



# Module 2.

INTRODUCTION TO SOILS



# Module 2a.

What is Soil?



## What is Soil?

- “You will die but the carbon will not; its career does not end with you. It will return to the soil, and there a plant may take it up again in time, sending it once more on a cycle of plant and animal life.” --Jacob Bronowski
- “ Soil, like air, like water is a natural resource that we must protect in order to have a future on planet earth” --Terry Cooper
- “The Nation that destroys its soil destroys itself” -- Franklin D. Roosevelt



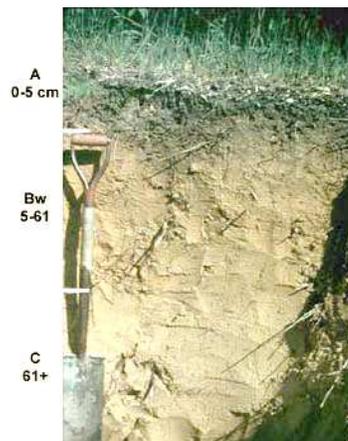
## SOIL Definition (1)

- **SOIL** - The unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.
- Sense the Soil – feel, smell, see, hear.....



## SOIL Definition (2)

The unconsolidated mineral and/or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors:



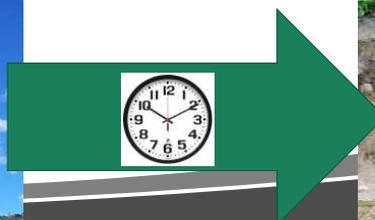
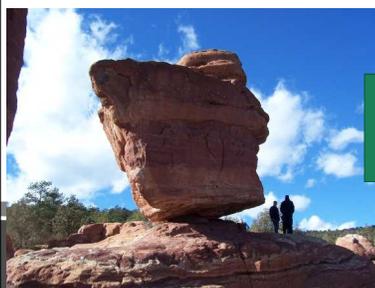
Active Factors	Passive Factors
Climate	Time
Organisms	Topography
	Parent Material



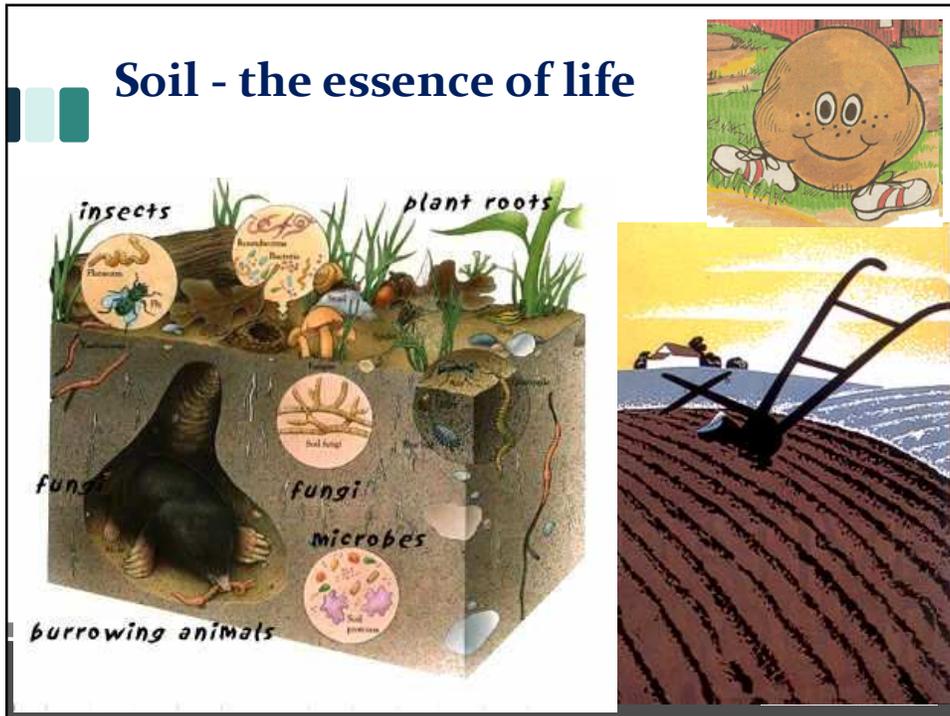
## Soil – A Product

Soil differs from its Parent Material in many aspects:

- a) physical
- b) chemical
- c) biological
- d) morphological properties and characteristics

