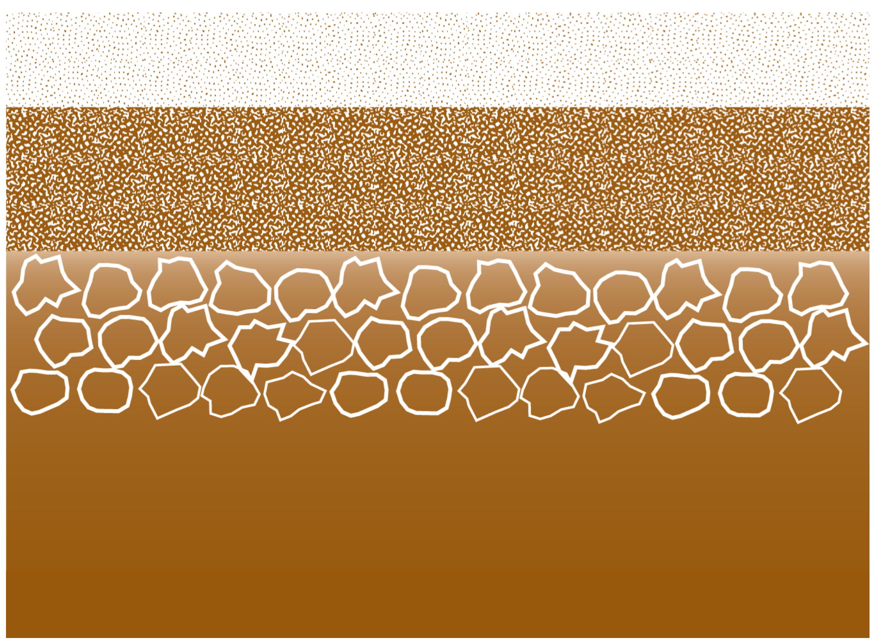
Bulletin 905

Soil and Site Evaluation
for Onsite Wastewater Treatment



THE OHIO STATE UNIVERSITY
EXTENSION

Soil and Site Evaluation

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Introduction

More than a million onsite wastewater treatment systems operate in Ohio. Consequently, about a quarter of a million acres of soil, or about a billion tons of soil is used in Ohio to renovate wastewater. Soils are the most important wastewater treatment resource in the state.

Many natural soils and soil materials are well suited to the task of renovating wastewater. Physical, chemical, and biological processes in soils work to remove nutrients, organic matter, disease-causing organisms, and odors from wastewater, to deliver clean water to the environment and for human use. Success in wastewater treatment in turn depends on appropriate properties of the soil and site, and a good match between the system design and the opportunities and limitations of the site. A detailed assessment of a proposed site and soil resources is essential for design of a functioning wastewater treatment system, and its continued operation in the long term.

This bulletin is a guide for Ohio onsite wastewater treatment system designers and regulators, as they consider developing appropriate sites, systems, and designs.

Desirable soil characteristics

Deep, permeable soils are ideal for wastewater treatment and dispersal. In Ohio, a depth of 4 feet of unsaturated soil is needed to renovate wastewater to meet standards of organic matter, suspended solids, ammonia, bacteria, and virus removal.

Efficient wastewater treatment in soil to remove contaminants relies on aerobic processes. Soil must be sufficiently permeable to allow for the passage of both wastewater and air. Most importantly, the soil where treatment occurs must remain unsaturated year-round. If wastewater is discharged into saturated soil, pollutants are not adequately treated or removed, and may move quickly over large distances (hundreds of feet) with groundwater, emerging in ditches, streams or lakes, or contaminating nearby wells.

In much of Ohio, the soil is not deep enough to provide for adequate treatment of applied wastewater. However, where some unsaturated soil is available, the natural soil can often be augmented with layers of selected sand to create the necessary depth of treatment to renovate the wastewater and disperse it. Mound systems and sand bioreactors can be used throughout much of Ohio to treat and disperse wastewater. The depth of soil above a limiting condition and the permeability of the soil material are both important factors to be considered when siting and designing any wastewater treatment and dispersal system.

For information on mound systems and sand bioreactors, ask for Bulletins 813, 829, 876 and 912 for sale through Ohio State University Extension offices. They can be found and downloaded online at www.ag.ohio-state.edu/~setll.

Threats to natural soil resources

Soil is a fragile and endangered resource. Each year in Ohio, many thousands of acres of soil are physically removed, eroded, covered with pavement and structures, compacted or contaminated. Ohio is fortunate to have large areas of valuable soil resources that support highly efficient and productive agriculture and forestry. Ohio's soils are put to many, sometimes conflicting, uses. Deep, permeable soils, on low gradient slopes, are ideal for agriculture and also for the recycling of waste products including manure, wastewater, and municipal and industrial wastes. These same soils are also ideal for urban development. In Ohio, deep, permeable soil profiles are only present over about 6.4% of the land area. Many of these areas are found in or around the largest cities in Ohio or in rapidly developing peri-urban or ex-urban areas. Many of these soils are no longer available for agricultural use, and may not be available for future wastewater recycling.

As shallower, less permeable soil materials are being considered for use in wastewater treatment, care must be exercised to carefully evaluate soil and site limitations and opportunities. Soil and site evaluation is a critical step in the process of designing an appropriate and functional wastewater treatment system.

In Ohio, a number of soil profile limitations provide challenges for soil-based wastewater treatment. Most of these limitations are natural or induced restrictions to water and air movement in the soil profile and limit the depth and duration of unsaturated soil conditions. Identification of these limiting conditions is a critical step in the process of designing effective onsite wastewater systems that protect soil and water resources and the public health.

The major limitations include:

- high water tables, with saturated soil conditions present near the soil surface,
- restricted soil depth above dense, slowly permeable substratum materials, including unfractured bedrock and dense glacial till,
- restricted soil depth above dense slowly permeable subsurface soil layers, including fragipans,

compacted soil, and heavy clay materials,
- other layers with inadequate permeability,
- poor drainage conditions,
- flooding,
- excessive slope,
- presence of excessive amounts of rock in the soil,
- fractured bedrock at shallow depth,
- sandy soil with excessive permeability, and
- sand and gravel layers below finer textured soil materials.

Restrictions to wastewater treatment and dispersal must be identified and appropriate systems designed to ensure adequate removal of pollutants before wastewater leaves the site to join the surface or groundwater resources.

