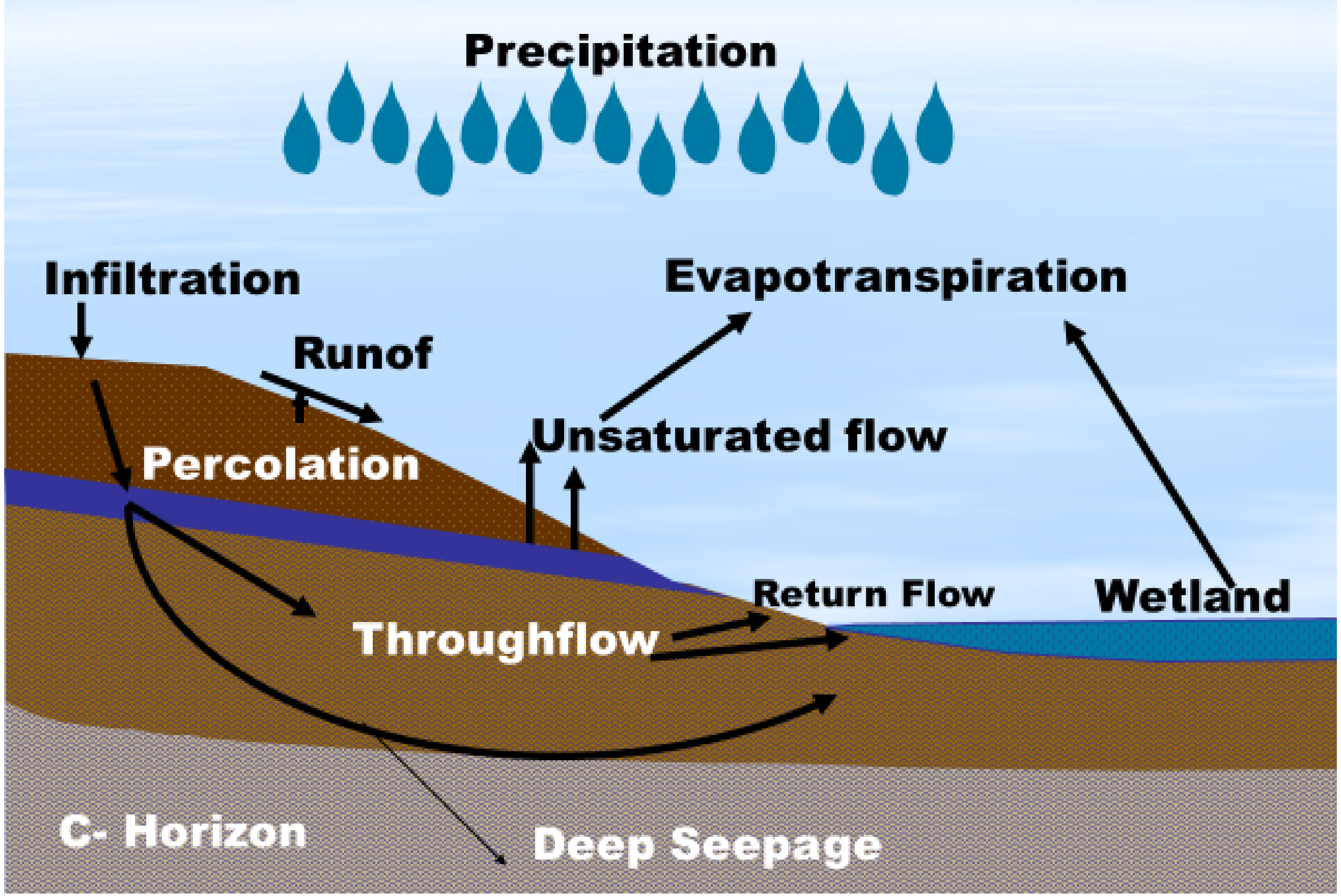
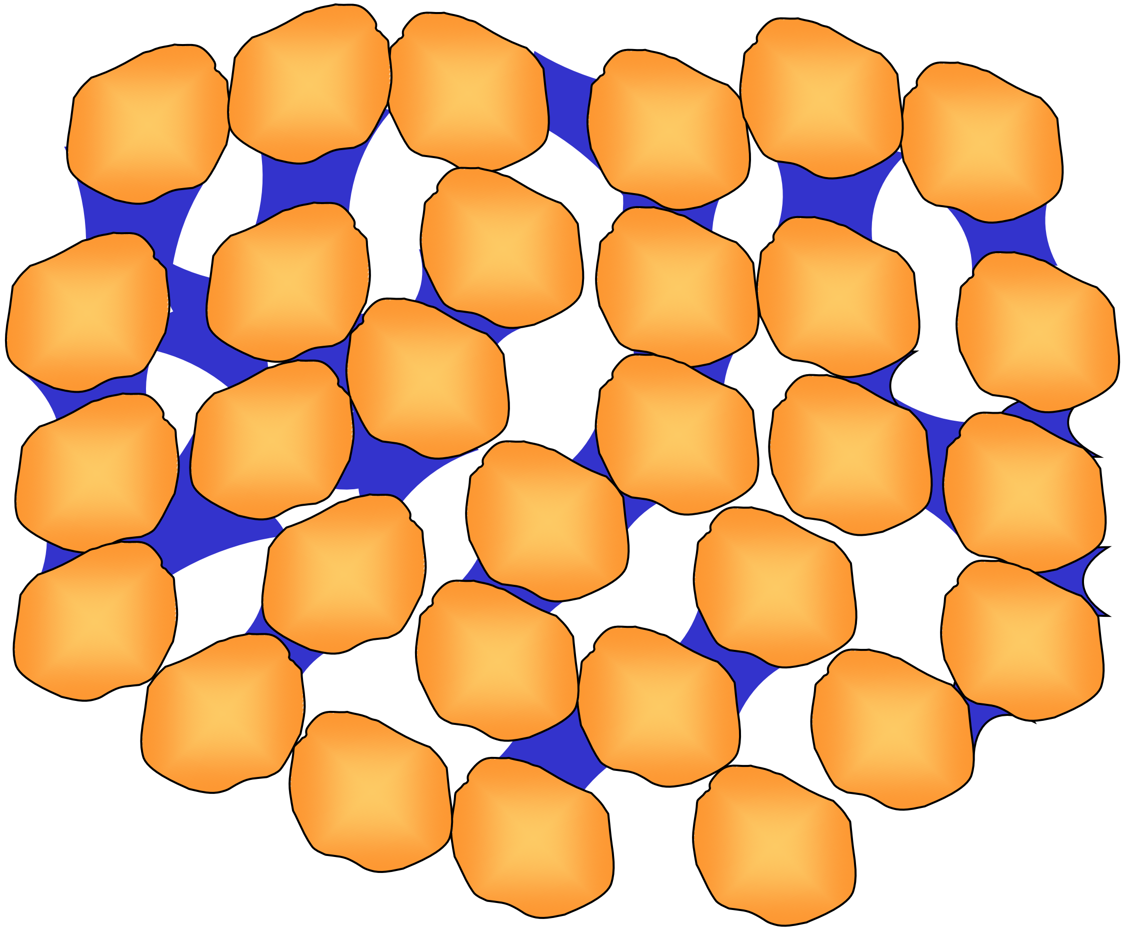
Soil, Landscape, Hydrology Relationships

