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Wetlands Regulatory Assistance Program

Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0)

U.S. Army Corps of Engineers

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Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0)

U.S. Army Corps of Engineers

U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
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Final report

Prepared for Headquarters, U.S. Army Corps of Engineers
Washington, DC 20314-1000

Abstract: This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual, which provides technical guidance and procedures for identifying and delineating wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act. The development of Regional Supplements is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. This supplement is applicable to the Great Plains Region, which consists of all or portions of 11 states: Colorado, Kansas, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming.

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Preface

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual. It was developed by the U.S. Army Engineer Research and Development Center (ERDC) at the request of Headquarters, U.S. Army Corps of Engineers (USACE), with funding provided through the Wetlands Regulatory Assistance Program (WRAP). This is Version 2.0 of the Great Plains Regional Supplement; it replaces the "interim" version, which was published in March 2008.

This document was developed in cooperation with the Great Plains Regional Working Group, whose members contributed their time and expertise to the project over a period of many months. Working Group meetings were held in Omaha, NE, on 2-4 November 2005 and Fort Worth, TX, on 9-10 March 2006. Members of the Regional Working Group and contributors to this document were:

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Rogers, U.S. Environmental Protection Agency (EPA), Seattle, WA; Stuart Santos, USAE District, Jacksonville, FL; Ralph Spagnolo, EPA, Philadelphia, PA; Ralph Tiner, U.S. Fish and Wildlife Service, Hadley, MA; Katherine Trott, USAE Institute for Water Resources, Alexandria, VA; P. Michael Whited, NRCS, St. Paul, MN; and James Wood, USAE District, Albuquerque, NM. In addition, portions of this Regional Supplement that address soils issues were reviewed and endorsed by the National Technical Committee for Hydric Soils (Karl Hipple, chair).

Independent peer reviews were performed in accordance with Office of Management and Budget guidelines. The peer-review team consisted of Ken Kuiper, Chair, NRCS, Salina, KS; Barbi Hayes, Hayes Environmental LLC, Elkhorn, NE; Gregory Johnson, Western EcoSystems Technology, Inc., Cheyenne, WY; James Jones, SWCA Environmental Consultants, Austin, TX; Greg Larson, Minnesota Board of Water and Soil Resources, St. Paul, MN; Frank Norman, Applied Ecological Services, Inc., Kansas City, MO; and Stephen Parker, Adaptive Ecosystems, Inc., Grandview, MO.

Technical editors for this Regional Supplement were Dr. James S. Wakeley, Robert W. Lichvar, and Chris V. Noble, ERDC. William L. James was the project proponent and coordinator at Headquarters, USACE. During the conduct of this work, Dr. Morris Mauney was Chief of the Wetlands and Coastal Ecology Branch; Dr. Edmond Russo was Chief, Ecosystem Evaluation and Engineering Division; Bob Lazor was Program Manager, WRAP; and Dr. Elizabeth Fleming was Director, EL.

COL Gary E. Johnston was Commander and Executive Director of ERDC. Dr. Jeffery P. Holland was Director.

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1 Introduction

Purpose and use of this regional supplement

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual (hereafter called the Corps Manual). The Corps Manual provides technical guidance and procedures, from a national perspective, for identifying and delineating wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act (33 U.S.C. 1344) or Section 10 of the Rivers and Harbors Act (33 U.S.C. 403). According to the Corps Manual, identification of wetlands is based on a three-factor approach involving indicators of hydrophytic vegetation, hydric soil, and wetland hydrology. This Regional Supplement presents wetland indicators, delineation guidance, and other information that is specific to the Great Plains Region.

This Regional Supplement is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. Regional differences in climate, geology, soils, hydrology, plant and animal communities, and other factors are important to the identification and functioning of wetlands. These differences cannot be considered adequately in a single national manual. The development of this supplement follows National Academy of Sciences recommendations to increase the regional sensitivity of wetland-delineation methods (National Research Council 1995). The intent of this supplement is to bring the Corps Manual up to date with current knowledge and practice in the region and not to change the way wetlands are defined or identified. The procedures given in the Corps Manual, in combination with wetland indicators and guidance provided in this supplement, can be used to identify wetlands for a number of purposes, including resource inventories, management plans, and regulatory programs. The determination that a wetland is subject to regulatory jurisdiction under Section 404 or Section 10 must be made independently of procedures described in this supplement.

This Regional Supplement is designed for use with the current version of the Corps Manual (Environmental Laboratory 1987) and all subsequent versions. Where differences in the two documents occur, this Regional Supplement takes precedence over the Corps Manual for applications in

the Great Plains Region. Table 1 identifies specific sections of the Corps Manual that are replaced by this supplement. Other guidance and procedures given in this supplement and not listed in Table 1 are intended to augment the Corps Manual but not necessarily to replace it. The Corps of Engineers has final authority over the use and interpretation of the Corps Manual and this supplement in the Great Plains Region.

Table 1. Sections of the Corps Manual replaced by this Regional Supplement for applications in the Great Plains Region.

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

Indicators and procedures given in this Supplement are designed to identify wetlands as defined jointly by the Corps of Engineers (33 CFR 328.3) and Environmental Protection Agency (40 CFR 230.3). Wetlands are a subset of the "waters of the United States" that may be subject to regulation under Section 404. One key feature of the definition of wetlands is that, under normal circumstances, they support "a prevalence of vegetation typically adapted for life in saturated soil conditions." Many waters of the United States are unvegetated and thus are excluded from the Corps/EPA definition of wetlands, although they may still be subject to Clean Water Act regulation. Other potential waters of the United States in the Great Plains include but are not limited to unvegetated playa lakes, mud and salt flats, and perennial, intermittent, and ephemeral stream channels. Delineation of these waters in non-tidal areas is based on the "ordinary

high water mark" (33 CFR 328.3e) or other criteria and is beyond the scope of this Regional Supplement.

Amendments to this document will be issued periodically in response to new scientific information and user comments. Between published versions, Headquarters, U.S. Army Corps of Engineers, may provide updates to this document and any other supplemental information used to make wetland determinations under Section 404. Wetland delineators should use the most recent approved versions of this document and supplemental information. See the Corps of Engineers Headquarters regulatory web site for information and updates (http://www.usace.army.mil/CECW/Pages/cecwo_reg.aspx). The Corps of Engineers has established an interagency National Advisory Team for Wetland Delineation whose role is to review new data and make recommendations for needed changes in wetland-delineation procedures to Headquarters, U.S. Army Corps of Engineers. Items for consideration by the Team, including full documentation and supporting data, should be submitted to:

National Advisory Team for Wetland Delineation
Regulatory Branch (Attn: CECW-CO)
U.S. Army Corps of Engineers
441 G Street, N.W.
Washington, DC 20314-1000

Applicable region and subregions

This supplement is applicable to the Great Plains Region, which consists of all or portions of 11 states: Colorado, Kansas, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming (Figure 1). The region encompasses a variety of landforms and ecosystems, but is differentiated from surrounding regions mainly by its relatively low level of topographic relief, semi-arid climate, dominance of grasslands, and paucity of forests (Bailey 1995; Commission for Environmental Cooperation [CEC] 1997).

The approximate spatial extent of the Great Plains Region is shown in Figure 1. The region map is based on a combination of Land Resource Regions (LRR) F, G, H, I, and J recognized by the U.S. Department of Agriculture (USDA Natural Resources Conservation Service 2006a).

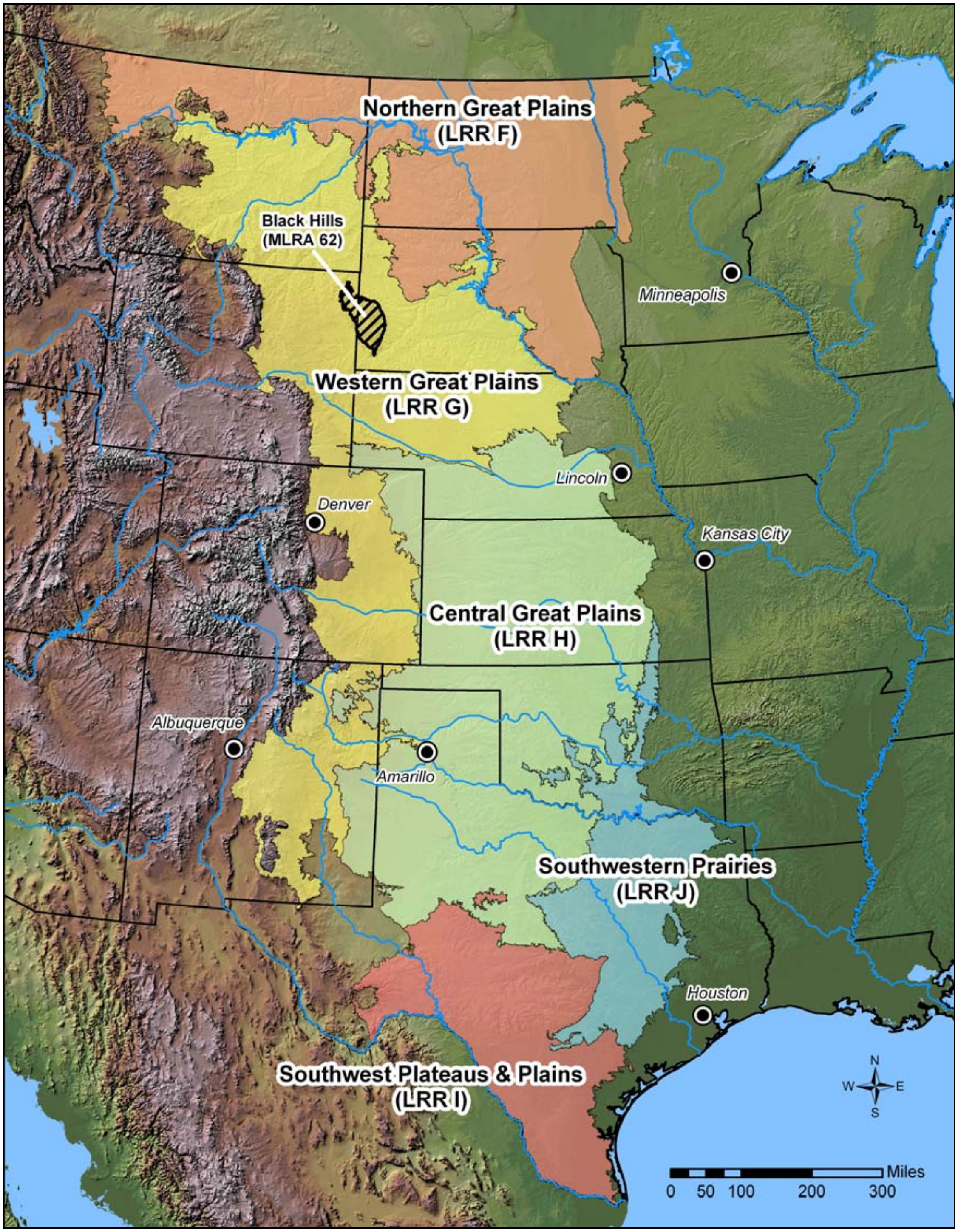

Figure 1. Approximate boundaries of the Great Plains Region. Subregions used in this supplement correspond to USDA Land Resource Regions (LRR). This supplement is applicable throughout the highlighted areas, although some indicators may be restricted to specific subregions or smaller areas. In the Black Hills (MLRA 62), indicated with black hatching, the Western Mountains, Valleys, and Coast Regional Supplement should be used in areas above the lower elevation limit of the ponderosa pine zone. See text and U.S. Army Corps of Engineers (2008), or current version, for details.

Subregions used in this supplement correspond to LRRs. Most of the wetland indicators presented in this supplement are applicable throughout the entire Great Plains Region. However, some indicators are restricted to specific subregions (i.e., LRR) or smaller areas (i.e., USDA Major Land Resource Areas [MLRA]). Within LRR G, portions of the Black Hills (MLRA 62) are excluded from the Great Plains Region. Specifically, those portions above the lower elevational limit of the ponderosa pine (*Pinus ponderosa*) zone, including interspersed meadows, shrublands, and riparian areas, are addressed in the Western Mountains, Valleys, and Coast Regional Supplement (U.S. Army Corps of Engineers [2008] or current version).

Region and subregion boundaries are depicted in Figure 1 as sharp lines. However, climatic conditions and the physical and biological characteristics of landscapes do not change abruptly at the boundaries. In reality, regions and subregions often grade into one another in broad transition zones that may be tens or hundreds of miles wide. The lists of wetland indicators presented in these Regional Supplements may differ between adjoining regions or subregions. In transitional areas, the investigator must use experience and good judgment to select the supplement and indicators that are appropriate to the site based on its physical and biological characteristics. Wetland boundaries are not likely to differ between two supplements in transitional areas, but one supplement may provide more detailed treatment of certain problem situations encountered on the site. If in doubt about which supplement to use in a transitional area, apply both supplements and compare the results. For additional guidance, contact the appropriate Corps of Engineers District Regulatory Office. Contact information for District regulatory offices is available at the Corps Headquarters web site (http://www.usace.army.mil/CECW/Pages/reg_districts.aspx).

Physical and biological characteristics of the region

The Great Plains is a region of flat to rolling topography extending from the foothills of the Rocky Mountains in the west to the often indistinct transition to more humid environments in the east. Across much of the plains, annual precipitation is less than potential evapotranspiration, resulting in moisture deficits and a semi-arid climate (Bailey 1995). Due to limited rainfall, groundwater recharge and discharge occur mainly in depressions, and water tables are usually mounded beneath depressions and drainages. This is in contrast to humid eastern landscapes, where considerable groundwater recharge occurs in uplands, wetlands are often

discharge systems, and the water table is a muted reflection of surface topography (Richardson et al. 2001).

Climatic conditions across the Great Plains vary considerably from north to south and from east to west. The western plains lie in the rain shadow of the Rocky Mountains and the climate is dry and continental. Conditions become more humid toward the east, but there is still insufficient soil moisture for extensive forest growth. In the north, winters are long and cold and the growing season is short, while southern winters are more moderate with most of the precipitation falling as rain rather than snow (Bailey 1995). High winds and periodic intense droughts are characteristic of the plains (CEC 1997).

The principal soil parent materials in the Great Plains are glacial tills and drifts; glacial lake sediments; wind-deposited loess and sands; residuum from the weathering of shales, sandstones, and limestones; mountain outwashes; alluviums deposited in floodplains; and marine sediments (Aandahl 1982). The glacial materials are primarily north and east of the Missouri River and in eastern Nebraska and northeastern Kansas. Loess mantles much of the southern glacial materials and is very extensive in Nebraska, Kansas, eastern Colorado, southeastern Wyoming, and the southern High Plains. The largest area of eolian sand is the Nebraska Sandhills. South and west of the Missouri River, in northeastern Wyoming, Montana, North and South Dakota, and northwestern Nebraska, most of the soils formed in residua from sandstones and shales. Deep loamy sediments of mixed origin are common east of the Rocky Mountains. Residua from limestones, sandstones, and shales are extensive in eastern Kansas, Oklahoma, and central Texas. South and east of the Edwards Plateau, most of the materials are of marine origin. Throughout the entire Great Plains, valley alluvium exists along streams and rivers.

Soils with dark-colored surface horizons high in organic matter (Mollisols) are very extensive in the Great Plains, particularly in wetlands. They develop primarily under grassland and savanna vegetation. Relatively undeveloped soils (Entisols) formed in recent alluvium or sand are common in floodplains and sandhills. Clay soils with high shrink-swell potential (Vertisols) are common in parts of Texas. Organic soils (Histosols) are rare but can be found locally (e.g., in the Nebraska Sandhills) in wetlands that are nearly permanently saturated or ponded.

Vegetation in the Great Plains grades generally from short-grass prairie in the west to mixed and tall-grass prairie in the east. Riparian habitats throughout the region often support woody communities dominated by cottonwoods (*Populus* spp.), willows (*Salix* spp.), and other woody species. In the southern plains, the prairies give way to communities dominated by grasses mixed with woody species, including mesquite (*Prosopis* spp.), junipers (*Juniperus* spp.), and oaks (*Quercus* spp.) (USDA Natural Resources Conservation Service 2006a). Details are presented by sub-region below.

The Great Plains Region is composed of five subregions: Northern Great Plains (corresponds to LRR F), Western Great Plains (LRR G), Central Great Plains (LRR H), Southwest Plateaus and Plains (LRR I), and South-western Prairies (LRR J) (Figure 1). Important characteristics of each subregion are described briefly below; further details can be found in USDA Natural Resources Conservation Service (2006a). Most of the indi-cators presented in this Regional Supplement are applicable across all subregions of the Great Plains.

Northern Great Plains (LRR F)

This subregion is covered by undulating deposits of glacial till and level to gently rolling lacustrine deposits. Mean annual precipitation ranges from 14 to 21 in. (355 to 535 mm) across much of the area. The area is subject to high winds and periodic intense droughts. The mean annual temperature in much of the area is 39 to 45 °F (4 to 7 °C), winters are cold, and the growing season is short. The vegetation is mixed and tall-grass prairie dominated mainly by western wheatgrass (*Pascopyrum smithii* = *Agropyron smithii*), green needlegrass (*Nassella viridula*), needle and thread (*Hesperostipa comata*), and blue grama (*Bouteloua gracilis*), with big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*) in the east (USDA Natural Resources Conservation Service 2006a).

Western Great Plains (LRR G)

This large subregion consists of an elevated piedmont plain that adjoins the Rocky Mountains along nearly their entire length. Many rivers flow east across the area from headwaters in the mountains. Average annual precipitation is 13 to 22 in. (330 to 560 mm) and average annual temp-erature is 44 to 51 °F (7 to 11 °C) across much of the area. Western

wheatgrass, green needlegrass, needle and thread, and blue grama are common species in the northern portion of the subregion, with sideoats grama (*B. curtipendula*), galleta (*Pleuraphis* spp.), alkali sacaton (*Sporobolus airoides*), little bluestem (*Schizachyrium scoparium*), and woody shrubs in the south (USDA Natural Resources Conservation Service 2006a).

Central Great Plains (LRR H)

Large portions of this subregion in the north and west consist of fluvial deposits derived from the erosion of the ancestral Rocky Mountains. Many areas are blanketed by wind-blown sand and loess, while large areas in the southcentral portion of the subregion contain red soils formed from Permian red-bed sediments. Average annual precipitation ranges from 20 to 29 in. (510 to 735 mm) in much of the area, most of which falls as rain in spring and fall. Average annual temperature ranges from 54 to 60 °F (12 to 16 °C). Blue grama, buffalo grass (*Bouteloua dactyloides*), little bluestem, big bluestem, switchgrass, Indian grass, and sideoats grama are common species (USDA Natural Resources Conservation Service 2006a).

Southwest Plateaus and Plains (LRR I)

This subregion contains many mesas, plateaus, hills, and incised canyons in the north and west. The south and east consist of the nearly level to hilly terrain of the Gulf Coastal Plain and Rio Grande Valley. Precipitation is moderate but air temperatures and evapotranspiration rates are high. Average annual precipitation is 20 to 29 in. (510 to 735 mm) and average annual temperature is 66 to 70 °F (19 to 21 °C). Vegetation is a mix of grasses, shrubs, and some trees, including sideoats grama, threeawn (*Aristida* spp.), Texas grama (*B. rigidiseta*), hairy grama (*B. hirsuta*), buffalo grass, curly-mesquite (*Hilaria belangeri*), juniper, mesquite, lotebush (*Ziziphus obtusifolia*), live oak (*Quercus virginiana*), cedar elm (*Ulmus crassifolia*), desert yaupon (*Schaefferia cuneifolia*), and spiny hackberry (*Celtis ehrenbergiana*) (USDA Natural Resources Conservation Service 2006a).

Southwestern Prairies (LRR J)

This area consists of nearly level to hilly terrain, dissected by numerous streams. Average annual precipitation is 31 to 44 in. (785 to 1,120 mm).

Average annual temperature is 62 to 67 °F (17 to 19 °C). The vegetation is dominated by mixed to tall-grass prairie species, with scattered oaks and other woody species, particularly along drainages. Common species include big bluestem, little bluestem, Indian grass, switchgrass, and sunflowers (*Helianthus* spp.) in the understory, and post oak (*Q. stellata*), blackjack oak (*Q. marilandica*), American elm (*Ulmus americana*), cottonwood, hackberry (*Celtis occidentalis*), and pecan (*Carya illinoensis*) in the overstory (USDA Natural Resources Conservation Service 2006a).

Types and distribution of wetlands

Wetlands occupy only a few percent of the semi-arid Great Plains landscape (Dahl 1990) but their diversity is high, including freshwater marshes, sloughs, wet meadows, floodplain and riparian wetlands, fens, seeps, fringe wetlands surrounding lakes and reservoirs, prairie potholes, playa lakes, and other fresh and saline depressional systems (Comer et al. 2003; NatureServe 2006). Wetlands are more numerous in the eastern Great Plains than in the drier western plains. Additional information on wetland plant associations in particular states or ecoregions is available from the NatureServe web site (http://www.natureserve.org/explorer/).

Freshwater emergent marshes are found throughout the region in depressions, as fringes around lakes, and sloughs along slow-moving streams. These wetlands range from temporarily to permanently inundated and may be dominated by floating-leaved plants in deeper areas (e.g., *Lemna*, *Potamogeton*, *Brasenia*, *Nuphar*) and sedges (*Carex*, *Cyperus*, *Rhynchospora*), bulrushes (*Scirpus*, *Schoenoplectus*), spikerushes (*Eleocharis*), cattails (*Typha*), rushes (*Juncus*), and grasses (e.g., *Phalaris*, *Spartina*) in seasonal wetlands (NatureServe 2006).

Floodplain and riparian systems occur along rivers and streams across the Great Plains, but most of these areas do not qualify as wetlands unless they are frequently flooded for long periods, pond water for long periods, or receive significant groundwater input. In Texas, for example, abandoned channels, flats, and depressions in floodplain landscapes underlain by clay soils, such as Vertisols, may pond water for weeks after local storm events; in these situations, ponding of precipitation and local runoff may be a more important source of wetland hydrology than overbank flooding (Miller and Bragg 2007). Common woody species in riparian and floodplain wetlands in the Great Plains include plains cottonwood (*Populus deltoides* ssp. *monilifera*), narrowleaf cottonwood (*P. angustifolia*),

various willows, green ash (*Fraxinus pennsylvanica*), cedar elm, eastern swampprivet (*Forestiera acuminata*), and the introduced saltcedar (*Tamarix ramosissima*) (National Research Council 2002; NatureServe 2006). Many streams in the region have been channelized or converted to reservoir systems (Barclay 1980).

Man-made reservoirs built for irrigation, flood control, navigation, and domestic water supply are a common feature of the Great Plains. Fringe wetlands surround most of these reservoirs and can be very extensive, particularly in the upper reaches of large reservoirs where incoming streams and rivers have deposited sediments in the calm waters of the lake and created broad deltas that may be intermittently exposed. Water regimes in these wetlands can be highly variable, depending upon local relief and the purpose and operating regime of the reservoir. Plant communities are also variable, including emergent, scrub/shrub, and forested wetlands. Extensive mud flats are common in some reservoirs.

Prairie potholes are depressional wetlands formed in glacial deposits that blanket the northern Great Plains in North and South Dakota, northern Montana, and northwestern Minnesota. Water regimes are highly variable across different pothole wetlands and range from seasonally saturated to permanently ponded except in extreme drought years. Wetlands formed in gently undulating lacustrine and till materials often have seasonally perched water tables due to the slow permeability of the soils and nearly level terrain. Areas of sand and gravel outwash are associated with these glacial materials and often support networks of wetlands with water tables reflecting more regional flow paths than similar wetlands in finer textured glacial drift. The importance of groundwater recharge, discharge, and throughflow varies depending upon soil conditions and the wetland's relative position in the landscape (Richardson et al. 2001). Pothole wetlands also vary in salinity. Recharge systems remain fresh due to continual input of precipitation and local runoff and the relative lack of groundwater inputs. However, some discharge systems receive groundwater containing dissolved salts, which subsequently become concentrated in the wetland due to evapotranspiration (Hubbard 1988; Richardson et al. 2001). The vegetation of prairie pothole wetlands is dominated by sedges, bulrushes, grasses, and forbs, but the composition varies greatly depending upon the hydrologic regime, salinity, current drought conditions, and extent of human disturbance (Hubbard 1988). Many pothole wetlands are planted to crops or hay.

The playa lakes region of northwestern Texas, eastern New Mexico and Colorado, and western Oklahoma, Kansas, and Nebraska also contains thousands of depressional wetlands, but they are very different from the potholes of the northern plains. Playa lakes are shallow circular basins apparently formed by wind erosion and/or calcium carbonate dissolution. Precipitation and local runoff are usually held at the surface by a clay-rich layer, forming shallow ponds and vegetated wetlands. Water is lost through evapotranspiration and seepage at the basin margins above the level of the clay layer. Many playa lakes have been modified for use as sources of irrigation water and sinks for irrigation return flow. Vegetation of playa lakes depends on the water regime, surrounding land use, and playa modifications. Vegetation composition can change rapidly as dry playas fill with water in response to local storm events. Common species in playa wetlands include grasses (e.g., *Echinochloa*, *Leptochloa*), smartweeds (*Polygonum*), bulrushes, and cattails (Bolen et al. 1989). Similar depressional systems in the western plains are often saline and support salt-tolerant species such as saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), and foxtail barley (*Hordeum jubatum*) (NatureServe 2006).

The Rainwater Basin of southcentral Nebraska consists of an undulating loess plain containing numerous closed basins underlain by clay soils that reduce infiltration of rain water and runoff. These depressions support temporarily to semi-permanently ponded wetlands. Many of the smaller wetlands that were present historically in the Basin have been destroyed by human activities, such as road building, sedimentation, grading, and filling for agricultural use. Of the nearly 4,000 Rainwater Basin wetlands that existed in the 1800s, fewer than 450 remain today. Vegetation of Rainwater Basin wetlands is distributed in zones in response to water depth and duration. Cattails, bulrushes, and pondweeds (*Potamogeton*) occupy the deeper zones, with spikerushes, smartweeds, sedges, reed canary grass (*Phalaris arundinacea*), and foxtail barley in seasonally wet areas, and western wheatgrass, buffalo grass, and blue grama at the margins (Stutheit et al. 2004).

The Sandhills region of northcentral Nebraska consists of wind-blown dune deposits containing numerous shallow lakes and wetlands in interdunal valleys and depressions. Many Sandhills wetlands are fens, a wetland type that is common in the humid eastern United States but rare in the Great Plains. Fens develop where nutrient-rich, calcareous

groundwater supports lush communities of sedges and other herbaceous plants, whose dead remains accumulate as organic soil layers (NatureServe 2006). Saline wetlands may exist around lake fringes.

