Supplemental Guide for Seasonal High Water Table Indicators in Georgia's Onsite Wastewater Manual Section C: Flatwoods Region

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Non-Thesis Research Paper

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November 29, 2011

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Introduction

Low urbanization in the Georgia flatwoods region has resulted in extensive use of onsite sewage systems (septic systems). Each county has at least one Environmental Health Specialist. Part of their job is the assessment of lots for soil suitability for septic systems. The Georgia Department of Public Health (GDPH) publishes the "Manual for Onsite Swage Management Systems" (GDPHa). The section C of this manual (GDPHb) contains guidelines for soil investigations addressing the suitability and design of septic systems. These guidelines rely only on the presence of redoximorphic features, chroma 2 gray, to identify seasonal high water table (SHWT) depth. The SHWT is an important determinant of septic system success or failure. More detailed morphological indicators of water saturation have emerged from the study of hydric soils associated with wetlands. These have application to SHWT and can potentially be used to refine the GDPH manual.

Environmental Health Specialists receive only one week of soils training; the rest must be learned 'on the job' with the help of a supervisor or independent study. A major judgment they must repeatedly make is the SHWT depth. They would benefit from having more complete and up-to-date soil indicators such as some that have been established and validated for hydric soils (USDA-NRCS, 2010).

Objectives

The objectives of this paper are to supplement the soil assessment component of Georgia's "Manual for Onsite Swage Management Systems" (section C) with an expansion of SHWT criteria and to serve as a learning aid for Environmental Health Specialist in the Flatwoods/Southern Coastal Plains regions of Georgia.

Background – Flatwoods and Flatwoods Soils

The flatwoods (shown in light blue in Figure 1) are part of the Atlantic Coast Flatwoods that run along the eastern shore of the US. They fall within the Coastal Plain Physiographic Province (Fenneman) and constitute a major soil province in Georgia as shown below in brown and light blue (UGA College of Agriculture). This area, as the name suggests, is relatively flat, with native forest (pine) vegetation. It is also characterized by wide meandering streams.

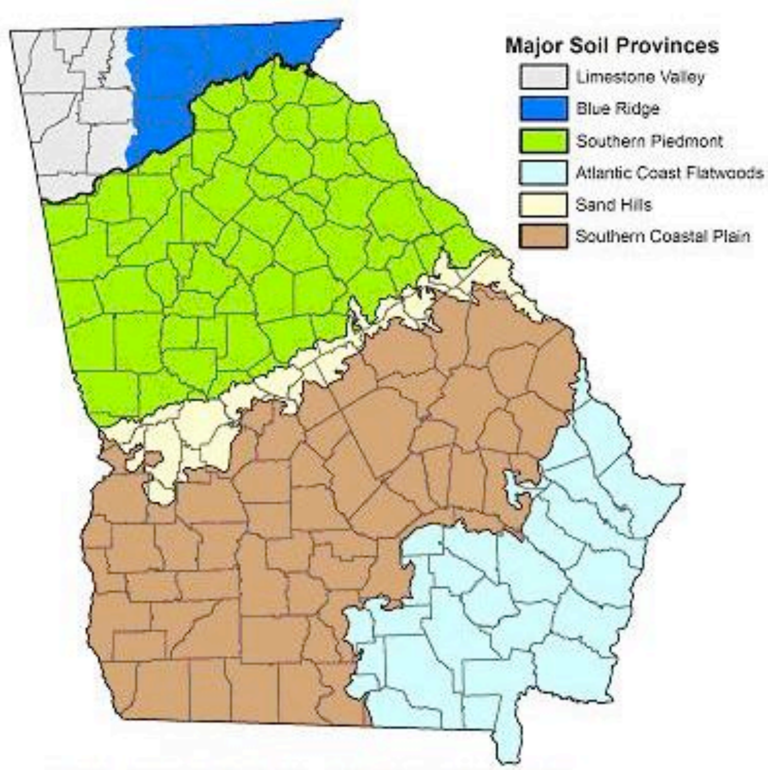

Figure 1- Six Soil Provinces of GA. Picture from UGA College of Ag.

Figure 1. Six soil provinces of Georgia (Source: University of Georgia College of Agriculture).

The definition of soil adopted by this paper to apply to flatwoods landscapes is that used by the United States Department of Agriculture – Natural Resources Conservation Service (Soil Survey Staff, 2003), which is as follows, - *Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment*.