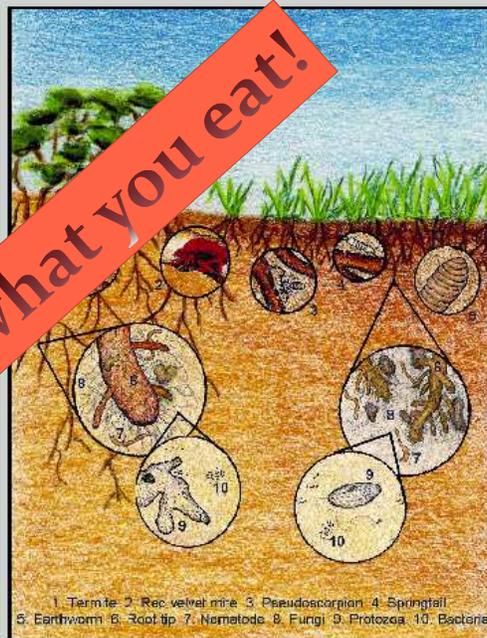


## Soil - the essence of life



## Soil is the Basis of the Ecosystem

The living systems occurring above and below the ground surface are determined by the properties of the soil. We often ignore the soil because it is hard to observe.



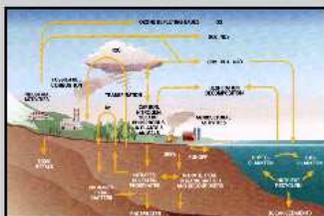
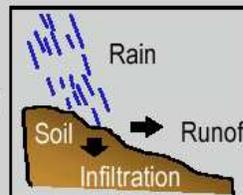
1. Termite 2. Red velvet mite 3. Pseudoscorpion 4. Springtail  
5. Earthworm 6. Root tip 7. Nematode 8. Fungi 9. Protozoa 10. Bacteria

## Soils Perform Vital Functions



Sustaining plant and animal life below and above the surface

Regulating and partitioning water and solute flow



Filtering, buffering, degrading, immobilizing, and detoxifying

Storing and cycling nutrients



Providing support to structures



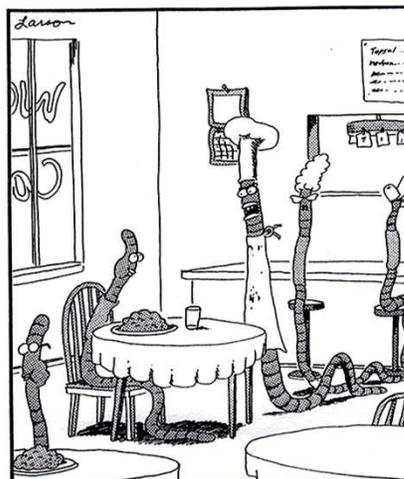
So!

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## Soil

- Soil – The most important natural resource on planet earth.
- All natural resources...are soil or derivatives of soil. Farms, ranges, crops, and livestock, forests, irrigation water and even water power resolve themselves into questions of soil. Soil is therefore the basic natural resource. ---

*Aldo Leopold*



"I've been told you don't like my dirt!"



## But in addition to growing plants

Soils determine the suitability of land for various uses; such as, housing developments, parks, golf courses, trails, .....





# Module 2b.

Soil Properties for construction & Development



## Soil Properties for Construction & Development

- Type/classification
- Horizon depth
- Depth to water table
- Hydrology/hydrologic rating
- Mineral constituents
- Organic matter
- Erodibility
- Texture
- Structure
- Bulk density
- Pore space
- Water holding capacity
- Compaction
- Sheer strength
- Soil chemistry
- Suitabilities and limitations for intended use
- Shrink-swell clays???
- Fertility





# Soil Classification

Map Unit Description: Bethera silt loam—James City and York Counties and the City of Williamsburg, Virginia

## James City and York Counties and the City of Williamsburg, Virginia

### 5—Bethera silt loam

**Map Unit Setting**  
 National map unit symbol: 41qw  
 Elevation: 30 to 120 feet  
 Mean annual precipitation: 40 to 55 inches  
 Mean annual air temperature: 57 to 61 degrees F  
 Frost-free period: 185 to 193 days  
 Farmland classification: Not prime farmland

**Map Unit Composition**  
 Bethera and similar soils: 85 percent  
 Estimates are based on observations, descriptions, and transects of mapunit.

**Description of Bethera**

**Setting**  
 Landform: Depressions  
 Landform position (three-dimensional): Trench  
 Down-slope shape: Concave  
 Across-slope shape: Concave  
 Parent material: Marine deposits

**Typical profile**  
 H1 - 0 to 7 inches: silt loam  
 H2 - 7 to 65 inches: clay loam

**Properties and qualities**  
 Slope: 0 to 2 percent  
 Depth to restrictive feature: More than 80 inches  
 Natural drainage class: Poorly drained  
 Runoff class: Negligible  
 Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.57 in/hr)  
 Depth to water table: About 0 inches  
 Frequency of flooding: None  
 Frequency of ponding: Rare  
 Available water storage in profile: High (about 9.4 inches)

**Interpretive groups**  
 Land capability classification (irrigated): None specified  
 Land capability classification (nonirrigated): 6w

