ERDC/EL TR-06-4

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Final report

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

ABSTRACT:
This Regional Guidebook characterizes the wetlands in the Upper Des Plaines River Basin using the hydrogeomorphic (HGM) approach. The HGM approach is a collection of concepts and methods used to develop functional indices to assess the capacity of a particular wetland to perform functions relative to similar wetlands in a region. Specifically, this report describes the rationale that was used to select functions for two subclasses of herbaceous freshwater depressions, the Isolated Depression subclass and the Floodplain Depression subclass. The report also describes the process used to select model variables and metrics and to develop assessment models. Data from reference wetlands are provided and used to calibrate model variables and assessment models. Protocols for applying functional indices to the assessment of wetland functions are provided.

Contents

List of Figures

List of Tables

Preface

This report was prepared by Jeff P. Lin, EL, Wetlands and Coastal Ecology Branch. The author wishes to acknowledge the efforts of the following people, without whom this document would not have been possible: Kate Bliss, Jaimee Hammit, Jean Sellar, Kim Fisher, Greg Moore, Mike Machalek, all from USACE Chicago District, Kristen Schultheis, Norris & Associates, John Tandarich, Hey & Associates, and Joe Hmieleski, Lake County Stormwater Management Commission, all assisted with the collection of field data. Jim Anderson, Lake County Forest Service, assisted greatly with the identification of reference sites in Lake County, IL. J.D. Ennis, Chicago District, readily provided many of the necessary GIS layers and aerial photography. Jim Anderson, Joe Hmieleksi, Jean Sellar, Barb Kleiss, EL, Jeff Mengler, U.S. Fish and Wildlife Service, Mike Miller, Illinois State Geological Survey, and Dave Brandt, USDA, all contributed to the creation and conceptual development of these models. Chris Noble, EL, and Tom Roberts, Tennessee Tech University, provided review of the initial draft of the Guidebook. Additional review was also provided by Tom Slawski, Southeastern Wisconsin Regional Planning Commission, Jim Anderson, Joe Hmieleski, and Jeff Mengler.

This report was completed under funding from the USACE Chicago District. This work took place under the general supervision of Dr. Morris Mauney, Jr., Chief, Wetlands and Coastal Ecology Branch; Dr. David J. Tazik, Chief, Ecosystem Evaluation and Engineering Division; and Dr. Edwin A. Theriot, Director, EL.

COL James R. Rowan was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

1 Introduction

Background

The Hydrogeomorphic (HGM) Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. The approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review sequence to consider alternatives, minimize impacts, assess unavoidable project impacts, determine mitigation requirements, and monitor the success of mitigation projects. However, a variety of other potential applications for the approach have been identified, including determining minimal effects under the Food Security Act, designing mitigation project impacts, and managing wetlands.

On 16 August 1996, a National Action Plan to Implement the Hydrogeomorphic Approach (NAP) was published *(Federal Register* 1997). The NAP was developed cooperatively by a National Interagency Implementation Team consisting of the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (USEPA), National Resources Conservation Service (NRCS), Federal Highways Administration (FHWA), and U.S. Fish and Wildlife Service (USFWS). Publication of the NAP was designed to outline a strategy and promote the development of Regional Guidebooks for assessing the functions of regional wetland subclasses using the HGM Approach; to solicit the cooperation and participation of Federal, state, and local agencies, academia, and the private sector in this effort; and to update the status of Regional Guidebook development.

The sequence of tasks necessary to develop a Regional Guidebook outlined in the NAP was used to develop this Regional Guidebook (see the section, "Development Phase"). An initial workshop was held in Libertyville, IL, in January 2003. The workshop was attended by hydrologists, geologists, soil scientists, wildlife biologists, and plant ecologists primarily from local, state, and federal government agencies with extensive knowledge of local wetland ecosystem. Based on the results of the workshop, two regional wetland subclasses were defined and characterized, a reference domain was defined, wetland functions were selected, model variables were identified, and conceptual assessment models were developed. Subsequently, field and GIS based work was conducted to collect data from reference wetlands. Field data were collected during July and

August, 2003. Data from 64 reference sites (Appendix B) were then used to revise and calibrate the conceptual assessment models.

Objectives

The objectives of this Regional Guidebook are to (a) characterize the wetlands in the Upper Des Plaines River Basin, (b) provide the rationale used to select functions for the Isolated Depression and Floodplain Depression Subclasses, (c) provide the rationale used to select model variables and metrics, (d) provide the rationale used to develop assessment models, (e) provide data from reference wetlands and document their use in calibrating model variables and assessment models, and (f) outline the necessary protocols for applying the functional indices to the assessment of wetland functions.

Scope

This guidebook is organized in the following manner. Chapter 1 provides the background, objectives, and organization of the guidebook. Chapter 2 provides a brief overview of the major components of the HGM Approach and the development and application phases required to implement the approach. Chapter 3 characterizes the wetlands in the Upper Des Plaines River Basin in terms of geographical extent, climate, geomorphic setting, hydrology, vegetation, soils, and other factors that influence wetland function. Chapter 4 discusses each of the wetland functions, model variables, and function indices. This discussion includes a definition of the function; a quantitative, independent measure of the function for validation; a description of the wetland ecosystem and landscape characteristics that influence the function; a definition and description of model variables used to represent these characteristics in the assessment model; a discussion of the assessment model used to derive the functional index; and an explanation of the rationale used to calibrate the index with reference wetland data. Chapter 5 outlines the steps of the assessment protocol for identifying and conducting a functional assessment of Isolated Depression and Floodplain Depression Wetlands in the Upper Des Plaines River Basin, and includes field and GIS data forms. Appendix A presents a Glossary. Appendix B contains the data collected at reference sites. Appendix C explains the use of Functional Capacity Units. Appendix D summarizes the functions, assessment models, and variables used in the models.

While it is possible to assess the functions of Depressional Wetlands in the Upper Des Plaines River Basin using only the information contained in Chapters 4 and 5, it is suggested that potential users familiarize themselves with the information in Chapters 2 and 3 prior to conducting an assessment.

2 Overview of the Hydrogeomorphic Approach

As indicated in Chapter 1, the HGM Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. The HGM Approach includes four integral components: (a) the HGM classification, (b) reference wetlands, (c) assessment models/functional indices, and (d) assessment protocols. During the development phase of the HGM Approach, these four components are integrated in a Regional Guidebook for assessing the functions of a regional wetland subclass. Subsequently, during the application phase, end users, following the assessment protocols outlined in the Regional Guidebook, assess the functional capacity of selected wetlands. Each of the components of the HGM Approach and the development and application phases are discussed in this chapter. More extensive discussions can be found in Brinson (1993, 1995a,b); Brinson et al. (1995, 1996, 1998); Hauer and Smith (1998); Smith (2001); Smith and Wakeley (2001); Smith et al. (1995); and Wakeley and Smith (2001).

Hydrogeomorphic Classification

Wetland ecosystems share a number of features, including relatively long periods of inundation or saturation, hydrophytic vegetation, and hydric soils. In spite of these common attributes, wetlands occur under a wide range of climatic, geologic, and physiographic situations and exhibit a wide variety of physical, chemical, and biological characteristics and processes (Cowardin et al. 1979; Ferren et al. 1996a,b,c; Mitsch and Gosselink 2000; Semeniuk 1987). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relative short time available for conducting assessments). Existing "generic" methods designed to assess multiple wetland types throughout the United States are relatively rapid, but lack the resolution necessary to detect significant changes in function. However, one way to achieve an appropriate level of resolution within the available time frame is to reduce the level of variability exhibited by the wetlands being considered (Smith et al. 1995).

The HGM Classification was developed specifically to accomplish this task (Brinson 1993). It identifies groups of wetlands that function similarly using three criteria that fundamentally influence how wetlands function: geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the landform and position of the wetland in the landscape. Water source refers to the primary water source in the wetland, such as precipitation, overbank floodwater, or groundwater. Hydrodynamics refers to the level of energy and the direction that water moves in the wetland. Based on these three classification criteria, any number of “functional” wetland groups can be identified at different spatial or temporal scales. For example, at a continental scale, Brinson (1993) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al. 1995). In many cases, the level of variability in wetlands encompassed by a continental scale hydrogeomorphic class is still too great to allow development of assessment models that can be rapidly applied while being sensitive enough to detect changes in function at a level of resolution appropriate to the 404 review process. For example, at a continental geographic scale the depression class includes wetland ecosystems in different regions as diverse as vernal pools in California (Zedler 1987), prairie potholes in North and South Dakota (Hubbard 1988, Kantrud et al. 1989), playa lakes in the high plains of Texas (Bolen et al. 1989), kettles in New England, and cypress domes in Florida (Ewel 1984, Kurz and Wagner 1953).

To reduce both inter- and intraregional variability, the three classification criteria are applied at a smaller, regional geographic scale to identify regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (Ferren et al. 1996a,b,c; Golet and Larson 1974; Stewart and Kantrud 1971; Wharton et al. 1982). Regional subclasses, like the continental classes, are distinguished on the basis of geomorphic setting, water source, and hydrodynamics. In addition, certain ecosystem or landscape characteristics may also be useful for distinguishing regional subclasses in certain regions. For example, depressional subclasses might be based on water source (i.e., groundwater versus surface water), or the degree of connection between the wetland and other surface waters (i.e., the flow of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo 1998). Slope subclasses might be based on the degree of slope, landscape position, the source of water (i.e., throughflow versus groundwater), or other factors. Riverine subclasses might be based on water source, position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Examples of potential regional subclasses are shown in Table 2, Smith et al. (1995), and Rheinhardt et al. (1997).

Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of its geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process.

Table 1
Hydrogeomorphic Wetland Classes at the Continental Scale

HGM Wetland Class	Definition
Depression	Depression wetlands occur in topographic depressions (i.e., elevation contours) that allow the accumulation of surface water. Depression wetlands may have any combination of inlets and outlets or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that range from diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, vernal pools, and cypress domes are common examples of depressional wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal current diminishes and riverflow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bidirectional flows from tides dominate over unidirectional flows controlled by floodplain slope of riverine wetlands. Because tidal fringe wetlands frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope uplands. Surface water flow is bidirectional, usually controlled by water-level fluctuations resulting from wind or seiche. Lacustrine wetlands lose water by flow returning to the lake after flooding and evaporation. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or sites with saturated overflow with no channel formation. They normally occur on sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depressional wetlands by the lack of a topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands.
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become organic soil flats. They typically occur in relatively humid climates. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.
Organic Soil Flats	Organic soil flats, or extensive peatlands, differ from mineral soil flats in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of the convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peatlands are examples of organic soil flat wetlands.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flats, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evaporation. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwoods on floodplains are an example of riverine wetlands.

Table 2
Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source, and Hydrodynamics

Geomorphic Setting Source	Dominant Water	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie potholes, marshes, Carolina bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (organic soil)	Precipitation	Vertical	Peat bogs, portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forest	Riparian wetlands

Reference Wetlands

Reference wetlands are wetland sites selected to represent the range of variability that occurs in a regional wetland subclass as a result of natural processes and disturbance (e.g., succession, channel migration, fire, erosion, and sedimentation) as well as cultural alteration. The reference domain is the geographic area occupied by the reference wetlands (Smith et al. 1995). Ideally, the geographic extent of the reference domain will mirror the geographic area encompassed by the regional wetland subclass; however, this is not always possible because of time and resource constraints.

Reference wetlands serve several purposes. First, they establish a basis for defining what constitutes a characteristic and sustainable level of function across the suite of functions selected for a regional wetland subclass. Second, they establish the range and variability of conditions exhibited by model variables and provide the data necessary for calibrating model variables and assessment models. Finally, they provide a concrete physical representation of wetland ecosystems that can be observed and measured.

Reference standard wetlands are the subset of reference wetlands that perform the suite of functions selected for the regional subclass at a level that is characteristic in the least altered wetland sites in the least altered landscapes. Table 3 outlines the terms used by the HGM Approach in the context of reference wetlands.

Table 3 Reference Wetland Terms and Definitions	
Term	**Definition**
Reference domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected (Smith et al. 1995).
Reference wetlands	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and disturbance and from human alterations.
Reference standard wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that is both sustainable and characteristic of the least human altered wetland sites in the least human altered landscapes. By definition, the functional capacity index for all functions in reference standard wetlands is assigned a 1.0.
Reference standard wetland variable condition	The range of conditions exhibited by model variables in reference standard wetlands. By definition, reference standard conditions receive a variable subindex score of 1.0.
Site potential (mitigation project context)	The highest level of function possible, given local constraints of disturbance history, land use, or other factors. Site potential may be less than or equal to the levels of function in reference standard wetlands of the regional wetland subclass.
Project target (mitigation project context)	The level of function identified or negotiated for a restoration or creation project.
Project standards (mitigation context)	Performance criteria and/or specifications used to guide the restoration or creation activities toward the project target. Project standards should specify reasonable contingency measures if the project is not being achieved.

Assessment Models and Functional Indices

In the HGM Approach, an assessment model is a simple representation of a function performed by a wetland ecosystem. It defines the relationship between one or more characteristics or processes of the wetland ecosystem. Functional capacity is simply the ability of a wetland to perform a function compared to the level of performance in reference standard wetlands.

Model variables represent the characteristics of the wetland ecosystem and surrounding landscape that influence the capacity of a wetland ecosystem to perform a function. Model variables are ecological quantities that consist of five components (Schneider 1994): (a) a name, (b) a symbol, (c) a measure of the variable and procedural statements for quantifying or qualifying the measure directly or calculating it from other measures, (d) a set of variables (i.e., numbers, categories, or numerical estimates (Leibowitz and Hyman 1997)) that are generated by applying the procedural statement, and (e) units on the appropriate measurement scale. Table 4 provides several examples.

Table 4
Components of a Model Variable

Name (Symbol)	Measure / Procedural Statement	Resulting Values	Units (Scale)
Substrate Disturbance *($V_{DISTURB}$)*	The alteration of the soils by activities such as addition of fill material, soil oxidation, rock plowing, or removal of sediment.	present absent	unitless (nominal scale)
Presence of Ditches *(V_{DITCH})*	The presence of ditches within a certain distance of the wetland	1.0 0.8 0.3	unitless (interval scale)
Cover of Woody Vegetation *(V_{WOODY})*	The average percent aerial cover of leaves and stems of shrubs and trees (> 1 m).	0 to >100	percent

Model variables occur in a variety of states or conditions in reference wetlands. The state or condition of the variable is denoted by the value of the measure of the variable. For example, percent herbaceous groundcover, the measure of the percent cover of herbaceous vegetation, could be large or small. Based on its condition (i.e., value of the metric), model variables are assigned a variable subindex. When the condition of a variable is within the range of conditions exhibited by reference standard wetlands, a variable subindex of 1.0 is assigned. As the condition deflects from the reference standard condition (i.e., the range of conditions within which the variable occurs in reference standard wetlands), the variable subindex is assigned based on the defined relationship between model variable condition and functional capacity. As the condition of a variable deviates from the conditions exhibited in reference standard wetlands, it receives a progressively lower subindex, reflecting its decreasing contribution to functional capacity. In some cases, the variable subindex drops to zero. For example, when the percent cover of herbaceous groundcover is 40 percent or greater, the subindex for percent herbaceous groundcover is 1.0. As the percent cover falls below 40 percent, the variable subindex score decreases on a linear scale to zero.

Model variables are combined in an assessment model to produce a Functional Capacity Index (FCI) that ranges from 0.0 to 1.0. The FCI is a measure of the functional capacity of a wetland relative to reference standard wetlands in the reference domain. Wetlands with an FCI of 1.0 perform the function at a level characteristic of reference standard wetlands. As the FCI decreases, it indicates that the capacity of the wetland to perform the function is less than that of reference standard wetlands.

Assessment protocol

The final component of the HGM Approach is the assessment protocol. The assessment protocol is a series of tasks, along with specific instructions, that allow the end user to assess the functions of a particular wetland area using the functional indices in the Regional Guidebook. The first task is characterization, which involves describing the wetland ecosystem and the surrounding landscape, describing the proposed project and its potential impacts, and identifying the wetland areas to be assessed. The second task is collecting the data for model variables. The final task is analysis, which involves calculation of functional indices.

Development phase

The Development Phase of the HGM Approach is ideally carried out by an interdisciplinary team of experts known as the “Assessment Team,” or “A-Team.” The product of the Development Phase is a Regional Guidebook for assessing the functions of a specific regional wetland subclass (Figure 1). In developing a Regional Guidebook, the A-Team will complete the following major tasks. After organization and training, the first task of the A-Team is to classify the wetlands within the region of interest into regional wetland subclasses using the principles and criteria of the HGM Classification (Brinson 1993; Smith et al. 1995). Next, focusing on the specific regional wetland subclasses selected, the A-Team develops an ecological characterization or functional profile of the subclass. The A-Team then identifies the important wetland functions, conceptualizes assessment models, identifies model variables to represent the characteristics and processes that influence each function, and defines metrics for quantifying model variables. Next, reference wetlands are identified to represent the range of variability exhibited by the regional subclass. Field data are then collected from the reference wetlands and used to calibrate model variables and verify the conceptual assessment models. Finally, the A-Team develops the assessment protocols necessary for regulators, managers, consultants, and other end users to apply the indices to the assessment of wetland functions. The following list provides the detailed steps involved in this general sequence:

Task 1: Organize the A-Team.

A. Identify A-Team members.
B. Train A-Team in the HGM approach.

Task 2: Select and Characterize Regional Wetland Subclasses.

A. Identify/prioritize wetland subclasses.
B. Select regional wetland subclasses and define reference domain.
C. Initiate literature review.
D. Develop preliminary characterization of regional wetland subclasses.

Task 3: Select Model Variables and Metrics and Construct Conceptual Assessment Models.

A. Review existing assessment models.
B. Identify model variables and metrics.
C. Define initial relationship between model variables and functional capacity.
D. Construct conceptual assessment models for deriving FCIs.
E. Complete Precalibrated Draft Regional Guidebook (PDRG).

Task 4: Conduct Peer Review of PDRG.

A. Distribute PDRG to peer reviewers.
B. Conduct interdisciplinary, interagency workshop of PDRG.
C. Revise PDRG to reflect peer review recommendations.

D. Distribute revised PDRG to peer reviewers for comment.
E. Incorporate final comments from peer reviewers on revisions into PDRG.

Task 5: Identify and Collect Data from Reference Wetlands.
A. Identify reference wetland field sites.
B. Collect data from reference wetland field sites.
C. Analyze reference wetland data.

Task 6: Calibrate and Field Test Assessment Models.
A. Calibrate model variables using reference wetland data.
B. Verify and validate (optional) assessment models.
C. Field test assessment models for repeatability and accuracy.
D. Revise PDRG based on calibration, verification, validation (optional), and field testing results into a Calibrated Draft Regional Guidebook (CDRG).

Task 7: Conduct Peer Review and Field Test of CDRG.
A. Distribute CDRG to peer reviewers.
B. Field test CDRG.
C. Revise CDRG to reflect peer review and field test recommendations.
D. Distribute CDRG to peer reviewers for final comment on revisions.
E. Incorporate peer reviewers' final comments on revisions.
F. Publish Operational Draft Regional Guidebook (ODRG).

Task 8: Technology Transfer.
A. Train end users in the use of the ODRG.
B. Provide continuing technical assistance to end users of the ODRG.

Application phase

The Application Phase involves two steps. The first is using the assessment protocols outlined in the Regional Guidebook to carry out the following tasks (Figure 1).

a. Define assessment objectives.

b. Characterize the project site.

c. Screen for red flags.

d. Define the Wetland Assessment Area.

e. Collect field data.

f. Analyze field data.

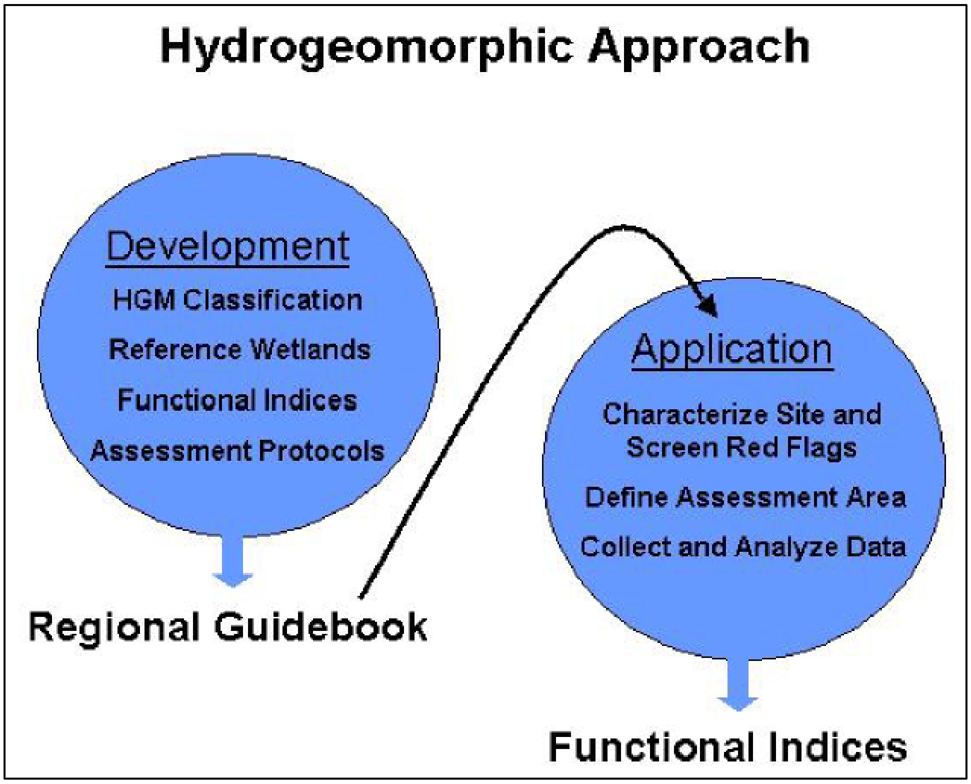

Figure 1. Development and application phases of the HGM Approach

The second step involves applying the results of the assessment, the FCI, to the appropriate decision-making process. Although the HGM approach was originally conceived for use in a regulatory context as part of Section 404 of the Clean Water Act, it has a variety of other potential applications as well. For instance, The HGM assessment model for the Upper Des Plaines River Basin was developed primarily for use in ecosystem restoration, done in an overall planning context.

There are several ways in which HGM models can be applied as part of an overall planning framework. For instance, in analysis of alternative plans, the HGM approach can be used to measure variable impacts to existing wetlands, or locating and evaluating potential wetlands restoration sites. Because the HGM approach produces a numerical value as a measure of various wetland functions, these numbers can be used to quantify and compare impacts and benefits to wetlands due to various alternative proposed plans and actions. These comparisons can be made through the calculation of Functional Capacity Units (see Appendix C), which take into account the number of wetland acres being affected.

