

Illinois Understanding Soil

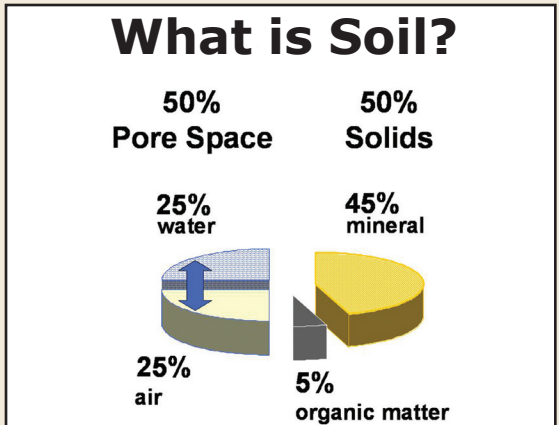


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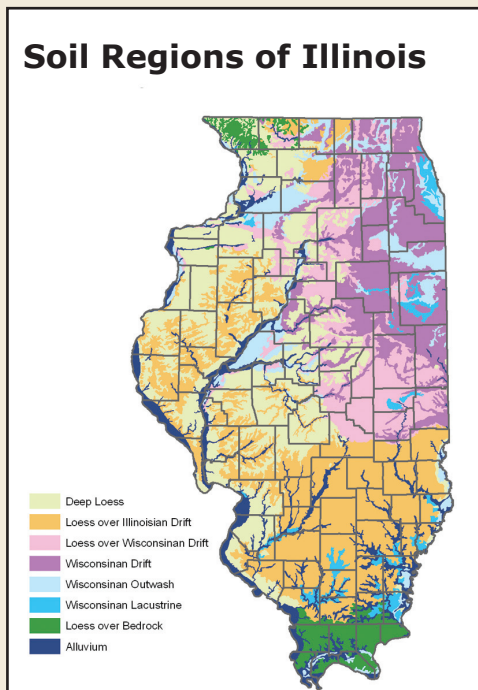
Introduction to Soil

Soil is the collective term for natural bodies made up of mineral and organic materials that cover much of the earth's surface. Soil contains living matter and can support vegetation; in some cases, the soil has been changed by human activity.

Soil is made up of solids and pore space. The pore space contains air and water that vary proportionally. The proportion of air and water is in a continuous state of change. The solid portion of soil consists mostly of ground up rock and other fine mineral material. A small portion of the solid material is organic matter.



Many people assume that all soil is more or less the same. They are unaware that great differences in soil properties can occur within even a short distance. Soils may be seasonally wet or subject to flooding. They may be shallow to bedrock. Soil may be unstable as a foundation for buildings or roads. Very clayey or wet soil is poorly suited to septic tank absorption fields. A high water table makes soils poorly suited for basements or underground installations.



Soil scientists and soil classifiers observe soil properties. They examine the soil in detail and classify it according to a national taxonomic system. Interpretations can then be made as to how the soil will respond when subjected to various uses and management.

There are more than 600 different kinds of soils, or soil series, in Illinois. These soils differ in slope, surface textures, flooding, and other features. About eight soil regions are identified across the state based upon the age and type of material from which these soils form. These regions are: *Deep Loess, Loess over Illinoian Drift, Loess over Wisconsinan Drift, Wisconsinan Drift, Wisconsinan Outwash, Wisconsinan Lacustrine, Residuum, and Alluvium.*

What is Soil?

Soils develop as a result of the interactions of climate, organisms, and relief as they influence parent material over time. Written as a mathematical formula, it would look like this: $\text{Soil} = f(\text{cl}, \text{o}, \text{r}, \text{p}, \text{t})$. These are the five soil forming factors. Differences in climate, organisms, relief, and parent material from one location to another as well as the amount of time the material has been in place, all influence the soil forming process.