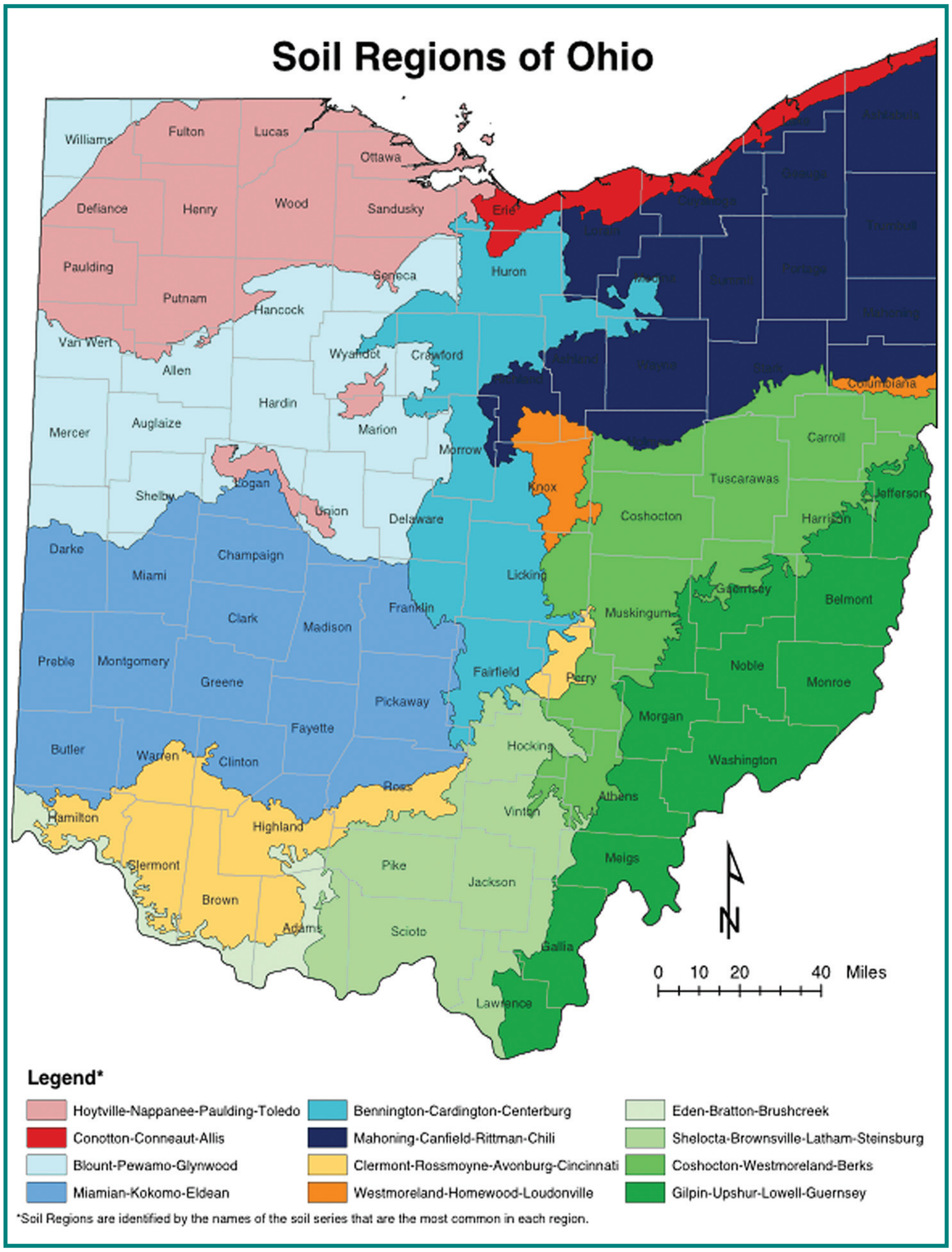


Figure 1. Soil regions of Ohio.

Soil variability

Soils are highly variable in space and also change with time, through natural processes, and with human management. Soil conditions change along with subtle changes in landscape and environmental conditions. Human activities frequently change local soil conditions. The local variability of soil attributes must be understood in order to design an appropriate onsite wastewater treatment system. Soil survey maps (Figure 1) and reports are useful tools to indicate general conditions expected in an area, but they cannot capture all the local diversity in soil conditions, or changes that have occurred since mapping was completed. Site specific observations by a qualified, experienced practitioner are essential for understanding the fine-scale local variability of soil properties and local site conditions.

Making soil observations

Soil contains a record of its natural history. The length of time a soil has been in place, the impact of climate and topography, parent materials, and biological and human activities are recorded in the soil as properties of horizontal layers (horizons), which can be elucidated by a skilled evaluator. Soil drainage conditions exert a major influence on the morphology of the soil profile. An experienced evaluator can uncover important information on soil water and air movement by careful observation of soil material, and the properties and sequences of soil horizons at a site. These observations can form a reliable basis for designing appropriate wastewater systems. Of the many soil morphological properties, soil color, structure, consistence, texture and depth of plant growth are the most often used indicators of soil hydrologic conditions to determining site suitability for wastewater treatment.

Soil Horizons

Soil horizons are approximately horizontal layers that result from the interaction of soil-forming factors. Soils are identified on the basis of the morphology of their horizon sequences, and their suitability for wastewater treatment is assessed on the basis of horizon characteristics.

Soil scientists call the major horizon forms “master horizons” and classify them with alphanumeric symbols. The major horizons are:

A horizons–generally considered to correspond with “topsoil”, where biological activity is often greatest and plant roots most concentrated

E horizons–lighter colored horizons from which some constituents such as clay have been removed

B horizons–generally considered to be “subsoil”, where constituents including clay may accumulate

C horizons–material below the developed soil affected by weathering or other geological processes

R horizons–unweathered or indurated bedrock

O horizons–horizons predominantly composed of organic matter

Transitional horizons are indicated by combining the master horizon letters (such as AB, a horizon dominated by A characteristics, but transitional to B, or E/A, a mixed horizon with distinct patches of E and A horizon materials).

The major horizons are frequently subdivided to indicate specific layers having distinct features; these are commonly indicated using lower case suffixes and numeric subdivisions.

Examples of suffixes describing specific features common in Ohio soils and subordinate horizons in which they commonly occur include:

- a (as in Oa) highly decomposed (sapric) organic matter
- b (as in Ab) buried horizon (as
- c (as in Bc) containing concretions or nodules
- d (as in Cd) dense layer (restrictive to the growth of roots, and frequently restrictive to wastewater treatment and disposal)
- g (as in Bg) “gley”, horizons strongly depleted of iron and manganese due to reduction, frequently exhibiting low chroma (“gray”) colors
- w (as in Bw) weak color or structure development
- t (as in Bt) accumulation of illuvial clay

Soil color

Soil color is an important indicator of soil genesis and of current and historic processes, particularly those associated with water and air storage and movement. Color is easily seen and described. However, because of the great variety of soil coloring agents, and the many processes that cause color to develop and change, exact interpretation is not always simple.

Soil color is a function of soil formation history, mineralogy of the soil constituents, biological activity, drainage conditions and aeration. The major coloring agents in soil include soil organic matter (dark), and metal oxides including iron, manganese and aluminum (red, yellow and black). The concentration and chemical form of organic matter and metal oxides are highly sensitive to drainage and aeration.

Most soil minerals are basically gray in color. Larger soil particles and aggregates (structural units of the soil made up of particles held together) are frequently coated with thin layers of very fine soil particles. Coatings of organic matter and metal oxides change the color of the underlying particles and aggregates, in a similar way to watercolor paint on a gray canvas. As drainage and aeration conditions change, processes that influence the breakdown or accumulation of organic matter, and the state and solubility of the oxide coatings also vary.

Under saturated conditions, biological activity is curtailed, and the oxidation and mineralization of organic matter, processes that involve soil microorganisms, also slow down. Dark colors, particularly in the surface layers of the soil, commonly represent accumulation of organic matter, masking gray-colored mineral material. Conversely, organic matter breaks down more quickly under well-aerated conditions, due to higher levels of biological activity.

Soils with strong, bright colors such as dominantly red materials often indicate the presence of oxide coatings, especially iron oxides. These coatings form and are stable in well-aerated conditions where plenty of oxygen is available.

Important chemical and biochemical reactions called redox reactions take place in soils under saturated conditions. As organisms remove the available oxygen, the chemical process called reduction is enhanced. During reduction, iron and other metal oxides that provide the strongest soil colors (red, yellow, black) change to less oxidized forms. The more reduced oxides are more soluble in oxygen-depleted water, and are stripped from the coatings of underlying mineral grains and aggregates. Where stripping, solution and movement of the dissolved oxides is most intense, predominantly gray soil materials remain. Soils that are dominantly gray are frequently saturated with water, and are often poorly aerated.