Soil Hydrologic Cycle



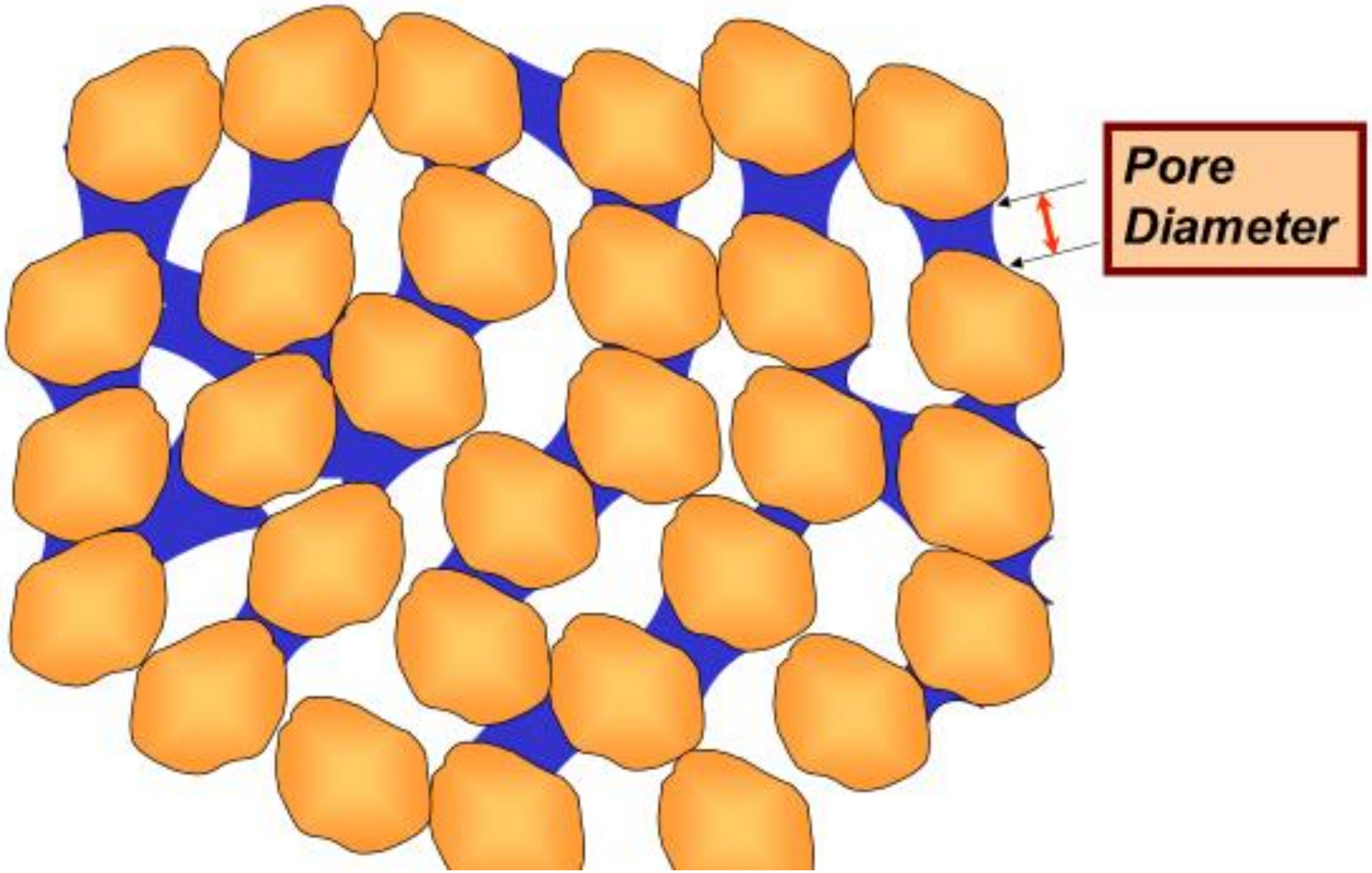
Unsaturated Soils with Suction (Tension) Forces