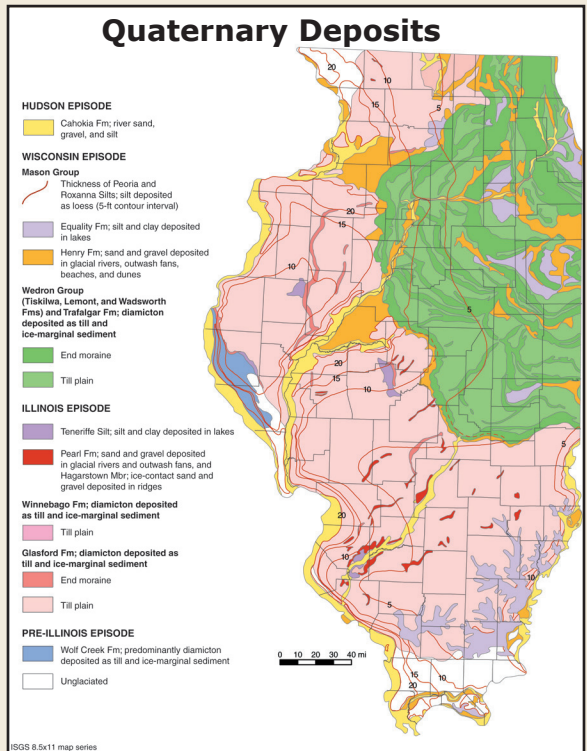
Factors of Soil Formation

Climate

Climate is a major factor in determining the kind of plant and animal life found on and in the soil. It determines the amount of water available for weathering minerals and the rate at which the minerals and elements released move through the soil. Soil temperature and air temperature also influence soil development by helping to determine rates of chemical weathering. Warm, moist climates encourage rapid plant growth and thus high organic matter production. The seasonal changes in rainfall and temperature also enhance soil structure development.

Organisms

Plants affect soil development by supplying layers with organic matter, recycling nutrients from lower to upper layers, and creating channels and cavities in the soil which aid in water infiltration and movement of soil animals. The leaves, twigs, roots, and bark that are deposited on and in the soil are broken down by fungi, bacteria, insects, earthworms, and other burrowing animals. The micro-organisms in the soil also produce a glue-like substance which helps to hold soil particles together in aggregates.



Relief

Relief causes localized changes in moisture and temperature. Sloping areas of the landscape shed water which runs onto lower or flatter parts of the land. Temperature differences also occur in a similar pattern. Both these processes cause different soil types to be formed at the bottom of the hill than what occurs at the top of the hill. The steepness and aspect of the slope also affects the type of natural vegetation which occurs. This in turn can cause differences in organic matter content from the top of the hill to the bottom of the slope.

Parent Material

Parent material refers to the variety of organic (peat) and mineral geologic material in which soil formation begins. Mineral material includes partially weathered rock, sediments moved and deposited by wind and water and ground up rock deposited by glaciers. The type of material has a strong effect on the soil developed as well as the rate at which soil development takes place. Soil development may take place quicker in materials that are more permeable to water than those that are dense and massive.

Continental glaciation has had a significant impact on the soils of Illinois. As a succession of the glaciers moved southward through the state, they incorporated sand, silt, clay and stones into an unsorted mixture. This material was deposited throughout the state and is known as glacial till. Some of this material was sorted by glacial meltwater and was deposited as outwash. Still other material was picked up by the predominantly westerly winds and was carried across the state. It was deposited in layers and is known as loess.

Time

Time is required for a soil to form and produce different layers or horizons. The longer the soil has been exposed to the soil forming agents, the greater the development of the soil profile. Soils that are “young”, like those on floodplains, will show very little profile development. Soils on older, stable parts of the landscape generally have well defined horizons. As soils age, many original minerals in the soil are destroyed or leached completely out of the profile. Soils become more weathered, more acid, and often times more clayey as they grow “older.”

Process of Soil Formation

There are four soil forming processes that further modify the soil during its development. These processes are additions, losses, transformations and translocations.