Another unique wetland type in the region occurs in the Texas Sand Sheet, a large area of wind-blown sand and silt covering several south Texas coastal counties near the Laguna Madre. In this desert-like landscape, numerous wetlands occur in dune swales and blown-out depressions that are close to the water table. Wetlands in the area have a variety of water regimes. They may be hydrologically isolated, part of a larger wetland complex, or have direct hydrologic connections to the Laguna Madre. Some of these wetlands may be dry for years during drought periods, then fill for months during active years for tropical storms. Vegetation in the wetlands is mainly herbaceous, with bulrushes, spikerushes, flatsedges (*Cyperus*), paspalums (*Paspalum* spp.), and other water-tolerant grasses in the fresher wetlands, and saltgrass and other halophytes in the more saline areas (Moulton and Jacob 2000). Huisache (*Acacia smallii*), a woody shrub or small tree, may dominate some of these wetlands.

Other common wetland types in the Great Plains include seeps, springs, and slope wetlands. The resultant wet soils are often high in salts depending upon the chemistry of the parent materials. In addition, various man-made wetlands also occur in the region, including those formed in abandoned sand and gravel mines, wildlife management areas, and irrigation tailwaters.

2 Hydrophytic Vegetation Indicators

Introduction

The Corps Manual defines hydrophytic vegetation as the community of macrophytes that occurs in areas where inundation or soil saturation is either permanent or of sufficient frequency and duration to exert a controlling influence on the plant species present. The manual uses a plant-community approach to evaluate vegetation. Hydrophytic vegetation decisions are based on the assemblage of plant species growing on a site, rather than the presence or absence of particular indicator species. Hydrophytic vegetation is present when the plant community is dominated by species that require or can tolerate prolonged inundation or soil saturation during the growing season. Hydrophytic vegetation in the Great Plains is identified by using the indicators described in this chapter.

Many factors besides site wetness affect the composition of the plant community in an area, including regional climate, local weather patterns, topography, soils, and current or historical plant distributional patterns at various spatial scales. The vegetation of the Great Plains varies greatly from north to south and east to west. These variations reflect climatic and elevation differences and the post-glacial influx of species that now comprise a flora best described as “recent and adventive in origin” (Barkley 1986). This distinctive flora has been maintained or further modified by fires and grazing.

Great Plains landscapes contain a variety of habitats requiring an array of adaptations for plants to survive in areas that include saline playas, expansive grasslands, sand hills, hardwood savannas, forested riparian bottomlands, and prairie potholes. In southern portions of the region, where numerous saline playas and small lakes occur, halophytes are associated with many wetland settings. Halophytes have morphological and physiological adaptations that allow them to exist in highly saline soil and water conditions. In the dry foothills region east of the Rocky Mountains, there are many intermittent stream channels. Associated with these habitats are phreatophytes with long roots that are adapted to reach deep subsurface water tables, allowing these species to survive in locations that otherwise only receive intermittent surface-water inputs. Although often found in wetlands, halophytes and phreatophytes that are located in areas with

ephemeral hydrology can sometimes be misleading indicators of wetland conditions. They may dominate plant communities in areas that are highly saline but lack wetland hydrology or hydric soils, or they may occur in areas where groundwater is below the depth required to meet wetland criteria.

The Great Plains Region is known for its short- and long-term climatic variability. Changes in weather and climatic conditions often produce seasonal and decadal-scale shifts in the species composition of plant communities (Barkley 1986), and wetlands show some of the greatest shifts of any communities in the region. Changes in species composition of woody shrubs and trees in wetlands are generally not dramatic. Decade-long drought conditions may stress woody plants but these species typically survive and persist at drought-influenced wetland and riparian sites. Herbaceous wetland communities, however, respond much more quickly and dramatically. Although most wetland plant communities in the Great Plains are affected to some degree by seasonal and/or longer-term changes in the availability of water, playa wetlands, prairie potholes, other depressional wetland types, seeps, and springs are particularly prone to cyclic shifts in plant species composition.

Community composition on a site reflects the adaptive capabilities of the plant species present, superimposed on a complex spatial and historical pattern of hydrologic, edaphic, and other environmental conditions. Disturbances and climatic fluctuations, such as floods, wildfires, grazing, and recent site modifications, are also important. They can set back or alter the course of plant succession and may even change the hydrophytic status of the community. See Chapter 5 for discussions of specific problematic wetland vegetation types in the region.

Hydrophytic vegetation decisions are based on the wetland indicator status (Reed [1988] or current approved list) of species that make up the plant community. Species in the facultative categories (FACW, FAC, and FACU) are recognized as occurring in both wetlands and uplands to varying degrees. Although most wetlands are dominated mainly by species rated OBL, FACW, and FAC, some wetland communities may be dominated primarily by FACU species and cannot be identified by dominant species alone. In those cases, other indicators of hydrophytic vegetation must also be considered, particularly where indicators of hydric soils and wetland hydrology are present. This situation is not necessarily due to

inaccurate wetland indicator ratings; rather, it is due to the broad tolerances of certain plant species that allow them to be widely distributed across the moisture gradient. Therefore, for some species, it is difficult to assign a single indicator status rating that encompasses all of the various landscape and ecological settings it can occupy.

Hydrophytic vegetation indicators and procedures presented in this chapter are designed to identify the majority of wetland plant communities in the Great Plains. However, some wetland communities may lack any of these indicators, at least at certain times. These situations are considered in Chapter 5 (Difficult Wetland Situations in the Great Plains).

Guidance on vegetation sampling and analysis

General guidance on sampling of vegetation for wetland-delineation purposes is given in the Corps Manual. Those procedures are intended to be flexible and may need to be modified for application in a given region or on a particular site. Vegetation sampling done as part of a wetland delineation is designed to characterize the site in question rapidly. A balance must be established between the need to accomplish the work quickly and the need to characterize the site's heterogeneity accurately and at an appropriate scale. The following guidance on vegetation sampling is intended to supplement the Corps Manual for applications in the Great Plains.

The first step is to stratify the site so that the major landscape units or vegetation communities can be evaluated separately. This may be done in advance using an aerial photograph or topographic map, or by walking over the site. In general, routine wetland determinations are based on visual estimates of percent cover of plant species that can be made either (1) within the vegetation community as a whole, or (2) within one or more sampling plots established in representative locations within each community. Percent cover estimates are more accurate and repeatable if taken within a defined plot or series of plots. This also facilitates field verification of another delineator's work. The sizes and shapes of sampling plots, if used, may be modified as appropriate to adapt to site conditions and should be recorded on the field data form if they deviate from those recommended in the Corps Manual. When sampling near a plant-community boundary, and particularly near the wetland boundary, it may be necessary to adjust plot size or shape to avoid overlapping the boundary and extending into an adjacent community having different vegetation,

soils, or hydrologic conditions. For wetland delineation purposes, an area is considered to be vegetated if it has 5 percent or more total plant cover at the peak of the growing season. See "Sparse and Patchy Vegetation" in Chapter 5 for guidance on dealing with areas that contain both vegetated and unvegetated wet areas.

If it is not possible to locate one or a few plots in a way that adequately represents the vegetation unit being sampled, then percent cover estimates for each species can be made during a meandering survey of the broader community. If additional quantification of cover estimates is needed, then the optional procedure for point-intercept sampling along transects (see Appendix B) may be used to characterize the vegetation unit. To use either of these sampling methods, soil and hydrologic conditions must be uniform across the sampled area.

Plot and sample sizes

Hydrophytic vegetation determinations under the Corps Manual are based on samples taken in representative locations within each community. Random sampling of the vegetation is not required except in unusual cases where representative sampling might give misleading results. For routine determinations in fairly uniform vegetation, one or more plots in each community are usually sufficient for an accurate determination. A multilayered community is sampled using a graduated series of plots, one for each stratum, or a number of small plots nested within the largest plot (Figure 2). Nested plots can be helpful to sample the herb stratum in forested areas with highly variable understories or in very diverse or patchy herbaceous communities. The smaller plots should be randomly distributed within the large plot, and plant abundance data averaged across the small plots.

The appropriate size and shape for a sample plot depend on the type of vegetation (i.e., trees, shrubs, herbaceous plants, etc.) and the size or shape of the plant community or patch being sampled. A plot should be large enough to include adequate numbers of individuals in all strata, but small enough so that plant species or individuals can be separated and measured without duplication or omission, and the sampling can be done in a timely fashion (Cox 1990; Barbour et al. 1999). For hydrophytic vegetation determinations, the abundance of each species is usually determined by estimating areal cover. Plot sizes should make visual sampling

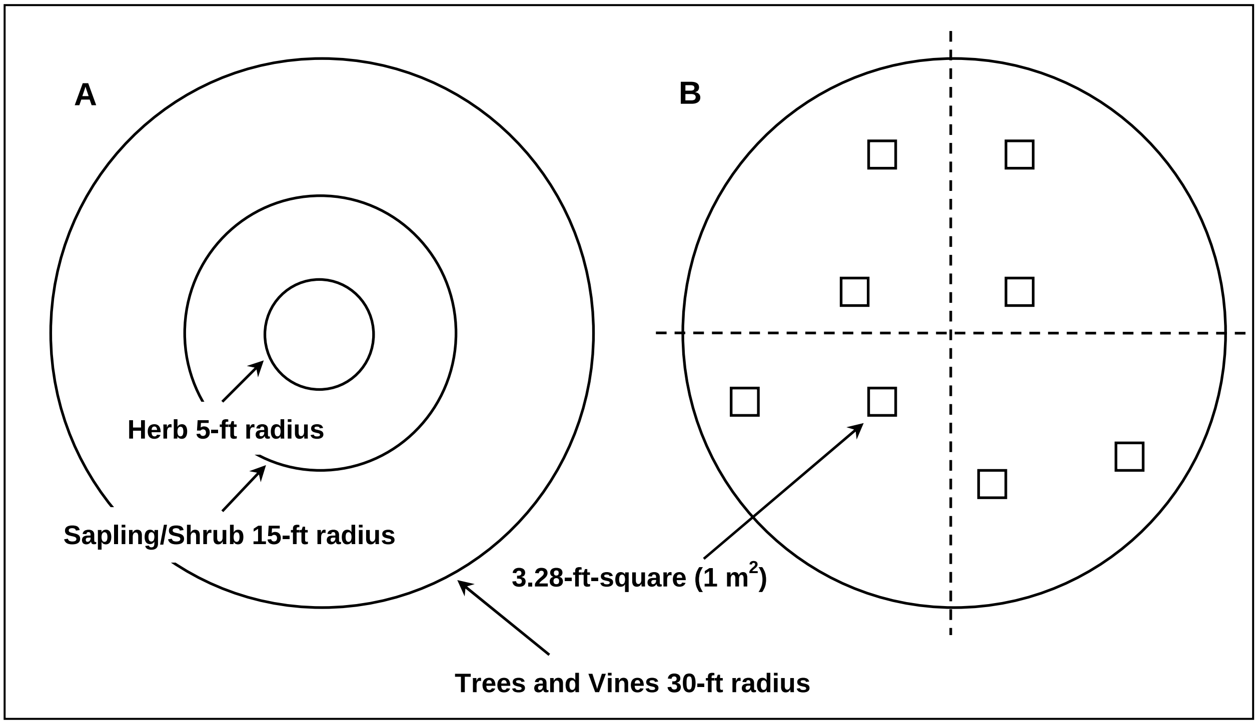

Figure 2. Examples of plot arrangements for vegetation sampling. (A) Single plots in graduated sizes. (B) Nested 3.28- by 3.28-ft (1-m^2) plots within the 30-ft (9.1-m) radius plot.

both accurate and efficient. The wetland delineator has many options for sampling plant communities. One option is circular plots. In the Great Plains, the following examples of plot sizes are suggested (Figure 2).

1. Trees – 30-ft (9.1-m) radius
2. Saplings and shrubs – 15-ft (4.6-m) radius
3. Herbaceous plants – 5-ft (1.5-m) radius
4. Woody vines – 30-ft (9.1-m) radius

The sampling plot should not be allowed to extend beyond the edges of the plant community being sampled or to overlap an adjacent community having different vegetation, soil, or hydrologic conditions. This may happen if vegetation patches are small or occur as narrow bands or zones along a topographic or moisture gradient. In such cases, plot sizes and shapes should be adjusted to fit completely within the vegetation patch or zone of interest. For example, in linear riparian communities where the width of a standard plot may exceed the width of the plant community, an elongated rectangular plot or belt transect that follows the stream may be needed. One approach is to sample an area of equivalent size to the 30-ft-radius plot (2,827 ft^2 [263 m^2]) for the tree stratum or the 15-ft-radius plot (707 ft^2 [65.7 m^2]) for the sapling/shrub stratum. Thus the sapling/shrub

stratum could be sampled using a 10- by 71-ft (3.1- by 21.6-m) plot lying completely within the riparian fringe. An alternative approach involves sampling a series of small subplots (e.g., 5 by 5 ft [1.5 by 1.5 m], or 10 by 10 ft [3.1 by 3.1 m]) in the riparian community and averaging the data across subplots.

A 30-ft-radius tree plot works well in most forests but can be adjusted to 35 ft (10.7 m) or 40 ft (12.2 m) or more in a nonlinear forest stand if tree diversity is high or diameters are large. Highly diverse or patchy herbaceous communities may be sampled with nested 3.28- by 3.28-ft (1-m^2) quadrats randomly located within a 30-ft radius (Figure 2B).

Vegetation sampling guidance presented here should be appropriate for most situations. However, many variations in vegetation structure, diversity, and spatial arrangement exist on the landscape and cannot be addressed adequately in this supplement. A list of references is given in Table 2 for more complex sampling situations. If alternative sampling techniques are used, they should be described in field notes or in the delineation report. The basic data must include abundance values for each species present. Typical abundance measures include basal area for tree species, percent areal cover, stem density, or frequency based on point-intercept sampling. In any case, the data must be in a format that can be used in the dominance test or prevalence index for hydrophytic vegetation (see Hydrophytic Vegetation Indicators).

In this supplement, absolute percent cover is the preferred abundance measure for all species. For percent cover estimates, it is not necessary for all plants to be rooted in the plot as long as they are growing under the same soil and hydrologic conditions. It may be necessary to exclude plants that overhang the plot if they are rooted in areas having different soil and hydrologic conditions, particularly when sampling near the wetland boundary.

Table 2. Selected references to additional vegetation sampling approaches that could be used in wetland delineation.

Reference	Comment
Barbour, M. G., J. H. Burk, and W. D. Pitts. 1999. *Terrestrial plant ecology, 3rd edition*. Toronto, Canada: Addison Wesley.	General background on various aspects of vegetation ecology with several chapters dedicated to sampling and analysis.
Daubenmire, R. F. 1959. Canopy coverage method of vegetation analysis. *Northwest Science* 33: 43-64.	The article focuses on various methods to measure forest canopy cover.
Daubenmire, R. F. 1968. *Plant communities: a textbook of plant synecology*. New York, NY: Harper and Row.	One section is dedicated to description and analysis of vegetation communities.
Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. *Measuring and Monitoring Plant Populations*. Technical Reference 1730-1. Washington, DC: U.S. Dept. of the Interior, Bureau of Land Management.	Clearly presented and easy-to-read information on determining sample size and adequacy.
Kent, M., and P. Coker. 1992. *Vegetation Description and Analysis: A Practical Approach.* New York, NY: Wiley.	Simple and clear methods for setting up a study, and collecting and analyzing the data. Initial chapters are helpful for data collection and sampling approaches in wetland delineation.
Mueller-Dombois, D., and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. New York, NY: Wiley.	A standard text in vegetation ecology, sampling, and analysis. This reference provides many sampling and analytical methods that are helpful in complex delineations.
Peet, R. K., T. R. Wentworth, and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. *Castanea* 63: 262-274.	Good background information on various aspects of vegetation and their influence on numerical outcomes. Useful for possible comprehensive sampling approaches.
Tiner, R. W. 1999. *Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping.* Boca Raton, FL: Lewis Publishers.	Includes reviews of various sampling techniques and provides a list of vegetation references.
U.S. Environmental Protection Agency. 2002. *Methods for Evaluating Wetland Condition: Using Vegetation To Assess Environmental Conditions in Wetlands*. EPA-822-R-02-020. Washington, DC.	Contains sections on vegetation sampling, standard field methods, and data analysis techniques that are aimed at biological monitoring studies but are applicable to site characterizations for wetland delineations.
Zar, J. H. 1996. *Biostatistical Analysis*. Englewood Cliffs, NJ: Prentice-Hall.	Provides many statistical approaches to analyzing vegetation and other biological data.

Definitions of strata

Vegetation strata within a plot are sampled separately when evaluating indicators of hydrophytic vegetation. The structure of vegetation varies greatly in wetland communities across the region. In some wetlands in the Great Plains, short-statured woody plants (i.e., less than 3.3 ft [1 m] high or “sub-shrubs”) are a common growth form. The Corps Manual combines

short woody plants and herbaceous plants into a single "herb" stratum for sampling purposes. However, in the Great Plains, more information about the plant community is gained when short shrubs and herbaceous plants are sampled separately. Therefore, the following vegetation strata are recommended for use across the Great Plains. This system places short woody shrubs in the sapling/shrub stratum and limits the herb stratum to only herbaceous plant species.

Unless otherwise noted, a stratum for sampling purposes is defined as having 5 percent or more total plant cover. If a stratum has less than 5 percent cover during the peak of the growing season, then those species and their cover values should be recorded on the data form but should not be used in the calculations for the dominance test.

1. *Tree stratum* – Consists of woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.
2. *Sapling/shrub stratum* – Consists of woody plants less than 3 in. DBH, regardless of height.
3. *Herb stratum* – Consists of all herbaceous (non-woody) plants, including herbaceous vines, regardless of size.
4. *Woody vines* – Consists of all woody vines, regardless of height.

Seasonal considerations and cautions

To the extent possible, the hydrophytic vegetation decision should be based on the plant community that is normally present during the wet portion of the growing season in a normal rainfall year. However, wetland determinations must often be performed at other times of year, or in years with unusual or atypical weather conditions. The Great Plains has a highly seasonal climate with cool wet springs and hot dry summers. In the north, winters are typically cold and snowy. Vegetation sampling for a wetland determination can be challenging when some plants die back in response to seasonal or long-term drought, freezing temperatures, or other factors. At these times, experience and professional judgment may be required to adapt the vegetation sampling scheme or use other sources of information to determine the plant community that is normally present.

For example, winter sampling in the northern plains may be hampered by snow and ice that cover the ground and make it impractical to identify plant species and estimate plant cover. When an on-site evaluation of the vegetation is impractical due to excessive snow and ice, one option is to

use existing off-site data sources, such as National Wetlands Inventory (NWI) maps, soil surveys, and aerial photographs, to make a preliminary hydrophytic vegetation determination. These sources may be supplemented with limited on-site data, including those plant species that can be identified. Later, when conditions are favorable, an on-site investigation must be made to verify the preliminary determination and complete the wetland delineation.

Other factors can alter the plant community on a site and affect a hydrophytic vegetation determination, including seasonal changes in species composition, intensive grazing, wildfires and other natural disturbances, and human land-use practices. These factors are considered in Chapter 5.

Hydrophytic vegetation indicators

The following indicators should be applied in the sequence presented. The stepwise procedure is designed to reduce field effort by requiring that only one or two indicators, variations of the dominance test, be evaluated in the majority of wetland determinations. However, hydrophytic vegetation is present if any of the indicators is satisfied. All of these indicators are applicable throughout the entire Great Plains Region.

Indicators of hydrophytic vegetation involve looking up the wetland indicator status of plant species on the wetland plant list (Reed [1988] or current list). For species listed as NI (reviewed but given no regional indicator) or NO (no known occurrence in the region at the time the list was compiled), apply the indicator status assigned to the species in the nearest adjacent region. If the species is listed but no adjacent regional indicator is assigned, do not use the species to calculate hydrophytic vegetation indicators. In general, species that are not listed on the wetland plant list are assumed to be upland (UPL) species. However, recent changes in plant nomenclature have resulted in a number of species that are not listed by Reed (1988) but are not necessarily UPL plants. Procedures described in Chapter 5, "Problematic Hydrophytic Vegetation," can be used if it is believed that individual FAC−, FACU, NI, NO, or unlisted plant species are functioning as hydrophytes on a particular site. For Clean Water Act purposes, wetland delineators should use the latest plant lists approved by Headquarters, U.S. Army Corps of Engineers (Figure 3) (http://www.usace.army.mil/CECW/Pages/reg_supp.aspx).

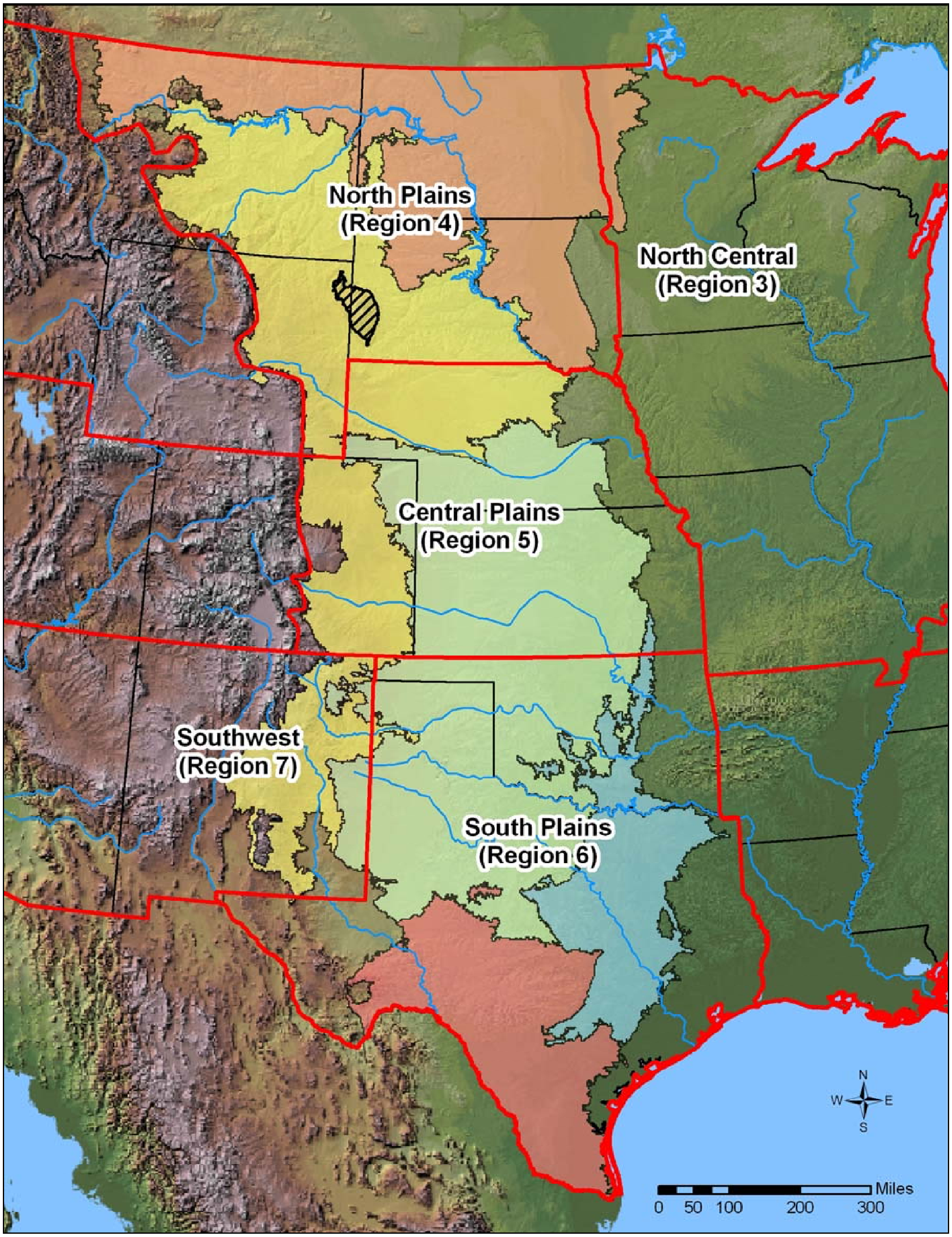

Figure 3. Plant list regional boundaries (red lines) currently used by the U.S. Fish and Wildlife Service, National Wetlands Inventory, in the Great Plains.

Evaluation of the vegetation can begin with a rapid field test for hydrophytic vegetation to determine if there is a need to collect more detailed vegetation data. The rapid test for hydrophytic vegetation (Indicator 1) is met if all dominant species across all strata are OBL or FACW, or a combination of the two, based on a visual assessment. If the site is not dominated solely by OBL and FACW species, proceed to the standard dominance test (Indicator 2), which is the basic hydrophytic vegetation indicator. Either Indicator 1 or 2 should be applied in every wetland determination. Most wetlands in the Great Plains have plant communities that will meet one or both of these indicators. These are the only indicators that need to be considered in most situations. However, some wetland plant communities may fail a test based only on dominant species. Therefore, in those cases where indicators of hydric soil and wetland hydrology are present, the vegetation should be re-evaluated with the prevalence index (Indicator 3), which takes non-dominant plant species into consideration, or by observing plant morphological adaptations for life in wetlands (Indicator 4). Finally, certain disturbed or problematic wetland situations may lack any of these indicators and are described in Chapter 5.

Procedure

The procedure for using hydrophytic vegetation indicators is as follows:

1. Apply Indicator 1 (Rapid Test for Hydrophytic Vegetation).

    a. If the plant community passes the rapid test for hydrophytic vegetation, then the vegetation is hydrophytic and no further vegetation analysis is required.
    b. If the rapid test for hydrophytic vegetation is not met, then proceed to step 2.

2. Apply Indicator 2 (Dominance Test).

    a. If the plant community passes the dominance test, then the vegetation is hydrophytic and no further vegetation analysis is required.
    b. If the plant community fails the dominance test, and indicators of hydric soil and/or wetland hydrology are absent, then hydrophytic vegetation is absent unless the site meets requirements for a problematic wetland situation (see Chapter 5).

   c. If the plant community fails the dominance test, but indicators of hydric soil and wetland hydrology are both present, proceed to step 3.

3. Apply Indicator 3 (Prevalence Index). This and the following step assume that at least one indicator of hydric soil and one primary or two secondary indicators of wetland hydrology are present.

   a. If the plant community satisfies the prevalence index, then the vegetation is hydrophytic. No further vegetation analysis is required.
   b. If the plant community fails the prevalence index, proceed to step 4.

4. Apply Indicator 4 (Morphological Adaptations).

   a. If the indicator is satisfied, the vegetation is hydrophytic.
   b. If none of the indicators is satisfied, then hydrophytic vegetation is absent unless indicators of hydric soil and wetland hydrology are present and the site meets the requirements for a problematic wetland situation (Chapter 5).

Indicator 1: Rapid test for hydrophytic vegetation

Description: All dominant species across all strata are rated OBL or FACW, or a combination of these two categories, based on a visual assessment.

User Notes: This test is intended as a quick confirmation in obvious cases that a site has hydrophytic vegetation, without the need for more intensive sampling. Dominant species are selected visually from each stratum of the community using the "50/20 rule" (see Indicator 2 – Dominance Test below) as a general guide but without the need to gather quantitative data. Only the dominant species in each stratum must be recorded on the data form.

Indicator 2: Dominance test

Description: More than 50 percent of the dominant plant species across all strata are rated OBL, FACW, or FAC (excluding FAC−).

