PDHonline Course H121 (3 PDH)

Advanced Wetlands Primer: Field Evaluation & Permitting Considerations for Design Professionals

Instructor: Patrick C. Garner, PLS

2012

PDH Online | PDH Center

5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone & Fax: 703-988-0088
www.PDHonline.org
www.PDHcenter.com

An Approved Continuing Education Provider

Advanced Wetlands Primer: Field Evaluation & Permitting Considerations for Design Professionals

Patrick C. Garner, PLS

Course Content

This course is a follow up to A WETLAND PRIMER FOR DESIGN PROFESSIONALS by the same author. Although a basic understanding of wetlands--crucial for architects, engineers, land surveyors and landscape architects--is mastered in that first course, design professionals often need a broader understanding of why wetlands play an increasingly important role in site considerations, and how they are identified.

This advanced course will allow you to speak with more authority about freshwater wetland delineation, and to be familiar with important federal or state legislation that must be considered during project design. You will be exposed to the perils of ignoring wetlands during project design. In addition, you will understand the key technical indicators for inland wetlands, and be able to speak with confidence to wetland scientists, as well as to state and federal permitting authorities about resource evaluations, and potential project impacts.

A BRIEF HISTORY OF WETLANDS

In the first PRIMER course, readers learned that scientists, working internationally, have agreed on universally accepted definitions for various wetland communities. Within the U.S., wetlands, which were once condemned as mosquito breeding grounds, are now routinely protected by local, state and/or federal legislation. The 1977 Clean Water Act (CWA) has driven this relatively new legislation on the federal level. These new regulations were created because of the growing realization that wetlands provide numerous values for humans, including flood mitigation, water supply and pollution attenuation.

Wetland scientists estimate that 114 million acres, or more than half of the original total of the country's wetlands, have been filled, drained or converted into farmland, homes or urban infrastructure in the last 300 years. An *Issue Brief* for the 107th U.S. Congress, published in October of 2002, states, "When European settlers first arrived, total wetland acreage was more than 220 million acres in the lower 48 states, according to the U.S. Fish and Wildlife Service... by 1997 total wetland acreage was 105.5 million acres. Losses continue..." Primal forests were considered a place of howling wolves, and to early settlers, wetlands were "dismal swamps."

Thousands of acres of wetlands, including rivers and large lakes, were drained, "culverted" or filled. Deep wetlands were considered useless for agriculture, dangerous for cattle, and at worst, habitat for "wild beasts. " Reflecting this almost universal belief, Congress passed numerous laws, including the Swamp Wetlands Act in the 1800s, all of which were intended to encourage conversion of wetlands into uplands.

The U.S. Corps of Engineers (Corps) itself, over the course of a century, destroyed hundreds of thousands of acres of wetlands along major rivers such as the Colorado, Missouri and Mississippi. The construction of levees and multiple control structures, including dams and locks, altered bordering wetland resource areas and flood plains.

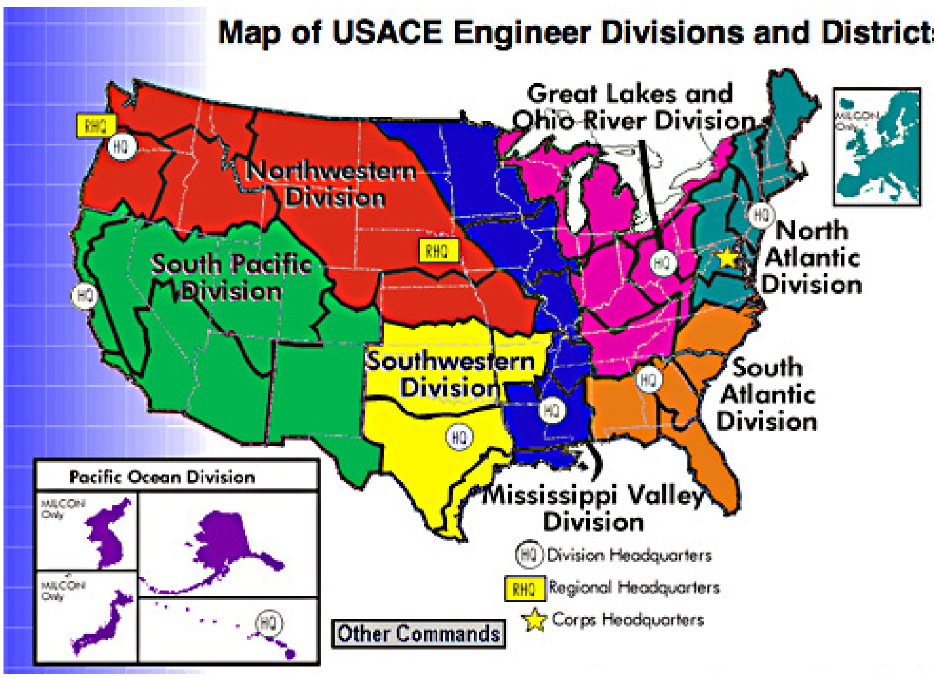
These massive changes to the natural landscape also encouraged subsequent farming expansions, as well as rapid urban expansion into what had once been extensive flood plains. Floods in the late 1990s along the Mississippi River generated outcries to move whole towns which had been built on flood plains. Hurricane Katrina which hit the New Orleans area in August of 2005 was partially so devastating because of the loss of extensive surrounding marshes, again the result of Corps river alterations. Today, in a complete reversal of the Corps' past, the 2003 Corps' Mission Statement reads, in part, "Working toward a national goal of "no net loss of wetlands," the [Corps] is undertaking projects to restore existing wetlands, or to create new ones."

This change in environmental consciousness occurred largely after World War II. Public ecological awareness grew with the publication of books such as Rachel Carson's *Silent Spring*. With increased momentum following the 1960s, scientists began to analyze the values and functions of wetlands. In the 1970s, some, but not all, states began to enact laws to protect wetlands. By the mid 1970s scientists adopted a multidisciplinary approach to wetland study.

In response to the 1977 federal CWA, in 1987 the Corps issued the *Corps of Engineers Wetlands Delineation Manual*. The *Manual* (available on the web in PDF format at *www.wes.army.mil/el/wetlands/wlpubs.html*) was at that date the most comprehensive definition of wetlands yet published. The *Manual* changed the public's "common sense" get-your-feet-wet definitions that had led to constant disagreements over what constituted a wetland. Today the *Manual* continues to have broad influence, and remains the primary federal guide to wetland delineation nationwide. (Note that in 2009, the Corps began issuing regional supplements to the *Manual.* Before using older copies of the *Manual*, a user should contact the Corp to obtain the latest, working version.)

Although the CWA protects the nation's wetlands, not all activities near or in wetlands are prohibited. The Corps states, "Numerous relatively minor activities in wetlands are covered by regional or nationwide general permits, allowing the regulatory staff to concentrate on more complex cases." (Corps, 1/03)

The Corps is managed through eight divisions (also called Corps Regional Business Centers) throughout the US, with 41 district offices. The Corps divisions and districts follow watershed boundaries, not state boundaries, so a given state may be divided into several divisions/districts. (See the illustration.) Further, the CWA is administered (and interpreted) differently from district to district. Therefore, as I stress through this course, check with all applicable local and regional authorities regarding impacts from your project before beginning any design.



WETLAND DEFINITIONS

The Corps *Manual* defines wetlands as:

"... those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."

The *Field Guide to Nontidal Wetland Identification,* another widely referenced text, states:

"...wetlands lie along the natural soil wetness continuum between the better drained, rarely flooded uplands and the permanently flooded deep waters of lakes, rivers and coastal embayments." [Tiner, 1988]

The scientific consensus running through these definitions is that all wetlands are characterized by three common components:

- *Hydrology*,
- *Hydrophilic* (water adapted) *vegetation,* and
- *Hydric soils*.

This course will cover each of these three elements in detail later, but first, let's take a broad approach to wetlands. Where do we look, what research do we conduct, and what tools should we use as we conduct our search?

A HYPOTHETICAL SITE VISIT (ON THE MORNING WHEN YOUR CLIENT SAYS, "MY HELICOPTER OR YOURS'?")