**Typical Profile**

- Horizon 1 – 0 to 7 inches silt loam
- Horizon 2 – 7 to 65 inches clay loam

**Properties and qualities**

- Depth to restrictive feature 80 inches
- Poorly drained
- Transmittal of water Very low to moderately high
- Depth to water 0 inches




# Soil Classification

	K-Factor	Depth to water table (cm)	Hydrologic rating	Texture
Bethera silt loam	.43	0	C/D	Silt loam
Izagora silt loam	.28	69	C	Fine sandy loam

**K - factors**

*K < 0.23 → low erodibility*

*0.24-0.36 → moderate erodibility*

*K > 0.37 → high erodibility*



## Soil Classification

 K-Factor	Depth to water table (cm)	Hydrologic rating	Texture	
Bethera silt loam	.43	0	C/D	Silt loam
Izagora silt loam	.28	69	C	Fine sandy loam



Dull gray general soil background, or matrix color, and bright red-orange iron concentrations, or mottles, indicate a fluctuating water table.



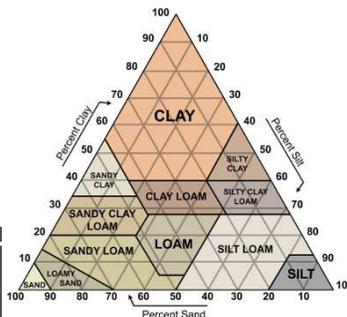
## Soil Classification

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## Soil Classification

 Web Soil Survey	K-Factor	Depth to water table (cm)	Hydrologic rating	Texture
Bethera silt loam	.43	0	C/D	Silt loam
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## Soil Constituents



### Soil solids

- Primary minerals:
  - Quartz
  - Feldspars
- Secondary Minerals
  - Clays
  - Iron oxides
- Course fragments
- Organic matter /Humus

FOUR KEY COMPONENTS OF SOIL COMPOSITION



## Soil Texture



= the relative composition of the particles in the soil.  
 or  
 = the particle size distribution.

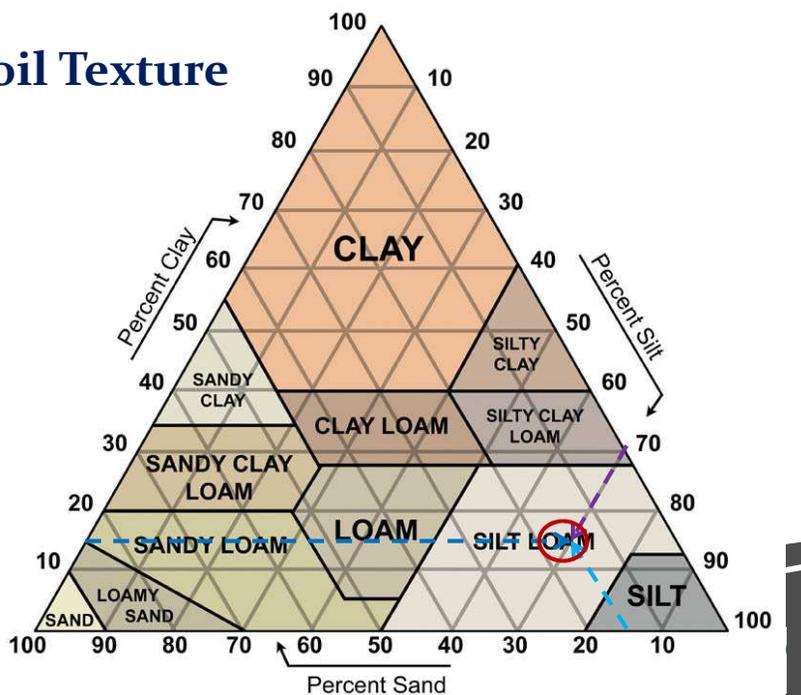
### Particle size distribution and feel for soil particles (USDA)

