Module 5 : Making a Decision if the Site Supports Wetland Hydrology, as Defined for FSA Purposes

2011

In this training module, course participants will be presented with the foundations to making a decision – if under normal circumstances the site in question supports wetland hydrology, as the phrase (wetland hydrology) is defined for FSA purposes. The FSA Wetland Identification Procedures provide for two decision-making options: (1) direct observation and (2) indicators. Normal Circumstances is of critical consideration for this wetland diagnostic factor. The statutory enactment date of December 23, 1985 is critical in the decision-making process for FSA wetland hydrology.

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Module 5 – Making a Decision if the Site Supports Wetland Hydrology, as Defined for FSA Purposes

It's all about the water….

Module Objectives

Familiarize participants with the Corps of Engineers Regional Supplements

Provide basic scientific information on wetland hydrology

Describe wetland hydrology evaluation process

Provide direction for finding tools on-line

Show how to complete field data form for hydrology

Module 5 Outline

1. Key concepts
2. Instructional organization
3. Scientific foundations and principles
    - 3.1. Water budgets
    - 3.2. Landscape Position
        - 3.2.1. Flood plains
        - 3.2.2. Seeps
        - 3.2.3 Flats
        - 3.3.4. Specific Regional Wetlands
    - 3.3. Hydrologic Data
        - 3.3.1. WETS Tables
        - 3.3.2. Climatic Data
    - 3.4. Altered hydrology
        - 3.4.1. Drainage Primer
        - 3.4.2. Compare Past and Present
        - 3.4.3. Drainage System Impacts
4. Wetland Hydrology Indicators
    - 4.1 Hydrology Chapters of the 1987 Manual and Regional Supplements
    - 4.2. Growing Season
    - 4.3. Wetland Hydrology Indicators
        - Group A. Observation of Surface Water or saturated soils
        - Group B. Evidence of Recent Inundation
        - Group C. Evidence of Current or Recent Soil Saturation
        - Group D. Evidence of Other Site Conditions or Data
    - 4.4. Hydrology Tools for Wetland Determinations
5. Difficult Wetland Situations and Wetland Hydrology
    - 5.1. Introduction
    - 5.2. Lands used for Agriculture and Silviculture
    - 5.3. Wetlands that periodically lack indicators of wetland hydrology
        - 5.3.1 Difficult situations caused by dry site conditions
            - 5.3.1.1. Description of the problem
            - 5.3.1.2. Procedure
                - 5.3.1.2.1. Site visits during the dry season
                - 5.3.1.2.2. Periods with below normal rainfall
                - 5.3.1.2.3. Drought years

PART 1 – KEY CONCEPTS

- A wetland isn't a wetland without hydrology (water). This is the most transient of the three parameters needed to define a wetland. One is seeking the preponderance of evidence that indicates whether wetland hydrology is present on the site under **Normal Environmental Conditions***.

- Wetland hydrology is controlled by both spatial and temporal factors. The spatial flow paths to and from a site differ among wetlands. The amounts of water entering and leaving via these flow paths vary at time scales of days, seasons, and years. The quantitative analysis of these water flows constitutes the water budget, a qualitative understanding of which is important for accurate wetland delineation.

- The Regional Supplements list four groups totaling over thirty hydrology indicators that can be used to infer that wetland hydrology occurs onsite: (1) direct observation of surface water or saturated soils, (2) evidence of recent **inundation**, (3) evidence of recent soil saturation, and (4) other evidence. Each site must be examined individually for hydrology indicators.

- Disruption of normal flow paths to and from a site alters both the type and expression of hydrology indicators observed during a field inspection. These physical disturbances can be either artificial or natural, and constitute deviations from **Normal Circumstances** (NC) if they are large enough to change plant community composition or the redox regime of the soils onsite. Physical disturbances (particularly post-1985) affecting onsite hydrology need to be documented during wetland delineation.

- Individual observations provide single-day snapshots from the decades-long hydrologic record that constitutes the 'wetland hydrology' of a site. On-site observations need to be evaluated in the context of recent hydrologic conditions and whether or not these fall within the normal seasonal patterns of hydrology. Normal hydrologic conditions for the wet part of the growing season constitute Normal Environmental Conditions (NEC). See the appendix for further information on NEC.

- Wetland hydrology indicators of inundation or saturation should be noted during the growing season because it is then that biological wetland functions operate most strongly and define a wetland.

* Words defined in the Glossary are printed in **bold** font the first time they are used in the body of the document.

- Difficult situations (Atypical and NEC issues) require additional effort. Chapter 5 of each Regional Supplement covers difficult wetland situations.

- Regardless of the methods used, or indicators discovered, the decision (determination) of presence or absence of wetland hydrology is ultimately based on whether the site under NC and NEC would meet the FSA definition of wetland hydrology.

- The National Food Security Act Manual, 4th Edition **(§**514.6 Wetland Hydrology), states this definition for wetland hydrology:

Wetland hydrology is defined as inundation or saturation by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions. (7 CFR 12.2)

PART 2 – Instructional Organization

The overriding objectives of this Module are to

1. familiarize you with the Hydrology sections of Corps Regional Supplements, including pertinent parts of the 1987 Manual.
2. introduce enough hydrology science that you can independently conduct the hydrology portions of wetland identification.
3. describe the wetland hydrology evaluation process, including use of available tools and providing appropriate documentation.

Instructional Approach

This module has three major parts

1. Technical Background (Sections 3 and 9)
2. The Regional Supplements (Sections 4, 5, and 6)
3. Knowledge assessment (Section 8)

Technical Background (Sections 3 and 9): Read the parts of the Sections 3 and 9 that are appropriate to your knowledge level and geographic region, and go through the exercises

Regional Supplements (Sections 4 – 6): These Sections go through the hydrology portions of the Supplements almost paragraph by paragraph, directing you to read a section of your supplement, asking questions, and providing discussion about points that experience has shown may cause problems.

Knowledge Assessment (Section 8):

1. A quiz is provided at the end of the training sections.
2. Instructions are provided for completing the hydrology portion of the field exercise that you started with the Vegetation and Soils Modules.

Why is this important to me? NRCS is required to maintain a list in each state of personnel who are qualified to complete wetland determinations and delineations. Only those who have had the proper training (as determined by the State Conservationist) and who have demonstrated a proficiency in the proper utilization of the wetland identification methods would be qualified (have job approval authority) to conduct certified determinations. This module is part of the Phase I training to prepare personnel to be qualified to conduct wetland determinations and delineations.

PART 3 - Scientific Foundations and Principles

Part 3 is designed to take 2 hours and includes required exercises. Links are provided as optional learning opportunities. Start time: __________

3.1. Water Budgets

Hydrology creates and maintains all wetlands. For the most part, vegetative composition and soil morphology reflect the long-term hydrology of the site. Prolonged saturation of the soil produces **anaerobic** conditions that favor wetland-adapted plants and promote distinctive soil characteristics. Evidence of CURRENT hydrology is needed to insure that vegetation and soil characteristics are not relics of a previous hydrologic regime.

Hydrology is defined as the science of water, its properties, its distribution and circulation, both on the surface and underground. Understanding the hydrologic cycle is key to evaluating the water budget of an individual wetland site.

Precipitation is a common input of water to any site. Other possibilities include runoff, springs, groundwater, and pumping. Water leaves wetland sites by evapotranspiration, infiltration, groundwater recharge, surface flow, and other means. Developing a water budget for a particular site can be challenging due to lack of quantified values in the water budget. However, some basic information can be usually discerned.

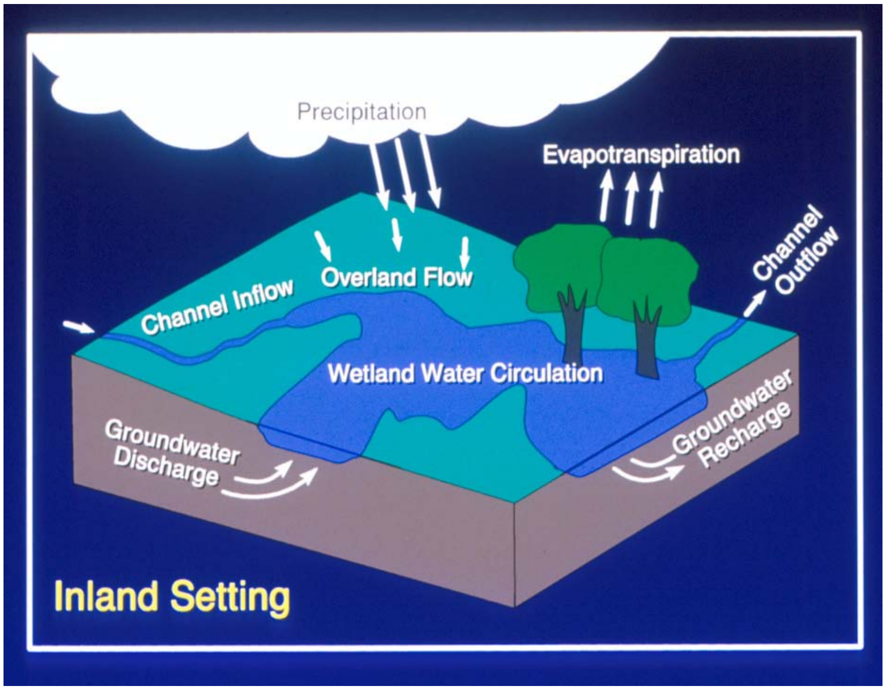
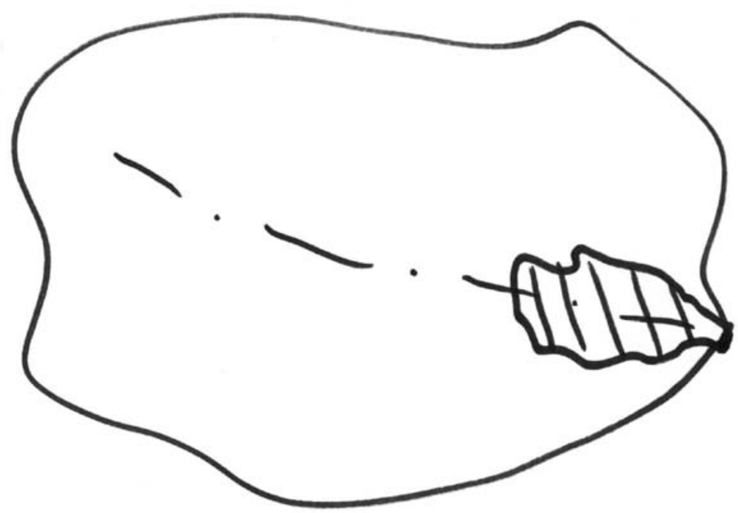


Figure 1. Water Budget/Hydrologic Cycle for an inland site

The **drainage area** above a wetland will indicate how much surface runoff will supply water to the site. Examination of the drainage area (DA) to **pool area** (PA) of the site may indicate that a site needs a source of water in addition to runoff to meet the necessary criteria for wetland hydrology. Water may be stored in a wetland above the surface or within the soil profile. A site that is not overly wet in a year with abundant precipitation but is wetter the following year may be supplied by groundwater which has a lag in time for the water to reach the wetland.



In the sketch at left, the pool area (PA) is the hatched polygon, and the larger polygon is the drainage area (DA). If the DA is 120 acres, and the PA is 10 acres, the DA:PA ratio is 12 (calculated as 120/10).

Water budgets provide comprehensive accounts of why wetland water contents change over time and with management; that is, they demonstrate how terrestrial and meteorological conditions vary. The water budget usually is expressed as

Water Inflows = Water Outflows + Storage.

where inflows include precipitation, run-off from upslope, and subsurface water discharges into the wetland; and outflows are the counterparts such as evapotranspiration, channelized flow out of the wetland, and any subsurface flows away from the wetland (throughflow and recharge) (Figure 1) . Storage is the water in the wetland both above and below ground.

For the purposes of wetland delineation, management, and training it is instructive to focus on the storage component of the water budget, and emphasize that storage is the total wetland water content at any one time under the prevailing management circumstances and hydrologic conditions (Figure 2). Thus, the water budget can be rearranged and relabeled as

Total wetland water content = Water In – Water Out

The total wetland water content refers to the water held within the delineated boundary of the wetland at any one time, including water ponded on the ground surface and water within the soil. In most parts of the country this water content is higher at the beginning of the growing season than later in the summer when the landscape is drying out due to high evapotranspiration. The water content sufficient to maintain hydrophytic vegetation and hydric soils up to the wetland boundary – but not beyond – could be considered the 'full wetland water content' or 'full wetland pool.' External hydrologic inputs necessary

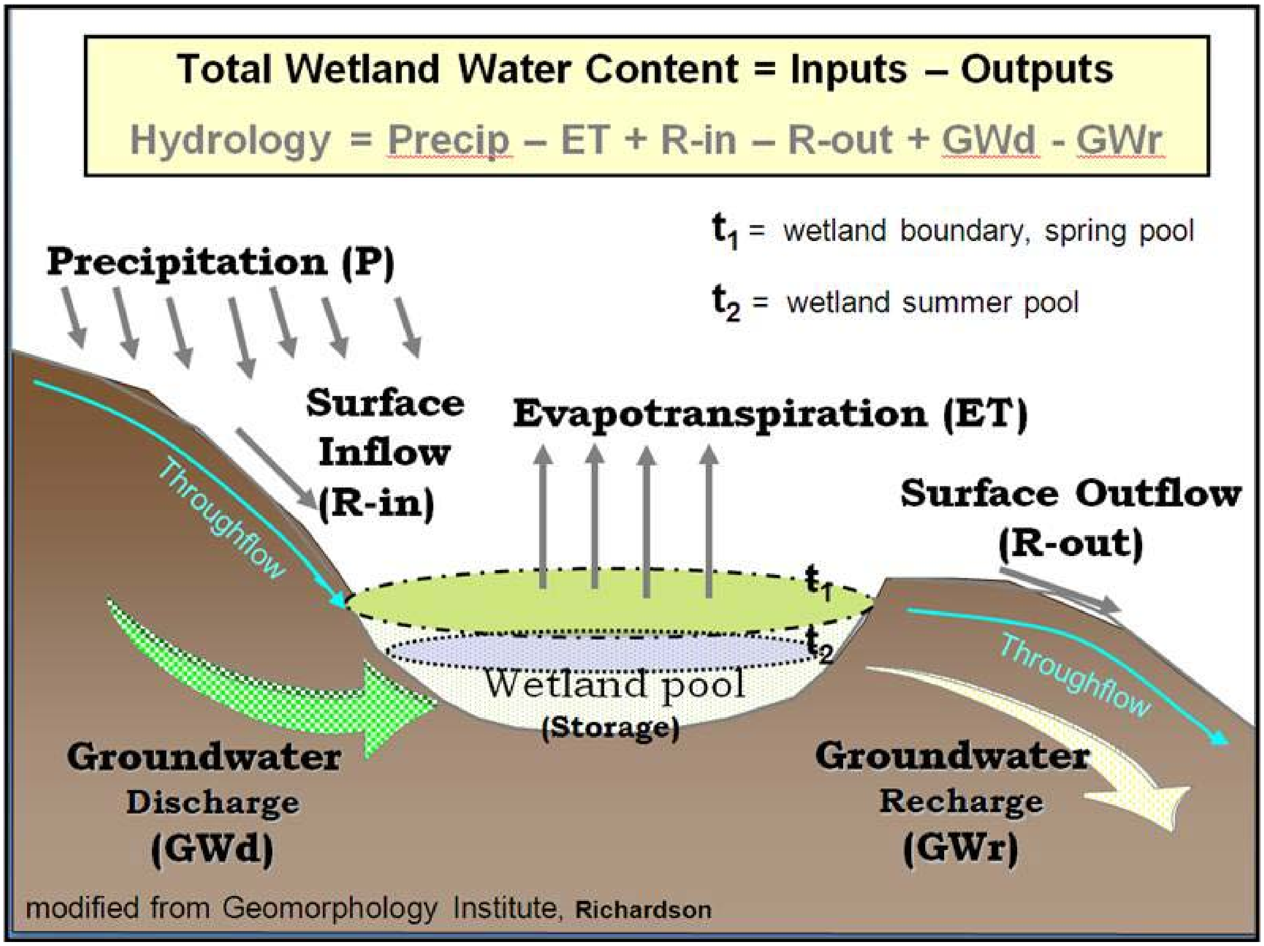


Figure 2. Generalized water budget and major flow paths, with seasonal pools.

to maintain this water content coincide with the concept of Normal Environmental Conditions, and external management practices that maintain this water content are Normal Circumstances. Temporal changes in the total wetland water content result from changes in hydrologic inputs and outflows.

As shown in Figures 1 and 2, forms of input and output are

Table 1. Components of the hydrologic budget for wetlands

Hydrologic Partition	Input	Output
Atmospheric	• Precipitation	• Evapotranspiration
Surface Flows	• Overland Flow • **Flooding** • Flow in streams or ditches entering site	• Any overland flow that may discharge downslope below the wetland on hillside seeps • Flood water recession • Outflow in ditches and streams •
Subsurface Flows	• Groundwater Recharge • Springs entering site	• Groundwater outflow
Artificial Pumping	• Active pumping in	• Active pumping out
Tidal Water	• Tide water flowing in	• Tide water flowing out

3.1.1. Precipitation in the water budget refers only to the rain, sleet, hail, or snow that lands from the sky directly within the boundary of the wetland. It is usually a relatively minor contributor to the water budget. However, at the landscape level precipitation drives and defines the water contents of most wetlands, because wetlands are concentration points on the landscape where rainfall and snowmelt accumulate from areas upslope (Figure 3). Even marshes of the Great Lakes are ultimately influenced by precipitation regimes that cause water levels to rise or fall over the seasons and years. Note that precipitation in mountains may have greatly delayed impacts on the hydrology of distant wetlands that receive large inputs of groundwater flow from the montane recharge areas long distances away (Figure 4).

3.1.2. Evapotranspiration (ET) consists of evaporation directly from the land and water surfaces and transpiration from plants with roots in the wetlands. Transpiration exceeds evaporation during most of the growing season. Evapotranspiration varies temporally, seasonally, and with management. During the summer ET drives the water budget in many wetlands when ET is larger than precipitation inputs (Figure 5). When plants are actively transpiring, even very heavy rainstorms raise **water tables** only temporarily (Figure 6). Surficial water tables fluctuate diurnally with ET. Forest clearing lowers ET and causes water tables to rise because the extensive tree root system has been disconnected from the enormous array of stomata in the canopy. Similarly, densely vegetated prairies transpire more than annual crops because the prairie root systems are more extensive than the crop root systems, just as crops have higher ET than fallow fields.

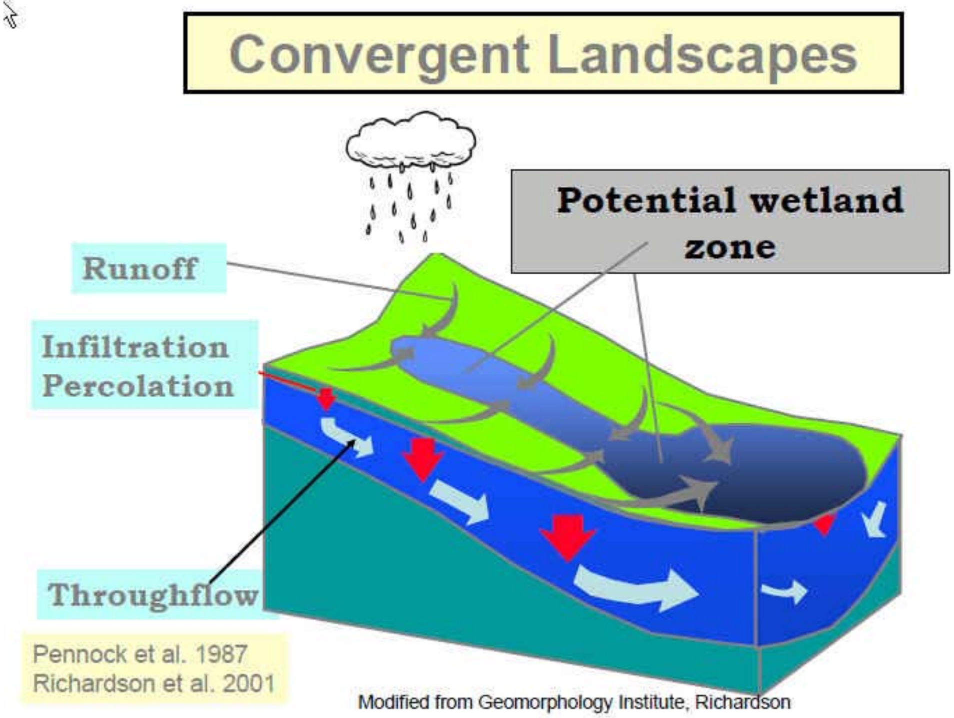


Figure 3. Wetlands form where water concentrates in the landscape.

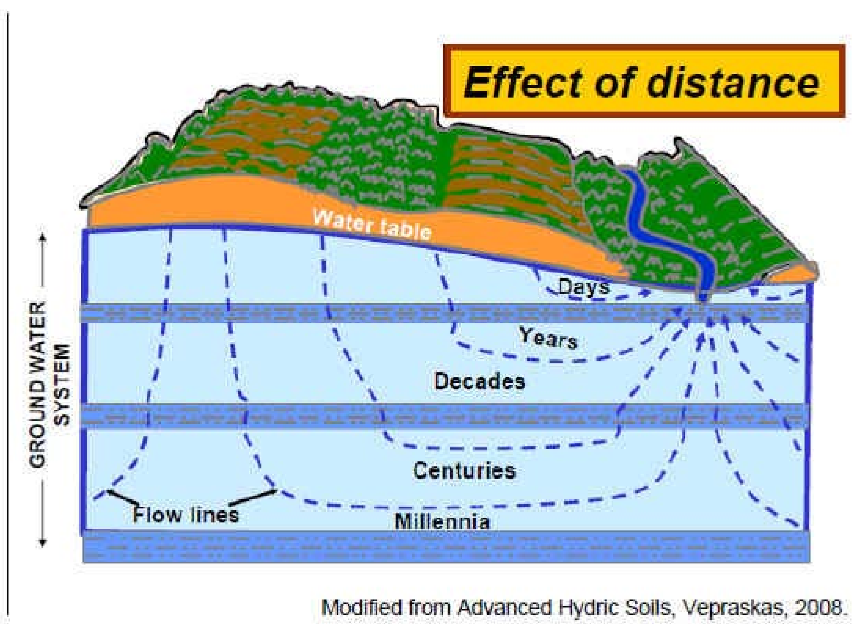
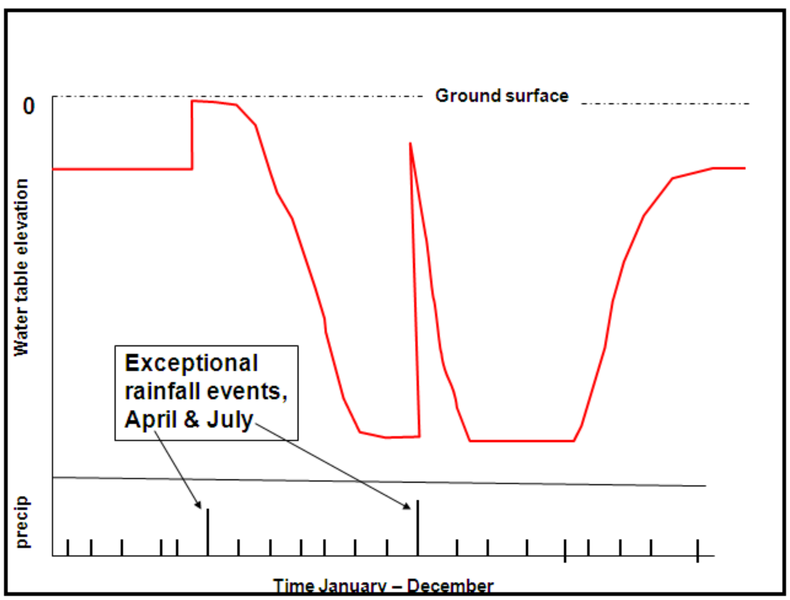


Figure 4. Longer flow paths delay time between recharge rainfall events and discharge into the wetland.

Figure 5. Example when ET exceeds Precipitation

Figure 6. Generalized graph showing water table response to rainfall and ET. The upper graph is water table depth (red line). Lower graph is precipitation spike graph showing individual events (black bars). X-axis is one year of time (months not marked). Water tables drop more rapidly after significant rainstorms in the summer than the early spring. Vertical scales are different for precipitation than for water table.



3.1.3. Surface Inflow (runoff from upslope in the **watershed**) is controlled by the size of the wetland's **catchment** area, the amount of precipitation there, and infiltration into the soil. When upslope soils are saturated, rainfall has nowhere to go but overland. Runoff increases as storms progress and surface soil pores fill up. When soils are frozen water cannot infiltrate so most precipitation becomes runoff. Snowmelt quantities, rates, and timing all interact to have variable influence on the size of the **wetland pool** at the beginning of the growing season.

3.1.4. Surface Outflow usually occurs via channels out of wetlands (Figure 1). Channels can be natural depressional swales or artificial drainage ditches. Surface outflow through ditches is reduced when channels fill with sediment from lack of maintenance. Surface outflow is controlled by the lowest elevation around the wetland perimeter. This is of particular significance in backwater swamps that receive overland flooding. Surface outflow by definition does not occur in 'closed systems,' where water has nowhere to go out of the depressional base of the landscape, except into the ground as infiltration (recharge) or into the air as ET.

3.1.5. Throughflow refers to the shallow subsurface flow of water through the upper horizons of the soil (Figure 2). It is referred to variously as *interflow, shallow subsurface storm flow*, and *storm seepage*.