A helpful example of how these three components might be observed in the field is to imagine viewing a site from a macro, or landscape perspective. Consider that your client offers to take you on a helicopter ride so that you can spend time looking at not only the site itself, but at the overall surrounding area.

As the helicopter traverses the site, you are not surprised to see a medium-sized river flowing through fields, areas of woods and a wide marsh nearby; you had already noted that river on a USGS quadrangle map at your office. You see that the river runs into a serpentine-shaped pond. In addition, as the helicopter descends, you see a weir outlet at the end of the pond where the river tumbles out over riprap and continues downhill, crossing through a corner of your site.

Another, smaller stream flows into the river near the same location. You can clearly see a wide marsh with old canals that borders the small stream; the canals are cut in perpendicular lines to the small stream. You realize that, historically, there may have been farming of some kind on the site, and you wonder if someone had tried to drain the marsh. The helicopter continues moving in a slow arc. Farther uphill, an apparently isolated pond sits beside a dirt road that crosses through another portion of your site.

Based on what you have already learned in this course, you know that you have wetlands on site. You do not know their extent without conducting a site walk, but you now have a strong sense of their location, and of the general topography and vegetative characteristics of this site. (By the way, several of these wetland features are not shown on the USGS quad map you reviewed, and an old boundary survey from the 1960s did not indicate the pond.)

To make your coming site walk as efficient as possible, you call a local wetland scientist. You ask her to accompany you on the walk, and tell her what you have seen. A week later the two of you drive to the site. The first thing she wants to do is examine the land that borders the river, particularly that area that crosses through your site.

As you walk toward that area, she explains that the majority of inland, or freshwater, wetlands border water bodies such as streams, rivers and lakes. She notes that these bordering areas tend to have highly saturated soils, largely because of ground water contact with the lower topographic features. The river flow itself may also create a zone of saturation that extends out from the riverbanks, resulting in a potential wetland plant community.

She also notes that after viewing the river and its uplands, she will want to walk over to the isolated pond. She suspects that it may harbor an intermittent or “ephemeral” stream--such a feature, she notes, might be difficult to see from the helicopter because of the woods. She also is carrying a long soil auger and periodically takes samples of soil for “hydric characteristics.” You note that there are small pockets of standing water slightly downhill from her test holes.

As she makes occasional notes in her field book, she casually mentions the names of plants she sees, and describes their probable wetland classification. You hear her use phrases such as, “Obligate--” and “That one’s facultative.” She briefly explains their meaning, but you remain somewhat confused. At the end of the site walk, the two of you agree that your site contains jurisdictional wetlands, including a river, a pond, an intermittent stream and a fairly wide marsh that borders the river. You suggest she send you a contract so that her firm can proceed to field mark all wetland edges at a later date.

MASTERING WETLAND LOCATION

This site visit illustrates several simple principles that, once you understand them, make wetland location far more logical, and far easier as well.

- *First*, *the majority of inland wetlands border, and are connected to, water bodies, including rivers, streams, lakes and ponds. Hence, the common description,* bordering *vegetated wetlands.*
- *Second, wetlands tend to lie in lower areas on a landscape*.
- *Last, the key for Mastering Wetland Location is that* where *saturation or flooding is likely, finding wetland communities is likely.*

Of course “isolated” wetlands do occur at times on a landscape due to ground water breakout on slopes, or because of unusual geological features. Wetlands may be found even on the top of drumlins (oval-shaped hills left behind by glaciers) and on hillsides. Streams and creeks originate at times from springs, or from ground water contact high in the mountains. Nature is full of surprises, but the majority of wetlands exist beside obvious water bodies, and inside the flatlands and low sloping transitional areas beside these known deep-water resources.

A stream crossing through a farm with minimal floodplain

WETLAND FUNCTIONS & VALUES

What wetland definitions do *not* do is define the *values* and *functions* of wetlands. An understanding of wetland functions, and the subsequent value of wetlands to humans, plants and animals, has driven local, state and national legislators to protect wetlands over the last three decades. The *functions* of wetlands include activities as diverse as biochemical changes from anaerobic conditions, and morphological plant adaptation due to constant saturation.

More importantly though for society, we now recognize that the *values* of wetlands are numerous. Wetlands values include:

- Mitigation of flooding,
- Habitat for numerous animals,

- Protection for private and public water supplies,
- Mitigation from flood and storm damage,
- Prevention of pollution,
- Recharge of groundwater, and
- Protection of fisheries and shellfish habitat.

Further, wetlands offer other, more diffuse, values. For instance, wetlands provide sanctuary for rare or endangered species, corridors for animal migration, and provide numerous educational and aesthetic opportunities for people. Many schools and universities, as well as state environmental departments, have active wetland-oriented ecological programs which introduce students and the general public to these concepts. Shifting wide public perception from, "wetlands as dismal swamps" to wetlands as diverse environmental communities remains a challenge.

WETLAND TYPES

Federal definitions of wetlands tend to compress wetland types into marshes, bogs, swamps "and similar areas." Scientists note that wetlands fall into two broad categories -- marine wetlands and inland, freshwater systems. Wetlands associated with lakes, rivers and marshes (freshwater systems) account for ninety percent of the nation's wetlands.

The varying types of wetlands are a byproduct of what is called a Wetland Water Budget--the total annual quantity of water available to a given wetland. By definition, every wetland system is saturated, or flooded, for a period of time. That period might vary between two weeks and ten months or more, depending on the type of wetland. This period of saturation is called a Wetland Hydroperiod. When the hydroperiod is short, wetlands tend to be marginal, and are often mistaken for uplands. When the hydroperiod is long, wetlands tend to be characterized by bogs, deep swamps and extensive riverine systems.

Inland wetlands are further categorized as:

Rivers & Streams

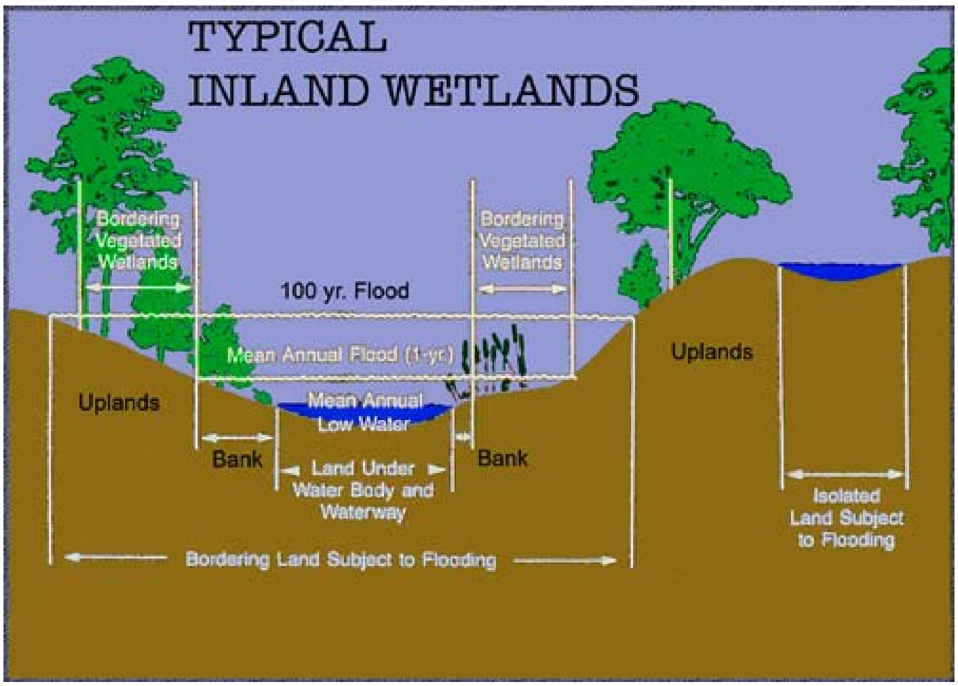
Many inland wetlands lie along or beside rivers, creeks and streams. Associated wetlands often form a rich ecosystem. Many riverine systems have extensive flood plains, and many have wide freshwater marshes that are frequently inundated from storm flows, snow melt and ground water fluctuations.