3 Characterization of Regional Wetland Subclasses in the Upper Des Plaines River Basin

This Regional Guidebook was developed to assess the functions of two subclasses of herbaceous freshwater depressions in the Upper Des Plaines River Basin: Isolated Depressional and Floodplain Depressional Wetlands. However, this chapter will also address the classification of other subclasses that are found in the basin.

The chapter begins with a general description of the Upper Des Plaines Basin reference domain, and then provides an overview of various physical and biological characteristics of the reference domain. It concludes with descriptions of the HGM wetland classes and regional wetland subclasses that occur in the reference domain, and guidelines for recognizing them with a combination of field observation and geographical information system (GIS) layers.

Reference Domain

The reference domain for this guidebook is the Upper Des Plaines River (UDPR) watershed, which encompasses the 13 northernmost subbasins of the Des Plaines River watershed in northeastern Illinois and southeastern Wisconsin (Figure 2). The UPDR consists of the portion of the Des Plaines River upstream of its confluence with Salt Creek near the city of Brookfield, IL, to where the river originates in the southernmost portion of Racine County, Wisconsin, near the town of Union Grove. The UDPR watershed covers approximately 479 square miles (1,241 square kilometers), of which 346 square miles (896 square kilometers) are in Lake County, north-central Cook County, and the northeastern portion of Du Page County, Illinois, and 133 square miles (344 square kilometers) in Kenosha County and the southernmost portion of Racine County in Wisconsin. At most, it spans approximately 10 miles (16 km) in an east-west direction. The watershed contains about 570 miles (917 km) of perennial streams and rivers, including the Des Plaines River and its major tributaries — Jerome Creek, Kilbourn Ditch, Dutch Gap Canal, and Brighton Creek in

Wisconsin, and Willow, Weller, Buffalo, Indian, Mill, and North Mill Creeks in Illinois.

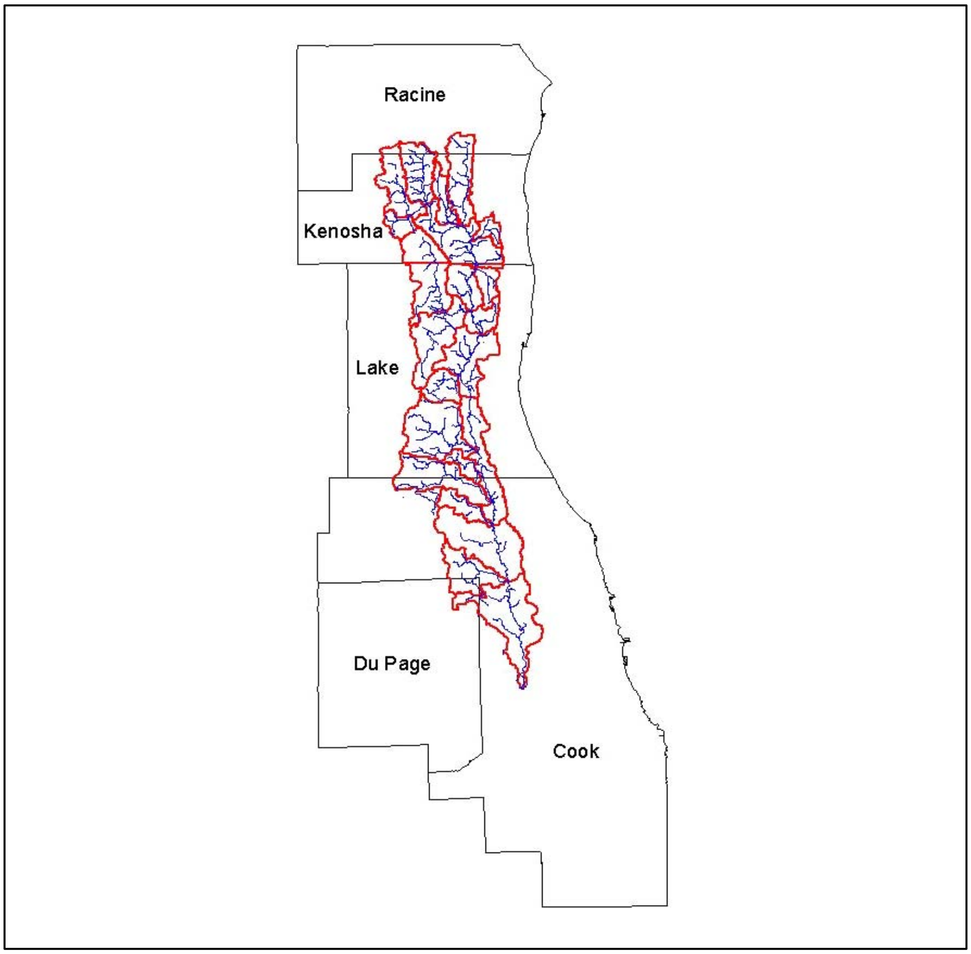

Figure 2. Upper Des Plaines Watershed

Environment and Resources of the Upper Des Plaines River Basin

The following subsections review major concepts that have bearing on the classification and functions of wetlands in the modern landscape of the Upper Des Plaines River Basin. Unless otherwise noted, the information presented here is derived primarily from the Critical Trends Assessment Program (CTAP) Upper Des Plaines River Area Assessment reports (IDNR 1998) and the Southeastern Wisconsin Regional Planning Commission's "Comprehensive Plan for the Des Plaines River Watershed" (SEWRPC 2003).

Physiography and climate

About 72 percent of the Upper Des Plaines Basin in Illinois occurs within the Wheaton Morainal Country physiographic divisions, with the remainder occurring in the heavily urbanized Chicago Lake Plain physiographic division, which encompasses the southeastern portion of the basin. Elevation in the entire basin ranges from 600 ft (183 m) to 891 ft (272 m) above sea level, and a majority of the land has a less than 2 percent slope, creating a relatively broad floodplain. The Chicago Lake Plain area was the floor of glacial Lake Chicago. The topography of this area generally is very flat, with low, gently sloping ridges (Willman 1971) and thus is far more uniform than that of the Wheaton Morainal Country.

The hummocky topographic features seen in the Wheaton Morainal Country were formed by the discontinuous deposition of glacial till superimposed on bedrock during the most recent (Wisconsin) glacial period. Generally ranging from 100 to 300 ft, these glacial deposits (unconsolidated sand, silt, clay, gravel, and boulders) left by stagnant and melting ice piles led to the formation of many depressional areas and subsequent lakes and marshes.

The climate of the Upper Des Plaines River basin is humid continental, with a wide range of temperature extremes, although this is tempered somewhat by the region's proximity to Lake Michigan. Temperature and precipitation are relatively uniform across the basin, although Cook County has slightly higher mean annual temperatures and precipitation levels than Lake and Kenosha Counties. From 1961 to 1990, mean temperatures at Chicago O'Hare International Airport in Cook County ranged from -6.1°C (21.0°F) in January to 22.8°C (73.0°F) in July, with an annual mean temperature of 9.4°C (48.9°F). In that same period, mean temperatures at Waukegan in northern Lake County ranged from -7.0°C (19.4°F) in January to 21.7°C (71.1°F) in July, with an annual mean temperature of 8.2°C (46.8°F). Mean temperatures measured at Union Grove, WI (the northernmost point of the watershed), are nearly identical to those measured in Waukegan.

Rainfall in the Upper Des Plaines River Basin is highest during June through September and lowest during January and February (where precipitation is primarily from sleet and snowfall). Mean annual rainfall from 1961 to 1990 was 35.8 in. (91.0 cm) at O'Hare and 34.2 in. (86.9 cm) at Waukegan. From 1945 to 1933, mean annual rainfall was 32.7 in. (83.0 cm) at Antioch, Wisconsin.

Stream flow and groundwater hydrology

Streams in the basin exhibit a consistent seasonal flow cycle, with high flows in the spring months and low flows common in the summer and fall. A substantial portion (approximately 25 percent in the main stem river) of this flow originates from wastewater treatment plants. The basin is subject to significant and damaging flooding due to a lack of channel capacity in the Des Plaines River and its tributaries and urban encroachment into the floodplain. The area has had, on average, one significant flood every 4 years. Major floods in 1986 and 1987 caused over $100 million in damages to surrounding communities (USACE

2001). Flooding on the main stem is most common in the spring, and flooding on the tributaries is most common in the summer.

Groundwater in the basin is stored in a complex system of glacial drift, Silurian shallow dolomite (shallow bedrock), and deep sandstone aquifers (deep bedrock), with vertical distributions ranging from near surface to around 1,700 ft in depth (Larsen 1973). The principal sources of water in the shallow aquifers are percolation from precipitation and infiltration from surface streams. Much of this groundwater eventually discharges to lower lying lakes and wetlands, and provides the base flow of surface streams (Sheaffer and Zeizel 1966).

Geology and geomorphology

The landscape of the Upper Des Plaines River Basin has been shaped primarily by glacial scouring and deposits that occurred 25,000 to 14,000 years ago during the Wisconsinan glaciation, the last major advance of the ice age. These deposits consisted primarily of till and outwash, as well as more minor deposits of lacustrine sediments and organic-rich debris. The glacial deposits were then overlaid by windblown silt, known as loess. Collectively, these deposits control, in part, land use, ecosystem development, and landscape processes in the basin.

The most prominent topographic features of the area are a series of north-south running moraines (ridges) that range from 1 to 3 miles wide and tens of miles long and were formed by the deposition of glacial till. Between these moraines are relatively flat lowland areas from which the drainage system of the basin developed. Also among the ridges are numerous undrained depressions, which create either small lakes or wetlands that formed in saturated organic soils (Larsen 1973).

The geology of the basin changes measurably from west to east. The moraines are hummockier at the western edge of the basin, indicating that glacial ice tended to stagnate and pile up in that area. Furthermore, in terms of grain size, the composition of the till is much more heterogeneous in this area, and the glacial drift layers are thicker as well.

Soils

In the Upper Des Plaines River Basin there is a wide variation in the characteristics of parent materials in which soils have developed, although a majority developed in silty clay and silty clay loam textured till. The northern part of the basin has a greater amount of wetlands and poorly drained soils than the southern part. For instance, large sections in the north are of the Morley-Markham-Ashkum soil association, and contain many poorly drained depressions. The more productive soils, particularly the Drummer series, are also found in the north on flatter portions of the till plain. In contrast, the southern portion of the basin has been heavily urbanized, and few natural surfaces remain.

Soils in the basin are primarily of the Alfisols and Mollisols soil orders, although there are also pockets of Entisols and Inceptisols, generally on floodplains and along steeper, eroded uplands. Common mineral soils found in wetlands in the basin include those in the Sawmill, Peotone, and Ashkum soil series. Additionally, many wetland depressional areas contain Histosols, with deep layers of muck and peat (primarily of the Houghton and Muskego soil series).

Vegetation communities

The *Upper Des Plaines River Area Assessment*, Volume 3 (1998) report lists 16 natural terrestrial community types (adapted from White and Madany 1978) that either occur, or are believe to have formerly occurred, in the basin. These 16 types fall under the more general forest, prairie, and wetland community categories. Four wetland community types are described below. Of the four, the sedge meadow, wet prairie, and marsh communities are relevant to the isolated and floodplain depressions HGM models that are presented in this guidebook.

Northern Flatwoods. Northern flatwoods occur on poorly drained sites in the Valparaiso morainic system. These wetlands are seasonally wet, and water is often retained in microdepressions during the wet periods. The canopy is dominated by various white oak species, while the ground cover species include a wide variety of *Carex* sedges. There are approximately 85 acres of high quality northern flatwoods remaining in the Upper Des Plaines River Basin.

Sedge Meadow. The sedge meadow is dominated by the mound forming hummock sedge (*Carex stricta*). This wetland type can occur either on mineral or organic soils, and is saturated, although not inundated, for most of the year. Sedge meadows are often found within other community types, such as wet prairie, marshes, and shrub swamps.

Wet Prairie. Wet prairies are found on poorly drained and slowly permeable soils. Wet prairie vegetation is characterized by prairie cord grass (*Spartina pectinata*), and a variety of sedges and forbs, and shrubs.

Marsh. Marshes are dominated by herbaceous vegetation, consisting largely of cattails (*Typha spp.*). They have either organic or mineral soils, and water at or near the surface during most of the growing season.

Fauna

The Upper Des Plaines watershed supports a wide range of fauna, including an estimated 43 mammal species, 16 amphibian species, 23 reptile species, and 270 bird species. In general, the greatest threat to these species is suburban/urban growth and the subsequent loss of habitat. Exotic faunal species are much less of a problem in the area than exotic and invasive plant species. Many of the faunal species (especially among birds and reptiles) found in wetlands will also utilize some other terrestrial or aquatic habitat during their life cycle.

Birds. Wetlands represent the most significant avian habitat in the region. The Deer Lake/Redwing slough complex, in particular, provides habitat for a wide variety of birds, including several state threatened and endangered species. Wetland habitats in the area are also used as stop-over sites by a number of migrating bird species.

Mammals. Common mammal species that utilize wetlands in the region include beavers (*Castor Canadensis*), muskrats (*Ondatra zibethicus*), minks (*Mustela vison*), red fox (*Vulpes vulpes*), white-tailed deer (*Odocoileus virginianus*), raccoons (*Procyon lotor*), and various shrew species. No known threatened or endangered mammal species are found in the area.

Amphibians and Reptiles. Typical amphibian species found in the wetlands in the region are the green frog (*Rana clamitans melanota*) and northern leopard frog (*Rana pipiens*); these frog species tend to be numerous in marsh areas. Typical reptiles are the painted turtle (*Chrysemys picta*), snapping turtle (*Chelydra serpentina serpentina*), and common garter snake (*Thamnophis sirtalis sirtalis*). The state threatened Kirtland's water snake (*Clonophis kirtlandii*) and state endangered massasauga snake (*Sistrurus catenatus*) both rely on wetland habitats, and prefer wet prairie areas with abundant ground cover.

Alterations to environmental conditions

Changes in Land use. In 1820, based on a Government Land Office survey done at the time, the land cover of the Upper Des Plaines River Basin was approximately 40 percent prairie and 60 percent forest and savanna. The presettlement historical coverage of wetlands in the basin (extrapolated from hydric soil acreage in Lake County) is estimated to have been 26 percent of the total area (57,600 acres). Since that time, the biological landscape of the basin has been drastically altered by human activity. Many historical wetlands have been tiled and drained to make use for agriculture, and large parts of the basin have become heavily urbanized. The construction and creation of agricultural fields, buildings, and roads have also fragmented once contiguous forest, wetland, and prairie habitats. More recently, urban development has replaced agricultural land, and now dominates large portions of the landscape (Figure 3).

By recent estimates, a majority (57 percent) of Upper Des Plaines River Basin land cover in Illinois is of the urban/built up class. Another 16 percent is upland forest, 11 percent is cropland, and 6 percent of the basin is classified as wetland (forested and non-forested). On the other hand, a majority of the Wisconsin portion of the watershed is in cropland (68 percent), while only about 12 percent is classified as urban, about 8 percent as wetland, and about 6 percent as woodland.

Invasive and Exotic Species. A major problem and threat to the natural diversity of ecosystems in the watershed has been the influx and diffusion of invasive and exotic plant species. Major causes of the proliferation of invasive species are altered flooding regimes and increased siltation. Many marshes have been completely overtaken by reed canary grass (*Phalaris arundinacea*), and dense stands of cattails (*Typha spp.*) have become nearly ubiquitous in these systems as well. Other introduced or invasive plant species posing problems in wetlands include common and glossy buckthorn (*Rhamnus cathartica* and

Rhamnus frangula), purple loosestrife (*Lythrum salicaria*), bittersweet nightshade (*Solanum dulcamara*), and common reed (*Phragmites australis*).

Figure 3. Aerial photos of the Rollins Savanna area, Lake County, taken in 2001 (on the left) and 1939 (on the right)

Description of Regional Wetland Subclasses

The following descriptions of wetland HGM classes and subclasses in the Upper Des Plaines River basin is not meant to encompass every type of wetland found in the region, but includes those types that were encountered during field reconnaissance and data collection in the area, and does comprise the majority of wetland subclasses to be found in the basin. Each subclass listed below would require its own separate assessment model. HGM functional assessment models have been created so far for the Isolated Depression and Floodplain Depression subclasses, and as such, more detail is provided in the description of these two subclasses.

The dichotomous key in Figure 4 can be used as a quick guide for distinguishing among the various subclasses that are described below.

1. Wetland is located in topographic depression	Go To #2
2. Wetland is wholly or the majority is outside of the mapped 10-year floodplain	Isolated Depression
2. Wetland is wholly or the majority is inside of the mapped 10-year floodplain	Floodplain Depression
1. Wetland is not located in topographic depression	Go To #2
2. Wetland is within mapped 2-year floodplain	Go To #3
3. Wetland is associated with a lake	Lacustrine Fringe
3. Wetland is associated with a stream or river	Go To #4
4. Wetland has ≤ 30% tree or shrub cover	Herbaceous Riverine
4. Wetland has > 30% tree or shrub cover	Forested Riverine
2. Wetland is outside of mapped 2-year floodplain	Flat

Figure 4. Dichotomous key to various HGM subclasses in the Upper Des Plaines River Basin

Depressions

In the Upper Des Plaines River Basin, the Depressions HGM class has been subdivided into several subclasses based on the presence of outlets and location within the floodplain. Generally speaking, depressional wetlands occur in topographic depressions that allow the accumulation of surface water. For the purposes of this HGM model, a depression is defined as having a minimum depth of 2 ft in at least part of the wetland. A 2-ft depth is used because of the availability of digital 2-ft elevation contour lines in the watershed. These contour lines can be used when applying the model to determine whether or not a site can be classified as a depression.

Historically, many undrained depressions of various sizes were formed in the basin from glacial movement and activity. These depressions were able to store water from precipitation and stream flooding (for those located in the floodplain), providing natural flood protection benefits in the watershed. However, subsequent human activity has led to the draining and filling of many of these. These changes are in part responsible for reducing the ability of the watershed to absorb major flooding events.

Currently, the depression class accounts for the majority of wetlands in the watershed (IDNR 1998). Their relative number, combined with their ecological and flood attenuation benefits, and their potential for restoration are the reasons that the A-Team decided to focus on this wetland type for the Guidebook.

Isolated Depressions. In the Upper Des Plaines Basin, wetlands are classified as isolated if they are located outside of the mapped 10-year floodplain (Figure 5). Their hydrology is driven by direct precipitation and associated runoff, with additional subsurface flow under certain geologic settings. It should be noted that the classification of wetlands as *isolated* in this document does not have any use or bearing on jurisdictional and regulatory determinations.

Figure 5. Aerial and ground views of an isolated depression located in Deer Grove Forest Preserve, Cook County, IL

Isolated depressions can have one or more surface outlets, or no outlets at all. These outlets can be a natural channel (such as a headwater stream), or manmade, as in the case of ditches and tiles. If there is no defined outlet, water can still leave the depression if it reaches a level higher than the depth of the wetland.

These depressions are mostly herbaceous systems, defined as having ≤ 30 percent tree/shrub cover (Cowardin et al. 1979). They consist primarily of low marsh or sedge meadow communities, or both. Plants commonly found in these systems include river bulrush (*Scirpis fluviatilis*) and smartweeds (*Polygnum spp.*) in the low marsh areas, and *Carex stricta* and *Carex lacustris* in the sedge meadow areas. Cattails (*Typha spp.*) are ubiquitous in both community types, although they tend to, along with reed canary grass (*Phalaris arundicae*), be far denser in the more disturbed areas.

Floodplain Depressions. Floodplain depressions are distinguished from isolated depressions in that they are located within the mapped 10-year floodplain. The 10-year floodplain is used as a boundary for two primary reasons, one functional and one utilitarian. The functional reason for use of the 10-year floodplain is that for wetlands within this area floodwater will play a periodic role in the site's hydrologic regime, but is not the dominant hydrologic influence in the wetland. The utilitarian reason is that a floodplain map is necessary for wetland classification, and in the UDPR basin (due to its geomorphology), the 10-year floodplain is similar to the more readily obtainable 100-year FEMA floodplain. Because of their location within the floodplain, these sites are able to export materials downstream, and also have the capacity to mitigate flooding in upland areas. Like isolated depressions, floodplain depressions are also primarily herbaceous systems. They will commonly have marsh vegetation communities that are dominated by *Typha spp.* In general, the floodplain systems tend to be less vegetatively diverse than their isolated counterparts (Figure 6).

Figure 6. Aerial and ground views of a floodplain depression located in Deer Grove Forest Preserve, Cook County, IL

Riverine

Riverine wetlands in the Upper Des Plaines Basin are wetlands not located within a topographic depression, but located within the mapped 10-year floodplain of the Des Plaines River and its tributaries. The primary water source for these sites is flooding from the adjacent river or stream. Additional water sources are precipitation and runoff from adjacent upland areas. Both forested and herbaceous Riverine wetlands are found in the reference domain (Figures 7 and 8).

Figure 7. Aerial and ground views of a forested Riverine wetland located in Deer Grove Forest Preserve, Cook County, IL

Figure 8. Aerial and ground views of an herbaceous Riverine wetland located in Kenosha County, WI

Lacustrine Fringe

Lacustrine Fringe wetlands are adjacent to lakes and are subject to regular (less than every 10 years) flooding from the lake. In the reference domain, these wetlands generally consist of dense stands of *Typha spp* (Figure 9).

Figure 9. Aerial and ground views of an herbaceous Lacustrine Fringe wetland located in Lake County, IL

Flats

In the reference domain, flats HGM class occurs primarily as the forested Northern Flatwoods community. Detailed information concerning the Northern Flatwoods community can be found in Anderson (1998).

4 Wetland Functions and Assessment Models

Overview

The following functions are performed by both Isolated Depressions and Floodplain Depressions in the Upper Des Plaines River Basin:

a. Maintain Characteristic Hydrologic Regime.

b. Maintain Characteristic Biogeochemical Processes.

c. Maintain Characteristic Plant Communities.

d. Maintain Characteristic Fauna.

e. Export Organic Carbon.[1]

This chapter begins with a description of all the variables used in the Isolated Depression and Floodplain Depression models. Each variable description includes what functions the variable is used in, the justification for using the variable, and the variable subindex scaling.

The following sequence is then used to present and discuss each of these functions:

a. *Definition:* defines the function and identifies an independent quantitative measure that can be used to validate the functional index.

b. *Rationale for selecting the function:* provides the rationale for why a function was selected and discusses onsite and offsite effects that may occur as a result of lost functional capacity.

c. *Characteristics and processes that influence the function:* describes the characteristics and processes of the wetland and the surrounding landscape that influence the function and lay the groundwork for the description of model variables.

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[1] This function is performed by Floodplain Depressions and not Closed Isolated Depressions.

d. Description of model variables: defines and discusses model variables and describes how each model variable is measured.

e. Functional Capacity Index: describes the assessment model from which the FCI is derived and discusses how model variables interact to influence functional capacity.