The flatwoods soil's parent material is marine sediments. The soils are generally very deep and range from well-drained to poorly-drained (NRCS), though poorly-drained conditions with high seasonal water tables are most prevalent. They commonly have sandy surface horizons and in some cases loamy or clayey subsurface horizons (NRCS). The dominant soil orders are Spodosols and Ultisols (NRCS; Soil Survey Staff, 2003). The Spodosols of flatwoods are particularly challenging in determining SHWT upper boundary because it usually occurs within a light-gray to white horizon of stripped quartz sand grains where morphological cues are extremely faint. The latter is a condition that has been addressed in the hydric soils indicators which this paper adapts to SHWT determinations for septic system site evaluations.

General Aspects and Terminology of Septic Systems

For the purposes of onsite waste disposal the upper boundary is air/vegetation and the lower boundary is forty-eight inches or seasonal high water table. There are basically only three soil characteristics that affect the sizing/location of septic drainfields in coastal plain soils: texture, slope, and SHWT with texture and SHWT being the most important in the flatwoods. For additional information on texture and slope see Georgia's Onsite Sewage Manual section C (GDPHb). These are the criteria that must be addressed during the site evaluation before an onsite system can be installed. First we need to define what an onsite wastewater system is and what qualifies as a site. The Georgia manual defines "on-site sewage management systems" as, a sewage management system other than a public or community sewage treatment system serving one or more buildings, mobile homes, recreational vehicles, residences, or other facilities designed or used for human occupancy or congregation. The manual also defines a site, "as the location where the adsorption field will be installed to include replacement area (Georgia onsite manual)". That means that there must be enough usable land to install two separate systems. This paper should show how to evaluate any given site within the flatwoods area and describe the soil by means of the above mentioned soil characteristics.

Background-Hydric Soil Indicators

Morphological indicators of seasonal water saturation ("hydric soils indicators") form when water rises frequently, filling soil pores and void spaces, resulting in saturated conditions (USDA-NRCS, 2010) . Soil saturation creates anaerobic conditions, thus activating anaerobic microbes. The anaerobic conditions cause biogeochemical processes that result in organic matter (OM) accumulation and the reduction, translocation, and/or accumulation of reducible elements such as iron. Due to these oxidation-reduction (redox) reactions, distinctive soil morphology characteristics are formed (redoximorphic features or RMFs), provided that the water is not moving through the profile (rainfall, etc) and the microbes are active (Vepraskas and Faulkner, 2001). These are the biogeochemical processes that are responsible for the formation or characteristic soil morphological organic and redox features that persist during both wet and dry periods, making them particularly useful for identifying hydric (wetland) and other wet soils (Mausbach and Richardson, 1994). Zones or horizons may have a stripped background color due to oxidized forms of iron, manganese, and carbon being chemically reduced and dissolved in water, resulting in translocation. This is called leaching. Leaching leaves a depleted background color of the natural uncoated mineral soil particles. These conditions can lead to the accumulation of OM at levels in the soil indicative of soil wetness. Soils with high amounts of highly decomposed OM accumulation (to exclude leaf litter or mats) at or near the surface are generally wet and will be classified as hydric if sufficiently wet. Flatwoods soils are typically sandy. Organic compounds may coat or mask sand grains resulting in the appearance of dark colored sand. Soluble, reduced forms of iron and manganese may oxidize and accumulate to form concentrations of soft masses, pore linings, concretions, and nodules (Vepraskas 1994), provided the soil solution contains iron and manganese. Both depletions and concentrations of organic iron and manganese may occur within the same horizon in sandy soils. The Georgia Onsite Sewage manual page C-12 heading G directs that freewater should not be used as an indicator, and that gray colors, especially chroma 2 gray should be the most reliable indication of SHWT. The indicators we are going to be using are hydric soil indicators taken from the NRCS (Natural Resources Conservation Service) manual, Field Indicators of Hydric Soils in the United States (USDA-NRCS, 2010).