Additions

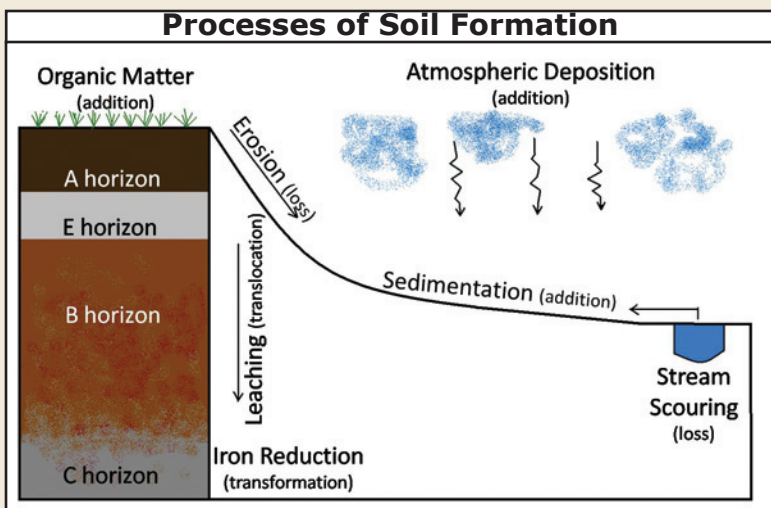
The most obvious addition is organic matter. As soon as plant life begins to grow in the parent material, organic matter begins to accumulate. Other additions may come with rainfall or depositions by wind.

Losses

Most losses occur by leaching. Water moving through the soil dissolves certain minerals and transports them into deeper layers or completely through the soil. Materials that are quite soluble, such as those containing carbonates, are moved through the soil quickly. As a result, soils in humid regions generally do not have carbonates present in the upper horizons. Solid mineral and organic particles can be lost by erosion. Such losses can be serious because the material lost is usually the most productive part of the soil profile.

Transformations

Transformations are changes that take place in the soil. Microorganisms that live in the soil feed on fresh organic matter and change it into humus. Chemical weathering can change minerals in the soil into another form or even destroy them entirely. Clay minerals in the soil are actually new minerals that form during soil development. Transformations readily affect the color of the soil. Iron is the mineral most affected by this change in humid climates. The red, gray, yellow, brown and mixtures of all these colors in the soil are visible evidence of iron transformations.



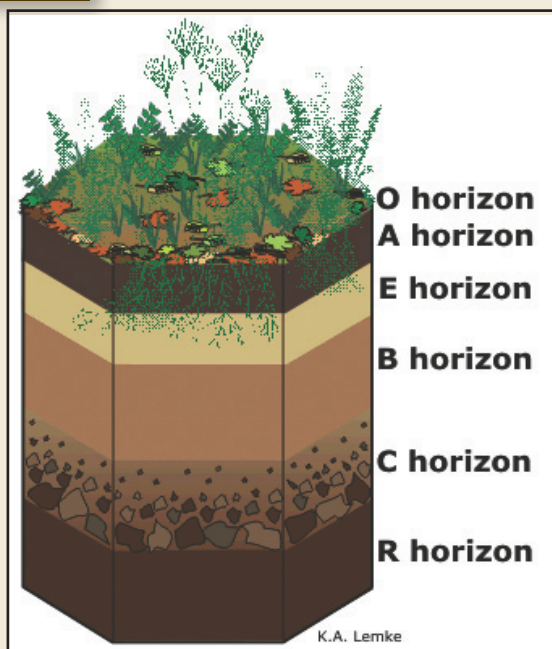
Translocations

Translocation means movement from one place to another. In low rainfall areas, material that is leached from the upper layers of the soil is only moved so far in the soil profile because the water driving the process dries up. When the water stops moving and evaporates, the material it was carrying is left behind. In humid regions, carbonates can be transported from the upper parts of the soil to the lower areas on a seasonal basis.

Features of Soil

Soil Horizons

Soils are described in a vertical profile by different layers, or horizons, that lay parallel to the surface. These horizons are natural segments to the soil. The major horizons are abbreviated using capital letters, such as: O horizon, A horizon, E horizon, B horizon, C horizon, and R horizon. Not all soils have all horizons. The depth and thickness vary and there are many additional subcategories and modifiers used in a detailed soil description.



