

Wetland Soils

CHAPTER 4

When evaluating land for the presence or absence of wetlands, the existing soil conditions are a source of considerable information. In accordance with the administrative rules for Part 303, the MDEQ may rely on soil characteristics as an indicator of wetland hydrology for sites that have a predominance of wetland vegetation but lack visible evidence of water at or near the surface. This chapter provides general information on soils and a more detailed description of hydric soils and their field indicators. Chapter 5 provides greater detail on methods recommended for identifying soil properties during an on-site evaluation. A discussion of atypical site conditions and problem areas, including altered, drained, and problem soils, is provided in Chapter 6.

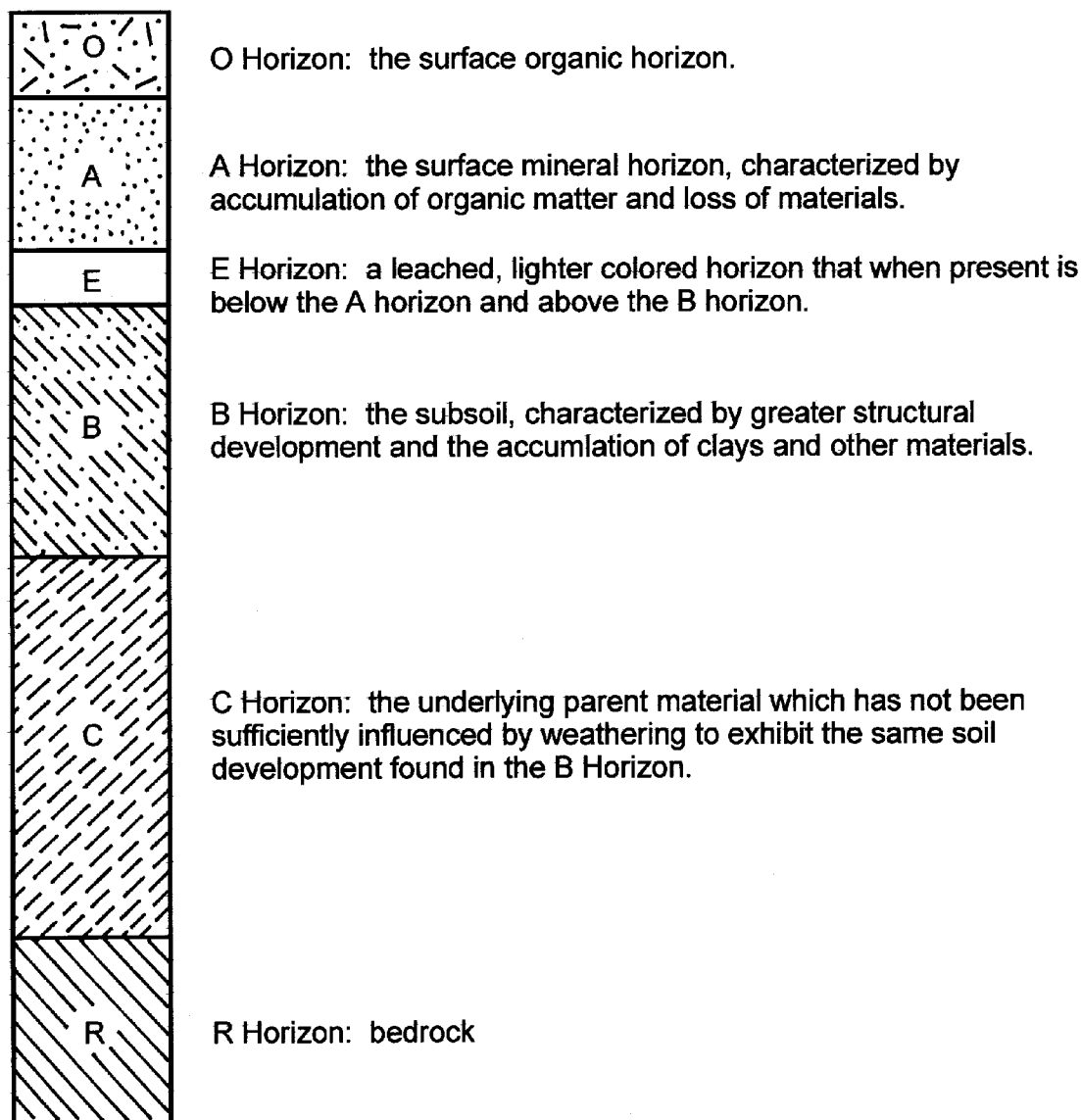
A. General Information on Soils

Soil is generally defined as the unconsolidated natural material present at the earth's surface that supports or is capable of supporting vegetation. A soil can be described as an independent body (soil type) having specific properties and morphological characteristics that can be used to differentiate it from adjacent soil types. The properties and characteristics of each soil type are influenced by such soil forming factors as climate, **parent material**, time, topography and living organisms. The key soil properties that are important in the development and identification of wetland soils include horizonation, organic matter content, texture, permeability, drainage, and color. These properties and associated morphological characteristics are unique to each soil type and can be described when examining a vertical column of soil, or **soil profile**, for a particular soil type.

The upper boundary of soil is the soil surface, and the lower boundary is recognized as either the **limit of biological activity** or the presence of the consolidated bedrock material. A soil profile (Figure 4.1) consists of recognizable layers or horizons of soil that are described in sequence from the surface downward. Most soils have two or more identifiable horizons. A **soil horizon** is a layer of soil approximately parallel to the land surface which can be differentiated from adjacent layers, or horizons, by identifiable physical, chemical, and biological characteristics that can be recognized in the field (e.g. color, structure, texture, etc.) (USDA, 1993). **Mineral soils** typically have A, E, B, and C horizons, and often have a surface organic layer (O horizon).