Most of these indicators use chroma 2 as part of the indicator description; however, they add what percentage of a matrix color needs to be chroma 2. These indicators are not limited to just gray colors, but any matrix that is depleted or gleyed (see definitions below for depleted and gleyed). These indicators also show percentages of redox concentrations needed to justify a SHWT in sandy horizons (concentrations are not used as an indicator for loamy or clayed textures). The Georgia onsite manual describes redox concentrations, but simply states that the presence of these concentrations is a reliable indicator for SHWT. Although the use of RMFs to identify a depth to the SHWT is a proven approach, a number of studies have observed saturated soil horizons without RMFs (Daniels et al., 1973; Franzmeier et al., 1983; Pickering and Veneman, 1984; Evans and Franzmeier, 1986; Genthner et al., 1998; Calmon et al., 1998) These studies suggested that the presence of RMFs is not necessarily indicative of the depth of the water table, but how long the water table is at that depth or above (cumulative saturation) (Morgan and Stolt, 2006).This implies that the SHWT may exist for brief periods in horizons free of RMFs. The hydric soil indicators listed below are a better approach even though most still use the presence of redox features. The addition of Stripped Matrix indicator (see below for details) is an exception, for it uses the depletion of organic material (OM) as the indicator and is used in the E horizon after all iron-manganese is removed. These indicators were developed to identify wetland soils by using soil morphology.

Overall there are forty-six indicators, but we will look at the six most likely to be used as SHWT indicators in nonhydric soils. The indicators are broken down into three main categories: “A” indicators which can be used in all soil textures, “S” indicators used only in sandy soils, and “F” indicators which are used in loamy and clayey soils. Note that these are written to identify wetland soils, but may be used as SHWT indicators. User notes are also provided from the literature (USDA-NRCS, 2010) to aid in understanding of the indicators. The following describes the identification of SHWT by making use of pertinent saturation indicators initially established for hydric soils identification.

SHWT Indicators

All of the common indicators used to identify water table relate to soil color. Soil color is one of the most easily observed descriptors of soil morphology and it indicates a wide range of soil properties (USDA-NRCS, 2010). Color perception differs from person to person. Soil scientist employ a reference guide for colors called the MUNSELL® color system in order to standardize color terminology and minimize individual discrepancies to the intent possible. MUNSELL® utilizes a standard set of color plates and three descriptive elements called hue, value, and chroma (Gretag-Macbeth. 2000). In the MUNSELL® book each page represents a hue. Hue is the relationship between the colors red, yellow, green, blue, and purple, which represents the basic spectral color or wavelength. For soils only the hues for red (R) and yellow (Y) are used. Pages used to describe hues between red and yellow are designated with YR. The general pages used in progression are 10R, 2.5YR, 5YR, 7.5YR, 10YR, 2.5Y, and 5Y. MUNSELL ® books also come with two more additional pages called the gley pages. Gley pages represent hues of grayish, bluish, and greenish which usually are only found in very wet soils. On each individual page colors are separated in rows/columns by the value and chroma. Value is an indication of lightness and darkness of the color. On each page value is assigned by columns with increasing value from bottom to top. Pure white has a value 10, while pure black has a value of 0. Chroma represents the strength or purity of the color. As chroma increases the colors become more vivid/intense. Chroma increases from left to right on the page. The following is an excerpt from the Hydric Soils of Florida Handbook describing how to properly measure the soil color using the MUNSELL ® book,

"When measuring soil color, the observer should stand with the sun to their back. Sunglasses or any type of tinted lenses should not be worn. Very early morning or late afternoon measurements are not accurate and should be avoided. Measurements should not be taken under artificial light. The sample should be moist (does not become darker when water is added), never dried out, but not too wet (sample does not glisten in sunlight). The sample should be placed behind the holes on the color chart and compared to the color chip that is most like the color of the soil sample. It is understood that an exact match is not likely, but that the closest color match will be used."

The values listed in the glossary for distinct and faint represent the change in between contrasting colors. For example if a soil's matrix was determined to be 10YR 6/2 and the contrasting color whether a redox feature or not was 10YR 4/1 then the contrast would be considered faint since the delta hue=0 (both were 10YR), delta value≤2 (matrix was a 6 and secondary color a 4; 6-4=2), and delta chroma≤1 (matrix was a 2 and secondary color a 1; 2-1=1).

We will start by looking at A indicators which can be used in all soil textures. The SHWT is the shallowest depth at which the indicators are observed. The only A indicator is that is applicable for our purposes is A4, which is the presence of hydrogen sulfide. This indicator is not visual, but olfactory; this is the "rotten egg" smell that only comes from soils saturated and under anaerobic conditions. Soils meeting this indicator would most likely be very-poorly drained and obviously not a prospect for onsite waste disposal.