Some layers in the soil are only saturated seasonally. As water levels move up and down in the soil, intermittent periods of low oxygen status are associated with dissolution, movement and leaching of the oxides. Deposition (re-precipitation) of oxides can occur in dryer parts of the soil or along root channels or other pathways of air movement. Hence brighter colors tend to accumulate in some places and to disappear from others. In these intermittently saturated soils, patches or mottles of contrasting colors can be seen. Mottles are examples of *redoximorphic features* in the soil, and frequently indicate intermittent saturation or seasonal high water tables which may not persist throughout the year.

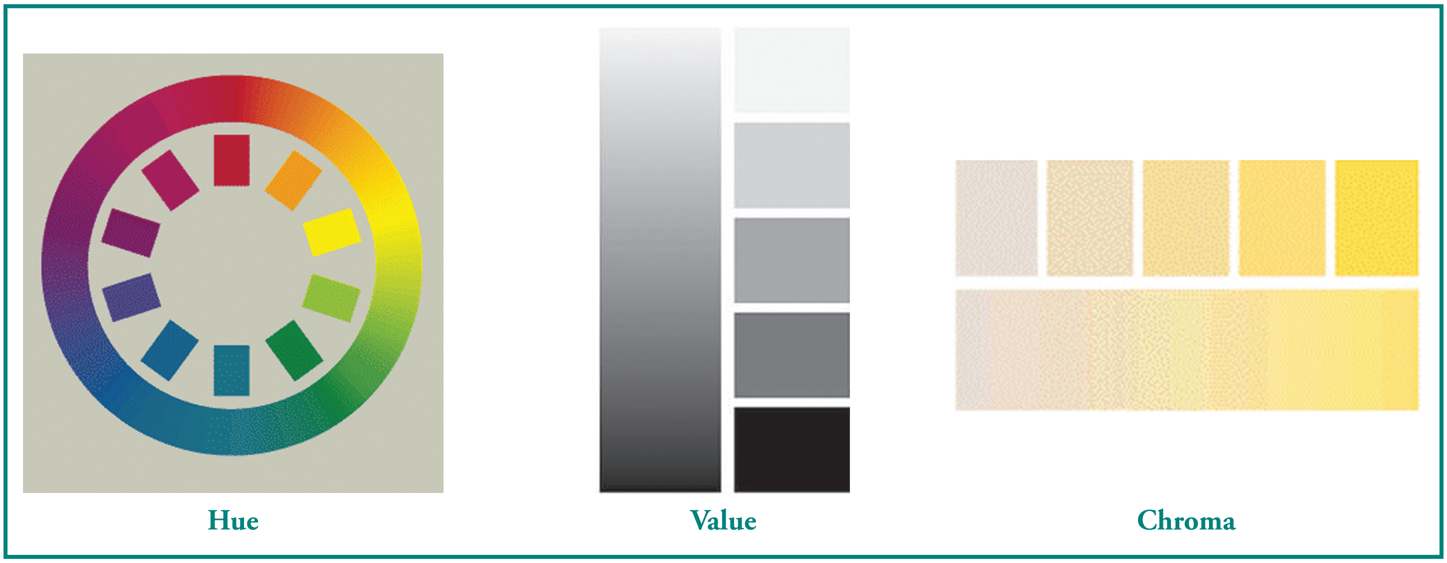


Figure 2. Soil color parameters.

The presence of strong redoximorphic features, particularly dull gray patches, is the most important morphological indicator of wetness in soil horizons, used by evaluators to determine limitations to wastewater treatment in the soil.

Describing color

Soil colors are described in a standard way so that different individuals can share information for decision making. Color chips matching as closely as possible the variety of soil colors are printed in a standard book called the Munsell Soil Color Charts. In the Munsell system, soil color is represented in three ways: Hue, Value and Chroma, each representing a different aspect or axis of color, as illustrated in Figure 2. Alphanumeric codes provide a shorthand method for describing the soil color, and are complemented by general color names. The first numbers and letters represent the hue, followed by the value and the chroma. For example 5YR4/3 describes a soil with hue of 5YR, value of 4 and chroma of 3. This soil material would be “reddish brown.”

Hue describes the dominant visible spectral shade (or wavelength). In the Munsell system, three dominant hues (R, red; Y, yellow; G, green) are used together with intermediate hues (for example YR for yellow-red). Soils cover a range of seven major classes of hue, ranging from red through yellow. Four equal steps are provided between each of the major hues (2.5, 5, 7.5, 10). Each of the dominant hues is represented by a letter (R for red, Y for yellow), with intermediate two-letter codes for transitions (YR for yellow-red). Each numeric code describes a single class of hue, for example, 10YR, 5R or 2.5Y. Each class of hue is allocated a single page in the Munsell book.

Value describes the relative lightness or darkness of the color. Values range from pure black to pure white. Gray is perceived as halfway between black and white. Black is assigned the value 0/, while white is 10/. A mid-gray would be 5/ with darker grays having lower values, and lighter grays having higher values. Soil color values are arranged on each page of the color book with the lightest colors at the top of the page and the darkest at the bottom.

Chroma represents the relative purity, strength and saturation of the color. The strongest expression of color (for a given hue and value) is given a high chroma code of /8. The absence of color would be described with a chroma code of /0, indicating complete dilution of the pure color by neutral gray. “Washed-out” colors have low chromas while intense saturated colors have high chromas. Chroma is arranged on each page horizontally, with the lowest (dullest) chromas on the left, and highest (most pure) chromas on the right.

The appearance of soil color varies according to lighting conditions, moisture content and treatment of the sample. For consistency, soil color should be judged under bright direct sunlight during the middle part of the day. The soil sample to be described should be moist but not wet (keep a water bottle handy to moisten dry material), and the soil should not be crushed or mixed.

Redoximorphic features

Oxidation and reduction processes in the soil associated with variable drainage and aeration are evidenced by the accumulation and depletion of materials such as organic matter and metal oxides. Accumulations and depletions can take many forms; as well as mottles or patches of color, minerals and oxides can accumulate as nodules, concretions, and surface coating and other forms. These accumulations and depletions can be used as indicators of soil wetness. In particular, depleted soil colors with a chroma of 2 or less and a value of 4 or more are the primary morphological indicators of wetness for assessing onsite wastewater suitability. (Figure 3)

Texture

The solid portion of the soil is made up mostly of particles of soil minerals and organic matter. Soil texture refers to the relative proportion of the three major size classes of primary soil particles. Texture generally is assessed on the fine earth fraction of the soil (particles less than 2 mm in size). Solid particles larger than 2 mm are considered coarse fragments and include pebbles and cobbles.

Clay is the finest of the particle size classes. Clays exert a great influence on soil chemical and physical properties, largely due to their large surface area and surface charge. Clay particles are chemically active and influence the movement, exchange and cycling of minerals, ions and organic constituents in the soil. The proportion of clay-sized particles also greatly influences soil physical properties, including aggregation, porosity, water movement and storage, aeration and workability of the soil.

Soil texture can be assessed in the field by an experienced soil scientist, who can judge the proportion of sand, silt and clay-sized particles by the feel of the soil when moistened and manipulated. A handful of soil is moistened and worked into a ball; the behavior of the material in terms of the amount of water needed to wet the soil, the coherence and stickiness of the material, and the dominance of coarse, medium or finer particles that can be sensed provides a series of clues to the texture of the sample. A flowchart illustrating the process is shown in Figure 4.