Sand	2 to 0.05 mm	Gritty
Silt	0.05 to 0.002 mm	Floury
Clay	<0.002 mm	Sticky



## Soil Texture

15% sand  
 15% clay  
 70% silt



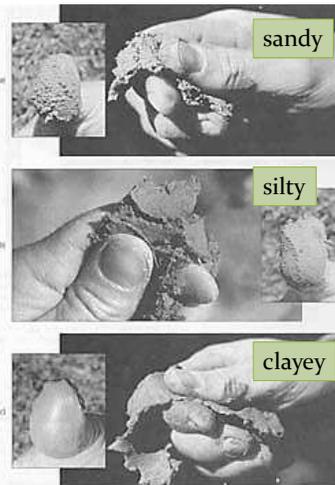
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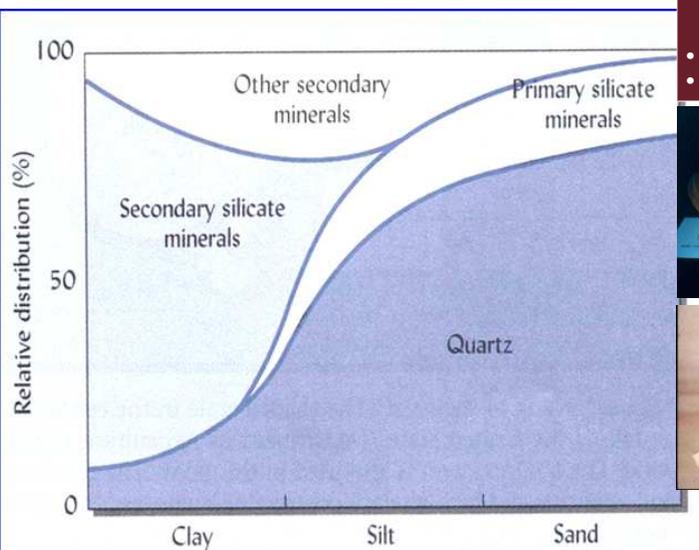


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Sand	2 to 0.05 mm	Gritty
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## Soil Texture



- Soil solids**
- Primary minerals:
    - Quartz
    - Feldspars
  - Secondary Minerals
    - Clays
    - Iron oxides
  - Course fragments
  - Organic matter /Humus



## Soil Structure

= a descriptor of how the soil particles are held (cemented) together.

**Aggregates or Peds**

Influenced by:

- Organic matter (humus)
- Electrostatic forces (i.e. clay particles)

The diagram features a title 'Soil Structure' with a decorative bar of three squares (dark teal, light teal, dark teal) to its left. Below the title is a dark red box containing the text '= a descriptor of how the soil particles are held (cemented) together.' A large green arrow points downwards from this box to a white cloud shape. Inside the cloud, a yellow box contains the text 'Aggregates or Peds'. Below this, the text 'Influenced by:' is followed by a bulleted list: 'Organic matter (humus)' and 'Electrostatic forces (i.e. clay particles)'. In the bottom right corner of the slide is the logo for the Virginia Department of Environmental Quality (DEQ).

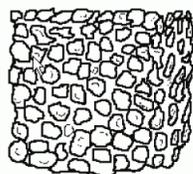
## Soil Structure

Weak, granular structure, common in sandy soils

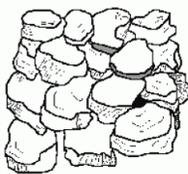
The photograph shows a person's hand holding a large amount of soil. The soil is light brown and has a loose, clumpy, granular texture, characteristic of sandy soil with weak structure. The background is blurred, suggesting an outdoor setting.

The logo for the Virginia Department of Environmental Quality (DEQ) is located in the bottom right corner of the slide.

## Soil Structure



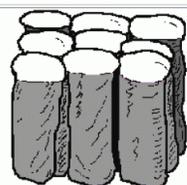
**Granular:** Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.



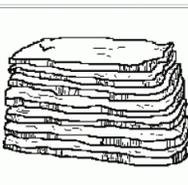
**Blocky:** Irregular blocks that are usually 1.5 - 5.0 cm in diameter.



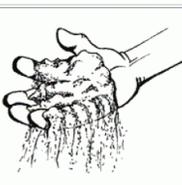
**Prismatic:** Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.



