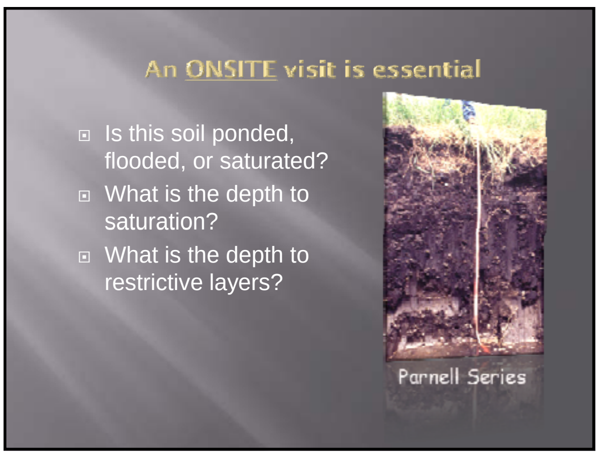
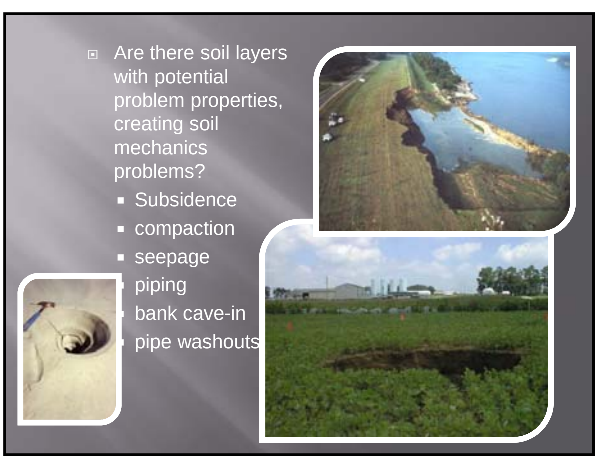
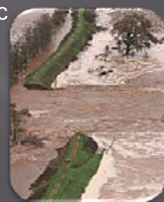

SOILS FOR ENGINEERING
Objective: Become aware of some key soil issues when engineering wetland restoration


An ONSITE visit is essential
Is this soil ponded, flooded, or saturated?
What is the depth to saturation?
What is the depth to restrictive layers?
Parnell Series


Are there soil layers with potential problem properties, creating soil mechanics problems?
Subsidence
compaction
seepage
piping
bank cave-in
pipe washouts

Preliminary investigations should accomplish the following goals:

1. Assess existing soil data.
2. Identify general soil conditions at the site.
3. Delineate any areas of potential problem soils, e.g. sodium, organic matter, rocks,
4. Identify any instabilities, slope failures, geologic faults,
5. Identify long term instabilities, streambed migration
6. Look for other potential problems, trash, contaminants



Is there any possible soil contamination?

Critical Soil Processes

1. Compaction characteristics of fill materials used to construct dikes
2. Slope stability
3. Settlement of earth dikes containing water and soils in wetlands
4. Compaction characteristics of wetland soils
5. Sedimentation and erosion characteristics of wetland soils
6. Flow of water through wetlands and dikes.

Why the processes are critical

- They influence
  - water and sediment storage capacity
  - water quality and flow
  - erosion from and collection of sediments on the surface of submerged wetland soils
  - levee stability

Office Wetland Soils – Engineering Tables

Soil Interpretations
- Embankments, dikes, levees
- Pond Reservoir areas
- Aquifer fed excavated pond
- Shallow Excavations

Risk of Corrosion
- Untreated Steel
- Concrete

Shrink - Swell Potential

Engineering: Soil Properties

- Permeability
- Elasticity
- Plasticity
- Cohesion
- Moisture content
- pH
- Density
- Shrink/swell potential
- Compressibility
- Grain size distribution
- Dispersion

Crucial engineering properties are strength, compressibility, and permeability. These properties influence the critical soil processes that govern the performance of a wetland when a force is applied to the soil.