Next we will look at the S indicators which are only used in sandy soil horizons. The first is S5 or sandy redox (Figure 2). This indicator is characterized by having a matrix with at least 60% chroma 2 or less and having prominent or distinct redox concentrations of at least 2 percent (prominent and distinct defined above), with diffuse boundaries to the matrix. These concentrations include root pore linings, for it is at the surface of pores that reduced Fe in the soil comes in contact with air as the soil drains.   Fe-rich pore linings are commonly found in horizons with a fluctuating water table (Stolt, 1994). The redox concentrations need to be (>2%) of the horizon. These concentrations in the horizon include Fe-Mn which will show up as reddish mottles.


Figure 2. Image of sandy redox (S5) taken by author in Wayne County, Ga)

Color patterns may be hard to see if soil is saturated, so the sample may have to dry to a moist (but not wet) condition before redox features become apparent. The other sandy soil indicator that we will focus on is S6 or stripped matrix (Figure 3). This indicator may also have been called streaking. As the term suggests, this is when the matrix color has regions where Fe-Mn oxides and/or organic matter have been stripped, exposing the primary base color of the soil.

Figure 3. Image of stripped matrix (S6) taken by the author in Wayne County, GA)

There are some rules that must be met. The stripped areas and the areas of translocated oxides and/or organic matter must form a faintly contrasting pattern of two or more colors with diffuse boundaries. The stripped area must comprise 10% or more of the volume and must be rounded or oval. These stripped areas are generally small, being only 1 to 3 cm (0.5 to 1 in.), but they can be larger or smaller. Also for a SHWT to be called the abundance again needs to be common to many areas of stripped soil. Most often the stripped areas will have a very low chroma of 1 or 2 against a matrix of 3 or 4; this again is common but will not be seen in all instances. This is the hardest of the indicators to see when using an auger; it is easier to see when a horizontal slice is viewed.

Lastly, we will look at the F indicators which are used only with Loamy or Clayey soil horizons. The first is F2 or loamy gleyed matrix. This indicator is basically when a horizon has a gleyed matrix that encompasses 60% or more of the layer. Gley is not the same as gray. Gley colors are found on the gley pages of the Munsell color book. They include grayish colors, but also include hues of green and blue. Soils with gleyed colors are saturated for significant periods of time so it is possible that a fainter indicator is present above if you have a fluctuating water table. The other F indicator is F3 or depleted matrix. This is characterized by a layer having a depleted matrix with 60% or more being chroma 2 or less and requires a value of 4 or more. The presence of redox concentrations is required only if the matrix color is 4/1, 4/2, or 5/2. Unless common or many distinct redox concentrations are present in an A or E horizon then it is excluded from the depleted matrix concept. Many A and E horizons have low chroma and high values, so they can be mistaken for a depleted matrix, but without redox concentrations they are excluded (USDA-NRCS, 2010). Again the above indicators describe extreme conditions.

If one is dealing with a loamy or clayey textured soil the depth to the SHWT is the depth at which 2% or more distinct or prominent redox depletions occur with a value of 5 or more and a chroma of 2 or less. These values are used when the indicator is seen between depths of 12 to about 40 inches. Below 40 inches you can call a SHWT with depletions of 5 or more and chroma 3 or less, but this is unnecessary due to the fact that a SHWT depth of 42 inches allows for 24 inch separation between trench bottom and SHWT with no fill material required.

SHWT and RMF

Data presented by Morgan and Stolt (2006) show that the relationship between average seasonal high water table (ASHWT), defined as the average of the highest and lowest water tables recorded during the two and a half month period of each year when water tables were at their highest levels, and RMFs can fluctuate depending on soil texture. These authors found that, for loamy soils, starting with the shallowest depth where RMFs are present is a good idea; however, where coarse textured horizons (sands) are present, additional considerations should be given to soil-based (i.e. field evaluations) interpretations of the depth to the SHWT. Their data are based on cumulative saturation, which is a percentage of how long water table levels occur at any given depth, using 18 months as their study length. Horizons with loamy sand or finer textures ranged from 3% for those with no RMFs to 36% for those with depleted matrix, while horizons with loamy sand or coarser ranged from 8% for those with no RMFs to 45% for those with >2% depletions. The research of Morgan and Stolt (2006) shows that the longer a water table is present in a horizon the more pronounced the RMFs will be, and that coarser horizons are less expressive in regards to the RMFs, thus making identification of SHWT more difficult.