Variables

General note on variable scaling

Variables are scaled either categorically or continuously. Variables are scaled categorically if they either (a) measured the presence or absence of features (V_{ALT} for example), or (b) owing to the outlined assessment methodology, where several variables are "visually estimated" (V_{CAT} for instance), the variable cannot be measured precisely, but instead can be more accurately placed in certain range of values. For variables that are measured continuously, a linear scaling was used based on best professional judgment and the lack of references or evidence to justify any alternative non-linear scaling.

V_{ALT} and $V_{ALT\text{-}OEX}$: Presence of hydrologic alteration

V_{ALT} variable is used in the Maintain Characteristic Hydrologic Regime and Maintain Characteristic Plant Communities functions. $V_{ALT\text{-}OEX}$ is used in the Export Organic Carbon (for Floodplain Depressions) function.

V_{ALT} is defined as the presence of artificial drainages such as tiles or ditches in or within 50 m of the wetland, and in the case of Floodplain Depressions, the presence of any modifications to or within 50 m the contributing stream channel (such as straightening and maintained channelization or the presence of levees and berms, see Table 6). All of these alterations will directly affect the hydrology of the wetland, either by increasing drainage or changing the flooding regime. Although ditch number, depth, and location, and soil texture of the site all factor into the effect ditches will have on the wetland, this variable only measures the presence or absence of any ditches, as it assumed that any functioning ditch will have at least some impact on the hydrology of the wetland. A subindex score of 0.5 is assigned for the presence of ditches as an "average" value, recognizing that most ditches will have more or less impact on the function.

The variable subindex scaling of V_{ALT} for Isolated Depressions is given in Table 5.

Table 5 **Subindex Scaling for V_{ALT} in Isolated Depressions and Site Alteration Portion of V_{ALT} for Floodplain Depressions**	
Type of Alteration to Wetland	**Subindex**
No alterations	1.0
Functioning ditch(es) within 50 m	0.5
Functioning tiles	0.2
Functioning ditch(es) and tiles	0.0

In Floodplain Depressions, alterations to the adjacent stream channel need to be considered as well. For the Maintain Characteristic Hydrologic Regime and Maintain Characteristic Plant Communities functions, the subindex score in Floodplain Depressions is determined by averaging the subindex score from the site alteration portion (Table 5) with the subindex score from the stream alteration portion (Table 6), so V_{ALT} = [(site alteration SI) + (stream alteration SI)]/2.

For the Export Organic Carbon function, only alterations to the stream channel are considered relevant, so for that function $V_{ALT\text{-}OEX}$ is used instead of V_{ALT}. $V_{ALT\text{-}OEX}$ is identical to the stream alteration portion of V_{ALT} (Table 6).

The variable subindex scaling of $V_{ALT\text{-}OEX}$ (stream alteration portion of V_{ALT}) for Floodplain Depressions is given in Table 6.

Table 6 **Subindex Scaling of $V_{ALT\text{-}OEX}$ (Stream Alteration Portion of V_{ALT}) for Floodplain Depressions**	
Type of Alteration to Stream	**Subindex**
No alterations/impact (Figure 10)	1.0
Moderate impact (Figure 11). a) Presence of artificial levees, spoil piles, roads, etc. along stream reach, and/or stream has been moderately downcut, channelized, excavated and/or straightened. Generally, alterations have not been maintained and some of the natural stream morphology has returned.	0.5
Severe impact (Figure 12). a) Presence of artificial levees, spoil piles, roads, etc. along stream reach, and/or stream has been severely downcut, channelized, excavated, and/or straightened. Alterations are being maintained and the natural stream morphology is not apparent.	0.1

Figure 10. Example of unimpacted stream reach. Stream is naturally meandering and point bars are evident. No evidence of spoil piles, etc., along streambank

Figure 11. Example of stream reach that has been moderately impacted. Stream appears to have had past alteration, as the streambanks are sharply defined and show evidence of having old spoil piles. However, the stream does maintain a meander and any alterations do not appear to be recent or maintained

Figure 12. Example of stream reach that has been severely impacted. Channel has been straightened and makes unnatural 90-deg turns. Streambanks show sharp, straight downward cuts along the edge, and water is flowing at an unnatural velocity. Evidence of spoil pile along the streambank

V_{BUFFER}: Wetland buffer

This variable is used in the Maintain Characteristic Biogeochemical Processes and Maintain Characteristic Fauna functions.

This variable is defined as the percentage of the wetland perimeter that can be classified as buffer (forest, unmowed grassland, other undeveloped habitat ≥ 30 m in width). Buffers can limit the amount of human encroachment and disturbance into the site, provide important additional terrestrial habitat for wildlife (Semlitsch and Bodie 2003), and limit silt, nutrient, and contaminant loading into the wetland (Lowrance et al. 1984). Buffers 30- to 60-m wide are generally acknowledged as being sufficient to effectively protect water resources (e.g., Lee and Samuel 1976, Phillips 1989, Davies and Nelson 1994). Buffers of 30 m were also considered as providing adequate protection for 77 percent of wetland dependent species (of all taxa) in Massachusetts (Boyd 2001).

Percentage of wetland perimeter buffered ranged from 3 to 100 percent in Floodplain Depressions, and 0 to 100 percent in Isolated Depressions. The subindex score increases linearly from 0.0 to 1.0 as the percent buffered increases from 0 to 100 percent.

The variable subindex curve of V_{BUFFER} for Isolated Depressions and Floodplain Depressions is given in Figure 13.

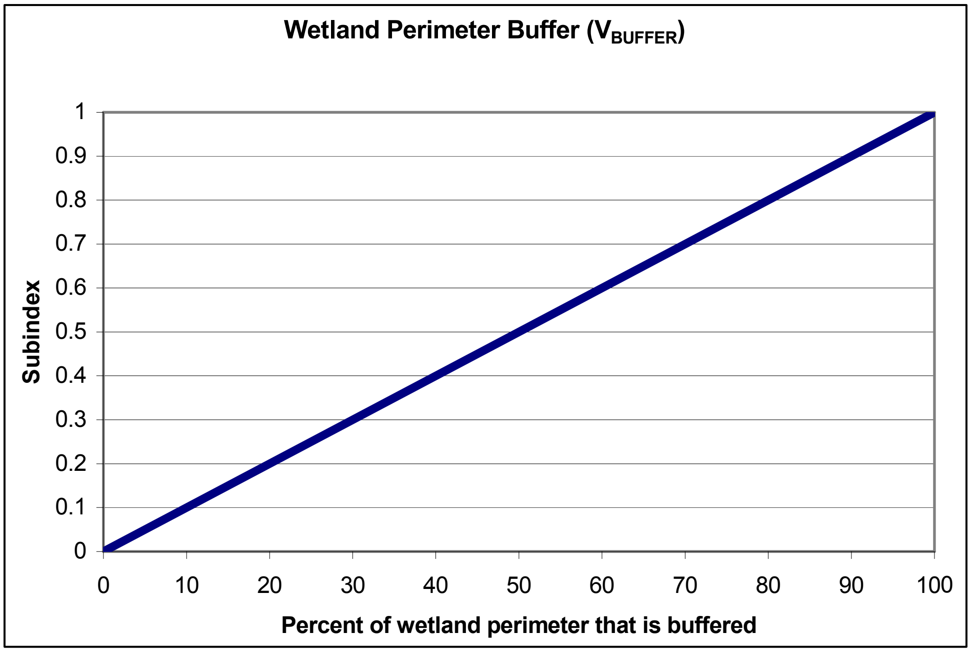

Figure 13. Relationship between percent buffer and subindex score

The equation used to calculate the V_{BUFFER} subindex score is:

$$V_{BUFFER} = 0.01\ (\%\ \text{Buffer})$$

V_c: Native mean c ($\bar{c}$) score

Variable is used in Maintain Characteristic Plant Communities function.

This variable is the native $\bar{c}$ value derived from a site inventory Floristic Quality Assessment (FQA) (Swink and Wilhelm 1994) of the assessment area. In an FQA, each plant is assigned a C value, called the "coefficient of conservatism." The $\bar{c}$ value (from 0-10) is a measure of a species' fidelity to a specific natural community or communities. Practically, it can be used as an indicator of site disturbance, in that plants with high C values are usually found only in natural undisturbed areas, while plants with low C values can populate highly disturbed areas.

Native $\bar{c}$ is the mean C of all native plants found at the site. For example, a site with the following species: *Ambrosia trifida* (C = 0), *Carex stricta* (C = 5), *Pilea pumila* (C = 5), and *Agrostis alba* (C = *), would have a native mean C of (0+5+5)/3, or 3.3. Because *Agrostis alba* is classified as an adventive species, it does not have a C value and therefore is not included in the calculation.

Reference floodplain depressions had native $\bar{c}$ values from 2.5 to 4.9; with reference standard sites generally having scores ≥ 4.2. Isolated Depressions had $\bar{c}$ values from 0.8 to 5.6; with reference standard sites generally having scores ≥ 5.0.

The variable subindex curve of V_c for Isolated Depressions is given in Figure 14. The scaling of the curve is based on a combination of the reference data and best professional judgment.

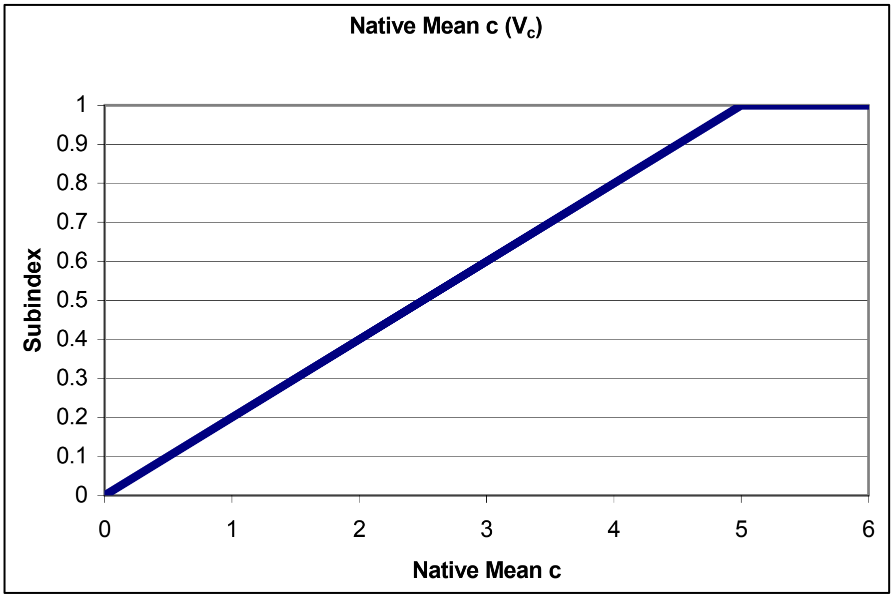

Figure 14. Relationship between native mean c score and subindex in Isolated Depressions

The equations used to calculate the V_c subindex score for Isolated Depressions are: $\bar{c} < 5.0, V_c = 0.20(\bar{c})$ and $\bar{c} \geq 5.0, V_c = 1.0$.

The variable subindex curve of V_c for Floodplain Depressions is given in Figure 15.

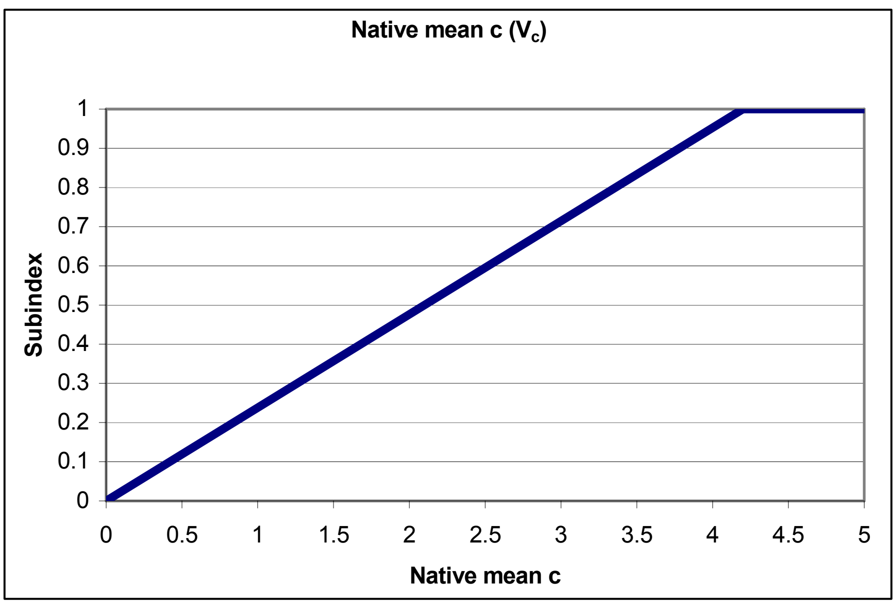

Figure 15. Relationship between native mean $\bar{c}$ score and subindex in Floodplain Depressions

The equations used to calculate the V_c subindex score are:

$\overline{c} < 4.2, V_c = 0.238(\overline{c})$ and $\overline{c} \geq 4.2, V_c = 1.0$.

V_{CAT}: Percent cover of *Typha spp.*

Variable is used in Maintain Characteristic Plant Communities function.

This variable is defined as the percentage of the assessment area that is covered by broadleaf cattail (*Typha latifolia*), narrowleaf cattail (*Typha angustifolia*), and their hybrid species (*Typha* X *glauca*). The possibly exotic *Typha angustifolia* and the *Typha* X *glauca* hybrid tend to be more aggressive than the native *Typha latifolia* and can eventually dominate a site, precluding the growth and establishment of other species (Galatowitsch et al. 1999). Because the three *Typha* species are not always easily distinguished by a quick visual glance, and all three often grow together in dense stands, this variable does not distinguish between the different species.

This variable is also used in the model to distinguish between sites with similar FQI and $\overline{c}$ scores. Many sites will have their plant diversity concentrated in a small sedge meadow boundary surrounding a much larger cattail marsh area. This structure is less desirable than a wetland where the plant diversity is distributed across the entire site. However, because the inventory FQA does not take into account species densities, these two sites may have similar FQI and $\overline{c}$ scores.

The variable is scaled identically for Isolated and Floodplains Depression, and the subindex is determined categorically, based on ranges of cattail cover. Reference standard sites had cattail cover of less than 20 percent.

The variable subindex scaling of V_{CAT} for Isolated Depressions and Floodplain Depressions is given in Table 7.

Table 7
Subindex Scaling of *Typha spp.* Cover

***Typha spp.* Percent Cover**	**Subindex**
0-20	1.0
21-50	0.75
51-80	0.50
81-100	0.25

V_{CATCH}: Ratio of wetland area to catchment area

Variable is used in the Maintain Characteristic Hydrologic Regime function.

This variable is the ratio of the wetland containing the assessment area to the area of its surrounding catchment, and is a measure of the relative amount of runoff the wetland is receiving and storing. A more appropriate measure would be the ratio of wetland volume to catchment area; however, as detailed depth data are not readily available for the entire watershed, estimating wetland volumes is not feasible.

Isolated Depression reference sites had ratios ranging from 0.05 to 0.82, with reference standard sites ranging from 0.02 to 0.16. Floodplain Depression reference sites had ratios ranging from 0.01 to 1.15, with reference standard sites ranging from 0.04 to 0.33. Sites may have changes in catchment size from historical conditions that resulted from the building of elevated roads or railroad tracks, which block normal overland flow, resulting in a larger ratio. Conversely, effective catchment size can be enlarged through the building of ditch and irrigation networks, which will result in a smaller ratio.

Ratios higher than the reference standard range would indicate that the depressional wetland is not receiving the amount of water necessary to maintain a hydroperiod characteristic of reference standard sites. Furthermore, at a certain point the depressional wetland would not be receiving enough water to sustain hydrophytic vegetation and saturated soils. Therefore, as the ratio increases above the reference standard range, the subindex score decreases linearly to 0.0. Similarly, the subindex score linearly decreases when the ratio is below the reference standard range, but only to 0.5, as even at the lower ratios the depressional wetland would still be receiving enough water to support basic characteristics of the wetland.

The variable subindex curve of V_{CATCH} for Isolated Depressions is given in Figure 16.

The equations used to calculate the V_{CATCH} subindex score for Isolated Depressions are:

Ratio(R) < 0.02, $V_{CATCH} = 25R + 0.5$
$0.02 \leq R \leq 0.16$, $V_{CATCH} = 1.0$
$0.16 < R < 1.0$, $V_{CATCH} = -1.19R + 1.19$
$R \geq 1.0$, $V_{CATCH} = 0.0$

The variable subindex curve of V_{CATCH} for Floodplain Depressions is given in Figure 17.

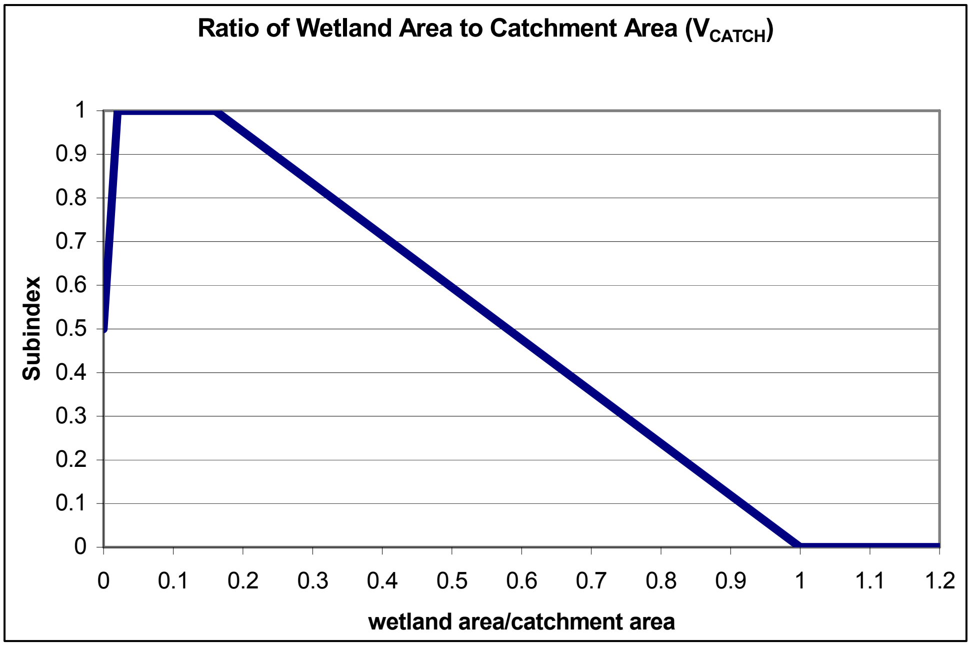

Figure 16. Relationship between wetland/catchment area ratio and subindex score in Isolated Depressions

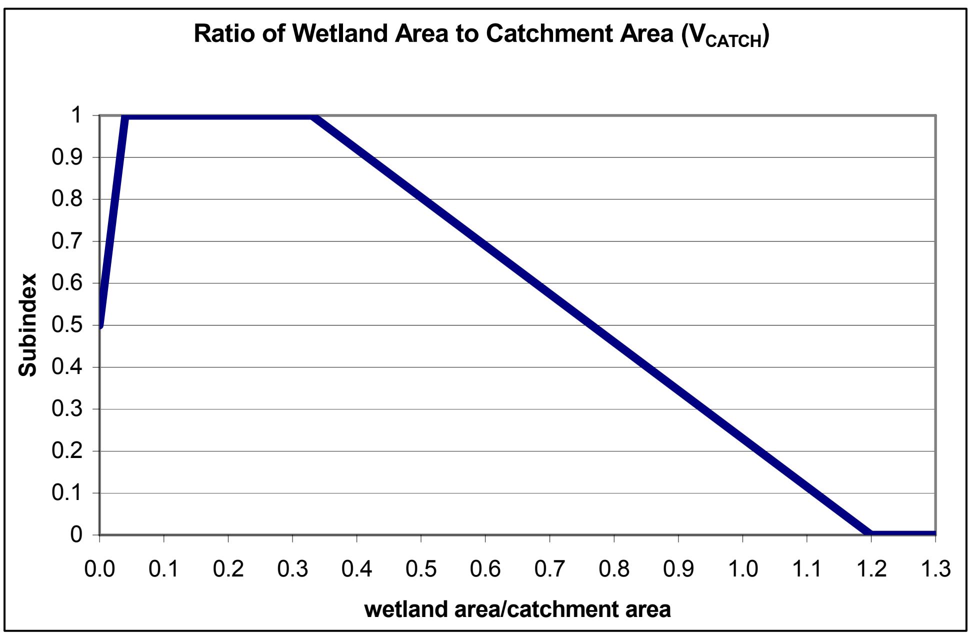

Figure 17. Relationship between wetland/catchment area ratio and subindex score in Floodplain Depressions

The equations used to calculate the V_{CATCH} subindex score for Floodplain Depressions are:

Ratio(R) < 0.04, $V_{CATCH} = 12.5(R) + 0.5$
$0.04 \leq R \leq 0.33$, $V_{CATCH} = 1.0$

$0.33 < R < 1.2$, $V_{CATCH} = -1.149(R) + 1.379$
$R \geq 1.2$, $V_{CATCH} = 0.0$

V_{FQI}: Native Floristic Quality Index

This variable is used in the Maintain Characteristic Plant Communities function.

This variable is the native Floristic Quality Index (FQI) score derived from a site inventory FQA of the assessment area. The FQI can be used as a measure of intrinsic plant biodiversity at the site.

Native FQI = $\bar{c}\sqrt{n}$, where *n* is the number of native species found at the site and $\bar{c}$ is the native mean C score (see V_C description). For example, a site with the following species: *Ambrosia trifida* (C = 0), *Carex stricta* (C = 5), *Pilea pumila* (C = 5), and *Agrostis alba* (C = *), would have an FQI of $3.33\sqrt{3}$, or 5.8. Because *Agrostis alba* is classified as an adventive species it is not included in the calculation.

In reference Isolated Depressions, native FQI scores ranged from 4.5 to 38.1. In reference Floodplain Depressions, native FQI scores ranged from 5.2 to 42.4.

The variable subindex curve of V_{FQI} for Isolated Depressions is given in Figure 18. The scaling of the curve is based on a combination of the reference data and best professional judgment.