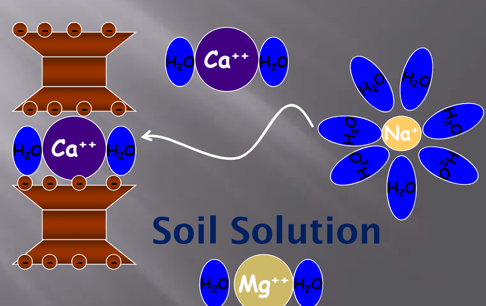
% Clay

- Important in
  - Construction
    - Liquid limit (LL): water content corresponding to the arbitrary limit between liquid and plastic states of soil consistency (high LL indicates high expanding clays)
    - Plastic limit (PL): water content corresponding to the arbitrary limit between plastic and semisolid states of soil consistency
    - Plasticity Index: Numerical difference between LL and PL (PI = LL - PL) (high PI indicates high expanding clays)
    - Used by engineers to determine soil suitability for projects.
  - vegetation
  - water storage

Dispersive soils

- Sodium is a compact molecule but has a large hydrated radius because it attracts water molecules.
  - fewer electrons, a tighter electron shell and less repulsion of electronegative oxygen molecules of water
- This hydrated radius results in Sodium's ability to disperse clays in the soil solution.

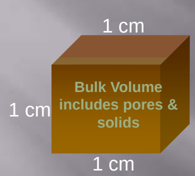
2:1 Silicate layer clay, montmorillonite, smectite



Treating Sodic Soils

- Gypsum can counteract the adverse effects of accumulated sodium in sodic soils.
  - Sodium tends to disperse soil aggregates into the individual soil particles that then clog the soil channels and pores.
  - Infiltration and percolation of water into and through the soil is reduced.
  - When gypsum is added to these soils, sodium is displaced from the exchange sites by calcium from the gypsum as it dissolves and the sodium is leached out.
  - Calcium being a divalent ion and having a smaller hydrated radius than the monovalent sodium ion tends to bind clay and organic matter particles together as aggregates.
  - As aggregation increases, water infiltration and percolation improves.

Bulk Density



Texture: Sand
Volume: 1cm x 1cm x 1cm = 1cm ^{3}
Weight: 1.6 grams

Bulk Density = 1.6g / 1.0 cm^3
= 1.6 g/cm^3

Texture: Clay
Volume: 1cm x 1cm x 1cm = 1cm ^{3}
Weight: 1.4 grams

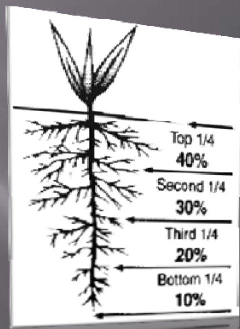
Bulk Density = 1.4g / 1.0 cm^3
= 1.4 g/cm^3

% pore space = 100-((bulk density / particle density) 100)
% pore space sand = 100-((1.6 g/cm^3 / 2.65 g/cm^3) 100) = 40%
% pore space clay = 100-((1.4 g/cm^3 / 2.65 g/cm^3) 100) = 47%

Relationship of bulk density to root growth based on soil texture

Soil texture	Ideal bulk densities	Bulk densities that may affect root growth	Bulk densities that restrict root growth
		(g/cm 3)	
sands, loamy sands	< 1.60	1.69	> 1.80
sandy loams, loams	< 1.40	1.63	>1.80
sandy clay loams, loams, clay loams	< 1.40	1.60	>1.75
silts, silt loams,	<1.30	1.60	>1.75
silt loams, silty clay loams	<1.40	1.55	>1.65
sandy clays, silty clays, some clay loams (35-45% clay)	<1.10	1.49	>1.58
Clays (> 45% clay)	<1.10	1.39	>1.47

- Depth to restrictive layer - a soil or rock layer that inhibits root or water movement into the soil.
  - Important in
    - Vegetation establishment
    - water storage
    - water percolation



Where plants get water in their root zone.