**Columnar:** Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.



**Platy:** Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.



**Single Grained:** Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.



## Soil Structure (and infiltration)

May crust/seal after a rain when they have a high clay content

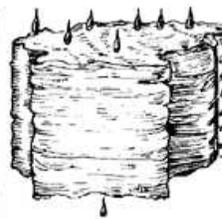
GRANULAR



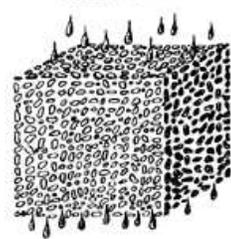
PRISMATIC



MASSIVE



SINGLE GRAIN



BLOCKY



PLATY



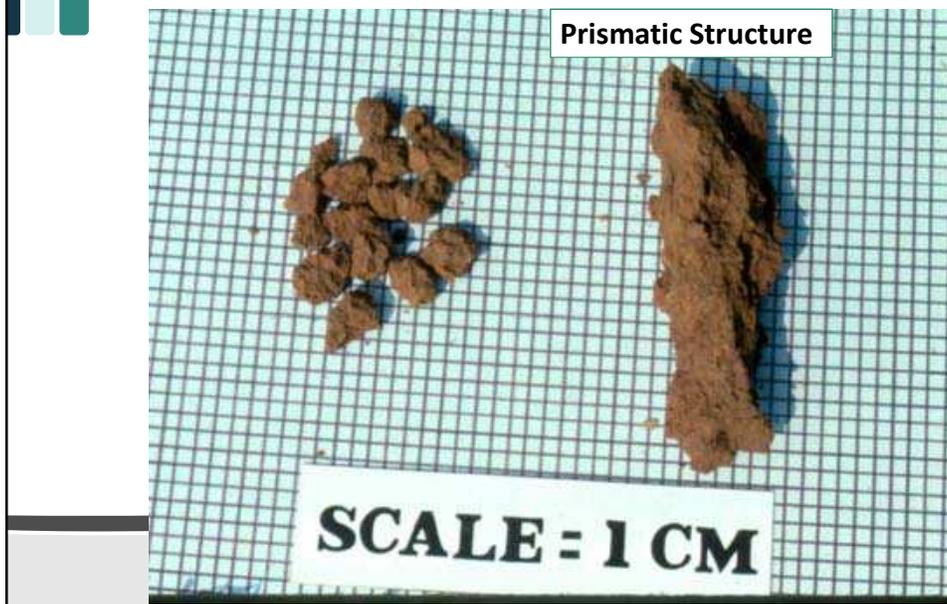
RAPID

MODERATE

SLOW



## Soil Structure



## Soil Structure

### Important for:

- Root growth
- Water infiltration
- Gas ( $O_2$  and  $CO_2$ ) exchange



## Bulk Density

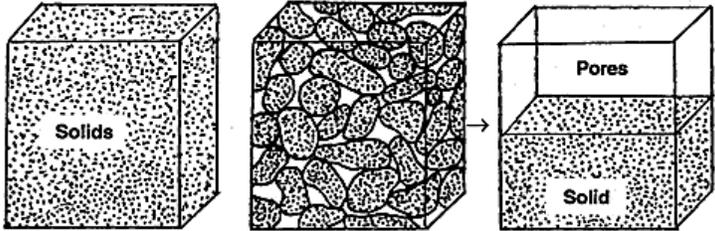
**Bulk Density (Db)** = The dry mass (weight) per unit volume

$$\frac{\text{dry mass of soil}}{\text{total soil volume}} \frac{g}{cm^3} \text{ or } \frac{g \times 10^6}{m^3}$$

	Db (g/cm <sup>3</sup> )	Db (kg/m <sup>3</sup> )
Normal Soil	1.0 - 1.8	1,000-1,800
Bertha Silt Loam	1.39	1,390
Dried Compacted Soil	2.65	2,650
Concrete	2.4	2,400




## Bulk Density



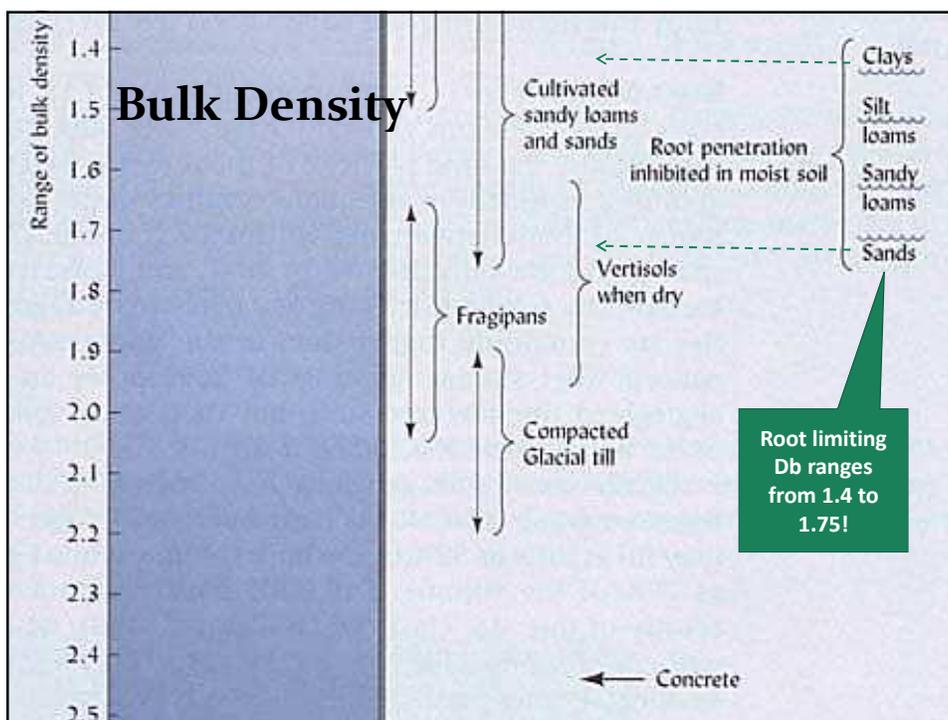
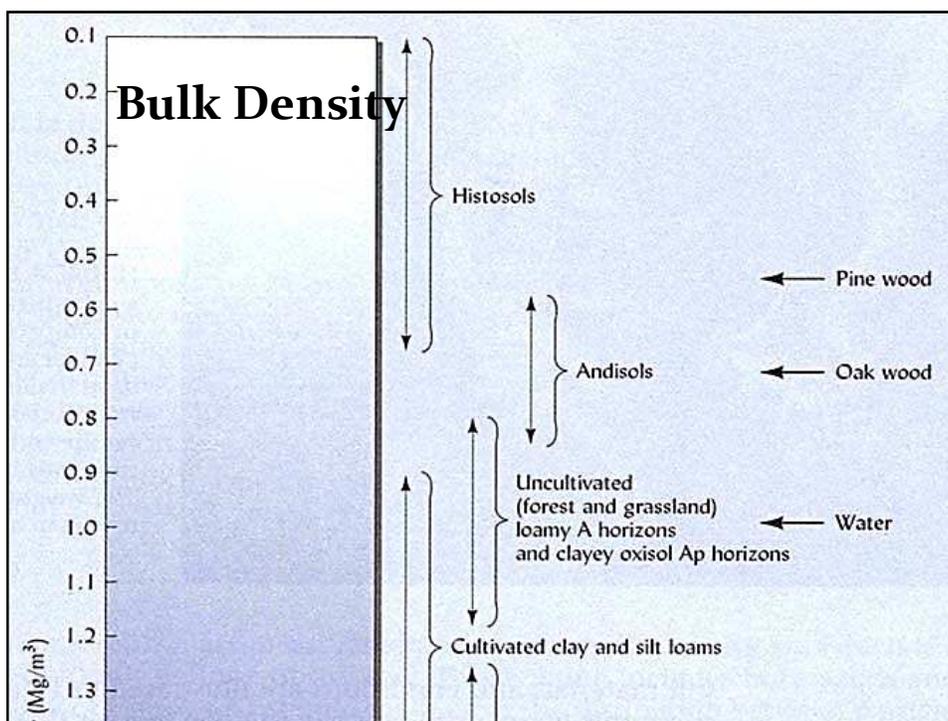
**Particle Density**