User Notes: Use the "50/20 rule" described below to select dominant species from each stratum of the community. Combine dominant species across strata and apply the dominance test to the combined list. Once a

species is selected as a dominant, its cover value is not used in the dominance test; each dominant species is treated equally. Thus, a plant community with seven dominant species across all strata would need at least four dominant species that are OBL, FACW, or FAC (excluding FAC−) to be considered hydrophytic by this indicator. Species that are dominant in two or more strata should be counted two or more times in the dominance test.

Procedure for Selecting Dominant Species by the 50/20 Rule: Dominant plant species are the most abundant species in the community; they contribute more to the character of the community than do the other non-dominant species present. The 50/20 rule is the recommended method for selecting dominant species from a plant community when quantitative data are available.

For rapid wetland determinations in relatively simple plant communities, a qualitative assessment of dominant species is often adequate and may be more efficient and economical than more intensive vegetation sampling. This option is most often applicable to plant communities that consist of nearly uniform or monotypic stands with low species diversity, low spatial heterogeneity, and abrupt boundaries between different vegetation communities or zones. In these situations, dominant species can be selected visually without invoking the 50/20 rule except as a general guide. A list of dominant species derived by the qualitative approach is adequate for the dominance test for hydrophytic vegetation (Indicator 2). If a prevalence index calculation (Indicator 3) is needed, however, then more intensive vegetation sampling is required.

Dominant species are chosen independently from each stratum of the community. In general, dominants are the most abundant species that individually or collectively account for more than 50 percent of the total coverage of vegetation in the stratum, plus any other species that, by itself, accounts for at least 20 percent of the total. For the purposes of this regional supplement, absolute percent cover is the recommended abundance measure for plants in all vegetation strata. See Table 3 for an example application of the 50/20 rule in evaluating a plant community.

Table 3. Example of the selection of dominant species by the 50/20 rule and determination of hydrophytic vegetation by the dominance test.

Stratum	Species Name	Wetland Indicator Status (Region 6)	Absolute Percent Cover	Dominant?
Herb	*Panicum virgatum*	FACW	40	Yes
	Ambrosia artemisiifolia	FACU−	15	Yes
	Iva annua	FAC	15	Yes
	Cardiospermum halicacabum	FAC	8	No
	Xanthium strumarium	FAC−	6	No
		Total cover	84.0	
		50/20 Thresholds: 50% of total cover = 42.0% 20% of total cover = 16.8%		
Sapling/shrub	*Salix nigra*	FACW+	20	Yes
	Celtis laevigata	FAC	12	Yes
		Total cover	32.0	
		50/20 Thresholds: 50% of total cover = 16.0% 20% of total cover = 6.4%		
Tree	*Salix nigra*	FACW+	30	Yes
	Maclura pomifera	UPL	12	Yes
		Total cover	42.0	
		50/20 Thresholds: 50% of total cover = 21.0% 20% of total cover = 8.4%		
Woody vine	*Toxicodendron radicans*[1]	FAC	4	No
Hydrophytic Vegetation Determination	Total number of dominant species across all strata = 7. Percent of dominant species that are OBL, FACW, or FAC = 71.4%. Therefore, this community is hydrophytic by Indicator 2 (Dominance Test).			

[1] The woody vine *Toxicodendron radicans* at 4% cover failed to meet the minimum cover required for consideration as a separate stratum. Therefore, it was not considered to be dominant.

Steps in selecting dominant species by the 50/20 rule are as follows:

1. Estimate the absolute percent cover of each species in the first stratum. Since the same data may be used later to calculate the prevalence index, the data should be recorded as absolute cover and not converted to relative cover.
2. Rank all species in the stratum from most to least abundant.
3. Calculate the total coverage of all species in the stratum (i.e., sum their individual percent cover values). Absolute cover estimates do not necessarily sum to 100 percent.
4. Select plant species from the ranked list, in decreasing order of coverage, until the cumulative coverage of selected species *exceeds* 50 percent of the

total coverage for the stratum. If two or more species are equal in coverage (i.e., they are tied in rank), they should all be selected. The selected plant species are all considered to be dominants. All dominants must be identified to species.

5. In addition, select any other species that, by itself, is at least 20 percent of the total percent cover in the stratum. Any such species is also considered to be a dominant and must be accurately identified.
6. Repeat steps 1–5 for any other stratum present. Combine the lists of dominant species across all strata. Note that a species may be dominant in more than one stratum (e.g., a woody species may be dominant in both the tree and sapling/shrub strata).

Indicator 3: Prevalence index

Description: The prevalence index is 3.0 or less.

User Notes: The prevalence index ranges from 1 to 5. A prevalence index of 3.0 or less indicates that hydrophytic vegetation is present. To calculate the prevalence index, at least 80 percent of the total vegetation cover on the plot (summed across all strata) must be of species that have been correctly identified and have assigned wetland indicator statuses (Reed [1988] or current list) or are upland (UPL) species.

Procedure for Calculating a Plot-Based Prevalence Index: The prevalence index is a weighted-average wetland indicator status of all plant species in the sampling plot, where each indicator status category is given a numeric code (OBL = 1, FACW = 2, FAC = 3, FACU = 4, and UPL = 5) and weighting is by abundance (absolute percent cover). In calculating the prevalence index, "+" and "−" modifiers on indicator status categories are not used. For example, FAC+, FAC, and FAC− species are all considered to be FAC and assigned a numeric code of 3. The prevalence index is a more comprehensive analysis of the hydrophytic status of the community than one based on just a few dominant species. It is particularly useful (1) in communities with only one or two dominants, (2) in highly diverse communities where many species may be present at roughly equal coverage, and (3) when strata differ greatly in total plant cover (e.g., total herb cover is 80 percent but sapling/shrub cover is only 10 percent). The prevalence index is used in this supplement to determine whether hydrophytic vegetation is present on sites where indicators of hydric soil and wetland hydrology are present but the vegetation initially fails the dominance test.

The following procedure is used to calculate a plot-based prevalence index. The method was described by Wentworth et al. (1988) and modified by Wakeley and Lichvar (1997). It uses the same field data (i.e., percent cover estimates for each plant species) that were used to select dominant species by the 50/20 rule, with the added constraint that at least 80 percent of the total vegetation cover on the plot must be of species that have been correctly identified and have an assigned indicator status (including UPL). For any species that occurs in more than one stratum, cover estimates are summed across strata. Steps for determining the prevalence index are as follows:

1. Identify and estimate the absolute percent cover of each species in each stratum of the community. Sum the cover estimates for any species that is present in more than one stratum.
2. Organize all species (across all strata) into groups according to their wetland indicator status (i.e., OBL, FACW, FAC, FACU, or UPL) and sum their cover values within groups. Do not include species that were not identified.
3. Calculate the prevalence index using the following formula:

$$PI = \frac{A_{OBL} + 2A_{FACW} + 3A_{FAC} + 4A_{FACU} + 5A_{UPL}}{A_{OBL} + A_{FACW} + A_{FAC} + A_{FACU} + A_{UPL}}$$

where:

PI = Prevalence index
A_{OBL} = Summed percent cover values of obligate (OBL) plant species;
A_{FACW} = Summed percent cover values of facultative wetland (FACW) plant species;
A_{FAC} = Summed percent cover values of facultative (FAC) plant species;
A_{FACU} = Summed percent cover values of facultative upland (FACU) plant species;
A_{UPL} = Summed percent cover values of upland (UPL) plant species.

See Table 4 for an example calculation of the prevalence index using the same data set as in Table 3. The following web link provides free public-domain software for simultaneous calculation of the 50/20 rule, dominance test, and prevalence index: http://www.crrel.usace.army.mil/rsgisc/wetshed/wetdatashed.htm.

Table 4. Example of the Prevalence Index using the same data as in Table 3.

Indicator Status Group	Species Name	Absolute Percent Cover by Species	Total Cover by Group	Multiply by:[1]	Product
OBL species	None	0	0	1	0
FACW species	*Salix nigra*[2] *Panicum virgatum*	50 40	90	2	180
FAC species	*Iva annua* *Celtis laevigata* *Cardiospermum halicacabum* *Xanthium strumarium* *Toxicodendron radicans*[3]	15 12 8 6 4	45	3	135
FACU species	*Ambrosia artemisiifolia*	15	15	4	60
UPL species	*Maclura pomifera*	12	12	5	60
Sum			162 (A)		435 (B)
Hydrophytic Vegetation Determination		Prevalence Index = B/A = 435/162 = 2.69 Therefore, this community is hydrophytic by Indicator 3 (Prevalence Index).			

[1] Where OBL = 1, FACW = 2, FAC = 3, FACU = 4, and UPL = 5.
[2] *Salix nigra* was recorded in two strata (see Table 3), so the cover estimates for this species were summed across strata.
[3] *Toxicodendron radicans* at 4% cover failed to meet the minimum cover required for consideration as a separate stratum in the dominance test (Table 3), but was included in the prevalence index.

Indicator 4: Morphological adaptations

Description: The plant community passes either the dominance test (Indicator 2) or the prevalence index (Indicator 3) after reconsideration of the indicator status of certain plant species that exhibit morphological adaptations for life in wetlands.

User Notes: Some hydrophytes in the Great Plains develop easily recognized physical characteristics, or morphological adaptations, when they occur in wetland areas. Some of these adaptations may help them to survive prolonged inundation or saturation in the root zone; others may simply be a consequence of living under such wet conditions. Common morphological adaptations in the Great Plains include, but are not limited to, adventitious roots, multi-stemmed trunks, shallow root systems developed on or near the soil surface, and buttressing in tree species. These adaptations may develop on FAC– or FACU species when they occur in wetlands, indicating that those individuals are functioning as hydrophytes in that setting.

To apply this indicator, these morphological features must be observed on more than 50 percent of the individuals of a FAC− or FACU species living in an area where indicators of hydric soil and wetland hydrology are present. Use caution in areas where buttressed tree bases and multiple stems may be due to shallow bedrock, browsing by herbivores, timber harvest, or other factors not related to wetness. Follow this procedure:

1. Confirm that the morphological feature is present mainly in the potential wetland area and is not also common on the same species in the surrounding non-wetlands.
2. For each FAC− or FACU species that exhibits morphological adaptations, estimate the percentage of individuals that have the features. Record this percentage on the data form.
3. If more than 50 percent of the individuals of a FAC− or FACU species have morphological adaptations for life in wetlands, that species is considered to be a hydrophyte and its indicator status on that plot should be reassigned as FAC. All other species retain their published indicator statuses. Record any supporting information on the data sheet, including a description of the morphological adaptation(s) present and any other observations of the growth habit of the species in adjacent wetland and non-wetland locations (photo documentation is recommended).
4. Recalculate the dominance test (Indicator 2) and/or the prevalence index (Indicator 3) using a FAC indicator status for this species. The vegetation is hydrophytic if either test is satisfied.

3 Hydric Soil Indicators

Introduction

The National Technical Committee for Hydric Soils (NTCHS) defines a hydric soil 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). Most hydric soils exhibit characteristic morphologies that result from repeated periods of saturation or inundation for more than a few days. Saturation or inundation, when combined with microbial activity in the soil, causes the depletion of oxygen. This anaerobiosis promotes certain biogeochemical processes, such as the accumulation of organic matter and the reduction, translocation, or accumulation of iron and other reducible elements. These processes result in distinctive characteristics that persist in the soil during both wet and dry periods, making them particularly useful for identifying hydric soils in the field (USDA Natural Resources Conservation Service 2006b).

This chapter presents indicators that are designed to help identify hydric soils in the Great Plains Region. Indicators are not intended to replace or relieve the requirements contained in the definition of a hydric soil. Therefore, a soil that meets the definition of a hydric soil is hydric whether or not it exhibits indicators. Guidance for identifying hydric soils that lack indicators can be found later in this chapter (see the sections on documenting the site and its soils) and in Chapter 5 (Difficult Wetland Situations in the Great Plains).

This list of indicators is dynamic; changes and additions to the list are anticipated with new research and field testing. The indicators presented in this supplement are a subset of the NTCHS *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service [2006b] or current version) that are commonly found in the Great Plains. Any change to the NTCHS *Field Indicators of Hydric Soils in the United States* represents a change to this subset of indicators for the Great Plains. Check the NRCS hydric soils web site (http://soils.usda.gov/use/hydric/) for updates to these indicators. To use the indicators properly, a basic knowledge of soil/landscape relationships is necessary.

Most of the hydric soil indicators presented in this supplement are applicable throughout the Great Plains Region; however, some are specific to certain subregions. As used in this supplement, subregions are equivalent to the Land Resource Regions (LRR) or Major Land Resource Areas (MLRA) recognized by the USDA Natural Resources Conservation Service (2006a) (see Chapter 1, Figure 1). It is important to understand that boundaries between subregions are actually broad transition zones. Although an indicator may be noted as most relevant in a specific subregion, it may also be applicable in the transition to an adjacent subregion.

Concepts

Hydric soil indicators are formed predominantly by the accumulation or loss of iron, manganese, sulfur, or carbon compounds in a saturated and anaerobic environment. These processes and the features that develop are described in the following paragraphs.

Iron and manganese reduction, translocation, and accumulation

In an anaerobic environment, soil microbes reduce iron from the ferric (Fe^{3+}) to the ferrous (Fe^{2+}) form, and manganese from the manganic (Mn^{4+}) to the manganous (Mn^{2+}) form. Of the two, evidence of iron reduction is more commonly observed in soils. Areas in the soil where iron is reduced often develop characteristic bluish-gray or greenish-gray colors known as *gley*. Ferric iron is insoluble but ferrous iron easily enters the soil solution and may be moved or translocated to other areas of the soil. Areas that have lost iron typically develop characteristic gray or reddish-gray colors and are known as *redox depletions*. If a soil reverts to an aerobic state, iron that is in solution will oxidize and become concentrated in patches and along root channels and other pores. These areas of oxidized iron are called *redox concentrations*. Since water movement in these saturated or inundated soils can be multi-directional, redox depletions and concentrations can occur anywhere in the soil and have irregular shapes and sizes. Soils that are saturated and contain ferrous iron at the time of sampling may change color upon exposure to the air, as ferrous iron is rapidly converted to ferric iron in the presence of oxygen. Such soils are said to have a *reduced matrix* (Vepraskas 1992).

While indicators related to iron or manganese depletion or concentration are the most common in hydric soils, they cannot form in soils whose parent materials are low in Fe or Mn. Soils formed in such materials may

have low-chroma colors that are not related to saturation and reduction. For such soils, features formed through accumulation of organic carbon may be present.

Sulfate reduction

Sulfur is one of the last elements to be reduced by microbes in an anaerobic environment. The microbes convert SO_4^{2-} to H_2S, or hydrogen sulfide gas. This results in a very pronounced “rotten egg” odor in some soils that are inundated or saturated for very long periods. In non-saturated or non-inundated soils, sulfate is not reduced and there is no rotten egg odor. The presence of hydrogen sulfide is a strong indicator of a hydric soil, but this indicator is found only in the wettest sites in soils that contain sulfur-bearing compounds.

Organic matter accumulation

Since the efficiency of soil microbes is considerably lower in a saturated and anaerobic environment, less organic matter and organic carbon is consumed. Therefore, in saturated or inundated soils, partially decomposed organic matter and carbon may begin to accumulate. The result in wetlands is often the development of thick organic surfaces, such as peat or muck, or dark organic-rich surface mineral layers.

Determining the texture of soil materials high in organic carbon. Material high in organic carbon could fall into three categories: organic, mucky mineral, or mineral. In lieu of laboratory data, the following estimation method can be used for soil material that is wet or nearly saturated with water. This method may be inconclusive with loamy or clayey textured mineral soils. Gently rub the wet soil material between forefinger and thumb. If upon the first or second rub the material feels gritty, it is mineral soil material. If after the second rub the material feels greasy, it is either mucky mineral or organic soil material. Gently rub the material two or three more times. If after these additional rubs it feels gritty or plastic, it is mucky mineral soil material; if it still feels greasy, it is organic soil material. If the material is organic soil material, a further division should be made, as follows.

Organic soil materials are classified as sapric, hemic, or fibric. Differentiating criteria are based on the percentage of visible fibers observable with a hand lens in an undisturbed state and after rubbing between thumb and

fingers 10 times (Table 5). Sapric, hemic, and fibric correspond to the textures muck, mucky peat, and peat. If there is a conflict between unrubbed and rubbed fiber content, rubbed content is used. *Live roots are not considered*.

Table 5. Proportion of sample that is fibers visible with a hand lens.

Soil Texture	Unrubbed	Rubbed	Horizon Descriptor
Muck	<33%	<17%	Sapric
Mucky peat	33-67%	17-40%	Hemic
Peat	>67%	>40%	Fibric
Adapted from USDA Natural Resources Conservation Service (1999).			

Another field method for determining the degree of decomposition for organic materials is a system modified from a method originally developed by L. von Post and described in detail in ASTM standard D 5715-00 (http://www.astm.org/). This method is based on a visual examination of the color of the water that is expelled and the soil material remaining in the hand after a saturated sample is squeezed (Table 6). If a conflict occurs between results for sapric, hemic, or fibric material using percent visible fiber (Table 5) and degree of humification (Table 6), then percent visible fiber should be used.

Table 6. Determination of degree of decomposition of organic materials.

Degree of Humification	Nature of Material Extruded on Squeezing	Nature of Plant Structure in Residue	Horizon Descriptor
H1	Clear, colorless water; no organic solids squeezed out	Unaltered, fibrous, undecomposed	Fibric
H2	Yellowish water; no organic solids squeezed out	Almost unaltered, fibrous	
H3	Brown, turbid water; no organic solids squeezed out	Easily identifiable	
H4	Dark brown, turbid water; no organic solids squeezed out	Visibly altered but identifiable	Hemic
H5	Turbid water and some organic solids squeezed out	Recognizable but vague, difficult to identify	
H6	Turbid water; 1/3 of sample squeezed out	Indistinct, pasty	
H7	Very turbid water; 1/2 of sample squeezed out	Faintly recognizable; few remains identifiable, mostly amorphous	Sapric
H8	Thick and pasty; 2/3 of sample squeezed out	Very indistinct	
H9	No free water; nearly all of sample squeezed out	No identifiable remains	
H10	No free water; all of sample squeezed out	Completely amorphous	

Cautions

A soil that is artificially drained or protected (for instance, by dikes or levees) is still hydric if the soil in its undisturbed state would meet the definition of a hydric soil. To be identified as hydric, these soils should generally have one or more of the indicators. However, not all areas that have hydric soils will qualify as wetlands, if they no longer have wetland hydrology or support hydrophytic vegetation.

Morphological features that do not reflect contemporary or recent conditions of saturation and anaerobiosis are called relict features. Contemporary and relict hydric soil features can be difficult to distinguish. For example, nodules and concretions that are actively forming often have gradual or diffuse boundaries, whereas relict or degrading nodules and concretions have sharp boundaries (Vepraskas 1992). Guidance for some of the most common problem hydric soils can be found in Chapter 5. When soil morphology seems inconsistent with the landscape, vegetation, or observable hydrology, it may be necessary to obtain the assistance of an experienced soil or wetland scientist to determine whether the soil is hydric.

Procedures for sampling soils

Observe and document the site

Before making any decision about the presence or absence of hydric soils, the overall site and how it interacts with the soil should be considered. The questions below, while not required to identify a hydric soil, can help to explain why one is or is not present. Always look at the landscape features of the immediate site and compare them to the surrounding areas. Try to contrast the features of wet and dry sites that are in close proximity. When observing slope features, look first at the area immediately around the sampling point. For example, a nearly level bench or depression at the sampling point may be more important to site wetness than the overall landform on which it occurs. By understanding how water moves across the site, the reasons for the presence or absence of hydric soil indicators should be clear.

If one or more of the hydric soil indicators given later in this chapter is present, then the soil is hydric. If no hydric soil indicator is present, the additional site information below may be useful in documenting whether the soil is indeed non-hydric or if it might represent a "problem" hydric soil that meets the hydric soil definition despite the absence of indicators.

- *Hydrology*–Is standing water observed on the site or is water observed in the soil pit? What is the depth of the water table in the area? Is there indirect evidence of ponding or flooding?
- *Slope*–Is the site level or nearly level so that surface water does not run off readily, or is it steeper where surface water would run off from the soil?
- *Slope shape*–Is the surface concave (e.g., depressions), where water would tend to collect and possibly pond on the soil surface? On hill-sides, are there convergent slopes (Figure 4), where surface or ground-water may be directed toward a central stream or swale? Or is the sur-face or slope shape convex, causing water to run off or disperse?
- *Landform*–Is the soil on a low terrace or floodplain that may be subject to seasonal high water tables or flooding? Is it at the toe of a slope (Figure 5) where runoff may tend to collect or groundwater emerge at or near the surface? Has the microtopography been altered by cultivation?
- *Soil materials*– Is there a restrictive layer in the soil that could slow or prevent the infiltration of water, perhaps resulting in a perched water table or hillslope seep? This could include consolidated bedrock, cemented layers such as duripans and petrocalcic horizons, layers of silt or substantial clay content, or strongly contrasting soil textures (e.g., silt over sand).
- *Vegetation*–Does the vegetation at the site indicate wetter conditions than at other nearby sites, or is it similar to what is found at nearby upland sites?

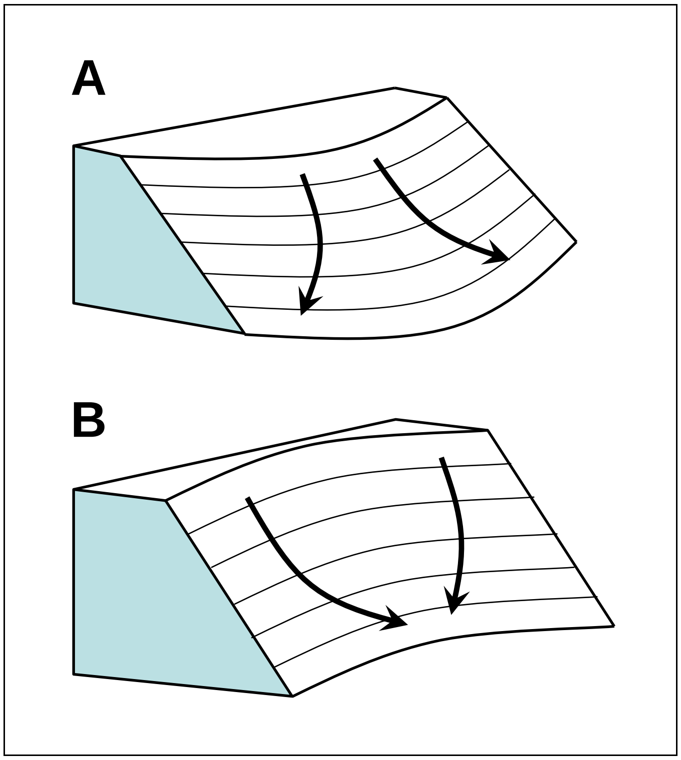

Figure 4. Divergent slopes (A) disperse surface water, whereas convergent slopes (B) concentrate water. Surface flow paths are indicated by the arrows.

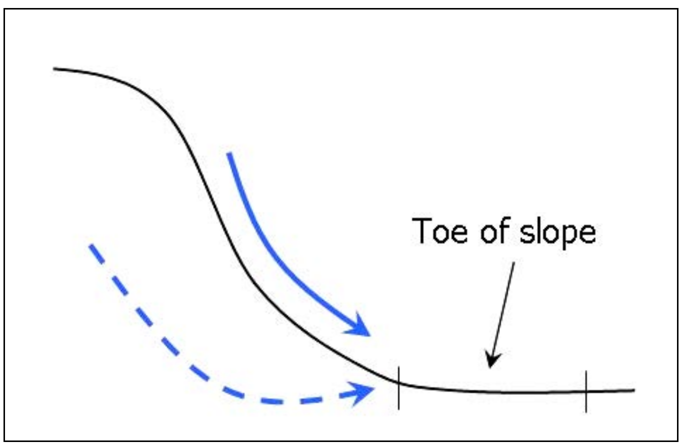

Figure 5. At the toe of a hill slope, the gradient is only slightly inclined or nearly level. Blue arrows represent flow paths of surface water (solid arrow) and groundwater (dashed arrow).

Observe and document the soil

To observe and document a hydric soil, first remove any loose leaves, needles, or bark from the soil surface. Do not remove the organic surface layers of the soil, which usually consist of plant remains in varying stages

of decomposition. Dig a hole and describe the soil profile. In general, the hole should be dug to the depth needed to document an indicator or to confirm the absence of indicators. For most soils, the recommended excavation depth is approximately 20 in. (50 cm) from the soil surface, although a shallower soil pit may suffice for some indicators (e.g., A2 – Histic Epipedon). Digging may be difficult in some areas due to rocks and hardpans. Use the completed profile description to determine which hydric soil indicators have been met (USDA Natural Resources Conservation Service 2006b).

For soils with deep, dark surface layers, deeper examination may be required when field indicators are not easily seen within 20 in. (50 cm) of the surface. The accumulation of organic matter in these soils may mask redoximorphic features in the surface layers. Examination to 40 in. (1 m) or more may be needed to determine whether they meet the requirements of indicator A12 (Thick Dark Surface). A soil auger or probe may be useful for sampling soil materials below 20 in.

Whenever possible, excavate the soil deep enough to determine if there are layers or materials present that might restrict soil drainage. This will help to understand why the soil may or may not be hydric. Consider taking photographs of both the soil and the overall site, including a clearly marked measurement scale in soil pictures.

Depths used in the indicators are measured from the muck surface, or from the mineral soil surface if a muck surface is absent. For indicators A1 (Histosol), A2 (Histic Epipedon), A3 (Black Histic), S2 (2.5 cm Mucky Peat or Peat), and S3 (5 cm Mucky Peat or Peat) depths are measured from the top of the organic material (peat, mucky peat, or muck), or from the top of any mineral material that may overlie the organic layer.

All colors noted in this supplement refer to moist Munsell® colors (Gretag/Macbeth 2000). Soil colors specified in the indicators do not have decimal points; however, intermediate colors do occur between Munsell chips. Soil color should not be rounded to qualify as meeting an indicator. For example, a soil matrix with a chroma between 2 and 3 should be listed as having a chroma of 2+. This soil material does not have a chroma of 2 and would not meet any indicator that requires a chroma of 2 or less. Always examine soil matrix colors in the field immediately after sampling.

Ferrous iron, if present, can oxidize rapidly and create colors of higher chroma or redder hue.

Soils that are saturated at the time of sampling may contain reduced iron and/or manganese that are not detectable by eye. Furthermore, under saturated conditions, redox concentrations may be absent or difficult to see, particularly in dark-colored soils. It may be necessary to let the soil dry to a moist state (5 to 30 minutes or more) for the iron or manganese to oxidize and redox features to become visible.

Particular attention should be paid to changes in microtopography over short distances. Small changes in elevation may result in repetitive sequences of hydric/non-hydric soils, making the delineation of individual areas of hydric and non-hydric soils difficult. Often the dominant condition (hydric or non-hydric) is the only reliable interpretation (also see the section on Wetland/Non-Wetland Mosaics in Chapter 5). The shape of the local landform can greatly affect the movement of water through the landscape. Significant changes in parent material or lithologic discontinuities in the soil can affect the hydrologic properties of the soil. After a sufficient number of exploratory excavations have been made to understand the soil-hydrologic relationships at the site, subsequent excavations can be limited to the depth needed to identify hydric soil indicators.