O horizon	Organic layer in undisturbed woodlands (rare in Illinois) or in very wet prairies, peat or muck soils
A horizon	Topsoil or mineral surface layer, highest amount of organic matter in a mineral layer
E horizon	Subsurface layer, generally formed under woodland, leached of clay and organic matter
B horizon	Subsoil, maximum clay and soil development
C horizon	Substratum, relatively unaltered parent material
R horizon	Bedrock

Soil Color

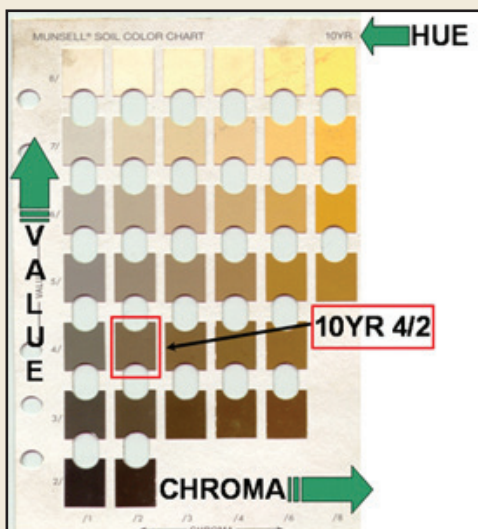
Soil Color is easily determined and typically represents significant soil properties, such as seasonal water saturation and organic matter content. The presence of water and oxygen in varying proportions in the soil pore space has a direct effect on the type and presence of iron (Fe) and manganese (Mn) which can affect soil color.

- Reddish brown colors form in well oxidized soils, with very short duration of saturation or a lack of saturation in the pore space (oxidation reactions).
- Grays and blues form in soil conditions of reduced oxygen or prolonged saturation (reduction reactions).
- Soil moisture conditions also affect the form of sulfur present. In very saturated soils, hydrogen sulfide may be present and a rotten egg odor can be detected.

Generally, in Midwestern soils, gray colors indicate wetness and the greater the volume of gray colors, the wetter the soil tends to be.

Munsell Color Notation is used to objectively record the soil colors found in the different layers. Soil colors in a humid region (e.g. Illinois) are generally described in a moist condition. This is the point where the color doesn't change with additional moistening. The Munsell system consists of about 250 different color chips, systematically arranged on pages.

The Munsell system uses three elements of color – hue, value and chroma. The color is identified with both a symbol and a common name. For an example, the color identified as dark grayish brown is also identified with the symbol 10YR 4/2, where 10YR is the hue, 4/ is the value, and 2 is the chroma.



Hue is based on five principal colors: red (R), yellow (Y), green (G), blue (B), and purple (P) with five intermediate hues at midpoints between each pair of hues, e.g. YR=yellow-red. Each of these is further subdivided into four equal visual steps that are designated by numerical values 2.5, 5, 7.5 and 10. There is also a neutral hue (N) which is expressed as the absence of color (black-gray-white).

Value indicates the degree of darkness or lightness from black 0/ to white 10/ for each hue.

Chroma is the relative purity or strength of the spectral color with /0 for neutral or gray to /8 for the strongest expression of color.

Mottles are spots of color in the soil surrounded by other colors which have formed by various processes. **Redoximorphic features** are those mottles that develop from the reduction and oxidation of iron. Redox features are important in evaluating a soil for septic systems because they indicate a fluctuating water table.



Depth of Soil Mottling means the depth to redox features that occur in the soil. Redox features that are yellow, orange or reddish consist mostly of oxidized iron. Gray redox features indicate that iron has been depleted from the soil through the process of reduction. This reduction only occurs when the soil has been saturated long enough for continuous anaerobic conditions to develop. The period of time needed to develop these iron depletions can be as short as two weeks. The depth of significant gray colors is considered to be an indicator of the depth to the Estimated Seasonal High Water Table (ESHWT). **Gray colors are defined as those colors having a Munsell value of 4 or more and a chroma of**

2 or less. Values of 3 or less with chroma of 2 or less are excluded, because those colors represent the organic matter that is present in the soil.

The amount of mottles is described as "abundance". **When describing soils for private sewage disposal, soil mottles are considered indicators of a seasonal high water table when at least 2 percent of the soil volume has a gray color.** The abundance of mottles can either be described as a percentage or in terms of the number of mottles present; few (< 2%) common (2% to 20%) or many (> 20%).