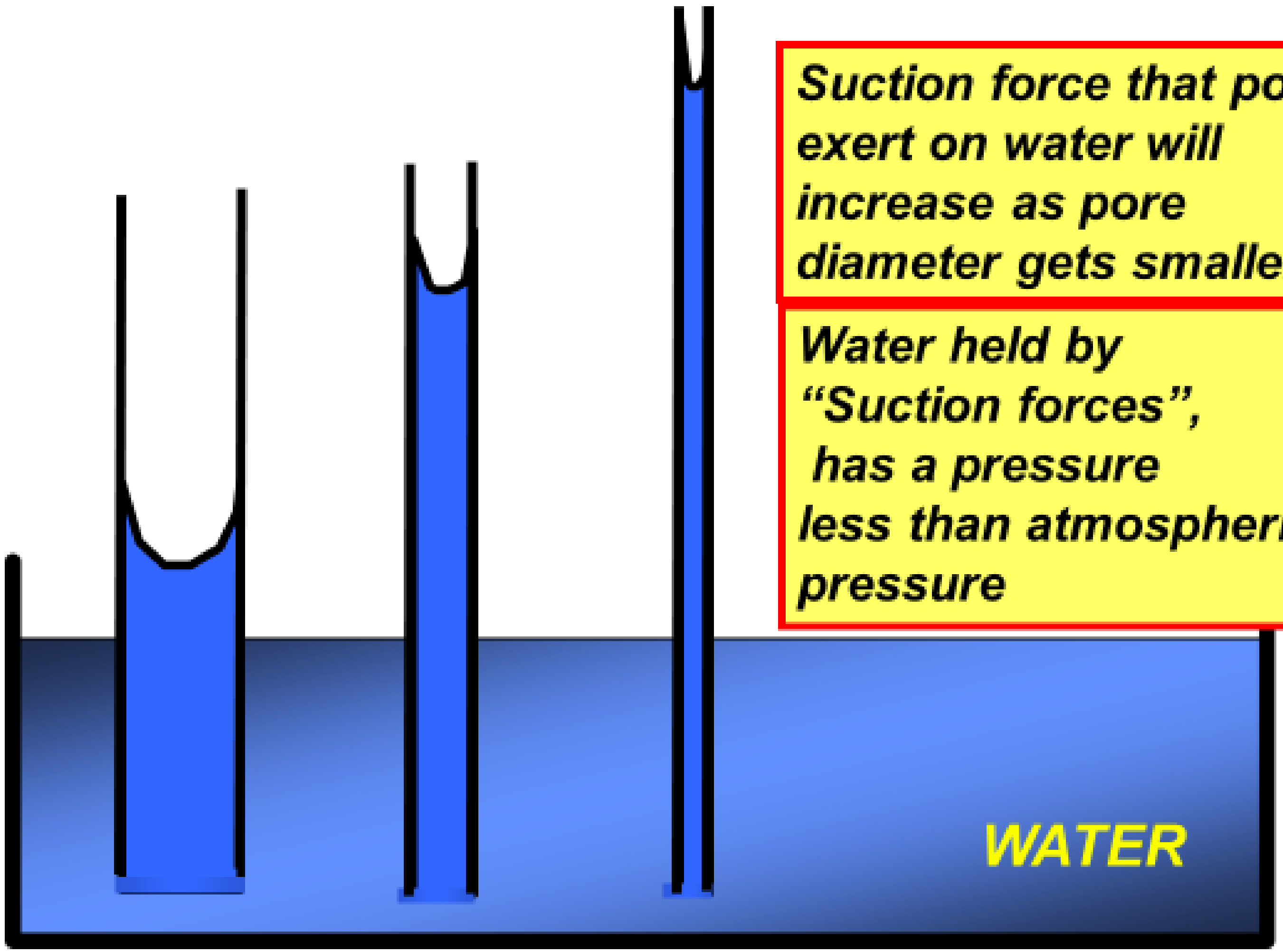
Water under a suction, pulls particles together.

This water is not “free water”, it is not free to Move.

Strength of suction force related to pore diameter



Capillary Rise



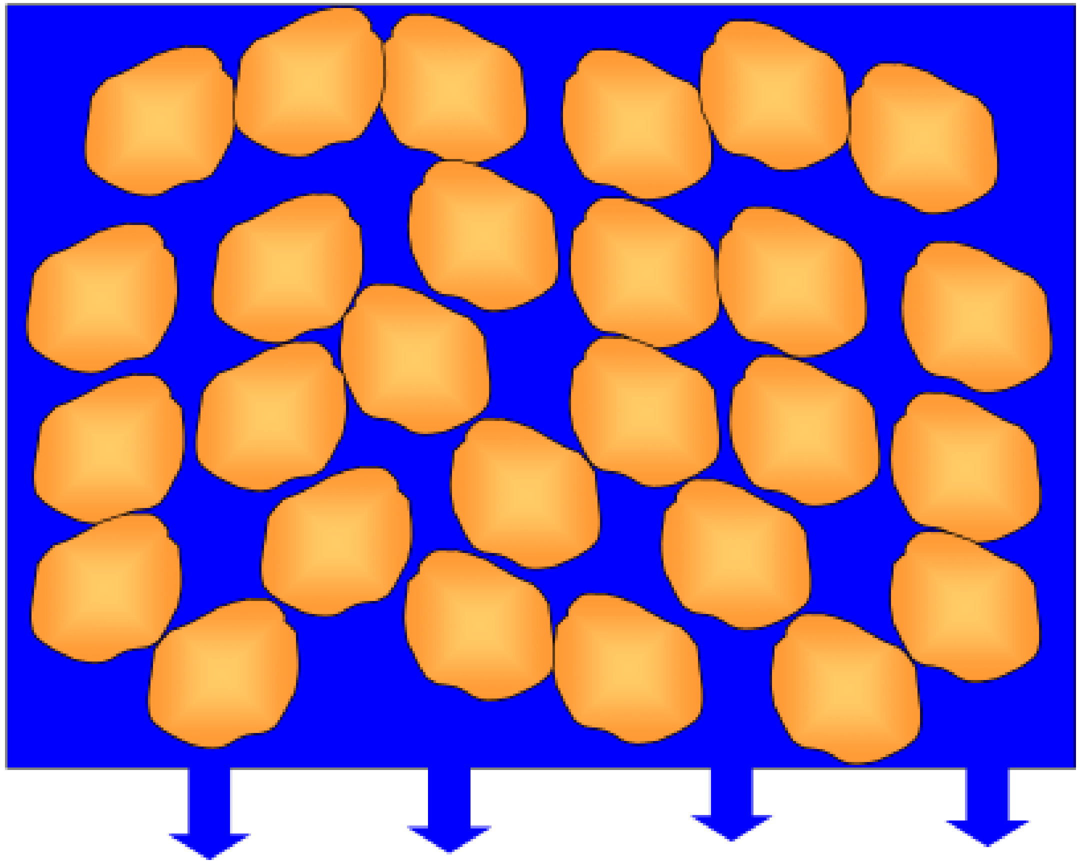
Suction force that pores exert on water will increase as pore diameter gets smaller