Use of existing soil data

Soil surveys

Soil surveys are available for most areas of the Great Plains and can provide useful information regarding soil properties and soil moisture conditions for an area. A list of available soil surveys is located at http://soils.usda.gov/survey/online_surveys/ and soil maps and data are available online from the Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/. Soil survey maps divide the landscape into areas called map units. Map units usually contain more than one soil type or component. They often contain several minor components or inclusions of soils with properties that may be similar to or quite different from the major component. Those soils that are hydric are noted in the *Hydric Soils List* published separately from the soil survey report. Soil survey information can be valuable for planning purposes, but it is not site-specific and does not preclude the need for an on-site investigation.

Hydric soils lists

Hydric Soils Lists are developed for each detailed soil survey. Using criteria approved by the NTCHS, these lists rate each soil component as either hydric or non-hydric based on soil property data. If the soil is rated as hydric, information is provided regarding which hydric criteria are met and on what landform the soil typically occurs. Hydric Soils Lists are useful as general background information for an on-site delineation. The hydric soils list should be used as a tool, indicating that hydric soil will likely be found within a given area. However, not all areas within a polygon identified as having hydric soils may be hydric.

Hydric Soils Lists developed for individual detailed soil surveys are known as Local Hydric Soils Lists. They are available from state or county NRCS offices and over the internet from the Soil Data Mart (http://soildatamart.nrcs.usda.gov/). Local Hydric Soils Lists have been compiled into a National Hydric Soils List available at http://soils.usda.gov/use/hydric/. However, use of Local Hydric Soils Lists is preferred since they are more current and reflect local variations in soil properties.

Hydric soil indicators

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 were not always examined; therefore, there are wetlands that lack any of the approved hydric soil indicators in the wettest interior portions. Wetland delineators and other users of the hydric soil indicators should concentrate their sampling efforts near the wetland edge and, if these soils are hydric, assume that soils in the wetter, interior portions of the wetland are also hydric even if they lack an indicator.

Hydric soil indicators are presented in three groups. Indicators for “All Soils” are used in any soil regardless of texture. Indicators for “Sandy Soils” are used in soil layers with USDA textures of loamy fine sand or coarser. Indicators for “Loamy and Clayey Soils” are used with soil layers of loamy very fine sand and finer. Both sandy and loamy/clayey layers may be present in the same soil profile. Therefore, a soil that contains a loamy surface layer over sand is hydric if it meets all of the requirements of matrix color, amount and contrast of redox concentrations, depth, and thickness for a specific A (All Soils), F (Loamy and Clayey Soils), or S (Sandy Soils) indicator.

It is permissible to combine certain hydric soil indicators if all requirements of the individual indicators are met except thickness (see Hydric Soil Technical Note 4, http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html). The most restrictive requirements for thickness of layers in any indicators used must be met. Not all indicators are possible candidates for combination. For example, indicator F2 (Loamy Gleyed Matrix) has no thickness requirement, so a site would either meet the requirements of this indicator or it would not. Table 7 lists the indicators that are the most likely candidates for combining in the region.

Table 7. Minimum thickness requirements for commonly combined indicators in the Great Plains Region.

Indicator	Thickness Requirement
S5 – Sandy Redox	4 in. (10 cm) thick starting within 6 in. (15 cm) of the soil surface
F1 – Loamy Mucky Mineral	4 in. (10 cm) thick starting within 6 in. (15 cm) of the soil surface
F3 – Depleted Matrix	6 in. (15 cm) thick starting within 10 in. (25 cm) of the soil surface
F6 – Redox Dark Surface	4 in. (10 cm) thick entirely within the upper 12 in. (30 cm)
F7 – Depleted Dark Surface	4 in. (10 cm) thick entirely within the upper 12 in. (30 cm)

Table 8 presents an example of a soil in which a combination of layers meets the requirements for indicators F6 (Redox Dark Surface) and F3 (Depleted Matrix). The second layer meets the morphological characteristics of F6 and the third layer meets the morphological characteristics of F3, but neither meets the thickness requirement for its respective indicator. However, the combined thickness of the second and third layers meets the more restrictive conditions of thickness for F3 (i.e., 6 in. [15 cm] starting within 10 in. [25 cm] of the soil surface). Therefore, the soil is considered to be hydric based on the combination of indicators.

Table 8. Example of a soil that is hydric based on a combination of indicators F6 and F3.

Depth (inches)	Matrix Color	Redox Concentrations			Texture
		Color	Abundance	Contrast	
0 – 3	10YR 2/1	--	--	--	Loamy/clayey
3 – 6	10YR 3/1	7.5YR 5/6	3 percent	Prominent	Loamy/clayey
6 – 10	10YR 5/2	7.5YR 5/6	5 percent	Prominent	Loamy/clayey
10 – 14	2.5Y 4/2	--	--	--	Loamy/clayey

Another common situation in which it is appropriate to combine the characteristics of hydric soil indicators is when stratified textures of sandy (i.e., loamy fine sand and coarser) and loamy/clayey (i.e., loamy very fine sand and finer) material occur in the upper 12 in. of the soil. For example, the soil shown in Table 9 is hydric based on a combination of indicators F6 (Redox Dark Surface) and S5 (Sandy Redox). This soil meets the morphological 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. [15 cm]) meets the more restrictive thickness requirement of either indicator (4 in. [10 cm]).

Table 9. Example of a soil that is hydric based on a combination of indicators F6 and S5.

Depth (inches)	Matrix Color	Redox Concentrations			Texture
		Color	Abundance	Contrast	
0 – 3	10YR 3/1	10YR 5/6	3 percent	Prominent	Loamy/clayey
3 – 6	10YR 4/1	10YR 5/6	3 percent	Prominent	Sandy
6 – 16	10YR 4/1	--	--	--	Loamy/clayey

All soils

"All soils" refers to soils with any USDA soil texture. Use the following indicators regardless of soil texture.

Unless otherwise noted, all mineral layers above any of the layers meeting an A indicator, except for indicator A16, 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. (15 cm) thick to meet any hydric soil indicator. Nodules and concretions are not considered to be redox concentrations unless otherwise noted.

Indicator A1: Histosol

Technical Description: Classifies as a Histosol (except Folists)

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: In most Histosols, 16 in. (40 cm) or more of the upper 32 in. (80 cm) is organic soil material (Figure 6). Histosols also include soils that have organic soil material of any thickness over rock or fragmental soil material that has interstices filled with organic soil material. Organic soil material has an organic carbon content (by weight) of 12 to 18 percent or more, depending on the clay content of the soil. The material includes muck (sapric soil material), mucky peat (hemic soil material), or peat (fibric soil material). See the glossary of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2006b) for definitions of muck, mucky peat, peat, and organic soil material. See the Concepts section of this chapter for field methods to identify organic soil materials, and Appendix A for the definition of fragmental soil material.

Figure 6. Example of a Histosol, in which muck (sapric soil material) is greater than 3 ft (0.9 m) thick.

This indicator is very rare in this region. It is most likely associated with fens and slope wetlands that are saturated to the surface, or depressions that are ponded or saturated nearly all of the growing season in most years.

Indicator A2: Histic Epipedon

Technical Description: A histic epipedon underlain by mineral soil material with a chroma of 2 or less.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: Most histic epipedons are surface horizons 8 in. (20 cm) or more thick of organic soil material (Figure 7). Aquic conditions or artificial drainage are required (see *Soil Taxonomy*, USDA Natural Resources Conservation Service 1999); however, aquic conditions can be assumed if indicators of hydrophytic vegetation and wetland hydrology are present. See the glossary of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2006b) for definitions. See the Concepts section of this chapter for field methods to identify organic soil materials. See indicator A1 for organic carbon requirements. Slightly lower organic carbon contents are allowed in plowed soils.

Figure 7. In this soil, the organic surface layer is about 9 in. (23 cm) thick.

This indicator is very rare in this region. It is most likely associated with fens and slope wetlands that are saturated to the surface, or depressions that are ponded or saturated nearly all of the growing season in most years.

Indicator A3: Black Histic

Technical Description: A layer of peat, mucky peat, or muck 8 in. (20 cm) or more thick that starts within 6 in. (15 cm) of the soil surface; has a hue of 10YR or yellower, value of 3 or less, and chroma of 1 or less; and is underlain by mineral soil material with a chroma of 2 or less (Figure 8).

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: This indicator does not require proof of aquic conditions or artificial drainage. See the glossary of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2006b) for definitions of peat, mucky peat, and muck. See the Concepts section of this chapter for field methods to identify organic soil materials. See indicator A1 for organic carbon requirements.

Figure 8. Black organic surface layer greater than 11 in. (28 cm) thick.

This indicator is very rare in this region. It is most likely associated with fens and slope wetlands that are saturated to the surface, or depressions that are ponded or saturated nearly all of the growing season in most years.

Indicator A4: Hydrogen Sulfide

Technical Description: A hydrogen sulfide (rotten egg) odor within 12 in. (30 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: Any time the soil smells of hydrogen sulfide (rotten egg odor), sulfur is currently being reduced and the soil is definitely in an anaerobic state. In some soils, the odor is pronounced; in others it is very fleeting as the gas dissipates rapidly. If in doubt, quickly open several small holes in the area of concern to determine if a hydrogen sulfide odor is really present. This indicator is extremely rare in this region and generally is not found at the boundary between wetlands and non-wetlands. It is most commonly found in areas that are permanently saturated or inundated.

Indicator A5: Stratified Layers

Technical Description: Several stratified layers starting within 6 in. (15 cm) of the soil surface. At least one of the layers has a value of 3 or less with a chroma of 1 or less or it is muck, mucky peat, peat, or mucky modified mineral texture. The remaining layers have chromas of 2 or less (Figure 9). Any sandy material that constitutes the layer with a value of 3 or less and a chroma of 1 or less, when observed with a 10- or 15-power hand lens, must have at least 70 percent of the visible soil particles masked with organic material (Figure 10). When observed without a hand lens, the material appears to be nearly 100 percent masked.

Figure 9. Stratified layers in loamy material.

Applicable Subregions: Applicable to the Northern Great Plains Subregion (LRR F).

Figure 10. Stratified layers in sandy material.

User Notes: Use of this indicator may require assistance from a soil scientist with local experience. An undisturbed sample must be observed. Individual strata are dominantly less than 1 in. (2.5 cm) thick. Many alluvial soils have stratified layers at greater depths; these are not hydric soils. Many alluvial soils have stratified layers at the required depths, but lack a chroma of 2 or less; these do not fit this indicator. Stratified layers occur in any type of soil material, generally in floodplains and other areas where wet soils are subject to rapid and repeated burial with thin deposits of sediment.

Indicator A9: 1 cm Muck

Technical Description: A layer of muck 0.5 in. (1 cm) or more thick with a value of 3 or less and chroma of 1 or less, starting within 6 in. (15 cm) of the soil surface.

Applicable Subregions: Applicable to the Northern Great Plains (LRR F), Western Great Plains (LRR G), and Central Great Plains (LRR H) Subregions.

User Notes: Normally the muck layer is at the soil surface; however, it may occur at any depth within 6 in. (15 cm) of the surface (Figure 11). Muck is sapric soil material with at least 12 to 18 percent organic carbon. Organic soil material is called muck (sapric soil material) if virtually all of the material has undergone sufficient decomposition to limit recognition of the plant parts. Hemic (mucky peat) and fibric (peat) soil materials do not qualify. To determine if muck is present, first remove loose leaves, needles, bark, and other easily identified plant remains. This is sometimes called leaf litter, a duff layer, or a leaf or root mat. Then examine for decomposed organic soil material. Generally, muck is black and has a greasy feel; sand grains should not be evident (see the Concepts section of this chapter for field methods to identify organic soil materials). Determination of this indicator is made below the leaf or root mat; however, root mats that meet the definition of hemic or fibric soil material are included in the decision-making process for indicators A1 (Histosol) and A2 (Histic Epipedon).

Figure 11. A layer of muck (dark material indicated by the knife point) occurs in the upper 6 in. (15 cm) of this soil.

Indicator A11: Depleted Below Dark Surface

Technical Description: A layer with a depleted or gleyed matrix that has 60 percent or more chroma of 2 or less, starting within 12 in. (30 cm) of the soil surface, and having a minimum thickness of either:

- 6 in. (15 cm), or
- 2 in. (5 cm) if the 2 in. (5 cm) consists of fragmental soil material.

Loamy/clayey layer(s) above the depleted or gleyed matrix must have a value of 3 or less and 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 and, when observed with a 10- or 15-power hand lens, must have at least 70 percent of the visible soil particles masked with organic material. When observed without a hand lens, the material appears to be nearly 100 percent masked.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: This indicator often occurs in prairie soils (Mollisols), but also applies to other soils that have dark-colored surface layers, such as

umbric epipedons and dark-colored ochric epipedons (Figure 12). For soils that have dark surface layers thicker than 12 in. (30 cm), use indicator A12. Two percent or more distinct or prominent redox concentrations, including iron/manganese soft masses, pore linings, or both, are required in soils that have matrix values/chromas of 4/1, 4/2, and 5/2 (Figure A1). If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. See the Glossary (Appendix A) for definitions of depleted matrix, gleyed matrix, distinct and prominent features, and fragmental soil material.

Figure 12. In this soil, a depleted matrix starts immediately below the black surface layer at approximately 11 in. (28 cm).

In some places, the gleyed matrix may change color upon exposure to air (reduced matrix). This phenomenon is included in the concept of a gleyed matrix (USDA Natural Resources Conservation Service 2002).

This indicator is commonly found at the boundary of wetlands in Mollisols or other dark-colored soils. It is often found in soils formed on alluvial terraces along larger river systems in areas subject to ponding due to high water tables.

Indicator A12: Thick Dark Surface

Technical Description: A layer at least 6 in. (15 cm) thick with a depleted or gleyed matrix that has 60 percent or more chroma of 2 or less starting below 12 in. (30 cm) of the surface. The layer(s) above the depleted or gleyed matrix must have a value of 2.5 or less and chroma of 1 or less to a depth of at least 12 in. (30 cm) and a value of 3 or less and chroma of 1 or less in any remaining layers above the depleted or gleyed matrix. Any sandy material above the depleted or gleyed matrix, when observed with a 10- or 15-power hand lens, must have at least 70 percent of the visible soil particles masked with organic material. When observed without a hand lens, the material appears to be nearly 100 percent masked.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: The soil has a depleted matrix or gleyed matrix below a black or very dark gray surface layer 12 in. (30 cm) or more thick (Figure 13). This indicator is most often associated with overthickened soils in concave landscape positions. Two percent or more distinct or prominent redox concentrations (Table A1), including iron/manganese soft masses, pore linings, or both, are required in soils that have matrix values/chromas of 4/1, 4/2, and 5/2 (Figure A1). If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. See the Glossary (Appendix A) for the definitions of depleted and gleyed matrix.

Figure 13. Deep observations may be necessary to identify the depleted or gleyed matrix below a thick, dark surface layer. In this example, the depleted matrix starts at 20 in. (50 cm).

In some places, the gleyed matrix may change color upon exposure to air (reduced matrix). This phenomenon is included in the concept of a gleyed matrix (USDA Natural Resources Conservation Service 2002).

This indicator is almost never found at the wetland/non-wetland boundary and is much less common than indicators A11 (Depleted Below Dark Surface), F3 (Depleted Matrix), and F6 (Redox Dark Surface).

Sandy soils

"Sandy soils" refers to soil materials with a USDA soil texture of loamy fine sand and coarser. Use the following indicators in soil layers consisting of sandy soil materials.

Unless otherwise noted, all mineral layers above any of the layers meeting an S indicator, except for indicator S6, 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. (15 cm) thick to meet any hydric soil indicator. Nodules and concretions are not considered to be redox concentrations unless otherwise noted.

Indicator S1: Sandy Mucky Mineral

Technical Description: A layer of mucky modified sandy soil material 2 in. (5 cm) or more thick starting within 6 in. (15 cm) of the soil surface (Figure 14).

Figure 14. The mucky modified sandy layer is approximately 3 in. (7.5 cm) thick. Scale in inches on the right side of ruler.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: This indicator is rare in this region. *Mucky* is a USDA texture modifier for mineral soils. The organic carbon content is at least 5 percent and ranges up to 14 percent for sandy soils. The percentage requirement is dependent upon the clay

content of the soil; the higher the clay content, the higher the organic carbon requirement. See the glossary of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2006b) for the definition of mucky modified mineral texture. A field procedure for identifying mucky mineral soil material is presented in the Concepts section of this chapter.

Indicator S2: 2.5 cm Mucky Peat or Peat

Technical Description: A layer of mucky peat or peat 1 in. (2.5 cm) or more thick with a value of 4 or less and chroma of 3 or less, starting within 6 in. (15 cm) of the soil surface, and underlain by sandy soil material.

Applicable Subregions: Applicable to the Western Great Plains (LRR G) and Central Great Plains (LRR H) Subregions**.**

User Notes: Mucky peat (hemic soil material) and peat (fibric soil material) have at least 12 to 18 percent organic carbon. Organic soil material is called peat if virtually all of the plant remains are sufficiently intact to permit identification of plant remains. Mucky peat is an intermediate stage of decomposition between peat and highly decomposed muck. Field procedures for identifying mucky peat and peat were presented in the Concepts section of this chapter.

Indicator S3: 5 cm Mucky Peat or Peat

Technical Description: A layer of mucky peat or peat 2 in. (5 cm) or more thick with a value of 3 or less and chroma of 2 or less, starting within 6 in. (15 cm) of the soil surface, and underlain by sandy soil material.

Applicable Subregions: Applicable to the Northern Great Plains Subregion (LRR F)**.**

User Notes: Mucky peat (hemic soil material) and peat (fibric soil material) have at least 12 to 18 percent organic carbon. Organic soil material is called peat if virtually all of the plant remains are sufficiently intact to permit identification of plant remains. Mucky peat is an intermediate stage of decomposition between peat and highly decomposed muck. Field procedures for identifying mucky peat and peat were presented in the Concepts section of this chapter.

Indicator S4: Sandy Gleyed Matrix

Technical Description: A gleyed matrix that occupies 60 percent or more of a layer starting within 6 in. (15 cm) of the soil surface (Figure 15).

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: The gleyed matrix only has to be present within 6 in. (15 cm) of the surface. Soils with gleyed matrices are saturated for significant periods; therefore, *no minimum thickness of gleyed layer is required*. See the Glossary (Appendix A) for the definition of a gleyed matrix.

Figure 15. In this example, the gleyed matrix begins at the soil surface.

This indicator is most frequently found on floodplains and generally is not found at the boundary between wetlands and non-wetlands. It is often found in oxbows associated with high water tables.

Indicator S5: Sandy Redox

Technical Description: A layer starting within 6 in. (15 cm) of the soil surface that is at least 4 in. (10 cm) 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 (Figure 16).

Figure 16. Redox concentrations (orange areas) in sandy soil material.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: Distinct and prominent are defined in the Glossary (Appendix A). Redox concentrations include iron and manganese masses (reddish mottles) and pore linings (Vepraskas 1992). Included within the concept of redox concentrations are iron/manganese bodies as soft masses with diffuse boundaries. Common (2 to less than 20 percent) to many (20 percent or more) redox concentrations (USDA Natural Resources Conservation Service 2002) are required. If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible.

This is a very common indicator of hydric soils and is often used to identify the hydric/non-hydric boundary in sandy soils. This indicator is often associated with depressions or swales within dune/swale complexes.

Indicator S6: Stripped Matrix

Technical Description: A layer starting within 6 in. (15 cm) of the soil surface in which iron/manganese oxides and/or organic matter have been stripped from the matrix and the primary base color of the soil material has been exposed. The stripped areas and translocated oxides and/or organic matter form a faintly contrasting pattern of 2 or more colors with diffuse boundaries. The stripped zones are 10 percent or more of the volume and are rounded (Figure 17).

Figure 17. Stripped areas form a diffuse, splotchy pattern in this hydric sandy soil.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: This indicator includes the indicator previously named streaking (Environmental Laboratory 1987). The stripped areas are typically 0.5 to 1 in. (1 to 3 cm) in size but may be larger or smaller. Commonly, the stripped areas have a value of 5 or more and chroma of 1 and/or 2 and unstripped areas have a chroma of 3 and/or 4. However, there are no specific color requirements for this indicator. The mobilization and translocation of the oxides and/or organic matter are the important processes involved in this indicator and should result in splotchy coated and uncoated soil areas. This may be a difficult pattern to recognize and is often more evident in a horizontal slice.

This is a very common indicator of hydric soils and is often used to identify the hydric/non-hydric boundary in sandy soils. This indicator is found in all wetland types and all wet landscape positions.

Loamy and clayey soils

"Loamy and clayey soils" refers to soil materials with USDA textures of loamy very fine sand and finer. Use the following indicators in soil layers consisting of loamy or clayey soil materials.

Unless otherwise noted, all mineral layers above any of the layers meeting an F indicator, except for indicator F8, 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. (15 cm) thick to meet any hydric soil indicator. Except for indicator F16, nodules and concretions are not considered to be redox concentrations unless otherwise noted.

Indicator F1: Loamy Mucky Mineral

Technical Description: A layer of mucky modified loamy or clayey soil material 4 in. (10 cm) or more thick starting within 6 in. (15 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: *Mucky* is a USDA texture modifier for mineral soils. The organic carbon is at least 8 percent, but can range up to 18 percent. The percentage requirement is dependent upon the clay content of the soil; the higher the clay content, the higher the organic carbon requirement. See the Concepts section of this chapter for guidance on identifying mucky mineral soil materials in the field; however, loamy mucky soil material is difficult to distinguish without laboratory testing.

Indicator F2: Loamy Gleyed Matrix

Technical Description: A gleyed matrix that occupies 60 percent or more of a layer starting within 12 in. (30 cm) of the soil surface (Figure 18).

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: Gley colors are not synonymous with gray colors. Gley colors are those colors that are on the gley pages (Gretag/Macbeth 2000). They have a hue of N, 10Y, 5GY, 10GY, 5G, 10G, 5BG, 10BG, 5B, 10B, or 5PB, with a value of 4 or more. The gleyed matrix only has to be present within 12 in. (30 cm) of the surface. Soils with gleyed matrices are saturated for significant periods; therefore, *no minimum thickness of gleyed layer is required*. See the Glossary (Appendix A) for the definition of a gleyed matrix.

Figure 18. This soil has a gleyed matrix in the lowest layer, starting about 7 in. (18 cm) from the soil surface. The layer above the gleyed matrix has a depleted matrix.

This indicator is found in soils that are inundated or saturated nearly all of the growing season in most years (e.g., in oxbows with permanent water) and is not usually found at the boundary between wetlands and non-wetlands.

Indicator F3: Depleted Matrix

Technical Description: A layer that has a depleted matrix with 60 percent or more chroma of 2 or less and that has a minimum thickness of either:

- 2 in. (5 cm) if 2 in. (5 cm) is entirely within the upper 6 in. (15 cm) of the soil, or
- 6 in. (15 cm) starting within 10 in. (25 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: This is one of the most commonly observed hydric soil indicators at wetland boundaries. Redox concentrations including iron/manganese soft masses or pore linings, or both, are required in soils with matrix values/chromas of 4/1, 4/2, and 5/2 (Figures 19 and 20). If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. Redox concentrations are not required for soils with matrix values of 5 or more and chroma of 1, or values of 6 or more and chromas of 2 or 1. The low-chroma matrix must be caused by wetness and must not be a relict or parent material feature. See the Glossary (Appendix A) for the definition of a depleted matrix.

Figure 19. Example of indicator F3 (Depleted Matrix), in which redox concentrations extend nearly to the surface.

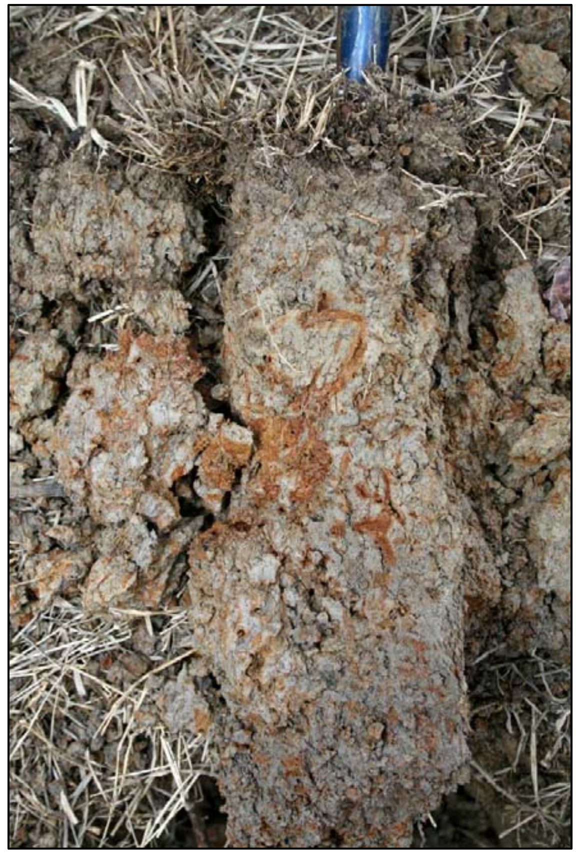

Figure 20. This soil has a depleted matrix with redox concentrations in a low-chroma matrix.

Indicator F6: Redox Dark Surface

Technical Description: A layer that is at least 4 in. (10 cm) thick, is entirely within the upper 12 in. (30 cm) of the mineral soil, and has a:

- Matrix value of 3 or less and chroma of 1 or less and 2 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings, or
- Matrix value of 3 or less and chroma of 2 or less and 5 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: This is a very common indicator used to delineate wetland boundaries in soils with dark-colored surface layers. The layer meeting the

requirements of the indicator may extend below 12 in. (30 cm) as long as at least 4 in. (10 cm) occurs within 12 in. (30 cm) of the surface. Redox concentrations are often small and difficult to see in mineral soils that have dark (value of 3 or less) surface layers due to high organic-matter content (Figure 21). The organic matter masks some or all of the concentrations that may be present; it also masks the diffuse boundaries of the concentrations and makes them appear to be more sharp. Careful examination is required to see what are often brownish redox concentrations in the darkened materials. 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 redox features to become visible. In some cases, further drying of the samples makes the concentrations (if present) easier to see. A hand lens may be helpful in seeing and describing small redox concentrations. Care should be taken to examine the interiors of soil peds for redox concentrations. Dry colors, if used, also must have matrix chromas of 1 or 2, and the redox concentrations must be distinct or prominent (see the Glossary [Appendix A] for definitions).

Figure 21. Redox features can be small and difficult to see within a dark soil layer.

In soils that are wet because of subsurface saturation, the layer immediately below the dark epipedon will likely have a depleted or gleyed matrix (see the Glossary for definitions). Soils that are wet because of ponding or have a shallow, perched layer of saturation may not always have a depleted/gleyed matrix below the dark surface. This morphology has been observed in soils that have been compacted by tillage and other means. It is recommended that delineators evaluate the hydrologic source and examine and describe the layer below the dark-colored epipedon when applying this indicator.