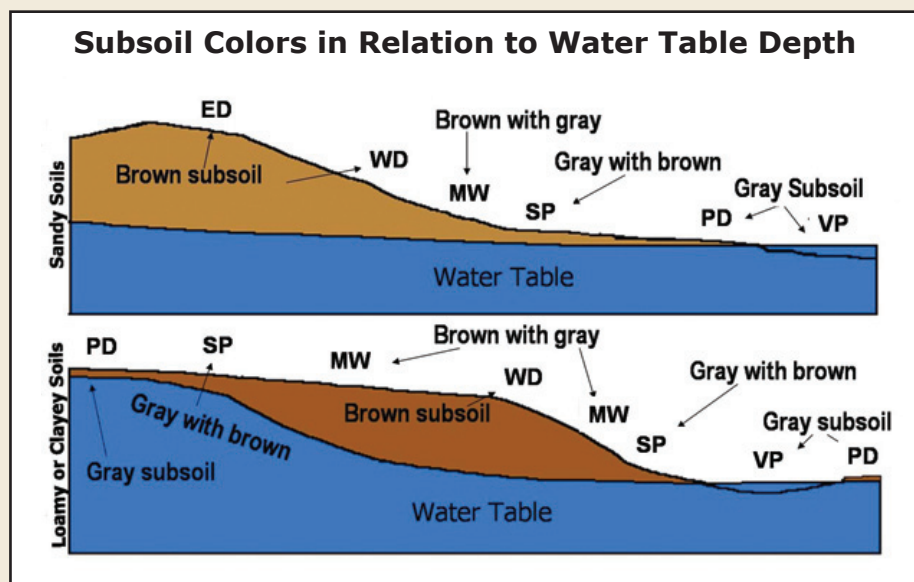
Drainage Classifications

Internal Drainage Classifications are categories of the depth to the Estimated Seasonal High Water Table (ESHWT). There are a range of depths used to help classify soil series. These ranges of depth vary from one soil series to another and are listed in the county soil survey reports.

The depth to seasonal water saturation can be a limiting soil characteristic for septic leach fields and other uses.

Artificial drainage does not affect the drainage classification, but may affect the actual depth and duration of the water table.

Subsoil Colors in Relation to Water Table Depth



Very Poorly Drained (VP)– Water is often above the surface and is at or near the soil surface during much of the growing season. Internal free-water is very shallow and persistent or permanent. Commonly, the soil occupies a depression or is level.

Poorly Drained (PD)– The soil is wet at shallow depths periodically during the growing season or remains wet for long periods. Internal free-water is shallow or very shallow and common or persistent. Commonly, the soil occupies a depression or is level.

Somewhat Poorly Drained (SP)– The soil is wet at a shallow depth for significant periods during the growing season. Internal free-water is commonly shallow to moderately deep and transitory to permanent. The soil has a high water table or receives water from lateral flow or some combination of these factors. The soil is level or nearly level.

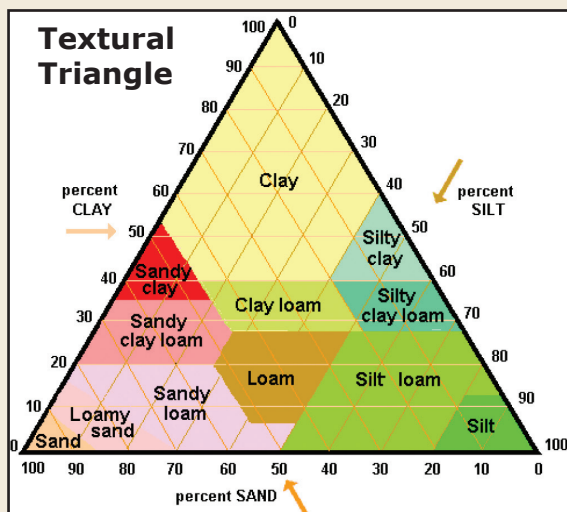
Moderately Well Drained (MW)– Water is removed from the soil somewhat slowly during some periods of the year. Internal free-water commonly is moderately deep and may be transitory or permanent. The soil is generally on higher or more sloping parts of the landscape.

Well Drained (WD)– Water is removed from the soil readily, but not rapidly. Internal free-water commonly is deep or very deep. The soil is generally on higher or more sloping parts of the landscape.

Somewhat Excessively Drained (SE) and Excessively Drained (ED)– Water is removed from the soil rapidly or very rapidly. Internal free-water commonly is very rare or very deep. The soils are commonly coarse-textured.