Lateral hydraulic conductivity can be much greater than vertical hydraulic conductivity if the upper soil horizons are more porous than underlying horizons. Underlying horizons typically have greater clay contents and are denser.

When vertically infiltrating rain water encounters a soil layer that is more difficult to enter (lower permeability or saturated hydraulic conductivity), then the water tends to change direction to a path of less resistance. On sloping land the path of least resistance is generally lateral rather than vertical. The infiltrating water therefore flows downslope through the topsoil, because topsoils usually have greater pore space for water flow than do the denser subsoils. This becomes especially pronounced if the subsoil layer is a sloping **restrictive layer**, such as a fragipan (Figure 7). Other common restrictive layers that enhance throughflow are argillic horizons, dense till, Ortstein, paralithic contacts, etc. Almost any change in soil texture or density that causes saturated hydraulic conductivity to decrease will cause lateral waterflow downslope. In agricultural systems compacted layers due to equipment traffic (traffic or plow pans) can provide the same kind of barrier to vertical infiltration.

This is of particular interest in wetland hydrology because a wetland is usually fed by precipitation water that lands upslope in the catchment area. A wetland at the bottom of the hillslope will receive throughflow inputs from a large drainage area relatively quickly. If most of that same water were to infiltrate to the deeper groundwater table, it could take longer to reach the wetland and could be redirected into deeper flow networks that bypass the wetland (Figure 4).

Figure 7. Throughflow on top of a restrictive layer (Bx/fragipan)

3.1.6. Episaturation and Endosaturation (Perched and Apparent Water Tables)
Episaturation and **endosaturation** are new terms replacing the old terms ‘perched’ and ‘apparent’ water tables.

For wetland science the presence of apparent water tables, or *endosaturation,* is the situation when the surficial aquifer extends from near the ground surface to depths deeper than two meters, without interruption. This is the most common kind of water table or saturation regime. In such wetlands the groundwater rises as discharge from depths in equilibrium with atmospheric pressure. Endosaturation endures weeks to months and excludes short term infiltration after a heavy rainstorm, shortly after which the upper soil returns to an unsaturated condition.

For wetland science, *episaturation* replaces the older term *perched water table*. Episaturation occurs over a layer that restricts water flow so much that surficial water inputs and outflows dominate the water budget of the surficial aquifer. If water leaks downward or upward through the aquitard, the quantities and rates are insignificant with respect to the water budget of the episaturated layer.

For field identification, episaturation is the condition where the soil is saturated in a horizon that overlies an unsaturated horizon and the unsaturated horizon lies within a depth of two meters from the surface. Check local Soil Survey tables (Customer Service Toolkit with Soil Data Viewer, eFOTG, Web Soil Survey, Soil Data Mart,) for information on whether perched water tables are likely in the soils in the area. The Soil Features table lists restrictive layers. The table of Physical Soil Properties reports whether saturated hydraulic conductivity is significantly lower in the perching layer. The Water Features table reports whether water tables are perched in such soils.

Note that episaturation is not limited to wetlands. Episaturated layers may be deep enough and sloping enough that the soils there are only somewhat poorly drained and are not hydric. Wetland hydrology only occurs if episaturation is shallow enough and persistent enough to meet wetland definitions.

Episaturation may be temporary. When a precipitation event occurs after several weeks of dry conditions, a band of water may move through the soil profile with dry bands above and below it.

3.1.7. Groundwater recharge and discharge (Figure 4). Recharge is the rain water that infiltrates vertically into the upper part of the landscape (usually uplands) and enters the groundwater. Discharge is the groundwater that later (after recharge) breaks through the land surface further down grade and discharges in the land surface as a spring, seep, wetland, or riverbed outflow.

Water flow paths underground are not immediately intuitive. Water flows preferentially through porous strata in landforms with horizontally stratified geology, such as sedimentary rocks, glacial complexes of till and outwash, alluvial systems with gravelly bed deposits and silty floodplain sediments, etc. Precipitation that infiltrates vertically to porous layers will be diverted laterally, sometimes intersecting the land surface as seeps, springs, or stream channels (Figure 8). Wetlands form preferentially in such discharge points. In relatively unstratified landforms water flows along flow paths determined by gradients in hydraulic head as the groundwater slowly migrates to outflow points at low areas of the landscape such as streams or wetlands (Figure 9). In both cases, the further water has to flow underground, the longer it takes to reach its outflow point (Figure 4). This is why some wetlands experience a lag in between a precipitation event and a water level change in a wetland. In wetlands maintained by strong groundwater inputs, the inflow may be independent of annual rainfall cycles.

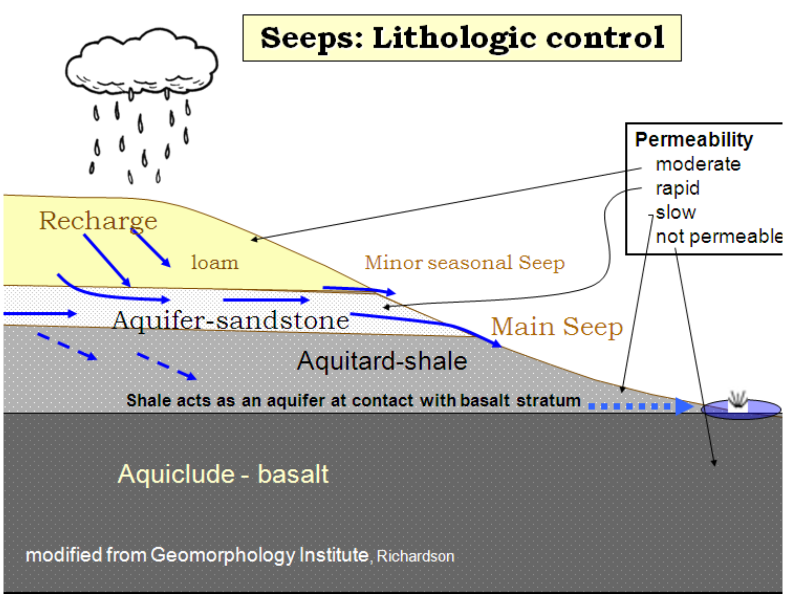


Figure 8. Recharge water diverted laterally to seeps due to strata with different permeabilities.

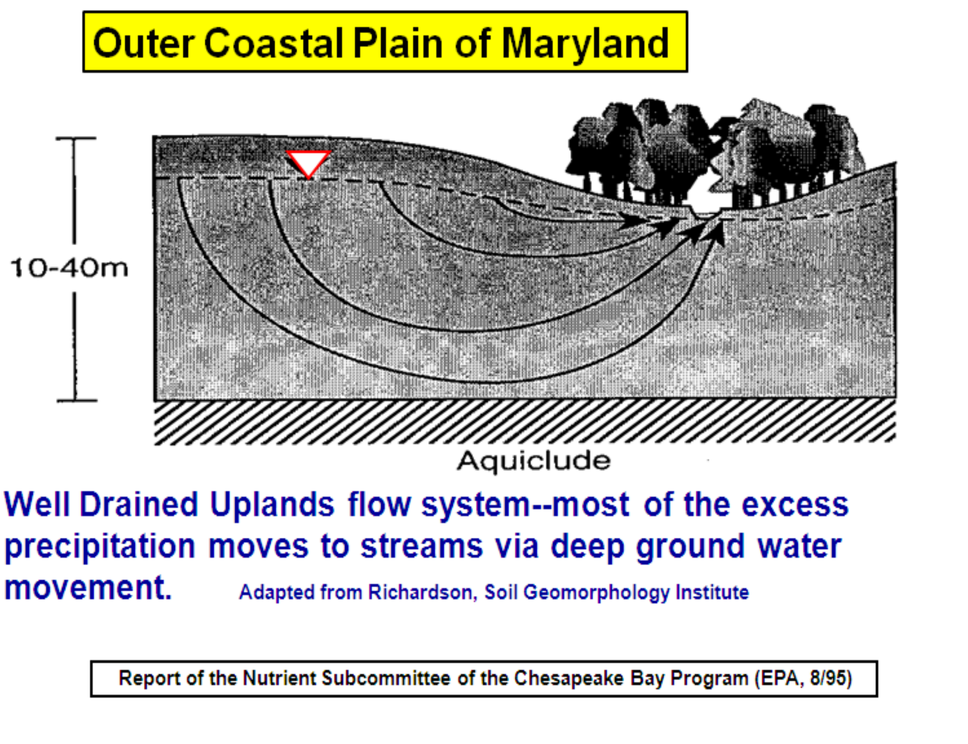


Figure 9. Relatively unstratified groundwater flow, discharge at stream and riparian fringe.

3.1.7. Floodwater inundation and recession are special forms of overland flow where the water source is usually well outside of the wetland's immediate catchment basin. They are particularly important to analyze because not all floodplains are wetlands. See discussion in Section 3.2.1.

3.2. Landscape Position

Geomorphic setting or landscape position is helpful to identify wetlands and understand their water budget. Three common landscape positions on which wetlands are found include lacustrine sites (adjacent to lakes), riverine sites, and depressional sites (often potholes). The water budget for a lacustrine site is frequently closely linked to the adjacent lake; use of lake level data may help evaluate a lacustrine wetland's response to precipitation and other inputs of water. A riverine wetland site's water budget is closely linked to the flows in the adjacent stream. Use of stream gage data may help to understand the water budget of a riverine site. Depressional sites may be connected to other depressions or function independently. Groundwater inputs may vary between recharge and discharge depending on the time of year and recent weather events.

The drainage area above a wetland influences how much surface runoff water reaches the site. Examination of the drainage area to pool area of the site may indicate that a source of water in addition to surface runoff may need to be identified in order to understand how the site meets wetland hydrology criteria..Water may be stored in a wetland above the surface or within the soil profile. A site that is not overly wet in a year with abundant precipitation but is wetter the following year may be supplied by groundwater which has a lag in time for the water to reach the wetland. Areas adjacent to the coast and great lakes may also have tidal influence in their water budget.

The relative sizes of the water budget components vary with landscape position. Some specialized situations are discussed below.

3.2.1. Floodplain backwaters. Floodplains contain more uplands than beginning wetland delineators may expect. The land closest to the river may be the highest and drain the best, while the land furthest from the river may be the lowest, wettest, and drain the most slowly. (Figure 10). During a flood event the sediment load in the flood water drops out along a gradient. The fastest flowing water is in the channel and right next to it and the largest particles drop out there. Gravels and sands drop out in the channel and sands and coarse silts drop out on the levee. Fine sands and silts drop out next on the backplain. The finest particles drop out in the back swamp, with silts and clays furthest from the channel.

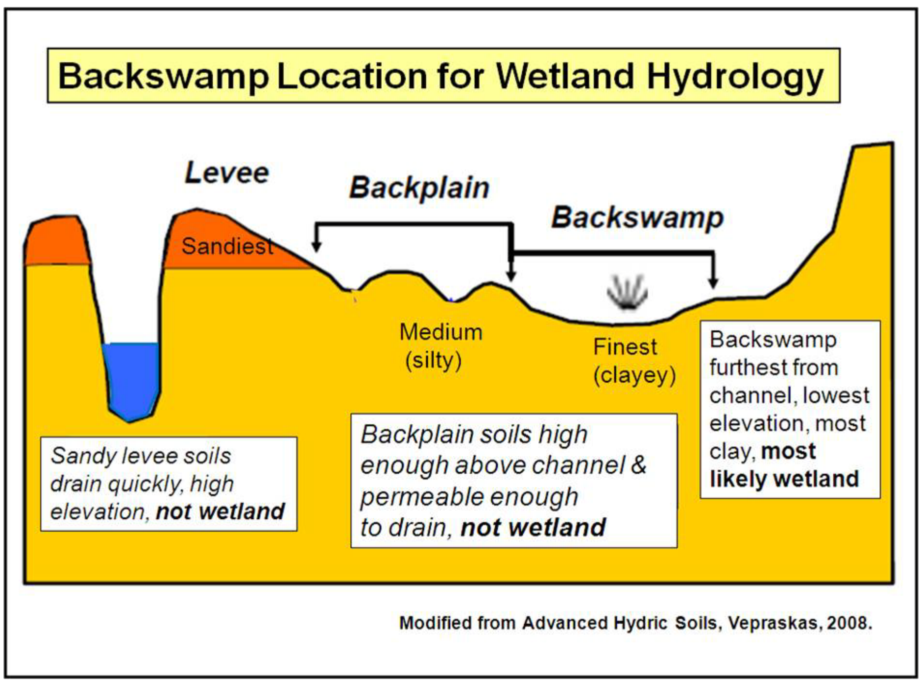


Figure 10. Riverine hydrology

After the floodwaters have drained off the land surface, subsurface flow becomes important and drains the floodplain towards the channel, which acts as a large drainage ditch. Subsurface flow is enhanced where floodplains are stratified with sand and gravel layers in a network of abandoned, buried channel beds. These formed as the river meandered back and forth across the floodplain over time.

In humid parts of the country rivers are called “gaining streams” because they receive significant amounts of water from the river valley and its side slopes via groundwater discharge and throughflow (Figure 11). Groundwater discharge will often continue to deliver water to the backswamp long after floodwaters have receded. Depending on how porous the alluvial sediments are and how far away the channel is, the stream may act as a drainage ditch and pull water via subsurface flow out of the swamp. The balance between such outflows and the compensating inflows from the river valley determines whether the backwater position develops into a wetland that meets the wetland hydrology criteria. Some floodplain wetlands are maintained by high groundwater supported directly by the stream water surface profile, and seldom experience long term flooding.

Figure 11. Water flow paths into a floodplain

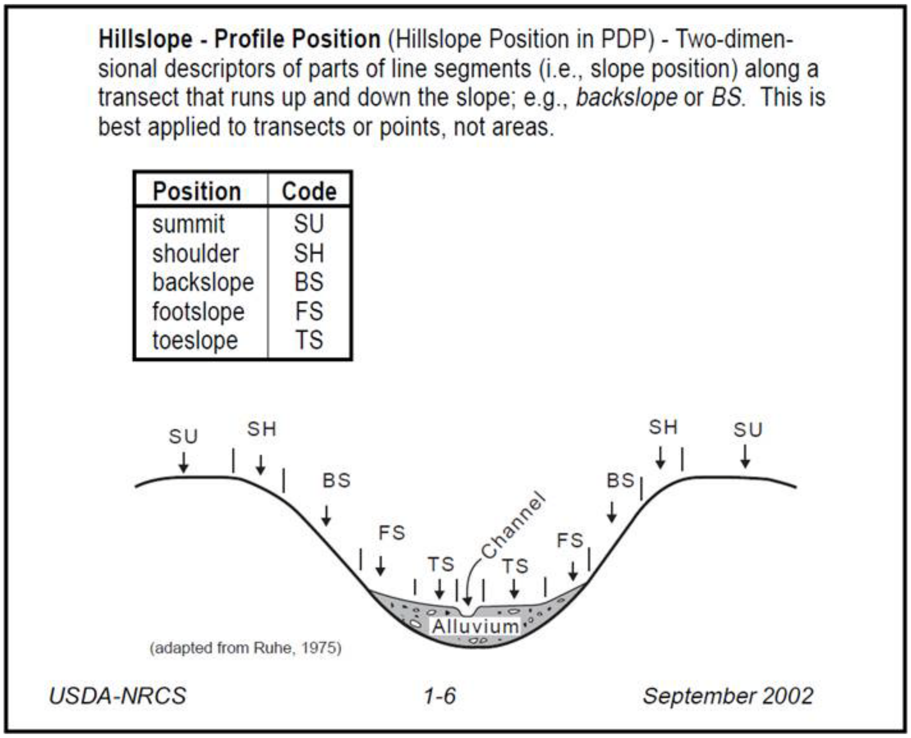
In arid parts of the country rivers are called “losing streams” because channel water actually seeps *into* the ground. Wetlands in such streams may be confined to sand and silt bars deposited between active channel braids.

3.2.2. Seeps. Groundwater discharge is the dominant water-budget factor in seeps and springs (Figure 8). Precipitation in recharge areas ultimately controls seep discharge, but the time lag can be large (Figure 4). Also, the subterranean recharge area can be much larger than most wetland catchments. Consequently, seeps may remain wet longer into a dry season than wetlands with more direct precipitation control.

Seeps vary depending on stratigraphy. Hillside springs often have source strata that carry water a long distance from large areas. Water flow within strata may be complex. Note in Figure 8 that the slowly permeable shale layer acts as an **aquitard** with respect to the highly permeable sandstone and as a minor **aquifer** with respect to the impermeable basalt. Sand seams can carry water preferentially as well..

Seeps often occur at the bases of hills, where the slope becomes more level and water concentrates, such as toe slopes and some foot slopes (Figure 12). This effect is more prominent where slopes are concave both up-and-down and across (CC configuration in

Figure 13). Consequently, in hilly or rolling landscapes, wetlands are most likely to develop at bases of head slopes where side slopes are curving in on themselves rather than diverging apart (Figure 14). This effect is not limited to hilly topography; it occurs wherever adjacent slopes contribute to water accumulation in wetlands, from both surface runoff and throughflow.



Hillslope - Profile Position (Hillslope Position in PDP) - Two-dimensional descriptors of parts of line segments (i.e., slope position) along a transect that runs up and down the slope; e.g., *backslope* or *BS*. This is best applied to transects or points, not areas.

Position	Code
summit	SU
shoulder	SH
backslope	BS
footslope	FS
toeslope	TS

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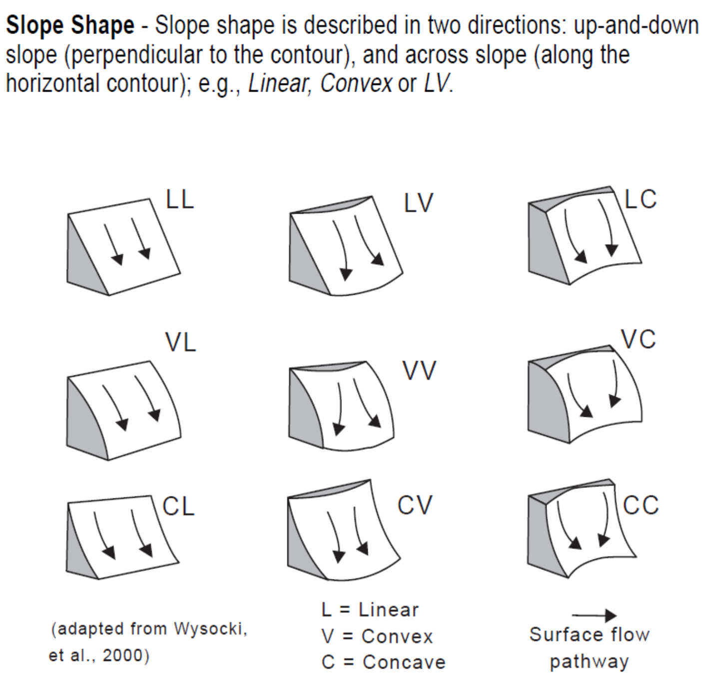
Figure 12. Schematic of hillslope positions. See explanation within figure. Water flowing downslope as run-off or throughflow will accumulate at concave landform positions, such as toe slopes or even footslopes. See Figure 13, too.



Slope Shape - Slope shape is described in two directions: up-and-down slope (perpendicular to the contour), and across slope (along the horizontal contour); e.g., *Linear, Convex* or *LV*.

Figure 13 Wetland hydrology most likely occurs where slope shapes converge, configuration CC.. (from NRCS, *Field Book for Describing and Sampling Soils).*

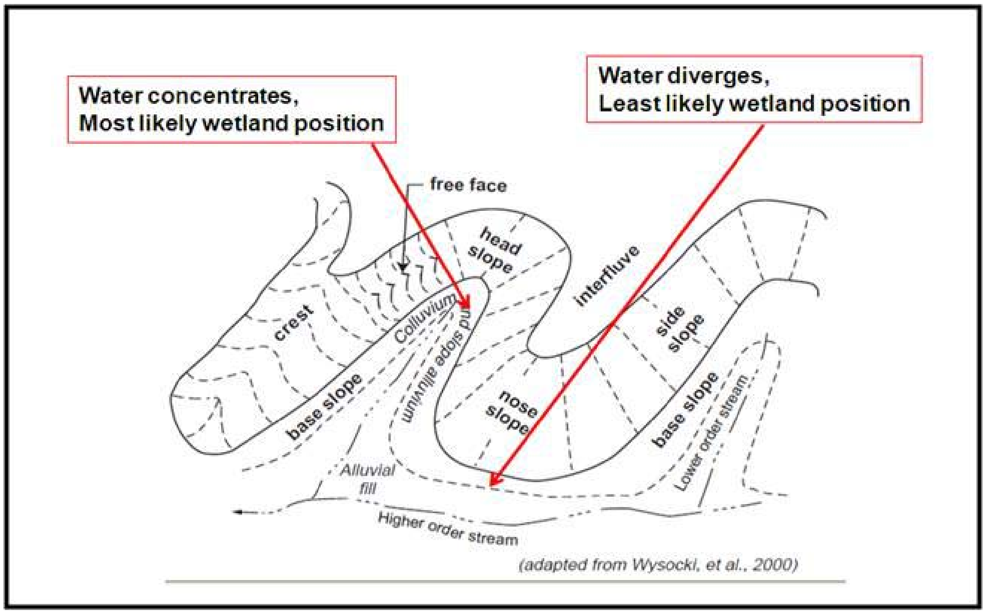


Figure 14. Wetland hydrology most likely at the bases of head slopes (from NRCS, *Field Book for Describing and Sampling Soils).*

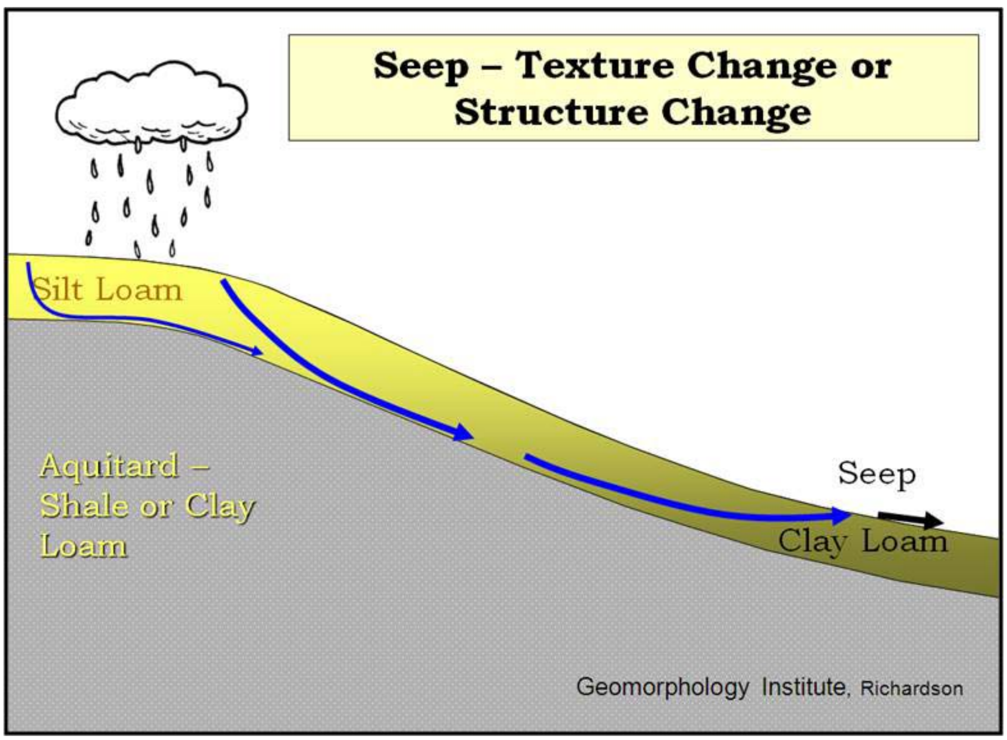


Figure 15. Seeps can form at texture changes in slopes.

Seeps may occur on slopes where soils become less permeable, for example, because of texture or changes in slope. (Figure 15). In these cases water flows laterally downslope along the boundary with the underlying aquitard. Water breaks out at the soil surface when it hits a less pervious layer (clay loam versus silt loam) or when water accumulates behind more slowly moving water where the gradient decreases.

3.2.3. Flats – In the humid east precipitation and evapotranspiration dominate the water budgets of large flat areas well away from streams and valleys (Figure 16). Surface water flows are slow because of very flat topography. Even in open depressions where surface water can eventually flow out, distances are so great and gradients so slight that water runs out of these systems more slowly than it is added by precipitation. Consequently, it tends to concentrate in the low areas, especially during seasons of low ET.

It is often difficult to identify wetland boundaries on flats because they dry out in most summers, but they provide important habitat functions.

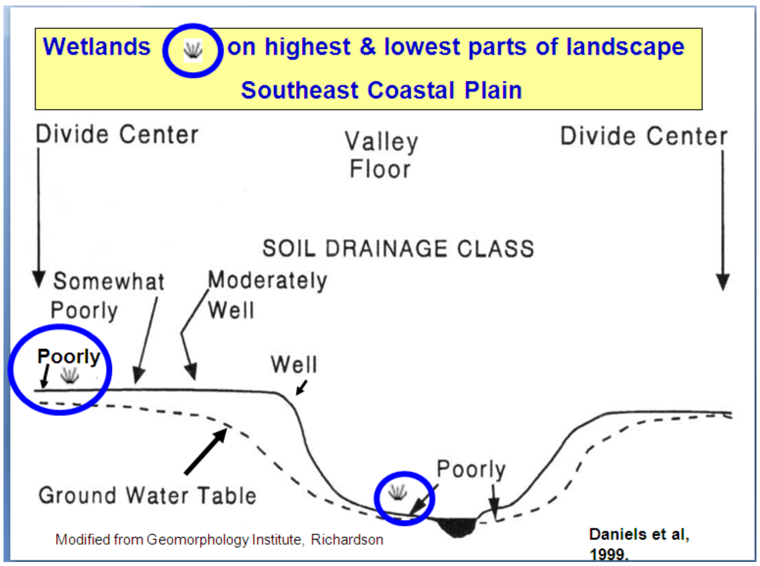


Figure 16. In the humid east wetlands are found at the lowest and highest parts of the landscape, including broad flats between distant river valleys.