100% solid  
Weight = 2.66 g  
Volume = 1 cm<sup>3</sup>

**Bulk Density**

50% solid, 50% pore space  
Weight = 1.33 g  
Volume = 1 cm<sup>3</sup>





## Bulk Density → Pore space

$$\frac{D_b}{D_p} = \frac{1.39}{2.65} = 0.52 \text{ (or 52\%)} \quad \text{Solid space ratio}$$

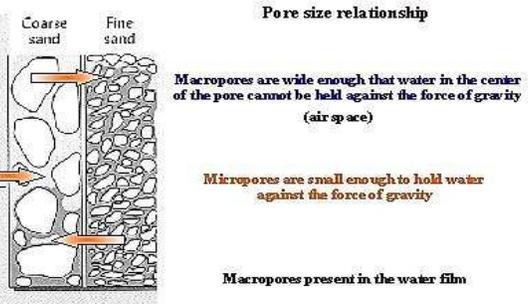
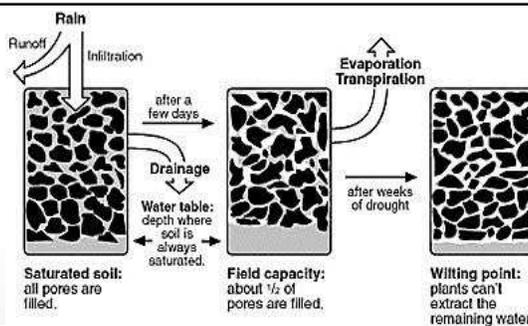
Pore space = 100% - 52% = 48%

	D <sub>b</sub> (g/cm <sup>3</sup> )	D <sub>p</sub> (kg/m <sup>3</sup> )
Normal Soil	1.0 - 1.8	1,000-1,800
<b>Bertha Silt Loam</b>	<b>1.39</b>	<b>1,390</b>
Dried Compacted Soil	2.65	2,650
Concrete	2.4	2,400

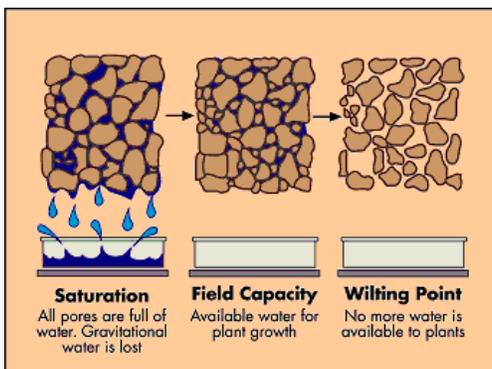
Soil Particle Density (D<sub>p</sub>)

## Pore Space Water Holding Capacity

Pore space ← Soil solids



## Available water



Texture	Field Capacity	Wilting point	Available water
Coarse sand	0.6	0.2	0.4
Fine sand	1.0	0.4	0.6
Loamy sand	1.4	0.6	0.8
Sandy loam	2.0	0.8	1.2
Light sandy clay loam	2.3	1.0	1.3
Loam	2.7	1.2	1.5
Sandy clay loam	2.8	1.3	1.5
Clay loam	3.2	1.4	1.8
Clay	4.0	2.5	1.5
Self-mulching clay	4.5	2.5	2.0