Soil Texture

Soil is composed of different sizes of particles. The proportion of these different sizes of particles is considered to be the "Soil Texture." Particles that are less than 2 mm in diameter are considered the finer particles of soil, and include sand (2-0.05 mm), silt (0.05-0.002 mm), and clay (<0.002 mm). Particles greater than 2 mm are not considered soil, rather they are rock fragments and are not included in the determination of the texture. The United States Department of Agriculture (USDA) system for determining soil texture is used for the Illinois Septic Code. The Textural Triangle shows the names of the 12 classes of soil texture used by USDA and the percentages of sand, silt, and clay for each class.



Sand particles feel gritty and can be seen with the naked eye. Soils high in sand tend to have low strength, greater susceptibility to wind erosion, and less water available for plants than soils of other textures.

Silt particles can be seen with powerful microscopes. Silt feels smooth like chalk or talcum powder. Soils high in silt have higher available water for plants to use.

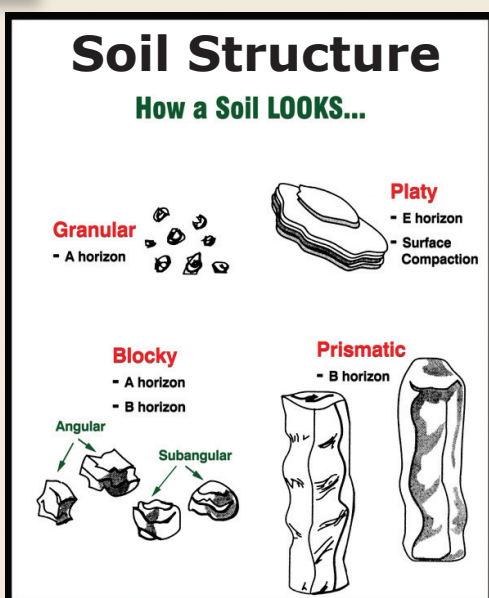
Clay particles are very tiny and individual particles cannot be seen. There are also many different types of clay minerals. The type of clay mineral can be determined by using x-ray diffraction. Clay feels sticky when moist and hard when dry. It has high load-bearing strength and often shrinks and swells upon drying and wetting.

Muck and peat are terms that are used in place of textural class names in organic soils. Muck is designated for well decomposed organic material and peat for less decomposed organic material.

Soil Structure

Soil structure is the natural aggregation of the soil separates held together by cohesion and the humic substances produced by soil organisms. These particles are clearly visible to the eye.

Soil structure is described by shape, size and grade or strength. Shape of soil structure can be granular, blocky, platy or prismatic. Size of the structure units can range from Very Fine (coffee ground size) to Very Coarse (several feet in diameter). Grade or strength is an indication of how durable the unit is and how well it retains its natural features. Weak structure indicates little ability to hold together when handled, while Strong structure indicates the ability to hold its shape even when handled or subjected to stresses such as cultivation. Strong structure allows better water movement through the soil.



Organic Matter

Organic matter, which is the fresh and partially decomposed residues of plants and animals, along with the tissue of living and dead microorganisms, makes up a small but very significant part of the soil. This material provides the natural fertility of the soil and is very important in providing a good rooting medium for plants. Organic matter acts like “glue,” holding the soil particles together, which in turn, improves soil structure and enhances water infiltration and movement within the soil.

Organic matter gives the surface layers of the soil a dark brown or black color. The amount of organic matter can be estimated in the soil by comparing the color of a crushed sample of soil to the chips on the Munsell Color Charts. Generally, the darker the color chip indicated, the more organic matter that is present in the soil.

Consistence

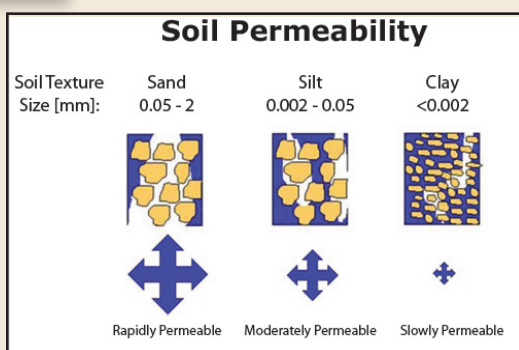
Soil consistence is the degree and kind of cohesion and adhesion that soil exhibits, and/or the resistance of soil to deformation or rupture under an applied stress. It also measures the amount of pore space in the soil compared to the volume the soil. In Illinois, consistence is measured when the soil is moist. The moist consistence classes are: *loose, very friable, friable, firm, very firm, and extremely firm*. Soils with a more friable consistence will allow water and septic effluent to pass through more readily.