An organic, or O, horizon may be present at the surface of mineral soils in varied thickness. An O horizon is formed from organic matter

Figure 4.1 - Soil Profile



derived from plants and animals that are deposited on the surface. The A horizon, which is the surface soil or topsoil if no O horizon is present, is a zone in which organic matter is usually being added to the mineral soil and where the mineral and organic matter is slowly moving downward. The E horizon is a leached, lighter horizon that, when present, is located between the A and B horizons. This horizon often has a loss of silicate clay, iron, and/or aluminum, with different coloration than the A and B horizons. The next major horizon, the B horizon, is often referred to as the subsoil and is a transitional zone usually characterized by higher content of clay particles, more pronounced soil development, and lower organic matter than the A horizon. The next major horizon is the C horizon which consists of unconsolidated parent material that has not been sufficiently

weathered to exhibit the degree of soil development found in the B horizon. Clay content in the C horizon is usually less than in the B horizon. The lowest major horizon, the R horizon, consists of consolidated bedrock. The R horizon often occurs at such depths that it has no significant influence on soil characteristics.

Soils can be categorized based on their organic matter content. Certain soils have very little organic matter content (mineral soils), while other soils are primarily composed of organic matter (organic soils). Specifically, organic soils have 20 to 30 percent organic matter (depending on the soil texture) for soils which have been saturated for prolonged periods and more than 34 percent organic matter for soils never saturated with water for more than a few days. Mineral soils can have a wide range of textures from sand to clay due to their various proportions of sand, silt, and/or clay, as well as some organic matter. Both of these soil categories include hydric and non-hydric soils.

Soil texture is the relative proportion of sand, silt, and clay sized particles present within a soil (Figures 4.2 and 4.3). It is influenced by the interaction of geologic and environmental factors present during the formation of the soil. Soil texture is an important property of soil due to its effects on soil **permeability**, which is a measure of the ability of gases and liquids, such as air and water, to move through a layer of soil. A soil with an abundance of clay size particles, for instance, allows less air and water to pass through than a soil having a high content of sand size particles.