Common technical terms that may be used by wetland experts or regulators, and therefore are frequently encountered by design professionals when working with riverine-based wetlands are:

- Bordering lands subject to flooding (also referred to as, 2, 10, 50, 100 and 500-year floodplains)

- Bordering vegetated wetlands
- Banks
- Land under a water body
- Isolated lands subject to flooding
- Mean annual low water
- Mean annual high water (also called, Bankfull)
- Vernal pools
- Rare or endangered species habitat
- Riverfront protection zones

See the accompanying graphic for a cross-section showing some of these resources.



Bogs

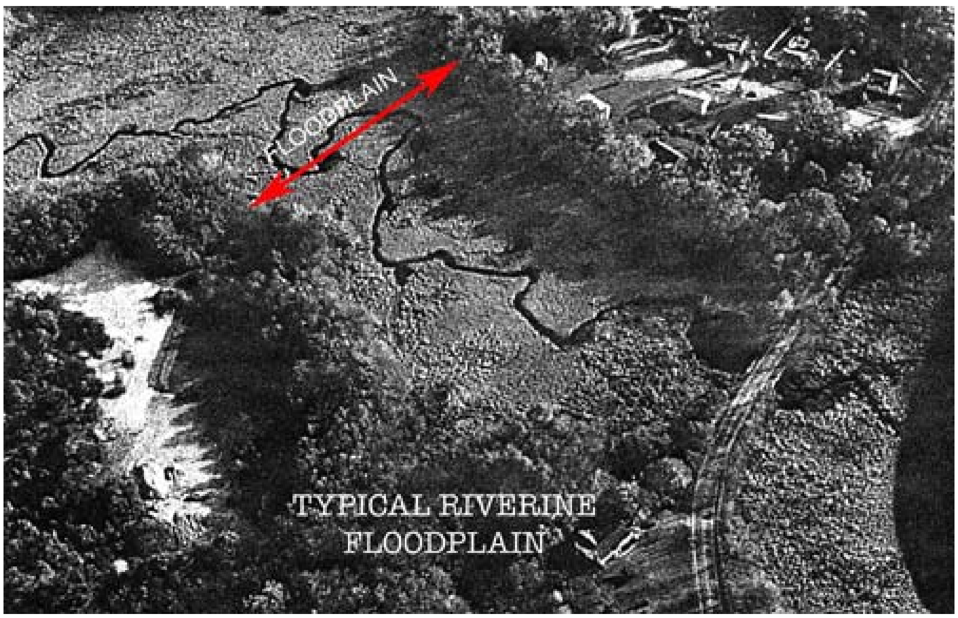
Bogs are primarily found in formerly glaciated portions of North America. Concentrated in the Northeast, north-central states and Canada, bogs are underlain with a deep substrate of peat and often lack mineral soils. Constant saturation from high ground water, large open areas of water, knolls of evergreen trees and transitional lands often dominated by low shrubs characterize bogs.

Lakes and Ponds

Known as lacustrine systems, lakes and ponds vary in size from "kettle holes" to vast bodies of water such as the Great Lakes. The often shallow waters besides lakes and ponds harbor diverse communities of hydrophilic vegetation and water-dependent animals such as turtles, salamanders and freshwater shellfish. Water deeper than six feet in lakes and ponds is not considered to be wetlands; it is the shallow edge waters that shelter a variety of adaptive vegetation.

Swamps and River Flood Plains

These areas are often the least understood wetlands. Commonly dry in summer, they may hold eight feet of moving water for short periods during winter and spring floods. Although in late summer they may appear to be uplands, they often have ground water within a foot or so of the surface. Since they often appear to be "high and dry," the majority of alterations and losses have occurred in these wetlands. Hundreds of thousands of acres of these flood plain areas have been deforested, drained and converted to agricultural lands. Hardwood trees, evergreens and wetland shrubs that thrive in the sandy, alluvial soils typically dominate swamps and flood plains.



Wet Meadows and Marshes

Marshes are characterized by wetland shrubs, and by soft-stemmed herbaceous plants such as reed and cattails. Seasonal fluctuations in water are typical, with levels varying from six inches to six feet. In deeper marshes, vegetation may be characterized by floating aquatics such as water lilies. Regional variations in these wetlands may be great. Examples are as diverse as the Everglades in Florida and prairie potholes in the upper Midwest. Many wet meadows are drier regimes, tending upon casual inspection to appear as vast areas of grasslands. These areas, to the common observer, rarely appear to be "wetlands."

A typical coastal freshwater marsh, Manitoba

Generally recognized types of coastal wetlands:

Tidal Salt Marshes
The hydrology and chemistry of tidal salt marshes varies dramatically from inland marshes. Salt marshes are inundated on a regular tidal cycle by the ocean, and consequently saturated on an almost constant basis. They represent some of the most productive ecosystems worldwide, and are a product of soil salinity, nitrogen limitations, and the constant accretion and depletion of organic sediments washed into their coastal terraces from both the sea and adjoining inland areas.

Tidal Freshwater Marshes
These areas are unique ecosystems that combine features of salt marshes and inland marshes. They have increased diversity of plant types because of decreased salinity. Wildlife tends to use freshwater marshes more than salt marshes for similar reasons. Freshwater marshes are also nurseries for young fish and many species of birds. These previously vast transitional marshes have also been subject to large losses in past centuries, as expanding urban areas -- often lying close to many of these marshes -- considered them convenient and inexpensive real estate for expansion.

Mangrove Wetlands
Mangroves exist in tropical and subtropical areas, and where found, largely displace tidal and freshwater marshes. In the continental United States, they are common only in Florida and Puerto Rico. The dominant plant is the mangrove, a large, woody, salt-tolerant shrub or tree, of which there are numerous species. Biodiversity is minimal, yet these wetlands play a key role in protecting adjoining uplands from unusual tides and from hurricane action.

WETLAND BUFFER ZONES

Many states and localities, in addition to protecting actual wetlands, protect or limit work within a specific *Buffer Zone* around or beside wetlands. Varying locally, a typical buffer zone may be 25 feet or as much as 300 feet wide. Usually any activity proposed within the buffer zone, even if the activity does not disturb the wetland itself, triggers a requirement for a wetland permit.

These zones serve many purposes. Regulators quickly discovered that allowing construction up to the edge of a protected wetland inevitably altered the wetland in some measurable way. For instance, if a site is cleared of all vegetation, including 30 to 40 foot trees up to the edge of a marsh, the loss of tree shadow changes the types of wetland vegetation that might have previously thrived in the adjoining wetland. Further, removal of all vegetation also changes temperatures of adjoining wetlands. Habitat for animals that might live in the wetland is altered. Because specialists in biodiversity and plant morphology became aware of these impacts, even as regulators were "saving" the entirety of an actual wetland, new regulations and restrictions were put into effect to limit these unexpected effects.

Typically, a buffer zone regulation may restrict construction impacts by some of the following means:

- Creation of building setbacks from a wetland edge
- Creation of a "no-disturb" setback, limiting clearing of vegetation to no closer than 25 or 50 feet (or more) to a wetland edge
- Distance restrictions for stormwater outlets and detention ponds
- In northern climates, limitations to road salt and sand quantities, and
- Restrictions to heights of buildings to limit shadow effects

A SHORT WAR STORY

Some years ago, a client of mine in New England wanted to subdivide a 55-acre parcel of land. He asked my civil engineering firm to locate the wetlands, survey them and prepare a map showing a preliminary subdivision. We did so, presenting him with several alternatives. While assessing the wetlands on site, we found a stream with extensive bordering vegetated wetlands that cut through the middle of the site.

Once mapped, the wetlands took up approximately 20 acres of the overall site. We designed a subdivision with 28 one-acre lots. Our client had expected to yield more than 50 lots, and was predictably upset.

Three days after I presented him with the preliminary plans, he came back to my office. During this visit he asked a number of probing questions about how wetlands were defined. I explained to him that on his site the vegetated wetlands consisted of a large, distinct hydric plant community, and that there was no question about the accuracy of our delineation, or his obligations under state law.