Water held by "Suction forces", has a pressure less than atmospheric pressure

Saturation

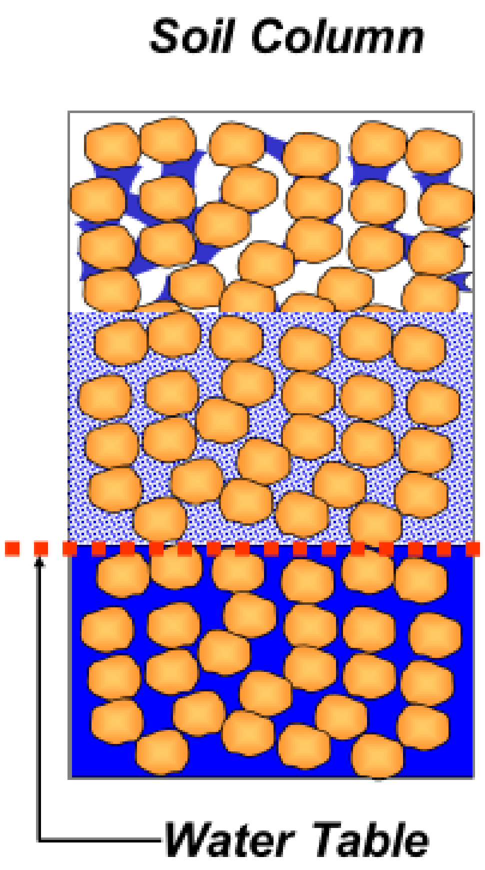
- A horizon is saturated when the soil **water pressure** is zero or positive.
- This water has a pressure greater than atmospheric pressure, and **pushes air out** of holes in the ground.

Saturated Soils with Free Water (no Suction)



Free water is not under a suction, and flows in response to gravity.

Unsaturated Zone, Capillary Fringe, Saturated Zone



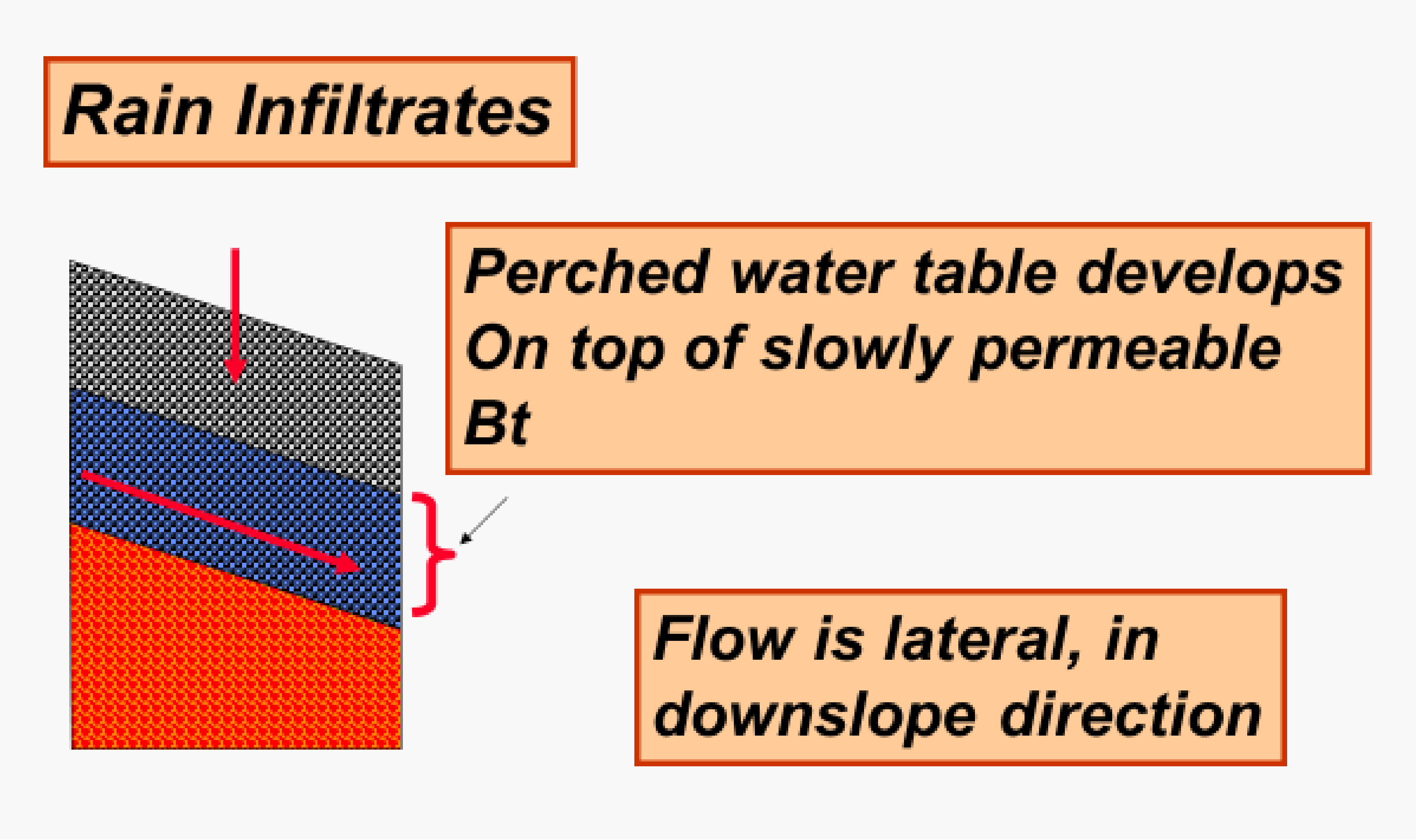
Term	All Pores Filled?	Water Pressure
Unsaturated Zone	No	< air pressure
Capillary Fringe	Yes	< air pressure (suction)
Saturated Zone	Yes	$\geq$ air pressure