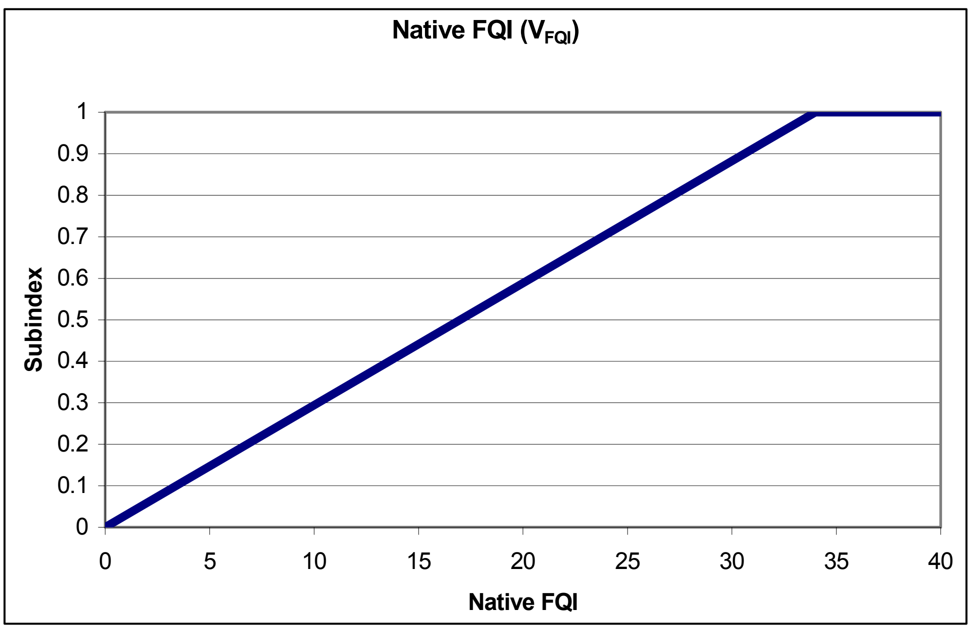

Figure 18. Relationship between native FQI and subindex in Isolated Depressions

The equations used to calculate the V_{FQI} subindex score for Isolated Depressions are:

FQI < 34, $V_{FQI} = 0.0294(FQI)$
FQI ≥ 34, $V_{FQI} = 1.0$

The variable subindex curve of V_{FQI} for Floodplain Depressions is given in Figure 19.

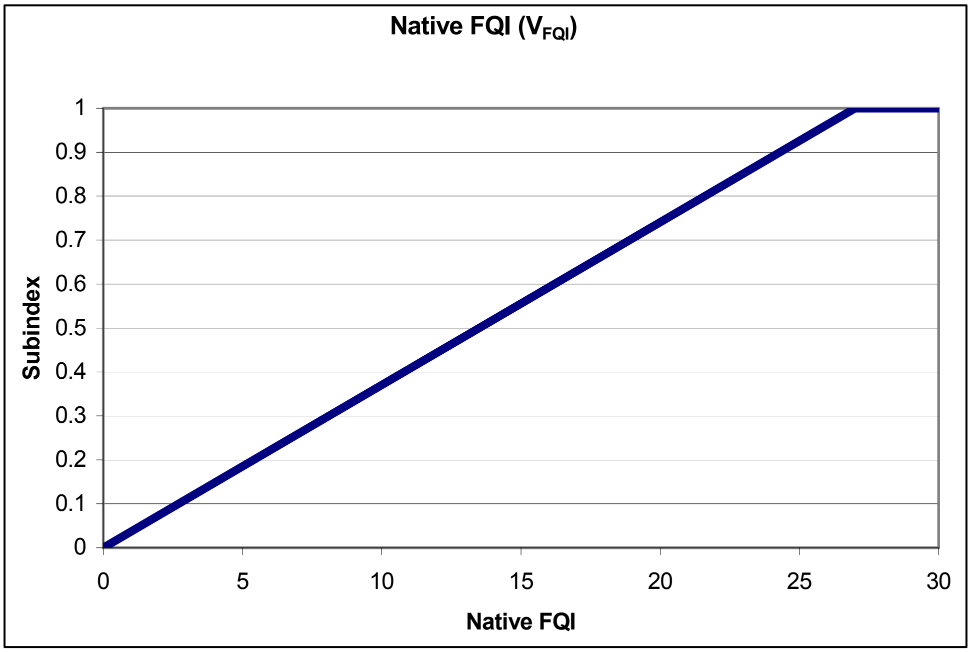

Figure 19. Relationship between FQI and subindex in Floodplain Depressions

The equations used to calculate the V_{FQI} subindex score for Floodplain Depressions are:

FQI < 27, $V_{FQI} = 0.03704(FQI)$
FQI ≥ 27, $V_{FQI} = 1.0$

V_{GVC}: Ground vegetation cover

This variable is used in the Maintain Characteristic Hydrologic Regime, Maintain Characteristic Biogeochemical Processes, Maintain Characteristic Fauna, and Export Organic Carbon (for Floodplain Depressions) functions.

This variable is defined as the percentage of the assessment area that is covered with herbaceous and woody-vine vegetation. The amount of ground vegetation cover serves as a measure of plant biomass available for evapotranspiration, and is also an indicator of primary productivity and vegetative structure in the assessment area. Ground vegetation cover at reference sites ranged from 60 to >95 percent, although most reference sites and all reference standard sites contained ground vegetation cover >95 percent. Sites with less ground vegetation cover were either recently restored or planted, formerly forested sites (with current tree cover around 30 percent), or had stunted growth of herbaceous plants.

The subindex score decreases linearly from 1.0 to 0.0 as ground vegetation cover in the assessment area decreases from 100 to 0 percent.

The variable subindex curve of V_{GVC} for both Isolated and Floodplain depressions is given in Figure 20.

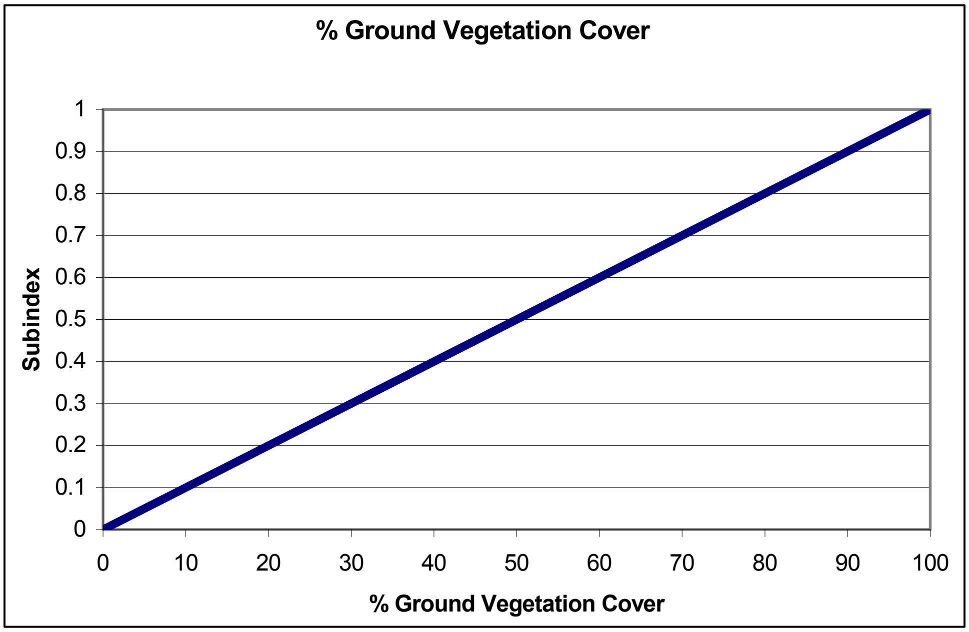

Figure 20. Relationship between ground vegetation cover and subindex score

The equation used to calculate the subindex score for V_{GVC} is:

V_{GVC} = 0.01 (% GVC)

V_{INV}: Invasive species cover

Variable is used in Maintain Characteristic Plant Communities and Maintain Characteristic Fauna functions.

This variable is defined as the percentage of the assessment area that is covered by invasive species, excluding *Typha spp.* In the reference domain, the most common invasive species encountered was reed canary grass (*Phalaris arundinacea*), and this variable can usually be scored by looking for the percent cover of this one particular species. *P. arundinacea* has the advantage of being highly productive in flooded areas but also very drought resistant (Rice and Pinkerton 1993). Other invasive species that may cover a significant portion of the wetland include common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and giant ragweed (*Ambrosia trifida*).

Invasive species generally spread into wetlands that have been disturbed by anthropogenic activity. These species spread aggressively in the wetland, replacing and preventing the establishment of indigenous vegetation (Galatowitsch et al. 1999). Based on personal observation in highly disturbed depressional wetlands in the reference domain, invasive species (*P. arundinacea* in particular) can come to dominate a site, accounting for over 95 percent of the ground vegetation cover in the wetland (Figure 21). The negative effect of *P. arundinacea* on the plant community has been further demonstrated in a study where wet meadow sites with *P. arundinacea* had roughly two-thirds of the species richness of plots without *P. arundinacea*, and sites with both *P. arundinacea* and hydrologic disturbance had roughly one-third of the species richness of sites without *P. arundinacea* (Kercher et al. 2004).

In reference to Isolated Depressions, invasive species percent cover ranged from <5 to 90 percent, in Floodplain Depressions, percent cover ranged from 7.5 to 95 percent. Reference standard sites in both classes generally contained < 10 percent invasive species cover. The variable is scaled identically for Isolated and Floodplains Depression, based on the reference data and best professional judgment. The subindex is determined categorically, based on ranges of invasive species cover.

Figure 21. Floodplain Depression located in Cook County, IL, that is almost completely covered by reed canary grass (*Phalaris arundinacea*)

The variable subindex scaling for V_{INV} in Isolated and Floodplain Depressions is given in Table 8.

Table 8 Subindex Scaling for Invasive Species Cover in Isolated and Floodplain Depressions	
Invasive Species Percent Cover	**Subindex**
0-10	1.0
11-25	0.8
26-50	0.6
51-80	0.3
81-94	0.1
95-100	0

$V_{LANDUSE}$: Land use within 300 m

Variable is used in Maintain Characteristic Fauna function.

This variable is defined as the overall land use (LU) within 300 m of the assessment area. The surrounding LU can affect how organisms move within and between wetlands, and also accounts for the amount of available terrestrial habitat around the wetland. A 300-m distance was used based on a literature review by Semlitsch and Bodie (2003). They reported that 289 m was the mean maximum distance (distance radiating from the outer edge of the wetland) of core terrestrial habitat that was utilized by various groups of amphibians and reptiles (with a range of 218 m for salamanders and 368 m for frogs).

The overall LU score is derived by dividing a 300-m buffer around the assessment area into grids, and assigning each grid one of three general LU categories — urban, agricultural, and forest/grassland/wetland. Each category is assigned an individual score: urban = 5, agriculture = 3, and forest/grassland/wetland = 1, using the logic that urban areas are generally more detrimental to wildlife than agricultural areas, and to be consistent with the scoring scheme used in the V_{LUC} variable. The overall LU score is average score of the individual grids.

In reference sites, 300-m LU scores ranged from 1.04 to 3.97 in Isolated Depressions, and from 1.42 to 3.66 in Floodplain Depressions. In order to reflect the realistic possibility that future land-use changes can achieve variable scores outside the range of what was found in reference sites, the subindex curves allow for the entire range of possible scores (1.00 to 5.00) for this variable. In Isolated Depressions, the subindex score decreases linearly from 1.0 to 0.0 as the catchment LU score increases from 1.00. In Floodplain Depressions, the subindex score decreases linearly from 1.0 to 0.0 as the 300-m LU score increases from 1.50, because reference standard Floodplain Depressions tended to have higher 300-m LU scores than Isolated Depressions.

The variable subindex curve of $V_{LANDUSE}$ for Isolated Depressions is given in Figure 22.

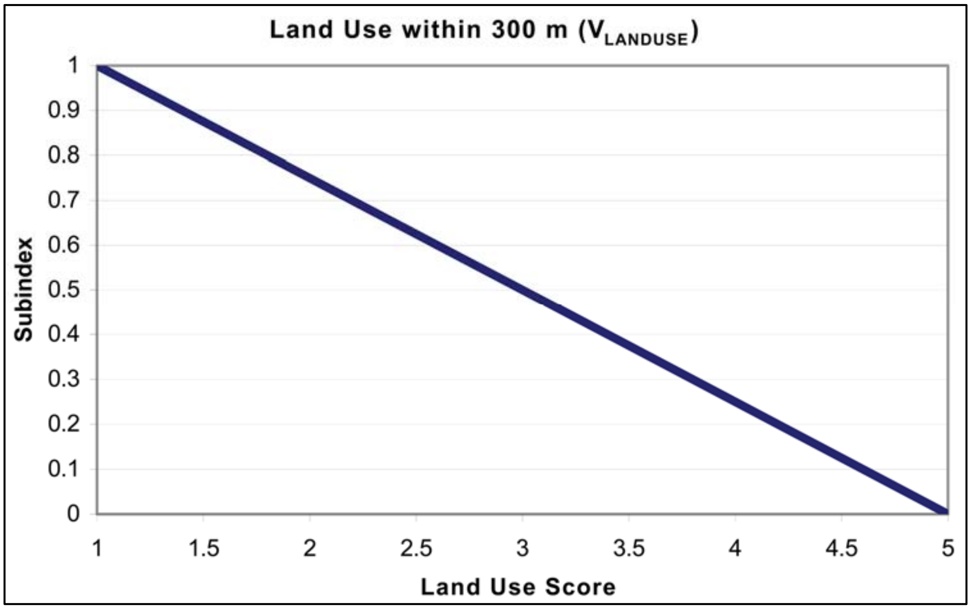

Figure 22. Relationship between land-use score and subindex in Isolated Depressions

The equation used to calculate the subindex score for $V_{LANDUSE}$ in Isolated Depressions is:

$$V_{LANDUSE} = -0.25(300\text{m LU Score}) + 1.25$$

The variable subindex curve of $V_{LANDUSE}$ for Floodplain Depressions is given in Figure 23.

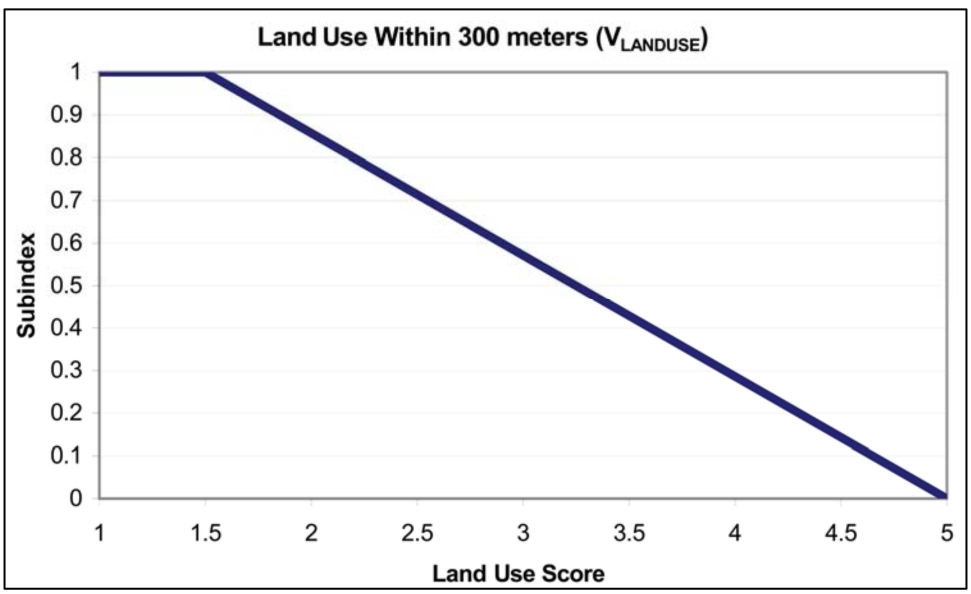

Figure 23. Relationship between land-use score and subindex in Floodplain Depressions

The equations used to calculate the subindex score for $V_{LANDUSE}$ in Floodplain Depressions are:

Land use Score (LU) ≤ 1.5, $V_{LUC} = 1.0$
LU > 1.5, $V_{LUC} = -0.2857(\text{Catchment LU Score}) + 1.4286$

V_{LUC}: Land use of the catchment area

Variable is used in the Maintain Characteristic Hydrologic Regime, Maintain Characteristic Biogeochemical Processes, and Maintain Characteristic Plant Community functions.

This variable is the overall LU score of the wetland's catchment. Land-use changes (e.g., urbanization) in the catchment can have a dramatic impact on both the hydrologic regime of wetlands (Euliss and Mushet 1996, Azous and Horner 2001, Bhaduri et al. 1997) and nutrient loading into those wetlands.

The overall LU score is derived by dividing the catchment area into grids, and assigning each grid one of three general LU categories — urban, agricultural, and forested/grassland/wetland. Each category is assigned an individual score: urban = 5, agriculture = 3, and forest/grassland/wetland = 1. The overall LU score is average score of the individual grids. The values (1,3,5) are based on "national average" export coefficients for nitrogen and phosphorus as reported in Rast and Lee (1977), where urban watersheds on average exported 5.8 times as much, and rural/agricultural watersheds exported on average 3.3 times as much combined total phosphorus and total nitrogen than forested watersheds. Additionally, having more impermeable surfaces and the subsequent increase in runoff, urban LU will have more of an impact on hydrology than rural/agriculture LU. The LU scores can obviously be more finely tuned than the "rougher" estimates used here, as different sub-categories within the urban and rural/agriculture classifications will have different effects on runoff and nutrient loading. However, finer estimates would require an additional level of detail and accuracy that is not currently available in the LU maps that cover the entire reference domain.

In reference sites, catchment LU scores ranged from 1.00 to 4.27 in Isolated Depressions, and from 1.11 to 4.15 in Floodplain Depressions. In order to reflect the realistic possibility that future land-use changes can achieve variable scores outside the range of what was found in reference sites, the subindex curves allow for the entire range of possible scores (1.00 to 5.00) for this variable. In Isolated Depressions, the subindex score decreases linearly from 1.0 to 0.0 as the catchment LU score increases from 1.00. In Floodplain Depressions, the subindex score decreases linearly from 1.0 to 0.0 as the catchment LU score increases from 1.50, as reference standard Floodplain Depressions tended to have higher catchment LU scores than Isolated Depressions.

The variable subindex curve of V_{LUC} for Isolated Depressions is given in Figure 24.

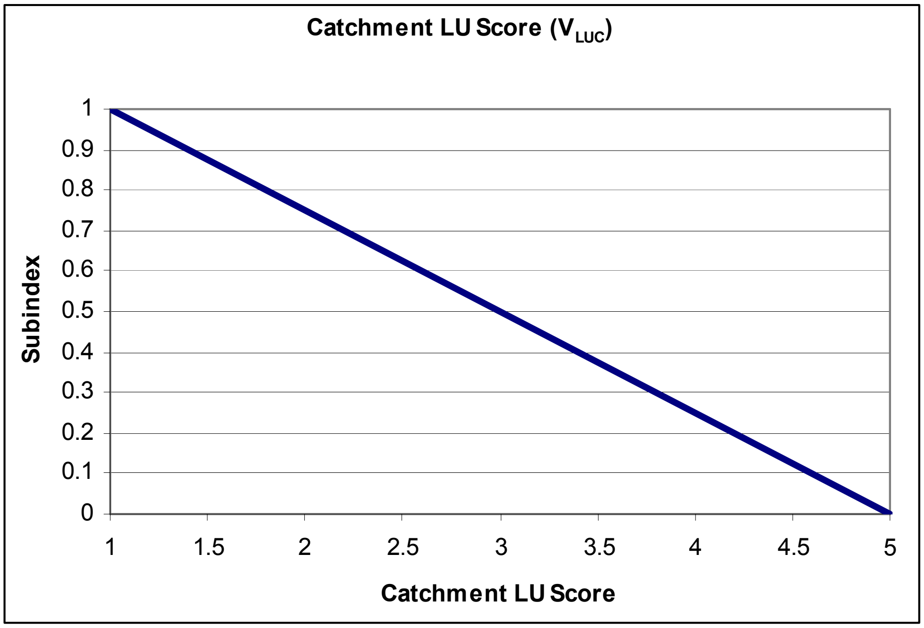

Figure 24. Relationship between catchment land-use score and subindex score in Isolated Depressions

The equation used to calculate the subindex score for V_{LUC} for Isolated Depressions is:

V_{LUC} = -0.25(Catchment LU Score) + 1.25

The variable subindex curve of V_{LUC} for Floodplain Depressions is given in Figure 25.

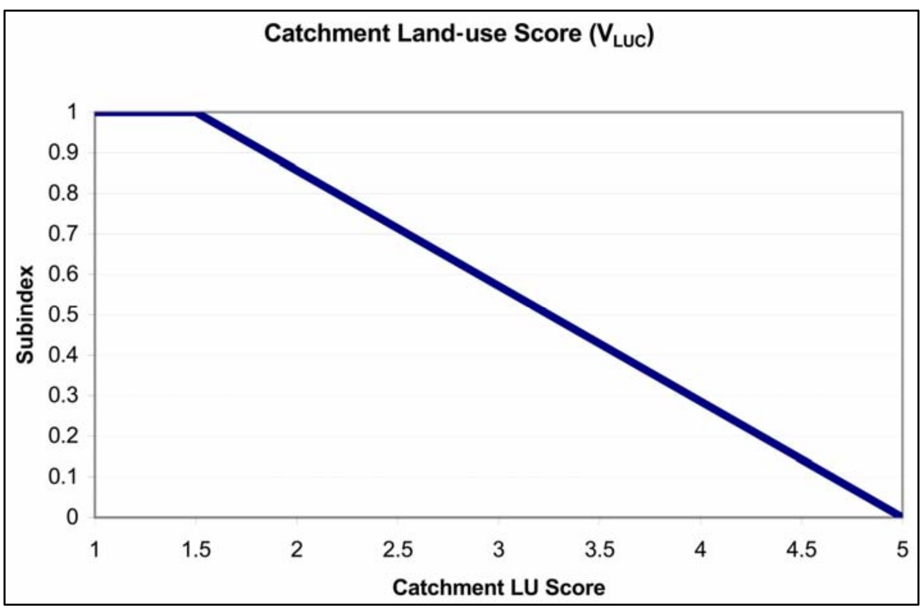

Figure 25. Relationship between catchment land-use score and subindex score in Floodplain Depressions

The equations used to calculate the subindex score for V_{LUC} for Floodplain Depressions are:

Catchment LU Score (LU) $\leq$ 1.5, V_{LUC} = 1.0
LU > 1.5, V_{LUC} = -0.2857(Catchment LU Score) + 1.4286

V_{NAT}: Percent of plant species that are native

Variable is used in Maintain Characteristic Plant Communities and Maintain Characteristic Fauna functions.

This variable is defined as the percent of total plant species counted at the site that are considered native in the FQA database. Some exotic species have the ability to out-compete native species, and having a high percentage of non-native species at the site can alter the natural ecosystem structure of the wetland, as well as serving as an indicator of unnatural levels of disturbance. Additionally, many faunal populations depend on native plants for food, cover, or nesting (Weller 1981).

In reference Isolated Depression sites, this variable ranged from 65 to 96 percent, with reference standard sites having more than 95 percent native species. In Floodplain Depressions, this variable ranged from 70 to 99 percent in isolated depressions, with reference standard sites having more than 90 percent native species.