After a long moment, he lowered his voice and asked, "And what if a fire on the site burned out the vegetation? What if it burned every tree and every shrub? How would you mark the wetland if the whole site was just ashes?"

I smiled at the ingenuity, and then said, "If the plants were completely gone, the underlying wetland soils would still define the identical area as being wetlands. The hydrology and saturation from the stream created the wetlands in the first place. Eliminating any one of the elements would not eliminate the entire wetland."

His eyes clouded over, and he shook his head. I wondered if we had lost him as a client, but he called the next day and asked us to proceed with final designs. I am pleased to note that our subdivision of 28 lots was later approved by all authorities and built as designed. The natural vegetation remained, and no fires were set.

This relatively sophisticated developer typifies the continuing public misperception about what constitutes a wetland. His attitude is also typical of what many design professionals encounter in their day-to-day meetings with the public.

Being able to easily summarize the characteristics of a wetland and explain the basic values of a wetland community are increasingly essential. The language of wetland professionals, phrases such as "hydric soils, hydrophilic vegetation, and bordering vegetated wetlands" should become the language of all working design professionals as well. You will learn the meaning of these terms later in this course.

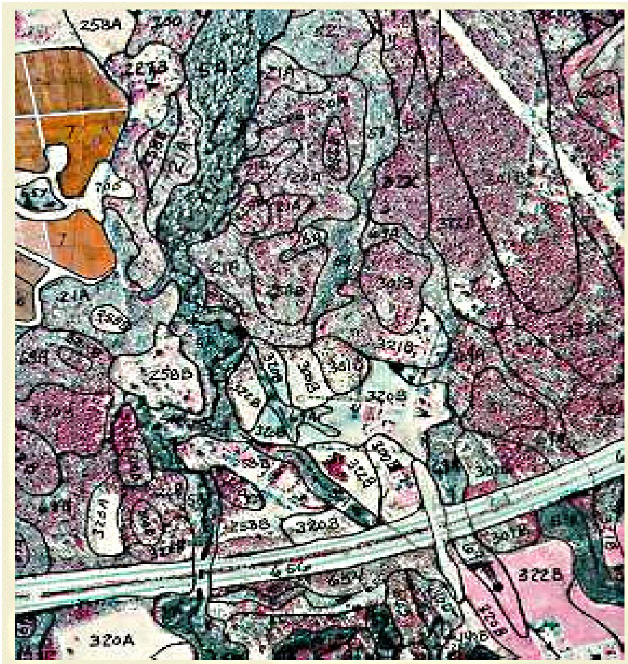
HOW WETLAND EXPERTS IDENTIFY INLAND WETLANDS

We have already learned that scientists characterize all inland wetlands as having three common components: *hydrology*, *hydrophilic vegetation* and *hydric soils*. Although regulatory identification of these components, as mandated in the 1987 *Manual*, can be a matter for wetland experts, in many cases locating wetlands generally is not complicated.

Before beginning any wetland resource analysis, a design professional should check public and governmental sources for resource mapping. Often these sources will provide established data about waterways, watersheds, known wetlands, flood plains, soils and topography. Some available sources are:

GIS Maps

Many local communities, particularly in urban and metropolitan areas, have GIS mapping that indicates wetland resources. State mapping is available in many states, and is often based on recent aerial topography and on infrared soils and vegetation analysis, as well as being a ready compilation of federal resource mapping. Soils mapping is also commonly available on these data maps, as well as waterways such as rivers, streams and ponds.



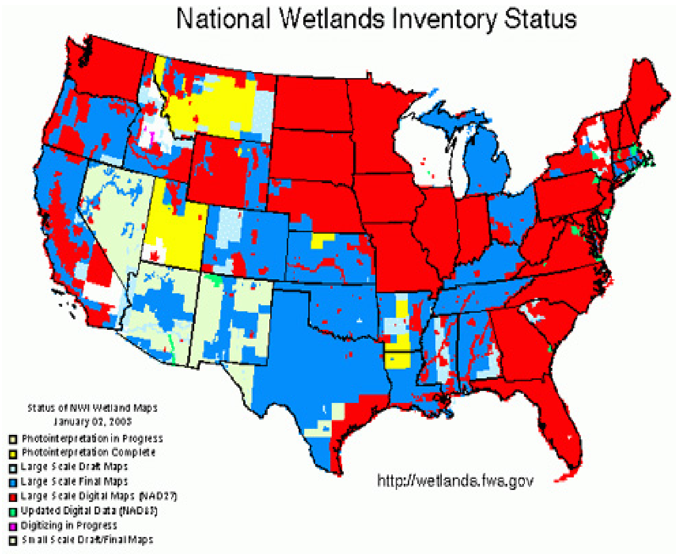
1996 NRCS Soil Map

Soils Maps

The state offices of the federal Natural Resource Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), will often have detailed soil mapping available--these maps identify areas of muck as well as other soils that are considered hydric. Often, hydric soil lists are available for specific counties or states. (A good Internet web source is the NRCS site: *www.nrcs.usda.gov/*; another source for exclusively U.S. hydric soils is *http://soils.usda.gov/soil_use/hydric/main.htm*)

USGS Maps

In addition, United States Geologic Survey (USGS) quadrangle maps show large wetland areas, particularly rivers, streams, ponds, lakes and broad marshes. A user should examine both 1:24/25,000 and 1:100,000 scale topographic maps for wetland indicator symbols. Often, topographic features will indicate potential wetland areas, even when not shown as wetlands on specific quad sheets. (See *www.usgs.gov/*)



NWI Maps

NWI, or National Wetlands Inventory Maps, are frequently available from the U.S. Fish and Wildlife Service (FWS). NWI maps were developed from aerial photographs in the 1970s and 1980s, and have the same scale and map names as corresponding USGS quadrangle maps. Although they are not available for all areas of the country, they cover most populated areas (See the illustration). The data is a general indication of possible wetlands, and because it was developed from aerial imaging, it must be field verified. (See www.nwi.fws.gov/)

Aerial Photographs

Aerial photographs are often available through both public and private sources. In more heavily populated parts of the country, private aerial companies often fly the entirety of cities and counties, and will sell a photo of a specific area for a minimal fee. Infrared photographs are sometimes available from universities and state government sources; when these images have been taken in the spring before leaf out in northern climates, they can be useful in identifying wetland areas. As with the NWI mapping, indications of wetland areas must be field verified and are considered generalizations only.

Local Topographic Maps

Many communities have recent community-wide topographic mapping available for public use. Unlike USGS quadrangle maps, these tend to be larger scale, often one to two foot contour, and provide far more accurate, updated information. They can be a useful tool to anticipate likely wetland locations that might border rivers, streams, flood plains and marshes.

FEMA Floodplain Maps

Nationwide floodplain maps are available from the Federal Emergency Management Agency (FEMA). Developed for the federal flood insurance rate program (also known as FIRM), these maps will indicate either general or detailed 100-year and 500-year flood prone areas, typically as Zones A or AE. Wetlands are commonly found within or beside these zones, particularly where they border rivers and streams. Professionals should note that floodplains under water during heavy periods of precipitation may appear to be broad, flat areas of upland during late summer. These maps are an excellent reference to avoid inadvertent design of infrastructure in a known floodplain area. (All FEMA maps are now available on the Internet for a nominal fee. See *www.fema.gov/)*

Corps of Engineers Regional Offices

Regional or district offices for the Corps are another potential source for data, particularly if you are aware that recent nearby developments have had to apply for a Corps Clean Water Act permit (also known as a 404 permit). Frequently, the regional office will have a contact person in the wetland section that will share in-house data, including wetland locations, types and unusual issues on an adjoining project that might pertinence to your project. (See *www.usace.army.mil/*)

Local Wetland Conservation Agencies or Commissions

Depending on your local bylaws or state regulations, your community may have an agency whose purpose is to protect wetlands, and permit certain developments in or around them. Contacting resource specialists at these offices may reveal that nearby or even adjoining lands have been mapped recently enough to be of interest. Regardless, if such an agency exists in your area, making contact and educated inquiries may save you many headaches later.