Effect of Hydraulic Gradient

- **Large Hydraulic Gradient (≥2%)**
  - Water flows through soil “fast”
  - Chemicals are added to or removed from soil

- **Small Hydraulic Gradient (≤1%)**
  - Water flows through soil “slowly”
  - Chemicals move internally within soil

Perched Water Tables



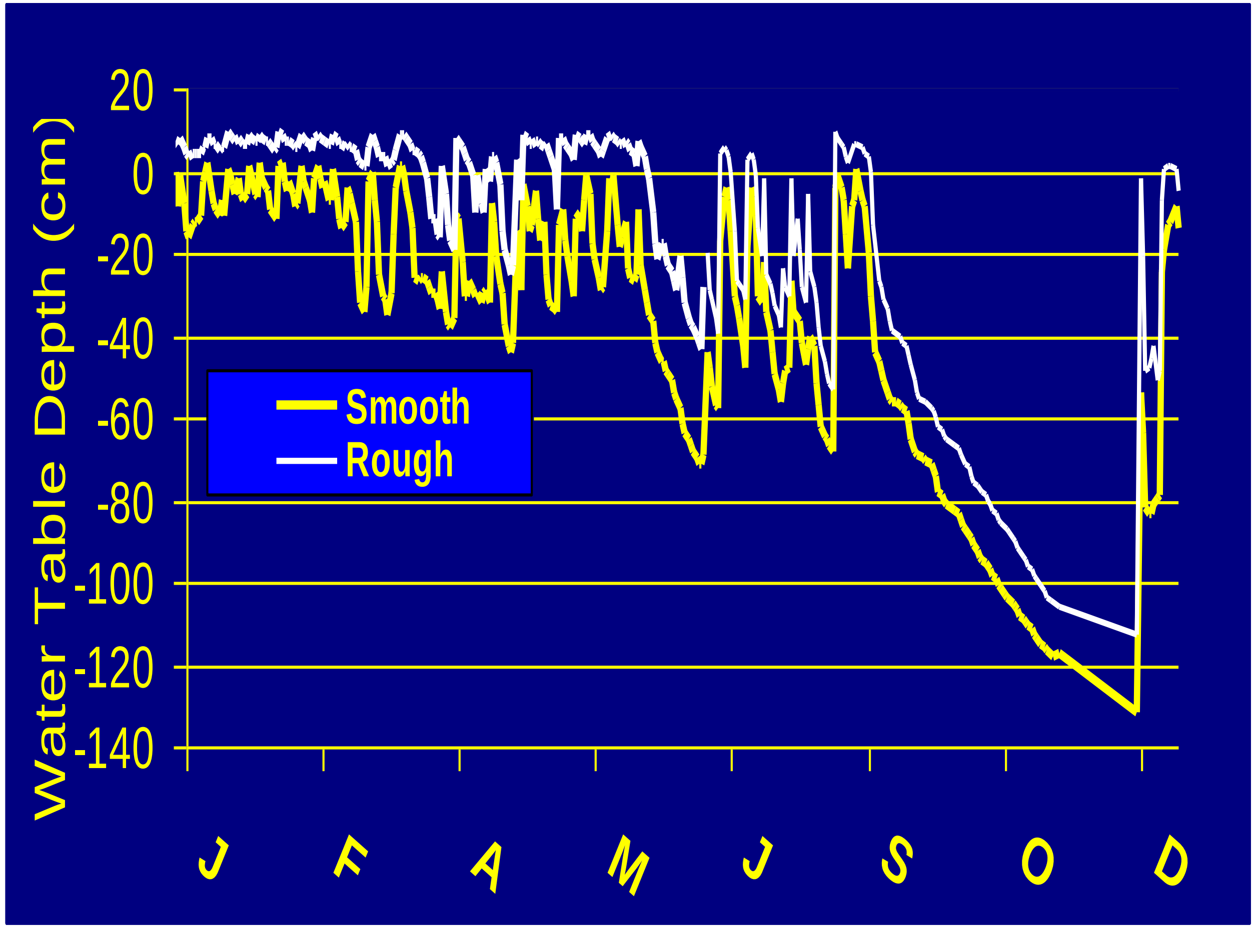
Perched Water Tables with Small Hydraulic Gradient Often Leads to Gleyed Colors

Fe^{2+} is present as shown by **strong** reaction to dipyridyl dye

Gley mineral may be Green Rust

Photo by D.L. Lindbo

Hydroperiod



- The duration an frequency a soil stays saturated.
  - Different hydroperiods produce different soils that provide different functions.

