.6 End view of a surface water diversion.



Reference
15A NCAC 18A 1950(15)(A)

❑ The system designer must provide a plan showing the location, depth, and specifications for the interceptor drain and its outlet. Interceptor drains must be at least 10 feet from the on-site system on the side going up the slope, 15 feet away on the sides across the slope, and 25 feet away on the side going down the slope. Interceptor drains must be sloped so the water will flow to the outlet. The outlet should extend into the channel of a drainage ditch or receiving water so that erosion does not occur at the outlet.

❑ Interceptor drain networks must be maintained to ensure that they are open and drain freely. Any blockages, especially at the outlet, will dramatically reduce the amount of water drained from the soil. The outlet of the interceptor drain must be protected from animals burrowing into it.

❑ The regulatory agency must evaluate the effects of the interceptor drain discharge on the receiving water to see that the drainage discharge will not degrade the receiving water. Generally a permit for an interceptor drain cannot be obtained if the interceptor will drain to certain waters, such as High Quality Waters and Outstanding Resource Waters.

Table 5.4.2 Decision Tree for Interceptor Drains

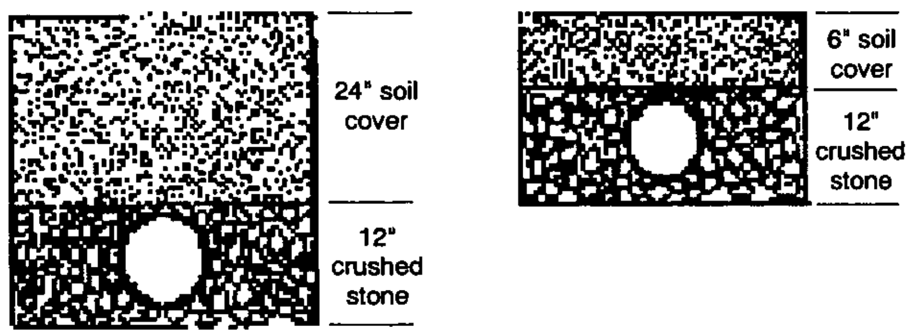
Condition	Action
Soil wetness condition 48 inches below the soil surface or deeper.	No need to install an interceptor drain.
Soil wetness from a local perched water table less than 48 inches deep AND there is a place to drain the ground water from the interceptor OR the lot is on a slope so that ground water moving horizontally through the soil layers can drain away from the site.	Interceptor drain can be used.
Soil wetness is an extensive perched water table or regional water table where there is no place to drain an interceptor OR the lot has no slope that would allow an interceptor to drain ground water away from the site.	Interceptor drains cannot be used.

Shallow Placement Treatment and Disposal Fields

Reference
15A NCAC 18A.1956(1)

Shallow placement of treatment and disposal trenches can be used where saprolite, bedrock, expansive clay, restrictive horizons, soil wetness, and weathered rock are at least 24 to 36 inches below the natural soil surface, and all other site and soil characteristics are classified as SUITABLE or PROVISIONALLY SUITABLE. On sloping sites, the depth of shallow placement trenches must be adjusted so that the trenches have adequate soil cover. See Figure 5.4.7 for a diagram of conventional and shallow placement trenches.

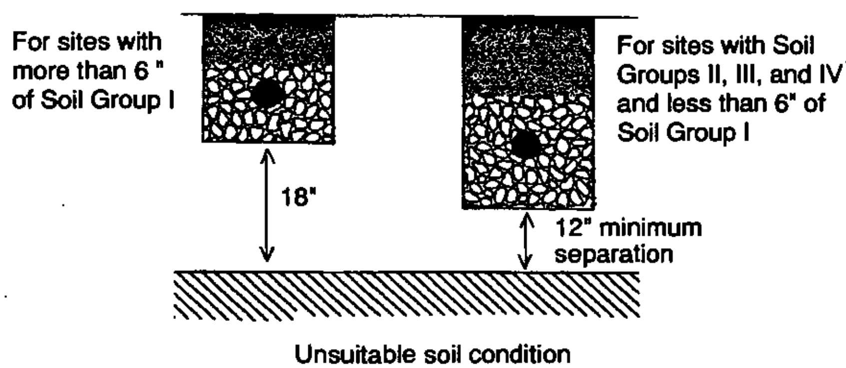
Figure 5.4.7 Cut-away end view comparing a conventional treatment and disposal trench to a shallow placement trench.



Reference
15A NCAC 18A.1955(m)

❑ In soils classified as Soil Groups II, III, and IV, a 12-inch separation distance is required between the trench bottom and a limiting factor, such as a clay layer or soil wetness. The effluent is considered to receive adequate treatment in these fine-textured soils when the combination of the above separation distance and required horizontal setbacks are met. See Figure 5.4.8.

Figure 5.4.8 Cut-away end views of trenches showing required separation between trench bottom and UNSUITABLE soil conditions.



❑ If the soil between the trench bottom and the unsuitable site characteristic has 6 inches or less of soil in Soil Group I, an 18-inch separation distance is necessary. If there are more than 6 inches of Soil Group I between the trench bottom and the restrictive layer, then a low pressure pipe system is required. The larger separation distances are needed for the sandy soil in Soil Group I because the effluent flows too quickly through sandy soil and does not receive the proper treatment. Figure 5.3.18 shows the increased separation required in Soil Group I soil.

Installation requirements.

Shallow-placement trenches should have the usual amount of crushed rock around the effluent pipe — 6 inches under, and 2 inches above the top of the pipe.

Reference
15A NCAC 18A.1955(i)

❑ The trenches in a shallow-placement treatment and disposal field should be covered with soil up to the original ground surface. In some cases, the crushed stone in the trench will be brought up to the original ground surface and capped with at least 6 inches of fill over the trench. The 6-inch cap of soil is needed to prevent odors and to keep animals from getting down into the wastewater in the crushed rock.

Reference

15A NAC 18A.1955(i)

❑ If a deeper soil cover over the treatment and disposal field is wanted or required, then the soil to the sides of the treatment and disposal field should be built up to the same height as the soil cover directly over the trenches. This built-up layer of soil should extend 5 feet out from the trenches on the edges of the field so that the soil cover is even over the trenches and on the edges of the field. The original soil surface should be broken up so that the added soil cover stays where it is placed.

Large-Diameter Pipe Systems

In many situations where site disturbance must be kept to a minimum, or where equipment must be carried in by hand, *large-diameter pipe systems* can be used. These systems use much larger pipes in the field trenches than in conventional systems.

Reference

15A NCAC 18A.1956(3)

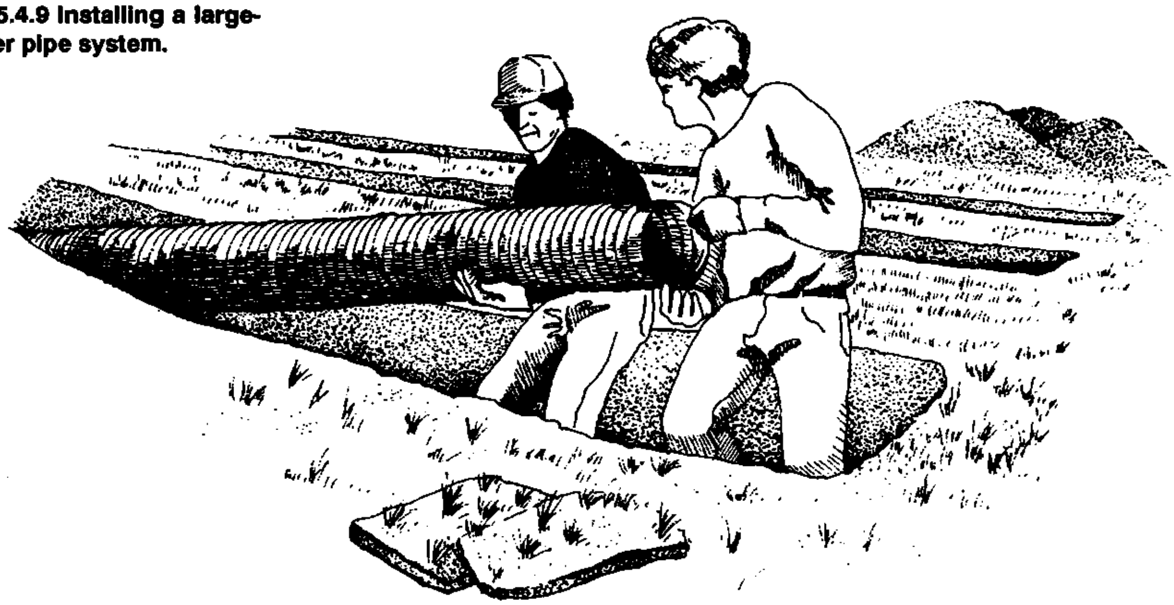
Treatment and disposal trenches in large-diameter pipe systems use a large pipe installed in a narrow trench with no crushed rock surrounding the pipe. In conventional systems, the effluent is stored in the open spaces in the crushed rock to allow it to flow into the soil. In a large-diameter pipe system, the large pipes serve as reservoirs to hold the effluent while it slowly flows into the soil through holes in the pipe.

Reference

15A NCAC 18A.1956(3)

Large-diameter pipe systems are used primarily in areas that have very limited access, such as steep, heavily-forested slopes in the mountains, areas where heavy equipment cannot operate, and steep areas with easily eroded soils where the soil should not be disturbed. On lots where heavy equipment cannot be brought in, the treatment and disposal fields have to be installed by hand. Here large-diameter pipe systems are ideal. The trenches are narrower than conventional treatment and disposal trenches making them much easier to dig manually. Also, no crushed rock is required, which makes installation much easier when all the materials must be carried in by hand. Figure 5.4.9 shows a large-diameter pipe system under construction. The requirements for large diameter pipe systems are as follows:

Figure 5.4.9 Installing a large-diameter pipe system.



❑ Large diameter pipe systems can overcome site problems such as shallow soils, or shallow soil wetness conditions on steep slopes. The narrower trench width used in large-diameter pipe systems allows these systems to be installed on steep slopes where the normal-width trench would not have enough depth.

❑ Large-diameter pipe systems must be backfilled with soil classified as Soil Groups I, II, or III.

Reference
15A NCAC 18A.1956(3)(a)(i)

❑ Pipe size should be 10 inches in inside diameter, although 8-inch pipe is permitted.

❑ A 10-inch diameter pipe is a better choice for an on-site system because the large pipe has more storage than the smaller 8-inch pipe. The larger storage gives the large pipe more reliability. For design purposes, the 10-inch large-diameter pipe has the same trench bottom area as a conventional system with 30-inch wide trenches, and the 8-inch pipe has the same trench bottom area as a 24-inch wide conventional trench. The LTAR for large-diameter pipe systems cannot be more than 0.8 gallons per day per square foot.

Characteristics of pipes.

Reference
15A NCAC 18A.1956(3)(a)(i)

Special pipes are used for these systems. The outlet holes are in two rows on the lower portion of the pipe and the top of the pipe is marked with a line for proper installation.

❑ To keep the pipes from filling in with soil and to help spread the effluent, the pipes are wrapped with a *geotextile fabric* or *filter wrap*. Geotextile fabric is a specially made nylon, polyester, or nylon/polyester blend cloth that holds back soil particles while allowing water to pass through. These special pipes come from the factory wrapped with the geotextile fabric and packaged in protective plastic sleeves. To prevent sunlight from degrading the geotextile fabric, the plastic sleeves should not be removed until just before installation.

❑ Large-diameter pipe systems should not be used for restaurants or other establishments where the wastewater contains large amounts of grease and oil. The grease and oil can plug the geotextile fabric wrap and cause the system to fail.

Prefabricated Permeable Block Panel Systems

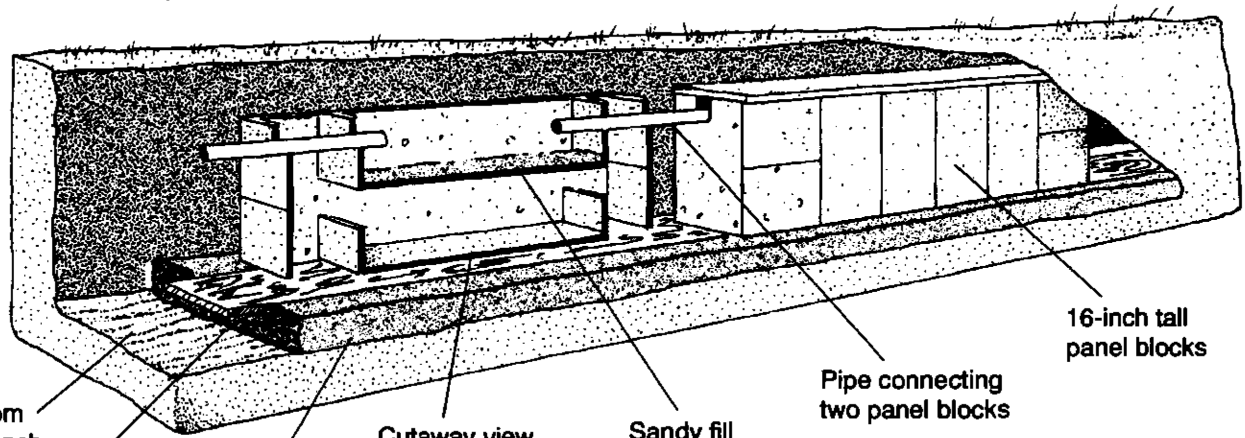
Reference
15A NCAC 18A.1956(3)(a)(ii)

Prefabricated Permeable Block Panel Systems, or PPBPS (Figure 5.4.10), are commonly referred to as *block panel systems* or *porous block systems.* These systems were developed in North Carolina to improve the ability of gravity systems to pretreat and distribute effluent to the trench sidewalls. Because more effluent flows into the soil through the trench sidewalls, a smaller treatment and disposal field can be used. The smaller treatment and disposal field helps overcome some space limitations on some lots.

PPBPS are designed to use less area than the conventional treatment and disposal field, but they require deeper soils to keep the required 12-inch separation distance between the trench bottom and any unsuitable soil condition. For example, a 16-inch block PPBPS needs a minimum of 40 inches of soil depth for proper installation.

These systems use a conventional septic tank and specially designed precast concrete blocks and panels for the treatment and disposal trenches to improve the absorption of effluent. The blocks are encased in coarse sand. The blocks and sand provide some treatment so that a cleaner effluent is absorbed by the soil.

Figure 5.4.10 Cutaway view of a prefabricated permeable block panel system.



- The designer of the system must carefully show the location of each treatment and disposal trench. These lines must be placed on contour with panels installed level.
- Installation of a block panel system must follow the manufacturer's specifications to ensure proper operation of the treatment and disposal field.
- Block panel trenches must be 24 inches wide and installed with a separation of at least 8 feet, center to center.
- For systems installed in soil of Soil Group IV, sandy clays, silty clays, and clays, the sidewalls of the dug trenches must be raked to break up any slick or glazed surface on the soil. The slick surface or glaze on the soil reduces the amount of effluent the soil will absorb.

Pump to Conventional Treatment and Disposal Field Systems

Frequently, the outlet of the septic tank is below the usable areas where a treatment and disposal field can be installed. In these situations, a pump can be installed to lift the effluent to a conventional treatment and disposal field placed in the usable area (Figure 5.4.11).

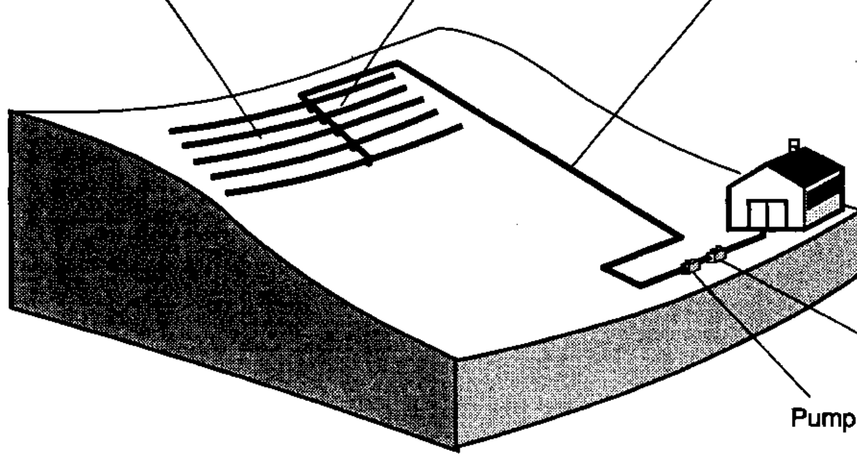


Figure 5.4.11 Diagram of a pumped system using center-feed drop boxes in a serial distribution field.

Reference
15A NCAC 18A.1954(b)

Systems using pumps to lift septic tank effluent must install a *pump tank* after the septic tank in the system. The pump tank is located after the septic tank so that most of the solids settle out in the septic tank and do not go through the pump and out to the treatment and disposal field.

Reference
15A NCAC 18A.1952(c)

The pump is installed in the pump tank and all the controls are mounted close to the pump tank. The pump controls must not be located inside or on top of the pump tank to prevent corrosion of the controls and to provide ready access for maintenance and operation. The discharge pipe from the pump carries effluent to the treatment and disposal field where the effluent flows by gravity into the trenches. Often a *pressure distribution manifold*, a pipe with many outlets and valves, receives the effluent from the pump and distributes it to the treatment and disposal field trenches. See Figure 5.4.11 for a diagram of a pumped on-site wastewater system and Figure 5.4.12 for a cut-away view of a pressure distribution manifold. Figure 5.4.13 shows the components of a pump tank.

Figure 5.4.12 Cut-away view of pressure manifold device.

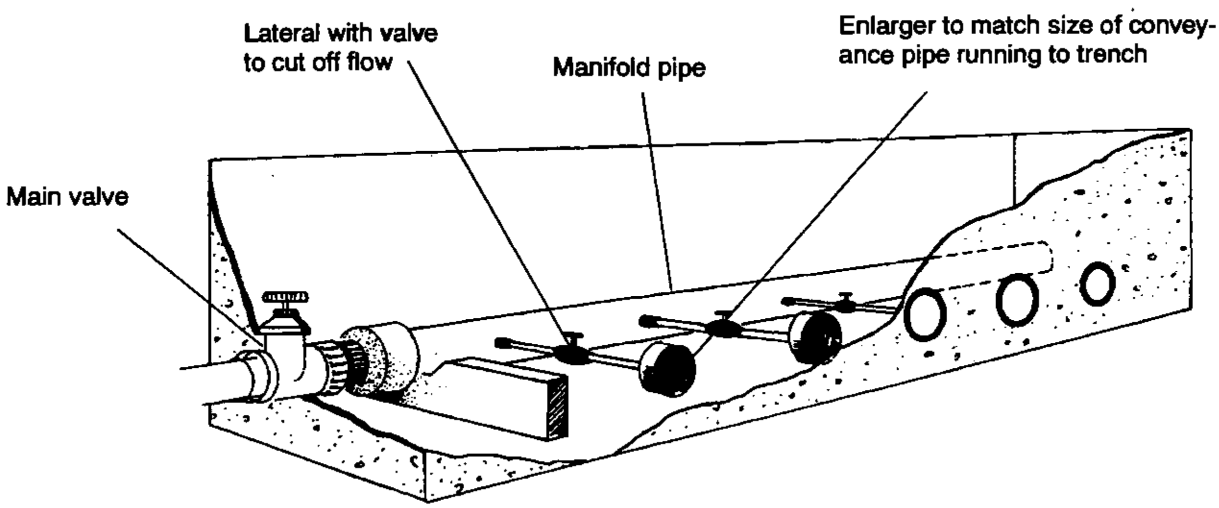
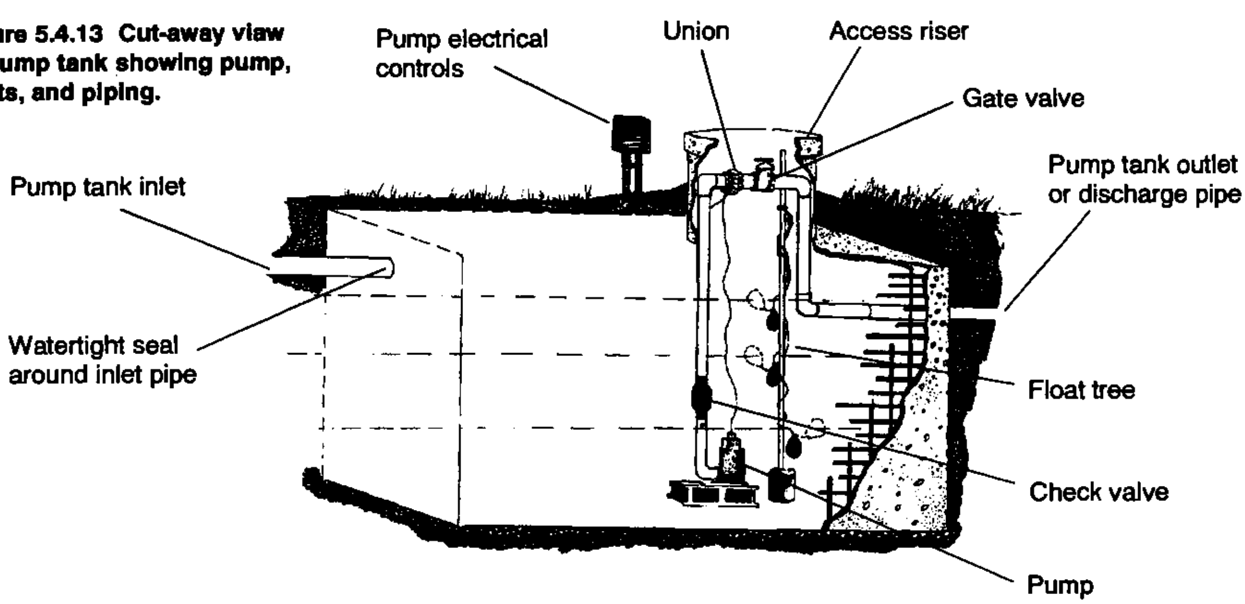


Figure 5.4.13 Cut-away view of pump tank showing pump, floats, and piping.



Important points in designing pump tanks to pump septic tank effluent to a conventional treatment and disposal field are listed below.

❑ **Warning** — Never go into a pump tank or a septic tank. They may contain dangerous gasses that can kill a human being or explode.

Storage volume.

The pump tank stores a large volume of liquid so that it can pump a reasonable volume of effluent to the treatment and disposal field each time it runs.

Reference
15A NCAC 18A.1952(a)

❑ Pumping a large volume of effluent each time the pump runs reduces the wear on the pump and pump controls.

❑ Each *dose* or volume of effluent pumped to the conventional treatment and disposal field using 4- or 6-inch corrugated tubing should fill the field trench pipes from 2/3 to 3/4 full. A trench with a 4-inch pipe should receive a 1/2 gallon of effluent for each foot of trench length; a 6-inch pipe should receive 1 gallon per foot of length.

Size of pump tanks.

The capacity of a pump tank is considered to be the entire internal volume of the tank, with no *freeboard* required. Freeboard is the height of the tank wall above the level of the liquid.

❑ Pump tanks must not be smaller than 750 gallons. Larger sizes for pump tanks are determined by the type of soil in the drainfield.

❑ For pump tanks with drainfields in Group I, II, or III soils, the minimum pump tank size is 2/3 of the volume of the septic tank.

❑ Pump tanks with drainfields in Group IV soils, which are sandy clays, silty clays, and clays, are required to have the same volume as the septic tank.

Reference
15A NCAC 18A.1941 and 1952(3)

❑ The pump must be carefully sized so that it will develop enough pressure to lift the effluent to the treatment and disposal field, and have enough pressure for proper distribution in the trenches. Pump selection should include consideration of the total lift required, hydraulic losses due to friction in the pipes and fittings, flow velocities necessary to avoid settling of solids, and pressure required for proper distribution to the trenches.

Reference
15A NCAC 18A.1952(c)

❑ Pumps must have approval of Underwriter's Laboratories or equivalent testing agency, be capable of handling 1/2-inch solids, and pumping at the rate and head required.

❑ Another method used to size a pump tank is to meet the minimum pump submergence requirement, minimum dosing requirement, and minimum emergency storage requirement. Determining the volume of a pump tank to meet these criteria is complicated and not practical for most small wastewater systems.

❑ Pump tanks should have only one compartment. If a two-compartment tank is to be used, then the partition in the tank must have at least two 4-inch holes in the partition no higher than 12 inches from the tank bottom to allow free flow of the effluent from one compartment to the other. Other types of openings may be allowed as long as the openings are equivalent to two 4-inch holes and are preformed into the tank.

Components of a pumping system.

Listed below are the components required for proper operation of a pumping system.

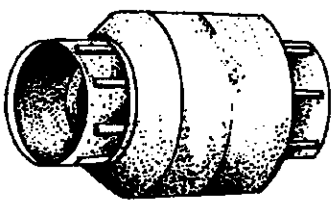
❑ A chain or rope that will not corrode should be attached to the submersible pump so that the pump can be pulled out of the tank for servicing without someone entering the tank. A nylon rope, stainless steel wire rope, or stainless steel chain would all work.

Reference
15A NCAC 18A>1952(c)

❑ The discharge pipe from the pump must be Schedule 40 PVC pipe and must have an accessible union or other fitting to allow the pump to be disconnected for repair.

❑ Flow velocities in the conveyance pipes should be 2 feet per second or more to keep sewage solids from settling out and blocking the pipe.

❑ Elbows and tees may require *thrust blocking* to minimize *water hammer* effects when pumps activate. Thrust blocks are blocks of concrete cast around a tee or elbow to strengthen the fitting and prevent it from being blown off by the water pressure. Water hammer occurs when pumps start or shut off, causing the water in a pipe to suddenly start or stop flowing. The sudden starts and stops can cause short pulses of high pressure in a pipe which can burst the pipe or break the fittings.



Check valve.

❑ Valves may be required in the pump discharge pipe to regulate flow or pressure. *Air release valves,* which allow air to escape from inside a pipe, should be placed at the uppermost elevation in the conveyance pipe when it must go over a high point before the treatment and disposal field to minimize air blockages in the pipes and trenches.

❑ Check valves are typically required between the pump and the treatment and disposal field to prevent backflow into the pump tank or through the pump when the drainfield is at a higher elevation. Also, pump warranties may be voided if a check valve is not installed. A check valve is pictured to the left.

❑ Check valves should also be installed if the volume in the pump discharge pipe is more than 25% of the dosing volume. The check valve ensures that the full dose of sewage is applied to the treatment and disposal field.

❑ In situations where the treatment and disposal field is lower than the high-water alarm elevation in the pump tank, an *anti-siphon hole* should be installed in the pump discharge pipe upstream or before the check valve. An anti-siphon hole keeps the water from being siphoned out of the pump tank by breaking the suction after the pump turns off. A 3/16-inch anti-siphon hole should be installed in the pump discharge pipe so that the hole discharges back into the pump tank.

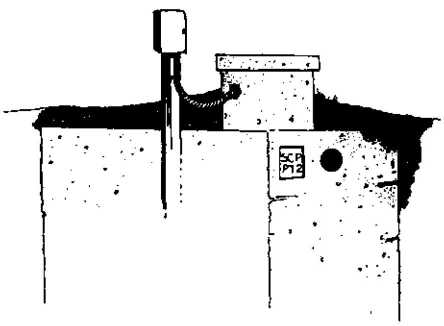
❑ The designer of the on-site wastewater treatment system must provide the regulatory agency with detailed drawings of each component. These components include the pumps and pump chamber, controls and control panels, and the valves and other parts necessary to convey effluent from the pump tank to the treatment and disposal field. Each component of the pressure system must be specified carefully.

Reference
15A NCAC 18A.1952(c)

❑ *Pressure manifolds* are often used to distribute the effluent to the treatment and disposal field trenches. A pressure manifold is a large pipe fitted with many small outlet pipes so that the small outlet pipes feed effluent to the trenches. If a pressure manifold is used, details of the manifold must be clearly shown on an engineering drawing. The number and size of the discharge outlets from the manifold, schedule of pipe used in the outlets, valves on these outlets, and details of the type of tap, such as a threaded tap or saddle tap for the outlets, must be clearly specified. Do not thread or tap a PVC pipe with a wall thickness less than Schedule 80.

❑ Conveyance piping from the pressure manifold to the trench must be specified clearly in a plan view drawing. Thrust blocking is generally not required at tees or elbows between the manifold and distribution lines, but a dam of compacted earth should be placed between the conveyance pipeline and the perforated pipe in the treatment and disposal trench. The conveyance pipeline should have at least a one percent downward slope in the direction of the treatment and disposal trench, so effluent flows to the trench as fast as it comes out of the manifold.

Pump control panels.



Pump tank showing access riser and pump control box.

The switches and the panel that houses the switches are very important for proper operation of the pump and overall system. The drawing to the left shows the location for pump controls.

❑ The pump control panel must be contained in a watertight enclosure, with a National Electrical Manufacturer's Association (NEMA) rating of NEMA 4X or an equivalent. The control panel must be at least 12 inches above the final ground level and have manual switches to override the automatic controls. Manual switches make service much easier and safer.

❑ Pump controls can be mercury float switches or mechanical (non-mercury) float switches. Float switches should be attached to a *float tree*, a vertical pipe or rod that will not rust or corrode in the pump tank that holds the float switches. A 1-inch plastic pipe works very well as a float tree. The pump discharge pipe cannot be used as the float tree, so the floats can be replaced or adjusted without removing the pump.

❑ Set the float switches so the correct volume of effluent is pumped to the treatment and disposal field for each on-off cycle of the pump. The distance between the pump "on" float and pump "off" float is the *draw down*, which determines the volume of effluent in the tank pumped to the field in one on-off cycle.

Reference
15A NCAC 18A.1952(c)

❑ Encase all electrical wires in waterproof and gasproof conduits, and make no connections inside the pump tank. Seal openings for all wires and conduits. These precautions are necessary to prevent explosions from gas build-up in the pump tank and to prevent the corrosive gas and moisture in the pump tank from corroding the electrical switches and wires.

5.5 INSTALLATION AND CONSTRUCTION OF ON-SITE SYSTEMS

On-site systems should be installed in a carefully planned manner. Each step of the installation process should be completed in order and the work should be done right the first time. The following guidelines will help installers avoid costly mistakes; be in compliance with the rules; and protect public land, water, and health.

This section includes the installation of septic and pump tanks, conveyance lines, pumps, and treatment and disposal fields. The discussion of each system component begins with required characteristics and then goes on to installation and inspection.

Manufacture of Prefabricated Septic Tanks and Pump Tanks

Septic tank manufacturers must meet a number of requirements to make an approved tank (Table 5.5.1). The following presentation discusses requirements for tank characteristics including load-bearing capacity, construction techniques, and structural strength.

General Tank Construction Requirements

Reference

15A NCAC 18A.1953

Tanks used for on-site systems must meet the requirements set by the North Carolina Department of Environment, Health and Natural Resources, the Division of Environmental Health. Tank manufacturers must apply for approval for each size and type of tank.

- An application package includes:
  - The manufacturer's name, address, and phone number;
  - A list of counties where the tank will be sold;
  - Three sets of plans and specifications for the tank and one set for each county; and
  - The manufacturer's identification or logo to be imprinted on the tank.
- Plans and specifications must contain the following information:
  - All dimensions of the tank, tank walls, locations of inlet and outlet blockouts;
  - The type, size, and placement of reinforcing;
  - The strength of the tank material;
  - Designed liquid depth;
  - Details of the joints, joint materials, sealers, and methods of sealing;
  - Details of the access manholes and risers;
  - All other design features, including methods of manufacture, molding, curing, lifting eyes, and earth and traffic load capability.

Precast Reinforced Concrete Tanks

Reference

15A NCAC 18A. 1954

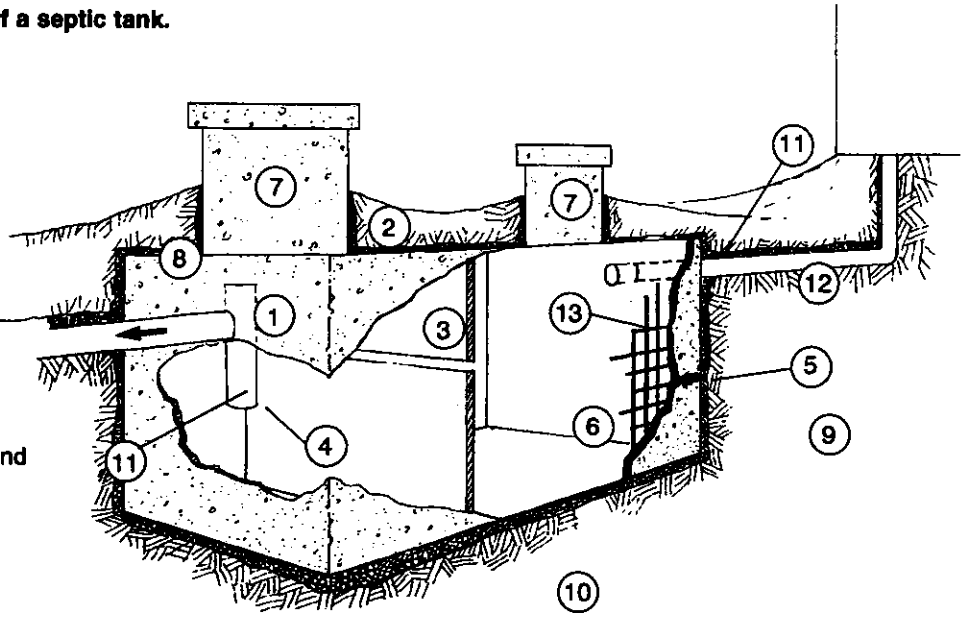
Minimum design and construction standards for precast reinforced concrete tanks ensure that tanks are structurally sound, watertight, and designed to do the best job of treating the sewage. Strong and watertight tanks have less failures and provide protection against pollution and disease. Figure 5.5.1 shows the parts of a septic tank. Requirements for septic tanks are listed in Table 5.5.1

Table 5.5.1 Requirements for an Approved Septic Tank

Tank Characteristic	Requirement
Tank capacity	750 gallons minimum
Tank length to width ratio	2 to 1, minimum
Number of compartments	2
Volume of inlet compartment	2/3 to 3/4 of total tank capacity
Volume of outlet compartment	1/4 to 1/3 of total tank capacity
Concrete compressive strength	3,500 psi at 28 days, minimum
Wall thickness, top, bottom and sides	2 1/2 inches, minimum
Steel reinforcement for concrete (min.)	6-inch by 6-inch, 10-gauge welded wire mesh or equivalent, minimum
Baffle wall thickness	2 1/2 inches, minimum
Interior height	45 inches, minimum
Liquid depth	36 inches, minimum
Freeboard (wall height above liquid)	9 inches, minimum
Baffle wall gas vent size	2 inches by 6 inches, minimum
Baffle wall liquid opening size	4 inches, minimum, entire width of tank
Baffle wall liquid opening	25 to 50% of the depth of the liquid measured from the liquid surface
Sanitary tee — material	2-inch thick cast-in-place concrete or 160 psi PVC or PE pipe
Depth of sanitary tee in liquid	25% of the liquid depth measured from the liquid level
Difference in elevations of inlet and outlet	2 inches, inlet invert higher than outlet invert
Inlet pipe blockouts	3
Location of inlet pipe blockouts	on inlet end of tank and on sides of tank at the inlet end
Outlet pipe blockout	1
Location of outlet pipe blockout	on outlet end of tank
Blockout size	4 inches minimum, 6 inches maximum
Blockout concrete thickness	1 inch minimum
Access covers — size	18 inches by 18 inches, minimum
Access cover handle- material	Number 3 rebar, minimum
Manufacturer's imprint location	to right of the outlet pipe blockout
Joint detail	tongue-in-groove or equivalent
Joint sealing method	mastic or equivalent, 1-inch thickness (nominal)

Figure 5.5.1 Cut-away view of a septic tank.

1. Tank identification stamp
2. Date of manufacture stamp
3. Baffle wall
4. Sanitary outlet tee
5. Watertight seam sealed with mastic
6. Tank walls minimum 2 1/2" thick, 3500 psi concrete
7. Access risers — watertight
8. Tank 36" or less below ground
9. Tank located away from house, well, property lines
10. Tank level, front-to-back and side-to-side
11. Inlet and outlet pipes sealed and watertight
12. House sewer pipe slopes 1/8" per foot or more
13. Reinforcing wire, throughout tank



Dimensions. The spacing and sizes of the tank parts are very important in making the tank work properly. Incorrect dimensions can reduce the settling of solids or allow grease to flow out to the trenches.

❑ A minimum liquid depth of 36 inches is required.

❑ The tank must be at least twice as long as it is wide to get the best settling of the solids. The first chamber must be two-thirds to three-fourths of the total tank volume to provide the maximum amount of storage of solids.

❑ The minimum *freeboard*, or wall height above the liquid, is 9 inches.

❑ The top, bottom, ends, and sides of the tank must be at least 2 1/2 inches thick except for *blockouts*.

Blockouts. Blockouts are precast indentations in the tank walls where inlet or outlet pipes can be placed.

Reference
15A NCAC 18A.1954

❑ Blockouts must have a wall thickness of at least 1 inch and must be able to accept 4- or 6-inch pipe.

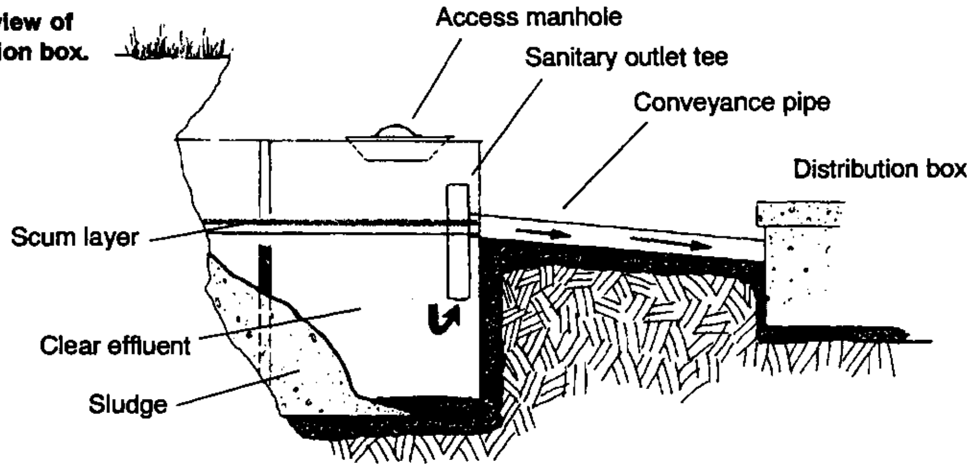
❑ There must be three blockouts for the inlet pipe on the inlet side of the tank, one in the end wall and one in each side. Only straight pipe can be used as an inlet; no elbows or tees are allowed. Typically only one inlet blockout is used because most houses have only one sewer line.

Outlet. A sanitary tee must be provided for the outlet. The tee is one of the most important devices in the tank because it keeps the grease from flowing into the treatment and disposal field. See Figure 5.5.2 for an illustration of septic tank outlets.

Reference
15A NCAC 18A. 1954

❑ A Class 160 plastic pipe tee, either polyvinyl chloride (PVC) or polyethylene (PE), or a cast-in-place, 2-inch-thick concrete tee is required. The tee must be extended one-fourth of the way down into the liquid depth to keep floating solids away from the absorption field. For example, for a tank with a 48-inch liquid depth, the bottom of the tee must be 12 inches into the liquid.

Figure 5.5.2. Cut-away view of septic tank and distribution box.



❑ The outlet opening must be at least 2 inches below the inlet opening so that the sewage does not back up into the inlet pipe.

❑ An optional *gas deflector* can help keep solids away from the opening to the sanitary tee. This is an angled plate of concrete, plastic, or corrosion-proof steel below the opening of the sanitary tee that keeps floating solids from entering the sanitary tee. The top edge of the plate should be no more than 6 inches below the sanitary tee opening, and should extend out 2 inches in front of the tee and on the sides.

Reference
15A NCAC 18A.1954

Tank strength. Tank walls must resist the sideways pressure of the soil on the walls and support the weight of the tank cover and the soil covering the tank. Also, the tank must be strong enough to resist uplift from ground water and any other loads that normally affect an underground tank.

❑ Tanks must be able to hold a live loading of 150 pounds per square foot and support the dead weight of the concrete tank cover and the soil above it.

❑ The strength of the tank depends on the strength of the concrete; the placement, wall thickness, and type of reinforcing steel in the tank; and the quality of the casting process. The following sections describe how to make a strong, high-quality tank.

Concrete strength and quality. The strength and quality of the concrete are very important in the overall quality of the tank. Strong, well-cast concrete helps make the tank strong and watertight.

❑ The concrete must conform to ASTM C 150 specifications, have a design minimum 28-day strength of 3500 pounds per square inch (psi), and must have hardened to 3000 psi before it is moved for installation. Concrete strength can be estimated using a Schmidt Rebound Hammer or Windsor Probe Test. The concrete can be strengthened by using the minimum amount of water possible and by curing the concrete properly.

❑ For the Schmidt Rebound Hammer test, select a smooth-formed area about 6 inches in diameter. All test areas must be made where concrete is a minimum of 4 inches thick, such as at the wall edges or baffle. Take 10 rebound readings with the hammer, moving the hammer to a fresh point of impact for each reading. The points of impact should be at least an inch apart, and any impact that breaks through an air pocket should be disregarded. Add the results of the 10 readings and divide by 10 to get the average. Discard any readings that differ from the average by more than 7 units and recalculate the average. This average is the final result. If more than 2 readings differ from the average by 7 units, discard the entire set of readings and do the test over.

Reference
15A NCAC 18A.1954

❑ Concrete gets weaker as more water is added to the cement. Very dry mixtures are the strongest and make the most watertight tanks. For the strongest tank, use the driest mixture possible that will properly fill the forms.

❑ All concrete must be thoroughly mixed to be sure that the cement coats all the gravel and is spread evenly through the entire batch.

❑ Additives that produce 5-6% *entrained air*, or tiny bubbles in the concrete, should be added to septic tank concrete. The entrained air aids in making the concrete watertight.

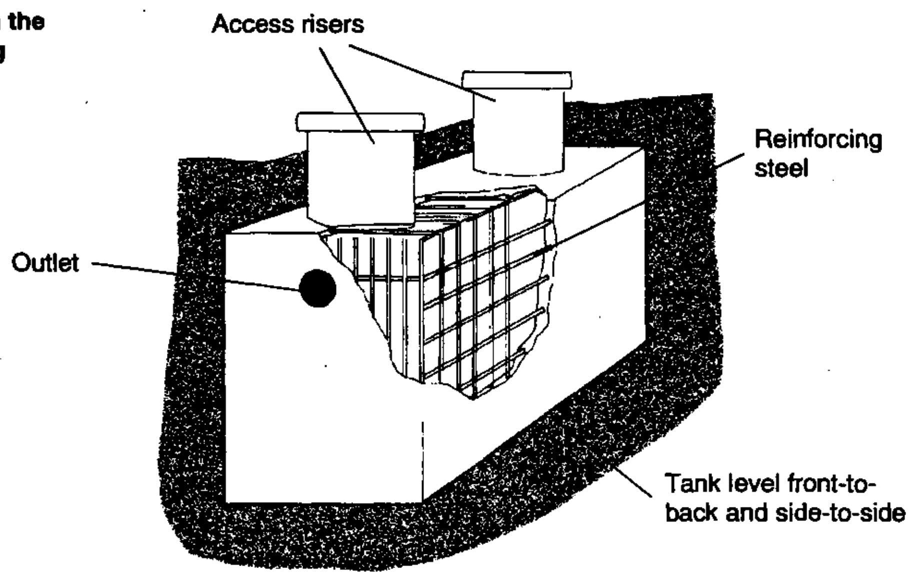
❑ The concrete should be vibrated as it is poured and once it is in the form. The vibration makes the concrete settle into the deep parts of the form and helps eliminate pockets and honeycomb (groups of small holes) areas. Pockets and honeycombs in the concrete will cause leaks and weak tanks.

An externally mounted bin vibrator does a good job on all tank shapes and sizes. For rectangular tanks, a hand-held vibrator with a 3/4-inch or 1-inch flexible shaft will do a good job. Flexible shaft vibrators are inserted into the wet concrete at several points around the form to shake the concrete down into all the parts of the form.

❑ Do not use concrete rejected by a construction site for making septic tanks.

Reinforcing steel. Concrete is strong in compressive strength, which means that it does not crush when it is pushed together or squeezed. However, concrete is very weak in tensile strength, which means that it can be pulled apart easily. To increase the tensile strength of the concrete in a tank, steel reinforcement must be used. Without steel reinforcement, tanks are not strong enough to do their job. Figure 5.5.3 shows the reinforcing steel in a septic tank.

Figure 5.5.3. Septic tank in the ground showing reinforcing steel in the tank walls.



❑ The top, bottom, ends, sides, access lids, and baffle wall of a concrete tank must have a minimum reinforcement of 6-inch by 6-inch No. 10 gage welded steel reinforcing wire mesh. Where two pieces of the reinforcing wire mesh join, the pieces should be lapped at least 6 inches over each other and tied together to keep the mesh centered in the slab. Centering the mesh makes the walls stronger and also gives the most corrosion protection to the steel.

❑ All steel reinforcement must be covered with concrete so that it will provide tensile strength to the concrete mixture. At least 1 inch of concrete should surround all reinforcing steel.

❑ The reinforcing steel must be bent through all corners and edges of the tank where most of the stress on tank walls occur.

❑ Reinforcing wire for the baffle wall should be bent at 90 degrees to make 4-inch legs that are laid parallel to the reinforcing wire in the side walls and tank top and bottom and tied in place.

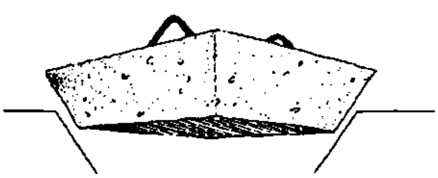
❑ Metal detectors can be used in inspections to detect whether steel reinforcing wire is present in tanks that are already cast.

❑ Special concrete design and reinforcement are required for large (≥ 2,000 gallons) septic tanks and when the septic tank must be placed below roadways or driveways or when the tank is going to be buried more than 3 feet deep. Tanks should not be installed below driveways or roads except when designed and approved for these special conditions.

Reference
15A NCAC 18A.1954

Manholes. Tanks must have manholes so that service personnel and the user can have access to measure the sludge depth; to inspect the inlet, sanitary tee, partition, and other tank parts; and to pump out the tank.

❑ All tanks must have two 18-inch by 18-inch manholes, one manhole over each chamber of the tank. Each manhole cover must be beveled on all sides to keep it from falling into the tank. See the drawing of an access manhole cover to the left.



Access manhole cover.

❑ Lids or covers for the manholes should have a handle of steel or other corrosion-resistant material equivalent in strength to a No. 3 reinforcing rod (rebar).

Joints. Well-sealed, properly-formed joints help make the tank watertight.

❑ Two-piece tanks should be joined after curing and sealed with a flexible sealer that is waterproof, corrosion-resistant and approved for use in septic tanks, such as mastics or butyl rubber. The tank halves should be lined up, the joint cleaned, and a 1-inch bead of sealer should be used to make the joint as waterproof as possible.

❑ If more sealing is needed, hydraulic cement or sand-cement mix can be applied to the inside and/or outside of the joint. Be sure the joint is clean so the cement will stick to the concrete in the tank.

Tank quality control. Tanks should be inspected by the manufacturer before they are shipped off the manufacturer's lot. Inspecting tanks on the lot avoids rejections by environmental health specialists or homeowners.

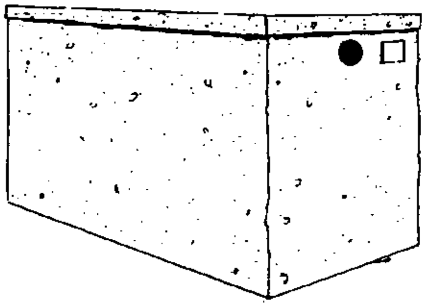
Reference
15A NCAC 18A.1954

Leaks. Leaking tanks can cause the entire on-site system to fail or contaminate ground water. Tanks must not leak.

❑ Look for honeycomb areas and open pockets, cracks and holes, and exposed reinforcing wire. Some types of minor defects can be repaired; however, repairs must conform to the standards for strength and quality of concrete. Tanks with honeycombs, cracks, and holes may be rejected by the state or local health department.

❑ Honeycombs in the tank wall and especially in the corners and on edges can cause leaking and weaken the tank. Usually honeycombs are caused when the concrete is not vibrated enough when it is poured. Joints and walls with honeycomb should be patched so they do not leak. If the honeycomb covers too much of the tank, the tank should be rejected.

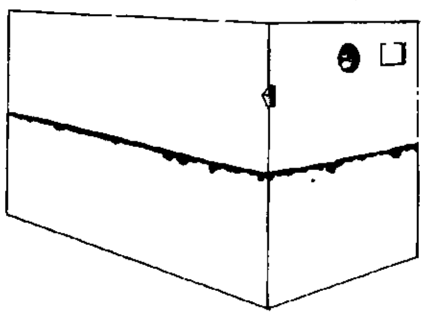
- Small cracks are a normal result of the curing process and can be disregarded.
- Large cracks in the concrete can weaken the tank and cause leaks. Large cracks occur because the concrete dried too quickly during curing, the concrete is too weak, or there is no steel reinforcement. Large cracks must be patched and proven not to leak. If the crack is visible inside and outside, the tank should be rejected.



One-piece tank with sealed lid.

❑ The joint between the tank halves must be smooth and level to make a watertight seal. If the concrete in the joint area is honeycombed, the honeycomb should be patched. Joints must be sealed with a 1-inch bead of mastic, as shown in the drawings on the left. Joints should also be plastered on the outside for septic tanks and on the inside and outside for pump tanks. Additional waterproofing is required for pump tanks. Poorly shaped joints are caused when the concrete is not vibrated enough when it is poured, the form contains a poor framework with warped joints, or dried concrete is not removed from the joint area between pourings in the mold.

- Pump tanks must be watertight; otherwise, ground water can leak into the tank and cause flooding of the treatment and disposal field.
- Tanks can be checked for leaks by vacuum testing or by water testing. If a tank can hold a vacuum of 3 inches of mercury for one hour, it will not leak. To test a tank with water, temporarily seal the inlet and outlet pipes. Fill the tank above the highest seam or pipe connection and let it stand 24 hours to allow the concrete to absorb all the water it will hold. Refill the tank and check the water level after 24 hours. A tank is considered watertight if the water level does not change more than ½ inch or ½% of the liquid volume in 24 hours (see table on page 5.6.2).
- A visual check for leaks can be made by observing the seam and tank walls after filling with water. Any leaks should show within one hour.



Two-piece tank with sealed middle seam.

Reference

15A NCAC 18A. 1954(c)

Tank specifications. Requirements that tanks must meet follow.

❑ Concrete in the tank must have a design compressive strength of 3500 psi at 28 days after pouring or 3000 psi before the tank is installed if the tank is installed before 28 days. Low compressive strength is caused by too much water in the concrete, not enough time to cure, or improper curing.

❑ Metal detectors can be used to detect whether steel reinforcing wire is present in tanks that are already cast. Steel wire must be in all parts of the tanks including the baffle wall, cast-in-place sanitary tee, and the tank cover.

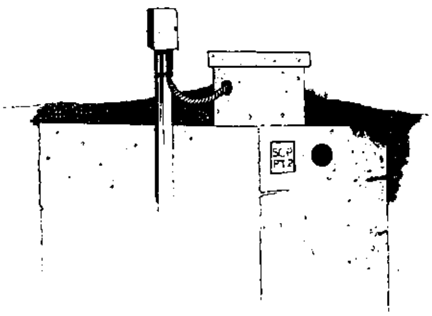
❑ Check the tank dimensions, especially the liquid capacity, the sanitary tee depth into the liquid, size of the manholes, and the thickness of the concrete in the walls and blockouts.

❑ The baffle wall vent should be clear of excess concrete or other material that could block it.

❑ Each septic tank must have the manufacturer's stamp or imprint to the right of the blockout made for the outlet pipe. The stamp must show the manufacturer's I.D., serial number assigned to the manufacturer's approved plans, and specifica-

Reference
15A NCAC 18A.1954

tions and the liquid or working capacity of each tank. Also, tanks must have the date of manufacture stamped or scratched into the concrete, or marked with permanent ink beside the tank imprint or on the top of the tank directly above the imprint.



Pump tank showing manufacturer's stamp to left of outlet.

❑ Pump tanks must be preapproved and must have the manufacturer's stamp or imprint to the left of the blockout made for the outlet pipe. The stamp must show the manufacturer's I.D., the serial number assigned to the manufacturer's approved plans and specifications and the liquid or working capacity of each tank. Also, tanks must have the date of manufacture stamped or scratched in concrete, or marked with permanent ink beside the tank imprint or on the top of the tank directly above the imprint. See the drawing to the left.

❑ Pump tanks can have one or two compartments. Two-compartment tanks must have at least two 4-inch flow-through holes within 12 inches of the tank bottom through the dividing wall.

❑ A 24-inch diameter riser must be installed on a pump tank over the pump and float tree. The top of the riser must be at least 6 inches above the ground and the riser must be sealed to the pump tank so that it is watertight.

Form release compounds. It is best to use the smallest amount of form release possible to avoid contaminating stormwater runoff at the manufacturing lot.

❑ Non-petroleum form release products should be used in order to avoid possible stormwater contamination on the manufacturer's lot and ground water contamination at the homeowner's site.

Fiberglass Tanks

Reference
15A NCAC 18A. 1954(c)

Fiberglass septic and pump tanks (Figure 5.5.4) can also be used for on-site systems. These tanks must meet the requirements set by the North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Health. Tank manufacturers must apply for approval for each size and type of tank.

In general, the requirements for fiberglass tanks are to help make sure tanks are structurally sound, watertight, and designed to do the best job of treating the sewage. Strong and watertight tanks have fewer failures and provide protection against pollution and disease.

❑ The requirements for approval of fiberglass tanks follow the requirements in the state document, "Guidelines for State-Approved Precast Septic Tanks," and also follow the specifications in ASTM D4021-81, " Standard Specifications for Glass-Fiber-Reinforced Polyester Underground Petroleum Storage Tanks." More information on the approval of fiberglass tanks can be found in these documents and by calling the On-Site Wastewater Section.

Design requirements. The following points must be met when designing a fiberglass tank.

1. The tank walls must be at least 0.2 inches thick.
2. The tank ends must have a radius of curvature that is less than or the same as the diameter of the tank.
3. All other requirements for fiberglass tanks are the same as in the Guidelines for State-Approved Precast Septic Tanks except for Sections 3e, 4b, 4c, 4d, 4t, 4x, and 4aa.

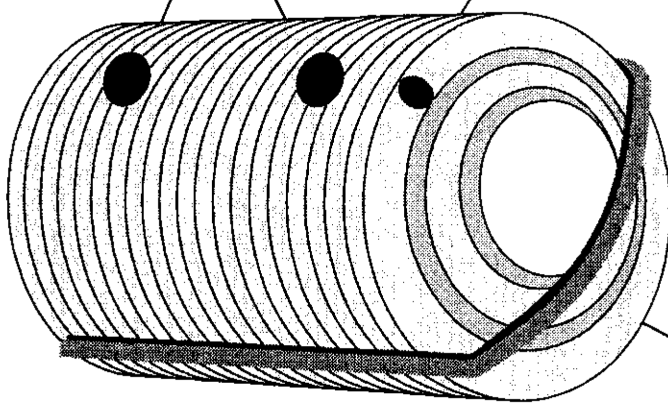


Figure 5.5.4 A fiberglass septic tank.

Materials. Materials used in fiberglass tanks must meet the requirements listed as follows:

- The resin used must be a commercial grade of unsaturated polyester resin. The resin and any sealants used must not be degraded by sewage, sewage gas, or by the soil.
- At least 30% by weight of the finished tank must be glass fiber reinforcement.
- The finished tank walls must have these strengths:

Ultimate tensile strength:	12,000 psi
Flexural strength:	19,000 psi
Flexural modulus of elasticity:	800,000 psi

Tank finish. A high-quality fiberglass tank will have a minimum of blisters, exposed fibers, pits, and voids.

❑ There cannot be any exposed glass fibers or any blister larger than 1/2 inch on the outside of the tank.

❑ The inside of the tank must be smooth and have no glass fibers exposed. Blisters or wrinkles in the surface can be present but they must be less than 1/8 inch deep. Up to 6 surface pits per square foot are allowed as long as they are smaller than 3/4 inch in diameter and less than 1/16 inch deep. There can be four voids per square foot if they are completely beneath the surface and less than 1/2 inch in diameter.

Testing. To be approved, a finished tank of each size to be manufactured must be tested by an independent testing laboratory. The testing laboratory must submit a report showing the results of the testing to the On-Site Wastewater Section.

❑ The strength of the tank walls must be tested for the following properties and follow the ASTM test procedure listed.