The soil textural triangle (Figure 5) is used to classify the sample according to the proportion of the primary particle size classes. Within a named texture class, soil materials share some common traits or ranges of physical behavior. For example, materials in the sand class have very low proportions of silt or clay size particles, and generally transmit water quickly, but do not have a great capacity to store moisture. At the other extreme, clay soils are dominated by the finest particles, and while able to store considerably more moisture, are often only able to transmit water very slowly. Medium textured

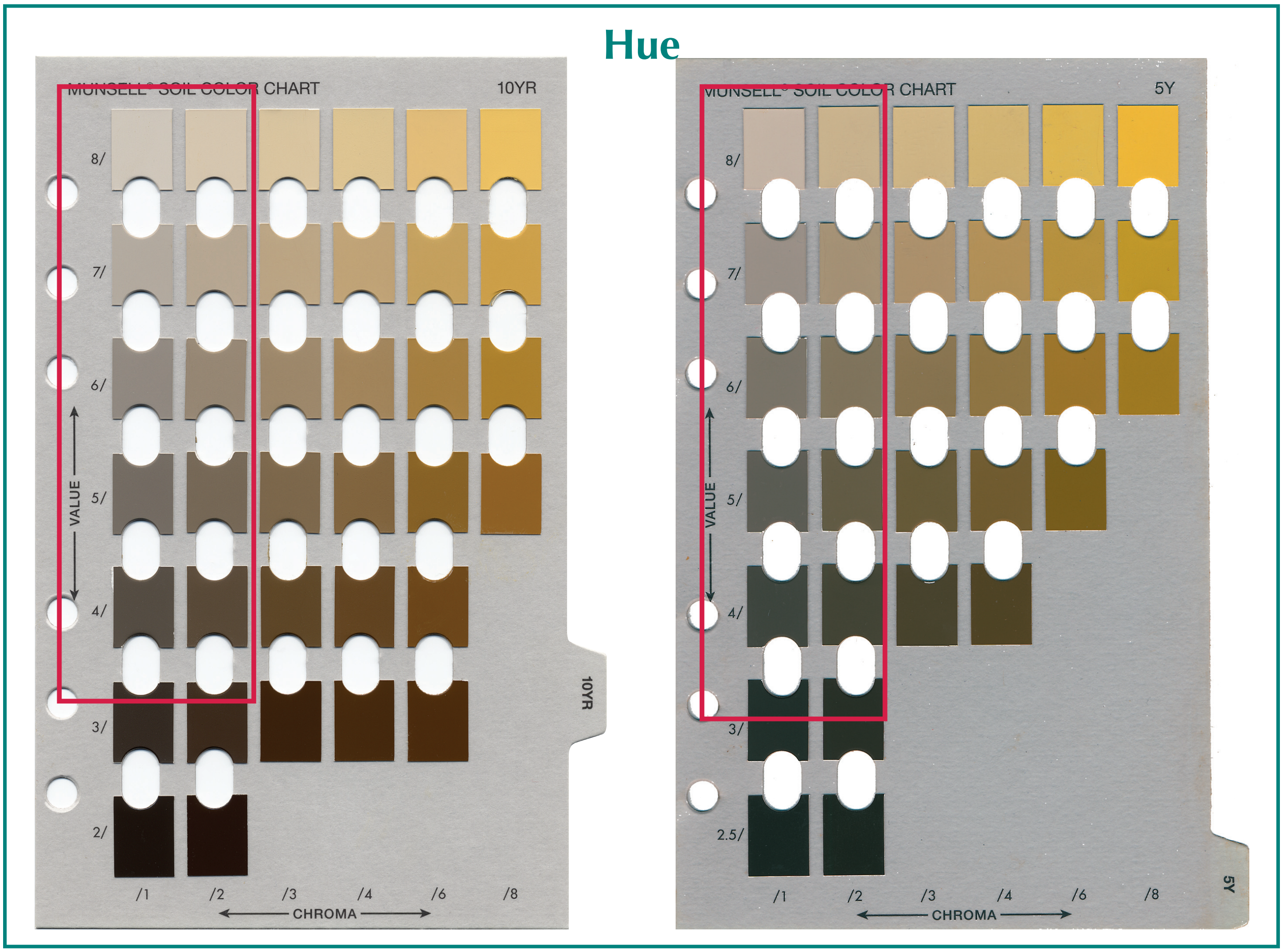
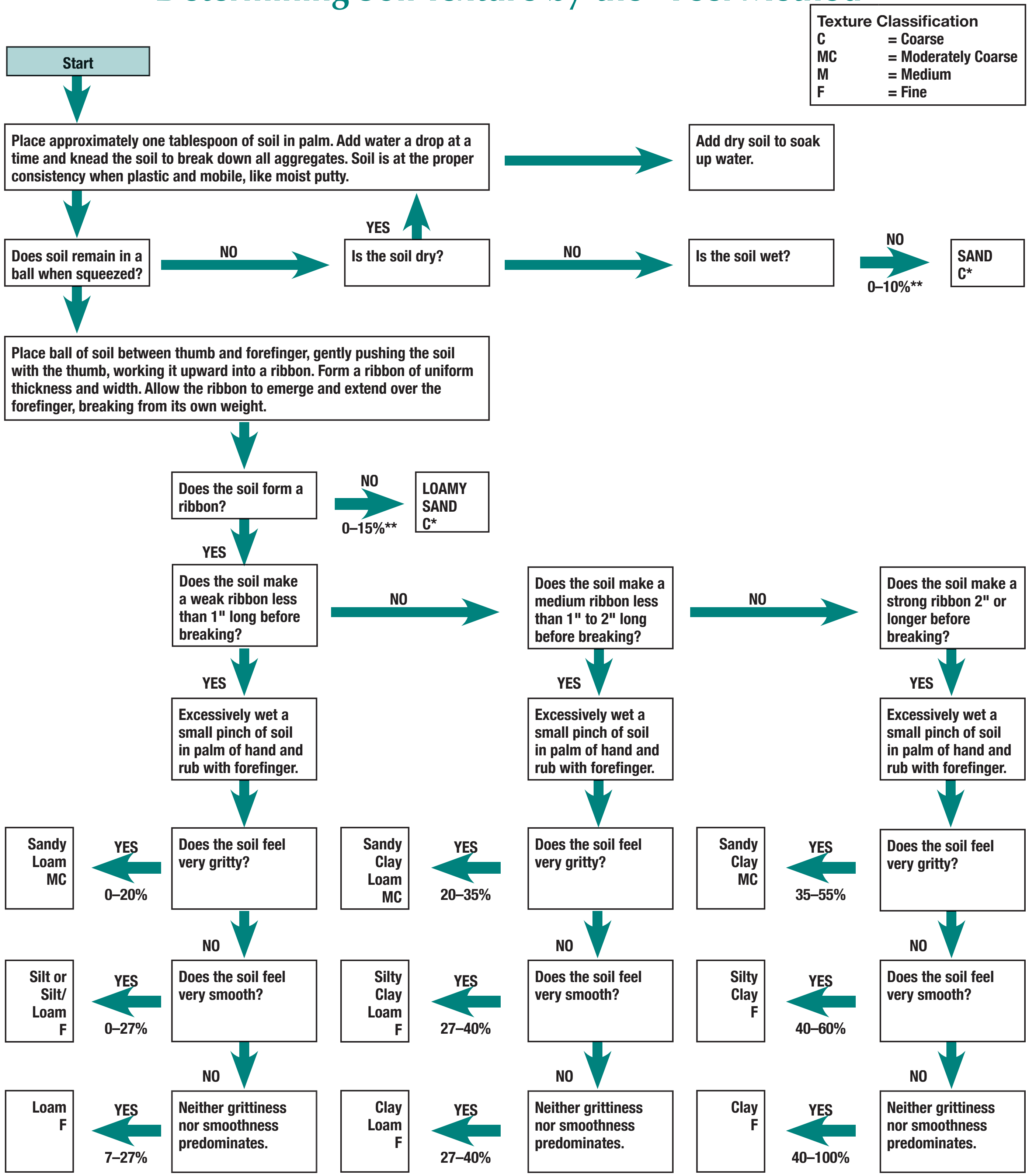


Figure 3. Example page from Munsell Soil Color Charts (2000). Boxed areas indicate soil colors that may indicate wetness. (note: The colors presented here are not true to the publication and are here to illustrate one use of the book. Be sure to use the actual Munsell Soil Color Charts. 2000. GretagMacbeth, 617 Little Britain Rd., New Windsor, NY 12553.)