Wetland Function

The biological, chemical, and physical processes that occur in wetlands

Different types of wetlands provide different functions well (ex. Most depressional wetlands are good for long term water retention while most slope wetlands do not provide this function)

Hydrologic Functions

Water retention (short term and long term)

Energy dissipation

Biogeochemical

Cycling of redox-sensitive compounds

Sediment retention

Carbon sequestration

Soil Characteristics that Affect Hydrologic Functions

Water retention

- Long-term storage
  - Slope
  - Drainage class/hydroperiod
  - Permeability
- Short term storage
  - Slope
  - Microtopography
  - Permeability
  - Surface organic carbon content

Energy dissipation

- Slope
- Microtopography
- Surface texture

Soil Characteristics Used that Affect Biogeochemical Functions

Cycling of Redox-Sensitive Compounds (nitrogen cycling)

- Permeability
- Drainage class/hydroperiod
- Organic carbon content
- Soil ecology (microbial community)

Sediment retention (phosphorous retention)

- Permeability
- Slope
- Microtopography
- Cation exchange capacity

Carbon sequestration

- Organic carbon content
- Drainage class/hydroperiod
- Topography
- Microtopography

Nitrogen Removal

Wetlands remove 70 to 90% of N from water.

Seasonally saturated wetlands are the most efficient at utilizing nitrogen.

Phosphorous Removal

Wetlands retain about 45% of phosphorous from waters.

Uplands are better at removing P.

An upland buffer between wetlands and open water will optimize removal of phosphorous.

Carbon Processes

Sequestering 22,000 kg of C in humus requires kg 1833 lbs. of N, 440 lbs. of P, and 315 lbs. of S.

22,000 lbs/acre of C is equivalent to an increase of about 0.7%.

Organic Soils

Low gradient, constant hydroperiod with periods of ponding

Soils with Dark Surfaces High in Organic Carbon

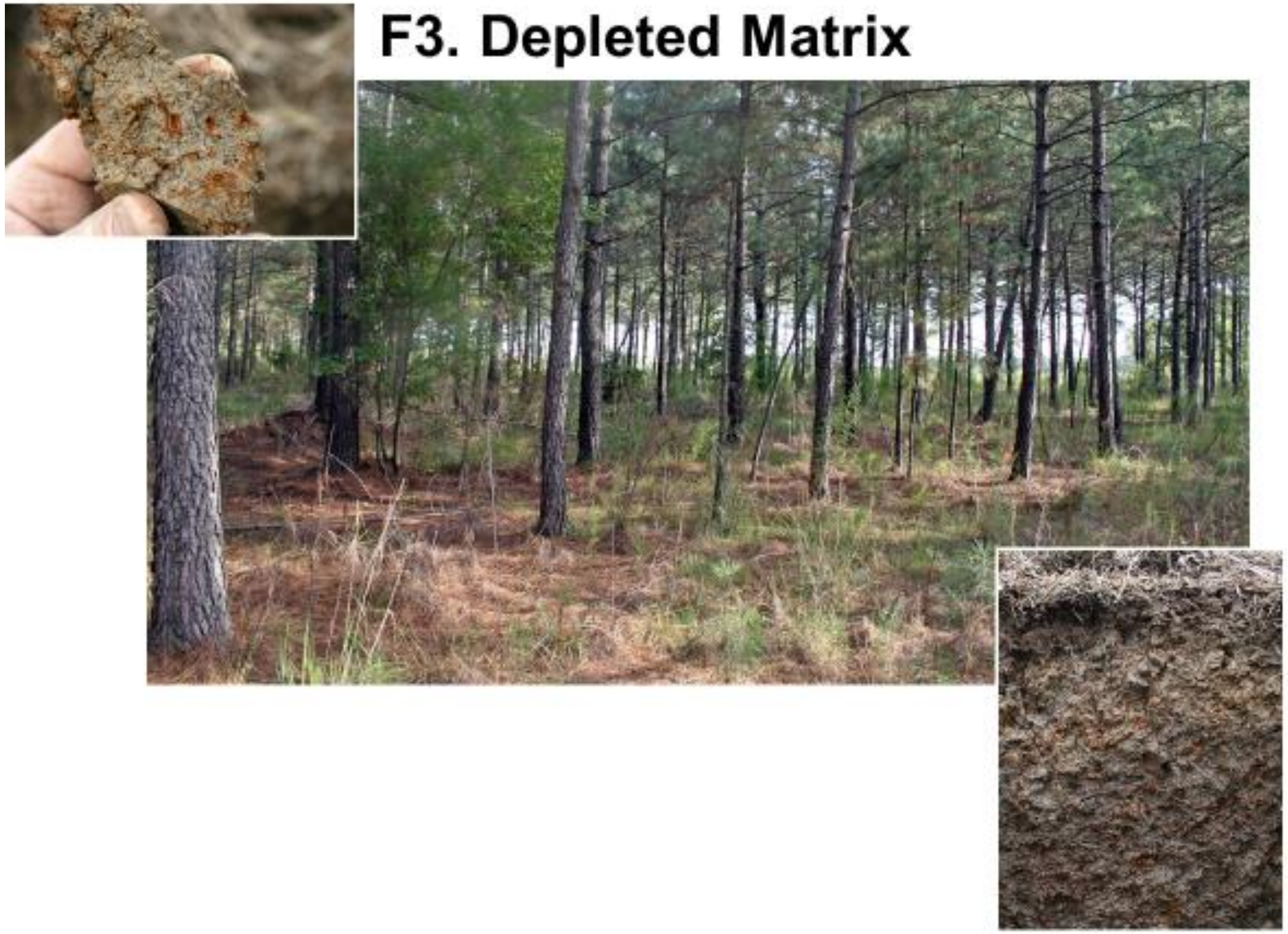
Low gradient, constant hydroperiod in wetter months and fluctuating in drier months