Ultimate tensile strength:	ASTM D-638
Flexural strength:	ASTM D-790
Flexural modulus of elasticity:	ASTM D-790

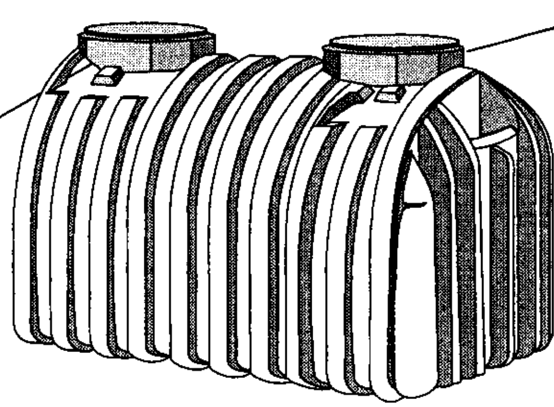
❑ The tank must also withstand a vacuum of 2.5 psi or 69.3 inches of water without leaking or breaking. This test must be done using ASTM D4201, Sections 6.11 and 8.11.

Polyethelene Tanks

Polyethylene tanks are sometimes used in on-site systems in North Carolina. Tanks made from polyethylene must meet standards of and be pre-approved by the North Carolina Department of Health, Environment and Natural Resources. The standards are based on standards set by the American society of Testing Materials, the International Association of Plumbing and Mechanical Officials, and the Canadian Standards Association (CSA). Requirements for these tanks are:

- ❑ Tanks must use Type II or III and Category 3 polyethylene as listed in ASTM Standard D1248, Specification for Polyethylene Plastics Molding and Extrusion Materials, Class B, requiring an ultraviolet stabilizer, or Class C, requiring a minimum of 1% carbon black.
- ❑ The plastic must meet ASTM Standard D 1693, Test Method of Environmental Stress-Cracking of Ethylene Plastics, with a measured stress crack resistance of 150 hours or more. Additionally, the plastic must have a tensile strength of 2400 psi or higher measured by ASTM D638, Test Method for Tensile Properties of Plastics; and must show a flexural modulus of elasticity of 85,000 psi or higher when measured by ASTM D 790, Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
- ❑ Volume, strength, and watertightness criteria per testing prescribed by CAN/CSA-B66-M90, Prefabricated Septic Tanks and Sewage Holding Tanks, Section 8, Checking and Testing.
- ❑ The side walls, top, bottom, inlet and outlet ends, and covers must be at least 1/4 inch thick, and the internal walls or partitions must be at least 3/16 inch thick.

Figure 5.5.5 A polyethylene septic tank.



Built-in-Place Concrete Tanks

Septic tanks can be built in place. Usually these tanks are made of cast-in-place concrete or concrete blocks. The following points must be met in order to get an acceptable built-in-place tank. Figure 5.5.6 shows an end cross-section (without top) of two ways to build tanks in place.

Reference
15A NCAC 18A.1954(d)

Tanks must be able to withstand a live loading of 150 pounds per square foot and support the dead weight of the tank cover and the soil cover over the tank. Tank walls must take the sideways pressure of the soil on the walls. Additionally, a tank that meets these criteria must be strong enough to take uplift from ground water.

Reference
15A NCAC 18A. 1954(d)

Steel reinforcement. The top, bottom, ends, sides, and baffle wall of a cast-in-place concrete tank must have a minimum wall thickness of 6 inches and should be designed by an engineer.

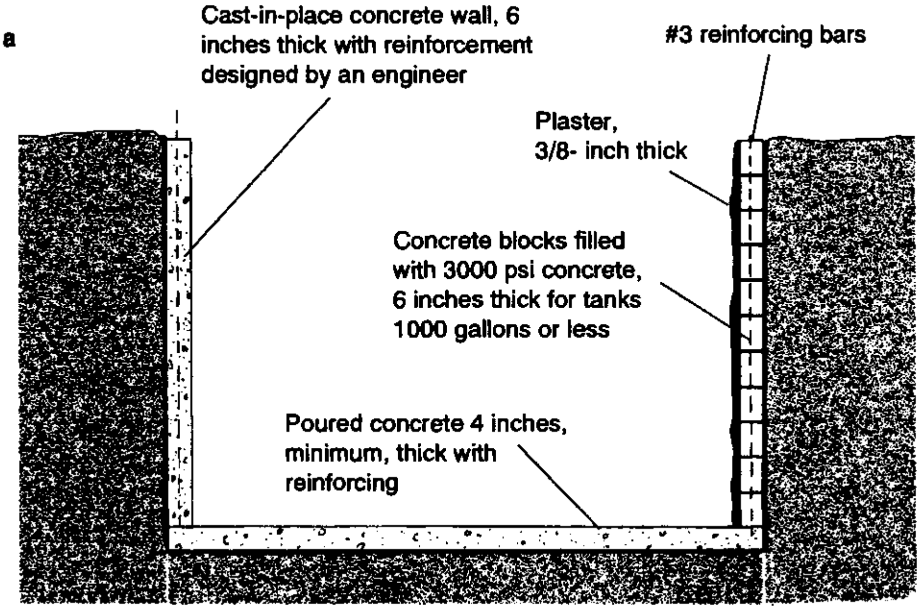


Figure 5.5.6 A cross-section of a built-in-place tank showing two different types of tank walls.

- ❑ All steel reinforcement must be covered with concrete so that it will not rust or be exposed to damage. At least 1 inch of concrete should surround all reinforcing steel.
- ❑ Reinforcing steel must be placed in all the corners and edges of the tank, where the most stress occurs.
- ❑ Reinforcing for the baffle wall should be bent at 90 degrees to make 4-inch legs that are laid parallel to the reinforcing in the side walls and tank bottom.
- ❑ More reinforcement and thicker concrete is needed when the tank is to be located under a driveway or road, or when the tank is going to be buried so that the top of the tank is more than 3 feet deep.

Tank bottoms. The bottom slabs of built-in-place tanks must be at least 4 inches thick.

Tank walls. The walls of tanks must have the strength to support the tank cover and soil over the tank and also take the sideways force of the soil on the walls.

- ❑ Cast-in-place concrete tanks must have walls at least 6 inches thick.
- ❑ Concrete-block tanks must have at least a 6-inch thick wall for sizes below 1000 gallons and 8-inch walls for sizes above 1000 gallons. The blocks should be mortared in place with masonry cement mortar at least 3/8 inch thick.
- ❑ Tanks made from concrete blocks must have at least No. 3 reinforcing bars on 20-inch centers or an equivalent arrangement of reinforcing. No matter what size reinforcing bar used, the reinforcing in either direction must not be more than 4 feet apart.
- ❑ All block walls must have the block cores filled with 3000 psi concrete.
- ❑ Concrete block tanks must be plastered on the inside because concrete blocks tend to crumble when under water for long periods. The plaster can be a mix of one part Portland cement to three parts of sand applied in a 3/8 inch layer. Other waterproofing materials can be used, if approved by the On-Site Wastewater Section.

Tank Tops, Lids, and Risers

Septic tanks must be accessible for maintenance or repairs. Tank tops and lids must be strong so the tank does not collapse. Risers provide easy access for maintenance and repairs.

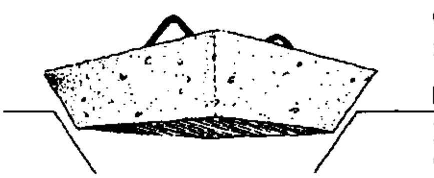
Reference

15A NCAC 18A. 1954

Tank tops and lids. A strong tank top with properly-sized manholes and well-made manhole lids makes the septic tank safe and easy to maintain.

❑ Tank tops must be able to support loads of least 150 pound per square foot and the load of the soil cover over the tank. Tops should have the same reinforcing as the tank bottoms and walls, a minimum of 6-inch by 6-inch No. 10 welded steel mesh in the center of the slab.

❑ For built-in-place tanks, one-piece tops are better than tops made of a number of narrow slabs that span the tank. The one-piece tops are stronger and provide more convenient access than the narrow slabs.



Access manhole cover.

❑ The covers should be beveled on all sides so that they can take a load of 150 pounds per square foot without damage to the cover or the tank. See the drawing on the left.

❑ Lids or covers for the manholes should have a handle of steel or other rot-resistant material equivalent in strength to a No. 3 reinforcing rod (rebar).

Risers. *Risers* are short casings or open-bottom boxes placed over septic tank manhole openings and/or distribution devices. The top of the riser box is above the ground and can be opened without digging. It is much easier to inspect the tank or perform maintenance when you don't have to dig away the soil.

All manholes and distribution devices should have risers so that homeowners and inspectors can quickly check for proper operation from the ground without having to go inside the tank. More information on risers is listed below.

❑ A riser must be at least as large as the manhole opening in the septic tank or at least large enough to allow access for maintenance and repairs, pumping, and inspection.

❑ Risers on pump tanks must be 24 inches in diameter or larger and at least 6 inches above the ground level.

❑ Risers can be made of precast concrete, fiberglass, plastic or can be built in place with bricks or block, if pre-approved.

❑ All risers must be waterproof to keep rain and ground water out of the septic tank. Built-in-place risers may be difficult to make waterproof.

❑ Precast concrete, fiberglass, and plastic risers must have a 1-inch sealing flange that sits flat on the septic tank. The riser base should be sealed with a permanent sealer such as butyl rubber, mastic, or other sealant approved for sealing joints in septic tanks to keep water from leaking into the tank.

❑ Risers and covers on risers must be strong enough to take loadings of 150 pounds per square foot.

❑ Covers on risers should have a hasp for a padlock or other lock to keep children out of the septic tank.

Installation of On-site Systems

Installing an on-site system requires a number of people working together to do the job correctly. This section presents information for installers and inspectors starting with a pre-installation conference and going through the final inspection.

Pre-installation conference. A short meeting before the digging begins can be a big help in understanding what the homeowner, the installer, and the environmental health specialist all have in mind.

Areas that have poor soil or terrain or very limited space especially need pre-installation conferences. Modified sites or systems may need to be discussed and many design options can be considered.

A good place for the conference is on the site where the system is proposed to be installed. At the site, the soil, slope, vegetation, water and wetlands can be seen and discussed. Usable areas can be marked to see where the system components will be placed.

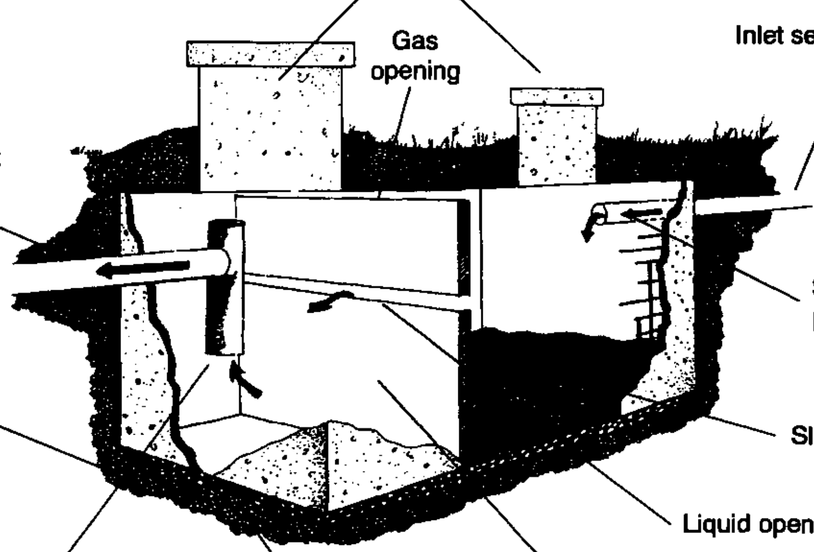
Installation equipment. The following list provides a start for those people who are installing on-site systems. Add to the list depending on the terrain, soil, and types of systems installed in the area.

- ☐ For clearing vegetation
  - Chainsaw
  - Brush axe
- ☐ For system layout
  - Engineer's level or laser level and a target rod
  - Measuring tape, 200 feet, open reel
  - Surveying flags, marking tape, and marking paint
  - Hammer
- ☐ For excavation for the tank and absorption trenches
  - Backhoe
  - Trencher
  - Small front-end loader
  - Shovels
  - Picks or mattocks
- ☐ For assembly of pipes
  - Pipe fittings, such as couplings, tees, elbows, unions
  - Pipe joint cleaner and solvent
  - Sealer, mastic, grout
  - Saws
- ☐ For testing tank and pipes
  - Source of water
  - Garden hose
  - Pipe plugs
- ☐ For pump tanks
  - Pumps
  - Float switches
  - Pump controls
  - Electrical wiring supplies and equipment

Installation of Tanks

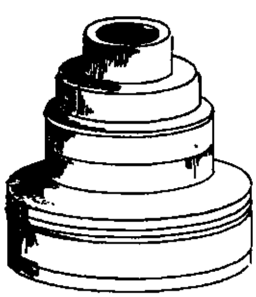
Tank installation must be done carefully to avoid damage to the tank and poor operation of the system. Points to consider when installing tanks follow. Figure 5.5.7 shows an operating septic tank.

Figure 5.5.7. Cut-away view of installed and functioning septic tank.



❑ Use the benchmark to determine the tank location and elevation. Using the benchmark ensures that the system is located where the designer intended and that the effluent will flow freely to the treatment and disposal field.

❑ The hole for the tank should be large enough to allow the installers to work and should be flat and level with no rocks or other objects that could crack or puncture the tank. Occasionally fine gravel or coarse sand will need to be placed on the bottom of the hole to provide a flat and cushioned bearing surface for the tank. The tank must be level so that there is a proper drop between the inlet and outlet, and so the scum and solids in the tank will not flow out the outlet and clog the treatment and disposal field.



Flexible boot for inlet or outlet pipes that can make a watertight seal for several sizes of pipe.

❑ *All connections to the tank should be watertight and strong.* Inlet and outlet pipes must be installed with the proper-sized boot, as shown on the left, or sealed with approved sealants. Leaks around the inlet and outlet pipes can allow large amounts of ground water to enter the tank and then flood the treatment and disposal field. This form of leakage is a big problem with many on-site systems.

❑ Backfilled soil can settle around the tank or the tank may settle and break the pipes going into and out of the tank. The soil under the pipes should be compacted as much as possible and other supports used to keep the pipes from being broken.

❑ Risers where needed should be centered over the manholes and sealed to the tank top. Only approved sealers should be used to keep ground water out of the tank.

❑ Carefully backfill the hole around and over the tank. Large stones and bricks should not be placed next to the tank.

❑ Backfilling should not occur until the environmental health specialist has inspected the tank.

Inspection of tanks at delivery to home site. Septic tanks are manufactured to strict specifications; however, the tank can develop cracks or other defects while sitting in the storage yard or it can be damaged during transport or installation. A careful field inspection of the tank should cover the following items.

Check the placement of the tank. Placing the septic tank properly is simple but must not be overlooked.

❑ *No portion of the tank should be covered with soil until it has been inspected.* Look over as much of the tank as can be seen. Check inside and out for cracks, holes, honeycombs, exposed reinforcing wire and overall quality of the concrete. Use a rebound hammer to check concrete strength and a metal detector to check for reinforcing.

❑ Check the location of the tank. The tank should be located as shown on the plan. If the location has changed, find out why. All alternatives from the plan must be approved and shown on an "as-installed plan."

❑ Determine the elevation of the tank from the benchmark and compare to the plan. Also, check that the tank is level. Be sure that the *inverts*, or lowest point at the bottom of the openings for the inlet and outlet, are at the proper elevation. The outlet must be 2 inches lower than the inlet to keep the inlet from being blocked.

❑ The sewer from the house should have enough slope, 1/8 of an inch per foot or more, to let the sewage flow into the tank. It is the responsibility of the plumber to ensure that the sewer has enough slope, but many problems can be headed off by communicating with the plumber, plumbing inspector, building contractor, and septic tank installer.

❑ Make sure the tank has the inlet end toward the house and has not been placed backwards.

Check the tank. The following checks help ensure that the tank will work properly.

❑ Be sure that the tank has the proper dimensions as far as total volume, depth of sanitary tee into the liquid, and thickness of the walls and blockouts.

❑ Check that the size, type of tank, and manufacturer's identification number are stamped into the tank to the right of the outlet. Also, be sure that the date of manufacture is marked on the tank beside the stamp or on the tank top above the stamp.

Check the tank components. Although a septic tank does not contain many parts, they must be designed and installed correctly in order for the on-site system to work properly.

❑ Inspect the sanitary tee at the outlet, the baffle wall, and the connections at the inlet and outlet. All connections should be watertight and sound.

❑ Examine any risers, the manholes, and covers. The risers should be placed directly over the manholes and properly sealed to the top of the tank. The risers should extend at least 6 inches above the finished grade or final soil level. Manhole covers should fit tightly and be strong enough to support a loading of 150 pounds per square foot.

Installation of Conveyance Pipes

Reference

15A NCAC.18A.1955(e)

Conveyance pipes carry the effluent from the septic tank to the distribution device and to the treatment and disposal field. These pipes must be strong and leakproof. Figure 5.5.8 shows conveyance pipes from the septic tank and from the distribution box.

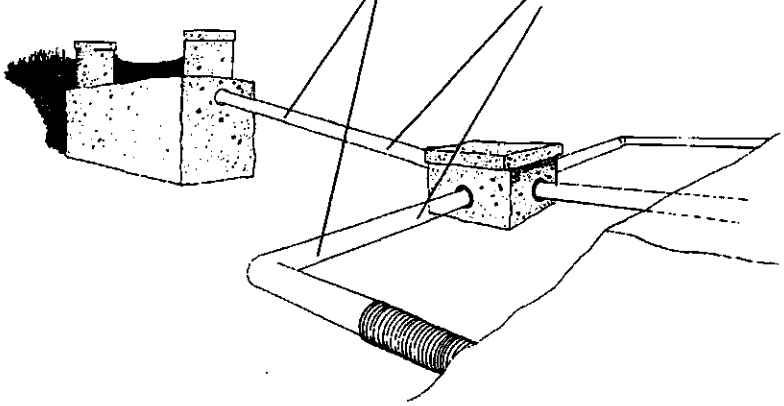


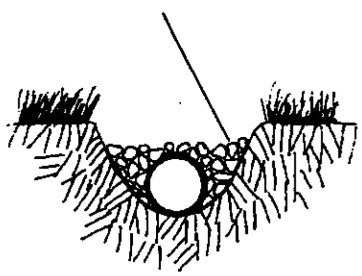
Figure 5.5.8 Conveyance pipes from septic tank to distribution box and from distribution box to trenches.

❑ Approved materials for conveyance pipes include Schedule 40 polyvinyl chloride (PVC), Schedule 40 polyethylene (PE), and Schedule 40 acrilonitrile-butadiene-styrene (ABS).

❑ Conveyance pipes must be solid pipe with no holes. Perforated pipe can be used only in the treatment and disposal field.

❑ Proper solvents and fittings for the type of pipe must be used. Most solvents will not work if used on the wrong type of pipe.

❑ The pipe must be 3 inches in diameter or larger. Four-inch pipe works best for houses and most small on-site systems. If the conveyance pipe must be run for long distances, cleanouts that come up to the ground surface should be installed every 100 feet.



Cutaway end view of properly bedded PE tubing used for conveyance pipe.

❑ While not as preferable as schedule 40 smooth pipe, corrugated polyethylene (PE) solid pipe may be used. The pipe should be placed in trenches a foot wide or wider with flat, smooth bottoms. The pipe must be covered with crushed rock so 3 inches of stone are on each side and 2 inches are on top of the pipe. This crushed rock provides support for the pipe to reduce the chances of it being crushed. The crushed rock should then be covered with at least 6 inches of compacted soil. See the drawing at left for proper bedding of PE tubing.

❑ All conveyance pipes must be bedded with *compacted soil.*

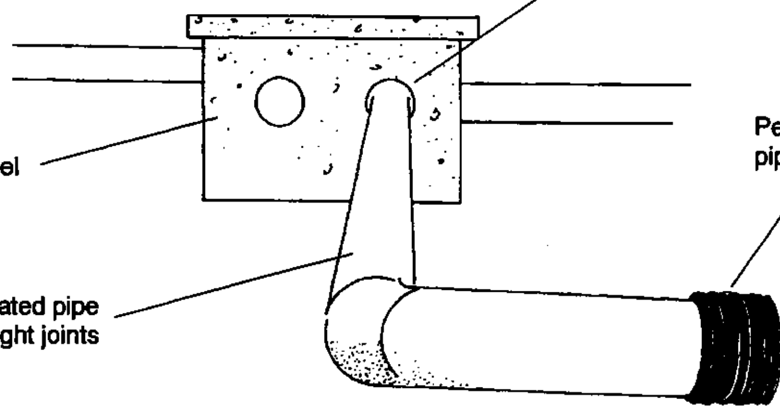
❑ Compacted or undisturbed earth dams must be installed where corrugated polyethylene (PE) pipe is used for conveyance pipe. The dams should be constructed of 2 feet of undisturbed or compacted earth around the pipe at each end of the trench. These dams keep effluent from following the gravel to the lowest trench if the pipe leaks, which helps ensure equal distribution of effluent to the trenches.

Installation of conveyance pipes.

Conveyance pipes must not leak and must be installed to prevent crushing or breaks (Figure 5.5.9). The following ideas can help in installing conveyance pipes.

❑ All joints in conveyance pipes must be watertight. Be sure to follow the manufacturer's directions when making the joints.

Figure 5.5.9. Conveyance pipe from distribution box to trench.



❑ The joint between the conveyance pipe and the trench pipe should be made inside the trench where the crushed stone is placed.

❑ Bedding the pipe is important in preventing breaks and leaks. Trench bottoms should be undisturbed earth and the backfill should not have large rocks or other objects that can puncture the pipe.

❑ Have as few bends and angles in the pipes as possible to avoid blockages. Straight pipes have the least chance of clogging.

❑ Conveyance pipes must be on the correct slope to make sure that the effluent flows to the treatment and disposal field and does not back up in the pipes. The slope of the trench should be laid out with a surveyor's or engineer's level at 1/8 inch fall per linear foot.

Reference
15A NCAC 18A.1955 (o)
ASTM Standard D 2774 —Recommended Practice for Underground Installation of Thermoplastic Pressure Piping —use for force mains and pressure sewers
Reference
15A NCAC 18A.1956 (3)(a)
ASTM Standard F 667 —Specifications for Large Diameter Corrugated Polyethylene Tubing and Fittings —use for large diameter pipe installations except as modified by rule 15A NCAC 18A.1956(3)(a)(i) which requires a different hole size and spacing.

Inspecting conveyance pipes.

Careful inspection of the conveyance pipes can catch mistakes that reduce the reliability of an on-site system (see Figures 5.4.8, 5.4.9, and 5.4.10).

❑ Pipe size and material are important. Conveyance pipes must be Solid Schedule 40, 3 inches or larger and made of PVC, PE or ABS.

❑ Proper connections and fittings, and the proper solvent for the type of pipe, must be used for watertight joints.

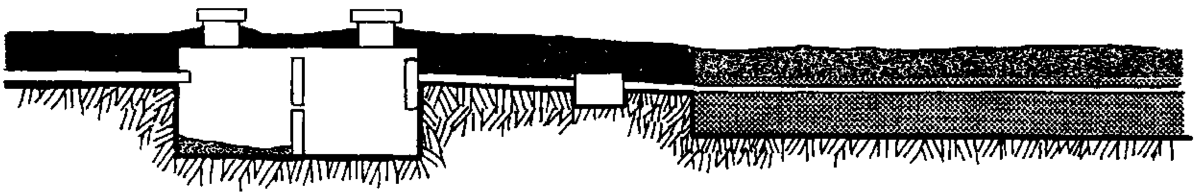
❑ Trenches should have flat bottoms and the backfill material should not have rocks or other hard objects against the pipe. Corrugated polyethylene (PE) pipe must be surrounded by crushed rock on the sides and top to prevent collapse of the pipe.

❑ Conveyance pipes should be installed with a constant slope to ensure that the effluent flows to the treatment and disposal field. The slope should be 1/8 inch per foot.

❑ There should be a 2-foot separation of undisturbed soil between the distribution box or flow splitter and the inlet to the treatment and disposal field trenches. This separation helps to keep the effluent from leaking back from the treatment and disposal field.

❑ Setback requirements should be checked to be sure that the pipes and the entire system are in compliance.

Figure 5.5.10 Side view of an on-site system using a distribution box and conventional gravity-fed trenches.



❑ Systems that pump sewage to a treatment and disposal field higher than the septic tank may require an air release valve to prevent air locks in the pipe. Pumped systems must have watertight joints to keep effluent from leaking into areas not usable for soil absorption.

Installation of Treatment and Disposal Fields

Reference

15A NCAC 18A.1955(f - j, m)

The treatment and disposal field of an on-site system is where the majority of the wastewater is treated. Underground pipes, or conveyance pipes, carry the liquid waste from the septic tank and distribution box or flow splitter to the trenches. As the liquid effluent flows from the treatment and disposal trench into the soil, the water is "treated" by bacteria and other soil organisms in a thin zone of soil around the trench. The water then flows into the soil.

Preparing to install treatment and disposal fields.

This section gives details of the materials needed and the preparations needed to install a treatment and disposal field.

Materials needed. Following is a list of materials needed to construct a treatment and disposal field.

Reference

15A NCAC 18A.1955(h)

❑ Stone: Crushed rock must meet ASTM Standard D-448 (Standard Size of Aggregates). Proper stone sizes are # 3, 4, 5, 57, or 6. (See Table 5.5.2.)

- Store the crushed stone on a piece of plywood or plastic sheet to avoid mixing soil in with the stone.
- Avoid driving equipment over the crushed stone. The weight of the vehicle breaks the stone and grinds it down, making more fines and dust.

Table 5.5.2 Crushed Stone Sizes and Limitations for On-Site Systems

Standard Size Number	Size in Inches Maximum	Average	Minimum	Limitations
# 3	21/2	1 1/2	1/2	Large pieces may dent or break pipe when backfilling trench.
# 4	2	1	3/4	
# 5	11/2	3/4	1/2	Watch amount of fines present in these sizes— fines may plug openings in crushed stone or plug soil.
# 57	11/2	1/2	1/4	
# 6	1	1/2	3/8	

Reference
15A NCAC 18A.1955(f)

ASTM Standard F 405 —Specifications for Corrugated Polyethylene (PE) Tubing and Fittings

ASTM Standard F 481—Installation of Thermoplastic Pipe and Corrugated Tubing in Septic Tank Leach Fields —use with ASTM F 405 except as modified by 15A NCAC 18A.1955(f) which requires a hole pattern that is different than in ASTM F 405.

❑ Pipe: 4 to 6 inch pipes are the best. These pipes must be ASTM Standard F-405, Standard Specification for Corrugated Polyethylene (PE) Tubing and Fittings. Other types of pipe can be used if the hole spacings and size meet specifications and if the pipe has the same or greater stiffness as the corrugated PE tubing.

- Trench pipes should have three holes, between 1/2 inch and 3/4 inch in size, around the pipe or on the bottom of the pipe, spaced every 4 inches along the length of the pipe. If the pipe has a stripe opposite the holes, the pipe is installed with the stripe up and the holes down (Figure 5.5.11).

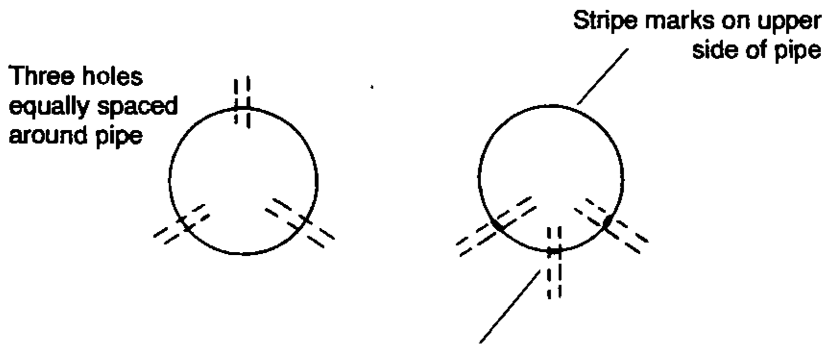
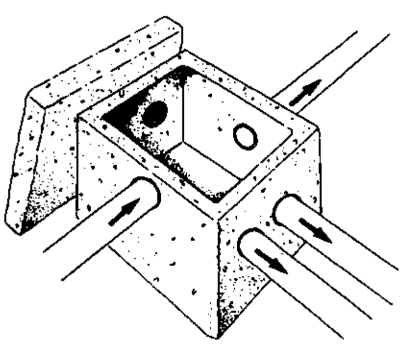


Figure 5.5.11 Hole patterns for perforated pipe

Reference
15A NCAC 18A.1955(j)

❑ Fittings: Only the proper fittings for the type of pipe being used should be installed as necessary to connect pipes.

❑ Distribution devices (if necessary): Select the proper type of distribution device, either a distribution box or a flow splitter. These devices must be well constructed, watertight, and corrosion-proof.



Distribution box.

Locate the treatment and disposal field.

The field must be located within the approved site and staked before installation can begin, as shown on the permit.

❑ Check the layout of the field to be sure that the field meets all setbacks required. (See Table 4.5.7, Figure 4.5.7, and Figure 4.5.9 for required setbacks.)

❑ For long contour runs, place several flags along each contour where the trench will run. It is not enough to mark the two endpoints because contour lines are usually not straight lines. If not enough flags are placed to follow the contour, it will be difficult to keep the trench level.

❑ Identify the locations of the distribution box, drop box, or flow splitter and all treatment and disposal trenches.

Clearing vegetation from treatment and disposal field.

The site vegetation must be cleared without disturbing the soil, in order to keep the soil in its natural condition for maximizing the absorptive capacity.

❑ Remove small trees by hand. Do not dig out the stumps; let them rot naturally.

❑ If large trees need to be removed, obtain prior approval from the health department before using heavy equipment. Try to use heavy equipment on the field site as little as possible so that the soil will not become compacted and lose its ability to absorb.

- Clearing with heavy equipment should be done only when the soil is dry to avoid compaction or destruction of soil structure.

- If the site is heavily disturbed, the benchmark must be reestablished, flags must be rechecked to ensure that they are still on-grade, and setbacks must be double-checked. The site should be vegetated to reduce soil erosion.

- It may be necessary to reevaluate the site if soil has been removed.

- If the permit does not specify a method(s) for clearing the vegetation, then the selected method must be approved by the local health department.

Installing Treatment and Disposal Fields

The correct installation of the treatment and disposal field is critical for an on-site system to function properly. Poor installation can cause sewage to back up into the house, pond on the ground surface, or pollute surface or ground water. These conditions are costly and can cause serious public health threats.

Treatment and disposal trenches.

Reference
15A NCAC 18A.1955(f - j, m)

Trenches are the heart of an on-site system. Their purpose is to distribute the effluent so that it can be absorbed by the soil. If trenches are constructed incorrectly, then the effluent will not be distributed properly and the system will fail. The proper way to construct the trenches and install the pipes is discussed in the following.

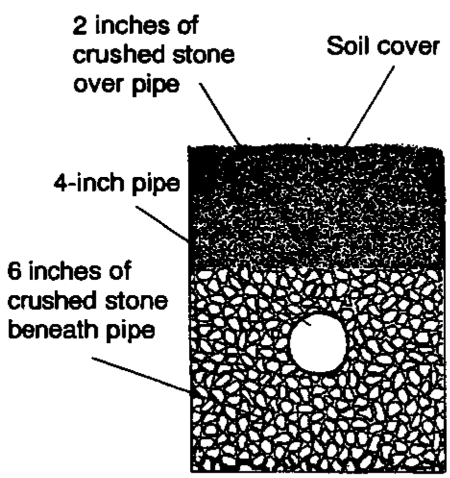
Trench specifications. The following specifications must be met when installing treatment and disposal trenches.

- Determine the elevation of the trench bottom for each trench using the permit specifications.

- Excavate each trench to the proper width and depth. Trenches cannot be wider than 3 feet or deeper than 3 feet without prior approval of the local health department.

- Check the elevation of the trench bottom by shooting elevations at points along the trench. The trench should be level. The maximum slope allowable is no more than 1/4 inch per 10 feet.

- The bottoms of the trenches should be level across the width of the trench and along its length. A level trench spreads the effluent evenly so that the whole trench can absorb the effluent.



End view of a conventional treatment and disposal trench.

Placing the pipe. One way to place the stone and pipe in the trench is to lay a 6-inch layer of crushed rock on the bottom of the trench. The stone should be spread evenly in the trench. Grade stakes or a grade board can assist in getting a consistent level of gravel.

- Next, place the pipe in the center of the trench, holes down, striped-side up.

- Fill the trench with crushed rock so 2 inches of stone covers the pipe. This will give a total of 12 inches of stone in the trench: 6 inches under the pipe, 4 inches beside the pipe, and 2 inches over the pipe. See the drawing at left for a diagram of the required depths of crushed stone.

❑ Another method is to make a small stand of wood or wire to hold the pipe 6 inches off the trench bottom. Then backfill the trench with crushed stone so that the stone is 12 inches deep.

❑ Other methods can be used to center the pipe and backfill the trench with crushed stone, as long as the pipe is centered with the holes down and it does not rise up when the stone is placed in the trench.

❑ When a Group I or II soil is used to cover the crushed stone, a geotextile fabric should be placed on top of the gravel. The fabric keeps the fine soil particles from dropping into the openings between the stones in the trench and clogging the gravel or the soil.

❑ Connections to the conveyance pipe must be made inside the part of the trench with the stone.

Installing Distribution Devices in Treatment and Disposal Fields

Reference

15A NCAC 18A.1955(j)

Treatment and disposal fields have special devices to control the flow of effluent to the trenches. This section contains information on how to install various special devices.

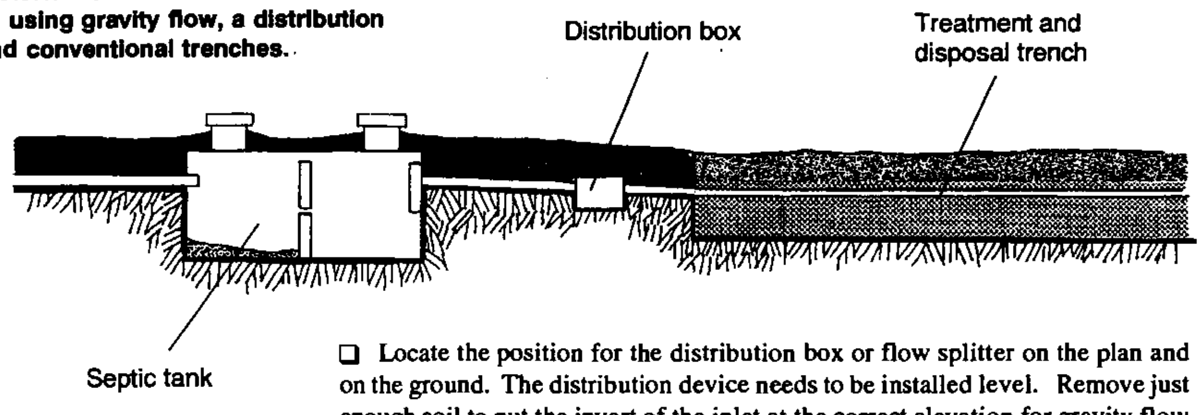
Distribution boxes, flow splitters, and flow diversion devices.

Distribution devices are used to distribute the effluent evenly among all trenches. Without even distribution of the effluent, some treatment and disposal trenches can be overloaded while other trenches will not be used.

❑ *All distribution devices must be installed level, front to back and side to side.*

❑ The distribution box, flow splitter, or other device must be separated from the septic tank and from the trenches by at least 2 feet of undisturbed soil. This dam of undisturbed soil helps keep the effluent from flowing back along the conveyance pipes. Figure 5.5.12 shows the separation between the septic tank, distribution box, and field.

Figure 5.5.12. Side view of an on-site system using gravity flow, a distribution box, and conventional trenches.



❑ Locate the position for the distribution box or flow splitter on the plan and on the ground. The distribution device needs to be installed level. Remove just enough soil to put the invert of the inlet at the correct elevation for gravity flow from the septic tank.

❑ When digging the hole, remember that the distribution box or flow splitter should rest on undisturbed soil or on a concrete pad so that it won't shift or settle. If the bottom of the hole must be filled in to bring the distribution device to the right level, it is best to put in a concrete pad. The concrete pad will keep the distribution box from shifting as the soil settles.

❑ Determine the elevation of the *inlet invert* and the *outlet invert* of the distribution box or flow splitter using the benchmark. The invert of a pipe or opening is the lowest point at the bottom of the pipe or opening. The invert of the inlet to the distribution box must be lower than the invert of the septic tank outlet for the sewage to flow by gravity. The conveyance pipe between the septic tank and the distribution device must have a fall of 1/8 inch per foot or more.

❑ Place the distribution box or flow splitter in the hole and connect it to the conveyance pipe from the septic tank. Be sure that the device is level and resting on undisturbed soil or a concrete pad. Seal all pipe connections. Use hydraulic cement, asphalt mastic, or any other sealers approved by the local health department.

❑ Test the distribution box or flow splitter and the connections to he sure that they do not leak. Run water into the septic tank outlet and watch for leaks and even flows from all outlets.

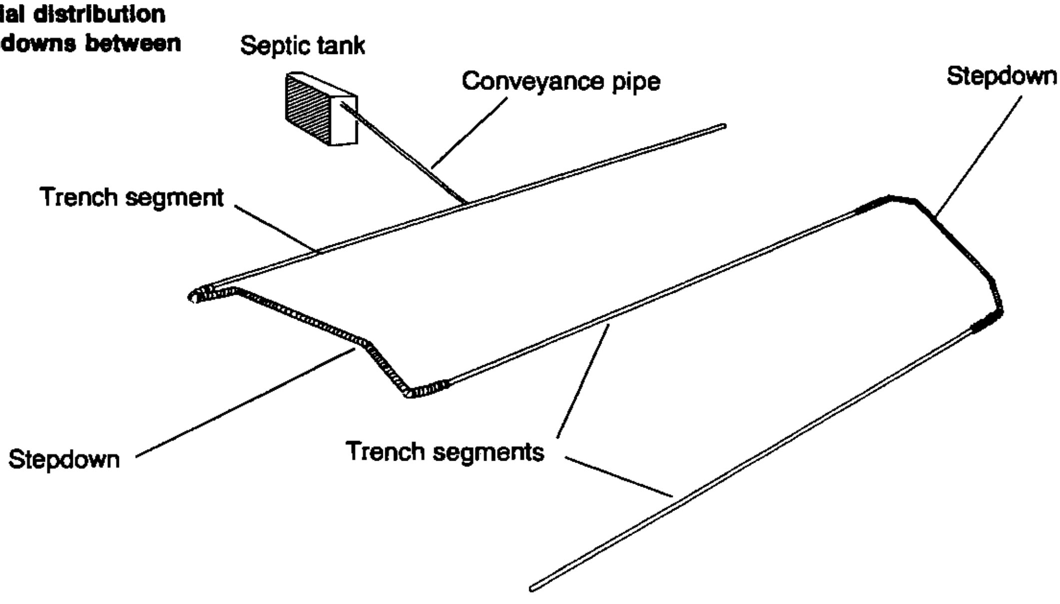
❑ If the effluent is not distributed evenly to all the outlets, then use *adjustable outlet devices* or *flow compensators* to distribute the effluent evenly to each treatment and disposal trench. Adjustable outlet devices and flow compensators are devices that can be installed in the outlet openings of distribution boxes so that the invert level of the outlet can be easily and quickly changed. Adjusting the level of the outlet inverts is a quick way to get even flows to all the trenches.

Installing a Serial Distribution Treatment and Disposal Field

Serial distribution may be used on sloping sites where slopes exceed 2%. The slope of the site allows effluent to flow to each trench segment by gravity. A serial distribution system is shown in Figure 5.5.13.

A serial distribution field is actually one long trench that winds back and forth across the slope. The horizontal parts of the trench are *trench segments*. The trench segments run across the slope along chosen contours so that each segment is level along its length and across its width. Trench segments are just like conventional treatment and disposal trenches — a pipe is centered in the trench and the trench is filled with gravel so that the septic tank effluent can flow out into the soil.

Figure 5.5.13. Serial distribution system using stepdowns between trench segments.

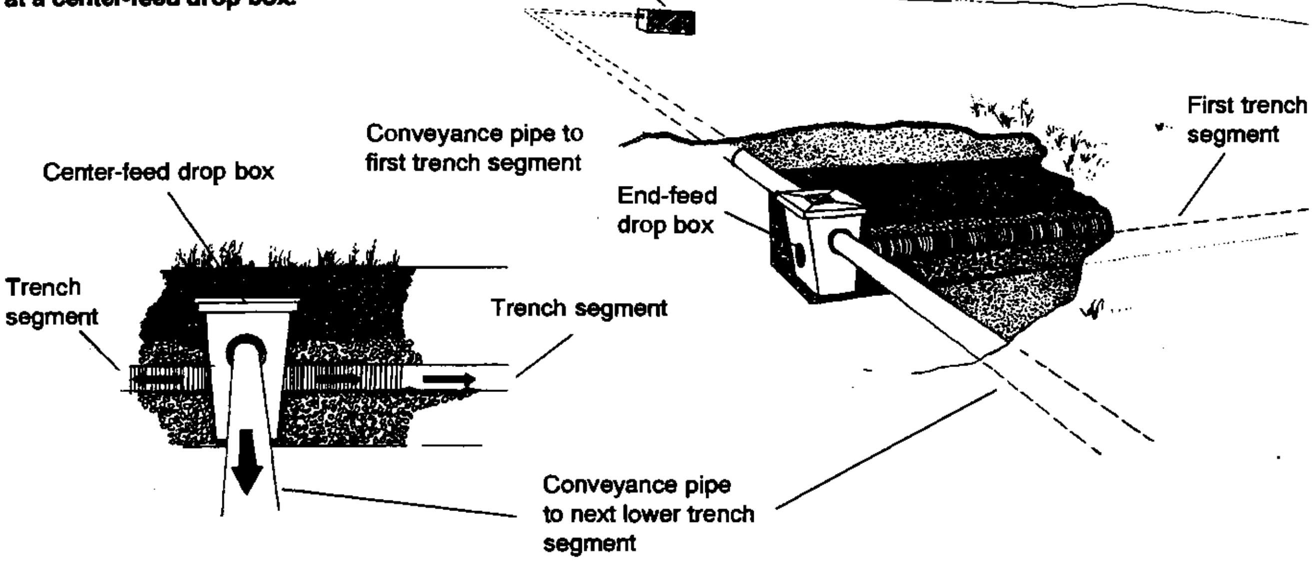


The total amount of required trench area is obtained by installing a number of trench segments at different levels on the slope. The segments at each level are connected with a *stepdown* or *drop box* so that effluent can flow to the segment at a lower contour. Stepdowns or drop boxes are only used to connect a trench segment to the segment at the next lower elevation. A drop box or stepdown is needed for each trench segment in the total treatment and disposal field.

Drop boxes.

Drop boxes are purchased from a manufacturer and are made of concrete or plastic. They can be located at the beginning or end of each trench segment in an end-feed system or they can be in the center of each trench segment in a center-feed system. Drop boxes allow each trench segment to fill completely with effluent before letting it flow into the next trench. Figure 5.5.14 gives close-up views of center-feed and end-feed drop boxes.

Figure 5.5.14. Two views of drop boxes. At right is a view of a drop box on an end-feed trench segment. At the left is a view looking upslope at a center-feed drop box.



❑ Drop boxes should be installed on level, undisturbed soil or a level concrete pad, which keeps the drop box from shifting as the soil cover settles after installation. If the bottom of the hole must be filled in to bring the distribution box up to the right level, *put in a concrete pad.*

❑ The drop box inlet should be at least 1 inch higher than the outlet and the outlet bottom must be 2 inches above the top of the pipe in the trench segment.

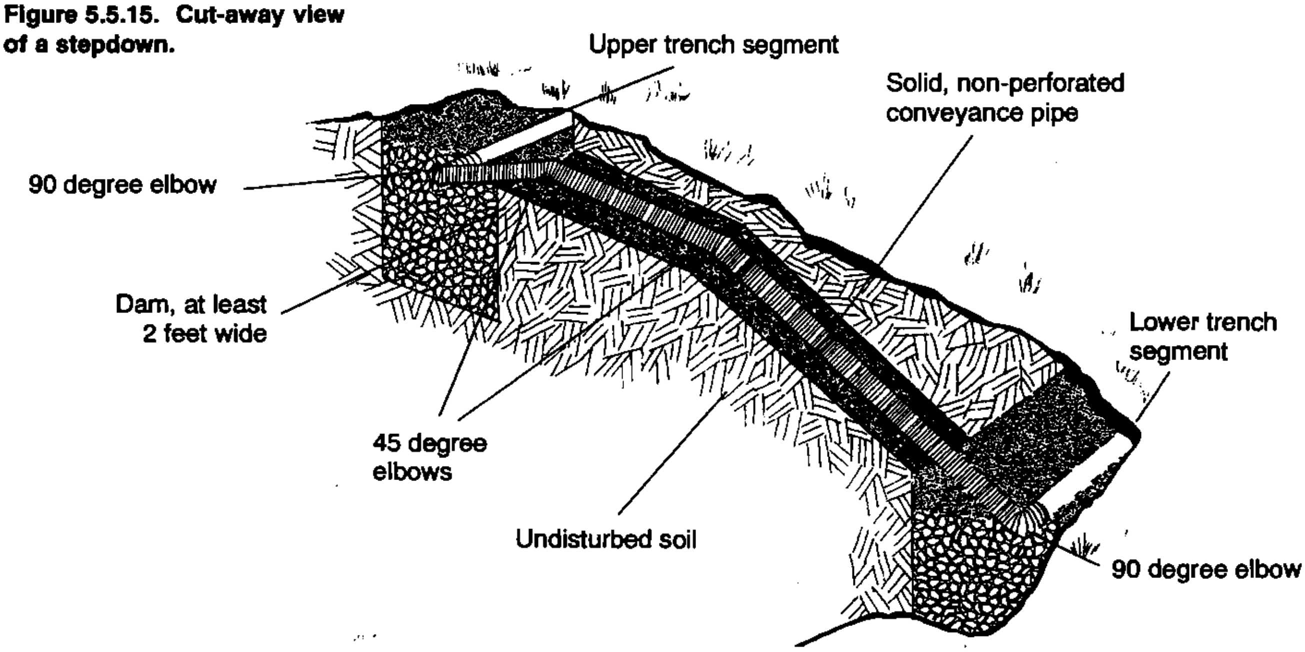
❑ Solid pipe must be used to connect the drop boxes to the trench segments. The solid pipe connection must be installed on undisturbed, level soil to keep it from shifting or breaking after it is covered with soil.

Stepdowns.

Reference
15A NCAC 18A.1955(l)

A *stepdown* is a dam of undisturbed soil located at the downstream end of each trench segment in some serial distribution systems. A solid pipe carries effluent over the dam and down to the next lower trench segment. Stepdowns are used to fill each trench segment completely before the effluent can flow into the next trench segment. A cut-away view of a stepdown is shown in Figure 5.5.15.

Figure 5.5.15. Cut-away view of a stepdown.



❑ Stepdowns must have a dam at least 2 feet long installed in undisturbed soil.

❑ The top of the dam for the stepdown must be at the same height as the top of the gravel in the trench. This configuration makes the effluent fill the trench segment up to the top of the gravel before the liquid flows over the dam and down to the next lower trench segment.

❑ Solid pipe must be installed over the stepdown to connect the two trench segments.

❑ The soil cover over the stepdown should be compacted carefully so that the pipe has proper bedding and is not crushed. A crushed stepdown could allow effluent to leak out of the trench.

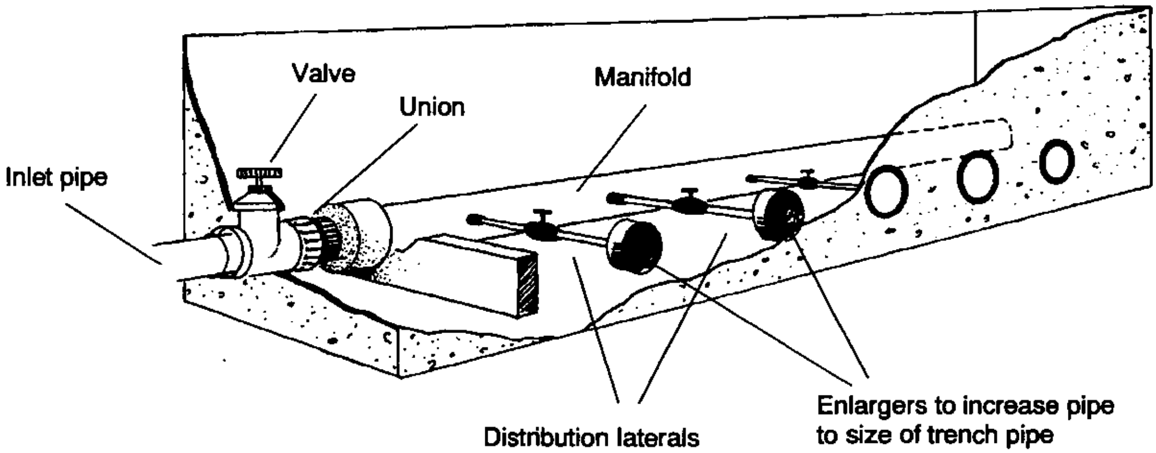
❑ On sloping lots with shallow placement trenches, stepdowns must be located carefully so that there is enough soil cover over the pipe to keep it from being crushed.

Installing Pressure Manifolds in Pumped Distribution Treatment and Disposal Fields

In a pumped system, the sewage pump lifts the sewage to a pressure manifold that distributes the effluent evenly to the treatment and disposal trenches. The pressure manifold must be installed so that adjustments can be made after the system is operating to ensure proper distribution of the effluent. See Figure 5.5.16 for a view of a pressure manifold.

❑ The pressure manifold can be made of PVC tees and short nipples or can be a commercially made manifold. Each outlet feeds an individual trench. All outlets from the manifold should have a valve so that the flow can be adjusted or turned off to each trench.

Figure 5.5.16. Cut-away view of pressure manifold in box.



❑ Pressure manifolds should be located in a box or riser that has easy access from the ground surface. Easy access is necessary because the valves on pressure manifolds provide a quick way to turn off trenches that are failing or that need repairs and because the manifold valve may require periodic adjusting. In some parts of the state, the box must be insulated to prevent freezing.

❑ It is easy to "rest" or turn off part of the treatment and disposal field with a pressure manifold. Simply turn off one or two outlets to let those trenches rest for six months. After six months, turn on the outlets that were off and turn off one or two other outlets to let the other trenches recover.

Installing Large-diameter-pipe (LDP) Treatment and Disposal Fields

Reference

15A NCAC 18A.1956(3)

Large-diameter-pipe treatment and disposal systems are installed in areas where backhoes or other power equipment cannot be used to dig trenches, such as on steep slopes or where the soil is too shallow for conventional trenches. These systems use large-diameter pipes wrapped with filter cloth and are installed directly into narrow, hand-dug trenches with no crushed rock. In North Carolina, these systems are installed mainly in the mountains.

❑ Dig the trenches by hand. The trench bottom must be contoured to the shape of the pipe and level along its length. The trench must be a minimum of 12 inches wide.

❑ The pipes come from the factory wrapped in filter cloth and covered with plastic to protect the filter cloth from sunlight. Do not remove the plastic cover until placing the pipes in the trenches. The plastic must be removed before the pipes are covered with soil. Once the plastic cover is removed, cover the pipes with soil as soon as possible to keep the filter cloth from being damaged by the sun. Be careful to not tear the filter cloth wrapping.

❑ Install the large diameter pipe with the striped side up, to ensure that the holes in the pipe face the ground.

❑ Remove all stones and rocks from the soil that is used to cover the pipes. Stones and rocks can tear the filter cloth. Group IV soils cannot be used for backfill.

Installing Prefabricated, Permeable Block Panel System (PPBPS) Treatment and Disposal Fields

The prefabricated permeable block panel system, or PPBPS, is a proprietary on-site system that is made of specially shaped panels and blocks. Installation of a PPBPS is allowed under state rules at some sites where the soil is suitable for a on-site system but the available space is limited.

- ❑ PPBPS trenches must be dug a minimum of 8 feet from center to center.
- ❑ Install the panels according to the manufacturer's directions.
- ❑ If the PPBPS is installed in a Class IV soil, rake the soil on the sides of the trench. Raking the soil opens soil pores that were sealed by the backhoe shovel as it slid over the soil.

Installing Diversions, Subsurface Drains, and Ground-water-lowering Systems to Improve Sites for Treatment and Disposal Fields

Several methods are used to improve a site by increasing the amount of land that is usable as a treatment and disposal field. This section contains information on surface water diversions, subsurface drains, and ground-water-lowering systems.

Surface water diversions.

To ensure the proper functioning of treatment and disposal areas, it is sometimes necessary to divert surface water. Surface water diversions keep surface water from flowing onto the treatment and disposal field. Usually the Improvement Permit will specify when these must be installed.

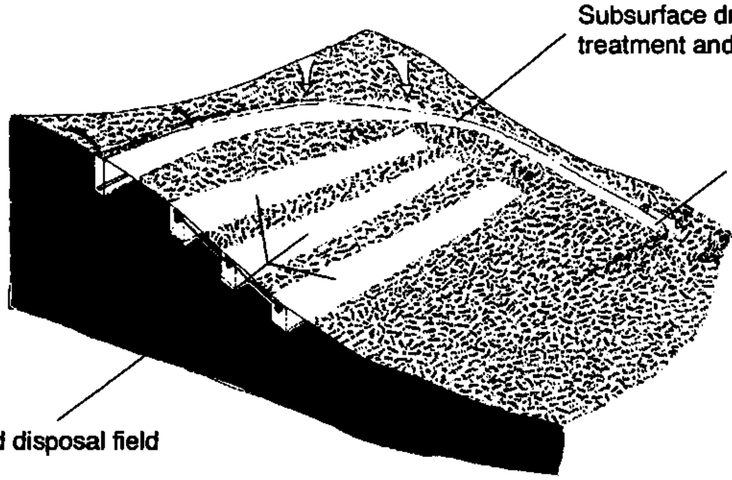
- ❑ Surface water diversions should be installed above the field to keep surface water off the field.
- ❑ A diversion could consist of a dike, a channel, or combination of a dike and a channel. The type of diversion to use depends on the site. One advantage of the dike and channel combination is that the soil from the channel can be used to make the dike.
- ❑ Dikes should be at least 6 inches higher than the top of the water. The top of the dike should be 2 feet wide, the sides should be sloped at 3:1 or less, and the soil must be compacted to prevent erosion. Plant or seed the dike to establish a healthy vegetative cover.
- ❑ Channels should be made large enough to carry the expected volume of water without eroding the soil or flowing over the top of the channel. Channel sides should have a slope of 3:1 or less so that the grass in the channel can be mowed.

Subsurface drains.

Subsurface drains are used on sloping sites to divert ground water that flows into the treatment and disposal field (Figure 5.5.17). Too much ground water can interfere with the field and cause it to fail. The Improvement Permit should specify if a subsurface drain is required.

- ❑ Subsurface drains are also called French drains, foundation drains, interceptor drains, or blind drains.
- ❑ Locate the subsurface drain upstream of the treatment and disposal field. On most sloping sites the subsurface drain should be installed higher up the slope than the field. Depending on the terrain and soil, more than one subsurface drain may be needed.

Figure 5.5.17. Cut-away view of subsurface drain.



❑ Subsurface drains should be installed so that they lower the water table to at least 12 inches below the bottom of the treatment and disposal trenches. If the subsurface drain must be installed deeper than 4 feet, a stronger pipe may be required to withstand the increased weight of more crushed stone on it.

❑ For high ground water flows, a larger pipe may be necessary. The pipe must be installed so that it slopes to an outlet and the outlet must be at a lower elevation so that the water will drain.

❑ Bed the pipe in crushed rock or gravel so that the pipe has at least 3 inches of rock on all sides. The rock should be the same sizes as used in the trenches, DOT sizes # 3, 4, 5, 57, or 6. The trench should be filled with rock to within 6 inches of the ground level so that the ground water is intercepted.

❑ Place filter cloth over the top of the rock before the soil is placed in the trench. The filter cloth keeps the soil from clogging the rock.

❑ Another way to install a subsurface drain is to line the bottom and sides of the trench with filter cloth and then place the rock and pipe inside the filter cloth lining. The filter cloth lining helps keep the soil from plugging the rock.

Ground-water-lowering systems.