Determining Soil Texture by the "Feel Method"



* Sand Particle size should be estimated (very fine, fine, medium, coarse) for these textures. Individual grains of very fine sand are not visible without magnification and there is a gritty feeling to a very small sample ground between the teeth. Some fine sand particles may be just visible. Medium sand particles are easily visible. Examples of sand size descriptions where one size is predominant are; very fine sand, fine sandy loam, loamy coarse sand.

** Cay percentage range.

Modified from: Thien, Steven J., Kansas State University, 1979 Jour. Agronomy education.

Figure 4. Flowchart illustrating the process to determine soil texture.

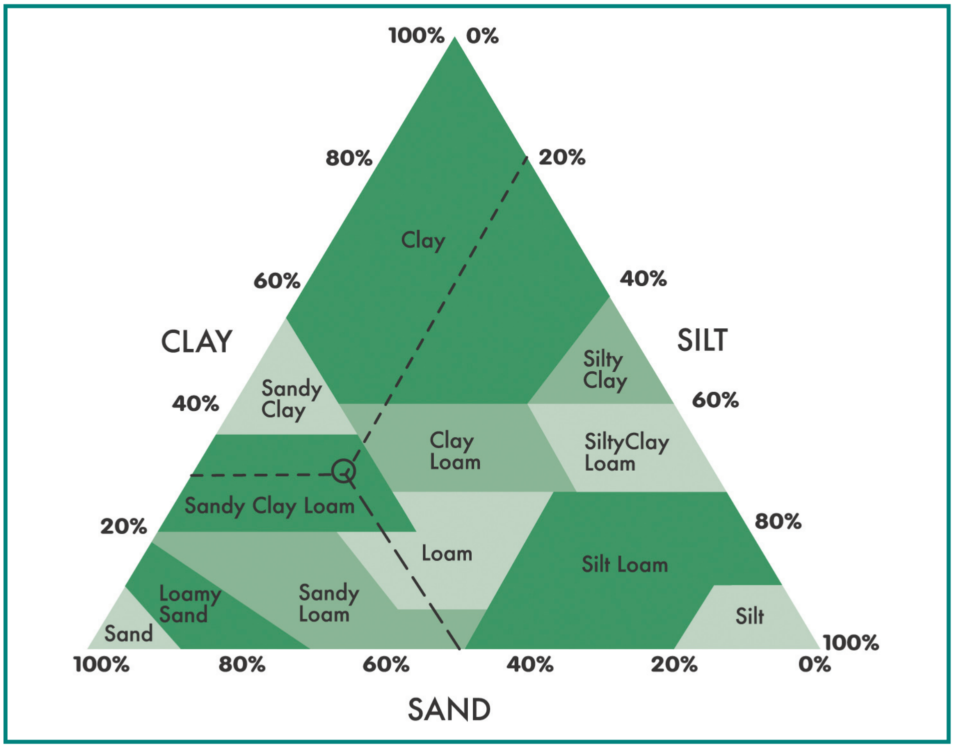


Figure 5. Soil texture triangle.

soils, such as loams, have a mixture of particle size classes, and may provide a moderate degree of moisture retention and moderate permeability, and hence are most useful for efficient treatment of wastewater. More precise laboratory measurements of texture can complement field assessments.

Structure

In most soils, solid particles are not present as separate individuals, but are aggregated into larger clusters of various sizes and shapes to form the structure of the soil. Soil aggregates (or "peds") are separated at zones of weakness when subjected to force. Structure is effectively the architecture of the soil.

Structure is an important property of the soil, because it influences the movement and storage of water and air, the growth of plant roots and the workability and stability of the soil when tilled or disturbed by machinery. Soil structure is a property best observed in the field and is described in terms of the degree of aggregation, and the size and shape of visible soil aggregates in each soil horizon.

Some soils are considered to be structureless. In these soils, individual particles are either not aggregated and separate readily into individual grains (single-grained condition), or are held together in such a way that no preferred planes of breakage can be induced (massive condition). Loose beach sands are an example of single-grained materials. Massive structureless materials occur commonly below the developed soil profile, and may be present in compacted soil horizons.

Common names have been given to various ped shapes as an aid in identification and communication (Figure 6). Granular peds are approximately spherical and are commonly found in surface horizons. Blocky peds have a more cubic shape with more or less planar faces. Angular blocky peds have mostly planar faces and sharper edges, while subangular blocky peds have more rounded faces and more irregular edges. Platey peds are flat or platelike in shape, and are longer in the horizontal direction. Prismatic peds are longer in the vertical direction.

Soil pores form between the solid structural units and within them. Pores are pathways for the movement of water, air, roots, nutrients, and even contaminants. Larger, connected pores are transmission pathways for fluid flow, so that connected pores influence soil drainage. Finer pores frequently store

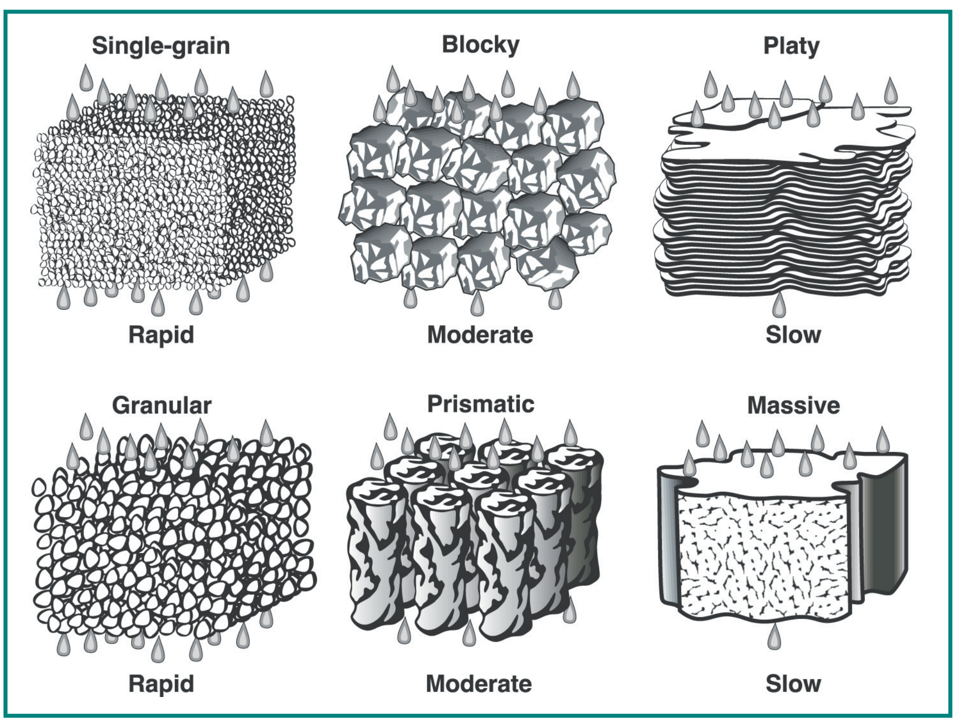


Figure 6. Soil structure shapes.
Source: USDA, 1951.

soil water. Pores are generally described simply in terms of their abundance.