3.2.4. Specific Regional Wetlands

Why is this important to me? You should become familiar with the stratigraphy and hydrologic flow paths that occur in the major types of wetlands in your area of responsibility. The Supplements give excellent overviews of their wetlands in *Chapter 1, Introduction, Types and distribution of wetlands*.

Instructions.

Skim the Introduction to your Supplement: "Types and distribution of wetlands." Try to figure out the major flow paths to the water budgets for a couple of the wetland types you are familiar with.

Skim the discussions of wetland types below, reading those that are significant to your Supplement.

Potholes – Potholes are shallow, water-holding depressions of glacial origin found in the prairies of the north central United States. To form, blocks of glacial ice occupied positions on the landscape long enough that sediments accumulated around them. After the ice melted, holes remained. These can be of many sizes and shapes. The Prairie Pothole Region of the Midwest and Great Plains is wetland-rich and known for its habitat for migratory waterfowl. European settlement brought drainage to this area. The potential for altered hydrology should be considered at these sites. They may have both groundwater discharge and surface runoff as hydrologic inputs

Prairie Wetlands – These occur throughout the Midwest and include seasonally flooded basins, wet prairies, sedge meadows, shallow and deep marshes, and open water systems. The hydrology of these sites ranges from saturated only to inundated with several feet of water.

Playas - Playas are shallow basins or ephemeral lakes that are dry most of the year, but fill naturally following rainstorms. Playas of the Southern Great Plains differ in morphology and hydrodynamics from those of the Mojave and Great Basin Deserts. Groundwater inputs usually are less than precipitation and overland inputs from their catchment basins. In both Texas and the far Southwest, ET is very high. Often clay soils line the basins and prevent surface water from percolating into the underlying water table. They typically are maintained by surface runoff, which is perched on a shallow aquitard, and have little groundwater inflow.

Beach Ridges – Glaciers formed ridges where the coarser material was deposited. These often have relatively rapid permeability and despite their height, convey water rapidly to the glacial plain. Wetlands at the base of beach ridges are often kept wet by the watershed above them in the beach ridge.

Bottomland Hardwood Forests – These extensive wetlands are located in the floodplains of large river systems, but they are more complex than the simple system described in Section 3.2.1. above. Large river systems have many abandoned channels and backwaters, so hydroperiods have changed in the various floodplain landscape positions. Some areas can share the characteristics of flats while others stay wet so long they are forested swamps. Bottomland hardwood forests are under considerable pressure for agricultural development.

Tidal Pools – Tidal wetlands border or lie beneath tidal waters and are subject to tidal action These include areas currently or formerly connected to tidal waters, and areas whose surface is at or below an elevation of one foot above local extreme high water. Tidal wetlands support a diverse wetland ecosystem of wildlife and hydrophytic vegetation. In general, tidal wetlands form in low energy environments protected from direct wave action. Low marsh areas are flooded by tidal waters twice a day, while high marsh areas are flooded a few times per month.

Wetlands Adjacent to Lakes – Low-lying land adjacent to lakes is influenced by the fluctuation of the lake. The adjacent area may lie just low enough in the landscape to remain saturated for long periods of time, if not permanently, due to the proximity of the open water. Unique species of vegetation often occupy these spaces. The soils may be very rich in organic matter.

Sand Dunes -- Along sea coasts and in deserts wetlands form in the swales between sand dunes. Sand dunes move with the wind across surfaces that are resistant to wind erosion. In dune fields this resistant feature often is the top of the capillary fringe of the surficial water table. The bulk of the dune field acts as a mulch to reduce evaporation out of the shallow water table, and the dunes themselves hold surprising amounts of water. Wetlands are found only in the lowest areas; don't be misled by how dry the sand dunes appear, because it is common for wetlands to form in the lowest areas between dunes. It has been said with only slight exaggeration that "Sand dunes are the driest lands in the Eastern US and the wettest in the Western US."

3.3. Hydrologic Data

Why is this important to me? These next two sections (3.3, Hydrologic Data) and (3.4, Altered Hydrology) discuss the background for filling out three critical lines on the Army Corp of Engineers Wetland Data Form. The hydrology sections of most of the Regional Supplements are focused on resolving problems identified in these three lines.

Section 3.3- Hydrologic Data will cover:

- Are climate/hydrological conditions on the site typical for this time of year?
- Is Vegetation, Soil, or Hydrology naturally problematic?

Section 3.4- Altered Hydrology will cover:

- Is Vegetation, Soil, or Hydrology significantly disturbed?
- Is Vegetation, Soil, or Hydrology naturally problematic?

The evaluation of the hydrology for a site is often an examination of the data available about the site and looking for the preponderance of evidence to know whether wetland hydrology criteria are met. Hydrologic data can assist with making this evaluation. These include stream gage data, monitoring well data, aerial photography, precipitation records, and lake level data. Of value also are the National Wetlands Inventory (NWI) maps and USGS quadrangle maps. A specific site may have useful survey data, soil temperature data, climate data, as-built plans, or other unique information. The decision about the presence or absence of wetland hydrology is often based on the preponderance of evidence so all relevant data should be considered.

3.3.1. WETS Tables

When using a sequence of aerial images NRCS has a procedure in the Engineering Field Handbook Chapter 19 (EFH19), "Hydrology Tools for Wetland Determination" for relating the precipitation data to what is seen in an individual aerial image. The procedure uses WETS data tables developed by the NRCS Water and Climate Center (WCC) in Portland, Oregon. A WETS table has been developed for each National Weather Service (NWS) climate station that has sufficient data to calculate ranges of normal for temperature and precipitation . These are available from the website www.wcc.nrcs.usda.gov . Figure 16 gives an example of a WETS table.

These provide statistical data about the amount and likelihood of precipitation at a given station. These use a 30-40-30 breakdown where 30% of the values in any given month are "dry", 40% are "normal" and 30% are "wet".

Participant Exercise #1

Use the website below to obtain and view a WETS table for a location of your choice. It is suggested that you choose a location you are familiar with. After choosing the state and county, look at the WETS table for the site of your choice. Determine the upper and lower boundaries for the month of June. These are labeled under precipitation on the table and are the two columns for "30% chance will have /less than/more than/".

http://www.wcc.nrcs.usda.gov/climate/climate-map.html

In the WETS table for Litchfield, MN on the next page, the June value for 30% less than is 3.17" and the value for 30% more than it is 5.96 inches.

```
WETS Station : LITCHFIELD, MN4778                  Creation Date: 09/06/2002
```

Latitude: 4507 Longitude: 09432 Elevation: 1130
State FIPS/County(FIPS): 27093 County Name: Meeker
Start yr. - 1971 End yr. - 2000

Month	Temperature (Degrees F.) avg daily max	avg daily min	avg	Precipitation (Inches) avg	30% chance will have less than	more than	avg # of days w/.1 or more	avg total snow fall
January	20.9	1.5	11.2	0.81	0.44	1.01	2	10.3
February	28.0	8.9	18.5	0.65	0.31	0.80	2	6.4
March	40.1	21.3	30.7	1.56	0.98	1.89	3	8.2
April	57.3	34.5	45.9	2.33	1.32	2.84	5	2.3
May	71.3	47.2	59.2	3.20	2.32	3.77	7	0.0
June	79.8	56.6	68.2	4.95	3.17	5.96	8	0.0
July	83.4	61.2	72.3	4.12	2.74	4.94	7	0.0
August	80.9	58.8	69.9	3.71	2.54	4.42	6	0.0
September	72.4	48.8	60.6	3.03	2.00	3.64	5	0.0
October	59.6	37.4	48.5	2.22	1.04	2.71	4	0.3
November	39.1	22.8	30.9	1.48	0.67	1.81	3	8.6
December	25.2	8.3	16.8	0.69	0.37	0.84	2	7.7
Annual	-----	-----	-----	------	22.39	31.68	--	----
Average	54.8	33.9	44.4	------	------	------	--	----
Total	-----	-----	-----	28.75	------	------	54	43.9

GROWING SEASON DATES

Probability	Temperature 24 F or higher	28 F or higher	32 F or higher
	Beginning and Ending Dates Growing Season Length		
50 percent *	4/ 7 to 10/20 196 days	4/20 to 10/ 7 170 days	5/ 3 to 9/29 149 days
70 percent *	4/ 3 to 10/25 204 days	4/14 to 10/12 181 days	4/29 to 10/ 3 158 days

* Percent chance of the growing season occurring between the Beginning and Ending dates.

Figure 16. Sample WETS table

Participant Exercise #2

Using the procedure from Participant Exercise #1, download the WETS table for Redwood County, Minnesota and navigate to the data for Redwood Falls. Answer the three questions below using that table and the rainfall data which follows the three questions.

1. During which years (1991 to 2005) was the total annual precipitation within the normal range?

2. During 2004, in which months was rainfall “dry” or below the lower 30% chance line?

3. During 2000, in which months was the rainfall “wet” or above the higher 30% chance line?

Precipitation data by month and year

Station : MN6835, REDWOOD FALLS FAA AP
------- Unit = inches

yr	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	annl
91	0.19	0.83	2.11	4.12	5.43	7.55	5.51	2.14	5.48	1.14	2.15	0.15	36.80
92	0.73	0.44	1.60	2.29	1.46	3.81	2.65	4.67	2.71	2.54	1.52	0.67	25.09
93	0.45	0.68	1.47	1.64	5.07	11.55	6.67	3.74	1.87	1.01	2.22	0.98	37.35
94	0.97	0.58	0.26	5.34	1.56	2.26	1.25	8.11	3.27	1.94	1.23	0.22	26.99
95	M0.06	0.11	3.54	4.00	4.35	3.68	6.58	3.03	3.11	2.73	0.71	0.70	32.60
96	1.86	0.06	1.03	0.49	3.74	4.45	2.37	4.64	1.29	2.32	3.82	1.98	28.05
97	0.98	0.55	1.07	1.49	1.63	2.99	4.46	2.92	1.44	0.83	0.82	0.33	19.51
98	0.77	0.84	3.12	1.04	2.67	3.99	3.91	1.73	1.05	4.25	0.72	0.26	24.35
99	1.35	0.37	0.93	3.27	4.78	3.49	2.37	6.81	1.48	0.93	0.19	0.31	26.28
00	0.82	1.55	0.71	1.37	4.95	3.13	4.82	1.72	0.45	1.27	2.42	0.29	23.50
01	1.13	0.83	1.30	7.55	2.18	2.32	2.26	0.87	2.90	0.61	M3.12	0.60	25.67
02	0	0.19	1.87	1.94*	3.17	3.06	3.21	5.70	0.72	2.74	0.09	0.18	22.87
03	0.29*	1.08	0.56	2.13	3.49	2.44	3.04	1.61	2.54	0.56	0.85*	0.66*	19.25
04	0.50	0.81	0.81	1.02	14.50	3.63	4.04	4.01	5.92	1.14	0.59	0.09	37.06
05	0.67	0.76	0.52	1.36	4.20	5.23	3.30	2.62	6.64	2.57	2.11*	0.91	30.89

* - county averaged used; data missing
M - data missing but less than 3 days and believed not to affect total

Answers:

1. ***1992,1994, 1996, 1998,1999,2000, 2001, 2002***
2. ***March, April, November, December***
3. ***February, May, July, November***

Question: Go to the eFOTG and find last month's precipitation data for the weather station whose WETS table you downloaded in Exercise 1 above. Current, recent, and archival weather data are available on the eFOTG in Section II, Climatology, AgACIS (Agricultural Applied Climate Information System). Choose Daily Data for a Month for daily precipitation data, or Monthly Averages/Totals for monthly data.

Was last month within the range of normal for your weather station? How about the current month?

Discussion: The precipitation analyses of the WETS tables are subject to the similar caveats that apply to growing season analyses:

1. The tables are better in flat parts of the country with dense networks of weather stations than in mountainous or sparsely populated regions, because precipitation varies spatially and with elevation and proximity to water bodies.

2. Precipitation analyses vary with scale. Precipitation within any particular month may be within the range of normal for those 30 calendar days but wetland biota may still be experiencing water excess or deficit if the preceding several months have been excessively wet or dry, respectively. This will be discussed more thoroughly below.

3. The WETS tables are going to be updated after 2010 data are available. Climatological normals are calculated for 3-decade periods of time; the current 3-decade period of analysis is January 1, 1971-December 31, 2000. The next version will be for 1981-2010, and will be published sometime in 2011.

Figure 17 on the next page is a sample of a rainfall spreadsheet that applies the procedure in Engineering Field Handbook Chapter 19 (EFH19), "Hydrology Tools for Wetland Determination" so that the data can be used to examine aerial imagery near Vesta, Minnesota and relate climate data to the wetland hydrology signatures that may be seen in aerial images. This type of spreadsheet is a tool which speeds application of the EFH19 procedure in a county or other area for which a given climate station is applicable. The information from the WETS table is summarized in the box at the lower left and used in calculating the monthly wetness evaluation. An example of the spreadsheet complete with working formulas is at http://www.mn.nrcs.usda.gov/technical/eng/Wetland_Hydrology.html for Jordan, Minnesota.

Rainfall Data Vesta

Station No.	21-8520											
Redwood County												
	Monthly Rainfall in Inches					Monthly Wetness Evaluation 30 % Chance					July Slides April - June	
Year	April	May	June	July	August	April	May	June	July	August	Product	Eval.
1979	2.09	4.72	5.47	3.66	8.97	2	3	3	2	3	17	3
1980	0.67	2.83	5.05	1.77	6.80	1	2	3	1	3	14	2
1981	1.79	0.96	4.28	5.06	5.67	2	1	2	3	3	10	2
1982	2.96	4.52	4.02	8.92	2.94	2	3	2	3	2	14	2
1983	2.14	2.59	4.16	1.99	1.50	2	2	2	1	1	12	2
1984	4.89	2.23	6.40	2.98	1.35	3	2	3	2	1	16	3
1985	4.42	2.82	3.59	2.39	8.02	3	2	2	1	3	13	2
1986	3.47	2.80	2.28	7.10	3.36	3	2	1	3	2	10	2
1987	0.59	3.26	3.43	5.33	1.21	1	2	2	3	1	11	2
1988	2.60	2.38	1.04	1.52	2.67	2	2	1	1	2	9	1
1989	2.81	1.19	2.70	3.76	1.13	2	1	2	2	1	10	2
1990	1.95	4.79	6.25	5.90	4.20	2	3	3	3	2	17	3
1991	4.12	5.39	10.05	7.24	2.68	3	3	3	3	2	18	3
1992	2.15	1.10	5.66	3.79	4.77	2	1	3	2	3	13	2
1993	1.98	5.89	11.88	6.36	4.80	2	3	3	3	3	17	3
1994	4.61	1.58	3.22	2.25	8.84	3	1	2	1	3	11	2
1995	4.04	3.67	2.43	8.40	2.34	3	2	1	3	2	10	2
1996	0.45	4.05	3.27	2.46	4.95	1	3	2	2	3	13	2
1997	2.24	1.12	3.18	5.36	2.08	2	1	2	3	1	10	2
1998	0.75	1.74	3.78	4.14	2.12	1	1	2	2	1	9	1
1999	2.91	3.90	1.91	1.88	4.92	2	3	1	1	3	11	2
2000	1.41	4.73	3.20	8.66	2.48	1	3	2	3	2	13	2
2001	4.97	2.49	2.37	3.00	1.06	3	2	1	2	1	10	2
2002	2.00	2.43	4.32	3.82	4.87	2	2	2	2	3	12	2
2003	4.61	3.58	4.06	2.44	1.05	3	2	2	2	1	13	2
2004	1.31	8.47	3.16	3.74	3.26	1	3	2	2	2	13	2
2005	2.54	4.37	3.90	3.03	2.92	2	3	2	2	2	14	2

Month	30% Lower Bound	N	30% Upper Bound
April	1.59	2.59	2.96
May	1.96	3.15	3.80
June	2.69	4.06	4.86
July	2.44	4.02	4.87
August	2.19	3.55	4.29

Figure 17. Sample rainfall spreadsheet for Vesta, MN
1= dry, 2= normal, and 3= wet

3.3.2. Climatic Data

Why is this important to me? Documentation of the weather conditions at the time of the field visit should be attached or described or both. Obtaining information about recent precipitation is critical for confirming that observations of inundation and/or saturation are valid for a given time and location. If the area has recently experienced a significant rain event, the observation of inundation or saturation may not be defensible as a field indicator of wetland hydrology. Similarly, if inundation or saturation is not observed, recent drought conditions would explain why this is so. These tools will be used extensively in Chapter 5.

Precipitation data needed for climate analysis can be accessed through various resources:

1. eFOTG for precipitation data
2. NRCS WETS Tables to analyze the precipitation data
3. Standardized Precipitation Index to analyze regional and long term trends in precipitation
4. US Drought Monitor for drought condition maps
5. Palmer drought index for analysis of precipitation, ET, and soil water storage in mid-range time scales
6. USGS streamflow statistics
7. Climatological information available from state units of government

State and Regional Climatologists may also supply these data and analyses, though sites vary.

Precipitation Data are best obtained from eFOTG using the following sequence of tabs and links:

i. eFOTG
ii. Section II
iii. Climatic Data
iv. AgACIS (Agricultural Applied Climate Information System) Both daily and monthly data are available from previous days, months, and years. NOAA supplies these gratis to NRCS National Water & Climate Center (NWCC) by special agreement.

These data are reported for the same stations for which WETS tables have been calculated. Data less than approximately 4 months old are provisional and should not be used for Appeals or legal cases. After about 4 months the National Climate Data Center usually completes their quality control process and releases the official ‘edited’ data, which are preferred for legal use.

Other sources of information on precipitation include:

- State Climatologists: http://www.stateclimate.org/ . Search both the Regional Climate Centers and the State Climate Offices linked from this URL.
- National Weather Service: http://www.weather.gov/climate/ . Go to the NOW-Data tab and select type of data and reporting station. These are the same data in the eFOTG.
- Universities, especially the Land Grant Universities appropriate to your region. Sometimes research station data are available that are not reported to the NOAA.
- NOAA National Data Center: https://ols.nndc.noaa.gov/sub-login.html . This site provides edited, official data free to people with email addresses that end in .gov, .edu, and .mil. Login information will be provided in class.
- Regional Climate Centers: http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html . The six regional climate centers vary in available resources. Most do not provide direct access to recent daily precipitation records.
- Remote Automated Weather Stations (RAWS Data): http://www.raws.dri.edu/index.html . Daily data may be available from automated weather stations located in remote sites. These are not integrated with WETS Tables network but may be useful for wetland projects located near a RAWS station..
- Onsite rain gauges may supply very useful data at remote wetland sites far distant from official weather stations. Normally only official NWS or NOAA data are suitable for wetlands appeals or court cases, but this is an exception if the research is overseen by an appropriately credentialed professional hydrologist.

National Climate Maps: Several different kinds of maps generalize climatological information around the nation. Most summarize data for regions within a state (Climate Divisions) and compile this information into a national map. The regional summaries are based on weather stations within each Climate Division. Although these maps do not provide site-specific information, it is much easier to learn long term drought patterns with them than to calculate these statistical analyses for your individual project area.

The rest of this section describes the most common national climate maps available.

Standardized Precipitation Index (SPI): http://www.wrcc.dri.edu/spi/spi.html .
This website provides normalized analyses of precipitation percentiles over time periods ranging from the preceding one month to the preceding 5 years. Data are reported for Climate Regions. This is a very powerful tool for learning how precipitation has varied on a regional scale over various preceding lengths of time (Figure 18).

The map in Figure 18 shows precipitation percentiles for the nation's climate divisions. The time period is the preceding 3-month period. The analyzed three month period is compared with precipitation records for the same three month period for the preceding three-decade reference period of record. In other words, the most recent December-January-February total precipitation sum was compared with all 30 precipitation sums for

December-January-February between 1971 and 2000. The data have been normalized so frequency distributions can be reported as percentiles.

US Drought Monitor: http://drought.unl.edu/dm/monitor.html .
This analysis only reports moisture deficit, not excess. Although the site does not evaluate wetter than normal periods, it provides excellent analysis for the drier half of the climatological frequency distribution (Figure 19). This is the only website discussed in this Module that employs a national team of professional climatologists to evaluate data every week. The other indices are pretty much mathematical models, untempered by on-the-ground reports from agricultural, urban, and state water planners and users. This site would be the best regional climate evaluation for wetland delineation if it reported moisture excess as well as moisture deficit.

Figure 18. Three month precipitation percentile

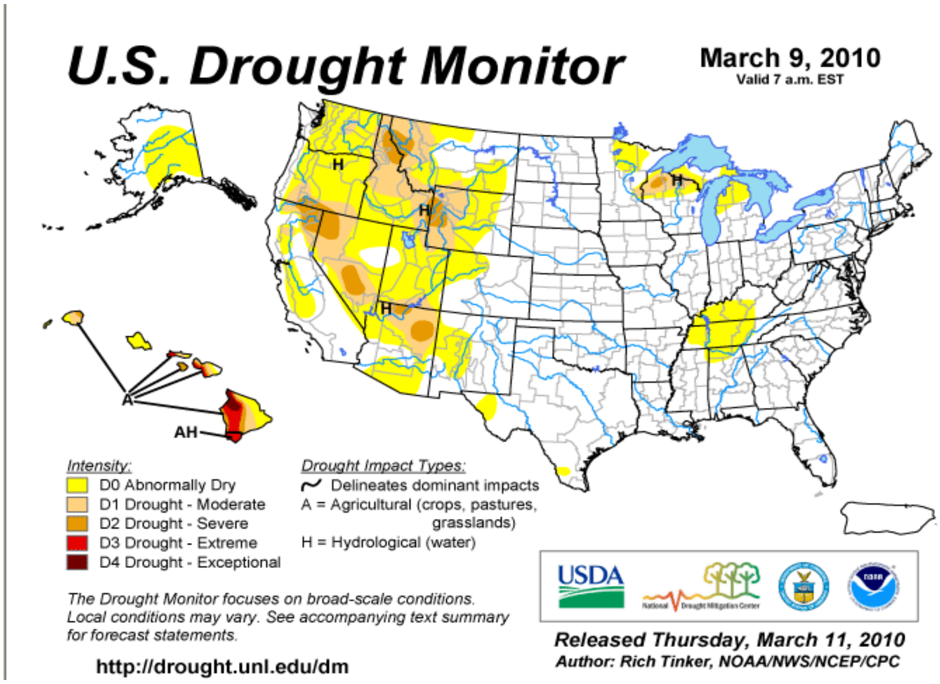


Figure 19. Weekly Drought Monitor map of drought in the US. Light blue boundaries within states are Climate Divisions. Note that this product is drawn without regard to division boundaries. Precipitation excess is not reported, so uncolored areas are in either normal or wetter than normal ground wetness conditions.

Palmer Drought Indices: http://drought.unl.edu/whatis/indices.htm#pdsi .

Since the 1960s the Palmer Drought Severity Indices (PDSI) have been a standard evaluation of drought and excess moisture. The models include precipitation, ET, and estimated soil moisture storage. The indices are updated weekly and are widely accepted for agricultural forecasts. Validation tests have found them to be most accurate in the Midwest and to be less accurate in the montane and arid West. For wetland delineators in the humid East they provide the most frequently updated regional analysis of drought and moisture excess available from a direct hyperlink.

The indices vary from -4.0 to +4.0, with 0.0 being roughly the median moisture condition for the area at that time of year. Negative values are drier than normal; positive values are wetter than normal. The larger the value, the greater the deviation from normal conditions. Consequently, PDSIs of zero in Death Valley and in southern Louisiana only report that both are experiencing normal moisture conditions for that time of year, not that they are comparably wet or dry.

Palmer Drought Severity Index (PDSI) is the most commonly used version of the Palmer calculations: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/palmer.gif .

This index is not standardized, so adjacent regions with the same index value may not be experience comparable moisture excess or deficit with respect to normal.

Palmer Drought Index Percentiles by Division
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/rpd07dcd.gif .

This map shows maps of standardized PDSI, so comparable values report comparable exceedence likelihoods (percentiles). This is a relatively new calculation but is superior to the PDSI because comparable percentiles report the same exceedence frequencies in different regions.

The concepts introduced above are discussed in more detail at the National Drought Mitigation Center website: http://drought.unl.edu/whatis/indices.htm#pdsi .

USGS Streamflow Data: http://waterwatch.usgs.gov/?m=mv01d&r=us&w=real%2Cmap . Select the product you want in the upper left drop-down box “Current Maps and Graphs.” Longer term averages are more representative of stream flows and groundwater flows. Remember, most streams in the eastern US are gaining streams and longer-term average flows represent a combination of groundwater flow and precipitation. Single-day maps may reflect unrepresentative ‘spikes’ due to localized storms near the gauge.

Groundwater Data:: http://groundwaterwatch.usgs.gov/ .
This site reports how much long term water wells depart from their median (normal) levels. Unfortunately, most of the wells are tens to hundreds of feet deep, so data reflect long-term regional conditions rather than near-term local and shallow conditions.

Vegetation Health:
http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_currentImage.php , and

Weekly Crop Bulletin: http://www.usda.gov/oce/weather/pubs/Weekly/Wwcb/wwcb.pdf .

Several internet sites report information that can be used as surrogates for climatological analysis. These two above provide data on vegetative response to weather patterns.