The equations used to calculate the V_{NAT} subindex score for Isolated Depressions and Floodplain Depressions are:

% Native species (NS) < 65, V_{NAT} = .001538(NS)
65 $\leq$ NS< 90, V_{NAT} = 0.036(NS) – 2.24
IF $\geq$ 90, V_{INV} = 1.0

The variable subindex curve of V_{NAT} for Isolated Depressions is given in Figure 26.

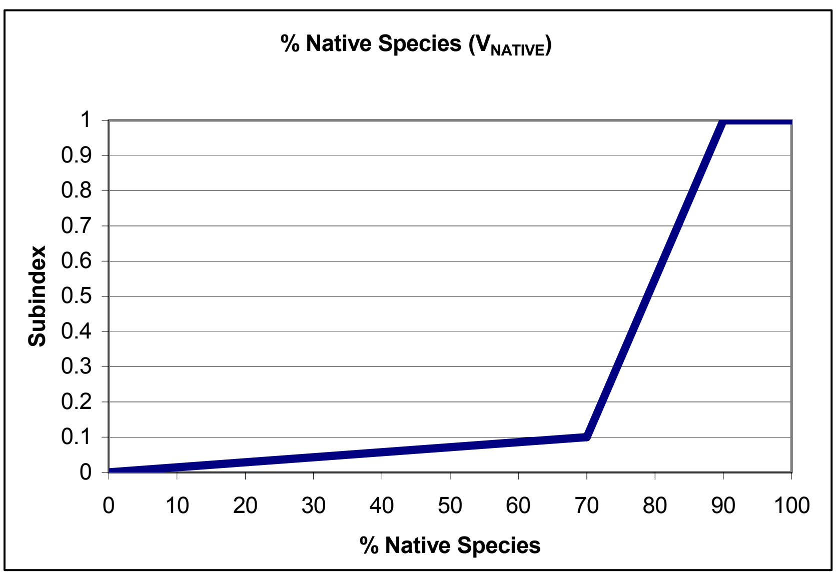

Figure 26. Relationship between native species percentage and subindex in Isolated Depressions

V_{OHOR}: Thickness of surface 'O' horizon

Variable is used in Maintain Characteristic Biogeochemical Processes and Export Organic Carbon (for Floodplain Depressions) functions.

This variable is defined as the thickness, in inches, of the 'O' horizon in the first 32 in. (80 cm) of the soil profile. It does not include 'O' horizons that are buried in the soil profile (beneath an A, B, C, or any mineral horizon or layer), because these below surface horizons are not as readily available for export or biological activity. The 'O' horizon is defined as a horizon containing greater than 20 percent by weight organic soil materials (Schoeneberger et al. 2002). The organic matter may range anywhere from partially to highly decomposed material.

Soil organic carbon is a source of and a sink for plant nutrients, aids infiltration, improves soil structure, promotes water retention, absorbs both anthropogenic and natural toxic substances, and is an energy source for heterotrophic organisms (Juregensen et al. 1989, Mitsch and Gosselink 2000, Craft 2001). This variable also serves as an indicator that nutrients in vegetative organic material are being recycled.

This variable is scaled differently, depending on whether the predominant soil type in the assessment area is mineral or organic. An organic soil (histosol) is defined as having 16 in. (40 cm) or more of the upper 32 in. (80 cm) as organic soil material (USDA, NRCS 2002). In the reference domain, organic soils, especially near the surface, will often be of a "mucky" texture. In reference Floodplain Depressions with mineral soils, average depth of surface 'O' horizons ranged from 0 to 6.5 in. (16.5 cm), and the average depth of surface 'O' horizons for organic soils ranged from 27.5 in. (69.9 cm) to 55 in. (139.7 cm, the maximum depth of the sample core). In Isolated Depressions, average depth of surface 'O' horizons in mineral soils ranged from 0 to 11.5 in. (29.2 cm), and average depth of surface 'O' horizons in organic soils ranged from 0 to 55 in. (139.7 cm).

The subindex curves are identical for Isolated and Floodplain Depressions if the soil is organic, with the subindex score decreasing linearly from 1.0 to 0 as the depth of the 'O' horizon decreases from 32 to 0 in. (80 to 1 cm). The subindex curves are scaled differently for the two subclasses if the soil is mineral, because Isolated Depressions with mineral soils tended to have deeper 'O' horizons in the Floodplain Depressions with mineral soils. In Isolated Depressions, the subindex score decreases linearly from 1.0 to 0 as the depth of the 'O' horizon decreases from 6 to 0 in. (15.2 to 0 cm). In Floodplain Depressions the subindex score decreases linearly from 1.0 to 0 as the depth of the 'O' horizon decreases from 3 to 0 in.

The variable subindex curves of V_{OHOR} for Isolated Depressions and Floodplain Depressions are given in Figures 27, 28, and 29.

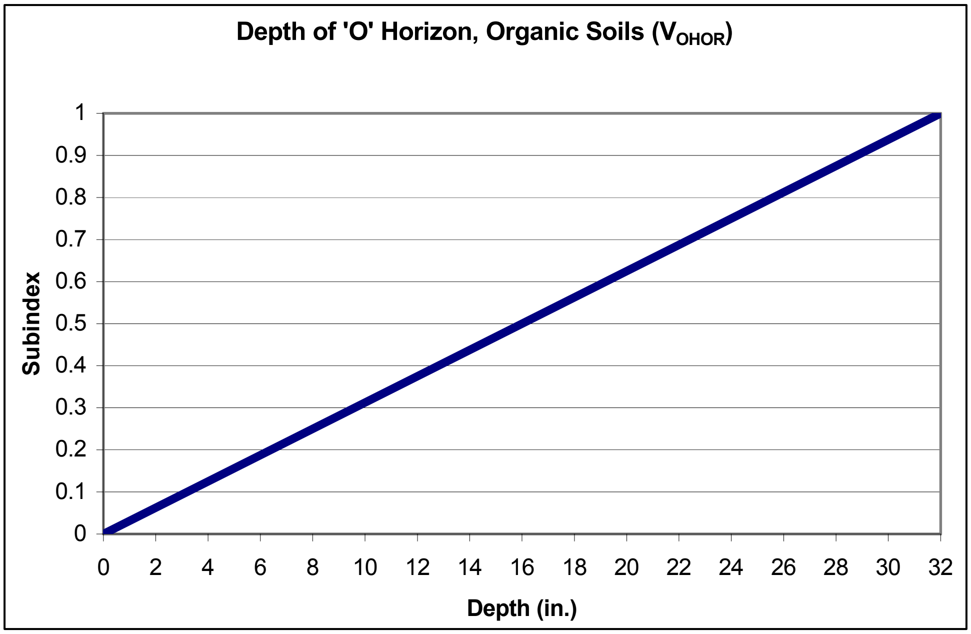

Figure 27. Relationship between ‘O’ horizon depth and subindex score in organic soils in Isolated Depressions and Floodplain Depressions

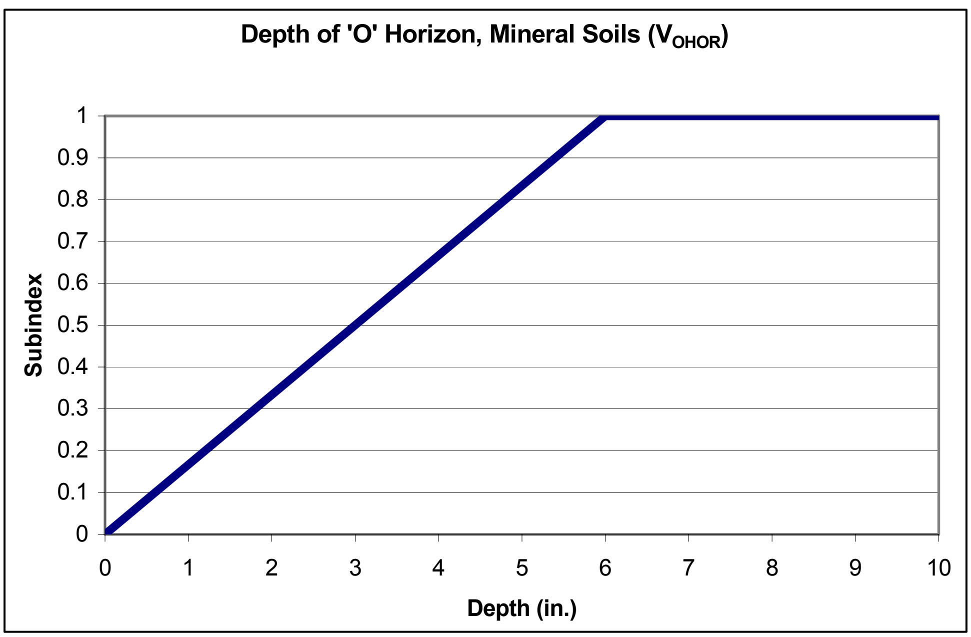

Figure 28. Relationship between ‘O’ horizon depth and subindex score in mineral soils in Isolated Depressions

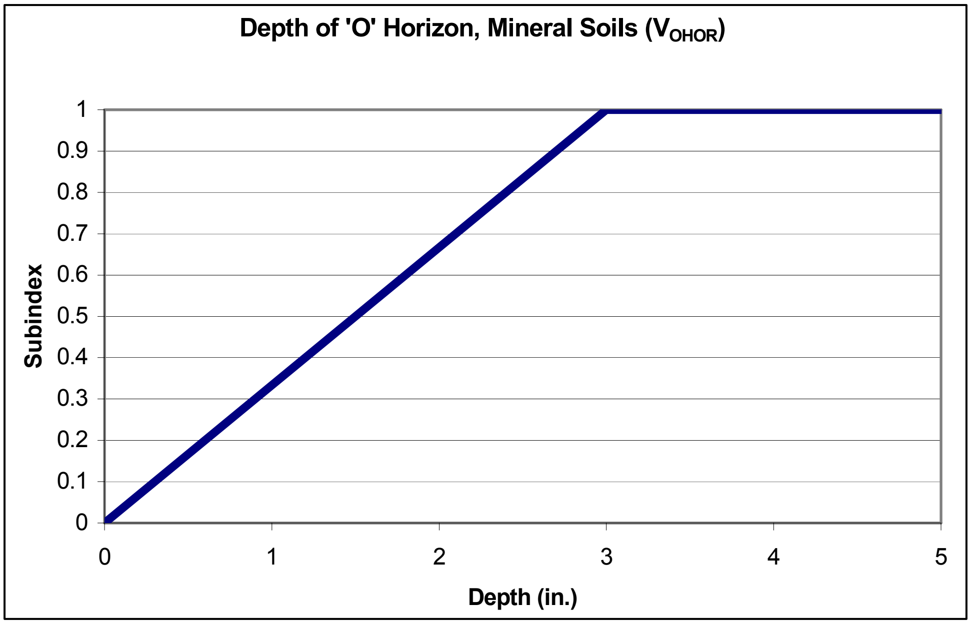

Figure 29. Relationship between 'O' horizon depth and subindex score in mineral soils in Floodplain Depressions

The equation used to calculate the V_{OHOR} subindex score for organic soils in Isolated Depressions and Floodplain Depressions is:

$V_{OHOR} = 0.03125(O)$

The equations used to calculate the V_{OHOR} subindex score for mineral soils in Isolated Depressions are:

Depth of O horizon $(O) \geq 6$, $V_{OHOR} = 1.0$
$O < 6$, $V_{OHOR} = 0.1667(O)$

The equations used to calculate the V_{OHOR} subindex score for mineral soils in Floodplain Depressions are:

Depth of O horizon $(O) \geq 3$, $V_{OHOR} = 1.0$
$O < 3$, $V_{OHOR} = 0.333(O)$

V_{SOIL}: Soil structure

Variable is used in the Maintain Characteristic Hydrologic Regimes and Maintain Characteristic Biogeochemical Processes functions.

This variable measures the percentage of the first 12 in. (30 cm) of the soil profile that is either a plow layer (an Ap horizon, which generally indicates past agricultural activity at the site), or has a "platy" or "massive" structure. It is used to assess anthropogenic impact to the natural near-surface properties of the soil.

Each soil has a naturally occurring arrangement of soil particles into distinct aggregates or shapes. At reference standard sites, soils are of primarily granular or subangular blocky shape. However, the natural aggregates can be altered or destroyed by disturbance. Soil compaction, for instance, can join aggregates and create a ‘massive’ or a ‘platy” structure, which results in decreases in pore size, water filled pore space, and soil temperature. These changes affect the activity of soil organisms by decreasing the rate of decomposition of soil organic matter and the subsequent release of nutrients. (USDA, NRCS 1996).

In both Isolated and Floodplain Depressions, the subindex score decreases linearly from 1.0 to 0 as the percentage of soil altered increases from 0 to 100 percent.

The variable subindex curve of V_{SOIL} for both Isolated Depressions and Floodplain Depressions is given in Figure 30.

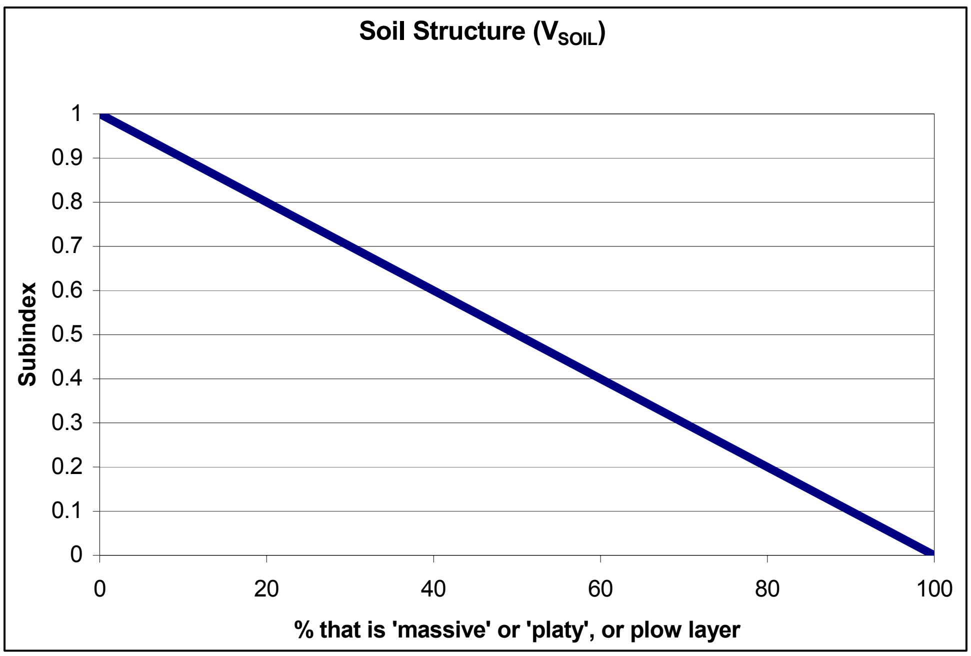

Figure 30. Relationship between soil structure and subindex score

The equation used to calculate the V_{SOIL} subindex score is:

$$V_{SOIL} = -0.01(SOIL) + 1.0$$

Alternate method of scaling V_{SOIL}. If the people applying this model in the field do not have the ability to readily discern a plow layer or the structure of the soil, this variable may be alternately scored using Table 9, which requires knowledge of any soil disturbance in the assessment area. Recognizing that alterations to the native soil may vary in their level of impact, an “average” subindex score of 0.4 is assigned if any alteration at all is known to have occurred in the past 20 years. If plowing or compaction has occurred between 20 and 50 years ago, it is presumed that the native soil properties have partially returned to what they were prior to the alteration, and a subindex score of 0.7 is assigned. At greater than 50 years, it is assumed that the native soil properties have fully returned to what they were prior to alteration, and there is no decrease in subindex score. These values and time periods are based on best professional judgment.

Table 9
Subindex Scaling for V_{SOIL} (Alternate Method) for Isolated and Floodplain Depressions

Soil Structure/Alteration	Subindex
No known alterations to native soil, or plowing or compaction occurred > 50 years ago	1.0
Native soils have been plowed or compacted within the past 20-50 years	0.7
Native soils have been buried with fill, or plowed or compacted within the past 20 years	0.4

V_{TSSC}: Tree-shrub-sapling percent cover

Variable is used in Maintain Characteristic Fauna function.

This variable is defined as the percent cover of living trees, shrubs, and saplings (all woody vegetation ≥ 4.5 ft (1.4 m) tall) in the assessment area. It partly accounts for the vegetative structure for wildlife habitat at the site. By definition, isolated depressions are non-forested (≤ 30 percent cover of trees/shrubs/saplings), although most sites contained at least a few trees and shrubs, especially near the edge of the wetland. Reference standard sites all had tree-shrub-sapling percent coverage of less than 10 percent. A larger percentage of tree-shrub-sapling percent coverage in these herbaceous wetlands is generally attributable to the encroachment of invasive species, such as common buckthorn (*Rhamnus cathartica*) and glossy buckthorn (*Rhamnus frangula*). Therefore, the subindex score decreases as the tree-shrub-sapling coverage increase above 10 percent. This variable is scored categorically using percent cover ranges.

The variable subindex scaling of V_{SNAG} for Isolated Depressions and Floodplain Depressions is given in Table 10.

Table 10
Subindex Scoring of V_{TSSC}

Tree-Shrub-Sapling % Cover	Subindex
0-10 percent	1.0
11-20 percent	0.7
21-30 percent	0.3

V_W: Plant wetness (W) score

Variable is used in the Maintain Characteristic Hydrologic Regime function.

This variable is the W/adventives (coefficient of wetness, including adventive species) score obtained from a site inventory Floristic Quality Assessment of the assessment area. The W/adventives score is the average plant wetness (W) value for all plants in the assessment area. The W value is a number assigned to each plant based on its wetness designation (OBL = -5, FACW+ = -4, FACW = -3, FACW- = -2, FAC+ = -1, FAC = 0, FAC- = 1, FACU+ = 2, FACU = 3, FACU- = 4, UPL = 5). The plant wetness designations are from the 'Plants of the Chicago Region' book (Swink and Wilhlem 1994), which primarily uses the wetness designations from the 'National List of Plant Species that Occur in Wetlands' (Reed 1988), except in a few cases where Swink and Wilhelm assigned a designation if one was lacking in the national list, or they strongly disagreed with the designation given in the national list. Isolated Depression reference sites had W/adventive scores ranging from -0.7 to -3.8, with reference standard sites having scores ranging from -2.4 to -3.8. Deviation from the lower end (-2.4) of the range would suggest that the hydrology of the site is such that it has become too "dry" and would not support a reference standard plant community. A score > 0.0 would suggest that the site is no longer a wetland.

This variable is not used for Floodplain Depressions because in those sites the variable did not distinguish reference standard sites from other sites. In Isolated Depressions the subindex score decreases linearly from 1.0 to 0.2 (the 0.2 value was set based on the best professional judgment of the A-team) as the W/adventives score goes from -2.4 to 0. If the W/adventives score is >0.0, then the subindex is 0.0.

The variable subindex curve of V_W for Isolated Depressions is given in Figure 31.

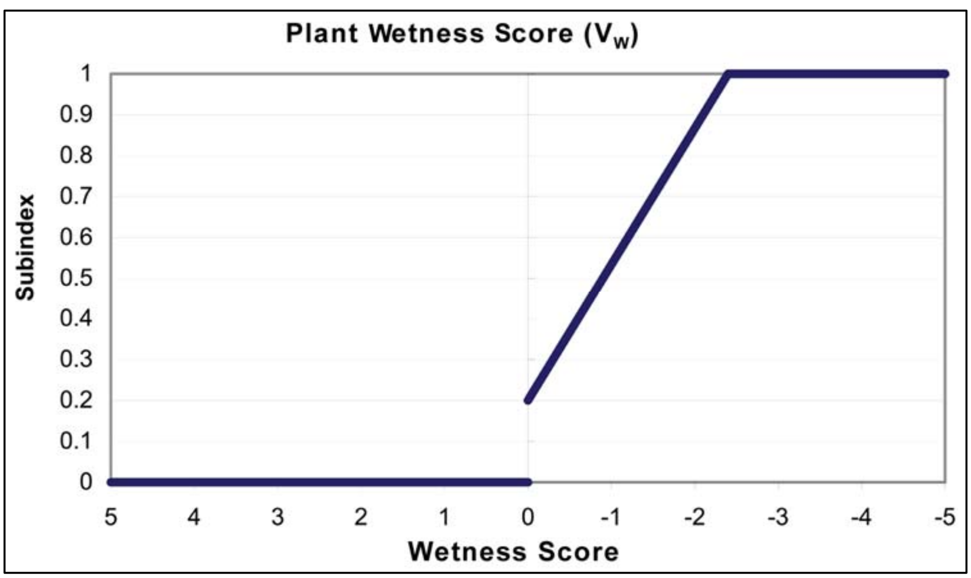

Figure 31. Relationship between W/adventives score and subindex score in Isolated Depressions

The equations used to calculate the V_W subindex score are as follows:

W/adventives > 0, $V_W = 0.0$
-2.4 < W/adventives ≤ 0 , $V_W = -.3333(W/adventives) + 0.2$
W/adventives ≤ -2.4, $V_W = 1.0$

V_{W500}: Wetlands within 500 m

Variable is used in Maintain Characteristic Fauna function.

This variable is a weighted measure of the number of wetlands located within 500 m of the assessment area. Each wetland within 500 m is multiplied by a factor from 1 to 3 based on its distance from the assessment area. The 'wetlands within 500 m score' is the sum of all the weighted values. More weight is given to wetlands that are closer to the assessment area, under the logic that a) closer wetlands will be more accessible to species with a limited dispersal range, and b) the less distance required for travel, the less chance deadly hazards will be encountered. Road traffic, for instance, can be a barrier to effective dispersal by amphibians (Fahrig et al. 1995). The 500-m dispersal range and the weighting system used here were selected based on the best professional judgment of the author and the A-team.

This variable is important at a landscape level (although it is more relevant for mammals, amphibians, and reptiles, than it is for birds), especially within the context of a mosaic of small wetlands (Gibbs 1993). It approximates both the density and proximity of wetlands in an area, and measures the ability of a meta-populations of animals to move from one wetland to another, thus increasing their viability.

In reference Isolated Depressions, scores ranged from 3.5 to 27.5. In reference Floodplain Depressions, scores ranged from 6 to 34. The scaling of the curve is based on the reference data and best professional judgment of the author.

The variable subindex curve of V_{W500} for Isolated Depressions is given in Figure 32.