Organic Matter

- weight of decomposed plant and animal residues expressed as a weight percent
  - Influences
    - Available Water Holding Capacity
    - Microbial Processes
    - Chemical Transformations, Redox Reactions
    - pH alkalinity or acidity of soil
    - Vegetation
    - Maintenance and building of structures

1924 - top of post at soil surface with ~9 feet organic matter
2002 – top of post exposed to ~3.5 feet organic matter
Florida Histosol

Field Tests: pH

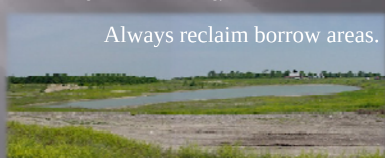
- Quickly done inexpensively
- Field Kit Indicators
  - Wide Spectrum
  - example; Truog
    - Table 16
      - Physical& Chemical Properties
- Limitations for
  - vegetation reestablishment &
  - construction materials

Other field tests

- Acid test. This test can determine the presence of calcium carbonate in the soil.
  - Calcium carbonate is normally desirable because of the cementing action it provides and the soil strength that can be added to compacted soil over time.
  - This test permits a better understanding of abnormally high strength values of fine-grained soils that are tested in-place.
  - The test is conducted by placing a few drops of hydrochloric acid on a piece of the soil. A fizzing reaction (effervescence) indicates the presence of calcium carbonate.

What to look for in Borrow areas

- Textures (Grain Size)
  - Engineers classify soils by grain size Table 15 (Engineering index properties)
    - Well graded refers to the size of the particles being distributed over a wide range of sizes. Uniformly graded refers to the size of particles being distributed over a narrow range of sizes.
- Quality
  - avoid trash, limbs, stones, organic debris, roots
  - ~25% clay (too much results in slippage, compaction, cracking, too little, leaking)



Levees etc.

- Location limitations
  - Erodibility, visually check for evidence of instability
    - Table 16 Physical & Chemical Properties, both K (erosion factor RUSLE) & T (erosion loss of productivity),
    - Table 17 Soil & Water Features,
      - hydrologic group (A-D sandy to clayey)
      - subsidence
      - flooding
      - water table
      - corrosion risk

Foundation

- Texture
  - ~25% clay for low permeability, leaking is bad but too much clay has its own problems
    - Elasticity - the ability of a material to return to its original shape or form after having been deformed by a load for a short period of time.
    - Any load applied that exceeds the shear strength of a soil will also exceed the elastic limit of the soil, and it will not return to its original shape or form but will fail by plastic deformation.
    - If sodium is present in large amounts (ESP>15%) look for evidence of dispersion.

Foundation

- Base material
  - Avoid Unconsolidated Alluvium & Coarse strata
    - Negative friction, in which the soil pulls down (down-drag) on the shaft or piling instead of supporting load, often occurs in regions of incompletely consolidated soft clay, silt and organic soil, but may also be the result of soils shrinking during extended dry periods.
  - Check within 2 feet of the foundation and deeper if necessary

Rules of Thumb

- pH< 5 - concrete corrosion, vegetation problems
- pH< 4.5 - steel corrosion, vegetation problems
- pH > 8 - sodium or salinity problems, vegetation problems
- ESP > 15%, potentially dispersive
- SAR > 9, potentially dispersive
- Crumb test ranking >3, potentially dispersive
- Averaged % clay < 10 = seepage
- Liquid Limit > 40 = low strength (LL< 35 preferred)
- Plasticity > 30 = low bearing strength
- High Shrink Swell Rating = severe cracking
- Organic Matter > 15 % = compacting, porosity, seepage, slipping (< 3% excellent)
- Bulk Density
  - Clay – 1.5 g/cm^3
  - Silt – 1.6 g/cm^3
  - Sand – 1.8 g/cm^3
- Specific Conductivity <4 dS/m

Summary

1. Understanding soil engineering properties is fundamental to a successful restoration
2. Don't ignore the obvious
3. Consult your experts, engineer, soil scientist, biologist, botanist, boss