State Climate Data:
Some states have a climatology resource that provides data within its boundaries. An example for Minnesota is shown in Figure 20.

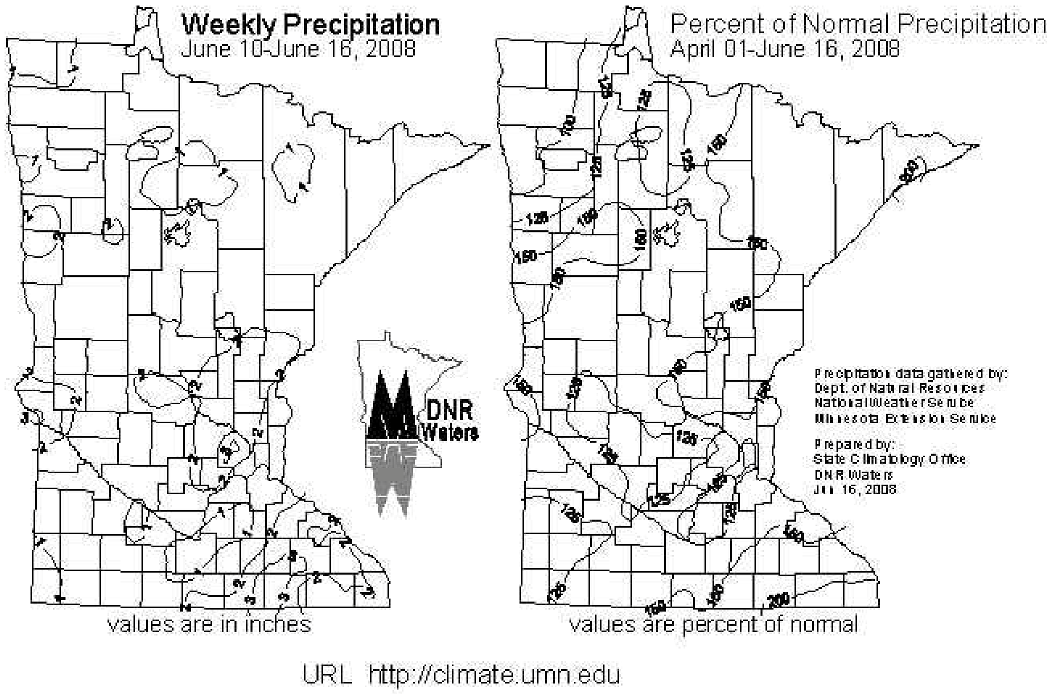


Figure 20. Sample weekly precipitation map (from http://climate.umn.edu)

3.4. Altered Hydrology

Why is this important to me? You should be familiar with this background information – at least qualitatively – when you evaluate a site for Normal Circumstances. In agricultural settings, the most common alteration to hydrology is drainage. All NRCS Agency Experts should have a working knowledge of these concepts.

3.4.1 Drainage Primer

Drainage can be isolated and involve a single wetland or local wetland systems, or it can be regional and influence wetlands over a wide area. Landowners install drainage systems for a variety of reasons. Research and practical experience has shown that fields can be worked earlier in the spring, yields increase, the water table can be managed for optimal crop production, plant roots grow deeper resulting in a healthier plant, and the cost of the drainage system is returned to the landowner through increased yields within 5-10 years. Crop monitors in tractors and combines show that yields are greater over tile lines and in drained areas compared to portions of the field without a drainage system. Research in Ontario resulted in the information in Figure 21 which clearly shows that yields increase with installation of a drainage system.

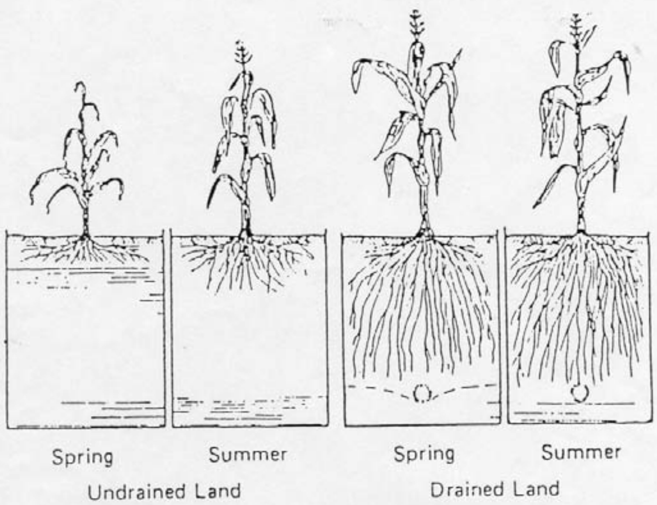


Figure 26. Effect of drainage on plant root growth.

Table 1. Average Yield of Field Crops, 1979-1986

Crop	Yield - bu/ac (t/ha) Tiled Land	Yield - bu/ac (t/ha) Untiled Land	Increase (%)
Winter Wheat	61 (4.02)	44 (2.93)	37
Spring Grain	58 (2.85)	36 (1.80)	58
Corn	101 (6.64)	75 (4.93)	35
Soybeans	37 (2.44)	30 (1.96)	25

Figure 21. Data from Ontario Research on drainage systems

The two most frequent alterations to natural hydrology are the installations of ditches and drainage tile. The outlet for either type of system is critical to the system's effectiveness. If the water does not have a free outlet, the system effectiveness is less than 100%. Consider a tile which outlets into a drainage ditch where the ditch stands with 4 feet of water such that the tile outlet is frequently submerged by about 2 feet. The water is not able to leave the tile until it has enough head or pressure on it to be greater than the depth of water that is submerging the outlet—two feet in this example.

Drainage systems are either surface systems - usually ditches - or subsurface systems - usually drainage tile. Basic information is presented here for those with limited experience with drainage systems.

3.4.1.1. Tile

The three primary types of drainage tile are clay, concrete, and corrugated plastic. Earlier in United States' drainage history, much of the tile was concrete or clay. Clay is the oldest form and had origins associated with the use of rounded clay portions for roofs in parts of Europe. Clay was abundant in parts of the United States and those areas produced much clay tile. In areas where clay was not readily available, concrete became the material of choice. In the past 30 to 40 years, the majority of the tile installed has been corrugated plastic for ease of installation and more cost-effective returns. Corrugated plastic tile or drainage tubing quickly became popular due to ease of installation, lighter weight for shipping, and availability. All tile materials require careful installation for optimal results, and all require periodic maintenance to continue to operate effectively.

Water enters concrete and clay tile primarily through the cracks between the individual segments of tile. Some claim water also enters through the porous surface of the tile but it is a small fraction compared to what enters via the gaps. Corrugated plastic tile has pre-cut slots or holes that allow water to enter the tile; most often the holes are scattered around the entire circumference. The corrugation on the inside of the walls of plastic tile slows the flow of water more than the smooth inside walls of concrete and clay tiles. Thus clay and concrete tile have a slightly larger capacity for the same diameter as a section of corrugated plastic tile. This should be considered when evaluating tile systems. Charts exist which indicate the discharge possible in a tile at a given grade and size. See National Engineering Handbook (NEH) Part 650, Engineering Field Handbook (EFH) Figures 14-34 and 14-35. Separate charts are provided for corrugated plastic tile and for clay and concrete tile.

In early days of drainage, most tile systems were random (Figure 22d), just removing water from isolated wet spots. Over time, the value of pattern tiling has been proved and systems of tile are designed to fit the natural topography – see Figure 22 for samples. A combination of main lines and lateral lines bring the water to an outlet, which may have a free-flowing (open) outlet into a ditch or water body, or end in a sump where the water is pumped to an open outlet. The latter may also be called a “forced” outlet.

A tile system that includes surface intakes (see Figure 23) requires larger conduits for the water to be removed efficiently compared to a system with no surface intakes. Surface intakes can be a source of nutrients and pollutants to downstream waters so research is underway to find ways to improve the water quality of water passing through a surface intake. Many sizes of tile allow approximately the same amount of water to enter the tile from the soil but the larger diameters of tile are needed to convey the water to the outlet. The more drainage area entering a system the larger the outlet tile needs to be. Most systems are a smaller size at the top of the watershed (such as 4” to 6”) and increase in size as they pick up more drainage area approaching the system outlet.

The majority of tile installed today is corrugated plastic drainage tubing. Clay and concrete tile installation require more labor and the tile pieces are more expensive to produce and ship. Many older systems are clay and concrete and may have been placed at shallower depths due to the lack of modern installation equipment. Sediment may accumulate to the point of causing a blowout in a tile which then renders the system ineffective without maintenance. A tile system is most efficient shortly after it is installed but the accumulation of sediment and shifts due to freeze and thaw cycles may reduce the system’s efficiency. Also, an outlet may become obstructed by sediment or by damage to the outlet section which may reduce the capacity of the outlet. If a drainage ditch is used as an outlet for tile, and the ditch becomes filled with dense vegetation, the ability of the tile to discharge freely is impaired and the quality of the whole system is reduced. This is why regular maintenance is required for ditches that serve as outlets for tile.

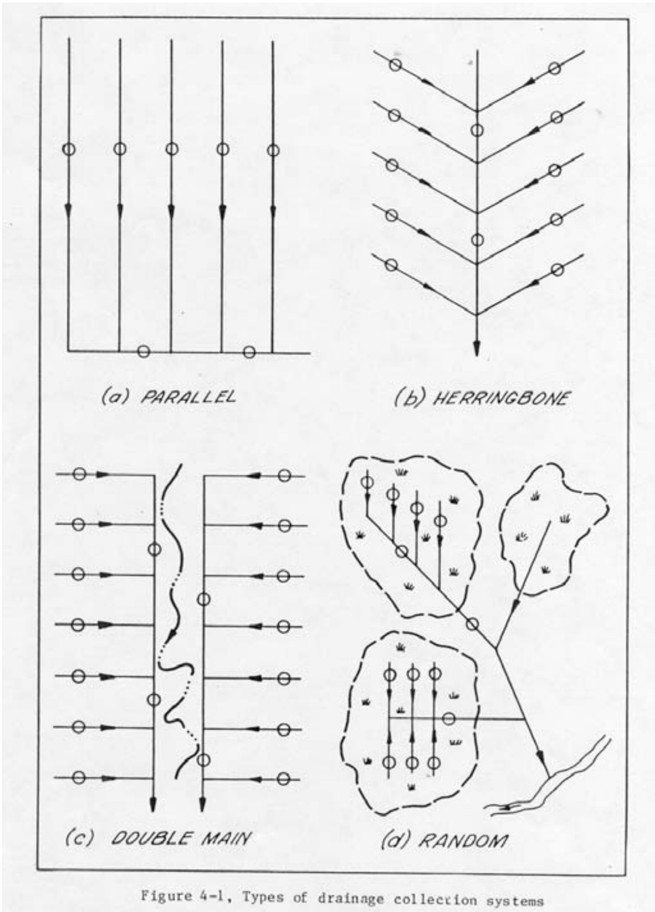


Figure 22. Drainage system configurations

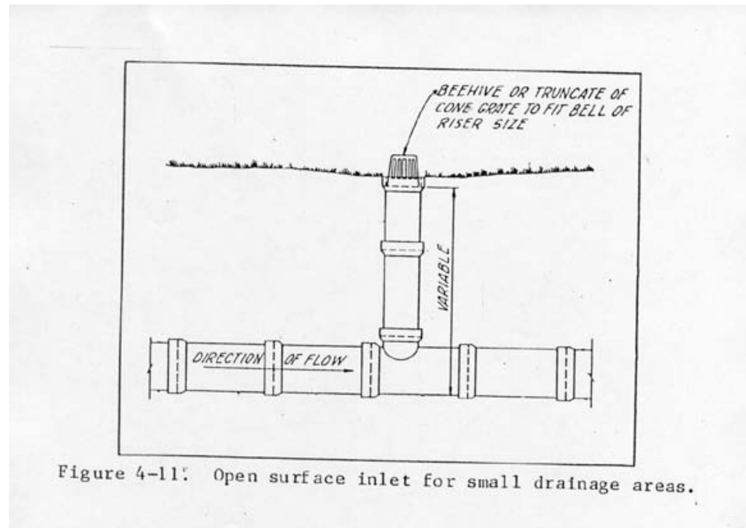


Figure 23. Open surface inlet for small drainage areas, placed in low spots in field

Figures 22 and 23 are from NEH Part 624 pages 4-23 and 4-102 respectively.

Figures 24, 25, and 26 depict the three types of tile.

Figure 24.

Figure 25

Figure 26.

Installation of tile is primarily achieved with two types of machines, those that "trench" in the tile and those that "plow" or "knife" it in. The proponents of trenching machines claim that the plowing machines smear the soil where the tile is installed and this seals the pores, causing water to reach the tile more slowly and in reduced quantity. The proponents of plowing machines claim that the trenching disturbs the soil profile such that the water movement over the tile is reduced. . Figures 27-31 illustrate trenching and plowing for tile installation.

Figure 27.

Figure 28.

Figure 29.

Figure 30.

Figure 31. Baskets loaded with sections of concrete tile. Operator has radio headset to communicate with driver in cab. Operator has a pole to tap the tile section into its final location.

Figure 32. Sample pattern tile system. Note laterals, main, and outlet (angled toward center bottom of photo)

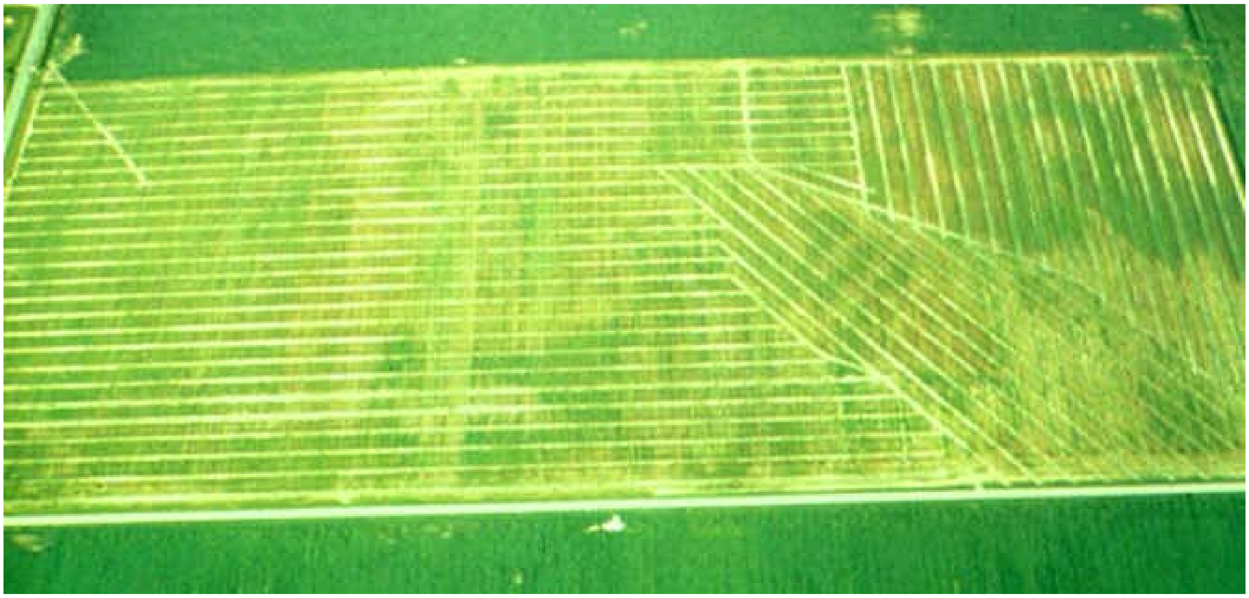


Figure 33. A heavily pattern tiled field.

Figure 34. If a soil has fines that might enter the tile and plug it, the corrugated plastic can be installed with a "sock" on it to filter out the fines, and prevent them from entering the tile.

Figure 35. Blowhole. If a tile has become plugged with sediment, the water pressure can build up behind the blockage and blow a hole out. This requires maintenance.

3.4.1.2 Ditches

Systems of drainage ditches that are the responsibility of a county, a judicial ditch authority, or a water district exist in many parts of the United States. State drainage law can be very specific about procedures for the maintenance and improvements to these systems. Wetlands may be impacted in the course of maintenance and improvement of public ditch and tile systems.

The effect of a drainage ditch is determined by seeking the typical free water surface in a ditch. If the ditch was over-excavated in spots, it will have pools when the ditch itself is not flowing. Also, if a culvert in a road crossing has an **invert** higher than the ditch bottom, the water will pool until it reaches the invert. The effectiveness of a ditch is related to the difference in head (elevation) between the land it is draining and the free water surface in the ditch.

Ditches are of various sizes and shapes. Traditionally they were dug by hand. Today, ditches are often excavated with a backhoe. They are designed to carry the runoff from the watershed above the ditch. Because water is not restricted to a given cross-sectional area as with a subsurface drainage tile, generally their capacity is much greater for conveying water. In Figure 36, a backhoe is cleaning accumulated sediment and vegetal matter from a ditch to restore its original capacity for water conveyance. This is a natural depositional process that requires periodic maintenance if the ditch system is to continue to function well. Note the tile outlet on the right side of the ditch. It has a corrugated metal pipe outlet for the last 8-10 feet as it enters the ditch. In cold climates, plastic tile must stay buried or it becomes brittle and is easily broken by ice in the ditch or other actions. In areas with significant amounts of snow, the side slopes will be flatter to encourage the melting and runoff of water in spring. Ditches need to have a positive grade (that is, flow downhill) to convey water. The grade should be steep enough to keep sediment from dropping out of the flow. This will reduce maintenance costs.

Figure 36.

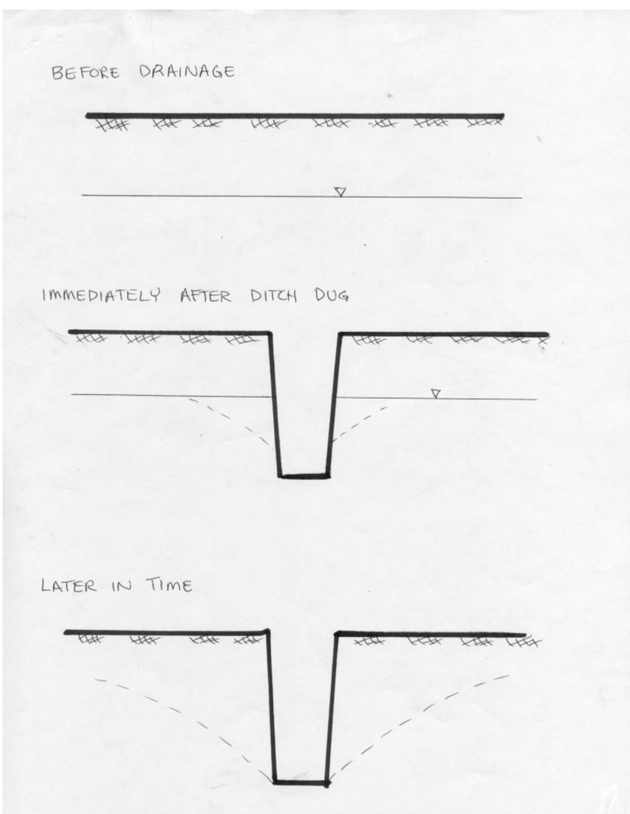


Figure 37. A cone forms after a drainage ditch is dug.

When a ditch is first dug, the water table slowly changes toward a cone shape as illustrated in Figure 37. The cone may be broad or narrow depending on the permeability of the soil. A sandy soil has a broader cone and thus a longer **lateral effect** when compared to a clay soil. The bottom of the cone forms at the elevation of free water in the ditch. When the ditch has standing water in it the point of the cone will be above the ditch bottom. A ditch may have been overexcavated for its outlet elevation which results in standing water. The cone becomes broad and flat during dry periods and re-forms after a rain event saturates the soil. The **zone of influence** of a drainage feature is the sum of the lateral effect on both sides of the ditch or tile. This simply notes the corridor of land that has its hydrology affected by the drainage feature.

3.4.1.3 Pumps

A landowner may choose to use a wetland as an outlet for a drainage system. The water may flow into the site by gravity or be pumped into the wetland. Often the water flowing through a drainage system would have reached the wetland naturally. However, sometimes a drainage system will bring water to a wetland that would not have naturally arrived there. This water is artificially added to the wetland.

A landowner may pump from a wetland to irrigate or water livestock among other purposes. Each site will require careful evaluation to understand the additions or subtractions to hydrology.

3.4.2. Compare Past and Present

In a number of cases, the evaluator is asked to decide what hydrology existed at some point in the past and what exists at present. This may also involve describing what caused a change to happen. Aerial imagery, especially those from the time period in question, can be helpful in knowing what hydrology existed on site in the past. If records are available describing drainage features installed, such as as-built plans or tile cut-sheets, these provide good evidence of possible alterations to hydrology. Any drainage system installed however, needs to have its age and condition considered. Sediment accumulates in both ditches and tile and reduces the effectiveness of a system. Sediment may accumulate to the point of causing a blowout in a tile which then renders the system ineffective without maintenance.

Some soils that are formed primarily in organic parent materials experience subsidence, a condition where the organic matter disappears over time due to microbial decomposition processes made possible by the removal of water. The drainage system may have been originally installed to a depth of four feet, but over time, with subsidence, the tile may now only have two feet of cover.

Participant Exercise #3

Study Figures 38 and 39. Something changed between 1985 and 1987. Look for clues. Small blotches that appear white may be clouds that were caught on the photos. What happened and why do you know that?

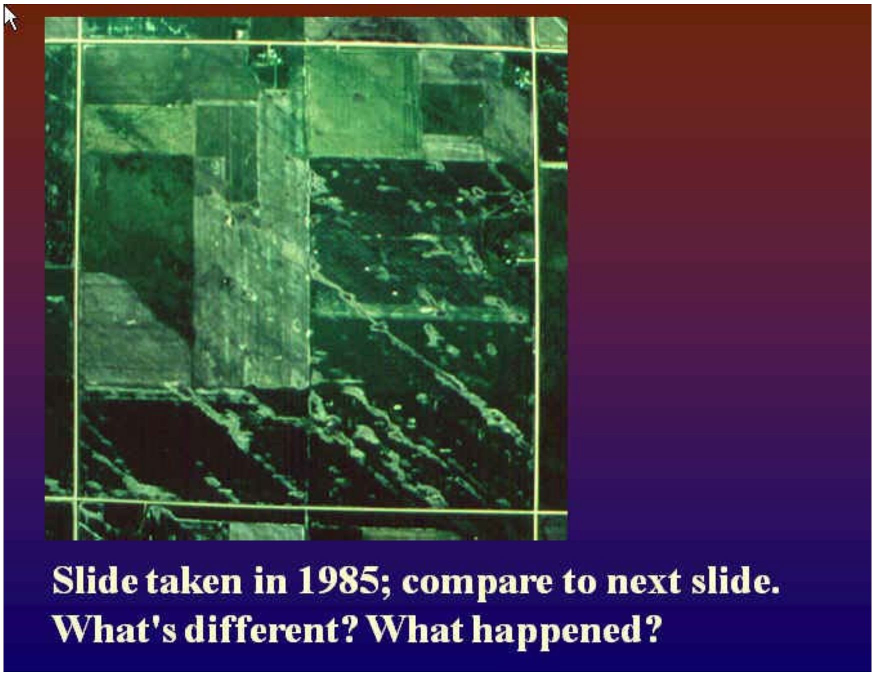


Figure 38.

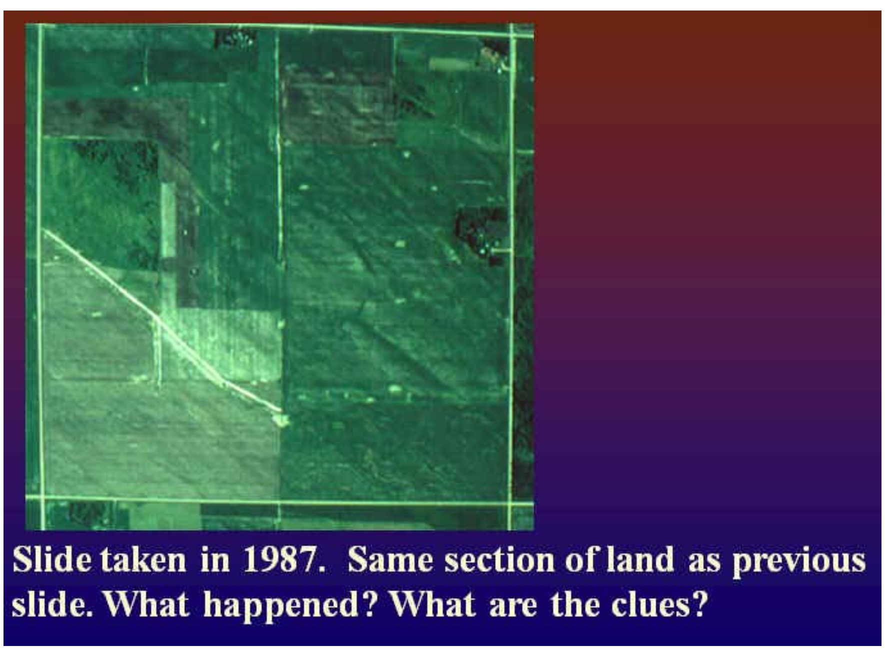


Figure 39.

Answer: A ditch was dug. The excavating exposed the grey subsoil so the ditch appears as an almost white line on the photo. Note the stub ditch in the north-south direction. This was a ditch and not tile because the spoil was sidecast on the southwest side of the main ditch and along the west side of the stub ditch. Note the mixture of darker and lighter color adjacent to the ditch in these locations.