Compaction

Compaction in soil occurs when natural soil structure is disrupted and external forces create a new soil mass. This can happen with the soil in place or it can happen during excavation and filling. Farm implements can create compaction, particularly if they are used when soils are wet. Some earthmoving equipment is designed to compact soils. Compaction formed in place may be detected if atypical soil structure is found. For example, moderate or strong angular blocky structure is not typically found in the surface layer unless it has been compacted. If a soil profile is made up of fill material and is compacted, soil peds of unusual shape and orientation may be found. Soils that have been compacted have extremely variable properties, particularly in fill material. This makes it difficult to predict water movement.

Permeability

Soil Permeability is the ability of the soil to conduct water through the profile when it is saturated. Saturated hydraulic conductivity is another term that describes the ability of the soil to conduct water through the profile. Permeability is directly related to the total amount, proportional sizes, and configuration of the soil pore space.



Soil pore space is directly related to soil texture, structure, consistence and in some cases, parent material. Finer-textured clayey soils, such as silty clays, have a higher proportion of small pores than coarser-textured sandy soils. Water will move more slowly through the smaller pores of the clayey soil and more rapidly through the larger pores of the sandy soil. Strongly developed structure has a greater number of larger pores than weakly developed structure. However, strong platy structure is an exception. It has slower permeability because of the horizontal nature of the structure. Soils developed in till generally have less total pore space than those developed in outwash or loess. Lacustrine soils have many layers with fine-textured sediments and a reduced permeability due to decreased pore continuity.

Water Movement in Soils is controlled by two forces: gravity and capillary action. Gravity is the most important force for water movement in saturated soils. It causes a downward force on water. When a soil is near saturation, the large pores are filled and water moves rapidly through them. When a soil is not saturated, the larger pores are empty and capillary action makes water move along the particle surfaces and through finer pores. Adhesion moves water in the direction of finer pores ignoring the force of gravity. These are the same forces that make water rise in capillary tubes and account for the absorptive properties of a sponge or a paper towel.

As water or effluent moves from a saturated to an unsaturated condition, a wetting front develops that ultimately moves downward. In a stratified soil with different layers (many soils have stratification), the size of the soil pores in each layer affects the water flow. If the advancing wetting front in coarser soil encounters clay, the resistance in the smaller pores will slow the movement. Although water does pass through the clay, its penetration is so slow that water tables often build up above the clay. If the wetting front comes to a sandy layer, water movement stops until the finer layer above is nearly saturated. Only after the layer of finer-textured material becomes saturated will the water move through the sandy layer.

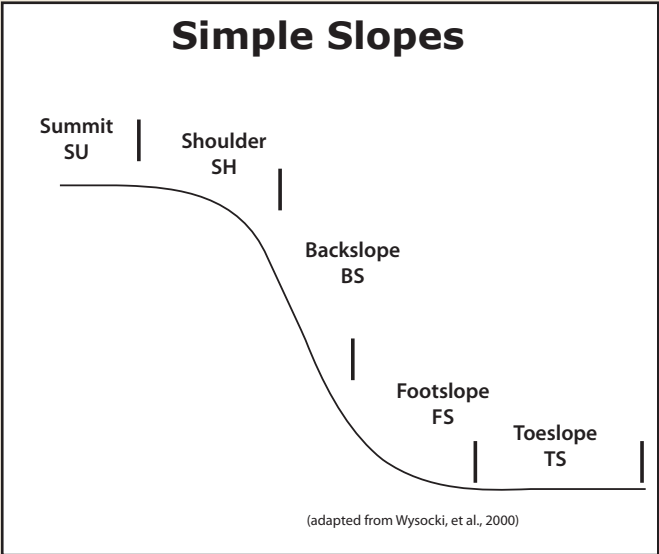
In the case of a septic system, the soils must not only accept and transport effluent, but must move it through unsaturated soil located ahead of the wetting front to ensure proper treatment. This fact is the basis for the requirement of separation between the bottom of the absorption trench and the seasonal high water tables.