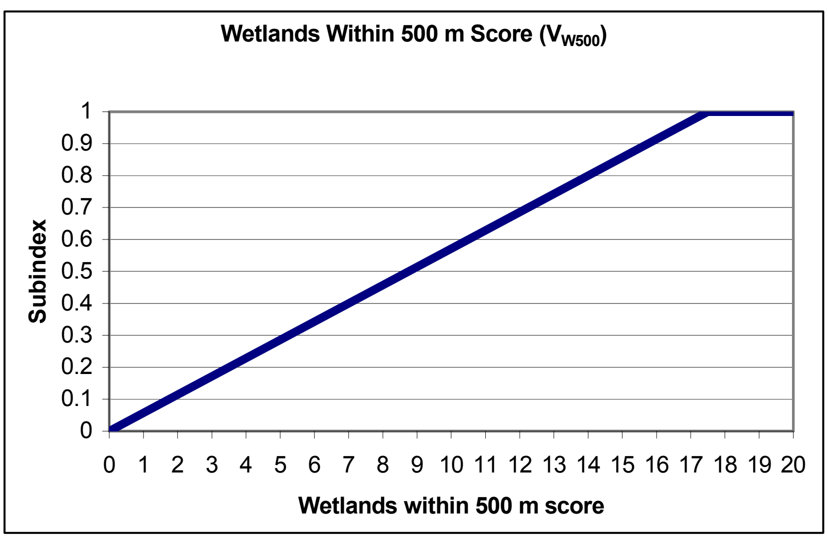

Figure 32. Relationship between wetlands within 500m score and subindex in Isolated Depressions

The equations used to calculate the V_{W500} subindex score for Isolated Depressions are:

W500 score ≥ 17.5, V_{W500} = 1.0
W500 score < 17.5, V_{W500} = 0.05714(W500)

The variable subindex curve of V_{W500} for Floodplain Depressions is given in Figure 33.

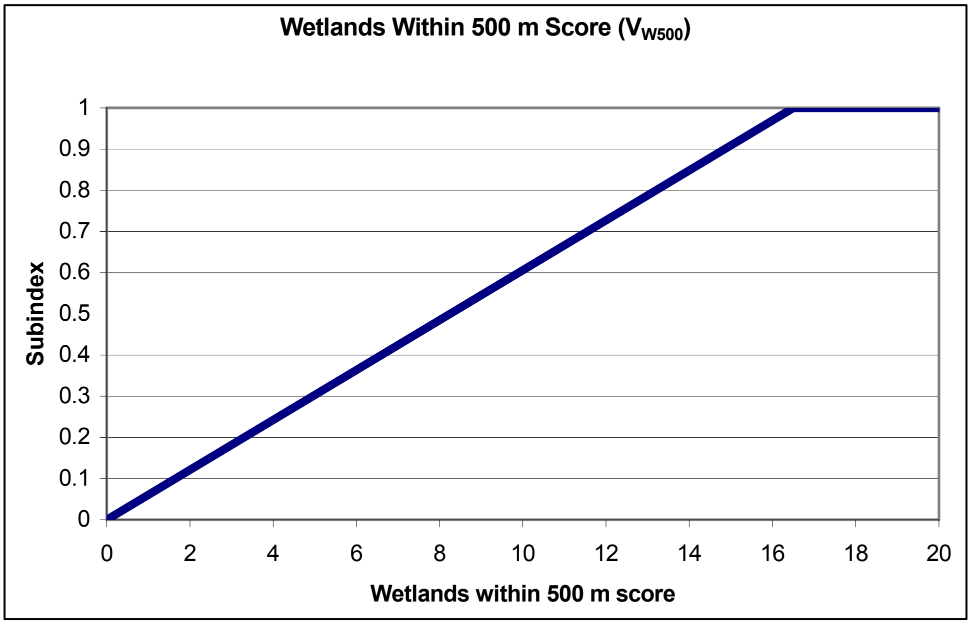

Figure 33. Relationship between wetlands within 500-m score and subindex in Floodplain Depressions

The equations used to calculate the V_{W500} subindex score for Floodplain Depressions are:

W500 score ≥ 16.5, V_{W500} = 1.0
W500 score < 16.5, V_{W500} = 0.0606(W500)

Functions

Functional Capacity Indices are, by definition, a measure of the function on a "per unit" basis, meaning that the size of the wetland is generally not taken into consideration when determining functional scores. For instance, with the "Maintain Characteristic Fauna" function, although wetland tract size is obviously correlated to available wetland wildlife habitat (10 acres of wetland provides more habitat than a similarly functioning 1 acre wetland), acre for acre the function is performed at the same level. Wetland size can be addressed through the use of Functional Capacity Units (FCUs), which are merely the size of the wetland multiplied by the individual functional capacity index. The use of FCUs is discussed in more detail in Appendix C.

Function 1: Maintain characteristic hydrologic regime

Definition. This function is defined as the capacity of a depressional wetland to maintain and exhibit variations in the depth and duration of surface and below-surface water levels, as well as the volume and frequency and timing of water inputs and outputs, similar to that found in reference standard conditions. In isolated depressions, this function occurs largely through the long- and short-term storage and movement of water received through runoff and direct precipitation, and in some systems, groundwater inputs. Floodplain depressions also have floodwater as another potential hydrologic input. Water can be lost from the system through evapotranspiration, groundwater recharge, or drainage through a natural or artificial outlet.

The function is modeled here by assessing direct and indirect evidence that the hydrologic regime has been modified. An independent measure of this function would be to use wells for long-term monitoring of the water table, and comparing hydrograph results between impacted and reference standard wetlands.

Rationale for selecting function. Maintenance of a characteristic hydrologic regime is integral to the performance of all other functions. For instance, the wetland must store water for a sufficient enough period of time to maintain other wetland characteristics (e.g., hydric soils and hydrophytic vegetation).

Prolonged saturation leads to anaerobic soil conditions, which is critical for the occurrence of several biogeochemical processes (such as the cycling of various elements, compounds, and nutrients) that are highly dependent on the oxygen concentrations and redox capacity of the soil (Mausbauch and Richardson 1994). A proper hydrologic regime is also necessary for the maintenance of a desirable plant community, and the creation of suitable faunal habitat.

Characteristics and processes that influence the function. In isolated depressions, the primary source of hydrology is direct precipitation into the wetland and associated runoff from the wetland catchment. In floodplain depressions, the primary sources of hydrology are direct precipitation into the wetland and associated runoff from the wetland catchment, as well as flooding from an associated stream channel. However, the extent and importance of stream flooding will vary among sites, depending on the nature of adjacent streams. For both subclasses, the hydrology of the wetland will generally be driven by the intensity, duration, areal extent, and frequency of precipitation events. Depending on its location in the watershed, groundwater may also play a substantial role in the hydrology of the depression. In the reference domain, precipitation during the late spring/summer/early fall period (April through September) is often associated with short thunderstorms (1 to 2 hr) and on a month-to-month basis is on average about twice as high then during the rest of the year (October through March), where precipitation is generally longer in duration but less intense (IDNR 1998).

The ability of the wetland to store surface and subsurface water is affected by a variety of natural and anthropogenic processes and activities. Climate and landscape scale geomorphic features are largely natural factors that influence the wetland's hydrology. On-site characteristics that directly affect this function include the relative size and volume of the wetland, soil sorption capabilities, and the amount of biomass present for evapotranspiration. Catchment characteristics can have a pronounced effect on hydrology (Brooks et al. 1991), and changes to the size or LU of the catchment will affect the timing and volume of runoff received in the wetland. Changes in LU (the removal of perennially vegetated areas in particular) can also increase erosional sediment loads into depressional wetlands, thereby decreasing their volume and reducing their water storage capacity and flood attenuation benefits (Ludden et al. 1983). Storage of water will also be affected by hydrologic modifications such as ditches or drainage tiles on or near the site, porosity of the soil, and, in the case of floodplain depressions, modifications to the stream channel that can either increase or decrease flooding to the site.

Ground vegetation cover can be used as an indicator of relative rates of evapotranspiration at both types of depressions. The presence of herbaceous vegetation can greatly increase evapotranspiration at a site. Broadleaf cattail (*Typha latifolia*), for instance, can in some cases have double or triple the evapotranspiration rate of an unvegetated area (Towler et al. 2004, Allen et al. 1997). Ground vegetation cover can also be used as an indicator that hydrologic alterations have occurred; sparse or stunted herbaceous vegetation at a site would suggest the hydrology is not able to support the vegetation. Similarly, the 'W' score (see the V_W variable) obtained from a Floristic Quality Assessment (Swink and Wilhelm 1994) is another possible vegetative indicator of the hydrologic condition of the wetland.

Functional Capacity Index. The model for assessing the Maintain Characteristic Hydrology function includes the following assessment variables:

- Variables used for Isolated Depressions:
  V_{ALT}: Presence of hydrologic alteration
  V_{CATCH}: Ratio of wetland area to catchment area
  V_{GVC}: Ground vegetation cover
  V_{LUC}: Land use of the catchment area
  V_{SOIL}: Soil structure
  V_W: FQA W/adventives score

- Variables used for Floodplain Depressions:
  V_{ALT}: Presence of hydrologic alteration
  V_{CATCH}: Ratio of wetland area to catchment area
  V_{GVC}: Ground vegetation cover
  V_{LUC}: Landuse of the catchment area
  V_{SOIL}: Soil structure

The forms of the assessment models are as follows:

a. *For Isolated Depressions:*

$$FCI = \frac{\left[\frac{\frac{(V_{GVC} + V_{SOIL} + V_{W})}{3} + V_{CATCH}}{2} + V_{ALT} + V_{LUC} \right]}{3}$$

The equation for this function measures direct (V_{ALT} and V_{LUC}) and indirect (V_{W}) indicators of change to the site hydrology, as well as relative storage capacity (V_{CATCH}, V_{SOIL}) and biomass (V_{GVC}) available for transpiration. More weight is given to V_{CATCH}, and the most weight is given to V_{ALT} and V_{LUC}, because, based on best professional judgment, those variables would presumably have a greater effect on site hydrology than the other three. Arithmetic means are used in the function, so the FCI would only equal 0.0 if all variable subindex scores equaled 0.0.

b. *For Floodplain Depressions:*

$$FCI = \frac{\left[\frac{\frac{(V_{GVC} + V_{SOIL})}{2} + V_{CATCH}}{2} + V_{ALT} + V_{LUC} \right]}{3}$$

The structure and logic of the model for this function in Floodplain Depressions are similar to the Isolated Depressions model, except V_{W} is not used.

Function 2: Maintain characteristic biogeochemical processes

Definition. This function is defined as the capacity of a wetland to maintain the rate, magnitude, and timing of various biogeochemical processes similar to that of reference standard conditions. These processes include the cycling of various nutrients and elements, organic matter accumulation and decomposition, and short- and long-term sequestration of inorganic and organic constituents. Directly and quantitatively measuring one or more of these processes, such as denitrification rates, net annual primary productivity, or annual rates of organic matter decomposition, can independently validate this function.

Rationale for selecting function. Biogeochemical processes are vital for determining and maintaining the nature of the wetland ecosystem. Nutrient cycling supports the development, growth, and subsequent decay and decomposition of the local plant community (Bormann and Likens 1970), which in turn provides habitat and energy sources for the animal community (Crow and MacDonald 1978). Nutrient cycling is a fundamental process performed by all ecosystems, but tends to be accomplished at particularly high rates in many wetland systems (Mitsch and Gosselink 2000).

This function also encompasses the removal and either storage or transformation of organic and inorganic elements and compounds (nitrogen, phosphorus, and various heavy metals, for example) from hydrologic inflows, which depressional wetlands are especially suited to do because of their location in the landscape (Crumpton and Baker 1993). The removal of elements and compounds has the value of providing water quality benefits by preventing or slowing the export of these contaminants from the wetland through groundwater or surface water and reducing pollution into a receiving lake, stream, or aquifer.

Characteristics and processes that influence the function. The ability of the wetland to perform this function depends upon the transfer of elements and materials between trophic levels within the wetland, rates of decomposition, and the movement of materials in and out of the wetland. These activities depend on a variety of biotic and abiotic processes. Biotic processes control the cycling and storage of nutrients among four major compartments: (a) the soil, (b) primary producers, such as vascular and nonvascular plants, (c) consumers, such as animals and bacteria, and (d) dead organic matter, such as litter and detritus. Decomposition and primary productivity rates will also depend on the hydrologic regime at the site. The removal and retention of elements and compounds from incoming water sources is affected by abiotic processes, such as the rate of water input and retention time, and the adsorption of materials to soil particles, and the actual amount of elements and compounds being delivered into the wetland. Also, the types and quantity of elements and compounds coming into the wetland will depend on the LU of its catchment, and the presence of any vegetative buffers. Wetlands, as the ecotone between terrestrial and aquatic environments (Naiman et al. 1989), are particularly subject to anthropogenic change that can affect material transport from the watershed or catchment into the wetland. Therefore, any changes to the natural soils, hydrology, vegetation, or LU surrounding the wetland can greatly impact the performance of this function.

This function is assessed by assuming that if material inputs, soil characteristics, and living and dead plant biomass in the wetland are similar to that of reference standard wetlands, then the biogeochemical processes will be occurring similarly as well.

Functional Capacity Index. The model for assessing the Maintain Characteristic Biogeochemical Processes function includes the following assessment variables:

V_{BUFFER}: Wetland buffer
V_{GVC}: Ground vegetation cover
V_{LUC}: Land use of catchment area
V_{OHOR}: Thickness of surface 'O' horizon
V_{SOIL}: Soil structure

The assessment model for this function is identical for Isolated Depressions and Floodplain Depressions. The form of the assessment model is:

$$FCI = \frac{\left[\frac{\left(V_{OHOR} + V_{GVC} + V_{BUFFER} \right)}{3} + V_{SOIL} + V_{LUC} \right]}{3}$$

The FCI for this function is calculated based on three general components: The first (V_{OHOR} and V_{GVC}) measure the amount of living and dead biomass at the site. The second (V_{SOIL}) measures disturbance to the soil and the subsequent effects on decomposition rates and nutrient storage, and the third (V_{LUC}, V_{BUFFER}) is a measure of inputs into the wetland. More weight is given to the V_{SOIL} and V_{LUC} variables because changes to these variables will likely have a greater impact on the amount and type of nutrients entering the wetland, as well as the length of time that the nutrients are stored for the processes of biogeochemistry to take place than the other three variables. Arithmetic means are used in the function so all variable subindex scores would have to equal 0.0 for the FCI to equal 0.0.

Function 3. Export organic carbon

Definition. This function is defined as the capacity of the wetland to export dissolved and particulate organic carbon produced in the wetland, which can be important for various ecological processes in downstream aquatic systems. The function is only applicable to the Floodplain Depressions subclass and not the Isolated Depressions subclass. An independent quantitative measure of this function is mass of carbon exported per unit area per unit time ([g/m^2]/yr).

Rationale for selecting function. The high productivity of wetlands connected to streams and rivers make them important sources of dissolved and particulate organic carbon for aquatic food webs and biogeochemical processes in downstream aquatic habitats (Vannote et al. 1980, Elwood et al. 1983, Sedell et al. 1989). Dissolved organic carbon is a significant source of energy for the microbes that form the base of the detrital food web in aquatic ecosystems, and possibly an energy source for shredders and filter-feeding organisms (Vannote et al. 1980).

Characteristics and processes that influence the function. Connected floodplain wetlands are able to export relatively high rates of organic carbon because of several factors, including: (a) the large amount of organic matter in the litter and soil layers that come into contact with surface water, (b) relatively long periods of inundation and, consequently, contact between surface water and organic matter, thus allowing for significant leaching, (c) the ability of the labile carbon fraction to be rapidly leached from organic matter when exposed to water, and (d) the ability of floodwater and precipitation runoff to transport dissolved and particulate organic carbon from the floodplain to the stream channel.

Performance of this function requires two general components: the production of organic carbon on site, and a mechanism for mobilizing and exporting it. Although the primary export mechanism (< 10-year flooding) is similar among floodplain depressions, the capability of the site to export carbon can be affected by alterations to the site hydrology.

Functional Capacity Index. The model for assessing the Maintain Characteristic Hydrology function includes the following assessment variables:

$V_{ALT-OEX}$: Presence of hydrologic alteration (stream portion)

V_{GVC}: Ground vegetation cover

V_{OHOR}: Thickness of surface 'O' horizon

The form of the assessment model is:

$$FCI = \frac{\left(V_{GVC} + V_{OHOR}\right)}{2} \times V_{ALT-OEX}$$

The FCI for this function measures the relative amount of living and dead biomass (V_{GVC} and V_{OHOR}) available for export, and hydrologic alterations ($V_{ALT-OEX}$) that can affect the flooding regime and, therefore, the ability of the site to export carbon. The two components are multiplied as organic carbon export cannot occur without both the carbon source and the export mechanism. Therefore, either component is equal to 0.0, the FCI will also equal 0.0.

Function 4: Maintain characteristic plant communities

Definition. This function is defined as the capacity of a wetland to provide the environment necessary for a characteristic plant community to develop and be maintained. In assessing this function, one must consider both the extant plant community as an indication of current conditions and the physical factors that determine whether or not a characteristic plant community is likely to be maintained in the future. A potential independent measure of this function would be to use direct or indirect ordination methods based on vegetation composition and abundance, as well as other environmental factors.

Rationale for selecting function. This function is important not only for the intrinsic value of the plant community, but also because the plant community influences other wetland processes, such as productivity and biogeochemical cycling, as well as providing habitat and food for wildlife communities.

Characteristics and processes that influence the function. A variety of physical and biological factors influence the ability of depressional wetlands to maintain characteristic plant communities. Fundamentally, the nature of the plant community will largely be influenced and maintained by the local hydrology (Goslee et al. 1997, Godwin et al. 2003). However, in recent history, anthropogenic alterations in and surrounding wetlands have greatly impacted depressional wetlands and their plant communities. Urbanization, conversion of natural lands to agriculture, and associated hydrologic manipulations have led to increased sedimentation, nutrient loading, and changes in the hydrologic regime in many wetlands. One of the major consequences of these changes is the aggressive establishment of non-native and invasive plant species (Kercher and Zedler

2004a). Once established, these species are often difficult to remove, and can prevent the growth of a more diverse plant community and possibly alter other fundamental ecological properties of an area, such as plant productivity and nutrient cycling (Mack et al. 2000). Wetlands, owing to their landscape sink position where disturbances, moisture, and nutrients all accumulate, are perhaps especially susceptible to invasions by single species that become monotypes (Zedler and Kercher 2004). Indeed, it is now typical for depressional wetlands in the Upper Des Plaines Basin to consist primarily of thick, near monotypic stands of cattails (*Typha spp.*) or reed canary grass (*Phalaris arundinacea*). Both of these species can thrive and are competitive dominants under a variety of hydrologic regimes, especially under high nutrient conditions (Kercher and Zedler 2004b).

To assess this function, both current vegetation compositions as well as environmental factors that can influence vegetation composition are evaluated.

Functional Capacity Index. The model for assessing the Maintain Characteristic Plant Communities function includes the following assessment variables:

V_{ALT}: Presence of hydrologic alteration
V_C: Native mean c score
V_{CAT}: Cover of *Typha spp.*
V_{FQI}: Native FQI score
V_{INV}: Invasive species cover (excluding *Typha spp.*)
V_{LUC}: Land use of the catchment area
V_{NAT}: Percent of plant species that are native

The assessment model for this function is identical for Isolated Depressions and Floodplain Depressions. The form of the assessment model is:

$$FCI = \left\{ \frac{\left(\frac{V_{NAT} + V_{FQI} + V_C}{3} \right) + \sqrt{\left(V_{INV} \times V_{CAT} \right) \times \left(\frac{V_{ALT} + V_{LUC}}{2} \right)}}{2} \right\}$$

The mathematical expression of the model has three general components. The first component (V_{NAT}, V_{FQI}, V_C) describes the composition of the extant plant community. The second and third components address the ability of that current community to either be maintained (if desirable) or improved. The second component measures the extent of various invasive plant species (V_{INV} and V_{CAT}) in the wetland, which can inhibit the establishment of a desirable native plant community. These two variables are multiplied to reflect the overriding effect of the V_{INV} variable on the V_{CAT} variable, i.e., having a high V_{CAT} subindex score (low *Typha* cover) does not benefit the function if the reason for low *Typha spp.* cover is that the site is completely covered with *Phalaris arundinacea*. V_{INV} and V_{CAT} are weighted heavily in this function, because they reflect both the nature of the current plant community and the capacity of that community to be positively altered. The third component (V_{ALT} and V_{LUC}) represents other on- and near-site environmental factors that, through a variety of factors, can influence the establishment and maintenance of the plant community. The geometric mean of these two components is used so that if either component is equal to 0.0, then the entire “maintain/improve” portion of the function would equal 0.0. However, for the entire function to equal 0.0, all variables in the function would have to equal 0.0.

Function 5: Maintain characteristic fauna

Definition. This function is defined as the capacity of a wetland to support and maintain a characteristic diversity and abundance of wildlife species that utilize wetlands during some part of their life cycles. This function includes maintaining habitat within the wetland and the surrounding area, as well as connectivity among wetlands within the landscape. Various existing animal inventory methods can be used as an independent measure of this function.

Rationale for selecting function. A variety of vertebrate and invertebrate species utilize wetlands during some or all of their life cycle. High performance of this function indicates that the wetland remains suitable for these wildlife species to utilize for refuge, habitat, and breeding.

Characteristics and processes that influence the function. The use of wetland depressions by wildlife is influenced by a variety of spatial, temporal, and structural factors. One of the most important factors within the wetland influencing wildlife is the structure and composition of the plant community (van der Valk 1989, Weller 1987). The plant community can be suitable, to various degrees, for food, shelter, nesting, breeding, and foraging, depending on the complexity and composition of the vegetation. Also, an increase in plant diversity and habitat patchiness (having multiple areas of different vegetation types with sharp boundaries) will generally lead to a greater diversity of wildlife species utilizing the wetland. However, the spread of invasive plant species in the wetland can displace desirable native plants and animals. Areas taken over by reed canarygrass (*Phalaris arundinacea*), for instance, may be of little use to wildlife (Hoffman and Kearns 1997).

Hydrology is also a major factor influencing the quality of the wildlife habitat, both in its effect on the plant community, and in providing the seasonal inundation and ponded areas necessary for the breeding and survival of several species of insects and amphibians (Johnson 1987).

Landscape factors will also influence usage by wildlife, although the landscape factors addressed in this function pertain more towards the viability of mammals, amphibians, and reptiles then they do towards birds. Because of urbanization and conversion to agriculture, most natural areas have become fragmented and as a consequence many wetlands exist in isolated patches. The adverse effects of fragmentation have been well documented for birds (Askins et al. 1987, Kilgo et al. 1997), reptiles and amphibians (Semlitsch 1998, Semlitsch and Jensen 2001), and to a lesser extent, mammals (Nilon 1986, VanDruff and Rowse 1986, Nilon and VanDruff 1987).