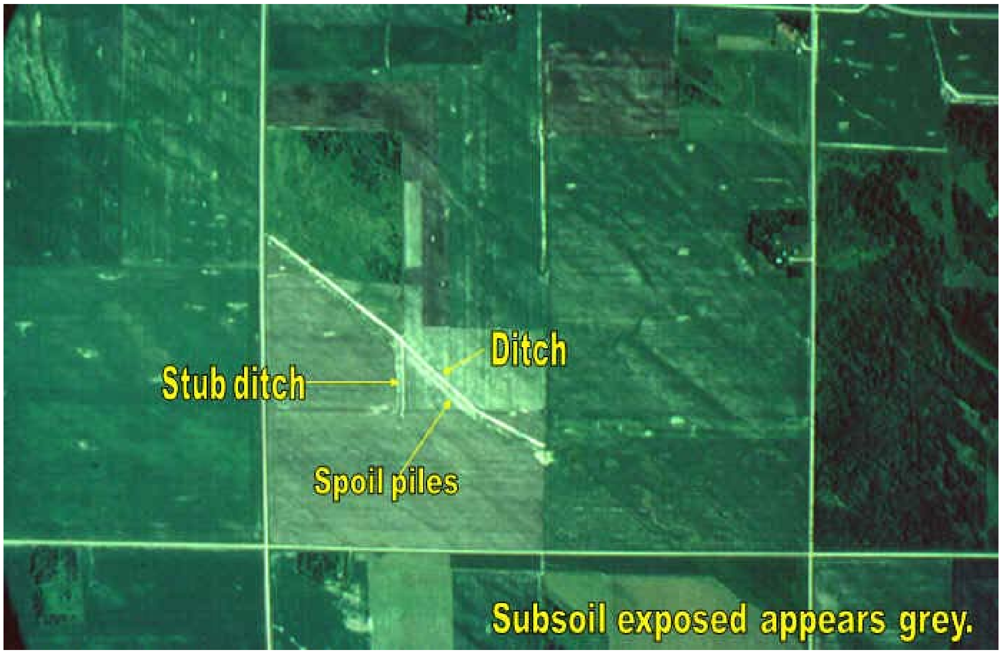


Figure 40.

3.4.3. Drainage System Impacts

Not all drainage systems completely remove the hydrology that causes a site to meet the wetland hydrology criterion. To meet the definition of **effectively drained,** a site must not have anaerobic conditions with sufficient frequency and duration to cause hydrophytic vegetation to dominate the site. Each site needs to be evaluated carefully.

Effectively drained is the condition where ground or surface water has been removed by artificial means to the point that an area no longer meets the wetland hydrology criterion. "Artificial means" often is a drainage tile or ditch. The area will not support a dominance of hydrophytic vegetation but hydric soil indicators often persist. Immediately after a site is drained, some passage of time is required for evidence of the removal of wetland hydrology to be seen. The drainage system may only partially remove hydrology in which case evidence of wetness remains, but is seen to a lesser extent; this does not meet the definition of effectively drained. Also, an alteration to the hydrology may be determined to have a negligible effect, such as when an equivalent drainage system is installed to replace an existing one. For example, in some instances, concrete or clay tile can be replaced at the same grade by corrugated plastic drainage tubing that is a little larger in diameter than the original tile because the corrugations in the plastic drainage tubing are less effective for conveying flow than the smooth sides of concrete or clay tile. Each situation must be evaluated on its own merits.

The outlet for a system is critical to its effectiveness. If the water can't leave in a timely fashion, it is retained in the system which keeps water in the soil pores. Outlets include ditches, subsurface drainage tile, a wetland, a lake, a river, or a pumping station.

An evaluation of a drainage system's impact on hydrology is done by calculating the lateral effect of each component of a system. Lateral effect is the distance on each side of a tile or ditch in its longitudinal direction where the ditch or tile has an influence on the hydrology. The lateral effect of the individual components is combined to identify portions of a site that still meet the wetland hydrology criterion. The failure to meet "effectively drained" may be caused by tile lines or ditches spaced sufficiently far apart to not influence hydrology over the whole field. Ditches with inverts above the low point in a wetland basin result in a site still meeting the wetland hydrology criterion. Shallow tile lines may not remove the hydrology when a deeper line would have a longer lateral effect and thus remove sufficient water to impact the entire field. If adequate maintenance has not been performed on a system, it will lose its ability to effectively drain a field.

In making a field visit, an observation of a tile system's effectiveness is seen in symptoms such as saturated or inundated areas and areas with a dominance of hydrophytic vegetation. The outlet can sometimes be examined to see whether it is free-flowing or obstructed, but a subsurface system by its very nature is underground and out-of-sight. Therefore, information may have to be gathered about the subsurface system in another way to complete a lateral effect evaluation. Often, information can be obtained from a landowner or public drainage authority about a drainage system. The tile can be probed to determine the depth of cover.

To fully understand the impact of a drainage system, one may need to determine the lateral effect of its components. This is frequently done using a scope and effect analysis. More information is given on this in EFH Section 650.1905.

If a tile or ditch completely encircles a wetland, it can cut off the subsurface water that keeps a wetland wet, similar to a diversion above ground diverting surface water away from a wetland. Such a practice is an alteration to the hydrology that is not allowed under NFSAM rules. It is commonly known as encirclement (see Figure 41).

Encirclement is not an issue with wetlands where the groundwater component of the water budget is zero or negligible. This illustrates the need to know the <u>primary source of water</u> for the wetland in question.

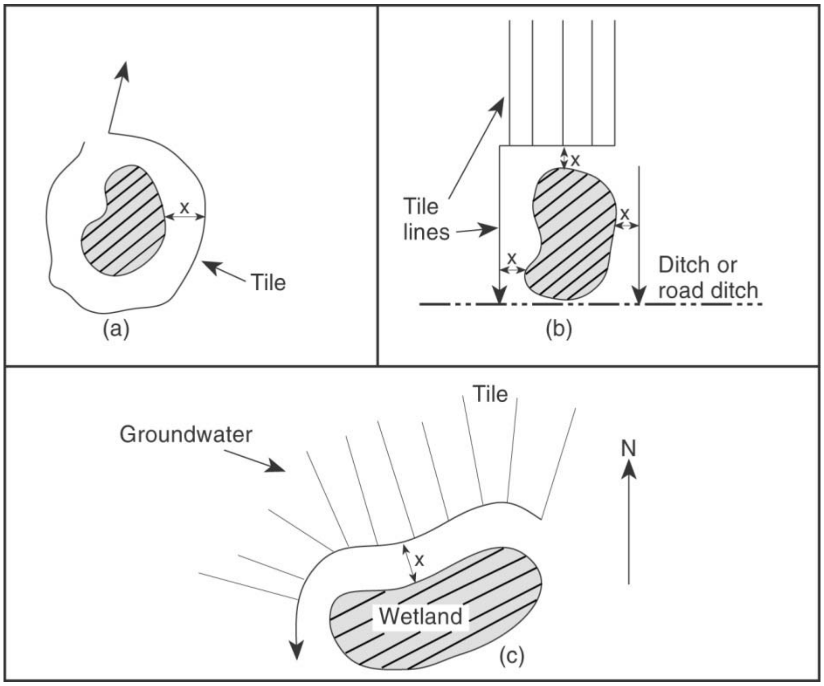


Figure 41.

(a) Most obvious case of encirclement; tile forms ring entirely around wetland (hatched area) at a distance very close to that calculated for lateral effect ($x=L_e$).

(b) Tile cuts off water on three sides and ditch removes water on fourth side; cuts off groundwater even though tile is distance away from wetland that lateral effect equations say it should be.

(c) Tile is only placed on north and west sides of wetland but this is the direction that the groundwater comes from to reach the wetland. The primary water source for the wetland hydrology is groundwater and hence the tile acts as a diversion. Tile is distance from wetland that was calculated by lateral effect equations.

RULE OF THUMB

Tile must be at least 3 times L_e distance from the wetland on the side where groundwater is likely to enter the wetland if the wetland even gives the appearance of being encircled, or where the tile may act as a diversion.

Stop time for Part 3 ___________

PART 4 – WETLAND HYDROLOGY INDICATORS

Part 4 is designed to take 2 hours and includes required exercises. Links are provided as optional learning opportunities. Start time: __________.

Why is this important to me? Most routine wetland identifications will employ the wetland hydrology indicators authorized by the Regional Supplements. The Corps Wetland Data Form is used to record which indicators are present on a site. Some indicators are used in all the regions, others are only used by some of the regions.
There are too many indicators for you to read all of them. Read those few required in Section 4.3 below (the most important ones), and then choose others that are appropriate in your area of responsibility.

4.1. The Hydrology Chapters of the 1987 Manual and Regional Supplements.

Why is this important to me? Section 4.1 is probably the only place you are ever going to get a paragraph by paragraph tour of the relationship between the hydrology sections of the National Food Security Act Manual, the Corps 1987 Manual, and the Regional Supplements. Be sure to complete all of Section 4.1.

Collect the following materials to refer to while using this section. These are available online at: http://www.usace.army.mil/cecw/pages/reg_supp.aspx .

1. 1987 Manual, Online Edition, Chapter 4, Wetland Hydrology (pp 28-34, **§**s 46-49) (hereafter, 'the Manual')
2. The Regional Supplement for your region, Chapter 4 (Wetland Hydrology Indicators) (hereafter, 'the Supplement')

Food Security Act definition of wetland hydrology

The National Food Security Act Manual, 4th Edition **(§514.6 Wetland Hydrology),** has this definition for wetland hydrology:

> *Wetland hydrology is defined as inundation or saturation by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions.* (7 CFR 12.2)

Question	Answer
Does the NFSAM require a specific number days of saturation or **ponding** for wetland hydrology?	No
Discussion	
See discussion after next question	

1987 Manual, Part III, Wetland Hydrology, Sections 46-49(a)

These sections of the 1987 Manual provide background to the Regional Supplements. The NRCS has not adopted Part III explicitly as part of our procedure, but the Regional Supplements assume the principles expressed here.

Read 1987 Manual, §46.

Question	Answer
Does the 1987 Manual require a specific number days of saturation or ponding for wetland hydrology?	No
Discussion	
The NRCS and Corps both define wetland hydrology in an operational manner. Wetland hydrology is the long-term water regime required to support the hydrophytic vegetation and develop the hydric soils of the wetland on a given site. Biological responses of plants and soil microbes to water stress vary too much for there to be a single **hydroperiod** common to all wetlands. Occasionally, a site has been disturbed severely enough to merit collection of information regarding the hydroperiod. This may include water table measurements at specific depths, lengths of time, and frequencies. This information is only a surrogate to approximate the altered hydrologic regime.	

See Table 1 of the Supplements, reproduced below. Chapter 4 of the Regional Supplements replaces only §49(b) of the 1987 Manual and associated references to these indicators in the chapter on Atypical Situations.

Read the Regional Supplement, Wetland Hydrology Indicators, Introduction, 1st paragraph.

Question	Answer
Does the Regional Supplement change the concept of wetland hydrology provided in the 1987 Manual, §46?	No
Discussion	
The Regional Supplements do not replace the 1987 Manual; they only regionalize the	

indicators and incorporate two decades of improved knowledge since the Manual was first adopted.

Skim through 1987 Manual §49.a & 49.b, and read highlighted rows of Table 1 below

Table 1. Sections of the Corps Manual replaced by the Regional Supplements.

Item	Replaced Portions of the Corps Manual (Environmental Laboratory 1987)	Replacement Guidance (this Supplement)
Hydrophytic Vegetation Indicators	Paragraph 35, all subparts, and all references to specific indicators in Part IV.	Chapter 2
Hydric Soil Indicators	Paragraphs 44 and 45, all subparts, and all references to specific indicators in Part IV.	Chapter 3
Wetland Hydrology Indicators	Paragraph 49(b), all subparts, and all references to specific indicators in Part IV.	Chapter 4
Growing Season Definition	Glossary	Chapter 4, Growing Season; Glossary
Hydrology Standard for Highly Disturbed or Problematic Wetland Situations	Paragraph 48, including Table 5 and the accompanying User Note in the online version of the Manual	Chapter 5, Wetlands that Periodically Lack Indicators of Wetland Hydrology, Procedure item 3(g)

Question	Answer
Are stream gage data, flood predictions, and historic records still authorized for use by the Regional Supplements?	Yes
Discussion	
Per Table 1 above, the Regional Supplements only replace §49(b) of the Wetland Hydrology chapter of the 1987 Manual. Use of other data is allowed by the NRCS and the Corps, as was emphasized in Module 2, Selection of Methods. When they are available, ascertain that they apply to the specific site being evaluated.	

1987 Manual §49(b), Field data.

Only now is it appropriate to switch from the 1987 Manual proper to the Regional Supplements. As pointed out in Table 1 above, the Regional Supplements only address the '*Field data*' portion of the 1987 Manual Hydrology procedures.

Read the Introduction to Chapter 4, Wetland Hydrology Indicators in your Supplement

Question	Answer
What information critical to wetland delineation do Wetland Hydrology indicators supply that is not given by the soils and vegetation indicators?	Wetland hydrology information tells us whether a parcel of ground currently receives sufficient water to support hydrophytic vegetation and hydric soils, or whether those wetland indicators might be

	relicts of earlier hydrologic conditions.
Discussion	
Remember that hydrology information is the most current information about the wetness regime of a site. Vegetation may reflect hydrologic regimes of previous years and decades; soils reflect hydrologic regimes of previous centuries. Only hydrology information provides knowledge sufficient to manage lands as they are functioning *now*.	

Question	Answer
What are some of the major problems with the Hydrology Indicators, as raised in the Introduction?	Hydrology indicators may not be present at the time of a site visit, though they were there at the beginning of the wet season. Weather conditions vary considerably so even if saturation or inundation is observed, they may not indicate whether Normal Environmental Conditions exist at the time of a site visit.
Discussion	
Because hydrologic data are rarely available for a site, a decision about the presence of wetland hydrology is often made by looking for field indicators during a site visit. Direct observations of inundation and saturation are strong indicators that wetland hydrology is present on a site. However, any observations must be tempered by knowledge of the hydrologic conditions at the time of the field visit. A state climatology office may publish weekly maps indicating the precipitation that fell during a week and relating that total to the normal amount received during the growing season up to that point. An example is shown in Figure 20. If the site has been experiencing a drought period, or an unusually wet period, the field visit observations must be evaluated in that context. If a large rain event occurred the day before a field visit, sites that normally do not meet the wetland hydrology criteria may have inundation. Also, in a wetter than normal season, sites that are not wet in normal circumstances may have standing water or saturation within 12 inches of the surface. It is important to stress that *lack* of an indicator is *not* evidence for the absence of wetland hydrology.	

4.2. Growing Season

Why is this important to me? Do this section unless you use the Pacific Islands or Caribbean Islands Supplements.

The growing season is significant to wetland delineation because non-wetlands may inundate or saturate in the winter or early spring. Indicators of inundation and shallow saturation are the easiest and most convincing hydrology indicators to note in the field, but should only be used when wetland biological processes are active, that is, during the growing season. Most other indicators of wetland hydrology may be used any time of the year.

The growing season is considered to be all year long in regions served by the Supplements for Hawaii and the Pacific Islands and The Caribbean Islands, as well as along much of the Gulf Coast.

Read the section on Growing Season in your Supplement, or in one of the Supplements for the continental states or Alaska.

Question	Answer
Which hydrology indicators require knowledge of growing season dates? Why? (Refer to Table 2 on page 61 of this Module.)	Inundation (A1), Shallow water table (A2), Shallow saturation (A3), Inundation visible on aerial photography (B7), Dry-season water table (C2), and Saturation visible on aerial imagery (C9) These indicators are valid only if observed during the growing season.
Discussion	
These indicators are all direct observations of high water levels onsite. Such observations made outside of the growing season are not direct evidence that plants and soil microbes are being stressed by excess water, because temperatures at the time of observation were below the threshold for effective biological activity. 'Winter-saturated non-wetlands' do not provide biologically mediated wetland functions if they dry out before the growing season commences.	

Question	Answer
The three methods for determining the growing season are vegetation activity, soil temperature, and air temperature records. Which are the two preferred methods? Which is the least accurate method?	Vegetation activity and soil temperature are preferred, and air temperature records are the least accurate.
Discussion	
The most significant problem with use of climatological records for defining growing season, such as the WETS tables, is spatial variability of temperature around a county or region served by a particular weather station. In the sparsely populated West weather stations are often far apart. In mountainous regions weather stations and wetland sites may be at significantly different elevations. Major weather stations are often located at regional airports, where air temperatures are warmer than in the rural areas they serve.	

Question	Answer
How do I know which plants are 'evergreen?'	The Corps Plants website documents whether species are evergreen.
Discussion	
The Corps plants website provides search options for a variety of habitat characteristics and spatial scales. ➢ Go to: https://rsgis.crrel.usace.army.mil/apex/f?p=703:1:2768962733000734 o All Botanical Searches o Geographic Query: *Click a state or Corps Region on the map* o Nomenclature Query: Type or use drop-down box for plant name (or genus or family) o Click red Accept Query button at upper right of screen o Click on name of plant you want o In bottom left of page, click on Biological Attributes arrow o In Morphology section, find evergreen status under Leaf Evergreen status is a generalization that may vary with habitat and even local and individual genetics. Your team of Agency Experts should discuss the species most likely to show early-season activity and identify specific cautions for your work area.	

Question	Answer
What do terms such as *crown, coleoptile, cotyledon, bud burst*, etc, mean?	See discussion
Discussion	
This is basic botanical knowledge. Seek assistance from one of the Agency biologists if you need help with these.	

Question	Answer
Why is early plant senescence due to the initiation of the summer dry season seldom a problem for wetland hydrology and growing season?	It is unlikely that you will find Group A wetland hydrology indicators during the summer dry season.
Discussion	
In most parts of the country water tables are highest during the beginning of the growing season. Exceptions may be arid region monsoons in the late autumn or rains in parts of Alaska with dry summers. Discuss local growing season problems with your State Biologist.	

Question	Answer
Why are soil temperatures to be taken at 12 inches (30 cm)?	Diurnal fluctuations in air temperature tend to dampen out at 30 cm and deeper.

Question	Answer
How do you take soil temperature at 12 inches if the water table is at 3 inches?	Excavate a slab of the soil on the blade of a tile spade ('sharp shooter') and insert the soil thermometer at the 12-inch depth within the soil sample.

Question	Answer
Has the growing season started if soil temperatures are colder than biologic zero (5 °C) but you find vegetative activity onsite?	You would conclude that you are in the growing season based on biological activity. Similarly, if the soil temperature is above 5 °C but no plant growth is evident, you would still conclude that you are within the growing season.

Discussion

The soil temperature threshold of 5 °C is chosen because that temperature has classically been considered to be 'biologic zero.' There are several flaws with this method.

1. Significant biological activity has been measured in Alaska soils at soil temperatures below freezing (0 °C), so the old concept of biologic zero is a generalization that may not apply with respect to the plants or soil microbial communities at your site or region.

2. The 12-inch depth was chosen so that the data would not be skewed by measurement during an uncommonly warm day close to the ground surface. However, significant biological processes may occur during daylight hours at shallow depths in the soil. These depths are where many biologically mediated ecosystem services are performed.

3. Soil temperatures may vary between poorly drained and well drained soils. In the spring wet soils tend to stay cold longer than drier soils, so it is likely that wetlands will be the last places in the landscape to warm up in the spring. Be careful to make your observations of both plant and soil growing seasons in the wetland, not in upland areas.

Read the last paragraph about growing seasons in your Supplement, and consult the Growing Season portion of the WETS table for Litchfield MN, below.

GROWING SEASON DATES *(for Litchfield MN)*

	Temperature		
Probability	24 F or higher	28 F or higher	32 F or higher
	Beginning and Ending Dates Growing Season Length		
50 percent *	4/ 7 to 10/20 196 days	4/20 to 10/ 7 170 days	5/ 3 to 9/29 149 days
70 percent *	4/ 3 to 10/25 204 days	4/14 to 10/12 181 days	4/29 to 10/ 3 158 days

* Percent chance of the growing season occurring between the Beginning and Ending dates.

Question	Answer
When does the WC growing season start and end at Litchfield, MN using the chart above for that weather station?	4/20-10/7

Discussion
The growing season can be estimated from NRCS WETS tables by selecting the column '28 F or higher' and row '50 percent.' These temperature tables were originally developed for frost free dates and were later adopted to estimate wetlands growing seasons. The tables were never intended for that purpose, but they were available in almost every county soil survey report in the nation and were therefore easily and widely accessible. They are a weak surrogate for onsite information and should be used only if onsite investigation is not practicable or helpful.

4.3. Wetland Hydrology Indicators

Read the paragraphs starting the section titled "Wetland Hydrology Indicators," leading up to the Table listing all the indicators in your Supplement.

Question	Answer
How does the Corps group Wetland Hydrology indicators?	The field indicators are grouped into four major categories in each region. A. Observation of surface water or saturated soils B. Evidence of recent inundation C. Evidence of current or recent soil saturation D. Evidence from other site conditions or data

Question	Answer
What is the difference between primary and secondary indicators?	Only one primary indicator is sufficient to meet the requirements for Wetland Hydrology on the data sheet, but two secondary indicators are necessary to reach the conclusion that wetland hydrology is present on a site.

Discussion
Note that you can reach false conclusions even with primary indicators if they don't reflect Normal Environmental Conditions or Normal Circumstances. Before you do your delineation, do your homework. Determine whether hydrologic inputs have been either more or less than normal, both recently and in the longer term. In the field, walk the entire site before collecting data, and check for evidence of disturbance or unusually wet or dry rainfall conditions. One of the biggest mistakes delineators make is to jump right into the delineation without understanding the water flows, water budget components, and current site conditions throughout the whole site and catchment basin. Walk the site first, and then collect data.

Instructions for Individual Indicators

The Wetland Hydrology Indicators are discussed below. Read those indicators and the Cautions and User Notes for the indicators used in your Regional Supplement. Answer the questions and read the discussions. Skip indicators that don't apply in your region.

Table 2 lists all of the Wetland Hydrology Indicators used in the Corps Supplements, along with which regions they are used in and how many of the supplements use the indicator as primary or secondary.

Table 2. Wetland Hydrology Indicators for use with Regional Supplements				
Indicator Code	Indicator Name	Region Used In	No. of Supplements Indicator Occurs As	
			Primary	Secondary
Group A: Observations of Surface Water or Saturated Soils				
A1	Surface Water	All	10	0
A2	High water table	All	10	0
A3	Saturation	All	10	0
Group B: Evidence of Recent Inundation				
B1	Water marks	All	10	1-partial
B2	Sediment deposits	All	10	1-partial
B3	Drift deposits	All	10	1-partial
B4	Algal mat or crust	All *but* Arid West	9	0
B5	Iron deposits	All *but* Arid West	9	0
B6	Surface soil cracks	All	3	7
B7	Inundation visible on aerial imagery	All	10	0
B8	Sparsely vegetated concave surface	All *but* Arid West	4	5
B9	Water-stained leaves	All	8	2
B10	Drainage patterns	All	0	10
B11	Salt Crust	Arid West, Great Plains, Western Mountains	3	0
B12	Biotic Crust	Arid West	1	0
B13	Aquatic invertebrates	All *but* Alaska	9	0
B14	True aquatic plants	Eastern. Mountains & Piedmont, Midwest	2	0
B15	Marl deposits	Alaska, Atlantic Gulf Coast, Caribbean, NC-NE	3	1
B16	Moss trim lines	Atlantic Gulf Coast, Eastern Mountains, NC-NE	0	3
B17	Tilapia nests	Pacific Isles	1	0
Group C: Evidence of Current of Recent Soil Saturation				
C1	Hydrogen sulfide odor	All	10	0
C2	Dry-season water table	All	2	8
C3	Oxidized rhizospheres along living roots	All	9	1
C4	Presence of reduced iron	All	9	1
C5	Salt deposits	Alaska, Pacific Islands	0	2
C6	Recent iron reduction in tilled soils	All *but* Alaska & Great Plains	8	0
C7	Thin muck surface	All *but* Alaska & Western Mountains	8	0
C8	Crayfish burrows	All *but* Alaska, Caribbean& Pac. Isles, Western. Mtns	0	6
C9	Saturation visible on aerial imagery	All *but* Alaska & Pacific Isles	0	8
C10	Fiddler crab burrows	Caribbean Isles & Pacific Isles	2	0
Group D: Evidence from Other Site Conditions or Data				
D1	Stunted or stressed plants	All *but* Arid West, At. Gulf, Carib Isles, Great Plains	1	5
D2	Geomorphic position	All *but* Arid West	0	9
D3	Shallow aquitard	All *but* Great Plains & Midwest	0	8
D4	Microtopographic relief	Alaska, Eastern Mountains, NC-NE	0	8
D5	FAC-Neutral test	All	0	10
D6	Raised ant mounds	Western Mountains	0	1
D7	Frost-heave hummocks	Great Plains, Western Mountains	0	2
D9	Gauge or well data	Midwest	1	0
Hydrology Tools for Wetland Determinations				
	Engineering Field Handbook Chapter 19, part 650		All NRCS	

Group A. Observation of Surface Water or Saturated Soils

Why is this important to me? The three Group A indicators are used in all Supplements. These are direct observations of hydrology and serve to document the definition of FSA wetlands. Read all three indicators.

A1. Surface water

Read Indicator A1, Surface water

Question	Answer
Give an example of when this indicator may give a false positive decision for NC and for NEC.	Blocked culverts for non-Normal Circumstances; unusual flooding for non-Normal Environmental Conditions.