Internet Web Sources

Many towns and states have web sites that list local laws and bylaws. Often a conservation agency itself will have a detailed web site that lists its requirements and restrictions. Almost all federal agencies, including the Corps, NRCS, FEMA, EPA and FWS, have informative web sites. Use an internet search machine when you need to find such an address.

For an excellent Internet source for government links, including both federal and state agencies, visit the Society of Wetland Scientists site. The Links section is available for public use, and has many (but not all) state wetland regulations. This site is highly recommended (see *www.sws.org/).* Also, a list of other helpful web sites follows the Bibliography at the end of this course.

Other Sources

Local and regional planning boards or agencies are another possible source for wetland resource mapping. Check for topographic mapping of your site.

Both field surveyed topography and aerial topography should show streams, rivers, ponds and the wide, broad potential flood plain areas that may border these obvious wetland features. Historic maps may show streams and ponds that you know to have been obliterated or moved; these historic alterations may still indicate areas subject to unusual inundation, or regular saturation.

A Caution

Although researching all or any of these sources is an important first step, a professional should always be aware that existing mapping from any public source may be incomplete, inaccurate or simply too broad in its information to be useful for accurate design on a particular site. Always be aware that wetland resources as defined both locally and under federal statute are not necessarily shown on existing maps, no matter how recent.

Wetland resources are also a moving target. By that I mean that they change physically. Because wetlands are part of a complex natural system, they tend to shift and move in location. I have seen many instances of an accurately located wetland edge moving 75 - 80 feet in less than three years. Relying on even recent maps for final design, without field verification, is foolish.

Further, reliance on general mapping sources for a specific site is not best practice, and may result in post-design litigation. If completed permitting must be redesigned because the design team misidentified, missed or minimized wetlands on a site, clients, lenders or other affected parties may consider action against a design firm.

There are, unfortunately, many cases around the country where design firms have been sued for negligence. Building sites, subdivisions, golf courses, roadways, even proposed shopping malls have been stopped deep in the design, permitting and even construction process because of misidentification of wetlands. Often hundreds of thousands of dollars have been spent on surveying and engineering for a project that suddenly could not be built.

Imagine the potential damages arising over litigation for a signature golf course that is stopped because your design firm minimized sensitive wetlands or other environmental resources on site. I know of instances recently where this has happened both in Massachusetts and Georgia.

Accordingly, in the same way that you do not want to represent yourself in a court of law, you do not want to perform final wetland analysis for any critical design project. Unless you are highly proficient in the field of wetland delineation, hire a wetland scientist or expert. Use the knowledge you gain from this course to speak with authority to these experts, but let their expertise be on the line for all crucial wetland determinations.

Also note that wetland scientists may or may not be certified, depending on the state.

The Society of Wetland Scientists, a private nonprofit organization, administers a national certification program, which licenses Professional Wetland Scientists (PWS). A number of individual states also individually certify wetland scientists for work within their state boundaries. Requirements for such certifications are typical of the requirements for other professional certification, and include the requirement, for instance, for an undergraduate degree in botany, hydrology or environmental science, with additional requirements of specified years of working experience in the field.

FIELD INVESTIGATION

Once you have conducted adequate research for a given area or site, you need to evaluate potential wetland areas on the ground. An *initial* field investigation does not have to be conducted by a professional wetland scientist. Design professionals with a basic understanding of wetland indicators, and an understanding of the scientific criteria used in delineation, are often competent to make these initial, preliminary determinations.

Also, professional land surveyors who are aware of wetland indicators can flag and locate *potential* wetlands when conducting ground surveys--such field locations may not be accurate enough to conduct final CAD design, but preliminary wetland location of suspected resource areas by a land survey crew may be an important design alert. I have seen wetland scientists called back on sites after experienced surveyors have noted resources apparently overlooked during the final delineation.

Wetland scientists examining a soil sample for hydric characteristics

Preliminary (as well as accurately marked and flagged) wetland edges may be field located with traditional surveying equipment, using total stations or theodolites. They may also be located using GPS or GIS instrumentation. If GPS/GIS equipment is used, at least submeter accuracy should be expected. If wetland edges must be extremely accurate, then proportionately accurate survey methods should be used.

Because a wetland edge, in practical terms, may vary in the field by a foot or more, typical survey location of a wetland line may also, like the wetland location itself, vary by plus or minus a foot or so. That is why submeter GIS or GPS instruments, depending on leaf cover and other factors, may be adequate. Check with your client and with permitting authorities for required accuracy criteria.

Often, confirmation that wetlands exist on a site is relatively simple, and can be confirmed without detailed analysis or calculations. Abrupt changes in plant communities and topographic slope may be strong indicators of a wetland edge. Hydrologic indicators such as wrack lines, stained leaves and areas of standing water are useful. Preliminary investigation of soils, particularly within the first 20 inches of the surface, is sometimes required in more complex wetland communities. Many of these standard field techniques will be discussed further in this course.

Remember that *hydrology* is the driving force in the creation of wetlands. In general, hydrology is defined as the properties, distribution and circulation of water. *Wetland hydrology* has a modified definition, and is considered to be the movement of water within and through a wetland. Hydrologic features include frequency and duration of inundation (the hydroperiod), timing, depth of saturation, ground water fluctuation and the movement of surface water.

Wetlands hydroperiod is a term characterizing the condition of saturation of a wetland, and is a function of flood duration and frequency. A wetland's net hydroperiod can be represented by an equation, where volume is based on factors including precipitation, surface inflow, groundwater inflow, evapotranspiration, water outflow and change in volume. Permitting authorities sometimes require this calculation, particularly when replication or creation of new wetlands is required on a project.

Water in a wetland is always characterized as being ground water, surface water (such as occasional sheet flow from storm flooding), or a combination of both. Either one or both of these physical conditions lead to saturated soil conditions. When most or all of the porous areas between soil particles are filled with water, saturation has occurred (a typical soil may have up to 40% voids when not saturated). Depending on the timing and duration of that saturation, the condition itself typically leads to the creation, or maintenance of, wetland systems.

Surface water in a wetland area sometimes comes from flooding from adjacent water bodies, such as may happen during periodic over topping of streams or rivers following intense storm precipitation or spring snow melt. Such over topping occurs at what is called the moment of *bankfull*, or when a river channel is at capacity. Although such over topping occurs as often as several times a year, depending on the size and amount of impervious area within a watershed, bankfull occurs on an average interval nationally of about every 1.4 years.

Ground water is a far more common source for surface inundation. Some wetland areas are fully saturated year round. Others are subject to extensive ground water fluctuation. Because ground water in many soils can vary vertically over a year's period by 12 feet or more, wetland areas that are typically flooded in the spring may appear completely dry several months later.

Ground water may also appear on a surface due to capillary action, a process which draws moisture up through the porous voids in soil. Wetland conditions typically occur on sites where ground water is within 20 inches of the surface for a long enough duration of time to create *anaerobic* (oxygen-depleted) conditions; anaerobic conditions are essential for the creation of wetlands.

Anaerobic conditions, which can be created in as little as 7 - 21 days, produce plant communities that differ from plant species in communities that grow in aerobic conditions. The wetland plants that are typically found in saturated conditions all have adapted in some manner to survive periods of inundation. These plants are commonly referred to as hydrophilic plants, or as hydrophytes.

Last, hydrology, through its creation of anaerobic conditions, in turn creates an identifiable category of wetland, or *hydric* soils. These soils are categorized predominately by color and texture. Soil colors are commonly gleyed (having neutral gray to blue colors), or may be dark chocolate browns to almost black. Their textures may be gritty when mineral soils, or slippery or fibrous when organic. These wetland soils will be discussed in greater detail in the section on Hydric Soils.

Fort Pond Brook, Acton, Massachusetts--note the cut bank and point bar

Hydrology Field Indicators

Evidence of hydrology is a strong indicator of a potential wetland community. Although not always available--as noted above, surface inundation may occur infrequently--these indicators are also surprisingly obvious.