Source: Department of Agriculture Bulletin 462, 1960



## Compaction

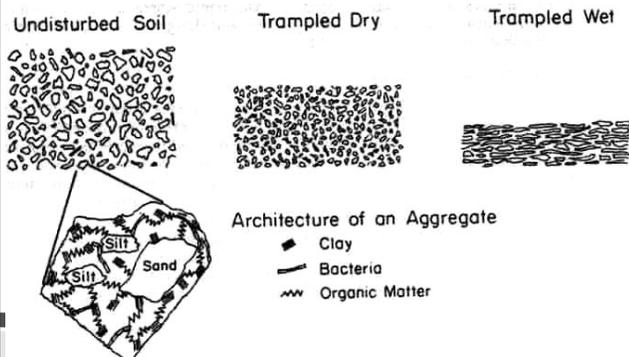
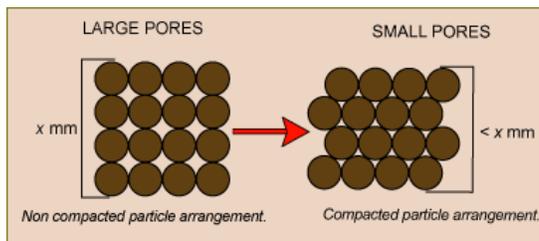


Figure 6.2. Conceptual architecture of a soil aggregate and the changes in soil aggregate structure caused by trampling under wet and dry conditions.



# Compaction

[http://www.multiquip.com/multiquip/pdfs/Soil\\_Compaction\\_Handbook\\_low\\_res\\_0212\\_Dataid\\_59525\\_Version\\_1.pdf](http://www.multiquip.com/multiquip/pdfs/Soil_Compaction_Handbook_low_res_0212_Dataid_59525_Version_1.pdf)

**RELATIVE DESIRABILITY OF SOILS AS COMPACTED FILL**  
(MNFAC 02-7.2, MAY 1982)

Relative Desirability for Various Uses  
(1=best; 14=least desirable)

• if gravelly  
-- erosion critical  
--- volume change critical  
--- not appropriate for this type of use

Group Symbol	Soil Type	Relative Desirability for Various Uses										
		Rolled Earth Fill Dams		Canal Sections		Foundations		Roadways				
		Heterogeneous Embankment	Cone	Shell	Erosion Resistance	Compacted Earth Layer	Storage Structures	Storage Structures	Not Subject to Freezing	Not Subject to Freezing	Surfing	
GRAVELS	GW	Well-graded gravels, gravel/sand mixtures, little or no fines	--	--	1	1	--	--	1	1	1	3
	GP	Poorly-graded gravels, gravel/sand mixtures, little or no fines	--	--	2	2	--	--	3	3	3	--
	GM	Silty gravels, poorly-graded gravel/sand mixtures	2	4	--	4	4	1	4	4	9	5
	GC	Clay-like gravels, poorly graded gravel/sand/clay mixtures	1	1	--	3	1	2	6	5	5	1
SANDS	SW	Well-graded sands, gravelly sands, little or no fines	--	--	3*	6	--	--	2	2	2	4
	SP	Poorly-graded sands, gravelly sands, little or no fines	--	--	4*	7*	--	--	5	6	4	--
	SM	Silty sands, poorly-graded sand/silt mixtures	4	5	--	8*	5**	3	7	6	10	6
	SC	Clay-like sands, poorly-graded sand/clay mixtures	3	2	--	5	2	4	8	7	6	2
LEAN CLAYS & SILTS	ML	Inorganic silts and very fine sands, rock flour, silty or clay-like fine sands with slight plasticity	6	6	--	--	6**	6	9	10	11	--
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	5	3	--	9	3	5	10	9	7	7
FAT CLAYS & SILTS	OL	Organic silts and organic silt-clays of low plasticity	8	8	--	--	7**	7	11	11	12	--
	MN	Organic silts, micaceous or distamaceous fine sandy or silty soils, elastic silts	9	9	--	--	--	8	12	12	13	--
FAT CLAYS	CH	Inorganic clays of high plasticity, fat clays	7	7	--	10	8**	9	13	13	8	--
	OH	Organic clays of medium high plasticity	10	10	--	--	--	10	14	14	14	--



# Compaction

**MATERIALS**

Lift Thickness	Vibrating Sheepfoot Rammer	Static Sheepfoot Grid Roller Scraper	Vibrating Plate Compactor Vibrating Roller Vibrating Sheepfoot	Scraper Rubber-tired Roller Loader Grid Roller	
	IMPACT	PRESSURE with kneading	VIBRATION	KNEADING with pressure	
GRAVEL	12+	Poor	No	Good	Very Good
SAND	10+/-	Poor	No	Excellent	Good
SILT	6+/-	Good	Good	Poor	Excellent
CLAY	6+/-	Excellent	Very Good	No	Good