Consistence

Consistence is a complex property related to the strength of soil materials. Consistence refers to the degree of cohesion or adhesion of soil materials and the resistance to applied force. Aggregates or clods can be made to deform or rupture when subjected to force. The resistance to applied forces depends on soil moisture content; moister soils generally fail more easily. Consistence is often described according to the force needed to crush soil between the thumb and forefinger. Strongly coherent soils, with high resistance, may indicate poor conditions for water movement, root growth and the growth of soil organisms. Layers or zones of high consistence may occur naturally (e.g., fragipans or dense glacial till) or be induced by imposed forces, as is the case with compaction caused by wheeled vehicles. Dense layers in the soil are considered restrictive for the purposes of wastewater treatment.

Other Observations

Soil evaluators look at a variety of other evidence to judge the ability of soils to transmit water and air and to treat wastewater. When describing the soil profile, the following additional observations may be noted:

Plant roots penetrate the aerated pore spaces of the soil to extract air, water and nutrients. An abundance of plant roots indicates conditions well suited to biological activity and hence to wastewater treatment.

Reaction is a measure of the acidity, alkalinity or lime status of the soil. **Effervescence** of the soil when acid is applied indicates the presence of carbonates, frequently derived from the soil parent materials under normal soil formation conditions in Ohio. Since these carbonates are relatively easily leached, their presence can be a useful indicator of the depth to which leaching frequently occurs, and hence the depth to which water moves without severe restriction. **Concentrations** or patches of minerals (including carbonates, oxides and sulfates) that accumulate as a result of soil processes may indicate contrasts or other changes in the soil significant to moisture conditions.

Wastewater is best treated by unsaturated soil material. Where large proportions of rock fragments are present (the **coarse fragment** fraction, greater than 2 mm in size), less soil is available for contact with and treatment of wastewater contaminants. Coarse fragments are essentially inert with respect to biological activity, so that the volume of treatment medium is restricted if the content of coarse fragments is high. Coarse fragments in the soil are described in terms of size, shape, abundance and form.

Boundaries are marked breaks between soil horizons. The shape and contrast of transitions between horizons indicates the degree of development of distinct horizon features. Abrupt breaks or discontinuities in soil properties may indicate marked changes in soil drainage conditions. Relatively young soils, those formed from recently deposited materials or at filled and disturbed sites, may exhibit less soil horizon development.

Using soil observations

The design of onsite wastewater treatment systems requires two important soil interpretations: the soil depth to a limiting condition, and an estimate of the soil's permeability to water and air. Based on this information, soil adsorption systems can be designed, or appropriate alternative wastewater treatment systems can be selected.

Soil layers that restrict the movement of water and air are a major cause of failure in onsite wastewater treatment systems. The soil evaluator must identify the presence of the following restrictive layers, and measure the depth of soil material available above the limiting layer:

- Zones of seasonal, perched or long-term saturation. Soil color and redoximorphic depletions serve as the most reliable morphological indicators of soil wetness.
- Hard, unfractured bedrock.
- Dense massive glacial till.
- Dense pans or cemented layers (such as fragipans) exhibiting massive structure and high consistence.
- Zones of coarse sand or gravel with few fine soil particles between the coarse fragments, occurring below finer textured soil material. Water will tend to perch above the coarser materials until the finer soil is nearly saturated, and the coarse layer will provide little residence time for untreated wastewater. Fractured bedrock behaves in a similar fashion.

The ability of the soil to transmit water has been called permeability (Table 1). Permeability is often estimated from soil texture, structure and consistence. Hydraulic conductivity is a more quantitative measure of water transmission through soil. Since hydraulic conductivity varies with soil moisture content, it is frequently measured in saturated soil to provide a standardized assessment of the maximum rate of water movement. Measurements of water movement need to be made on individual horizons.

A percolation or perc test indicates the rate at which water moves into the soil. Local health departments or designers often use this test for site-specific data before sizing the soil absorption system. The perc test is conducted using several test holes placed throughout the area proposed for the soil absorption system. Each hole is presoaked with water for at least 24 hours. The percolation rate is then measured in each hole. The percolation rate is frequently expressed as the number of minutes taken for an inch of water to soak into the soil.

Perc tests do not give reliable information when the soil is dry and cracked, or in soil where a seasonal shallow water table is present. Perc tests by themselves do not provide enough information to site and design an onsite wastewater system. Soil profile information must be gathered to determine the depth to a limiting condition, and to estimate permeability using observed texture, structure, consistence and other morphological indicators. The perc test may provide additional information to confirm the estimated permeability. By assessment at several test holes, perc tests may provide a range of values for use in adjusting a design.

Table 1. Classes of soil permeability.

Permeability Class	***Inches/hour***
Impermeable	<0.0015
Very slow	0.0015-<0.06
Slow	0.06-<0.2
Moderately slow	0.2-<0.6
Moderate	0.6-<2.0
Moderately rapid	2.0-<6.0
Rapid	6.0-<20
Very rapid	≥20

Making landscape observations

Soils are highly variable across the landscape. An individual site and its soil profile is only part of the story of water movement in a landscape. The processes at broader scales are very important in deciding on the suitability of an on-site wastewater system and adequately siting and designing it. Subtle changes in slope and environmental conditions frequently provide a variety of soil forming conditions, and are associated with soils with contrasting properties. Site-specific observations made by a qualified, experienced practitioner are necessary for understanding the fine-scale variability of soil properties and local site conditions.

Topography is an important feature of the site and its surroundings. Topography is itself an important soil-forming factor, and has a strong influence on surface and subsurface water flow (hydrology). Sequences of contrasting soils exist along slopes (geomorphic gradients), largely related to the movement of soil, water and dissolved materials (solutes). On a sloping site, rapid changes in soil air and water properties can occur, reflecting past and current drainage and soil transport conditions, parent material, and vegetation differences. Slope grade itself may influence suitability and design. Assessments of a site should include observations of slope gradient, shape, aspect and slope position, particularly as they affect drainage.

Water not only moves over and into the soil, but on sloping sites, water moves through the soil. It is important to understand the dynamics of water movement at the slope scale to understand where and how wastewater will move, and how the seasonal water table and ground water table, as well as surface water, will interact with it.

Observation of the topography around the site will help provide an understanding of the locations of water accumulation and dispersion zones in and on the landscape. Water collecting areas (often with concave shapes) may have more poorly drained soils, while water-spreading areas (convex) may have better drained soils.

The best soils for wastewater treatment are deep, and topography can provide information to help locate them. More soil development may occur where water and soil accumulate. Hence deeper soils may be present in lower slope positions where erosion moves material removed from higher positions and where weathering may have extended to greater depths. However, these sites may have poor drainage and shallow seasonal or permanent water tables.

High, convex sites tend to shed water and to be better drained, but may have been subject to more erosion and less soil development, and hence have limiting conditions such as bedrock at shallow depths.