Because of the fragmented landscape, wetland density and proximity to nearest neighbors are important determinants of the success of metapopulations, where organisms live in multiple populations that are occasionally connected through migration from one wetland to another (Gibbs 1993). For instance, many species of reptiles and amphibians will move overland to seek out wetlands with more favorable conditions when their current habitat has deteriorated (Beebee 1996). Successful movement of individuals and facilitation of metapopulations is more likely in areas that contain a high number of wetlands that are relatively close to one another. The presence of wildlife corridors, which can provide safety from predators and anthropogenic hazards, are also important for the movement of individuals between wetlands and from upland environments. Also, having other natural areas surrounding the wetland can provide essential core terrestrial habitat for many species (Semlitsch and Bodie 2003).

Besides reducing natural wildlife corridors and adjacent habitat, urban and agricultural LU can also have other negative effects on fauna. Certain amphibians and reptiles are particularly susceptible to changes in food sources brought about as a result of urbanization. For example, populations of the western fox snake (*Elaphe vulpine vulpine*) and eastern milk snake (*Lampropltis triangulum tiangulum*) are likely to be reduced over time because of the potential reduction of the species of rodent upon which they prey (SEWRPC 2003). Other amphibians and reptiles are highly sensitive to agricultural pesticides and herbicides. Ingestion of toads that have incidentally been sprayed by these chemicals, for instance, can prove fatal to hognose snakes (*Heterodon platirhinos*) (SEWRPC 2003).

Functional Capacity Index. The model for assessing the Maintain Characteristic Faunal Habitat function includes the following assessment variables:

V_{ALT}: Presence of hydrologic alteration
$V_{BUFFER:}$ Percentage of wetland perimeter that is buffered
V_{GVC}: Ground vegetation cover
V_{INV}: Invasive species cover (excluding *Typha spp.*)
$V_{LANDUSE}$: Land use within 300 m of site
V_{NAT}: Percent of plant species that are native
V_{TSSC}: Tree-shrub-sapling % cover
V_{W500}: Wetlands within 500-m score

The form of the assessment model is as follows:

$$FCI = \frac{\sqrt{V_{INV} \times \frac{\left(V_{NAT} + V_{ALT} \frac{\left(V_{GVC} + V_{TSSC}\right)}{2} \right)}{3}} + \frac{\left(V_{W500} + V_{BUFFER} + V_{LANDUSE}\right)}{3}}{2}$$

The mathematical expression of this model measures two general components necessary for performance of the function. The first component (V_{INV}, V_{TSSC}, V_{GVC}, V_{NAT}, and V_{ALT}) measures habitat quality inside the wetland, i.e., the structural and aerial distribution and composition of living and dead standing vegetation in the assessment area, and the potential for periodic inundation. V_{INV}

is given the most weight, and is multiplied with the average of the other variables, as a site that is completely covered with invasive species would have little wildlife value (Hoffman and Kearns 1997). Although hydrology is an important factor, V_{ALT} is not given more weight because hydrologic changes would potentially also be reflected in some of the other variables in this component.

The second component (V_{BUFFER}, V_{W500}, and $V_{LANDUSE}$) measures landscape factors that can influence the function. The FCI is equal to the arithmetic mean of both components. Even if the wetland itself is currently poor wildlife habitat, if it is restored, the improved habitat and fauna will be more sustainable if the surrounding landscape factors are optimal. Therefore, both components would have to equal 0.0 for the FCI to equal 0.0.

5 Assessment Protocol

Introduction

Previous chapters of this Regional Guidebook provide background information on the HGM Approach, and document the variables and models used to assess the functions of Herbaceous Isolated Depression and Herbaceous Floodplain Depression wetlands. This chapter outlines a protocol for collecting and analyzing the data necessary to assess the functional capacity of a wetland in the context of a 404 permit review process or similar assessment scenario.

The typical assessment scenario is a comparison of pre-project and post-project conditions in the wetland. In practical terms, this translates into an assessment of the functional capacity of the WAA under both pre-project and post-project conditions and the subsequent determination of how FCIs have changed as a result of the project. Data for the pre-project assessment are collected under existing conditions at the project site, while data for the post-project assessment are normally based on the conditions that are expected to exist following proposed project impacts. A skeptical, conservative, and well-documented approach is required in defining post-project conditions. This recommendation is based on the often-observed lack of similarity between predicted or engineered post-project conditions and actual post-project conditions. This chapter discusses each of the tasks required to complete an assessment of depressional wetlands:

a. Define assessment objectives.

b. Characterize the project site.

c. Screen for red flags.

d. Define the Wetland Assessment Area.

e. Collect field and GIS data.

f. Analyze field and GIS data.

g. Apply assessment results.

Define Assessment Objectives

Begin the assessment process by unambiguously identifying its purpose. This can be as simple as stating, "The purpose of this assessment is to determine how the proposed project will impact wetland functions." Other potential objectives could be as follows:

a. Compare several wetlands as part of an alternatives analysis.

b. Identify specific actions that can be taken to minimize project impacts.

c. Document baseline conditions at the wetland site.

d. Determine mitigation requirements.

e. Determine mitigation success.

f. Determine the effects of a wetland management technique.

Characterize the Project Area

Characterizing the project area involves describing the project area in terms of climate, surficial geology, geomorphic setting, surface and groundwater hydrology, vegetation, soils, land use, proposed impacts, and any other characteristics and processes that have the potential to influence how wetlands at the project area perform functions. The characterization should be written, and accompanied by maps and figures that show project area boundaries, jurisdictional wetlands, WAA (discussed later in this chapter), proposed impacts, roads, ditches, buildings, streams, soil types, plant communities, threatened or endangered species habitat, and other important features. Some information sources that will be useful in characterizing a project area are aerial photographs, topographic maps, available wetlands maps, and county soil surveys.

Screen for Red Flags

Red flags are features within or in the vicinity of the project area to which special recognition or protection has been assigned on the basis of objective criteria (Table 11). Many red flag features, such as those based on national criteria or programs, are similar from region to region. Other red flag features are based on regional or local criteria. Obviously, not all of the red flag features listed in Table 11 will be applicable to the Upper Des Plaines reference domain. Screening for red flag features represents a proactive attempt to determine if the wetlands or other natural resources in and around the project area require special consideration or attention that may preempt or postpone an assessment of wetland function. If a red flag feature exists, the assessment of wetland functions may not be necessary if the project is unlikely to occur as a result of the red flag feature. For example, if a proposed project has the potential to impact a threatened or endangered species or habitat, an assessment of wetland functions may be unnecessary because the project may be denied or modified strictly on the basis of the impacts to threatened or endangered species or habitat.

Table 11
Red Flag Features and Respective Program/Agency Authority

Red Flag Features	Authority[1]
Native lands and areas protected under the American Indian Religious Freedom Act	A
Hazardous wastes sites identified under CERCLA or RCRA	I
Areas protected by a Coastal Zone Management Plan	E
Areas providing Critical Habitat for Species of Special Concern	B, C, F
Areas covered under the Farmland Protection Act	K
Floodplains, floodways, or floodprone areas	J
Areas with structures/artifacts of historic or archeological significance	G
Areas protected under the Land and Water Conservation Fund Act	K
Areas protected by the Marine Protection Research and Sanctuaries Act	B, D
National wildlife refuges and special management areas	C
Areas identified in the North American Waterfowl Management Plan	C, F
Areas identified as significant under the RAMSAR treaty	H
Areas supporting rare or unique plant communities	C,H
Areas designated as Sole Source Groundwater Aquifers	I, L
Areas protected by the Safe Drinking Water Act	I, L
City, County, State, and National Parks	D, F, H, L
Areas supporting threatened or endangered species	B, C, F, H, I
Areas with unique geological features	H
Areas protected by the Wild and Scenic Rivers Act or Wilderness Act	D

[1]Program Authority/Agency
A = Bureau of Indian Affairs
B = National Marines Fisheries Service
C = U.S. Fish and Wildlife Service
D = National Park Service
E = State Coastal Zone Office
F = State Departments of Natural Resources, Fish and Game, etc.
G = State Historic Preservation Office
H = State Natural Heritage Offices
I = U.S. Environmental Protection Agency
J = Federal Emergency Management Administration
K = National Resource Conservation Service
L = Local Government Agencies

Define the Wetland Assessment Area

The WAA is an area of wetland within a project area that belongs to a single regional wetland subclass, and is relatively homogeneous with respect to the site-specific criteria used to assess wetland functions (i.e., hydrologic regime, vegetation structure, topography, soils, successional stage, etc.). In many project areas, there will be just one WAA representing a single wetland subclass, as illustrated in Figure 35. However, as the size and heterogeneity of the project area increase, it is more likely that it will be necessary to define and assess multiple WAAs or Partial Wetland Assessment Areas (PWAAs) within a project area.

At least three situations necessitate defining and assessing multiple PWAAs within a project area.

The first situation exists when widely separated wetland patches of the same regional subclass occur in the project area (Figure 34). The second situation exists when more than one regional wetland subclass occurs within a project area (Figure 35). The third situation exists when a physically contiguous wetland area of the same regional subclass exhibits spatial heterogeneity with respect to hydrology, vegetation, soils, disturbance history, or other factors that translate into a significantly different value for one or more of the site-specific variable measures. These differences may be a result of natural variability (e.g., zonation on large river floodplains) or cultural alteration (e.g., logging, surface mining, hydrologic alterations) (Figure 36). Designate each of these areas as a separate PWAA and conduct a separate assessment on each area.

There are elements of subjectivity and practicality in determining what constitutes a significant difference in portions of the WAA. Field experience with the regional wetland subclass under consideration should provide the sense of the range of variability that typically occurs, and the common sense necessary to make reasonable decisions about defining multiple PWAAs. Splitting an area into many PWAAs in a project area based on relatively minor differences resulting from natural variability should not be used as a basis for dividing a contiguous wetland into multiple PWAAs. However, zonation caused by different hydrologic regimes or disturbances caused by rare and destructive natural events (i.e., hurricanes) should be used as a basis for defining PWAAs.

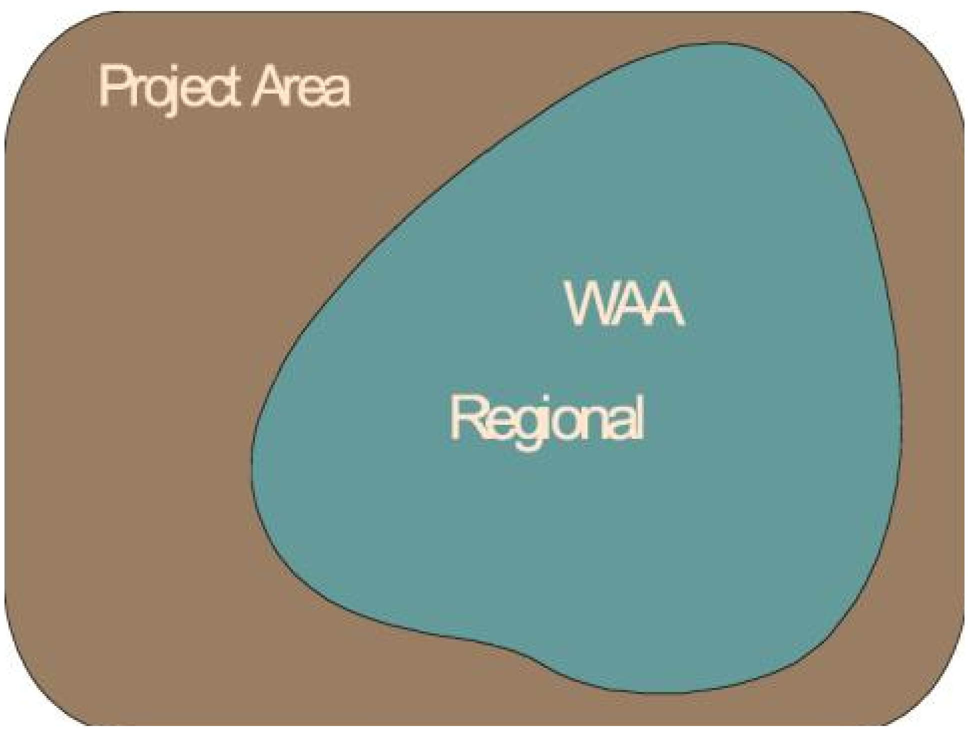

Figure 34. A single WAA within a project area

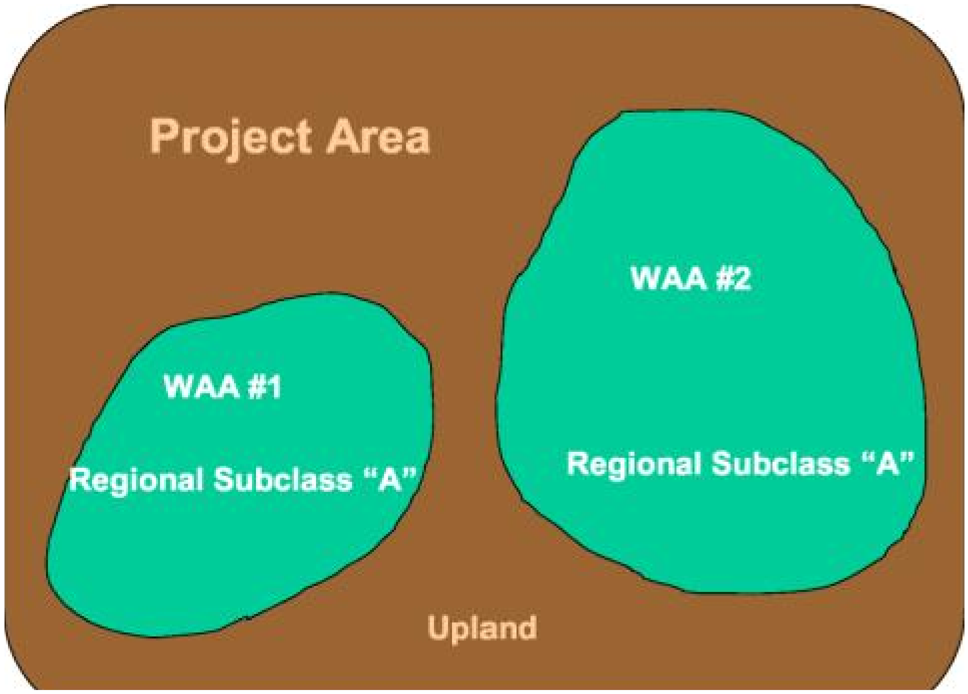

Figure 35. Spatially separated WAAs from the same regional wetland subclass within a project area

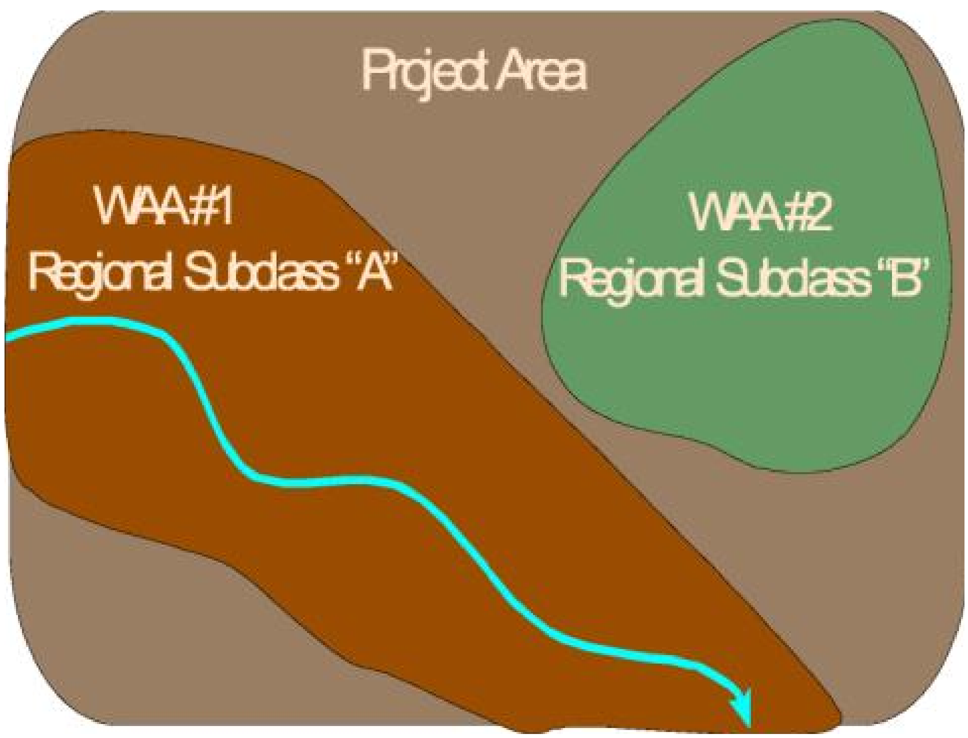

Figure 36. More than one regional subclass within a project area

Determine Subclass

The dichotomous key (Figure 4) provided in Chapter 3 can be used as a guide for determining wetland subclass. Determination of subclass can largely be done prior to the site visit with the use of various digital or hard copy maps. The first task is to determine whether or not the assessment area is located in a topographic depression. For the purposes of this model, a depression is defined as a wetland that is a minimum of 2 ft deep in at least some areas. Using a digital map and 2-ft contour lines, this would mean that there is at least one contour line drawn inside the wetland that is lower than all contour lines that form the edge of the wetland (see Figure 37 for an example). A 10-year flood coverage is essential for determining whether or not a site is considered a "floodplain" or "isolated" depression. If a 10-year coverage is not available for an area, the FEMA 100-year map can be used instead; because of the geomorphology of the reference domain, the 10- and 100-year floodplains are fairly similar.

Collect Field and GIS Data

Calculating the variable subindex scores used to assess functions in this guidebook requires a combination of field data collection and Geographical Information System (GIS) data collection and analysis. This section provides details on the methodology used to collect these data. In the case of GIS based data collection, although step by step instructions are provided for determining variable scores, the methodology assumes that the assessor has a working familiarity with ESRI's ArcView 3.x ® GIS software, on which the instructions are based. The same operations can also be performed using ESRI's ArcGIS 8.x and 9.x software, although the steps may differ slightly from what is presented here.

Field data

Although a single individual can collect the necessary field data, it is suggested that the field crew consist of at least two people. Besides safety and time considerations, the advantage of having two people is that they can concur on the visual estimate of variables requiring a percent cover range. At least one person on the field crew should, at minimum, be able to identify common sedge meadow and marsh plant species. One person in the field crew should also have the ability to identify and distinguish soil horizons.

The following equipment is recommended for the collection of field data:

a. Plant identification keys.

b. Soil probe/sharpshooter shovel.

c. Soil survey.

d. Meter stick.

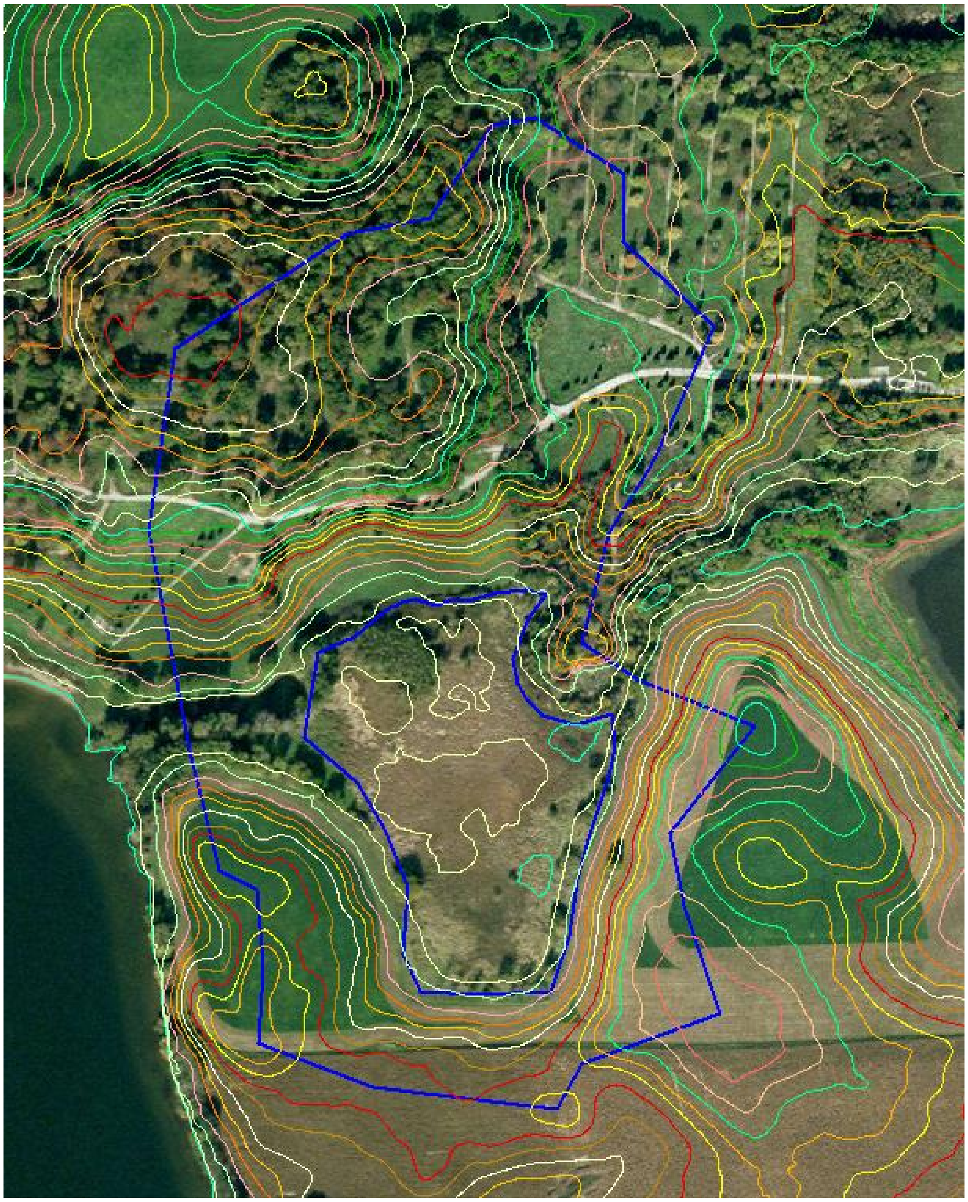

Figure 37. Example of wetland catchment drawn using 2-ft contour lines

Many of the field-collected data are visually estimated during a walk-through of the WAA, rather than through the use of data plots or transects. Because of the nature of many of these sites (which often have high levels of standing water), using plots or transects would often be either too time consuming, or physically impractical.

Several of these field data can also be measured using recent high-resolution aerial photography, but field reconnaissance of the site should also be done to confirm that no major changes have occurred to the site since the photograph was taken.

For smaller WAAs (< 25 acres), it is recommended that the samplers walk around the entire perimeter of the site, as well as, if feasible, walking at least one random transect across the site. For larger WAAs, the sampler should traverse selected areas, until they are confident that they have observed representative areas of the entire WAA. Field sampling of the entire assessment area should usually take no longer than 2 hr.