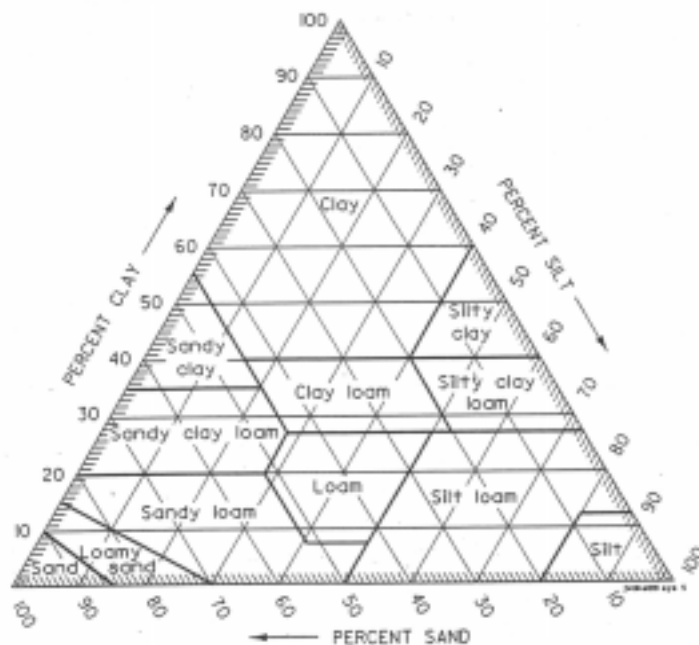
The arrangement or aggregation of primary soil particles into secondary particles, units or **peds**, known

Figure 4.2 – Soil Particle Sizes

<i>Name of Separate</i>	<i>Diameter (mm.)</i>
Very coarse sand	2.0 - 1.0
Coarse sand	1.0 - 0.5
Medium sand	0.5 - 0.25
Fine sand	0.25 - 0.10
Very fine sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	Below 0.002

Source: Soil Survey Manual, USDA, 1993.

Figure 4.3 - Soil Texture Triangle



Source: Soil Survey Manual, USDA, 1993.

as the **soil structure**, also affects a soil's permeability. Indicators of saturation are often found along the edges of peds and other soil aggregates where water moves most easily.

The NRCS has defined a set of soil drainage classes (Figure 4.4) to describe the amount of water present within a soil and its influence on the potential use of a soil. The seven soil drainage classes indicate the frequency and duration of wet periods that may occur, and range

Figure 4.4 - Natural Drainage Classes

Very poorly drained: Water is removed from the soil so slowly that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most **mesophytic** crops cannot be grown. The soils are commonly level or depressed and frequently **ponded**. If rainfall is high or nearly continuous, slope gradients may be greater.

Poorly drained: Water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods. The occurrence of internal free water is shallow or very shallow and common or persistent. Free water is commonly at or near the surface long enough during the growing season so that most mesophytic crops cannot be grown, unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow-depth. Free water at shallow depth is usually present. This water table is commonly the result of low or very low saturated hydraulic conductivity of nearly continuous rainfall, or of a combination of these.

Somewhat poorly drained: Water is removed slowly so that the soil is wet at a shallow depth for significant periods during the growing season. The occurrence of internal free water commonly is shallow to moderately deep and transitory to permanent. Wetness markedly restricts the growth of mesophytic crops, unless artificial drainage is provided. The soils commonly have one or more of the following characteristics: low or very low saturated hydraulic conductivity, a high water table, additional water from seepage, or nearly continuous rainfall.

Moderately well drained: Water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory through permanent. The soils are wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a moderately low or lower saturated hydraulic conductivity in a layer within the upper 1 meter, periodically receive high rainfall, or both.

Well drained: Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of the deep to redoximorphic features that are related to wetness.

Somewhat excessively drained: Water is removed from the soil rapidly. Internal free water occurrence commonly is very rare or very deep. The soils are commonly coarse-textured and have high saturated hydraulic conductivity or are very shallow.

Excessively drained: Water is removed very rapidly. The occurrence of internal free water commonly is very rare or very deep. The soils are commonly coarse-textured and have very high hydraulic conductivity or are very shallow.

Source: Soil Survey Manual, USDA, 1993.

from “excessively drained” to “very poorly drained” (USDA, 1993). Although other soil drainage classes may display indicators of wetland conditions, poorly drained soils and very poorly drained soils should always display indicators of wetland conditions.

The color of a soil and its location within the soil profile can indicate the conditions under which the soil developed. A bluish or greenish color of a soil, for example, can result after prolonged saturation. Soil color is affected primarily by organic matter content and the presence of iron and manganese. The colors present within a soil horizon are described by comparison with color charts. The color chart most commonly used to describe soil color is a segment of the Munsell Soil Color Chart that consists of systematically arranged pages of colored squares, or “chips.” The color chips are arranged by a color’s hue, value, and chroma (Figure 4.5). **Hue** refers to principle spectral colors such as yellow (Y), red (R), and their intermediate midpoints, such as yellow-red (YR). The **value** describes the lightness or darkness of a color from black (0) to white (10). **Chroma** refers to the relative purity or dullness of a color, ranging from the purest colors (8) to the most neutral colors (0). A color’s hue, value and chroma are combined in a numerical expression to form a designation for each color chip. For example, a color chip having a designation of 10 YR 4/2 has a hue of 10 YR, a value of 4, and a chroma of 2.

The dominant color in a soil horizon is referred to as the **soil matrix** and the contrasting colors or areas marked with spots of color are referred to as **mottles**. In addition to being described by their color, mottles can be described by their abundance, size, and contrast (Figure 4.6). The abundance, or quantity, of mottles can be described by three areal percentage classes. The size of a mottle is described by its dimensions. The contrast refers to the degree of visual distinction between mottles and the background, or matrix. When needed, the character of boundaries, shape (such as

Figure 4.5 – Munsell Soil Chart Page

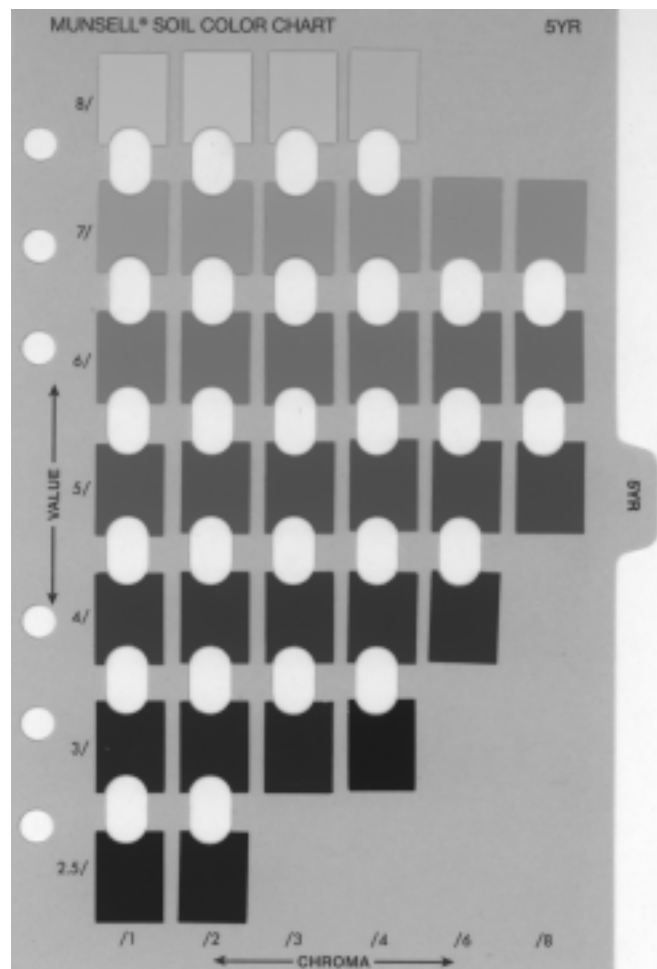


Figure 4.6 - Mottle Descriptions

<i>Abundance/Quantity</i>	Few: less than 2 percent Common: 2 to 20 percent Many: more than 20 percent
<i>Size</i>	Fine: smaller than 5mm Medium: 5 to 15mm Coarse: larger than 15mm
<i>Contrast</i>	Faint: evident only on close examination Distinct: readily seen but contrast only moderately with the matrix Prominent: contrast strongly with the color to the matrix
<i>Character of Boundaries</i>	Sharp: color graduation is not discernable with the naked eye Clear: color grades over less than 2mm Diffuse: color grades over more than 2mm

Source: Soil Survey Manual, USDA,

streaks, bands, tubes or spots), and location can also be indicated for mottles.

Based upon a knowledge and understanding of soil formation, NRCS has developed a highly structured hierarchical soil taxonomic system for classifying soil types. The morphological, chemical, and biological properties of a soil are used as criteria to divide soils among several categorical levels: order, suborder, great group, subgroup, family, and series. The information collected from examining soil profiles and classifying soils is further compared and combined with other geographical information and used by NRCS in the development of landscape maps depicting the location and extent of specific soils. Recent soil maps are available for most Michigan counties and represent a valuable source of information in identifying wetlands.

B. Hydric Soils

Soils that develop or occur under anaerobic conditions exhibit unique morphological and chemical properties that result from the presence of water for extended periods of time. The occurrence of these unique properties within the landscape can be used as indicators of wetland conditions.

Based on properties unique to soils that occur within wetland areas, the NRCS developed a grouping of soils referred to as hydric soils.

An ad hoc committee formed by the NRCS, the National Technical Committee for Hydric Soils (NTCHS), developed the hydric soil definition, including a set of criteria necessary for a soil to meet the hydric soil definition. Soil series that meet at least one of the criteria have been placed on the National Hydric Soil List. The NRCS has also compiled state and local hydric soil lists. The local (county) hydric soil lists are preferred over the state or national lists as they also include wet miscellaneous areas (e.g., swamps or marshes), soils classified at higher level than the series, smaller map units, and map units of non-hydric soil which contain small areas, or inclusions, of hydric soil.

The NTCHS hydric soil definition is as follows:

A soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

Based on the above definition, NTCHS developed the following hydric soil criteria:

1. All Histels except Folistels and Histosols except Folists, or
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that are:
 - a. Somewhat poorly drained with a water table equal to 0.0 foot (ft) from the surface during the growing season, or
 - b. Poorly drained or very poorly drained and have either:
 - (1) Water table equal to 0.0 ft during the growing season if textures are coarse sand, sand, or fine sand in all layers within 20 inches (in),
 - or for other soils
 - (2) Water table at less than or equal to 0.5 ft from the surface during the growing season if permeability is equal to or greater than 6.0 in/hour (h) in all layers within 20 in, or
 - (3) Water table at less than or equal to 1.0 ft from the surface during the growing season if permeability is less than 6.0 in/h in any layer within 20 in, or
3. Soils that are frequently ponded for long duration or very long duration during the growing season, or
4. Soils that are frequently flooded for long duration or very long duration during the growing season.

A Hydric Soil is:

A soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

Figure 4.7 – Oxidation-Reduction Sequence of Inorganic Substances

Disappearance of O ₂	$O_2 + 4H + 4e \leftrightarrow 2 H_2O$
⇓	Oxygen Water
Disappearance of NO ₃ ⁻	$NO_3^- + 2H^+ + 2e \leftrightarrow NO_2^- + H_2O$
⇓	Nitrate Nitrite
Formation of Mn ²⁺	$MnO_2 + 4H^+ + 2e^- \leftrightarrow Mn^{2+} + 2H_2O$
⇓	Manganic Manganous
Reduction of Fe ³⁺ to Fe ²⁺	$Fe(OH)_3 + 3H^+ + e^- \leftrightarrow Fe^{2+} + 3H_2O$
⇓	Ferric Ferrous
Formation of H ₂ S (rotten egg smell)	$SO_4^{2-} + 10H^+ + 8e^- \leftrightarrow H_2S + 4H_2O$
⇓	Sulfate Sulfide
Formation of CH ₄ (swamp gas)	$CO_2 + 8H^+ + 8e^- \leftrightarrow CH_4 + 2H_2O$
	Carbon Dioxide Methane

Hydric soils can be either organic or mineral soils. Organic hydric soils are commonly referred to as peat or **muck**. Organic soils formed in waterlogged situations, where decomposition is inhibited and plant debris slowly accumulates, are called Histosols. All histosols are hydric soils except Folists, which are freely drained soils occurring on dry slopes where excess litter accumulates over bedrock. Mineral hydric soils are those soils periodically saturated for sufficient duration to produce chemical and physical soil properties associated with a reducing or anaerobic environment. Under conditions of a fluctuating water table, mineral soils may exhibit a variety of contrasting colors within the soil profile. Mineral hydric soils are usually gray and/or mottled immediately below the surface horizon, or have thick, dark-colored surface layers overlaying gray or mottled subsurface horizons. The Munsell Soil Color Charts contain pages, called gley pages, with color chips for the gray, blue, and green colors often found in mineral hydric soils.

While the formation of hydric soils is influenced by the interactions of several soil-forming factors (climate, parent material, relief, organisms, and time), the overriding factor is water. The unique characteristics of hydric soils result from the periodic or permanent inundation or saturation. Prolonged soil saturation results in the displacement of oxygen within the **soil pore** spaces by water. After the remaining oxygen concentration has been depleted by organisms, anaerobic conditions develop in the soil and organisms reduce other available compounds for energy. Depletion of the oxygen in the soil

or reduction in other chemicals present in the soil can be measured as an electrochemical quantity, referred to as the **redox potential**.

Within saturated soils, as oxygen becomes less available, the redox potential of the soil declines as other elements are reduced from their oxidized state. Once oxygen is depleted, microorganisms produce electrons that reduce nitrogen, manganese, iron, sulfur and carbon compounds, respectively in order (Figure 4.7). The reduction, translocation, and/or oxidation of iron and manganese compounds in seasonally saturated soils results in the development of morphological soil characteristics referred to as **redoximorphic features**. Within hydric soils, the presence of redoximorphic features is often used to describe the soil profile.

Redoximorphic features can be redox concentrations, redox depletions, or reduced matrices (Figure 4.8). **Redox concentrations** result when reduced iron and manganese dissolve in the soil, precipitate out, and accumulate. Redox concentrations typically form bright areas in soils that are alternately wet and dry. Areas where iron and manganese have been dissolved and removed are referred to as **redox depletions**. A **reduced matrix** occurs when ferric iron, which under normal oxygen concentrations exhibits yellowish to reddish colors, is reduced and the soil appears gray.

Redoximorphic Features are:

Features formed by the processes of reduction, translocation, and/or oxidation of Iron and Manganese oxides.

Figure 4.8 – Redoximorphic Features

<i>Redox Concentrations</i>	<p>Nodules: firm, irregularly shaped bodies that are uniform when broken.</p> <p>Concretions: firm, irregularly shaped bodies that have concentric layers when broken.</p> <p>Masses: soft bodies within the matrix which are often referred to as reddish mottles.</p> <p>Pore Linings: zones of accumulation near or coating a pore surface. Oxidized rhizospheres, a secondary indicator of hydrology, are a form of pore lining occurring around root channels.</p>
<i>Redox Depletions</i>	<p>Iron depletions: low chroma bodies with clay contents similar to that of the adjacent matrix. Iron depletions are often referred to as gray mottles.</p> <p>Clay depletions: low chroma bodies containing less iron, manganese, and clay than the adjacent soil matrix. The clay eluviated from the clay depletions frequently is found coating ped surfaces in underlying horizons.</p>
<i>Reduced matrices</i>	<p>Soil matrices that have a low chroma color but whose color changes in hue or chroma when exposed to air.</p>

Source: Redoximorphic Features for Identifying Aquic Conditions (Vepraskas, 1995)

C. Hydric Soil Indicators

1. Hydric Soil Indicators for Non-sandy Soils

Several indicators are available for determining whether a particular non-sandy soil, under normal conditions, is a hydric soil. The hydric soil indicators for non-sandy soils listed below are from the 1987 USACE Wetlands Delineation Manual. Although all are valid indicators, some indicators are stronger than other listed indicators. The indicators are listed in order of decreasing reliability. Any one of the following indicate that hydric soils are present:

- a. Organic soils (Histosols) - A soil is an organic soil when (1) more than 50 percent (by volume) of the upper 32 inches of soil is composed of organic soil material or (2) organic soil material of any thickness rests on bedrock. Organic soils are saturated for long periods and are commonly called peats or mucks.
- b. Histic epipedons - A histic epipedon is an 8 to 16 inch layer at or near the surface of a mineral hydric soil that is saturated with water for 30 or more consecutive days in most years and contains a minimum of 20 percent organic matter when no clay is present, or a minimum of 30 percent organic matter when clay content is 60 percent or greater. Soils with histic epipedons are inundated or saturated for sufficient periods to greatly retard **aerobic** decomposition of the organic surface and are considered to be hydric soils.
- c. Sulfidic material - When mineral soils emit an odor of rotten eggs, hydrogen sulfide is present. Such odors are only detected in waterlogged soils that are permanently saturated and have sulfidic material within a few centimeters of the soil surface. Sulfides are produced only in a **reducing environment**.
- d. Aquic or peraquic moisture regime - An **aquic moisture regime** is a reducing one; i.e., it is virtually free of dissolved oxygen because the soil is saturated by groundwater or by water of the capillary fringe. Because dissolved oxygen is removed from groundwater by **respiration** of microorganisms, roots, and soil fauna, it is also implicit that the soil temperature is above biologic zero (5 degrees Celsius) at some point while the soil is saturated. Soils with **peraquic moisture regimes** are characterized by the presence of groundwater always at or near the soil surface.
- e. Reducing soil conditions - A soil saturated for long or very long duration will usually exhibit reducing conditions. Under such conditions, ions of iron are transformed from a ferric valence state to ferrous valence state. This condition often can be detected in the

field with a ferrous iron test. A simple colorimetric field test kit has been developed for this purpose. When a soil extract changes to a pink color upon addition of a, a'-dipyridyl, ferrous iron is present, which indicates a reducing soil environment.

NOTE: This test cannot be used in mineral hydric soils having low iron content, organic soils, and soils that have been desaturated for significant periods during the growing season.

f. Soil colors - The colors of various soil components are often the most diagnostic indicator of hydric soils. Colors of these components are strongly influenced by the frequency and duration of soil saturation, which leads to reducing soil conditions. Mineral hydric soils will be either **gleyed** or will have bright mottles and/or low matrix chroma.

1. Gleyed soils (gray colors) - Gleyed soils develop when anaerobic soil conditions result in pronounced **chemical reduction** of iron, manganese, and other elements, thereby producing gray soil colors. Anaerobic conditions that occur in waterlogged soils result in the predominance of reduction processes, and such soils are greatly reduced. Iron is one of the most abundant elements in soils. Under anaerobic conditions, iron is converted from the oxidized (ferric) state to the reduced (ferrous) state, which results in the bluish, greenish, or grayish colors associated with the gleying effect. Gleying immediately below the A horizon or 10 inches (whichever is shallower) is an indication of a markedly reduced soil, and gleyed soils are hydric soils. Gleyed soil conditions can be determined by using the gleyed pages of the Munsell Color Book.

2. Soils with bright mottles and/or low matrix chroma - Mineral soils that are saturated for substantial periods of the growing season (but not long enough to produce gleyed soils) will either have bright mottles and a low matrix chroma or will lack mottles but have a low matrix chroma. Mottled means "marked with spots of contrasting color." Soils that have brightly colored mottles and a low matrix chroma are indicative of a fluctuating water table. The soil matrix is the portion (usually more than 50 percent) of a given soil layer that has the predominant color. Mineral hydric soils usually have one of the following color features in the horizon immediately below the A-horizon or 10 inches (whichever is shallower):

- (a) Matrix chroma of 2 or less in mottled soils, or
- (b) Matrix chroma of 1 or less in unmottled soils.

NOTE: The matrix chroma of some dark (black) mineral hydric soils will not conform to the criteria described in (a) or (b) above; in such soils, gray mottles occurring at 10 inches or less are indicative of hydric conditions.

CAUTION: Soils with significant coloration due to the nature of the parent material may not exhibit the above characteristics. In such cases, this indicator cannot be used.

g. Soil appearing on hydric soils list - Using the criteria for hydric soils, the NTCHS has developed a list of hydric soils. Listed soils have reducing conditions for a significant portion of the growing season in a major portion of the root zone and are frequently saturated within 12 inches of the soil surface.

NOTE: The NRCS has developed local lists of hydric soil mapping units that are available from NRCS county and area offices. These local lists are the preferred hydric soil lists to use in making wetland determinations

CAUTION: Be sure that the profile description of the mapping unit conforms to that of the sampled soil.

Hydric Soil Indicators for Non-sandy Soils:

- a. Organic soils (*Histosols*)
- b. *Histic epipedons*
- c. *Sulfidic material*
- d. *Aquic or peraquic moisture regime*
- e. *Reducing soil conditions*
- f. *Soil colors*
 - 1. *Gleyed soils (gray colors)*
 - 2. *Soils with bright mottles and/or low matrix chroma*
 - (a) *Matrix chroma of 2 or less in mottled soils, or*
 - (b) *Matrix chroma of 1 or less in unmottled soils*
- g. *Soil appearing on hydric soils list*
- h. *Iron and manganese concretions*

h. Iron and manganese concretions - During the **oxidation-reduction process**, iron and manganese in suspension are sometimes segregated as oxides into concretions or soft masses. These accumulations are usually black or dark brown. Concretions more than 2 mm (0.75 in) in diameter occurring within 7.5 cm (3.0 in) of the surface are evidence that the soil is saturated for long periods near the surface.

2. Hydric Soil Indicators for Sandy Soils

Not all indicators listed above can be applied to sandy soils. In particular, soil color should not be used as an indicator in most sandy soils. However, three additional soil characteristics listed in the 1987 USACE Wetlands Delineation Manual may be used as indicators of sandy hydric soils, including:

i. High organic matter in the surface horizon - Organic matter tends to accumulate above or in the surface horizon of sandy soils that are inundated or saturated to the surface for a significant portion of the growing season. Prolonged inundation or saturation creates anaerobic conditions that greatly reduce oxidation of organic matter.

j. Streaking of subsurface horizons by organic matter - Organic matter is moved downward through sand as the water table fluctuates. This often occurs more rapidly and to a greater degree in some vertical sections of a sandy soil containing high content of

organic matter than in others. Thus, the sandy soil appears vertically streaked with darker areas. When soil from a darker area is rubbed between the fingers, the organic matter stains the fingers.

k. **Organic pans** - As organic matter is moved downward through sandy soils, it tends to accumulate at the point representing the most commonly occurring depth to the water table. This organic matter tends to become slightly cemented with aluminum, forming a thin layer of hardened soil (spodic horizon). These horizons often occur at depths of 12 to 30 inches below the mineral surface. Wet spodic soils usually have thick dark surface horizons that are high in organic matter with dull, gray horizons above the spodic horizon.

CAUTION: In recently deposited sandy material (e.g., accreting sandbars), it may be impossible to find any of these indicators. In such cases, consider this as a natural atypical situation.

3. Supplemental Hydric Soil Indicators

In 1998, the NRCS, in cooperation with the NTCHS, published a guidebook entitled Field Indicators of Hydric Soils in the United States that can be used to identify hydric soils. Information in this NRCS guidebook can be used as supplemental information to confirm the presence of hydric soil criteria listed in the 1987 USACE Wetlands Delineation Manual, but it is not a replacement for the hydric soil indicators discussed in this chapter. Field indicators from the guidebook that have been tested and approved for Michigan are provided in Appendix F. Appendix F also provides a list of the correlations between the NRCS field indicators and the USACE 1987 Hydric Soil Indicators.

Hydric Soil Indicators for Sandy Soils:

- i. High organic matter in the surface horizon*
- j. Streaking of subsurface horizons by organic matter*
- k. Organic pans*