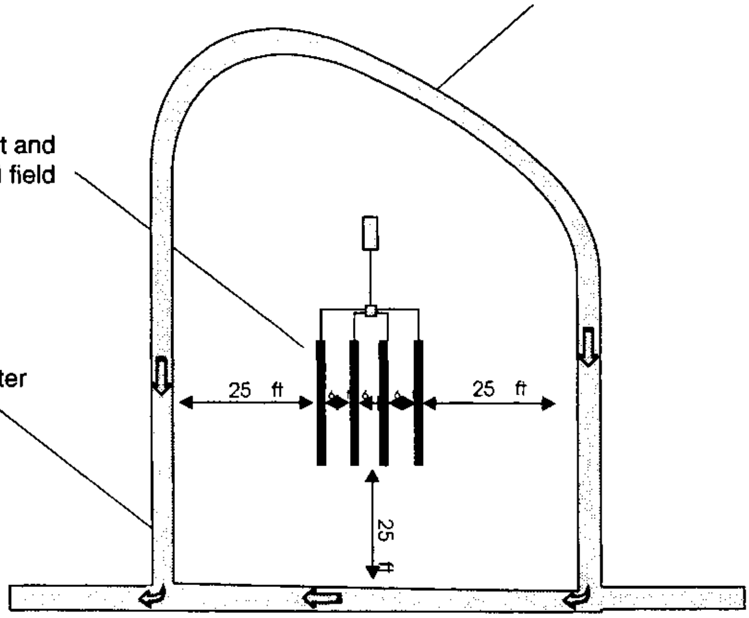
Ground-water-lowering systems enable treatment and disposal areas to be installed in soils that would normally be unsuitable. The most common technique is to install open channels or ditches to drain the ground water from the upper 3 feet of the ground (Figure 5.5.18).

❑ The open channels allow the ground water to drain from the soil into the channel and flow to an *outlet*. In an outlet, the ground water flows away from the site and into a large drainage ditch or stream. Usually outlets have some simple device to control the height of the water in the open channels of the ground-water-lowering system. The height of the control device controls the height of the water table.

❑ Because a water table lowering system is controlled by the outlet, the outlet must be protected to ensure that the system works as it was designed. Outlet pipes must extend into the receiving stream and be protected from burrowing animals or other things that block free flow of the water into the receiving stream.

❑ When open channels are used to lower the water table, the channels must be at least 25 feet from any portion of the on-site system.

Figure 5.5.18. Ground-water-lowering system draining to stream.



❑ The open ditches must slope so that the water drains to the outlet. The ditches or channels should be constructed with a 2:1 or less slope to prevent the banks from collapsing.

❑ In areas where the elevation of the water in the receiving ditch is sometimes or always above the ground water elevation required, a pumped ground-water-lowering, or drainage, system may be required. The pump lifts the water over the outlet and discharges into the receiving ditch. In this way, the pumped drainage system can lower the water table below the level of the water in the receiving ditch. A pumped drainage system must be designed to discharge the required volume of drainage water to the receiving stream.

❑ The pumped drainage system must comply with all setback requirements and all management requirements established by the state.

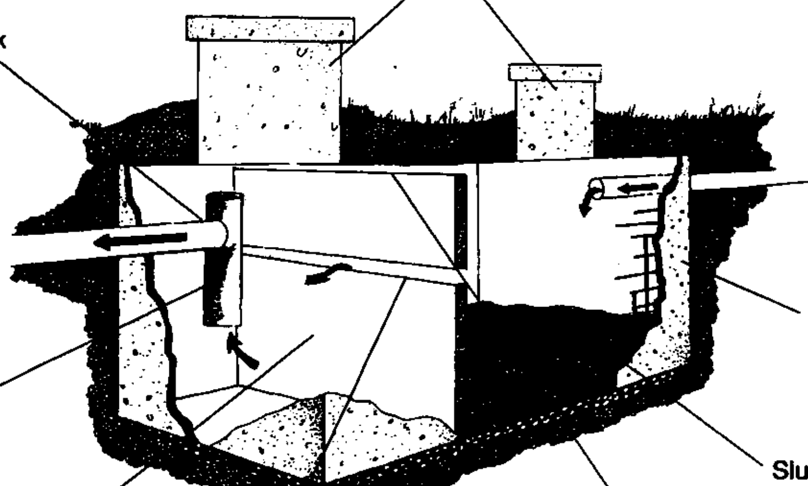
5.6 FIELD INSPECTION OF CONVENTIONAL AND MODIFIED CONVENTIONAL ON-SITE SYSTEMS

All on-site systems must be inspected before the system is put into operation. This section gives details on what to look for and how to properly inspect the various parts of a system.

Field Inspection of Septic Tanks

An installed septic tank should be inspected carefully to verify that it will operate properly and reliably. The list below presents important points to check during an inspection. See Field Inspection Checklist for Septic Tanks, page 5.6.7, for more details on inspecting installed septic tanks. Figure 5.6.1 shows a septic tank in operation.

Figure 5.6.1. Cut-away view of installed septic tank.



❑ The septic tank should be located as marked on the plan. If the tank has been installed at another location, the new location must be approved. The tank must not be installed where it would violate setback requirements.

❑ Septic tanks should not be installed so that the top of the tank is deeper than 36 inches. Deeper installations or installations where the tank is under roads or driveways require specially made stronger tanks.

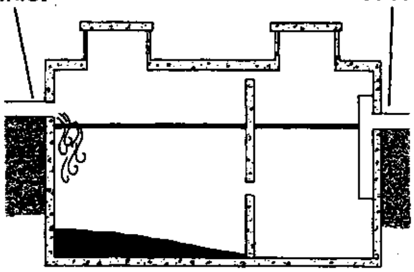
Reference
15A NCAC 18A.1950(i)

❑ A septic tank must not be installed where it could be flooded, unless it has been designed and installed to remain watertight and to function in a 10-year flood.

❑ The entire tank must remain visible for inspection prior to backfilling.

❑ All septic tanks must be level, side to side and inlet end to outlet end. The inlet and outlet must be located in the right directions so that the effluent will flow to the treatment and disposal field.

❑ The tank must be stamped or marked to state the manufacturer, approval number, tank size, and the date of manufacture.



View of conveyance pipe from septic tank to distribution box.

Reference

15A NCAC 18A.1952(a)

Leak Testing Septic Tanks

Water test: Temporarily seal inlet and outlet pipes. Fill the tank above highest seam or pipe connection and wait 24 hours for the concrete to absorb water. Refill the tank and check the level after 24 hours. The water level should not change more than ½ inch drop or rise in 24 hours, or lose more than ½% of liquid volume in 24 hours, whichever is less. Also check the outside of the tank for visible leaks. Visible leaks should show up within one hour.

Vacuum test: Temporarily seal inlet and outlet pipes. Draw vacuum: 3 inches of mercury for 1 hour. 5 inches of mercury for 10 minutes. 10 inches of mercury for 1 minute. Maximum drop is 10% of the vacuum for the test period.

❑ Septic tank walls should not be cracked, have honeycombs, or show other defects that may cause the tank to weaken or leak. Reinforcing steel should be covered in at least 1 inch of concrete to keep it from corroding. All tanks should be leak tested, using either a water or vacuum test.

❑ The baffle wall should be located between two-thirds and three-fourths of the tank length from the inlet end and should have a 4-inch slot the full width of the tank to allow the effluent to flow to the outlet. The top of the baffle wall should leave a 2-inch slot for gas passage. Waste concrete may be in this slot — simply break it out to open up the 2-inch slot.

❑ The sanitary tee should be undamaged and extend into the liquid one-fourth of its depth. The tank outlet should be 2 inches below the inlet. See the drawing to the left.

❑ All joints in the tank should be sealed and watertight. Joints should be sealed with a nominal 1-inch diameter bead of mastic or other approved sealer plus hydraulic cement along its joints.

❑ A septic tank riser over each manhole is required if the top of the tank is more than 30 inches in the ground. The riser is required to come within 6 inches of the ground surface. Pump tanks must have a riser over the pump access manhole and the riser must extend 6 inches above ground.

❑ Tank risers should be large enough to allow easy access to the tank manholes and should have a strong lid.

❑ Pipes must enter and exit the tank through the blockouts provided. The outlet pipe from the tank must be sealed on the inside and outside of the tank to be sure that it will not leak.

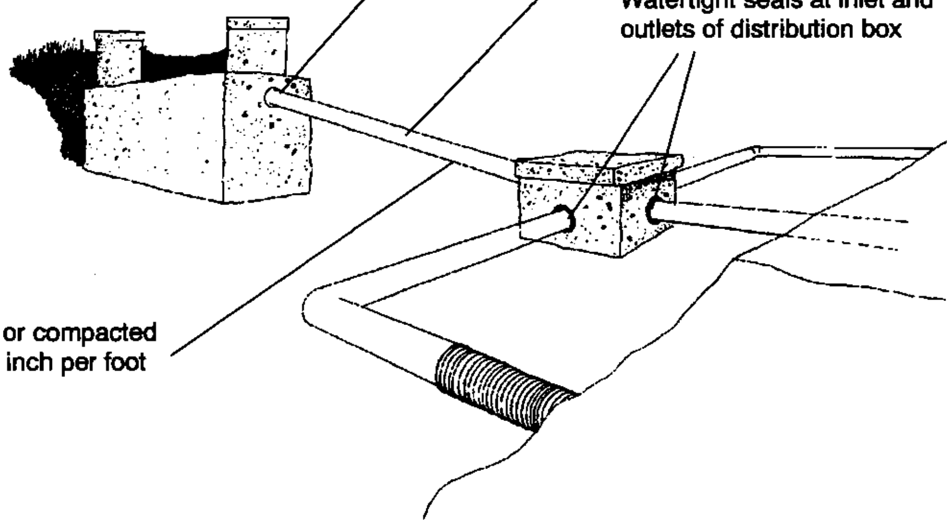
❑ The inlet pipe from the house should have a slope of 1/8 inch per foot so that the sewage will flow to the septic tank. This pipe must be sealed to prevent groundwater from leaking into the septic tank.

Field Inspection of Conveyance Piping

The conveyance piping must be inspected to be sure that there are no leaks and that the pipe or pipes will not block the flow of the effluent to the distribution device or the treatment and disposal trenches. See the Field Inspection Checklist for Conveyance Pipe, page 5.6.8, for more details, and Figure 5.6.2 for points to inspect on conveyance piping.

A separation of at least 2 feet of undisturbed or compacted soil is needed between the septic tank and the distribution device or trench. This separation of reduces the problems of effluent leaking back around the pipe to the septic tank.

Figure 5.6.2. View of conveyance piping from septic tank to distribution box and from distribution box to trenches.



Pipes

Conveyance pipes must be solid, non-perforated, Schedule 40 pipe at least 3 inches in diameter. The pipe can be made of PVC, PE or ABS and the joints must be made using the correct solvent and fittings for the type of pipe.

❑ The pipes should be installed in trenches with bottoms of undisturbed or compacted soil so that the soil will not settle and break the pipe.

❑ All conveyance pipe should have a constant slope of 1/8 inch per foot to allow the sewage to flow by gravity to the distribution device or trench. The slope of the pipe can be determined by measuring the height of the pipe at the septic tank outlet and at the distribution device or trench inlet.

❑ The conveyance pipes must be installed to meet all required setback distances.

❑ All the joints in the conveyance pipe and its connections to the septic tank and the distribution device or trench should be watertight.

Reference
15A NCAC 18A1955(e),(o)

PE pipes.

Corrugated PE pipe can be used as conveyance pipe if non-perforated pipe is used and if the corrugated PE pipe is installed properly.

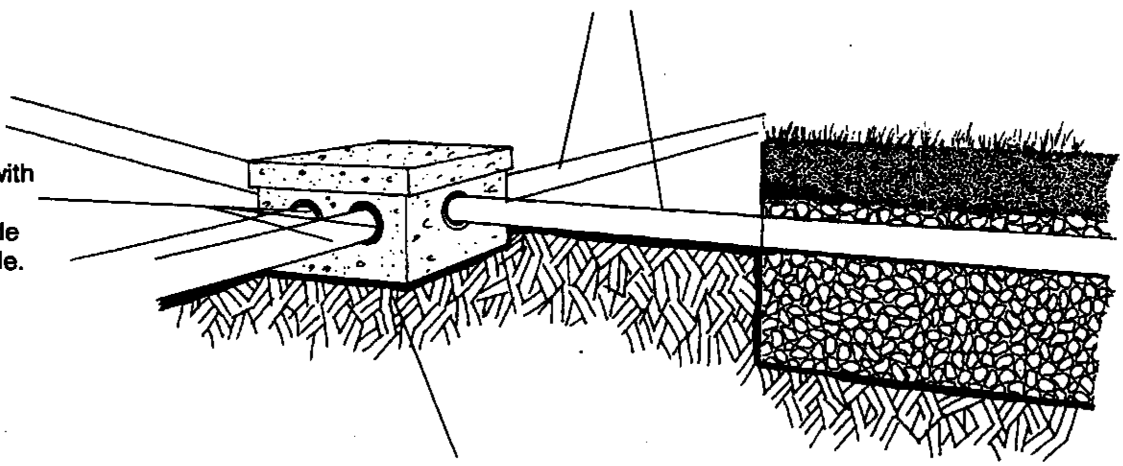
❑ Trenches for corrugated PE pipe must be at least 1 foot wide and the pipe must be surrounded and covered by at least 2 inches of crushed rock. The corrugated PE pipe must have crushed rock around it to give it enough strength to not be crushed when the trenches are backfilled.

❑ All joints and connections to corrugated PE pipe should be watertight.

Field Inspection of Distribution Devices

Distribution devices include distribution boxes, flow splitters, and other flow diversion devices. All of these devices must be inspected for proper installation and so that the effluent will flow equally to all the trenches. Figure 5.6.3 shows a distribution box and conveyance piping.

Figure 5.6.3. View of distribution box.



- ❑ Be certain that the distribution box, flow splitter, or other flow diversion device is installed at the proper location and as marked on the plans. Check that the location meets all setback distances.

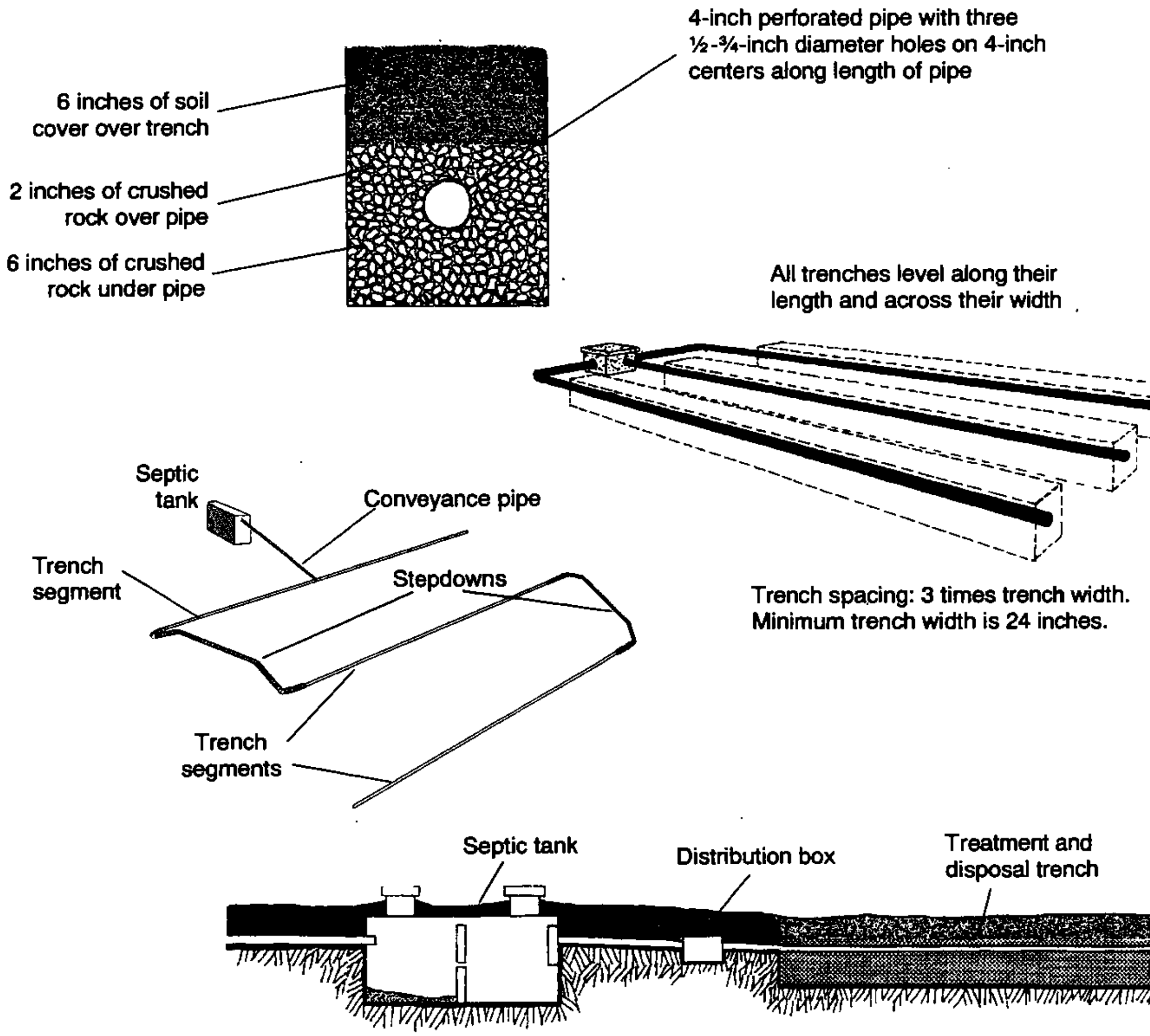
Reference
15A NCAC 18A.1955(j)

- ❑ Install all distribution devices on a base of level, undisturbed earth or a level concrete pad to prevent the soil from settling. If the soil settles, the device can tilt so that the effluent is not evenly distributed, possibly leaking from the device. A good test is to stand on the box and try to rock it — it should not rock or tilt.
- ❑ Test all distribution devices, especially distribution boxes, to be sure that the outlets are at the same level. The testing should be done by pouring water into the distribution box in its installed location and watching for the water to flow out of the outlets at the same time and with the same flow from each outlet.
- ❑ Check the connections of the conveyance pipes to the distribution device to make sure there are no leaks.
- ❑ Inspect distribution boxes to be sure that they are watertight and strong enough to not collapse in the soil.
- ❑ One way to check for a leaking distribution box is to check the water level early in the inspection and then at the end of the inspection. If the water level has dropped below the outlet, there is a leak in the box.
- ❑ Be sure that the distribution box inlet is higher than the outlet so the effluent will flow out to the treatment and disposal trenches. Often, distribution boxes are installed backwards, so it is important to check the orientation.
- ❑ Make certain the distribution box outlets are at least 6 inches below the septic tank outlet so the full trench depth can be used without directing effluent up into the septic tank.

Field Inspection of Trenches

Treatment and disposal trenches are where most of the treatment takes place in on-site wastewater disposal. Proper installation of trenches is critical to the overall performance of the system. Figure 5.5.4 shows several views of treatment and disposal trenches.

Figure 5.6.4. Several views of treatment and disposal trenches.



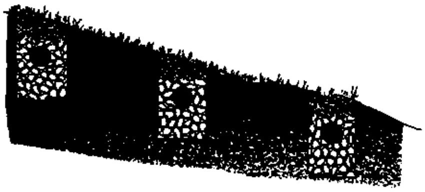
❑ The trenches must be installed on the contour so that the entire trench is at the same level. If the trench is level, all parts of the trench will accept effluent, instead of only the low parts in an uneven trench.

Reference

15A NCAC 18A.1955 (f-j), (l-m)

❑ Trenches installed on the contour on slopes will not be parallel with each other unless the grade has the same slope at every place. The trenches will be closer to each other at the steeper end and farther apart at the flatter end.

❑ The treatment and disposal field must be located in the proper place on the site and at the place marked on the plan. If the field has been relocated, check that all setback requirements have been met.



End view of trenches on a slope.

❑ Treatment and disposal fields must not be placed under driveways, roads, or buildings. The heavy compaction of the soil under a driveway, road, or building will keep the effluent from flowing into the soil.

❑ The number of trenches, the length of each trench, and the total area of the trench bottom should be as shown on the permit. If the gravel is a uniform 12-inch depth, then the top of the gravel will give a good reading of the trench bottom.

❑ Trench bottoms should be level, within plus or minus 1/4 inch per 10 feet.

❑ The width and depth of the trenches should be as shown on the permit.

❑ Trenches should be spaced properly. Usually trenches are 3 feet wide, which means that the trenches should be spaced at least 9 feet on center and there will be at least 6 feet of undisturbed soil between the edges of the trenches. If the trenches are narrower than 3 feet, spacing can be reduced to 3 times the width of the trench. See Table 5.5.1 for a listing of trench spacing by trench width.

❑ Trenches cannot be more than 36 inches wide.

Table 5.6.1 Trench Width and Trench Spacing

Trench width, in inches	Trench spacing, in feet, center to center
36 inches	9 feet
30 inches	71/2 feet
24 inches	6 feet

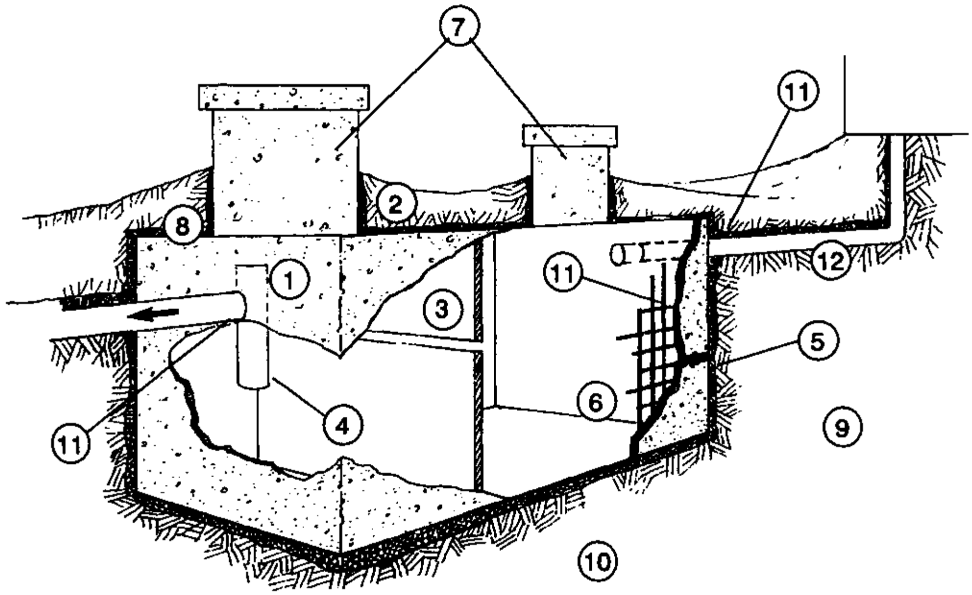
❑ Pipes used in trenches should be located in the center of the trench and covered with crushed rock. The pipe should be 4-inch corrugated polyethylene (PE) tubing with three 1/2-inch to 3/4-inch holes around the pipe every 4 inches along the pipe length. The holes should be toward the bottom of the trench as much as possible.

❑ The crushed stone or gravel in the trenches should be hard and resist crumbling when wet with the effluent. Only washed stone must be used so that the fines have been removed. Fines can plug the soil or fill in the spaces between the crushed stone.

❑ There should be 6 inches of crushed stone under the pipe, and the crushed stone should surround the pipe on all sides, with 2 inches covering the pipe. Acceptable sizes are ASTM Numbers 3, 4, 5, 57, and 6.

❑ To avoid grinding the stone together and making more fines, crushed stone must not be driven over with equipment. The stone is not to be mixed with the soil at the bottom of the stockpile. Placing a piece of plywood or sheet plastic under the stockpile can reduce the amount of soil that mixes in with the stone.

FIELD INSPECTION CHECKLIST FOR SEPTIC TANKS



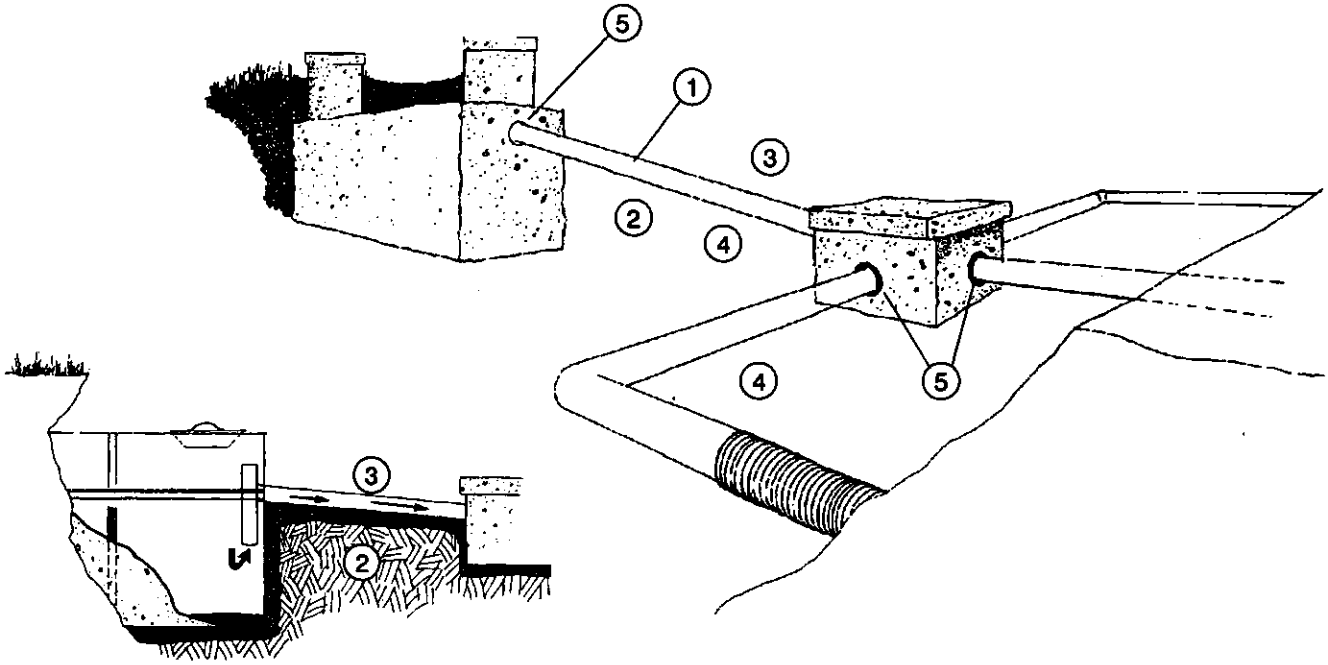
Reference

15A NCAC 18A.1952

15A NCAC 18A.1954

1. Tank identification stamp — tank size, type of tank, manufacturer's ID. Tank type codes: STB means a septic tank with a baffle wall; PT means a pump tank.
2. Date tank was manufactured — next to or above tank identification stamp.
3. Baffle wall — present and undamaged.
4. Sanitary tee — present and undamaged and proper depth — 1/4 of liquid depth for a septic tank, at least 1/2 of liquid depth for a grease trap tank.
5. Seam — sealed with 1 inch mastic and watertight — additional hydraulic sealing may be necessary. Can use hydraulic cement applied to the inside and outside of the tank.
6. Tank construction quality — check for proper concrete thickness, strength, reinforcement, and structural soundness.
7. Riser — look for proper size, lid, sealing on inside and outside of riser for watertightness, and riser 6 inches above finished grade.
8. Tank depth below grade — if more than 30 inches deep or if in parking area, driveway, etc. then additional reinforcement of tank is needed.
9. Tank located at proper spot — appropriate horizontal setbacks, and not where it can be flooded by surface waters unless specially designed and installed.
10. Tank set level — both front-to-back and side-to-side, and in proper direction, inlet-to-outlet.
11. Watertight sealing of conveyance piping — on both the inside and outside of tank.
12. Adequate drop in elevation from the house — 1/8 inch per foot or more.
13. Reinforcing wire throughout tank.

FIELD INSPECTION CHECKLIST FOR CONVEYANCE PIPE

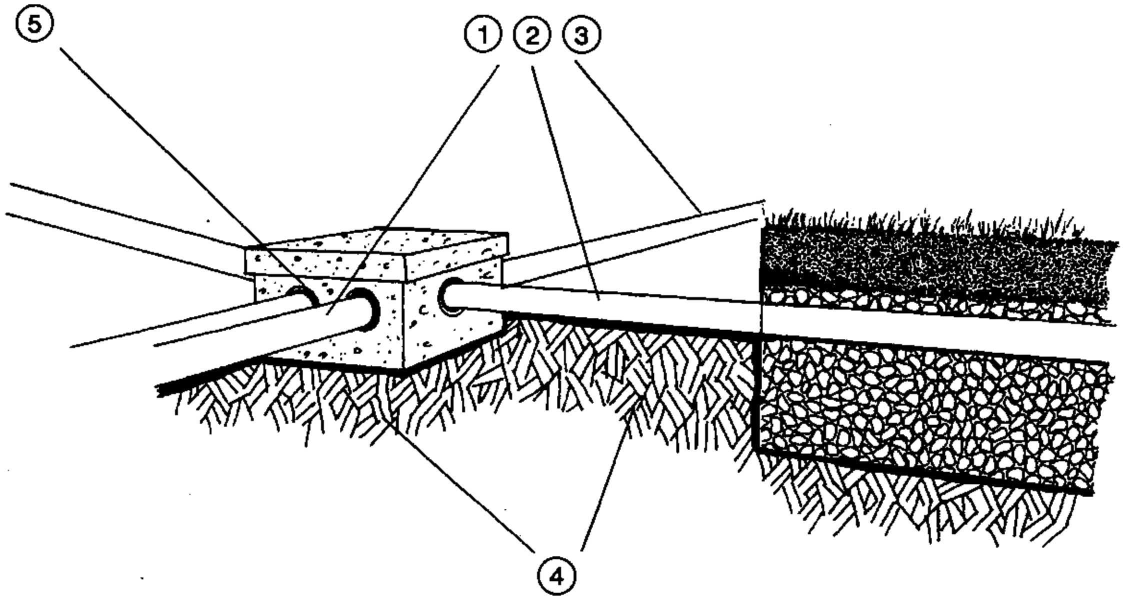


Reference
15A NCAC 18A.1955(e)

Reference
15A NCAC 18A.1955(c)

1. Solid, non-perforated Schedule 40 PVC, PE, or ABS pipe, 3" diameter or larger.
2. Uniform, stable, downhill grade of undisturbed or compacted soil.
3. Gravity flow from tank to D-box or trench — minimum slope or grade of 1/8" inch drop per foot of distance. Determine by comparing conveyance pipe invert at tank outlet with invert where conveyance pipe enters the D-box or trench. Usually, the elevation of the top of the pipe is measured instead of the invert.
4. Minimum 2-foot separation of undisturbed soil between tank and D-box, and between D-box and trenches.
5. Watertight seal of conveyance pipe on both inside and outside of tank, and at inlet and outlet of distribution box.
6. Check all horizontal and vertical setbacks, for instance, water lines, wells, etc.

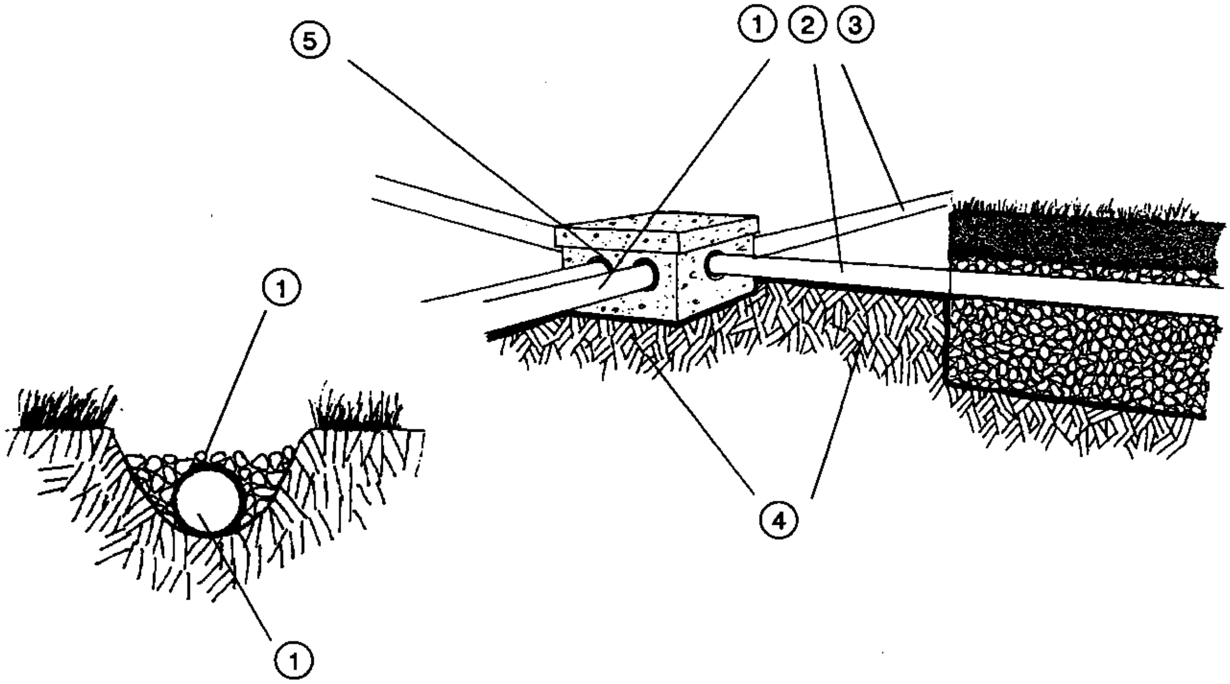
FIELD INSPECTION CHECKLIST FOR CONVEYANCE PIPE FROM D-BOX TO TRENCH USING SCHEDULE 40 PIPE



Reference
15A NCAC 18A.1955(e),(o)

1. Solid, non-perforated Schedule 40 PVC, Schedule 40 PE, or Schedule 40 ABS pipe, 3 inch diameter or greater.
2. Uniform, stable downhill grade on undisturbed or compacted soil.
3. Gravity flow from D-box to trenches with a minimum slope or grade of 1/8 inch drop per foot of distance. Determine by comparing conveyance pipe invert at D-box outlet with invert where conveyance pipe enters the trench. Usually the elevation of the top of the pipe is measured instead of the invert. Also, should have minimum elevation drop of 6 inches from the tank outlet invert to the pipe invert where the pipe enters the trench.
4. Minimum 2-foot separation of undisturbed soil between D-box and trench.
5. Watertight seal of conveyance pipe on both inside and outside of D-box.
6. Check all horizontal and vertical setbacks.

FIELD INSPECTION CHECKLIST FOR CONVEYANCE PIPE FROM D-BOX TO TRENCH USING PE TUBING

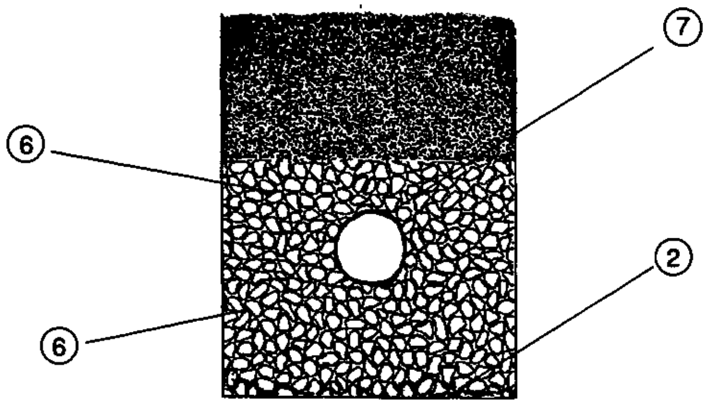


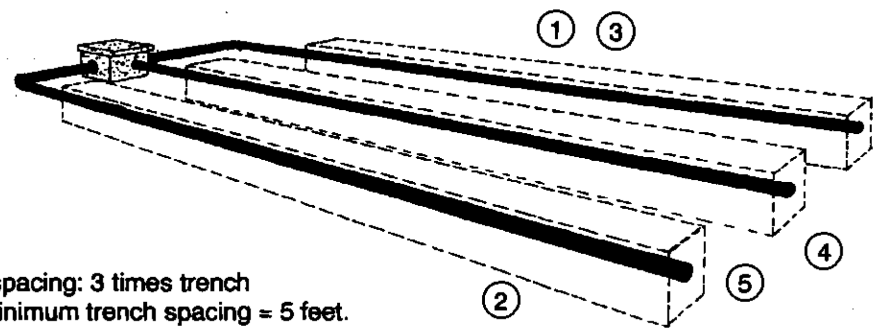
1. Non-perforated, corrugated PE tubing placed in exact center of greater than or equal to 1-foot wide conveyance pipe trench. Gravel placed beside and 2 inches over pipe in the trench.
2. Uniform, stable downhill grade of undisturbed or compacted soil.
3. Gravity flow from D-box to trenches.
4. Minimum 2-foot separation of undisturbed soil at both ends of conveyance pipe trench.
5. Watertight seal of conveyance pipe on both inside and outside of D-box.
6. Check all horizontal and vertical setbacks.

Reference

15A NCAC 18A.1955(e),(o)

FIELD INSPECTION CHECKLIST FOR TRENCHES





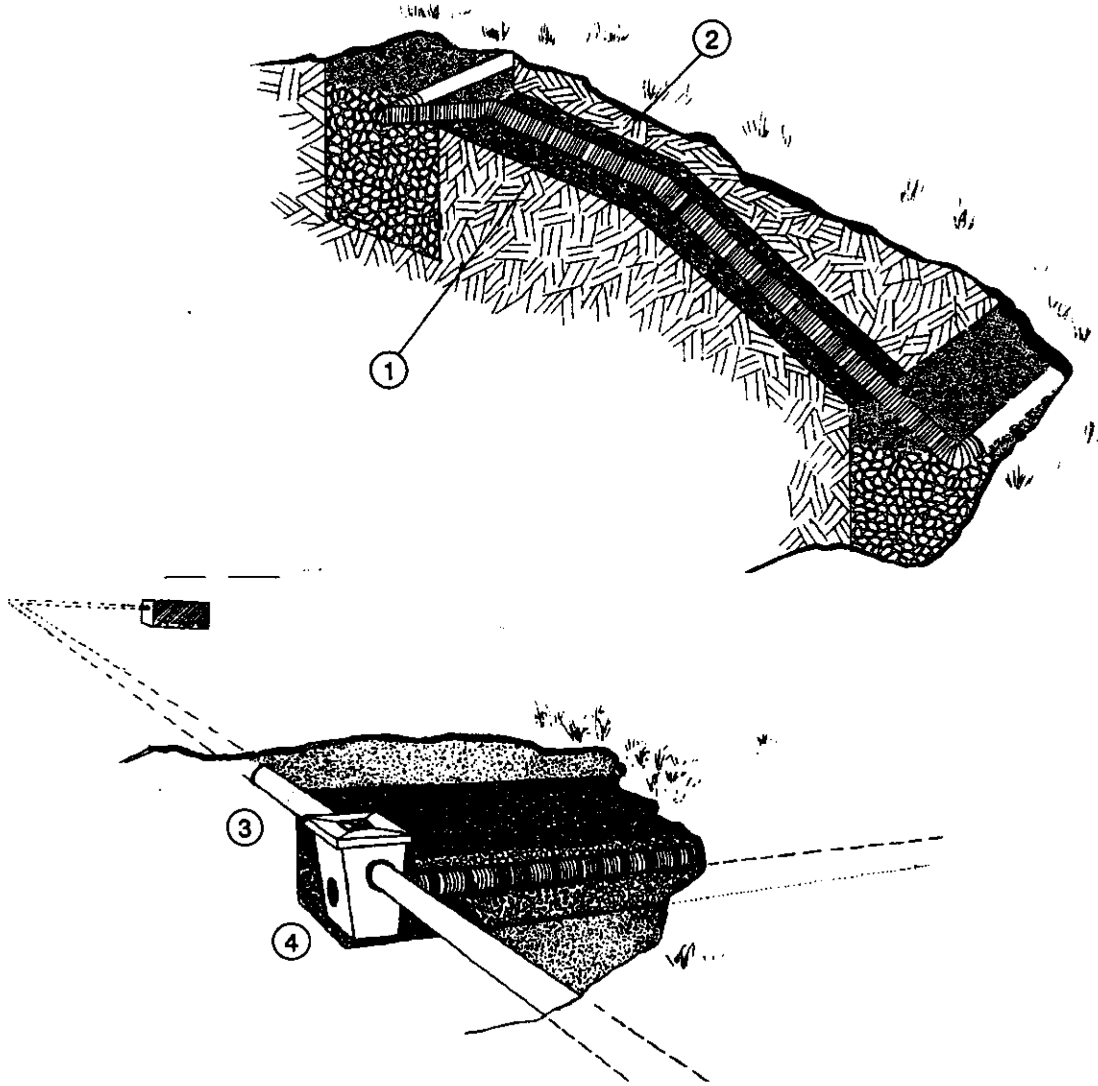
Trench spacing: 3 times trench width. Minimum trench spacing = 5 feet.

Reference

15A NCAC 18A.1955(f-j, l-m)

1. Proper location of treatment and disposal field — relative to benchmark, house, driveway, etc., and according to layout on permit.
2. Check elevation of trench bottom — should follow contour, which means it is level along entire length and across its width.
3. Number of trenches, length of trenches, total square footage of trench bottom area as per permit specifications.
4. Width and depth of trenches per permit.
5. Spacing of trenches as per permit — distance from center of trench to center of next trench is normally 9 feet, but can be less if trenches are narrower than 3 feet wide.
6. Correct size, hardness, and amount of gravel under and over pipe in trenches — 3, 4, 5, 57, 6 ASTM gravel grades.
7. Correct size, type, location, and hole orientation of pipe in trenches — 4-inch or 6-inch diameter corrugated PE plastic tubing with 3 holes — ½ - ¾ inch diameter spaced on 4-inch centers along the pipes. Painted stripe on pipe faces up.

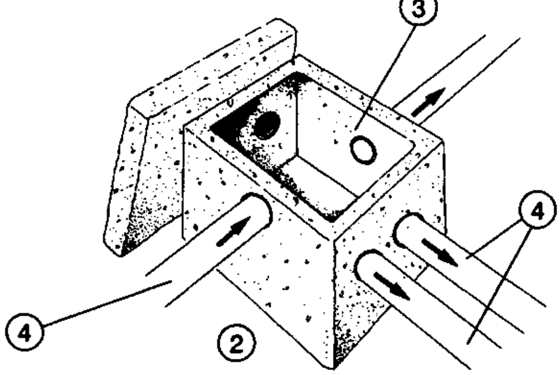
FIELD INSPECTION CHECKLIST FOR SERIAL DISTRIBUTION SYSTEMS



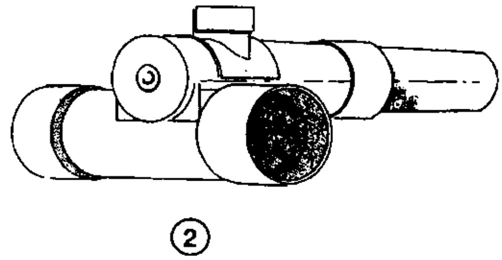
1. Top of dam for stepdown at top of crushed stone — so that the first trench segment fills with effluent before allowing flow to next segment — dam of undisturbed or compacted soil. Stepdown conveyance is nonperforated.
2. Depth of soil cover over stepdown sufficient to prevent crushing.
3. Drop boxes installed in correct flow direction — inlet is highest opening — outlet to next trench segment above outlet to trench segment served by drop box.
4. Drop boxes level in all directions — on concrete pad if necessary.

FIELD INSPECTION CHECKLIST FOR EFFLUENT DISTRIBUTION DEVICES (DISTRIBUTION BOXES, FLOW SPLITTERS, AND FLOW DIVERSION DEVICES)

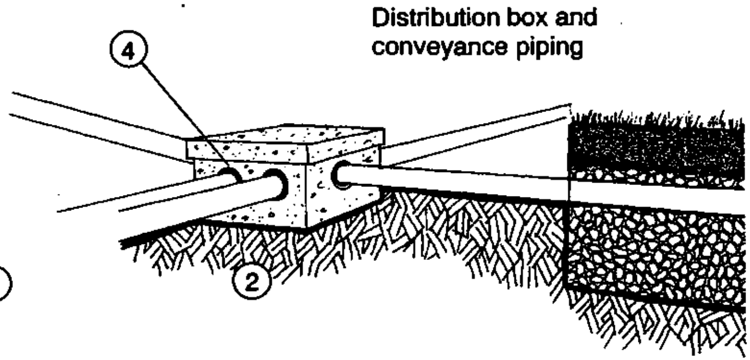
Distribution box



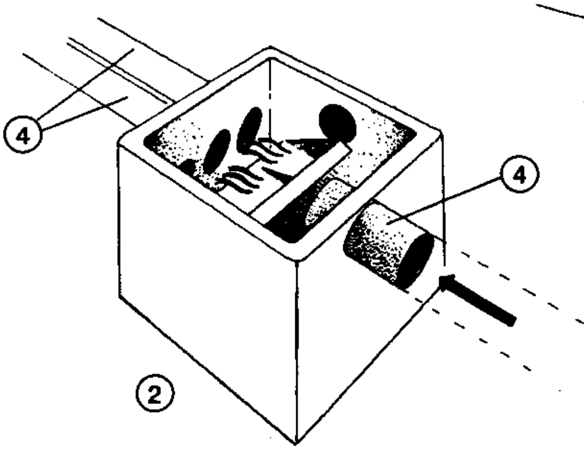
Adjustable flow splitter



Distribution box and conveyance piping



Tipping distribution box



Reference
15A NCAC 18A.1955(j)

1. Distribution device at proper location and elevation with appropriate horizontal setbacks.
2. Proper base — firm and level. Concrete pad 6 inches larger on all sides than distribution device installed.
3. Water test distribution device to assure that all outlet inverts are at the same elevation.
4. Conveyance pipes into and out of distribution device properly sealed on both inside and outside.
5. Distribution device has appropriate drop within it from its inlet to its outlets — not installed backwards.
6. Distribution device of sound construction and watertight.

5.7 PUMPS, FLOATS, ELECTRICAL CONTROLS, AND SIPHONS

Reference
15A NCAC 18A.1952(c)

Reference
15A NCAC 18A.1952(a)

In many cases, an on-site system may need a pump to lift the effluent over a high spot, or pump up to a usable area that is higher than the outlet of the septic tank, or when the treatment and disposal trenches are more than 750 feet long. Also, pressure manifolds and pressure distribution systems require a pump to supply the pressure for the manifold or the pressure dosing. In all these situations, a second tank, called a *pump tank*, is needed to house the pump and controls so that the *septic tank effluent*, the effluent flowing out of a septic tank, can be pumped properly.

This section presents information on how to design, construct, and inspect pumps and controls for on-site systems.

Terms Used in Pumped On-Site Systems

The following list of terms will explain many of the words used in pumped on-site systems.

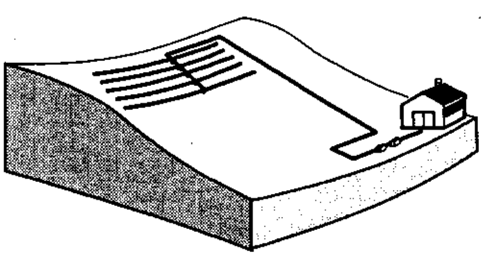
❑ *Dose* or *dosing volume* is the volume of septic tank effluent pumped to the treatment and disposal field during one run cycle of the pump. It is important to determine this volume carefully so that the field is delivered enough effluent for proper distribution and enough resting time is provided before the next pump cycle.

❑ *Drawdown* is the distance between the pump turn-on and turn-off levels in the pump tank that provides the proper dose to the treatment and disposal field.

❑ *Flow rate* or *discharge* is the amount of water pumped by a pump in a certain time. Flow rate is usually given in gallons per minute. Flow rate is important because the treatment and disposal field must receive the dose of effluent fast enough to fill the trench pipes or pressurize a pressure manifold or a low pressure pipe system.

❑ *Head* is the driving force that makes water flow through pipes or channels. The head of a pump is measured in feet, which is how high the water would rise in the discharge pipe when the pump is running. Several types of head must be considered in a system with a pump.

- *Elevation head* is the height of the treatment and disposal field above the pump tank from which the effluent must be pumped. For example, if the treatment and disposal field is 20 feet higher than the pump turn-off level, then the pump must lift the effluent 20 feet and supply enough pressure to make the pressure manifold or low pressure pipe system work properly.
- *Friction head* is the resistance to the flow of effluent in the pipes and fittings. This resistance is measured in feet.
- *Pressure head* is the pressure that is applied to the effluent to make the pressure manifold or low pressure pipe system work properly. Pressure head is also measured in feet.
- *Total dynamic head* is the total of all three heads — elevation head plus friction head plus pressure head. Total head also is measured in feet.



Pumped system with center-feed treatment and disposal field.

EXAMPLE: An effluent pump is needed to pump septic tank effluent to a pressure manifold distributing effluent to a treatment and disposal field that is 23 feet above the pump turn-off level. The friction head through the pipe leading to the pressure manifold is 8 feet of head at the desired pump flow rate, and the pressure manifold requires 5 feet of head to work properly. To determine the total dynamic head rate follow this equation:

The total dynamic head is the sum of the elevation head, the friction head and the pressure head. In this situation, the heads are:

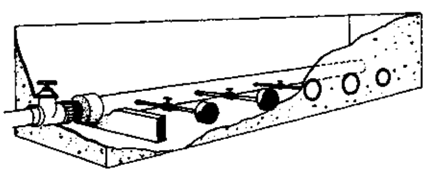
Total dynamic head = elevation head + friction head + pressure head

Total dynamic head = 23 feet + 8 feet + 5 feet

Total dynamic head = 36 feet

❑ An *invert* is the bottom point of a pipe or an opening. This lowest point is where a flow of water will first start and will be deepest. Knowing the vertical distances between the inverts of tank openings and pipes is important because these differences in height determine the path water will take in flowing through a system.

- *Outlet invert* is the bottom point of the outlet from a septic tank, pump tank, or distribution box. The outlet invert should be below the inlet invert.
- *Inlet invert* is the bottom point of the inlet to a septic tank, pump tank, or distribution box. The inlet invert should be above the outlet invert.
- *Tank invert* is the bottom of a septic tank or pump tank.



Pressure manifold.

❑ An *orifice* is a small hole in a pipe from which effluent discharges under pressure. Usually orifices are the holes in a pressure manifold or in the distribution lateral of a low pressure pipe system.

❑ A *low-pressure pipe lateral* is the small pipe, usually 1 or 2 inches in diameter, with small orifices that let effluent flow out under pressure into the soil. The pressure in the laterals is usually 2 to 5 feet of head and the orifices are from 5/32 to 1/4 inch holes.

❑ A *pressure manifold* is a 3 to 8-inch pipe which distributes septic tank effluent to many outlets. The outlets in the pressure manifold range in size from 1/2 to 1-inch holes. Each outlet takes effluent to a conventional gravity trench for treatment and disposal. See the drawing of a pressure manifold at the left.

Types of Pumps

Pumping sewage can cause problems if the right pump is not used. The pump can burn out or clog if it pumps the wrong substance. This section gives details on the type of pump to use for a given situation.

Pump Terms

Pumps are actually a combination of a motor and a pump. The motor uses electric power to turn the shaft of the pump, thus moving the liquid.

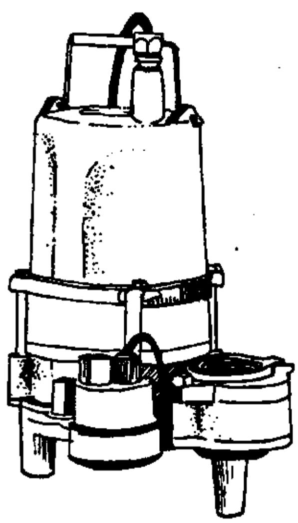
The pumps usually used in on-site systems are known as *centrifugal pumps*. This is because the liquid is moved by the centrifugal motion of an *impeller* that is spun by an electric motor. The impeller gives the liquid pressure as it moves it through the pump. There are many designs and types of impellers, depending on the use of the pump. The following discusses various aspects of pumps.

❑ The impeller forms the main part of a *stage* in a pump. The term stage is used because each impeller can pump liquid to only a certain height. Pumps that force liquids to high elevations or create high pressures are usually multi-stage pumps that have a number of impellers. Each impeller lifts the liquid a certain height or creates a designated amount of pressure, and this lift or pressure is added to the liquid as it flows to the next impeller or stage. Most pumps used in on-site systems have only one stage.

❑ There are many different types of pumps and each type of pump is designed to handle only a certain type of liquid. For example, pumps made to handle raw sewage and septic tank effluent can withstand solids in the liquid without clogging or burning out. On the other hand, pumps not made to pump sewage will quickly clog and fail.

❑ Power in a pump usually refers to the size or power of the motor that runs the pump. Motors are rated in horsepower, so that in typical situations, motors for sewage effluent pumps may have power ratings of 1/3, 1/2, 3/4, or 1 horsepower.

❑ Higher power motors do not necessarily mean that a pump can pump more liquid, or pump to a higher level or higher pressure. The actual volume of liquid pumped and the pressure of the liquid is only partly determined by the horsepower of the motor. The pump impeller and casing are what mainly determine how much liquid is pumped and to what pressure. For example, a solids-handling pump with a 3/4 horsepower motor may only pump the same amount as an effluent pump with a 1/2 horsepower motor because the effluent pump has closer tolerances. However, the solids-handling pump can typically handle much larger solids and flows than the effluent pump.


Effluent pump.

❑ Pump efficiency is a measure of the electricity used to pump a determined volume of sewage. More efficient pumps use less electricity to pump the same amount of liquid and cost less to run than less-efficient pumps. In small on-site systems, the cost of operating the pump will be only a few cents per day. Because the cost is small, pump efficiency is usually not important in selecting a pump for an on-site system. It is much more important to select the proper type of pump to avoid clogging or pump burnout.

❑ The *flow rate* from a pump is the amount of liquid pumped in a particular time at a set pressure. Flow rate is represented as the letter Q.

❑ The pressure or head that a pump can generate at a designated flow rate is called the *total dynamic head*, or TDH. This is the pressure or head of the entire system when the liquid is flowing at the specified rate.

❑ The flow rate, Q, and the total dynamic head , TDH, are the two most important characteristics in specifying a pump for a particular installation. These two factors determine that the pump can pump the correct amount of effluent to the required height.

Effluent Pumps

Effluent pumps are the pumps most often used in small on-site systems. They are designed to pump effluent, the effluent flowing out of a septic tank. This effluent is relatively clear liquid because the solids have settled out in the septic tank. Effluent pumps can pump to higher levels and are more efficient than the other types of sewage pumps because these pumps do not have to handle sewage solids. Other characteristics of effluent pumps are discussed below.

❑ Effluent pumps are often used where the sewage effluent from the septic tank has to be pumped to a treatment and disposal field located on a level higher than the septic tank or where pressurized distribution is used.

❑ Most effluent pumps look like sump pumps. They are short and compact with an inlet on the bottom of the pump housing and a single stage or single impeller. The pump and motors are hermetically sealed so that they can operate completely under the liquid level on the pump tank and will not rust or corrode. The short, compact type of effluent pumps can lift large volumes of sewage effluent to moderate heights.

- Effluent pumps are made much differently from the usual sump pump. The materials in the effluent pump can withstand the very corrosive septic tank effluent and the pump can handle some solids. Sump pumps are not made to resist the corrosion of septic tank effluent and they cannot handle solids.

❑ Some effluent pumps are long and thin, like submersible well pumps. The pump has a long, narrow shape because it is a multi-stage pump, with a number of impellers rather than a single impeller like the short, compact pump. In general, more impellers or stages means that it can pump to higher levels than a single-stage pump. Long, thin effluent pumps are designed to operate completely submerged, just like the short, compact pumps.

❑ The pump controls should usually be set so that the pump is always under the liquid. Keeping the pump submerged keeps it cool and also reduces corrosion caused by exposure to the air.

Solids-Handling Pumps

These pumps, also called sewage ejector pumps, are made to pump raw sewage. Raw sewage contains too many solids for most pumps, so only solids-handling pumps should be used where raw sewage has to be pumped.

❑ These pumps have a special impeller and space between the impeller and housing to allow the solids to pass through without clogging the pump.

❑ Solids-handling pumps can be installed in tanks outside the building to pump the raw sewage to a septic tank and treatment and disposal field that is far from the building.

❑ In some sensitive areas, such as lakefront property, solids-handling pumps can be used to pump raw sewage to an on-site system located away from the lake.

Grinder Pumps

A grinder pump is much like a solids-handling pump in that it can pump raw sewage. The difference is that the grinder pump has rotating blades, like a garbage grinder, that cut and grind the solids into small particles before the sewage is pumped. Grinder pump functions are discussed below.

❑ Grinder pumps are used for some community on-site systems where raw sewage is pumped from individual homes to small-diameter gravity or pressurized collector sewers. The sewage is treated and disposed at a common treatment and disposal site.