Conclusions

Using the presence of chroma 2 gray as the only means of SHWT identification is a safe approach that will yield positive results most of the time. However, knowledge of the hydric soil indicators will narrow the margin of error and increase an environmentalist ability to assess a seasonal water table correctly. The addition of the stripped matrix indicator is especially useful in the flatwoods sandy soil where chroma 2 alone is not a direct indicator of SHWT because it also arises from other processes that produce the white to light gray E horizon of Spodosols that are prevalent on this landscape.

Appendix 1-Additional SHWT Criteria from the Florida Soils Training Manual

Background

The state of Florida has provided its environmental staff with a "Basic Soil Training Manual" (Florida Dept. of Health, 2010) that comprises multiple properties of soils from color, texture, and SHWT. We will focus on the SHWT determination criteria provided in that manual that augments those of the Georgia manual. The Florida manual defines SHWT as the highest average depth to a zone of saturation. It states that although soil morphology is the basis for SHWT, other factors should be considered including vegetation, organic matter content, and drainage class. Soil color is the dominant morphological feature used to determine SHWT. The Munsell® system is used to describe soil color. Both the matrix and redox features must be taken into account when describing color of any given soil horizon, as well as the level of contrast to which the redox features are present (faint, distinct, prominent).

Redoximorphic Features in Loamy or Clayey Soils

In the state of Florida the classification of loamy or clayey soils includes the texture of loamy very fine sand or finer. The best indicator of the depth to the seasonal high water table below a depth of 12" from the soil surface is the depth to grayish low chroma soil colors, either in the matrix or in mottles (iron depletions). These low chroma colors have a chroma of 2 or less with a value of ≥ 5 (note the higher values). The depth at which these low chroma colors are encountered is the estimated depth of the SHWT (Florida Soils Manual 2010). The manual also states that if this color pattern is seen directly below a dark surface horizon the SHWT is at, near, or above the soil surface. Additionally it states that the Hydric Soil indicators described previously can be used to identify SHWT at any depth. In loamy or clayey soils that are not hydric (6 inches or less for sandy soils and 12 inches or less for loamy/clayey in Florida) the depth to saturation is the depth to common to many distinct or prominent redox depletions with value 5 or more and chroma 2 or less and occurs between 30 cm (12 inches) and 1 meter (39.37 inches). If the distinct of prominent depletions occur at a depth greater than 1 meter (39.97 inches) then a value of 5 or more and a chroma of 3 or less may be used (Florida Soil Manual 2010).

Redoximorphic Features in Sandy Soils

In Florida the classification of sandy soils includes loamy fine sand and coarser. The best indicator of SHWT below 12 inches in a sandy soil is the presence of distinct or prominent colored redox concentrations and/or a gleyed matrix. The matrix has a chroma of 3 or more with or without high value, while the redox concentrations have a hue of 10YR or redder, value 5 or more, and chroma 6 or more. Again this is for depths greater than 12 inches. If shallower than 12 inches then the hydric indicators are used (Florida Soil Manual).

Another indicator used in sandy soils is the presence of a stripped matrix. This appears as a "splotchy" arrangement of 2 or more colors where one has low chroma and the others are "dull" (Florida Soils Manual 2010). The manual defines dull in Munsell® notation as having a value of 5 or more and a chroma of 3 or 4. The boundaries of this pattern are diffuse and the stripped (light color) comprises at least 10 % of the sample. In most areas of Florida, the stripped matrix may be difficult to identify because of its characteristic subtle color patterns (Florida Dept. of Health, 2010).

Vegetation and SHWT

Vegetation is a natural indicator which can provide support for SHWT, but should only be used in rare instances to predict a SHWT due to so many “exceptions” to rules. Vegetation is also easily changed by natural or human forces. For more information on vegetation see the Florida Soils Manual referenced below.