Indicator F7: Depleted Dark Surface

Technical Description: Redox depletions with a value of 5 or more and chroma of 2 or less in a layer that is at least 4 in. (10 cm) thick, is entirely within the upper 12 in. (30 cm) of the mineral soil (Figure 22), and has a:

- Matrix value of 3 or less and chroma of 1 or less and 10 percent or more redox depletions, or
- Matrix value of 3 or less and chroma of 2 or less and 20 percent or more redox depletions.

Figure 22. Redox depletions (lighter colored areas) are scattered within the darker matrix. Scale is in centimeters.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: Care should be taken not to mistake the mixing of eluvial (highly leached) layers that have high value and low chroma (E horizon) or illuvial layers that have accumulated carbonates (calcic horizon) into the surface layer as depletions. Mixing of layers can be caused by burrowing animals

or cultivation. Pieces of deeper layers that become incorporated into the surface layer are not redox depletions. Knowledge of local conditions is required in areas where light-colored eluvial layers and/or layers high in carbonates may be present. In soils that are wet because of subsurface saturation, the layer immediately below the dark surface is likely to have a depleted or gleyed matrix. Redox depletions will usually be associated with microsites that have redox concentrations occurring as pore linings or masses within the depletion(s) or surrounding the depletion(s).

Indicator F8: Redox Depressions

Technical Description: In closed depressions subject to ponding, 5 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings in a layer that is 2 in. (5 cm) or more thick and is entirely within the upper 6 in. (15 cm) of the soil (Figure 23).

Figure 23. In this example, the layer of redox concentrations begins at the soil surface and is slightly more than 2 in. (5 cm) thick.

Applicable Subregions: Applicable throughout the Great Plains Region.

User Notes: This indicator occurs on depressional landforms, such as vernal pools, playa lakes, rainwater basins, and potholes; but not micro-depressions on convex landscapes. Closed depressions often occur within

flats or floodplain landscapes. *Note that there is no color requirement for the soil matrix.* The layer containing redox concentrations may extend below 6 in. (15 cm) as long as at least 2 in. (5 cm) occurs within 6 in. (15 cm) 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 redox features to become visible. See the Glossary for definitions of distinct and prominent.

This is a common but often overlooked indicator found at the wetland/ non-wetland boundary on depressional sites.

Indicator F16: High Plains Depressions

Technical Description: In closed depressions that are subject to ponding, a mineral soil that has a chroma of 1 or less to a depth of at least 13.5 in. (35 cm) and a layer at least 4 in. (10 cm) thick within the upper 13.5 in. (35 cm) of the mineral soil that has either:

- 1 percent or more redox concentrations occurring as nodules or concretions, or
- redox concentrations occurring as nodules or concretions with distinct or prominent coronas.

Applicable Subregions: Applicable in MLRA 72 and 73 of the Central Great Plains Subregion (LRR H) (Figure 24).

User Notes: This indicator is for closed depressions (known locally as “playas”) in western Kansas, southwestern Nebraska, eastern Colorado, and southeastern Wyoming (Figure 25). It occurs in soils such as the Ness and Pleasant series. The matrix color of the 13.5-in. (35-cm) layer must be a chroma of 1 or less; chroma 2 matrix colors are excluded; value is usually 3. The nodules/concretions are rounded, hard to very hard, range in size from less than 1 mm to 3 mm, and most commonly are black or reddish black. The coronas usually are reddish brown, strong brown, or yellowish brown. The nodules/concretions can be removed from the soil and the coronas (halos) will occur as coatings on the concentration or will remain attached to the soil matrix. A 10- to 15-power lens may help to identify these features.

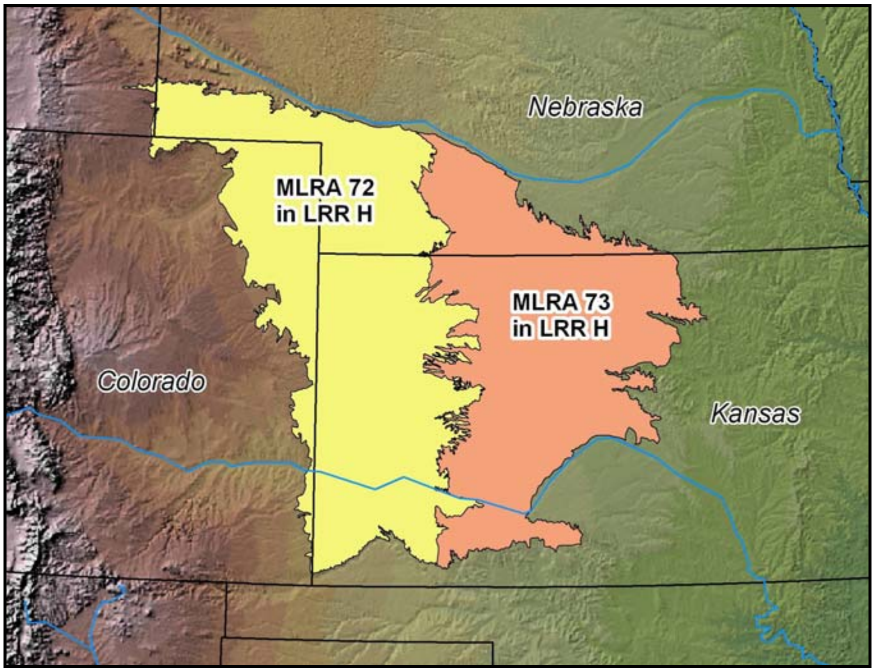

Figure 24. Location of MLRAs 72 and 73 in LRR H.

Figure 25. Depressional wetland in Nebraska. Photo by the Nebraska Game and Parks Commission.

Hydric soil indicators for problem soils

The following indicators are not currently recognized for general application by the NTCHS, or they are not recognized in the specified geographic area. However, these indicators may be used in problem wetland situations in the Great Plains where there is evidence of wetland hydrology and hydrophytic vegetation, and the soil is believed to meet the definition of a hydric soil despite the lack of other indicators of a hydric soil. To use these indicators, follow the procedure described in the section on Problematic Hydric Soils in Chapter 5. If any of the following indicators is observed, it is recommended that the NTCHS be notified by following the protocol described in the "Comment on the Indicators" section of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2006b).

Indicator A9: 1 cm Muck

Technical Description: A layer of muck 0.5 in. (1 cm) or more thick with a value of 3 or less and chroma of 1 or less, starting within 6 in. (15 cm) of the soil surface.

Applicable Subregions: For use with problem soils in the Southwest Plateaus and Plains (LRR I) and Southwestern Prairies (LRR J) Subregions.

User Notes: See the User Notes for indicator A9 given previously in this chapter.

Indicator A16: Coast Prairie Redox

Technical Description: A layer starting within 6 in. (15 cm) of the soil surface that is at least 4 in. (10 cm) thick and has a matrix chroma of 3 or less with 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings.

Applicable Subregions: For use with problem soils in the Northern Great Plains (LRR F), Western Great Plains (LRR G), and Central Great Plains (LRR H) Subregions.

User Notes: These hydric soils occur mainly on depressional and intermound landforms. Redox concentrations occur mainly as iron-dominated

pore linings. Common to many redox concentrations are required. If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. Chroma 3 matrices are allowed because they may be the color of stripped sand grains, or because few to common sand-sized reddish particles may be present and may prevent obtaining a chroma of 2 or less.

Indicator S7: Dark Surface

Technical Description: A layer 4 in. (10 cm) thick starting within 6 in. (15 cm) of the soil surface with a matrix value of 3 or less and chroma of 1 or less. When observed with a 10- or 15-power hand lens, at least 70 percent of the visible soil particles must be masked with organic material. When observed without a hand lens, the material appears to be nearly 100 percent masked. The matrix color of the layer immediately below the dark layer must have the same colors as those described above or any color that has a chroma of 2 or less.

Applicable Subregions: For use with problem soils in the Western Great Plains (LRR G).

User Notes: If the dark layer is greater than 4 in. (10 cm) thick, then the indicator is met, because any dark soil material in excess of 4 in. (10 cm) meets the requirement that "the layer immediately below the dark layer must have the same colors as those described above... ." If the dark layer is exactly 4 in. (10 cm) thick, then the material immediately below must have a matrix chroma of 2 or less.

The organic carbon content of this indicator is slightly less than that required for "mucky." An undisturbed sample must be observed. Many moderately wet soils have a ratio of about 50 percent soil particles covered or coated with organic matter and about 50 percent uncoated or uncovered soil particles, giving the soil a salt-and-pepper appearance. Where the percent coverage by organic matter is less than 70 percent, a Dark Surface indicator is not present.

Indicator F16: High Plains Depressions

Technical Description: In closed depressions that are subject to ponding (Figure 25), a mineral soil that has a chroma of 1 or less to a depth of at

least 13.5 in. (35 cm) and a layer at least 4 in. (10 cm) thick within the upper 13.5 in. (35 cm) of the mineral soil that has either:

- 1 percent or more redox concentrations occurring as nodules or concretions, or
- Redox concentrations occurring as nodules or concretions with distinct or prominent coronas.

Applicable Subregions: For use with problem soils in the Central Great Plains Subregion (LRR H) outside of MLRA 72 and 73 where the indicator is approved for general use.

User Notes: See the User Notes for indicator F16 given previously in this chapter.

Indicator F18: Reduced Vertic

Technical Description: In Vertisols and Vertic intergrades, a positive reaction to alpha, alpha-dipyridyl that:

- Is the dominant (60 percent or more) condition of a layer at least 4 in. (10 cm) thick within the upper 12 in. (30 cm) (or at least 2 in. [5 cm] thick within the upper 6 in. [15 cm]) of the mineral or muck soil surface,
- Occurs for at least 7 continuous days and 28 cumulative days, and
- Occurs during a normal (within 16 to 84 percent of probable precipitation) or drier season and month.

Applicable Subregions: For use with problem soils throughout the Great Plains Region in areas containing Vertisols and Vertic intergrades.

User Notes: The time requirements for this indicator were identified from research in MLRA 150A in LRR T (Gulf Coastal Prairies); these or slightly modified time requirements may be found to identify wetland Vertisols and Vertic intergrades in other parts of the nation. These soils usually have thick dark surface horizons but indicators A11, A12, and F6 are often lacking, possibly due to masking of redoximorphic features by organic carbon. Follow the procedures and note the considerations in Hydric Soil Technical Note 8 (http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html).

Indicator TF2: Red Parent Material

Technical Description: In parent material with a hue of 7.5YR or redder, a layer at least 4 in. (10 cm) thick with a matrix value and chroma of 4 or less and 2 percent or more redox depletions and/or redox concentrations occurring as soft masses and/or pore linings. The layer is entirely within 12 in. (30 cm) of the soil surface. The minimum thickness requirement is 2 in. (5 cm) if the layer is the mineral surface layer.

Applicable Subregions: For use with problem soils throughout the Great Plains Region in areas containing soils derived from red parent materials.

User Notes: Redox features most noticeable in red material include redox depletions and soft manganese masses that are black or dark reddish black. If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. This indicator is commonly found on floodplains in alluvial soils derived from Permian- and Triassic-age red sedimentary rocks. Examples include the Brazos and Red River floodplains and their tributaries in Texas and Oklahoma. Users of this indicator should document the probable source of red parent materials found on the site.

Indicator TF12: Very Shallow Dark Surface

Technical Description: In depressions and other concave landforms, one of the following:

a. If bedrock occurs between 6 in. (15 cm) and 10 in. (25 cm), a layer at least 6 in. (15 cm) thick starting within 4 in. (10 cm) of the soil surface with a value of 3 or less and chroma of 1 or less, and the remaining soil to bedrock must have the same colors as above or any other color that has a chroma of 2 or less.

b. If bedrock occurs within 6 in. (15 cm), more than half of the soil thickness must have a value of 3 or less and chroma of 1 or less, and the remaining soil to bedrock must have the same colors as above or any other color that has a chroma of 2 or less.

Applicable Subregions: For use with problem soils throughout the Great Plains Region.

4 Wetland Hydrology Indicators

Introduction

Wetland hydrology indicators are used in combination with indicators of hydric soil and hydrophytic vegetation to determine whether an area is a wetland under the Corps Manual. Indicators of hydrophytic vegetation and hydric soil generally reflect a site's medium- to long-term wetness history. They provide readily observable evidence that episodes of inundation or soil saturation lasting more than a few days during the growing season have occurred repeatedly over a period of years and that the timing, duration, and frequency of wet conditions have been sufficient to produce a characteristic wetland plant community and hydric soil morphology. If hydrology has not been altered, vegetation and soils provide strong evidence that wetland hydrology is present (National Research Council 1995). Wetland hydrology indicators provide evidence that the site has a *continuing* wetland hydrologic regime and that hydric soils and hydrophytic vegetation are not relicts of a past hydrologic regime. Wetland hydrology indicators confirm that an episode of inundation or soil saturation occurred recently, but may provide little additional information about the timing, duration, or frequency of such events (National Research Council 1995).

Hydrology indicators are often the most transitory of wetland indicators. Those involving direct observation of surface water or saturated soils are usually present only during the normal wet portion of the growing season and may be absent during the dry season or during drier-than-normal years. The climate of the Great Plains Region grades from sub-humid in the east to semi-arid in the west (Commission for Environmental Cooperation (CEC) 1997). Much of the region is characterized by long dry seasons in most years and by alternating series of wet years and drought years. During the annual dry season, and particularly during drought periods, some wetlands in the region may lack hydrology indicators. However, the lack of an indicator is not evidence for the absence of wetland hydrology. See Chapter 5 (Difficult Wetland Situations in the Great Plains) for help in identifying wetlands that may lack wetland hydrology indicators during dry periods. On the other hand, some indicators may be present on non-wetland sites immediately after a heavy rain or during periods of unusually high precipitation, river stages, reservoir releases, runoff, or snowmelt.

Therefore, it is important to consider weather and climatic conditions prior to the site visit to minimize both false-positive and false-negative wetland hydrology decisions. An understanding of normal seasonal and annual variations in rainfall, temperature, and other climatic conditions is essential in interpreting hydrology indicators in the Great Plains. Some useful sources of climatic data are described in Chapter 5.

Areas that have hydrophytic vegetation and hydric soils generally also have wetland hydrology unless the hydrologic regime has changed due to natural events or human activities (National Research Council 1995). Therefore, when wetland hydrology indicators are absent from an area that has indicators of hydric soil and hydrophytic vegetation, further information may be needed to determine whether or not wetland hydrology is present. If possible, one or more site visits should be scheduled to coincide with the normal wet portion of the growing season, the period of the year when the presence or absence of wetland hydrology indicators is most likely to reflect the true wetland/non-wetland status of the site. In addition, aerial photography or remote sensing data, stream gauge data, runoff estimates, scope-and-effect equations for ditches and subsurface drain lines, or groundwater modeling are tools that may help to determine whether wetland hydrology is present when indicators are equivocal or lacking (e.g., USDA Natural Resources Conservation Service 1997). Off-site procedures developed under the National Food Security Act Manual (USDA Natural Resources Conservation Service 1994), which use wetland mapping conventions developed by NRCS state offices, can help identify areas that have wetland hydrology on agricultural lands. The technique is based on wetness signatures visible on standard high-altitude aerial photographs or on annual crop-compliance slides taken by the USDA Farm Service Agency. Finally, on highly disturbed or problematic sites, direct hydrologic monitoring may be needed to determine whether wetland hydrology is present. The U.S. Army Corps of Engineers (2005) provides a technical standard for monitoring hydrology on such sites. This standard requires 14 or more consecutive days of flooding or ponding, or a water table 12 in. (30 cm) or less below the soil surface, during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability) (National Research Council 1995). See Chapter 5 for further information on these techniques.

Growing season

Beginning and ending dates of the growing season may be needed to evaluate certain wetland indicators, such as visual observations of flooding, ponding, or shallow water tables on potential wetland sites. In addition, growing season dates are needed in the event that recorded hydrologic data, such as stream gauge or water-table monitoring data, must be analyzed to determine whether wetland hydrology is present on highly disturbed or problematic sites.

Depletion of oxygen and the chemical reduction of nitrogen, iron, and other elements in saturated soils during the growing season is the result of biological activity occurring in plant roots and soil microbial populations (National Research Council 1995). Two indicators of biological activity that are readily observable in the field are (1) above-ground growth and development of vascular plants, and (2) soil temperature as an indicator of soil microbial activity (Megonigal et al. 1996, USDA Natural Resources Conservation Service 1999). Therefore, if information about the growing season is needed and on-site data gathering is practical, the following approaches should be used in this region to determine growing season dates in a given year. The growing season has begun and is ongoing if either of these conditions is met. Therefore, the beginning of the growing season in a given year is indicated by whichever condition occurs earlier, and the end of the growing season is indicated by whichever condition persists later.

1. The growing season has begun on a site in a given year when two or more different non-evergreen vascular plant species growing in the wetland or surrounding areas exhibit one or more of the following indicators of biological activity:

    a. Emergence of herbaceous plants from the ground
    b. Appearance of new growth from vegetative crowns (e.g., in graminoids, bulbs, and corms)
    c. Coleoptile/cotyledon emergence from seed
    d. Bud burst on woody plants (i.e., some green foliage is visible between spreading bud scales)
    e. Emergence or elongation of leaves of woody plants
    f. Emergence or opening of flowers

The end of the growing season is indicated when woody deciduous species lose their leaves and/or the last herbaceous plants cease flowering and their leaves become dry or brown, generally in the fall due to cold temperatures or reduced moisture availability. Early plant senescence due to the initiation of the summer dry season in some areas does not necessarily indicate the end of the growing season, and alternative procedures (e.g., soil temperature) should be used.

This determination should not include evergreen species. Observations should be made in the wetland or in surrounding areas subject to the same climatic conditions (e.g., similar elevation and aspect); however, soil moisture conditions may differ. Supporting data should be reported on the data form, in field notes, or in the delineation report, and should include the species observed (if identifiable), their abundance and location relative to the potential wetland, and type of biological activity observed. A one-time observation of biological activity during a single site visit is sufficient, but is not required unless growing season information is necessary to evaluate particular wetland hydrology indicators. However, if long-term hydrologic monitoring is planned, then plant growth, maintenance, and senescence should be monitored for continuity over the same period.

2. The growing season has begun in spring, and is still in progress, when soil temperature measured at the 12-in. (30-cm) depth is 41 °F (5 °C) or higher. A one-time temperature measurement during a single site visit is sufficient, but is not required unless growing season information is necessary to evaluate particular wetland hydrology indicators. However, if long-term hydrologic monitoring is planned, then soil temperature should also be monitored to ensure that it remains continuously at or above 41 °F during the monitoring period. Soil temperature can be measured directly in the field by immediately inserting a soil thermometer into the wall of a freshly dug soil pit.

If the timing of the growing season based on vegetation growth and development and/or soil temperature is unknown and on-site data collection is not practical, such as when analyzing previously recorded stream-gauge or monitoring-well data, then growing season dates may be approximated by the median dates (i.e., 5 years in 10, or 50 percent probability) of 28 °F (−2.2 °C) air temperatures in spring and fall, based on long-term records gathered at National Weather Service meteorological stations (U.S. Army

Corps of Engineers 2005). These dates are reported in WETS tables available from the NRCS National Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/wetlands.html) for the nearest appropriate weather station.

Wetland hydrology indicators

In this chapter, wetland hydrology indicators are presented in four groups. Indicators in Group A are based on the direct observation of surface water or groundwater during a site visit. Group B consists of evidence that the site is subject to flooding or ponding, although it may not be inundated currently. These indicators include water marks, drift deposits, sediment deposits, and similar features. Group C consists of other evidence that the soil is saturated currently or was saturated recently. Some of these indicators, such as oxidized rhizospheres surrounding living roots and the presence of reduced iron or sulfur in the soil profile, indicate that the soil has been saturated for an extended period. Group D consists of landscape and vegetation features that indicate contemporary rather than historical wet conditions. Wetland hydrology indicators are intended as one-time observations of site conditions that are sufficient evidence of wetland hydrology in areas where hydric soils and hydrophytic vegetation are present. Unless otherwise noted, all indicators are applicable throughout the Great Plains Region.

Within each group, indicators are divided into two categories – *primary* and *secondary* – based on their estimated reliability in this region. One primary indicator from any group is sufficient to conclude that wetland hydrology is present; the area is a wetland if indicators of hydric soil and hydrophytic vegetation are also present. In the absence of a primary indicator, two or more secondary indicators from any group are required to conclude that wetland hydrology is present. Indicators of wetland hydrology include, but are not necessarily limited to, those listed in Table 10 and described on the following pages. Other evidence of wetland hydrology may also be used with appropriate documentation.

Table 10. Wetland hydrology indicators for the Great Plains.

Indicator	Category	
	Primary	Secondary
Group A – Observation of Surface Water or Saturated Soils		
A1 – Surface water	X	
A2 – High water table	X	
A3 – Saturation	X	
Group B – Evidence of Recent Inundation		
B1 – Water marks	X	
B2 – Sediment deposits	X	
B3 – Drift deposits	X	
B4 – Algal mat or crust	X	
B5 – Iron deposits	X	
B7 – Inundation visible on aerial imagery	X	
B9 – Water-stained leaves	X	
B11 – Salt crust	X	
B13 – Aquatic invertebrates	X	
B6 – Surface soil cracks		X
B8 – Sparsely vegetated concave surface		X
B10 – Drainage patterns		X
Group C – Evidence of Current or Recent Soil Saturation		
C1 – Hydrogen sulfide odor	X	
C2 – Dry-season water table	X	
C4 – Presence of reduced iron	X	
C7 – Thin muck surface	X	
C3 – Oxidized rhizospheres along living roots	X	X (where tilled)
C8 – Crayfish burrows		X
C9 – Saturation visible on aerial imagery		X
Group D – Evidence from Other Site Conditions or Data		
D2 – Geomorphic position		X
D5 – FAC-neutral test		X
D7 – Frost-heave hummocks		X (LRR F)

Group A – Observation of Surface Water or Saturated Soils

Indicator A1: Surface water

Category: Primary

General Description: This indicator consists of the direct, visual observation of surface water (flooding or ponding) during a site visit (Figure 26).

Figure 26. Wetland with surface water present.

Cautions and User Notes: Care must be used in applying this indicator because surface water may be present in non-wetland areas immediately after a rainfall event or during periods of unusually high precipitation, runoff, tides, or river stages. Furthermore, some non-wetlands flood frequently for brief periods. Surface water observed during the non-growing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season for sufficient duration in most years. If this is questionable and other hydrology indicators are absent, a follow-up visit during the growing season may be needed. Note that surface water may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., wetlands are inundated or saturated at least 5 out of 10 years, or 50 percent or higher probability). In addition, groundwater-dominated wetland systems may never or rarely contain surface water.

Indicator A2: High water table

Category: Primary

General Description: This indicator consists of the direct, visual observation of the water table 12 in. (30 cm) or less below the surface in a soil pit, auger hole, or shallow monitoring well (Figure 27). This indicator

includes water tables derived from perched water, throughflow, and discharging groundwater (e.g., in seeps) that may be moving laterally near the soil surface.

Figure 27. High water table observed in a soil pit.

Cautions and User Notes: Sufficient time must be allowed for water to infiltrate into a newly dug hole and to stabilize at the water-table level. The required time will vary depending upon soil texture. In some cases, the water table can be determined by examining the wall of the soil pit and identifying the upper level at which water is seeping into the pit. A water table within 12 in. of the surface observed during the non-growing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season for sufficient duration in most years. If this is questionable and other hydrology indicators are absent, a follow-up visit during the growing season may be needed. Care must be used in interpreting this indicator because water-table levels normally vary seasonally and are a function of both recent and long-term precipitation. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., wetlands are inundated or saturated at least 5 out of 10 years, or 50 percent or higher probability). For an accurate determination of the water-table level, the soil pit, auger hole, or well should not penetrate any restrictive soil layer capable of perching water near the surface.

Indicator A3: Saturation

Category: Primary

General Description: Visual observation of saturated soil conditions 12 in. (30 cm) or less from the soil surface as indicated by water glistening on the surfaces and broken interior faces of soil samples removed from the pit or auger hole (Figure 28). This indicator must be associated with an existing water table located immediately below the saturated zone; however, this requirement is waived under episaturated conditions if there is a restrictive soil layer or bedrock within 12 in. (30 cm) of the surface.

Cautions and User Notes: Glistening is evidence that the soil sample was taken either below the water table or within the saturated capillary fringe above the water table. Recent rainfall events and the proximity of the water table at the time of sampling must be considered in applying and interpreting this indicator. Water observed in soil cracks or on the faces of soil aggregates (peds) does not meet this indicator unless ped interiors are also saturated. A water table is not required below the saturated zone under episaturated conditions if the restrictive layer or bedrock is present within 12 in. (30 cm) of the surface. Note the restrictive layer in the soils section of the data form. The restrictive layer may be at the surface.

Figure 28. Water glistens on the surface of a saturated soil sample.

Group B – Evidence of Recent Inundation

Indicator B1: Water marks

Category: Primary

General Description: Water marks are discolorations or stains on the bark of woody vegetation, rocks, bridge supports, buildings, fences, or other fixed objects as a result of inundation (Figure 29).

Figure 29. Water marks (dark stains) on trees in a seasonally flooded wetland.

Cautions and User Notes: When several water marks are present, the highest reflects the maximum extent of inundation. Water marks indicate a water-level elevation and can be extrapolated from nearby objects across lower elevation areas. Use caution with water marks that may have been caused by extreme, infrequent, or very brief flooding events. In regulated systems, such as reservoirs, water-level records can be used to distinguish unusually high pools from normal operating levels.

Indicator B2: Sediment deposits

Category: Primary

General Description: Sediment deposits are thin layers or coatings of fine-grained mineral material (e.g., silt or clay) or organic matter (e.g., pollen), sometimes mixed with other detritus, remaining on tree bark

(Figure 30), plant stems or leaves, rocks, and other objects after surface water recedes.

Figure 30. Silt deposit left after a recent high-water event forms a tan coating on these tree trunks (upper edge indicated by the arrow).

Cautions and User Notes: Sediment deposits most often occur in riverine backwater and ponded situations where water has stood for sufficient time to allow suspended sediment to settle. Sediment deposits may remain for a considerable period before being removed by precipitation or subsequent inundation. Sediment deposits on vegetation or other objects indicate the minimum inundation level. This level can be extrapolated across lower elevation areas. Use caution with sediment left after infrequent high flows or very brief flooding events. This indicator does not include thick accumulations of sand or gravel in fluvial channels that may reflect historic flow conditions or recent extreme events. Use caution in areas where silt and other material trapped in the snowpack may be deposited directly on the ground surface during spring thaw.

Indicator B3: Drift deposits

Category: Primary

General Description: Drift deposits consist of rafted debris that has been deposited on the ground surface or entangled in vegetation or other fixed objects. Debris consists of remnants of vegetation (e.g., branches, stems, and leaves), man-made litter, or other waterborne materials. Drift material may be deposited at or near the high water line in ponded or flooded areas, piled against the upstream side of trees, rocks, and other fixed objects (Figure 31), or widely distributed within the dewatered area.

Figure 31. Drift deposit on the upstream side of a sapling in a floodplain wetland.