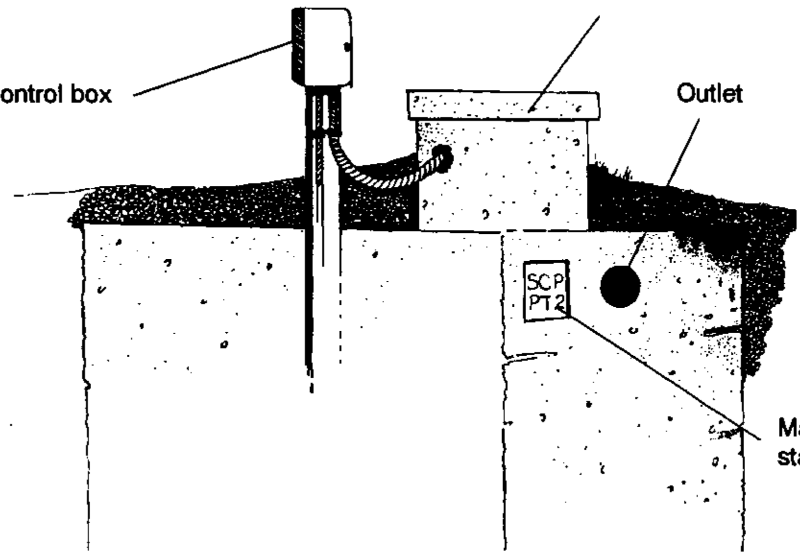
❑ A grinder pump can clog if the cutting blades become dull. The pump should be replaced or rebuilt on a regular basis so that the pump operates well.

❑ Because grinder pumps need more torque to start, the starting mechanism for the electric motor is different from effluent or solids-handling pumps.

Pump Tank Design and Installation

Pump tank location and design is critical for proper operation of a pumped on-site system. A pump tank contains the pump, float switches for the pump, and discharge piping and valves. Electrical controls for the pump must be in a separate panel box near the pump tank. All these components must work well for the system to perform properly. This section contains information on the proper installation of the tank, pump, controls and piping. Figure 5.7.1 shows an installed pump tank.

Figure 5.7.1. Outside view of a pump tank.



Pump Tank Location

In some situations, the designer can choose where to locate a septic tank and pump tank. Listed below are some points that can help make an on-site system with a pump easier to maintain.

❑ If an on-site system must use a pump, try to locate the septic tank and pump tank so that *only septic tank effluent is pumped.* Fewer problems, clogs, and burnouts are involved in pumping septic tank effluent because the solids and grease have been removed in the septic tank. Locate the septic and pump tanks near the house and pump the septic tank effluent to the treatment and disposal field, rather than pumping raw sewage to a septic tank far from the house. See the drawing on the left.

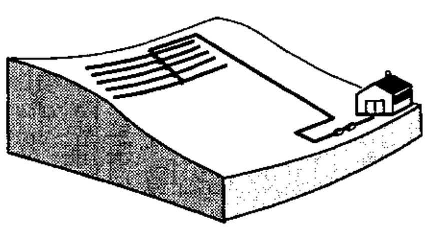


Diagram shows septic tank and pump tank located near house so that only septic tank effluent is pumped.

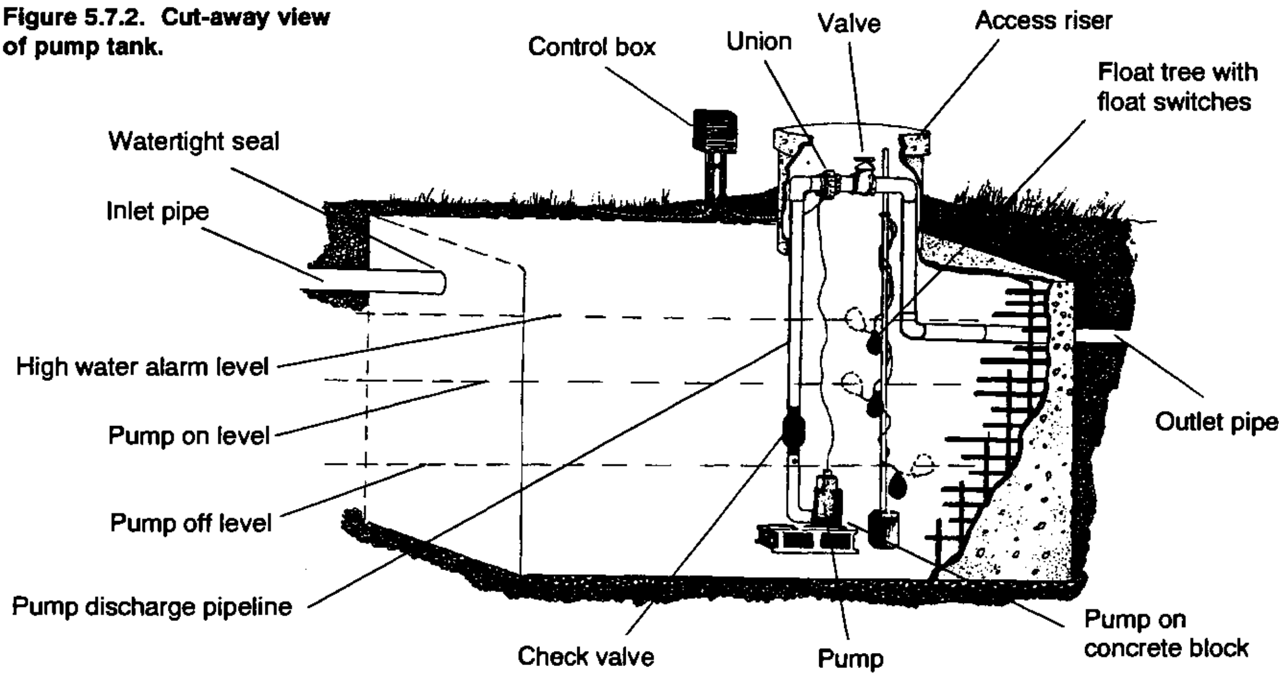
❑ The septic tank and pump tank should be kept as shallow as possible, with less than 30 inches of soil cover. Shallow septic tanks and pump tanks are much easier to find and maintain. Deep tanks are hard to find, inspect, repair, or pump out; and deep tanks also tend to have more problems with ground water leaking in.

❑ If the sewer from a building is deep in the ground, a sump should be installed in the house basement to pump the raw sewage up to a normal depth, rather than install the septic and pump tanks deep in the ground. Reroute the drains in the house so that upper floors drain directly to the septic tank and raw sewage is pumped only from the lowest floor of the house.

Pump Tanks

A pump tank functions differently from a septic tank. The pump tank provides a temporary storage of sewage for the pump so that the proper volume of effluent can be dosed to the treatment and disposal field and emergency storage is provided during pump failure conditions. Electrical controls on an outside panel switch the pump on and off and turn on alarms if the liquid level rises too high. The pump tank may also provide for some additional settling of solids before the effluent is pumped. Pump tanks are described below. Figure 5.7.2 shows a cut-away view of a pump tank.

Figure 5.7.2. Cut-away view of pump tank.



Reference
15A NCAC 18A.1954(b))

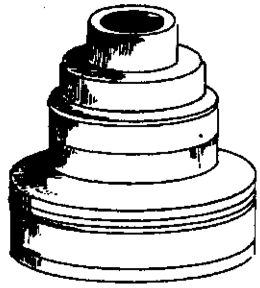
❑ Pump tanks should have only one compartment. If a two-compartment tank is to be used, then the partition in the tank must have at least two 4-inch holes in the partition no higher than 12 inches from the tank bottom to allow free flow of the effluent from one compartment to the other. Other openings of different shapes are allowed as long as the openings are as large as the two 4-inch holes.

❑ The liquid level is normally much lower in a pump tank than in a septic tank. Under normal operation, a pump tank will have only about 2 feet of liquid, enough to dose the treatment and disposal field, and still keep the pump covered. This low liquid level in the tank can cause several problems:

- The lower liquid level in the pump tank is like a large open hole in the ground. Ground water or surface runoff will tend to flow into the tank through cracks or unsealed seams to fill the "open hole." This ground water causes the pump to operate more often, increasing the amount of liquid dosed to the treatment and disposal field, possibly overloading the field.
- The lower level also leaves more space in the pump tank for air and corrosive gases. This mixture can cause corrosion of the pump, tank, and other devices when wet surfaces are exposed.
- Because there is less liquid in the pump tank, the tank weighs less and may float out of the ground if the water table is high.

The following points can help prevent problems caused by the low liquid level in a pump tank.

❑ Seal the pump tank well so that ground water cannot enter the tank or sewage leak out. Many pumped systems fail because the pump tank leaks, especially around the inlet and outlet pipes, letting in large amounts of ground water. The ground water is then pumped to the treatment and disposal field, which can be flooded with too much water.



Rubber boot that can provide watertight seals around inlet and outlet pipes.

❑ Be sure that inlets, outlets, and all seams are sealed with a durable sealant that will not crack or leak. Inlet and outlet pipe openings should be connected with solvent welds, O-ring seals, or rubber boots with stainless steel straps to make these connections absolutely watertight. Seams along the half-sections of the tank and risers should be sealed with a permanent, waterproof mastic so that the seam is watertight.

❑ The pump-off level of liquid in the pump tank should be high enough to keep the pump covered in liquid. Keeping the pump covered in liquid greatly slows the rate at which the pump corrodes. The pump will corrode very quickly if it is exposed to the gases in the tank.

❑ On lots where there is a high water table, the pump tank may float on the ground water and come out of the ground. Special weights or anchors can be installed to hold the tank in the ground.

Reference

15A NCAC 18A.1941 and .1952(c)(1))

❑ A 24-inch diameter riser with a strong and tight lid should be installed so that the pump tank, pump, float switches, and piping can be easily serviced. The riser should extend at least 6 inches above the ground level so that ground water and surface runoff cannot enter the tank.

❑ Pump tanks must not be smaller than 750 gallons. Larger sizes for pump tanks are determined by the type of soil in the drainfield.

- For pump tanks with drainfields in Group I, II, or III soils, the minimum pump tank size must be at least two-thirds of the volume of the septic tank.
- Pump tanks serving drainfields in Group IV soils are required to have the same volume as the septic tank.

❑ Another method to size a pump tank is to meet the minimum pump submergence requirement, minimum dosing requirement, and minimum emergency storage requirement. Determining the volume of a pump tank to meet these criteria is complicated and not practical for most small wastewater systems.

Pumps and Installation

A pump must be installed properly to be reliable. The following list gives a number of requirements that make pumped on-site systems work well.

Reference

15A NCAC 18A.1952(c)

Reference

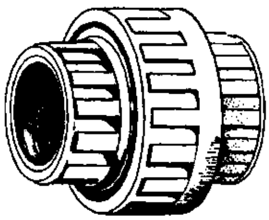
15A NCAC 18A.1952(c)(2)

❑ The pump must be able to pump solids that are 1/2 inch in size and also be able to lift the septic tank effluent to the treatment and disposal field at a rate that allows proper dosing. All pumps should be listed by Underwriter's Laboratory or similar testing organization to be sure that it is constructed properly and is safe from electrical hazards. Professional engineers can specify unlisted sewage or effluent pumps for on-site systems that they design if the engineer determines that the proposed pump is appropriate for the intended system.

Reference

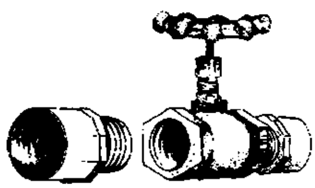
15A NCAC 18A.1952(c)(3)

❑ A rope or chain that will not corrode should be attached to the pump so that the pump can be removed without having to go inside the tank. The other end of the rope or chain should be fastened to the riser to keep it from falling into the tank and to be easily reached without entering the tank.

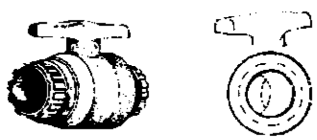


Quick disconnect pipe union.

Reference
15A NCAC 18A.1952(c)(3)

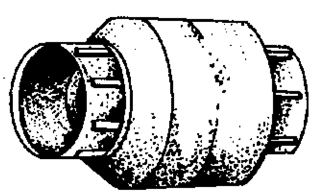


Gate valve and adaptor for solvent-weld pipe.



Ball valve.

Reference
15A NCAC 18A.1952(c)(4)



Check valve.

❑ Valves, the disconnect device, float switches, the float tree and other important parts of the system must be positioned where they can be operated or removed so that the service person should not have to enter the pump tank.

❑ Set up the pump controls so that the pump is always under the liquid. Keeping the pump submerged helps cool it and also reduces corrosion caused by exposure to the air.

Pipes, valves, and disconnects. The proper types of pipe, fittings, valves, and disconnects are extremely important in making a pumped on-site system reliable and easy to repair. Some pipe fittings and valves are shown at left.

❑ All pipes, fittings and valves connected to the pump must be Schedule 40 PVC or stronger and made of corrosion-resistant material.

❑ The pump discharge pipe must have a union, flange, or other device to allow the pump to be disconnected quickly from the pipe. The disconnect device makes servicing the pump much easier. This union or flange should be located within easy reach from the top of the riser so the serviceman does not have to enter the tank.

❑ A turn-off valve should be installed on the treatment and disposal field side or after the union or disconnecting device. This valve can be closed so that the sewage in the pipe will not run back onto the repairman when the union is disconnected.

❑ The pipes, fittings, valves, and disconnecting devices must be corrosion-resistant so that they will not be destroyed by sewage and gases.

Anti-siphon holes. In some installations, the treatment and disposal field can be flooded if the discharge pipe from the pump starts a siphon that drains all the liquid from the pump tank at once. Siphoning action will only happen if the treatment and disposal field is lower than the height of the water level in the pump tank.

❑ The siphon action must be stopped by drilling a 3/16-inch *anti-siphon hole* in the discharge pipe above the pump and before the pipe leaves the tank.

❑ If a check valve and an anti-siphon hole are needed, the anti-siphon hole should be drilled in the discharge pipe above the pump and below the check valve.

Check valves. A check valve keeps the effluent in the pump discharge pipe from draining back into the pump tank or through the pump when the pump turns off. In this way, the proper amount of effluent is dosed to the treatment and disposal field.

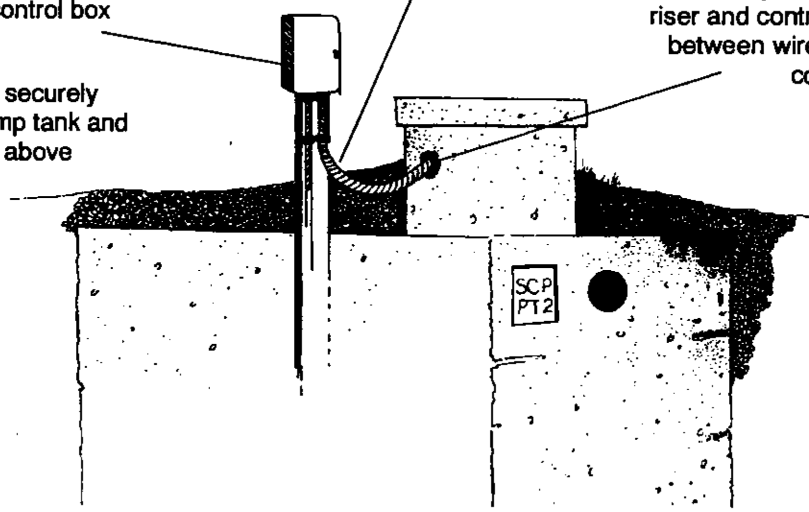
❑ A check valve may be required if the volume of liquid in the pump discharge pipe going to the treatment and disposal field is more than 25% of the dosing volume. Too much of the effluent would drain back into the pump tank when the pump shuts off if there is no check valve to stop it.

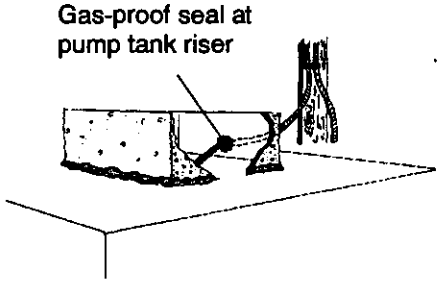
❑ Some pump manufacturers require a check valve on the pump discharge pipe regardless of the drainback volume.

❑ If a check valve and an anti-siphon hole are needed, the anti-siphon hole should be drilled in the discharge pipe above the pump and below the check valve.

Pump controls. Electrical controls are used to turn the pump on and off and to signal if the sewage level in the pump tank is too high. Pump controls are discussed in the following. See Figure 5.7.3 for proper installation of pump controls.

Figure 5.7.3. Outside view of a pump tank.





Pump tank cable routing to the control box.

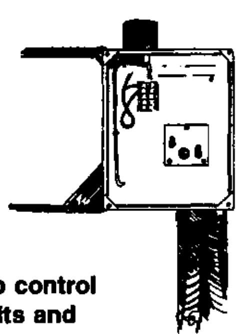
❑ All electrical wires must be installed in waterproof, gas-proof, and corrosion-proof conduit. The conduits must be sealed with duct seal, wire grips, or other sealants around the wire and around the conduit holes in the pump tank and in the disconnect enclosure. Sealing around the conduit and the wires keeps the gas inside the pump tank and out of the disconnect enclosure. It is important to keep the gas out of the disconnect enclosure, because the gas can explode, burn, or corrode the electrical controls. The drawing at the left shows how the cable is sealed at the pump tank riser.

Pump float switches. Pumps should be turned on and off by float switches, such as sealed mercury float switches, or other devices that detect the liquid level in the pump tank. The following points discuss pump float switches.

Reference

15A NCAC 18A.1952(c)(5)

❑ Set the pump float switches so that the pump remains submerged after the pump is turned off and at least 12 inches of water is left in the tank. Keeping the pump submerged helps cool it and prevents the pump from corroding from contact with the gas in the tank. Also, a certain amount of solids settle to the bottom in pump tanks. By leaving 12 inches of liquid in the tank, the pump will not pick up the solids and pump them to the treatment and disposal field, which could clog the field.



Pump control circuits and manual disconnects must be installed in NEMA4X box.

❑ The pump float switches should be set so that the proper dosing volume of effluent is pumped each time the pump turns on and off. To set the height of the turn-on float at the right height above the turn-off float, divide the required dosing volume in gallons by the width and length of the tank and by 7.48 gallons per cubic foot. To put the height in inches, divide again by 12 inches per foot. See the following box for this formula.

> Height for turn-on float (inches) = Dosing volume ÷ [width (feet) x length (feet) x 7.48 (gallons per cubic foot) ÷ 12 (inches per foot)]

❑ The turn-on float should be no more than six inches below the high water alarm float switch. The high water alarm signals when the pump has failed to turn on and the liquid level is too high in the pump tank.

Manual disconnects. There must be a way to turn the pump on and off by hand without having to get into the pump tank or use special tools. This makes checking the pumping rate and setting the controls much more convenient.

Reference
15A NCAC 18A.1952(c)(6)

❑ Pump control switches typically have three positions: hand, off, and automatic. The hand position allows the serviceman to turn the pump on and off by hand, bypassing the automatic controls, to determine if the pump is working but the automatic controls have failed.

Reference
15A NCAC 18A.1952(c)(6)

❑ The pump circuits and float control circuits must have manual circuit disconnects located in a waterproof and corrosion-proof enclosure such as NEMA 4X or an equivalent enclosure such as a fiberglass or stainless steel box. The enclosure for the disconnects must be at least 12 inches above the ground and securely fastened to a strong post or other support. Installing the disconnects this way keeps them from corroding and stops surface water from entering the enclosure.

High-water alarm. The *high-water alarm* is required to warn the users that the sewage has risen too high in the pump tank, which can happen when the pump has clogged or failed to start. The following list describes high-water alarms.

❑ All pump tanks must have a high-water alarm system to warn the users that the water is above the pump turn-on level in the pump tank.

References
15A NCAC 18A.1952(a)
15A NCAC 18A.1952(c)(5)
15A NCAC 18A.1952(c)(9)

❑ A separate float switch or liquid level detector must be used for a high-water alarm.

❑ The high-water alarm must have its electrical supply ahead of the fuses or circuit breakers for the pump. Installing the power supply for the alarm ahead of the pump fuses allows the high-water alarm to work even if the pump has blown a fuse.

❑ The float switch for the high-water alarm should be set to come on when the liquid is no more than 6 inches above the pump turn-on level.

❑ The alarm must sound a warning signal and turn on an alarm light so that the system users know that the water level is rising in the pump tank. The alarm must be able to be seen and heard by the system users.

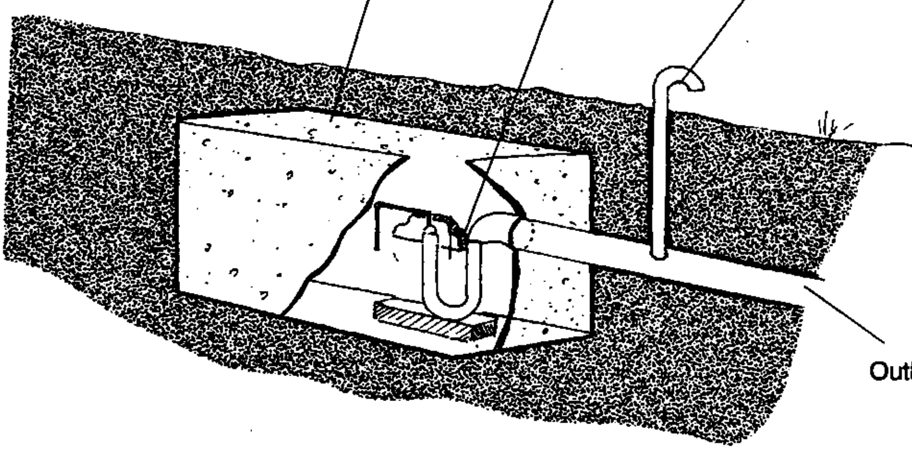
❑ High-water alarms must be installed in weatherproof enclosures such as a NEMA 4X enclosure or an equivalent.

Siphons

A siphon can be used to provide dosing of a treatment and disposal field when the field is at least 2 feet lower than the outlet of the siphon. The siphons used in on-site systems are self-starting or self-priming siphons that operate from the difference in height of the water in the tank and the height of the siphon outlet. The big advantages of self-priming siphons are that they do not require an electrical power supply to be installed, they operate automatically, they will operate during power failures, and they can very quickly dose the treatment and disposal field with the proper volume of effluent.

Siphons have several disadvantages. The treatment and disposal field must be 2 feet lower than the siphon outlet. Because self-priming siphons operate from the difference between the water level in the tank and the siphon outlet, it is not possible to use siphons to lift effluent to a treatment and disposal field higher than the outlet of the septic tank or over high spots. Siphons may be difficult to repair or service if they do not work properly.

Figure 5.7.4. Cut-away view of siphon tank.



Siphon Design

The following points describe the rules for the design and use of a wastewater siphon for an on-site system. Refer to Figure 5.7.4 for a cut-away view of a siphon tank.

Construction and installation. Siphon tanks must be constructed to meet the same structural requirements as pump tanks and septic tanks.

❑ All parts of the siphon and the discharge pipe must be corrosion-proof. They can be made of cast iron, high-density plastic, fiberglass, or equivalent materials.

❑ The siphon and the discharge pipe must be installed according to the factory directions.

❑ The inlet into the siphon tank must be at least 3 inches above the turn-on level for the siphon to make an air gap between the highest liquid level and the inlet. This air gap keeps the siphon from pulling sewage out of the septic tank.

❑ A 24-inch or larger riser must be installed over each siphon and the riser must extend at least to finished grade so that there is easy access to the siphon. The riser must be sealed at the tank, covered on top, and the soil around it sloped so that surface water cannot get into the siphon tank.

❑ There must be at least 12 inches of freeboard in the siphon tank. This space provides storage if the siphon fails to operate.

References

15A NCAC 18A.1952(d)

15A NCAC 18A.1952(d)(4)

15A NCAC 18A.1952(d)(2)

15A NCAC 18A.1952(d)(1)

15A NCAC 18A.1952(d)

15A NCAC 18A.1952(a)

Treatment and disposal fields. The following items must be considered when using a siphon to dose a treatment and disposal field.

❑ The treatment and disposal field must be at least 2 feet below the outlet of the siphon so that the siphon will discharge freely into an open pipe. Otherwise, the conveyance pipe could fill up and stop the siphon because the water flows too slowly through the pipe.

Reference

15A NCAC 18A.1952(d)(3)

❑ Siphon dose volume should fill the treatment and disposal field pipes from 66% to 75% of their capacity on each dose.

❑ Siphons operate on the difference in the water level in the siphon tank and the level of the siphon outlet. Thus, when the siphon is flowing, the flow rate through the siphon will vary as the effluent level drops in the siphon tank. The flow rate will be higher when the siphon first turns on and will decrease as the liquid level drops in the tank.

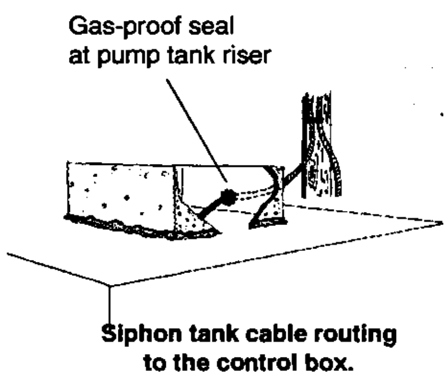
❑ The discharge pipe from the siphon must be large enough so that the pipe will not flow full even when the siphon discharges at its maximum rate. If the pipe becomes full, it may stop the siphon before the proper dose of effluent flows to the treatment and disposal field.

Reference

15A NCAC 18A.1952(d)(3)

Vent and discharge pipes. The discharge pipe from a siphon must have a vent that comes above the ground outside the siphon tank. The vent keeps the siphon from stopping if air is trapped in the discharge pipe.

❑ The vent also serves as an inspection port to determine if the siphon is working. An inspector can look down the vent pipe to see if effluent is flowing from the siphon or if the siphon is leaking.



❑ To keep insects and water out of the vent pipe, the end should be turned down and screened. Two elbows can be used for the turned-down end. The turned-down end should be easy to remove so that operators and inspectors can look at the flow from the siphon.

❑ The vent pipe must not go back into siphon tank or be installed so that it would be an overflow outlet when the siphon fails to operate. If an overflow were installed, then the wastewater would flow out the overflow and users would not know that the siphon is not working.

❑ *Overflow* outlets are pipes or openings that let effluent flow out of a siphon tank if the liquid level rises too high. Overflow outlets are not allowed on siphon tanks because the overflow outlets let the effluent drain out of the tank into the conveyance pipe continuously rather than in set doses. This continuous application of effluent to the treatment and disposal field can flood the field or cause it to fail. Overflow outlets should never be installed on a siphon tank.

High-water alarm. The *high-water alarm* is required to warn the users that the effluent has risen too high in the siphon tank, which can happen when the siphon has clogged or failed to start.

References

15A NCAC 18A.1952(d)(5)

15A NCAC 18A.1952(a)

15A NCAC 18A.1952(d)(1)

15A NCAC 18A.1952(d)(5)

❑ All siphon systems must have a high-water alarm system to let the users know that the water is above the siphon turn-on level in the siphon tank.

❑ A separate float switch or liquid level detector must be used for the high water alarm.

❑ The float switch for the high-water alarm should be set to come on when the liquid is 2 inches above the siphon turn-on level.

❑ The alarm must sound a warning signal and turn on an alarm light so that the system users know that the water level is rising in the siphon tank. The alarm must be visible and audible to the system users.

❑ High water alarms must be installed in watertight, corrosion-resistant enclosures such as a NEMA 4X enclosure or an equivalent enclosure.

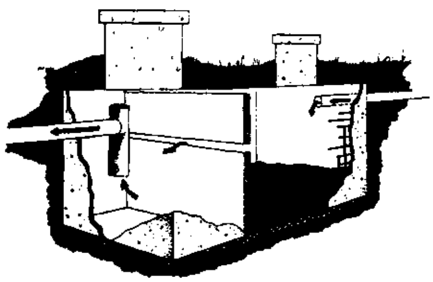
5.8 LONG-TERM OPERATION AND MAINTENANCE OF ON-SITE SYSTEMS*

Operation of On-Site Systems

Most on-site systems do not require much effort to operate and maintain. Even though the effort is small, the system must be maintained properly so that it operates reliably and at minimum cost. The following material presents ways to operate and maintain on-site systems properly.

Minimize sludge build-up.

The ideas listed here can help preserve an on-site system so that it operates as it should for many years. Most of these items are easy for homeowners to do.



Septic tank showing flow of sewage through the tank.

Kitchen. Keep as many solids out of the septic tank as possible, minimizing the need to pump out the tank.

The following tips reduce the solids in the septic tank that come from kitchen activities.

❑ Garbage disposals should not be used in on-site systems. The ground garbage adds large amounts of solids to a septic tank, causing sludge to build up very quickly.

❑ Grease and cooking oils should never be put into a septic tank. The grease and oil harden and may clog the inlet or outlet. Also, the grease makes the scum layer build up quickly in the septic tank, which will mean that the tank must be pumped more often. If grease and oil flow through the septic tank, the treatment and disposal field may become clogged with hard grease. If this happens, the field must be replaced.

❑ Coffee grounds also cause rapid build-up of sludge because the grounds decompose very slowly.

Bathroom. Solids in the septic tank can be reduced by using the following ideas.

❑ Items such as sanitary napkins, tampons, disposable diapers, cigarettes, facial tissues, and other solid or paper wastes should not be flushed into the on-site system. Because none of these materials decompose in septic tanks, they add to a rapid accumulation of solids in the tank. Wet-strength paper towels have nylon reinforcing fibers that will not decompose in the septic tank, which can cause clogging in drain pipes.

❑ On-site system owners should use a toilet tissue that easily breaks up in water to prevent clogging drain pipes or septic inlets or outlets. Test toilet tissue by putting a portion of tissue in a jar half full of water and shaking the jar. If the tissue breaks up easily, it will work well in the on-site system.

Miscellaneous. The following can reduce solids buildup in the septic tank.

❑ Used motor oil and other such oily liquids should not be put into a septic tank. These oils can build up in the septic tank or clog the treatment and disposal field.

❑ Cat box litter, mud, and grit from cleaning automobile or machine parts are mineral materials that do not degrade in a septic tank and fill the tank at a faster rate than is necessary.

**Information on long-term operation and maintenance for on-site systems was adapted from the following publications:*

Sponenberg, T.D., Kahn, J.H., and Sevebeck, K.P. 1985. A Homeowner's Guide to Septic Systems. *Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg, VA.*

Hoover, M. T. 1990. Soil Facts: Septic Systems and Their Maintenance. *AG-439-13. North Carolina Agricultural Extension Service, North Carolina State University, Raleigh, NC.*

White, Amy. 1989. Septic Systems, part of the Clean Water Series. *Series produced as a cooperative effort of the Delaware Nature Society, the Delaware State Federation of Woman's Clubs, and the US Environmental Protection Agency through the Delaware Department of Natural Resources and Environmental Control and the New Castle Conservation District.*

Use Less Water

The volume of water which must be absorbed by the treatment and disposal field has a big effect on how long the field lasts. By reducing water usage, less water flows to the field, giving the field more time to recover for the next load of effluent. The following is a list of suggestions for using less water.

- Simply teaching all those living in the home to use less water can reduce the amount of water flowing to the treatment and disposal field. Save water by turning off the water while doing something that does not require a constant flow of water.
- Water-saving fixtures and devices can be installed on sinks, toilets, and showers to reduce the rate at which the water flows from the fixture.
- Dishwashers and washing machines should only be run with full loads. These appliances use the same amount of water whether they are full or not.
- Leaky faucets and toilets can add large volumes of water to the daily flow of water into the on-site system. Repair the leaks to save water and give the treatment and disposal field a rest.
- Homeowners can effectively reduce the amount of water used in the home by taking short showers. Showers longer than 5 to 10 minutes use too much water. Low-flow showerheads reduce the rate of water flow. On/off buttons on the showerhead can save much water because they allow the user to turn off the water while soaping up and back on again to rinse, without having to readjust the temperature.
- Roof drains, basement sump pumps, foundation drains, and other such drains should not empty into the on-site system. These drains should be directed to another part of the lot away from the treatment and disposal field.
- Other ways to save water include taking showers instead of baths and not flushing the toilet to dispose of facial tissues or other items that should be put into wastebaskets.

Protect the Treatment and Disposal Field

The treatment and disposal field is the most expensive part of a conventional on-site system. It pays to protect the field so that it works reliably for the longest time possible.

- If a new treatment and disposal field is being installed, be sure that it is installed properly and with adequate trench length. Installing more trench length than is required by the regulations may pay off because the larger field does not need to work as hard as the smaller field.
- Large trees and shrubs should be kept reasonable distances from the field to prevent problems with roots clogging or crushing trench pipes.
- Vehicles and construction equipment should not drive over the field. The weight of the vehicles could crush the trench pipes or break a conveyance pipe.

Keep the Bacteria Working

Bacteria in the soil around the treatment and disposal field trenches are the key to proper treatment of the sewage. If these bacteria are killed or missing, the effluent will not receive proper treatment and will cause pollution of ground water or surface streams. Also, bacteria in the septic tank help to decompose some of the solids, which can increase the times between pumping.

- No poisons, synthetic chemicals, or other substances that can harm the on-site system should be dumped down the drain.

❑ Substances such as pesticides, herbicides, weed killers, disinfectants, acids, medicines, paint, paint thinner, solvents, chemical cleaners, photographic solutions, and other similar substances should not be put into the drains. These substances can be taken to a hazardous waste disposal site in most localities.

Monitoring On-Site Systems

The homeowner or user of an on-site system should monitor the system for performance and maintenance. Making measurements on a on-site system is easy and the results give the user valuable information on the state of the system.

General Observation of On-Site Systems.

Making a general inspection of the overall on-site system can provide important information used to prevent failure and costly repairs.

❑ Watch as water drains from sinks, tubs, and toilets. If the flow is sluggish, the pipes or the septic tank inlet or outlet may be clogged.

❑ Check the treatment and disposal field area. Look for wet spots or mushy ground. Also sniff for odors. All of these are indicators that the field may be malfunctioning. A properly operating on-site system should not have wet spots, mushy ground, or foul odors.

Perform measurements and inspections annually. To be sure that the on-site system does not become clogged beyond repair or create other nuisance problems, the measurements and inspection described above should be done once each year. Inspect the system and measure the scum and sludge during the wettest time of the year, which will show how well the system performs under the worst conditions. In North Carolina, winter is the wettest time of the year for most areas of the state.

Sludge and Scum Measurements

The sludge and scum in a septic tank will build up at different rates. Two simple measurements can determine how much sludge and scum has accumulated and whether the tank must be pumped out. To make the measurements, the manhole over the septic tank outlet must be uncovered and opened. The following directions indicate how to measure the thickness of the scum layer and the depth of sludge in the tank. **DO NOT ENTER THE TANK.**

1. To measure the thickness of the scum layer, nail a 6-inch square flat board to the end of an 8-foot stick. Using the end of the stick with the flat board, push the stick through the scum layer. Then, move the stick over to the outlet and lift up so that the flat board catches on the bottom of the sanitary tee or outlet pipe. Hold the stick with the flat board on the bottom of the sanitary tee and mark the stick to show how deep the outlet of the sanitary tee is.

2. Next, move the stick away from the sanitary tee and gently raise the stick until you feel increased weight on the stick when the flat board is at the bottom of the scum layer. Mark the stick to show the depth of the bottom of the scum layer.

3. If the two marks are closer than 3 inches, then the septic tank should be pumped. Otherwise, the scum will begin to flow out the outlet and clog the treatment and disposal field.

4. To measure the amount of sludge, use the same 8-foot stick. Push the stick into the septic tank until the stick contacts the bottom of the tank. Mark the stick to show how deep the tank bottom is.

5. Now, remove the stick from the septic tank and wrap an old piece of bath towel around the bottom 3 feet of the stick. Push the stick with the towel wrapped around it into the tank until the stick is on the tank bottom. Twirl the stick a few times and let the stick stand in the tank for a minute or so. Remove the stick and look for the line of black particles on the bath towel. This line is the top of the sludge layer.

6. If the distance between the top of the sludge layer and the bottom of the sanitary tee is less than 12 inches, the tank should be pumped. If the tank is not pumped, sludge may begin to flow out the septic tank outlet and can clog the treatment and disposal field.

7. After inspecting the tank, immediately replace all lids and covers.

Routine Upkeep and Maintenance

All wastewater treatment and disposal systems, including on-site systems, must have certain maintenance performed to keep them operating properly. Fortunately, maintenance for most conventional on-site systems is easy and inexpensive. The following list provides information on routine upkeep and maintenance.

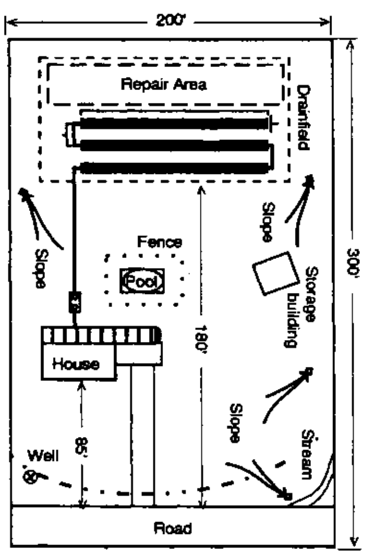
Drawing of the on-site system. Perhaps the easiest and one of the most important ways to maintain the on-site system is to make a diagram of the entire system (see drawing at left). The following lists what should be included in the diagram.

Reference
15A NCAC 18A. 1961(a)

❑ The diagram should show the location, depth, and size of the septic tank, distribution device, and the field trenches.

❑ Be sure to include the location of the repair area.

❑ Use a permanent benchmark such as a large tree, power pole, or corner of the house to locate each part of the system. Write the distances from the benchmark on the diagram of the system.



Layout of system.

Access risers. The harder it is to get to a system, the less likely maintenance will occur. To increase the chances of maintenance being done, make it easier to get to the septic tank and distribution device. Putting risers over the tank and the distribution device allows easy access for the user. Also, the homeowner or on-site system repairman will not have to spend time and effort trying to locate the septic tank and digging to get to the access covers.

❑ A riser over the septic tank outlet makes it easy to measure the sludge and scum layers and to check the condition of the outlet tee.

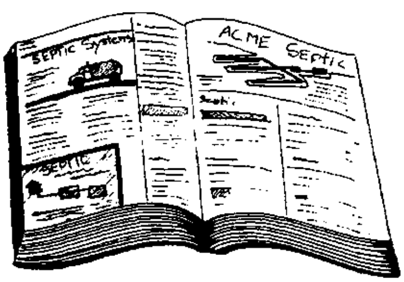
❑ The septic tank inlet can be checked and clogs in the house sewer removed more easily if a riser is installed over the inlet.

❑ A riser over a distribution box, a tipping distribution box, or a flow splitter can be very helpful if troubles develop with an on-site system. A quick check of the distribution device can help determine if plugging is in the treatment and disposal field or in the conveyance piping.

❑ All risers should be installed so that they are watertight. Riser covers should be secured by padlocks or chains to prevent access by children or others who may be in danger if the risers are opened.

Reference

15A NCAC 18A. 1961(a)



Septic tank pumpers can be found in the yellow pages.

Pump the tank. All on-site systems using septic tanks must have the tank pumped on a regular schedule. Even though bacteria decompose some of the solids, they still build up in tanks.

❑ The tank must be pumped out before the solids begin to flow into the field. The field will clog rapidly if this basic maintenance is not performed.

❑ How often a septic tank needs to be pumped out depends on how fast the solids build up in the tank, which is influenced by:

- The size of the tank.
- The daily flow of sewage.
- The amount of solids in the sewage.

❑ The number of people in a household is a common way to determine how often the tank should be pumped.

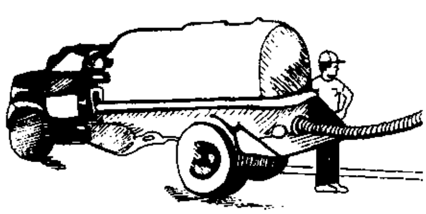
❑ The rate of solids build-up can be measured as described above in *Sludge and scum measurements*. After a few measurements are made over several years, the user can judge how fast the solids are building up and when the septic tank will need to be pumped. If the scum layer is within 3 inches of the bottom of the outlet tee or outlet baffle, the tank should be pumped. If the sludge has built up to within 12 inches of the bottom of the outlet tee or outlet baffle, the tank should be pumped.

Use Table 5.8.1 to determine a rough estimate of how often the tank should be pumped. Remember, the listings in the table are only rough guidelines.

Table 5.8.1 Estimated Time for Pumping a Septic Tank (in Years)

Tank Size (gallons)	Number of People Using the On-Site System: 1	2	4	6	8
	Number of Years				
900	11	5	2	1	1
1,000	12	6	3	2	1
1,250	16	8	3	2	1
1,500	19	9	4	3	2

Adapted from Mancl, K. 1984. *Estimated Septic Tank Pumping Frequency*. Journal of Environmental Engineering, 110.



Septic tank pumper truck.

❑ To properly pump out a septic tank, the following procedure should be used.

1. The pumper should first pump out enough liquid to lower the level in the tank to below the entrance to the outlet. Lowering the level keeps the solids and scum from overflowing through the outlet as the tank is being cleaned.
2. Next, the pumper should pump some of the liquid back into the tank to mix the sludge and scum so that all of it can be removed. Sometimes the scum layer may be hard and may need to be broken up with compressed air or with a long-handled shovel. The pump will not be able to remove hardened sludge and scum without being broken up first.
3. After the solids and scum are mixed with the water, the entire contents of the tank is pumped into the tank truck.

4. Some pumpers like to leave a little of the mixed solids and water in the tank "to start the bacteria working again." Because the bacteria will start again by themselves, it is better to have it all pumped out.
5. When the tank is empty, check the inlet and outlet to see if they are damaged or clogged. Replace or repair broken inlets or outlets. Also, check the septic tank baffle to be sure that it is in good condition.
6. Have the septic tank pumper clear out the distribution box, if one is used, to remove any solids that may have built up in the distribution box and to keep it from clogging. Once the distribution box is empty, check to see whether it needs repair or whether it should be re-leveled or the speed levelers adjusted.
7. Put the covers back on the septic tank and fill in the holes dug to get to the covers or secure the covers on the risers. Never go into a septic tank or let anyone else into a septic tank. Septic tanks can be filled with poisonous gas that can kill people.

Vegetation. The field will work best if there is a strong stand of grass or other plants over the trenches. The plants keep the soil from eroding and help to take up some of the water from the effluent.

Drain water away. The treatment and disposal field can be overloaded with water from surface drains, roof drains, or runoff from other areas makes the job harder. There are a number of ways to direct water away from the field. Two are listed below:

- ❑ Use a *diversion*, a combination of a small dike and a channel, to catch water flowing on the ground and move the water away from the field. Place the diversion on the sides of the field where water flows in. The channel should be on the outside of the diversion so that the water flows into the channel and around the field. The outlet of the channel should be in an area below the field.
- ❑ Install roof drains and other such drains so that they empty water into areas away from the field where it will not flow back onto the field.

No traffic. On-site systems are not made to withstand heavy loads such as cars, trucks, and other heavy equipment. Pipes and septic tanks can be easily broken, and are very expensive to repair or replace. Route all traffic around the on-site system.

In addition, the soil around the trenches cannot absorb effluent if the soil is compacted by driving over it with cars and other equipment. Keep all activity on the field to a minimum to prevent soil compaction and possible system failure.

No construction. On-site systems must dispose of a large amount of water every day. Constructing various things such as house additions, driveways, garages, or swimming pools near or over an on-site system can cause problems. If the on-site system needs repair, it will be very difficult to locate and get to the system if it is under part of the house or under a driveway. Also, a driveway can reduce the amount of water the on-site system can handle because there is no vegetation over the treatment and disposal field to help take up water. The following two points should be considered when constructing a system.

- Keep the repair area free of construction because it may be needed one day in the event of failure.

- Keep in-ground pools away from an on-site system because of the potential for effluent to seep into the pool.

No additives. Hundreds of substances are sold that claim to help the septic tank decompose solids or prevent clogging. None of these additives can prevent failure of the on-site system. In fact, some additives can be harmful to the bacteria in the septic tank and in the treatment and disposal field and can pollute the ground water. Some of the chemicals in septic tank additives have contaminated drinking water wells, making the water unfit for drinking.

Additives containing the following chemicals should not be used because these chemicals are not decomposed in an on-site system. The chemicals will simply flow through the on-site system and into the soil, possibly contaminating the ground water.

Acrolein	Naphthalene
Acrylonitrile	Pentachlorophenol
Benzene	Toluene
Benzidine	Trichloroethylene
Carbon tetrachloride	Trichloroethane
Halogenated benzenes	Trichlorophenol
Methylene chloride	

Indicators of Problems

Reference

15A NCAC 18A. 1961(a)

Most on-site systems function as they are intended for long periods of time with only little attention or maintenance. However, systems can encounter problems or fail outright. Few of these on-site systems fail suddenly. Usually a failure starts as a small problem and continues growing until the problem is too large to ignore.

On-site system failures take place over a long period of time. Problems can be discovered early by performing regular inspections, thus preventing a failure of the full system.

On-site systems fail in two ways:

- Systems can fail because the treatment and disposal field cannot absorb the daily flow of water. This type of failure is the most common (see drawing at left).

- The second type of failure is when the effluent is not being treated by the soil to remove the pollutants and bacteria. Ground water and even water in streams, lakes, or bays may be polluted by on-site systems that are not treating the effluent. This type of failure is much harder and usually much more expensive to detect.

The following situations can help determine if an on-site system is not functioning properly.

Surfacing effluent presents hazards to children.

Ponding of water and muddy or mushy areas over or near the treatment and disposal field. The most common indicator that an on-site system cannot handle the daily flow of water is that a puddle or muddy area forms over or near the field. Discovering the cause of the problem is often difficult. If the residents have added new appliances such as a dishwasher or a garbage disposal, too much water may be entering the field. Likewise, leaking faucets or toilets can allow large amounts of water into the on-site system. Also, surface water may be running onto the field from other yards or from roof drains. The cause of the problem must be determined for the system to work properly.

Slow drains. Drains that run slowly may indicate that the treatment and disposal field is failing or that the septic tank outlet or conveyance pipes are clogged. If the problem is in the on-site system, all drains in the house will be slow. If only one drain is slow, chances are that the house plumbing is clogged.

Odors. A properly operating on-site system should not give off any odors. The system is not working right if it can be smelled.

High bacteria levels in ground water or in a stream, river, lake, or bay. The presence of high bacteria requires a laboratory analysis to determine the number and type of bacteria present in a water body. The water from on-site systems flows with shallow ground water and eventually discharges into streams or rivers at a point lower than the on-site system. If the soil is not filtering out the bacteria, then bacteria can be carried into the stream.

High levels of nitrates, phosphates, detergents, or other chemicals in ground water or in a stream, river, lake, or bay. Another indicator of a problem that requires a laboratory analysis is the presence of high levels of nitrates, phosphates, detergents, or other chemicals. Depending on the pollutant in the water body, the cost of the analysis can range from moderate to very expensive. This indicator means that the soil in the area cannot treat the pollutant that is being found in the ground water or stream.

Troubleshooting to Improve System Performance

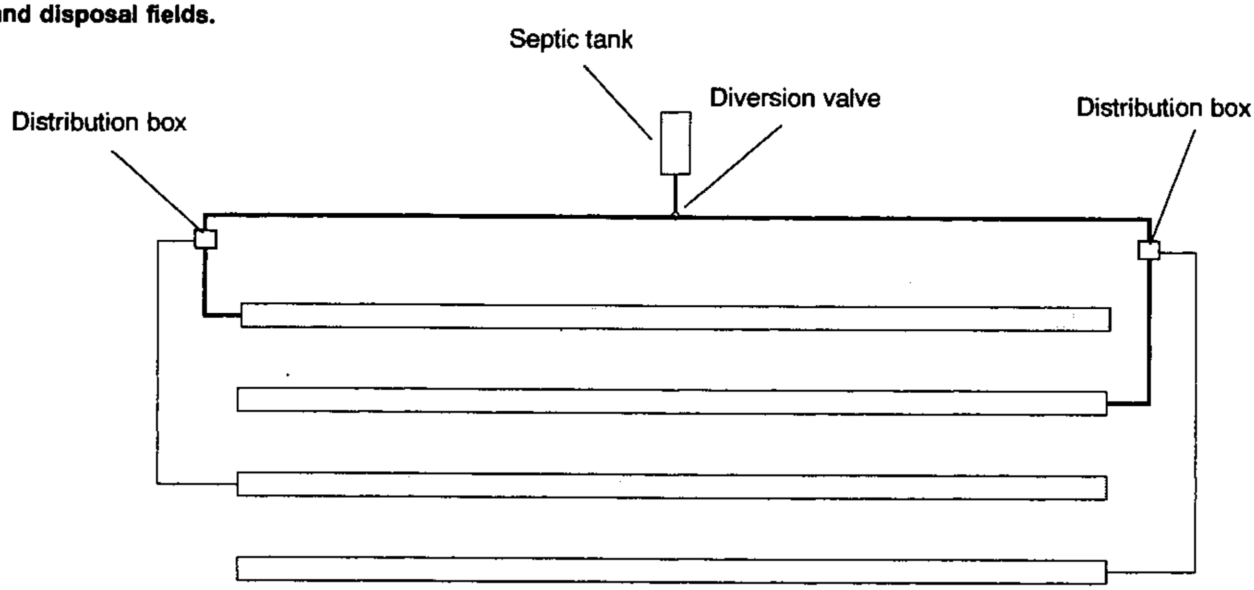
If an on-site system is not functioning well, a deliberate and systematic approach is needed to find the trouble and correct it. A few things can be checked quickly that can possibly correct a system failure. This section contains information on how to check or repair a system.

Alternate the treatment and disposal fields. If the system has dual fields and the field that is being used has a wet area, switch the diversion valve to the other field. Switching fields may allow the first field to recover so that it can absorb the daily flow of effluent when it is time to alternate the fields again (see Figure 5.8.1).

Level the distribution box. Many systems have wet spots over one treatment and disposal trench, usually because the distribution box has shifted in the ground and one trench, the wet one, gets all the effluent and the others are dry. A level concrete pad under the distribution box is a permanent cure for a shifting distribution box. Another option is to install invert adjusters and correct the discharge elevation.

Install plastic tees in the septic tank outlet. The original tee in the septic tank may have corroded or is broken. When this happens, solids from the tank move into the field and can cause clogging. Replacing the tee with a plastic PVC tee is good insurance against solids getting out of the septic tank.

Figure 5.8.1. Schematic diagram of alternating treatment and disposal fields.



Check water use. Read the water meter early in the morning and later in the day to give a good indication whether the users are putting too much water into the on-site system. Water may be leaking from faucets or from a toilet, or the users may have recently installed a washing machine or a dishwasher or other water user that is overloading the on-site system. Also, while all water-using fixtures are off, check the water meter to indicate leaks.

Check on hot tubs and whirlpool baths in the house. These appliances not only need a lot of water to be filled, but they can cause problems with on-site systems when they are emptied. When homeowners drain the hot tub or whirlpool rapidly, a large amount of wastewater flows into the on-site system quickly. Also, draining the hot tub rapidly stirs up the solids in the septic tank, which can cause clogging in the treatment and disposal field.

Check on the amount of water being used for laundry. Increased flow to the on-site system caused by a sudden increase in laundry may overload the system. The homeowner may be able to avoid expensive repairs by using a laundromat until the amount of clothes washing drops off. Also, the homeowner may only need to take clothes to the laundromat during the winter wet season.

Repairs and Remedies for On-Site Wastewater Systems

8

Repairs and Remedies for On-Site Wastewater Systems

8.1 ON-SITE WASTEWATER SYSTEM REPAIR

When on-site systems fail, the key to repairing the system is to use a systematic, or logical, approach to determine the problem. This chapter presents a logical approach to finding what has gone wrong in the system and suggests remedies for the failure.

Systematic Problem Identification

Listed below are steps used to determine why a system is failing. The basic idea is to check the easy things first and then go to the more difficult items if the problem is not fixed.

As defined by the Laws and Rules for Sewage Treatment and Disposal Systems,

"Sewage" means the liquid and solid human waste and liquid waste generated by water-using fixtures and appliances, including those associated with food handling.

"Effluent" means the liquid discharge of a septic tank or other sewage treatment device.

Reference
15A NCAC 18A.1935(11)(39)

Permit information.

Locate the improvement permit, approval form, operating permit, or other forms that contain information about the system design and system layout. The original permit may be hard to find, depending on the filing system. If permits are filed by address, it is easier to find the right permit, even if the house has changed owners several times.

- ❑ The original site and soil evaluation may contain valuable information to help determine what is not working.
- ❑ Look to see if the design included a pump to distribute the effluent to the treatment and disposal field. If a pump is included, check the head or discharge pressure needed to lift the effluent to the treatment and disposal field.
- ❑ Check the proposed delivery rate from the pump to the treatment and disposal field.

Determine the type of failure.

The type of failure can indicate, to a large extent, what is causing the problem. To properly determine the type of failure, a field inspection must be done.

❑ Surface discharges can indicate which part of the system is failing. Note where the discharge is and appears to be coming from. Is the discharge:

- over the septic tank?
- over the pump tank?
- over the distribution box, tipping distribution box, or flow splitter?
- over the treatment and disposal field? What part of the field?

❑ Are drains backing up into the house?

❑ Do fixtures in the house drain slowly?

❑ Is the problem occurring only in the wet season, after heavy rains, or throughout the year?

❑ Does the problem occur only on weekends, or every day?

❑ Is the effluent flowing at the failure site or is it a small wet spot that soaks back into the ground?

❑ Has the system operated well for a number of years and failed just recently, or has it been failing for a long time?

Check the easy things first.

The cause of the on-site system failure often can be determined easily without complicated tests. Some failures may mean that complicated tests must be done, but many problems can be solved by checking the easy things.

❑ If the water is backing up into the house or the toilets are flushing slowly, check for clogged plumbing first. A clog in the drain or house sewer going to the septic tank may be the problem.

❑ Plugged plumbing vents, located on the roof of the house, also cause slow drains. Once the vent pipes are cleared, it may be helpful to put a screen over the vent pipe to keep out insects and birds.

❑ If the house drains and roof vents are not plugged, check the septic tank. Uncover the access hatches and check for a clogged inlet or outlet.

❑ If the inlet is clogged with solids, the house sewer coming into the tank may need to have more slope, may need replacing with a larger pipe, or may have collapsed and need replacing.

❑ A clogged outlet may mean that the outlet has broken or that the solids need to be pumped out. A *gas deflector*, a plate of stainless steel or rigid plastic installed below the outlet entrance, may help deflect solids that rise into the outlet and plug it.

❑ If the tank is completely full of solids and scum, it must be pumped. The residents must be informed that septic tanks should be pumped on a regular schedule. Pumping the tank keeps it from plugging and protects the treatment and disposal field from clogging with solids.

❑ Distribution boxes can also be easily checked. Uncover the distribution box and check for clogs and excessive solids in the box and for unequal distribution of flow to the outlets.

❑ Check to see if the distribution box is out of level. Re-level as needed.

❑ Distribution boxes can help determine which part of the system is having the problem.

- Clear water flowing through the distribution box may indicate leaking fixtures and excessive water use.
- Solids in the distribution box mean that the septic tank outlet is not keeping the solids in the tank or that the tank is too full of solids and needs to be pumped.
- If no effluent is flowing to the distribution box, then there is a clog in the conveyance pipe to the distribution box, in the septic tank, or in the house plumbing.
- If the box is flooded, the effluent is not flowing out of the box to the treatment and disposal field, indicating that the problem is either in the conveyance pipes going to the treatment and disposal field or in the treatment and disposal field.

❑ In systems that pump to a conventional treatment and disposal field, check to see if the pump is working.

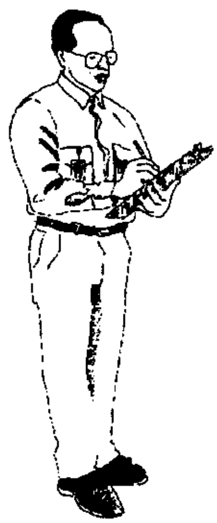
❑ In Low-Pressure Pipe (LPP) systems, check the pump, the water level in the pump tank, and the water level in the septic tank.

If these quick checks do not indicate what the problem is, the following sections may help determine why an on-site system is failing.

Determine the sewage volume.

The volume or total daily flow of sewage going to a system can cause it to fail if the system was designed for a smaller flow.

❑ Find the original design flow or expected daily flow of sewage. This information should be on the permit or other approval forms.



Keeping detailed records is important in determining the cause of a failure.

❑ There are several ways to find the actual flow into the on-site system. An easy way is to check the water bills for records of water used. This is a good indication of how much water is going into the on-site system unless there is a leak that drains somewhere else, such as under the house.

❑ If the water bills do not help, keep a record of the water meter reading over a period of time, say a month or two. If you are keeping records of the water meter reading, be sure that the plumbing is not leaking into the ground outside the house. Water from a leak outside the house will not go into the on-site system.