Organic Matter Content and SHWT

The presence of organic matter in soils can help one determine SHWT. The presence of muck, mucky peat, or peat indicates that the SHWT is at or near the surface. The determination of peat, mucky peat, or muck can be made by using the ‘near saturated rub test” which is not the same as the textural rub test. In the ‘near saturated run test’ the sample is wet enough to squeeze water out. If, after two light quick rubs between your thumb and forefinger, the soil feels either gritty (meaning dominated by sand particles) or slick (meaning dominated by silt or clay particles), the soil is neither muck nor mucky mineral, it is mineral. If, after 3 or 4 MORE light quick rubs, soil feels either gritty or slick, the soil is not muck, it is mucky mineral. Only after not feeling grit or slick after at least 6 rubs (preferably 10) should the soil be considered to be a muck (Florida Soil Manual 2010). Organic matter in lesser amounts can also be used as a reference for SHWT determination. For example, a black surface horizon indicates SHWT within 12 inches of the surface, while a dark gray surface horizon can indicate a SHWT around 9-15 inches (Florida Soil Manual 2010).

USDA Drainage Classes

Drainage classes are broad categories that usually have groups of soils with similar SHWT. However, a drainage class does not indicate a specific depth to seasonal saturation and hence is not a substitute for SHWT. There are 6 drainage classes in use in the state of Florida: very poorly drained (SHWT 0-24 inches above surface), poorly drained (SHWT 0-18 inches below the surface), somewhat poorly drained (SHWT 12-30 inches below the surface), moderately well drained (SHWT 24-48 inches below surface), and well drained (SHWT >60 inches below surface), excessively well drained (SHWT >72 inches below surface). Again these are general SHWT relative to the drainage classes and not exact figures.

Appendix 2-Soils Training for EH Staff in Florida vs. Georgia

Georgia and Florida share a border and a number of the same flatwoods soils. Political boundaries don't affect scientific assessments of soil suitability for septic system installation. Therefore, hopefully those interpretations would be relatively consistent between the states. There are many similarities between Environmental Health (EH) in Georgia and Florida. Both require attendance and completion of training units to become a certified inspector. In Georgia, all new staff are trained in all EH programs; there are 5 modules in all with one being soils training which is required for onsite permits. Florida also requires a soil training and certification program for staff who will issue onsite permits. The soils training programs are very similar for both states. Each state requires 4 days of training with half of the time spent as traditional lecture and half as field work with "hands on" experience. The soils training amounts to a "crash" course where soil and hydrology topics are placed in reference to onsite sewage conditions. The courses of both states show relationships between soil and water in the landscapes, geology of regions from across the state, soil profiling, soil types, textures, SHWT, and soil formation. They also show how each of the before-mentioned topics relates to onsite system permitting, inspection, and maintenance. Instructors in Georgia provide notebook that contains the information presented in the course. The same is true of Florida instructors; however, EH professionals in Florida are also given a soils manual which is discussed in appendix 1. A comprehensive final exam is administered and a passing grade is required for completion of the course.

There are some differences between the two state's programs, as well. The soil training in Georgia is offered in the Atlanta area and is instructed by University of Georgia Crop and Soil Sciences Department staff. The training in Florida is offered in the Orlando area is conducted by state EH staff with the occasional help of University of Florida staff from around the state. Both are conducted in association with an urban area, but the biggest concern is in Georgia. Georgia is broken up into six soil provinces with the upper/lower coastal plains soils (which include flatwoods) to the south, and the piedmont soils to the north. Soil characteristics change dramatically from north to south. Northern soils contain more clay, whereas the coastal plains soils contain far more sandy soils. Florida is all located in the coastal plains.

In conclusion, I have a few recommendations for soils training for Georgia EH. First establish two locations for soils training: one located in the piedmont region and one in the coastal plains region. This will allow staff to be trained by soils professionals using their local soil types. Secondly a soils manual should be created to aid EH in their site evaluations modeled after the Florida soils manual which covers all essential data needed for proper permitting. Lastly, a field exercise should be administered to supplement the final exam and allow for demonstration of knowledge learned in the field.

Appendix 3- Summary of SHWT Indicators

Sandy Soils	**Loamy or Clayey Soils**	**General Notes for All Soils**
1. (S5) Sandy Redox --60% of matrix must be chroma 2 or less with at least 2% prominent/distinct redox concentrations with diffuse boundaries. --includes root pore linings	1. (F2) Loamy Gleyed Matrix --60% of matrix color found on gleyed pages of Munsell® book.	1. (A4) Presence of hydrogen sulfide (rotten egg smell). Soils meeting this criterion are generally poorly drained with SHWT near the surface. 2. In Georgia site must have a water table of at least 10 inches for use of a conventional onsite system. SHWT < 10 inches are to be deemed unsuitable. 3. Presence of muck, mucky peat, or peat at the surface indicates a hydric soil.
2. (S6) Stripped Matrix --Matrix chroma generally 3 or 4, with regions where Fe-Mn-OM have been stripped exposing base color. Generally low chroma of 1 or 2. --stripped areas have faintly contrasting pattern and are usually 1 to 3 cm in size.	2. (F3) Depleted Matrix --60% of matrix having chroma 2 or less with a value of 4 or more. --presence of redox concentrations only required when color is 4/1, 4/2, or 5/2. --A and E horizons generally excluded unless redox concentrations are common to many.	
	3. 2% or more prominent/distinct redox depletions with value of 5 or more and chroma 2 or less.	