[http://www.multiquip.com/multiquip/pdfs/Soil\\_Compaction\\_Handbook\\_low\\_res\\_0212\\_Dataid\\_59525\\_Version\\_1.pdf](http://www.multiquip.com/multiquip/pdfs/Soil_Compaction_Handbook_low_res_0212_Dataid_59525_Version_1.pdf)

## Shear Strength

LARGE PORES      SMALL PORES

x mm

Non compacted particle arrangement.

< x mm

Compacted particle arrangement.

Sliding of soil particles

## Suitabilities and limitations for intended use

### Spotsylvania County

Corrosion of Concrete

Corrosion of Concrete— Summary by Map Unit— Spotsylvania County, Virginia (VA177)				
Map unit symbol	Map unit name	Rating	Acres in ACP	Percent of ACP
01	Asiatic gravelly substratum	High	0.0	0.2%
17D	Dipetrocheila-Litella complex, moderately stony	High	0.1	0.1%
17E	Dipetrocheila-Litella complex, steep	High	16.7	13.2%
23	Fluviopetrae-Litelluena complex	Moderate	62.3	55.0%
25C	Kanawhae gravelly sands, 7 to 15 percent slopes	Moderate	0.5	0.5%
H0B	Litelluena-Litelluena complex, stony sloping		10.1	14.5%
H0	Litelluena-Litella complex, unshaded		8.9	7.2%
<b>Totals for Area of Interest</b>			<b>111.4</b>	<b>100.0%</b>

**Soils**

**Soil Rating Polygons**

- High
- Moderate
- Low
- Not rated or not available

## Hydric soils

In our Wetland Course we have seen that Hydric Soils are difficult to use for many land uses due to high water table and regulatory restrictions



- Are there any wetlands?
- Are the wetlands permitted?
- Where is the water table?
- BMP selection



## Module 2c.

Soil tools



# Web Soil Survey

The screenshot shows the home page of the Web Soil Survey. At the top, there is a navigation bar with links for Home, About Soils, Help, and Contact Us. Below this is a search bar and a 'Browse by Subject' menu. The main content area is titled 'Welcome to Web Soil Survey (WSS)' and includes a 'START WSS' button with a red arrow pointing to it. The page also features a 'Four Basic Steps' section with sub-titles 'Define...' and 'View...'. On the right side, there are sections for 'I Want To...' and 'I Want Help With...'. The bottom right corner features the logo for the Virginia Department of Environmental Quality (DEQ).

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

# Web Soil Survey

The screenshot shows the 'Area of Interest (AOI)' interactive map. The map displays the United States with state boundaries and labels. A red arrow points to the state of Virginia. The interface includes a search bar, a 'Quick Navigation' sidebar with fields for Address, State and County, Soil Survey Area, Latitude and Longitude, PLS (Section, Township, Range), Bureau of Land Management, Department of Defense, Forest Service, National Park Service, and Hydrologic Unit. The map controls include a 'View Extent' dropdown set to 'Contiguous U.S.', a 'Scale' dropdown set to 'not to scale', and a 'Shopping Cart (Free)' button. The bottom of the page contains a footer with links for FOIA, Accessibility Statement, Privacy Policy, Non-Discrimination Statement, Information Quality, USA.gov, and White House.

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

# Web Soil Survey

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

FOIA | Accessibility Statement | Privacy Policy | Non-Discrimination Statement | Information Quality | USA.gov | White House

# Web Soil Survey

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
21C	Frederick silty clay loam, 7 to 15 percent slopes, severely eroded	10.9	68.3%
21D	Frederick silty clay loam, 15 to 30 percent slopes, severely eroded	5.1	31.7%
<b>Totals for Area of Interest</b>		<b>15.9</b>	<b>100.0%</b>

K=0.32!

**K - factors**  
 K < 0.23 → low erodibility  
 0.24-0.36 → moderate erodibility  
 K > 0.37 → high erodibility

Warning: Soil Map may not be valid at this scale.

You have zoomed in beyond the scale at which the soil map for this area is intended to be used. Mapping of soils is done at a particular scale. The soil surveys that comprise your AOI were mapped at 1:20,000. The design of map units and the level of detail shown in the resulting soil map are dependent on that map scale. Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

## Web Soil Survey

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm



Chemical	Erosion	Physical	Quality	Water
7 different variables	K Factor (2)	21 different variables	11 different variables	Depth to water table
pH	Wind (2)	Bd	Hydrologic Soil group	Flooding frequency
	Composite (T factor)	Water availability	Drainage class	Ponding frequency

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