Cautions and User Notes: Deposits of drift material are often found adjacent to streams or other sources of flowing water in wetlands. They also occur in tidal marshes, along lake shores, and in other ponded areas. The elevation of a drift line can be extrapolated across lower elevation areas. Use caution with drift lines that may have been caused by extreme, infrequent, or very brief flooding events, including areas with functioning tile drains. Use caution as drift material can persist for many years in a dry climate.

Indicator B4: Algal mat or crust

Category: Primary

General Description: This indicator consists of a mat or dried crust of algae, perhaps mixed with other detritus, left on or near the soil surface after dewatering.

Cautions and User Notes: Algal deposits include those produced by green algae (Chlorophyta) and blue-green algae (cyanobacteria). They may

be attached to low vegetation or other fixed objects, or may cover the soil surface (Figure 32). Dried crusts of blue-green algae may crack and curl at plate margins (Figure 33). Algal deposits are usually seen in seasonally ponded areas, lake fringes, and low-gradient stream margins. They reflect prolonged wet conditions sufficient for algal growth and development.

Figure 32. Dried algal deposit clinging to low vegetation.

Figure 33. Dried crust of blue-green algae on the soil surface.

Indicator B5: Iron deposits

Category: Primary

General Description: This indicator consists of a thin orange or yellow crust or gel of oxidized iron on the soil surface or on objects near the surface.

Cautions and User Notes: Iron deposits form in areas where reduced iron discharges with groundwater and oxidizes upon exposure to air. The oxidized iron forms a film or sheen on standing water (Figure 34) and an orange or yellow deposit (Figure 35) on the ground surface after dewatering.

Figure 34. Iron sheen on the water surface may be deposited as an orange or yellow crust after dewatering.

Figure 35. Iron deposit (orange streaks) in a small channel.

Indicator B7: Inundation visible on aerial imagery

Category: Primary

General Description: One or more recent aerial photographs or satellite images show the site to be inundated.

Cautions and User Notes: Care must be used in applying this indicator because surface water may be present on a non-wetland site immediately after a heavy rain or during periods of unusually high precipitation, runoff, tides, or river stages. See Chapter 5 for procedures to evaluate the normality of precipitation prior to the photo date. Surface water observed during the non-growing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season for sufficient duration in most years. Surface water may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., wetlands are inundated or saturated at least 5 out of 10 years, or 50 percent or higher probability). If available, it is recommended that multiple years of photography be evaluated. If 5 or more years of aerial photography are available, the procedure described by the USDA Natural Resources Conservation Service (1997, section 650.1903) is recommended (see Chapter 5, section on Wetlands that Periodically Lack Indicators of Wetland Hydrology, for additional information).

Indicator B9: Water-stained leaves

Category: Primary

General Description: Water-stained leaves are fallen or recumbent dead leaves that have turned grayish or blackish in color due to inundation for long periods.

Cautions and User Notes: Water-stained leaves are usually found in depressional wetlands and along streams in shrub-dominated or forested habitats; however, they also occur in herbaceous communities. Staining often occurs in leaves that are in contact with the soil surface while inundated for long periods. Water-stained leaves maintain their blackish or grayish colors when dry (Figure 36). They should contrast strongly with fallen leaves in nearby non-wetland landscape positions.

Figure 36. Water-stained leaves in a temporarily ponded depression.

Indicator B11: Salt crust

Category: Primary

General Description: Salt crusts are hard or brittle deposits of salts formed on the ground surface due to the evaporation of saline surface water.

Cautions and User Notes: Hard or brittle salt crusts form in arid and semi-arid regions in ponded depressions, seeps, and lake fringes when saline surface waters evaporate (Jones 1965; Boettinger 1997) (Figure 37). This indicator does not include fluffy or powdery salt deposits or efflorescences resulting from capillary rise and evaporation of saline groundwater that may be derived from a deep water table. Salt crusts are not known to occur in the Southwestern Prairies Subregion (LRR J).

Figure 37. A hard salt crust on plant stems and the soil surface in a seasonally ponded area.

Indicator B13: Aquatic invertebrates

Category: Primary

General Description: Presence of numerous live individuals, diapausing insect eggs or crustacean cysts, or dead remains of aquatic invertebrates, such as clams, snails, insects, ostracods, shrimp, and other crustaceans, either on the soil surface or clinging to plants or other emergent objects (Figures 38 and 39).

Cautions and User Notes: Examples of dead remains include clam shells, chitinous exoskeletons, insect head capsules, and aquatic snail shells. Invertebrates or their remains should be reasonably abundant; one or two individuals are not sufficient. Use caution in areas where invertebrate remains may have been transported by high winds, unusually high water, or other animals into non-wetland areas. Shells and exoskeletons are resistant to tillage but may be moved by equipment beyond the boundaries of the wetland. They may also persist in the soil for years after dewatering.

Figure 38. Bivalve shell in a seasonally inundated area.

Figure 39. Carapaces of tadpole shrimp (*Triops* sp.) and clam shrimp (*Leptestheria compleximanus*) in dried sediments of an ephemeral pool. Photo by Brian Lang (New Mexico Dept. of Game & Fish).

Indicator B6: Surface soil cracks

Category: Secondary

General Description: Surface soil cracks consist of shallow cracks that form when fine-grained mineral or organic sediments dry and shrink, often creating a network of cracks or small polygons (Figure 40).

Cautions and User Notes: Surface soil cracks are often seen in recent fine sediments and in concave landscape positions where water has ponded long enough to destroy surface soil structure, such as in depressions, lake fringes, and floodplains. Use caution, however, as they may also occur in temporary ponds and puddles in non-wetlands; these situations are easily distinguished by the absence of hydrophytic vegetation and/or hydric soils. This indicator does not include deep cracks due to shrink-swell action in clay soils (e.g., Vertisols).

Figure 40. Surface soil cracks in a seasonally ponded depression.

Indicator B8: Sparsely vegetated concave surface

Category: Secondary

General Description: On concave land surfaces (e.g., depressions and swales), the ground surface is either unvegetated or sparsely vegetated (less than 5 percent ground cover) due to long-duration ponding during the growing season (Figure 41).

Figure 41. A sparsely vegetated, seasonally ponded depression.

Cautions and User Notes: Ponding during the growing season can limit the establishment and growth of ground-layer vegetation. Sparsely vegetated concave surfaces should contrast with vegetated slopes and convex surfaces in the same area. A woody overstory of trees or shrubs may or may not be present. Examples in the region include concave positions on floodplains, seasonally ponded swales in sandhills, and some playa lakes.

Indicator B10: Drainage patterns

Category: Secondary

General Description: This indicator consists of flow patterns visible on the soil surface or eroded into the soil, low vegetation bent over in the direction of flow, absence of leaf litter or small woody debris due to flowing water, and similar evidence that water flowed across the ground surface.

Cautions and User Notes: Drainage patterns are usually seen in areas where water flows broadly over the surface and is not confined to a channel, such as in areas adjacent to streams (Figure 42), in seeps, vegetated swales, and tidal flats. Use caution in areas subject to high winds or affected by recent extreme or unusual flooding events.

Figure 42. Vegetation bent over in the direction of water flow across a stream terrace.

Group C – Evidence of Current or Recent Soil Saturation

Indicator C1: Hydrogen sulfide odor

Category: Primary

General Description: A hydrogen sulfide (rotten egg) odor within 12 in. (30 cm) of the soil surface.

Cautions and User Notes: Hydrogen sulfide is a gas produced by soil microbes in response to prolonged saturation in soils where oxygen, nitrogen, manganese, and iron have been largely reduced and there is a source of sulfur. For hydrogen sulfide to be detectable, the soil must be saturated at the time of sampling and must have been saturated long enough to become highly reduced. These soils are often permanently saturated and anaerobic at or near the surface. To apply this indicator, dig the soil pit no deeper than 12 in. to avoid release of hydrogen sulfide from deeper in the profile. Hydrogen sulfide odor serves as both an indicator of hydric soil and wetland hydrology. This observation proves that the soil meets the definition of a hydric soil (i.e., anaerobic in the upper part), plus has an ongoing wetland hydrologic regime. Often these soils have a high water table (wetland hydrology indicator A2), but the hydrogen sulfide odor provides further proof that the soil has been saturated for a long time.

Indicator C2: Dry-season water table

Category: Primary

General Description: Visual observation of the water table between 12 and 24 in. (30 and 60 cm) below the surface during the normal dry season or during a drier-than-normal year.

Cautions and User Notes: Due to normal seasonal fluctuations, water tables in wetlands often drop below 12 in. during the summer dry season. A water table between 12 and 24 in. during the dry season, or during an unusually dry year, indicates a normal wet-season water table within 12 in. of the surface. Sufficient time must be allowed for water to drain into a newly dug hole and to stabilize at the water-table level. The required time will vary depending upon soil texture. In some cases, the water table can be determined by examining the wall of the soil pit and identifying the upper level at which water is seeping into the pit. For an accurate determination of the water-table level, the soil pit, auger hole, or well should not penetrate any restrictive soil layer capable of perching water near the surface. Water tables in wetlands often drop well below 24 in. during dry periods. Therefore, a dry-season water table below 24 in. does not necessarily indicate a lack of wetland hydrology. See Chapter 5 (section on Wetlands that Periodically Lack Indicators of Wetland Hydrology) to determine average dry-season dates and drought periods.

Indicator C4: Presence of reduced iron

Category: Primary

General Description: Presence of a layer containing reduced (ferrous) iron in the upper 12 in. (30 cm) of the soil profile, as indicated by a ferrous iron test or by the presence of a soil that changes color upon exposure to the air.

Cautions and User Notes: The reduction of iron occurs in soils that have been saturated long enough to become anaerobic and chemically reduced. Ferrous iron is converted to oxidized forms when saturation ends and the soil reverts to an aerobic state. Thus, the presence of ferrous iron indicates that the soil is saturated and anaerobic at the time of sampling, and has been saturated for an extended period. The presence of ferrous iron can be verified with alpha, alpha-dipyridyl reagent (Figure 43) or by

observing a soil that changes color upon exposure to air (i.e., reduced matrix). A positive reaction to alpha, alpha-dipyridyl should occur over more than 50 percent of the soil layer in question. The reagent does not react when wetlands are dry; therefore, a negative test result is not evidence that the soil is not reduced at other times of year. Soil samples should be tested or examined immediately after opening the soil pit because ferrous iron may oxidize and colors change soon after the sample is exposed to the air. Avoid areas of the soil that may have been in contact with iron digging tools. Soils that contain little weatherable iron may not react even when saturated and reduced. There are no minimum thickness requirements or initial color requirements for the soil layer in question.

Figure 43. When alpha, alpha-dipyridyl is applied to a soil containing reduced iron, a positive reaction is indicated by a pink or red coloration to the treated area.

Indicator C7: Thin muck surface

Category: Primary

General Description: This indicator consists of a layer of muck 1 in. (2.5 cm) or less thick on the soil surface.

Cautions and User Notes: Muck is highly decomposed organic material (see the Concepts section of Chapter 3 for guidance on identifying muck). In a dry climate, muck accumulates only where soils are saturated to the surface for long periods each year. Thick muck layers can persist for years after wetland hydrology is effectively removed; therefore, a muck layer greater than 1 in. thick does not qualify for this indicator. However, thin muck surfaces disappear quickly or become incorporated into mineral horizons when wetland hydrology is withdrawn. Therefore, the presence of a thin muck layer on the soil surface indicates an active wetland hydrologic regime.

Indicator C3: Oxidized rhizospheres along living roots

Category: Primary (Secondary in tilled areas)

General Description: Presence of a layer containing 2 percent or more iron-oxide coatings or plaques on the surfaces of living roots and/or iron-oxide coatings or linings on soil pores immediately surrounding living roots within 12 in. (30 cm) of the soil surface (Figures 44 and 45).

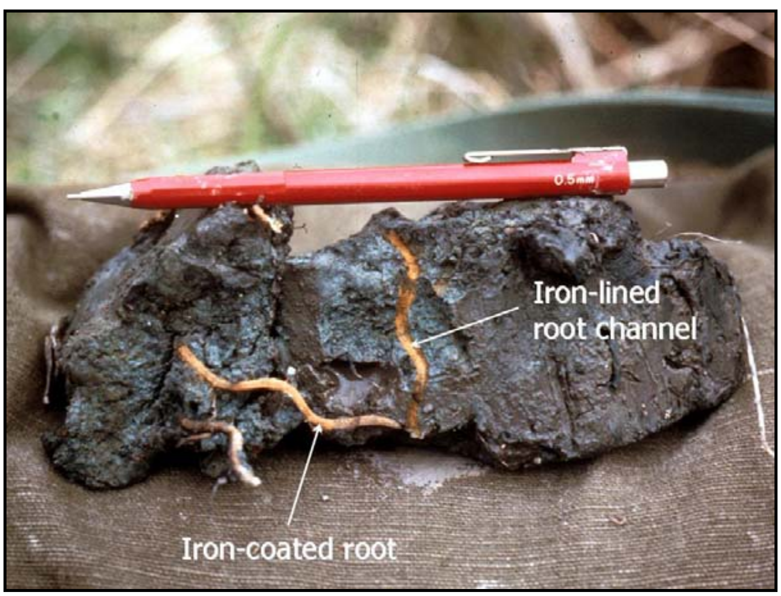

Figure 44. Iron-oxide plaque (orange coating) on a living root. Iron also coats the channel or pore from which the root was removed.

Figure 45. This soil has many oxidized rhizospheres associated with living roots.

Cautions and User Notes: Oxidized rhizospheres are the result of oxygen leakage from living roots into the surrounding anoxic soil, causing oxidation of ferrous iron present in the soil solution. They are evidence of saturated and reduced soil conditions during the plant's lifetime. Iron concentrations or plaques may form on the immediate root surface or may coat the soil pore adjacent to the root. In either case, the oxidized iron must be associated with living roots to indicate contemporary wet conditions and to distinguish these features from other pore linings. Care must be taken to distinguish iron-oxide coatings from organic matter associated with plant roots. Viewing with a hand lens may help to distinguish mineral from organic material and to identify oxidized rhizospheres along fine roots and root hairs. Iron coatings sometimes show concentric layers in cross section and may transfer iron stains to the fingers when rubbed. Note the location and abundance of oxidized rhizospheres in the soil profile description or remarks section of the data form. There is no minimum thickness requirement for the layer containing oxidized rhizospheres. Oxidized rhizospheres must occupy at least 2 percent of the volume of the layer.

In this region, oxidized rhizospheres are a secondary indicator in areas that are mechanically plowed or tilled because they can form above plow pans in non-wetland soils that have been compacted by tillage or where a pan has developed due to plow shear. Plow pans form just below the maximum tillage depth (generally 6 to 8 in. [15 to 20 cm]), and can be identified by their higher bulk density; massive, cloddy structure; and roots growing horizontally on top of the compacted zone.

Indicator C8: Crayfish burrows

Category: Secondary

General Description: Presence of crayfish burrows, as indicated by openings in soft ground up to 2 in. (5 cm) in diameter, often surrounded by chimney-like mounds of excavated mud.

Cautions and User Notes: Crayfish breathe with gills and require at least periodic contact with water. Some species dig burrows for refuge and breeding (Figure 46). Crayfish burrows are usually found near streams, ditches, and ponds in areas that are seasonally inundated or have seasonal high water tables at or near the surface. They are also found in wet meadows and pastures where there is no open water. Crayfish may extend their burrows 10 ft (3 m) or more in depth to keep pace with a falling water table; thus, the eventual depth of the burrow does not reflect the level of the seasonal high water table.

Figure 46. Crayfish burrow in a saturated wetland.

Indicator C9: Saturation visible on aerial imagery

Category: Secondary

General Description: One or more recent aerial photographs or satellite images indicate soil saturation. Saturated soil signatures must correspond to field-verified hydric soils, depressions or drainage patterns, differential crop management, or other evidence of a seasonal high water table.

Cautions and User Notes: This indicator is useful when plant cover is sparse or absent and the ground surface is visible from above. Saturated areas generally appear as darker patches within the field (Figure 47). Inundated (indicator B7) and saturated areas may be present in the same field; if they cannot be distinguished, then use indicator C9 for the entire wet area. Care must be used in applying this indicator because saturation may be present on a non-wetland site immediately after a heavy rain or during periods of abnormally high precipitation, runoff, tides, or river stages. Saturation observed during the non-growing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season for sufficient duration in most years. Saturation may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., wetlands are inundated or saturated at least 5 out of 10 years, or 50 percent or higher probability). If available, it is recommended that multiple years of photography be evaluated. If 5 or more years of aerial photography are available, the procedure described by the USDA Natural Resources Conservation Service (1997, section 650.1903) is recommended. Use caution, as similar signatures may be caused by factors other than saturation. This indicator requires on-site verification that saturation signatures seen on photos correspond to hydric soils or other evidence of a seasonal high water table.

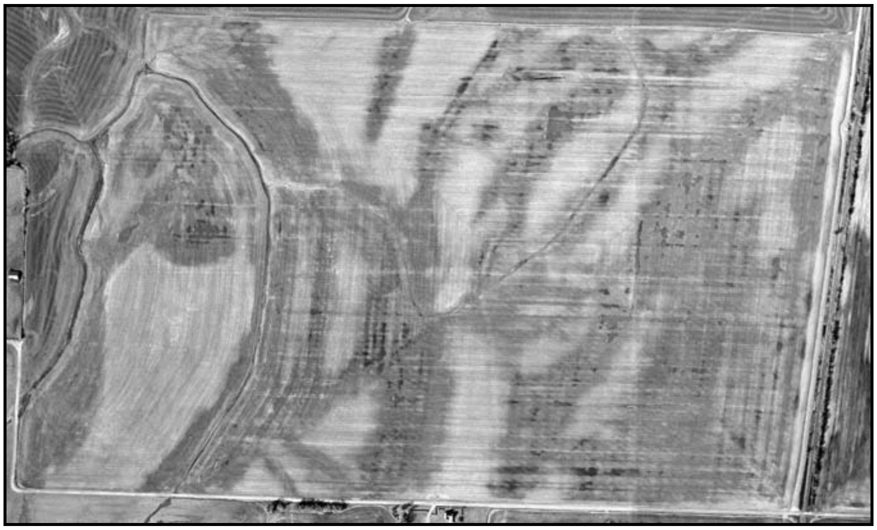

Figure 47. Aerial photograph of an agricultural field with saturated soils indicated by darker colors.

Group D – Evidence from Other Site Conditions or Data

Indicator D2: Geomorphic position

Category: Secondary

General Description: This indicator is present if the area in question is located in a localized depression, drainageway, concave position within a floodplain, at the toe of a slope, on the low-elevation fringe of a pond or other water body, or in an area where groundwater discharges.

Cautions and User Notes: Excess water from precipitation and snowmelt naturally accumulates in certain geomorphic positions in the landscape, particularly in low-lying areas such as depressions, drainages, toe slopes, and fringes of water bodies. These areas often, but not always, exhibit wetland hydrology. This indicator does not include concave positions on rapidly permeable soils (e.g., floodplains with sand and gravel substrates) that do not have wetland hydrology unless the water table is near the surface.

Indicator D5: FAC-neutral test

Category: Secondary

General Description: The plant community passes the FAC-neutral test.

Cautions and User Notes: The FAC-neutral test is performed by compiling a list of dominant plant species across all strata in the community, and dropping from the list any species with a Facultative indicator status (i.e., FAC, FAC–, and FAC+). The FAC-neutral test is met if more than 50 percent of the remaining dominant species are rated FACW and/or OBL. This indicator may be used in communities that contain no FAC dominants. If there are an equal number of dominants that are OBL and FACW versus FACU and UPL, non-dominant species should be considered. This indicator is only applicable to wetland hydrology determinations.

Indicator D7: Frost-heave hummocks

Category: Secondary

General Description: This indicator consists of hummocky microtopography produced by frost action in saturated wetland soils.

Applicable Subregion: Applicable to the Northern Great Plains Subregion (LRR F).

Cautions and User Notes: In the Northern Great Plains, freeze/thaw action creates hummocky microtopography in saturated soils in and along the edges of wetlands (Figure 48). This indicator is not known to occur outside of LRR F. This indicator does not include pimple mounds, gilgai microrelief in clay soils (e.g., Vertisols), or other factors (e.g., trampling by livestock) that can produce hummocky topography.

Figure 48. Frost-heave hummocks.

5 Difficult Wetland Situations in the Great Plains

Introduction

Some wetlands can be difficult to identify because wetland indicators may be missing due to natural processes or recent disturbances. This chapter provides guidance for making wetland determinations in difficult-to-identify wetland situations in the Great Plains. It includes regional examples of problem area wetlands and atypical situations as defined in the Corps Manual, as well as other situations that can make wetland delineation more challenging. Problem area wetlands are naturally occurring wetland types that lack indicators of hydrophytic vegetation, hydric soil, or wetland hydrology periodically due to normal seasonal or annual variability, or permanently due to the nature of the soils or plant species on the site. Atypical situations are wetlands in which vegetation, soil, or hydrology indicators are absent due to recent human activities or natural events. In addition, this chapter addresses certain procedural problems (e.g., wetland/non-wetland mosaics) that can make wetland determinations in the Great Plains difficult or confusing. The chapter is organized into the following sections:

- Problematic Hydrophytic Vegetation
- Problematic Hydric Soils
- Wetlands that Periodically Lack Indicators of Wetland Hydrology
- Wetland/Non-Wetland Mosaics

The list of difficult wetland situations presented in this chapter is not intended to be exhaustive and other problematic situations may exist in the region. See the Corps Manual for general guidance. Furthermore, more than one wetland factor (i.e., vegetation, soil, and/or hydrology) may be disturbed or problematic on a given site. In general, *wetland determinations on difficult or problematic sites must be based on the best information available to the field inspector, interpreted in light of his or her professional experience and knowledge of the ecology of wetlands in the region.*

Problematic hydrophytic vegetation

Description of the problem

Many factors affect the structure and composition of plant communities in the Great Plains, including climatic variability, long-term grazing, fires, groundwater withdrawal, and other human land-use practices. As a result, some wetlands may exhibit indicators of hydric soil and wetland hydrology but lack any of the hydrophytic vegetation indicators presented in Chapter 2, at least at certain times. To identify and delineate these wetlands may require special procedures or additional analysis of factors affecting the site, including recent changes in hydrologic conditions that may not be reflected in the current vegetation on a site. To the extent possible, the hydrophytic vegetation decision should be based on the plant community that is normally present during the wet portion of the growing season in a normal rainfall year. The following procedure addresses several examples of problematic vegetation situations in the Great Plains.

Procedure

Problematic hydrophytic vegetation can be identified and delineated using a combination of observations made in the field and/or supplemental information from the scientific literature and other sources. These procedures should be applied only where indicators of hydric soil and wetland hydrology are present, unless one or both of these factors is also disturbed or problematic, but no indicators of hydrophytic vegetation are evident. The following procedures are recommended:

1. Verify that at least one indicator of hydric soil and one primary or two secondary indicators of wetland hydrology are present. If indicators of either hydric soil or wetland hydrology are absent, the area is likely non-wetland unless soil and/or hydrology are also disturbed or problematic. If indicators of hydric soil and wetland hydrology are present (or are absent due to disturbance or other problem situations), proceed to step 2.

2. Verify that the area is in a landscape position that is likely to collect or concentrate water. Appropriate settings include the following. If the landscape setting is appropriate, proceed to step 3.

    a. Concave surface (e.g., depression or swale)
    b. Floodplain

c. Level or nearly level area (e.g., 0- to 3-percent slope)
d. Toe slope (Figure 5) or an area of convergent slopes (Figure 4)
e. Fringe of another wetland or water body
f. Area with a restrictive soil layer or aquitard within 24 in. (60 cm) of the surface
g. Area where groundwater discharges (e.g., a seep)
h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)

3. Use one or more of the approaches described in step 4 (Specific Problematic Vegetation Situations below) or step 5 (General Approaches to Problematic Hydrophytic Vegetation on page 108) to determine whether the vegetation is hydrophytic. In the remarks section of the data form or in the delineation report, explain the rationale for concluding that the plant community is hydrophytic even though indicators of hydrophytic vegetation described in Chapter 2 were not observed.

4. Specific Problematic Vegetation Situations

   a. *Temporal shifts in vegetation.* As described in Chapter 2, the species composition of many wetland plant communities in the Great Plains can change in response to seasonal weather patterns and long-term climatic fluctuations. Wetland types that are particularly influenced by these shifts include prairie potholes, riparian and floodplain wetlands, edges of lakes and impoundments, ephemeral pools, playa edges, seeps, and springs. Lack of hydrophytic vegetation during the dry season, when warm-season grasses and annuals dominate many areas, should not immediately eliminate a site from further consideration as a wetland, because the site may have been dominated by wetland species earlier in the growing season. A site qualifies for further consideration if the plant community at the time of sampling does not exhibit hydrophytic vegetation indicators, but indicators of hydric soil and wetland hydrology are present. The following sampling and analytical approaches are recommended in these situations:

      (1) Seasonal Shifts in Plant Communities

         (a) If possible, return to the site during the normal wet portion of the growing season and re-examine the site for indicators of hydrophytic vegetation.

(b) Examine the site for identifiable plant remains, either alive or dead, or other evidence that the plant community that was present during the normal wet portion of the growing season was hydrophytic.

(c) Use off-site data sources to determine whether the plant community that is normally present during the wet portion of the growing season is hydrophytic. Appropriate data sources include early growing season aerial photography, NWI maps, soil survey reports, remotely sensed data, public interviews, and previous reports about the site. If necessary, re-examine the site at a later date to verify the hydrophytic vegetation determination.

(d) If the vegetation on the site is substantially the same as that on a wetland reference site having similar soils, landscape position, and known wetland hydrology, then consider the vegetation to be hydrophytic (see step 5b in this procedure for more information).

(2) Drought Conditions (lasting more than one growing season)

(a) Investigate climate records (e.g., WETS tables, drought indices) to determine if the area is under the influence of a drought (for more information, see the section on "Wetlands that Periodically Lack Indicators of Wetland Hydrology" later in this chapter). If so, evaluate any off-site data that provide information on the plant community that exists on the site during normal years, including aerial photography, Farm Service Agency annual crop-compliance slides, NWI maps, other remote sensing data, soil survey reports, public interviews, NRCS hydrology tools (USDA Natural Resources Conservation Service 1997), and previous site reports. Determine whether the vegetation that is present during normal years is hydrophytic.

(b) If the vegetation on the drought-affected site is substantially the same as that on a wetland reference site in the same general area having similar soils and known wetland hydrology, then consider the vegetation to be hydrophytic (see step 5b in this procedure).

b. *Sparse and patchy vegetation.* Wetlands located within saline basins in the Great Plains sometimes have sparse or patchy vegetation cover. Examples include some playa lakes, coastal salt flats, and saline seeps and springs that may be influenced by seasonal ponding or discharge of saline groundwater. These areas may have indicators of hydric soils and wetland hydrology, but the vegetation is not continuous across or along the boundary of the wetland. Some saline wetlands may also lack the typical morphological indicators of a hydric soil. Delineation of these areas can be confusing due, in part, to the interspersion of wetlands and other potential waters of the United States. For wetland delineation purposes, an area should be considered vegetated (and a potential wetland) if there is 5 percent or more areal cover of plants at the peak of the growing season. Unvegetated areas have less than 5 percent plant cover. Patchy vegetation is a mosaic of both vegetated and unvegetated areas (Figure 49). In some cases, the unvegetated portions of a site may be considered as other waters of the United States if they exhibit ordinary high water (OHW) indicators (33 CFR 328.3). Approved OHW indicators may be available from the appropriate District regulatory office. Contact information for District regulatory offices is available at the Corps Headquarters web site (http://www.usace.army.mil/CECW/Pages/reg_districts.aspx).