Question	Answer
You are on a site at the beginning of the wet season and growing season and observe indicator A1: Surface water (inundation) onsite, Does the extent of inundation indicate the wetland boundary?	It depends on the landform and upon recent weather history. You are seeing the site at one instant in time.
Discussion	
Inundation usually is found well inside the wetland boundary, and soil saturation usually extends further upslope beyond the zone of ponding. However, sometimes wetlands have abrupt boundaries and inundation is very close to the outside edge. Recent weather may have been wetter or drier than normal and that must be considered. Note carefully the landform and ask why the site is inundated. Are there outlets? Is the site within a floodplain? Some sites stay inundated much longer than others. Another cause of standing water is shallow compaction. Water standing in wheel ruts in a farm lane may not be accompanied by saturated conditions in the adjacent meadow.	

A2. High water table

Read Indicator A2, High water table

Question	Answer
What is a restrictive layer?	A shallow aquitard, or soil layer that prevents water from flowing downward.

Question	Answer
What flow paths would supply shallow	Shallow throughflow on top of a restrictive

water tables but not surface water?	layer; groundwater discharge onto a slightly sloping area or an area with a drainage outlet, such as seeps.
Discussion	
Shallow water tables are more common than inundation because many wetlands have surface outlets that drain excess water off the land surface as fast as it discharges out of the ground. The source of saturation is usually either shallow or deep groundwater. Precipitation will saturate the soil down to a restrictive layer and a perched water table can form. In most wetlands with high water tables the water table exists very near the soil surface at some time during the wet season, but then drops as ET begins to balance inputs.	

A3. Saturation

Read Indicator A3, Saturation

Question	
Should you record the depth of the water table when you document Indicator A3?	Yes
Discussion	
The supplements state that “This indicator must be associated with an existing water table located immediately below the saturated zone.” Such a saturated zone would be either the **capillary fringe** above the top of the aquifer (the water table) or part of that aquifer where water has not had time to fill the soil pit yet.	

Question	Answer
Which of these (any or all) are accepted methods to determine glistening? 1. Break open a soil ped. 2. Squeeze a soil ped. 3. Gently shake a soil ped.	Only # 1
Discussion	
Breaking soil peds retains the pore structure and pore size distribution within the ped. Glistening shows fully saturated pore spaces in the broken ped. Squeezing compresses the pore matrix, so expressed water reflects conditions with a smaller total pore volume. Shaking causes water to break free from light absorption to the soil pore matrix; if the ped glistens only after shaking, then the entire pore space was not fully saturated.	
Question	Answer
How far above the water table do you	A few inches, not many inches except

expect to find glistening?	perhaps in organic soils.
Discussion	
The capillary fringe is pretty thin in natural soils. Half a foot would be the maximum, even in silts with high organic matter content. Organic soils, however, can be saturated several inches above the free water surface in an unlined borehole.	

Question	Answer
Why does the User Note mention recent rainfall events?	Rainfall infiltration can be mistaken for saturation.
Discussion	
During and after storms rain water enters the soil and percolates through the pore space downward until it can go no further because of a water table or a restrictive layer. The movement of rainwater into a dry soil is called the wetting front. The slug of infiltration water behind the wetting front can be saturated, but it is not caused by shallow water tables and wetland hydrology unless it has reached the water table. The concept of saturated soil conditions raises a contradiction in the glossary. Note in the glossary that the 1987 Manual defines saturation as water at atmospheric pressure, that is, at or below the water table in an unlined borehole. The Regional Supplement, on the other hand, defines saturation to include the zone within the capillary fringe above the water table. This indicator (glistening) captures the capillary fringe and it also captures soils with very slow permeability where soil water seeps out of the side of the soil into the bore hole more slowly than the investigator is able to wait around for.	

Group B. Evidence of Recent Inundation

Why is this important to me? Read these seven indicators thoroughly as they are frequently used: B1, B2, B3, B7, B8, B9, and B10. Do others as appropriate to your region and as time allows.

B1. Water marks

Read Indicator B1, Water marks

Question	Answer
What are the biggest problems with this indicator?	You do not know if the inundation event occurred during the growing season. Nor if such events occur in 5 out of 10 years.
Discussion	
Several of the Group B indicators provide strong evidence that high water stood on the ground surface at some time in the past, but you rarely know when or how frequently these events occurred. This is why we have a three parameter system. If the site has both hydric soils and hydrophytic vegetation, then this evidence of standing water is a	

pretty good indicator of how the plants and soils were stressed to become wetland indicators. On the other hand, Water Marks, Sediment Deposits, Drift Deposits, etc., without hydric soils or hydrophytic vegetation, only show that there was a high water event sometime in the past and that it may occur only rarely.

B2. Sediment deposits

Read Indicator B2, Sediment deposits

Question	Answer
Which indicator might be more reliable, B1 or B2?	Probably B2.
Discussion	
Sediment deposits are a fairly reliable indication of flooding earlier in this growing season, especially if they are found on this year's leaves. Alluvial silt is much more likely to be washed away by subsequent rainstorms than are water marks. Note also that sediment deposits are less obvious than water marks and are often overlooked by novice delineators.	

B3. Drift deposits

Read Indicator B3, Drift deposits

Question	Answer
What are common forms in which drift deposits may be observed?	Drift deposits may be a pile of debris accumulated against a fixed feature such as a rock or tree. They may also form a circle or polygon on the perimeter of an area where water stood for a period of time. A drift deposit may appear as a line, for example where waves have deposited debris from a body of water.
Discussion	
Drift lines or drift deposits usually indicate short duration ponding or flooding. They are usually formed where either water carried floating debris, or the wind blew in debris on waves in open water (lakes, for example). In vegetated settings drifted debris is often laid down as piles of twigs or stems oriented parallel to each other. In a pothole setting, the stems of vegetation will float to the perimeter of the pond and remain there when the water infiltrates or evaporates. The debris may be remnants of vegetation (e.g., branches, stems, leaves), man-made litter, or other waterborne materials.	

B4. Algal mat or crust

Read Indicator B4, Algal mat or crust

Question	Answer
Are algal mats usually found near the wetland boundary or further into the wetland interior?	Further towards the interior where prolonged wet conditions occur.

Discussion
The user notes point out that algal mats indicate prolonged wet conditions sufficient for algal growth and development. The wetland boundary will often be upslope of the indicator. If you see algal mats during the dry season, they are strong evidence that the wetland is at least as extensive as algal mats and probably more so. This indicator is not used in the Arid West Supplement. It is a new indicator for the Corps, introduced with the Regional Supplements.

B5. Iron deposits

Read Indicator B5, Iron deposits

Question	Answer
Why should iron films observed in bottoms of ditches not be recorded for this indicator?	Ditch bottoms are usually lower than the depths required for wetland hydrology.

Discussion
Iron discharge films on the bottoms but not the sides of ditches only indicate that iron-enriched waters discharged to the depth of the bottom of the ditch. This indicator is most useful if found on the dry ground surface, as in the photograph in the Regional Supplement. Iron deposits show that large amounts of reduced iron (Fe^{++}) have been discharged onto the surface from some source where much iron was reduced, such as reduced groundwater in a discharge position in the landscape The Fe^{++} oxidizes when it is exposed to air and becomes reddish Fe^{+++}. A similar process causes **ocher** to form in drainage lines and in hillside seeps. This indicator is not used in the Arid West Supplement. It is a new indicator for the Corps, introduced with the Regional Supplements.

B6. Surface soil cracks

Read Indicator B6, Surface soil cracks (In some Supplements this indicator is not used, and in others it is a secondary indicator and described after the primary indicators within Group B.)

Question	Answer
In what kind of materials is this indicator usually found?	Recently deposited fine sediments and surficial soil material in concave landscape positions
Discussion	
This is a secondary indicator in most of the country but is primary in Alaska, the Arid West, and the Western Mountains. In dry regions with unvegetated lake beds the surface soil cracks form in materials much different from the surrounding landscape. In the rest of the nation they are a more ambiguous formation with a tenuous interpretation. They can also be found in mud deposits in parking lots and need to be interpreted in the context of the entire habitat of plants, soils, and water flow paths.	

B7. Inundation on aerial imagery

Read Indicator B7, Inundation on aerial imagery

Question	Answer
Does *any* occurrence of standing water in aerial imagery cause indicator B7 to be met?	No
Discussion	
Inundation in a very wet period is not conclusive evidence. Such an observation must be coupled with precipitation data from the period when the aerial imagery was taken. Inundation on aerial imagery is most conclusive if a pattern of wetness emerges that correlates with wet, normal, and dry periods in the precipitation record.	

B8. Sparsely vegetated concave surface

Read Indicator B8, Sparsely vegetated concave surface

Question	Answer
What kind of hydro-regime is necessary to stress vegetation so much that there is almost no vegetation growing there?	Probably alternating very wet and very dry
Discussion	
These areas must stress both wetland and non-wetland plants, by alternating between very wet and very dry conditions. They are often very shady, too, under forest canopy.	

The conditions seem to prevent survival of young woody species. On dry season inspections there is little to go on in these flats. If vegetation is missing, it is also difficult to document the Hydrophytic Vegetation indicator, except for the trees around the edge of the sparsely vegetated concave area.

B9. Water-stained leaves

Read *Indicator B9, Water-stained leaves*

Question	Answer
How do you distinguish water-stained leaves from darkly colored, decomposing leaves in non-wetlands.	They should contrast strongly with fallen leaves in nearby non-wetland landscape positions.
Discussion	
Water stained leaves has always been a controversial indicator because of uncertainty about whether leaves are dark because of inundation or simply because of natural decomposition processes in non-wetland settings. The best teacher is experience comparing fallen leaf morphology on transects in and out of depressions. You will often find water stained leaves on sparsely vegetated concave surfaces. Water-stained leaves is a primary indicator in all supplements except Alaska and parts of the Western Mountains.	

B10. Drainage patterns

Read Indicator B10, Drainage patterns

Question	Answer
Could a lack of leaf litter provide evidence that indicator B10 is met?	Yes
Discussion	
This indicator consists of flow patterns that are visible on the soil surface or eroded into the soil, low vegetation bent over in the direction of flow, absence of leaf litter or small woody debris due to flowing water, and similar evidence that water flowed across the ground surface. Indicator B10 is met when a site that previously had leaf litter scattered over it now has leaves removed from an area where water probably flowed.	

B11. Salt crust

Read Indicator B11, Salt crust

Question	Answer
How do you distinguish between evaporative salt crusts (B11) and the fluffy salt deposits mentioned in the User Notes?	B11 salt crusts usually are horizontal whereas capillary fringe salt crusts often precipitate on the sides of silt mounds that form around the bases of plants and can have hollow cavities within the 'fluffy' crenulations.

Salt crusts in depressions or lake bed fringes usually form on hard surfaces that are difficult to penetrate with a shovel or auger. Around the edge of the depression there may be concentric rings of different kinds of salts that precipitate out at different solution concentrations as the pool evaporates. Salt crusts that form from capillary rise often form up the sides of undulating surfaces, especially mounds around phreatophytic plants. They are puffy and strongly three-dimensional whereas the B11 salt crusts are flatter and more planar. Contact your local experts to learn where salt crusts are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

B12. Biotic crust (Arid West Supplement only)

Read Indicator B12, Biotic crust, including the accompanying 7 figures

Question	Answer
Which of the figures are examples of what biotic crusts are *NOT* B12 Wetland Hydrology indicators?	The last two, Figures 31 and 32

Discussion
Contact your local experts to learn whether biotic crusts are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

B13. Aquatic fauna

Read Indicator B13, Aquatic fauna

Discussion

The remains of aquatic fauna are occasionally the best evidence still present on closed depressional sites that dry out seasonally due to water table draw-down and ET. Contact your local experts to learn your local aquatic fauna, what non-aquatic fauna should not be used as a primary indicator of wetland hydrology, and what pitfalls are associated with using this indicator in the field. Consult with your local experts about the quantity of aquatic fauna considered to be sufficient to indicate whether indicator B13 is met.

B14. True aquatic plants

Read Indicator B14, True aquatic plants

Question	Answer
Where would you find a list of true aquatic plant species for your region or state?	The Corps Plants website. Technical Floras note if species are aquatic.
Discussion	
This indicator complements Indicator A1, Surface water. It is useful for inspections conducted during drought or extreme dry season draw down when aquatic plant remains are the major source of your information about wetland hydrology. The Corps Plants website is: https://rsgis.crrel.usace.army.mil/apex/f?p=703:1:158550515867352, o Go to All Botanical Searches. o Select your geographic area o Select Aquatic Plants in the drop down box by Habitat o Click on the red Accept Query button Contact your local experts to learn which plants are true aquatic plants, what non-aquatic plants should not be used as a primary indicator of wetland hydrology, and what pitfalls are associated with using this indicator in the field.	

B15. Marl deposits (included in only 4 regional supplements)

Read Indicator B15, Marl deposits

Question	Answer
A soil has 8 inches of soft, black muck overlying 60 inches of marl. Does this soil have Indicator B15?	No
Discussion	

Indicator B15 is for active deposition of marl under current wetland hydrologic regimes. It appears as a thin film on top of the soil or on top of horizontal debris on the ground surface. Its primary use is for areas that would have indicators A1 or A2 during the wet period of a normal growing season, but your site visit is during the dry season or during a drought, when water levels have dropped severely. Contact your local experts to learn whether Marl deposits are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

B16. Moss trim lines (included in only 3 regional supplements)

Read Indicator B16, Moss trim lines

Question	Answer
What other indicators can this be confused with?	B1 and B2.
Discussion	
This is a variant of the Water Marks and Sediment Deposits indicators, which are primary indicators in all of the country. Moss trim lines are formed when water-intolerant mosses growing on tree trunks and other upright objects are killed by prolonged inundation, forming an abrupt lower edge to the moss community at the high-water level. Contact your local experts to learn whether moss trim lines are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.	

B17. Tilapia nests (included in only the Pacific Isles supplement)

Read Indicator 18, Tilapia nests

Discussion
Contact your local experts to learn whether Tilapia nests are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

Group C. Evidence of Current or Recent Soil Saturation

Why is this important to me? Read these four indicators carefully as they are frequently used: C2, C3, C6, and C7. Do others as appropriate to your region and as time allows.

C1. Hydrogen sulfide odor

Read Indicator C1, Hydrogen sulfide odor

Question	Answer
Can you have Indicator C1 without Indicators A1, A2, or A3?	Probably not
Discussion	
Hydrogen sulfide is present only under very reducing conditions. For this indicator to be present, the soil has to be thoroughly anaerobic, which only occurs when the soil is saturated. The indicator's utility is that it dispenses with any doubt that wetland hydrology conditions may be an artifact of unusually wet weather. In order for hydrogen sulfide to produce an odor in a soil pit there must be a fair amount of free sulfur in the soil and water. This indicator is usually found in coastal situations. Sulfurous odors in inland settings can sometimes be associated with volatile petroleum products.	

C2. Dry-season water table

Read Indicator C2, Dry-season water table

Question	Answer
What is an easy way to document that you are in the normal dry season when you want to use the indicator?	Use the local soil survey Water Features Table data or climatological data available for the area being evaluated.
Discussion	
This indicator should be used only where hydric soils have distinct seasonal differences in water table depth. This information can be found easily by consulting Customer Service Toolkit with Soil Data Viewer, eFOTG, Soil Data Mart, or Web Soil Survey for the soil you are inspecting or hydric soils associated with landscapes and landforms you are working in. All programs have print options for inclusion in the file. Note also that the User Notes recommend documenting that precipitation levels have been drier than normal if the indicator is used in the wet season. Information may be available from your state climatological office. Procedures for nationally available climate data are found in section 3.3.2.	

C3. Oxidized rhizospheres along living roots

Read Indicator C3, Oxidized rhizospheres along living roots.

Question	Answer
Do the iron deposits have to be on the roots or may they be on the walls of the root channel?	Orange or red Fe^{+++} deposits may be found either on the root or on the walls of its root channel.
Discussion	
The General Description is explicit that the iron coatings can be either on the root or on the walls of the channel. The important thing is that they be associated with living roots. Compare the two photographs of this feature in the Supplement. The first photograph is of a black or very dark gray soil where the iron deposits are visible on living, white, root surfaces. The second photograph is of a soil that has many (more than 20 percent by volume) oxidized rhizospheres, mostly impregnating channels enough to be seen at this coarse magnification. Take a hand lens in the field with you if oxidized rhizospheres are common in your area.	

C4. Presence of reduced iron

Read Indicator C4, Presence of reduced iron

Question	Answer
Which other indicator from Group C is similar to this indicator (Presence of reduced iron)?	C1, Hydrogen sulfide odor
Discussion	
Both C1 and C4 require soil saturation at the moment of observation, so Indicator A3 and probably A2 will also be present. These indicators just confirm that this hydroperiod is long term and not a temporary consequence of unusually wet conditions. See the Soils Module for use of alpha, alpha dipyridyl. The reagent is relatively unstable. It probably is more appropriate to soils studies than for routine wetland hydrology determinations. It is fairly common to observe soil color change from dull gray to light brown on exposure to air. This, too, meets Indicator C4.	

C5. Salt deposits

Read C5, Salt deposits

Discussion
Contact your local experts to learn where Salt deposits are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

C6. Recent iron reduction in tilled soils

Read Indicator C6, Recent iron reduction in tilled soils

Question	Answer
What is likely to be the most common error committed when using this indicator?	Confusing redox concentrations with brownish B-horizon material pulled up into the Ap horizon.

Discussion
People who are not soil scientists frequently are unsure whether orange bodies within the A horizon are redox concentrations or B-horizon contamination from below brought up by tillage. A hand lens will help here. Hunt for spatial patterns where soft masses are associated with natural features within the soil ped or clod, color changes are gradual rather than abrupt, and orientation can be explained by natural differences in the pedologic micro-environment. In contrast, hand lens inspection will show that subsoil material brought up by tillage equipment will have a different amount of visual graininess, different amounts of organic matter distributed through the soil matrix, and will be a distinct body with arbitrary orientation in the Ap matrix. If in doubt, use the hand lens to compare the orange body in the topsoil with some subsoil material; it should be obvious if they are similar or different material.

C7. Thin muck surface

***Read** Indicator C7, Thin muck surface*

Question	Answer
What is the minimum thickness for this indicator?	No minimum thickness is stated.

Discussion
This is an unusual indicator in that less is *better*. The problem is that in agricultural regions most of the organic soils have been drained. Thick layers of muck remain at the land surface, but that muck only indicates an earlier hydrologic regime, not the current one. Currently active wetlands frequently accumulate organic matter on the soil surface. They may accumulate an inch or two of mucky mineral material at the uppermost mineral layer and/or a thin layer of muck on top. This layer of muck will not

persist if the soil dries out for a couple seasons, but it does persist if the soil is saturated to the surface or ponded regularly.

C8. Crayfish burrows

Read Indicator C8, Crayfish burrows

Question	Answer
Why is this a secondary indicator and B13 (aquatic fauna) is a primary indicator?	B13 requires observation of the aquatic fauna themselves in their normal habitat. C8 relies on inference from a very mobile animal that can live feet below the ground surface.

Discussion
Personal experience shows that crayfish burrows are usually located in wetlands but sometimes are found in somewhat poorly drained soils outside of wetlands. The depth that they can dig to in order to follow falling water tables makes them only a secondary indicator of wetland hydrology.

C9. Saturation visible on aerial imagery

Read *Indicator C9, Saturation visible on aerial imagery*

Question	Answer
If a color tone difference is seen in an aerial image, is this sufficient to be labeled as Saturation visible on aerial imagery?	No. A color tone difference may or may not indicate saturation.

Discussion
Saturation in a very wet period is not conclusive evidence. Such an observation must be coupled with precipitation data from the period when the aerial imagery was taken. Saturation on aerial imagery is most conclusive if a pattern of wetness emerges that coincides with dry, normal, and wet periods in the precipitation record. Saturated soil signatures must correspond to field-verified hydric soils, depressions or drainage patterns, differential crop management, or other evidence of a seasonal high water table.

C10. Fiddler crab burrows (only in Caribbean Isles and Pacific Isles supplements)

Read Indicator C10, Fiddler crab burrows

Discussion
Contact your local experts to learn where Fiddler crab burrows are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

Group D. Evidence of Other Site Conditions or Data

Why is this important to me? Read these four indicators carefully as they are frequently used: D2, D3, D4, and D5. Do others as appropriate to your region and as time allows.

D1. Stunted or stressed plants

Read Indicator D1, Stunted or stressed plants

Question	Answer
Would this indicator be used if this is seen in aerial imagery?	No
Discussion	
These indicators from the regional supplements are field indicators, not for off-site methods. If stunted or stressed crops were seen repeatedly in aerial imagery, this may be able to be used to support the presence of wetland hydrology as an application of the Remote Sensing Tool (Part 650.1903) in Engineering Field Handbook Chapter 19. This indicator is related to the vegetation that is experiencing the stunting or stress. Crops such as corn and soybeans are sensitive to anaerobic conditions and will begin to be affected in as little as 48-72 hours. Typically this is not long enough for hydrophytic vegetation to change from recessive to dominant. Profitable crops of corn are grown on wetlands. Exercise caution when applying this indicator. The wetland hydrology criterion does not include firm numbers on frequency and duration of the wetness, so knowledge of the vegetation must temper application of this indicator.	

D2. Geomorphic position

Read Indicator D2, Geomorphic position

Question	Answer
Is this indicator applicable in an area with a functioning drainage system?	Maybe
Discussion	

Some supplements specifically indicate that the D2 indicator does not apply where a functioning drainage system exists in a site in a water-receptive geomorphic position; others do not. If the drainage system elevation is higher than the bottom of the basin, this indicator may still apply. The user may be required to evaluate the drainage system and determine its impact on the site's capacity for runoff retention. Other problems can also cloud the application of indicator D2. This indicator is an excellent guideline for identifying potential wetland sites but professional judgment should be used before making the final call.

D3. Shallow aquitard

Read Indicator D3, Shallow aquitard

Question	Answer
Where would you go to document that local aquitards are restrictive enough to support wetland hydrology?	Local Soil Survey information.

Discussion
The definition of an aquitard is relative rather than quantitative. Several pedologic restrictive layers can be discontinuous and therefore allow leakage. Furthermore, slope position and percentage can change the hydrologic functioning of aquitards and restrictive layers, as can position within a catchment basin. Check local Soil Survey tables to determine and document that restrictive layers in your area function to perch water sufficiently for hydric soils to be present. Use this secondary indicator only in conjunction with strong evidence of hydrophytic vegetation and hydric soils.

D4. Microtopographic relief

Read Indicator D4, Microtopographic relief

Discussion
Contact your local experts to learn where Microtopographic relief is important in your region, how to identify it, what similar features it can be confused with, and what pitfalls are associated with using this indicator in the field.

D5. FAC-neutral test

Read Indicator D5, FAC-neutral test

Question	Answer
On a site, four dominant plant species across all strata are identified. Two are FACW and two are FACU. Does this site meet the FAC-neutral test?	No

Discussion
The FAC-neutral test is met if more than 50% of the dominant species are FACW and/or OBL. In this example, the FACW species are exactly 50%. This is not MORE THAN 50%. The test is not met.

D6. Raised ant mounds (only Western Mountains regional supplement)

Read Indicator D6, Raised ant mounds

Discussion
Contact your local experts to learn where Raised ant mounds are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

D7. Frost-heave hummocks (only Western Mountains and Great Plains regional supplements)

Read Indicator D7, Frost-heave hummocks

Discussion
Contact your local experts to learn where Frost heave hummocks are important in your region, how to identify them, what similar features they can be confused with, and what pitfalls are associated with using this indicator in the field.

D8. Not used in any Supplement

D9. Gauge or well data

Read Indicator D9, Gauge or well data

Question	Answer
Which NRCS tools are to be used to evaluate any gauge or well data available for a site?	Hydrology Tools for Wetland Determination, Engineering Field Handbook Chapter 19, Use of Stream and Lake Gages 650.1901 and Observation

	Wells 650.1907
Discussion	
Quantitative hydrologic investigations are acceptable and strong evidence for determining presence or absence of wetland hydrology if conducted with acceptable methods and overseen by qualified personnel. NRCS Hydrology Tools for Wetland Determination provide those safeguards.	

4.4. Hydrology Tools for Wetland Determinations

National Engineering Handbook Part 650 is the Engineering Field Handbook (EFH). Chapter 19 of the EFH is titled "Hydrology Tools for Wetland Determination." It describes the use of both on site and off-site data that can be used to assess the duration and frequency of inundation and saturation on potential wetland sites. The descriptions of the tools include limitations, sources of data, methodology, and sample calculations.

The conclusions drawn from these tools can be used as primary indicators of Wetland Hydrology in two ways:

1) The tools can determine the frequency and duration of saturation and inundation on a reference site. The results can be used as objective criteria to apply to the delineation site to determine the extent of wetland hydrology.
2) The State Off Site Methods may define the requisite frequency and duration criteria for wetland hydrology for a particular region or wetland type, and the Hydrology Tools can be applied directly against these criteria.

It is important to recognize that the Hydrology Tools do not define wetland hydrology. They can only determine the frequency and duration of hydrologic conditions. There are only two instances where wetland hydrology are defined by objective criteria. One is in the definition of the Food Security Act wetland label for Farmed Wetland, and is defined as either 7 days of inundation or 14 days of saturation, or 15 days of inundation at a 50% chance annual frequency. Documenting the hydrology for this label criteria is NOT the definition for wetland hydrology, and the use of FSA labels is beyond the scope of this training. The other case is found in the COE Regional Supplements, under "Long-term hydrologic monitoring". In this case, according to COE standards, wetland hydrology is proven if a site has a high water table for 14 consecutive days with a 50% chance annual probability, unless another standard has been set for a geographic area or wetland type.

Participant Exercise #4

Go to your office copy of EFH 19 and look at the list of tools described. List the seven tools and note any which may apply in your work area. The on-line version is found at http://policy.nrcs.usda.gov. Select Handbooks on the left side.