❑ The water meter should be checked as frequently as possible; once each day may be necessary. If the water meter has a dial or pointer that indicates small volumes, see if it turns when no water is being used. This is a sure sign of a leak.

❑ Study the records of water use to find if there has been an increase in flow to the system. Leaking faucets and toilets can add large amounts of water to the daily flow of sewage, causing the on-site system to fail.

❑ Has a water-using appliance been installed or added to the household recently? A system that was not designed for high flows may fail when a washing machine or dishwasher is added.

❑ Have the water use habits in the home changed? A new baby can greatly increase the amount of water used in washing clothes, or teenagers can spend long amounts of time in the shower, which increases the total sewage flow.

❑ Have the residents changed the use of the washing machine? Are they washing clothes once per day when they used to wash once per week? Sometimes an on-site system fails if the residents take in wash or if they wash all of their laundry on one day of the week. The residents can try washing one load each day, as opposed to all loads in one day.

❑ Has the use of the home changed? For instance, has a business that uses water been started? Businesses such as day care centers, beauty shops, taxidermy shops, and hobbies such as photograph processing can cause problems.

❑ Has water been added to the daily sewage flow in other ways? Examples are:

- sump pump installation which discharges into sanitary drain,
- roof runoff from downspouts connected to sanitary drains,
- foundation drainage flowing into sanitary drain,
- heat pump discharging ground water into sanitary drain,
- water softener recharge brine flows into septic tank,
- swimming pool filter backwash water discharged into septic tank,
- ice machine adds to daily sewage flow,
- industrial wastewater added to domestic wastewater flow,
- commercial wastewater added to domestic wastewater flow, and
- floor drains adding water to daily sewage flow.

Check topographic and landscape factors.

A number of features of the land can cause an on-site system to fail.

❑ Observe the density of development around the failing on-site system. Make a note of the lot sizes and the shape of the lot with the failing system. The density and lot shape may be important in deciding how to repair the system.

❑ Find out how other systems in the area are performing. This information can indicate how well the soil can absorb the sewage.

❑ Study the topographic position of the failing system. Is it at the base of a hill where surface drainage from the hill could flow onto the treatment and disposal field? On long slopes, water can flow several hundred feet through the soil and flood an on-site treatment and disposal field.

❑ Is the treatment and disposal field downstream from a large drainage area where the water drains onto it?

❑ Do roadside ditches, swales, or other channels drain water onto the treatment and disposal field?

❑ Does ground water flow into the treatment and disposal field or does the water table rise in wet weather, causing a failure?

Check house location.

The location of the house is very important in some on-site system failures.

❑ Does water from roof drains or downspouts drain onto the treatment and disposal field? Sometimes water from downspouts can be drained to a dry well that is close to the treatment and disposal field, which could add water during wet weather.

❑ Look for drainage from other impervious surfaces such as driveways, patios, pools, or pool backwash that may flow onto the treatment and disposal field.

Note slopes.

Installation of on-site systems on sloping lots requires careful attention for a properly functioning system.

❑ Were stepdowns or drop boxes installed on the treatment and disposal field trenches?

❑ Was the treatment and disposal field installed in an area with so many slopes and hills that it is impossible to put the trenches on the contours? Good installation is very difficult in certain areas.

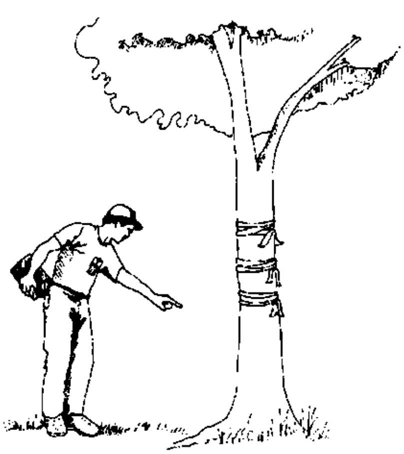
Note cut or excavated areas.

If topsoil has been removed in an area, on-site systems will not operate properly. Usually, these areas have much less capacity to absorb and treat the effluent once the topsoil is gone.

❑ Try to find out if the system was placed in an area that had been excavated and the soil removed. Subsoil and saprolite are not the best soils for on-site systems.

❑ Check for cut or excavated areas downslope from the system. Effluent may be coming to the surface in the cut area after it flows downhill from the treatment and disposal field.

❑ Old farming terraces upslope can trap rain water, causing the soil downslope to become saturated.



Certain trees can cause failures in on-site wastewater systems.

Check location and types of trees.

Tree roots can clog treatment and disposal trench pipes, causing the system to back up.

❑ Are roots clogging the pipes or outlet holes in the pipes? If you can inspect a pipe in a trench you may be able to see if roots are a problem.

❑ Another way to determine if trees are causing a problem is to remove one or more trees and see if the amount of saturation in the trenches decreases.

❑ LPP systems can fail if the holes in the pipes are clogged with roots. Here the effluent cannot flow at the design rate from the pipes into the treatment and disposal field.

❑ These trees can cause problems for on-site systems:

Willow	Tulip Poplar
Willow Oak	Some Maples
Elm	Sweet Gum

❑ These trees do not harm on-site systems. They do not need to be cut if the on-site system is failing:

Hickory	White Oak
Dogwood	Sourwood

Evaluate site and soil properties.

An on-site system must have a soil that can absorb the effluent flowing into the system. Also, the information from a proper soil evaluation can determine if the site can be used to repair a treatment and disposal field that has failed.

Soil borings can provide much information about a failing system.

❑ Determine the types of soil present. Use soil borings, textural determination, and other techniques to determine the type of soil. Complete a soil evaluation and fill out an evaluation sheet.

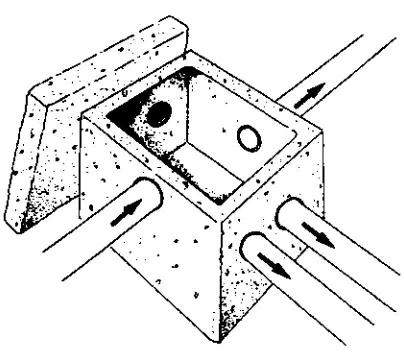
❑ Determine the appropriate loading rate, or acceptance rate, for the soil. This is the volume of effluent the soil can absorb in a day's time. Check the following items:

- soil depth,
- soil wetness,
- soil characteristics or morphology,
- restrictive horizons,
- changes in soil characteristics either with depth or over the treatment and disposal field area,
- loading rate for the trench bottoms,
- loading rate for the entire area of the treatment and disposal field, which is the volume of effluent per square foot of the field, and
- loading rate along trench length, volume of effluent per foot of trench.

❑ Determine which type of on-site system will fit the site and soil conditions and the available area.

Investigate distribution devices.

Determine if a distribution device, such as a distribution box, flow splitter, or pressure manifold, is causing the problem.



Concrete distribution box.

❑ Uncover the distribution box on a conventional system and check the conditions in the box. These conditions tell whether the problem is upstream or downstream of the distribution box.

❑ If no effluent flows into the distribution box, then the septic tank is clogged and the effluent cannot flow out of the tank.

❑ If effluent is overflowing the distribution box, then the treatment and disposal field trenches are higher than the distribution box or the trenches are clogged or completely ponded.

❑ If too many solids are in the distribution box, the outlet on the septic tank may be broken or may have fallen off.

❑ If some treatment and disposal trenches are receiving too much effluent and other trenches are receiving none, then some trenches are overloaded because the box has settled unevenly. Re-install the box so that it is perfectly level. A concrete pad under the box is a good way to keep the box level. The pad should be 2 1/2 inches thick and 6 inches bigger than the box on all sides.

❑ For pressure manifolds, check the water level in the pump tank and the pressure head in the pump discharge pipe downstream of the gate valve.

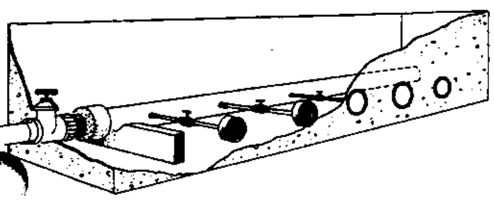
❑ If the pressure head in the discharge pipe is high, the holes in the treatment and disposal field trench pipes may be clogged. The clogged holes keep the effluent from flowing easily into the trench.

❑ Low pressure head in the discharge pipe can mean that a conveyance pipe is broken or that the gate valve is clogged or improperly adjusted.

❑ Check the pump counters to see if they are receiving the correct impulse and if the pumps run for the correct amount of time.

❑ Check the pumps, controls, floats and alarms to see if they are functioning correctly.

❑ Check the actual wastewater dosing volume to see if it is the same as or close to the design dosing volume. Use the following method:

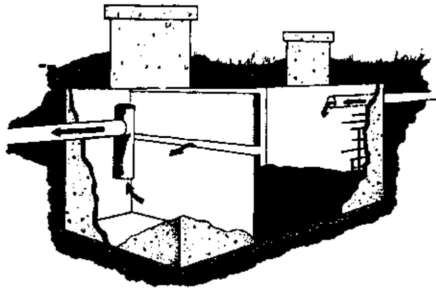


Pressure manifold.

1. Measure the length and width of the pump tank. Measure the water level.
2. Turn on the pump so that it runs the amount of time needed to properly dose the treatment and disposal field. Measure the drop in the water level in the pump tank.
3. Using the length and width of the tank and the drop in water level, calculate the volume of effluent pumped into the treatment and disposal field. For example, if the pump tank is 10 feet long and 5 feet wide, then the area of the tank is 50 square feet. When the water level drops 1/2 foot because the pump is running, the volume of water pumped to the treatment and disposal field is 50 square feet by 1/2 foot, which equals 25 cubic feet of water. Multiply 25 cubic feet of water by 7.5 gallons per cubic foot to get 187. 5 gallons of water dosed to the treatment and disposal field.
4. Compare the volume of effluent actually pumped in this test to the design dosing volume. If the dosing rate is higher than the design dosing volume, then the pump running time should be shortened so that the proper volume of effluent is dosed to the treatment and disposal field.

Investigate the septic tank.

The inspection of the distribution device may suggest that the septic tank is not functioning well.



Cut-away view of operating septic tank.

❑ Inspect the septic tank inlet. Check the inlet to see if it is clogged and make sure sewage is flowing to the septic tank. A clogged inlet or crushed inlet pipe will cause sewage to back up into the house.

❑ Inspect the septic tank outlet. Is the outlet broken or clogged?

❑ Is the outlet working properly, holding back the solids, grease, and scum? Measure the depth of the scum layer and the solids to see if either is flowing into the outlet.

❑ If the outlet is full of solids and grease because too much solids and grease have accumulated in the tank, then the tank must be pumped out.

❑ Check the depth to the top of the tank. If the tank is too deep, the effluent may have to flow uphill to reach the treatment and disposal field, causing the sewage to back up in the septic tank. This problem occurs only in new systems; if the system has worked for a number of years, this condition should not be present.

Find the treatment and disposal trenches and determine the amount of ponding.

Many on-site system failures occur because the treatment and disposal field is not handling the effluent properly.

❑ Do not dig an open hole in a trench and leave it open. Open holes can spread bacteria and disease.

❑ Observation tubes can be installed to check the water level in the trenches. These tubes are vertical, open-ended pipes with one end in the trench and the other end sticking above the ground and covered by a removable cap. By removing the cap and looking or measuring down the observation tube, the water level in the trench can be easily observed and measured. By measuring the depth of water and how long the water stays in the trench, you can get an idea of whether the trenches are clogged.

❑ If the water level in the trench rises quickly and drops rapidly, the trenches are not clogged. The treatment and disposal field is being overdosed with effluent and some of the effluent is ponding.

❑ If the water level rises quickly and drops very slowly or continues to rise, then the trenches are clogged and will need to be repaired or replaced.

❑ Use the observation tubes to determine if the trenches are flooded permanently or only temporarily.

❑ If effluent is ponding on the ground surface, find out if the ponding is permanent or if it only happens during wet periods, after heavy use, during certain days of the week, etc.

❑ Is one part of the treatment and disposal field being overloaded? A distribution box that has shifted may direct all the effluent to one trench.

❑ Look for changes in the soil across the treatment and disposal field, especially for soil types that cannot absorb much effluent.

❑ Are the trenches too deep? Have the trenches been installed below the seasonal high water table? Is there a perched water table under the treatment and disposal field that may restrict the flow of effluent away from the trenches?

❑ For serial distribution systems, check the step downs or drop boxes to see if they have been installed properly and are functioning well.

❑ Have the trenches been installed so that they run up a hill or are not on the contour? Is there too much fall on the trenches so that the effluent runs to the end of the trenches?

❑ In areas with very uneven ground, be sure that the trenches have been placed deep enough so that the trench is not too shallow in low spots.

❑ If effluent is surfacing somewhere other than over the treatment and disposal field, it may mean that a utility trench has been cut across the treatment and disposal field. Effluent flows through the loose backfill in underground electrical, cable TV, telephone or water lines, and surfaces in a low spot along utility trenches.

The utility trench should be moved so that it does not cross the treatment and disposal field.

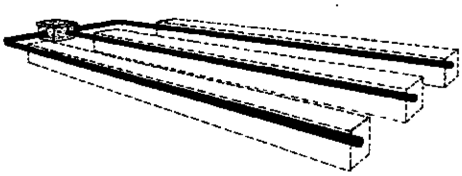
❑ If effluent is discharged from only a few holes, the gravel or crushed rock may be filled in with soil. Uncover the trench and inspect the gravel to see if soil has filled in the openings in the crushed rock.

❑ Discharge from only a few holes may mean that root mats have clogged the treatment and disposal trench pipes. The trench must be uncovered and the pipe inspected to see if roots are the problem.

Determine the rate of absorption of wastewater by the soil.

A method to determine the absorption rate of the soil in the trenches is presented below. This technique is useful because it gives a value of the treatment and disposal rate for the trenches as they really are. Once the treatment and disposal rate has been found, you can better understand why the system is failing.

1. Determine the daily usage of water by reading the water meter. Take readings for at least a week or longer to be sure that you have a good idea of the amount of water being used.
2. Install observation tubes in the trenches.
3. To begin the test, mark the level of water in the trenches as seen through the observation tubes.
4. Use no water in the house for at least eight hours. The water at the meter should be turned off so that the residents will not use the water.



Parallel distribution treatment and disposal field fed by a distribution box.

5. Read the water meter after it has been turned off. This reading will be used to find how much water can be absorbed by the system over the eight-hour period.
6. Watch the water level in the trenches drop over the eight-hour period. At the end of the eight-hour period, measure the level of the water in the trenches.
7. Turn the water on and let the water flow so that the trenches fill to the same level as at the beginning of the eight-hour period. When the trenches have filled to the level at the beginning of the test, turn off the water at the faucet and read the water meter.
8. Subtract the water meter reading at the beginning of the eight-hour test from the meter reading at the end of the test to find the total volume of water used to fill the trench back to the water level at the beginning of the test. This volume of water also is the volume of water absorbed in eight hours.
9. Take the volume of water absorbed in eight hours and multiply it by three to get the volume of wastewater absorbed in one day.
10. If the rate of wastewater treatment and disposal per day is less than the amount of water used per day, then the system is overloaded. Determine the percentage that the system is overloaded using the following equation:

$$\text{Percent overloaded} = \frac{\text{Average daily water use} - \text{wastewater absorbed per day}}{\text{Wastewater absorbed per day}} \times 100$$

For example: After reading the water meter for several weeks, you find the family uses 280 gallons of water per day. You perform a test to find the treatment and disposal rate of wastewater. For an 8 hour period, 70 gallons of water were absorbed by the trenches.

The treatment and disposal rate per day is 3 x 70 gallons per 8 hours = 210 gallons per day. Using the formula you get:

$$\text{Percent overloaded} = \frac{\text{Average daily water use} - \text{wastewater absorbed per day} \times 100}{\text{Wastewater absorbed per day}}$$

$$= 0.30 \times 100$$

$$\text{Percent overloaded} = \frac{280 \text{ gallons used per day} - 210 \text{ gallons absorbed per day} \times 100}{210 \text{ gallons absorbed per day}}$$

$$\text{Percent overloaded} = \frac{70 \text{ gallons not absorbed per day} \times 100}{210 \text{ gallons absorbed per day}}$$

$$\text{Percent overloaded} = 30\%$$

This system is overloaded by 30% or is receiving 30% more water than it can handle.

❑ If the system is less than 35% overloaded, then the residents may be able to correct the system failure by water conservation. Water conservation includes using low-flow showerheads, low-flush toilets, flow restrictors on all faucets, and other methods to reduce the volume of water flowing to the on-site system. Installation of these devices is much cheaper than rebuilding an on-site system.

❑ If the plumbing system has a pressure-regulating valve, the pressure in the house can be reduced somewhat, which will help lower water usage. On well systems, the pressure switch for the well pump can be set to operate over a cycle of 30 to 50 psi rather than the usual 40 to 60 psi setting.

❑ The residents can lower their water use by a number of simple actions. Shutting off the water while shaving or brushing teeth, taking short showers, and taking laundry to a laundromat are all ways to decrease water use.

❑ For large overloads the system may have to be expanded or a replacement system installed.

Interpret information gathered.

At this stage, you should have most of the information that can be obtained. The information must be interpreted to determine the cause of the problem and whether the problem can be corrected. Some failing systems cannot be corrected.

❑ See if the information points to the cause of the problem. Use the information in the previous sections to help decide what is causing the problem.

❑ Environmental health professionals have much experience with on-site systems. Check with the Regional Soil Specialists and the On-Site Wastewater Section office in Raleigh for assistance. Discuss the situation and the information you have with them. Check with the North Carolina Cooperative Extension Service for help also.

❑ Do some research. Read publications, articles and books about on-site systems for clues to what is happening. Workshops about repairing on-site systems are occasionally offered.

❑ Keep well-organized files of the information you have gathered and where you found the information. These files may help you or someone else in another situation with a failing system.

Taking Corrective Action

If the problem has been identified, then it is time for corrective action. Generally, *repair* is the term used for modifications or expansion of the existing on-site system, while *maintenance* includes replacing broken parts, such as switches, pipes, fittings, or readjusting valves.

Reference

GS 130A-334(9a)

GS 130A-334(3a)

As defined by the rules, repair means

> **"the extension, alteration, replacement, or relocation of existing components of a wastewater system."**

Maintenance means

> **"normal or routine maintenance including replacement of broken pipes, cleaning, or adjustment to an existing wastewater system."**

The following list contains actions that will correct many problems.

❑ The best thing to do in any system failure is to start a schedule of regular maintenance and operation checks. Homeowners rarely maintain their on-site systems properly, and maintenance can easily make the difference between a system with problems and one that functions well.

❑ If the plumbing or conveyance pipes are clogged, clean them out.

❑ If water leaks are overloading the on-site system, then repair the leaking plumbing fixtures or pipes.

❑ If the system is being flooded by runoff from roof downspouts, change the downspouts to direct the runoff away from the on-site treatment and disposal field.

❑ For systems where the treatment and disposal field is plugged by roots, remove the trees or shrubs that are causing the problem. The roots will decay after the tree or shrub is cut, as long as new shoots from the stump are removed.

❑ In situations where the tank is plugged with solids or the inlet or outlet is clogged because of solids in the tank, pumping the septic tank will help the system to function properly again.

❑ Sometimes cleaning or flushing the system will make the system function again.

❑ If mechanical or electrical parts have broken, replace the parts.

❑ If pipes have collapsed or trenches have filled in, then the pipes should be replaced and reinstalled.

❑ Broken conveyance pipes or laterals on pumped systems must be replaced.

❑ Leaking septic tanks and pump tanks must be repaired or replaced.

When corrective measures will not work.

In some cases, nothing can be done to correct the existing on-site system, which means that the homeowner is in for big changes and probably high costs. Here are some alternatives to consider when whole systems must be repaired.

- ❑ The owner may be able to obtain an easement for use of a neighbor's property for an expanded or additional treatment and disposal field. This option depends greatly on the type of neighborhood and how close the houses are to each other.
- ❑ Be certain that smaller corrections will not fix the system before you go to larger system repairs. For instance, if there is only a small failure where water is ponding on the surface, then adding one or two trenches of the same size as the original trenches may be enough.
- ❑ If there is a large failure over most of the treatment and disposal field, the entire field will have to be replaced. Sometimes the old field will recover if it is not used for six months or a year, and is then put back into service.
- ❑ Another alternative is to install dual alternating treatment and disposal fields, alternating the flow between the old field and the new field. The old field may recover in a few months and be ready for use when the flow is turned on again.
- ❑ Another piece of land may be purchased to install another or an expanded treatment and disposal field.
- ❑ Alternative wastewater disposal methods that might work on the property can be investigated.
- ❑ A wastewater disposal system with a surface discharge may be the only possible solution. The owner will need some direction on where to get permits for a surface discharge system.

Keeping records is very important when handling cases of failing on-site systems.

On-site system owner fails to comply.

Some owners fail to comply with requests to repair the system or correct system failures. Appendix A, *Human Relations*, may help you to handle a tense situation.

Follow the next steps to try to reach the owner, with the objective of bringing the failing system into compliance.

- ❑ Try to get the owner to repair the system. Getting the owner to take action on his own is better than taking legal action. Legal battles are expensive and time consuming.
- ❑ Call or write the owner, offering to meet to discuss the system's problems. Meet with his engineer, attorney, or septic tank installer, if that is what the owner wants, so that the owner gets a complete idea of what is being requested and what needs to be done. State a deadline to complete the repair. Letters should be sent certified mail with a return receipt requested to prove that the owner has been informed.
- ❑ Sometimes messages on voice mail or telephone answering machines get through when the person cannot be reached for a direct telephone conversation. Also, try a FAX letter. Different people respond to different styles of communication.
- ❑ When you have tried all means available and the owner still will not respond, then you must begin legal action.

Legal action.

If you are entering legal proceedings against an owner, carefully follow all procedures listed. Too many cases are lost because the environmental health professional did not follow the necessary legal procedures.

❑ Finish collecting all the data you can get on the failing system. If more research should be done, do it before you get into the legal procedures. It is better to do the work ahead of time rather than find out later that you do not have all the information you need.

❑ Consult with the program staff and legal personnel for your agency. They should be able to guide you in the overall procedure and tell you how to prepare.

❑ Determine what legal action is appropriate for the situation. A number of actions can be taken. The appropriate action gets the failing system repaired while not unduly burdening the owner.

❑ Create a legal action plan. List all the steps that will occur so that you will know what to expect and be prepared for it.

❑ Once you begin legal proceedings, follow through to be sure that repairs are made to the failing system.

Continued monitoring required.

Even after legal action has been taken against an owner and the system has been repaired, follow-up on how the repaired system is functioning is necessary. Here are a few ideas for follow-up.

❑ Inspect the repaired system and review the operation and maintenance of the system. If the system is not being maintained or operated properly, it will likely fail again.

❑ Try to educate the owner and users of the system so that the system is not abused. Education can prevent another failed system and legal action.

❑ Be sure that the owners and users know what maintenance is necessary for the system. Try to find out if the maintenance is being done.

❑ Inspect the system periodically to check for recurring problems.

❑ Continue keeping records on the system for future needs.

Appendices

Appendix A

Appendix B

Appendix C

9

Appendices

APPENDIX A* HUMAN RELATIONS

One of the hardest parts of your job as an environmental health professional is dealing with people. Because on-site wastewater management affects all of us, you provide a service for the public. You will have to interact with homeowners, installers, builders, contractors, developers, and neighbors, all of whom have rights and concerns. Keep in mind the following points.

**This appendix was adapted from material written by the North Carolina Office of State Personnel, Division of Employee and Management Development, Personnel Development Center. The center has additional information on human relations and also offers workshops in dealing with angry people and other human relations topics.*

- ❑ You must be as consistent as possible. Consistency is one mark of a professional. Your work will be easier because the people you deal with will know what to expect from you.
- ❑ Environmental health professionals must carry out their responsibilities in a professional manner. At times there will be pressures to approve UNSUITABLE sites or to not report system failures, but you must not allow public health or environmental quality to be compromised. The goal of the program and your job is to protect public health and the environment from inadequate and improper on-site wastewater systems. The environmental health professional must maintain his integrity if he is to do the job well and be respected as a professional.
- ❑ Your job will take you to many home sites, construction sites, offices, and other locations. It can help to prepare a short introduction telling who you are, your job, and why you are present. Keep a supply of business cards handy to give to those you meet to help them with your name and duties.

Interacting With Angry/Difficult People

Homeowners and business owners with complaints come to the organization responsible and often confront the first employee they meet. In the field of on-site wastewater systems, that person is usually the environmental health specialist. As far as the people with complaints are concerned, the environmental health specialist is the organization, and it is the environmental health specialist who has to handle heated confrontations.

These are homeowner-initiated discussions and you will not have time to prepare a response — you must resolve these situations spontaneously. You can be prepared, however, by developing skills for dealing with conflict situations. The short lesson that follows gives general ideas on how to handle angry people. You do not have to use each idea, rather, pick out those ideas or techniques that fit your personality and style.

Key Steps

A situation with an angry homeowner should be handled in a manner that is satisfactory to the homeowner, to you, and to your organization. You are an important representative of your organization and your organization relies on you to handle these situations effectively.

Use these key steps as a guide to develop your skills in dealing with angry people according to your personality and strengths.

Step 1. Maintain a friendly and professional manner.

You are likely to be the first person an angry individual confronts. Be careful not to argue, because it will only make the person become defensive and even more difficult. Instead, the following techniques may work much better.

❑ Show an interest in the homeowner's problem. Communicate that you are interested in solving the homeowner's problem.

❑ Do not let the person's anger arouse your desire to retaliate. The professional views dealing with angry people as part of the job. Handling a conflict situation diplomatically is your professional responsibility and can be rewarding.

❑ Do not take what the homeowner says personally. Though the anger may be directed toward you, the person is actually angry with the organization. The individual probably feels that your organization has treated him or her unfairly.

Step 2. Acknowledge that a difficult situation exists.

It is important that you maintain the homeowner's self esteem. He must not feel that you think his complaint is not important or silly - this person wouldn't be complaining if the problem wasn't important to him. Give him the feeling that he is important and that you take his complaint seriously by doing the following.

❑ What an angry homeowner wants to know is that you understand the situation. What an angry homeowner doesn't want to hear, and is not able to hear when he is in the midst of anger, is that he is wrong. Use terms and a tone of voice that show sensitivity to the situation the homeowner presents.

❑ Express empathy by responding to both what the homeowner says and feels. Expressing empathy does not mean you agree with the person. It means simply that you recognize and respond to what the homeowner is experiencing.

❑ If an apology is in order, apologize for the specific incident and no more.

Step 3. Calm the homeowner by questioning and verifying.

Questioning and verifying shows that you are interested in his problem and working with the person. It also gets the homeowner to work with you. Follow these steps.

❑ Ask questions to determine what the problem is. Never assume that you understand.

❑ Give the person feedback to show that you understand the problem.

❑ Do this until you and the person are satisfied you both understand the problem.

Step 4. Focus the homeowner on the problem.

The next step is to cooperate in exploring alternatives for solving the problem. Let him know that you are interested in helping him solve the problem. By discussing all possibilities and the consequences of each, you can keep the person focused on the problem and avoid side issues.

❑ Ask the homeowner to help you solve the problem. Do this by requesting suggestions from him about how the problem can be solved, and by offering your assistance to help correct the situation. Here, your knowledge of on-site wastewater systems can guide the person to a reasonable and legal solution

❑ Continue to ask questions to get information, and to keep the homeowner focused on solving the problem. If the person is still angry, continue to empathize showing that you understand the problem.

Step 5. Handle the problem.

Having explored the possible solutions, focus on the most feasible and satisfying solution. Be positive with the person. Tell him what you are going to do, and explain it so the homeowner understands.

❑ If the homeowner resists, go on to another alternative. Take extra steps to help if possible. Satisfying a person's desire for service and special attention sometimes turns an opponent into an advocate.

❑ Decide on a follow-up action to ensure that the problem was resolved satisfactorily.

❑ Follow up to ensure that the problem is solved.

Being The Bearer of Bad News

You will sometimes have to be the bearer of bad news. You may have to tell a person that you cannot solve a complaint to his or her satisfaction, or you may have to inform a responsible party of a violation. These situations can be very stressful for both you and the other person. The following section lists key steps that will help you deliver bad news and help the recipient cope with it.

In all cases, be certain to provide the information in writing as well as verbally. A letter helps minimize problems in recalling exactly what the problems are or the nature of the violations, especially if the situation is taken to a third party or to a legal action.

Key Steps

Step 1. Present the situation.

Explain the situation to the person with as few words as possible. When your discussion is concise, direct, and to the point, the person is spared the anxiety of wondering how bad the news is.

❑ Prepare the person for the negative information. It may be necessary to provide a short background about the events leading up to the present situation.

❑ Provide reasons why the situation has occurred. You may be able to show that the person's actions were not responsible for the situation.

❑ Don't try to give the person good news first and then the bad news — this can appear patronizing.

❑ Do not try to make the bad news seem insignificant; it probably isn't insignificant to the person involved.

Step 2. Allow the person time to adjust.

Most people need a little time to collect their thoughts and react emotionally to the bad news. Allow the person some time, but try not to leave long periods of silence. Some people perceive silence as pressure to react and therefore may react inappropriately.

❑ Try discussing the positive aspects of the situation. The person may or may not hear you, but positive comments can help keep the conversation constructive and the outlook optimistic.

Step 3. Ask for the person's reaction.

Ask the person to express his or her feelings and opinions. Reacting emotionally to bad news is normal. Allowing people to ventilate their emotions shows that you accept their feelings and it helps to diffuse the negative aspects of the situation.

❑ If the person does not offer a reaction, try talking about how you have felt or would feel in a similar situation. Then ask for the person's reaction. Use this technique to stress that *you are empathetic to the other person's* dilemma. However, *do not get caught up in discussing your own troubles.*

Step 4. Demonstrate acceptance of the person's reaction.

A person may react emotionally in many different ways and may not clearly express his or her feelings. Most of us find it hard to talk about emotions in the workplace, and we have trouble accurately identifying the emotions of others. You must observe and listen carefully to determine if the person's true feelings are being expressed.

❑ When receiving bad news, the person may feel a wide range of emotions, such as anger, dissatisfaction, embarrassment, fear, panic, shock, or confusion. You can choose an appropriate response to these emotions by remaining calm, expressing empathy, offering reassurance, or providing further explanation.

❑ After you have identified the person's reaction, mentally name it. This allows you to accept the reaction for what it is—that is, not a personal affront to you. Understanding how the other person feels also helps you anticipate upcoming statements and remain in control of your own emotions.

❑ Develop a strategy that helps you avoid taking the person's reaction personally.

❑ People often react by blaming another person, a group, or the system. Listen to the person and identify who is being blamed. This way you are less likely to feel that the blame is being placed upon you.

❑ Avoid being caught in answering *questions* that are really meant as *statements*. For instance, "Don't you think this is unfair?" really means "I think this is unfair." Restate the question as a statement, such as "I understand you think this is unfair." You can also try redirecting the topic of conversation.

❑ Sometimes you may be able to use self-disclosure to calm the situation. In other words, state how you have felt in similar situations. Statements such as, "I know just how you feel," can be taken as patronizing. Rather, say, "I know how I've felt in situations like this."

Step 5. Restate positive points.

Once the initial emotional reaction has passed, help the person put the situation into perspective.

❑ You can help the person see the situation more positively by expressing confidence in his or her ability to meet the challenge and by providing genuine praise for efforts put forth.

❑ Reemphasize the basic facts about the situation and discuss any steps that can be taken to address the problem.

Step 6. Offer assistance.

If appropriate, you can offer to assist the person in future actions or planning.

❑ Do not offer to do something that you are not authorized to do.

❑ Inform the person that it may be necessary to submit revised plans or seek legal help.

Step 7. Express your expectations.

An emotionally upset person may not be able to fully understand the situation or may misconstrue the conversation. Be sure that the person understands the information you have provided and knows what is expected to correct or address the situation.

❑ Repeat the actions that must be taken and the required time frames.

❑ Discuss the required the action. If you cannot change the requirements or time frames, tell the person that you regret that you cannot change them.

❑ A good way to ensure that the person understands the information you have discussed is to ask the person to repeat back to you the details of your discussion in his or her own words.

Step 8. Allow for future contact and follow-up.

Give the person a chance to contact you again for further discussion. You may need to schedule a future meeting. You should always leave the person your business card and phone numbers where you can be reached.

APPENDIX B HYDRAULIC CONDUCTIVITY

29 Hydraulic Conductivity of Saturated Soils: Field Methods

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29-1 INTRODUCTION

The hydraulic conductivity is a measure of a soil's ability to transmit water. Water movement, whether under saturated or unsaturated conditions, is highly dependent on the hydraulic conductivity. The basic relationship describing soil water flow is Darcy's law, which relates flux density $\bar{v}$ to the hydraulic conductivity K and the gradient of the soil water potential H:

$$\bar{v} = -K \text{ grad } H . \qquad [1]$$

The conductivity is a spatially variable characteristic, but is constant under saturated conditions for any given position in the field, at any given time. It is a key parameter for all aspects of water and solute movement.

Several methods have been developed to determine the saturated conductivity in the field. They include methods applied to areas with shallow water tables as well as those with deep water tables. In principle, K is calculated from Darcy's law after measuring soil water flux and hydraulic gradient.

29-2 SHALLOW WATER TABLE METHODS

The most common methods to determine the saturated hydraulic conductivity of the soil in the presence of a water table are the auger-hole method and the piezometer method. Other methods, such as the two well, four well, multiple well, well-point, pit bailing, and field mon-

 Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods—Agronomy Monograph no. 9 (2nd Edition)

oliths are also available, but will be discussed in less detail. For methods primarily developed for groundwater systems, such as pumping or slug tests, see, for example, Bouwer (1978) or Freeze and Cherry (1979).

29–2.1 Auger-hole Method

29–2.1 PRINCIPLES

The auger-hole method introduced by Diserens (see Boersma, 1965a), is the procedure most widely used to measure the saturated hydraulic conductivity. Modifications and improvements have been introduced by Kirkham and van Bavel (1948), van Bavel and Kirkham (1948), Johnson et al. (1952), Kirkham (1958), van Beers (1958), Boast and Kirkham (1971), and others (see Bouwer & Jackson, 1974). The auger-hole method, in principle, involves preparation of a cavity extending below the water table, with minimum disturbance of the soil. To decrease the puddling effects, water is pumped out of the hole and then the cavity is allowed to refill several times (similar to priming water wells). After priming the hole, the water is allowed to equilibrate with the groundwater. At equilibrium, the level in the hole will be at the water table. The depth of water in the hole, H, the diameter of the hole, $2r$, and the distance between the bottom of the hole and the underlying impermeable layers, s, must be determined (Fig. 29–1). Then the water is pumped out of the hole and the rate of the rise of the water level measured, allowing calculation of the saturated conductivity of the surrounding soil.

Unlike laboratory methods, where simple equations can describe the saturated hydraulic conductivity as a function of the flux and hydraulic gradient, no simple equation is available for the accurate determination of the conductivity. This is because the flow of water into the auger hole is three-dimensional. In addition, the flow properties could be different in each direction and the cavity might extend through strata with different hydraulic characteristics. To overcome these problems, several variations of the auger-hole method have been developed. Maasland (1955, 1957), for example, presented the theory of the water flow in anisotropic soils

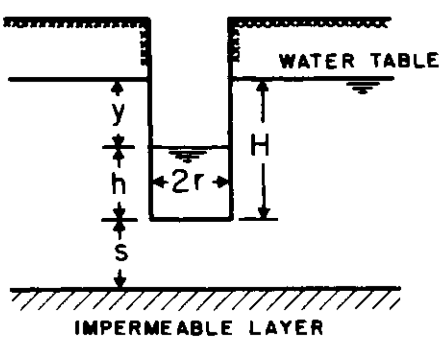


Fig. 29–1. Geometry of an auger hole.

as applicable to the auger-hole method. Luthin (1957) reviewed methods proposed for layered soils. Recently, Topp and Sattlecker (1983) introduced an inflatable assembly and hole liner which allows measurement of either horizontal or vertical components of saturated hydraulic conductivity.

Luthin (1957) as well as Bouwer and Jackson (1974) reviewed various relationships for calculating saturated hydraulic conductivity using the auger-hole method. Johnson et al. (1952) presented still another equation and nomographs to facilitate calculations. Ernst presented an approximate equation for K based on his numerical solution for an auger-hole sufficiently above an impermeable layer

$$K = \{4.63\, r^2/[y(H + 20r)(2 - y/H)]\}(\Delta y/\Delta t) \qquad [2]$$

where r (units of length, L) is the radius of the hole, H (units L) is the depth of the groundwater in the hole, y (units L) is the difference between the depth of groundwater and the depth of the water in the hole, and $\Delta y/\Delta t$ is the rate of change of y with respect to time t (units of time, T) (see Bouwer & Jackson, 1974; Boast & Kirkham, 1971). For the case where the auger hole is extended to the impermeable layer, $s = 0$, the equation is

$$K = \{4.17\, r^2/[y(H + 10r)(2 - y/H)]\}(\Delta y/\Delta t)\,. \qquad [3]$$

For both equations, K has the same units as $\Delta y/\Delta t$ (e.g., cm/day).

Boast and Kirkham (1971) presented the simple equation

$$K = (\Delta y/\Delta t)C/864 \qquad [4]$$

where K is the saturated hydraulic conductivity, $\Delta y/\Delta t$ is the rate of rise of water in the auger hole, and C is a shape factor. Values of C for a variety of cases are presented in Table 29–1. In Eq. [4], $C/864$ is dimensionless; thus, K has the same units as $\Delta y/\Delta t$.

29–2.1.2 SPECIAL APPARATUS

1. Auger. Use any type of bucket auger to make a hole with a diameter in the range for which Table 29–1 can be used. A post-hole closed-end auger is recommended for coarse-textured soils.
2. Water pump or bailer. To remove the water from the hole as fast as possible use a pump with adequate capacity or a bailer. For small-diameter holes, a bailer constructed of thin-wall tubing with a check valve at the bottom can be used.
3. A device to measure the depth of water in the cavity. Use a float attached to the end of a nonexpanding, flexible measuring tape or a lightly weighted, wooden rod graduated for easy measuring. The float must be smaller than the diameter of the hole and care must be taken

Table 29-1. Values of C for Eq. [4] for an auger hole underlain by an impermeable or infinitely permeable layer (after Boast & Kirkham, 1971).

		s/H for impermeable layer								s/H	s/H for infinitely permeable layer			
H/r	y/H	0	0.05	0.1	0.2	0.5	1	2	5	∞	5	2	1	0.5
1	1	447	423	404	375	323	286	264	255	254	252	241	213	166
	0.75	469	450	434	408	360	324	303	292	291	289	278	248	198
	0.5	555	537	522	497	449	411	386	380	379	377	359	324	264
2	1	186	176	167	154	134	123	118	116	115	115	113	106	91
	0.75	196	187	180	168	149	138	133	131	131	130	128	121	106
	0.5	234	225	218	207	138	175	169	167	167	166	164	156	139
5	1	51.9	48.6	46.2	42.8	38.7	36.9	36.1		35.8		35.5	34.6	32.4
	0.75	54.8	52.0	49.9	46.8	42.8	41.0	40.2		40.0		39.6	38.6	36.3
	0.5	66.1	63.4	61.3	58.1	53.9	51.9	51.0		50.7		50.3	49.2	46.6
10	1	18.1	16.9	16.1	15.1	14.1	13.6	13.4		13.4		13.3	13.1	12.6
	0.75	19.1	18.1	17.4	16.5	15.5	15.0	14.8		14.8		14.7	14.5	14.0
	0.5	23.3	22.3	21.5	20.6	19.5	19.0	18.8		18.7		18.6	18.4	17.8
20	1	5.91	5.53	5.30	5.06	4.81	4.70	4.66		4.64		4.62	4.58	4.46
	0.75	6.27	5.94	5.73	5.50	5.25	5.15	5.10		5.08		5.07	5.02	4.89
	0.5	7.67	7.34	7.12	6.88	6.60	6.48	6.43		6.41		6.39	6.34	6.19
50	1	1.25	1.18	1.14	1.11	1.07	1.05			1.04			1.03	1.02
	0.75	1.33	1.27	1.23	1.20	1.16	1.14			1.13			1.12	1.11
	0.5	1.64	1.57	1.54	1.50	1.46	1.44			1.43			1.42	1.39
100	1	0.37	0.35	0.34	0.34	0.33	0.32			0.32			0.32	0.31
	0.75	0.40	0.38	0.37	0.36	0.35	0.35			0.35			0.34	0.34
	0.5	0.49	0.47	0.46	0.45	0.44	0.44			0.44			0.43	0.43

so the tape or the rod does not touch the cavity wall. The floating device is best suited for shallow holes. As an alternative, an electric probe can be used to measure the depth of water in the well (see Luthin, 1949; Van Bavel & Kirkham, 1948). The electric probes are available commercially or can easily be constructed.

4. Stop watch or regular watch to measure time.
5. Data sheet. Prepare a set of data sheets for recording. A sample data sheet is shown in Fig. 29–2.

29–2.1.3 PROCEDURE

1. Clean plant materials, trash, and loose soil from the selected area.
2. Bore a hole with minimum disturbance to the wall, and extend the hole at least 30 cm below the water level. Check the soil texture while

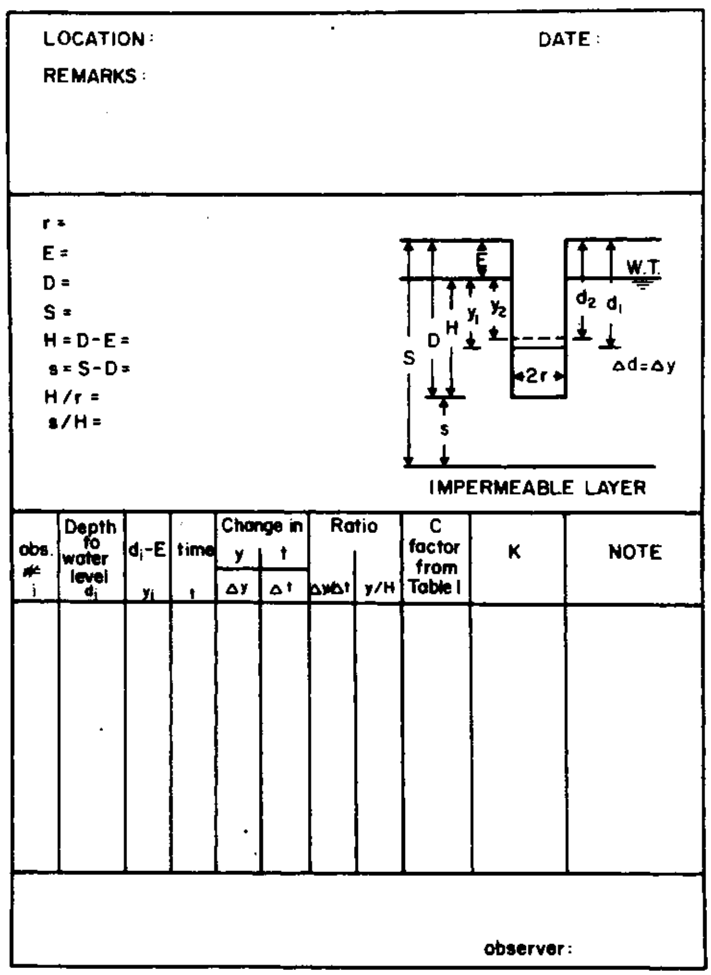


Fig. 29–2. Data sheet for auger-hole method

digging the hole to determine any layering of the profile. If the soil is layered, an alternative method may be preferable. Make sure that the groundwater is not under artesian pressure. If the groundwater is under pressure, the water level in the hole will increase abnormally fast when the confining layer is penetrated.

3. To eliminate puddling effects, remove the water from the hole and allow the groundwater to fill the cavity. Repeat this step several times. Measurements can be made during this process to obtain an estimate for the rate of rise of water level in the hole. Dump the water away from the hole or keep it in a large bucket so that water flow into the hole will not be affected by the water dumped around the area.
4. After step *3*, allow equilibrium with the groundwater. Measure the diameter of the hole, $2r$, the depth of water in the hole, H, the distance between the bottom of the hole and the underlying impermeable layer s. (Or alternatively, estimate s.)
5. Remove the water from the hole and measure the rate of rise by measuring the change in the water level during a given period of time. Make more than one measurement of Δy and Δt before the depth of water in the hole, h, reaches about half of the depth of the groundwater in the hole at equilibrium, H.
6. Let the water in the hole come to equilibrium with the water table and repeat step *5*. If the results are not consistent with the results of the previous step, steps *5* and *6* must be repeated until consistent results are obtained for consecutive runs.

29-2.1.4 CALCULATIONS

Use Eq. [2] or [3] for an approximation of the saturated hydraulic conductivity. If a more accurate result is desired, find the shape factor from Table 29-1 and calculate K using Eq. [4]. To find the shape factor from Table 29-1, calculate the values of s/H, y/H, and H/r and find the value of C for the corresponding row and column. If the values of s/H, y/H and/or H/r fall between the given values in the table, the logarithm of H/r, y/H and C should be taken before doing an interpolation. For the case where an impermeable layer exists, the nomograph presented as Fig. 29-3 can be used as an alternative to Table 29-1 and Eq. [4]. The use of the nomograph will be demonstrated by an example: Assume an auger hole with $r = 6$ cm, $s = 30$ cm, $H = 60$ cm, $y = 45$ cm, and $\Delta y/\Delta t = 10$ cm/h. Find the value of y/H (= 0.75) on the curved scale (Point I). Connect Point I to Point O and find $H/r = 10$ on the line (Point II). At Point II, construct a perpendicular line until it intersects the curve on $s/H = 0.5$ (Point III). Draw a horizontal line to intersect the vertical scale at $C = 15.7$ (Point IV). Connect the Point IV to the value of $\Delta y/\Delta t$ (Point V) and continue to Point VI, reading the value of K as 4.4 cm/day or 0.18 cm/h.

If the soil below the water table is composed of two or more layers, the conductivity of each layer could be calculated separately. For a two-

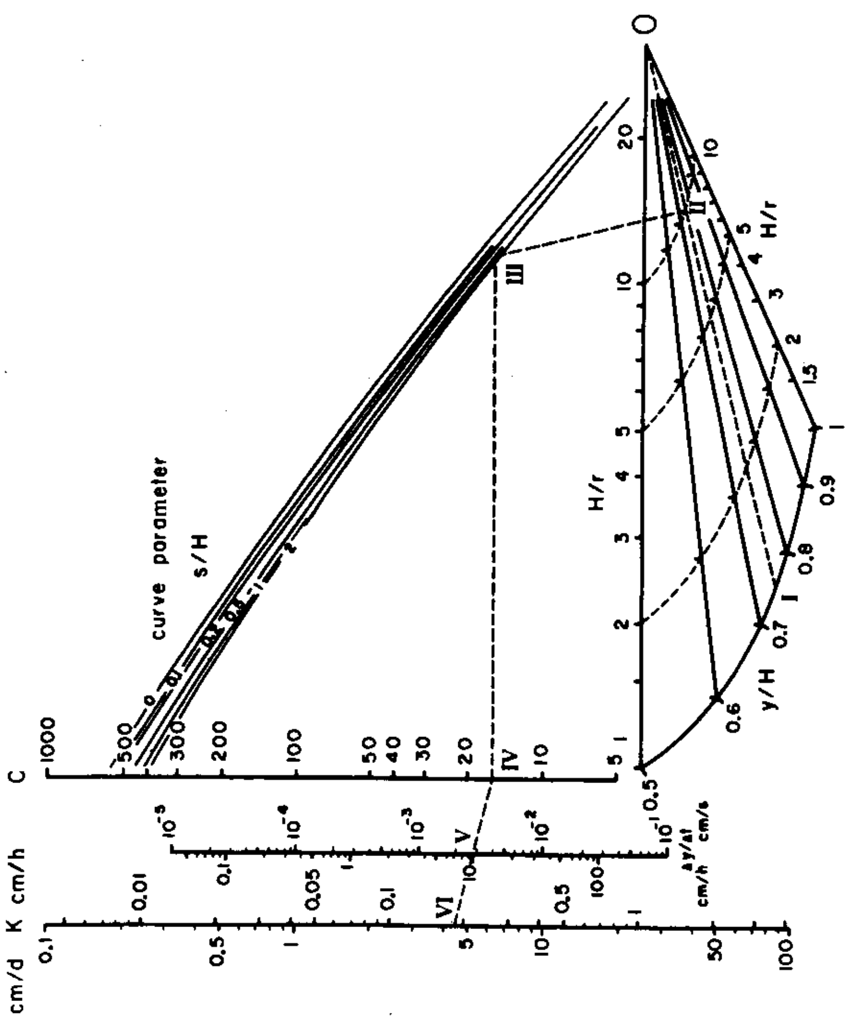


Fig. 29-3. Nomograph to determine the saturated hydraulic conductivity above an impermeable layer by the auger-hole method.

layered soil, bore out the soil through the upper layer at least 10 cm above the second layer (Fig. 29–4A). Determine the conductivity of the upper layer using the procedure described earlier. Deepen the hole through the second layer (Fig. 29–4B) and measure the conductivity again. The calculated value, K, is for the combined profile and the conductivity of the second layer may be calculated using the following equation (Luthin, 1957):

$$K_2 = (KH_2 - K_1H_1)/(H_2 - H_1) \qquad [5]$$

For a third layer, the procedure could be extended by assuming the upper two layers as one layer. The error resulting from the assumptions made for the calculation of K for two-layered soil is $< 10\%$ (see Luthin, 1957). If an accurate value of K is desired for the second layer, possibly the measurements can be delayed until the water table falls below the first layer.

29–2.1.5 COMMENTS

The saturated hydraulic conductivity measured by the auger-hole method is dominated by the average value of the horizontal conductivity of the profile (Maasland, 1955). The volume of the soil where the conductivity is measured is about $10Hr^2$ to $40Hr^2$ (units L^3) for commonly used hole diameters (about 10–20 cm) (Bouwer & Jackson, 1974).

Maasland and Haskew (1957) indicated that auger-hole measurements are reproducible to within 10%. They also indicated that the best results are obtained if the amount of return flow into the hole is limited to 20% of the amount of water removed from the hole. Boersma (1965a) suggested that the measurement be completed before the height of the water in the hole, h, reaches to 20% of the depth of water in the hole at equilibrium, H (i.e., $h/H = 0.2$). Boast and Kirkham (1971), on the other hand, presented shape factor values, C, for auger holes up to one-half full. Therefore, it is advised not to make any measurements after the hole is one-half full.

Bouma (1983) found that the auger hole gave a much smaller saturated hydraulic conductivity than alternative methods for some Dutch

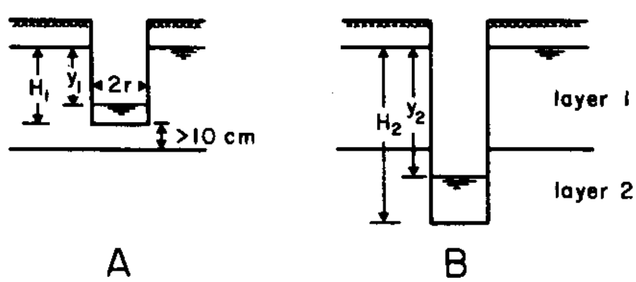


Fig. 29–4. Geometry of the auger hole for a two-layered soil.

clay soils (also see Bouma et al., 1979a). He indicated that smearing the wall of the auger hole during boring of the hole closes the planar pores which allow the water movement into the hole (Bouma et al., 1979b). Hoffman and Schwab (1964), however, reported that the saturated conductivity values obtained by the auger-hole procedures were generally greater than those obtained from drainage tile flow for a silty clay soil in a lakebed region in Ohio.

If smearing of the hole wall, and therefore clogging of the pores and planar voids is suspected, step *3* (as discussed in procedure) should be repeated until puddling effects are eliminated. If after step *3* the effects of smearing are still present, an alternative method, e.g., the column method using large undisturbed columns (Bouma et al., 1976, 1979a, 1981; Bouma and Dekker, 1981), must be used.

Serious errors might result if proper steps are not taken or if equations, tables, or nomographs are extrapolated beyond their range. For example, the water table level in the hole should equilibrate before measurements start (Kirkham, 1965). If measurements are made in units other than those suggested for the equations, tables, or nomographs, proper conversions must be performed so that all units are consistent.

Although it is difficult to use the auger-hole method in rocky or very gravelly soils, it could be performed if a power-assisted auger is available. For unstable soils, the cavity could be lined with a perforated pipe to avoid caving.

When the water level is above the soil surface or if artesian conditions exist, the results obtained by the auger-hole method are not reliable. Also, if the soil is layered extensively or small strata of high permeability occur, results may be inaccurate. According to Luthin (1957), Eq. [5] and the corresponding procedure can give reliable results if the conductivity of the lower layer in a two-layered soil is greater than the conductivity of the upper layer. If the conductivity for the lower layer is less, a negative value might result.

29-2.2. Piezometer Method

29-2.2.1 PRINCIPLES

The principle of the piezometer method for measuring the saturated hydraulic conductivity of soils was first presented by Kirkham (1946). Luthin and Kirkham (1949) developed a field procedure, which consists of installing a piezometer tube or pipe into an auger hole as big as the tube's diameter without disturbing the soil. A cavity is then provided at the bottom of the pipe (see Fig. 29-5) and after the puddling effect is eliminated, water is removed from the cavity. The rate of rise of water in the pipe then is measured and the conductivity is calculated with the help of nomographs or tables.

The conductivity is calculated by

Table 29-2. Values of C/r for Eq. [6] for piezometer method (after Youngs, 1968).

		s/r for impermeable layer							s/r for infinitely permeable layer						
h_c/r	H/r	∞	8.0	4.0	2.0	1.0	0.5	0	∞	8.0	4.0	2.0	1.0	0.5	0
0	20	5.6	5.5	5.3	5.0	4.4	3.6	0	5.6	5.6	5.8	6.3	7.4	10.2	∞
	16	5.6	5.5	5.3	5.0	4.4	3.6	0	5.6	5.6	5.8	6.4	7.5	10.3	∞
	12	5.6	5.5	5.4	5.1	4.5	3.7	0	5.6	5.7	5.9	6.5	7.6	10.4	∞
	8	5.7	5.6	5.5	5.2	4.6	3.8	0	5.7	5.7	5.9	6.6	7.7	10.5	∞
	4	5.8	5.7	5.6	5.4	4.8	3.9	0	5.8	5.8	6.0	6.7	7.9	10.7	∞
0.5	20	8.7	8.6	8.3	7.7	7.0	6.2	4.8	8.7	8.9	9.4	10.3	12.2	15.2	∞
	16	8.8	8.7	8.4	7.8	7.0	6.2	4.8	8.8	9.0	9.4	10.3	12.2	15.2	∞
	12	8.9	8.8	8.5	8.0	7.1	6.3	4.8	8.9	9.1	9.5	10.4	12.2	15.3	∞
	8	9.0	9.0	8.7	8.2	7.2	6.4	4.9	9.0	9.3	9.6	10.5	12.3	15.3	∞
	4	9.5	9.4	9.0	8.6	7.5	6.5	5.0	9.5	9.6	9.8	10.6	12.4	15.4	∞
1.0	20	10.6	10.4	10.0	9.3	8.4	7.6	6.3	10.6	11.0	11.6	12.8	14.9	19.0	∞
	16	10.7	10.5	10.1	9.4	8.5	7.7	6.4	10.7	11.0	11.6	12.8	14.9	19.0	∞
	12	10.8	10.6	10.2	9.5	8.6	7.8	6.5	10.8	11.1	11.7	12.8	14.9	19.0	∞
	8	11.0	10.9	10.5	9.8	8.9	8.0	6.7	11.0	11.2	11.8	12.9	14.9	19.0	∞
	4	11.5	11.4	11.2	10.5	9.7	8.8	7.3	11.5	11.6	12.1	13.1	15.0	19.0	∞
2.0	20	13.8	13.5	12.8	11.9	10.9	10.1	9.1	13.8	14.1	15.0	16.5	19.0	23.0	∞
	16	13.9	13.6	13.0	12.1	11.0	10.2	9.2	13.9	14.3	15.1	16.6	19.1	23.1	∞
	12	14.0	13.7	13.2	12.3	11.2	10.4	9.4	14.0	14.4	15.2	16.7	19.2	23.2	∞
	8	14.3	14.1	13.6	12.7	11.5	10.7	9.6	14.3	14.8	15.5	17.0	19.4	23.3	∞
	4	15.0	14.9	14.5	13.7	12.6	11.7	10.5	15.0	15.4	16.0	17.6	20.1	23.8	∞
4.0	20	18.6	18.0	17.3	16.3	15.3	14.6	13.6	18.6	19.8	20.8	22.7	25.5	29.9	∞
	16	19.0	18.4	17.6	16.6	15.6	14.8	13.8	19.0	20.0	20.9	22.8	25.6	29.9	∞
	12	19.4	18.8	18.0	17.1	16.0	15.1	14.1	19.4	20.3	21.2	23.0	25.8	30.0	∞
	8	19.8	19.4	18.7	17.6	16.4	15.5	14.5	19.8	20.6	21.4	23.3	26.0	30.2	∞
	4	21.0	20.5	20.0	19.1	17.8	17.0	15.8	21.0	21.5	22.2	24.1	26.8	31.5	∞
8.0	20	26.9	26.3	25.5	24.0	23.0	22.2	21.4	26.9	29.6	30.6	32.9	36.1	40.6	∞
	16	27.4	26.6	25.8	24.4	23.4	22.7	21.9	27.4	29.8	30.8	33.1	36.2	40.7	∞
	12	28.3	27.2	26.4	25.1	24.1	23.4	22.6	28.3	30.0	31.0	33.3	36.4	40.8	∞
	8	29.1	28.2	27.4	26.1	25.1	24.4	23.4	29.1	30.3	31.2	33.8	36.9	41.0	∞
	4	30.8	30.2	29.6	28.0	26.9	25.7	24.5	30.8	31.5	32.8	35.0	38.4	43.0	∞

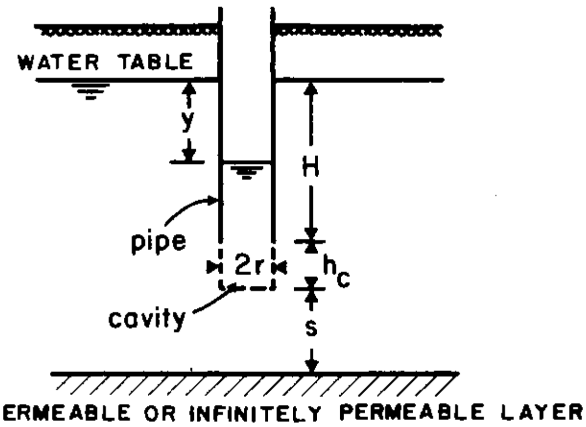


Fig. 29-5. Diagram of a piezometer hole.

$$K = \{\pi r^2/[C\,(t_{i+1} - t_i)]\}\ \ln(y_i/y_{i+1}) \qquad [6]$$

where
- K = saturated hydraulic conductivity (units L/T),
- r = radius of the cavity (units L),
- y_i = the difference between the depth of groundwater and the depth of water in the pipe (units L) at time t_i (units T),
- y_{i+1} = the difference between the depth of groundwater and the depth of water in pipe at time t_{i+1}, and
- C = a shape factor (units L).