Dark Surfaces High in Organic Matter with Redox

Slight gradient, fluctuating hydroperiod near edge of discharge wetland

- -water leaves through evapotranspiration allowing iron to accumulate in the dark surface

Gray matrix with redox

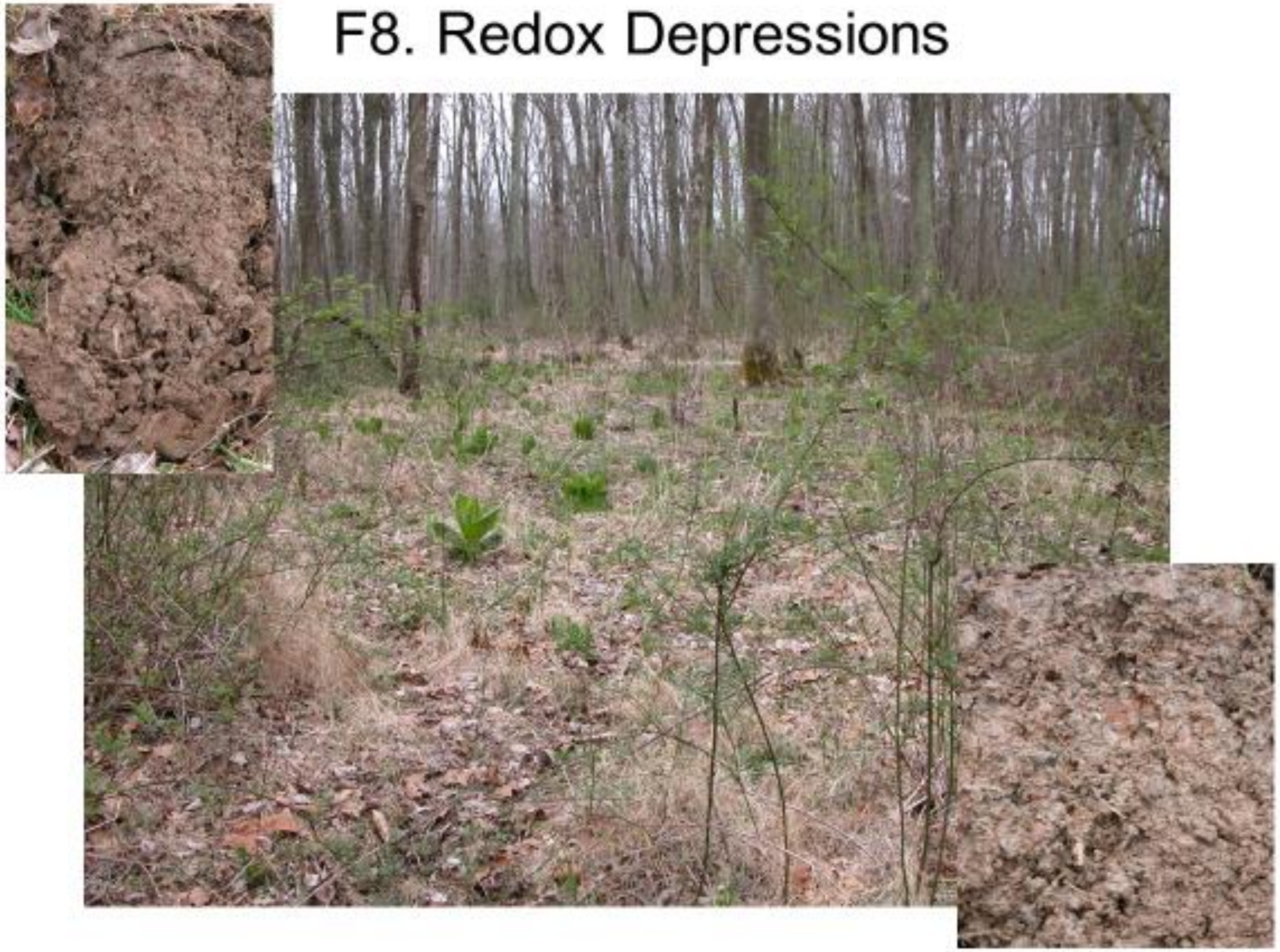


Gradient can be variable, fluctuating hydroperiod

Soils that Flood

Moderate gradient, overland flow, recent sediment deposition

Soils that Pond



Low gradient, often perched, ponded

-saturation leaves through evapotranspiration

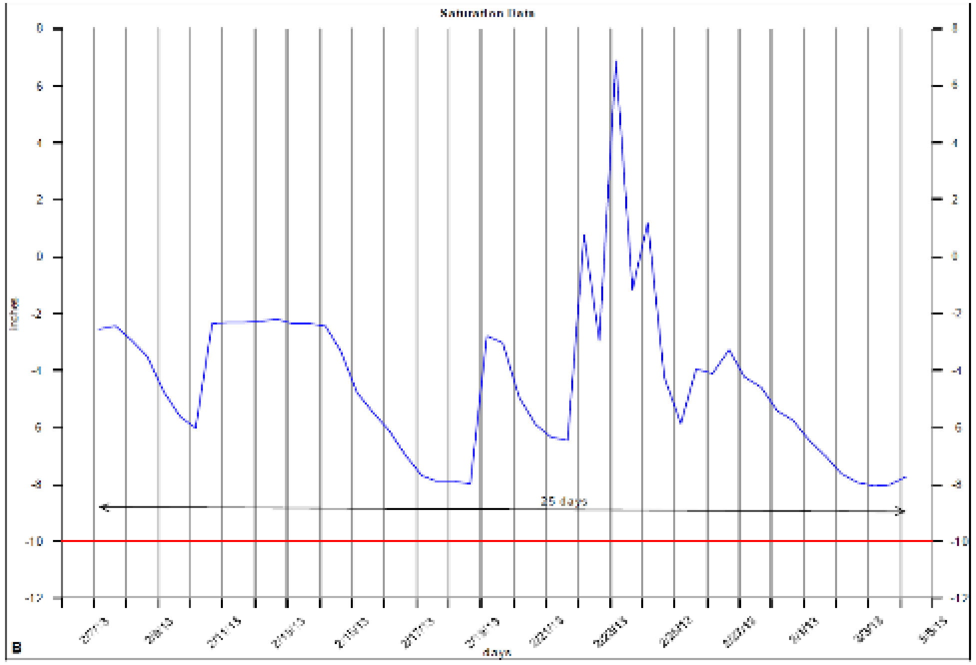
Things to think about from a soils perspective

- How is the water going to get there?
- How are you keeping the water in the upper part to saturate the soil?
- How are you going to keep the water there long enough for it to go anaerobic?
- Have you compacted the soil and if so is that going to affect the hydroperiod needed to replicate functions desired?
- What functions are you trying to replicate and what hydroperiod is needed to do so?
- Do you have enough organic matter at the surface to jump start the microbial processes that provide soil functions?
- Where does the water go once it leaves the wetland?

Tools for Assessing Whether you Have Achieved Soil Hydrology

- **Direct measurements to show that the soil is saturating in the upper part.**
- **Direct measurements to show that the soil is going anaerobic in the upper part.**