Two features of soil that have a large effect on water movement are compaction and permeability. Compaction can greatly reduce the volume of the pore spaces which will have a direct impact on the permeability. Generally, the smaller the pore space, the slower the permeability and the slower the water will move through the soil.

Landscape

Landscape Position refers to the different locations on the land such as summit or toe slope. The landscape position affects the amount of rainfall that runs off or accumulates on a specific site. Sloping landscapes are susceptible to erosion while low, flat positions tend to receive water and sediment. The depth to seasonal saturation can generally be estimated by knowing the position of the soil on the landscape. Therefore, soil differences follow landscape differences and specific soil series occur on specific landscape positions.

Slope is the vertical rise or fall of the landscape measured in feet in a lateral distance of 100 feet expressed as a percentage. For soil survey mapping, soil mapping units include not only the soil series, but also the range of slopes and the erosion class. Slope shape influences the movement of water on the surface.



Soil Surveys

Soil Surveys are prepared by the USDA Natural Resources Conservation Service (USDA NRCS) through the National Cooperative Soil Survey program. Federal, state and local units of government, and state colleges and universities are cooperators in this effort in Illinois. Soil surveys are the most ground-tested, county-wide natural resource maps made. A professional soil scientist/soil classifier prepared

each map in the field. Because of this, the county soil surveys are quite valuable in understanding the soils of an area.



Soil survey reports are organized somewhat differently from county to county, but all contain soil maps, soil descriptions and interpretations. The behavior of the soil for a specific use can be interpreted from an understanding of soil properties and the formation of the soil.

Web Soil Survey (WSS)

is available for all areas of the country. This is a web-based program to access soil survey maps and data. It requires no special software, but does not function well on dial-up internet access. The WSS is very user-friendly and operates with simple use of a computer mouse. After using the program for the first time, the user will be very familiar with how the program operates. The WSS allows the user to easily locate an area, explore the soil data, and print custom reports and interpretive maps. The soil survey data, both spatial and tabular, may also be downloaded into a geographic information system (GIS) on a home or office computer. The WSS can be accessed at:

<http://websoilsurvey.nrcs.usda.gov/app/>

The information presented in a soil survey is very useful for land-use planning and for choosing alternative conservation practices or alternative structural or engineering designs. Limitations to the use of the soil survey should be well understood.

Information is generally not available for soil material below a depth of 5 or 6 feet. Also, because of the scale of the detailed map, small areas of soils that differ from the dominant soil may be included in mapping. *Thus, a soil survey does not eliminate the need for on-site investigations, testing, and analysis by professionals with expertise in the specific land use contemplated.*





Beyond the soil survey there are private Professional Soil Classifiers certified with the Illinois Soil Classifiers Association (ISCA) and certified with the American Registry for Certified Professionals in Agronomy, Crops and Soils (ARCPACS) through the Soil Science Society of America. These professionals have the skill and knowledge to evaluate soil for agricultural purposes, home sites, on-site sewage disposal, and other uses. One can locate ISCA soil classifiers at: [http:// www.illinoissoils.org](http://www.illinoissoils.org) .



Also, there are Resource Soil Scientists with USDA NRCS in all areas of Illinois. Their mission is to provide technical soils assistance to state, county and municipal agencies and land users through the local NRCS field office and the local Soil and Water Conservation District.

This document was produced jointly with the USDA Natural Resources Conservation Service and the Illinois Soil Classifiers Association. Photos and graphics were provided, unless otherwise noted, by Illinois Soil Classifiers Association, Illinois State Geological Survey, and USDA Natural Resources Conservation Service.

The Illinois Soil Classifiers Association is an organization promoting the wise use of the soil resource. ISCA is made up of professional soil classifiers in public service, private industry and education, and includes students and others interested in preserving soil. A soil classifier maps, describes and interprets soils according to a national system of soil classification. ISCA was established in 1975 and is affiliated with the Soil Science Society of America.

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