Luthin and Kirkham (1949) presented values of C for certain geometries. Johnson et al. (1952) presented a nomograph for a piezometer tube 4.9 cm in diameter and a cavity 10.9 cm long. Youngs (1968) determined values of C/r (dimensionless) for a variety of cases using an electrical analog. His results are presented in Table 29-2, where H is the length of the pipe extended in the groundwater, h_c is the length of cavity and s is the distance between the bottom of the cavity and the impermeable or infinitely permeable layer (see Fig. 29-5).

29-2.2.2 SPECIAL APPARATUS

1. Piezometer tube. Any kind of pipe, plastic or metal, with a diameter in the range such that Table 29-2 can be used. Aluminum pipes used for the neutron probe with a diameter of about 5 cm are suitable.
2. Auger. Use a bucket auger or screw type auger that fits inside the piezometer pipe.
3. Data sheet. Prepare a set of date sheets as shown in Fig. 29-6.
4. Items 2, 3, and 4 described in auger hole method.

29-2.2.3 PROCEDURE

1. Clear plant materials, trash, and loose soil from the area.
2. Bore a hole to a depth of about 10 cm. Remove the auger and insert

9

LOCATION: DATE:

REMARKS:

$r =$

$E =$

$D =$

$S =$

$h_c =$

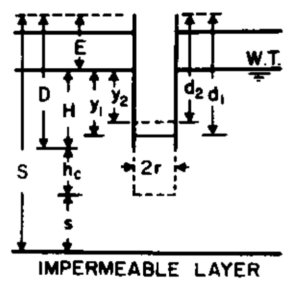
$H = D - E =$

$s = S - D - h_c =$

$h_c / r =$

$H / r =$

$s / r =$



obs. # i	depth to water level d_i	$d_i - E$ y_i	time t	Ratio y_i / y_{i+1}	chng in time Δt	C / r factor Table 2	K	NOTE

observer:

Fig. 29–6. Data sheet for piezometer method.

the piezometer pipe into the hole. Insert the auger into the pipe, excavate an additional 10 to 15 cm, and tap the pipe into the hole. Repeat the process until the bottom of the pipe is at the desired depth below the water table. Carefully bore a cavity at the bottom of the hole to a depth of h_c such that Table 29–2 may be used.

3. To eliminate the puddling effect, insert a tube down the pipe into the cavity and remove the water from the cavity. Let the water rise into the pipe and remove the water from the cavity again. Repeat this step until the rate of rise of the water reaches a constant value and the water from the cavity does not contain appreciable amounts of soil materials.
4. Allow the water level in the pipe to equilibrate with the groundwater. Measure and record H, r, h_c, and s (see Fig. 29–5).

5. Remove the water from the pipe to a distance y below the water table and record the rise of water in the pipe y_i and y_{i+1} in a specified length of time $\Delta t = t_{i+1} - t_i$. This measurement can be repeated a few times before the depth of water in the pipe reaches to within about 20 cm of the water table.
6. Let the water in the pipe come to equilibrium with the groundwater and repeat step *5*. If the rate of rise of water in the pipe is not consistent with the results of the previous measurement, repeat steps *4* and *5*. Continue the process until the results of two successive measurements are consistent.
7. If the hydraulic conductivity of soil at deeper depths is required, go back to step *2* and continue to extend the hole to the desired depth as in that step. Then, repeat steps *3* to *6* to find K.

29–2.2.4 CALCULATIONS

1. Calculate values of h_c/r and H/r. Determine if there is an impermeable or infinitely permeable layer at a distance s below the bottom of the cavity.
2. Find the value of C/r from the corresponding column and row of Table 29–2. Interpolate between the values if necessary.
3. Calculate the hydraulic conductivity using Eq. [6].

For the case where an impermeable layer exists at depth s, the nomograph in Fig. 29–7 can be used to find the value of C/r and the conductivity. As an example, assume $H = 80$ cm, $r = 5$ cm, $h_c = 30$ cm, and $s = 40$ cm. Find the value of h_c/r (=6) on the scale H/r (=16) (Point I), draw a vertical line to intersect the curve $s/r = 8$ (Point II), draw a horizontal line to intersect scale C/r (Point III), and read C/r (=22.5). Using Eq. [6] for $y_1/y_2 = 1.4$ and $t_2 - t_1 = 10$ min, the calculated value of K is 0.023 cm/min or 1.41 cm/h. To use the nomograph, connect Point III to the value of r (5 cm) (Point IV) and continue to intersect scale A at Point V. Connect the value of y_1/y_2 (Point VI) to $t_2 - t_1$ (Point VII) to intersect scale B at Point VIII. Connect the two points on scales A and B (i.e., Points V and VIII, respectively). Read or interpolate the value of $K = 1.5$ cm/h at the intersection of the latter line and scale K.

29–2.2.5 COMMENTS

The piezometer method, unlike the auger-hole method, can be used to measure either horizontal or vertical hydraulic conductivity. If the length of cavity h_c is great compared to the diameter of the cavity, the measurement is primarily the horizontal conductivity. If h_c is small compared to r, then the vertical conductivity is approached. A special case of the piezometer method, called the "tube method," was first suggested by Kirkham (1946) and developed by Frevert and Kirkham (1948). In the tube method, no cavity is provided at the bottom of the piezometer tube (i.e., $h_c = 0$). The conductivity determined by the tube method is the vertical conductivity, and the procedure is exactly the same as the

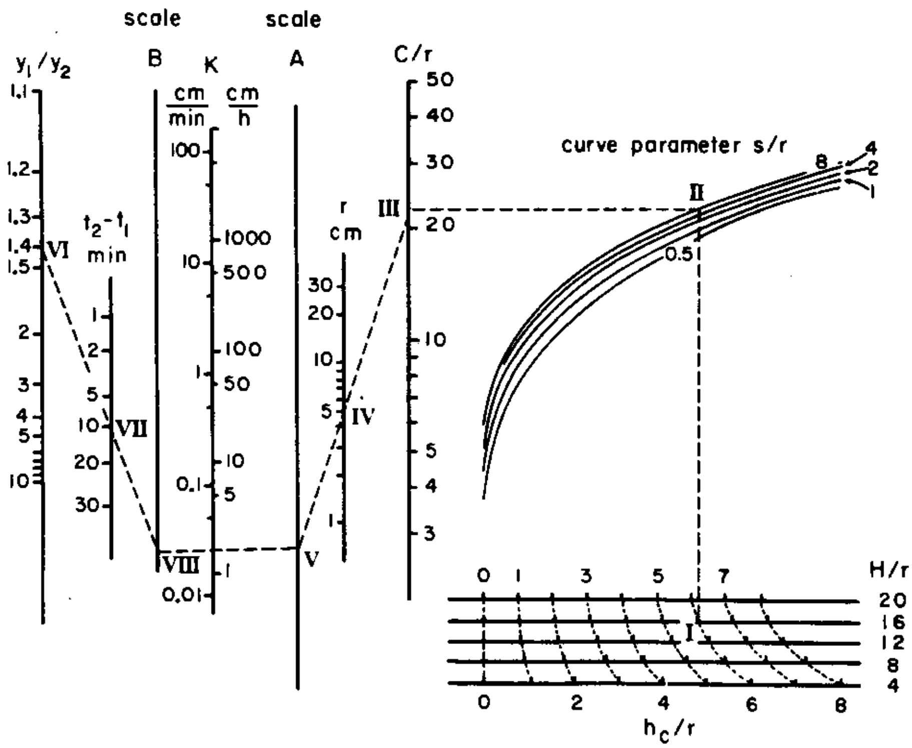


Fig. 29-7. Nomograph to determine the saturated hydraulic conductivity above an impermeable layer by piezometer procedure.

piezometer tube method. Values of C/r for the tube method are given in Table 29-2, and Eq. [6] is used to calculate the conductivity.

For stratified soils the piezometer method can be used to determine the conductivity of each individual layer. The piezometer method is not suitable for rocky and gravelly soils. In these soils, it will be difficult to bore the soil through the pipe, and the pipe might not fit tightly in the auger hole, causing channeling along the side of the pipe.

To measure the conductivity at deeper depths, King and Franzmeier (1981) bored a hole somewhat larger than diameter of the tube and then drove the tube to the desired depth. The large hole was backfilled and tamped to form a seal around the tube. The above procedure must be used with caution, to make sure that the soil will not cave in. Also, the cavity at the bottom of the pipe must be dug after the pipe is installed.

29-2.3 Other Methods

There are other methods to determine the saturated hydraulic conductivity in the presence of a shallow water table which will be discussed briefly. For additional information see Luthin (1957) and Bouwer and Jackson (1974).

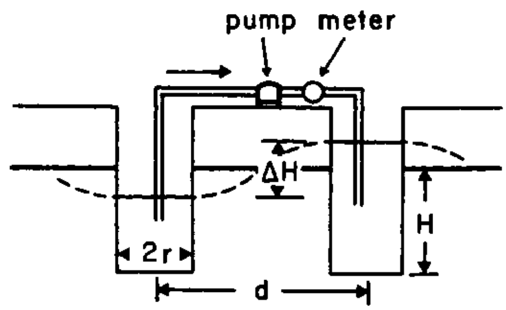


Fig. 29-8. Diagram of the geometry of two-well techniques.

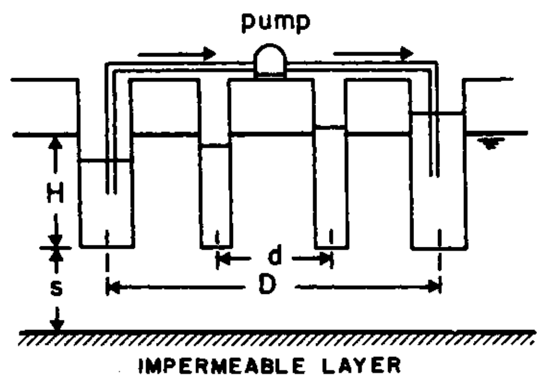


Fig. 29-9. Geometry of the four-well technique to determine the saturated hydraulic conductivity.

Childs (1952) and Childs et al. (1953) proposed a two-well technique which consists of two auger holes of equal diameter ($2r$) extended to the same depth, preferably to an impermeable layer (Fig. 29-8). The distance between the centers of the two holes, d, (units L) is about 1 m. Water is pumped from one hole and carried to the other hole at a constant rate Q (units L^3/T) until an equilibrium between the level of the water in the two holes is reached. The hydraulic conductivity can be calculated by the equation

$$K = Q \cosh^{-1}(d/2r)/[\pi \Delta H(H + L_f)] \quad [7]$$

where H is the average depth of water in the holes (units L), ΔH is the equilibrium hydraulic head difference between the two holes, L_f is an end correction factor, (units L), and $\cosh^{-1}$ is the inverse hyperbolic cosine. The end correction factor is zero if the wells are extended to an impermeable layer and there is no capillary fringe.

To overcome the problem of clogging in the walls and bottom of the receiving wells (pump-in well) in the two-well technique, Kirkham (1954) proposed the four-well technique (Fig. 29-9). Two additional wells are located symmetrically between the discharge (pump-out) well and receiving well. The two center wells can be of smaller diameter and cased (piezometer-type wells). The distance between the two inner wells is d and the radius and the distance between the outer wells are r and D, respectively. The equations defining saturated hydraulic conductivity K where $D > 12r$ are

$$K = 0.221\ (GQ/H\Delta H) \quad [8a]$$

for $D/d = 3$, and

$$K = 0.512\ (GQ/H\Delta H) \quad [8b]$$

for $D/d = 1.5$ (Snell & van Schilfgaarde, 1964).

In the above equations, G is a geometrical factor (dimensionless), Q is the flow rate (units L^3/T), H is the average depth of water in the well (units L), and ΔH is the water level difference between the two inner wells. The coefficients (0.221 and 0.512) are dimensionless. Using an electric analog, Snell and van Schilfgaarde determined the geometrical factor which is available as Fig. 3 and 4 of Snell and van Schilfgaarde (1964) and also Fig. 23–9 and 23–10 of Bouwer and Jackson (1974).

Smiles and Youngs (1963) proposed a method known as the multiple-well technique, in which an array of wells is constructed on the circumference of a circle. The discharge and receiving wells are arranged in an alternate and symmetrical fashion (Fig. 29–10). The advantage of the multiple-well over the two-well technique is the larger soil volume sampled for K. However, the problem of clogging of receiving wells still exists. The equation for calculating K is

$$K = [2Q/n\pi\Delta H(H + L_f)]\ \ln(4a/nr) \quad [9]$$

where n is the number of auger holes on the circle, a is the radius of the circle, ΔH is the average hydraulic head difference for each pair of ad-

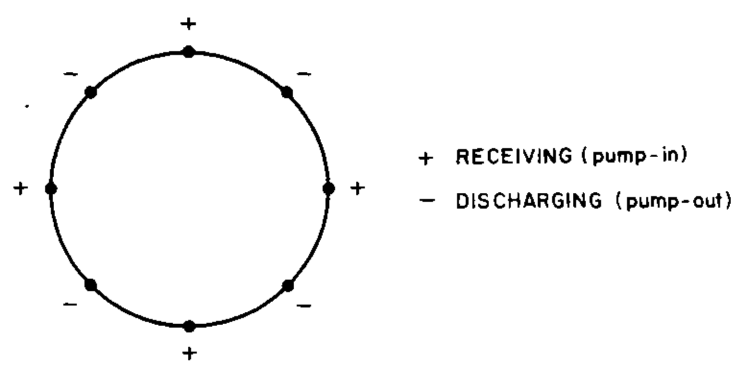


Fig. 29–10. Geometry of the multiple-well technique.

jacent wells, Q is the total flow rate into the system, and H, r, and L_f are the same as for the two-well method.

The pit-bailing method was developed by Healy and Laak (1973) to measure the in situ saturated hydraulic conductivity for septic-tank drainfield design. Recently, Bouwer and Rice (1983) extended the use of the pit-bailing technique to measure saturated conductivity of the soil below a water table. The procedure is useful particularly for stony soils where the auger-hole and other techniques are not practical.

In the pit-bailing method a large hole is dug extending below the water table (a backhoe can be used). After the water level in the pit comes to equilibrium with the water table, the water level in the pit is lowered rapidly. The rise of the water level in the hole is then measured for calculating the hydraulic conductivity.

Bouwer and Rice (1983) applied the piezometer theory to the pit-bailing technique. To find the shape factor for the pit hole, they extrapolated results of Youngs (1968) (also see Table 29-2). Recently, Boast and Langebartel (1984) have applied the auger-hole technique to the pit-bailing method and presented shape factors for pits with length/radius ratios ranging from 0.05 to 2, and for conditions ranging from an empty pit to 90% full. In their analysis, both impermeable barrier and very permeable lower boundary conditions were considered. The shape factors presented by Boast and Langebartel are an extension of the shape factors for auger holes by Boast and Kirkham (1971). Bouwer and Rice (1983) found that piezometer-derived geometry factors gave better results in a laboratory sand-tank than geometrical factors derived for an auger hole. Although there are discrepancies between the values of hydraulic conductivity calculated by the two methods, both procedures seem to be more reliable than the method originally suggested by Healy and Laak (1973) (see Boast & Langebartel, 1984).

Stibbe et al. (1970) described a method to evaluate saturated conductivity using large in situ monoliths. In principle, trenches are dug around a soil column (1.5-m^2 surface to a depth about 1.8 m, in their study). A series of piezometers are installed in the column and a plywood box is constructed around the column. The conductivity is measured by ponding water at the surface and evaluating the rate of water entry into the column. Bouma et al. (1976) described yet another procedure to isolate an undisturbed soil column in the field and used it to measure the vertical conductivity of some Dutch soils (also see Bouma & Dekker, 1981). Bouma et al. (1981) also described a field method to measure the saturated conductivity of the soil adjacent to the tile drains. The procedure is based on isolating an undisturbed soil volume around a tile drain and measuring the saturated K on the undisturbed sample. Although these procedures are alternative methods to auger-hole and piezometer-tube methods, their applicability is limited and the procedures resemble those of laboratory methods. For more detailed discussion of these procedures, the reader is referred to the above articles.

29–3 DEEP WATER TABLE METHODS

The methods to determine the saturated hydraulic conductivity in locations above a water table or in the absence of a water table are more elaborate and time consuming. In fact, a large quantity of water may be needed to saturate the nearby soil before the measurement. These methods include the double-tube method, shallow well pump-in method, cylindrical permeameter method, air entry permeameter and infiltration gradient technique.

29–3.1 Double-tube Method

29–3.1.1 PRINCIPLES

The double-tube method as proposed by Bouwer (1961, 1962, 1964) utilizes two concentric cylinders installed in an auger hole. An auger hole is dug to the desired depth, cleaned with equipment shown in Fig. 29–11, and the outer tube is installed in the hole and pushed about 5 cm into the hole bottom. The inner tube and the top-plate assembly (as shown in Fig. 29–12) are then installed in the outer tube and pushed about 2 cm into the bottom of the hole. With valve B open and valve C closed, water is supplied to both inner and outer tubes through valve A. After water reaches the top of the outer tube standpipe, valve A is adjusted so that water level in the inner tube standpipe stays at the zero mark (the end of the outer tube standpipe is at the same height as the zero mark on the inner tube standpipe). This can be achieved by allowing the outer standpipe to overflow slightly. Due to the large head of water, a wet zone with positive pressure is created at the bottom of the hole.

After saturation of the bottom of the hole is achieved (usually after 1 h for fine-textured soils), two sets of data are collected. First, valve B is closed and the water level in the inner tube standpipe decreases while the water level in the outer tube stays at the top of the outer tube standpipe. The fall of water in the inner tube standpipe, H, and time, t, are recorded; t starts with the closing of valve B. Due to the decrease in head

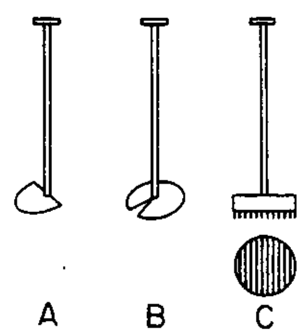


Fig. 29–11. Schematic diagram of equipment used to construct the auger hole for double-tube method. (A) spoon; (B) rotary or hole planer; and (C) hole cleaner.

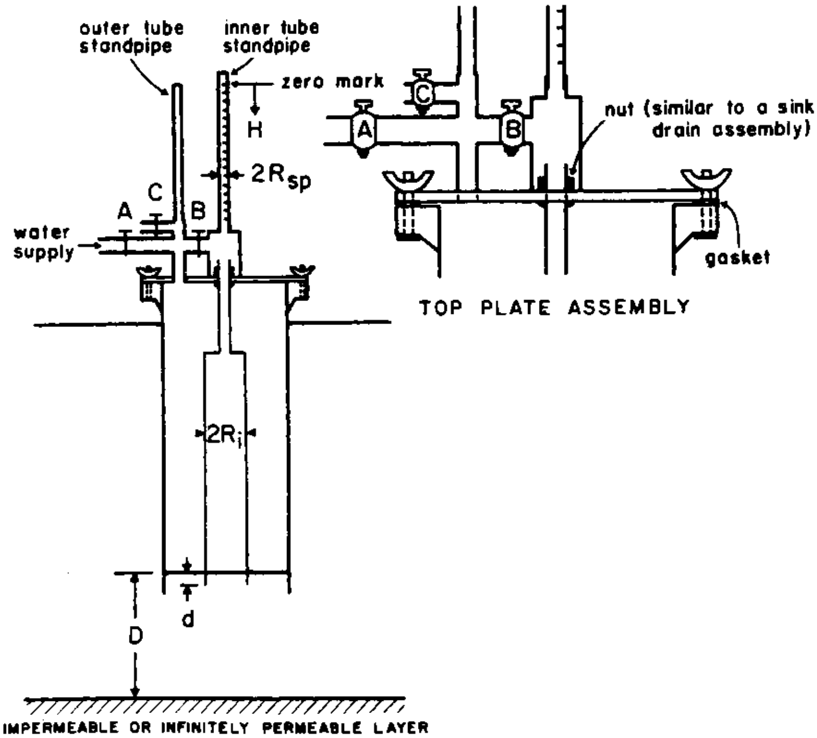


Fig. 29-12. Diagram of the equipment used for double-tube method.

in the inner tube and the greater head in the outer tube, the rate of fall of head in the inner tube decreases with time (see Fig. 29-13). After H vs. t is obtained, valve B is opened and water level in the inner tube standpipe is brought back to the zero mark. After the initial equilibrium is reached, valve B is closed and valves A and C are adjusted in such a way that the level of water in the outer tube standpipe stays at the same level as water in the inner tube standpipe. The rate of fall of water in the inner tube standpipe is recorded and the fall of water H is plotted vs.

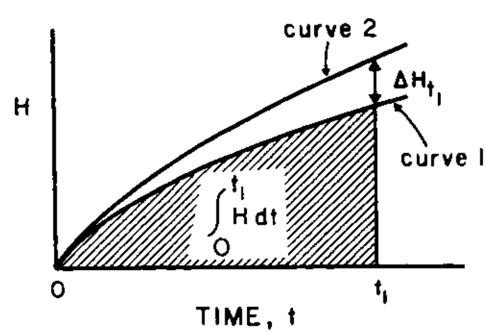


Fig. 29-13. Graph of H vs. t for double-tube procedure.

time on the same graph as data set 1 (Fig. 29–13). The second curve lies above the first curve because there is no difference between the head of water in the inner and outer tubes.

The saturated hydraulic conductivity is calculated using the H vs. t graphs and

$$K = R_{sp}^2\,\Delta H_{t_1}/(FR_i\int_0^{t_1} H\,dt) \quad [10]$$

where

R_{sp} = radius of the inner tube "standpipe",
R_i = radius of the inner tube,
ΔH_{t_1} = vertical distance between the two curves, (see Fig. 29–13) at a certain time $t = t_1$,
$\int_0^{t_1} H\,dt$ = area under the lower curve between $t = 0$ and $t = t_1$, and
F = a dimensionless quantity dependent on the geometry of the flow system. The value of F depends on the diameter of the inner tube R_i, depth of penetration of the inner tube d, and the depth and nature of the lower boundary. The nomograph in Fig. 29–14A gives values of F for an impermeable layer located below the bottom of the hole. If a highly permeable layer is located below the hole, the nomograph in Fig. 29–14B can be used.

29-3.1.2 APPARATUS

1. Double-tube apparatus. The double-tube apparatus is commercially available (from Soil Test, Inc., 2205 Lee Street, Evanston, IL 60202, USA) under the name "Tempe Double Tube Hydraulic Permeability Device." The apparatus can also be assembled as shown in Fig. 29–12. The materials needed are:
   a. Galvanized steel or aluminum pipe, approximately 25 cm in diameter.
   b. Galvanized steel or aluminum pipe, approximately 12 cm in diameter.
   c. Top assembly plate as shown in Fig. 29–12.
   d. Clear plastic or glass tubes with marks for the inner tube standpipe.
   e. Gasket and necessary hardware to assemble the equipment.
2. Auger. Use any auger that can make a round, clean hole with a diameter equal to that of the outer tube. (i.e., 25 cm).
3. Hole-cleaning equipment (Fig. 29–11):
   a. Spoon, to remove soil from the hole.
   b. Rotary or hole planer.
   c. Hole cleaner, consisting of thin steel plates, 2 cm wide, which are mounted 1 cm apart on a cylindrical block of the same diameter as the auger hole.
4. Auxiliary water reservoir: a 200-L drum is well suited for the purpose.

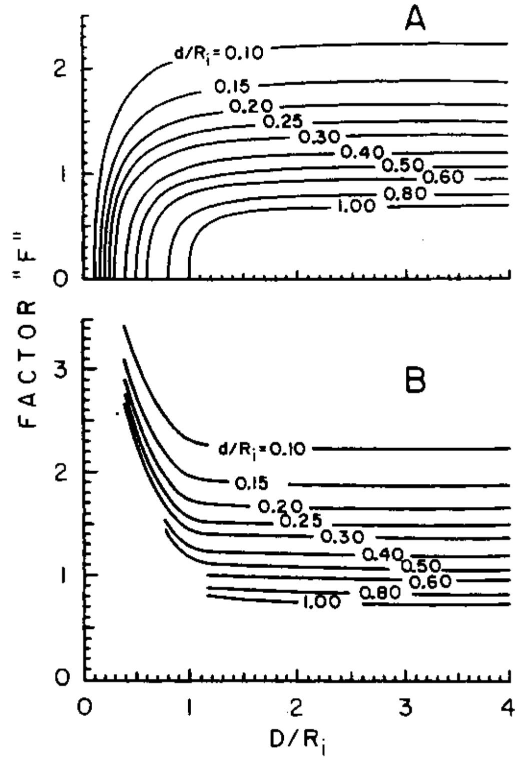


Fig. 29–14. Values of *F* for Eq. [10] for double-tube method. (A) An impermeable layer below the hole; (B) An infinitely permeable layer below the hole (Bouwer, 1961).

5. Data sheet such as the one shown in Fig. 29–15.
6. Graph paper.
7. Planimeter (if available) to measure the area under the curve.
8. Watch or timer.

29-3.1.3 PROCEDURE

1. Bore out the hole to the desired depth. Use the rotary planer (Fig. 29–11) to square the bottom of the hole. Insert the hole cleaner and push down so that the steel plates penetrate the hole bottom for about 1 cm. Apply a slight torque to the device, causing the soil to stick between the plates, and pull it up. If the soil is hard and/or very dry, add a small amount of water to the hole and wait for the water to soften and moisten the soil before proceeding with the rotary planer.
2. After the hole is squared and cleaned, apply a protective 1- to 2-cm layer of sand to the hole.
3. Insert the outer tube into the hole and push it down so it penetrates about 5 cm into the soil. Backfill any cavity that may be around the outer tube and tamp it to form a tight seal.

in step *9* to reach H_1 (i.e., t_1) and for the water level in step *7* to reach H_1. Other parameters are the same as in Eq. [10]. For more information see Bouwer and Rice (1964).

Due to the soil disturbance around the inner tube, the diameter of the outer tube must be at least twice that of the inner tube (Bouwer & Rice, 1967). An inner tube with a diameter of <10 cm is not recommended for this procedure. Combinations of 10 and 20 or 12.5 and 25 cm for the inner and outer tube diameters have proved to be satisfactory.

The hydraulic conductivity value obtained by this method is affected by both vertical and horizontal conductivity of the soil. However, it is closer to the vertical direction conductivity for anisotropic soils. For more information see Bouma and Hole (1971).

Depending on the permeability of the soil, the double-tube method requires 2 to 6 h for completion. The method requires over 200 L of water for each site and is not suitable for rocky soils.

29–3.2 Shallow Well Pump-in Method

29–3.2.1 PRINCIPLES

To measure the saturated hydraulic conductivity by the shallow well pump-in technique (also referred to as constant head well permeameter or dry auger hole method), a hole is bored to the desired depth and a constant head of water is maintained in the hole (Fig. 29–17). When the water flow into the soil reaches a constant value, i.e., a steady-state condition, the flow is measured while the level is kept constant.

For an impermeable layer located at relatively great depth where $s > 2H$, the equation for K is due to Glover (Zangar, 1953, Eq. [8B]):

$$K = Q\,[\sinh^{-1}(H/r) - (r^2/H^2 + 1)^{1/2} + r/H]/(2\pi H^2)\,. \qquad [12]$$

When $H >> r$, Eq. [12] can be simplified to (Zangar 1953, Eq. [10B])

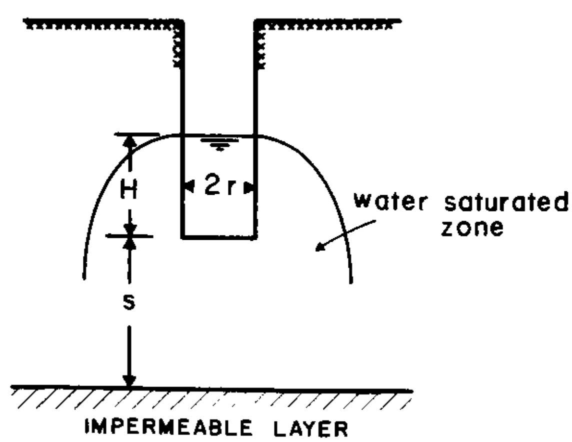


Fig. 29–17. Geometry of shallow well pump-in technique.

$$K = Q\,[\sinh^{-1}(H/r) - 1]/(2\pi H^2) \qquad [13]$$

or equivalently to

$$K = Q\{\ln[(H/r) + (H^2/r^2 + 1)^{1/2}] - 1\}/(2\pi H^2) \qquad [14]$$

where Q is the flow rate at equilibrium (units L^3/T), H is the depth of water in the auger hole (units L), r is the radius of the hole (units L), and s is the distance between the impermeable layer and the bottom of the hole (units L). For conditions where $0 < s < 2H$, the resulting equation is:

$$K = 3Q \ln(H/r)/[\pi H(3H + 2s)]\,. \qquad [15]$$

Note that in shallow well pump-in, the auger hole should not penetrate any impermeable layer.

To prevent caving, a perforated pipe or commercial well screen may be used as casing. If casing materials are not available, the hole may be filled with coarse sand. When a casing pipe or screen is used, a layer of sand, gravel, or burlap must be placed at the bottom of the hole to prevent erosion caused by water application.

29-3.2.2 SPECIAL APPARATUS

1. Auger (use a bucket auger), with diameter on the order of 5 to 15 cm.
2. Constant head system (see Fig. 29-18) consists of
   a. A 200-L tank (a 54-gallon drum is suitable)
   b. A 250-ml flask.
   c. Tall cylinder, 1 m long, 10-cm diameter.
   d. Glass or metal tubing.
   e. Plastic tubing.
   f. Four rubber stoppers for cylinder, flask, and hole into drum.
3. Water supply tank with 1- to 2-m^3 (1000–2000 L) capacity.
4. Garden hose for rapid filling of the constant head reservoir.
5. Casing (perforated) pipe or commercial well screen, if available.
6. Sand or gravel, to be used when casing pipe or screen is not available.
7. Sand, gravel, or burlap to be placed on the bottom of the hole where casing is used.
8. Large round brush to clean the wall of the auger hole. As an alternative, narrow pieces of flat brush can be assembled around a stick.
9. Measuring tape or meter stick.
10. Watch or timer.
11. Data sheet, such as the one shown in Fig. 29-19.

29-3.2.3 PROCEDURE

1. Clean plant material, trash, and loose soil from the surface.
2. Bore a hole to the desired depth with minimum disturbance to the

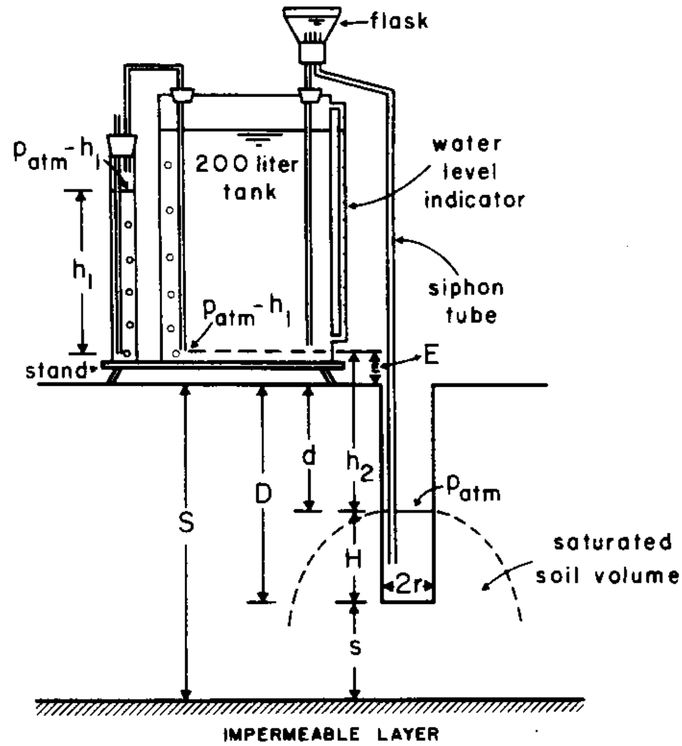


Fig. 29–18. Diagram of the constant head device and geometry of the shallow well pump-in set up.

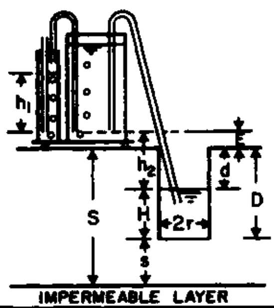
wall of the hole. Check and record the texture of the profile as you bore out the hole. Make sure that you do not penetrate any impermeable layer.

3. After the hole is dug to the desired depth, brush the side of hole to remove any possible sealing and compaction caused by the auger. Use a metal brush with short and separate bristles for fine textures.
4. Measure the dimensions of the hole (r and D) and determine (or estimate) the depth of impermeable layer from the bottom of the hole s. Also determine the depth of water to be maintained in the hole (H).
5. Case the hole with perforated pipe or screen. The perforation should extend from the bottom of the hole to the predetermined water level. If coarse sand or gravel is used in place of casing, fill the hole to within 15 cm of the predetermined controlled water level.
6. Set up the constant head system as shown in Fig. 29–18. At equilibrium, the constant head device maintains the water level in the hole so that $h_1 = h_2$. When the water level in the hole drops, a pressure gradient is created which causes the water to move to the hole through the siphon tube while air enters the water reservoir from the tall cylinder to replace the water. As a result, the air pressure in the tall

LOCATION: DATE:

REMARKS:

S =
D =
E =
h_1 = h_2 =
d = h_2 − E
H = D − d
r =
s = S − D



Before Steady State			After Steady State	NOTE
amount of water	time t	flow rate		
cm³	min	cm³/min	Tank reading: initial: final: t = Q = temperature adjusted Q K =	

observer:

Fig. 29–19. Data sheet for shallow well pump-in technique.

cylinder decreases, causing the air to enter the chamber through the regulator pipe. The difference between the air pressure inside the tall cylinder and atmospheric pressure corresponds to the length h_1. The air pressure head at the tip of the connecting tube inside the reservoir is therefore equal to $(P_{atm}/\rho g) - h_1$, which in turn must be equal to $(P_{atm}/\rho g) - h_2$. This maintains the water level inside the auger hole at a distance $h_2 = h_1$ below the tip of the connecting tube in the reservoir. A 250-mL flask filled with water will trap any air bubbles formed in the siphon system. The siphon system may be replaced by a spigot attached to the lower part of the reservoir and connected to a plastic tube extended below the water level in the hole. (As an alternative to the constant head system, a small constant-level float-valve can be used. The float-valve can be lowered in the hole, secured at the predetermined depth by a rod, and connected to the water reservoir by plastic or rubber tubing.)

7. Adjust the level regulator tube in the constant-head system to maintain water at the predetermined level (or install the float-valve at the desired depth).
8. Fill the hole to the water level and start the constant-head system to keep the water level steady.
9. Check the water reservoir tank regularly and refill the tank as needed. Check the water temperature and record the data.
10. Record the time and the amount of water moving from the tank regularly. Time intervals should be short enough so that the tank never runs out of water.
11. Compute the flow rate for each measurement. The flow rate can be corrected for any desired temperature by multiplying the rate by the ratio of water viscosity at the temperature during the measurement and the desired temperature (cf. viscosity for water at 10, 20, and 30°C are 1.3077, 1.002, and 0.7975 centipoise, respectively). A reference temperature may be chosen as the mean annual soil temperature at the depth of interest.
12. If the data for consecutive measurements are not consistent, repeat steps *8* to *11*. If the flow rate has become constant (over a 24-h period or for at least three consecutive measurements each for a few hours), proceed with calculations.

29–3.2.4 CALCULATIONS

Compare the depth of the impermeable layer from the bottom of the hole s and depth of water in the hole H, and select the appropriate equation (Eq. [12] to [14] or [15]) to calculate the hydraulic conductivity.

29–3.2.5 COMMENTS

The hydraulic conductivity determined by this procedure can be taken as an average hydraulic conductivity for the full depth of the hole being tested. However, in reality, the calculated K reflects the conductivity of the most permeable layers. If the soil is uniform, the measured value is dominated by the horizontal conductivity.

The volume of soil effective in testing is about the same as for the auger hole method [i.e., about 10 Hr^2 to 40 Hr^2 (units L^3)]. The hydraulic conductivity, however, might not be the same as by the auger hole method. In comparing the two methods, the measured values differed by as much as 100% (Boersma, 1965b).

The disadvantages of the method are the requirement of large quantities of water and a considerable amount of equipment, and the long duration of testing. The construction of the auger hole and installation of the equipment will take several hours, and the test itself might require several days. Water with chemical composition comparable to the natural soil or irrigation water is desirable.

Reynolds et al. (1983) presented new analytical and numerical solutions for the shallow well pump-in technique which result in considerably higher calculated saturated conductivity values. Compared to Eq. [14], their numerical solution produces increases in the saturated conductivity values of 68 and 65% for H/r ratios of 5 and 10, respectively. More recently Reynolds et al. (1985) and Philip (1985) have extended the theory of water flow from the auger hole to include the effects of unsaturated flow on the measured saturated conductivity.

In addition to the theory, Reynolds et al. (1983) presented a constant head apparatus (called a Guelph Permeameter, which is commercially available from Soilmoisture Equip. Corp., P. O. Box 30025, Santa Barbara, CA 93105) for maintaining a constant water level in a small auger hole. With their apparatus the conductivity can be measured in a small well of approximately 2 cm radius with a 10 to 20 cm depth of water in the hole (e.g., H/r ratios of 5–10). Such an auger hole can be constructed by a small screw soil auger or by a 4-cm diameter soil probe equipped with an inward-beveled cutting tip instead of the usual outward-beveled cutting tip. According to them, the measurement time and the amount of water needed for conductivity determination depend on the soil texture, initial water content of the soil, and H/r ratio. In their study, conductivity measurements on sandy loam soils near field capacity required < 0.5L of water and were completed in 5 min. Sandy soils below field capacity and clayey soils required measurement time of 15 to 30 min and up to 2 L of water. For detailed procedures with example calculations see Reynolds and Elrick (1986). Talsma and Hallam (1980) also used a simplified well permeameter assembly to determine K in an auger hole 6.4 cm diameter using 2 to 3 L of water. They reported that steady state flow was achieved after 20 min for initially dry soil, and after 8 min for moist soil.

The procedure used in the shallow well pump-in technique is similar to percolation tests used for septic tank suitability. However, in percolation tests, the rate of water flow into the soil (after saturation is achieved) is determined by measuring the rate of fall of water level in the hole rather than maintaining a constant head. For a more complete discussion of the percolation test, see Barbarick (1975) or Barbarick et al. (1976).

29–3.3 Other Methods

29–3.3.1 PERMEAMETER (OR CYLINDRICAL PERMEAMETER) METHOD

A large-diameter hole is dug to the desired depth and a cylinder (such as infiltrometer ring) > 35 cm long, with a diameter of 45 to 50 cm, is placed in the center of the hole. The cylinder is driven about 15 cm into the soil with minimum disturbance to the natural profile. Four tensiometers are placed around the cylinder in a symmetrical fashion 10 cm from the cylinder and about 23 cm below the level surface inside the hole. Water is applied to the hole and inside the cylinder to a depth of about 15 cm and the tensiometers are monitored. When the tensiometers read zero, it is assumed that saturation is achieved and the rate of water flow into the soil through the cylinder is measured. Before a positive pressure builds up (i.e., tensiometers show < zero tension) the measurement is terminated and the conductivity is calculated using Darcy's equation.

The procedure is time-consuming and requires in excess of 100 L of water. It measures the conductivity in the vertical direction and is not suitable for rocky soils. For more information see Winger (1960) or Boersma (1965b).

29-3.3.2 INFILTRATION-GRADIENT METHOD

Bouwer (1964) proposed the infiltration-gradient technique to measure the vertical hydraulic conductivity. It is a modification of the cylinder-permeameter and double-tube method. Two concentric tubes are placed in an auger hole with small, fast-reacting piezometer tubes placed at different depth inside the inner cylinder. The piezometer tubes provide a complete vertical hydraulic gradient for the system when equal water depths, ranging from 20 to over 200 cm, is kept within the two cylinders. The method determines the K in the vertical direction. It takes about 3 h to complete, requires 100 L of water, and is not suitable for stony soils. For more information regarding the procedure and equipment see Bouwer (1978) and Bouwer and Jackson (1974). Both vertical and horizontal conductivities can be measured by combining the infiltration gradient technique with the double-tube method in the same hole (see Bouwer, 1964).

29-3.3.3 AIR-ENTRY PERMEAMETER METHOD

This method is a fast technique to determine the hydraulic conductivity K above a water table, with about 10 L of water. The method, as developed by Bouwer (1966), yields K from Darcy's law using the infiltration rate under a high head and gradient without using a tensiometer and/or piezometer installed in the soil. Fig. 29-20 shows the apparatus to measure the air entry value and hydraulic conductivity at the soil surface or at the bottom of a pit.

A cylinder, 20 to 30 cm in diameter and over 10 cm long, is driven about 10 cm into the soil with a minimum disturbance to the soil. A layer of sand is placed inside the cylinder with a disk on top to dissipate the energy and prevent the puddling effect of water application. The top-plate assembly is then secured and water is applied to the ring through the reservoir keeping the gage valve closed. The air escape valve is kept open to allow the air to escape and is shut when all the air is driven out of the system.

The infiltration rate is calculated by stopping the water application to the supply tank when the wetting front reaches the lower part of the cylinder. (The time for the wetting front to reach the lower part of the cylinder is estimated by a few trials before the actual procedure starts.) After the infiltration rate is measured, the supply valve is closed, halting

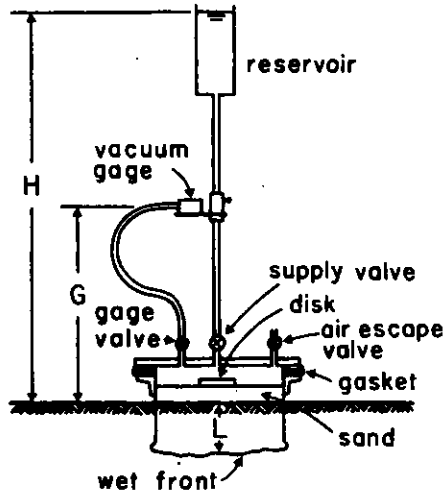


Fig. 29-20. Diagram of the equipment for the air-entry permeameter technique (after Bouwer, 1966).

the wetting front movement, and the gage valve is opened to measure the pressure inside the cylinder. The pressure inside the cylinder decreases to a minimum at which air begins to bubble up through the soil. As soon as the minimum pressure is reached, the equipment is removed and the depth of the wet front is determined by digging. The air entry value $P_a/\rho g$ (units L) is evaluated from the minimum pressure and the conductivity is calculated by

$$K = L(\Delta H/\Delta t)(R/R_c)^2/[H + L - (P_a/2\rho g)] \quad [16]$$

where L is depth of the wet front when the supply valve was closed; H is the height of the water level above the soil; $\Delta H/\Delta t$ is the rate of fall of water level in the reservoir just before the supply valve was closed; and R and R_c are the radius of the reservoir and cylinder, respectively.

The conductivity calculated by this method is for the wetted zone, and according to Bouwer (1966), the saturated conductivity may be estimated as double the measured K. For heavy soils, however, measured K needs to be multiplied by a factor of 4. For more information see Bouwer (1966) and Bouwer and Jackson (1974).

Aldabagh and Beer (1971) evaluated the air entry permeameter technique by measuring the saturated conductivity at three different depths. They selected 30 sampling locations within a 150- by 60-m rectangular field. Their results indicate that the air-entry permeameter is a fast and reliable method for measuring K above a water table. The low manpower, low water-requirement and short time needed to make the measurement are among the advantages listed by them.

A modified version of the air-entry permeameter technique has been

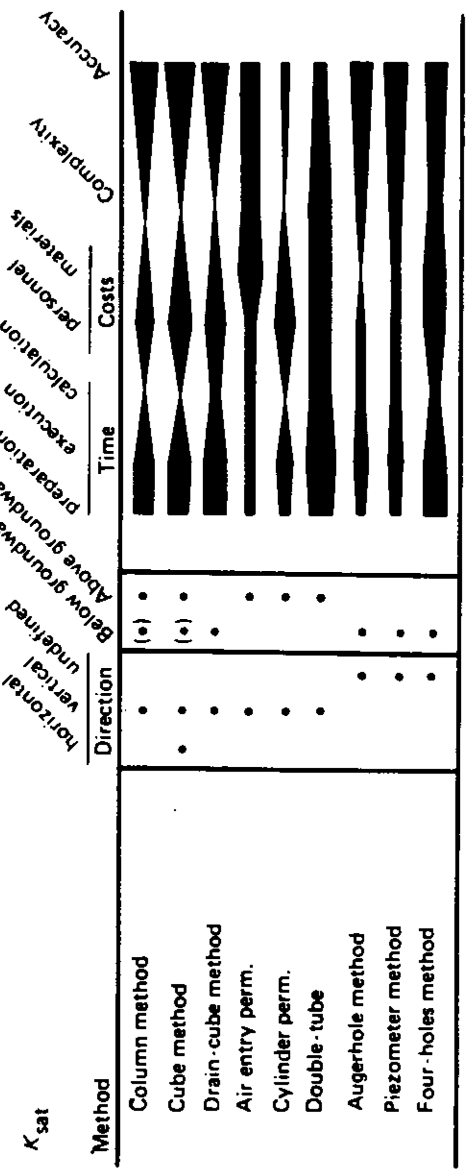


Fig. 29–21. Operational aspects of nine methods for measuring saturated hydraulic conductivity (K_{sat}) (after Bouma, 1983.).

presented by Topp and Binns (1976). In their procedure, the position of the wetting front can be detected by a fine tensiometer probe. These investigators also recommend the procedure for its reliability, low water requirement, and speed. McKeague et al. (1982) used the procedure to compare measured saturated conductivity with estimated values from soil morphology. They discussed some of the problems associated with using the procedure in the presence of biopores and cracks (i.e., macropores) in the soil.

29–4 COMMENTS

One of the important considerations in determining the saturated hydraulic conductivity in the field is the spatial variability of the soil hydraulic conductivity (Nielsen et al., 1973; Warrick & Nielsen, 1980). The conductivity values obtained from two locations only a few meters apart could be drastically different due to soil heterogeneity.

The presence of macropores can lead to unrealistic values of conductivity in the field (Bouma, 1983; Beven & Germann, 1982). Undoubtedly, even a few large pores will allow water to move at rates faster than the saturated conductivity of surrounding soil body. The amount of macropores and their contribution to the saturated conductivity of the soil depend on structure. Bouma et al. (1982), for example, described infiltration into a soil with vertical worm-channels. They state that on the average each channel occurred in a 200-cm^2 cross-sectional area. Therefore they suggested that, ideally, the area of infiltration in the infiltrometer should be a multiple of 200 cm^2 and should contain a corresponding number of channels for that particular site.

To obtain an unbiased estimate of the soil hydraulic conductivity, an optimal soil sample is needed for analysis. The sampling volume should contain a proportional amount of macropores compared to the main soil body under consideration; i.e., a minimum volume of soil is needed such that the variability of the macropores does not change with increasing sample volume. Such a sample size is referred to as the representative elementary volume (REV) (see Fig. 4 of Beven & Germann, 1982). Bouma (1983) presented REV values for four hypothetical classes of soil texture and structure. His reported values range from 10^2 cm^3 for a sandy soil with no peds to 10^5 cm^3 for a clayey soil with large peds and continuous macropores.

Care should be taken in selecting the appropriate number of replications and the site of each conductivity measurement within a field. Bouma (1983) evaluated the auger-hole method as well as other procedures, with respect to time required, cost, complexity, and accuracy of the measurements. His results are presented as Fig. 29–21, where the width of the band indicates favorability of the parameters on top. For example, the ease of preparation of the auger-hole method is indicated by a narrow band, whereas the difficulty of the double-tube method is shown as a wide band.

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Alternative, Innovative, and Experimental On-Site Wastewater Systems

7

Alternative, Innovative, and Experimental On-Site Wastewater Systems

7.1 ADVANCED ON-SITE WASTEWATER TREATMENT

This chapter deals with a number of more advanced on-site wastewater systems that use techniques for wastewater management. These advanced systems require special permits and special designs to ensure that the system will function properly. Generally, these systems are more expensive and require more maintenance and management than conventional or modified conventional systems.

Special Systems for Difficult Sites

In many cases, sites cannot meet the criteria to obtain approval for installation of a conventional or modified conventional on-site system. For some of these sites, it may be possible to install an *alternative, innovative,* or *experimental* on-site system.

Although these systems offer the potential of allowing owners to use an otherwise unacceptable site, the systems are more costly and require more involvement to operate and maintain than conventional or modified conventional systems. As is the case with all on-site systems, care must be taken in the design and installation of an alternative, innovative, or experimental system to give it the best chances of satisfactory operation.

To help meet these requirements, this chapter presents criteria for the design, installation, operation, maintenance, and inspection of alternative, innovative, and experimental systems.

As defined by the Laws and Rules for Sewage Treatment and Disposal Systems,

"Sewage" means the liquid and solid human waste and liquid waste generated by water-using fixtures and appliances, including those associated with food handling.

"Effluent" means the liquid discharge of a septic tank or other sewage treatment device.

Reference

15A NCAC 18A.1935(11),(39)

Definitions

Each of these more complex systems is specifically defined and each has different criteria for approval.

Alternative systems.

These systems have demonstrated capability, and we know a good deal about appropriate sites and installation for best performance. Criteria for their design, installation, operation, maintenance, and inspection are found under 15A NCAC 18A.1957. Alternative systems include:

- *low-pressure pipe systems,*
- *area-fill systems,* and
- *individual aerobic treatment unit systems.*

Innovative systems.

Innovative systems have shown promise as useful technologies for certain sites but information on these systems is still limited. Thus, the approval procedure is different from conventional, modified conventional, or alternative systems. Some of these systems must be designed by a professional engineer. This category of on-site systems includes:

- *chamber systems,*
- *polystyrene trench media systems,*
- *drip distribution systems, and*
- *gravity and pressure-dosed bed-fill systems.*

Experimental systems.

Experience with these technologies is even more limited; each system is given approval only as a part of a state-approved research or testing program. Experimental system approval helps us gain experience with the experimental technology so it can obtain innovative or alternative system status. Thus, the research or testing program must be designed to lead eventually to approval as an alternative or innovative system. Examples of experimental systems include:

- *constructed wetland systems,*
- *peat filter systems,* and
- *tire-chip aggregate trench media systems.*

Design Criteria for Alternative On-Site Systems

The following three sections present information to help in designing and installing alternative on-site systems. The first section covers the design, installation, and maintenance of low-pressure pipe systems. Next, systems that use area-fills for the treatment and disposal field are discussed. Finally, individual aerobic treatment unit design, installation, and maintenance are presented.

7.2 LOW-PRESSURE PIPE SYSTEMS

Under some conditions, such as limited soil depth, shallow depth to soil wetness, clayey soil with a low permeability, or shallow restrictive horizons, *low-pressure pipe*, or LPP, on-site systems may be used. LPP systems pump effluent under low pressure to specially designed pipes in the treatment and disposal field, evenly distributing the effluent in the soil and avoiding overloading one area. These systems cannot be used on all sites that are UNSUITABLE for conventional or modified conventional systems, but they have proven satisfactory for many sites with limiting conditions.

LPP systems are relatively economical compared to more advanced systems and are effective if designed, installed and operated properly. Because LPP systems discharge to aerobic, biologically active soil near the ground surface, the effluent may receive better treatment than if it were discharged into a deeper conventional trench.

Site and Soil Suitability

The requirements that follow must be met to install an LPP system on a site that is classified SUITABLE or PROVISIONALLY SUITABLE for conventional or modified conventional on-site systems and on other sites where specific conditions can be met.

Reference

15A NCAC 18A. 1957

Reference

15A NCAC 18A. 1957 (2)

❑ The suitability of the site for LPP systems depends on the 24 inches of the soil immediately beneath the ground surface. This first 24 inches of soil must either be SUITABLE or PROVISIONALLY SUITABLE as determined by rules 15A NCAC 18A .1941 - .1944 and .1956.

❑ LPP treatment and disposal fields cannot be installed on sites with a slope greater than 10% unless special designs are used and approved. These special designs must incorporate site-specific measures to ensure that effluent will be evenly distributed over the entire treatment and disposal field.

❑ The treatment and disposal field must be landscaped to shed rain water and prevent runoff from flowing onto the field. All criteria in rule 15A NCAC 18A.1940 must be met for an LPP system.

❑ The septic tank, all pretreatment units, the pump tank or dosing tank, and the treatment and disposal field must be located as required by rule 15A NCAC 18A.1950.

❑ Horizontal distances from the treatment and disposal field must be measured from the outside edge of the dosed area. The outside edge of the dosed area is 2 ½ feet from the lateral or manifold pipes.

❑ The site for the treatment and disposal field and for the repair field for an LPP system must not be disturbed except for installing the system.

❑ LPP systems have the same space requirements as under 15A NCAC 18A.1945.

LPP System Components

A simple LPP system consists of a standard septic tank, a pumping or siphon dosing tank, and an LPP treatment and disposal field; however, there are a number of pretreatment systems and other components that can be used with an LPP treatment and disposal field. See Figure 7.2.1 for a diagram of a simple LPP system.

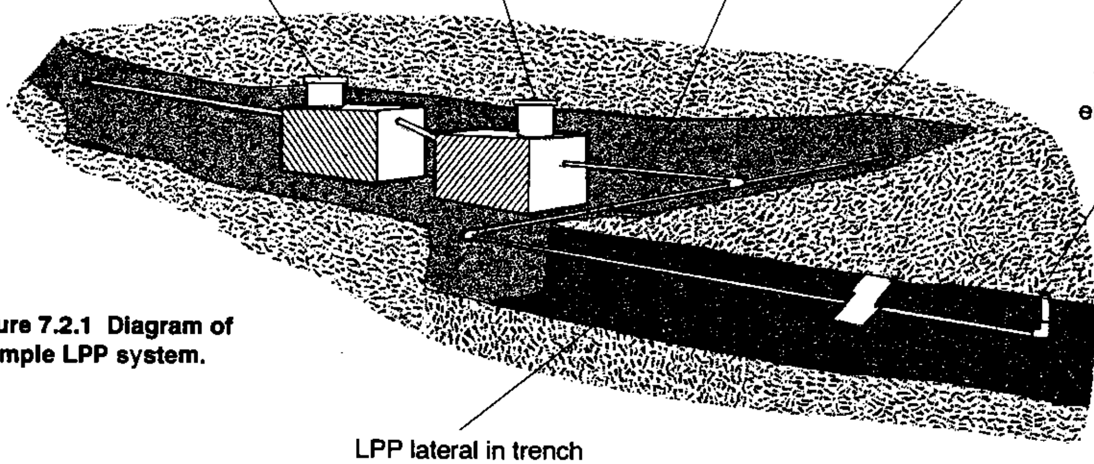


Figure 7.2.1 Diagram of a simple LPP system.