Some nationally recognized indicators of hydrology are:

- *Actual surface flooding or inundation*
- *Water marks or ice scars on tree trunks*

  -- Ice scars are formed when spring thaws occur in a river, causing ice shards to cascade downstream, often at high velocity, scarring trees and other objects in the flood plain that they hit.

- *Drift or wrack lines*

  -- These are usually branches, small trees and other debris that are caught in shrubs or even trees at periods of flooding; such debris may be found in late summer as much as six to eight feet above the apparent stream channel, and are an indication of the extent of high flow.

- *Sediment deposits*

  -- Depositional material, often alluvial, from periods of bankfull; these deposits are typically mineral soils, but may also be stones and pebbles of varying sizes.

- *Surface drainage patterns, or distinct channelization, or scouring*

  -- The result of sheet flow, most commonly flowing from an apparent upland into a low lying area; these channels can also be what are called braided channels, or tiny secondary (and often multiple) stream channels from the main stem that only carry flows during strong storm events.

- *Water-stained leave*s

  -- Usually matted leaves that are stained gray and brown from a light deposit of suspended particulate that settles after storm flows or periods of ponding.

- *Depth to free water in an observation hole of less than 12 inches*

  -- Free water or weeping within 12 inches of the surface is a good indicator of wetland conditions.

- *Depth to saturated soil in an observation hole of less than 20 inches*

  -- Standing water in an observation hole with a depth of less than 20 inches is another excellent indicator; holes sometimes have to be left open for a period of time for water to appear.

- *Sulfide odor from an opened observation hole*

  -- A “rotten egg” smell is an indicator of hydrogen sulfide, which almost always indicates the presence of organic hydric soil. The smell originates from decomposing organic materials, such as leaves and grasses.

Not all indications of scouring or evidence of sheet flow necessarily denote a wetland community. For instance, at times evidence of scouring may simply denote an unusual and infrequent flood. Some stream systems may over top their banks only during a 25-year or greater flood; at such times, the adjoining upland may show water marks and drift lines. Longer-term saturation is required to create a wetland, and these unusual flood markings would be misleading if used alone. A wetland expert uses best professional judgment in all cases.

WETLAND VEGETATION

As we learned earlier, wetland plant communities are created in areas that are periodically flooded, or saturated, and grow in response to the subsequent anaerobic soil conditions that follow inundation. Wetland plant communities are unique in that they consist of plants that have adapted to varying periods of flooding. This is known as *morphological* or physiological adaptation. Indications of such adaptation may be as subtle as microscopic changes on stems, or as bold as massive changes to root and trunk structures. Examples of physiological adaptation might be shallow root systems, buttressed or multiple trunks, adventitious roots, or unobservable adaptations such as a plant's modified metabolism.

Botanists have classified all known plants on the American continent by genealogy, and organized them by different groups. Plants have common names, but scientists do not consider these reliable, as common plant names change from region to region, and even from town to town. In response to this, scientists have identified plants by a single scientific name, consistent worldwide, and always indicated in italics. For instance, a red maple has the scientific name, *Acer rubrum,* whether found in the United States or in Canada, and an American larch has the scientific name*, Larix latifolia*.

Scientists have also been able to categorize plants by their propensity to live in an upland regime, versus in a wetland community. This classification is based on the frequency or percentage of time that each plant is found in a wetland versus upland community. In the late 1980s, the FWS published the *National List of Plant Species That Occur in Wetlands* (see bibliography at the end of this course). The state by state *National List* is now recognized by all federal agencies, as well as all states, and was the product of collaboration between the FWS, the Corps, the Environmental Protection Agency (EPA), NRCS and regional botanists.

The publication lists all major plants found in a given state by both common name, and scientific name. Each plant is assigned an "indicator" category that indicates the likelihood that that plant will be found in a wetland. For instance, in New Hampshire, Massachusetts and Rhode Island, a red maple (*Acer rubrum*) is classified as Facultative (FAC), indicating that it is equally likely to occur in uplands and wetlands.

Plant species that almost always grow in inundated wetland conditions during the growing season are classified as *obligate wetland* (OBL) species. Upland plants (that is, plants rarely found in wetlands) are classified as *Facultative upland* (FACU). An example of a FACU plant is a red oak (*Quercus rubra*). Plants that are between these two extremes have other classifications (see below). Clearly, by identifying common plants in your area, and correlating those plants to the *National List* that applies to your state, you can quickly determine the percentage of wetland plants encountered in a given area.

Inland wetland plants bordering a perennial brook--the large, leafy plant is Skunk Cabbage

Note that the Corps *Manual* requires a wetland community to be composed of at least 50% wetland plants, with, in addition, hydric soil and indications of hydrology. Finding scattered wetland plants does not indicate that an area is a protected wetland community. Use the *National List* to make a preliminary assessment, and rely on a known wetland expert for important or difficult determinations. Importantly too, definitions of wetlands in your state may differ from Corps definitions. In some cases wetland boundaries regulated by the Corps and those regulated by your state are the same; in other states, they may differ so that your site actually contains two distinct wetland lines!

Always remember that if state's wetland definitions are less stringent than federal definitions, federal regulations prevail. If your state does not have specific wetland regulations, federal regulations still prevail. On the other hand, if your state has certain resource area protections that are more protective than federal regulations, you may find that your project will require and trigger both state and federal permits. The bottom line is to always check the status and applicability of federal statutes, as well as regulations for your particular town and state, before proceeding with permitting or final design.

FWS indicator categories for nationally identified plants are:

- Obligate wetland OBL >99% frequency in wetlands
- Facultative wetland FACW 67-99% frequency

- Facultative FAC equally likely wet or upland
- Facultative upland UPL <01% frequency in wetlands

FACW, FAC and FACU categories are refined in the *National List* by the addition of a "+" or "-" sign to further define the regional frequency of the plant occurrence. These refinements are used by wetland experts during difficult or complex delineations, and need not normally be applied by the casual user.

Plant guides are widely available, and are strongly recommended for field investigations. These guides are also be helpful seasonally when, depending on the region of the country, leaves may not be out, and herbaceous plants may have died back, leaving only dried stem material. Plant field identification is also particularly difficult under snow cover, and may only be possible then using buds and stems, and analysis of soils.

Field guides will almost always give a plant's common and scientific name, as well as its likelihood of existing in your region. They will also give clues to a plant's identification based on flowers, fruits, nuts, catkins and seeds. Their flowers or seeds can identify some plants, particularly sedges and grasses.

Several recommended guides follow. Many others are available.

Common Marsh, Underwater and Floating-leaved Plants of the United States and Canada by Neil Hotchkiss. 1972. Dover Publications.

Field Guide to Nontidal Wetland Identification by Ralph W. Tiner Jr. 1988. Maryland Department of Natural Resources and USFWS.

Freshwater Wetlands by Dennis Magee. 1981. University of Massachusetts Press.

Plants in Wetlands by Charles B. Redington. 1994. Kendall Hunt Publishing.

Wetlands, Audubon Society Nature Guides by William Niering. 1987. Alfred A. Knopf.

A Field Guide to the Trees and Shrubs by G.A. Petrides. 1972. Houghton Mifflin Co.

The Audubon Society Field Guide to North American Trees by E.L. Little. 1985. Alfred A. Knopf.

Winter Botany: An Identification guide to native trees and shrubs by William Trelease. 1931. Dover Press.

ASSESSING VEGETATIVE COMMUNITIES

As we have seen, many wetland communities can be determined solely by vegetation. Such determinations are often relatively simple, and a simple site walk through an area may be used to conduct a preliminary assessment. Often, the line between upland and wetland plant communities is surprisingly abrupt.

A common wetland edge may occur at the bottom of a steep slope that suddenly levels out into a flat or bottomland. Standing at such a break, you may be able to easily see the differences in types of trees and shrubs. The ground may even feel spongy, or softer. Hydrologic indicators in combination with plant determinations may also quickly be used to cross check a questionable area.

Of course not all wetland communities are as easily determined. Many wetland communities creep into transitional areas, particularly in areas of gently sloping topography. Where a stream meanders through a relatively flat area, wetlands may border a river and extend out from the river's bank by hundreds of feet. Often, the only way to determine where the line between wetlands and uplands occurs is to conduct a highly detailed vegetative assessment that may also include soils analysis, and a count of visible hydrologic indicators.