- For sandy soils (Indicator presenting >10 inches) the depth to SHWT is depth to sandy redox or stripped matrix.
- For loamy/clayey soils (Indicator presenting >10 inches) the depth to SHWT is the depth to gleyed/depleted matrix or to a depth of 2 % or more prominent/distinct redox depletions with value 5 or more and chroma 2 or more.
- For loamy/clayey soils (Indicator presenting >40 inches) the depth to SHWT is depth to common or many redox depletions with value of 5 or more and chroma of 3.

Glossary

Common- When referring to redox concentrations and/or depletions, "common" represents 2 to 20 percent of the observed surface.

Depleted Matrix- The following is a partial definition that only states the requirements for a depleted matrix: The following combinations of value and chroma identify a depleted matrix:

1. Matrix value of 5 or more and chroma of 1 or less with or without redox concentrations occurring as soft masses and/or pore linings; or
2. Matrix value of 6 or more and chroma of 2 or less with or without redox concentrations occurring as soft masses and/or pore linings; or
3. Matrix value of 4 or 5 and chroma 2 and 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings; or
4. Matrix value of 4 and chroma of 1 and 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings.

Diffuse Boundary- Used to describe redoximorphic features that grade gradually from one color to another. The color grade is commonly more than 2mm wide. "Clear" is used to describe boundary color graduations intermediate between sharp and diffuse.

Distinct- Readily seen but contrasting only moderately with the color to which compared. The contrast is distinct if:

1. Delta hue= 0, then
   a) Delta value ≤2 and delta chroma > 1 to < 4, or
   b) Delta value >2 to < 4 and delta chroma < 4.
2. Delta hue= 1, then
   a) Delta value ≤1 and delta chroma > 1 to < 3, or

b) Delta value >1 to < 3 and delta chroma < 3.

3. Delta hue= 2, then

    a) Delta value= 0 and delta chroma >0 to < 2, or

    b) Delta value> 0 to <2 and delta chroma < 2.

Regardless of the magnitude of hue difference, where both colors have value ≤3 and chroma ≤2, the contrast is faint.

Faint- Evident only on close examination. The contrast is faint if:

1. Delta hue= 0, then delta value ≤2 and delta chroma ≤1, or
2. Delta hue=1, then delta value ≤1 and delta chroma ≤1, or
3. Delta hue=2, then delta value=0 and delta chroma=0, or

Any delta hue if both colors have value ≤3 and chroma ≤2.

Gleyed matrix- Soils with a gleyed matrix have the following combinations of hue, value, and chroma (the soils are not glauconitic):

1. 10Y, 5GY, 10GY, 10G, 5BG, 10BG, 5B, 10B, OR 5PB with value of 4 or more and chroma of 1; or
2. 5G with value of 4 or more and chroma of 1 or 2; or
3. N with value of 4 or more; or

In some places the gleyed matrix may change color upon exposure to air. (See Reduced matrix). This phenomenon is included in the concept of gleyed matrix.

Many- When referring to redox concentrations and/or depletions, “many” represents more than 20 percent of the observed surface.

Pore linings- Zones of accumulation that may be either coatings on a ped or pore surface or impregnations of the matrix adjacent to the pore or ped. See Vepraskkas (1994) for a complete discussion.

Prominent- Contrasts strongly in color. Color contrasts more contrasting than faint and distinct are prominent.

Reduced matrix- A sol matrix that has low chroma and high value, but in which the color changes in hue or chroma when the soil is exposed to air. See Vepraskas (1994) for a complete discussion.

Soft masses- Noncemented redox concentrations, frequently within the soil matrix, that are of various shapes and cannot be removed as discrete units."

(Glossary excerpts form the Field Indicators of Hydric Soils in the United States, Version 7.0, 2010)

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