- The most important part of the LPP system is the treatment and disposal field. This field consists of a network of small-diameter polyvinyl chloride (PVC) plastic pipes called laterals that have specially sized and located holes drilled into the pipes. The pipes are placed into shallow trenches and surrounded by crushed stone.
- An LPP treatment and disposal trench is 12 to 18 inches wide and must have 5 inches of crushed stone under the lateral, 2 inches of stone over the lateral, and at least 4 inches of soil cover over the crushed stone. The total trench depth is usually 12 to 18 inches, depending on the diameter of the lateral and the depth of the soil cover.
- The LPP system must have a pump tank or dosing tank to supply the low pressure needed to pressure dose the LPP treatment and disposal field.
- Most LPP systems typically dose the treatment and disposal field at a pressure of 2 to 5 feet of head. The effluent is distributed evenly because the discharge holes in the lateral pipes are spaced to compensate for hydraulic losses and elevation differences.
- A supply pipeline conveys the effluent from the pump tank to the treatment and disposal field. This pipeline must be watertight and made of Schedule 40 PVC pipe or equivalent.
- The supply manifold receives the effluent from the supply pipeline. This manifold divides the flow of effluent to the lateral pipelines which, in turn, distribute the effluent evenly throughout the entire area of the field. It is important that the supply manifold be properly sized to provide the correct flow to all the laterals.
- Laterals are the small, typically 1¼-inch to 1½-inch pipelines in the trenches. The laterals have specially sized holes to allow a very even dosing of effluent to each trench and the entire field.

Design Requirements for LPP Systems

Several requirements for LPP system design have been developed through years of experience with hundreds of systems. The following sections list requirements for approval of an LPP system and recommendations for improved operation. Table 7.2.1 lists requirements and recommended designs for LPP systems.

Table 7.2.1 Requirements and Recommended Designs for LPP Systems

Design Component	Requirement	Recommended Design
Lateral pipeline diameter	1 inch, minimum	1 ¼ - 1 ½ inch maximum
Trench width	8 inches,	12 inches to 18 inches minimum when site conditions allow
Cover over lateral	4 inches soil over 2 inches crushed stone, minimum	Protect stone by covering with geotextile fabric to prevent soil migration into voids
Orifice size	5/32 inch for 2/3 of holes, minimum; 1/8 inch, absolute minimum for 1/3 of holes	5/32 inch, minimum 3/16 inch, minimum, for food services
Lateral sleeve or shields	None required	Reduce orifice clogging by sleeving lateral with 4-inch corrugated perforated PE tubing, all lateral orifices pointing upwards except two, one in the middle and one near the end, which point downward

LPP system dosing: design requirements.

The septic tank, pump tank, dosing systems, siphons, and siphon-dosing tanks for an LPP system must meet the requirements of rule 15A NCAC 18A.1952.

❑ The pressure in the lateral must be between 2 and 5 feet of static head, measured at the downstream end of each lateral, when the lateral is discharging at the design flow rate.

❑ The design dose volume is 5 to 10 times the volume of the lateral pipes plus the volume of the manifold and supply pipeline that drains to the field between doses.

LPP treatment and disposal fields: design requirements.

The main advantage of LPP systems is even distribution of effluent over the entire treatment and disposal field. Listed below are ways to improve the distribution and increase the life of an LPP treatment and disposal field.

❑ The long-term acceptance rate, or LTAR, for an LPP system can be found in Table 7.2.2. When designing the system, the LTAR is the acceptance rate of the most hydraulically limiting natural soil horizon within 2 feet of the ground surface or within 1 foot of the trench bottom, whichever is deeper.

❑ For facilities where the wastewater contains large amounts of grease, such as food services, meat markets, and restaurants, the LTAR for an LPP system cannot be higher than the mean value for the limiting soil group. This limit on the LTAR helps prevent early failure if the treatment and disposal field becomes clogged with grease or from long-term exposure to high-strength wastewater.

❑ Food service facilities that can show data that wastewater from comparable facilities contains less than 30 mg/l of grease and oil and less than 500 mg/l of COD may be permitted to use a higher acceptance rate for the limiting soil for the LTAR for the system.

❑ The area required for the treatment and disposal field must be determined by dividing the design daily sewage flow, in gallons per day, by the assigned LTAR. To calculate the total length of trenches needed, the area of the treatment and disposal field, in square feet, must be divided by 5 feet. Five feet is considered to be the effective width of the area dosed by each LPP lateral.

❑ LPP systems must distribute the effluent uniformly. Trenches must be level along their entire length and each trench must follow a single contour on sloping sites.

Table 7.2.2 Long-Term Acceptance Rate for Low-Pressure Pipe Systems

Soil Group	Soil Texture Classes (USDA Classification)	Acceptance Rate (gpd/ft²)
I	Sands	0.6 - 0.4
	Sand	
	Loamy Sand	
II	Coarse Loams	0.4 - 0.3
	Sandy Loam	
	Loam	
III	Fine Loams	0.3 - 0.15
	Sandy Clay Loam	
	Silt Loam	
	Clay Loam	
	Silty Clay Loam	
	Silt	
IV	Clays	0.2 - 0.05
	Sandy Clay	
	Silty Clay	
	Clay	

*Soil Texture Class for soils that have SUITABLE or PROVISIONALLY SUITABLE structure and clay mineralogy. (USDA Classification)

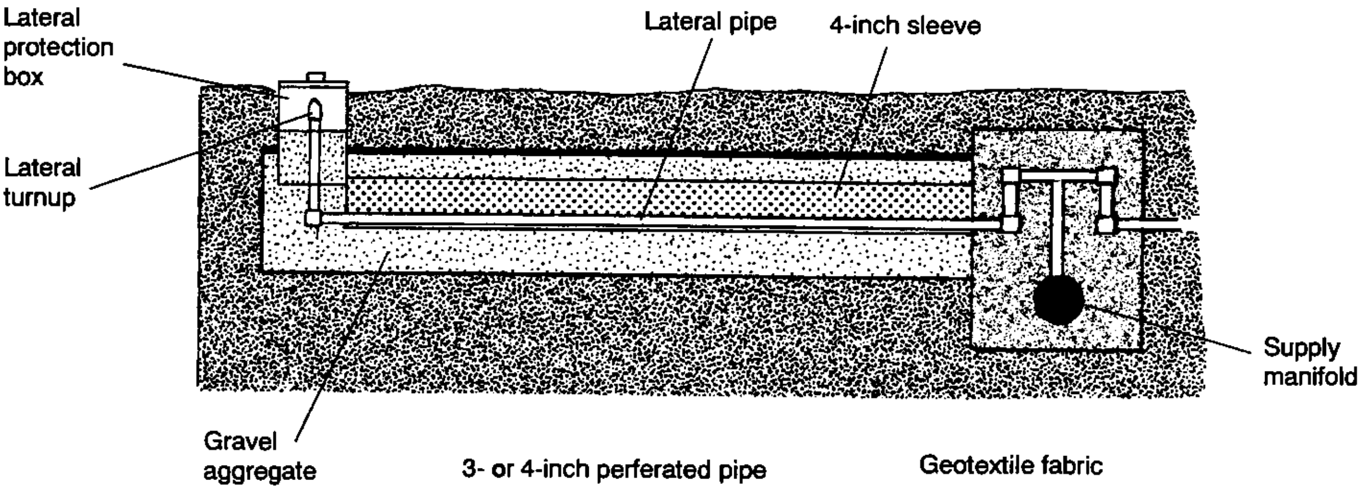
LPP lateral pipes: design requirements.

Laterals can be made from 160 psi PVC or equivalent pipe 1 to 2 inches in diameter. One and one-fourth-inch or 1 ½-inch pipes are most commonly used for the laterals. Figure 7.2.2 shows a side profile and Figure 7.2.3 shows a cross-section of an LPP trench.

❑ Lateral length is limited so that there is no more than a 10% difference in the rate of discharge of effluent from the first hole and the last hole in the lateral. Longer laterals can be installed by using larger diameter pipe and higher discharge pressure.

❑ Discharge holes must not be smaller than 5/32 inch for at least 2/3 of the total laterals in the field, although 1/3 of the laterals may have holes 1/8 of an inch or larger in size if the small holes are needed to balance the discharge of effluent on sloping sites.

Figure 7.2.2 Side profile detail of recommended LPP trench, including cross-section of recommended manifold-to-lateral connection.



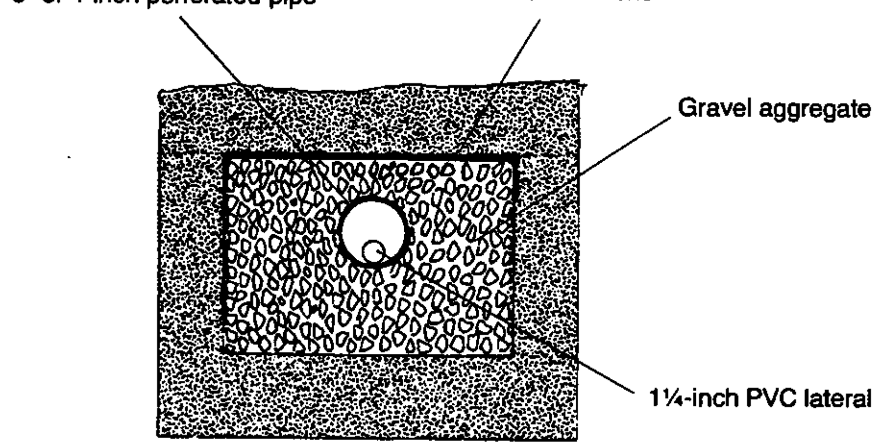


Figure 7.2.3 Cross-sectional, profile detail of recommended LPP trench.

❑ Facilities such as restaurants, food stands, meat markets, and other places where the effluent has a high potential to clog the discharge holes, must install discharge holes 5/32 inch or larger in the laterals. The recommended hole size for these facilities is 3/16 inch.

❑ Spacing between the holes depends on the soil in which the system is installed. To obtain even distribution of effluent, the holes cannot be farther apart than the following limits:

Maximum spacing between holes:

- Soil Group I = 5 feet
- Soil Group II = 6 feet
- Soil Group III = 8 feet
- Soil Group IV = 10 feet

❑ Experience has shown that LPP systems perform better if the laterals are sleeved in 3- or 4-inch perforated corrugated PE tubing typically used for conventional on-site systems. The sleeve reduces root intrusion and hole blockages by the crushed stone and makes it much easier to replace the laterals if necessary.

❑ To make the sleeved lateral function better, place all the discharge holes in the lateral facing up except for a single downward-facing hole in the middle and a second downward-facing hole 25% from the end of the lateral. The advantages of the upward-facing holes are that they cannot be blocked by corrugations in the sleeve, they vent air trapped in the laterals when the pump starts, they help break siphon action when the pump stops to reduce the overloading of the lowest laterals, and they are much harder to block by solids and biomats. The downward-facing holes drain the water so that water is not standing in the laterals between doses. Draining the lateral keeps plant roots from being attracted to otherwise standing water, reduces the build-up of biomat, and prevents anaerobic conditions and freezing in the lateral.

LPP treatment and disposal trenches: design requirements.

Trenches for the laterals must be at least 8 inches wide and spaced at least 5 feet apart; however, trenches 12 or 18 inches wide are recommended if site conditions permit. The wider trenches permit better installation, more storage and better reliability. See Figures 7.2.2 and 7.2.3 for details of LPP trenches.

❑ The trenches must contain 5 inches of washed stone below the lateral pipe and 2 inches of stone above the pipe, with at least 4 inches of soil cover over the stone. A layer of geotextile fabric over the stone keeps soil particles from falling into the stone, reducing trench storage capacity or plugging the trench bottom.

❑ An earthen dam, made of undisturbed or compacted soil and higher than the stone in the trench, must be constructed at the upstream end of each trench. The dam keeps effluent from flowing back into the supply manifold trench.

LPP treatment and disposal fields on sloping sites: design requirements.

Sloping sites require that certain adjustments be made in the hydraulic network so that the treatment and disposal field receives an even distribution of effluent.

❑ If the difference in elevation is more than 3 feet in a proposed field, the field must be split into subfields supplied by separately-valved manifolds. Each subfield must be hydraulically independent so that effluent can be evenly distributed both within and between the subfields. Subfields are required because differences of a few feet greatly affect the pressure and the discharge in each lateral, and because effluent remaining in the laterals at the end of the dosing cycle will tend to flow to the lower laterals.

❑ For elevation differences more than 10 feet in a field, even distribution of flow between multiple subfields must be accomplished without requiring simultaneous adjustment of multiple valves. In some cases, the original field must be divided into separate fields that are dosed independently with separate pumps.

❑ For elevation differences between the highest and lowest laterals of 3 feet or more, effluent must be supplied by separately-valved manifolds. The separate manifolds maintain the proper pressures in all the laterals, preventing the lower laterals from being overloaded by the difference in elevation.

❑ Because the lower laterals within a subfield receive more effluent at the beginning and end of the dosing cycles, and operate at a higher discharge pressure when the lateral pipes are full, the hole size and hole spacing must be adjusted to maintain even distribution. This adjustment must result in the upper laterals receiving 10 to 30% higher flow than the lower laterals when the laterals are under full pressure to reduce the tendency to overload the lower laterals.

❑ A separate, independently-dosed field, with its own pump or siphon, is required if more than 2000 linear feet of laterals are in the field, or if more than 3000 gallons per day of effluent flows to the field. Other means of splitting flow to multiple fields may be approved by the On-Site Wastewater Section on a case-by-case basis.

LPP lateral turn-ups: design requirements.

Each lateral in an LPP treatment and disposal field must have a *turn-up* pipe at the distall end. Turn-ups are short pieces of pipe that connect to the lateral pipe and then turn up to extend up to the ground surface. They are used to inspect the system, set or measure the pressure head, and to flush the laterals of accumulated solids. Figure 7.2.2 shows details of a properly installed turn-up.

❑ A turn-up must be made of Schedule 40 PVC pipe or equivalent and must have a protective sleeve made of 6-inch or larger pipe or be a specially-designed valve vault. Both the turn-up and the protective sleeve must be cut off at or just above the ground surface for easy accessibility and protection from damage by lawnmowers, etc. The turn-up and the sleeve must be capped to prevent effluent from flowing on the ground surface and to keep out animals. Caps must be readily removable by the operator or inspectors.

❑ The best way to make a turn-up is to use a 90-degree elbow. Elbows make it easy to measure the head in the laterals. Other fittings, such as 45-degree bends, make it easier to snake lines out, but difficult to measure the head and are not recommended unless used in addition to a 90-degree elbow or a riser tee.

LPP manifolds: design requirements.

The supply manifold must be sized so that less than a 15% variation exists in the discharge rate between the first and last laterals. This requires minimizing friction losses and entry losses along the length of the manifold. See Figure 7.2.2 for a view of a typical supply manifold.

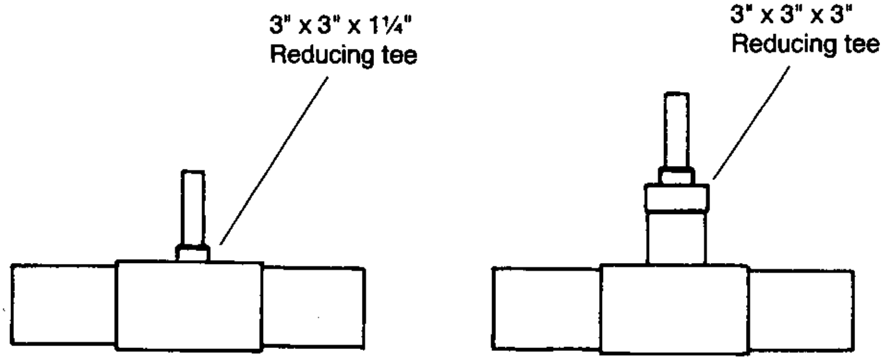
❑ The inside area of the supply manifold must be 70% or more of the sum of the inside cross-sectional areas of all the connected laterals.

❑ Reducing tees must be used in the supply manifold so that the pipe size is reduced to the size of the laterals at the manifold. These tees make a neat installation, reduce friction losses, minimize solids build-up, and still allow for the removal of blockages by cleaning the manifold. For example, use a 3-inch x 3-inch x 1 ¼-inch tee in the manifold rather than a 3-inch x 3-inch x 3-inch tee with a 3-inch x 1 ¼-inch bushing to reduce the pipe to the size of the laterals. See Figure 7.2.4 for a drawing of the supply manifold reducers.

❑ Cleanouts must be installed at both ends of the supply manifold and the cleanouts must extend to the ground surface. One or two 45-degree bends work very well as manifold cleanouts. Cleanouts at the top and the bottom of the manifold help blow out solids without pushing the solids into the laterals.

❑ Elbows should be used to bring the lateral pipes from the manifold over the earthen dam at the beginning of the trench. The elbows reduce the amount of effluent that drains back into the manifold after the pump stops, especially when used with sleeved laterals and upturned holes as recommended. Figure 7.2.2 shows the proper installation of the elbows and earthen dam at the pressure distribution manifold.

Figure 7.2.4 Side profile detail of typical supply manifold-to-lateral connection.



❑ Gate valves for adjustment of pressure in the manifolds must be provided in the supply line to the manifolds when the supply line is more than 100 feet in length. The valves must be installed in valve boxes and accessible from the ground surface. In the case of multiple manifolds and a number of these pressure-adjustment gate valves, locate all the valves for one field in a common valve vault so operators can easily set the correct pressure.

❑ Pressure-adjustment gate valves should be the smallest valve that is possible to use without causing head loss that cannot be overcome by the pump. The small valves can be adjusted more precisely, are not as subject to blockage and are less expensive. Usually the valve should be one nominal size smaller than the supply line.

Overloading of lower trenches in LPP systems: design requirements for sloping lots.

The following points help prevent overloading the lower trenches in an LPP treatment and disposal field. Overloading usually occurs because the lowest laterals fill up first and empty last, and because they often receive effluent that drains from the upper laterals and manifold after the pump turns off. Also, effluent discharged to the soil may move downhill from the upper trenches to the lower trenches, which adds to the total amount of effluent flowing to the lower trenches. The following design techniques help to prevent overloading the lower trenches in an LPP system.

❑ Use 90-degree elbows in the lateral pipes where the laterals go over the dam at the manifold. The elbows reduce the backflow of effluent into the manifold when the pump turns off.

❑ Dose 10 to 30% more effluent to the upper laterals when the system is under full pressure. This can be accomplished by varying the hole sizes and spacing.

❑ Use a drainback system to return the effluent in the manifold and supply pipe back to the pump tank after the pump turns off.

- Change the shape of the treatment and disposal fields to minimize the number of laterals at different elevations. The field can be made wider to run longer laterals along fewer contours.

- Check valves can be used to keep effluent pumped to upper subfields from draining to lower subfields.

- Prevent backflow entirely by dosing the trenches with a pressure manifold located at least three feet higher than the highest trench. With this technique, the effluent is pumped to the pressure manifold and split to flow downward into each lateral and the corresponding trench. The downward slope of the lateral feed lines allows the effluent to flow by gravity and build up 2 to 5 feet of head in the laterals to discharge under pressure uniform amounts of effluent to each trench.

7.3 AREA-FILL SYSTEMS

Reference

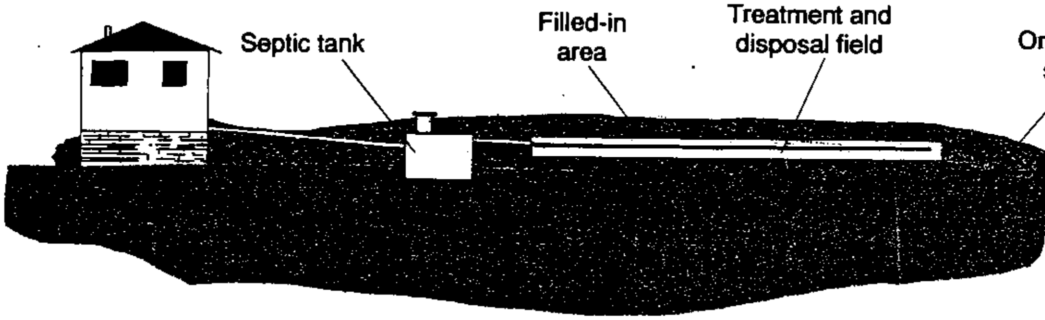
15A NCAC 18A.1957(b)

Some sites do not have adequate soil depth or have a limiting horizon too close to the ground's surface to install a conventional or modified conventional on-site system. It may be possible to install an *area-fill system* on these sites. These systems get their name because an area is filled in with SUITABLE soil to make an acceptable treatment and disposal field.

Area-fill systems may have all or only part of the treatment and disposal field made up of filled-in soil. The systems can use conventional gravity-fed trenches or can be combined with LPP systems to obtain more even distribution of effluent. Area-fill systems can be used on sites with no existing fill or on sites that were filled prior to July 1, 1977. See Figure 7.3.1 for a diagram of a typical area-fill system.

The following information presents the requirements for approval of an area-fill system.

Figure 7.3.1 Cut-away view of an area-fill system.



Site and Soil Suitability

Area-fill systems can be used on sites with limiting soil conditions or shallow soil wetness. The following points give details about the limitations of area-fill systems.

Reference

15A NCAC 18A.1957(b)(1)(A - D)

- The site must have at least 18 inches of natural soil that has SUITABLE or PROVISIONALLY SUITABLE soil structure and clay mineralogy, and where there are no organic soils, restrictive horizons, saprolite, or rock. Additionally, no soil wetness conditions can exist within 12 inches of the ground surface and a ground-water-lowering system cannot be used to lower the ground water below the 12-inch depth.
- Area-fill systems cannot be installed on land designated as a wetland unless an approval is granted by the appropriate agency.
- If gravity-fed trenches are to be used, the trench bottoms must be at least 24 inches above any soil horizon that has UNSUITABLE soil structure, clay mineralogy, organic soil, rock, or saprolite. Low-pressure pipe systems can be installed with trench bottoms 18 inches above the limiting horizon.
- Gravity-fed trench bottoms must be at least 18 inches above soil wetness conditions, and low-pressure pipe system trench bottoms must be 12 inches above the soil wetness. Ground-water-lowering systems may be used to meet these separations only in Soil Groups I and II, where there is SUITABLE structure and clay mineralogy.
- Area-fill systems can be installed on sites with slopes up to 15%. To reduce the possibility of overloading an area-fill system on a slope, stormwater diversions and ground water interceptor drains may be required on the upslope side of the filled area.

❑ For most soils, the long-term acceptance rate, or LTAR, for the site is based on the most hydraulically limiting soil horizon within 18 inches of the original ground surface or within 12 inches of the trench bottom, whichever is deeper. The LTAR is the lowest acceptance rate for the Soil Group of the hydraulically limiting soil horizon.

❑ If 18 inches or more of Group I soil are below the original soil surface or 12 inches or more of Group I soil below the trench bottom (whichever is deeper), the LTAR cannot be higher than 1.0 gallons per day per square foot for a gravity distribution system or 0.5 gallons per day per square foot for an LPP system.

Area-Fill Systems: Dosing Design Requirements

Gravity flow distribution may be used when the design daily sewage flow is 480 gallons or less, the trench bottom is 24 inches above any unsuitable soil horizon and at least 18 inches above any soil wetness condition. LPP distribution shall be used when the design flow exceeds 400 gpd, the trench bottom is 18 inches to less than 24 inches above any suitable soil horizon, and 12 inches to less than 18 inches above any soil wetness condition. (See Table 7.3.1)

Reference
15A NCAC 18A.1957(b)(1)(A)(B)(E)

Reference
15A NCAC 18A.1957(b)(2)(D)

Table 7.3.1 Siting and Dosing Requirements for Area Fill Systems

Area Fill Dosing System	Minimum Separation (Inches)
New Fill System —Gravity	24 inches between trench bottom and U soil horizon 18 inches between trench bottom and soil wetness condition
New Fill System —Pressure Dosed	18 inches between trench bottom and U soil horizon 24 inches between trench bottom and U soil horizon
Existing (old) Fill System —Gravity	48 inches between trench bottom and any U soil horizon and soil wetness condition
Existing (old) Fill System —Pressure Dosed	24 inches between trench bottom and any U soil horizon and soil wetness condition

Area-Fill Treatment and Disposal Fields: New Sites Design Requirements

The points listed below are requirements for *new sites with no existing filled areas*. For sites with existing filled areas, see the next section.

❑ The treatment and disposal field must be filled with two types of soil. The bottom layer of fill must be sand or Group I loamy sand soil classed and the layer must come to the top of the proposed trenches. A second layer of soil used to cover the filled area must be a 6-inch layer of soil from Soil Group II or III. Finer soil should be used in the top 6-inch of cover so that vegetation can be grown on the field.

❑ Material used for fill cannot contain more than 10% by volume of roots, limbs, or other plant material, or building rubble or other debris. The fill material must be placed so that no layers of material contain more than 35% shell fragments.

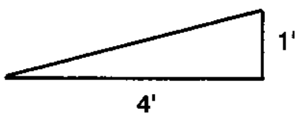
Reference
15A NCAC 18A.1957(b)(1)(F-M)

❑ Heavy covers of organic litter or vegetation must be removed from the area to be filled before the fill material is placed.

❑ The fill material and the native soil must be mixed together to 6 inches below the original ground surface. Mixing prevents forming an impervious layer where the 2 soils meet.

❑ The filled area must be a raised berm that follows the contours of the slope of the site. Its longer sides should be parallel to the contour lines of the site.

❑ For most soils, the sides of the raised berm should have a slope of 1:4 or less (for each foot the slope goes up, it should go out 4 feet). If the first 18 inches of soil below the ground surface are Soil Group I, then the sides of the raised berm can have slopes of 1:3 or less.



❑ The top of the side slope of the raised berm must be at least 5 feet from the outside edge of the nearest trench.

❑ To reduce the possibility of flooding the filled areas, the raised berm should be shaped to shed rain water.

❑ A vegetative cover must be established on the filled areas to prevent erosion.

❑ Setback distances are to be measured from the bottom of the slope of the raised berm. Under the following circumstances, the setback can be measured from the outside edge of the nearest trench:

- The site cannot have a slope greater than 2%,
- The first 18 inches of original soil at the site are Group I Soils;
- The lot or tract of land must have been recorded on or before December 31, 1989, and
- The Improvement Permit requires that the facility connect to a public or community sewer system within 90 days after the system is available to the facility and if less than 300 feet of sewer pipeline is required for connection.

References

15A NCAC 18A.1957(b)(1)(M)

15A NCAC 18A.1945

❑ All available space requirements for a properly-sized treatment and disposal field and a repair area must be met. Larger systems that discharge more than 480 gallons per day and are installed on lots recorded in recent years must have a repair area equal in size to the treatment and disposal field.

Area-Fill Treatment and Disposal Fields: Existing Filled Sites Design Requirements

The following requirements are for sites with existing filled areas where installing an area-fill on-site system is proposed.

❑ The owner of the lot must produce documentation that the fill material was placed on the lot before July 1, 1977.

❑ Area-fill systems proposed for sites with existing fills cannot have a design daily flow larger than 480 gallons per day.

References

15A NCAC 18A.1957(b)(2)

15A NCAC 18A.1957(b)(2)(A-B)

15A NCAC 18A.1957(b)(2)(F)

15A NCAC 18A.1942(a)

15A NCAC 18A.1957(b)(2)(C-D)

15A NCAC 18A.1942(a)

❑ At least 24 inches of existing Soil Group I sand or loamy sand fill material must have been placed on the site before July 1, 1977. The existing fill cannot have more than 10% by volume of roots, limbs and other organic debris, building rubble or other debris, or separate layers that contain more than 35% shell fragments. Additional Soil Group I fill material may be placed to meet the separation requirements for UNSUITABLE soil horizons or soil wetness conditions.

❑ Soil wetness conditions must be at least 18 inches below the ground level of the existing fill; ground-water-lowering systems cannot be used to lower the soil wetness to meet the 18-inch requirement.

❑ Existing filled lots must use low-pressure pipe, or LPP, treatment and disposal fields with an LTAR for the site of 0.5 gallons per day per square foot or less. There must be 24 inches of separation between the trench bottom and any soil wetness or soil horizon that has UNSUITABLE soil structure, clay mineralogy, organic soil, rock, or saprolite. Ground-water-lowering systems cannot be used to meet the requirements.

- If the first 48 inches of fill material or soil on a lot with existing fill is Soil Group I soils, then conventional gravity-distribution treatment and disposal fields may be used. A separation of 48 inches is required between the trench bottom and any soil wetness conditions or soil layers that have UNSUITABLE soil structure, clay mineralogy, organic soil, rock, or saprolite.

Reference
15A NCAC 18A.1945

- Area-fill systems proposed for sites with existing filled areas must meet the requirements for available space for on-site systems. Systems with daily flows less than 480 gallons per day do not have include a repair area.

Reference
15A NCAC 18A.1957(b)(2)(D)

Additional Soil Group I fill material may be added to the site to obtain the necessary separations between the trench bottoms and UNSUITABLE soil horizons. If fill is added it must meet the following requirements.

- The site must have a slope less than 15%. To reduce the possibility of overloading an area-fill system on a slope, stormwater diversions and ground water interceptor drains may be required on the upslope side of the filled area.
- The treatment and disposal field must be filled with two types of soil. The bottom layer of fill must be sand or loamy sand soil classed as Soil Group I and must come to the top of the proposed trenches. A second layer of soil, used to cover the filled area, must be a 6-inch layer of soil from Soil Group II or III. Finer soil should be used in the top 6-inch of cover so that vegetation can be grown on the field.
- The fill material and the native soil are required to be mixed together to 6 inches below the original ground surface. This mixing prevents forming an impervious layer where the 2 soils meet.
- Heavy covers of organic litter or vegetation must be removed from the area to be filled before the fill material is placed.
- The filled area must be a long, raised berm that follows the contours of the slope of the site. Its longer sides should be parallel to the contour lines of the site.
- The top of the side slope of the raised berm must be at least 5 feet from the outside edge of the nearest trench.
- To reduce the possibility of flooding the filled areas, the raised berm should be shaped to shed rain water.
- A vegetative cover must be established on the filled areas to prevent erosion.
- The side slopes of the filled berm must have a slope of 1:4 or less.
- Setback distances are to be measured from the bottom of the slope of the raised berm. Under the following circumstances, the setback can be measured from the outside edge of the nearest trench:
  - the site cannot have a slope greater than 2%,
  - the first 18 inches of original soil at the site are Group I Soils,
  - the lot or tract of land must have been recorded on or before December 31, 1989, and
  - the Improvement Permit requires that the facility be connected to a public or community sewer system within 90 days after the system is available to the facility and if less than 300 feet of sewer pipeline is required for connection.

Area-Fill Systems: Other Design Requirements

Other designs for area-fill systems may be approved on a case-by-case basis. All proposed systems have to meet the requirements of rule 15A NCAC 18A.1948.

7.4 AEROBIC TREATMENT UNITS

Individual aerobic treatment units, or ATUs, are small packaged sewage treatment plants that use aerobic biological processes to treat the sewage before it is discharged. Like the other alternative systems, ATUs may be used on some sites that have UNSUITABLE soil depth, soil wetness conditions, restrictive horizons, or saprolite present. Because the effluent from an ATU has undergone a high degree of treatment, the chance of contaminating the ground water when the effluent is discharged is much lower. Thus, the required separation distances between trench bottoms and UNSUITABLE soil horizons or soil wetness can be relaxed with the use of an ATU. Figures 7.4.1, 7.4.2, and 7.4.3 show cut-away views and some features of three types of ATUs.

Figure 7.4.1 Cut-away view of a batch-type ATU.

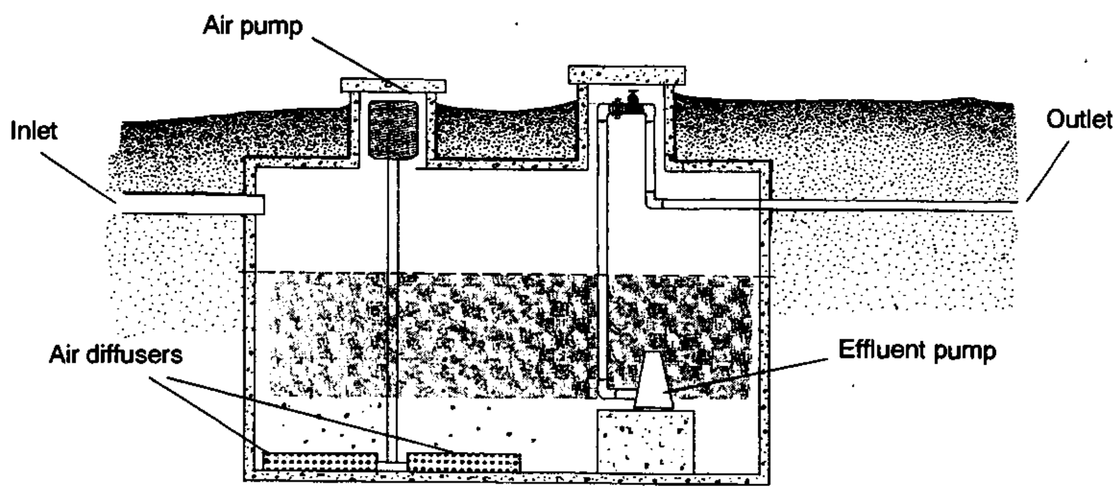


Figure 7.4.2 Cut-away view of a continuous-flow-type ATU.

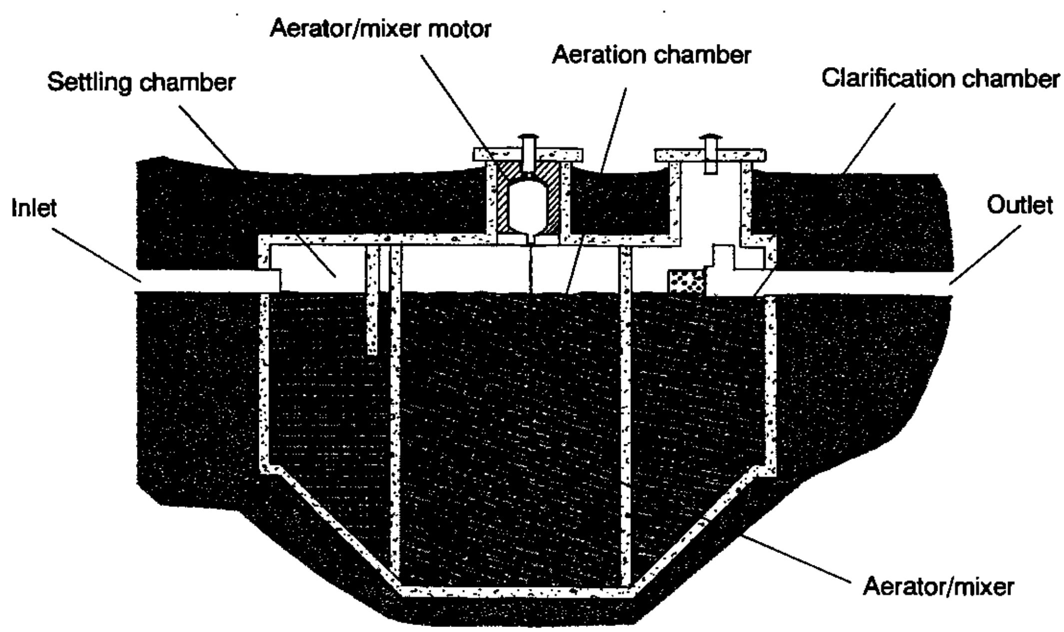
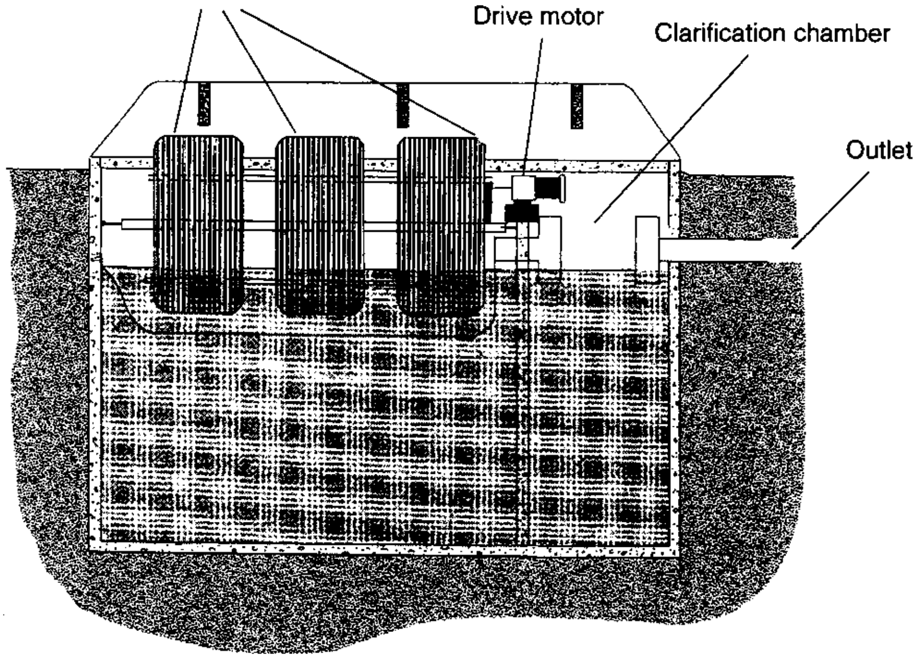


Figure 7.4.3 Cut-away view of a rotating biological contactor-type ATU.



Site and Soil Suitability

ATU systems can be paired with conventional or modified conventional subsurface treatment and disposal fields, or alternative systems, such as LPP or area-fill systems, to discharge effluent. The following site and soil requirements must be met when using an ATU.

Reference

15A NCAC 18A.1957(c)

❑ Most of the usual setback requirements for on-site systems apply to ATU systems; however, the following less-restrictive setbacks can be used with an ATU system.

Protected facility	Setback for ATU system
Private water supply except uncased wells or springs	50 feet
Streams with a WS-I classification	70 feet
Waters with an SA classification	70 feet
Other coastal waters not classified as SA	35 feet
Any other stream, canal, marsh, or other surface water	35 feet
Any Class I or Class II reservoir	70 feet from normal pool elevation
Any permanent stormwater retention pond	35 feet from flood pool elevation
Any other lake or pond	35 feet from normal pool elevation

References

15A NCAC 18A.1955(m)

15A NCAC 18A.1956(1)

15A NCAC 18A.1956(2)

15A NCAC 18A.1956(6)

15A NCAC 18A.1957(b)(1)

15A NCAC 18A.1957(b)(2)

❑ Some of the requirements for conventional trenches, modified conventional trenches, systems placed in saprolite, and area-fill are less restrictive when using an ATU. See the references at the left for the usual requirements for these system.

- LPP distribution is not required for an ATU system where the separation between the trench bottom and a soil wetness condition is at least 12 inches but less than 18 inches and more than 6 inches of the separation is soil in Soil Group I.
- New area-fill systems employing ATUs do not have to use LPP distribution when a separation of 18 inches or more is between the trench bottoms and any UNSUITABLE soil horizon, rock, or saprolite.
- Area-fill systems using ATUs on lots with existing fills of Soil Group I soil may have less separation between the trench bottoms and any soil wetness condition or soil horizon with UNSUITABLE soil structure, clay mineralogy, organic soil, rock, or saprolite. When using conventional treatment and disposal fields, a 36-inch separation is required. For LPP systems, the separation is 18 inches.

❑ ATU systems allow for a 25% increase in LTAR for treatment and disposal fields installed in Soil Groups I and II if the soils have SUITABLE structure and clay mineralogy. This increase in LTAR cannot be used in conjunction with any other adjustments in the area of the treatment and disposal field, unless further reductions can be warranted by adjusting the daily sewage flow in accord with rule 15A NCAC 18A.1949(c).

ATU System Components

An on-site system using an ATU is similar to conventional on-site systems with a few exceptions. Most ATU systems do not use a septic tank because the domestic sewage flows directly to the ATU. ATUs can discharge to a number of types of treatment and disposal fields that vary depending on the limitations of the site. Systems with a daily flow greater than 500 gallons per day must have a settling tank upstream of the ATU. The settling tank functions like a septic tank to remove a large portion of the pollutants from the sewage before the effluent flows to the ATU. An approved septic tank or specially designed tank approved by the On-Site Wastewater Section can be used. The tank must have a capacity equal to the daily sewage flow.

ATU Operation Requirements

Because ATUs are much more complex than the standard septic tank, several requirements must be met so that the system will treat the sewage properly and minimize the possibility of polluting the ground water.

Before an Operation Permit can be issued for an ATU system, the following items must be completed.

1. The manufacturer's representative must certify that the ATU has been properly installed.
2. A contract for operation and maintenance, as required by 15A NCAC 18A.1961(b), must be signed by the system owner and the certified operator in responsible charge.
3. One condition in the contract is that future owners of the property must sign a similar contract.
4. Another condition is that the ATU meet and continue to meet National Sanitation Foundation Standard Number 40 Class I effluent quality standards in effect when the Operation Permit is approved.

5. Other contract conditions include requirements and responsibilities for operation, maintenance, and proper performance of the ATU by the owner and system operator. A contract must be in effect as long as the system is used.

The system operator must carry out the monitoring listed below to be sure that the system is working properly.

1. Inspections of the system must include: checking for proper mechanical operation; inspecting the treatment chambers for unusual colors, clogging, oily films, odors, and foam; measuring the settleable solids in the aeration chamber; and determining the need to remove solids, backwash, or clean filters; and for other maintenance. The operator is responsible for ensuring that the system is maintained properly.
2. The operator must inspect the treatment and disposal field and evaluate its performance.
3. Semi-annual samples of the effluent must be taken by the operator and analyzed for biological oxygen demand, total suspended solids, and pH by an approved laboratory. Also, the aeration chamber must be sampled for mixed-liquor suspended solids.
4. Each quarter, results of the performance monitoring and the semi-annual sampling must be reported to the local health department and the On-Site Wastewater Section.
5. If the monitoring results or the inspections indicate that the Class I effluent standards are not being met, then legal action and additional sampling are required to bring the ATU system into compliance.

Design Requirements for ATU Systems

On-site systems using ATUs must meet a number of design requirements to ensure proper operation and performance. The information below presents requirements for systems using ATUs, and then lists specific requirements for concrete, fiberglass, and other ATUs and their electrical requirements.

On-site systems using ATUs: design requirements.

All ATUs used in on-site systems must have a National Sanitation Foundation mark and the NSF model number or a certification mark and model number of an accredited program. Programs must be accredited by the American National Standards Institute (ANSI) according to their policy to certify ATUs to meet NSF Standard Number 40. Copies of the NSF or ANSI standards can be obtained at the On-Site Wastewater Section office in Raleigh.

Reference

15A NCAC 18A.1949

❑ Facilities proposing to use an ATU must have a daily sewage flow of 1500 gallons per day or less.

❑ ATUs must only be used where the strength of the wastewater is similar to domestic sewage. BOD and total suspended solids must not be higher than 300 mg/l.

Wastewaters that contain large amounts of grease and oil, such as from restaurants and food services, cannot use ATUs for on-site systems. The grease and oil can foam and interfere in ATU processes.

❑ The proposed ATU must meet the National Sanitation Foundation (NSF) Standard 40 and be classified as producing Class I effluent.

Reference G.S130A-342(b)

❑ A certified wastewater operator must be scheduled to operate and maintain the ATU according to the *Laws and Rules for Sewage Treatment and Disposal Systems* before an improvement permit can be issued.

❑ Plans and specifications for each ATU system manufactured for use in North Carolina must be approved by the Division of Environmental Health under rule 15A NCAC 18A.1953, and the ATU system must be constructed as shown on the plans.

❑ Rated capacity of the ATU, listed as complying with NSF Standard 40, must be equal to or greater than the daily flow determined under rule 15A NCAC 18A.1949.

❑ Each ATU unit must have an imprint on the outside of the unit to the right of the outlet that shows the manufacturer, Division of Environmental Health approval number, and the working capacity of the ATU. The date of manufacture of the unit must be embossed or written in permanent ink near the imprint or on the top of the unit above the imprint.

❑ All ATU systems must be designed, constructed, and operated to prevent bypassing the wastewater.

Concrete ATUs: design requirements.

Requirements for concrete ATUs are similar to the requirements for precast concrete septic tanks.

❑ Blockouts for the inlet and outlet pipes must accept either 4 or 6-inch pipe and have a wall thickness of at least one inch. Blockouts must not be below the water line in the ATU.

❑ The inlet must be a straight pipe and its invert must be 2 inches higher than the outlet invert.

❑ Interior walls or baffles must be reinforced with 6 x 6-inch, 10-gauge welded wire mesh. The interior wall mesh must have 90-degree, 4-inch legs placed along the outside wall mesh where the 2 walls join to provide strength to the walls.

❑ All ATUs must have adequate access openings with watertight risers that extend to 6 inches above ground level. The risers must be sealed to the ATU to prevent ground water entry, and must not let surface water flow into the unit. The access openings must be large enough to clean out the inlet pipe, clean out air or gas passage spaces, pump out solids, sample effluent, and repair or maintain parts in the ATU.

❑ ATUs must be located above the 10-year floodplain or designed to be watertight and operable during a flood. All mechanical and electrical components must be above or protected from the 100-year flood.

❑ Concrete ATUs must be constructed with 2 1/2 inches thick 3500 psi concrete, with reinforcing at least equal to 6 x 6-inch, 10-gauge, welded wire mesh in the top, bottom, and all interior and exterior walls. The ATU must be able to support a live load of 150 pounds per square foot and all dead loads that are associated with an underground tank. Joints between sections must be sealed with an approved, permanent, waterproof mastic.

❑ ATUs that are subjected to traffic or heavy soil loads due to deep burial or other causes must be constructed with sufficient strength to support the additional loads.

Fiberglass ATUs: design requirements.

ATUs made from fiberglass-reinforced plastic must be corrosion resistant and structurally strong enough to support 150 pound per square foot live loads and the dead loads involved in underground tanks.

❑ The wall material must have the following minimal properties: the ultimate tensile strength must be 12,000 psi or more, the flexural strength must be 19,000 psi or more, and the flexural modulus of elasticity must be 800,000 psi or more.

❑ Each model of fiberglass ATU must pass a vacuum test of 2.5 psi vacuum or 69.3 inches of water vacuum without leaking or failing. The test must meet ASTM D-4021, Standard Specification for Glass-Fiber Reinforced Polyester Underground Petroleum Storage Tanks and the test results must be submitted to the OSWS for approval.

❑ The tank walls must be at least 1/4 of an inch thick and contain at least 30% fiberglass reinforcement by weight. The tank must be watertight and the inside and outside surfaces must have no exposed fibers, no blisters larger than 1/4 of an inch in diameter, and no pores or indentations deeper than 1/16 of an inch.

ATU electrical requirements: design requirements.

All electrical connections, wire junctions, splices, and controls must be securely mounted in watertight and corrosion-resistant outside enclosures that have an NEMA 4X or similar rating and are mounted at least 12 inches above the finished ground level.

❑ Wires must be run in waterproof, gasproof, and corrosion-resistant conduits that are sealed with wire grips, duct seal, or other similar sealants around the wires and the openings for the conduit inside and outside the ATU.

❑ A manual circuit disconnect must be located near the ATU and in an NEMA 4X or similar enclosure mounted at least 12 inches above the ground.

❑ ATUs must have alarms to warn the users about malfunctions and high water levels in the ATU. The alarms must be visible and audible, and mounted near the unit or inside the facility they serve. If the alarms are mounted outside, they must be in an NEMA 4X or similar enclosure and have a power supply ahead of the ATU and ATU fuses or circuit breakers so that the alarms operate even if a circuit is tripped.

7.5 INNOVATIVE ON-SITE SYSTEMS

Reference

15A NCAC 18A.1969(1,2,3)

The term "innovative" when used to describe an on-site system refers to several specific and legally-defined technologies that can be used for on-site systems. Unlike conventional, modified conventional, and alternative systems, innovative systems are not described in detail in the *Laws and Rules for Sewage Treatment and Disposal Systems.*

Innovative on-site systems may not be as common as conventional or alternative systems, so there is less experience about how these systems perform under various site conditions and for the long term. When an innovative system is approved by the On-Site Wastewater Section, Division of Environmental Health, the local health department must issue an Improvement Permit when the rules and conditions of the approval are met.

Because standard designs for these systems have not been established, the approval of a specific product for an innovative on-site system is essentially done on a case-by-case basis. Each installation is somewhat different, which makes it difficult to provide a general description of the technical aspects of innovative on-site systems in a manual such as this.

Innovative Approval Process

The following procedures must be followed during the innovative approval process:

❑ Application submitted to On-Site Wastewater Section, Division of Environmental Health.

❑ Request innovative approval.

❑ Describe system, material specifications, and proposed use.

❑ Provide published research, pertinent literature, previous experience, and performance of the system.

❑ Results of product testing and research on monitoring of systems conducted by a third party research or testing organization.

❑ Identify the research or testing organizations and the principal investigators, along with their qualifications.

❑ Specify installation, operation, and maintenance procedures.

❑ Provide notification of any proprietary information.

❑ Application reviewed by On-Site Wastewater Section, Division of Environmental Health [see Rule 1969(3)].

❑ Innovative Approval Granted, with conditions for use, monitoring, and operation.

Because it would be difficult to describe a standard system design for the innovative systems, and to protect the industries producing innovative systems, the innovative technologies are not presented in detail in this section. Rather, the approvals for innovative on-site systems issued by the On-Site Wastewater Section are shown so that the reader can gain some knowledge of the technology and where it may be used. If an innovative on-site system is being considered for use, contact the local health department, the Regional Soil Specialist and the On-Site Wastewater Section of the North Carolina Department of Environment, Health, and Natural Resources for assistance.

NORTH CAROLINA DEPARTMENT
OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

INNOVATIVE WASTEWATER SYSTEM APPROVAL

INNOVATIVE WASTEWATER SYSTEM NO.: IWWS-95-1

ISSUED TO: Brunswick County Health Department
Post Office Box 9
Bolivia, North Carolina 28422

FOR: "Brunswick" Bed/Fill Wastewater Disposal Systems

DATE: August 10, 1995

In accordance with 15A NCAC 18A .1969, the "Brunswick" Bed/Fill System has been found to meet the standards for an innovative system when all of the conditions specified herein and in the applicable laws and rules are met.

I. PERMITTING

Prior to the installation of the "Brunswick" Bed/Fill System at a site for which application is being made for an improvement permit or at a site for which an improvement permit has been previously issued for a system described in 15A NCAC 18A .1955, .1956, or .1957, the owner or authorized agent shall notify the local health department. The local health department shall issue an improvement permit allowing for the use of the proposed innovative system upon a finding that all provisions of this approval and all other applicable laws and rules are met. Use of the proposed innovative system and any conditions shall be described in the improvement permit. Such information shall also be described on the operation permit to be issued upon acceptable completion of the system installation. Any improvement permit and operation permit issued for a bed/fill system shall include the specific condition required in Rule .1957(b) (1)(L)(iv).

II. SYSTEM DESCRIPTION

On-site wastewater systems using fill material are permitted under the provisions of 15A NCAC 18A .1957(b) as an alternative system and have several requirements, including the use of nitrification trenches. Bed systems may be permitted as a modified conventional system under the provision of 15A NCAC 18A .1955(d). The Brunswick County Health Department bed/fill system would combine the alternative fill system with the conventional modified bed-type system. Bed-type systems have greatly reduced sidewall area when compared with nitrification trenches, which in turn reduces oxygen diffusion through the sidewall area. Thus, the required conventional trench bottom area in 15A NCAC 18A .1955(c) must be increased by fifty percent (50%) [Rule .1955(d)] when a bed-type system is used.

III. SITING CRITERIA

A bed-type system may be installed in fill material on sites where at least the first thirty-six inches (36") below the naturally occurring soil surface consist of sand or loamy sand (Soil Group I). A bed/fill system shall only be used when the local health department determines that there is inadequate space to install a gravity flow trench-type system as required in 15A NCAC 18A .1957(b). The site shall have a uniform slope not exceeding two percent (2%). No soil wetness condition shall exist within the first twelve inches (12") below the naturally occurring soil surface. Artificial drainage shall not be used to meet this requirement. The horizontal setbacks of Rule .1950 shall apply as measured from a point five feet (5') from the nearest edge of the bed sidewall.

IV. SIZING BED-TYPE SYSTEMS IN FILL MATERIAL

The maximum design daily sewage flow shall not exceed 480 gpd (e.g., 4-bedroom dwelling unit). The LTAR shall not exceed 1.0 gpd/ft^2. No industrial process wastewater shall discharge to bed-type systems. The bed bottom surface area requirement shall be determined by dividing the design daily sewage flow by the LTAR plus fifty percent (50%) [see Rule .1955(d)]. The available space requirements of Rule .1945 shall apply, except that an approved innovative system may be designated as the required replacement system.

V. INSTALLATION CRITERIA FOR BED/FILL SYSTEMS

Fill material shall be sand or loamy sand, containing not more than ten percent (10%) debris, and shall be approved prior to placement by the local health department. Prior to fill placement, the site shall be void of a vegetative cover, organic litter, and any debris. Fill shall be placed in six inch (6") lifts, with each fill layer mixed with the underlying layer of natural soil or sandy fill material. The side slope of the fill shall not exceed a rise to run ratio of 1:3.

The bed/fill system shall be constructed as an elongated berm with the long axis parallel to the ground elevation contours of the slope. The bottom of the bed shall be excavated level (±¼") in all directions. The gravel used in the bed/fill system shall be in accordance with Rule .1955(h). The gravel depth in the bed/fill system shall comply with the provisions of Rule .1955(b) or Rule .1957(a)(1)(A), as applicable. The gravel or rock surface of the bed/fill system shall be covered by a geotextile fabric capable of preventing the downward movement of silt-sized particles while allowing the movement of moisture and gases.

a. Bed/fill systems using gravity distribution shall meet the following conditions:
   - ➡ The bed bottom shall have a minimum separation of twenty-four (24") from any soil wetness condition.

- ➡ The bed bottom shall have a minimum separation of thirty inches (30") from any soil horizon unsuitable as to soil structure, clay mineralogy, organic soil, restrictive horizon, rock, or saprolite.
- ➡ The distribution device shall be placed in the center of the bed.
- ➡ A maximum of sixteen (16) nitrification lines, eight (8) on each side of the distribution device, shall be placed three feet (3') on centers with the outer-most nitrification lines located one and one-half feet (1½') from the bed side walls.
- ➡ The bed width shall be constructed in a multiple of three feet (3') up to a maximum of twenty-four feet (24').
- ➡ The final six inches (6") of fill placed over the gravel bed and side slopes shall be classified as a Group II or III soil.

b. Bed/fill systems using low pressure distribution shall meet the following conditions:
- ➡ The bed bottom shall have a minimum separation of eighteen inches (18") from any soil wetness condition.
- ➡ The bed width shall be constructed in a multiple of three feet (3') up to a maximum width of twenty-four feet (24').
- ➡ The low-pressure laterals shall be placed three feet (3') on centers and located no closer than one and one-half feet (1½') from the bed side walls. All laterals shall be sleeved in perforated tubing meeting the requirements of 15A NCAC 18A .1955(f).
- ➡ Except as described herein, the provisions of Rule .1957(a) shall apply.
- ➡ The final four inches (4") of soil cover over the gravel bed and side slopes shall be classified as a Group II or III soil.

c. Bed/fill systems using approved alternative aerobic treatment units (ATU) or approved innovative pretreatment systems shall meet the following conditions:
- ➡ The ATU shall be approved in accordance with the provisions of Rule .1957(c).
- ➡ The bed bottom shall have a minimum separation of eighteen inches (18") from any soil wetness condition.
- ➡ The bed system may utilize a gravity distribution as described in V(a) above.
- ➡ If a low-pressure distribution is utilized, the requirements of V(b) shall apply except that the bed bottom shall have a minimum separation of twelve inches (12") from any soil wetness condition.

VI. OPERATION AND MAINTENANCE REQUIREMENTS

The provisions of Table V(a) of Rule .1961(b) shall apply as applicable.

VII. REPAIR OF SYSTEMS

The provisions of Rule .1961(c) shall govern the use of the bed/fill system for repairs to existing malfunctioning septic tank systems.