Although beyond the scope of this course, detailed vegetative assessment methodology usually includes an analysis of each layer, or strata, of a particular plant community. A skilled practitioner commonly identifies five layers. Those layers are ground cover, shrub, sapling, climbing woody vine, and tree. An analysis of the percentage of wetland species is conducted for *each* layer, and the quantities then averaged to determine the overall percentage of "wetness."

The Corps *Manual*, as well as many other guides, requires the establishment of round observation plots, typically set along transect lines that may roughly intersect a wetland edge at a perpendicular. Plants are counted for abundance, and soils assessed, within these plots. Circular plots with a radius of up to 30 feet are normal, depending on the layer. Plot sizes and shapes may vary based on regulations and site conditions. Consistent plot sizes from transect to transect are used as much as possible to insure both regularity, and objectivity.

Because indications of hydrology are often difficult to determine, and soils analysis requires observation holes and extensive expertise, analysis of plant communities only is relied upon in many common situations. This level of analysis is adequate, typically, when wetland indicator plants strongly dominate three or more of the five vegetative layers.

The presence of large numbers of obligate (OBL) and facultative wetland (FACW) plants in a plant community is strongly indicative of a wetland regime or ecosystem. On the other hand, if you find that upland plants and wetland plants seem to be approximately equal in number or dominance, use of additional wetland assessment techniques such as soils analysis is warranted (and may be required by statute).

HYDRIC SOILS

Wetlands, or hydric soils, are produced under anaerobic conditions, the result of saturation, flooding or ponding over a sufficient period (usually two weeks or more). A previous section of this course described how saturated or inundated conditions produce anaerobic soil conditions. This diagnostic condition leads to changes in soil chemistry and coloration, and can take place in as little as a year's time depending on the type of soil and the length of growing season.

An “EarthColors” soil book

Note that soil science and its practice is challenging, typically requiring a specialized undergraduate degree as a minimum. Specialists usually conduct soils analysis, although many civil engineers, landscape architects and wetland scientists within their particular specialty use aspects of soil science evaluations. This portion of the course will give an overview of the science, techniques, terminology and use of soils for wetland determination.

Hydric soils are partially described by what is called a specific *Munsell* color (Kollmorgen Corporation 1975), and further defined within that system by hue, value and chroma. We talked about hydric soil colors and textures earlier in this course.

To create a nationwide wetland soils system, the NRCS in 1991 developed a classification system for hydric soils. The publication, *Hydric Soils of the United States*, categorizes the two major soil groups--organic and mineral soils--by their field indicators. Organic soils are divided into groups based on their percentage of decomposed plant fibers and material. Mineral soils are characterized by water table, permeability, and duration of ponding.

For instance, assuming the soils have not been artificially drained, all soils classified by NRCS as very poorly or poorly drained are considered hydric. Soil mapping provided on NRCS soils maps (see **Soils Maps** section above) indicates the soils series drainage class. The NRCS mapping for any site may be field confirmed using detailed criteria in the Corps *Manual*. Typically, observation holes, where necessary, are made to a depth of 20-22 inches using a shovel or tile spade.

As noted earlier, Munsell colors are used to provide critical information on the degree of soil wetness and inundation, and serve to standardize color description. Colors are described by hue, value and chroma in relation to spectral colors (predominately reds, yellows, greens, blues, and purple).

Soils are sampled using a circular observation hole that may have a 12 inch or greater radius. The sampled soil is carefully removed from the hole. The sample, laid sideways, is itself referred to as the *soil profile*. The profile is examined and broken down by the analyst into *horizons*.

Horizons are layers of soil, parallel to the surface, having distinct characteristics produced by soil forming processes. The top layer is called the O and/or A horizon; the subsurface layer is the B horizon; and further layers below are the C and R horizon. These layers may be further categorized by structure, texture and other other physical properties. An example near the end of this course will show the applicability, and importance of using horizons in soils analysis.

Paxton soil, a typical profile (note the C-horizon colors below 24).

Master Soil Horizons & Layers

O-Horizon This layer, sometimes commonly called "duff" or the "litter layer," is dominated by organic material in varying states of decomposition. If the O-horizon is at least eight inches deep, it is hydric, and classified as a *histosol*.

A-Horizon A mineral horizon formed at the surface or just below the O-layer, commonly referred to as "topsoil." Most A-horizon soils are not used to determine hydric status, unless shown to have evidence of *oxidized rhizospheres* (see below)

B-Horizon Horizon formed below an A or O-layer, and commonly called "subsoil." Considered hydric if it has a soil chroma of 1 or less.

C-Horizon The layer little effected by processes of weathering and that lacks the properties of an O, A or B-layer.

R-Layer Hard bedrock.

Within each layer, the background, or predominant, color of a soil sample is called the *matrix*. At times, due to varying chemical reactions and mixes of soil types in a given layer, colors may vary noticeably. Anaerobic conditions may produce a reduced condition, commonly called *mottling* (or more technically, *redox concentrations* or *depletions*) that may create varying colors throughout a small soil sample. Mottling may be diagnostic of wetland conditions. Further, indications of wetland soils occur when the matrix *chroma* immediately below the A horizon, or top horizon, is 2 or less in mottled soils, or 1 or less in unmottled soils. Worded differently, hydric status is usually assumed if the matrix chroma of the B-horizon is 1 or less.

An example of a hydric soil would be a 5GY 4/1. The GY stands for gleyed; the 1 is the chroma. All hydric soils do not have to have the GY designation (and often do not). Another hydric soil example would be a 10R 2.5/1. Again, note the "1."

"Color books" are commercially available books of color chips that follow the Munsell patterns. These books are sold through universities, and engineering and forestry supply catalogues. The two major color book publishers are Kollmorgen, which publishes several variations of Munsell books with the same name, and Color Communications, which sells a book called *EarthColors, the Globe Edition*. Both are nationally recognized and widely used for diagnostic purposes.

A CAVEAT

Color chips, regardless of the publisher, fade by as much as two chroma with intensive use, altering their accuracy. They should be replaced at least every other year.

This was brought home to me several years ago when I delineated a highly controversial wetland line, relying on soils and plants. On a follow up site walk to review the line, the local conservation administrator argued that my soils analysis was incorrect.

Having conducted a careful analysis, I responded that I was certain the information I had submitted was accurate. He then took out his personal color book, held it up to a soil sample, and declared that the sample was hydric. Holding my own color book, I borrowed his sample and showed him that it was not. Our confrontation reminded me of two cowboys pointing pistols at each other.

Luckily, a third party held out her color book--a new one that had never been used--and confirmed that my analysis was right. The sample was not hydric. It took all of us a few minutes to realize that the agent's color book was so old (he later admitted that he had owned it about ten years) that many of the chips had faded by up to two chroma. I presume he quickly replaced his book after our confrontation!

HYDRIC SOILS FIELD INDICATORS

The following field indicators are nationally recognized, and were developed in 1987 and 1989 by the NRCS. A detailed explanation of each of these indicators is not possible in this course, but a familiarity with the terms may be useful to a professional who works with wetland or soil scientists.

Field indicators of hydric soils (applied to the profile within the root zone) are:

- *Organic soils* (also known as histosols, organic layers greater of than 16 inches)
- *Histic epipedons* (thick organic surface layers, 20-40 cm, or greater than 8 inches)
- *Sulfidic materials or smell* (described previously)
- *Aquic moisture regime* (areas of elevated groundwater levels)
- *Reducing condition*
- *Soil color* (always checked when samples are moist)
- *Mottling or evidence of concretions* (concretions are cemented minerals)
- *High organic matter in the surface horizon*
- *Subsurface streaking* (often caused by fluctuating groundwater)
- *Spodic horizon* (a complex chemical change that takes place under certain geologic conditions)
- *Oxidized rhizospheres* (roots that grow in saturated conditions and produce brightly colored areas in the soil; for instance, roots found in the A-layer may exhibit a bright orange along plant root filaments)

Note that there are some hydric soils that are difficult to identify, even for trained personnel. In these instances, a soil scientist may have to be called upon to make a final determination. Examples of difficult soils may be some sandy soils, floodplain soils and soils from highly colored parent material. Also, soils are difficult to identify in areas that have recently been impacted by human activities. Particularly in areas of dumping or excavation, soils analysis may not be possible.