Stop time for Part 4 ______________

PART 5 – DIFFICULT WETLAND SITUATIONS

Part 3 is designed to take 1 hour and includes required exercises. Links are provided as optional learning opportunities. Start time: __________

Why is this important to me? This Part of the Module and Supplements provides tools to resolve problems when delineations must be conducted under abnormally dry conditions or significantly disturbed circumstances. Climatic Data and Altered Hydrology were described in Sections 3.3 and 3.4 of this Module.

5.1. Introduction

Module 2 of these training materials discussed the purpose of the Difficult Wetland Situations chapter of the Regional Supplements, its relationship to the 1987 Manual and NRCS's authority to implement the chapter's provisions. To summarize that relationship:

> Most of the Difficult Wetland Situations tie in to Part IV of the 1987 Manual (Methods), Section G (Problem Areas, pp 84-86). For hydrology, the major type of Problem Area is Seasonal Wetlands (p. 84). The recommended procedure is
> 1. Identify the problem,
> 2. Evaluate and document the problematic environmental conditions
> 3. Determine whether Normal Environment Conditions would usually be met in the wettest part of the growing season (page 86 of the Online Edition of the Manual).

The final decision must be made on "best available evidence," as always.

The situations that sometimes make it difficult to identify wetland hydrology include not only non-Normal Circumstances (such as drainage ditches) and non-Normal Environmental Conditions (such as low snowpack), but also seasonal water-table drawdown. It is also possible that due to high summer-time ET the wetland pool is often so low that it is very difficult to document the location of the outward edge of the spring-time pool.

The Corps Regional Supplements offer several tools to get around these problems including resources put forth by the NRCS.

- The Regional Supplements identify numerous field indicators of inundation and long term soil saturation that were not included in earlier iterations of the Corps Manual.

- The supplements include an increased reliance on remote sensing tools from the National Food Security Act Manual.

- Scope-and-effect equations, hydrologic models, and State drainage guides are more prominently recommended.

- The option is available to postpone a final decision until you have conducted additional site visits during the next season of normal wetland hydrology.

- The NRCS Hydrology Tools for Wetland Determination are recommended for use, including long-term hydrologic monitoring.

- Comparison to reference wetlands is authorized.

- Wetland hydrology can be presumed even in the absence of hydrology field indicators if

    - Hydric soils and hydrophytic vegetation are found *and*
    - Landscape position is appropriate for wetlands *and*
    - Normal Circumstances apply *and*
    - You can document that the site visit occurred during the summer dry season, during a period of below-normal rainfall, or during an annual drought *and*
    - In your best professional judgment the area would have wetland hydrology during Normal Environmental Conditions.

All of the Regional Supplements provide guidance for wetlands that periodically lack indicators of wetland hydrology. Some supplements also offer special advice for using data from SNOTEL and/or for identifying wetland hydrology on lands used for agriculture and silviculture.

For the rest of this chapter refer to the appropriate sections of Chapter 5 of your Regional Supplement. Some supplements do not discuss *Lands used for agriculture and silviculture;* in this case either proceed to the next section of this Hydrology Module or read the appropriate section in a Supplement that does cover the topic (Table 3 below).

Table 3. Hydrology Topics covered in Chapter 5 of the Regional Supplements		
Supplement	Lands used for Agriculture and Silviculture	Wetlands that periodically lack hydrology indicators
Alaska		x
Arid West		x
Atlantic & Gulf Coast	x	x
Caribbean Islands	x	x
E-Mtns & Piedmont	x	x
Great Plains		x
Hawaii & Pacific Islands	x	x
Midwest	x	x
N-Central & N-East	x	x
Western Mountains		x

5.2 Lands used for Agriculture and Silviculture

Agricultural and silvicultural disturbances to wetland hydrology typically are removal of water with drainage tiles, ditches, land-leveling, or protection from overland in-flow with levees or berms. Often of these activities have occurred before December 23, the 1985 cut-off date for Wetland Conservation provisions.

Skim the introductory paragraphs of the section Lands used for agriculture and silviculture, and read the entire Hydrology section. Note the references to EFH Chapter 19, Hydrology Tools for Wetland Determinations.

Question	Answer
The effectiveness of drainage in an area depends on what?	Many factors including soil characteristics, timing and amount of rainfall, depth and spacing of ditches or subsurface drains.
Discussion	
Keep in mind that drainage may be partial so that the site still meets wetland hydrology criteria, or drainage may be effective in removing wetland hydrology completely. Also, an older drainage system that has not been maintained will have reduced effectiveness, possibly to the point of being ineffective. See Section 3.4 for information on altered hydrology and drainage systems. Evaluation of these disturbances requires quantitative methods that should be performed by Agency hydrologists and engineers.	

5.3. Wetlands that periodically lack indicators of wetland hydrology

Why is this important to me? The Supplements discuss circumstances where climatic conditions may be problematic, and offers other means by which information can be added to the record when the issue is either climate-related or disturbance-related.

5.3.1. Difficult situations caused by dry site conditions

5.3.1.1. Description of the problem

Go to your Supplement's section on *Wetlands that periodically lack indicators of wetland hydrology.* Read the two paragraphs 'Description of the problem'

Question	Answer
Does this section address situations when the site lacks Normal Circumstances or when it lacks Normal Environmental Conditions?	Normal Environmental Conditions

Discussion
This section deals mainly with climatic or meteorologic situations that cause a wetland to have less stored moisture above the ground, below the ground, or both. The rest of this section will discuss tools to evaluate dry weather conditions.

5.3.1.2. Procedure

Read Procedure, Steps 1, 2 , and 3

Discussion
After you have determined that the site has Hydrophytic Vegetation and Hydric Soils, evaluate the landscape to see why water might accumulate enough to support them. If you find appropriate landform features, you may use one of the approaches listed in Step 3. A short discussion of each is given there.

Skim the paragraphs of sub-steps on:

- Site visits during the dry season
- Periods with below-normal rainfall
- Drought years
- Years with unusually low winter snow-pack (if in your Supplement).

Discussion
Note that each of these sub-steps includes some variation on the following sentence: If the site visit occurred during [*one of the stated dry situations*], and wetland hydrology indicators appear to be absent on a site that has hydrophytic vegetation and hydric soils, and there is no evidence of

hydrologic manipulation (e.g., no drainage ditches, dams, levees, water diversions, etc.), then the area should be identified as a wetland.

Question	Answer
Do you always need to have 1 primary or 2 secondary indicators of Wetland Hydrology to determine that an area is a wetland?	No

Discussion
This is a significant development in wetland determination protocols. The option to determine existence of a wetland without Wetland Hydrology Indicators has always been implicit in both Corps and NRCS procedures by allowing use of best professional judgment. The Regional Supplements still require professional judgment but they supply explicit guidelines to assist in documenting those judgment calls. To facilitate discussion, this option to dispense with the field indicators of hydrology will be referred to as the 'dry-period hydrology exemption' in the rest of this section.

Question	Answer
Do you have to verify that the "site is in a landscape position that is likely to collect or concentrate water" in order to make a 2-factor wetland determination?	Yes. One should also be certain that the site has not been effectively drained by a drainage system.

5.3.1.2.1. Site visits during the dry season

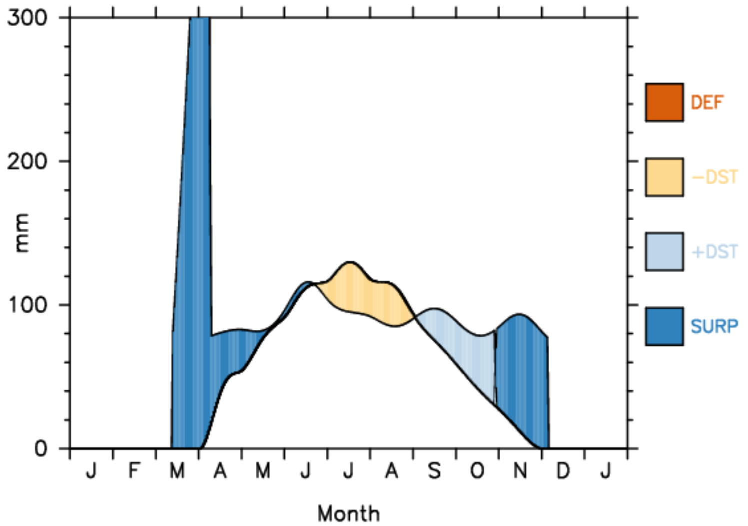
Re-read the sub-step "Site visits during the dry season." (sub-step a. in most Supplements)

Discussion
This sub-step requires documentation that the site visit occurred during the normal dry-season. Some of the supplements list when those normal dry seasons are for the region. For example, in the Alaska region, the Aleutian Islands have no normal dry season. State climatology offices may provide information on whether a time period was wet, normal, or dry compared to 30-year normals at a given location.

The supplements identify the water budget model WebWIMP as a tool for examining generalized monthly moisture deficits and soil moisture changes as a function of normal ET and precipitation. The resultant graphs shown in Figures 42 and 43 are generalized for average soils in the region.

Water Balance at 78.5W, 42.5N
Project Title: Cattaraugus Co, NY

Figure 42, WebWIMP graph.



Location: **78.5W 42.5N** Elevation: **489 m**
Soil water-holding capacity: **150 mm**
Declining availability function: **G**
Prescribed average-monthly air-temperature changes: **0.0°**C
Prescribed average-monthly precipitation changes: **0.0 %**

Monthly and annual climatic water balance **table**

MON	TEMP	UPE	APE	PREC	DIFF	ST	DST	AE	DEF	SURP	SMT	SST
Jan	-5.6	0	0	64	0	150	0	0	0	0	0	125
Feb	-4.9	0	0	60	0	150	0	0	0	0	0	185
Mar	-0.2	0	0	71	155	150	0	0	0	155	109	101
Apr	6.5	30	34	80	147	150	0	34	0	147	101	0
May	12.4	60	76	85	9	150	0	76	0	9	0	0
Jun	17.3	86	109	110	1	148	-2	109	0	3	0	0
Jul	19.4	97	125	96	-29	119	-29	125	0	0	0	0
Aug	18.6	92	110	88	-22	97	-22	110	0	0	0	0
Sep	14.8	73	75	95	20	116	19	75	0	0	0	0
Oct	9.3	44	42	82	40	150	34	42	0	6	0	0
Nov	3.2	14	12	89	77	150	0	12	0	77	0	0
Dec	-3.0	0	0	71	10	150	0	0	0	10	0	61
Total			**583**	**991**				**583**	**0**	**407**		

Monthly and annual climatic water balance **graph**

Figure 43, WebWIMP table.

Figures 42 and 43 are the results of the WebWIMP analysis of the water balance for the county seat of Cattaraugus County, NY. These show that the average soils in this hilly county are in moisture deficit for July and August (DIFF values are negative in Figure 43). This is the time period that the Regional Supplements would recommend use of the “dry season” provisions of Chapter 5. Note again, this is a county-wide average, regardless of landscape position.

NRCS personnel are probably more familiar with Soil Survey tools. Customer Service Toolkit with Soil Data Viewer , eFOTG, Soil Data Mart and Web Soil Survey all list expected monthly water table depths in the Water Features tables (Figure 44). These data are specific to the soils and map units that occur on appropriate landscape positions. If monthly water table data have not been usefully populated for the soils of your site, use data for similar soils on similar landscape positions in your area.

Figure 43 shows two hydric soils in Cattaraugus County, NY. From the table it is apparent that the Wayland soil exhibits a water table in all months except July through September and the Wallington soil exhibits a water table in all months except June through October., The Upper Limit shows the depth of the water-table (groundwater surface) in the months it occurs. The Lower Limit shows how deep the groundwater extends in the months it occurs. The water table in Wallington is perched on top of a restrictive layer, in this case on a fragipan, which is evident from the shallow lower limit.

In summary, the dry-period hydrology exemption requires documentation that the site visit occurred during a season when water tables are usually significantly deeper than required for wetland hydrology.

Water Features

Cattaraugus County, New York

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Pondir	
				Upper limit	Lower limit	Surface depth	Duratic
				Ft	*Ft*	*Ft*	
5:							
Wayland	C/D	Very high	January	0.0-0.5	>6.0	---	---
			February	0.0-0.5	>6.0	---	---
			March	0.0-0.5	>6.0	---	---
			April	0.0-0.5	>6.0	---	---
			May	0.0-0.5	>6.0	---	---
			June	0.0-0.5	>6.0	---	---
			October	0.0-0.5	>6.0	---	---
			November	0.0-0.5	>6.0	---	---
			December	0.0-0.5	>6.0	---	---
33A:							
Wallington	C	Very high	January	0.5-1.5	1.0-2.0	---	---
			February	0.5-1.5	1.0-2.0	---	---
			March	0.5-1.5	1.0-2.0	---	---
			April	0.5-1.5	1.0-2.0	---	---
			May	0.5-1.5	1.0-2.0	---	---
			November	0.5-1.5	1.0-2.0	---	---
			December	0.5-1.5	1.0-2.0	---	---

Figure 44. Part of Water Features table in Soil Data Mart.

5.3.1.2.2. Periods with below normal rainfall

Read the sub-step "Periods with below-normal rainfall." (sub-step b. in most Supplements)

Discussion
The dry-period hydrology exemption can also be applied if a site visit occurs during a period of drought. The Supplements recommend documentation with the WETS tables and local precipitation records. These were discussed above in Section 3.3. The Supplements recommend additionally that you evaluate precipitation that occurred during the preceding two or three months to ascertain if antecedent precipitation was below normal. The referenced method evaluates whether antecedent precipitation was normal during the current month and the preceding two months and assigns them 'condition values' (dry = 1, normal = 2, wet = 3), and then weights the monthly condition values (1st prior month = 3, 2nd prior month = 2, third prior month = 1) with the most recent month being weighted the most. These weighted condition values are then used to decide whether the entire preceding 3-month period was dry, normal or wet.

The precipitation values for the demonstration table below were taken for Avon, Livingston Co, NY, for July 28, 2009. The ranges of normal were taken from the appropriate WETS table. Pro-rate precipitation amounts for partial month evaluations.

Long-term rainfall records

	Month	3 yrs in 10 less than	3 yrs in 10 more than	Rain fall	Condition dry, wet normal	Condition value	Month weight value	Product of previous two columns
1st prior month*	July	1.78	3.22	4.18	wet	3	3	9
2nd prior month*	June	2.38	4.44	4.94	wet	3	2	6
3rd prior month*	May	1.97	3.33	2.54	normal	2	1	2
	* Compared to site observation date						Sum	16

Note:

If sum is		Condition value:	
6 - 9	then prior period has been drier than normal	Dry	=1
10 - 14	then prior period has been normal	Normal	=2
15 - 18	then prior period has been wetter than normal	Wet	=3

Conclusions:

July Rainfall prorated from July 1-27, 2009, data.

The "Rainfall Documentation" procedure generates a conclusion that the prior period was ***wetter than normal***

The long term climate history should be evaluated before accepting this conclusion.

Figure 45 – Antecedent Rainfall Evaluation

WETS Station : AVON, NY0343 Latitude: 4255 Longitude: 07745 Elevation: 00540
State FIPS/County(FIPS): 36051 County Name: Livingston
Start yr. - 1971 End yr. - 2000

Month	Temperature (Degrees F.) avg daily max	avg daily min	avg	Precipitation (Inches) avg	30% chance will have less than	more than	avg # of days w/.1 or more	avg total snow fall
January	32.6	16.4	24.5	1.79	0.98	2.02	4	14.0
February	34.8	17.1	26.0	1.54	0.99	1.91	4	12.1
March	42.8	23.6	33.2	2.34	1.71	2.76	5	10.3
April	55.3	34.7	45.0	2.82	2.11	3.45	6	3.0
May	68.2	45.1	56.7	2.85	1.97	3.33	6	0.2
June	77.3	54.8	66.1	3.51	2.38	4.44	7	0.0
July	81.6	59.1	70.4	2.78	1.78	3.22	6	0.0
August	79.7	57.0	68.3	3.31	2.18	3.68	6	0.0
September	72.0	49.7	60.8	3.46	2.73	3.81	7	0.0
October	60.8	39.4	50.1	2.58	1.74	2.98	6	0.1
November	47.9	31.6	39.7	2.62	1.79	3.14	6	4.2
December	36.7	22.2	29.4	2.23	1.53	2.62	5	12.0
Annual	-----	-----	-----	------	29.57	33.59	--	----
Average	57.5	37.6	47.5	------	------	------	--	----
Total	-----	-----	-----	31.83	------	------	68	55.9

Figure 46 – WETS Table

This drought analysis should be confirmed with longer term evaluations available on the Internet, especially against the

- US Drought Monitor: http://drought.unl.edu/DM/MONITOR.html)
- Standardized Precipitation Index: http://www.wrcc.dri.edu/spi/spi.html

both of which are discussed in Section3.3.2 above. The Drought Monitor in particular should be checked weekly during the field season (see Section 3.2.2 above).

5.3.1.2.3. Drought years

Read the sub-step “Drought years” (sub-step c. in most Supplements)

Discussion

The dry-period hydrology exemption also applies to site visits conducted in drought years. The Regional Supplements recommend consulting the Palmer Drought Severity Index, especially their time series archives. Consult with your State Climate Liaison or State Climatologist before relying on Palmer indices. As was discussed in more detail in Section 3.3.2, this index was developed for use in the Great Plains; climatological experience has cast doubt on its applicability to mountainous regions in the West, and perhaps other regions as well. For precipitation analysis, consult the Standardized Precipitation Index (http://www.wrcc.dri.edu/spi/spi.html), which provides percentile precipitation analyses for time periods ranging from one month to five years before the current month. Whichever method you use also look at the monthly rainfall distribution within the calendar year of low rainfall.

5.3.1.2.4. Years with unusually low winter snowpack (Western Mountains, Alaska, Arid West supplements)

Read the sub-step "Years with unusually low snow-pack"

Discussion
Consult your State Wetlands Leader and Engineering Section for further information about SNOTEL and its applicability in your Region. As with the preceding sub-steps, the 'dry-period hydrology exemption' applies to wetlands that lack hydrology indicators because of unusually low winter snowpack. This is the last of the difficult wetland situations that uses the dry-period hydrology exemption.

5.3.2. Tools for difficult situations caused by site disturbance

Why is this important to me? When a site has been so heavily disturbed that it is no longer feasible to evaluate wetland hydrology, Corps procedures allow the wetland identification decision to be made using the vegetation and soils factors alone. The NRCS has adopted this 2-parameter test if there is so little information that the following tools cannot be used.

5.3.2.1. Reference sites

Read the sub-step "Reference sites"

Discussion
Reference sites can provide useful information for inspections conducted under difficult conditions. The obvious problem is finding such sites with comparable landscape positions and water budgets. Certainly use them if they are available, perhaps at parks or university research stations. Exercise caution in selecting a reference site. Often what is selected can determine the answer to the question about whether wetland hydrology is present. If you have a disturbed site where information about a delineation factor cannot be gathered, both the NRCS and the Corps authorize collecting the missing information at a nearby site with soils and other site characteristics similar to those found on the

disturbed site before alteration.

5.3.2.2. Hydrology Tools

Read the sub-step “Hydrology tools”

Discussion
Chapter 19 of the EFH was discussed in Section 4.4, above.

5.3.2.3. Evaluating multiple years of aerial photography

Read the sub-step “Evaluating multiple years of aerial photography”

Discussion
This topic is discussed in section 650.1903 in the Engineering Field Handbook Chapter 19. The method is widely used in the upper Midwest region of the United States.

5.3.2.4. Long-term hydrologic monitoring

Read the sub-step “Long-term hydrologic monitoring”

Question	Answer
Do the findings of long-term monitoring overrule evidence from the hydrology indicators?	No
Discussion	
The criterion is to be used for scientific and forensic studies, not to challenge wetland determinations performed with the various Routine Methods of the Manual. Quantitative criteria for interpreting the long-term water-well data are: • water tables at or above 12 inches • for 14 consecutive days • during the growing season • at a frequency of at least 5 years in 10. Such research projects should be conducted by appropriately trained hydrologists or engineers.	

Stop time for Part 5 _______________

PART 6 – DECISION MAKING

Part 6 is designed to take 0.5 hour and includes required exercises. Links are provided as optional learning opportunities. Start time: __________

Overview

The decision-making process for wetland identification roughly follows the sequence in which the Corps Manuals and this training module are presented.

6.1 Gather background information
6.2 Be aware of any special data needs
6.3. Collect primary data (both on- and off-site) and document it on the Corps data form
6.4 Collect additional information if required because of difficult situations, and record it.
6.5 Based on the preponderance of the information you have gathered, use your professional judgment, training, and experience to make a final decision, and document it.

6.1. Background information

The gathering of background information on current and antecedent climatic conditions and on site disturbance was covered in the Hydrology Data and Altered Hydrology Sections above (Sections 3.3 and 3.4).

6.2. Be Aware of Any Special Data Needs

If it is suspected that hydrology has been altered since 1985, then additional consideration is required. In these situations, NRCS wetland specialists are mandated to confirm that the *sampling unit* has retained enough hydrology (saturation and/or ponding) to meet the FSA wetland criteria of being "*inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soils conditions*." When hydrology has been altered, further investigation is required.

If the alteration occurred prior to 1985, further investigation shall be performed to confirm if wetland hydrology remains within the *sampling unit*. In this verification process, the objective is to confirm that under *normal environmental conditions* the site is still subject to *inundation or saturation* and that these wetting events still occur at such a *frequency and duration* to support hydrophytic vegetation. This is accomplished by either:

1. Directly observing wetland identification factors as specified in Food Security Act wetland definitions, or
2. Inferring that the definitions have been met by using the indicator-based approach.

Most of the Corps of Engineers wetland identification procedures discussed in this Module use the Indicator based approach.

6.3. Hydrology Portions of Wetland Determination Data Form

The hydrology portions of the Wetland Determination Data Form for the Atlantic and Gulf Coastal Plain Region are presented below in Figure 47. Other supplements have a similar form but each reflects the field indicators that are valid in that region. The portions pertinent to hydrology are the Hydrology block at the bottom of the page and the three lines above the 'Summary of Findings' block, where the data form solicits information about climatic/hydrologic conditions, disturbed or problematic hydrology, and normal circumstances.

The subjects of Normal Circumstances and Normal Environmental Conditions are discussed in Module 2 of this training. Definitions are given in the appendix to this module. Individual field indicators have been discussed in Part 4 above.

When making a field visit, observation is critical. It is extremely important to document well what is observed. The investigator may wish to take photographs to document this point in time and what was observed. At times a survey can be used to document the relative locations of features on the landscape.

Investigators should document which indicators are observed on site. The total record is stronger if each of the indicators checked is described further in remarks or on a separate written report of observations. Each field indicator that is marked can be further described in the narrative, as appropriate.

The three lines in the box titled "Field Observations" document direct observations of water onsite. If these observations were made at a time that Normal Environmental Conditions occur onsite, then the observations constitute proof that the FSA wetland definition of wetland hydrology is met.

The three boxes titled "Field Observations" also provide further information to support indicators A1, A2, and A3 if they are present on site. If a boring or auger hole does not display any evidence of a water table or saturation, do not write "none", but instead indicate at what depth the searching ceased, such as ">24 inches". This indicates that the professional visiting the site had an observation hole that extended to 24 inches but that evidence of saturation was not observed up to that point. If no water was observed standing on the surface, it is appropriate to indicate "NA" or say "none". The box asking "Wetland Hydrology Present?" is a summary for the whole visit. This data sheet, however, is inadequate to really describe all that may need to be said about the hydrology of a site. The two boxes for "Remarks" and to "Describe Recorded Data" are too narrow to give any explanation. The user is encouraged to say "see attached" and use a separate narrative to describe all that was seen that relates to the hydrology of the site.

If a survey was made of the site to record elevations or grade rod readings, a plan view should show pertinent locations. If a GPS unit was used to record points, a plan view should identify those with a descriptive narrative attached. An appeals hearing officer picking up this case file will not have the advantage of going on-site so the case file needs to clearly explain and document what was seen.

6.4. Difficult Situations for Wetland Hydrology

Part 5 of this training module covered additional protocols that the Corps recommends using for dry conditions or significant disturbance. These situations go beyond the Wetland Data Form and require additional documentation.

6.5. Preponderance of Evidence

The NRCS and the Corps of Engineers authorize and recommend the methods of Chapters 4 and 5 for routine and difficult situations. To finish up this part of the course,

Return to the beginning of Chapter 5 of the Supplement and re-read the last paragraph of the Introduction.

Question	Answer
What is the summarizing admonition underpinning all methods to identify wetlands, whether it is for hydrophytic vegetation, hydric soils, or wetland hydrology?	Determinations must be based on best professional judgment.
Discussion	
Do not be afraid to apply your professional training and experience when identifying wetlands. When physical or meteorological conditions are difficult, document that you have followed standard procedures to justify using the tools supplied in Chapter 5. Then document that you have used these tools and justify why. Then use your professional judgment to make a decision based on your experience and on all of the information you have gathered from these tools. The preponderance of evidence will lead you to a decision.	

Experienced wetland experts in both the NRCS and the Corps of Engineers repeatedly find that science is respected in both Agency appeals and in court. Do not feel tied down to the data forms. There are times that official forms are only the beginning. Trust the science underlying these other tools. And trust your judgment. To finish up this Module:

"***Wetland determinations must be based on the best information available to the field inspector, interpreted in light of his or her professional experience and knowledge of the ecology of wetlands in the region."***

Stop time for Part 6 ____________

PART 7 – SUMMARY

Wetland hydrology is met when the site is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions. Without water, a wetland isn't a wetland. The hydrology can be the most elusive of the three parameters.