Gathering information on the site and its resources

Since soils are three-dimensional entities, their vertical extent and arrangement of horizons must be examined to understand how they will behave in treating and dispersing wastewater.

A number of auger borings and other exposures, such as soil pits, are needed to examine the soil variability on the site. A soil pit is the best form of exposure for description and evaluation of the soil that is proposed as a treatment site.

Site and soil evaluation is a five-step process.

Step 1 Do your homework.

Collect background information on the site before making a visit. By knowing what soil conditions are likely to be found at a site, the site visit can be conducted in an efficient manner. Familiarity with available information will save valuable field time. Figure 5 is a guide to help in recording background information.

Soil surveys are the most useful information source on expected site and soil conditions. The following sequence provides a general approach for gaining useful information from a published soil survey:

- Locate the site using the general location maps.
- Find the site on the detailed photo-based maps.
- Record the soil map units delineated at and adjacent to the site, and other dominant soils in the area.
- Read the detailed soil map unit descriptions for the listed map units.
- List the soil series associated with the mapped series.
- Read the appropriate detailed soil map unit descriptions for map units where the associated soil series are dominant.
- Note the depth and features of each major horizon for the mapped and associated series in the detailed soil series descriptions. (Figure 7)
- Note any limitations related to water and air movement through the soil, such as compacted soil or evidence of saturated soil conditions. Saturated conditions are evidenced by the presence of redox depletions or gray soil matrix (with chroma 2 or less and value 4 or more).
- Note the depth to seasonal high water table, soil permeability, and other physical features in the tables in the soil survey, for each mapped series and associated series.

Soil Profile Description (Kokomo Silty Clay Loam)

Ap— 0 to 9 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; weak fine and medium granular structure; friable; few fine roots; neutral; abrupt smooth boundary.

A— 9 to 16 inches; black (10YR 2/1) silty clay loam; moderate fine and medium angular blocky structure; firm; few fine roots; neutral; gradual smooth boundary. (Combined thickness of the A horizon is 10 to 24 inches thick)

Btg1— 16 to 31 inches; dark gray (5Y 4/1) silty clay loam; moderate medium and fine subangular and angular blocky structure; firm; few fine roots; many discontinuous distinct olive gray (5Y 5/2) clay films on faces of ped; few discontinuous distinct very dark gray (10YR 3/1) organic coatings in root channels; common medium prominent dark yellowish brown (10YR 4/4) and few medium prominent yellowish brown (10YR 5/6) masses of iron accumulation in the matrix; neutral; gradual smooth boundary.

Btg2— 31 to 50 inches; olive gray (5Y 5/2) silty clay loam; moderate coarse subangular blocky structure; firm; few fine roots; many discontinuous distinct olive gray (5Y 5/2) clay films on faces of peds; few discontinuous distinct very dark gray (10YR 3/1) organic coatings in root channels; common coarse prominent strong brown (7.5YR 5/6) and yellowish brown (10YR 5/8) masses of iron accumulation in the matrix; 2 percent rock fragments; neutral; abrupt wavy boundary. (Combined thickness of the Btg horizon is 23 to 45 inches thick)

2C— 50 to 64 inches; brown (10YR 5/3) loam; massive; friable; 2 percent rock fragments; strongly effervescent; moderately alkaline.

Key:

Horizon Designation	Structure
Horizon Depth	Consistence
Color (Munsell Hue, Value, Chroma)	Redoximorphic Features
Texture	Coarse Fragments

Figure 7. Location of important information in soil survey description for use in wastewater treatment soil assessment.

- Use a guide sheet, like Figure 8, to record and organize information from the soil survey

Soil survey maps will also show the location of nearby streams, drainage ways and wetlands.

Plat maps and titles should be examined to identify the property lines, rights of way and easements. These maps or documents may also indicate past or present structures and other improvements or disturbances to the site.

Local utilities should be contacted to mark the location of underground service lines. Drainage districts may need to be contacted about the location of subsurface drainage mains.

Property owners, past property owners and long-time neighbors should be consulted about past land uses. Try to find out if parts of the property have been excavated or filled, and if artificial surface or sub-surface (tile) drainage has been installed. Buried tanks or cisterns may be present or have been present on the property. The history of fences, driveways or tree plantings (for example, old orchards) helps to eliminate surprises when making a field visit.

Step 1: Homework	Site:		
	Mapped Series 1	Associated Series	Associated Series
Limiting depth			
Limiting condition			
Surface perm			
18” perm			
Landscape position			
Layer 1			
Depth			
Color			
Redox features			
Texture			
Structure			
Permeability			
Consistence			
Layer 2			
Depth			
Color			
Redox features			
Texture			
Structure			
Permeability			
Consistence			
Layer 3			
Depth			
Color			
Redox features			
Texture			
Structure			
Permeability			
Consistence			
Layer 4			
Depth			
Color			
Redox features			
Texture			
Structure			
Permeability			
Consistence			
Layer 5			
Depth			
Color			
Redox features			
Texture			
Structure			
Permeability			
Consistence			

Figure 8. Guide sheet for recording and organizing homework information of expected soil at a site.

Step 2 Conduct a visual assessment.

Make a visual assessment of the landscape at the site. Mark with pins or flags the major breaks in slope. Figure 9 shows the pin placement at a proposed site. Look for evidence of seasonal springs, wet areas and drainage ways. The vegetation at the lot is a good indication of soil conditions. Table 2 lists some olants that may indicate wet or well drained areas. Be especially watchful for dead vegetation, which may indicate a change in drainage patterns or the disposal of toxic substances. Make note of features that may predispose the site to increased risk of pollution, including the location of nearby wells, ponds, lakes and streams.

Figure 9. Based on observed breaks in the landscape, the second step is to place pins where major changes in soil conditions are likely to exist.

Table 2. Plants that grow in wet areas and in well drained soils.

Well Drained		Poorly Drained	Wet Soils
American holly	Mountain laurel	Box elder	Cattail
American beech	Pitch pine	Green ash	Rush
Black walnut	Red oak	Highbush blueberry	Sedge
Black Oak	Red pine	Pin oak	Skunk cabbage
Black locust	Shagbark hickory	Red maple	
Basswood	Sugar maple	River birch	
Cherry	Sweet birch	Redosier dogwood	
Chestnut oak	Sassafras	Silver maple	
Crab apple	Tulip poplar	Swamp white oak	
Eastern white pine	Virginia creeper	Spicebush	
Flowering dogwood	White oak	Silky dogwood	
Hazelnut	White ash	Sweet gum	
Lowbush blueberry		Sycamore	
		Willows	

Step 3 Estimate the extent of each soil.

Estimate the extent of each soil type at the site. Using the marked breaks in slope as a guide, use a soil probe to look for obvious changes in soil type. The notes on the mapped soil series and associated soils act as a guide to interpret the soil probe findings. Soil probes are useful in identifying changes in features with depth and area as shown in Figure 10.

Since soil probes, with their small diameter, cause little soil disturbance, dozens of observations can be made quickly, without damaging the site of a wastewater treatment system. Soil probes, however, give a limited assessment of the soil and its properties. By themselves, soil probes only help outline the extent of each soil type at the site.

Figure 10. Using a soil probe, soil is examined on either side of the pins to confirm soil differences. Pins are moved as necessary.

Step 4 Determine site suitability.