ENTERING WHAT SOIL SCIENTISTS CALL "THE REALM OF LIVELY DARKNESS" (OR, LET'S DIG A HOLE)

As a final example of field procedure, this time using hydric soils, let's presume that in late summer you have found a wetland area on a project site. The slopes around this wetland community are very gentle. You have analyzed wetland plants, using the procedures you have already learned. Unfortunately, there is no distinct wetland line because the plants seem somewhat evenly mixed between upland (FACU) and wetland (FACW or OBL) plants. Given the season, there are no obvious signs of hydrology. The wetland edge could be 60 feet up or down the slope. Your client, a local school department, wants to expand its soccer fields as much as possible.

Based on local regulations, the proposed athletic fields must lie at least 50 feet from the edge. An accurate wetland line is critical. Frustrated that the wetland edge seems so elusive, you decide to examine soils for hydric characteristics.

Knowing you need to dig a 20-inch deep hole roughly one foot by one foot, you bring along a tile spade. (You could use a soil auger--see photograph--but augers sometimes compress the soil sample, and soils sampled by this method are more difficult to analyze. Until you gain more experience, stick with sampling soils with a spade.)

You also bring along other basic equipment--your new color book, a field book, a 100-foot tape, flagging and perhaps a compass. Arriving at the site, you stop at a location that you believe may be the wetland edge. You set down your equipment, note the date and approximate location in your field book, and find an open area where you decide to dig the first hole.

Remembering that you should record the depth of the "O" (organic or litter) layer, you use a knife to probe the depth of the litter layer. You measure it at about two inches, and duly record this in your book. Because it is less than eight inches in depth, this layer cannot be hydric.

Delineating the edge of a forested swamp in early Fall.

Then using your spade, you dig a hole. When you are through, you kneel down to determine if a hydrogen sulfide (rotten egg) smell is present. If so, you know that the soil is hydric, and you won't need to do any further analysis. However, you smell nothing but dank loam, nothing different than what you remember from your own garden.

You then use the spade to obtain a single long slice from the top of the hole to the bottom. This soil profile is carefully set on the ground beside the hole. Usually these slices are about 4-6 inches wide, and about 20 inches long. Because the tile spade is about 30 inches in length, you easily pull out your sample.

Your first job is to determine the depth of the A-horizon. You can clearly see a light yellow brown mineral top layer. Using the color book, you decide that the A-horizon is a 10YR 6/4 color. That data is recorded. You measure the depth of the A-horizon as ending at 14 inches, and record that as well. You next examine the lower B-horizon.

This B layer is distinctly different than the A. The soil seems less granular, and the color is grayish. Again, using the color book, you determine that the matrix color is a 2.5Y 5/1. The depth measures eight inches. All the data for this new hole is recorded. You remember that because the chroma is 1, the B-horizon must be hydric. You also note that the total depth of the hole is twenty-two inches, which, you conclude, must be too little to get down to a C- or R-horizon. Last, there is no obvious saturation or weeping anywhere in the hole.

You have, at the least, determined that this particular location has hydric soil. In addition, you know from analyzing the vegetation at an earlier time that the plant community is slightly more than 50% hydric. But you still haven't found the actual wetland edge. You only know that you are standing somewhere in a jurisdictional wetland.

You decide to move slightly uphill, and you measure the distance as 22 feet from hole to hole. You repeat the first exercise, this time determining from the new sample that the soil is non-hydric -- the B-horizon soil color in this hole is 2.5Y 5/3. Now this exercise is making sense. You know the actual wetland edge must lie somewhere between your first two holes. You move slightly downhill, taping your distance at exactly 10 feet from hole two.

Hole three reveals a B-horizon color of 2.5Y 5/2, marginally non-hydric. You admit to yourself that the soil chroma could be interpreted as being darker, perhaps a 1. Even better, the plant community is almost 50/50 wetland to upland plants. This must be close to the edge. You carefully record everything, back fill your holes, and mark the flagging so that you can find the correct location at a later time. Congratulations! You successfully found the wetland edge.

SUMMARY

In this course you have learned a number of technical concepts, including recognition of the predominant natural forces that act together to create a wetland. You have seen the importance of being familiar with the macro, or landscape, conditions that form wetlands.

You have seen that the three major characteristics of a wetland include hydrology, hydric soils and hydrophilic vegetation. In addition, you have learned basic wetland terminology and field techniques for recognizing a wetland. You know when to identify wetlands yourself, and when critical wetlands location requires the use of a professional.

You now have a strong sense of how to prepare for a wetland analysis, and what guidebooks may help you confirm your preliminary findings. You understand the concepts behind wetland hydrology, including primary hydrologic indicators. You similarly understand the physical processes that form wetland plants, and how they are classified.

You understand the role of wetland soils in wetland delineation, and the unique terminology that soil scientists use to describe hydric soils. Last, you understand the key federal legislation that protects wetland areas. You know that federal legislation, if more restrictive, always trumps state law, and you know that wetland legislation often varies regionally, locally, and from state to state.

Bibliography

107th U.S. Congress. October, 2002. *Issue Brief: Wetlands*. Washington, D.C.

Color Communications Inc. 1997. *EarthColors Manual*. Poughkeepsie, NY

Environmental Laboratory. 1987. *Corps of Engineers Wetlands Delineation Manual*. Technical Report Y-87-1. Vicksburg: Department of The Army.

Kent, Donald M., editor. 1994. *Applied Wetlands Science and Technology*. Ann Arbor: Lewis Publishers

Kohnke, Helmut and Franzmeier, DP. 1995. *Soil Science Simplified*. Prospect Heights: Waveland Press.

Massachusetts Department of Environmental Regulations. 1995. *Delineating Bordering Vegetated Wetlands: A Handbook*. Boston: Massachusetts Department of Environmental Protection.

Massachusetts Department of Environmental Regulations. 1997. *Wetlands Protection Act Regulations*. Boston: Massachusetts Department of Environmental Protection.

Niering, William A. Undated. *Wetlands, Audubon Society Nature Guides*. New York: Alfred Knoph.

Porter B. Reed, Jr. 1988. *National List of Plant Species That Appear in Wetlands: Rhode Island*. Washington, D.C.: Fish & Wildlife Service.

Tiner, Ralph W. Jr. 1988. *Field Guide To Nontidal Wetland Identification*. Maryland: Department of Natural Resources.

Wetland Training Institute. 1989. *Field Guide for Delineating Wetlands: Unified Federal Method*. WTI 89-1.

Web Resources

1987 Corps Manual (PDF file of the entire manual) — www.wes.army.mil/el/wetlands/wlpubs.html

US Corps of Engineers — www.usace.army.mil/

Environmental Protection Agency, Wetlands, Oceans, Watershed — www.epa.gov/owow/

NWI Wetland Inventory Maps — www.nwi.fws.gov/

Hydric Soils of the United States — http://soils.usda.gov/soil_use/hydric/main.htm

Soils of New England — www.nesoil.com/

USGS (General Information) — www. usgs.gov/

Society of Wetland Scientists (excellent source for wetland links, & for wetland regulations in many states) — www.sws.org

Wetland Science Institute (federal venture between USGS, USDA & NRCS: great source for soils data, training materials, plants guides & hydrology tools) www.pwrc.usgs.gov/wli/wetdel.htm

Credits

Two photographs courtesy of USDA/NRCS (men testing soil, & stream with wetlands beside agricultural fields)

Photograph of soil “Paxton” profile courtesy of Jim Turenne, www.nesoil.com.

Photograph of Delta Marsh courtesy of University of Manitoba.

Marsh hibiscus photograph courtesy of University of Florida.

Remaining photographs, Copyright, Patrick C. Garner 2009.

The NWI U.S. map, and the Corps U.S. divisions map, courtesy of the NWI program, and the Corps.