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: J/M Doe Farm City/County: Somewhere, Brazoria Sampling Date: April 1, 2009

Applicant/Owner: J & M Doe State: Texas Sampling Point: 12

Investigator(s): J Smith Section, Township, Range: ______

Landform (hillslope, terrace, etc.): relic stream meander depression Local relief (concave, convex, none): concave Slope (%): 0%

Subregion (LRR or MLRA): LRR T Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: Leton loam NWI classification: PEM

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ☑ No ☐ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ☑ No ☐

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ☑ No ☐	Is the Sampled Area within a Wetland? Yes ☑ No ☐
Hydric Soil Present?	Yes ☑ No ☐	
Wetland Hydrology Present?	Yes ☑ No ☐	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

☐ Surface Water (A1)	☐ Water-Stained Leaves (B9)	
☑ High Water Table (A2)	☐ Aquatic Fauna (B13)	
☑ Saturation (A3)	☐ Marl Deposits (B15) **(LRR U)**	
☐ Water Marks (B1)	☐ Hydrogen Sulfide Odor (C1)	
☐ Sediment Deposits (B2)	☑ Oxidized Rhizospheres on Living Roots (C3)	
☐ Drift Deposits (B3)	☐ Presence of Reduced Iron (C4)	
☐ Algal Mat or Crust (B4)	☐ Recent Iron Reduction in Tilled Soils (C6)	
☐ Iron Deposits (B5)	☐ Thin Muck Surface (C7)	
☑ Inundation Visible on Aerial Imagery (B7)	☐ Other (Explain in Remarks)	

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☑ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☑ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ☐ No ☑	Depth (inches): ______
Water Table Present?	Yes ☑ No ☐	Depth (inches): 10
Saturation Present? (includes capillary fringe)	Yes ☑ No ☐	Depth (inches): 11

Wetland Hydrology Present? Yes ☑ **No** ☐

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

FSA Photos dates mo/dy/yr, mo/dy/yr, mo/dy/yr

Remarks:

US Army Corps of Engineers Atlantic and Gulf Coastal Plain Region – Interim Version

Figure 47

PART 8 – KNOWLEDGE ASSESSMENT

The knowledge assessment part a is expected to take 0.5 hour. Start time ________

1. Under what circumstance would the observation of shallow inundation on a site be questioned or disregarded?
    a. Within a short time after a significant rain event
    b. When the site has trees
    c. When the site has been plowed so no vegetation is visible
    d. When the site's soil is organic

2. Indicator C3 (Oxidized Rhizospheres) requires red mottles in root channels within the top 12 inches of the soil. Which of the following statements is true?
    a. The red mottles have to around living roots, and can be either iron deposits or organic coatings.
    b. The red mottles have to around living roots, and must be iron deposits. Organic coatings alone are not sufficient.
    c. The red mottles must be around roots, either living or dead.
    d. The red mottles must be in root channels, with or without roots.

3. If Geomorphic Position (D2) is to be claimed as an indicator, what should be true about any drainage system affecting the site?
    a. It should be subsurface tile only.
    b. It should be surface ditches only.
    c. It should have been installed within the last 10 years.
    d. The site should not have a functioning drainage system.

4. Which of these may be evidence of Soil Saturation (Indicator A3)?
    a. Water can be squeezed out of a soil clod with hand pressure
    b. Water glistening on an undisturbed soil surface
    c. Wetness at the bottom of the A horizon 2 feet above free water in the soil pit
    d. Water can be seen on the surface of ball of soil that is gently shaken back and forth in the hand (dilatency)

5. Is Sparsely Vegetated Concave Surface (Indicator B8) a primary or secondary indicator in this region?
    a. Primary
    b. Secondary

6. Is Dry-season Water Table (Indicator C2) a primary or secondary indicator in this region?
    a. Primary
    b. Secondary

7. How many primary indicators are needed as a minimum to indicate a site has wetland hydrology present?
    a. One
    b. Two
    c. Three
    d. Four

8. How many secondary indicators are needed as a minimum to indicate a site has wetland hydrology present?
    a. One
    b. Two
    c. Three
    d. Four

9. If two primary indicators are observed on a site along with three secondary indicators, which should be recorded on the field data sheet?
    a. Only the first two observed
    b. All of them
    c. Only the one that seems to be strongest
    d. Only the primary indicators

10. The growing season can be identified on a site in two ways and one alternate manner. Which of the following is NOT a way to identify the growing season?
    a. The growing season has begun on a site in a given year when two or more different non-evergreen vascular plant species exhibit certain characteristics of biological activity.
    b. The growing season has begun in spring and is still in progress when the soil temperature measured at a 12” depth is 41^{o}F or higher.

c. The growing season extends into the fall until the soil temperature measured at a 20” depth falls below 35 ^{o}F.

d. The growing season may be approximated by the median dates when the air temperature is 28 ^{o}F in both spring and fall according to National Weather Service records.

11. The wetland hydrology criterion requires that a site has water tables at or above 12 inches for ________
    a. 5 percent of the growing season
    b. 14 consecutive days of the growing season
    c. 30 cumulative days of the growing season
    d. The NFSM and Corps Manuals have no quantitative hydrologic criterion for undisturbed wetlands.

12. If a forested site has been artificially drained, cleared, and converted to agricultural uses in the last year, how would you document whether it had wetland hydrology prior to disturbance?
    a. Compare hydrology found at an undrained comparison site that has similar soils.
    b. Check for evidence of inundation on FSA compliance photographs.
    c. Calculate scope and effect of the drainage ditches or tiles.
    d. All of the above.

13. Chapter 5 of the regional supplements provides rules for doing wetland determinations during dry times of the year. If a site has (1) hydrophytic vegetation, (2) hydric soils, (3) a landscape position that is likely to collect or concentrate water, and (4) if you can also document that water tables are usually low during the season of the site visit, which of the following is required to document presence of wetland hydrology?
    a. One secondary indicator suffices to infer wetland hydrology.
    b. You have to revisit the site during the normal wet season.
    c. The four conditions listed in the question are sufficient to infer presence of wetland hydrology, even if no indicators are found onsite.
    d. Two primary indicators are required to document wetland hydrology.

14. The Corps Wetland Determination Data Form asks

"Are Vegetation ___, Soil ___, or Hydrology ____naturally problematic? (If needed, explain any answers in Remarks.)"

Which of the following is an example of naturally problematic hydrology?

a. You are in a seepage wetland.
b. This season is one of the wettest springs on record.
c. The site has drainage ditches on three sides of the perimeter.
d. All of the above.

15. On a site visit you examine the soils to 20 inches and find no water table in your soil pit. How should you record this on the Wetland Determination Data Form?

A.	Water Table Present?	Yes		No	X	Depth (inches):	0
B.	Water Table Present?	Yes	X	No		Depth (inches):	>20
C.	Water Table Present?	Yes		No	X	Depth (inches):	>20
D.	Water Table Present?	Yes		No		Depth (inches):	na

16. Which of the following is NOT a problem with the use of precipitation data to determine whether normal environmental conditions exist?
a. Dominant water inputs to the wetland may be from deep groundwater discharge from sources not significantly influenced by the last three months of precipitation.
b. Precipitation data are posted too late to be useful for most site Wetland Conservation site inspections.
c. Evapotranspiration may be significantly different than normal.
d. In colder climates, surficial water storage (both above and below ground) may reflect hydrology inputs more than three months previous to the site visit.

17. Which of the following are FSA variances to Chapter 4 of the Corps 1987 Manual
a. Hydrology Tools for Wetland Determinations (NEH 650, Chapter 19) can be used as a primary indicator to document wetland hydrology.
b. Direct observation of inundation and/or saturation during Normal Circumstances can be used in lieu of the indicators in Chapter 4 to directly verify wetland hydrology.

c. Hydrology Tools for Wetland Determinations (NEH 650, Chapter 19) can be used to verify objective hydrology criteria that are included in State Offsite Methods.

18. Which or the following statements are true?
    a. The Hydrology Tools for Wetland Determinations (NEH 650, Chapter 19) lists numerical criteria for wetland hydrology.
    b. The Corps 1987 Manual lists numerical criteria for wetland hydrology.
    c. Wetland hydrology exists if a site has 7 days of inundation and/or 14 days of saturation.
    d. Wetland hydrology exists if a site is inundated or saturated for 5% of the growing season.
    e. None of the above.

ANSWERS

1. A. If a field visit is made soon after a significant rain event, more sites are likely to have standing water than would meet the duration and frequency necessary to conclude that wetland hydrology is present. Other evidence is needed.
2. B. This is an indicator of contemporary anaerobiosis, not historic conditions. Therefore the roots channels must be occupied by living roots, from which we infer that the iron precipitated recently. Organic coatings do not necessarily indicate reducing soil conditions.
3. D. Evaluation of a site with a functioning drainage system (even if it is at less than 100% efficiency) cannot rely on geomorphic position without documentation or explanation as to why the functioning drainage system has little or no impact on the site's hydrology. Read the User Notes for Indicator D2.
4. B. A site where saturation is observed has a high likelihood that water will glisten on the surfaces and broken interior faces of a soil sample (ped) removed from an auger hole or pit. The other three options are common mistakes made by novices in the field. Read the General Description for Indicator A3.
5. Read the Description, Cautions and User Notes for Indicator B8. It is a primary indicator in 4 regions, a secondary indicator in 5 regions, and does not apply in the Arid West Region.
6. Read the Description, Cautions and User Notes for Indicator C2. It is primary in two regions and a secondary indicator in 8 regions.
7. A. See the Wetland hydrology indicators subsection of Chapter 4 (which is also called Wetland Hydrology Indicators).
8. B. See the Wetland hydrology indicators subsection of Chapter 4 (which is also called Wetland Hydrology Indicators).
9. B. Always record all indicators observed on site and use the remarks section or a separate document to describe their applicability in detail. On later examination or appeal, one or more indicators may become unusable.
10. C. See the Growing Season subsection of Chapter 4 (which is titled Wetland Hydrology Indicators).
11. D. The Corps Manual used to be interpreted to require a quantitative hydroperiod but that has been eliminated with the regional supplements. The NFSAM does not require a duration of flooding, ponding, or saturation for the *hydrology* factor. This should not be confused with the *hydric soils* criterion of flooding or ponding.
12. A. Chapter 5 of the regional supplements and NFSAM procedures both recommend use of Reference Sites (Corps regional supplements) or Comparison Sites (NFSAM) to infer what conditions were like on a site prior to recent disturbance. Air photos would not be much use to determine saturation in a wood lot. Scope and effect equations tell the theoretical effectiveness of ditches or tiles but not what ground water levels were prior to drainage.

13. C. Chapter 5 of the regional supplement provides rules where wetlands can be documented with just hydrophytic vegetation and hydric soils, if landscape position is compatible with wetland hydrology AND if you can document from certain published records that water tables are normally deep during the season of the site visit.
14. B. Exceptionally wet conditions could cause you to delineate wetland boundaries upslope of the normal wetland boundary. Seep wetlands are natural but the discharge hydrology is the natural cause of the wetland, not a problem. Artificial drainage is not a “natural” problem.
15. C. Fill out data forms so they can be understood by people who have never been onsite. “No” indicates that you did not find a watertable during your inspection. “>20” shows the depth that you dug to without finding the water table. Answer C provides more information than the other answers.
16. B. For most weather stations, recent precipitation data are posted in the eFOTG within days of the rainfall event. The other answers are all potential problems with relying solely on precipitation data to evaluate recent hydrologic conditions.
17. B. and C. The Hydrology Tools, used alone can only determine probabilities, frequencies and durations of inundation and/or saturation. These results must be compared to objective criteria included in State Offsite Methods. The variances also allow the direct verification of wetland hydrology without the use of Chapter 4 indicators IF the observation is made on site, and the site visit is conducted during a time when Normal Circumstances exist. Hydrology Tools alone do not contain any objective criteria for wetland hydrology. They can only provide numbers.
18. E. None of the above. Wetland hydrology exists if a site, under Normal Circumstances can support hydrophytic vegetation. The probability, duration, and frequency of inundation and saturation vary with wetland type, climate, landscape, and region. The State Offsite Methods (SOSM) developed by each state can make local determinations on objective numerical criteria for wetlands. The Hydrology Tools can be used to determine the presence of water in numerical and statistical terms, but these criteria must be compared against the criteria in the SOSM.

Stop time for part a of knowledge assessment _____________

Part 9. Glossary

Why is this important to me? This glossary gives definitions according to the Glossaries of the Regional Supplements, which give priority to the following sources:

1. Corps Manual (Environmental Laboratory 1987 (http://el.erdc.usace.army.mil/wetlands/pdfs/wlman87.pdf).

2. Field Indicators of Hydric Soils in the United States (USDA Natural Resources Conservation Service 2006b) (http://soils.lusda.gov/use/hydric/)

3. National Soil Survey Handbook, Part 629 (USDA Natural Resources Conservation Service)

Other terms are included with sources noted

Anaerobic. A situation in which molecular oxygen is virtually absent from the environment.

When the soil becomes saturated, air between soil particles is replaced by water. Because the rate of diffusion of oxygen through water is 1/10,000th that of the rate of diffusion through air, losses of oxygen in the wet soil cannot be replaced rapidly by diffusion of oxygen from the atmosphere. Instead, soil microorganisms quickly deplete the available oxygen and the soil becomes anaerobic.

Aquifer. A saturated, permeable geologic unit of sediment or rock that can transmit significant quantities of water under hydraulic gradients (National Soil Survey Handbook).

For wetland science an aquifer is usually the top-most layer of the groundwater that is under atmospheric pressure. The bottom of this layer is a lower soil horizon with markedly different storage and flow properties. Wetland aquifers are *unconfined* in that their top is under atmospheric pressure; they do not have a retarding or excluding layer on top i.e. they do not flow under artesian pressure. Plant roots penetrate down into them and extract water from them.

It is important to note the definition of *water table* below. The surficial aquifer has to be at least 6 inches (15 cm) thick and persist for more than a few weeks. The two-dimensional top of the three-dimensional aquifer is the 'water table.'

'Aquifer' is also used in its more general sense as a larger body of subterranean groundwater within a geologic stratum with consistent storage and flow properties. The uppermost aquifer, or wetland aquifer, is then called the *surficial aquifer* to distinguish it from deeper ones.

Aquitard*.* A layer of soil or rock that retards the downward flow of water and is capable of perching water above it.

For the purposes of this supplement, the term aquitard also includes the term **aquiclude**, which is a soil or rock layer that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients (Regional Supplement Definitions). For wetland science, aquitards are usually deeper soil horizons or strata that transmit water much more slowly than the uppermost horizons. A typical example would be subsoil that has more clay and is denser than the topsoil. The topsoil transmits water more rapidly. Here the topsoil is the *aquifer* and the denser subsoil is the *aquitard*.

For hydrology aquitard is a relative term. A shallow shale bed could be an aquitard with respect to the overlying unconsolidated wetland soil but the same shale bed would be an aquifer with respect to an underlying bed of impermeable basalt. In soils aquitards are usually relatively leaky in that they have cracks and imperfect formation and continuity Overlying water can seep through. Typical soil aquitards are fragipans (Bx), some Ortstein (Bsm), some argillic horizons (Bt), dense glacial till (Cd), and thick clay subsoils.

Capillary fringe**.** Zone immediately above the water table where the soil is saturated but under subatmospheric pressure (Soil Science Society of America).

Capillary fringes in natural, mineral soils reach a few inches above a water table depending on soil texture and porosity. The highest capillary fringes are present in organic soils, where pores can be effectively saturated for several inches above the free water surface.

Catchment. This term is used interchangeably with drainage area (DA), drainage basin, or watershed. It is frequently used in publications of British or Australian origin.

Drainage Area. The land from which the water runs off and is collected at a single point.

Effectively drained**.** The condition where ground or surface water has been removed by artificial means to the point that an area no longer meets the wetland hydrology criteria. “Artificial means” often is a tile or drainage ditch. The area will not support a dominance of hydrophytes but hydric soil often persists. Immediately after a site is drained, some passage of time is required for evidence of the removal of wetland hydrology to be seen.

Endosaturation. The condition in which soil is saturated with water in all layers from the upper boundary of saturation to a depth of 200 cm or more from the mineral soil surface. (Glossary of Soil Science Terms)

Episaturation. Condition in which the soil is saturated with water at or near the surface, but also has one or more unsaturated layers below the saturated zone. The zone of saturation is perched on top of a relatively impermeable layer (Regional Supplement).

Flooding**.** The soil surface is temporarily covered with flowing water from any source, such as overflowing streams or rivers, runoff from adjacent slopes, and inflow from high tides.

Growing season. See Section 4.2 in this Module.

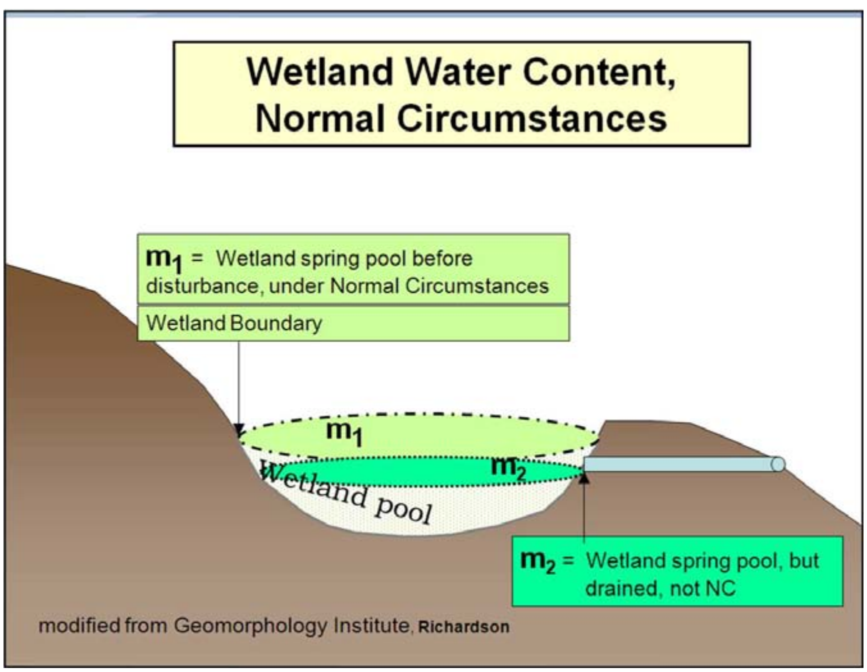
Hydroperiod*.* Seasonal pattern of water in a wetland.

Inundation. A condition in which water from any source temporarily or permanently covers a land surface. Two types of inundation are ponding and flooding.

Invert. The lowest part of the internal cross-section of a channel or culvert, sometimes referred to as a flowline.

Lateral effect**.** The distance on each side of a tile or ditch in its longitudinal direction where the ditch or tile has an influence on the hydrology.

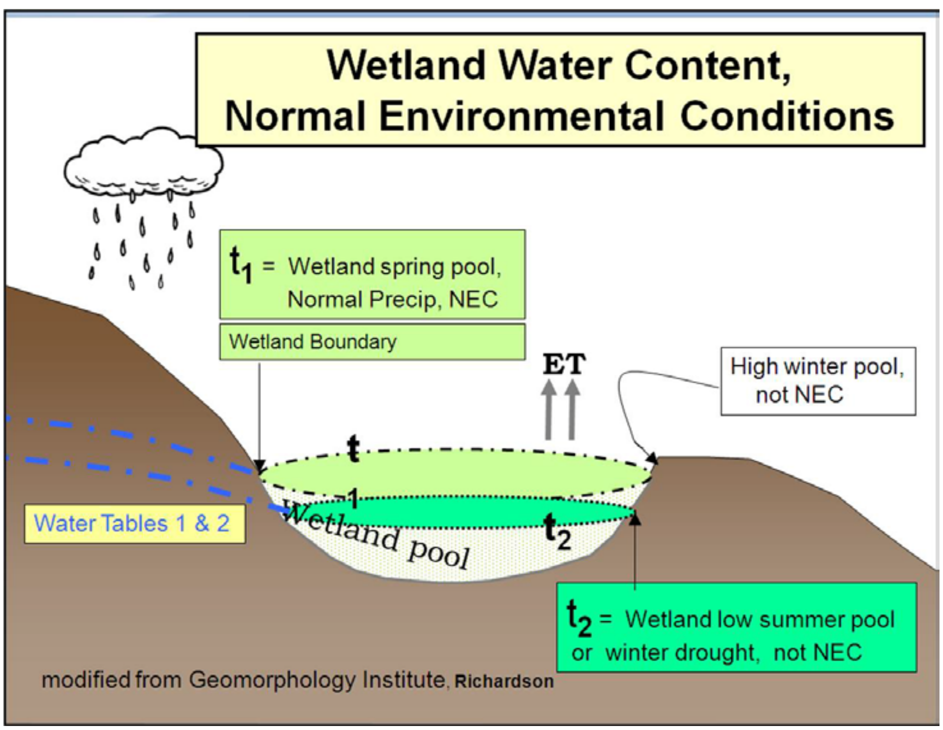
Normal Circumstances (NC)**.** For the purposes of wetland hydrology, normal circumstances is the absence of factors such as ditches, subsurface drainage, blocked culverts, burial, excavation, regional water table draw down, etc., which would



significantly alter the ability of water to rise to the ground surface within the wetland boundary . Most deviations from normal circumstances are physical disturbance of either surface or subsurface water flows to or from the wetland. After disturbance, Wetland Hydrology Indicators of inundation, shallow water tables, and shallow saturation no longer reflect the same hydrologic regimes that would have been found before the alteration. Non-normal circumstances can also be caused by natural events, such as inundation from an exceptional storm or flood. The figure here depicts both normal circumstances as well as a drained condition which is not normal circumstances.

Normal Environmental Conditions. Normal Environmental Conditions (NEC) occur when wetland inundation and shallow saturation are at critical threshold levels at the boundary but not upslope in adjacent non-wetlands (Figure 18). In order to assess whether Normal Environmental Conditions prevail it is necessary to know how the hydrologic components of the water budget compare to long-term averages. For example, has precipitation been within the range of normal for the preceding months and seasons? Is snowmelt normal? Are deeper water tables at approximately normal levels so groundwater inputs and outflows are not aberrant? Are floods typical of the stream or river?

In much of the country the ideal time to conduct wetland delineations is early in the growing season of a spring that is neither wetter nor drier than normal. Water levels would be at their critical thresholds (but not higher into uplands), and any ephemeral hydrophytic vegetation would still be dominant before FACU and UPL species replace them as the dry summer progresses. Even some of the strongest hydric soil indicators are present only when the ground is saturated and reduced, such as Reduced Matrix and Hydrogen Sulfide Odor. Wetland delineations conducted under such conditions present the strongest evidence regarding where the wetland boundary is.



In the figure of NEC here, the extent of the wetland's pool is considered to be NEC in the spring after the growing season has begun. If the saturation or inundation is unusually high due to a wetter than normal winter, this is not NEC. When evapotranspiration exceeds precipitation and the pool is low, this is seasonally affected and is not considered NEC. In a time of drought, the pool is likely to be at a lower elevation than NEC also.

Ocher . An earthy, pulverulent, red, yellow, or brown iron oxide that often precipitates at drainage line outlets and on hillside seeps (Glossary of Geology). In both cases, the cause is anaerobic water carrying large amounts of reduced iron (Fe^{++}) coming into contact with air, at which point the ferrous iron precipitates into a soft, reddish mass, referred to in drainage engineering as ocher.

***Ponding*.** A condition in which water stands in a closed depression. The water is removed only by percolation, evaporation, transpiration or pumping.

Pool Area. The surface area of a body of water at its normal elevation (not in time of drought or flood)

Restrictive layer. A "restrictive layer" is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The Soil Features table in Soil Survey Reports indicates the hardness and thickness of the restriction, both of which significantly affect the ease of excavation (Soil Data Mart). "Depth to top" is the vertical distance from the soil surface to the upper boundary of the restrictive layer. (Soil Data Mart).

The effectiveness of a restrictive layer in creating episaturated conditions is indicated in the Water Features Table (depth and nature of water table) and the Soil Physical Properties Table (Ksat – saturated hydraulic conductivity).

Saturated soil conditions. A condition in which all easily drained voids (pores) between soil particles in the root zone are temporarily or permanently filled with water to the soil surface at pressures greater than atmospheric (1987 Manual).

***Saturation*.** For wetland delineation purposes, a soil layer is saturated if virtually all pores between soil particles are filled with water (National Research Council 1995, Vepraskas and Sprecher 1997). This definition includes part of the capillary fringe above the water table (i.e., the tension saturated zone) in which soil water content is approximately equal to that below the water table (Freeze and Cherry 1979; Regional Supplement).

These definitions of *saturated conditions* and *saturation* contradict each other. The 1987 Manual excludes the capillary fringe from the definition of saturation whereas the Regional Supplements include it. The issue here is identifying the topmost boundary of the zone of anaerobic conditions that drive wetland processes and functions. This is where hydric soil processes are initiated and hydrophytic vegetation begins domination over FACU and UPL species.

Water table. The upper surface of groundwater, or that level below which the soil is saturated with water. It is at least 6 inches thick and persists in the soil for more than a few weeks (1987 Corps Manual).

This unusual definition of a water table prescribes a minimum thickness of the associated surficial aquifer to require that perched water tables have a practical minimal depth and thickness in order to limit Clean Water Act regulation to waters that persist long enough and are thick enough to significantly affect wetland ecosystem functions and maintain a hydrophytic plant community.

Watershed. This term is used synonymously with drainage area or catchment. See Drainage Area in these definitions.

Wetland Pool. This is the surface area of the water body associated with a wetland. It will fluctuate in size with weather and may at times extend outside the wetland boundary. In times of drought, it may disappear.

***Zone of influence*. ** The combined distance on both sides of a ditch or tile in its longitudinal direction where the drainage feature has an influence on the hydrology. The zone of influence length is usually twice the lateral effect distance.

NEXT : MODULE 6