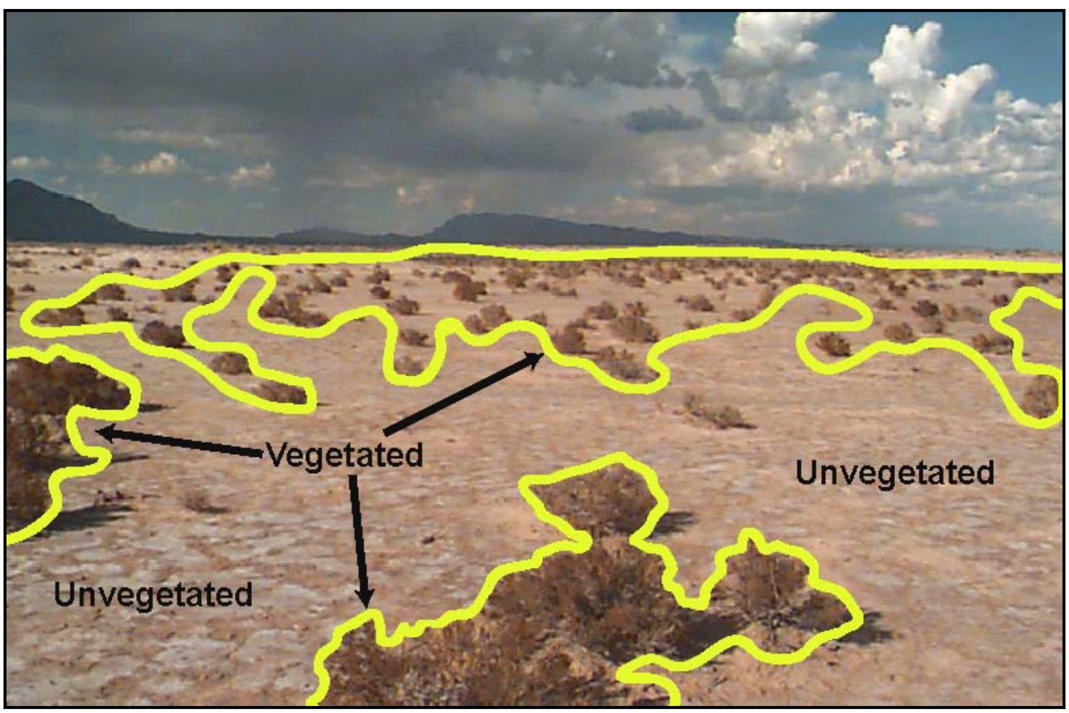

Figure 49. Example of sparse and patchy plant cover in a wetland. Areas labeled as vegetated have 5 percent or more plant cover.

The following procedure is recommended in these situations:

(1) Develop a site map showing the vegetated and unvegetated areas of concern. Sampling points should be placed in representative locations within both the vegetated and unvegetated areas.
(2) In the vegetated areas (i.e., 5 percent or more plant cover), use the standard three-factor approach for identifying wetlands. If indicators of hydrophytic vegetation, hydric soil, and wetland hydrology are present, then these areas are wetlands. Use caution when vegetation, soils, or hydrology are problematic.
(3) In unvegetated areas (less than 5 percent plant cover), and in vegetated areas that fail the three-factor wetland test, examine the site for OHW indicators. If OHW indicators are present, these areas should be identified as potential non-wetland waters of the United States.
(4) If present, identify any unvegetated areas that lack OHW indicators but have indicators of hydric soil and wetland hydrology. These areas should be included in the delineation if they are part of a mosaic with vegetated wetlands and other waters.
(5) The final delineation should encompass (a) all vegetated areas determined to be wetlands (i.e., indicators of hydrophytic vegetation, hydric soil, and wetland hydrology are present), (b) areas that are potential other waters of the United States (i.e., OHW indicators are present), and (c) interspersed areas that are unvegetated but have indicators of hydric soils and wetland hydrology.

c. *Riparian areas*. Riparian ecosystems are common along most rivers and streams in the Great Plains, and can contain both wetland and non-wetland components. Riparian corridors can be lined with hydrophytic vegetation, upland vegetation, unvegetated areas, or a mosaic of these types. Soils may lack hydric soil indicators in recently deposited materials (i.e., Entisols) even when indicators of hydrophytic vegetation and wetland hydrology are present. Surface hydrology can vary from perennial to intermittent and, after a flooding event, water tables can drop quickly to low levels. Many riparian areas contain remnant stands of tree species that may have germinated during unusually high water events or under wetter conditions than currently exist at the site (Figure 50). Some areas have a high frequency of phreatophytic species that, when mature, are able to exploit groundwater that is too deep to

support wetlands. Great Plains riparian corridors are often non-wetland but frequently contain areas of both wetlands and other waters of the United States. Delineating wetlands and other waters in riparian corridors requires the application of both wetland and OHW indicators. The following procedure is recommended:

Figure 50. Mature stand of *Populus deltoides* with a xeric understory isolated from the active channel on the Cheyenne River floodplain, Wyoming.

(1) In riparian areas having indicators of hydrophytic vegetation, hydric soils, and wetland hydrology, use the standard three-factor test for identification of wetlands.
(2) In riparian corridors lacking indicators of hydrophytic vegetation, hydric soils, and/or wetland hydrology, evaluate the site as a potential non-wetland water of the United States using OHW indicators.

d. *Areas affected by grazing*. Both short- and long-term grazing can cause shifts in dominant species in the vegetation. For instance, trampling by large herbivores can cause soil compaction, altering soil permeability and infiltration rates, and affecting the plant community. Grazers can also influence the abundance of plant species by selectively

grazing certain palatable species (decreasers) or avoiding less palatable species (increasers) (Table 11). Shifts in species composition due to grazing can influence the hydrophytic vegetation determination. Be aware that shifts in both directions, favoring either wetland species or upland species, can occur in these situations. Limited grazing does not necessarily affect the outcome of a hydrophytic vegetation decision. However, the following approaches are recommended in cases where the effects of grazing are so great that the hydrophytic vegetation determination would be unreliable or misleading.

Table 11. Examples of increaser and decreaser plant species in response to grazing in the Great Plains.

Increasers	Decreasers
Aristida longiseta	*Acer negundo*
Artemisia ludoviciana	*Andropogon hallii*
Beckmannia syzigachne	*Elymus canadensis*
Bouteloua gracilis	*Juncus balticus*
Cirsium arvense	*Panicum virgatum*
Equisetum arvense	*Schizachyrium scoparium*
Gutierrezia sarothrae	*Sisyrinchium angustifolium*
Hordeum jubatum	*Sorghastrum nutans*
Shepherdia argentea	*Spartina pectinata*
[1] Source: Montana State University Extension Service (http://www.montana.edu/wwwpb/pubs/mt8402ag.pdf).	

(1) Examine the vegetation on a nearby, ungrazed reference site having similar soils and hydrologic conditions. Ungrazed areas may be present on adjacent properties or in fenced exclosures or stream-side management zones. Assume that the same plant community would exist on the grazed site, in the absence of grazing.

(2) If feasible, remove livestock or fence representative livestock exclusion areas to allow the vegetation time to recover from grazing, and reevaluate the vegetation during the next growing season.

(3) If grazing was initiated recently, use off-site data sources such as aerial photography, NWI maps, and interviews with the land owner and other persons familiar with the site or area to determine the plant community present on the site before grazing began. If the

previously ungrazed community was hydrophytic, then consider the current vegetation to be hydrophytic.

(4) If an appropriate ungrazed area cannot be located or if the ungrazed vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soils and wetland hydrology.

e. *Managed plant communities*. Many natural plant communities throughout the Great Plains have been altered and are managed to meet human goals. Examples include clearing of woody vegetation on rangelands, periodic disking or plowing, mowing, planting of native and non-native species (including cultivars or planted species that have escaped and become established on other sites), irrigation of pastures and hayfields, suppression of wildfires, and the use of herbicides. These actions can result in elimination of certain species and their replacement with other species, changes in abundance of certain plants, and shifts in dominant species, possibly influencing a hydrophytic vegetation determination. The following approaches are recommended if the natural vegetation has been altered through management to such an extent that a hydrophytic vegetation determination may be unreliable:

(1) Examine the vegetation on a nearby, unmanaged reference site having similar soils and hydrologic conditions. Assume that the same plant community would exist on the managed site in the absence of human alteration.

(2) For recently cleared or plowed areas (not planted or seeded), leave representative areas unmanaged for at least one growing season with normal rainfall and reevaluate the vegetation.

(3) If management was initiated recently, use off-site data sources such as aerial photography, NWI maps, and interviews with the land owner and other persons familiar with the site or area to determine the plant community present on the site before the management occurred.

(4) If the unmanaged vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soil and wetland hydrology.

f. *Areas affected by fires, floods, and other natural disturbances*. Wildfires, floods, and other catastrophic disturbances can dramatically alter the vegetation on a site. Vegetation can be completely or partially removed, or its composition altered, depending upon the intensity of the disturbance. Limited disturbance does not necessarily affect the investigator's ability to determine whether the plant community is or is not hydrophytic. However, if the vegetation on a site has been removed or made unidentifiable by a recent fire, flood, or other disturbance, then one or more of the following approaches may be used to determine whether the vegetation present before the disturbance was hydrophytic. Additional guidance can be found in the Atypical Situations section of the Corps Manual.

(1) Examine the vegetation on a nearby, undisturbed reference site having similar soils and hydrologic conditions. Assume that the same plant community would exist on the disturbed site in the absence of disturbance.
(2) Use off-site information sources such as aerial photography, NWI maps, and interviews with knowledgeable people to determine the plant community present on the site before the disturbance.
(3) If the undisturbed vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soil and wetland hydrology.

g. *Vigor and stress responses to wetland conditions*. Plant responses to wet site conditions are often easily observable. Many plants develop stress-related features, such as stunting in agricultural crops and browning or yellowing of native or planted vegetation, when subjected to long periods of soil saturation in the root zone. Crop stress in wet agricultural fields is identifiable both in the field and on aerial photography. In addition, many species show increased abundance or plant vigor when growing on wet sites, particularly later in the growing season when adjacent areas are drying out but moist soils are still present in wetlands. These responses are not species specific or easily measurable but are evident when the vegetation of wetlands and adjacent non-wetlands is compared. The following procedure can help determine whether an observed increase or decrease in plant vigor or stress is the result of growing in wetlands. The procedure assumes that indicators of hydric soil and wetland hydrology are present in the potential wetland area. Use caution in areas where variations in plant

vigor or stress may be due to variations in salinity or other soil conditions, uneven application of fertilizers or herbicides, or other factors not related to wetness.

(1) Compare and describe in field notes the size, vigor, or other stress-related characteristics of individuals of the same species between the potential wetland area and the immediately surrounding non-wetlands. Emphasize features that can be measured or photographed and include this information in the field report. To qualify for this procedure, most individuals of the affected species must show vigor/stress responses in the wet area. If there are clear differences in plant vigor/stress responses between potential wetland and adjacent non-wetland areas, proceed to step 2.
(2) Observe and describe trends in plant vigor or stress conditions along the topographic or wetness gradient from the potential wetland to the adjacent non-wetland areas. Trends in plant vigor/stress responses must reflect the distribution of hydric soils, wetland hydrology indicators, topography, and/or landscape conditions relevant to wetlands. If so, proceed to step 3.
(3) Consider the area containing indicators of hydric soil, wetland hydrology, and evidence of plant vigor or stress to be a wetland. Determine the wetland boundary based on the spatial patterns in these features plus topography and landscape characteristics.

5. General Approaches to Problematic Hydrophytic Vegetation. The following general procedures are provided to identify hydrophytic vegetation in difficult situations not necessarily associated with specific vegetation types or management practices, including wetlands dominated by FAC–, FACU, NI, NO, or unlisted species that are functioning as hydrophytes. These procedures should be applied only where indicators of hydric soil and wetland hydrology are present (or are absent due to disturbance or other problem situations) but indicators of hydrophytic vegetation are not evident. The following approaches are recommended:

a. *Direct hydrologic observations.* Verify that the plant community occurs in an area subject to prolonged inundation or soil saturation during the growing season. This can be done by visiting the site at 2- to 3-day intervals during the portion of the growing season when surface water is most likely to be present or water tables are normally high. Hydrophytic vegetation is considered to be present, and the site is a

wetland, if surface water is present and/or the water table is 12 in. (30 cm) or less from the surface for 14 or more consecutive days during the growing season during a period when antecedent precipitation has been normal or drier than normal. If necessary, microtopographic highs and lows should be evaluated separately. The normality of the current year's rainfall must be considered in interpreting field results, as well as the likelihood that wet conditions will occur on the site at least every other year (for more information, see the section on "Wetlands that Periodically Lack Indicators of Wetland Hydrology" in this chapter).

b. *Reference sites.* If indicators of hydric soil and wetland hydrology are present, the site may be considered to be a wetland if the landscape setting, topography, soils, and vegetation are substantially the same as those on nearby wetland reference areas. Hydrologic characteristics of wetland reference areas should be documented through long-term monitoring or by application of the procedure described in item 5a above. Reference sites should be minimally disturbed and provide long-term access. Soils, vegetation, and hydrologic conditions should be thoroughly documented and the data kept on file in the district or field office.

c. *Technical literature.* Published and unpublished scientific literature may be used to support a decision to treat specific FAC− or FACU species or species with no assigned indicator status (e.g., NI, NO, or unlisted) as hydrophytes or certain plant communities as hydrophytic. Preferably, this literature should discuss the species' natural distribution along the moisture gradient, its capabilities and adaptations for life in wetlands, wetland types in which it is typically found, or other wetland species with which it is commonly associated.

Problematic hydric soils

Description of the problem

Soils with faint or no indicators

Some soils that meet the hydric soil definition may not exhibit any of the indicators presented in Chapter 3. These problematic hydric soils exist for a number of reasons and their proper identification requires additional information, such as landscape position, presence or absence of restrictive soil layers, or information about hydrology. This section describes several soil situations in the Great Plains Region that are considered to be hydric if

additional requirements are met. In some cases, these hydric soils may appear to be non-hydric due to the color of the parent material from which the soils developed. In others, the lack of hydric soil indicators is due to conditions that inhibit the development of redoximorphic features despite prolonged soil saturation and anoxia. In addition, recently developed wetlands may lack hydric soil indicators because insufficient time has passed for their development. Examples of problematic hydric soils in the Great Plains include, but are not limited to, the following.

1. **Moderately to Very Strongly Alkaline Soils.** The formation of redox concentrations and depletions requires that soluble iron and organic matter be present in the soil. In a neutral to acidic soil, iron readily enters into solution as reduction occurs and then precipitates in the form of redox concentrations as the soil becomes oxidized. Identifiable iron or manganese features do not readily form in saturated soils with high pH. High pH (7.9 or higher) can be caused by many factors. In the Great Plains, salt content is a common cause of high soil pH. If the pH is high, indicators of hydrophytic vegetation and wetland hydrology are present, and landscape position is consistent with wetlands in the area, then the soil may be hydric even in the absence of a recognized hydric soil indicator. In the absence of an approved indicator, thoroughly document soil conditions, including pH, in addition to the rationale for identifying the soil as hydric (e.g., landscape position, vegetation, evidence of hydrology, etc.). The concept of high pH includes the USDA terms Moderately Alkaline, Strongly Alkaline, and Very Strongly Alkaline (USDA Natural Resources Conservation Service 2002).
2. **Volcanic Ash.** This problem is only known to occur in the Western Great Plains (LRR G). Soils of volcanic origin that have high levels of volcanic ash (silica) are inherently low in iron, manganese, and sulfur. Many hydric soil indicators are formed predominantly by the accumulation or loss of iron, manganese, or sulfur and, therefore, cannot form in these soils. In the absence of an approved indicator, soil and landscape conditions should be documented thoroughly, along with the rationale for considering the soil to be hydric (e.g., landscape position, vegetation, evidence of hydrology, etc.). A soil scientist with local experience may be needed to help determine whether soils are volcanic in origin.
3. **Fluvial Sediments within Floodplains.** These soils commonly occur on vegetated bars within the active channel and above the bankfull level of rivers and streams. In some cases, these soils lack hydric soil indicators due to seasonal or annual deposition of new soil material, low iron or

manganese content, and low organic matter content. Redox concentrations can sometimes be found on the bottoms of coarse fragments or between stratifications where organic matter gets buried and should be examined closely to see if they satisfy an indicator.

4. **Recently Developed Wetlands.** Recently developed wetlands include mitigation sites, wetland management areas (e.g., for waterfowl), other wetlands intentionally or unintentionally produced by human activities, and naturally occurring wetlands that have not been in place long enough to develop hydric soil indicators.
5. **Seasonally Ponded Soils.** Seasonally ponded, depressional wetlands occur in basins and valleys throughout the Great Plains. Most are perched systems, with water ponding above a restrictive soil layer, such as a hardpan or clay layer that is at or near the surface (e.g., in Vertisols). Ponded depressions also occur in floodplains where receding floodwaters, precipitation, and local runoff are held above a slowly permeable soil layer. Some of these wetlands lack hydric soil indicators due to limited saturation depth, saline conditions, or other factors.
6. **Red Parent Material.** Soils formed in alluvium derived from Permian- and Triassic-age sedimentary rocks often exhibit strong red colors that can mask or inhibit the development of redoximorphic features. These soils often continue to receive new deposits from flooding. Red parent materials are common on floodplains in southern Kansas, Oklahoma, and Texas.
7. **Black Parent Material.** In the Blackland Prairie region of Texas (MLRA 86A and 86B), fine-textured soil particles are deposited in the Trinity and Sulphur River floodplains and their tributaries from upland soils that typically have values/chroma of 2/1 and 3/1. These soils have high pH, high cation exchange capacity, high organic matter content, and often receive new deposits that inhibit the development of redoximorphic features. Soils in some areas contain as much as 5 percent visible redoximorphic features, but other areas with similar hydrology may have no visible redoximorphic features.

Soils with relict or induced hydric soil indicators

Some soils in the Great Plains exhibit redoximorphic features and hydric soil indicators that formed in the recent or distant past when conditions may have been wetter than they are today. These features have persisted even though wetland hydrology may no longer be present. For example, wetlands drained for agricultural purposes starting in the 1800s, such as large areas of North and South Dakota, may contain persistent hydric soil features. Wetland soils drained during historic times are still considered to

be hydric but they may no longer support wetlands. Relict hydric soil features may be difficult to distinguish from contemporary features. However, if indicators of hydrophytic vegetation and wetland hydrology are present, then hydric soil indicators can be assumed to be contemporary.

There are also areas where hydric soil features have developed in former uplands due to human activities, such as the diversion of water for irrigation or other uses. The application of irrigation water to upland areas can create wetland hydrology and, given adequate time, induce the formation of hydric soil indicators. In some cases, a soil scientist can distinguish naturally occurring hydric soil features from those induced by irrigation. Characterizing the naturally occurring hydrology is often important to the determination, and the timing of field observations can be critical. Observations made during the early part of the growing season, when natural hydrology is often at its peak and irrigation has not yet begun, may help to differentiate naturally occurring and irrigation-induced hydric soil features.

Procedure

Soils that are thought to meet the definition of a hydric soil but do not exhibit any of the indicators described in Chapter 3 can be identified by the following recommended procedure. This procedure should be used only where indicators of hydrophytic vegetation and wetland hydrology are present (or are absent due to disturbance or other problem situations) but indicators of hydric soil are not evident.

1. Verify that one or more indicators of hydrophytic vegetation are present or that the vegetation is disturbed or problematic. If so, proceed to step 2.

2. Verify that at least one primary or two secondary indicators of wetland hydrology are present or that indicators are absent due to disturbance or other factors. If so, proceed to step 3. If indicators of hydrophytic vegetation and/or wetland hydrology are absent, then the area is probably nonwetland and no further analysis is required.

3. Thoroughly describe and document the soil profile and landscape setting. Verify that the area is in a landscape position that is likely to collect or concentrate water. Appropriate settings are listed below. If the landscape setting is appropriate, proceed to step 4.

a. Concave surface (e.g., depression or swale)
b. Floodplain
c. Level or nearly level area (e.g., 0- to 3-percent slope)
d. Toe slope (Figure 5) or an area of convergent slopes (Figure 4)
e. Fringe of another wetland or water body
f. Area with a restrictive soil layer or aquitard within 24 in. (60 cm) of the surface
g. Area where groundwater discharges (e.g., a seep)
h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)

4. Use one or more of the following approaches to determine whether the soil is hydric. In the remarks section of the data form or in the delineation report, explain why it is believed that the soil lacks any of the NTCHS hydric soil indicators described in Chapter 3 and why it is believed that the soil meets the definition of a hydric soil.

   a. Determine whether one or more of the following indicators of problematic hydric soils is present. Descriptions of each indicator are given in Chapter 3. If one or more indicators is present, then the soil is hydric.

      (1) 1 cm Muck (A9) (applicable to LRR I and J)
      (2) Coast Prairie Redox (A16) (applicable to LRR F, G, and H)
      (3) Dark Surface (S7) (applicable to LRR G)
      (4) High Plains Depressions (F16) (applicable to LRR H outside of MLRA 72 and 73)
      (5) Reduced Vertic (F18) (applicable throughout the Great Plains Region in areas with Vertisols and Vertic intergrades)
      (6) Red Parent Material (TF2) (applicable throughout the Great Plains Region in areas containing soils derived from red parent materials)
      (7) Very Shallow Dark Surface (TF12) (applicable throughout the Great Plains Region)

   b. Determine whether one or more of the following problematic soil situations is present. If present, consider the soil to be hydric.

      (1) Moderately to Very Strongly Alkaline Soils
      (2) Volcanic Ash
      (3) Fluvial Sediments within Floodplains
      (4) Recently Developed Wetlands

(5) Seasonally Ponded Soils
(6) Red Parent Material
(7) Black Parent Material
(8) Other (in field notes, describe the problematic soil situation and explain why it is believed that the soil meets the hydric soil definition)

c. Soils that have been saturated for long periods and have become chemically reduced may change color when exposed to air due to the rapid oxidation of ferrous iron (Fe^{2+}) to Fe^{3+} (i.e., a reduced matrix) (Figures 51 and 52). If the soil contains sufficient iron, this can result in an observable color change, especially in hue or chroma. The soil is hydric if a mineral layer 4 in. (10 cm) or more thick starting within 12 in. (30 cm) of the soil surface that has a matrix value of 4 or more and chroma of 2 or less becomes redder by one or more pages in hue and/or increases one or more in chroma when exposed to air within 30 minutes (Vepraskas 1992).

Care must be taken to obtain an accurate color of the soil sample immediately upon excavation. The colors should be observed closely and examined again after several minutes. Do not allow the sample to become dry. Dry soils will usually have a different color than wet or moist soils. As always, do not determine colors while wearing sunglasses. Colors must be obtained in the field under natural light and not under artificial light.

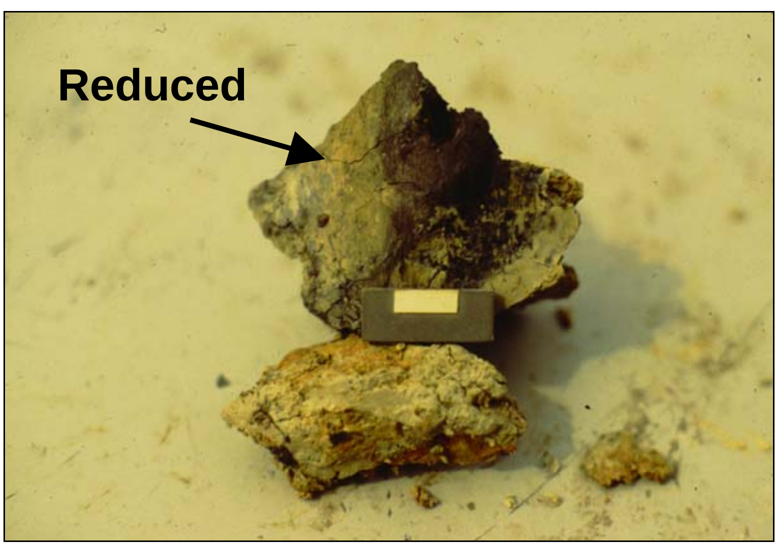

Figure 51. This soil exhibits colors associated with reducing conditions. Scale is 1 cm.

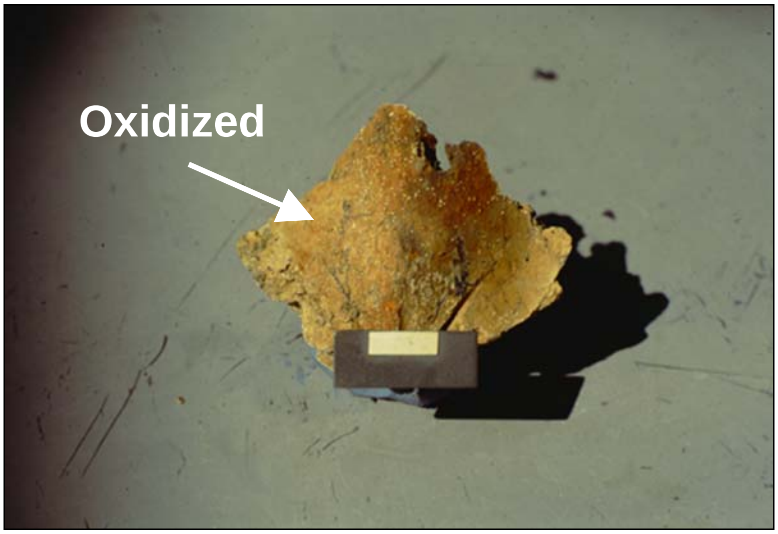

Figure 52. Soil in Figure 51 after exposure to the air and oxidation has occurred.

d. If the soil is saturated at the time of sampling, alpha, alpha-dipyridyl reagent can be used in the following procedure to determine if reduced (ferrous) iron is present. If ferrous iron is present as described below, then the soil is hydric.

Alpha, alpha-dipyridyl is a reagent that reacts with reduced iron. In some cases, it can be used to provide evidence that a soil is hydric when it lacks other hydric soil indicators. The soil is likely to be hydric if application of alpha, alpha-dipyridyl to mineral soil material in at least 60 percent of a layer at least 4 in. (10 cm) thick within a depth of 12 in. (30 cm) of the soil surface results in a positive reaction within 30 seconds evidenced by a pink or red coloration to the reagent during the growing season.