Approved by: [signature] Date: 8|10|95

NORTH CAROLINA DEPARTMENT
OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

INNOVATIVE WASTEWATER SYSTEM APPROVAL

INNOVATIVE WASTEWATER SYSTEM NO.: IWWS-95-2

ISSUED TO: Hancor, Inc.
Post Office Box 1047
Findlay, Ohio

FOR: "Hancor EnviroChamber" sewage effluent subsurface disposal system [Standard 12 in High Unit with H-10 Load Design]

DATE: August 10, 1995

In accordance with 15A NCAC 18A .1969, an application by Hancor, Inc. of Findlay, OH for approval of the chamber (gravel-less) nitrification trench system has been reviewed, and the standard unit Infiltrator system has been found to meet the standards of an innovative system when all of the conditions are met:

I. PERMITTING

Prior to the installation of the standard unit EnviroChamber nitrification trench system at a site for which application is being made for an improvement permit or at a site for which an improvement permit has been previously issued for a system described in 15A NCAC 18A .1955, .1956, or .1957, the owner or authorized agent shall notify the local health department. The local health department shall issue an improvement permit or amend the previously issued improvement permit allowing for the use of the proposed innovative system upon a finding that all provisions of this approval and all other applicable rules shall be met. Use of the proposed innovative system and any conditions shall be described in the improvement permit or amended improvement permit, as applicable. Such information shall also be described on the operation permit to be issued upon the acceptable completion of the system installation.

II. SYSTEM DESCRIPTION

a. Minimum pretreatment by septic tank as required in 15A NCAC 18A .1952.

b. Standard chamber unit consisting of a high density polyethylene arch-shaped injection molded chamber with an inside width of 32.5 to 28.5 inches (35 inches outside width) and an overall length of 75 inches. The standard unit height is approximately one foot high with 1/4-inch wide slotted sidewalls approximately 8 inches high. The chamber sidewall slope is approximately 20 degrees toward the chamber center or away from the trench sidewall. Note: 16 standard EnviroChamber units are approximately equal to 100 linear feet.

c. Each chamber unit is designed to mechanically interlock with the downstream chamber forming a complete nitrification trench that consists of an inlet plate in the first chamber with a splash plate located below the inlet on the trench bottom and a solid end plate to be located at the distal end of any chamber nitrification line.

III. SITING CRITERIA

The standard unit EnviroChamber nitrification trench assembly may be utilized on sites which meet the following criteria:

a. Sites which are classified Suitable or Provisionally Suitable for a conventional nitrification field system in accordance with 15A NCAC 18A .1948(a) or (b).

b. Sites which have been reclassified as Provisionally Suitable in accordance with 15A NCAC 18A .1956(1), (2), (4), (5), and (6).

c. Sites which meet the criteria for new or existing fill in accordance with 15A NCAC 18A .1957(b).

d. The required vertical separation shall be measured from the bottom edge of the chamber.

IV. ENVIROCHAMBER SYSTEM SIZING

a. The maximum long-term acceptance rate (LTAR) shall be as follows:

		LTAR (gpd/ft^2)	
		Natural Soil	**Saprolite**
Soil Group I	Sands	0.8 - 1.0	0.4 - 0.6
Soil Group II	Coarse Loams	0.6 - 0.8	0.1 - 0.4
Soil Group III	Fine Loams	0.3 - 0.6	---
Soil Group IV	Clays	0.1 - 0.4	---

b. The LTAR shall be based on the most hydraulically limiting naturally occurring soil horizon within three feet of the ground surface or to a depth of one foot below trench bottom, whichever is deeper.

c. To determine the total trench bottom area (ft^2) required; the design daily sewage flow shall be divided by the applicable long-term acceptance rate shown in (a) above. The minimum linear footage of EnviroChamber system required shall be determined by dividing the total trench bottom area by 4 feet when used in a conventional nitrification trench. No reduction in area is allowed for EnviroChamber systems installed in bed or fill systems.

EXAMPLE:

Assume: Three bedroom residence with a design daily sewage flow of 360 gallons on a sandy clay loam (Group III) soil.

Then: Total computed trench bottom area is:
360 gpd/0.5 LTAR = 720 ft^2;

The required linear footage of EnviroChamber system is:
720 ft^2/4.0 ft = 180 linear ft.
(Where 4.0 ft. is the equivalency factor for the standard unit EnviroChamber system)

d. To determine the minimum number of EnviroChamber units required in a nitrification trench, divide the trench bottom area by 24 and round to the nearest whole number.

720 ft^2/24 = 30 units

e. The minimum area (without reduction or equivalency factor) for a bed system shall be determined as required in 15A NCAC 18A .1955(d) except that the chambers shall be placed in rows next to each other.

f. The available space requirements of 15A NCAC 18A .1945 shall apply. Also this approved innovative system may be designated as the required replacement system.

V. DESIGN AND INSTALLATION CRITERIA

a. The EnviroChamber system used in nitrification trenches shall be in 3 ft. wide maximum excavation and constructed not less than nine feet on centers.

b. The inlet to the EnviroChamber shall be in the uppermost portion of the specially prepared inlet panel with a splash plate below the inlet on the trench bottom.

c. Clean Group I, II, or III soil backfill (soil normally found in the upper 10 inches of the trench excavation) shall be placed along the chamber sidewall area to a minimum compacted (walked in) height of 8 inches above the trench bottom. Additional backfill (Group I, II, III, or IV) shall be placed to a minimum compacted height of 12 inches above the chamber. No excavation equipment shall travel over the chamber system. It is critical to note that the nitrification trench bottom shall be at least 24 inches below finished grade, and the inlet invert shall be approximately 8 inches above the trench bottom, and at least 17 inches below finished grade.

d. Individual chamber trenches shall be constructed level in all directions (both across and along the trench bottom) and shall follow the contour the ground surface elevation (uniform depth) with continuous interlocking chambers, including specially constructed contour fitting EnviroChamber units, without any dams, stepdowns or other water stops.

e. EnviroChamber systems installed on a sloping site may use distribution devices or stepdowns as described in 15A NCAC 18A .1955(j) and (l) when it is necessary to change level nitrification line segments from upper to lower elevations.

f. Manufacturer's installation instructions for the EnviroChamber system used in septic tank systems shall be followed except as required herein or 15A NCAC 18A .1900 et.seq.

g. The system shall be installed by a contractor authorized in writing by Hancor, Inc.

VI. OPERATION AND MAINTENANCE REQUIREMENTS

The EnviroChamber system shall have a minimum classification as a Type III g. system (other non-conventional trench systems) in accordance with Table V(a) of 15A NCAC 18A .1961(b).

VII. REPAIR OF SYSTEMS

The provisions of 15A NCAC 18A 1961(c) shall apply to the use of the standard Infiltrator chamber system for repairs to existing malfunctioning septic tank systems.

Approved by: [signature] Date: 8|10|95

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NORTH CAROLINA DEPARTMENT
OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

INNOVATIVE WASTEWATER SYSTEM APPROVAL

INNOVATIVE WASTEWATER SYSTEM NO.: IWWS-95-3

ISSUED TO: EEE-ZZZ LAY DRAIN COMPANY, INC.
1700 Lakeside Avenue
St. Augustine, Florida 32086-5177

FOR: Houck Drainage System (HDS) 2012 Drainfield System

DATE: August 8, 1995

In accordance with 15A NCAC 18A .1969, the Houck Drainage System 2012 Drainfield System has been found to meet the standards for an innovative system when all of the conditions specified herein are met.

I. Permitting:

The Houck Drainage System 2012 Drainfield System may be permitted to be used at any site where a system may be permitted in accordance with Rules 15A NCAC 18A .1955, .1956, and/or .1957 when the local health department is notified in writing that the owner or authorized agent proposes to use this system. For any such system newly proposed, the intended use of this innovative system shall be noted on the improvement permit using the appropriate Approval Number. At sites for which an improvement permit has been previously issued for another system, the HDS 2012 Drainfield System may also be used upon the written request of the owner or authorized agent, as long as all conditions of this innovative approval are met. The use of this innovative system shall be described on the operation permit to be issued upon the acceptable completion of the system installation.

II. System Description and Design Criteria:

The HDS 2012 Drainfield System utilizes wastewater absorption trenches containing bundles of loosely packed, expanded polystyrene (EPS) aggregate in place of rock aggregate. Aggregate consists of block shaped particles of EPS with a particle density of 1.0 pounds per cubic foot, or greater, ranging in nominal size between 0.75 and 1.50 inches and graded similar to No. 4 mineral aggregate.

Cylindrical bundles are 12 inches in diameter and ten feet in length. The expanded polystyrene is held in a cylindrical shape with a high strength polyethylene netting. The netting shall be strong enough to retain the shape of the bundles during system installation and backfilling, corrosion resistant, and sized to prevent the loss of aggregate.

a. Conventional trench alternative: The 2012 HDS conventional trench alternative consists of three, 12-inch diameter cylinders across the bottom of a three foot wide trench. The outer cylinders contain aggregate only, with the netting tied off at both ends to prevent the escape of aggregate. The central cylinder contains aggregate and a four inch diameter perforated flexible plastic pipe as typically used in nitrification lines. The pipe shall be certified as complying with ASTM F 405, Standard Specifications for Corrugated Polyethylene (PE) Tubing and Fittings, and shall be in accordance with Rule .1955(f). The four inch pipe is offset from center towards the top of the cylinder whereby six inches of aggregate is located between the bottom of the pipe and the bottom of the cylinder, and 1-1/2 to 2 inches of aggregate is located between the top of the pipe and the top of the cylinder. The netting for the central cylinder is tied off at both ends to the pipe. The pipe may be connected by an Internal Coupling device or an Endcap to allow continuous flow from one section to the next so as to bring each section adjacent to the next.

b. Low pressure piping (LPP) trench alternative: The 2012 HDS trench alternative consists of a single 12-inch diameter cylinder installed within a 12-inch wide trench which contains EPS aggregate and the offset four-inch pipe as described under II(a), above. The LPP small diameter pressure laterals (one to two inches) shall be placed within the four-inch pipe sleeve and otherwise designed in accordance with Rule .1957(a). All orifices shall be drilled in the LPP laterals to face upwards, except for a hole placed in the middle and a hole placed 25 percent from the distal end of each line, which shall face downwards to allow for drainage.

III. Siting:

The 2012 HDS Drainfield System may be used at any site which may be permitted for a conventional, modified, or alternative system in accordance with Rules .1955, 1956 and/or .1957, as appropriate.

Use of the 2012 HDS Drainfield System at sites proposed by a professional engineer to receive industrial process wastewater shall be evaluated by the Department on a case-by-case basis prior to approval.

IV. Sizing:

The sizing requirements both with respect to system area and linear footage of trenches shall be equivalent to the sizing requirements for the equivalent system, in accordance with Rules .1955, .1956, and/or .1957, as appropriate.

V. Installation:

Installation shall be in accordance with applicable requirements of Rules .1955, .1956, and/or .1957 as appropriate.

For use as a conventional trench alternative, a backfill barrier shall be placed over the EPS aggregate cylinders to prevent the infiltration of backfill material into the trench void spaces between the cylinders. The barrier shall not be placed along the trench sidewalls below the pipe invert elevation.

Manufacturer installation instructions for the 2012 HDS Drainfield System shall be followed, except as required herein or in 15A NCAC 18A .1900 et seq. The system shall be installed by a contractor authorized in writing by the manufacturer.

VI. Maintenance Requirements:

The 2012 HDS Drainfield System shall have a minimum classification as a Type IIIg System ("other non-conventional system") in accordance with Table V(a) of Rule .1961(b).

VII. Repair of Systems:

The provisions of Rule .1961(c) shall govern the use of the 2012 HDS Drainfield System for repairs of existing malfunctioning wastewater systems.

Approved by: [signature] Date: 8|8|95

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT,
HEALTH AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

INNOVATIVE WASTEWATER SYSTEM APPROVAL

Innovative Wastewater System No: IWWS-93-1

ISSUED TO: Wastewater Systems, Inc.
4386 Lilburn Industrial Way
Lilburn, GA 30247

FOR: "Perc-Rite" Subsurface Wastewater Drip Irrigation System

DATE: October 22, 1993

In accordance with 15A NCAC 18A .1969, an application by Wastewater Systems, Inc., of Lilburn, Georgia for approval of their "Perc-Rite" system has been reviewed, and the system has been found to meet the standards of an innovative system when the following conditions for use, monitoring and operation are met:

I. System description:

The Perc-Rite system consists of the following key components:

a. Collection system (conventional gravity, pressure sewer fed by Grinder pumps or individual septic tank effluent tank pumping units)

b. Pretreatment (septic tank/sand filter, aerobic treatment unit, or equivalent: See below)

c. Automatic, self flushing Arkal disc filters (patented)

d. Netafin drip polytubing with pressure compensating Ram emitters (patented)

e. Automatic field flushing technique (patent pending)

f. Microprocessor software (proprietary), controlling all functions, including self diagnostics, audible/visible alarms and telemetry system

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II. Siting criteria:

a. The Perc-Rite Innovative Wastewater System may be utilized on-sites which meet the following criteria:

i. Sites which are classified suitable or provisionally suitable in accordance with Rules .1939-.1948;

ii. Sites which have been reclassified to be provisionally suitable in accordance with .1956(1), (2), (4), (5) or (6a);

iii. Sites which meet the criteria for low pressure pipe systems in accordance with .1957(a)(2); or

iv. Sites which meet the criteria for new or existing fill, in accordance with .1957(b).

Required vertical separation requirements shall be measured from the location of the dripper tubing.

b. The following modifications to the siting criteria in a, above, shall also be considered acceptable:

i. All reductions in vertical separation allowed in the State Rules based on use of low pressure pipe distribution systems shall also apply;

ii. The restriction in Rule .1956(6)(a)(v) that saprolite be overlain by at least one foot of suitable or provisionally suitable naturally occurring soil shall not apply; and

iii. For existing fill systems, the minimum separation requirements of Rule .1957(b)(2)(D) shall be reduced to 18 inches.

c. The same horizontal setback requirements as allowed for aerobic treatment units shall also apply to the Perc-Rite Innovative Wastewater System, in accordance with .1957(c)(5)(A).

III. System sizing:

a. The following table shall be used in determining the long-term acceptance for the Perc-Rite Innovative drip irrigation system. The long-term acceptance rate shall be based on the most hydraulically limiting, naturally occurring soil horizon within two feet of the ground surface or to a depth of one foot below the emitter tubing, whichever is deeper.

Soil Group	Soil Textural classes (USDA classification)	Soil Textural Classes (USDA Classification)	Long-Term Acceptance Rate gpd/ft^2
I.	Sands (with S or PS structure and clay mineralogy)	Sand Loamy Sand	0.5 to 0.4
II.	Coarse Loams (with S or PS structure and clay mineralogy)	Sandy loam Loam	0.4 to 0.25
III.	Fine Loams (with S or PS structure and clay mineralogy)	Sandy Clay Loam Silt Loam Clay Loam Silty Clay Loam Silt	0.25 to 0.10
IV.	Clays (with S or PS structure in clay mineralogy)	Sandy Clay Silty Clay Clay	0.10 to 0.05

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b. The following table shall be used in determining the long-term acceptance rate for Perc-Rite Innovative Wastewater Systems installed in saprolite pursuant to .1956(6). The long-term acceptance rate shall be based on the most hydraulically limiting, naturally occurring saprolite to a depth of two feet below the emitter tubing.

Saprolite group	Saprolite Textural Classes	Saprolite Textural Classes.	Long-term acceptance rate gpd/ft^2
I.	Sands	Sand Loamy sand	0.30 to 0.25 0.25 to 0.2
II.	Coarse Loams (with less than 20% clay)	Sandy Loam Loam	0.2 to 0.15 0.15 to 0.05

c. In calculating the number of square feet for the nitrification field, the design daily sewage flow rate shall be divided by the long-term acceptance rate determined from the appropriate table, above. In calculating the minimum length of dripper tubing to be used, the total square footage of nitrification field shall be divided by two feet.

IV. <u>Design criteria</u>:

a. Pretreatment:

At this time, the Perc-Rite Innovative Wastewater System shall be preceded by a pretreatment process designed to reduce the wastewater biological oxygen demand (BOD) and total suspended solids (TSS) concentrations to 15 milligrams per liter (mg/l), each. This level of pretreatment can generally be expected to be achieved by specially designed recirculating sand filters, by <u>some</u> aerobic treatment units (ATUs) and by tertiary package wastewater treatment plants.

b. Dosing tank:

i. The dosing tank shall meet the design and construction criteria of Rules .1952-.1954, except that the minimum liquid capacity shall not be less than the total liquid capacity of the septic tank that would be required for this system.

ii. The intake pipe shall contain a screen and foot valve as specified by the drip system manufacturer. Pipe and screen shall be removable from the ground surface without requiring entrance into the tank.

iii. Level control floats in the dosing tank shall be adjustable and replaceble from the ground surface without entrance into the tank.

iv. The requirement for a separate high water alarm which is audible and visible by system users shall be met, in addition to the self monitoring features of the Perc-Rite system.

c. <u>Central Perc-Rite processing and control center</u>:

i. Center shall include suction lift self priming centrifugal pumps (manufactured by Sta-Rite, or equal); inlet and discharge piping; two-way motor actuated valves (for systems with integral sand filter); two or more, parallel, 115 micron disk filters (Arkal, or equal); solenoid valves (Dorot, or equal); flow meter; protective enclosure and control panel.

ii. Controls shall provide for automatic backflushing of integral unit filters with filtered effluent, initiated by a timer and/or a preset pressure differential across the filters; delivery of preprogramed volumes of effluent to each field zone (adjustable and variable between zones) at prespecified time intervals (flow equalization); automatic flushing of the field dripper laterals with filtered effluent at prespecified time intervals; and monitor alarm conditions (high water, power outage), flow volume to each zone (and to sand filter zone, when applicable), flow variance + or - 10%, pump run times, number and time of filter backwash and field flushing cycles.

iii. Filter backwash and flushing residuals shall be plumbed into the upstream end of the pretreatment system, with provisions made to minimize disturbance of any solids settling chamber (eg: provide baffles or comparable intake structure in septic tank to minimize solids re-suspension in the inlet compartment).

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iv. Controls and float levels shall be synchronized to assure the minimum dose required for any field zone is present prior to initiating an irrigation cycle for that zone. Minimum dose volume per zone shall be five times the liquid capacity of the dripper laterals plus the liquid capacity of the supply and return manifold lines which drain between doses. Minimum flushing volume per zone shall be two times the liquid capacity of the dripper laterals plus the liquid capacity of supply and return and manifold lines which drain between doses.

v. Duplex pumping system shall be provided whenever the design sewage flow rate exceeds 3000 gallons per day, the design sewage flow rate exceeds 1500 gallons per day when an integral sand filter is utilized, or when the total length of dripper lines exceeds 10,000 feet.

vi. A telemetry system shall be provided, whereby the manufacturer or operator shall be notified immediately of alarm conditions (highwater and power outage) and flow variance (+ or - 10%). Telemetry system and alarm shall include automatically rechargeable battery backup power supply.

vii. The control panel shall be listed as a unit by the Underwriter's Laboratory or equivalent third party electrical testing and listing organization, and protected by a NEMA 4X, or equal, watertight corrosion-resistent enclosure, unless mounted within a weatherproof building. Panel and control equipment shall include lightning protection, be protected from unauthorized access, and remain accessible at all times to the system operator.

d. Perc-Rite drip irrigation field design:

i. The field network shall utilize ½-inch or ¾-inch nominal size Netafin polethylene dripper line (½-inch: 0.67 inch O.D, 0.57 inch I.D; ¾-inch: 0.8 inch O.D, 0.70 inch I.D), containing RAM pressure compensating emitters on at least two foot centers designed to delivery 0.61 gallons per hour per emitter (+ or - 5%) at pressures of 10 to 60 pounds per square inch.

ii. Dripper lines shall be designed to be installed along the natural ground contour (+ or - 12 inches within any 100-foot long segment). Solvent welded heavy duty nonperforated flexible ½-inch or ¾-inch PVC tubing shall be used to connect the supply and return manifolds with the dripper lines, or to connect common dripper lines installed at varying depths or locations (eg: in stepdowns or to connect looped to dripper line segments). These connection lines shall be made to the dripper lines by solvent welded and pressure rated barbed couplings, and connected to the manifolds by reducing solvent welded fittings, with the reduction made directly off the manifold.

iii. The hydraulic design shall be based on achieving the following conditions:

- No more than a 10% variation in flow per emitter anywhere within a separately dosed zone

- Maintenance or scour velocity of at least 1.2 feet per second in the supply line from the dosing tank to the beginning of the drip field during irrigation flow

- Maintenance of scour velocities of at least 1.2 feet per second in each supply manifold segment during field flushing flows, and maximum velocities less than 10 feet per second in each supply and return manifold segment

- Maintenance of scour velocities of at least two feet per second in each dripper line during field flushing

- Minimum pressure of 10 pounds per square inch during flushing flows and a maximum of 60 pounds per square inch during irrigation flows.

iv. Field appurtenances include an air release valve and isolation valve at the high point/outlet of each zone; solenoid valve and isolation valve at each low point/inlet to each zone; cleanout at each end of the supply and return manifolds; a separate cleanout at the distal end of the supply line; and pressure monitoring nipples at the field inlet and outlet points in the supply and return manifolds, respectively. Valves and cleanouts shall be provided with protective vaults.

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V. Installation and Testing Procedures:

a. Dosing tank shall be demonstrated to be watertight by a 24-hour leakage test (maximum of ½-inch rise or fall in 24 hours) or vacuum test.

b. Drainfield area shall be prepared in a manner which minimizes site disturbance. No equipment shall cross the field areas during rainfall events, or when the fields are "too wet to plow". Lightweight equipment only shall be used to remove trees and rocks, with hand incorporation of select fill material used to eliminate weak spots where roots or boulders must be removed.

c. Field laterals shall be staked out by use of an engineer's level and tape to assure confirmation with natural contours and design requirements for sizing, location and separations.

d. Field shall be installed in accordance with manufacturer's recommendations for each site. A vibratory plow, static plow or trencher are most typically used and soil moisture must be dry enough so that compaction will not occur in the soil around the tubing.

e. Maximum dripper line depth shall be in accordance with health department's specifications based upon the detailed soil/site evaluation.

f. Minimum soil backfill depth shall be six inches.

Backfill around dripper lines shall be from Soil Groups I, II or III, and free of rocks or debris.

Minimum depth of valves in protective vaults shall be at least 18 inches below grade.

g. Extreme care must be taken during system installation to assure no extraneous debris enters the tankage, supply lines, and dripper line pipe network. Supply lines and manifolds shall be flushed out prior to system startup.

h. Manufacturer's recommendations shall be followed for system startup. All leaks from emitters and indications of wet spots during irrigation periods comparable to normal operating conditions shall be repaired. Irrigation and flushing flow rates and flushing pressures at the ends of field supply and return manifolds shall be measured and determined to be in accordance with the design criteria.

i. Fields shall be finish graded to shed surface water and in a matter which facilitates easy maintenance with standard mowing equipment. Provisions shall be made to establish and protect a permanent vegetative (eg: grass) cover.

j. All mechanical components, pumps, pump cycling, filters, backwashing, high water alarm and telemetry systems must be demonstrated to be fully operable in accordance with their design.

VI. Operation, maintenance and monitoring requirements:

a. System management entity, inspection/maintenance and reporting frequency requirements shall be comparable to Type V(a) systems in Rule .1961(b), Table V(b), except that the minimum inspection frequency shall be quarterly for any system.

b. The manufacturer and/or the system operator shall be telemetrically notified of high water, power outage, flow variance (+ or - 10%) and catastrophic failure (+ or - 30%) conditions.

c. The operator shall provide monitoring reports to the health department and state which include a log of all malfunction notifications and maintenance activities, wastewater volume delivered to each zone between each required monitored period. Measured irrigation flow rates taken during each required monitoring inspection, and pressure head measurements during flushing at the inlet and outlet of each field zone taken at least once per year.

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VII. Responsibilities and permitting procedures:

a. Unless system pretreatment components have received prior approval, the system shall be designed by a registered professional engineer, with plans and specifications prepared, reviewed and approved in accordance with Rules .1938(e) and (f).

b. The system shall be installed by a contractor authorized in writing by the manufacturer to install the system.

c. Prior to issuance of an operation permit, a contract for operation and maintenance shall be executed between the system owner and a management entity as required in accordance with Rule .1961(b), and which is authorized in writing and empowered by the manufacturer to operate and maintain the system. A condition of the operation permit shall be that a contract for operation and maintenance with such an entity shall remain in effect for as long as the system is to remain in use.

SB/dh

Approved by: Steven Berkowitz Date: 10|22|93

Division of Environmental Health

On-Site Wastewater Section

Innovative Wastewater System Approval

Innovative Wastewater System No: IWWS-93-2-R1

Issued to: Infiltrator Systems, Inc.
P. O. Box 768
Old Saybrook, CT 06475

For: "Infiltrator" chambered sewage effluent subsurface disposal system.
[Standard Model with H-10 Load Design]

Date: August 25, 1994

In accordance with 15A NCAC 18A .1969, an application by Infiltrator Systems, Inc. of Old Saybrook, CT for approval of the chamber (gravel-less) nitrification trench system has been reviewed, and the standard unit Infiltrator system has been found to meet the standards of an innovative system when all of the following conditions are met:

I. Permitting:

Prior to the installation of the standard unit Infiltrator nitrification trench system at a site for which application is being made for an improvement permit or at a site for which an improvement permit has been previously issued for a system described in 15A NCAC 18A .1955, .1956, or .1957, the owner or authorized agent shall notify the local health department. The local health department shall issue an improvement permit or amend the previously issued improvement permit allowing for the use of the proposed innovative system upon a finding that all provisions of this approval and all other applicable rules shall be met. Use of the proposed innovative system and any conditions shall be described in the improvement permit or amended improvement permit, as applicable. Such information shall also be described on the operation permit to be issued upon the acceptable completion of the system installation.

II. System Description:

a. Pretreatment by septic tank as required in 15A NCAC 18A .1952.

b. Standard chamber unit consisting of a high density polyethylene arch-shaped injection molded chamber with an average inside width of 2.5 ft.(30 inches) and an overall length of 6 ft 2¼ inches. The standard unit height is approximately one foot high with ¼ inch wide slotted sidewalls approximately 6 inches high. The chamber sidewall slope is approximately 20 degrees toward the chamber center or away from the trench sidewall. Note: 16 Infiltrator chamber units are approximately equal to 100 linear feet.

c. Each chamber unit is designed to mechanically interlock with the downstream chamber forming a complete nitrification trench that consists of an inlet plate with a splash plate located below the inlet on the trench bottom and a solid end plate to be located at the distal end of any chamber nitrification line.

III. Siting Criteria:

The standard unit Infiltrator nitrification trench assembly may be utilized on sites which meet the following criteria:

a. Sites which are classified Suitable or Provisionally Suitable for a conventional nitrification field system in accordance with 15A NCAC 18A .1948(a) or (b).

b. Sites which have been reclassified as Provisionally Suitable in accordance with 15A NCAC 18A .1956(1), (2), (4), (5), and (6).

c. Sites which meet the criteria for new or existing fill in accordance with 15A NCAC 18A .1957(b).

d. The required vertical separation shall be measured from the bottom edge of the chamber.

IV. Infiltrator chamber system sizing:

a. The maximum long-term acceptance rate (LTAR) shall be as follows:

		LTAR (gpd/ft^2)	
		Natural Soil	Saprolite
Soil Group I	Sands	0.8 - 1.0	0.4 to 0.6
Soil Group II	Coarse Loams	0.6 - 0.8	0.1 to 0.4
Soil Group III	Fine Loams	0.3 to 0.6	---
Soil Group IV	Clays	0.1 to 0.4	---

b. The LTAR shall be based on the most hydraulically limiting naturally occurring soil horizon within three feet of the ground surface or to a depth of one foot below trench bottom, whichever is deeper.

c. To determine the total trench bottom area (ft^2) required; the design daily sewage flow shall be divided by the applicable long-term acceptance rate shown in (a) above. The minimum linear footage of Infiltrator chamber system required shall be determined by dividing the total trench bottom area by 4 feet when used in a conventional nitrification trench. No reduction in area is allowed for Infiltrator systems installed in bed or fill systems.

Example:

Assume: Three bedroom residence with a design daily sewage flow of 360 gallons on a sandy clay loam (Group III) soil.

Then: Total computed trench bottom area is:
360 gpd/0.5 LTAR = 720 ft^2;

The required linear footage of Infiltrator system is:
720 $ft.^2$/4.0 ft = 180 linear ft.
(where 4.0 ft. is the equivalency factor for the standard unit Infiltrator chamber system).

d. To determine the minimum number of Infiltrator chamber units required in a nitrification trench divide the trench bottom area by 24 and round to the nearest whole number.

720 ft^2/24 = 30 units

e. The mininum area (without reduction or equivalency factor) for a bed system shall be determined as required in 15A NCAC 18A.1955(d) except that the chambers shall be placed in rows next to each other.

f. The available space requirements of 15A NCAC 18A. 1945 shally apply. Also this approved innovative system may be designated as the required replacement system.

V. Design and Installation Criteria:

a. The Infiltrator chamber system used in nitrification trenches shall be in 3 ft. wide maximum excavation and constructed not less than nine feet on centers.

b. The inlet to the Infiltrator chamber shall be in the uppermost portion of the specially prepared inlet panel with a spash plate below the inlet on the trench bottom.

c. Clean Group I, II, or III soil backfill (soil normally found in the upper 10 inches of the trench excavation) shall be placed along the chamber sidewall area to a minimum compacted (walked in) height of 6 inches above the trench bottom.

Addition backill (Group I, II, III, or IV) shall be placed to a minimum compacted height of 12 inches above the chamber. No excavation equipment shall travel over the chamber system.

It is critical to note that the nitrification trench bottom shall be at least 24 inches below finished grade, and the inlet invert shall be approximately 8 inches above the trench bottom, and at least 17 inches below finished grade.

d. Individual chamber trenches shall be constructed level in all directions (both across and along the trench bottom) and shall follow the contour the ground surface elevation (uniform depth) with continuous interlocking chambers, including specially constructed Infiltrator angle chamber units, without any dams, step downs or other water stops.

e. Infiltrator systems installed on a sloping site may use distribution devices or stepdowns as described in 15A NCAC 18A .1955(j) and (l) when it is necessary to change level nitrification line segments from upper to lower elevations.

f. Manufacturer's installation instructions for the Infiltrator system used in septic tank systems shall be followed except as required herein or 15A NCAC 18A .1900 et seq.

g. The system shall be installed by a contractor authorized in writing by the manufacturer.

VI. Operation and Maintenance Requirements

The Infiltrator chamber system shall have a <u>minimum</u> classification as a Type III g. system (other non-conventional trench systems) in accordance with Table V(a) of 15A NCAC 18A .1961(b).

VII. Repair Systems

The provisions of 15A NCAC 18A .1961(c) shall apply to the use of the standard Infiltrator chamber system for repairs to existing malfunctioning septic tank systems.

Approved by: [signature]

Date: 8|25|94

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT,
HEALTH AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

INNOVATIVE WASTEWATER SYSTEM APPROVAL

INNOVATIVE WASTEWATER NO: IWWS-95-3R

ISSUED TO: EEE-ZZZ Lay Drain Company Incorporated
P.O. Box 867
Pisgah Forest, North Carolina 28768

FOR: Houck Drainage Systems (HDS) 2003 Triangular, 2012 Triangular, and 2012 Horizontal Drainfield Systems

DATE: October 10, 1995

In accordance with 15A NCAC 18A .1969, the Houck Drainage System 2003 Triangular, 2012 Triangular, and 2012 Horizontal Drainfield Systems have been found to meet the standards for an innovative system when all of the conditions specified herein are met.

I. PERMITTING

Prior to the installation of the EEE-ZZZ Lay Drain 2003 Triangular, 2012 Triangular, or 2012 Horizontal Drainfield Systems at a site for which application is being made for an Improvement Permit or Authorization to Construct or at a site for which an Improvement Permit or Authorization to Construct has been previously issued for a system described in 15A NCAC 18A .1955, .1956, or .1957, the owner or authorized agent shall notify the local health department. The local health department shall issue an Improvement Permit or Authorization to Construct or amend the previously issued Improvement Permit or Authorization to Construct allowing for the use of the proposed innovative system upon a finding that all provisions of this approval and all other applicable rules shall be met. Use of the proposed innovative system and any conditions shall be described in the Improvement Permit and Authorization to Construct or amended Improvement Permit and Authorization to Construct, as applicable. Such information shall also be described on the Operation Permit to be issued upon the acceptable completion of the system installation.

II. SYSTEM DESCRIPTIONS AND DESIGN CRITERIA

The HDS Drainfield Systems utilize wastewater absorption trenches containing bundles of loosely packed, expanded polystyrene (EPS) aggregate in place of rock aggregate. Aggregate consists of block-shaped particles of EPS with a particle density of 1.0 pounds per cubic foot, or greater, ranging in nominal size between 0.75 and 1.50 inches and graded similar to No. 4 mineral aggregate.

Cylindrical bundles are 10 inches (2003 Triangular) or 12 inches (2012 series) in diameter and 10 feet long. The expanded polystyrene aggregate is held in a cylindrical shape with a high strength polyethylene netting. The netting shall be strong enough to retain the shape of the bundles during system installation and backfilling, corrosion resistant, and sized to prevent the loss of aggregate.

Alternative configurations are described below:

a. **The HDS System 2003 Triangular Drainfield System** consists of three, 10-inch diameter cylinders placed in a trench 24 inches wide. Two bottom cylinders containing aggregate only, with the netting tied off at both ends to prevent the escape of aggregate, are placed against opposite sides of the trench bottom (retaining a gap of approximately four inches between the bundles when placed in the 24-inch wide trench). A third cylinder containing aggregate and a four-inch diameter flexible plastic perforated pipe as is typically used in nitrification lines is centered on top of the bottom two bundles in the middle of the trench. The pipe shall be certified as complying with ASTM F 405, Standard Specification for Corrugated Polyethylene (PE) tubing and fittings, and shall be in accordance with 15A NCAC 18A .1955(f). The four-inch pipe is surrounded by 2-1/2 to 3-inches of expanded polystyrene aggregate. The netting for the central cylinder is tied off at both ends to the pipe. The pipe may be connected by an internal coupling device or an endcap to allow continuous flow from one section to the next so as to bring each section adjacent to the next.

b. **The HDS 2012 Triangular Drainfield System** consists of three, 12-inch diameter cylinders in a trench 30 inches wide. Two bottom cylinders containing aggregate only, with the netting tied off at both ends to prevent the escape of aggregate, are placed against opposite sides of the trench bottom creating a gap of approximately five to six inches between the bundles. A third cylinder containing aggregate and a four-inch diameter perforated flexible plastic pipe as is typically used in nitrification lines is centered on top of the bottom two bundles in the middle of the trench. The pipe shall be certified as complying with ASTM F 405, Standard Specification for Corrugated Polyethylene (PE) tubing and fittings, and shall be in accordance with 15A NCAC 18A .1955(f). The four-inch pipe is offset from center towards the top of the cylinder whereby six inches of aggregate is located between the bottom of the pipe and the bottom of the cylinder, and 1-1/2 to 2 inches of aggregate is located between the top of the pipe and the top of the cylinder. The netting for the central cylinder is tied off at both ends to the pipe. The pipe may be connected by an internal coupling device or an endcap to allow continuous flow from one section to the next so as to bring each section adjacent to the next.

c. **The HDS 2012 Horizontal Drainfield System** consists of three, 12-inch diameter cylinders across the bottom of a trench 36 inches wide. The outer cylinders contain aggregate only, with the netting tied off at both ends to prevent the escape of aggregate. The central cylinder contains aggregate and a four-inch diameter perforated flexible plastic pipe as typically used in nitrification lines. The pipe shall be certified as complying with ASTM F 405, Standard Specifications for Corrugated Polyethylene (PE) Tubing and Fittings, and shall be in accordance with 15A NCAC 18A .1955(f). The four-inch pipe is offset from center towards the top of the cylinder whereby six inches of aggregate is located between the bottom of the pipe and the bottom of the cylinder, and 1-1/2 to 2 inches of aggregate is located between the top of the pipe and the top of the cylinder. The netting for the central cylinder is tied off at both ends to the pipe. The pipe may be connected by an internal coupling device or an endcap to allow continuous flow from one section to the next so as to bring each section adjacent to the next.

III. SITING CRITERIA:

The HDS Drainfield Systems may be utilized on sites which meet the following criteria:

a. Sites which are classified Suitable or Provisionally Suitable for a conventional nitrification field system in accordance with 15A NCAC 18A .1948(a) and (b).

b. Sites which have been reclassified as Provisionally Suitable in accordance with 15A NCAC 18A .1956(2), (4), (5), and (6).

c. Sites which may be reclassified as Provisionally Suitable in accordance with 15A NCAC 18A .1956(1), except that for the HDS Triangular configurations at least 29 inches of naturally occurring soil must be present above saprolite, rock, or soil wetness conditions, and all other factors are Provisionally Suitable or Suitable.

d. Sites which meet the criteria for new or existing fill in accordance with 15A NCAC 18A .1957(b). The provisions of Rule .1957(b) are applicable whenever any portion of the aggregate bundles in an HDS Drainfield System extends up into fill material.

e. The required vertical separation shall be measured from the trench bottom.

f. Use of HDS Drainfield Systems at sites proposed by a professional engineer to receive industrial process wastewater shall be evaluated by the Department on a case-by-case basis prior to approval.

IV. HDS DRAINFIELD SYSTEM SIZING:

a. The maximum long-term acceptance rate (LTAR) shall be as follows:

		LTAR (GPD/ft^2)	
		Natural Soil	Saprolite
Soil/Group I	Sands	0.8 - 1.0	0.4 - 0.6
Soil Group II	Coarse Loams	0.6 - 0.8	0.1 - 0.4
Soil Group III	Fine Loams	0.3 - 0.6	----
Soil Group IV	Clays	0.1 - 0.4	----

b. The LTAR shall be based on the most hydraulically limiting naturally occurring soil horizon within three feet of the ground surface or to a depth of one foot below the trench bottom, whichever is deeper.

c. To determine the minimum total trench bottom area (ft^2) required, the design daily sewage flow shall be divided by the applicable LTAR shown in (a) above. The minimum linear footage for the HDS Drainfield Systems shall be determined by dividing the total trench bottom area by the following equivalency factors:

HDS Configuration	Excavated Trench Width	Design (Equivalent) Trench Width (equivalency factor*)
2003 Triangular	24-inch	36-inch (3.0)
2012 Triangular	30-inch	50-inch (4.17)
2012 Horizontal	36-inch	48-inch (4.0)

**The Design (equivalent) trench width and equivalency factor shall not exceed the excavated trench width for systems installed in fill or for food service facilities, meat markets, and other places of business where accumulation of grease can cause premature failure of soil absorption systems. Reductions in trench bottom area up to those allowed by applying the Design (equivalent) trench width and equivalency factors may be permitted for facilities where data from comparable facilities indicate that the grease and oil content of the effluent will be less than 30 mg/l and the chemical oxygen demand (COD) will be less than 500 mg/l.*

Example:

Assume: Three bedroom residence with a design daily sewage flow of 360 gallons on a sandy clay loam (Group III) soil:

Then: Total computed trench bottom area is:
360/0.5 LTAR = 720 ft^2

The minimum required linear footage of HDS Drainfield Systems are:
720 ft^2 /3.0 ft = 240 linear ft (HDS 2003 Triangular)
720 ft^2/4.17 ft = 173 linear ft (HDS 2012 Triangular)
720 ft^2/4.0 ft = 180 linear ft (HDS 2012 Horizontal)
(Where 3.0, 4.17 and 4.0 are the equivalency factors for the HDS 2003 Triangular, 2012 Triangular and 2012 Horizontal Drainfield Systems, respectively).

d. The HDS 2012 Horizontal Drainfield System may be used in a bed system with the three cylindrical bundles placed in rows next to each other. The minimum area (without reduction or equivalency factor) for a bed system shall be determined as required in 15A NCAC 18A .1955(d).

e. The central cylinder of the HDS 2012 configuration which contains the off-set four-inch pipe may be used as an alternative to rock aggregate in a low pressure pipe (LPP) system, sized equivalent to LPP systems as required in 15A NCAC 18A .1957(a). The single 12-inch diameter cylinder shall be installed within a 12-inch wide trench. The LPP small diameter pressure laterals (one to two inches) shall be placed within the four-inch pipe sleeve and otherwise designed in accordance with Rule .1957(a). All orifices shall be drilled in the LPP laterals to face upwards, except for a hole placed in the middle and a hole placed 25 percent from the distal end of each line, which shall face downwards to allow for drainage. The minimum backfill requirement of six inches, as described below, shall also apply.

f. The available space requirements of 15A NCAC 18A ..1945 shall apply. Also these approved innovative systems may be designated as the required replacement system.

V. **INSTALLATION CRITERIA:**

a. The HDS Drainfield Systems shall be configured in accordance with Section II, above, installed in excavated trenches constructed with the following minimum center-to-center spacings:

HDS DRAINFIELD SYSTEM CONFIGURATION	MINIMUM EXCAVATED TRENCH SPACING
HDS 2003 Triangular (24-inch trench)	7-1/2 feet
HDS 2012 Triangular (30-inch trench)	9 feet
HDS 2012 Horizontal (36-inch trench)	9 feet

b. Minimum required trench depth below finished grade, depth to pipe invert below finished grade, and approximate pipe invert height above the trench bottom shall be as follows:

HDS Configuration	Minimum Trench Depth Below Finished Grade*	Minimum Pipe Invert Depth Below Finished Grade	Approximate Height to Pipe Invert Above Trench Bottom
2003 Triangular	23	13	10
2012 Triangular	24	12	12
2012 Horizontal	18	12	6

***note that on sloping lots, minimum required trench depths shall be greater**

c. A backfill barrier shall be placed over the EPS aggregate cylinders to prevent the infiltration of backfill material into the trench void spaces between the cylinders. The barrier shall <u>not</u> be placed along the trench sidewalls below the pipe invert elevation.

d. Clean Group I, II, or III soil backfill (soil normally found in upper 10 inches of trench excavation) shall be placed along the sidewalls in the HDS Triangular Drainfield Systems to a minimum compacted (walked in) height level with the center of the top EPS cylinder. Additional backfill (Group I, II, III or IV) shall be placed over all HDS Drainfield Systems to a minimum depth of six inches above the top of the central EPS cylinder and uniform with finished grade. No excavation equipment shall travel over the system.

e. The HDS Drainfield Systems shall be constructed level in all directions (both across and along the trench bottom) and shall follow the contour of the ground surface elevation (uniform depth), with continuous adjoining 10-foot cylindrical bundles butted up against one another and with bundles containing perforated pipe connected end-to-end, without any dams, stepdowns or other water stops.

f. HDS Drainfield Systems installed on sloping sites may use distribution devices or stepdowns as described in 15A NCAC 18A .1955(j) and (l) when it is necessary to change level nitrification line segments from upper to lower elevations. The minimum stepdown height for the HDS Triangular configurations may be reduced to be only up to the center of the pipe in the upstream trench.

g. Manufacturer's installation instructions for the HDS Drainfield Systems shall be followed, except as required herein or by 15A NCAC 18A .1900 et. seq.

h. The system shall be installed by a contractor authorized in writing by EEE-ZZZ Lay Drain Company Incorporated.

VI. OPERATION AND MAINTENANCE REQUIREMENTS:

The HDS Drainfield Systems shall have a <u>minimum</u> classification as a Type IIIg. system (other non-conventional trench systems) in accordance with Table V(a) of Rule 15A NCAC 18A .1961(b).

VII. REPAIR OF SYSTEMS:

The provisions of 15A NCAC 18A .1961(c) shall govern the use of the HDS Drainfield Systems for repairs to existing malfunctioning wastewater systems.

VIII. APPLICABILITY

This Innovative Wastewater System Approval supersedes previous approvals IWWS-94-1 and IWWS-95-3.

Approved by: Steven J. Berkowitz Date: 10-10-95

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT,
HEALTH AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
ON-SITE WASTEWATER SECTION

INNOVATIVE WASTEWATER SYSTEM APPROVAL

INNOVATIVE WASTEWATER NO: IWWS-94-1

ISSUED TO: EEE-ZZZ Lay Drain Company Incorporated
P. O. Box 867
Pisgah Forest, North Carolina 28768

FOR: EEE-ZZZ Lay Drain 2003 Triangular Nitrification Trench Assembly

DATE: March 2, 1994

In accordance with 15A NCAC 18A .1969, the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly has been found to meet the standards for an innovative system when all of the conditions specified herein are met.

I. Permitting

Prior to the installation of the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly at a site for which application is being made for an improvement permit or at a site for which an improvement permit has been previously issued for a system described in 15A NCAC 18A .1955, .1956, or .1957, the owner or authorized agent shall notify the local health department. The local health department shall issue an improvement permit or amend the previously issued improvement permit allowing for the use of the proposed innovative system upon a finding that all provisions of this approval and all other applicable rules shall be met. Use of the proposed innovative system and any conditions shall be described in the improvement permit or amended improvement permit, as applicable. Such information shall also be described on the operation permit to be issued upon the acceptable completion of the system installation.

II. System description and design criteria

The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly is a gravelless nitrification trench utilizing three bundles of loosely packed, expanded polystyrene aggregate configured in a triangular fashion to form a nitrification trench. The following component specifications are applicable:

a. Aggregate shall be particles of expanded polystyrene, with a minimum particle density of 0.93 pounds per cubic foot, except that a maximum of 5 percent of lighter density expanded polystyrene (down to a minimum particle density of 0.7

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pounds of cubic foot) may be used if co-mingled with denser aggregate.

b. Aggregate size shall be between ½-inch and one inch, as determined in accordance with ASTM Standard C 136, Standard Method For Sieve Analysis of Fine and Course Aggregates (100% passing one inch sieve, less than one percent passing ½-inch sieve).

c. Bundles are 10 inches in diameter and 10 feet long. Bundles containing the specified expanded polystyrene aggregate are held in place with a high strength polyethylene netting. The netting shall be strong enough to retain the shape of the bundles during system installation and backfilling, corrosion resistant, and sized to prevent the loss of aggregate.

The two bottom bundles in the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly contain aggregate only, with the netting tied off at both ends to prevent the escape of aggregate. The top bundle contains a four-inch diameter perforated flexible plastic pipe as is typically used in conventional nitrification lines. The pipe shall be certified as complying with ASTM F 405, Standard Specification for Corrugated Polyethylene (PE) tubing and fittings, and shall be in accordance with 15A NCAC 18A .1955(f). The four-inch pipe is surrounded by two-and-one-half to three inches of expanded polystyrene aggregate. The netting for the top tube is tied off at both ends to the pipe. The pipe in the top bundle has complimentary male and female end cap fittings on opposite ends.

d. The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly is placed in an excavation twenty-four (24) inches wide. The two bottom bundles are placed against opposite sides of the trench bottom, retaining a gap of four inches between the bundles. The top bundle containing the pipe is centered on top of the bottom two bundles in the middle of the trench.

III. Siting criteria:

The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly may be utilized on sites which meet the following criteria:

a. Sites which are classified Suitable or Provisionally Suitable for a conventional nitrification field system in accordance with 15A NCAC 18A .1948(a) and (b).

b. Sites which have been reclassified as Provisionally Suitable in accordance with 15A NCAC 18A .1956(2), (4), and (5).

c. Sites which may be reclassified as Provisionally Suitable in accordance with 15A NCAC 18A .1956(1), except that at least 30 inches of naturally occurring soil must be present above saprolite, rock, or soil wetness conditions, and all other factors are Provisionally Suitable or Suitable.

d. Sites which may be reclassified as Provisionally Suitable in accordance with 15A NCAC 18A .1956(6). The trench construction requirement of .1956(6)(d) shall be that the trenches have a width of two feet and a maximum depth of 30 inches on the down slope side of the nitrification trench.

e. Sites which meet the criteria for new or existing fill in accordance with 15A NCAC 18A .1957(b). The provisions of Rule .1957(b) are applicable whenever any portion of the aggregate bundles in the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly are to be installed in fill material.

f. Vertical separation requirements shall be measured from the trench bottom to rock, saprolite, soil wetnesss condition, or any otherwise unsuitable soil horizon.

g. Horizontal setback and location requirements in 15A NCAC 18A .1950 shall apply.

h. Use of the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly at sites proposed to receive industrial process wastewater shall be evaluated by the Department on a case-by-case basis prior to approval.

IV. <u>System sizing</u>:

a. Nitrification area requirement shall be determined in accordance with 15A NCAC 18A .1955(b) and .1955(c), or Rule 15A NCAC 18A .1956(6)(b), as applicable.

b. The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly shall be considered equivalent to a two-and-one-half-foot-wide conventional trench. The long term acceptance rate shall not exceed 1.0 gallons per day per square foot.

c. The minimum area for a bed system shall be determined as in 15A NCAC 18A .1955(d).

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d. The available space requirements of 15A NCAC 18A .1945 shall apply, except that an approved innovative system may also be designated as the required replacement system.

V. Installation criteria:

a. The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly shall be installed in a 24-inch wide trench. **Trench excavation wider or narrower than 24 inches shall not be approved, nor shall any trench constructed wider than 24 inches be backfilled in order to achieve a 24-inch trench width.**

b. The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly shall be configured in strict accordance with section I(d), above. To form a complete nitrification trench, the adjoining bottom bundles are butted up against one another, and the top bundles are installed so that the pipes shall snap together using the complimentary male and female fittings bringing the surrounding aggregate of each adjoining top bundle into contact with one another.

c. Adjacent trenches shall be constructed not less than seven-and-one-half-feet on centers.

d. A clean Group I, II, or III soil backfill shall be placed over the aggregate bundles and carefully compacted to the degree necessary to prevent settling. The elevation of the compacted height of backfill shall be a minimum of 12 inches above the top of the top bundle and uniform with finished grade. A water-porous, geotextile fabric is recommended to be used at the backfill-aggregate interface when the backfill material is Group I Sands (similar recommendation is now made for all conventional and low pressure pipe systems installed in Group I Sands).

It is critical to note that the nitrification trench bottom shall be at least 29 inches below finished grade, and the nitrification line pipe invert shall be approximately 10 inches above the trench bottom (and at least 19 inches below finished grade).

e. The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly shall be installed on level trench bottoms parallel to the site elevation contours. Stepdowns or drop boxes may be used only where it is determined by the local health department that elevation changes are required. Rule 15A NCAC 18A .1955(l) shall apply, except that the minimum height of a stepdown shall be 13 inches above the bottom of the upstream nitrification trench. Effluent shall be conveyed over the stepdown through non-perforated pipe or tubing and backfilled with compacted soil.

f. Beds may be used for the installation of the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly when the local health department determines that the siting and sizing requirements of 15A NCAC 18A .1955(d) shall be met. The excavation width for a bed shall be in even increments of 20 inches (for example, bed width may be 40 inches, 60 inches, 80 inches, etc.). The bottom bundles shall be placed on 10-inch centers directly adjacent to each other across the bottom of the bed, and top bundles containing the four-inch pipe shall be centered on top of each adjoining pair of bottom bundles, resulting in the top bundles being placed on 20-inch centers.

g. Except as required herein, the system installation shall meet all applicable requirements of 15A NCAC 18A .1900 et seq.

h. Manufacturer installation instructions for the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly shall be followed, except as required herein or in 15A NCAC 18A .1900 et seq.

i. The system shall be installed by a contractor authorized in writing by the manufacturer.

VI. <u>Operation and maintenance requirements</u>:

The EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly shall have a <u>minimum</u> classification as a Type IIIg. system (other non-conventional trench systems) in accordance with Table V(a) of 15A NCAC 18A .1961(b).

VII. <u>Repair of systems</u>:

The provisions of 15A NCAC 18A .1961(c) shall govern the use of the EEE-ZZZ Lay Drain 2003 triangular nitrification trench assembly for repairs to existing malfunctioning septic tank systems.

Approved by: [signature] Date: 3|2|94

7.6 EXPERIMENTAL ON-SITE SYSTEMS

Experimental on-site systems, like alternative and innovative systems, are specifically and legally defined. Experimental systems are technologies not covered in the *Laws and Rules for Sewage Treatment and Disposal Systems* under 15A NCAC 18A. 1955 - 1958. Additionally, experimental systems must have a certain research potential that may help meet a widespread need for on-site systems in the state. Thus, only certain types of proposed on-site systems qualify for the experimental designation.

This section presents information about the requirements for installation of an experimental system and the necessary research protocol that must be established for the system.

Requirements for Approval of an Experimental On-Site System

Experimental systems are not installed simply because a site is classified as UNSUITABLE. An installation of an experimental system must have the potential to contribute valuable information toward meeting a reasonably widespread need in the state of North Carolina. Both the site and the installed system must possess reasonable research potential.

Permit Requirement

Reference

15A NCAC 18A.1969(1,2,4)

15A NCAC 18A.1969(1)

A permit for the installation of an experimental system may be issued for any location in the state of North Carolina. The permit is issued through the local health department after a detailed review by the On-Site Wastewater Section.

Desired Characteristics for Experimental Systems

Experimental systems are viewed as research projects. Thus, the proposed system must offer the potential to add information needed to overcome limitations found on a reasonable number of sites in the state. Desired characteristics for experimental projects are listed as follows:

❑ Research objectives should be designed so that if the objectives are met, the experimental system can meet the standards for approval as an innovative on-site system.

❑ Expected results from the project can be used for sites where horizontal setbacks or separations, vertical separations, or buffer requirements cannot be met. For example, some experimental systems may demonstrate that sites with shallow soil wetness conditions can be reclassified as PROVISIONALLY SUITABLE if the proper systems are installed.

❑ Anticipated findings of the experiment may result in an increased long-term acceptance rate, or LTAR, for certain sites and soils. If an experimental system demonstrates that a higher LTAR is possible for a site, then the treatment and disposal field can be reduced in size or an on-site system may be installed on a lot that was too small or did not have enough usable area under the usual LTAR.

❑ The proposed experimental system must be included as part of a research or testing program conducted by an appropriate research or testing organization that has relevant experience and knowledge of on-site systems. The research or testing organization must have no conflict of interest or potential financial gain from the use of the experimental technology.

❑ The experimental design and the proposed testing of the system should be planned so that the proposed project has a reasonable likelihood of meeting the research objectives.

Other Requirements for Issuance of an Improvement Permit

The requirements for an Improvement Permit can be found in rule 15A NCAC 18A.1969 (4). A few important provisions are listed below.

❑ A statement must be submitted by the owner acknowledging that the owner is aware of the experimental nature of the system and that the system may need to be shut down if the system fails or cannot be repaired, or if the research program terminates early. Also, the owner must state that he is aware that the state and the local health department do not guarantee the operation of the system.

❑ Experimental on-site systems for residences, businesses and public facilities must have a repair area set aside to use with a non-experimental on-site system in case the experimental system fails.

❑ The owner of the experimental system must grant an easement allowing the research organization access to the system for research purposes. The easement must be recorded with the register of deeds.

Research Protocol for Experimental On-Site Systems

Improvement permits issued for experimental on-site systems are *site specific*, which means the proposed experimental system can be used only on the specific site described in the permit application. Because the system is experimental, a *research protocol*, or detailed description of how the on-site system is to be studied and its performance evaluated must be included with the permit application. The research protocol must include the following items.

❑ All system components must be described, including the materials used in construction and the proposed use of the components.

❑ A summary of relevant research, published literature, previous experience, and performance of previously installed systems should be included. Results of pilot or full-scale tests performed by appropriate research or testing organizations should also be included.

❑ A description of the research objectives, methodology, and the duration of the research including how the system will be *monitored* must be submitted. Monitoring refers to observing and measuring the performance of the system, usually by analyzing samples of effluent from the system or its components.

❑ The research protocol must state operation and maintenance procedures, system classification, the management entity and the system operator, the number of systems in the research program, the criteria for site selection, and the system monitoring and reporting procedures.

❑ The owner must issue a statement concerning what is to be done if the system malfunctions, or if the research is terminated early.

Experimental System Operation Permit

A special permit, the experimental system operation permit or ESOP, must be issued before the system can begin operation. The ESOP is issued by the local health department and is valid for up to five years. The permit specifies maintenance, monitoring, and testing requirements for the experimental system to carry out the research or testing program.

❑ If the experimental system performs satisfactorily, the local health department can issue an Operation Permit prior to the expiration of the ESOP. The Operation Permit allows the continued use of the system.

❑ After the research program is completed, the research organization must complete a report covering the results of operating the system and giving recommendations on further use of the experimental system. If the OSWS determines that the experimental system meets the requirements of 15A NCAC 18A.1969(3), then the experimental system may be granted innovative system status.

Approved Experimental On-Site Wastewater Systems

Reference

15A NCAC 18A.1969(4)(c)(ix)

According to the rules, each

"proposed Improvement Permit and subsequent operation permits for experimental systems shall be reviewed by the state* and found to be consistence with the approved research or testing program prior to issuance by the local health department."

*the On-Site Wastewater Section of the North Carolina Department of Environment, Health, and Natural Resources

Experimental system approvals are very dynamic. Not only do the design and installation change from site to site, but installations on the same site change as the research progresses. Interested parties are encouraged to contact the On-Site Wastewater Section for more information on obtaining approval for an experimental system.