- **Identification of physical features in the soil to show that the soil is saturating and going anaerobic in the upper part.**

Soil Saturation

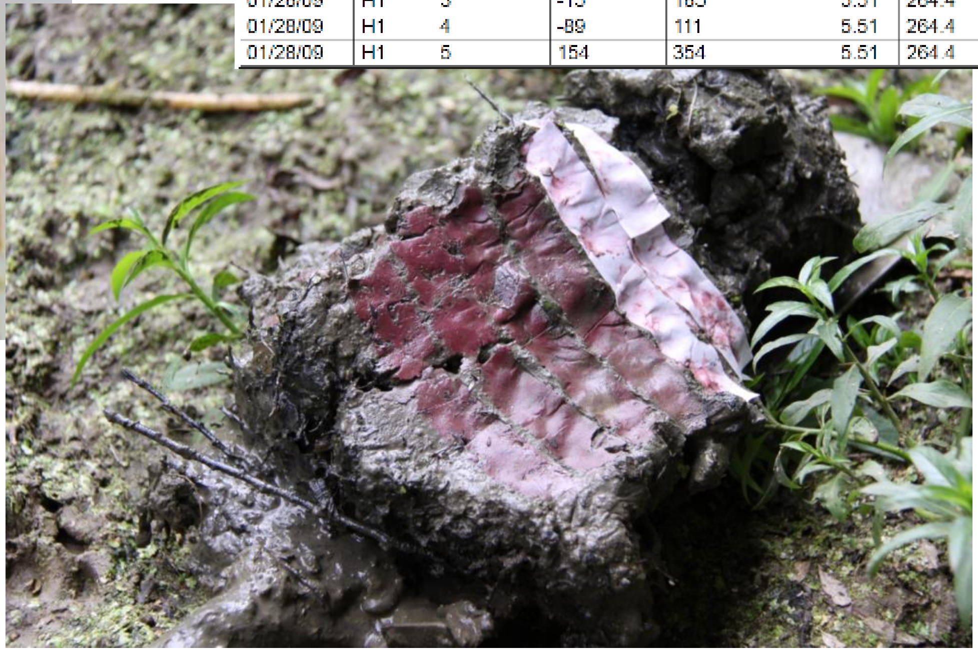


Piezometers or shallow wells

Anaerobic Conditions

Table 4. Example of data from five redox probes at two adjacent sites. N1 is outside the hydric soil boundary, and H1 is inside the hydric soil boundary associated with the same wetland. N1 had one of five probes that was reduced, and H1 had three of five probes reduced on 28 January 2009. H1 would meet the minimum requirements of reduction for that date.

Date	Site	Replicate Probe #	Reading (mV)	Reference Probe Correction (mV)	Soil pH	Required for Reduction (595-60*(pH))	Reduced
01/28/09	N1	1	176	376	6.2	223	No
01/28/09	N1	2	302	502	6.2	223	No
01/28/09	N1	3	163	363	6.2	223	No
01/28/09	N1	4	70	13	6.2	223	Yes
01/28/09	N1	5	306	306	6.2	223	No
01/28/09	H1	1	33	233	5.51	264.4	Yes
01/28/09	H1	2	95	295	5.51	264.4	No
01/28/09	H1	3	-15	185	5.51	264.4	Yes
01/28/09	H1	4	-89	111	5.51	264.4	Yes
01/28/09	H1	5	154	354	5.51	264.4	No



IRIS tubes

Physical Evidence in the Soil

Physical evidence may be evident if the environmental factors are present. However, in many cases in the short period of time that you have to evaluate you may have to look closely to find evidence. Also, if soils were hydric before restoration you must look closely to ensure that features are actively forming around root channels or organic matter and not remnants of the former condition.