Using a dropper, apply a small amount of reagent to a freshly broken ped face to avoid any chance of a false positive test due to iron contamination from digging tools. Look closely at the treated soil for evidence of color change. If in doubt, apply the reagent to a sample of known upland soil and compare the reaction to the sample of interest. A positive reaction will not occur in soils that lack iron and may not occur in soils with high pH. The lack of a positive reaction to the reagent does not preclude the presence of a hydric soil. Specific information about the use of alpha, alpha-dipyridyl can be found in NRCS Hydric Soils Technical Note 8 (http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html).

e. Using gauge data, water-table monitoring data, or repeated direct hydrologic observations (see item 5a in the procedure for Problematic Hydrophytic Vegetation in this chapter), determine whether the soil is ponded or flooded, or the water table is 12 in. (30 cm) or less from the surface, for 14 or more consecutive days during the growing season in most years (at least 5 years in 10, or 50 percent or higher probability) (U.S. Army Corps of Engineers 2005). If so, then the soil is hydric. Furthermore, any soil that meets the NTCHS hydric soil technical standard (NRCS Hydric Soils Technical Note 11, http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html) is hydric.

Wetlands that periodically lack indicators of wetland hydrology

Description of the problem

Wetlands are areas that are flooded or ponded, or have soils that are saturated with water, for long periods during the growing season in most years. If the site is visited during a time of normal precipitation amounts and it is inundated or the water table is near the surface, then the wetland hydrology determination is straightforward. However, much of the Great Plains is characterized by long, hot summer dry seasons. During the dry season, surface water recedes from wetland margins, water tables drop, and many wetlands dry out completely. Superimposed on this seasonal cycle is a long-term pattern of multi-year droughts alternating with years of higher-than-average rainfall. Wetlands in general are inundated or saturated in most years (at least 5 years in 10, or 50 percent or higher probability) over a long-term record. However, some wetlands in the Great Plains do not become inundated or saturated in some years and, during drought cycles, may not inundate or saturate for several years in a row.

Wetland hydrology determinations are based on indicators, many of which were designed to be used during dry periods when the direct observation of surface water or a shallow water table is not possible. However, some wetlands may lack any of the listed hydrology indicators, particularly during the dry season or in a dry year. The evaluation of wetland hydrology requires special care on any site where indicators of hydrophytic vegetation and hydric soil are present but hydrology indicators appear to be absent. Among other factors, this evaluation should consider the timing of the site visit in relation to normal seasonal and annual hydrologic variability, and whether the amount of rainfall prior to the site visit has been normal. This section describes a number of approaches that can be used to

determine whether wetland hydrology is present on sites where indicators of hydrophytic vegetation and hydric soil are present but hydrology indicators may be lacking due to normal variations in rainfall or runoff, human activities that destroy hydrology indicators, and other factors.

Procedure

1. Verify that indicators of hydrophytic vegetation and hydric soil are present, or are absent due to disturbance or other problem situations. If so, proceed to step 2.

2. Verify that the site is in a landscape position that is likely to collect or concentrate water. Appropriate settings are listed below. If the landscape setting is appropriate, proceed to step 3.

    a. Concave surface (e.g., depression or swale)
    b. Floodplain
    c. Level or nearly level area (e.g., 0- to 3-percent slope)
    d. Toe slope (Figure 5) or an area of convergent slopes (Figure 4)
    e. Fringe of another wetland or water body
    f. Area with a restrictive soil layer or aquitard within 24 in. (60 cm) of the surface
    g. Area where groundwater discharges (e.g., a seep)
    h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)

3. Use one or more of the following approaches to determine whether wetland hydrology is present and the site is a wetland. In the remarks section of the data form or in the delineation report, explain the rationale for concluding that wetland hydrology is present even though indicators of wetland hydrology described in Chapter 4 were not observed.

    a. *Site visits during the dry season*. Determine whether the site visit occurred during the normal annual "dry season." The dry season, as used in this supplement, is the period of the year when soil moisture is normally being depleted and water tables are falling to low levels in response to decreased precipitation and/or increased evapotranspiration, usually during late spring and summer. It also includes the beginning of the recovery period in late summer or fall. The Web-Based Water-Budget Interactive Modeling Program (WebWIMP) is one source for approximate dates of wet and dry seasons for any

terrestrial location based on average monthly precipitation and estimated evapotranspiration (http://climate.geog.udel.edu/~wimp/). In general, the dry season in a typical year is indicated when potential evapotranspiration exceeds precipitation (indicated by negative values of DIFF in the WebWIMP output), resulting in drawdown of soil moisture storage (negative values of DST) and/or a moisture deficit (positive values of DEF, also called the unmet atmospheric demand for moisture). Actual dates for the dry season vary by locale and year.

In many wetlands, direct observation of flooding, ponding, or a shallow water table would be unexpected during the dry season. Wetland hydrology indicators, if present, would most likely be limited to indirect evidence, such as water marks, drift deposits, or surface cracks. In some situations, hydrology indicators may be absent during the dry season. If the site visit occurred during the dry season on a site that contains hydric soils and hydrophytic vegetation and no significant hydrologic manipulation (e.g., no dams, levees, water diversions, land grading, etc., and the site is not within the zone of influence of any drainage ditches or subsurface drains), then consider the site to be a wetland. If necessary, re-visit the site during the normal wet season and check again for the presence or absence of wetland hydrology indicators. If wetland hydrology indicators are absent during the wet portion of the growing season in a normal or wetter-than-normal rainfall year, the site is probably non-wetland.

b. *Periods with below-normal rainfall.* Determine whether the amount of rainfall that occurred in the 2 to 3 months preceding the site visit was normal, above normal, or below normal based on the normal range reported in WETS tables. WETS tables are provided by the NRCS National Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/wetlands.html) and are calculated from long-term (30-year) weather records gathered at National Weather Service meteorological stations. To determine whether precipitation was normal prior to the site visit, actual rainfall in the current month and previous 2 to 3 months should be compared with the normal ranges for each month given in the WETS table (USDA Natural Resources Conservation Service 1997, Sprecher and Warne 2000). The lower and upper limits of the normal range are indicated by the columns labeled “30% chance will have less than” and “30% chance will have more than” in the WETS table. The USDA Natural Resources Conservation Service (1997, Section

650.1903) also gives a procedure that can be used to weight the information from each month and determine whether the entire period was normal, wet, or dry.

When precipitation has been below normal, wetlands may not flood, pond, or develop shallow water tables even during the typical wet portion of the growing season and may not exhibit other indicators of wetland hydrology. Therefore, if precipitation was below normal prior to the site visit, and the site contains hydric soils and hydrophytic vegetation and no significant hydrologic manipulation (e.g., no dams, levees, water diversions, land grading, etc., and the site is not within the zone of influence of any drainage ditches or subsurface drains), it should be identified as a wetland. If necessary, the site can be re-visited during a period of normal rainfall and checked again for hydrology indicators.

c. *Drought years*. Determine whether the area has been subject to drought. Droughts lasting two to several years in a row are common in the Great Plains. Drought periods can be identified by comparing annual rainfall totals with the normal range of annual rainfall given in WETS tables or by examining trends in drought indices, such as the Palmer Drought Severity Index (PDSI) (Sprecher and Warne 2000). PDSI takes into account not only precipitation but also temperature, which affects evapotranspiration, and soil moisture conditions. The index is usually calculated on a monthly basis for major climatic divisions within each state. Therefore, the information is not site-specific. PDSI ranges generally between –6 and +6 with negative values indicating dry periods and positive values indicating wet periods. An index of –1.0 indicates mild drought, –2.0 indicates moderate drought, -3.0 indicates severe drought, and –4.0 indicates extreme drought. Time-series plots of PDSI values by month or year are available from the National Climatic Data Center (http://www.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgr.html#ds). If wetland hydrology indicators appear to be absent on a site that has hydrophytic vegetation and hydric soils, no significant hydrologic manipulation (e.g., no dams, levees, water diversions, land grading, etc., and the site is not within the zone of influence of any drainage ditches or subsurface drains), and the region has been affected by drought, then the area should be identified as a wetland.

d. *Reference sites*. If indicators of hydric soil and hydrophytic vegetation are present on a site that lacks wetland hydrology indicators, the site may be considered to be a wetland if the landscape setting, topography, soils, and vegetation are substantially the same as those on nearby wetland reference areas. Hydrology of wetland reference areas should be documented through long-term monitoring (see item g below) or by application of the procedure described in item 5a on page 108 (Direct Hydrologic Observations) of the procedure for Problematic Hydrophytic Vegetation in this chapter. Reference sites should be minimally disturbed and provide long-term access. Soils, vegetation, and hydrologic conditions should be thoroughly documented and the data kept on file in the District or field office.

e. *Hydrology tools*. The "Hydrology Tools" (USDA Natural Resources Conservation Service 1997) is a collection of methods that can be used to determine whether wetland hydrology is present on a potential wetland site that lacks indicators due to disturbance or other reasons, particularly on lands used for agriculture. Generally they require additional information, such as aerial photographs or stream-gauge data, or involve hydrologic modeling and approximation techniques. They should be used only when an indicator-based wetland hydrology determination is not possible or would give misleading results. A hydrologist may be needed to help select and carry out the proper analysis. The seven hydrology tools are used to:

(1) Analyze stream and lake gauge data
(2) Estimate runoff volumes to determine duration and frequency of ponding in depressional areas
(3) Evaluate the frequency of wetness signatures on aerial photography (see item f below for additional information)
(4) Model water-table fluctuations in fields with parallel drainage systems using the DRAINMOD model
(5) Estimate the "scope and effect" of ditches or subsurface drain lines
(6) Use NRCS state drainage guides to estimate the effectiveness of agricultural drainage systems
(7) Analyze data from groundwater monitoring wells (see item g below for additional information)

f. *Evaluating multiple years of aerial photography*. Each year, the Farm Service Agency (FSA) takes low-level aerial photographs in agricultural

areas to monitor the acreages planted in various crops for USDA programs. NRCS has developed an off-site procedure that uses these photos, or repeated aerial photography from other sources, to make wetland hydrology determinations (USDA Natural Resources Conservation Service 1997, Section 650.1903). The method is intended for use on agricultural lands where human activity has altered or destroyed other wetland indicators. However, the same approach may be useful in other environments.

The procedure uses five or more years of growing-season photography and evaluates each photo for wetness signatures that are listed in "wetland mapping conventions" developed by NRCS state offices. Wetland mapping conventions can be found in the electronic Field Office Technical Guide (eFOTG) for each state (http://www.nrcs.usda.gov/technical/efotg/). From the national web site, choose the appropriate state, then select any county (the state's wetland mapping conventions are the same in every county). Wetland mapping conventions are listed among the references in Section I of the eFOTG. However, not all states have wetland mapping conventions.

Wetness signatures for a particular state may include surface water, saturated soils, flooded or drowned-out crops, stressed crops due to wetness, differences in vegetation patterns due to different planting dates, inclusion of wet areas into set-aside programs, unharvested crops, isolated areas that are not farmed with the rest of the field, patches of greener vegetation during dry periods, and other evidence of wet conditions (see Part 513.30 of USDA Natural Resources Conservation Service 1994). For each photo, the procedure described in item b above is used to determine whether the amount of rainfall in the 2 to 3 months prior to the date of the photo was normal, below normal, or above normal. Only photos taken in normal rainfall years, or an equal number of wetter-than-normal and drier-than-normal years, are used in the analysis. If wetness signatures are observed on photos in more than half of the years included in the analysis, then wetland hydrology is present. Data forms that may be used to document the wetland hydrology determination are given in section 650.1903 of USDA Natural Resources Conservation Service (1997).

g. *Long-term hydrologic monitoring*. On sites where the hydrology has been manipulated by man (e.g., with ditches, dams, levees, water

diversions, land grading) or where natural events (e.g., downcutting of streams) have altered conditions such that hydrology indicators may be missing or misleading, direct monitoring of surface and groundwater may be needed to determine the presence or absence of wetland hydrology. The U.S. Army Corps of Engineers (2005) provides minimum standards for the design, construction, and installation of water-table monitoring wells, and for the collection and interpretation of groundwater monitoring data, in cases where direct hydrologic measurements are needed to determine whether wetlands are present on highly disturbed or problematic sites. This standard calls for 14 or more consecutive days of flooding, ponding, or a water table 12 in. (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability), unless a different standard has been established for a particular geographic area or wetland type. A disturbed or problematic site that meets this standard has wetland hydrology. This standard is not intended (1) to overrule an indicator-based wetland determination on a site that is not disturbed or problematic, or (2) to test or validate existing or proposed wetland indicators.

Wetland/non-wetland mosaics

Description of the problem

In this supplement, "mosaic" refers to a landscape where wetland and non-wetland components are too closely associated to be easily delineated or mapped separately. These areas often have complex microtopography, with repeated small changes in elevation occurring over short distances. Tops of ridges and hummocks are often non-wetland but are interspersed throughout a wetland matrix having clearly hydrophytic vegetation, hydric soils, and wetland hydrology. Examples of wetland/non-wetland mosaics in the Great Plains Region include many areas of gilgai microtopography on clay soils (e.g., Vertisols), ridge-and-swale topography in floodplains, areas where wind-thrown trees have created mound-and-pit topography, and complex spatial arrangements of deposition and scour in some floodplain areas.

Wetland components of a mosaic are often not difficult to identify. The problem for the wetland delineator is that microtopographic features are too small and intermingled, and there are too many such features per acre, to delineate and map them accurately. Instead, the following sampling

approach can be used to estimate the percentage of wetland in the mosaic. From this, the number of acres of wetland on the site can be calculated, if needed.

Procedure

First, identify and flag all contiguous areas of either wetland or non-wetland on the site that are large enough to be delineated and mapped separately. The remaining area should be mapped as "wetland/non-wetland mosaic" and the approximate percentage of wetland within the area determined by the following procedure.

1. Establish one or more continuous line transects across the mosaic area, as needed. Measure the total length of each transect. A convenient method is to stretch a measuring tape along the transect and leave it in place while sampling. If the site is shaped appropriately and multiple transects are used, they should be arranged in parallel with each transect starting from a random point along one edge of the site. However, other arrangements of transects may be needed for oddly shaped sites.

2. Use separate data forms for the swale or trough and for the ridges or hummocks. Sampling of vegetation, soil, and hydrology should follow the general procedures described in the Corps Manual and this supplement. Plot sizes and shapes for vegetation sampling must be adjusted to fit the microtopographic features on the site. Plots intended to sample the troughs should not overlap adjacent hummocks, and vice versa. Only one or two data forms are required for each microtopographic position, and do not need to be repeated for similar features or plant communities.

3. Identify every wetland boundary in every trough or swale encountered along each transect. Each boundary location may be marked with a pin flag or simply recorded as a distance along the stretched tape.

4. Determine the total distance along each transect that is occupied by wetland and non-wetland until the entire length of the line has been accounted for. Sum these distances across transects, if needed. Determine the percentage of wetland in the wetland/non-wetland mosaic by the following formula.

$$\%\ wetland = \frac{Total\ wetland\ distance\ along\ all\ transects}{Total\ length\ of\ all\ transects} \times 100$$

An alternative approach involves point-intercept sampling at fixed intervals along transects across the area designated as wetland/non-wetland mosaic. This method avoids the need to identify wetland boundaries in each swale, and can be carried out by pacing rather than stretching a measuring tape across the site. The investigator uses a compass or other means to follow the selected transect line. At a fixed number of paces (e.g., every two steps) the wetland status of that point is determined by observing indicators of hydrophytic vegetation, hydric soil, and wetland hydrology. Again, a completed data form is not required at every point but at least one representative swale and hummock should be documented with completed forms. After all transects have been sampled, the result is a number of wetland sampling points and a number of non-wetland points. Estimate the percentage of wetland in the wetland/non-wetland mosaic with the following formula:

$$\%\ wetland = \frac{Number\ of\ wetland\ points\ along\ all\ transects}{Total\ number\ of\ points\ sampled\ along\ all\ transects} \times 100$$

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Appendix A: Glossary

This glossary is intended to supplement those given in the Corps Manual and other available sources. See the following publications for terms not listed here:

- Corps Manual (Environmental Laboratory 1987) (http://el.erdc.usace.army.mil/wetlands/pdfs/wlman87.pdf).
- Field Indicators of Hydric Soils in the United States (USDA Natural Resources Conservation Service 2006b) (http://soils.usda.gov/use/hydric/).
- National Soil Survey Handbook, Part 629 (USDA Natural Resources Conservation Service 2005) (ftp://ftp-fc.sc.egov.usda.gov/NSSC/Soil_Survey_Handbook/629_glossary.pdf).

Absolute cover. In vegetation sampling, the percentage of the ground surface that is covered by the aerial portions (leaves and stems) of a plant species when viewed from above. Due to overlapping plant canopies, the sum of absolute cover values for all species in a community or stratum may exceed 100 percent. In contrast, "relative cover" is the absolute cover of a species divided by the total coverage of all species in that stratum, expressed as a percent. Relative cover cannot be used to calculate the prevalence index.

Aquitard. A layer of soil or rock that retards the downward flow of water and is capable of perching water above it. For the purposes of this supplement, the term aquitard also includes the term aquiclude, which is a soil or rock layer that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients.

Contrast. The color difference between a redox concentration and the dominant matrix color. Differences are classified as faint, distinct, or prominent and are defined in the glossary of USDA Natural Resources Conservation Service (2006b) and illustrated in Table A1.

Table A1. Tabular key for contrast determinations using Munsell notation.

Hues are the same (Δ h = 0)			Hues differ by 2 pages (Δ h = 2)		
Δ Value	Δ Chroma	Contrast	Δ Value	Δ Chroma	Contrast
0	≤1	Faint	0	0	Faint
0	2	Distinct	0	1	Distinct
0	3	Distinct	0	≥2	Prominent
0	≥4	Prominent	1	≤1	Distinct
1	≤1	Faint	1	≥2	Prominent
1	2	Distinct	≥2	---	Prominent
1	3	Distinct			
1	≥4	Prominent			
≤2	≤1	Faint			
≤2	2	Distinct			
≤2	3	Distinct			
≤2	≥4	Prominent			
3	≤1	Distinct			
3	2	Distinct			
3	3	Distinct			
3	≥4	Prominent			
≥4	---	Prominent			
Hues differ by 1 page (Δ h = 1)			**Hues differ by 3 or more pages (Δ h ≥ 3)**		
Δ Value	Δ Chroma	Contrast	Δ Value	Δ Chroma	Contrast
0	≤1	Faint	Color contrast is prominent, except for low chroma and value.		Prominent
0	2	Distinct			
0	≥3	Prominent			
1	≤1	Faint			
1	2	Distinct			
1	≥3	Prominent			
2	≤1	Distinct			
2	2	Distinct			
2	≥3	Prominent			
≥3	---	Prominent			

Note: If both colors have values of ≤3 and chromas of ≤2, the color contrast is Faint (regardless of the difference in hue).

Adapted from USDA Natural Resources Conservation Service (2002)

Depleted matrix. The volume of a soil horizon or subhorizon from which iron has been removed or transformed by processes of reduction and translocation to create colors of low chroma and high value. A, E, and calcic horizons may have low chromas and high values and may therefore be mistaken for a depleted matrix. However, they are excluded from the concept of depleted matrix unless common or many, distinct or prominent redox concentrations as soft masses or pore linings are present. In some places the depleted matrix may change color upon exposure to air (reduced matrix); this phenomenon is included in the concept of depleted matrix. The following combinations of value and chroma identify a depleted matrix:

- Matrix value of 5 or more and chroma of 1, with or without redox concentrations occurring as soft masses and/or pore linings, or
- Matrix value of 6 or more and chroma of 2 or 1, with or without redox concentrations occurring as soft masses and/or pore linings, or
- Matrix value of 4 or 5 and chroma of 2, with 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings, or
- Matrix value of 4 and chroma of 1, with 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings (USDA Natural Resources Conservation Service 2006b).

Common (2 to less than 20 percent) to many (20 percent or more) redox concentrations (USDA Natural Resources Conservation Service 2002) are required in soils with matrix colors of 4/1, 4/2, and 5/2 (Figure A1). Redox concentrations include iron and manganese masses and pore linings (Vepraskas 1992). See “contrast” in this glossary for the definitions of “distinct” and “prominent.”

Diapause. A period during which growth or development is suspended and physiological activity is diminished, as in certain aquatic invertebrates in response to drying of temporary wetlands.

Figure A1. Illustration of values and chromas 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 Charts reprinted courtesy of Munsell Color Services Lab, a part of X-Rite, Inc.

Distinct. See Contrast.

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

Fragmental soil material. Soil material that consists of 90 percent or more rock fragments; less than 10 percent of the soil consists of particles 2 mm or smaller (USDA Natural Resources Conservation Service 2006b).

Gilgai. Microtopography that is produced by the expansion and contraction of certain clay soils upon repeated wetting and drying.

Gleyed matrix. A gleyed matrix has one of the following combinations of hue, value, and chroma and the soil is not glauconitic (Figure A2):

- 10Y, 5GY, 10GY, 10G, 5BG, 10BG, 5B, 10B, or 5PB with value of 4 or more and chroma of 1; or
- 5G with value of 4 or more and chroma of 1 or 2; or
- N with value of 4 or more (USDA Natural Resources Conservation Service 2006b).

Growing season. In the Great Plains Region, growing season dates are determined through onsite observations of the following indicators of biological activity in a given year: (1) above-ground growth and development of vascular plants, and/or (2) soil temperature (see Chapter 4 for details). If onsite data gathering is not practical, growing season dates may be approximated by using WETS tables available from the NRCS National Water and Climate Center to determine the median dates of 28 °F (−2.2 °C) air temperatures in spring and fall based on long-term records gathered at the nearest appropriate National Weather Service meteorological station.

Halophyte. A plant adapted to saline or alkaline soils.

High pH. pH of 7.9 or higher. Includes Moderately Alkaline, Strongly Alkaline, and Very Strongly Alkaline (USDA Natural Resources Conservation Service 2002).

Figure A2. For hydric soil determinations, a gleyed matrix has the hues and chroma identified in this illustration with a value of 4 or more. *Due to inaccurate color reproduction, do not use this page to determine soil colors in the field.* Background image from the Munsell Soil Color Charts reprinted courtesy of Munsell Color Services Lab, a part of X-Rite, Inc.

Nodules and concretions. Irregularly shaped, firm to extremely firm accumulations of iron and manganese oxides. When broken open, nodules have uniform internal structure whereas concretions have concentric layers (Vepraskas 1992).

Phreatophyte. A deep-rooted plant that obtains water from the water table or permanent groundwater source.

Prominent. See Contrast.

Reduced matrix. Soil matrix that has a low chroma in situ due to presence of reduced iron, but whose color changes in hue or chroma when exposed to air as Fe^{2+} is oxidized to Fe^{3+} (Vepraskas 1992).

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

Throughflow. Lateral movement of groundwater in saturated substrates, such as on sloping terrain.

Appendix B: Point-Intercept Sampling Procedure for Determining Hydrophytic Vegetation

The following procedure for point-intercept sampling is an alternative to plot-based sampling methods to estimate the abundance of plant species in a community. The approach may be used with the approval of the appropriate Corps of Engineers District to evaluate vegetation as part of a wetland delineation. Advantages of point-intercept sampling include better quantification of plant species abundance and reduced bias compared with visual estimates of cover. The method is useful in communities with high species diversity, and in areas where vegetation is patchy or heterogeneous, making it difficult to identify representative locations for plot sampling. Disadvantages include the increased time required for sampling and the need for vegetation units large enough to permit the establishment of one or more transect lines within them. The approach also assumes that soil and hydrologic conditions are uniform across the area where transects are located. In particular, transects should not cross the wetland boundary. Point-intercept sampling is generally used with a transect-based prevalence index (see below) to determine whether vegetation is hydrophytic.

In point-intercept sampling, plant occurrence is determined at points located at fixed intervals along one or more transects established in random locations within the plant community or vegetation unit. If a transect is being used to sample the vegetation near a wetland boundary, the transect should be placed parallel to the boundary and should not cross either the wetland boundary or into other communities. Usually a measuring tape is laid on the ground and used for the transect line. Transect length depends upon the size and complexity of the plant community and may range from 100 to 300 ft (30 to 90 m) or more. Plant occurrence data are collected at fixed intervals along the line, for example every 2 ft (0.6 m). At each interval, a “hit” on a species is recorded if a vertical line at that point would intercept the stem or foliage of that species. Only one “hit” is recorded for a species at a point even if the same species would be intercepted more than once at that point. Vertical intercepts can be determined using a long pin or rod protruding into and

through the various vegetation layers, a sighting device (e.g., for the canopy), or an imaginary vertical line. The total number of "hits" for each species along the transect is then determined. The result is a list of species and their frequencies of occurrence along the line (Mueller-Dombois and Ellenberg 1974; Tiner 1999). Species are then categorized by wetland indicator status (i.e., OBL, FACW, FAC, FACU, or UPL), the total number of hits determined within each category, and the data used to calculate a transect-based prevalence index. The formula is similar to that given in Chapter 2 for the plot-based prevalence index (see Indicator 3), except that frequencies are used in place of cover estimates. The community is hydrophytic if the prevalence index is 3.0 or less. To be valid, more than 80 percent of "hits" on the transect must be of species that have been identified correctly and placed in an indicator category.

The transect-based prevalence index is calculated using the following formula:

$$PI = \frac{F_{OBL} + 2F_{FACW} + 3F_{FAC} + 4F_{FACU} + 5F_{UPL}}{F_{OBL} + F_{FACW} + F_{FAC} + F_{FACU} + F_{UPL}}$$

where:

PI = Prevalence index
F_{OBL} = Frequency of obligate (OBL) plant species;
F_{FACW} = Frequency of facultative wetland (FACW) plant species;
F_{FAC} = Frequency of facultative (FAC) plant species;
F_{FACU} = Frequency of facultative upland (FACU) plant species;
F_{UPL} = Frequency of upland (UPL) plant species.

Appendix C: Data Form

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: ____________ City/County: ____________ Sampling Date: ________

Applicant/Owner: ____________ State: ______ Sampling Point: ________

Investigator(s): ____________ Section, Township, Range: ____________

Landform (hillslope, terrace, etc.): ____________ Local relief (concave, convex, none): ________ Slope (%): ____

Subregion (LRR): ____________ Lat: ________ Long: ________ Datum: ______

Soil Map Unit Name: ____________ NWI 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? Are "Normal Circumstances" present? Yes ____ No ____

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

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

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

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	____ = Total Cover		
Sapling/Shrub Stratum (Plot size: ____)			
1.			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: ____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	____ = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
	____ = Total Cover		
% Bare Ground in Herb Stratum ____			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): ________ (A)

Total Number of Dominant Species Across All Strata: ________ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ________ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
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 = ________

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ____ No ____

Remarks:

SOIL

Sampling Point: ____________

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

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

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______________________________

Depth (inches): ______________________

Hydric Soil Present? Yes ______ No ______

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

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

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes _____ No _____ Depth (inches): ____________

Water Table Present? Yes _____ No _____ Depth (inches): ____________

Saturation Present? (includes capillary fringe) Yes _____ No _____ Depth (inches): ____________

Wetland Hydrology Present? Yes ______ No ______

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

Remarks:

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14. ABSTRACT

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual, which provides technical guidance and procedures for identifying and delineating wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act. The development of Regional Supplements is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. This supplement is applicable to the Great Plains Region, which consists of all or portions of 11 states: Colorado, Kansas, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming.

15. SUBJECT TERMS

Delineation	Plant communities	Vegetation
Hydrology	Soil	Wetlands

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