Excavate the soil in small bore holes in different regions of the site to estimate the depth to a limiting condition and the soil's permeability. Soil augers or narrow spades work well for this task. Carefully lift the soil out of a six-inch wide bore hole and place it, in order, in a line on the ground surface as shown in Figure 11. As the soil is removed from the bore hole, note the color, texture and structure of the soil layers on the soil description sheet (Appendix 1). Using the homework notes from the soil survey as a guide, look for evidence of limiting conditions by looking for:

- Low chroma mottles (/0, /1 or /2) that indicate seasonal saturation.
- Black soil overlying low chroma soils (gray matrix and mottles) indicating wet soil with an accumulation of organic matter.
- Restrictions to root growth, indicating limitations to air movement through the soil.
- Obvious limitations including the presence of standing water or hard bedrock.
- Impermeable soil layers can be felt with the auger or spade when it reaches hardpan, fragipan and dense clay layers.
- Soil boring reveals excessively stony, sandy and gravelly layers in the soil.

The soil removed from the bore hole can give indications of soil permeability. Observe the size, shape and strength of soil aggregates (peds) being removed. Permeable soils will have well-developed structure. Massive or weak soil structure may serve as a limiting condition.

The following tools are useful for soil profile descriptions:

- Soil auger
- Spade or shovel
- Soil and site description form
- Water bottle
- Tape measure
- Knife or trowel
- Hand lens
- Munsell soil color book
- Dilute hydrochloric acid
- Camera and film

Using the information collected from several soil bore holes, indicate the most suitable location for the proposed system. Suitable sites should be marked on the plan and on the ground.

Figure 11. Detailed descriptions of the identified soil types on the lot are generated from several soil cores. Soil is lifted out of a small hole with a spade or auger and placed on the ground in order. Evaluator observes and notes color patterns, texture, structure and consistence of each soil horizon.

Step 5 Confirm site suitability.

Confirmation of soil permeability and depth to the limiting condition must be made before a final system design can be approved. This can best be done by excavating soil pits. Soil pits range from 3 to over 6 feet deep and are large enough for 2 people to stand in them to examine the soil profile (Figure 12).

Since soil pits disturb the site and can be expensive to excavate, they are the last step in site and soil evaluation. Using the proposed system location from step 4, site the soil pit or pits just outside of the possible wastewater treatment site as shown in Figure 13.

Instruct the backhoe operator not to drive on the proposed spot for the wastewater treatment system or to remove site markers when excavating the soil pits. Rope or fence off the open excavations to avoid accidents.

Figure 12. Confirmation of the soil to be used for wastewater treatment is made in a soil pit. An excavation, large enough for a person to safely stand in is made to enable the evaluator and the regulator to make detailed observations, in situ, of the soil in consideration. Since soil pits disturb the site for wastewater treatment, pits are excavated just outside the planned treatment area.

Soil Descriptions

Color change in the soil profile is the most obvious feature evident in the soil pit. While standing in the soil pit, mark the easily recognizable horizon breaks. Large nails work well for this. Measure the depth to each horizon break and record them on the site and soil evaluation form. Write down on the soil description sheet the soil colors present in each soil horizon, using the alphanumeric symbols which stand for hue, value and chroma from the Munsell soil color book. Be especially alert to and carefully describe the presence of redoximorphic features, such as mottled colors.

Record other important soil and horizon features on the description sheet. Observations of the texture, structure and consistence of each horizon should be recorded. Also indicate on the description sheet the depth of root penetration and the nature of the horizon boundaries.

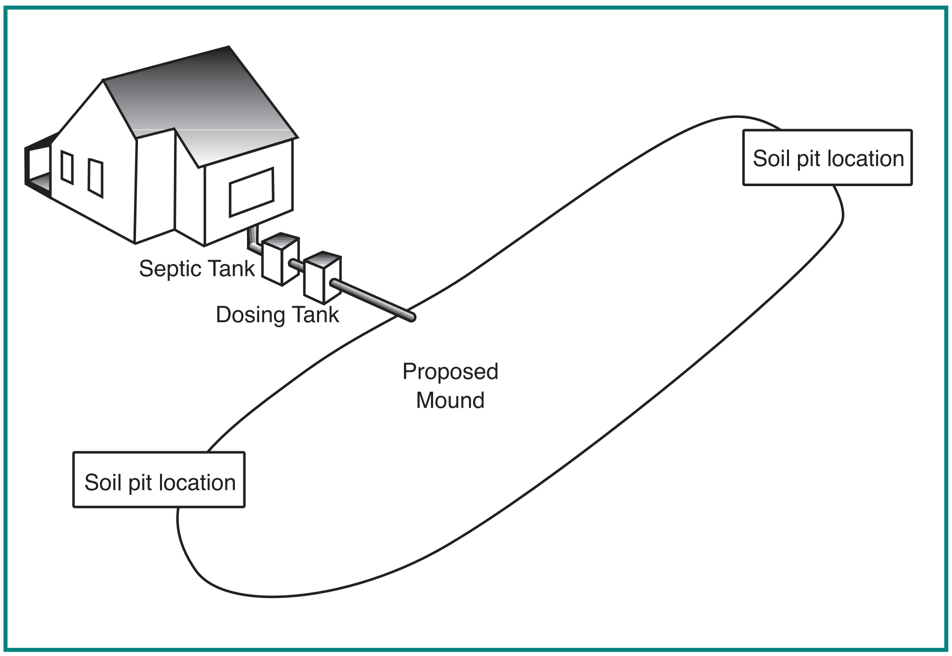


Figure 13. Location of soil pit excavations relative to proposed location of mound system.

Complete soil descriptions on the appropriate form must be prepared for each distinct soil profile observed at the site.

Completing the site and soil assessment

The soil pit examination should reveal no surprises though every location is different. Steps 1 through 4 should lead the system designer to the appropriate areas of the site for wastewater treatment and aid in selecting the proper system type for the site conditions. The soil pits, excavated for Step 5 are critical in confirming the suitability of the site for wastewater treatment.

Once the soil pits are scheduled for excavation, make a site evaluation appointment with the responsible regulator. Before issuing a permit for a wastewater treatment system, the regulator must check to make sure the site and its proposed wastewater treatment system will work to protect the public health and the environment.

The regulator should make the following observations when viewing the soil pits.

- The soil present at the site is the same as that mapped or consistent with the mapping unit descriptions. If not, why not.
- The site has not been modified by human activity. Evidence of soil erosion, compaction, excavation, fill or other modifications should be observed or ruled out.
- Confirm the depth to the limiting condition and the permeability of all soil horizons.

Make sure provisions are in place to protect the wastewater treatment system from damage during building construction and use of the property.

- Note the proposed location of structures, driveways and landscaping changes.
- Make sure they will not cause excess surface water to drain onto the area for the wastewater treatment system. Also, no structures or driveways should be sited just downslope of the wastewater treatment system.
- Make sure fences and signs are put up, if needed, to protect the soil being used for the wastewater treatment system from compaction and damage during site development.
- Finally, date and sign the site and soil assessment. Property owners sometimes change their mind and do not proceed with land development projects in a timely manner. As time passes or property changes hands, the site can be disturbed or considered for development in different ways. A new site and soil assessment may be needed if too many changes occur.

For More Information

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Appendix 1

Soil Description Sheet

Name:	Date:	Land Use:
Location:	Slope:	Vegetation: Soil Name:

Layers		Estimate Drainage Conditions		Estimate Permeability						
Horizon	Depth (inches)	Dominant Color	Redox Features (Type, Quantity, Size, Contrast, Color)	Texture	Structure (Grade, Size, Type)	Consistence	Coarse Fragments	Boundary	Roots	Remarks

Nature of Limiting Condition: Depth to Limiting Condition:	Notes: