Massachusetts Handbook for Delineation of Bordering Vegetated Wetlands

Massachusetts Department of Environmental Protection
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Wetlands Program
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MassDEP
Commonwealth of Massachusetts
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This revision of the BVW Delineation Handbook replaces the former Handbook released in 1995. Note that MassDEP is proposing new regulations that will update the plant list used for BVW Delineation to the 2020 edition of USACE National Plant List, although the current regulations refer to the 1988 Plant List at 310 CMR 10.55(2). Although this updated guidance refers to the 2020 Plant List, projects under review prior to promulgation of the new regulations should be using the 1988 Plant List in accordance with the regulations. Note that the 2020 plant list does not include indicator status categories FAC+, FACW- or FACW+. Most of the plants classified in these categories in the 1988 plant list are listed as FAC or FACW in the 2020 plant list and are still considered wetland indicator plants.

Delineation Handbook Acknowledgement Section, Suggested Citation, and Non-discrimination Statement

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- Wetlands provide important benefits to landowners and the public. protection of public and private water supply, protection of groundwater supply, flood control, storm damage prevention, prevention of pollution, protection of land containing shellfish, protection of fisheries, and protection of wildlife habitat. These represent all eight of the "**Interests**" protected by the Massachusetts Wetlands Protection Act (WPA).

- Bogs, swamps, marshes, and wet meadows that border on water bodies are defined in the WPA Regulations as **Bordering Vegetated Wetlands (BVWs)** and described as areas where soils are saturated or inundated such that they support plants adapted to tolerate at least periodically saturated conditions.

- The delineation of a BVW boundary is critical because it defines the extent of the jurisdictional wetland (and its 100-foot buffer zone) and ultimately influences both project design and the effectiveness of wetland protection efforts.

- In the Request for a Determination of Applicability, Abbreviated Notice of Resource Area Delineation, and Notice of Intent processes, **a boundary delineation decision is effective for 3 years**.

- This Handbook provides updated guidance on the use of vegetation, soils, and Other Indicators of Hydrology to delineate the boundary of wetlands, including BVWs, in Massachusetts.

The Massachusetts WPA, Massachusetts General Law Chapter 131, Section 40, and associated 310 Code of Massachusetts Regulations 10.55 (Regulations) provides the jurisdictional authority and necessary definitions and procedures for protecting wetlands in Massachusetts. Bogs, swamps (see Intro-1), marshes, and wet meadows that border on water bodies are defined in the Regulations as **BVWs** and described as areas where soils are saturated or inundated such that they support plants adapted to tolerate at least periodically saturated conditions.

Intro.1 — Wooded Swamp

Following a revision to the Regulations in 1995, the Wetlands Protection Program Policy 95-1 (Policy) *Bordering Vegetated Wetlands Delineation Criteria & Methodology* was issued, recommending a procedure for vegetation analysis and providing guidance to applicants and conservation commissions on how to delineate the boundary of a BVW. The definitions and procedures provided in the Regulations and Policy were intended to provide consistency in BVW delineations statewide.

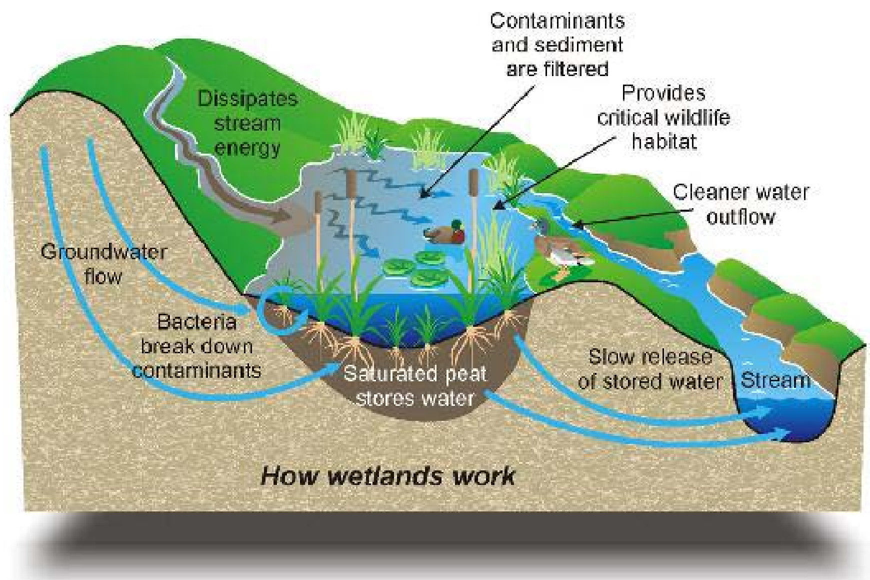
Following the issuance of the Policy, the first edition of Massachusetts Department of Environmental Protection's (MassDEP's) *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act: A Handbook* was published in 1995. That handbook defined wetland indicator plants, specified when vegetation-only delineations could be used, and clarified when indicators of hydrology must be considered along with vegetation.

This revised edition of the handbook (Handbook) provides updated guidance on the use of vegetation, soils, and Other Indicators of Hydrology to delineate the boundary of wetlands, including BVWs, in Massachusetts. The definitions and procedures contained in the Handbook are consistent with the WPA and Regulations.

The Handbook provides background information on wetland processes as well as detailed information on BVW boundary delineation. It addresses the conceptual basis for wetland delineation, delineation procedures, and recommendations for reviewing BVW boundaries as part of the regulatory process. Much of this Handbook is background information. Specific procedures are presented in Chapter 5 and in the appendices as step-by-step instructions with graphics and examples.

Wetlands are areas where groundwater is at or near the surface, or where surface water frequently collects for a significant part of the growing season, and where a significant part of the vegetative community is made up of plants adapted to life in saturated soil. The ground and surface water conditions and plant communities that typically occur in each of these wetland types are specified in the WPA. Hydrology (water) and vegetation (plants) are the two characteristics that define freshwater wetlands protected by the WPA.

Wetlands provide important benefits (see Intro-2) to landowners and the public. These benefits include protection of public and private water supply, protection of groundwater supply, flood control, storm damage prevention, prevention of pollution, protection of land containing shellfish, protection of fisheries, and protection of wildlife habitat (all eight "**Interests of the Act**"). Proper identification and delineation of BVWs is essential to preserve the important functions and values that these wetlands provide.



Intro.2 — Important Benefits Provided by Wetlands[1]

The level of analysis used to delineate the BVW boundary should reflect the complexity of the site. Some wetlands have abrupt and obvious boundaries and rigorous analyses may not be necessary. Other areas may require detailed analysis of vegetation, soils, and hydrology in order to accurately locate the boundaries. The Regulations establish criteria to determine when vegetation alone may be used to delineate the BVW boundary and when vegetation and other evidence of hydrology (including soils) are required. Although vegetation-only delineation is allowed in specific situations, it is recommended that vegetation, soils, and Other Indicators of Hydrology always be considered when delineating BVWs.

The delineation of a BVW boundary is critical because it defines the extent of the jurisdictional wetland (and its 100-foot buffer zone) and ultimately influences both project design and the effectiveness of wetland protection efforts. In the permitting process, a delineation is required to correctly identify BVW resource areas and to evaluate whether performance standards are being

[1] Image sourced from: https://wmap.blogs.delaware.gov/files/2015/11/how-wetlands-work.jpg

met. In the Request for a Determination of Applicability, Abbreviated Notice of Resource Area Delineation, and Notice of Intent processes, **a boundary delineation decision is effective for 3 years**. BVW boundaries may be appealed in any of these permitting processes. For these reasons, the accuracy of the delineation is important for successful wetlands protection.

Permitting requirements under the WPA are primarily administered by conservation commissions. Conservation commissioners play an important role in protecting BVWs and other resource areas because their local knowledge is incorporated into the wetlands permitting process. For this reason, the MassDEP and its Wetlands Program are committed to providing conservation commissions the training and necessary tools to implement the WPA. The first and often most important step in protecting wetlands is identifying and delineating them in the field.

Handbook Overview

MassDEP developed this Handbook because the overall success of wetlands protection efforts relies on accurately identifying the boundary of BVWs. The Handbook provides background information on wetland processes, procedures for delineating BVW boundaries, a new field data form (see Appendix A) for use in delineating BVWs, and recommendations for reviewing boundary delineations as part of the regulatory review process.

Chapter 1 introduces wetland hydrology as the driving force that creates and maintains wetlands. The physical and chemical conditions that are produced by frequent and/or prolonged saturation are discussed, as well as the characteristics of wetland soils and vegetation that make them important wetland indicators.

Chapter 2 discusses wetland vegetation. This chapter covers classification of plants based on their tendency to occur in wetlands, methods for measuring plant abundance, and provides procedures for assessing vegetative communities.

Chapter 3 covers wetland soils and their utility for delineating wetlands**.** This chapter includes background information on how hydric soils are formed, important soil characteristics such as texture and color, and provides guidance on how to use soil characteristics to establish wetland boundaries.

Chapter 4 addresses various Other Indicators of Hydrology, such as water-stained leaves and water marks on trees and boulders, which can be used to establish that wetland hydrology currently exists at a site. Soils and vegetation are good long-term indicators of wetland hydrology but may not accurately reflect current conditions if the site had been altered at some time in the past.
The Other Indicators of Hydrology discussed in this chapter can be important for determining and documenting if soils and/or vegetation reflect current, rather than historic, conditions at a site.

Chapter 5 describes criteria and procedures for delineating BVWs in the field. Procedures emphasize the use of vegetation and soils as primary indicators for delineating wetlands, but also consider circumstances when delineations can be based on vegetation alone, as well as when Other Indicators of Hydrology should be used. This chapter also provides recommendations for reviewing BVW delineations.

Chapter 6 is a list of references used within this Handbook.

Appendices are included at the end of this Handbook, providing resource information and more detailed instructions on how to analyze vegetation and soils. A summary of the appendices is provided below.

Appendix A includes a revised field data form, ***Bordering Vegetated Wetland Determination Form*** (Data Form), and instructions for completing the form.

Appendix B provides detailed information about how to assess vegetative communities in the field.

Appendix C includes a list of plants that are identified in the WPA as **wetland indicator plants**.

Appendix D provides detailed information about identifying organic matter in soil and determining whether a site contains an O-horizon or organic soils such as peats and mucks.

Appendix E provides detailed information about soil texture and how to determine soil texture classes in the field.

Appendix F provides a detailed list, along with descriptions, of indicators that can be used to identify hydric soils.

Appendix G describes the recommended procedures for evaluating soils in the field.

Appendix H provides contact information for MassDEP offices, as well as sources of information useful for delineating or reviewing BVW boundaries.

Appendix I is a glossary of terms used in this Handbook.

Summary

In some environmental settings, BVW delineation may be relatively simple, and may be accomplished without detailed measurements and calculations. Where an abrupt change in plant communities and elevation occurs, the Regulations allow that delineations can be done visually, using vegetation and topography to determine the BVW boundary. Even in these cases, it is recommended that spot-checks of the soil be used to determine whether hydric soils are present and precisely locate the BVW boundary. For more complex sites, or delineations associated with controversial projects, soil indicators and other evidence of hydrology, along with an analysis of vegetative communities, should be used to determine BVW boundaries. To select delineation procedures that are appropriate for a particular site, it is important to become familiar with wetland indicators and how they are used to delineate wetlands.

Information and procedures in this Handbook will be sufficient to delineate or review delineations of Massachusetts wetlands under most circumstances. However, some wetlands may be particularly difficult. This Handbook identifies situations when delineations are likely to be difficult, and additional expertise may be needed to accurately identify the wetland boundaries. When these situations are encountered, MassDEP recommends that conservation commissioners request assistance from peer reviewers[2] or MassDEP technical staff. Additional technical manuals and references, such as the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (Version 2.0),* can also be helpful.

[2] Conservation commissions that have adopted rules under M.G.L. Ch. 44 §53G can impose reasonable fees to cover consulting services for application review.

Chapter 1: Hydrology

Summary

- **Hydrology**, including the frequency, seasonal timing, depth and duration of inundation, water table fluctuations, and the movement of ground and surface water, is the driving force behind all wetland systems.

- Under saturated conditions, plants and microbes use available oxygen faster than it is replaced by diffusion from the air. Soils that are saturated long enough during the growing season will experience periods of low oxygen known as **anaerobic conditions**.

- The recurring and regular presence of anaerobic conditions is a defining characteristic of wetlands, distinguishing whether an area is wet enough to be considered a wetland.

- The length of saturation needed to produce anaerobic conditions varies among wetlands and is dependent, in part, on soil type. Anaerobic conditions can develop with as little as 15 days of saturation during the growing season.

- Although water is the driving force behind wetlands, it is not always possible to directly observe hydrology (e.g., frequency, depth, or duration of saturation). Inundated or saturated conditions may only be present in a wetland for a short period of time during the year.

- The presence of wetland plants (hydrophytes) and wetland soils (hydric soils) are the most reliable indicators of wetland hydrology and are more practical for delineating wetland boundaries than observations of hydrology itself.

- Other Indicators of Hydrology, such as silt deposits, water marks on trees, and water-stained leaves, can be used to confirm that a disturbed site has wetland hydrology, especially if vegetation or soils have been altered.

The properties, distribution, and circulation of water are collectively referred to as hydrology. Wetland hydrology refers to the movement of water within and through a wetland. Hydrologic features such as the frequency, seasonal timing, depth and duration of inundation, water table fluctuations, and the movement of ground and surface water are the driving forces behind all wetland systems.

Water in a wetland may be surface water, groundwater, or a combination of the two. Both surface water and groundwater may lead to saturated conditions that, after a sufficient length of time, will create wetlands.

1.1 Surface Water

Surface water runoff or flooding from adjacent water bodies can create ponding or inundated site conditions. Periodic and lengthy inundation then creates saturated soil conditions. In wetlands, surface water can either provide minimal or substantial contributions to site hydrology.

1.2 Groundwater

When surface water infiltrates or percolates into the ground it becomes groundwater. In wetlands, groundwater is commonly found at or near the ground surface during wetter seasons of the year. The water table is a term that is commonly used to describe the upper limit, or depth below the ground, that is completely saturated with water. The water table can fluctuate throughout the year so that saturated conditions may only be seasonally present. Groundwater also occurs in soil above the water table due to capillary action, a process where water is drawn up through pores in the soil. This area of nearly saturated soil above the water table is known as the **capillary fringe** (see Figure 1.1).

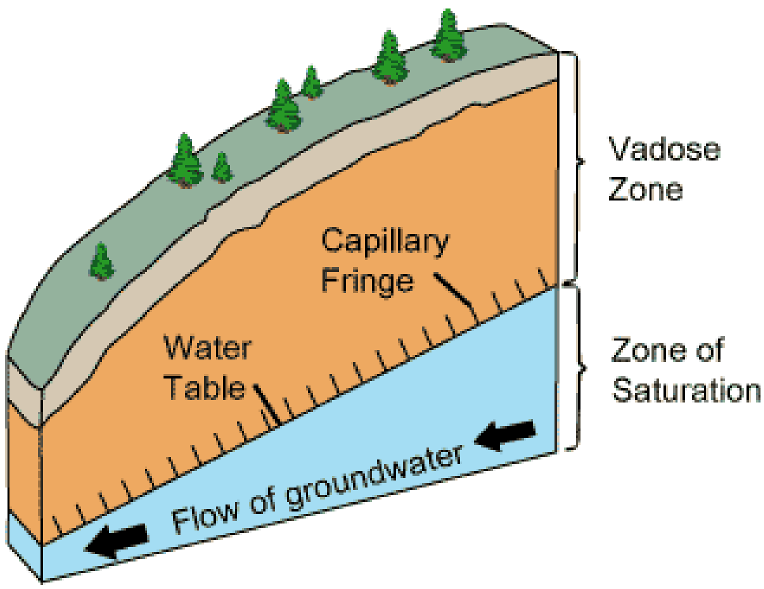


Figure 1.1 — Illustration of Capillary Fringe[3]

Groundwater can also revert to surface water when it discharges to the surface via springs or topographic areas such as the toe of slopes. Where the water table intersects topographic depressions, groundwater can create standing or flowing surface water. Wetland conditions may develop in areas where groundwater occurs at or near the surface during the growing season, even if water is not visible at the surface.

1.3 Anaerobic Conditions

Soils that are saturated during the growing season, due either to an elevated water table or inundation by surface water, may develop conditions where oxygen levels in the soil are reduced and not as readily available to plants and other organisms. These periods of low oxygen are known as **anaerobic conditions**. Under saturated conditions, plants and microbes use available oxygen faster than it is replaced by diffusion from the air. The rate at which oxygen is depleted depends on the amount of biological activity in the soil. Biological activity, in turn, is affected by soil temperature and the amount of organic matter in the soil. **The recurring and regular presence of anaerobic conditions is a defining characteristic of wetlands.** It can be used to distinguish whether an area is wet enough to be considered a wetland. Anaerobic conditions influence the plant

[3] Image sourced from: https://upload.wikimedia.org/wikipedia/commons/f/f2/Vadose_zone.gif

communities and soil characteristics that occur in wetlands, which is why an assessment of vegetation and soils is so important for determining the presence and extent (i.e., boundaries) of wetlands.

1.4 Growing Season

It is not only the presence of saturated conditions in soil, but also the presence of these conditions during the growing season that is important. The growing season is the part of the year when soil temperatures are high enough to support biological activity (above biological zero: 41 degrees Fahrenheit or 4 degrees centigrade). In Massachusetts, the growing season generally extends from March to November.

Water can be present for relatively long periods of time during the winter without having a significant impact on plants or soils. This is because there is little biological activity in the soil during the colder months of the year. Soils that are saturated or inundated only during the winter may never become anaerobic; or if they do, plants may be dormant and therefore not affected by anaerobic conditions. During the growing season, however, wetland soils can become anaerobic after a relatively brief period of saturation or inundation.

1.5 Length of Saturation

The length of saturation needed to produce anaerobic conditions varies among wetlands and is dependent, in part, on soil type. Anaerobic conditions can develop with as little as 15 days of saturation during the growing season. These anaerobic conditions during the growing season produce plant communities and soil characteristics in wetlands that differ from plants and soils in uplands. Plants that grow in wetlands are generally able to tolerate anaerobic conditions in the soil. Different plants are adapted to longer or shorter periods of inundation or saturation, but all have adaptations that allow them to cope with regular periods of saturation. **Soils exposed to anaerobic conditions generally differ in color from non-wetland soils due to an accumulation of organic matter (because decomposition proceeds more slowly under anaerobic conditions) and changes in the chemical state of iron and manganese.**

1.6 Indicators of Hydrology

Although water is the driving force behind wetlands, it is not always possible to directly observe hydrology (e.g., frequency, depth, or duration of saturation). Inundated or saturated conditions may only be present in a wetland for a short period of time during the year (see Figure 1.2 and Figure 1.3), and even this pattern is subject to climatic conditions that can produce very wet or very dry years. Even if hydrology is monitored in an area, it can be difficult to equate the patterns of inundation or saturation with the presence or absence of anaerobic conditions. Because of this, **hydrologic indicators** are relied upon as proof that sufficient hydrology is present at the site rather than relying on direct observation of inundation and saturation. When undisturbed, soil characteristics and plant communities are generally present throughout the year and serve as reliable indicators of hydrologic conditions.

Figure 1.2 — Example of an Inundated Wetland

Figure 1.3 — Example of Inundated Conditions for a Short Period of Time

Figure 1.3. is an example of inundated or saturated conditions that may only be present in a wetland for a short period of time during the year. Therefore, it is necessary to use indicators of hydrology (i.e., wetland plants, hydric soils, and Other Indicators of Hydrology) to determine whether a site is wetland or upland.

The presence of wetland plants (hydrophytes) and wetland soils (hydric soils) are the most reliable indicators of wetland hydrology and are more practical for delineating wetland boundaries than observations of hydrology itself. Other features, such as silt deposits, water marks on trees, and water-stained leaves, are considered in this revised edition of the Handbook to be “Other Indicators of Hydrology.” Some of these Other Indicators of Hydrology are often not available, at least not near the wetland boundary (water-stained leaves); others can be hard to interpret in terms of frequency, duration, and timing of inundation/saturation (e.g., silt deposits, drift lines). That said, Other Indicators of Hydrology can be used to confirm that a disturbed site has wetland hydrology, and are especially useful when vegetation or soils have been altered. MassDEP recommends that conservation commissions always use a site visit to review BVW boundaries and to utilize all available information when evaluating hydrology.

Chapter 2: Vegetation

Summary

- Plants have evolved adaptations for life in a wide range of wet conditions resulting in plant species that demonstrate varying degrees of affinity for wet habitats.

- Although some species grow only in habitats that are wet year-round, most wetland plants tolerate a range of hydrologic conditions and may occur in uplands as well as wetlands.

- Plants are assigned to one of five **indicator status** categories based on their frequency of occurrence in wetlands: **obligate wetland (OBL)**, **facultative wetland (FACW)**, **facultative (FAC)**, **facultative upland (FACU)**, and **upland (UPL)**.

- **Wetland indicator plants** are plant species that typically occur in wetlands and considered good indicators of wetland hydrology.

- The WPA Regulations define **wetland indicator plants** as 1) those plant species with an indicator status of OBL, FACW, and FAC; 2) species listed in the WPA; and 3) individual plants that exhibit morphological or physiological adaptations to life in saturated or inundated conditions.

- The WPA Regulations define BVWs, in part, as areas where 50 percent or more of the vegetative community consists of wetland indicator plants.

- In order to evaluate whether 50 percent or more of the vegetative community in an area is made up of wetland indicator plants, it is necessary either to estimate or measure plant species abundance. Procedures for assessing plant communities and determining whether a vegetative community is wetland or non-wetland, are described in Appendix B.

Vegetation is one of the main indicators of jurisdictional BVWs. Wetlands range in wetness from areas that are permanently flooded to those that are only saturated or inundated for relatively brief times during the growing season. Plants have evolved adaptations for life in a wide range of wet conditions resulting in plant species that demonstrate varying degrees of affinity for wet habitats. Although some species grow only in habitats that are wet year-round, most wetland plants tolerate a range of hydrologic conditions and may occur in uplands as well as wetlands. Plant species that typically occur in wetlands and serve as good indicators of wetland hydrology are considered "**wetland indicator plants**."

2.1 Plant Classification

All plants, whether wetland or non-wetland, are classified according to their natural relationships and genealogy, and are organized into various groups (e.g., Kingdom, Phylum, Class, Order, Family, Genus, and Species). These groups range from broad (Kingdom) to narrow (Species). A scientific name is given to plants that would produce similar offspring. The scientific name includes the genus name and the species name. In the case of the plant winterberry, *Ilex* is the genus name and *verticillata* is the species name. Plants also have common names. However, a common name is not as reliable a label to use because one plant may have more than one common name, or a common name may be used to identify more than one species of plant. For example, a plant that has one scientific name, *Ilex verticillata*, may have more than one common name; in this case, winterberry also is called black alder. Under this classification system, plants also are grouped into families. *Ilex verticillata* is a member of the holly family (Aquifoliaceae). **To avoid confusion, scientific names of plants should be used when describing vegetation present at a site**.

The *U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5* (Wetland Plant List) is a comprehensive list assembled by scientists from the U.S. Fish and Wildlife Service, United States Environmental Protection Agency, U.S. Army Corps of Engineers (USACE), and Natural Resources Conservation Service (NRCS), with the help of regional botanists and ecologists. The Wetland Plant List uses a common name and the scientific name for each plant and classifies each plant based on the frequency, or the percentage of times, that it is found in wetland versus upland conditions. Plants are assigned to one of five plant **indicator status** categories based on their frequency of occurrence in wetlands: OBL, FACW, FAC, FACU, and UPL. Plants that are not on the Wetland Plant List are presumed to be upland plants[4]. Table 2.1 lists the plant status categories and a brief summary for each.

Table 2.1
Plant Indicator Status Categories
(Occurrence in Wetlands)

Category	Abbreviation	Descriptor
Obligate wetland	OBL	Almost always occur in wetlands
Facultative wetland	FACW	Usually occur in wetlands
Facultative	FAC	Occur in wetlands and non-wetlands
Facultative upland	FACU	Usually occur in non-wetlands
Upland	UPL	Almost never occur in wetlands

Plant species that almost always grow in saturated or inundated conditions during the growing season are classified as **OBL** species. Examples include skunk cabbage (*Symplocarpus foetidus*) (see Figure 2.1), broadleaf cattail (*Typha latifolia*), and buttonbush (*Cephalanthus occidentalis*) (see Figure 2.2).

[4] A few upland plants are listed because they are rated facultative upland or wetter in at least one other USACE Region.

Figure 2.1 — Skunk Cabbage (*Symplocarpus foetidus*), Obligate

Figure 2.2 — Buttonbush (*Cephalanthus occidentalis*), Obligate

Species that are tolerant of flooding or saturation during the growing season and are adapted to live in a variety of wet or dry conditions are assigned to one of three facultative categories, depending on how frequently they are observed in wetlands.

FACW plants usually occur in wetlands, but may occur in uplands. These are typically referred to as "fac-wet" species. Examples include silver maple (*Acer saccharinum*), speckled alder (*Alnus incana*), and sensitive fern (*Onoclea sensibilis*) (see Figure 2.3).

Figure 2.3 — Sensitive Fern (*Onoclea sensibilis*), Facultative Wetland

FAC plants are equally likely to occur in wetlands and uplands. These are typically referred to as "fac" species (see Figure 2.4). Examples include yellow birch (*Betula alleghaniensis*), sheep laurel (*Kalmia angustifolia*), and interrupted fern (*Osmunda claytoniana*).

Figure 2.4 — Red Maple (*Acer rubrum*), Facultative

FACU plants usually occur in uplands but may occur in wetlands. These are typically referred to as "fac-up" species (see Figure 2.5). Examples include red oak (*Quercus rubra*), princess pine (*Dendrolycopodium obscurum*), and multiflora rose (*Rosa multiflora*).

Figure 2.5 — Bracken Fern (*Pteridium aquilinum*), Facultative Upland

Plants that almost never occur in wetlands are considered **UPL** species. Examples include Norway maple (*Acer platanoides*), white baneberry (*Actaea pachypoda*), and Queen Anne's lace (*Daucus carota*).

2.2 Wetland Indicator Plants

Wetland indicator plants are plant species that typically occur in wetlands and considered good indicators of wetland hydrology. Wetland indicator plants are defined in the Regulations (310 CMR 10.55) as any of the following:

1. Any plant in the *U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5* with an indicator status of OBL, FACW, or FAC is a wetland indicator plant. Note that any plant not included in the Wetland Plant List is regarded as an upland species.

2. The WPA lists wetland plants (see Figure 2.6 and Appendix C) by a common name and one of the following: family name, genus name, or species name. (Note: the species name, also known as the scientific name, is made up of the genus and species.) The list in the WPA is general, and is not meant to include all plants that occur in wetlands. In addition, plants are sometimes listed only by family or genus. These are broad categories that often include wetland plants as well as non-wetland plants. For instance, the family Juncaceae is comprised of many rushes of which only some are good indicators of wetland conditions. The genus Fraxinus includes species that commonly occur in wetlands (e.g., green ash, *Fraxinus pennsylvanica*; black ash*, Fraxinus nigra)*, as well as one common species (e.g., white ash, *Fraxinus americana)* that only occasionally occurs in areas with wetland hydrology. As a result, MassDEP has determined that, with the exception of mosses in the genus *Sphagnum*, only plants listed in the WPA by their full scientific name (i.e., plants with a genus and species name) are considered wetland indicator plants. For plants listed in the WPA only by family or genus to be considered wetland indicator plants, they must also be listed in the Wetland Plant List as OBL, FACW, or FAC species. In addition, all plants in the

genus *Sphagnum* are considered wetland indicator plants (species in this genus have not yet been categorized by indicator status). Currently, only one species (i.e., eastern hemlock, *Tsuga canadensis*) is listed in the WPA and has a wetland indicator status (FACU) that does not meet criterion 1 above.

Figure 2.6 — Cranberry (*Vaccinium macrocarpon*), a Wetland Indicator Plant listed by the WPA

3. Individual plants, that are not included in criteria 1 and 2 above, but that exhibit morphological or physiological adaptations to life in saturated or inundated conditions should be included as wetland indicator plants for estimating the percentage of the vegetative community that is made up of wetland indicator plants. Morphological adaptations are evident in the form or shape of a plant, such as shallow root systems (see Chapter 4). Physiological adaptations are related to a plant's metabolism and generally are not observable without the use of specific equipment or tests. Individual plants with indicator status of UPL or FACU that exhibit adaptations to life in saturated conditions can be considered wetland indicator plants (e.g., white pine, *Pinus strobus*, FACU, with a buttressed trunk and a shallow root system due to saturated soil conditions).

Only plants that meet at least one of these criteria are considered wetland indicator plants.

Wetland Indicator Plants — Summary

- Plant species list as OBL, FACW, and FAC in the *U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5*, plus…
- Eastern hemlock (*Tsuga canadensis*), plus…
- Species in the genus *Sphagnum*, plus…
- Individual plants with morphological or physiological adaptations to life in saturated or inundated conditions

2.3 Plant Identification

Plant identification is an important aspect of reviewing or delineating wetland boundaries. In addition to being able to identify a number of wetland and non-wetland plants, it is also important to be able to recognize them at different times of the year. In winter, twigs and buds possess important characteristics that aid in the identification of woody plants. Many herbaceous plants die back during the winter and are unavailable for identification. In the spring, it is important to be able to identify the early growth stages of plants, such as the fiddleheads of ferns (see Figure 2.7) or the flowers of skunk cabbage (*Symplocarpus foetidus*) (see Figure 2.8). During the growing season, leaves, flowers, fruits, nuts, catkins, and seeds are available for inspection. Some plants, such as grasses and sedges, can only be identified when they are in flower or when seeds are present.

Figure 2.7 — Cinnamon Fern Fiddleheads (*Osmundastrum cinnamomeum)*

Figure 2.8 — Skunk Cabbage (*Symplocarpus foetidus*) Flowers

A variety of field guides are available to help with identification. Some focus on particular plant groups, such as ferns, grasses, trees, or shrubs. Others contain keys (identification guides) that use various characteristics of plants (e.g., twigs, fruit, leaves, flowers) for identification. Although it is useful to be able to recognize common plants in the field, it is also important to learn how to use field guides to identify plants.

2.4 Assessing Vegetative Communities

Although the ability to identify individual plant species is an important skill, it is also important to consider the plant community when reviewing or delineating wetland boundaries. The WPA specifies that a "significant part of the vegetational community" must be made up of wetland plants. The Regulations define BVWs, in part, as areas where 50 percent or more of the vegetative community consists of wetland indicator plants. Therefore, "significant part" means "50 percent or more." In order to evaluate whether 50 percent or more of the vegetative community in an area is made up of wetland indicator plants, it is necessary either to estimate or measure plant species abundance.

Measuring plant abundance is an integral process in assessing the plant community. Procedures for assessing plant communities and determining whether a vegetative community is wetland or non-wetland, are explained in Appendix B. Appendix B describes how vegetative communities are divided into strata, or layers, for analysis (i.e., herb, sapling/shrub, woody vine, and tree) and then characterized within one of two different types of plots. Percent cover and percent dominance are described, along with how to perform a rapid test, a dominance test, and calculate a prevalence index, in order to determine whether the area being assessed supports a wetland or non-wetland vegetative community.

Chapter 3: Soils

Summary

- Soils that have been subject to repeated and prolonged saturation at or very near the ground surface are referred to as **hydric soils**, and these types of soils exhibit a specific combination of characteristics that can be observed and measured in the field.

- Soils provide the best evidence for the presence (or absence) of long-term wetland hydrology for the purposes of wetland boundary delineation.

- To assess the presence or absence of a hydric soil, shallow test pits ((at least 18 inches) must be dug and a vertical slice of the soil examined and described, carefully noting the depth, texture, and color(s) of each horizontal layer of soil.

- A **soil profile** is a vertical slice of the soil, which will typically include several distinct horizontal layers, each called a horizon. Common soil horizons include the O-, A-, E-, B-, and C-horizons.

- One aspect of horizon designation that plays an important role in hydric soil identification is the presence (or absence) of a layer of organic material at the soil surface along with the thickness of this layer and the degree of decomposition of the organic material. Appendix D provides additional information about identifying organic matter in soil and determining whether a site contains an O-horizon or organic soils such as peats and mucks.

- **Texture** is a term used to describe how something feels such as but not limited to gritty, smooth, greasy, or sticky. In a more technical sense, soil texture refers to "the relative amounts of sand, silt, and clay-sized particles that make up the soil." Appendix E provides detailed information about soil texture and how to determine soil texture classes in the field.

- The primary coloring agents in the soil are organic matter and iron. Organic matter tends to make topsoil look dark brown in color, and when a great deal of organic matter is present, the soil might actually look black. In upland soils, iron gives subsoil its typical rust coloration, and a wide array of different iron oxide minerals can cause soils to look bright orange, brick red, and even slightly yellow in color, depending on the site conditions.

- Soil color has three components: **hue** (spectral wavelength of light), **value** (gray scale from light to dark), and **chroma** (brightness or strength). Color can be described numerically, and the **Munsell Soil Color Book** is commonly used to evaluate and identify soil colors. When evaluating soil color, it is important to note the predominant color of each layer (called the **matrix** color), as well as any less abundant colors that may be present within each layer (called **mottles**). When mottles form due to anaerobic conditions, they are called redoximorphic features.

- **Redoximorphic features** are specific color patterns that develop in soil as a result of periodic, prolonged anaerobic conditions. Most of these features are the result of naturally occurring iron being chemically transformed due to anaerobic conditions, and then becoming dissolved and stripped from one place in the soil and redeposited as rusted iron in another location where oxygen is present.

- Hydric soils have observable physical characteristics, including color and the amount of organic content, that serve as **hydric soil indicators**. Hydric soil indicators generally take many years to form, and thus serve as good indicators of the long-term hydrology of an area.

- It is important to recognize that there may be instances when the soil has been artificially drained and/or the soil disturbed in some way that negates its usefulness as an indicator of current wetland hydrology.

Soil is a complex mixture of minerals, decaying organic matter, and living organisms (most of which are only visible under a microscope). This complex mosaic provides water and nutrients for plants, as well as support for anchoring their roots. It can take centuries for soil to form through the actions of water, wind, freezing, thawing, and by interactions with the plant life and biological community living within it. Soil can vary in thickness from a few inches to many feet, and it can vary in texture and mineral composition based on the conditions under which the soil formed. For instance, the organic matter content of soil is strongly influenced by how “wet” or “dry” the soil stays for most of the year. Evidence of excessive soil wetness is exhibited in the accumulation of decomposing organic materials in the topsoil, along with unique color patterns that develop in both the topsoil and subsoils under water-logged conditions. Soils that have been subject to repeated and prolonged saturation at or very near the ground surface are referred to as **hydric soils**, and these types of soils exhibit a specific combination of characteristics that can be observed and measured in the field.

Soils provide the best evidence for the presence (or absence) of long-term wetland hydrology for the purposes of wetland boundary delineation, particularly at times of the year when the water table may not occur near the soil surface. Even when standing water is observed during a site visit, soils can provide evidence of whether the water table remains at or near the ground surface for long enough to meet the wetland hydrology threshold. It is important to recognize that there may be instances when the soil has been artificially drained and/or the soil disturbed in some way that negates its usefulness as an indicator of current wetland hydrology. These circumstances are discussed at the end of Appendix F.

3.1 Soil Characteristics

To assess the presence or absence of a hydric soil, shallow test pits (at least 18 inches) must be dug, and a vertical slice of the soil examined and described, carefully noting the depth, texture, and color(s) of each horizontal layer of soil. In addition to its importance for delineating wetlands, the ability to understand descriptions of soil characteristics is important for reviewing BVW delineations. These include soil profiles (i.e., horizons), texture, and color.

3.1.1 Soil Profile

A **soil profile** (see Figure 3.1) is a vertical slice of the soil starting at the ground surface and continuing downward until the geologic parent material is observed. In Massachusetts, parent material is usually encountered within 4 feet (ft.) of the surface. The soil profile will typically include several distinct horizontal layers, each called a horizon. Horizons can usually be separated from one another based on differences in color and/or texture. Common soil horizons include the O-, A-, E-, B-, and C-horizons, further described below. Although it is quite useful to be able to correctly identify the horizon designations for a soil profile, this skill is not critical for the purpose of hydric soil identification. Emphasis is instead placed upon the characteristics of soil "layers" in the profile, which are not necessarily the same thing as horizons. This point will be expanded upon in an upcoming section "Layers versus Horizons."

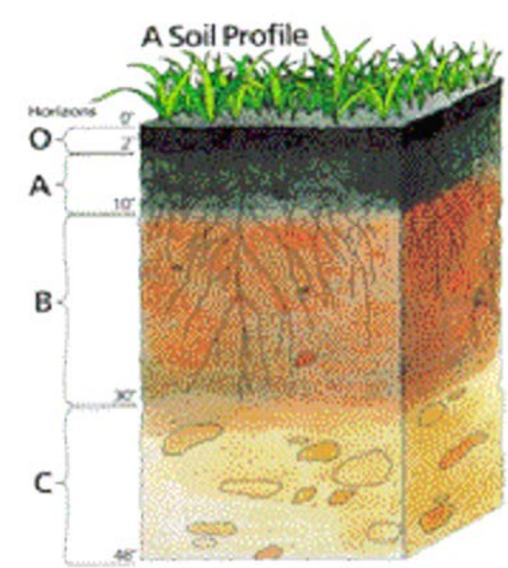


Figure 3.1 — Example of Soil Profile shown without Soil Layer E. Layer E is located above B if it exists.

One aspect of horizon designation that does play an important role in hydric soil identification is the presence (or absence) of a layer of organic material at the soil surface along with the thickness of this layer and the degree of decomposition of the organic material. When soils are left undisturbed (as in a forested setting), organic material will accumulate on the surface to some degree. If enough organic matter has accumulated, this layer is designated as the **O-horizon.** In upland woods, this layer will often consist of deciduous and/or evergreen leaf litter in various stages of decomposition. In "wet" landscape positions, this organic layer will often be mucky; it will feel greasy to the touch, and appear dark brown or black in color.

The **A-horizon**, also known as the "topsoil," is a mineral horizon that is enriched with some organic material that coats the mineral grains and results in this layer having a medium to dark brown color, depending on how much organic matter is present. It can sometimes be challenging to distinguish an A-horizon from an O-horizon, but since this can be an important distinction when identifying hydric soils, additional descriptive guidance is provided in Appendix D.

Under forested conditions and in marshy areas, the A-horizon is often found directly underlying an O-horizon. In managed landscapes (such as those that have been cultivated, grazed or regularly mowed) organic matter does not accumulate on the soil surface and in the absence of an O-horizon, the A-horizon will start right at the soil surface. If the soil has been plowed in the last decade or so, the A-horizon will be fairly uniform in color throughout its entire depth due to the mixing and redistribution of organic matter, and the lower boundary of the horizon will be even and abrupt, with the underlying horizon usually looking distinctly different in color. These horizons are designated as **Ap**.

Topsoils that have been plowed in the past generally have a thickness ranging from 8 to 10 in. When situated at the base of a slope, however, A-horizons may be thicker due to an accumulation of soil materials that eroded from higher on the hillslope. In Massachusetts, it is rare to find a landscape that has not been cleared and cultivated at some point in history. However, where these soils do occur, the A-horizon is typically only about 3 in. thick and the lower horizon boundary will not be abrupt (as found in a plowed soil), but instead will gradually transition in color (over a couple of inches) into the horizon below.

Under specific environmental circumstances, it is possible to find a pale-colored horizon under the A-horizon. This pale horizon is known as an **E-horizon**. The "E" comes from the term "eluviation," which is the process that happens when the coloring agents of organic matter and iron are stripped out of the soil layer and leached downward in the soil, leaving the bare mineral grains exposed in the leached horizon. In Massachusetts, E-horizons are usually limited in distribution to soils with forested evergreen vegetation (or that previously had forested evergreen vegetation) and sandy soil conditions, which promote better leaching for the acidified percolating water to remove the organic and iron coatings and strip them away.

The **B-horizon,** also called the "subsoil," is commonly located below the A-horizon (or below the E-horizon if one is present). The B-horizon is considered the zone of true soil formation, where iron "weathers" out of the mineral soil grains, and where materials accumulate that were translocated from higher in the soil profile. The B-horizon has much less organic matter than the A-horizon, and iron becomes the dominant coloring agent in the subsoil. Some wetland soils lack a B-horizon, because the processes of soil formation are quite limited due to the wet conditions.

Below the B-horizon is the **C-horizon**, which is made up of relatively un-weathered geologic deposits, which are collectively referred to as the **parent material** of the soil. In Massachusetts, nearly all of the soils have **transported** parent materials that were deposited either during or since the last period of continental glaciation, which ended roughly 10,000 —14,000 years ago. Most Massachusetts' soils are underlain by either dense glacial till, well-sorted and sandy glacial outwash, clayey glacial lake-bottom materials, silty wind-blown deposits, or more recent fluvial materials that were deposited on modern floodplains. In some cases, bedrock is shallow enough to be encountered beneath the soil horizons, and this is identified as the **R-layer.** Outcroppings of ledge above the surface of the ground are good indicators that bedrock is near the surface and soils are fairly shallow.

3.1.2 Soil Texture

Texture is a term used to describe how something feels, such as but not limited to gritty, smooth, greasy, or sticky. In a more technical sense, soil texture refers to the relative amounts of sand, silt, and clay-sized particles that make up the soil. For instance, if mostly sand-sized particles are present, the soil will feel gritty, and it will probably drain water fairly readily. By contrast, soils that feel smooth often have many silt-sized particles, which tend to hold onto water and make it available for plant use. Soils high in clay content will usually be sticky, heavy, and will not allow water to drain as readily. Therefore, soil texture plays an important role in how water moves through the soil. Not surprisingly, hydric soils that are sandy (i.e., coarse) in texture will often develop very different color patterns compared to hydric soils that are finer in texture. In fact, there are specific color criteria that can be used to identify hydric sandy soils that do not apply to finer textured soils and vice versa.

Mineral soil particles are divided into several size categories, without regard to their chemical composition, color, weight, or other properties. These sizes range from slightly less than 1/10 in. diameter for very coarse sand down to microscopic clay particles of less than 1/12,500 in. Individual sand particles are large enough to be seen without magnification, but clay particles are microscopically small. Many physical, chemical, and biological properties of soil are due to the effects of particle size on the available surface area within the soil and on the resulting distribution of void spaces between the soil particles.

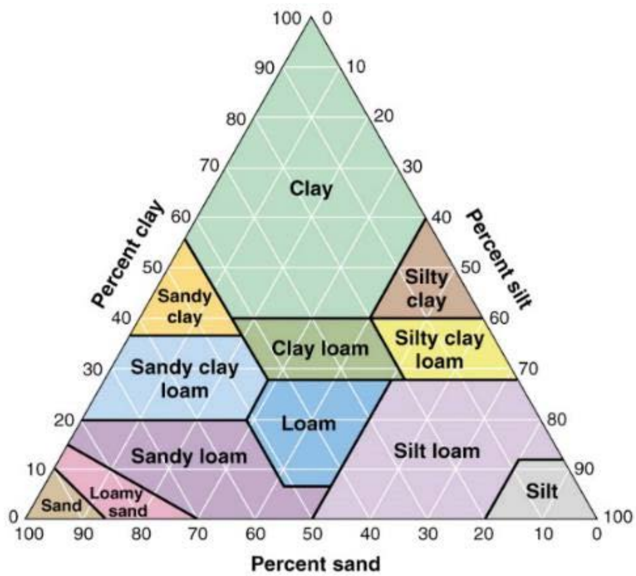


Figure 3.2 — USDA Texture Triangle.
To use: find the percentage amounts for sand, silt, and clay along the perimeter of the triangle. Draw a line along the percentage for each fraction. The three lines should meet at a single point within the triangle. The soil's texture is determined by the block within the triangle where the three lines meet.

For example: a soil with 30 percent sand, 60 percent silt, and 10 percent clay would be a silt loam.

Rarely are soils comprised of only one size of mineral particles. Instead, they usually consist of blends of these various particle sizes. The specific percentages of sand, silt, and clay-sized particles that are present will determine a soil's textural classification. A soil's specific texture is determined by using the United States Department of Agriculture (USDA) texture triangle (see Figure 3.2), which compares the relative abundance of each mineral particle size class to arrive upon its assigned texture classification. In horticulture, soils get divided into one of three general management categories as being either "sandy," "loamy," or "clayey," with the name indicating the predominate characteristics of the particles present, with "loamy soils" containing a balance of all three particle size categories so that none of the three will dominate over the other two

When identifying mineral hydric soils, texture is broken into only two groupings of "sandy soils" and "loamy soils." Soils with textures of sandy loam, silt loam, loam, silt, and all clayey textures fall under the loamy soil heading. Soils with sand textures are always grouped as "sandy soils," however **soils that have a loamy sand texture can potentially fall into either category depending on the size of the sand particles**. If the soil is mostly comprised of very fine sand grains (smaller than 0.10 millimeter [mm]), then it behaves more like a loamy soil; but if the sand grains are larger than this (0.10-2.00 mm) then the soil is considered a sandy soil. Appendix E contains more information on soil texture and how to determine soil texture in the field.

3.1.3 Soil Color

The primary coloring agents in the soil are organic matter and iron. Organic matter tends to make topsoil look dark brown in color, and when a great deal of organic matter is present, the soil might actually look black. In upland soils, iron gives subsoil its typical rust coloration, and a wide array of different iron oxide minerals can cause soils to look bright orange, brick red, and even slightly yellow in color, depending on the site conditions, as elaborated on below.

Under well-drained (non-wetland) conditions, there tends to be a balance between the amount of organic matter that is added to the soil (as plants die or shed their leaves) and the amount that gets consumed by soil organisms and/or recycled back into the soil as nutrients that growing plants can absorb. Most of the organisms responsible for this recycling process require oxygen for their respiration. When the soil is waterlogged, all the pore spaces (the voids between the solid particles) are filled with water, and oxygen is unable to enter the soil as fast as it is consumed. This leads to anaerobic conditions in the soil. Without oxygen, the decay process slows down considerably, and organic materials start to accumulate. When this happens repeatedly over many years, mucky soils start to form, and these soils show evidence of organic matter accumulation due to prolonged waterlogging conditions.

Saturation and its resulting anaerobic conditions also affect the chemistry of iron minerals. Under well-oxygenated conditions, iron tends to remain **oxidized** as a solid in one of its many colorful “rust” forms. This is what gives non-wetland subsoils their uniform rusty brown coloration. However, under prolonged anaerobic conditions, iron will change states (i.e., from oxidized to chemically **reduced**), becoming soluble in water and turning the soil gray in those areas where iron has been stripped away (see Figure 3.3) and is no longer present in its solid rust form. The relative abundance of gray colors in the subsoil is directly related to the frequency and duration of anaerobic conditions at that depth. Soils that are anaerobic for only a few weeks each growing season will show evidence of small patches of gray color in the subsoil, whereas soils that remain saturated and anaerobic for many months will often have gray as the dominant subsoil color.

Figure 3.3 — Areas of Oxidized Iron (Orange Mottles) Within a Gray Matrix Where Iron Has Been Stripped Away.

Reduced iron that has been dissolved from one portion of the soil can then be transported with soil water and transported to other locations. Whenever dissolved iron encounters oxygen (such as would occur along a living plant root that is leaking oxygen into the soil), the dissolved iron will spontaneously react with the oxygen and form rust, which is a brightly colored solid. Thus, when these bright orange/red iron streaks are found in the topsoil, in combination with an accumulation of organic matter causing the topsoil to be very dark in color, this provides evidence of prolonged saturation at or very near the soil surface.

Color can be described numerically, and the **Munsell Soil Color Book** is commonly used to evaluate and identify soil colors. When evaluating soil color, it is important to note the predominant color of each layer (called the **matrix** color), as well as any less abundant colors that may be present within each layer (called **mottles**). When mottles form due to anaerobic conditions, they are called **redoximorphic features**.

Color has three components: hue, value, and chroma.

Hue represents the spectral wavelength of light that is present in the color. One can think about this as if you were looking at light that had passed through a prism and was broken into a spectrum of rainbow colors. Each page in the Munsell Soil Color Book represents a different wavelength of light, and the hue designation is indicated in the upper right-hand corner. Colors indicative of hydric soils occur on every page of the Munsell Soil Color Book, but most Massachusetts soils can be matched to colors on the 7.5YR (7.5 yellow-red), 10YR (10 yellow-red), 2.5Y (2.5 yellow), or 5Y (5 yellow) pages of the Munsell Soil Color Book.

Value is a representation of a “gray scale” that varies from white to black with various tones of gray in between, with lighter tones at the top of each Munsell Soil Color Book page and darker tones at the bottom of each page. Values are listed on the left side of each page, with each row of color chips having the same value. One can think of the value as being the neutral base color to which pigments get added when mixing custom paint colors.

Chroma is the brightness (or strength) of the color. Chroma increases from left to right across each Munsell Soil Color Book page, with each column of chips having the same chroma. As one moves from left to right across a single row of chips (all with the same value), the chroma will increase. Chroma represents the amount of the pigment (hue) that has been added to the neutral base color. Low chroma colors (less than 2) are often indicative of wetland soils.

To document soil color in the field, moist soil samples should be collected and compared against the color chips on pages of the Munsell Color Soil Color Book (see Figure 3.4) to find the best match. It is important to do this comparison in natural (full spectrum) sunlight using an undisturbed sample of soil (i.e., one that has not been smeared, molded, or otherwise manipulated). Once the closest match is determined, color information is recorded as: hue value/chroma (e.g., 10YR 5/6). There are also special pages for “gleyed” soils, which are very gray wetland soils. These pages are arranged differently than the rest of the Munsell Soil Color Book, with all of the color chips on these special pages being either a 1 or 2 chroma, and each column representing a different spectral hue, which is noted across the bottom of the page. There are specific combinations of value and chroma that are used to identify hydric soils, which are detailed below (A Simplified List of Hydric Soil Indicators) and in Appendix F (which includes a detailed list and descriptions of hydric soil indicators).

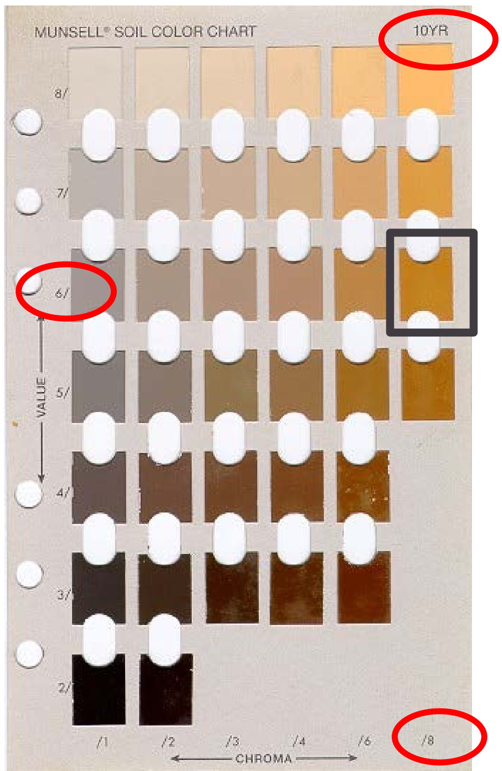


Figure 3.4 — A Page from the Munsell Soil Color Book. Hue is identified in the upper right-hand corner. Value is identified along left side of chart. Chroma is identified along the bottom. Each color can be described as a combination of Hue Value/Chroma. For example, the color chip in the **black box** is described as 10YR 6/8.

3.2 Hydric Soil

The National Technical Committee for Hydric Soils defines a **hydric soil** (see Figure 3.5) as 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 (USDA Soil Conservation Service 1994). As a result of prolonged saturation and the development of anaerobic conditions, hydric soils undergo biological and chemical changes that are different than the processes that occur in non-wetland soils. Consequently, hydric soils have observable physical characteristics that serve as **hydric soil indicators**. Hydric soil indicators generally take many years to form, and thus serve as good indicators of the long-term hydrology of an area. After development, the physical indicators of saturated, anaerobic soil conditions characteristic of hydric soils will persist even after the hydrology of an area has been altered and the wetland has been drained or the water table lowered. Therefore, in situations where the hydrology of a site has been altered, this should be clearly documented on the Data Form (Appendix A). The date of the alteration may be relevant if recent enough to constitute a violation of the WPA.

This Handbook is to be used to delineate the boundary between bordering vegetated wetlands and their adjacent upland areas. Many of the hydric soil indicators were developed specifically for wetland-delineation purposes. During the development of these indicators, soils in the interior of wetlands (those away from the wetland boundaries) were not always examined. Therefore, Section 3.2.1 focuses on the hydric soil indicators that occur in transitional soils that are closer to the wetland/non-wetland boundary as opposed to wetland soil features that occur in the wetter, interior portions of wetlands.

Figure 3.5 — Hydric Soil

3.2.1 Organic versus Mineral Soil Material

Hydric soils are separated into two major types based on their composition: **Organic soils** and **mineral soils**. In general, soils with at least 16 in. of organic material in the upper part of the soil (O-horizon) are considered organic hydric soils, while wetland soils with a lesser organic content are considered mineral hydric soils.

In areas with prolonged surface saturation, organic matter decomposition may be slowed to the extent that mucky O-horizons form. Sometimes it can be challenging in the field to determine whether an O-horizon is present, and then to determine how thick it is. O-horizons must have an accumulation of at least 20-30 percent organic matter by dry weight (depending on how much clay is present). Laboratory analysis is needed for a precise measurement of organic matter content, but estimates can be made in the field to determine whether this threshold has been met (see Appendix D for information about how to identify O-horizons and organic soils).

Under wetland conditions, O-horizons will generally be very dark in color, slippery or greasy to the touch, and tend to result in stained fingers when handled. This material can be described as having the consistency of “mashed potatoes.” Organic materials do not have much strength, and when a hand full of the organic material is squeezed, it will start to ooze between one’s fingers. Mineral soil material (i.e., soils having less than 20-30 percent organic matter) will form a ball when squeezed with one’s hand and will not ooze between fingers.

When examined “in place” along the face of a test pit, organic materials will allow for easy penetration by one’s finger, a trowel, or a knife, whereas mineral soils will provide greater resistance to penetration by these instruments. The thickness of an organic layer is measured from the soil surface down to the depth of the top of the mineral soil where a knife tip cannot easily penetrate. This depth marks the start of the mineral A-horizon (which might appear to be just as dark in color as the overlying O-horizon). If the organic layer is greater than 8 in. thick, the soil is referred to as having a **histic epipedon** (see Figure 3.6). Soils with a histic epipedon are always hydric.

Figure 3.6 — Histic Epipedon (Scale is in Centimeters)

If a mucky O-horizon is present, it is likely that other hydric soil indicators will be present even when the O-horizon is less than 8 in. thick. More information on determining the difference between organic and mineral soil material can be found in Appendix D.

3.2.2 Redoximorphic Features

Redoximorphic features are specific color patterns that develop in soil as a result of periodic, prolonged anaerobic conditions. Most of these features are the result of naturally occurring iron being chemically transformed under anaerobic conditions, becoming dissolved and stripped from one place in the soil, and redeposited as rusted iron in another location where oxygen is present.

The term “redoximorphic” comes from the combination of “redox” and “morphic.” Redox is a shortened form of the term “reduction-oxidation,” which relates to chemical processes where electrons are transferred between two substances. “Morphic” refers to the morphology or appearance of something. So, redoximorphic features are those color patterns in the soil that are the result of anaerobic conditions that cause electrons to be transferred among iron, manganese, and other substances in the soil. Anaerobic conditions are referred to as **reducing conditions**, and aerobic conditions are considered to be **oxidizing conditions**. Redoximorphic features include, but are not limited to, redox concentrations (such as soft masses and pore linings), iron depletions, and reduced/depleted matrices. The abundance and depth of these features in the soil determine whether a soil is hydric or not hydric.

3.2.2.1 Redox Concentrations

Redox concentrations form when dissolved iron (and sometimes manganese) (see Figure 3.7) encounters oxygen in the soil and then spontaneously oxidizes and forms solid deposits in the soil. Redox concentrations can range in color from yellow-orange to red, or in the case of manganese can look somewhat dark purple.

Figure 3.7 — Manganese Concentrations

Redox concentrations provide evidence of fluctuating groundwater at the depth where these features occur, because iron and manganese would have been previously dissolved and transported in the anaerobic soil water. Concentrations can occur as **soft masses** of solid iron (or manganese) when they occur in the soil matrix; or they can occur as **pore linings** when these features are linear and formed along a live plant root that is leaking oxygen into the soil. This area around a plant root is known as an **oxidized rhizosphere**, but the resulting iron feature is called a **pore lining**. When bright iron pore linings are found in conjunction with a darkly colored topsoil matrix, these features provide evidence of saturation just below the ground surface. These features will remain in place even after the seasonal high water table has dropped below the depth at which the feature occurs.

3.2.2.2 Redox Depletions

Redox depletions are features that are formed when iron is chemically reduced due to anaerobic conditions, changes to a dissolved form, and is stripped from the mineral grains in the soil, leaving the bare mineral particles exposed. This process results in grayish mottles within the soil matrix. Redox depletions must have a Munsell Soil Color Book value of 4 or more, and a chroma of 2 or less.

3.2.2.3 Depleted Matrix

A depleted matrix (see Figure 3.8) exists when the processes of iron reduction, dissolution and translocation have occurred in more than 60 percent of the soil volume, thus making gray redox depletions the dominant (matrix) color of the horizon. The same processes that form redox depletions will form a depleted matrix when the conditions of saturation and anaerobic conditions occur with such regularity that the resulting soil matrix has a high value (light color) and low chroma. The low-chroma matrix must be the result of wetness and not weathering of a parent material feature. In some areas, the depleted matrix may change color upon exposure to air. In these instances, chemically reduced iron is present in the soil, and it is spontaneously reacting with the oxygen in the air and forming oxidized iron (rust). This chemical change causes the soil to change color within the first 30 minutes of exposure, and the soil is said to have a **reduced matrix** when this occurs.

Figure 3.8 — Iron Concentrations in Depleted Matrix

There are specific color combinations for determining whether a depleted matrix exists (see Figure 3.9). The following combinations of value and chroma from the Munsell Soil Color Book identify a depleted matrix:

1. Matrix value of 5 or more and chroma of 1 or less, with or without redox concentrations occurring as 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 masses and/or pore linings; or

3. Matrix value of 4 or 5 and chroma of 2, and 2 percent or more distinct or prominent redox concentrations occurring as 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 masses and/or pore linings.

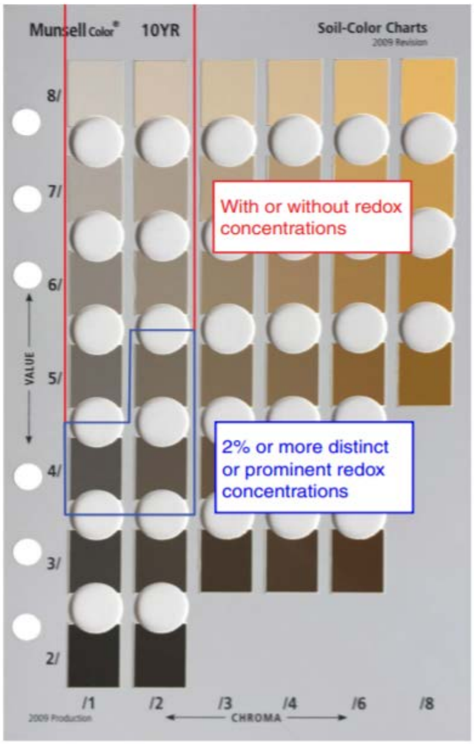


Figure 3.9 — Illustration of Values and Chroma Combinations

Illustration of values and chroma combinations that require 2 percent or more distinct or prominent redox concentrations and those that do not, for hue 10YR, to meet the definition of a depleted matrix. [Due to inaccurate color reproduction, do not use this page to determine soil colors in the field. Background image from the Munsell Soil Color Book.]

3.2.2.4 Gleyed Matrix

A gleyed matrix (see Figure 3.10) exists when the matrix color of a horizon is a depleted matrix whose color occurs on one of the Gley pages in the Munsell Soil Color Book. In gleyed soils, iron has either been chemically reduced, dissolved, and removed from the soil, or in conditions of persistent saturation with stagnant water, the iron has been preserved in a chemically reduced state in the soil. Gley colors include:

1. Hues of 10Y, 5GY, 10GY, 10G, 5BG, 10BG, 5B, 10B, or 5PB with value 4 or more and chroma is 1; or

2. Hue of 5G with value 4 or more and chroma is 1 or 2; or

3. Neutral hue and chroma (N) with value 4 or more.

In some places, the gleyed matrix may change color upon exposure to air. This phenomenon is included in the concept of a gleyed matrix.

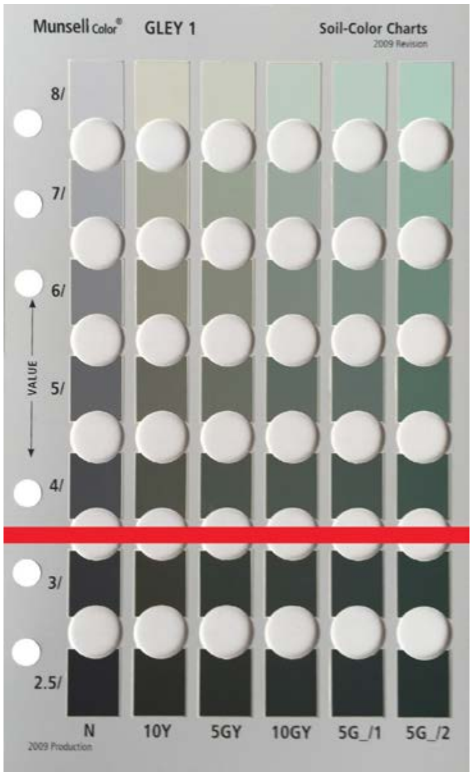


Figure 3.10 — Munsell Soil Color Page for Gleyed Soils. For Hydric Soil Determinations, a gleyed matrix must have the colors on one of the two pages showing gley colors in the Munsell Soil Color Book. Values must be 4 or more (above the red line). [Due to inaccurate color reproduction, do not use this page to determine soil colors in the field.]

3.3 Hydric Soil Indicators

In this Handbook, field indicators of hydric soil are presented in two different lists: 1) a simplified list of hydric soil indicators that covers most (but not all) hydric soils in Massachusetts, and 2) a detailed list and descriptions (in Appendix F) of hydric soil indicators that occur in Massachusetts. The detailed list is further divided into hydric soil indicators that occur under common conditions (Group I) and indicators that are found in more difficult to analyze situations (Group II). It may be necessary to consult with a professional trained and experienced in soil science and hydric soil evaluations when dealing with more difficult to analyze hydric soil indicators.

3.3.1 Layers versus Horizons

Hydric soil indicators do not reference pedogenic soil horizons (i.e., O-, A-, E-, B-horizons, etc.), but instead refer to the presence of certain layers in the soil. In some circumstances, these layers may be the same as the horizons in the soil profile, but it is important to understand that the two terms are not synonymous. The term "layer" is used to describe the presence of a horizontal "zone" within the soil profile, which may be the same as a horizon or it may encompass multiple horizons. For instance, a dark-colored layer with redox concentrations may encompass soil material across both an O-horizon and an A-horizon in order to meet the thickness requirement for a given indicator.

3.3.2 A Simplified List of Hydric Soil Indicators

The following list of hydric soil indicators are sufficient (along with vegetation and Other Indicators of Hydrology) to delineate most (but not all) wetland boundaries in Massachusetts. **It is important to note that some wetland soils will not meet any of these indicators but still may be hydric. The detailed list and descriptions of hydric soils in Appendix F should be consulted if soils do not match the descriptions on this simplified list, yet topography, vegetation, or Other Indicators of Hydrology suggest that an area might be wetland.** Associated Federal Indicators[5] described in the detailed list are included in parentheses.

1. A strong "rotten egg" smell (hydrogen sulfide), generally noticed immediately after the soil test pit is dug (*Indicator A4*).

[5] USDA-NRCS, 2018. Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils, Version 8.2.

2. **Any soil** with at least 8 in. of naturally occurring organic soil due to wetness measured from the ground surface (*Indicator A2, and sometimes A1 and A3*) [see Appendix D for more details on organic soils].

3. **Gleyed soils**. Soils that are predominantly neutral gray, or occasionally greenish or bluish gray in color (the Munsell Soil Color Book has special pages for gleyed soils; see Figure 3.10).

   - Within 6 in. from the soil surface for sandy soils *(Indicator S4).*
   - Within 12 in. from the soil surface for fine-textured soils (*Indicators A11 and F2*).

4. **Any soil** with a layer at least 6 in. thick, **beneath a dark surface layer*,** with a matrix chroma of 2 or less and values of 4 or higher within 12 in. from the surface of the soil (*Indicator A11*; also see Figure 3.9).

   - With at least 2 percent redox concentrations required for value of 4 with a chroma of either 1 or 2 (4/1 or 4/2).

   - With at least 2 percent redox concentrations required for value 5 and chroma 2 (5/2).

   - Redox concentrations not required for a value/chroma combination of 5/1 and for values > 5.

   *** For loamy soils**, a dark surface layer must have a value of 3 or less and a chroma of 2 or less. **For sandy soils**, a dark surface must have a value of 3 or less and a chroma of 1 or less.

5. **Loamy soils** with a layer at least 6 in. thick, with a matrix chroma due to wetness of 2 or less and values of 4 or higher within 10 in. from the surface of the soil (*Indicator F3b*; see Figure 3.9).

   - With at least 2 percent redox concentrations required for value of 4 (4/1 or 4/2).
   - With at least 2 percent redox concentrations required for value 5 and chroma 2 (5/2).
   - Redox concentrations not required for a value/chroma combination of 5/1 and for values > 5.

6. **Sandy soils** with a layer at least 4 in. thick with a chroma of 2 or less with at least 2 percent distinct or prominent redox concentrations within 6 in. of the soil surface (*Indicator S5*).

7. **Loamy soils** within a dark surface layer with a value of 3 or less and a chroma of 2 or less that contains a 4 in. thick zone with at least 5 percent redox concentrations, starting within 8 in. of the surface of the ground. To ensure that these characteristics are due to wetness, there should be redox concentrations and/or depletions in the soil immediately below the dark surface layer) *(F6)*.

NOTE: Refer to the Appendix F for definitions of specific hydric soil indicators. Refer to Appendix E for detailed descriptions of "sandy soils" and "loamy soils".

Chapter 4: Other Indicators of Wetland Hydrology

Summary

- Under normal circumstances, wetland plants and hydric soils are sufficient for establishing that an area is wetland. However, additional indicators of hydrology, such as water marks on trees and water-stained leaves, when combined with soils and vegetation, can also be used to determine whether an area is wetland or non-wetland. These **Other Indicators of Hydrology** can be especially important for evaluating disturbed sites.

- Other Indicators of Hydrology are important when there is reason to suspect that a site's natural hydrology has been altered, and the plant community and/or soil characteristics are artifacts of past hydrology and not indicative of current conditions.

- Indicators of hydrology, other than wetland plants and hydric soils, vary considerably in their usefulness for identifying areas with wetlands hydrology. Some of these indicators can be used on their own to confirm the presence or absence of wetland hydrology. In most situations, Other Indicators of Hydrology should be used in combination with other evidence of wetland hydrology, and considering the context in which the indicators are observed, before concluding that wetland hydrology is present.

- Other Indicators of Hydrology are organized in three categories based on how useful they are for indicating the presence of wetland hydrology: Reliable Indicators of Wetlands Hydrology, Indicators that can be Reliable for Establishing Wetlands Hydrology with Proper Interpretation, and Indicators of the Influence of Water.

- **Reliable Indicators of Wetlands Hydrology** are almost always located in areas that experience inundation or soil saturation sufficient to establish the presence of wetlands. Examples of indicators in this category are water-stained leaves, evidence of aquatic fauna, oxidized rhizospheres/pore linings, and hydrogen sulfide (rotten egg) odor.

- **Indicators that can be Reliable for Establishing Wetlands Hydrology with Proper Interpretation** are associated with surface water or groundwater within 12 in. of the surface of the ground; however, they can be temporary in nature and must be considered in the context of the site's landscape position, time of year observed, and other wetland indicators. Examples include free water in a soil test pit, trees with shallow root systems, and water marks on trees, boulders, bridge abutments, or other objects.

- **Indicators of the Influence of Water** can indicate the presence or influence of water, but on their own, these characteristics are not sufficient to establish that wetland hydrology is present at a particular site. Used in combination, or with indicators in the other categories, these characteristics can be used to document wetland hydrology. However, these indicators can also be misinterpreted or misused to assert that an area is wetland when, in fact, it may not be a wetland. Examples of these indicators include direct observation of inundation, drift lines, scoured areas, drainage patterns, and microtopographic relief such as pit and mound topography.

As discussed in Chapter 1, hydrology is the driving force behind wetland systems. There are several ways to determine whether wetland hydrology is present at a site. Wetland plants (discussed in Chapter 2) and hydric soils (discussed in Chapter 3) generally are very reliable indicators of long-term hydrology. Under normal circumstances, these two indicators are sufficient for establishing that an area is wetland. However, additional indicators of hydrology, such as water marks on trees and water-stained leaves, when combined with soils and vegetation, can also be used to determine whether an area is wetland or non-wetland. These Other Indicators of Hydrology can be especially important for evaluating disturbed sites.

It will be necessary to utilize Other Indicators of Hydrology to delineate the boundaries of certain wetlands where hydric soil indicators are not present. For example, hydric soils are not always present in disturbed soils, alluvium (floodplain soils) located immediately adjacent to rivers and streams, and sandy coastal soils in freshwater wetlands located near salt marshes or other coastal resource areas. Other Indicators of Hydrology are particularly useful when there is reason to suspect that a site's natural hydrology has been altered and the plant community and/or soil characteristics are artifacts of past hydrology and not indicative of current conditions. These indicators are often confined to wetter portions of the site and may be of little use for determining the wetland boundary. However, they may be sufficient to confirm that wetland conditions do occur on a site.

When delineating or reviewing a wetland boundary, note the presence of any of these Other Indicators of Hydrology and consider them in the evaluation of whether an area is wetland. When encountering difficult sites, it may be necessary to actively look for these Other Indicators of Hydrology to make the determination. Keep in mind, however, that some of these indicators can be affected by recent heavy rain or seasons with above average amounts of precipitation. Conversely, these Other Indicators of Hydrology may not be present throughout the year or may be absent for multiple years during prolonged periods of abnormally dry conditions.

Indicators of hydrology, other than wetland plants and hydric soils, vary considerably in their usefulness for identifying areas with wetlands hydrology. Some of these indicators can be used on their own to confirm the presence or absence of wetland hydrology. In most situations, Other Indicators of Hydrology should be considered in combination with other evidence of wetland hydrology and the context in which the indicators are observed before concluding that wetland hydrology is present. The following Other Indicators of Hydrology are organized in three categories based on how useful they are for indicating the presence of wetland hydrology: Reliable Indicators of Wetlands Hydrology, Indicators that can be Reliable for Establishing Wetlands Hydrology with Proper Interpretation, and Indicators of the Influence of Water. Professional judgment should be used in deciding whether the presence of one or more of these Other Indicators of Hydrology in an area is sufficient for establishing that wetland hydrology is present.

4.1 Reliable Indicators of Wetlands Hydrology

When the following indicators are observed, they almost always are in areas that experience inundation or soil saturation sufficient to establish the presence of wetlands. They may not occur near the wetland boundary but can generally be found in more interior (i.e., wetter) areas of bordering vegetated wetlands. While the following characteristics are very good indicators of wetland hydrology, the absence of these characteristics does not indicate that wetlands hydrology is not present.

Water-stained leaves (see Figure 4.1) on the ground are an indicator of inundation. Water-stained leaves are usually dull gray or black in color, and are flattened compared with those in surrounding (upland) areas. They generally contrast strongly with leaves in nearby non-wetland landscape positions.

Figure 4.1 — Water-Stained Leaves

Evidence of aquatic fauna such as shells of fingernail clams, aquatic snail shells, and caddisfly cases (see Figure 4.2), can occasionally be found in dry depressions and are good indicators of extended periods of inundation during the growing season. Be aware, however, that there are terrestrial snails in Massachusetts; their presence is not an indicator of wetland hydrology. Freshwater mussels, unlike fingernail clams, only occur in areas that are permanently flooded. The presence of mussel shells in areas other than aquatic habitats are not good indicators of wetland hydrology because predators often transport them. Caddisflies are insects that are aquatic as larvae and winged as adults. The larvae of many species construct tube-like cases around themselves, made of leaf fragments, twigs, pine needles, or sand. These cases often persist long after the water has dried up and serve as good indicators of extended periods of inundation during the growing season.

Figure 4.2 — Evidence of Aquatic Fauna: Fingernail Clam Shells, Aquatic Snail Shells, and Caddisfly Cases

Iron deposits (see Figure 4.3) consisting of a thin orange or yellow crust, gel, and/or streaking on the ground surface, are formed when groundwater laden with dissolved iron is exposed to oxygen.

Figure 4.3 — Iron Deposits

Algal mats or crusts (see Figure 4.4) are typically found in seasonally ponded areas where prolonged periods of inundation provide conditions suitable for algal growth and mat development.

Figure 4.4 — Algal Mat

Oxidized rhizospheres/pore linings (see Figure 4.5) along living roots within the A-horizon together with low-chroma colors right below the A-horizon are a good indicator of soil saturation during the growing season. Look for orange-stained channels along living plant roots in upper parts of the soil (within 12 in. of the ground surface).

Figure 4.5 — Oxidized Rhizopheres Along Pore Linings in Root Channels

Thin muck surfaces can occur as a layer of muck on the ground an inch or less thick, and indicate wetland hydrology currently exists at a site. Muck is well-decomposed organic matter that accumulates under wet conditions. Thin layers of surface muck disappear quickly when wetland hydrology is no longer present, whereas thick muck layers can persist for many years after a wetland has been effectively drained.

Hydrogen sulfide odor is a strong “rotten egg” smell, generally noticed immediately after the soil test pit is dug.

Morphological plant adaptations that only occur when part or all the plant has been submerged in water for significant periods of time include:

Air-filled tissue (aerenchyma) (see Figure 4.6) that forms in the roots and stems of plants in response to prolonged periods of saturation or inundation. These specialized tissues help move oxygen from plant structures above water to those that are underwater or in saturated soil. Plants that possess these air-filled tissues are spongy when squeezed and the air cells are obvious when the plants are cut.

Polymorphic leaves form on certain plant species when portions of the plant are submerged while other portions extend above water. Plants such as mermaid weed (*Proserpinaca palustris*), water parsnip (*Sium suave*), and arrowhead (*Sagittaria latifolia*) have different leaf forms depending on whether the leaves grow above or below the water surface. Underwater leaves tend to be narrow or finely divided; leaves above the water surface tend to be broader and less divided. Where both forms occur on the same plant (polymorphic leaves), this is good evidence of surface water for an extended period during the growing season.

Floating leaves are plant adaptations for life in standing water. These flat, round, or elliptical leaves are generally tough and waxy on top. These plants are not usually exposed, but may occur in depressions without standing water during especially dry conditions.

Figure 4.6 — Air-Filled Issue (Aerenchyma)

4.2 Indicators that can be Reliable for Establishing Wetlands Hydrology with Proper Interpretation

These indicators are associated with surface water or groundwater within 12 in. of the surface of the ground; however, they can be temporary in nature and must be considered in the context of the site's landscape position, time of year observed, recent weather conditions, and other wetland indicators.

Hydrological records, such as those from U.S. Geological Survey (USGS) stream gauging stations, USACE data for major water bodies, state and local flood data, or NRCS state offices, can provide information on flood elevations, as well as the frequency and duration of flooding. Hydrological records that provide evidence of periods of continuous flooding from 14 to 21 days during the growing season are indicators of wetland hydrology.

Free water in a soil test pit (see Figure 4.7) indicates depth to the water table at that particular time. The depth at which water is observed weeping out of the soil into the test pit also is an indicator of water table depth. Free water or weeping within 12 in. of the surface is a good indicator of wetland hydrology. However, recent weather conditions should be considered when using this indicator.

Figure 4.7 — Free Water in Soil Test Pit

Saturated soil usually occurs in areas above the water table due to capillary action within the soil. Saturated soils will yield water when squeezed or are indicated by water glistening on the surfaces and broken interior faces of soil samples. Saturated soil within 12 in. of the surface generally is a good indicator of wetland hydrology. However, time of year and recent weather conditions should be considered when using this indicator.

Water marks (see Figure 4.8) on trees, boulders, bridge abutments, or other objects are good indicators of extended periods of inundation. Water marks can be stained, or silt covered areas, or an abrupt change in plant or lichen growth that is present on several objects at a consistent elevation.

Figure 4.8 — Water Marks and Moss Trim Lines on Trees

Moss trim lines are areas on trees with abrupt lower limits of moss cover caused when water-intolerant mosses are eliminated from lower portions of tree trunks by prolonged flooding. Where these trim lines occur on multiple trees, they should all be at the same elevation. Moss trim lines do not include lines caused by ice scour or abrasion, or lichen trim lines that may occur in response to infrequent flooding events. Some mosses and liverworts are tolerant of flooding; absence of a moss trim line does not mean that a site does not experience flooding.

Presence of reduced iron can be documented using the chemical alpha-alpha dipyridyl (e.g., dye or strips), which reacts with the reduced form of iron (ferrous iron) to produce a deep red color indicating the presence of reduced iron, although this indicator is rarely used.

Morphological plant adaptations that usually indicate inundation or saturation for significant periods of time but that can also be artifacts of past hydrological conditions or shallow soil conditions include:

> Adventitious roots (see Figure 4.9) are roots that form on plant stems in positions where roots normally do not occur. This adaptation is most common on active floodplains and in beaver impoundments, and may be found on speckled alder (*Alnus incana*), box elder *(Acer negundo),* American sycamore *(Platanus occidentalis),* pin oak *(Quercus palustris),* green ash *(Fraxinus pennsylvanica), eastern* cottonwood *(Populus deltoides),* and willows *(Salix spp.).*

Figure 4.9 — Adventitious Roots

Shallow root systems (see Figure 4.10) are commonly observed in forested wetlands and often indicate wetland hydrology in areas near the wetland/non-wetland boundary. Look for swollen trunks and/or roots along the surface of the ground as evidence of shallow root systems, or observe them directly on windthrow trees. The key is to compare the root structures of like or similar species growing further upslope in an upland setting. Be aware that shallow root systems also form in upland areas where bedrock is close to the surface or in very stony soils. Use USDA Soil Survey maps and topography to confirm that shallow root systems are the result of wetland hydrology and not due to stony soils or bedrock.

Figure 4.10 — Shallow Root System

Enlarged (hypertrophied) lenticels on woody plants are indicators of inundated or saturated growing conditions. Lenticels are small pores, usually resembling dots or thin horizontal lines on the stems and twigs of woody plants. In response to saturated or inundated growing conditions, these pores can become swollen or enlarged. Enlarged lenticels can occasionally be found on red maple *(Acer rubrum),* silver maple *(Acer saccharinum),* and willows *(Salix spp.).*

4.3 Indicators of the Influence of Water

The following characteristics can indicate the presence or influence of water, but on their own these characteristics are not sufficient to establish that wetland hydrology is present at a particular site. Used in combination, or with indicators in the other categories (above), these characteristics can be used to document wetland hydrology. However, these indicators can also be misinterpreted or misused to assert that an area is wetland when, in fact, it may not be a wetland.

Direct observation of inundation during the growing season is an obvious indicator of the presence of water. Observations over a period of days or weeks will provide a more reliable indication that the area has wetland hydrology. Recent weather conditions (e.g., periods of unusually wet weather) should be taken into consideration when using this indicator to establish the presence of wetland hydrology.

Sparsely vegetated concave surfaces occur in depressions and swales where the ground is either unvegetated or sparsely vegetated due to ponding or flooding during the growing season. This indicator is most useful when it occurs with other evidence that the site supports wetland hydrology.

Drift lines are accumulations of plant material or debris that are deposited, usually in lines parallel to the stream flow, during flood events. Drift deposits may be evident on the ground or occasionally in the branches of trees and shrubs. They are good indicators of surface water, but do not provide much information about the timing or duration of flooding.

Scoured areas are good indicators of flowing water. These generally can be recognized by the relative absence of leaf litter and other debris on the ground, or where fine soils have been washed away, leaving gravel and cobble. Scoured areas are good indicators of flowing conditions, but do not provide much information about the timing or duration of flowing water.

Sediment deposits on plants, leaves, or the ground are indicators of surface water, but generally do not provide much information about the timing or duration of inundation.

Surface soil cracks (see Figure 4.11) are shallow cracks that form in fine-grained or organic sediments when previously wet soils dry and shrink. These cracks can occasionally be found in wetland areas that are drawn down during portions of the growing season. However, they also occur in areas that are not wet long enough to be considered wetland.

Figure 4.11 — Cracks in Organic Soil

Drainage patterns left by flowing water indicate the presence of surface water. These can be water-induced patterns on the ground (washboard or braided patterns in the sediments), channels in the leaf litter, or where vegetation has been bent in one direction by the force of running water. Although these patterns do serve as indicators of surface water, they also may occur in upland areas.

Microtopographic relief in wetlands includes hummocks, tussocks, and pit and mound topography (see Figure 4.12) resulting from windthrow of shallow-rooted trees. The uprooting of tree roots and the soil bound up in them create small depressions, or pits, while decomposed root stumps become intervening mounds. These should not be confused with uneven terrain in non-wetland areas resulting from rocks, boulders, and fallen trees.

Figure 4.12 — Shallow Roots of Trees Creating Pits and Mounds

Geographic position can suggest areas that might be wetlands, although these features can just as easily occur in non-wetlands:

- Depressions, especially when they occur in floodplains
- Toe of slope
- Lowlands that abut water bodies

For more detailed descriptions and photographs of these indicators of hydrology, consult the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (Version 2.0)*.

Chapter 5: Delineating and Reviewing Bordering Vegetated Wetland Boundaries

Summary

- Wetlands often occur as transitional areas between water bodies (and waterways) and uplands. Where the transition is gradual, it can be difficult to determine exactly where the BVW ends, and the upland begins.

- BVWs are areas that border a river, stream, pond, lake or the ocean, and that are characterized by wetland hydrology. **The key criteria for a BVW are that 1) the area borders a waterway or water body, and 2) the area is characterized by wetland hydrology**.

- To meet the “bordering” criterion, an area needs to abut or touch the bank of a river, stream, pond, or lake or be connected to those water features via continuous wetland conditions or surface water connections.

- Areas with wetland hydrology are defined as areas that are inundated by surface water or saturated with groundwater long enough during the growing season to produce anaerobic (low oxygen) conditions in the upper part of the soil and under normal conditions, support wetland vegetation.

- Vegetation alone can **only** be used to delineate a wetland in areas that 1) are undisturbed, 2) where all dominant plants have an indicator status of OBL or FACW, and 3) the wetland boundary is clear and abrupt. Although vegetation-only delineation is allowed in these specific situations, it is recommended that vegetation, soils, and Other Indicators of Hydrology always be considered when delineating BVWs.

- Under normal (undisturbed) conditions, the presence of a wetland plant community and hydric soils are generally sufficient indicators of hydrology to identify and delineate a BVW. Under some natural circumstances (e.g., floodplain soils, rocky soils), or when there is evidence of disturbance, it is necessary to use Other Indicators of Hydrology to determine whether a site qualifies as wetland.

- Delineating or verifying BVW boundaries during the winter months, especially with snow cover or frozen soil conditions, is difficult and under some circumstances virtually impossible. MassDEP recommends that BVW delineations be avoided, if possible, when snow cover or “frozen soil” conditions exist.

- Appendix A includes a new *Bordering Vegetated Wetland Determination Form*, which facilitates the recording and assessment of vegetation, soils, and Other Indicators of Hydrology. Completed Data Forms should be submitted with a Request for a Determination of Applicability (RDA), Abbreviated Notice of Resource Area Delineation (ANRAD), or Notice of Intent (NOI) for complex delineations or whenever required to do so by the Issuing Authority (conservation commission or MassDEP).

- Recommended procedures are provided for BVW delineations using vegetation, soils, and Other Indicators of Hydrology. Appendix B provides detailed information about how to assess vegetative communities. Appendix G describes the recommended procedure for evaluating soils.
- During RDA, ANRAD, and NOI review, the Issuing Authority is responsible for reviewing the accuracy of an applicant's flagged BVW boundary and ensuring that the boundaries are accurately represented on the maps/plans.

Wetlands often occur as transitional areas between water bodies (and waterways) and uplands. Where the transition is gradual, it can be difficult to determine exactly where the BVW ends, and the upland begins. Procedures for analyzing plants, soils, and Other Indicators of Hydrology are used for determining whether a particular area is a BVW and for delineating its boundary.

The level of analysis used to delineate the BVW boundary should reflect the complexity of the site. Some wetlands have abrupt and obvious boundaries, and rigorous analyses may not be necessary. Other areas may require detailed analysis of vegetation, soils, and hydrology in order to locate accurate boundaries. The Regulations establish criteria to determine when vegetation alone may be used to delineate the BVW boundary and when vegetation and other evidence of hydrology (including soils) are required.

5.1 Criteria for Determining that an Area is Wetland

BVWs are areas that border a river, stream, pond, lake or the ocean, and that are characterized by wetland hydrology. **The key criteria for a BVW are that 1) the area borders a waterway or water body, and 2) the area is characterized by wetland hydrology**.

5.1.1 Bordering

To meet the "bordering" criterion, an area needs to abut or touch the bank of a river, stream, pond, or lake (most vegetated wetlands that border, or touch, the ocean are salt marshes, a different resource area) or be connected to those water features via continuous wetland conditions or surface water connections. Wetlands are "bordering" despite a discontinuity in wetland coverage as long as a surface water connection, such as a culvert, is present. Connection by groundwater is insufficient for meeting the "bordering" criterion. Once the "bordering" criterion is met, the process of BVW delineation involves moving up gradient from the waterway or water body until you first encounter an area that is no longer characterized by wetland hydrology.

5.1.2 Wetland Hydrology

The key to BVW delineation is finding where an area with wetland hydrology abuts an area that lacks wetland hydrology. Areas with wetland hydrology are defined as areas that are inundated by surface water or saturated with groundwater long enough during the growing season to produce anaerobic (low oxygen) conditions in the upper part of the soil and under normal conditions, support wetland vegetation. It is not sufficient for an area to experience these conditions only during exceptionally wet years, as conditions must be representative of the long-term hydrology of the site.

It is not feasible to use the actual presence of water or anaerobic conditions to delineate BVWs because they may be presence for only a portion of the growing season. Therefore, we rely instead on indicators of wetland hydrology.

Under normal (undisturbed) conditions, the presence of a wetland plant community and hydric soils are generally sufficient indicators of hydrology to identify and delineate a BVW. Under some natural circumstances (e.g., floodplain soils, rocky soils), or when there is evidence of disturbance, it is necessary to use Other Indicators of Hydrology to determine whether a site qualifies as wetland. Other Indicators of Hydrology vary in their usefulness, and it is difficult to prescribe what combination of indicators are sufficient to establish that wetland hydrology exists at a site. All indicators available at a site should be considered, and sound judgement used, to accurately determine the BVW boundary. Even experts may disagree on the precise location of a wetland boundary. However, the goal must always be the accurate interpretation of available evidence to determine the limits of wetland hydrology.

When Plants Alone are Sufficient to Delineate a BVW

The Regulations currently allow for a vegetation-only delineation in specific situations. Note that although this is allowed, it is recommended that vegetation, soils, and Other Indicators of Hydrology always be considered when delineating BVWs. Vegetation alone can only be used to delineate a wetland in areas:

- that are undisturbed,
- where all dominant plants have an indicator status of OBL or FACW, and
- the wetland boundary is clear and abrupt.

Otherwise, additional evidence of wetland hydrology is required. When determining if a site is undisturbed or not, the delineator, and those reviewing boundary delineations, should consider that disturbances are not always obvious. This can be especially true when the disturbance is a change in hydrology (e.g., groundwater withdrawal or storm water discharge) that occurs some distance from the site being assessed. Ecological succession occurs slowly, and it may take many years for vegetation (especially trees and shrubs) to respond to a change in hydrology.

Undisturbed Sites Where Plants and Soils are Reliable Indicators

In areas where plants and soils are undisturbed and there is no evidence of hydrological alterations (e.g., ditching, subsurface drainage, groundwater withdrawals), the presence of hydric soils and a wetland plant community are generally sufficient for determining the BVW boundary. It is still recommended that all evidence from a site, including Other Indicators of Hydrology, be considered in delineating a BVW.

Sites with Evidence of Altered Hydrology

In sites that have been hydrologically altered by ditching, subsurface drainage (e.g., tile drains), or groundwater withdrawals, wetland plants and hydric soil characteristics may persist even though the site lacks wetland hydrology. The loss of iron that so dramatically changes the color of wetland soils cannot be reversed by dewatering a site. These characteristics will persist indefinitely (at least until the next glacial period) unless the soils themselves are disturbed. Once established, wetland plants (especially trees and shrubs) may take a long time to yield to more upland vegetation after a site has been drained. At sites with evidence of altered hydrology (see Figure 5.1), wetland plants and hydric soils must be supplemented with Other Indicators of Hydrology sufficient to confirm that the area still has wetland hydrology.

Figure 5.1 — Example of Altered Hydrology in an Excavated Channel

Sites where Vegetation is an Unreliable Indicator of Hydrology

In addition to sites with altered hydrology, vegetation may be an unreliable indicator in heavily managed landscapes, such as cropland, pastureland, golf courses, lawns, and other areas where the vegetation is heavily manipulated. In these areas, hydric soils, reinforced by Other Indicators of Hydrology, should be used to determine whether an area is a wetland. Where vegetation has been cut or removed (e.g., ongoing logging activity), remnant vegetation should be considered, along with soils and Other Indicators of Hydrology, to establish the BVW boundary.

Sites where Soils are an Unreliable Indicator of Hydrology

Sites with altered hydrology, areas of fill, and areas where soils have been physically disturbed, may lack or have misleading hydric soil characteristics. In these areas, use vegetation and Other Indicators of Hydrology to delineate the BVW boundary.

Sites where Both Soils and Vegetation are Unreliable

An example of a site where both soils and vegetation are unreliable is a cornfield surrounded by ditches. Cropland typically lacks natural vegetation that can be used to determine whether a wetland plant community would normally occur on the site (absent farming activity). Hydric soil characteristics may be present, but it may be unclear whether these are indicators of current conditions or of a hydrology that has long since been altered by ditching and draining. In these cases, National Wetlands Inventory (NWI) maps, MassDEP wetland maps, aerial photographs, and visual assessments of adjacent sites may be useful in establishing the BVW boundary. Absent reliable Other Indictors of Hydrology (see Chapter 4), these sites should be considered problem areas that require groundwater monitoring or consultation with experts to determine whether any of the area is wetland and where the BVW boundaries are located.

Sites that have been Recently Altered

In areas where hydrology has been recently altered in ways that create flooded conditions, hydric soils may not have had sufficient time to form. As a result, indicators of hydric soils may not be present even if wetland hydrology exists. Areas that have been recently drained (i.e., potential WPA violations) will usually possess hydric soil indicators but lack Other Indicators of Hydrology. Wetland plants may be present or absent depending on how recently and how extensively the hydrology has been altered. Hydric soils are often the best indicators for delineating recently drained wetlands.

Areas where fill has been placed in wetlands require the analysis of soils directly beneath the fill. A test pit must be dug through the fill until the original soil is uncovered. Look for evidence of a buried surface horizon (i.e., an A- or O-horizon) and evidence of normal horizonation (topsoil and subsoil layers). NRCS Soil Survey maps may be useful as a reference for distinguishing between the original soil and fill material. Once you have dug through the fill, analyze the original soils, and determine whether they are hydric or non-hydric soils. Look for evidence of soil saturation. If the fill is recent, there also may be identifiable plant parts beneath the fill that can be used to help delineate the BVW boundary.

5.2 Winter Delineations

Delineating or verifying BVW boundaries during the winter months, especially with snow cover or frozen soil conditions, is difficult and under some circumstances virtually impossible. Vegetation and Other Indicators of Hydrology that could otherwise be used to determine wetland boundaries may not be readily observable or may be misleading during the winter months.

Herbaceous vegetation or remnant vegetation (e.g., nuts, fruits, leaves) may be present but not visible if covered with snow. An example is the fertile frond of the sensitive fern (*Onoclea sensibilis*), which is persistent throughout the year, but may be hidden by snow.

Other Indicators of Hydrology may be misleading or covered with snow. An example of this would be pockets or channels of ice on the ground surface. This condition may appear to indicate the presence of wetland hydrology, but also may be due to a number of different factors, such as snowmelt that quickly refreezes or a quick temperature drop after a brief rain that occurred on frozen soil. As a practical matter, frozen soil conditions make digging holes and accurately observing the soil profile difficult or nearly impossible. Morphological adaptations (such as shallow root systems) and subtle changes in topography also are difficult to observe when deep snow conditions are present.

For these reasons, MassDEP recommends that BVW delineations be avoided, if possible, when snow cover or “frozen soil” conditions exist. It is best for applicants and conservation commissions to agree upon a reasonable time period for continuing the RDA, ANRAD, or NOI processes in order to conduct or review the BVW boundary delineation at such time when frozen or snow-covered conditions are less likely to occur. Because winter delineations are more difficult to perform, disagreements — and subsequent appeals — may arise. Avoiding lengthy appeals and disagreements will benefit all parties involved.

> 310 CMR 10.05 (6)(c): “If the conservation commission finds that the information submitted by the applicant is not sufficient to describe the site, the work, or the effect of the work on the interests identified in M.G.L. Ch. 131, § 40, it may issue an Order prohibiting the work. The Order shall specify the information which is lacking and why it is necessary.”

When snow covered ground conditions do not exist, it may be possible to delineate BVW boundaries during the winter by using twigs, buds, leaf scars, and other vegetative indicators to assess the plant community along with soils or Other Indicators of Hydrology.

5.3 Preparing for the Site Visit

Preparation before visiting the site is an important first step in the delineation or review process. Maps and other materials that can provide information about an area should be reviewed before you make a site visit. These data sources may include important information about the topography and soils of a site, water bodies, floodplains, and areas that may already have been mapped as wetlands. This preparation may improve your efficiency at the site by highlighting difficult areas where you can focus your attention, such as disturbed areas or gradual slopes. Also, be sure to secure permission from the landowner before entering private property.

5.3.1 Useful Data Sources

Below is a list of useful data sources which can be used when determining a BVW boundary (links to many of these data sources are provided in Appendix H).

- **USGS topographic maps.** Topographic maps prepared by the USGS are essential sources of information about site conditions. They provide information about the topography of a site and many wetlands and water bodies are shown as well. It is important to note, however, that not all wetlands and not all waterbodies (e.g., intermittent streams) are shown on the topographic maps. In many cases, illustrated features on the topographic maps can be used to identify areas that may contain wetlands and streams not otherwise shown on the map.

- **NRCS Soil Survey maps and hydric soils lists.** Soil Surveys are published by the USDA NRCS (formerly the Soil Conservation Service). The Soil Survey (see Figure 5.2) provides maps depicting soil types, their boundaries, and descriptions of soil properties. When using Soil Surveys, consult the list of hydric soils for the county. Both Soil Surveys and hydric soils lists are available from the NRCS. It is important to note that the soil boundaries depicted on the maps are for planning purposes only. Only field assessments can determine whether a soil is hydric.

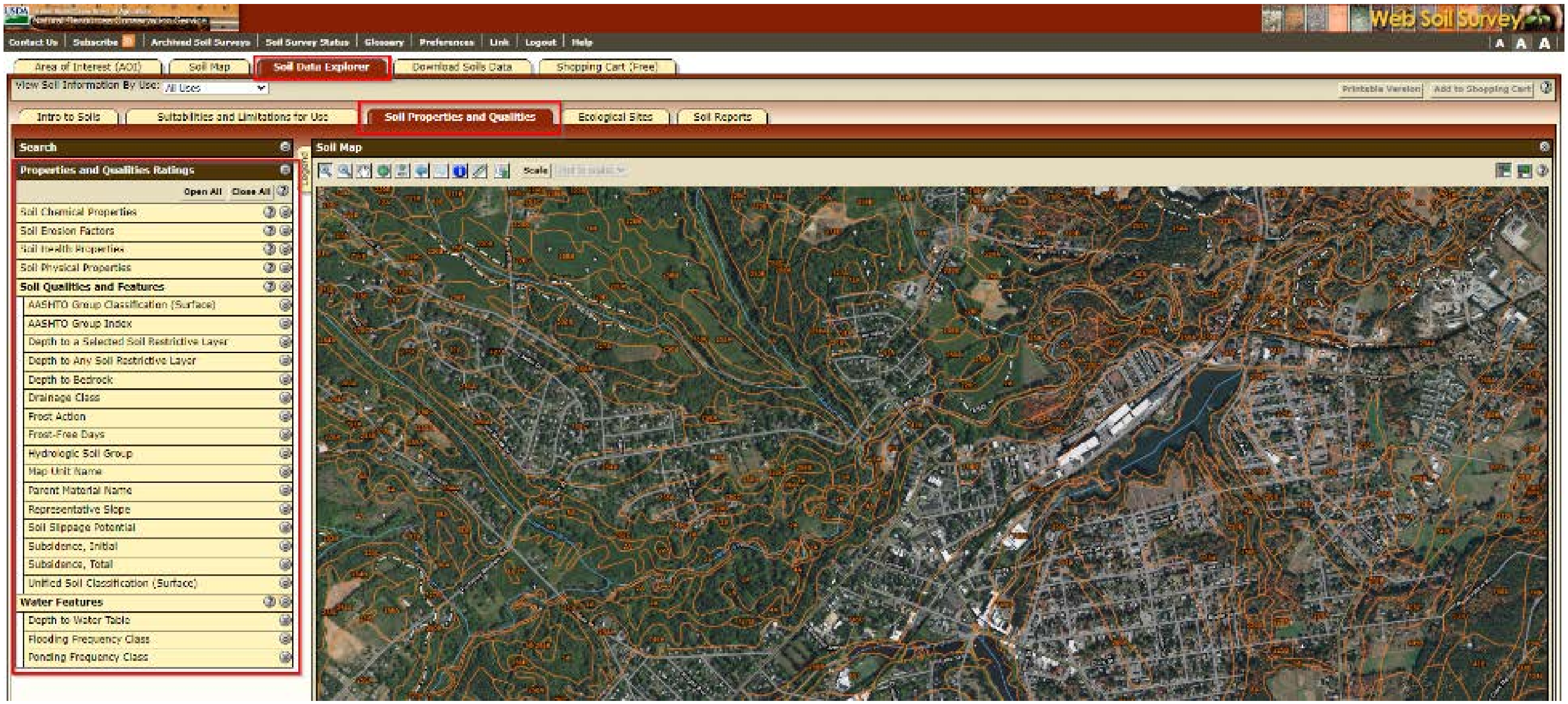


Figure 5.2 — Example of an NRCS Soil Survey Map and Data That Can Be Accessed Via Web Soil Survey Online or Using the SoilWeb Mobile Application Available for iOS and Android.

- **MassDEP Wetlands Maps.** MassDEP has mapped wetlands statewide using aerial photography (see Figure 5.3). It is important to note that the wetland polygons depicted on the maps are for planning purposes only. They do not necessarily represent, and should not be used as, jurisdictional determinations. All BVW delineations for regulatory purposes should be based on in site-specific field assessments using the procedures outlined in this Handbook.

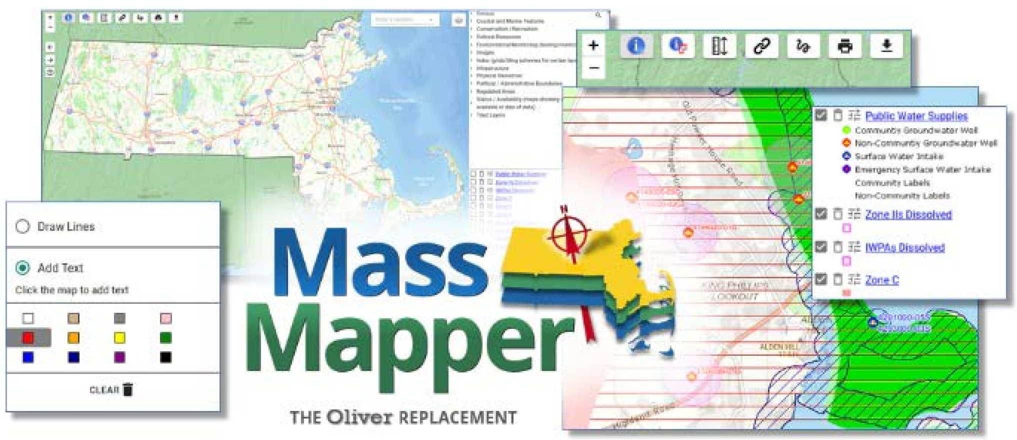


Figure 5.3 — MassMapper is MassGIS's Interactive Map That Can Be Used To Access MassDEP Wetlands Maps and The Latest Aerial Imagery

- **National Wetlands Inventory (NWI) maps.** The U.S. Fish and Wildlife Service has mapped wetlands in Massachusetts as part of the NWI. NWI maps wetlands at a nationwide scale so it is it is important to note that many small wetlands are not shown on the maps, and that wetland boundaries on the maps are approximate. In cases where wetlands have been altered or destroyed, NWI maps can indicate the extent and location of previously existing BVWs for the purposes of enforcement.

- **Aerial photographs.** Aerial photography is available from MassGIS and other sources. Infrared photography, taken in the spring before leaves are out, is the most useful for identifying wetlands. Aerial photographs can be used to document wetland violations; however, an experienced photo interpreter might be required.

- **Local wetlands and/or topographic maps (city or town).** In some cities and towns in Massachusetts, local topographic or wetlands maps are available. These maps may provide details about a site that may not be identified on other maps.

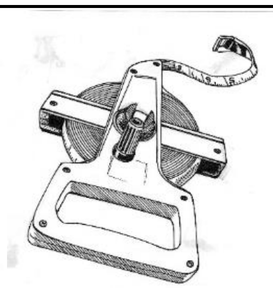
- **Floodplain maps (National Flood Insurance Program)**. Developed for the National Flood Insurance Program, these maps provide useful information on flood prone areas and may indicate the presence of floodplain soils that may be difficult to analyze for hydric soil indicators. One-hundred-year floodplains and 500-year floodplains are delineated for rivers and larger streams, and some water bodies.

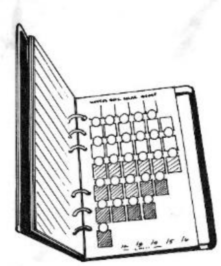
- **Site plans prepared by the applicant**. Before going out to a site to review a BVW boundary delineation, it is important to review site plans for the area. Applicants are required to submit information that describes conditions at a project site. This includes identification of all wetland resource areas. The BVW boundary should be marked in the field by numbered flags that correspond with the project site plan.

- **Data Forms**. When reviewing BVW boundary delineations, Data Forms prepared for the site should be reviewed prior to a site visit. The Data Forms should list the plant species found at various locations on the site. Reviewing the Data Forms prior to the site visit gives you an opportunity to check field guides for species with which you are not familiar, check the wetland indicator status of particular species, and consult related soils information, as needed.

Some or all of the following tools may be useful to have in the field while delineating BVWs.

- Site plans
- Data Forms
- Flagging tape (pink flagging marked with "Wetland Delineation" preferred)
- USACE Wetland plant list for Massachusetts
- Plant identification guides
- Shovel (tiling spade)
- Dutch (soil) auger
- Munsell Soil Color Book
- Spray bottle with water
- Knife
- Hand lens/magnifying glass
- 100-foot measuring tape
- Flexible tape measure (sewing tape measure or masons ruler)
- Compass
- Global Positioning System (GPS) enabled device
- Clip board
- Pen or pencil, and permanent marking pen
- Calculator

5.4 The *Bordering Vegetated Wetland Determination Form*

Appendix A includes a new *Bordering Vegetated Wetland Determination Form* (Data Form), which facilitates the recording and assessment of vegetation, soils, and Other Indicators of Hydrology. Completed Data Forms should be submitted with an RDA, ANRAD, or NOI for complex delineations or whenever required to do so by the Issuing Authority (conservation commission or MassDEP). Data Forms provide important information, which can be used by conservation commissions and MassDEP when reviewing a BVW boundary delineation.

5.5 Delineating Bordering Vegetated Wetland Boundaries

BVWs must border on a creek, river, stream (including an intermittent stream), pond, or lake. Bordering means that the wetland is adjacent to or abutting a water body, is contiguous with wetlands that abut a water body, or is connected via surface water (or culvert) to wetlands adjacent to the water body. Use topographic maps, site plans, or other sources of information such as those described in the Useful Data Sources section above, to locate water bodies that may be associated with wetlands and then verify them in the field.

Once at the site, establish some general reference points such as property boundaries, stonewalls, fences, or other field markers. This will help keep you oriented. Begin at the water body or an obvious wetland that borders the water body, and walk the site to determine whether BVW exists on the site. If one or more BVWs occur on the site, determine whether vegetation alone is adequate to delineate the BVW boundaries or if vegetation, soils, and Other Indicators of Hydrology should be used. (See Section 5.1 on Criteria for Determining that an Area is Wetland.)

5.5.1 Delineation Procedures

When delineating a BVW using vegetation alone (i.e., the site is undisturbed, with dominant plants that are OBL and/or FACW, and the boundary between wetlands and non-wetlands appears to be clear and abrupt), it is not necessary to document soils and Other Indicators of Hydrology. Although vegetation alone BVW delineation is allowed under these circumstances, disturbances are not always obvious and it is recommended that vegetation, soils, and Other Indicators of Hydrology always be considered when delineating a BVW.

The following procedures are for BVW delineations using vegetation, soils, and Other Indicators of Hydrology. While conducting these steps, site information should be recorded on Data Forms (Appendix A).

1. Establish one or more transects from an obvious wetland to an obvious upland area.
   A transect is an imaginary line across the land along which observations are made and data collected. Transects should be established moving upslope, perpendicular to the presumed location of the BVW boundary. The number of transects should reflect the complexity of the site and may range from one to several. Mark the beginning and end of each transect with a flag (use a different color than the one used for the boundary line or make a note on the flag).

2. Starting at the wetter end of the transect line, walk towards the upland. Observe plant communities, topography, and any indicators of hydrology along the transect line(s), and identify zones within which vegetation, topography, and hydrology are relatively uniform. Any significant change in any of these characteristics should be used to identify a new zone. Begin by assessing the vegetative community and soils in the zone on each side of the presumptive wetland boundary. If necessary, assess additional zones until you find a wetland zone that abuts a non-wetland zone.

3. In each zone, assess the plant community using the concepts in Chapter 2 and procedures in Appendix B, to determine whether it is a wetland or non-wetland vegetative community.

4. Choose one or more locations for soil test pits within each zone. Soil test pits should be located in areas that are representative of the topography and vegetative community (wetland or upland) within the observation plots used for vegetative analyses.

5. Dig soil test pits and, using procedures described in Appendix G, examine the soil characteristics for hydric soil indicators described in Chapter 3 and Appendix F, to determine whether hydric soils are present.

6. Use all available data (including Other Indicators of Hydrology) to determine for each zone, whether that zone is wetland or upland. Other Indicators of Hydrology can be useful for confirming wetland hydrology even if they are not observed in the zone being assessed, but occur in an area nearby. The BVW boundary should be somewhere near the boundary between the highest elevation wetland zone and the adjacent non-wetland zone just above that wetland zone.

7. Use vegetative and soil characteristics to determine the BVW boundary point for each transect. Use additional soil test pits, as needed, to determine the boundary between hydric soils and non-hydric soils. Topographic and vegetation changes also may be helpful in determining a boundary point for that transect.

8. Once all transects have been completed, use topographic features, vegetation, and soil characteristics to establish a line connecting individual BVW boundary points. If only one transect is completed, use topographic and vegetative features, and soil characteristics to establish a boundary from that transect. Following are examples of site conditions that may be useful to consider when determining the BVW boundary line. These are just a few of the visual cues to look for at a site.

    - A change in topography, such as an abrupt change in slope, may indicate a boundary between wetland and upland.

    - Variations in the herbaceous plant community, such as an obvious decrease in abundance of a specific wetland indicator plant like cinnamon fern (*Osmundastrum cinnamomeum*, FACW), or an increase in abundance of a specific non-wetland plant like princess pine (*Dendrolycopodium obscurum*, FACU), may reflect a change in conditions at that location.

- Variations in the shrub plant community may signal a wetland-upland boundary, such as when a non-wetland shrub like mountain laurel (*Kalmia latifolia*, FACU) starts to become more abundant in an area with a decrease in wetland shrubs like highbush blueberry (*Vaccinium corymbosum*, FACW).

- Soil characteristics also may be used to locate the BVW boundary between transect points. Use a soil auger or spade to check soil characteristics and identify hydric and non-hydric soils to establish the boundary.

- The presence or absence of Other Indicators of Hydrology also may be useful when establishing a BVW boundary. One example would be shallow root systems indicated by windthrow trees or horizontal roots protruding out of the ground. Remember that the absence of Other Indicators of Hydrology near the wetland boundary does not mean that an area (zone) is non-wetland.

9. At complex sites, use periodic soil test pits, with visual assessment of vegetation, to verify or adjust the BVW boundary.

10. Use sequentially numbered flags (e.g., flagging or stakes) to mark the BVW boundary and the location of soil test pits. Flags should be spaced no more than 50 ft. apart, and while standing at a flag you should be able to see the next flag in each direction along the BVW delineation line.

11. Identify the location of BVW boundary flags, and soil test pits on the site plans. If possible, take a GPS point at the location of each flag.

5.5.2 Reviewing Boundary Delineations

Much of the information included in this Handbook, especially the procedures for assessing vegetation and soils, and conducting delineations, can be applied to the review of wetland boundary delineations, as proposed by an Applicant.

Information about how the BVW boundary was delineated should be submitted by the applicant as part of RDA, ANRAD, and NOI filings. Applicants should submit plans with surveyed BVW delineation lines depicting the location of each of the sequentially numbered flags. For complex sites or sites with large wetlands, Data Forms, or an explanation of the assessment method used to determine the BVW boundary should be submitted.

For small projects within (or beyond) the 100-foot buffer zone — such as construction of a house where work is limited to the buffer zone — surveyed plans, detailed assessments, and Data Forms may not be necessary for issuing a Determination of Applicability. In these cases, an assessors' map or plot plan with the house location and BVW boundary noted on the plan may be sufficient. In all cases, however, the BVW boundary should be marked in the field and must be accurately represented on a map or plot plan.

During RDA, ANRAD, and NOI review, the Issuing Authority is responsible for reviewing the accuracy of an applicant's flagged BVW boundary and ensuring that the boundaries are accurately represented on the maps/plans. In reviewing BVW boundary delineations, the Issuing Authority should review all the information submitted by the applicant or that is otherwise available. Vegetation must always be considered, soils must be considered in all but the most obvious delineations, and Other Indicators of Hydrology must be reviewed when that additional information is submitted. It is helpful to have the applicant or the applicant's representative present during the site visit to answer questions about the BVW boundary delineation.

Wetland boundary delineations often involve much interpretation and judgement. In some cases, it may be difficult to precisely locate the wetland/upland boundary, and experienced professionals may differ in where they choose to put the line. However, any differences in wetland boundary points should not be large. Conservation commissions may want to hire a consultant to review delineations in difficult situations. Those conservation commissions that have adopted rules under section 53G of Massachusetts General Law Chapter 44 (Municipal Finance) can hire third-party consultants at the applicant's expense, to conduct peer reviews of BVW boundary delineations.

The following are some suggested procedures for reviewing delineations:

1. Before going to the site, review topographic maps, aerial photographs, NRCS Soil Survey maps, site plans, and other available information so that you are familiar with the site. In particular, look for areas on the maps that might be wetlands but are not included on the site plans provided by the applicant. Make notes of any questions or concerns based on your review of the maps and plans, and ask these questions at the site visit. Determine which procedure the applicant used to analyze the vegetation. Review the Data Forms, when submitted, to become familiar with the vegetation and soils information, and Other Indicators of Hydrology documented on the site.

2. Conduct a site visit to review the BVW boundary delineation. Once at the site, walk around the area using the site plans to orient yourself. Is there any evidence that the vegetation or hydrology of the site have been altered? If so, refer to information in previous sections for delineating BVWs where the hydrology or vegetation has been altered.

3. Once you are well-oriented to the site, walk the BVW boundary as represented by the applicant. The boundary should be flagged so that when standing at one flag location, the next flag is always visible. These flags should be sequentially numbered, and the numbered flags identified on the site plans.

4. Determine if the BVW boundary in the field matches the site plans. If the site plans were drawn incorrectly, they should be adjusted accordingly.

5. Determine whether the BVW boundary is accurately delineated:

    - If the delineation is based on vegetation alone, confirm that the site is not disturbed, review the vegetative community to determine if all of the dominant plants are OBL and/or FACW wetland indicator plants, and determine whether the wetland boundary is clear and abrupt. Review materials submitted by the applicant for evidence of disturbance or early successional stages of vegetation. If any of these conditions (no disturbance, all dominant plants are OBL or FACW, and the boundary is clear and abrupt) are not met, then soils and Other Indicators of Hydrology must also be used to delineate the BVW.

- If the delineation is based on vegetation, soils, and Other Indicators of Hydrology review the vegetative community to determine if 50 percent or more of the dominant plants are wetland indicator plants. Examine soils on each side of the delineated boundary to determine whether hydric soils are present. You can examine the applicant's soil test pits or dig new ones (or use a Dutch auger for spot checks). In addition, consider the presence or absence of Other Indicators of Hydrology and look for field indicators, such as topographic changes, variation in the herbaceous plant community, or an obvious change in the presence or absence of one or more specific plant species, that can be used to locate the precise wetland boundary.

6. If there are questions about the location of the BVW boundary:

   - Ask the person who delineated the boundary to explain their decision in areas where you have questions. Request additional Data Forms and transects in specific areas that are in dispute after an onsite assessment. If additional fieldwork is requested for a certain area, the Issuing Authority should indicate why it has questions or concerns about that portion of the delineation (e.g., the boundary does not appear to reflect a change in the vegetative community in a specific area).

   - If agreement with the applicant cannot be reached, the Issuing Authority may need to determine the location of the BVW boundary. In these circumstances, the Issuing Authority should adjust the delineation by hanging flags in the field or making notes on the plans (e.g., flag A-12, moved 15 ft. up gradient). The applicant should submit a revised site plan showing the Issuing Authority's BVW boundary. When adjusting the BVW boundary, it is important to rely on the judgement of someone (e.g., a commissioner, municipal conservation staff, MassDEP personnel, or a consultant) who has experience and expertise in wetlands delineation, especially when that adjusted BVW line is disputed by the applicant.

Appendix A
Bordering Vegetated Wetland Determination Form

Bordering Vegetated Wetland Determination Form Instructions

The *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands* recommends the use of the Bordering Vegetated Wetland (BVW) Determination Form (Form) to document the presence and/or absence of wetlands and delineate wetland boundaries. This appendix provides instructions for completing the site information, hydrology, vegetation, and soil indicator sections based on data collected during the wetland determination. Note that the Form is only part of a complete delineation report. Information submitted in the Form should align with submitted photographs and site figures. Photographic logs typically include photos of the sampling location and soil details, along with any other information noted in the Form. BVW delineation figures typically include sampling point locations overlain on aerial photography, topographic maps, and/or soil maps.

Best professional judgement should be used to determine how many Forms should be completed for each site. In most cases, one wetland Form and one non-wetland Form should be completed for each delineated wetland. On a larger site with numerous delineated wetlands that are homogenous (same Cowardin wetland classification), one wetland Form and one corresponding non-wetland Form can serve as the data for several delineated features. Conversely, if a delineated wetland consists of numerous wetland classifications, more than one wetland Form should be submitted for each corresponding wetland type.

The Form can also be used to document the absence of BVWs when submitting documents to an Issuing Authority. If the proposed site does not contain any U.S. Department of Agriculture (USDA)-mapped hydric soils, or National Wetland Inventory (NWI) or Massachusetts Department of Environmental Protection (MassDEP) – mapped wetlands, one non-wetland sampling point and a completed Form should be submitted. The location of that sampling point should be selected at the lowest elevation on the site. If the project site contains USDA-mapped hydric soils or MassDEP-mapped wetlands that are not BVWs, the Issuing Authority should receive completed Forms for each one of those locations.

The goal of the Form is to align with the USACE Wetland Determination Data Sheets to the extent possible. More information can be found within the below reference:

U.S. Army Corps of Engineers. 2012. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast region (Version 2.0),* ed. J.S. Wakeley, R.W. Lichvar, C.V. Noble, and J.F. Berkowitz. ERDC/EL TR-12-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Site Information: General site Information is needed to adequately describe the location and provide sampling details. This information is integral for the Form reviewer to understand the location and any potential discrepancies between submitted site characteristics and desktop references. For instance, if the submitted data point occurs within an USDA – mapped hydric soil and/or MassDEP-mapped wetland, the reviewer should perform a more-thorough review of this location if the applicant suggests it is not a wetland.

Project Site: Enter the name of the project. The project name should align with all submittals to the conservation commission(s).

City/Town: List the associated town(s). If the project overlaps multiple towns, list all that are applicable.

Sampling Date: Enter the date when the site visit was performed. This can be particularly relevant for documenting when/if soil conditions were frozen or for comparison with site photographs.

Applicant/Owner: The applicant/owner should align with all submittals to the Issuing Authority.

Sampling Point: This field on the Form indicates the sampling point evaluated in the field corresponding to a point depicted on the delineation site plans. Typical sampling point designations include either wetland or non-wetland followed by the sample number (e.g., WET-1, NONWET-1, etc.). The sampling points labeled in the field should align with submitted delineation figures/maps that depict the specific location of each sampling point.

Investigator(s): List the field delineator(s) completing the form

Latitude/Longitude: Enter the latitude and longitude for the sampling point. This should also be indicated on the submitted figures and forms.

Soil Map Unit Name: List the USDA soil type where the sampling point was located. If the sampling location occurs within a hydric soil, the reviewer should pay close attention to data sheets submitted that indicate the soils are non-hydric. The USDA Natural Resources Conservation Service provides and maintains the Web Soil Survey map (available at https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).

National Wetlands Inventory or DEP Classification: If the sampling point location occurs within an U.S. Fish and Wildlife Service NWI map, list the Cowardin wetland classification code.
The U.S. Fish and Wildlife Service provides and maintains the map at: https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/. Additionally, if the sampling point location occurs within a MassDEP-mapped wetland as indicated on the MassDEP Online Map Viewer, list the wetland abbreviation (e.g., SM = salt marsh, SS = shrub swamp, etc.). If the sampling point is not mapped as wetland, enter “none”. The MassDEP GIS layer is at: http://maps.massgis.state.ma.us/images/dep/omv/wetviewer.htm.

Are climatic/hydrologic conditions on the site typical for this time of year? Drought and unusually wet weather should be considered when performing a BVW delineation. Indicate whether the delineation was conducted under either of these conditions. Details should be discussed in the Remarks (discussed below) section.

Are Vegetation/Soil/Hydrology significantly disturbed? Are Vegetation/Soil/Hydrology naturally problematic? Both questions are discussed in Chapter 5 of the USACE’s regional supplement referenced above. In general, difficult or problematic sites must be assessed using the best information available to the field investigator at the time of the delineation and interpreted with best professional judgement.

Summary of Findings — The Summary of Findings provides an overview of the remaining sections of the Form. The goal of the Summary of Findings is for the Issuing Authority to be able to quickly identify if a sampled location occurred within a wetland, determine if the area was flagged (and how many flags were used to delineate it), and determine whether there are photographs for the sampled location in the accompanying photograph log, if provided.

Wetland vegetation criterion met? Following completion of the Vegetation section of the Form, indicate "yes" or "no" whether field observations supported a conclusion that vegetation in the sampled area met the criterion for a wetland plant community.

Hydric Soils criterion met? Following completion of the Soil section of the Form, indicate "yes" or "no" whether field observations identified hydric soils.

Wetlands hydrology present? Following completion of the Hydrology section of the Form, indicate "yes" or "no" whether the field observations, including vegetation, soils, and Other Indicators of Hydrology were sufficient to conclude that the sampled area has wetland hydrology.

Is the Sampled Area within a Wetland? Following completion of the Hydrology, Vegetation, and Soils sections, indicate "yes" or "no" if the sampled area occurs within a wetland.

Remarks, Photo Details, Flagging, etc.: Provide details on potential disturbances or if any of the criteria were problematic. Indicate photograph numbers in the corresponding photograph log that indicate site conditions for this sampling point. If the sampling point is associated with a wetland, list the flags used to delineate the boundary.

Hydrology (Field Observations) — Respond to each of the three questions as applicable.

Surface Water Present? If surface water is observed, indicate "yes" and provide the depth at which it was observed. If surface water depth varies across the site, indicate the range of depth in the Remarks section.

Water Table Present? If a water table is observed, indicate "yes" and provide the depth beneath the ground surface (within 12 inches [in.]) that the water level occurs. Note that this section is typically filled out after digging a soil pit for the Form's Soil section.

Saturation Present (including capillary fringe)? If saturation occurs within the soil, indicate "yes" and record the depth (within 12 in. of the soil surface) to which it occurs. This may be observed as water glistening on the surfaces and/or broken interior faces of soil samples removed from the soil pit. For groundwater saturation, this should occur when an existing water table is immediately below the saturated zone. For surface water saturation, this will likely only occur when a restrictive soil layer (e.g., agricultural hardpan) or bedrock exists within 12 in. of the surface.

Hydrology (Wetland Hydrology Indicators) — Assess the site for hydrologic indicators.

Reliable Indicators of Wetlands Hydrology — Mark all that apply. Each indicator is described in Chapter 4 of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands.*

Indicators that can be Reliable with Proper Interpretation — Mark all that apply. Each indicator is described in Chapter 4 of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands.*

Indicators of the Influence of Water — Mark all that apply. Each indicator is discussed in Chapter 4 of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands.*

Remarks — General site hydrology should be noted in this field. If surface water depth, water table, or saturation depths vary, ranges should be provided. If there is evidence that hydrology conditions have changed, provide details (e.g., historical aerial photography shows inundation, but the soils were dry during the site visit, etc.).

Vegetation — Record the plant species, percent cover, and indicator status in the plot for each vegetative stratum. Vegetative information should be collected for each stratum where the total percent cover for that stratum is 5 percent or greater. Within each stratum, record all species with greater than 1 percent cover. Perform the Rapid Test, Dominance Test, or Prevalence Test to determine if the vegetative community is wetland or non-wetland.

Plot size: If a variable-size observation plot is used, record the approximate size of the plot and use that plot to assess plant species abundance for all strata. If small observation plots are used, plot size varies for each stratum. In general, it is recommended that for small observation plots, the Tree Stratum and Woody Vine Stratum be sampled in a 30-foot radius plot, the Sapling/Shrub Stratum be sampled in a 15-foot radius plot, and the Herb Stratum be sampled in a 5-foot radius plot. If multiple plots are used for a stratum, combine results (i.e., average percent cover for each species across plots) before entering data in the Form.

Common name: List the colloquial name of the plant.

Scientific name: List the scientific name of the plant (i.e., *Genus species*).

Indicator Status: List the associated Wetland Indicator Status for each plant as shown in the USACE's*, Northcentral and Northeast Region, National Wetland Plant List, version 3.0* (2020) or more current version. Indicator status categories are OBL = obligate, FACW = facultative wetland, FAC = facultative, FACU = facultative upland, and UPL = upland.

Absolute Percent Cover: For each species in each stratum, estimate the percent of the ground surface that would be covered if foliage from a particular species or vegetative layer was projected on the ground, ignoring small gaps between the leaves and branches**.**

Dominant (yes/no)? Dominant species should be identified using the 50/20 Rule of the Dominance Test as described in Appendix B of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands*.

Wetland Indicator (yes/no)? The Massachusetts Wetlands Protection Act (WPA) Regulations define wetland indicator plants as 1) those plant species with an indicator status of OBL, FACW, and FAC; 2) species listed in the WPA; and 3) individual plants that exhibit morphological or physiological adaptations to life in saturated or inundated conditions. A list of wetland indicator species is included in Appendix C of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands*. Eastern hemlock (*Tsuga canadensis*) is the only plant species listed in the WPA that doesn't have an indicator status of OBL, FACW or FAC.

Total Percent Cover: Total Percent Cover is the sum of Absolute Percent Cover for all plants within a stratum. This value can be less than 100 percent (if space exists between plants) or greater than 100 percent (if plants within a stratum substantially overlap).

Rapid Test: Indicate "yes" or "no" whether all dominant plant species have an indicator status of OBL or FACW. The Rapid Test is described in Appendix B of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands*.

Dominance Test: Record in this section of the Form, the number of dominant plant species for the sampled area, the number of dominant species that are Wetland Indicator Plants, and whether Wetland Indicator Plants make up ≥ 50% of dominant plant species. The Dominance Test is described in Appendix B of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands.* It is not necessary to conduct a dominance test if the rapid test determines the vegetative community to be wetland.

Prevalence Index: Use this section of the Form to calculate the Prevalence Index for the sampled area. It is not necessary to calculate the Prevalence Index if either the Rapid Test or Dominance Test determines the vegetative community to be wetland. The Prevalence Index is described in Appendix B of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands.*

Wetland vegetation criterion met? Following completion of the Vegetation section of the Form, indicate "yes" or "no" whether the Wetland Vegetation Criterion was met by either the Rapid Test, Dominance Test, or Prevalence Index.

Soil (Profile Description) — Dig a shallow test pit (at least 18 inches) and assess the vertical layers and associated details.

Depth: The depth range of each layer is recorded in inches with starting and ending depths separated using a dash (e.g., 0 — 2 in., 2 — 4 in., etc.) The upper limit of each subsurface layer should match the lower limit of the layer above. Users should start with a depth of 0-in.

Matrix Color and Percent: Soil matrix colors should be recorded using the same format provided by the Munsell Soil Color Book (e.g., 10YR 3/1) for each depth range (e.g., 0 — 2 in., 2 — 4 in., etc.). The percent for the matrix color(s) and redox feature(s) should combine to 100 percent.

Redox Features Color and Percent: Soil matrix colors should be recorded using the same format provided by the Munsell Soil Color Book (e.g., 10YR 3/1) for each depth range (e.g., 0 — 2 in., 2 — 4 in., etc.). Note that it is common to have multiple Redox colors within each depth range. The percent for the matrix color(s) and redox feature(s) should combine to 100 percent.

Type & Location: Codes for the "Type" and "Location" of redox features are listed at the bottom of the Profile Description section of the Form. Redox feature "Types" include concentration (C), depletion (D), reduced matrix (RM), and masked sand grains (MS). Redox feature "Locations" include pore lining (PL), and matrix (M). If the redox features of the layer being examined is observed in a combination of locations, "PL/M" should be entered into the data field.

Texture: Texture designations and guidance on describing soils and determining soil textures can be found in Appendix E of *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands.*

Remarks: Report the contrast between the soil matrix and redox feature colors as "prominent", "distinct", or "faint" in the remarks column for each entry in the Profile Description section of the Form. More information on soil contrast details can be found in Chapter 3 of the USACE's *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast region (Version 2.0)* (2012). Any additional remarks should be recorded in the "Remarks" section below the list of hydric soil indicators.

Soil (Hydric Soil Indicators): Check all that apply. Assess the soils and determine if they meet the definition of any hydric soil indicator(s) described in Chapter 3 or Appendix F of the *Massachusetts Handbook for the Delineation of Bordering Vegetated Wetlands*. The Handbook focuses on commonly encountered hydric soil indicators that generally occur at or near the wetland/upland boundary. A comprehensive list of all hydric soils in Massachusetts is in Chapter 3 of the USACE's *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast region (Version 2.0)* (2012).

Soil (Restrictive Layer): Indicate if a soil layer is observed that restricts water infiltration, such as bedrock or an agricultural hardpan. Additional restrictions that prevent digging a soil pit (e.g., thick roots, debris, etc.) can also be indicated here.

Remarks: Include any additional remarks here including, but not limited to, if the soils are disturbed or problematic, details on the restrictive layer, etc.

Hydric Soils criterion met? Following completion of the Soil section of the Form, indicate "yes" or "no" whether field observations determined that soils in the sampled area were hydric.

BORDERING VEGETATED WETLAND DETERMINATION FORM

Project/Site: ________________________________ City/Town:____________________Sampling Date: ________________

Applicant/Owner: ____ Sampling Point or Zone: ________________

Investigator(s):____Latitude/Longitude: __________________________

Soil Map Unit Name: ______________________________________ NWI or DEP Classification: _______________________

Are climatic/hydrologic conditions on the site typical for this time of year? Yes______No _____ (If no, explain in Remarks)

Are Vegetation ________ , Soil_______ , or Hydrology _______ significantly disturbed? (If yes, explain in Remarks)

Are Vegetation ________ , Soil_______ , or Hydrology _______ naturally problematic? (If yes, explain in Remarks)

SUMMARY OF FINDINGS – Attach site map and photograph log showing sampling locations, transects, etc.

Wetland vegetation criterion met? Yes ______ No _____ Hydric Soils criterion met? Yes ______ No _____ Wetlands hydrology present? Yes ______ No _____	**Is the Sampled Area within a Wetland?** Yes ____ No ______
Remarks, Photo Details, Flagging, etc.:	

HYDROLOGY

Field Observations:		
Surface Water Present? Yes _______ No ________ Depth (inches) __________		
Water Table Present? Yes _______ No ________ Depth (inches) __________		
Saturation Present (including capillary fringe)? Yes _______ No ________ Depth (inches) __________		
Wetland Hydrology Indicators		
Reliable Indicators of Wetlands Hydrology	Indicators that can be Reliable with Proper Interpretation	Indicators of the Influence of Water
_____ Water-stained leaves _____ Evidence of aquatic fauna _____ Iron deposits _____ Algal mats or crusts _____ Oxidized rhizospheres/pore linings _____ Thin muck surfaces _____ Plants with air-filled tissue (aerenchyma) _____ Plants with polymorphic leaves _____ Plants with floating leaves _____ Hydrogen sulfide odor	_____Hydrological records _____Free water in a soil test hole _____Saturated soil _____Water marks _____Moss trim lines _____Presence of reduced iron _____Woody plants with adventitious roots _____Trees with shallow root systems _____Woody plants with enlarged lenticels	____ Direct observation of inundation ____ Drainage patterns ____ Drift lines ____ Scoured areas ____ Sediment deposits ____ Surface soil cracks ____ Sparsely vegetated concave surface ____ Microtopographic relief ____ Geographic position (depression, toe of slope, fringing lowland)
Remarks (describe recorded data from stream gauge, monitoring well, aerial photos, previous inspections, if available):		

This form is only for BVW delineations. Other wetland resource areas may be present and should be delineated according to the applicable regulatory provisions.

Sampling Point ___________

VEGETATION – Use both common and scientific names of plants.

Tree Stratum Plot size ___________________________

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

__________ = Total Cover

Shrub/Sapling Stratum Plot size ___________________________

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

__________ = Total Cover

Herb Stratum Plot size ___________________________

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					

__________ = Total Cover

Sampling Point ___________

VEGETATION – continued.

Woody Vine Stratum	Plot size ________________________				
Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1.					
2.					
3.					
4.					
			_________ = Total Cover		

Rapid Test:	Do all dominant species have an indicator status of OBL or FACW?			Yes _______ No_______
Dominance Test:	Number of dominant species	Number of dominant species that are wetland indicator plants		Do wetland indicator plants make up ≥ 50% of dominant plant species? Yes _______No ________
Prevalence Index:		Total % Cover (all strata)	Multiply by:	Result
	OBL species		X 1	=
	FACW species		X 2	=
	FAC species		X 3	=
	FACU species		X 4	=
	UPL species		X 5	=
	Column Totals	(A)		(B)
	Prevalence Index	B/A =		Is the Prevalence Index ≤ 3.0? Yes _______No ________
Wetland vegetation criterion met?	**Yes _________ No __________**			

Definitions of Vegetation Strata

Tree -	Woody plants 3 in. (7.62 cm) or more in diameter at breast height (DBH), regardless of height
Shrub/Sapling -	Woody plants less than 3 in. (7.62 cm) DBH and greater than or equal to 3.3 ft. (1 m) tall
Herb -	All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.3 ft. (1 m) tall
Woody vines -	All woody vines greater than 3.3 ft. (1 m) in height

Cover Ranges	
Range	Midpoint
1-5 %	3.0 %
6-15 %	10.5 %
15-25 %	20.5 %
26-50 %	38.0 %
51-75 %	63.0 %
76-95 %	85.5 %
96-100 %	98.0 %

Sampling Point ___________

SOIL

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators)

Depth (inches)	Matrix		Redox Features				Texture	Remarks
	Color (moist)	%	Color (moist)	%	Type[1]	Location[2]		

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators (Check all that apply)		**Indicators for Problematic Hydric Soils**
____ Histosol (A1)	____ Sandy Redox (S5)	____ 2 cm Muck (A10)
____ Histic Epipedon (A2)	____ Stripped Matrix (S6)	____ 5 cm Mucky Peat or Peat (S3)
____ Black Histic (A3)	____ Polyvalue Below Surface (S8)	____ Dark Surface (S7)
____ Hydrogen Sulfide (A4)	____ Thin Dark Surface (S9)	____ Polyvalue Below Surface (S8)
____ Stratified Layers (A5)	____ Loamy Mucky Mineral (F1)	____ Thin Dark Surface (S9)
____ Depleted Below Dark Surface (A11)	____ Loamy Gleyed Matrix (F2)	____ Iron-Manganese Masses (F12)
____ Thick Dark Surface (A12)	____ Depleted Matrix (F3)	____ Mesic Spodic (A17)
____ Sandy Mucky Mineral (S1)	____ Redox Dark Surface (F7)	____ Red Parent Material (F21)
____ Sandy Gleyed Matrix (S4)	____ Depleted Dark Surface (F8)	____ Very Shallow Dark Surface (TF12)
____ Dark Surface (S7)		____ Other (Include Explanation in Remarks)

Restrictive Layer (if observed) Type: ______________________________ Depth (inches): ________

Remarks:

Hydric Soils criterion met? Yes _________ No __________

Appendix B
Assessing the Vegetative Community

Measuring Plant Abundance

Measuring plant abundance is an integral process in assessing the vegetative community. This Appendix, along with the information in Chapter Two, provides detailed information on how to measure plant abundance and fill out and/or review the vegetation section on the *Bordering Vegetated Wetland Determination Form* (Appendix A).

Vegetative Strata (Layers)

For the purposes of assessing vegetative communities, plants are divided into strata, or layers, for analysis. Four strata are used in this assessment: herb, sapling/shrub, woody vine, and tree:[6]

- The herb stratum: includes woody vegetation less than 3.3 feet (ft.) in height (seedlings), woody vines less than 3.3 ft. in height, and all non-woody vegetation (e.g., ferns, clubmosses, grasses, sedges, rushes, forbs, herbs, and mosses) of any height.
- Shrubs and saplings: woody vegetation greater than or equal to 3.3 ft. in height, but less than 3 inches (in.) in diameter at breast height (DBH).
- Trees: woody plants with a DBH of 3 in. or greater regardless of height.
- Woody vines: woody vines greater than 3.3 ft. in height.

Observation Plots

Observation plots are used for measuring or estimating plant abundance. The size and number of plots should be based on the complexity of the site. Water bodies often have an adjacent area of obvious wetland with a transition zone further from the water body that eventually yields to an upland area. Observation plots need not be in areas of obvious wetland or obvious upland but should be located in relatively uniform vegetative zones on each side of the presumptive boundary. Plots should be representative of the vegetative community being assessed. The process of establishing observation plots typically includes an informal vegetation analysis prior to formal data collection.

Variable-size Observation Plots

The recommended approach for establishing observation plots is to use large, variable-size plots that extend 50 ft. perpendicular from a transect line in each direction and extending the length of the transect within the vegetative zone being evaluated (Figure B.1). Vegetative zones are areas of relatively homogeneous vegetation, elevation, and topography. These relatively large plots avoid having to make decisions about the appropriate number and placement of smaller plots but require the delineator to estimate percent cover over a larger area. Only include in the plot those areas within 50 ft. of the transect line that are within the vegetative zone being evaluated.

[6] The previous version of the Handbook used five strata; this version of the Handbook adopts the current federal approach using four strata. The reduction in strata from five to four is the result of combining shrubs and saplings into a single stratum. There are also some minor changes in strata names and definitions.

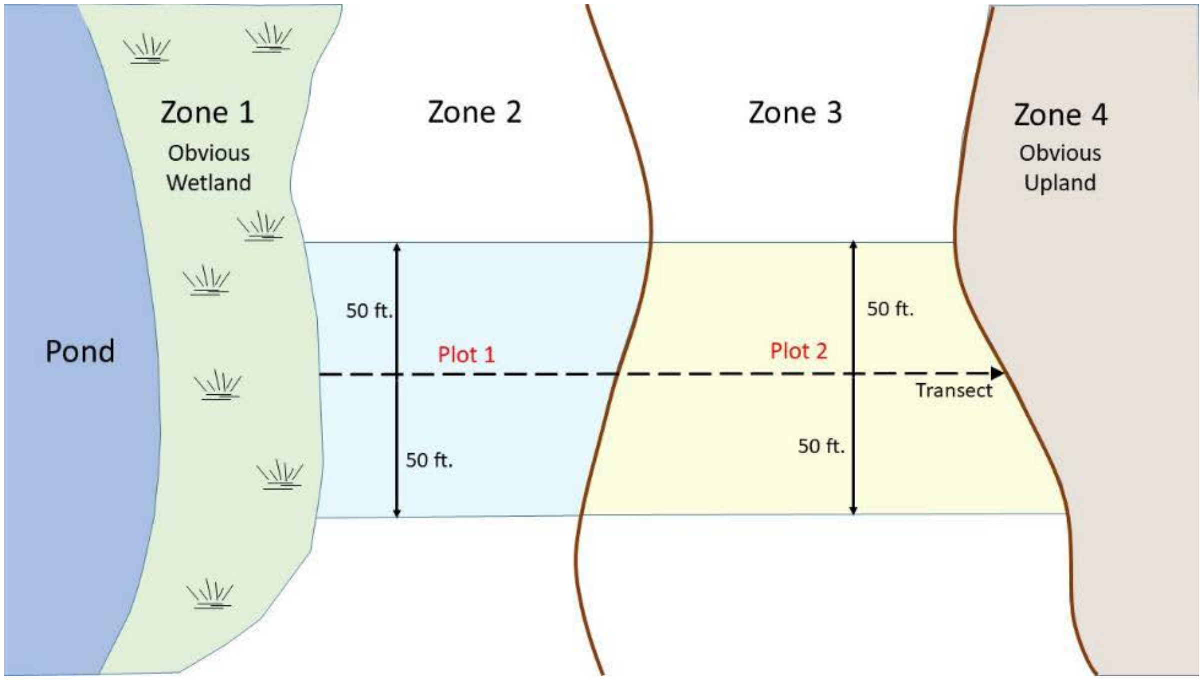


Figure B.1. Configuration of Variable-size Observation Plots. Zone 1 is an obvious wetland and Zone 4 is obviously upland. Zones 2 and 3 are areas of relatively uniform vegetation, elevation and topography between an obvious wetland and obvious upland. The Bordering Vegetated Wetland (BVW) boundary is likely to be in the area where Zones 2 and 3 meet. Plot 1 for vegetation assessment extends 50 ft. perpendicular out in both directions from the transect line including only Zone 2 vegetation. Plot 2 is an area that includes that portion of Zone 3 than falls within 50 ft. of the transect line. Assessment of the vegetative communities should be conducted separately for Zones 2 and 3 using the entire areas of Plot 1 and Plot 2.

Small Observational Plots

As an alternative to large, variable-size plots, multiple smaller observational plots can be used instead. Small plot sampling is typically used as part of a replicate sampling procedure (Figure B.2). With small observational plots there is a risk that the number and placement of plots may not be adequate to characterize the entire zone.

When using small observational plots, circular plots with the following dimensions are recommended.

Circular plot dimensions	
Herb stratum	5-ft. radius
Shrub/sapling stratum	15-ft. radius
Woody vine stratum	30-ft. radius
Tree stratum	30-ft. radius

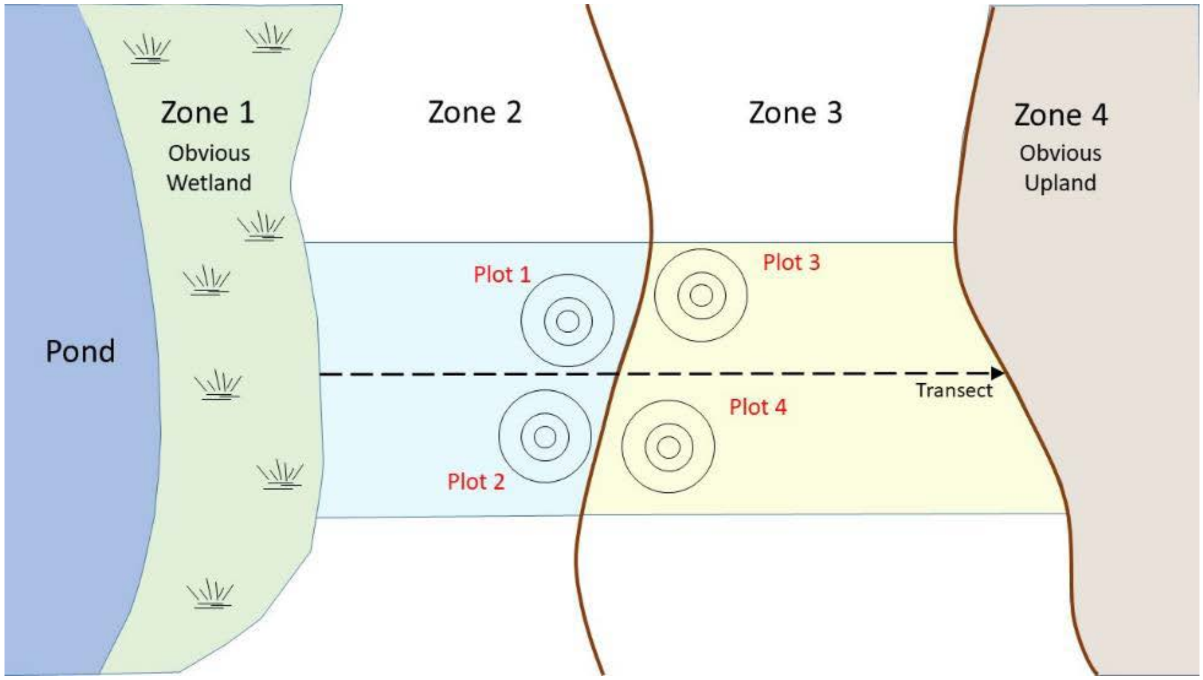


Figure B.2. Configuration of Small Observation Plots. The BVW boundary is likely to be in the area where Zones 2 and 3 meet. Each plot contains concentric circular plots near the presumptive boundary for evaluating trees and woody vines (30 ft.), shrubs & saplings (15 ft.) and herbs (5 ft). There are two plots each for Zones 2 and 3 because of the desirability of having replicates (multiple samples) when using small plot sizes.

The sampling plot should not include vegetation from any other vegetation zones (i.e., should not extend into an adjacent community having different vegetation, soil, or hydrologic conditions, nor should it include plants rooted in an adjacent community). Plot locations should be selected to ensure that the vegetative stratum being sampled is representative of the plant community within the zone being assessed. Plot size and shape may be varied to ensure that the plot contains only vegetation from the appropriate zone. For example, when assessing a linear wetland on the shoulder of a road, the recommended circular plot dimension should be adjusted to reflect the linear nature of the wetland. An adjustment is commonly required for small vegetative zones (i.e., smaller than radii recommended above) and/or in areas where the land may have been disturbed.

At the site, do a quick check of the vegetation and identify the strata involved. When choosing your plots, be sure that the vegetation in your sample plot is representative of the vegetation in that stratum as a whole. From a central location (using a tape measure), measure circular plots to the size noted for each stratum. Tie flags in the vegetation or use stakes to mark the boundaries of your circular plots.

As you become more comfortable and experienced doing this analysis, you will be able to estimate plot sizes. You should begin your assessment with the herb stratum (if present) before this stratum is trampled. With the observation plots marked, you can now evaluate plant abundance for each stratum and species in the plot using percent cover.

Percent Cover

Absolute percent cover (percent cover) is a simple metric for evaluating plant abundance and can be used for all strata (herb, shrub/sapling, woody vine, and tree). Percent cover is the percent of the ground surface that would be covered if the foliage from a particular species or stratum were projected onto the ground, ignoring small gaps between the leaves and branches. Foliage from different plant species in the same stratum can overlap, and as a result, total percent cover for a given stratum may exceed 100 percent.

Percent cover can be estimated visually, or it can be measured using techniques such as point-intercept or quadrat sampling methods (for more information about these techniques, consult the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region, Version 2.0*). For most sites, however, a visual estimation of percent cover is likely to yield an accurate result. The accuracy should improve as you become more familiar with the percent cover method.

To visually estimate percent cover in the field, it is necessary to be able to focus your attention on one stratum, and often, one plant species within the stratum. Visual estimates of percent cover can be highly variable when observations from different individuals are compared. This variability can be reduced by using cover ranges. The following cover ranges should be used when visually estimating percent cover. When using cover ranges, the midpoint values noted below should be used for analyses of vegetative communities.

Cover Ranges	
Range	Midpoint
1-5%	3.0
6-15%	10.5
16-25%	20.5
26-50%	38.0
51-75%	63.0
76-95%	85.5
96-100%	98.0

It may be useful to ask a series of questions when estimating percent cover. Is the percent cover for the species greater than 5 percent? If so, is it greater than 15 percent? 25 percent? 50 percent? Once you've answered "no" to a particular threshold, you have identified the appropriate cover range: the range directly below the threshold that was not exceeded. You should then use that range's midpoint value as the percent cover for that plant species. For example, if the cover range of 26 to 50 percent is selected, the midpoint value of 38 percent should be used. Using cover ranges and midpoint values reduces the variability of results from different people.

When estimating or measuring percent cover, include any foliage in the stratum that extends over the observation plot only if the stem or trunk of the plant originates within the plot, or if outside the plot, if the plant is growing under the same soil and hydrologic conditions (i.e., same vegetative zone).

Plant abundance should be estimated or measured and recorded for each stratum where the total percent cover (combined percent cover for all species in the stratum) is 5 percent or greater. Within each of those strata, estimate or measure plant abundance for each species. Any plant species with 1 percent cover or less should not be included. Once plant abundance has been measured or estimated in each stratum, use the following hierarchy of methods to determine whether a wetland vegetative community occurs on the site.

Vegetative Community Analysis

MassDEP recommends use of a hierarchy of assessment methods to determine whether the area supports a wetland or non-wetland vegetative community, beginning with the least time-intensive method and moving on to more time-intensive methodologies only if necessary. The first two levels in this hierarchy are based on the dominant plants in each of the vegetative strata with a total percent cover of 5 percent or more. Additional information about how to determine which plants are dominant plants is provided in the section detailing the Dominance Test procedure. The three levels of the hierarchy are:

- Rapid Test
- Dominance Test
- Prevalence Index

Level 1: Rapid Test for a Wetland Vegetative Community

If all dominant plants (dominant plants for all strata with total percent cover of 5 percent or more) consist of species with an indicator status of obligate wetland (OBL) or facultative wetland (FACW), then the vegetative community is wetland, and no further vegetation analysis is needed. This is meant to be a rapid test for situations where it is obvious that all dominant plants in the vegetative community are OBL or FACW species. If not all dominant plant species fall within these indicator status categories, proceed to Level 2. Dominant species are defined as they would be for the Dominance Test (Level 2) and should be recorded on the Data Form, but it should not be necessary to use intensive sampling or calculations to determine dominance. If there is any doubt that all dominant species have an indicator status of OBL or FACW, proceed to Level 2.

Level 2: Dominance Test

The dominance test is an assessment approach that uses dominant plants within an observation plot to determine if the plot supports a wetland or a non-wetland vegetative community. If, among the dominant species in a plot, the number of wetland indicator plants is equal to or greater than the number of non-wetland indicator plants, the vegetation of that observation plot is considered to be a wetland vegetative community. Results of the dominance should be interpreted as follows.

- If the vegetative community is determined by the dominance test to be wetland, then no further vegetation analysis is needed.

- If the vegetative community is determined by the dominance test to be non-wetland, hydric soils and Other Indicators of Hydrology are absent, and the site is undisturbed, then no further vegetation analysis is needed, and the vegetative community is considered non-wetland.

- If the vegetative community is determined by the dominance test to be non-wetland and either hydric soils or Other Indicators of Hydrology are present, then proceed to Level Three.

The Dominance Test Procedure Summary

1. **Evaluate percent cover:** For each observation plot do the following:
   a. Identify the vegetative strata (herb, shrub/sapling, woody vine, tree) that have a total percent cover of 5 percent or more within the observation plot. Only those strata with a total percent cover of 5 percent or greater are to be used for the dominance test.
   b. For each vegetative stratum, estimate or measure percent cover for each plant species in the stratum. Any plant species with 1 percent cover or less should not be included. If you know a plant's name, list the name and the plant's estimated percent cover on the Data Form. If you do not recognize a plant (i.e., do not know a plant's common name or scientific name), use a generic identifier for the plant (e.g., Species A, B, C, et cetera) and list the plant's percent cover. If it ends up that an unidentified species is not a dominant plant, or if dominant, would not affect the determination (wetland vs. non-wetland) as either a wetland indicator plant or not, then it is not essential that the plant be identified to species. If the unidentified plant could affect the determination, then the plant species must be identified (or move on to a Level 3 assessment).

2. **Determine percent dominance for plants in each stratum:** For those strata within the observation plot with 5 percent cover or more, determine percent dominance for each plant species as follows:
   a. Add up percent cover for all plant species in the stratum to determine the total percent cover for each stratum.
   b. Divide the percent cover for each plant species by the total percent cover for the stratum and multiply this by 100. This will yield percent dominance for each plant species in each stratum.

3. **Identify dominant plants:** Within the observation plot, identify the dominant plants in each stratum:
   a. Beginning with the most abundant plant species, list the plants in the stratum until the cumulative total for percent dominance meets or exceeds 50 percent. In some cases, this will only be one plant species; in other cases, two or more species may be needed to meet or exceed the 50-percent threshold. Those species that individually or together meet or exceed the 50-percent threshold are considered dominant plants for the stratum.
   b. Other plant species, not already listed in 3a, with a percent dominance of 20 percent or greater are also considered dominant plants and are listed as such.
   c. If other plant species in the individual stratum have the same percent dominance as any plant species listed in 3a or 3b, those species also are dominant plants and should be listed as such.
   d. Those plants that meet the criteria above in 3a, 3b, or 3c are dominant plants for the stratum. Identify the scientific name and wetland indicator status for all dominant plants. The wetland indicator status should be taken from the U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5

4. **Determine whether the plant community is wetland or non-wetland:**
   a. List the dominant plants (from 3a, 3b, and 3c above) for all strata being evaluated. A plant species may appear more than once on this list if it is a dominant plant in more than one stratum.
   b. Determine how many of the dominant plants are wetland indicator plants according to the Regulations. Wetland indicator plants are 1) plant species listed in the Wetlands Protection Act (see Appendix C), 2) plants in the genus Sphagnum, 3) plants in the U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5 classified as OBL, FACW, and FAC, and 4) any individual plants demonstrating morphological or physiological adaptations to life in saturated or inundated conditions.
   c. Determine the total number of wetland indicator plants and the total number of plants that are not wetland indicator plants.
   d. If the number of wetland indicator plants is equal to or greater than the number of plants that are not wetland indicator plants, the vegetative community is considered to have met the vegetation criterion for a wetland.

Dominance Test Example

The dominance test determines a plant species' dominance by evaluating percent cover. Information on percent cover is recorded for all plant species in each vegetative stratum (herb, shrub/sapling, woody vine, tree) present in the observation plot (plants with a percent cover less than 1 percent are excluded), but only for those strata with total percent cover greater than 5 percent. Once dominant plants have been identified in each stratum, they can be combined for purposes of the dominance test. Dominant plants from all strata are combined and the number of dominant species that are wetland indicator plants is determined.

The dominance test is less rigorous than other assessment techniques and can be performed fairly rapidly with practice. It is a method that generally yields good results. An Issuing Authority can apply the dominance test as a quick check in the field by visually identifying dominant plants in an area (without detailed estimates or measurements) and then determining whether 50 percent or more of the dominant plants are wetland indicator plants.

1. **Evaluate percent cover:** For each observation plot do the following:

   a. Identify the vegetative strata (herb, shrub/sapling, woody vine, tree) that have a **total percent cover** of 5 percent or more within the observation plot. Only those strata with a **total percent cover** of 5 percent or greater are to be used for the dominance test.

   b. For each vegetative stratum, estimate or measure percent cover for each plant species in the stratum. Any plant species with 1 percent cover or less should not be included. If you know a plant's name, list the name and the plant's estimated percent cover on the Data Form. If you do not recognize a plant (i.e., do not know a plant's common name or scientific name), use a generic identifier for the plant (e.g., Species A, B, C, et cetera) and list the plant's percent cover. If it ends up that an unidentified species is not a dominant plant, or if dominant, would not affect the determination (wetland vs. non-wetland) as either a wetland indicator plant or not, then it is not essential that the plant be identified to species. If the unidentified plant could affect the determination, then the plant species must be identified (or move on to a Level 3 assessment).

Example:

Plant Species	Scientific Name	Percent Cover
Herb stratum		
Canada mayflower	*Maianthemum canadense*	38.0
Cinnamon fern	*Osmundastrum cinnamomeum*	38.0
Partridge berry	*Mitchella repens*	10.5
Goldthread	*Coptis trifolia*	3.0
Princess pine	*Dendrolycopodium obscurum*	3.0
Shrub/sapling stratum		
Winterberry	*Ilex verticillata*	38.0
Red maple	*Acer rubrum*	20.5
Mountain laurel	*Kalmia latifolia*	10.5
Highbush blueberry	*Vaccinium corymbosum*	10.5
Smooth arrowwood	*Viburnum recognitum*	3.0

Woody vine		
Virginia creeper	*Parthenocissus quinquefolia*	3.0
Tree		
Red maple	*Acer rubrum*	38.0
Yellow birch	*Betula alleghaniensis*	20.5
Northern red oak	*Quercus rubra*	10.5

2. **Determine percent dominance for plants in each stratum**: For those strata within the observation plot with 5 percent cover or more, determine percent dominance for each plant species as follows:

    a. Add up **percent cover** for all plant species in the stratum to determine the **total percent cover** for each stratum.

Example:

Herb stratum	38.0 + 38.0 + 10.5 +3.0 + 3.0 = 92.5
Shrub/sapling stratum	38.0 + 20.5 + 10.5 + 10.5 + 3.0 = 82.5
Woody vine	< 5.0% (this stratum not used)
Tree stratum	38.0 + 20.5 + 10.5 = 69.0

    b. Divide the percent cover for each plant species by the total percent cover for the stratum and multiply this by 100. This will yield percent dominance for each plant species in each stratum.

Example:

Herb stratum		
Canada mayflower	(38.0/92.5) x 100 =	41.1
Cinnamon fern	(38.0/92.5) x 100 =	41.1
Partridgeberry	(10.5/92.5) x 100 =	11.4
Goldthread	(3.0/92.5) x 100 =	3.2
Princess pine	(3.0/92.5) x 100 =	3.2
Shrub/sapling stratum		
Winterberry	(38.0/82.50) x 100 =	46.1
Red maple	(20.5/82.5) x 100 =	24.8
Mountain laurel	(10.5/82.5) x 100 =	12.7
Highbush blueberry	(10.5/82.5) x 100 =	12.7
Smooth arrowwood	(3.0/82.5) x 100 =	3.6
Woody vine		
Virginia creeper		
Tree		
Red maple	(38.0/69.0) x 100 =	55.1
Yellow birch	(20.5/69.0) x 100 =	29.7
Northern red oak	(10.5/69.0) x 100 =	15.2

3. **Identify dominant plants:** Within the observation plot, identify the dominant plants in each stratum:

a. Beginning with the most abundant plant species, list the plants in the stratum until the cumulative total for **percent dominance** meets or exceeds 50 percent. In some cases, this will only be one plant species; in other cases, two or more species may be needed to meet or exceed the 50-percent threshold. Those species that individually or together meet or exceed the 50-percent threshold are considered dominant plants for the stratum.

b. Other plant species, not already listed in 3a, with a **percent dominance** of 20 percent or greater are also considered dominant plants and are listed as such.

c. If other plant species in the individual stratum have the same percent dominance as any plant species listed in 3a or 3b, those species also are dominant plants and should be listed as such.

Example:
In the herb stratum, Canada mayflower (*Maianthemum canadense*) (41.1%) does not break the 50-percent threshold, but the combined total for Canada mayflower and cinnamon fern (*Osmundastrum cinnamomeum*) (82.2%) does. Both species are considered dominant plants.

In the shrub/sapling stratum, winterberry (*Ilex verticillata*) and red maple (*Acer rubrum*) are considered dominant plants because they are the most abundant species in their stratum and their percent dominance taken together (70.9%) exceeds the 50-percent threshold.

In the tree stratum, the two most abundant species, red maple (*Acer rubrum*) and yellow birch (*Betula alleghaniensis*), are considered dominant plants. The most abundant plant, red maple (55.1%), alone exceeds the 50-percent threshold and is a dominant species. Yellow birch also is considered a dominant plant because its percent dominance (29.7%) exceeds the 20-percent threshold for a stratum.

d. Those plants that meet the criteria above in 3a, 3b, or 3c are dominant plants for the stratum. Identify the scientific name and wetland indicator status for all dominant plants. The wetland indicator status should be taken from the U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5

Example:

Dominant Plants	**Scientific Name**	**Wetland Indicator Status**
Herb stratum		
Canada mayflower	*Maianthemum canadense*	FACU
Cinnamon fern	*Osmundastrum cinnamomeum*	FACW
Shrub/sapling stratum		
Winterberry	*Ilex verticillata*	FACW
Red maple	*Acer rubrum*	FAC
Tree		
Red maple	*Acer rubrum*	FAC
Yellow birch	*Betula alleghaniensis*	FAC

4. **Determine whether the plant community is wetland or non-wetland:**

a. List the dominant plants (from 3a, 3b, and 3c above) for all strata being evaluated. A plant species may appear more than once on this list if it is a dominant plant in more than one stratum.

Example:

Dominant Plants	Stratum	Wetland Indicator Status
Canada mayflower (*Maianthemum canadense)*	Herb	FACU
Cinnamon fern (*Osmundastrum cinnamomeum)*	Herb	FACW
Winterberry (*Ilex verticillata)*	Shrub/sapling	FACW
Red maple (*Acer rubrum)*	Shrub/sapling	FAC
Red maple (*Acer rubrum)*	Tree	FAC
Yellow birch (*Betula alleghaniensis)*	Tree	FAC

b. Determine how many of the dominant plants are wetland indicator plants according to the Regulations. Wetland indicator plants are 1) plant species listed in the Wetlands Protection Act (see Appendix C), 2) plants in the genus Sphagnum, 3) plants in the U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5 classified as OBL, FACW, and FAC, and 4) any individual plants demonstrating morphological or physiological adaptations to life in saturated or inundated conditions.

Example:

Canada mayflower	*Maianthemum canadense*	FACU	
Cinnamon fern	*Osmundastrum cinnamomeum*	FACW	*
Winterberry	*Ilex verticillata*	FACW	*
Red maple	*Acer rubrum*	FAC	*
Red maple	*Acer rubrum*	FAC	*
Yellow birch	*Betula alleghaniensis*	FAC	*

Wetland Indicator Plant (*)

c. Determine the total number of wetland indicator plants and the total number of plants that are not wetland indicator plants.

Example:

Total number of wetland indicator plants (*) = 5
Total number of non-wetland indicator plants = 1

d. If the number of wetland indicator plants is equal to or greater than the number of plants that are not wetland indicator plants, the vegetative community is considered to have met the vegetation criterion for a wetland.

Example:

The area used for this example has six dominant plants. The total number of wetland indicator plants (5) is greater than the total number of species that are not wetland indicator plants (1), therefore, the vegetative community has met the vegetation criterion for a wetland.

Level 3: Prevalence Index

On rare occasions when results of a dominance test are inconsistent with evidence from soils and/or Other Indicators of Hydrology, the prevalence index should be used to determine whether the plant community is wetland or non-wetland. The prevalence index is a weighted average, calculated using all plant species (not just dominant species) that cover greater than 1 percent of the vegetative zone, without regard to strata. In order to use the prevalence index, it is necessary that plant species be identified (and have a designated wetland indicator status) for 80 percent of the total percent cover for the area being evaluated. If the prevalence index indicates that the plant community is wetland, no further vegetation analysis is needed, and the vegetative community is considered to be wetland. Otherwise, the vegetative community is considered non-wetland.

Prevalence Index Procedure

1. Use the same **percent cover** data as for the dominance test. Note that plants must be identified to species (and have a designated wetland indicator status) for at least 80 percent of the total percent cover.

2. List plant species by indicator status and include each plant's **percent cover**. For species listed in more than one strata combine the percent cover values for this list.

3. For each wetland indicator status (OBL, FACW, FAC, FACU, and UPL), sum the **total percent cover** for all species in that category.

4. Sum the percent cover values from all wetland indicator status categories (all categories combined).

5. Multiply the total percent cover for each wetland indicator status category by its **weighting factor** from the Table B.1.

Table B.1
Prevalence Index Weighting by Wetland Indicator Status

Wetland Indicator Status	Prevalence Index Weighting Factor
OBL	1
FACW	2
FAC	3
FACU	4
UPL	5

6. Sum the **weighted percent cover** values from all wetland indicator status categories (all categories combined).

7. Divided the **combined weighted percent cover** values (step 6) by the **combined percent cover** values (step 4). This is the **prevalence index**.

8. If the **prevalence index** is less than or equal to 3.0, the vegetative community has met the vegetation criterion for that wetland. Otherwise, the vegetative community is considered non-wetland.

Prevalence Index Example

1. Use the same **percent cover** data as for the dominance test. Note that plants must be identified to species (and have a designated wetland indicator status) for at least 80 percent of the total percent cover.

Example:

Plant Species	Scientific Name	Percent Cover
Herb stratum		
Canada mayflower	*Maianthemum canadense*	38.0
Cinnamon fern	*Osmundastrum cinnamomeum*	38.0
Partridge berry	*Mitchella repens*	10.5
Goldthread	*Coptis trifolia*	3.0
Princess pine	*Dendrolycopodium obscurum*	3.0
Shrub/sapling stratum		
Winterberry	*Ilex verticillata*	38.0
Red maple	*Acer rubrum*	20.5
Mountain laurel	*Kalmia latifolia*	10.5
Highbush blueberry	*Vaccinium corymbosum*	10.5
Smooth arrowwood	*Viburnum recognitum*	3.0
Woody vine		
Virginia creeper	*Parthenocissus quinquefolia*	3.0
Tree		
Red maple	*Acer rubrum*	38.0
Yellow birch	*Betula alleghaniensis*	20.5
Northern red oak	*Quercus rubra*	10.5

2. List plant species by indicator status and include each plant's **percent cover**. For species listed in more than one strata, combine the percent cover values for this list.

Example:

Plant Species	Scientific Name	Wetland Indicator Status	Calculation	Percent Cover
Cinnamon fern	*Osmundastrum cinnamomeum*	FACW	38.0	38.0
Goldthread	*Coptis trifolia*	FACW	3.0	3.0
Winterberry	*Ilex verticillata*	FACW	38.0	38.0
Highbush blueberry	*Vaccinium corymbosum*	FACW	10.5	10.5
Red maple	*Acer rubrum*	FAC	20.5 + 38.0	58.5
Smooth arrowwood	*Viburnum recognitum*	FAC	3.0	3.0
Yellow birch	*Betula alleghaniensis*	FAC	20.5	20.5
Canada mayflower	*Maianthemum canadense*	FACU	38.0	38.0
Partridge berry	*Mitchella repens*	FACU	10.5	10.5
Princess pine	*Dendrolycopodium obscurum*	FACU	3.0	3.0
Mountain laurel	*Kalmia latifolia*	FACU	10.5	10.5

Plant Species	Scientific Name	Wetland Indicator Status	Calculation	Percent Cover
Virginia creeper	*Parthenocissus quinquefolia*	FACU	3.0	3.0
Northern red oak	*Quercus rubra*	FACU	10.5	10.5

Note that red maple occurs in two strata, so the percent cover for those two strata are combined to calculate the percent cover for that species.

3. For each wetland indicator status (OBL, FACW, FAC, FACU, and UPL), sum the **total percent cover** for all species in that category .

Example:

Wetland Indicator Status	Calculation	Total Percent Cover
OBL	—	0.0
FACW	38.0 + 3.0 + 38.0 + 10.5	89.5
FAC	58.5 + 3.0 + 20.5	82.0
FACU	38.0 + 10.5 + 3.0 + 10.5 + 3.0 + 10.5	75.5
UPL	—	0.0

4. Sum the percent cover values from all wetland indicator status categories (all categories combined).

Example:
Combined Total Percent Cover = 0.0 + 89.5 + 82.0 + 75.5 + 0.0 = 247.0

5. Multiply the total percent cover for each wetland indicator status category by its **weighting factor** from Table B.2.

Table B.2
Calculating Weighted Percent Cover

Wetland Indicator Status	Total Percent Cover		Weighting Factor		Weighted Percent Cover
OBL	0.0	x	1	=	0.0
FACW	89.5	x	2	=	179.0
FAC	82.0	x	3	=	246.0
FACU	75.5	x	4	=	302.0
UPL	0.0	x	5	=	0.0

6. Sum the **weighted percent cover** values from all wetland indicator status categories (all categories combined).

Example:
Combined Weighted Percent Cover = 0.0 + 179.0 + 246.0 + 302.0 + 0.0 = 727.0

7. Divided the **combined weighted percent cover** values (step 6) by the **combined percent cover values** (step 4). This is the **prevalence index**.

Example:
Prevalence Index = 727.0 ÷ 247.0 = 2.94

8. If the **prevalence index** is less than or equal to 3.0, the vegetative community has met the vegetation criterion for a wetland. Otherwise, the vegetative community is considered non-wetland.

   Example:
   The prevalence index for this area (vegetative zone) is 2.94, which is less than 3.0. Therefore, the vegetative community has met the vegetation criterion for a wetland.

Summary

Evaluating vegetative communities is an important step toward locating a BVW boundary. In some cases, reliance on vegetation alone will yield an accurate boundary. In most cases, vegetation should be used along with soils and Other Indicators of Hydrology to locate the boundary. Chapter 5 provides information on when vegetation alone may be used and when soils and Other Indicators of Hydrology should be used in addition to vegetation. Procedures for delineating BVW boundaries are also described in Chapter 5.

Appendix C
Wetland Indicator Plants Identified in the Massachusetts Wetlands Protection Act (M.G.L. Ch. 131, §40)

The Wetlands Protection Act lists wetland plants by a common name and one of the following: family name, genus name, or species name. (Note: the species name, also known as the scientific name, is made up of the genus and species.) The list in the Act is general and is not meant to include all plants that occur in wetlands. In addition, plants are sometimes listed only by family or genus. These are broad categories that often include wetland plants as well as non-wetland plants. For instance, the family Juncaceae is comprised of many rushes of which only some are good indicators of wetland conditions. The genus Fraxinus includes species that commonly occur in wetlands (green ash, *Fraxinus pennsylvanica*; black ash*, Fraxinus nigra)*, as well as one common species (white ash, *Fraxinus americana)* that only occasionally occurs in areas with wetland hydrology. As a result, MassDEP has determined that, with the exception of mosses in the genus *Sphagnum*, only plants listed in the Act by their full scientific name (plants with a genus and species name) are considered wetland indicator plants. For plants listed in the Act only by family or genus to be considered wetland indicator plants, they must also be listed in the U.S. Army Corps of Engineers 2020, Northcentral and NortheastRegion, National Wetland Plant List, version 3.5 as OBL, FACW, or FAC species. In addition, all plants in the genus *Sphagnum* are considered wetland indicator plants (species in this genus have not yet been categorized by indicator status).
The following plants are listed by their full scientific name in the Act.

American or white elm, *Ulmus americana*
aster, *Aster nemoralis* (now *Oclemena nemoralis*)
azalea, *Rhododendron canadense*
azalea, *Rhododendron viscosum*
black alder, *Ilex verticillata*
black gum tupelo, *Nyssa sylvatica*
black spruce, *Picea mariana*
buttonbush, *Cephalanthus occidentalis*
cowslip, *Caltha palustris*
cranberry, *Vaccinium macrocarpon*
hemlock, *Tsuga canadensis*
highbush blueberry, *Vaccinium corymbosum*
larch, *Larix laricina*
laurel, *Kalmia angustifolia*
laurel, *Kalmia polifolia*
leatherleaf, *Chamaedaphne calyculata*
marsh fern, *Dryopteris thelypteris* (now *Thelypteris palustris*)
pitcher plants, *Sarracenia purpurea*
poison sumac, *Toxicodendron vernix*
red maple, *Acer rubrum*
sensitive fern, *Onoclea sensibilis*
skunk cabbage, *Symplocarpus foetidus*
spicebush, *Lindera benzoin*
sweet gale, *Myrica gale*
sweet pepper bush, *Clethra alnifolia*
water willow, *Decodon verticillatus*
white cedar, *Chamaecyparis thyoides*
white hellebore, *Veratrum viride*

Appendix D
Field Determination of Organic Material

Adapted from materials originally developed by Peter C. Fletcher, Jim Turenne, and Gillian Davies

Estimating the organic content of a soil and describing it accurately are essential skills needed when making a hydric soil determination. The amount of organic matter in the soil is expressed as a percentage of the total soil on a dry weight basis. All soil material falls into one of the following three categories based on the amount of organic matter present: Organic Soil Material, Mineral Soil Material, or Mucky Mineral Soil.

For the purpose of this Handbook, it is most important to be able to distinguish Organic Soil Material from Mineral Soil Material. Because organic matter weighs less compared to mineral soil materials, relatively small percentages (20-30%) of organic content are needed to meet the threshold of Organic Soil Material. Sandy soils (with no clay) require only 20 percent organic matter to be classified as Organic Soil Material; while soils with 60 percent clay (or more) require at least 30 percent organic matter to qualify for this same designation. For soils with clay contents more than 0 percent but less than 60 percent, a proportional amount of organic matter is needed to qualify as organic soil material. Soils with slightly less organic matter may be classified as Mucky Mineral Soil (see Table D.1), depending on the amount of clay in the soil.

Table D.1
Description of Soil Material based on Clay and Organic Material contents

Percent Clay in Soil*	OM content	Material Classification	OM Composition
0%	>8% but <20%	Mucky Mineral	Only applies when well decomposed OM is present
60% or more	>20% but <30%	Mucky Mineral	
0%	20% or more	Organic Material	Can be variable degrees of decomposition
60% or more	30% or more	Organic Material	

*For soils with >0% but < 60% clay, the intermediate amounts of clay and organic matter are proportional.

Field Method for Differentiating Classes of Organic Matter (OM)

Depending on the degree of decomposition, soil organic matter is classified into one of four categories: undecomposed litter, fibric material, hemic material, or sapric material. Undecomposed litter is plant material that has no observable evidence of decomposition. This material can be easily brushed aside or blown by the wind. Undecomposed litter is not considered part of the soil. Certain hydric soil indicators require one to differentiate between organic material that is well decomposed (as in sapric material, or muck) as compared to materials that are more fibric and less decomposed.

- **Fibric material** is only slightly decomposed. Most often, the original source of the organic material can still be identified. Soil horizons with this material are designated Oi.
- **Hemic material** is partially decomposed organic material. It often has the look and feel of mature compost. Soil horizons with this material are designated Oe.
- **Sapric material** is highly decomposed and is often black or very dark reddish black in color with a massive, mucky appearance. Soil horizons with this material are designated Oa.

When organic material accumulation is associated with wetness, the terms ***"peat, mucky peat, and muck"*** are used to describe fibric, hemic and sapric materials, respectively.

Rubbed Fiber Content Test

This test can be used to determine the degree of decomposition of the organic matter. Rubbed fiber content is estimated by taking a moist sample (about the size of a golf ball) and removing live roots (and any mineral materials larger than 2 mm) which are not counted. The sample is then rubbed in the palm of one's hand using the thumb of the other hand for about 10 strokes under firm pressure. The rubbing breaks up any partially decomposed material that is still intact. After rubbing, the sample is compressed into a single mass and then broken in half and examined using a hand lens (10x or stronger). The amount of remaining fibers in the material is estimated as a percentage of the total volume.

- **Fibric** organic material = "peat" >40 percent rubbed fiber content
- **Hemic** organic material = "mucky peat" = 17 to 40 percent rubbed fiber content
- **Sapric** organic material = "muck" <17 percent rubbed fiber content

Tips for Differentiating between Organic and Mineral Soil Materials in the Field

Penetration Resistance Test

When a tile spade can be pushed into the soil column by use of hands alone, the extent of easy penetration is often coincident with the depth of organic material in the soil profile. When probing a horizon face in an open pit (or an extracted slice), a finger, trowel or knife can be pushed into the soil face where organic materials occur. When mineral material is encountered there is much greater resistance to penetration.

Strength Test

A properly moistened sample is extruded between the fingers when hand squeezed.
Organic materials ooze between one's fingers, whereas mineral material will remain firm in a solid mass when squeezed.

Air-dried Soil Test

For this test, one must take a moist soil mass (about the size of a lime) and note its weight and color. After letting this dry for 1 to 2 days, evaluate the weight and color of the dried chunk of soil. Organic material will become significantly lighter in weight upon drying and will be nearly as dark in color as it was when moist. Mineral soil will retain a significant amount of its original weight and will often turn considerably lighter in color upon drying. A dried organic soil sample is comparatively light in weight, as opposed to a similar sized mineral sample.

Cautions

1. Never assume that a thick black surface layer is the same soil texture throughout. In many situations, a black surface layer of well-decomposed organic matter (Oa horizon) is underlain by a black mineral soil (A horizon). Always check (using tests above) to confirm whether there is a black mineral horizon under the surface organic materials.

2. Before trying to assess the texture of an organically enriched surface layer, first determine the texture of the mineral layers directly underlying the organic rich layer. In many instances, the mineral composition is consistent throughout the upper part of the soil, and this makes for a good comparison with an overlying organic rich layer that will not conform to the expected outcomes using the hand-texturing flow chart provided in this Handbook.

Appendix E
Guide for Determining Basic Soil Texture Classes

Soil Texture Classes

Soils are named on the basis of the separates (i.e., sand, silt, and clay) they contain (Figure E.1, Table E.1). Textural categories include sand, loamy sand, sandy loam, silt loam, clay loam, and sandy clay loam, just to name a few. These terms relate to the relative composition of sand, silt, and clay in a soil sample, and it is helpful to understand what these terms mean.

If the textural name contains two words (like sandy loam), then the second word indicates the dominant physical properties of the soil, and the first term is used as a descriptive modifier regarding how the sample feels. For instance, a sandy loam has many loam-like properties, but it has more sand and feels much grittier to the touch than basic loam. “Loam” is itself a specific soil texture that has relatively equal amounts of sand and silt, with just enough clay present to add strength and cohesiveness to the sample.

The term “loam” is commonly misused. It is not correct to refer to all topsoil as loam. It is important to understand that the term has very specific meaning regarding a soil’s physical composition. A soil can be “loamy” without actually meeting the strict compositional requirements of a true loam texture.

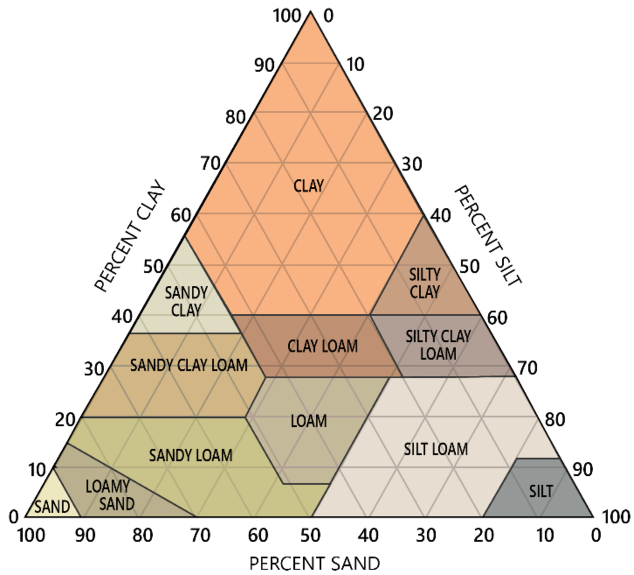
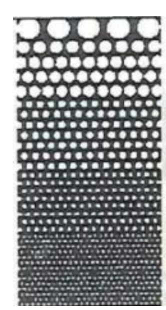


Figure E.1
USDA Texture Triangle

Table E.1
Mineral Soil Particle Categories

Soil Separate		Diameter in millimeters*	Physical characteristics	Visual Scale reference
Sand	Very coarse sand	2.00-1.00	grains easily seen, very gritty	
	Coarse sand	1.00-0.50	coarse gritty, grains visible	
	Medium sand	0.50-0.25	gritty, grains visible	
	Fine sand	0.25-0.10	fine gritty, each grain visible	
	Very fine sand	0.10-0.05	barely gritty, grains barely visible	
Silt		0.05-0.002	smooth, talcum-powder feel	
Clay		less than 0.002	sticky when wet, hard when dry	

Hand-texturing

The presence of the three basic separates (sand, silt, and clay) can be determined in a soil sample by rubbing a small amount of moistened soil between the fingertips. Sand, being granular, has a gritty feeling, silt has a smooth feeling (like talcum powder) and clay, a slippery sticky feeling. A laboratory analysis must be conducted to determine the exact amount of sand, silt, and clay-sized particles in a sample. This level of precision, however, is rarely needed and a reasonably good field estimate can be made based on how the soil feels and how well it can be molded in one's hands.

Because organic matter will produce a greasy feel and can confound an assessment of texture (when using the hand-texturing technique), it is wise to initially skip over the surface horizon and begin texturing a subsoil in the soil profile. Care should be used not to overestimate the silt and clay content in a soil that also contains a significant amount of organic matter.

The following descriptions can be used to conduct a field determination of mineral soil texture. The descriptions can be followed in the order presented as a type of flow-chart. Start by reading the description for Sand (presented below) and continue working through the list of textures until arriving at one matching the characteristics of the sample. Begin by taking about a tablespoon of soil (roughly the size of a golf ball). Remove all gravel and roots and crush any aggregates of soil in the sample so that all materials are less than 2 mm in size. If the soil is dry, determine first if it is loose and single-grained, and able to flow between fingers. Then moisten the soil by adding water slowly to the sample until it is moistened and well mixed. Follow the instructions below, reading from one paragraph to the next as a flow chart.

Texturing Instructions

Sand is loose and single-grained. The individual grains can readily be seen and felt. Squeezed in the hand when dry, it will fall apart when the pressure is released. Squeezed when moist, it will form a weak cast (or ball) that will crumble when touched. (If the cast does not crumble when touched or when rolled in the palm of your hand, read the next paragraph.)

Loamy Sand usually feels very gritty. Unlike Sand, the moist cast it forms will stay together when touched. However, the cast will break apart when tossed from hand to hand. (If the cast can be tossed from hand to hand without breaking, keep reading below.)

This is the cut-off for Sandy vs. Loamy Soils. All of the remaining soil texture classes (below) are considered to be Loamy/Clayey.

Important Note: some **Loamy Sand** soils are comprised predominantly of **very fine sand** (0.05-0.1 mm in diameter), which will hold onto water better than a coarser loamy sand soil and will often withstand moderate handling when a moist ball of this material is tossed from hand to hand. These Loamy (very fine) Sand soils are treated as Loamy Soils for the purpose of applying the Hydric Soil Indicators.

Sandy Loam is a soil mostly containing sand but that has enough silt and clay to make it somewhat cohesive. The individual sand grains can readily be seen and felt when the sample is rubbed between fingers. The moist cast will bear moderate handling and can be tossed from hand to hand repeatedly without breaking. Fingers will become somewhat coated with fine particles. In most cases, Sandy Loam soil will not form a "ribbon" when pressed between the fingers. Ribbons are made by placing a ball of moist soil between thumb and forefinger and gently pushing with thumb to squeeze soil upwards and into a ribbon over the index finger (see Figure E.2). It is important to allow the ribbon to emerge and extend over forefinger, breaking from its own weight. (If the sample does form a ribbon 1 in. or greater in length before breaking, continue with descriptions below.)

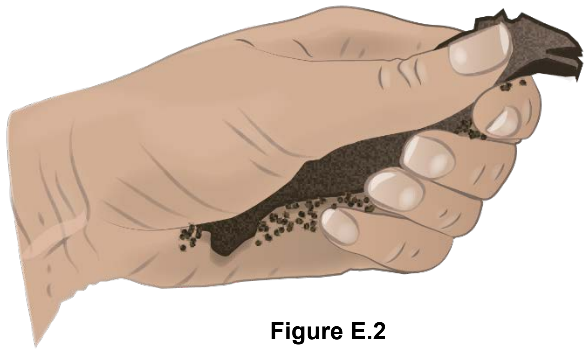


Figure E.2
Forming a Ribbon

Loam is a soil having a relatively even mixture of the sand and silt, with a moderate amount of clay present. Dry Loam samples may feel somewhat gritty and yet also velvety when rubbed. Loam will form a moist cast that is very stable and can withstand being tossed from hand to hand repeatedly without breaking. Moist samples will feel fairly smooth, and slightly plastic. Loams with clay contents greater than 20 percent will be able to form a ribbon around 1 in. long. (If the sample forms a stable cast and makes a ribbon greater than 1 in., continue with descriptions below.)

Silt Loam is a soil comprised primarily of silt, with varying amounts of sand and clay-sized particles. The sand portion of most Silt Loam soils is commonly “fine” or “very fine” in size (Table E.1). This results in a very smooth feeling soil, which lacks the characteristic grittiness of the textures already described. Dry Silt Loam feels soft and “powdery” or “flour-like” to the touch, and dry clumps are easily crushed under moderate pressure. Moist Silt Loam will feel smooth, and sometimes greasy, when rubbed. It will hold a stable cast and will form a ribbon that will usually reach 1 to 1½ in. long before breaking. The surface of the ribbon will usually appear cracked or rippled as the sample begins to quickly dry out.

The “ribbon test” helps determine the relative amount of fine particles in the soil (silt and clay collectively, versus the sand particles). The length of the ribbon correlates to the amount of fines in the soil. To differentiate between the silt and clay particles, a different “wire” test is performed. See next textural class description for these instructions.

Silty Clay Loam is a soil that dries to form very firm clumps that are very difficult to crush by hand. When pulverized, the dry soil has a velvety feeling. Moist soil can be pinched between the thumb and finger to form a ribbon generally greater than 1½ in. long. The moist soil is plastic and sticky and will form a very stable cast. To distinguish a Silty Clay Loam from a Silt Loam,” one must be able to form a “wire” from the material when it is rolled between two vertically positioned palms.

To “pass the wire test,” the worm-like wire must be at least 2 in. long and less than 1/8 in. in diameter. Clay particles will retain moisture better and permit a wire to form with a very narrow diameter. Soils with less clay (and more silt) will smear and/or crack before reaching the 1/8-inch threshold. It is important not to add any additional water while conducting these tests. Adding water to the sample during the testing will bias the results towards a more clayey texture determination.

Clay Loam is a soil whose cohesive properties are very similar to the Silty Clay Loam described above. The Clay Loam, however, contains more sand than does Silty Clay Loam. The Clay Loam will therefore feel gritty whereas the Silty Clay Loam feels smooth.

Clay. Clay is a fine textured soil that usually forms very hard lumps or clods when dry and is quite plastic and usually sticky when wet. When the moist soil is pinched out between the thumb and fingers, it will form a flexible "ribbon” more than 3 in. long. Wires formed from this material can be greater than 3 in. long, with diameters much less than 1/8 in.

Mineral Texture Determination Flow Chart for Major Textural Groups

Cast Test	
Will not form moist cast or ball	= **Sand**
Cast formed, but breaks in hand, no palm roll	= **Sand**
Cast forms and rolls, but breaks when tossed	= **Loamy Sand***
Stable cast, does NOT break when tossed (Sandy Loam will not form a Ribbon greater than ~½ inch long. Finer textures described below)	= **Sandy Loam** (or finer)
Ribbon Test Ribbon forms ~ 1 in. or greater	
If Ribbon <1.5 in. but Wire (<1/8 in. dia.) will NOT form (Can be moderately sticky, somewhat smooth when rubbed)	= **Loam**
If Ribbon ~1 in. to <2 in. but Wire (<1/8 in. dia.) will NOT form (Can be somewhat sticky, very smooth when rubbed)	= **Silt Loam**
If Ribbon >1.5 in. but <3 in. and Wire (<1/8 in. dia.) WILL form (Very sticky, very smooth when rubbed)	= **Silty Clay Loam**
If Ribbon >3 in. and Wire (<1/8 in. dia.) WILL form (Very sticky)	= **Silty Clay**

Notes:
Textures noted in **Blue** will fall into the Loamy/Clayey hydric soil indicators.
Textures noted in **Red** will fall into the Sandy category.
***Loamy very fine sand** will hold together when tossed.

Appendix F
Detailed List and Descriptions of Hydric Soil Indicators

In addition to the simplified list of hydric soil indicators presented in Chapter 3, this appendix provides a more thorough list of hydric soil indicators commonly found in Massachusetts with their representative indicator names and codes (e.g., A2, F2, S4, etc.).[7] The following is not a comprehensive list of all hydric soil indicators that occur in Massachusetts. As previously discussed, this Handbook focuses on commonly encountered hydric soils that generally occur at or near the wetland/non-wetland boundary. A comprehensive list of all hydric soils that occur in Massachusetts is available in:

> U.S. Army Corps of Engineers. 2012. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast region (Version 2.0),* ed. J.S. Wakeley, R.W. Lichvar, C.V. Noble, and J.F. Berkowitz. ERDC/EL TR-12-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

This Army Corps of Engineers Regional Supplement utilizes a subset of the hydric soil indicators that were accepted for use across the United States, with certain indicators having widespread geographic use and others having only limited regional application. The most recent list of approved hydric soil indicators is available in:

> U.S. Department of Agriculture, Natural Resources Conservation Service. 2018, *Field Indicators of Hydric Soils in the United States, Version 8.2.* L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.) USDA, Natural Resources Conservation Service (NRCS), in cooperation with the National Technical Committee for Hydric Soils.

There is a defined subset of the national hydric soil indicators that can be used in Massachusetts, and therefore, the numbering system is non-sequential. Consistent with the federal field indicator organization, Massachusetts' hydric soil indicators are described in this Handbook with respect to their applicability for use within three specific texture groupings:

i. <u>All Soils</u> refers to soils with any USDA soil texture. These hydric soil indicators can be used with any texture of soil, and their indicator codes begin with the letter "A."

ii. <u>Sandy Soils</u> refers to soil materials with a USDA soil texture of loamy fine sand and coarser. Sandy soil indicators can only be used for soils that fall within one of these texture classes. Their hydric soil indicator codes begin with the letter "S."

iii. <u>Loamy and Clayey Soils</u> refers to soil materials with USDA textures of loamy very fine sand and finer. Loamy/clayey indicators can only be used for soils that fall within one of these texture classes. Their hydric soil indicator codes begin with the letter "F."

[7] Images of hydric soil indicators are from *A Field Companion to Field Indicators for Identifying Hydric Soils in New England*, Version 4, NEHSTC, May 2017.

Establishing the Soil Surface for Depth Measurements

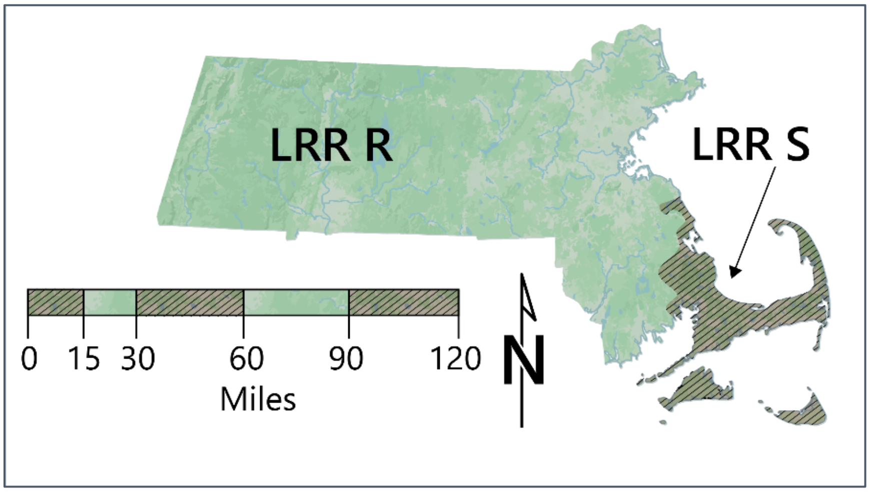


Figure F.1
Approximate extent of USDA Land Resource Regions in Massachusetts.

It is important to take correct soil depth measurements when applying the hydric soil indicators, and some of the indicators will have differing "zero points" that identify the **relevant soil surface** depending on the geographical zone.

The USDA uses a system of Land Resource Regions to define different geographic areas across the country. Massachusetts includes two different USDA Land Resource Regions — "R" and "S" (Figure F.1). In the following section, each hydric soil indicator will include a note specifying the "zero point" of reference for that indicator in each of the regions within Massachusetts.

Group I: Common hydric soil indicators

Indicators for All Soils: regardless of texture

Indicator A2. Organic surface/Histic epipedon. These soils have 8-16 in. of organic material on the surface due to wetness (aquic conditions) and are underlain by a mineral soil horizon with a chroma of 2 or less.

In New England, these soils are relatively abundant and are often found in wetlands that are ponded or saturated to the ground surface nearly all of the growing season in most years. For the purpose of this Handbook, the histic epipedon indicator will also apply to soils with more than 16 in. of organic material *(Federal Indicator A1)*, as well as black histic soils (*Federal Indicator A3*). These hydric soils are generally <u>not</u> found near the wetland-upland boundary.

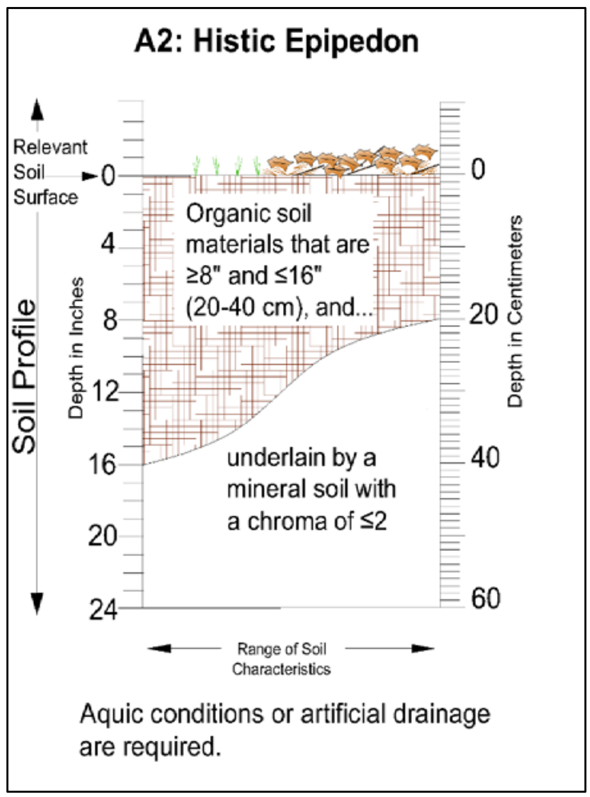


Figure F.2
Histic Epipedon Indicator

User Notes:

- Soils with aquic conditions (Figure F.2) are those that currently undergo continuous or periodic saturation and reduction. The presence of these conditions is indicated by redoximorphic features.

- Aquic conditions can be assumed if indicators of hydrophytic vegetation and wetland hydrology are present.

- The actual soil surface is used as the zero-point of reference for this indicator regardless of LRR region.

Indicator A4. Hydrogen Sulfide. A hydrogen sulfide odor (rotten egg smell) is encountered immediately after a shallow test pit is dug, within 12 in. of the soil surface. Soil can be any texture.

User Note: The actual soil surface is used as the zero-point of reference for this indicator regardless of LRR region.

Indicator A11. Depleted Matrix Below a Dark Surface.(Figure F.3) These soils have a very dark colored surface layer underlain by a depleted or gleyed matrix starting within 12 in. of the soil surface.

To meet the color requirement in the dark surface layer, any organic/loamy/or clayey layers must have a matrix value of 3 or less and a chroma of 2 or less. Any sandy material above the depleted or gleyed matrix must have a value of 3 or less and chroma of 1 or less.

Sandy material must have at least 70 percent of the visible soil particles masked with organic material when viewed using a 10x or 15x hand lens. When viewed without a hand lens, the material appears to be nearly 100 percent masked. The dark layer must begin at or within 6 in. of the soil surface and extend down to the depleted or gleyed matrix.

To meet the color requirement for the depleted matrix, at least 60 percent of the layer must have a chroma of 2 or less (and a value of 4 or more). The depleted or gleyed layer must be at least 6 in. thick.

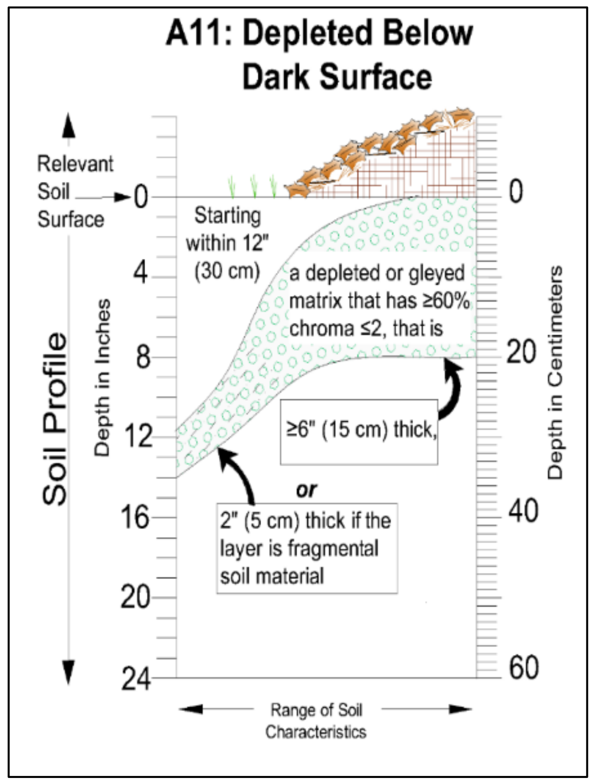


Figure F.3
Depleted Matrix Below Dark Surface Indicator

User Notes:

- If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redoximorphic features to become visible.

- The zero-point of reference for this indicator is measured from the top of the muck or mineral surface (underneath any peat and/or mucky peat material) regardless of LRR region (see Figure F.1).

Indicator A12. Unusually Thick Surface Horizons/Thick Dark Surface Indicator. (Figure F.4) This indicator is often found in concave landscape positions, such as would occur at the toe of a slope, where erosional materials collect from higher on the landscape. This situation might also exist in an area that has been cultivated and plowed deeper than typical depths.

To meet this indicator, there must be a layer (of any texture) that is at least 6 in. thick with a depleted or gleyed matrix starting below 12 in. of the surface. There must also be a thick dark layer at least 12 in. thick with a value of 2.5 or less and chroma of 1 or less, and any additional layer(s) present above the depleted or gleyed matrix must have value of 3 or less and chroma of 1 or less.

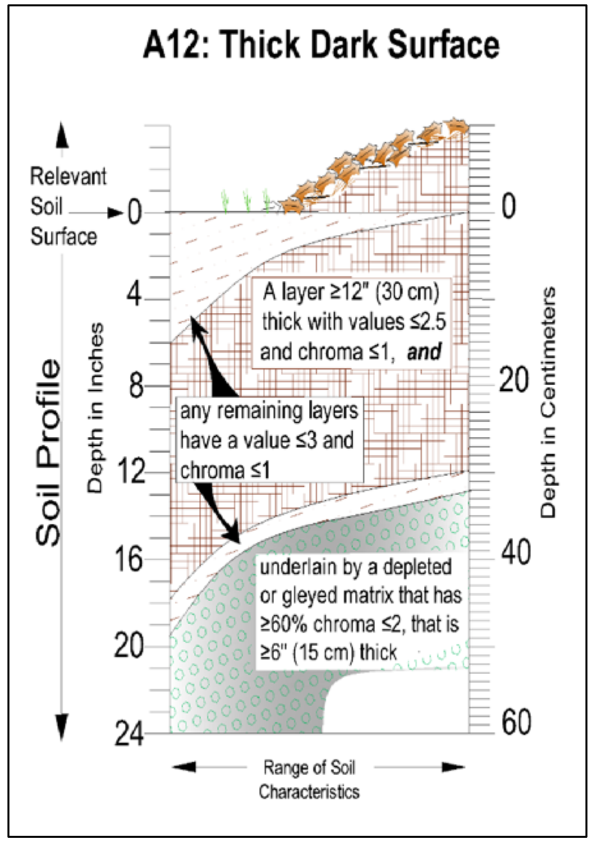


Figure F.4
Thick Dark Surface

User Notes:

- In New England, this indicator is often applicable to soils that have been modified by agriculture and some soils formed in dark parent materials.

- This indicator applies to soils that have a black layer 12 in. or more thick and have value of 3 or less and chroma of 1 or less in any remaining layers directly above a depleted or gleyed matrix.

- The zero-point of reference for this indicator is measured from the top of the muck or mineral surface (underneath any peat and/or mucky peat material) regardless of LRR region.

Indicators for Sandy Soils Only

Indicator S4. Sandy Gleyed Matrix. (Figure F.5). A gleyed matrix that occupies 60 percent or more of a layer starting within 6 in. of the soil surface. Gley colors are not synonymous with gray colors. They are the colors on the gley color pages in the Munsell Soil Color Book that have hue of N, 10Y, 5GY, 10GY, 5G, 10G, 5BG, 10BG, 5B, 10B, or 5PB, and value of 4 or more.

Note: Soils with gleyed matrices are saturated for periods of a significant duration. As a result, there is no thickness requirement for the gleyed layer. This indicator is generally not found at the boundaries between wetlands and uplands.

User Note: In LRR “R,” depth measurements start at the mineral surface, whereas in LRR “S” depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material).

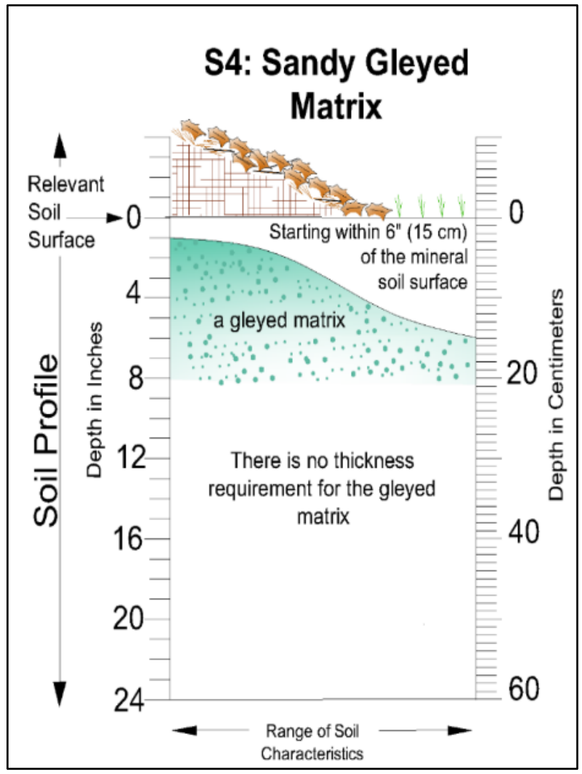


Figure F.5
Sandy Gleyed Matrix Indicator

Indicator S5. Sandy Redox. (Figure F.6). A layer starting within 6 in. of the soil surface that is at least 4 in. thick and has a matrix with 60 percent or more chroma of 2 or less with 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings.

In New England, this is a very common indicator of sandy hydric soils and is often used to identify the hydric/non-hydric soil boundary.

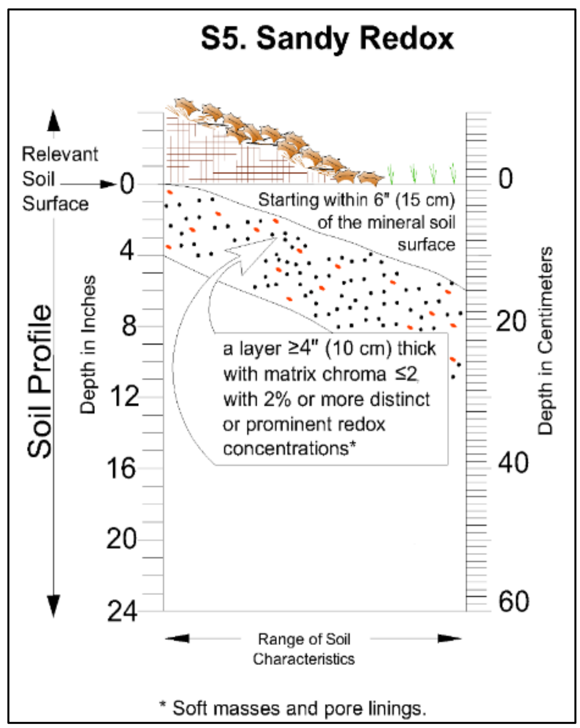


Figure F.6
Sandy Redox Indicator

User Notes:

- If the soil is saturated, it may be necessary to let it dry to a moist condition for redoximorphic features to become visible. Redox concentrations include iron and manganese soft masses and pore linings. Included within the concept of redox concentrations are iron-manganese bodies occurring as soft masses with diffuse boundaries. Nodules and concretions are not considered to be redox concentrations.
- In LRR “R,” depth measurements start at the mineral surface, whereas in LRR “S” depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material).

Indicators for Loamy and Clayey Soils Only

Indicator F2. Loamy Gleyed Matrix. (Figure F.7). A gleyed matrix that occupies 60 percent or more of a layer starting within 12 in. of the soil surface.

All mineral layers above the gley layer must have a dominant chroma of 2 or less, or the layer(s) with a dominant chroma of more than 2 must be less than 6 in. thick.

<u>User Notes</u>:

- Gley colors are not synonymous with gray colors. They are the colors on the gley color pages and have a value of 4 or more. Soils with gleyed matrices are saturated for periods of significant duration. As a result, there is no thickness requirement for the layer.

- Soils that meet this indicator are typically inundated or saturated during nearly all of the growing season in most years and are not usually found at the boundaries between wetlands and uplands.

- In LRR "R," depth measurements start at the mineral surface, whereas in LRR "S" depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material)

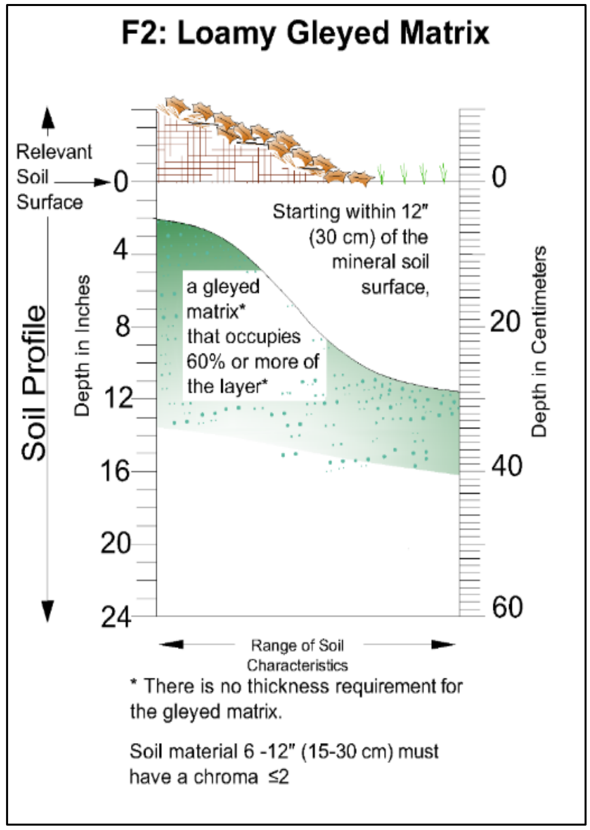


Figure F.7
Loamy Gleyed Matrix Indicator

Indicator F3. Loamy Depleted Matrix. (Figure F.8). A layer that has a depleted matrix with 60 percent or more chroma of 2 or less and that has a minimum thickness of:

a) 2 in. if the 2 in. starts within 4 in. of the soil surface.

b) 6 in. starting within 10 in. of the soil surface.

This is one of the most commonly observed hydric soil indicators at wetland boundaries. This indicator can be met in one of 2 ways as shown in the illustrations, directly below.

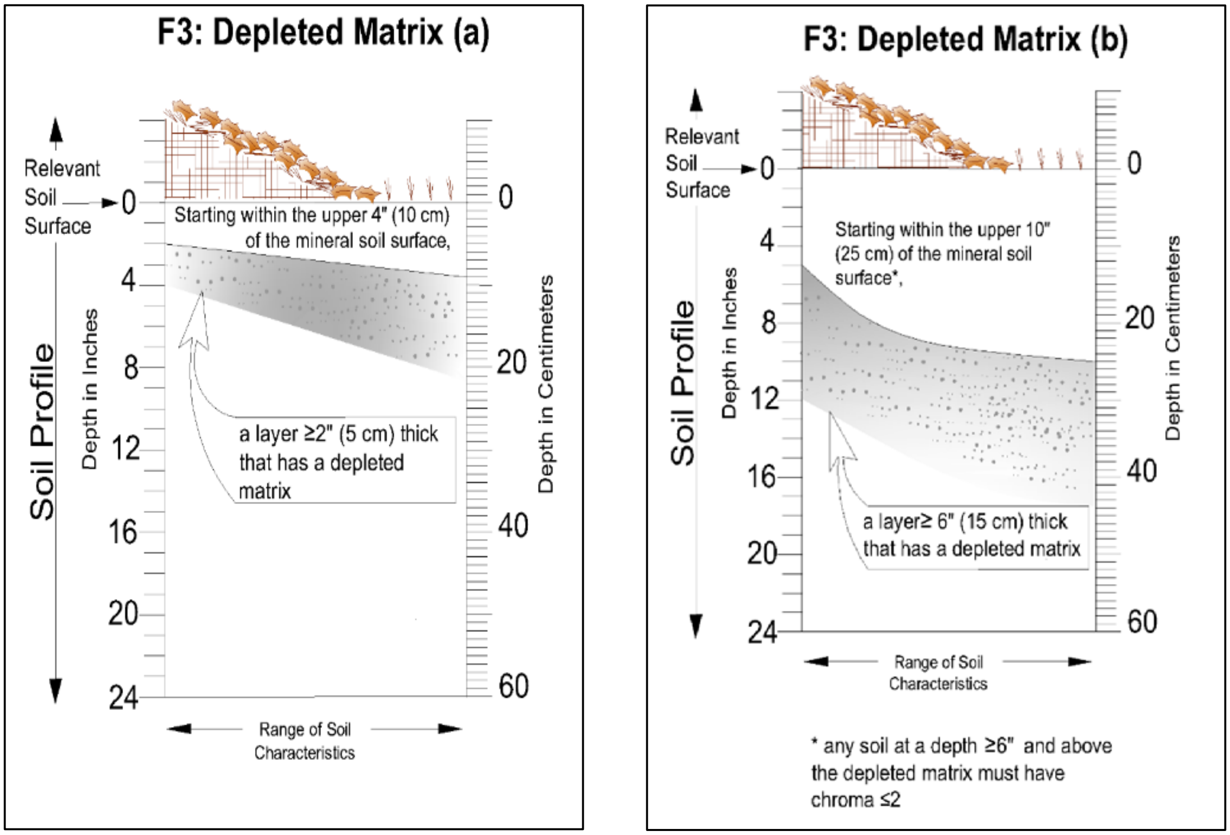


Figure F.8
Loamy Depleted Matrix (a) left, and (b) right

User Notes:

- The low-chroma matrix must be the result of wetness and must not be the result of weathering or the type of parent material. If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redoximorphic features to become visible.

- A depleted matrix requires a value of 4 or more and chroma of 2 or less. Redox concentrations, including iron-manganese soft masses and/or pore linings, are required in soils with matrix colors of 4/1, 4/2, or 5/2. Concentrations are not required if the color is 5/1 or those with values of 6 or greater (with a chroma of 2 or less). The A and E horizons are excluded from the concept of depleted matrix unless the soil has more than 2 percent distinct or prominent redox concentrations occurring as soft masses or pore linings.

- In LRR "R," depth measurements start at the mineral surface, whereas in LRR "S" depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material)

Indicator F6. Loamy Dark Surface with Redox. (Figure F.9). A layer that is at least 4 in. thick, starting within 8 in. of the mineral soil, and has:

a) Matrix value of 3 or less, matrix chroma of 1 or less, and 2 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings; or

b) Matrix value of 3 or less, matrix chroma of 2 or less, and 5 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings.

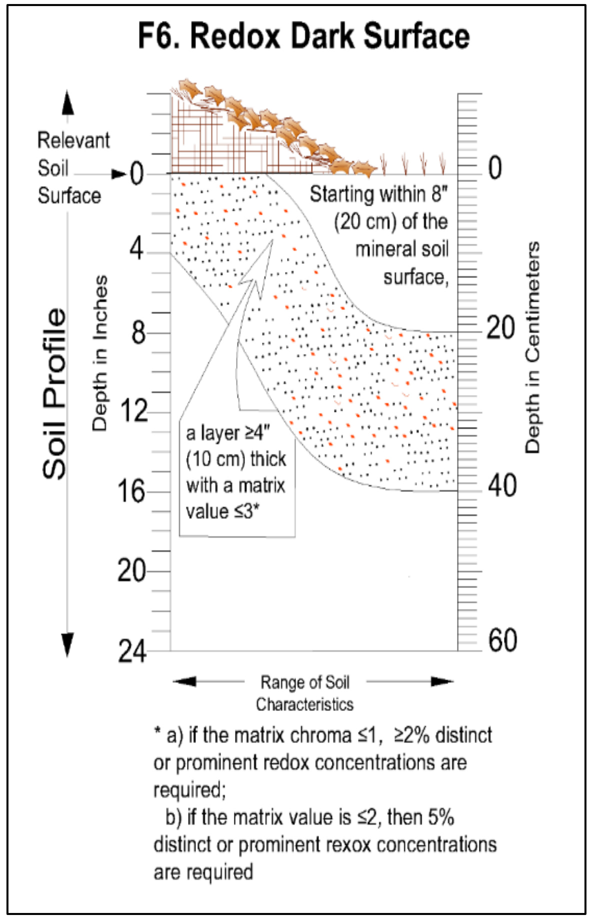


Figure F.9
Loamy Dark Surface with Redox

<u>User Notes:</u>

- If the soil is saturated at the time of sampling, it may be necessary to let it dry at least to a moist condition for redoximorphic features to become visible.

- Soils that are wet because of ponding or that have shallow perched water may have any color below the dark surface. This morphology has been observed in soils that have been compacted by tillage and other means.

- Delineators should evaluate the source of water and examine and describe the layer below the dark colored surface layer.

- Users should be aware that this indicator may lead to false positive interpretations for hydric soil. Careful analysis of the topography, evidence of wetness, presence of wetland vegetation and morphological plant adaptations should be considered when applying this indicator.

- Redox concentrations in mineral soils with a high content of organic matter and a dark surface layer are commonly small and difficult to see. The organic matter masks some or all of the concentrations that may be present. Careful examination is required to see what are often brownish concentrations in the darkened materials.

- In Land LRR “R,” depth measurements start at the mineral surface, whereas in LRR “S” depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material).

Indicator F8. Redox Depressions (Figure F.10). These soils occur in closed depressions subject to ponding, with 5 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings in a layer that is 2 in. or more thick and starts within 4 in. of the soil surface.

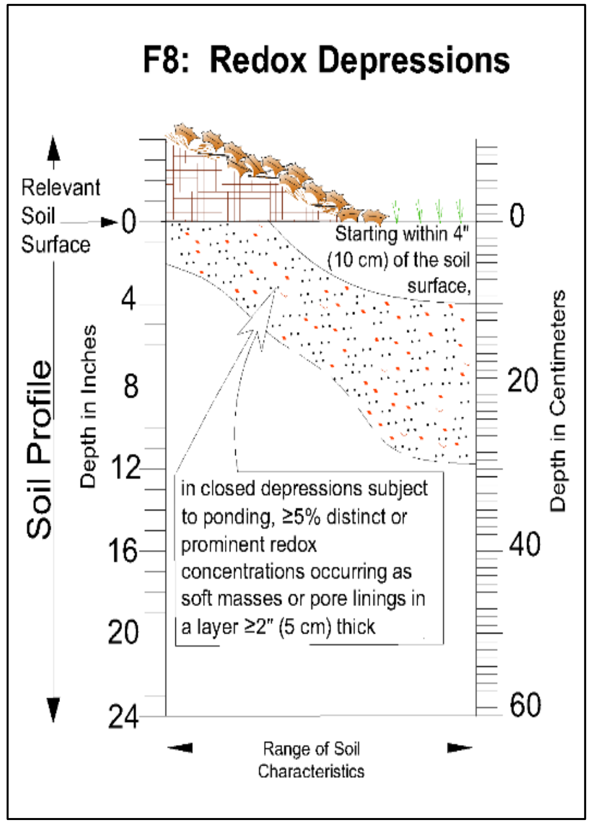


Figure F.10
Redox Depressions Indicator

User Notes:

- This indicator is not meant to be applied to micro-depressions (approximately 3.3 ft. in diameter) on convex or plane (flat) landscapes.
- There is no color requirement for the matrix.
- The layer containing concentrations may extend below 6 in. if at least 2 in. occurs within 6 in. of the surface.
- If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redoximorphic features to become visible.
- This is a common, but often overlooked, indicator for identifying the wetland/upland boundary in landscape depressions.
- In LRR “R,” depth measurements start at the mineral surface, whereas in LRR “S” depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material).

Summary of Group I: Common Hydric Soil Indicators

Description	Federal Indicator Code	Texture restriction
Histic Epipedon	A2	All soils
Hydrogen Sulfide	A4	All soils
Depleted Matrix Below Dark Surface	A11	All soils
Thick Dark Surface Horizons	A12	All soils
Sandy Gleyed Matrix	S4	Sandy
Sandy Redox	S5	Sandy
Loamy Gley Matrix	F2	Loamy
Loamy Depleted Matrix	F3	Loamy
Loamy Dark Surface with Redox	F6	Loamy
Redox Depressions/Vernal Pool Soils	F8	Loamy

Group II: Difficult to Analyze Hydric Soils

In this Handbook, difficult to analyze soils include both undisturbed soils and disturbed/altered soils that have morphological features that require evaluation by a wetland scientist well trained in soil science. In these soils, features of wetness do not match up with the hydric soil indicators discussed in the section above. In some situations, redox features are present but masked in some way, in other situations, redox features may be present, but soil morphology can be easily misinterpreted without appropriate training, leading to false positive determinations.

Each of the scenarios presented below represents recognized hydric soil indicators at the federal and regional levels, but these indicators should only be applied by trained wetland scientists. When faced with a boundary delineation that relies upon the presence/absence of any of these indicators, wetland scientists with training in soil science should be consulted.

Difficult Indicators for All Soils: Regardless of Texture

Indicator A5. Hydric Floodplain Soils/Stratified Layers. (Figure F.11). Active floodplain soils receive periodic inputs of sediment, which essentially reinitiate the time clock on soil horizon formation. This leads to stratified layers of sediment, which rarely contain well-developed redox features (as described for Group I hydric soil indicators).

To be a hydric floodplain soil, several stratified layers must occur starting within 6 in. of the soil surface; and at least one of the layers must have a value of 3 or less with a chroma of 1 or less; or it must have a significant accumulation of organic matter such that it is a muck, mucky peat, peat, or mucky modified mineral texture. The remaining layers must have chroma of 2 or less.

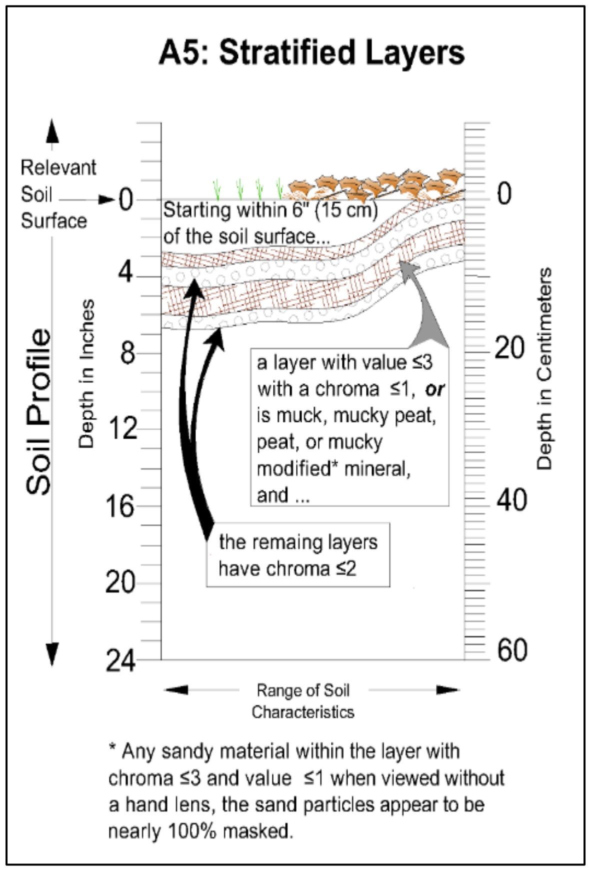


Figure F.11
Stratified Layers

User Notes:

- A stratified layer is a layer of soil that has been deposited (often by floodwaters) and has not formed in place gradually, over time due to natural pedogenic (soil forming) processes. Keep in mind that one layer of soil has to either have a value of 3 or less and a chroma of 1 or less or be composed of organic soil material.
- The stratified layers may have any soil texture.
- Individual strata are usually less than 1 in. thick. A hand lens (i.e., magnifying glass) is an excellent tool to aid in the identification of this indicator.

- Stratified layers generally occur on floodplains and other areas where soils are subject to rapid and repeated burial with thin deposits of sediment.
- In LRR "R," depth measurements start at the mineral surface, whereas in LRR "S" depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material)

Difficult Indicators for Sandy Soils

Sandy soils can be particularly challenging to evaluate. Iron is often lacking in these soils, and so depleted color patterns and redox concentrations do not always form even when wetland hydrology is present. Instead, it is often necessary to look for the accumulation of organic material on or near the soil surface. It is also possible to see evidence of a fluctuating water table near the soil surface by looking for movement of organic coatings that have been stripped from one portion of the soil and redistributed to another (Indicator S6 and Indicator S7). A more dramatic instance of translocated materials is seen in the process of podsolization, which is best expressed in sandy soil materials under evergreen vegetation (Indicator S6 and Indicator S8).

Indicator S6. Sandy Stripped Matrix (Organic Streaking). (Figure F.12). A layer starting within 6 in. of the soil surface in which iron and manganese oxides and/or organic matter have been stripped from the matrix and the base color of the sandy soil material has been exposed. The stripped areas and translocated oxides (either iron oxide or manganese oxide) and/or organic matter form a faintly contrasting pattern of two or more colors with diffuse boundaries. The stripped zones are 10 percent or more of the volume and are somewhat rounded in shape.

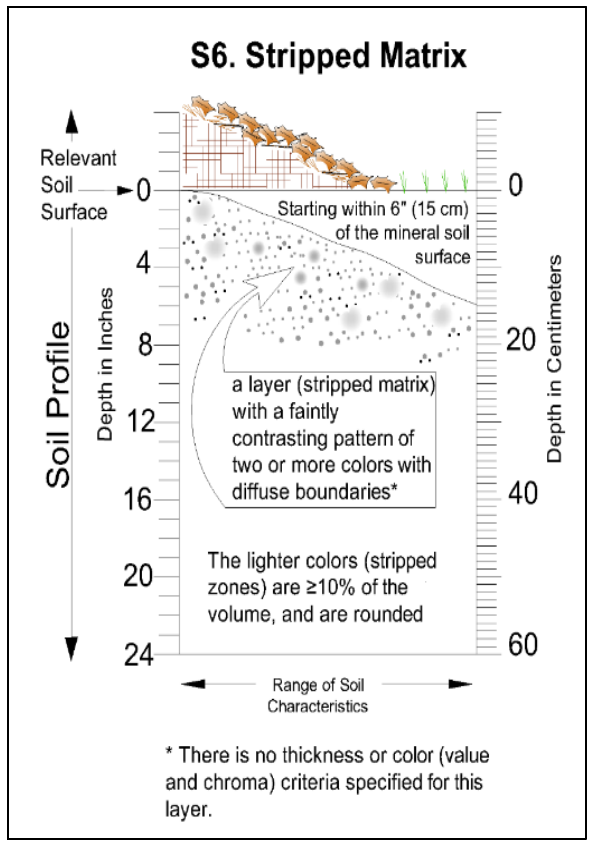


Figure F.12
Sandy Stripped Matrix

User Notes:

- In New England, proper application of this indicator requires a determination that the features observed in the horizon with the stripped matrix are indicative of wetness.
- Commonly, the stripped areas have a value of ≥5 and chroma of ≤2, with unstripped areas having a chroma of 3 or 4. However there are no specific color requirements for this indicator.
- Very commonly, directly underlying the horizon with the stripped matrix is a thick dark **spodic horizon**, which may be cemented. A spodic horizon is a mineral horizon characterized by an accumulation of amorphous material transported from higher in the soil that includes organic carbon and aluminum, with or without oxidized iron, and is often reddish in color but may also be darkened with organic carbon. (It is important to note that the presence of a spodic horizon in and of itself is not an indicator of hydric soils.)

- This is a very common indicator of hydric soils and is often used to identify the hydric/non-hydric boundary in sandy soils. However, users should be aware that this indicator may lead to false interpretations that a soil is hydric. Careful analysis of the topography, evidence of wetness, presence of wetland vegetation and morphological plant adaptations should be considered when applying this indicator.

- In LRR “R,” depth measurements start at the mineral surface, whereas in LRR “S” depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material).

Indicator S7. Sandy Dark Surface. (Figure F.13). A layer 4 in. thick starting within 6 in. of the soil surface with a matrix value of 3 or less and matrix chroma of 1 or less. The matrix color of the layer directly below the dark layer must have the same colors as those described above (matrix value ≤ 3 and matrix chroma ≤ 1) or any color that has a chroma of 2 or less.

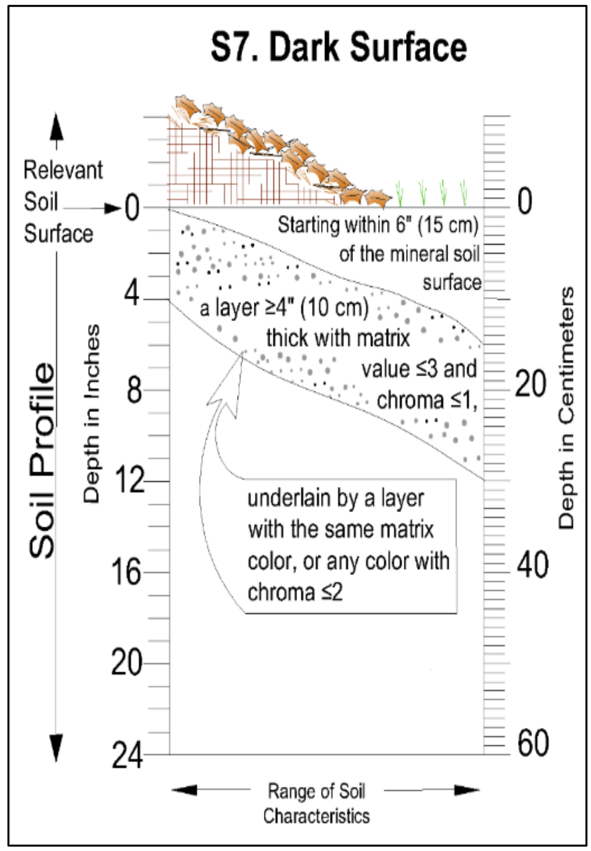


Figure F.13
Sandy Dark Surface Indicator

User Notes:

- Many wet sandy soils have a ratio of about 50 percent soil particles that are masked with organic matter and about 50 percent unmasked soil particles, giving the soils a salt-and-pepper appearance. These cases are under the minimum of 70 percent masked criterion (see Indicator A11) and the Sandy Dark Surface indicator would not apply in these circumstances.

- If the dark layer is greater than 4 in. thick, then the indicator is met, because any dark soil material in excess of 4 in. meets the requirement that the layer directly below the dark layer must have the same colors as those described above. If the dark layer is exactly 4 in. thick, then the material directly below must have a matrix chroma of 2 or less. Horizons meeting the dark surface criteria are rich in soil organic carbon.

- Care must be taken to ensure that this indicator is only applied to soils with textures of Loamy (fine) Sand and coarser.

- In LRR “R,” depth measurements start at the mineral surface, whereas in LRR “S” depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material)

Indicator S8. Sandy Evergreen Soils/Polyvalue below Surface. (Figure F.14). This indicator applies to sandy soils with a very dark gray or black surface or near-surface layer that is less than 4 in. thick and is underlain by a layer in which organic matter has been differentially distributed within the soil. The translocation of organic matter results in splotchy coated and uncoated soil areas, resulting in shades of black and gray throughout the top 12 in. of soil.

Look for a soil layer with a matrix value of 3 or less and matrix chroma of 1 or less starting at a depth less than or equal to 6 in. from the soil surface.

Directly below this layer, 5 percent or more of the soil volume must have a value of 3 or less and chroma of 1 or less, and the remainder of the soil volume must have a value of 4 or more and chroma of 1 or less to a depth of 12 in. or to the spodic horizon, whichever is less.

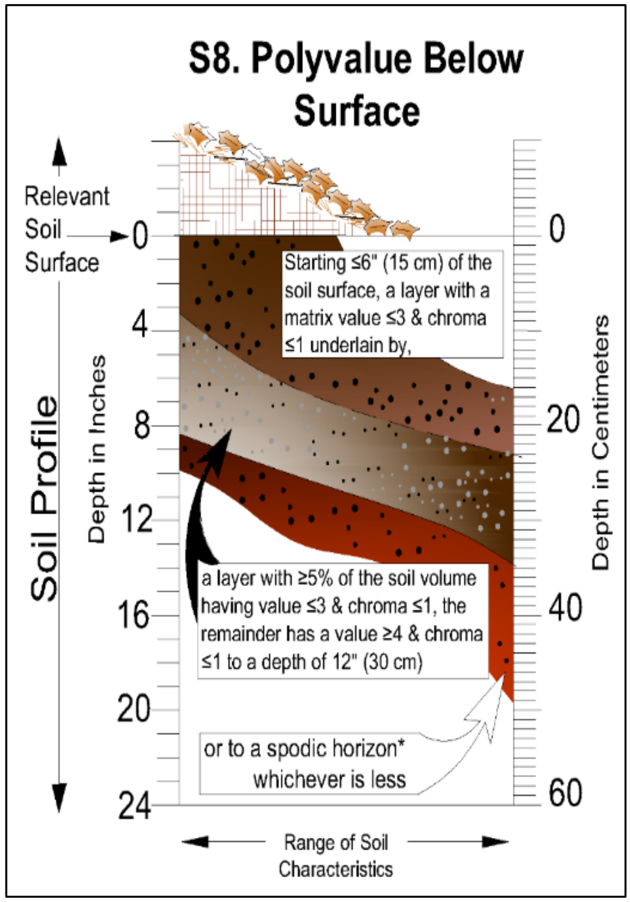


Figure F.14
Polyvalue below Dark Surface

<u>User Notes:</u>

- A spodic horizon is a mineral horizon characterized by an accumulation of amorphous material transported from higher in the soil profile that includes organic carbon and aluminum, with or without oxidized iron, and is often reddish in color but may also be darkened with organic carbon. It is important to note that the presence of a spodic horizon in and of itself is not an indicator of hydric soils.
- For this indicator, the spodic horizon occurs beneath an E horizon that has a value of 4 or more with chroma 1 or less, within which 5 percent or more of the soil volume has a value of 3 or less and chroma 1 or less where organic carbon has been deposited.
- In LRR "R," depth measurements start at the mineral surface, whereas in LRR "S" depth measurements start at the top of the muck or mineral surface (underneath any peat and/or mucky peat material)

For additional information on identifying spodic hydric soils users should consult Appendix 5 of *Field Indicators for Identifying Hydric Soils in New England Version 4* (June 2020).

While iron is often lacking in sandy soils, there can also be circumstances where there is a source of iron-rich groundwater entering the site that can lead to bright (oxidized) iron colors in the subsoil, even though the soil is saturated. These colors often occur in a layer of material that is coarser than the surrounding soil layers. The higher saturated conductivity rate of the coarser (sandier) material causes the rapid discharge of iron-rich groundwater (which may also contain relatively higher levels of dissolved oxygen than that found in the surrounding soil). If the bright, sandy layer is deeper than 2 ft., these soils will typically still meet one or more of the previously described hydric soil indicators. If the iron-rich groundwater is moving horizontally through a layer situated closer to the surface, this may mask the development of redoximorphic features and confound the use of the field indicators. In these cases, a wetland scientist with advanced training in soil science should be consulted.

Summary of Group II:
Hydric Soil Indicators for Difficult to Analyze Situations

Description	Federal Indicator Code	Texture Restriction
Hydric Floodplain Soils/Stratified Layers	A5	All soils
Stripped Matrix (Organic Streaking)	S6	Sandy
Sandy Dark Surface	S7	Sandy
Sandy Evergreen Soils/Polyvalue below Dark Surface	S8	Sandy

Disturbed Soils

In many places in Massachusetts, the soil has been altered by human activity and such soils are referred to as human-altered, anthropogenic, or disturbed soils. Changes that affect local groundwater levels, such as groundwater withdrawals and soil drainage (e.g., field ditching or storm water discharge), can transform a non-hydric soil into a hydric soil or vice versa.

There are very few locations in Massachusetts that have not seen some degree of human alteration. Much of the region was deforested for agriculture during the 19th century, and the effects of those activities can still be observed throughout our landscape. From a practical point of view, the older the disturbance, the more likely the criteria established for identifying hydric soils in this Handbook can be applied.

Most alterations will result in a disruption of the normal sequence of soil horizons. Clues within the soil that suggest a location has been altered include: foreign objects within the soil (such as pieces of glass, bricks, asphalt, etc.), inverted soil horizons, missing or duplicated soil horizons, textural discontinuities, abrupt color discontinuities, randomly oriented redoximorphic features, or soil horizons that are not parallel to the ground surface.

If an alteration has occurred within the last few decades and hydric soil indicators previously described in this Handbook are not evident, but site conditions (i.e., hydrology and vegetation) suggest that a wetland exists or existed, then Chapter 5 of the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region* (Version 2.0) should be consulted.

Plowed soils are a type of disturbed soil that is common in Massachusetts. If the plowing occurred within the last several years, the soil may not contain easily identifiable redoximorphic features in the upper part of the soil. Soil mixing (via cultivation) tends to homogenize the topsoil and more evenly distribute darker surface materials throughout the entire plowed depth, causing the resulting color to be less dark while also obscuring or blending together any redoximorphic features that may have been present. In these cases, the soil may not meet any of the hydric soil indicators previously described in this Handbook (Chapter 3 and this appendix). Evidence of wetness is best identified by the relative darkness of the topsoil material as compared to a portion of the site that has not been plowed; and there should be strong redoximorphic evidence of a seasonal high-water table immediately beneath the lower boundary of the plowed layer. Depending on the thickness and color of the plowed layer and the color of the underlying horizon, it may be possible to utilize Indicators F2, F3, A11, or A12. Consultation with a wetland scientist trained in soil science may also be required if none of the hydric soil indicators in this Handbook are met but landscape position and redoximorphic activity in the soil strongly suggests that the soil may be hydric.

Appendix G
Procedure for Evaluating Soils

When documenting the presence or absence of hydric soils, it is recommended that soils be observed in paired test pits dug on either side of the presumed wetland boundary (see Figure G.1). These paired soil test pits should be approximately 10-12 ft. apart unless there is a distinct change in topographic contour at the wetland boundary that would provide for more distinct soil differences over shorter linear distances. Although professionals trained and experienced in soil science and hydric soil evaluations can analyze subtle differences between more closely spaced pits, it is recommended that most users of this Handbook keep a separation of 10 to 12 ft. between their representative hydric and nonhydric soil test pits so that the presence or absence of hydric soil indicators is clearly confirmed.

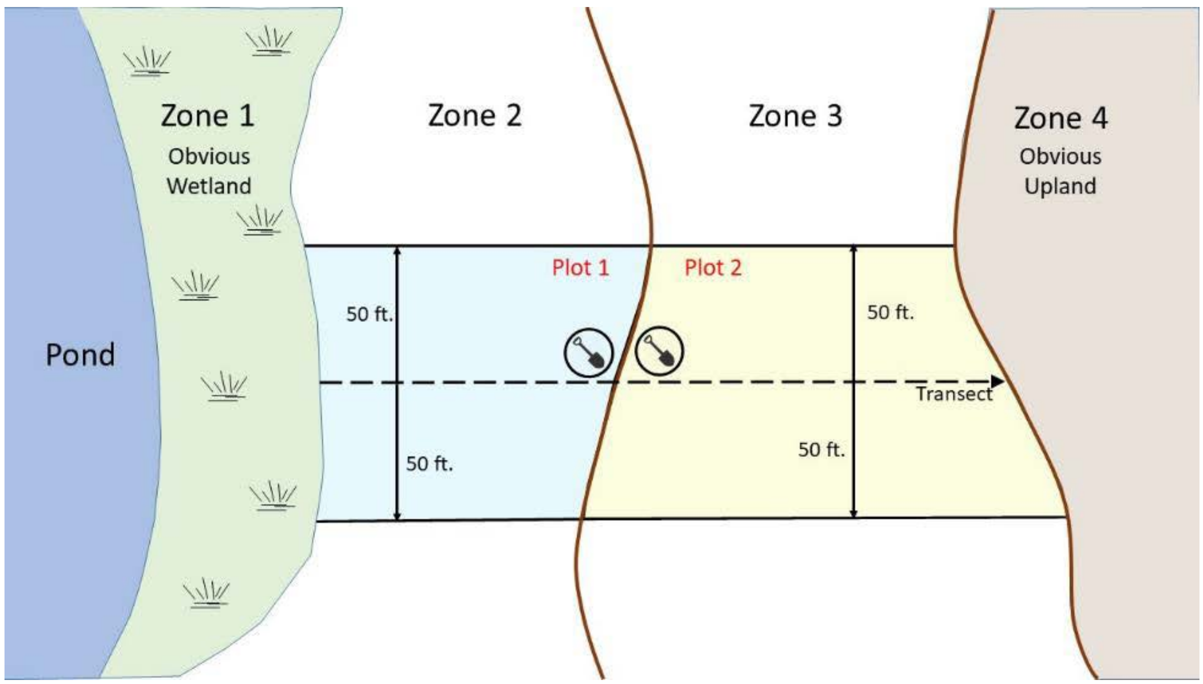


Figure G.1
Locate soil test pits on each side of the presumptive wetland boundary.

Step 1: Digging Test Pit/Removing Soil Slice

It is recommended that soils be observed in test pits dug to a depth of at least 18 in. or more using a tile spade. Hand-dug test pits should be at least 12 x 16 in. or 12 in. in diameter. Full excavation should be completed to the depth of the tile spade blade (typically 14.5 in.), and a Dutch auger may be used in order to obtain representative soil samples from 14.5 in. to a depth of 24 in. or more. It is often possible to measure horizon thickness and depths directly in the test pit. However, it is also useful to remove a “slice” of the soil from the side of the test pit and lay it flat on the adjacent soil surface. This slice can be used for examining soil samples from each layer/horizon and determining soil colors and identifying redoximorphic features in full sunlight. If the soil is saturated at the time of sampling, the soil profile slice should be allowed to drain somewhat before an assessment of soil color is made. Please note that leaf litter that has recently fallen (i.e., within the past year) should not be included as part of the soil profile description.

Step 2: Describing the Soil Profile

Identify and describe the visible layers

Soil layers should be identified, and the thickness and depth of each soil layer should be recorded. While it is helpful to assign horizon designations to each layer (A-horizon, vs. E-horizon, vs. B-horizon, vs C-horizon), the accuracy of these horizon label designations is not critical to using the hydric soil indicators because the indicators are based on the presence of "layers" within the soil profile that do not necessarily correspond directly with naturally occurring horizons.

After distinct layers have been identified in the soil profile, the matrix color of each layer should be described using Munsell Soil Color Book notation, and the soil texture should be noted (see Appendix E). Redoximorphic features are critical morphologic indices of saturation and reduction in the soil, and these require careful attention. The abundance of redoximorphic features should be estimated and recorded to the nearest percentage (Figure G.2). Field identification of redoximorphic features is most reliable when their contrast with the matrix color is distinct or prominent, and their abundance is 2 percent or more.

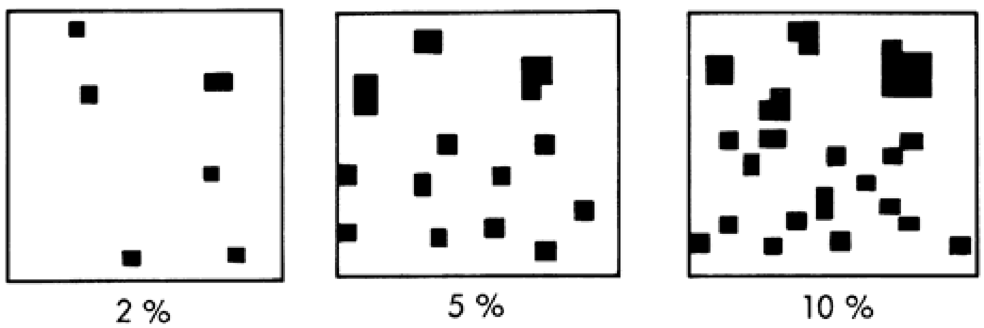


Figure G.2
Example of Percent Coverage for Use in Estimating Redox Depletion or Concentration Abundance.

When redoximorphic features are faint in contrast to the matrix and/or less than 2 percent in abundance, it is recommended that a professional trained and experienced in soil science and hydric soil evaluations be consulted before identifying a soil with these characteristics as a hydric soil.

It is important to determine whether surface muck is present and if so to what extent/depth. Care should be taken when evaluating suspected organic materials to properly determine whether the threshold for organic content has been met (see Appendix D for information on identifying organic soils). Dark-colored topsoil material does not always equate with the presence of a true O-horizon. Under wetland conditions, O-horizons will generally be very dark in color, slippery or greasy to the touch, and have a tendency to stain fingers when handled. Organic materials do not have much strength, and when a ball of the material is squeezed, it will start to ooze between one's fingers.

When examined "in place" along the side of a test pit face, organic materials will allow for easy penetration by a probing finger, trowel, or knife, whereas mineral soils will provide greater resistance to probing. Measurements for the thickness of an O-horizon can be made from the soil surface down to the depth of the mineral soil surface where a knife tip cannot easily penetrate. This depth marks the start of the mineral A-horizon.

Comparison of Soil Profile Description with Field Indicators

Once a complete soil profile description has been prepared, this description can be compared against the hydric soil indicators presented in this Handbook or the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (Version 2.0)*. Be sure that a given hydric soil indicator is applicable to the texture of soil in your soil profile.

The first three common hydric soil indicators (A2, A4, and A11) are applicable in all soil textures, and they often occur in some combination with one another (although this combination is not necessary to make a hydric soil determination.)

If there is an accumulation of mucky material at the soil surface, but one is unsure whether it contains enough organic matter to be an O-horizon, or whether the organic material is thick enough (8 in.) to meet hydric soil indicator A2 for Histic Epipedon, then check deeper to determine if hydric soil indicator A11 is met with a depleted matrix within 12 in. of the soil surface.

If there is a dark surface layer(s) that is thicker than 12 in. with a depleted matrix beneath it, then check out hydric soil indicator A12 and determine if it is applicable.

If none of the hydric soil indicators in the paragraphs above are met, then one must assess the applicability of the other indicators described in this appendix. Pay careful attention to the soil texture(s) present and determine if Sandy layers (loamy fine sand and coarser) or Loamy/Clayey layers (all textures finer than loamy fine sand), or a combination of both are present.

Combining Indicators to meet thickness requirements

Both sandy and loamy/clayey layers may be present in the same soil profile. In fact, it is fairly common for sandy subsoils to be overlain by a loamy surface layer. In some cases, there will be layers present in the upper 12 in. of the soil profile that meet the color requirements of specific F or S hydric soil indicators, but the layers are **not thick enough** to individually qualify as meeting the indicator. In these situations, it is acceptable to combine the characteristics of hydric soil indicators across textural layers to meet indicator thickness requirements.

Interpreting mixed-texture soil profiles can be somewhat confusing and an example is provided in Table G-1. This soil profile is hydric based on a combination of indicators S5 (Sandy Redox) and F6 (Redox Dark Surface). This soil meets the texture and color characteristics of F6 in the first layer and S5 in the second layer, but neither layer by itself meets the thickness requirement for its respective indicator. However, the combined thickness of the two layers (6 in.) meets the more restrictive thickness requirement of the two indicators, which in this case is 4 in. It is strongly recommended that input be sought from a wetland scientist trained in soil science when interpreting soil profiles with respect to whether the soil meets any of the hydric soil indicators based on combining indicators across textural layers to meet thickness requirements.

Table G-1
Example Soil Profile for Combining Indicators to Meet Thickness Requirements

Layer	Depth (in)	Matrix Color	Redox Concentrations			Texture
			Color	Abundance	Contrast	
1	0 — 3	10YR 3/1	10YR 5/6	3%	Prominent	Loam
2	3 — 6	10YR 4/1	10YR 5/6	3%	Prominent	Loamy Sand
3	6 — 14	10YR 4/1				Loam

Because some hydric soil indicators have thinner layer thickness requirements, when combining layers to meet a thickness requirement, the more restrictive thickness requirement must be met. Not all hydric soil indicators are possible candidates for combination. For example, F2 (Loamy Gleyed Matrix) has no thickness requirement, so a site would either meet the requirements of this indicator or it would not.

Cautions: Relict Features (distinguishing between contemporary and relict features)

Many redoximorphic features will remain visible in the soil many years after an alteration in hydrology has occurred. Such alterations can be either human caused (e.g., ditching and draining) or natural (e.g., stream downcutting), but when the result is a lowering of the local water table, caution must be taken in interpreting soil redoximorphic features. Contemporary (current) redoximorphic features will have crisp clear edges and brightly contrasting colors, whereas relict features tend to have somewhat “blurred” or “fuzzy” edges where redox concentrations appear to gradually fade into the adjacent soil matrix color.

Likewise, features such as a depleted matrix may still be present even after the local water table has been lowered if there is no longer sufficient iron present in the soil to become oxidized in the upper part of the soil profile.

If one suspects that relict features may be present that do not represent the current site hydrology, it is important to take careful note of all soil morphological features as well as the vegetative ground cover of the area (plants in the ground cover respond more quickly to changes in hydrology than other vegetative strata, such as trees). Surface soils that are no longer saturated for long periods will gradually become less dark in color as soil microbes more readily decompose the accumulated organic material under the better-aerated conditions. This process will cause the topsoil to be less dark than one would expect for a wetland soil. A soil with these characteristics may still meet one or more hydric soil indicators, but great care should be taken to evaluate whether wetland hydrology is still present at the site.

Nodules and concretions are hard, cemented pellets of precipitated iron or manganese oxides. Although these features do form as a result of redox processes, they are discounted for the purposes of hydric soil identification because these somewhat durable pellets of iron or manganese oxides can be transported intact (along with eroded soil materials) and then be found in locations in which it would be impossible for them to form.

Appendix H
Contact Information and Data Sources

Department of Environmental Protection — Wetlands Program
(For the most up-to-date contact information, check the MassDEP website.)

Boston Office
100 Cambridge Street, Suite 900
Boston, MA 02114
617-292-5500

Central Regional Office
8 New Bond Street
Worcester, MA 01606
508-792-7650

Northeast Regional Office
150 Presidential Way
Woburn, MA 01801
978-694-3200

Southeast Regional Office
20 Riverside Drive
Lakeville, MA 02347
508-946-2700

Western Regional Office
State House West, 4th Floor
436 Dwight Street
Springfield, MA 01103
413-784-1100

Useful Data Sources
USGS Topographic Maps. Topographic maps prepared by the U.S. Geological Survey are essential sources of information about site conditions. They provide information about the topography of a site and many wetlands and water bodies are shown as well. It is important to note, however, that not all wetlands and not all waterbodies (e.g., intermittent streams) are shown on the topographic maps. In many cases, illustrated features on the topographic maps can be used to identify areas that may contain wetlands and streams not otherwise shown on the map. Topographic maps are viewable using the MassGIS online map viewer (MassMapper) under “Images”: https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html.

NRCS Soil Survey Maps and Hydric Soils Lists. Soil Surveys are published by the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service). The Soil Survey provides maps depicting soil types, their boundaries, and descriptions of soil properties. When using Soil Surveys, consult the list of hydric soils for the county. Both Soil Surveys and hydric soils lists are available from the NRCS. Soil Survey maps are available online via the Web Soil Survey at: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. Soil Survey maps are also viewable using the MassMapper online map viewer, under “Physical Resources”: https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html. It is important to note that the soil boundaries depicted on the maps are for planning purposes only. Only field assessments can determine whether a soil is hydric.

MassDEP Wetlands Maps. MassDEP has mapped wetlands statewide using aerial photography. These wetland maps can be viewed online at the MassDEP Wetlands and Wetlands Change Map Viewer at: http://maps.massgis.state.ma.us/images/dep/omv/wetviewer.htm. They can also be viewed via the MassMapper online map viewer, under “Physical Resources > Hydrography Water Features”: https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html. These map layers can be downloaded as GIS data from MassGIS (https://www.mass.gov/orgs/massgis-bureau-of-geographic-information). It is important to note that the wetland polygons depicted on the maps are for planning purposes only. They do not necessarily represent, and should not be used as, jurisdictional determinations. All Bordering Vegetated Wetland (BVW) delineations for regulatory purposes should be based on in site-specific field assessments using the procedures outlined in this Handbook.

National Wetlands Inventory Maps. The U.S. Fish and Wildlife Service has mapped wetlands in Massachusetts as part of the National Wetlands Inventory (NWI). NWI maps wetlands at a nationwide scale so it is it is important to note that many small wetlands are not shown on the maps, and that wetland boundaries on the maps are approximate. In cases where wetlands have been altered or destroyed, NWI maps can indicate the extent and location of previously existing BVWs for the purposes of enforcement. NWI maps can be viewed online at https://www.fws.gov/wetlands/data/mapper.html. They can also be viewed via the MassMapper online map viewer, under “Physical Resources > Hydrography Water Features”: https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html.

Aerial photographs. Aerial photography is available from MassGIS and other sources. Infrared photography, taken in the spring before leaves are out, is the most useful for identifying wetlands. Aerial photographs can be used to document wetland violations; however, an experienced photo interpreter might be required. Aerial photographs are available for viewing using the MassMapper online map viewer, under “Images”: https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html. Recent and historic aerial photographs are also available using Google Earth: https://earth.google.com/web/.

Floodplain maps (National Flood Insurance Program). Developed for the National Flood Insurance Program, these maps provide useful information on flood prone areas and may indicate the presence of floodplain soils that may be difficult to analyze for hydric soil indicators. One-hundred-year floodplains and 500-year floodplains are delineated for rivers and larger streams, and some water bodies. Floodplain maps for some communities are available from the Federal Emergency Management Agency (FEMA; https://msc.fema.gov/portal/home). They can also be viewed via the MassMapper online map viewer, under “Regulated Area”: https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html. Digital maps are currently not available for all communities.

Appendix I
Glossary

Glossary:

A-horizon: a surface layer of mineral soil darkened by the presence of organic matter; also known as topsoil.

Adventitious roots: roots found on plant stems in positions where roots do not normally occur. These roots may or may not form in response to inundation or saturation.

Aerenchyma: plant tissue that contains large air cells, resulting in a spongy texture.

Aerobic: a condition where free oxygen is present.

Anaerobic: a condition where free oxygen is unavailable.

B-horizon: a zone of weathered mineral soil below the O, A, or E-horizons.

Bordering Vegetated Wetland (BVW): a freshwater wetland that borders a creek, river, stream, pond, or lake; a wetland resource area defined in the Massachusetts Wetlands Protection Regulations (310 CMR 10.55).

Buttressed trunks: the swollen or enlarged bases of trees that develop in response to prolonged inundation.

Capillary action: a process where water is drawn up through pores in the soil directly above the groundwater table.

Capillary fringe: a zone just above the water table that is nearly saturated with water due to capillary action.

C-horizon: a zone of unweathered soil below the A-horizon and, if present, the B-horizon.

Chroma: the relative purity or intensity of a color; one of three variables of color.

Concretion: a cemented body of material, such as iron or manganese, formed by precipitation of dissolved material, with an internal symmetry, which can be removed from the soil intact.

Cover range: a category into which plant species would fit based upon their percent cover.

Diameter at breast height (dbh): the width of a tree trunk as measured at breast height (4.5 feet above the ground).

Dominant plant: based on calculations in the dominance test, a plant determined to be dominant in a particular vegetative stratum.

Dominance test: a method of vegetative community assessment based on the number of dominant plant species that are wetland indicator plants.

Drift line: an accumulation of waterborne debris often deposited in lines that are roughly parallel to the direction of water flow.

E-horizon: a layer below the O and A-horizons where iron and aluminum oxides and organic matter have been leached out of the soil by organic acids.

Evaporation: loss of surface water due to the conversion of liquid water to gaseous water vapor.

Facultative species (FAC): classification of plants that commonly occur both in wetland and non-wetland areas; also known as "fac" species (U.S. Fish and Wildlife Service).

Facultative upland species (FACU): classification of plants that usually occur in non-wetland areas; also known as "fac-up" species (U.S. Fish and Wildlife Service).

Facultative wetland species (FACW): classification of plants that usually occur in wetlands; also known as "fac-wet" species (U.S. Fish and Wildlife Service).

Flooded: a condition in which an area is temporarily covered with flowing or standing water.

Gleyed: a soil condition resulting from gleization which is characterized by the presence of neutral gray, bluish, or greenish colors in the soil matrix or in mottles among other colors.

Ground cover: a vegetative layer that includes woody vegetation less than 3 feet in height, woody vines less than 3 feet in height, and all non-woody vegetation (including mosses) of any height.

Growing season: the portion of the year when soil temperatures are above biologic zero (41 degrees Fahrenheit, 4 degrees centigrade); generally March to November in Massachusetts.

Herb: a non-woody (herbaceous) plant.

Histic epipedon: A layer of 8-16 inches (in.) of organic soil within a hydric soil measured from the ground surface.

Histosol: a type of hydric soil with at least 16 in. or more of organic material measured from the ground surface; histosols include fibrists (peats), saprists (mucks) and hemists (peaty-mucks and mucky-peats).

Horizon: a distinct layer of soil generally parallel with the soil surface having similar properties such as color and texture.

Hue: a characteristic of color related to one of the main spectral colors (red, yellow, green, blue, or purple), or various combinations of these principle colors; one of the three variables of color.

Hydric soil: a soil that is saturated, ponded, or flooded long enough during the growing season to cause anaerobic conditions at or near the surface.

Hydrology: the properties, distribution, and circulation of water.

Hydrophyte: any plant that generally grows in water or is adapted to wet conditions; generally, the same as a wetland indicator plant.

Hypertrophied lenticels: pores on the stem of woody plants which can become swollen or enlarged in response to saturated or inundated conditions**.**

Inundation: a condition, such as flooding, in which water temporarily or permanently covers an area.

Litter: a layer of recently deposited leaves and/or pines needles; may be found above the O-horizon on the forest floor.

Matrix: the undisturbed soil material composed of both mineral and organic matter; matrix color refers to the predominant color(s) of the soil in a particular horizon or layer.

Mineral soil: any soil consisting primarily of mineral material (sand, silt, clay, and gravel) rather than organic matter.

Morphological adaptation: an adaptation that is evident in the form or shape of a plant, such as adventitious roots and aerenchymous tissues.

Mottles: spots or blotches of different color or shades of color interspersed within the dominant matrix color in a soil horizon.

Mucks: organic soils (saprists) in which most of the plant material is decomposed and the original constituents cannot be recognized; less than one-third of the fibers remain visible upon rubbing the materials between fingers.

Nodule: same as concretion but without internal symmetry.

Non-hydric soil: a soil that has developed under predominantly aerobic soil conditions.

O-horizon: a layer of organic soil usually at the surface.

Obligate wetland species (OBL): classification of plants that almost always occur in wetlands; also known as "obligate" species (U.S. Fish and Wildlife Service).

Observation plot: an area of land within which vegetation and/or soils are sampled, and a wetland determination made**.**

Organic soil: soil that contains a minimum of 20 percent organic matter when no clay is present or a minimum of 30 percent organic matter when 60 percent or more clay is present.

Oxidation: chemical changes resulting from the presence of oxygen.

Oxidized rhizospheres: oxidized channels and soil surrounding living roots and other underground plant structures.

Parent material: the consolidated or unconsolidated material from which soils form. This could be bedrock (consolidated), or unconsolidated material transported and deposited by glaciers, wind, or flowing water.

Peats: organic soils in which plant fragments show very little decomposition and retain their original form; more than two-thirds of the fibers remain after rubbing the materials between fingers.

Percent cover: the percent of the ground surface that would be covered if foliage from a particular species or vegetative layer were projected on the ground, ignoring small gaps between the leaves and branches.

Percent dominance: a measurement calculated by dividing the percent cover for a species by the total percent cover for all species in that stratum; a value used in the dominance test.

Physiological adaptation: an adaptation of the basic physical and chemical activities that occur in cells and tissues of an organism; generally not observable without the use of specific equipment or tests.

Plant community: an assemblage of plant species coexisting in a shared habitat or environment. Same as a vegetative community.

Polymorphic leaves: two or more different types of leaves that form on the same plant.

Precipitation: water droplets or ice particles condensed from atmospheric water that fall to the earth's surface, such as rain, sleet, or snow.

R-horizon: a layer of hard, unbroken bedrock such as granite, basalt, and quartzite; occurs below all other horizons where present, or may occur as outcroppings of ledge above the surface of the ground.

Reduction: chemical changes resulting from the absence of oxygen.

Sandy: a soil texture of loamy fine sand or coarser that is dominant within 20 in. of the soil surface.

Sapling: a vegetative layer that includes woody vegetation over 20 feet in height with a diameter at breast height (dbh) greater than or equal to 0.4 in. but less than 3 in.

Saturated: a condition in which the soil has all or most of its pores within the root zone filled with water.

Scientific name: the name of a plant or animal that is comprised of a genus name and a species name.

Seedling: woody vegetation that is less than 3 feet in height.

Shrub: a vegetative layer that includes woody vegetation less than 3 in. diameter, and greater than or equal to 3 feet but less than 20 feet in height.

Soil: unconsolidated material on the earth's surface that supports or is capable of supporting plants.

Soil profile: vertical section of the soil through its horizons**.**

Soil series: a group of soils similar in characteristics and arrangements in the soil profile.

Soil taxonomy: a classification system for soils developed by the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service).

Soil texture: the relative proportions of the various particle sizes (silt, sand, and clay) in a soil**.**

Species name: the name of a plant in a Latinized form made up of genus and species, which serves as the plant's scientific name.

Spodic horizon: in a spodosol, a subsurface layer of soil characterized by the accumulation of aluminum oxides (with or without iron oxides) and organic matter.

Stratum: a layer of vegetation used to determine dominant species in a plant community.

Surface water: water present above the substrate or soil surface**.**

Topography: the position in a landscape, including elevation and slope.

Transect: an imaginary line on the ground that bisects a parcel of land, along which observations are made or plots established for collecting data.

Transpiration: loss of water from plant surfaces.

Tree: a vegetative layer that includes woody plants with a diameter at breast height of 3 in. or greater.

Uplands: non-wetlands**.**

Upland species (UPL): classification of plants that almost always occur in uplands (U.S. Fish and Wildlife Service).

Value (soil color): is a representation of a "gray scale" that varies from white to black with various tones of gray in between; one of the three variables of color.

Vegetative community: an assemblage of plant species coexisting in a shared habitat or environment. Same as a plant community.

Water mark: a line on vegetation, rocks or other upright structures that represents the height reached in an inundation event.

Water table: the upper limit of groundwater that is saturating soil.

Wetlands: Wetlands are areas where groundwater is at or near the surface, or where surface water frequently collects for a significant part of the growing season, and where a significant part of the vegetative community is made up of plants adapted to life in saturated soil. Under normal circumstances wetlands have hydrophytic vegetation, hydric soils, and wetland hydrology.

Wetland boundary: a line between an upland and a wetland, such as a Bordering Vegetated Wetland.

Wetland hydrology: in general terms, periods of inundation or saturation sufficient to create anaerobic conditions in upper part of the soil.

Wetland indicator category: categories to which plant species are assigned based on the frequency with which each species occurs in wetlands; categories include obligate wetland, facultative wetland, facultative, facultative upland, and upland (U.S. Fish and Wildlife Service).

Wetland indicator plants: as defined in the Massachusetts Wetlands Protection Act (WPA) Regulations, wetland indicator plants are 1) those plant species with an indicator status of OBL, FACW, and FAC; 2) species listed in the WPA; or 3) individual plants that exhibit morphological or physiological adaptations to life in saturated or inundated conditions. Eastern hemlock (*Tsuga canadensis*) is the only plant species listed in the WPA that doesn't have an indicator status of OBL, FACW or FAC**.**

Wetland plant list: the *U.S. Army Corps of Engineers 2020, Northcentral and Northeast Region, National Wetland Plant List, version 3.5* or more current version.

Woody vine: a woody plant that uses other objects, such as trees, rocks, and cliff faces, for support in order to rise above the ground.