Soil data require the collection of at least three soil cores at each assessment area. More cores may be required if there is large variability in the soil types within the assessment area. Use the following steps to collect soil data (used for the V_{OHOR} and V_{SOIL} variables):

a. Use digital or hard copy soil survey maps to determine the dominant (> 50 percent aerial coverage) mapped soil type in the assessment area. Determine if the dominant soil type mapped is mineral or organic.

b. Select a minimum of three representative points within the boundaries of the dominant mapped soil type in which to collect soil cores. Representative areas can be selected when on site, generally by choosing areas that contain the dominant vegetative community of the assessment area. Cores should be taken up to 32 in. (81.3 cm) in depth, or to the end of the surface 'O' horizon, whichever comes first. The cores should also be of the same type (organic or mineral). Organic soils are defined as soils with at least 16 in. (40.6 cm) of organic material in the first 32 in. (81.3 cm) of the profile.

c. Measure the thickness of the organic material at the surface and average the thickness from the three cores to obtain a final depth of 'O' horizon measurement.

d. Using the same soil cores, determine how much of the first 12 in. (30 cm) has been plowed, or is of massive or platy structure (see instructions for V_{SOIL}).
or
Based on previous knowledge of the assessment area, note if it has been buried, plowed, or compacted, and when the alteration occurred (< 20 years ago, between 20-50 years ago, or > 50 years ago).

Data collected in the field are entered into Data Form 1 (Figure 38).

GIS data

The following data layers are necessary to collect the GIS-based data:

a. Land use coverages.

b. Contour line coverage.

c. Digital aerial photos.

If digital contour line maps or aerial photos are not available, USGS topographic maps can be used instead, although their use is less desirable and generally will not be as accurate for calculating variable scores.

DATA FORM 1: HGM FIELD DATA COLLECTION SHEET

Site [ ] **Date** [ ] **Type:** Isolated Floodplain

GENERAL FIELD DATA

Assessment Team [ ]

Ground Vegetation Cover (%) (Visual Estimate): OR [ ]

GVC (%) by plot: Plot 1_____2____ 3____ 4____ 5_____6_____7_____8_____9_____10_____11_____12_____AVG_____

Tree-Shrub-Sapling Cover (Circle One): 0-10% 11-20% 21-30%

Invasive Speceis Cover (Circle One): 0-5% 6-20% 21-50% 51-80% 81-94% 95-100%

***Typha spp.* Cover (Circle One):** 0-20% 21-50% 51-80% 81-100%

Hydrologic Alteration (Circle if Observed):

Ditch(es) within 50 meters of site

Alterations to stream channel: None Moderate Severe N/A

Tiles/evidence of tiling

FQA DATA

Native FQI Score [ ]

Native mean c score [ ]

W/adventives score [ ]

Native Species (%) [ ]

SOIL DATA

Dominant Soil Type of Assessment Area (Circle One): Mineral Organic

PLOT 1	**PLOT 2**	**PLOT 3**
"O" Horizon Depth (in.) [ ]	"O" Horizon Depth (in.) [ ]	"O" Horizon Depth (in.) [ ]
Massive or Platy Structure or Plow Layer (in.) [ ]	Massive or Platy Structure or Plow Layer (in.) [ ]	Massive or Platy Structure or Plow Layer (in.) [ ]

Figure 38. Field Data Sheet

Several variables in this model are designed to be collected using ESRI ArcView® software. The instructions provided for calculating each of these variables are for those using ArcView® 3.x, although the instructions will also largely be applicable for those using ArcView® 8.x/9x. The detail of the instructions assumes that the user has working knowledge of ArcView® 3.x, and the ability to edit and process polygons using the program.

The two essential polygons that must be created by the user are:

a. The wetland boundary.

b. The wetland's catchment.

Creating the polygon of the wetland boundary will require either a digital aerial photo (preferred method), or a digital topographic map. Using the "Create Polygon" feature in ArcView, digitize the entire wetland area, using the aerial photo or map as a guide. In lieu of digitizing the wetland boundaries, pre-existing polygons from a wetlands map (NWI, etc.) can be used, although, depending on the source, these may be less accurate.

The catchment can be drawn using digital contour lines as a guide (see Figure 37 for an example). The catchment does not include the wetland itself. The easiest way to create the catchment area is to draw the entire catchment polygon (including the wetland), then use the Geoprocessing "Erase" feature to erase the wetland area from it. What is left is defined henceforth as the catchment area.

To actually delineate the catchment, use these steps:

a. Identify the high points surrounding the wetland.

b. Draw a line connecting all the high points. This line should run as perpendicular to the contour lines as possible.

c. The wetland may be receiving additional drainage (from urban storm sewers, for instance) from outside the catchment area. If this is the case, the additional area needs to be included in the catchment area.

d. The real catchment may also be smaller, owing to the presence of elevated roads within the natural catchment. If these roads do not have drainage culverts, then the roads should be considered part of the boundary of the catchment.

Calculation of two of the variables requires use of the XTools extension for ArcView® 3.x, which has the ability to calculate the area and perimeter of polygons. XTools can be downloaded for free at this website: *http://arcscripts.esri.com/details.asp?dbid=11526.*

GIS data are recorded in Data Form 3 (Figure 39).

DATA FORM 2: HGM GIS DATA COLLECTION SHEET

Site ______ Date ______ Assessment Team ______

Wetland Area (ha): ______
Catchment Area (ha): ______
Wetland Area/Catchment Area ratio: ______

Catchment Landuse Score ______
300 m Landuse Score ______
Wetland Perimeter That is Buffered (percent) ______

Wetlands within 500 meters Assessment Area

Distance (m)	Number	Multiplier
0-100		3
101-200		2.5
201-300		2
301-400		1.5
401-500		1

Total Score: ______

Figure 39. GIS Data Sheet

Procedures for Measuring Assessment Variables

For each variable, it is indicated whether the data are collected primarily in the field or using GIS.

V_{ALT}: Presence of hydrologic alteration (field data)

Based on the site walk through or aerial photos, look for the presence of ditches in or within 50 m adjacent to the assessment area. With very large sites, aerial photos may need to be relied on, although smaller ditches may not appear on aerial photos. The presence of tiles is harder to determine; the indicator used here is that if a site has recently been taken out of agricultural production (and tiles have not been removed), it is assumed that the site has been tiled. Local knowledge may also be useful in determining whether a site has been tiled. For stream alteration (in the case of Floodplain Depressions), determine if no impact, moderate impact, or severe impact has occurred, using the criteria in Table 12. Also, see Figures 10, 11, and 12 in Chapter 4 for examples of these levels of impact.

Table 12
Descriptions of Impact Levels to Stream

Level of Impact	Description
No alterations/impact	No artificial levees, spoil piles, roads, etc. along the stream reach. Stream has not been downcut, channelized, or straightened.
Moderate impact	(a) Presence of artificial levees, spoil piles, roads, etc., along stream reach, and/or stream has been moderately downcut, channelized, and/or straightened. Generally, alterations have not been maintained and some of the natural stream morphology has returned. *and/or* (b) Knowledge that flooding frequency has been somewhat reduced from natural conditions, but is still < 10 years.
Severe impact	(a) Presence of artificial levees, spoil piles, roads, etc., along stream reach, and/or stream has been severely downcut/channelized, and/or straightened. Alterations are being maintained and the natural stream morphology is not apparent. *and/or* (b) Knowledge that flooding frequency has greatly reduced from natural conditions, and is > 10 years.

V_{BUFFER}: Wetland buffer (GIS data)

The files needed to calculate this variable are:

a. Wetland area shapefile.

b. Aerial photo, or topographic map, or county land-use file.

Use the following steps to calculate this variable score:

a. Use XTools to determine the length of the wetland perimeter.

b. Using the ArcView “Measuring” tool, manually determine the length of the wetland perimeter that is surrounded by buffer (using the aerial photo, topo map, or land-use coverage as a guide). Buffer is defined as any natural area (forest, wetland, grassland, etc.) ≥ 30 m in width.

c. Divide the buffered perimeter by the total wetland perimeter, and multiply by 100. This value is the raw V_{BUFFER} score, which is used to calculate the V_{BUFFER} subindex score.

V_{CAT}: Cover of *Typha spp*. (field data)

Based on the site walk through, visually estimate the percentage of the assessment area covered by *Typha spp*. Record the estimate as one of the following cover categories: 0-20 percent, 21-50 percent, 51-80 percent, 81-100 percent.

V_{CATCH}: Ratio of wetland area to catchment area (GIS data and field data)

The files needed to calculate this variable score are:

a. Wetland area shapefile.

b. Catchment area shapefile.

Use the following steps to calculate this variable score.

a. Use XTools to calculate the areas (unit not important) of the wetland area and its corresponding catchment area.

b. Divide wetland area by catchment area. This ratio is the raw V_{CATCH} score, which is then used to calculate the V_{CATCH} subindex score.

It is possible that the actual catchment area is either larger or smaller than the measured catchment area. There are two situations where the catchment size should be checked in the field:

a. There are urban areas adjacent to the measured catchment. In this case, it is possible that storm water is being diverted from the urban area into the wetland. If this is the case, then the extent of the urban area needs to be added to the catchment. The existence of storm drains from the adjacent areas should be verified in the field.

b. There are elevated roads in the catchment that do not have drainage culverts. If there are no culverts, then the road becomes part of the catchment boundary. The presence of culverts in these roads should be verified in the field.

V_{GVC}: Ground vegetation cover (GIS data or field data)

Based on the site walk through, visually estimate and record the percentage of the assessment area (not including open water areas) covered by living herbaceous plants. Most sites in the reference domain had ground vegetation cover of 95 to 100 percent, which is easy to visually estimate. If ground vegetation is lower than this, however, it is suggested that the percent cover is estimated in a minimum of 12 randomly placed 1-m^2 plots (the plots can be placed around the area the soil cores are taken). The percent ground vegetation cover of the assessment area is the average percent cover from the 12 plots. If aerial photography is available, this variable can also be estimated using the photo, although the field visit should be used to confirm that cover has not changed significantly from the photo.

V_{INV}: Invasive species % cover (field data)

Based on the site walk through, visually estimate the percentage range of the assessment area (not including open water areas) covered by invasive species, excluding any *Typha spp*. The percentage ranges used are 0-5, 6-20, 21-50, 51-80, 81-94, and 95-100 percent for isolated depressions, and 0-10, 11-25, 26-50, 51-80, 81-94, and 95-100 percent for floodplain depressions.

The most common invasive species in the reference domain is *Phalaris arundinacea* (reed canary grass), so this variable can often be scored by looking for percent cover of *P. arundinacea*. Other invasive species that will occasionally be found in abundance (enough to contribute meaningfully to a percent cover estimate) are *Phragmites australis* (common reed), *Lythrum salicaria* (purple loosestrife), and *Ambrosia trifida* (giant ragweed).

$V_{LANDUSE}$: Land use within 300 m of site
V_{LUC}: Land use of the catchment area (GIS data)

Calculation of the V_{LUC} and $V_{LANDUSE}$ variables requires use of the Spatial Analyst extension for ArcView® 3.x and a land-use file in GRID (raster) format. The land use then needs to be reclassified so that:

a. Urban (includes commercial, industrial, and all residential densities) = 5.

b. Agriculture (includes all farmland and pasture) = 3.

c. Natural (includes forest, grasslands, and wetlands) = 1.

If first converting from a shapefile to GRID, a cell size of 10 m^2 or less is recommended.

The files needed to calculate the $V_{LANDUSE}$ variable score are:

a. Wetland area shapefile.

b. Land-use GRID file.

Use the following steps to calculate the $V_{LANDUSE}$ variable score:

a. Use the “Create Buffers” feature to create a 300-m buffer around the wetland area shapefile.

b. Make sure the Spatial Analyst extension has been opened. Make the new buffer shapefile active, then go to “Summarize Zones” under the “Analysis” menu.

c. When asked, “Pick theme containing variable to summarize,” select the land-use grid file. A table of various statistics will then be displayed.

d. The “Mean” statistic is the raw $V_{LANDUSE}$ score, which is used to calculate the $V_{LANDUSE}$ subindex score.

The files needed to calculate the V_{LUC} variable score are:

a. Catchment area shapefile.

b. Land-use GRID file.

Use the following steps to calculate the V_{LUC} variable score:

a. Make sure the Spatial Analyst extension has been opened. Make the catchment area shapefile active, then go to "Summarize Zones" under the "Analysis" menu.

b. When asked, "Pick theme containing variable to summarize," select the land-use grid file. A table of various statistics will then be displayed.

c. The "Mean" statistic is the raw V_{LUC} score, which is used to calculate the V_{LUC} subindex score.

V_{OHOR}: Depth of 'O' horizon (field data)

Measure and average the depth of the 'O' horizon for all three soil cores. See the V_{OHOR} variable in Chapter 4 for more information on the 'O' horizon.

V_{SOIL}: Soil structure (field data)

For each core, determine the total depth of any layer that is either (a) a plow layer (Ap horizon) or (b) "massive" or "platy" in structure (Figure 40) in the first 12 in. of soil. Calculation example:

Layer	Depth (in.)	Structure
Ap	0-5	Granular
A1	5-11	Platy
A2	11-12	Granular

For the above profile, a total of 11 of the first 12 in. is either a plow layer and of 'platy' structure — so 11/12 = 92 percent.

V_{TSSC}: Tree-shrub-sapling vegetation percent cover (GIS/field data)

Based on the site walkthrough, visually estimate the percentage of the assessment area covered by living trees, shrubs, and saplings. Trees-shrubs-saplings are defined as all woody vegetation ≥ 4.5 ft (1.4 m) tall. Record the estimate as one of the following cover categories: 0-10 percent, 11-20 percent, 21-30 percent. This variable can also be estimated using aerial photography.

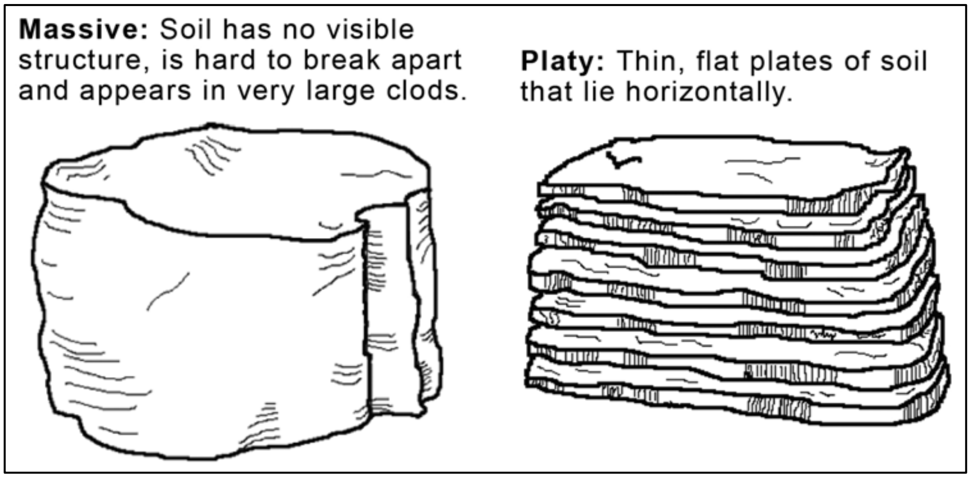

Figure 40. “Massive” and “Platy” soil structures

V_W, V_C, V_{FQI}, V_{NAT}: W/adventives score, native mean c, native FQI, percent of species that are native (field data)

All four of these variables are obtained from a site inventory Floristic Quality Assessment (FQA), based on a single visit (optimally during June through August). A site inventory FQA entails a walk through of the assessment area and making a record of every plant species that is seen. Each plant species is recorded once. It is suggested that the inventory is done using a time-meander search (Goff et al. 1982), using 15-min intervals, with a maximum search time of 2 hr (searches done during reference data collection were limited to 2 hr.) The survey ends when less than 10 percent (from the preceding interval) new species are found in the subsequent 10-min interval. For example:

a. In the first 15-min interval, 10 species are identified.

b. In the second 15-min period, 8 new species are identified (53 percent additional species, so the search continues).

c. In the third 15-min interval, 4 new species are identified (50 percent additional species from the previous interval, so the search continues).

d. In the fourth 15-min interval, no new species are identified. The search ends.

Calculation of W/adventives, native mean C, and native FQI requires either the FQA software with the Chicago Plant Database (both available from Conservation Research Institute/Conservation Design forum — *http://www.cdfinc.com/CRI/FQA%20Order%20Form%202004.pdf*) or either a printed copy of the Chicago Plant Database or the *Plants of the Chicago Region* book (Swink and Wilhelm 1994), in which case the variables can be calculated manually. V_{NAT} is calculated by dividing the number of native species from the total number of species, using the native/non-native designations from the FQA Chicago database.

V_{W500}: Wetlands within 500 m (GIS data)

The files needed to calculate this variable score are:

a. Polygon of wetland assessment area.

b. Wetlands map.

Use the following steps to calculate this variable score.

a. Use the "Buffer" tool to create a 500-m buffer, divided into 100-m segment bands, around the project area.

b. Count the number of wetlands ≥0.25 acre that are contained within each band. If a wetland spans across multiple bands, count it as belonging to the band it is in closest to the project area. The 0.25-acre minimum is used to eliminate small patches of misclassified areas in the land-use grids.

c. Multiply the number of wetlands in each band by the following:

- Band 1, (0-100 m) × 3.0
- Band 2, (101-200 m) × 2.5
- Band 3, (201-300 m) × 2.0
- Band 4, (301-400 m) × 1.5
- Band 5, (401-500 m) × 1.0

d. Add together the scores from all bands. This is the raw V_{W500} score, which is then used to calculate the V_{W500} subindex score.

Apply Assessment Results

Once the assessment and analysis phases are complete, the results can be used to (a) compare the same WAA at different points in time, (b) compare different WAAs at the same point in time, (c) compare different alternatives to a project, or (d) compare different HGM classes or subclasses as per Smith et al. (1995).

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Appendix A
Glossary

Abiotic: Not biological.

Assessment model: A simple model that defines the relationship between ecosystem and landscape scale variables and functional capacity of a wetland. The model is developed and calibrated using reference wetlands from a reference domain.

Assessment objective: The reason an assessment of wetland functions is being conducted. Assessment objectives normally fall into one of three categories: documenting existing conditions, comparing different wetlands at the same point in time (e.g., alternatives analysis), and comparing the same wetland at different points in time (e.g., impact analysis or mitigation success).

Assessment team (A-Team): An interdisciplinary group of regional and local scientists responsible for classification of wetlands within a region, identification of reference wetlands, construction of assessment models, definition of reference standards, and calibration of assessment models.

Biotic: Of or pertaining to life; biological.

Direct impacts: Project impacts that result from direct physical alteration of a wetland, such as the placement of dredge or fill.

Direct measure: A quantitative measure of an assessment model variable.

Functional assessment: The process by which the capacity of a wetland to perform a function is measured. This approach measures capacity using an assessment model to determine a Functional Capacity Index.

Functional capacity: The rate or magnitude at which a wetland ecosystem performs a function. Functional capacity is dictated by characteristics of the wetland ecosystem and the surrounding landscape, and interaction between the two.

Functional Capacity Index (FCI): An index of the capacity of a wetland to perform a function relative to other wetlands in a regional wetland subclass. Functional Capacity Indices are by definition scaled from 0.0 to 1.0. An index of 1.0 indicates the wetland is performing a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An index of 0.0 indicates the wetland does not perform the function at a measurable level, and will not recover the capacity to perform the function through natural processes.

Glacial outwash: Sand and gravel that have been "washed out" from the ice in meltwater streams along the margin of a glacier.

Glacial till: Accumulations of unsorted, unstratified mixtures of clay, silt, sand, gravel, and boulders, leftover from glacial movements.

Highest sustainable functional capacity: The level of functional capacity achieved across the suite of functions by a wetland under reference standard conditions in a reference domain. This approach assumes that the highest sustainable functional capacity is achieved when a wetland ecosystem and the surrounding area are undisturbed.

Hydrogeomorphic wetland class: The highest level in the hydrogeomorphic wetland classification. There are five basic hydrogeomorphic wetland classes: depression, riverine, slope, fringe, and flat.

Hydrogeomorphic unit: Hydrogeomorphic units are areas within a wetland assessment area that are relatively homogeneous with respect to ecosystem scale characteristics such as microtopography, soil type, vegetative communities, or other factors that influence function. Hydrogeomorphic units may be the result of natural or anthropogenic processes. See **Partial wetland assessment area.**

Hydroperiod: The annual duration of flooding (in days per year) at a specific point in a wetland.

Indicator: Indicators are observable characteristics that correspond to identifiable variable conditions in a wetland or the surrounding landscape.

Indirect measure: A qualitative measure of an assessment model variable that corresponds to an identifiable variable condition.

Indirect impacts: Impacts resulting from a project that occur concurrently or at some time in the future, away from the point of direct impact. For example, indirect impacts of a project on wildlife can result from an increase in the level of activity in adjacent, newly developed areas, even though the wetland is not physically altered by direct impacts.

Invasive species: Generally exotic species without natural controls that out compete native species.

Jurisdictional wetland: Areas that meet the soil, vegetation, and hydrologic criteria described in the "Corps of Engineers Wetlands Delineation Manual" (Environmental Laboratory 1987) or its successor.

Loess: Windblown silt of late glacial and post-glacial age.

Mitigation: Restoration or creation of a wetland to replace functional capacity that is lost as a result of project impacts.

Mitigation plan: A plan for replacing lost functional capacity resulting from project impacts.

Mitigation wetland: A restored or created wetland that serves to replace functional capacity lost as a result of project impacts.

Model variable: A characteristic of the wetland ecosystem or surrounding landscape that influences the capacity of a wetland ecosystem to perform a function.

Organic matter: Plant and animal residue in the soil in various stages of decomposition.

Organic soil material: Soil material that is saturated with water for long periods or artificially drained and, excluding live roots, has an organic carbon content of 18 percent or more with 60 percent or more clay, or 12 percent or more organic carbon with 0 percent clay. Soils with an intermediate amount of clay have an intermediate amount of organic carbon. If the soil is never saturated for more than a few days, it contains 20 percent or more organic carbon.

Organic soils (Histosol): A soil of which more than half of the upper 80 cm (32 in.) is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic material.

Oxidation: The loss of one or more electrons by an ion or molecule.

Partial wetland assessment area (PWAA): A portion of a Wetland Assessment Area (WAA) that is identified a priori, or while applying the assessment procedure, because it is relatively homogeneous and different from the rest of the WAA with respect to one or more model variables. The difference may occur naturally or as a result of anthropogenic disturbance. See **Hydrogeomorphic unit.**

Project alternative(s): Different ways in which a given project can be done. Alternatives may vary in terms of project location, design, method of construction, amount of fill required, and other ways.

Project area: The area that encompasses all activities related to an ongoing or proposed project.

Project target: The level of functioning identified for a restoration or creation project. Conditions specified for the functioning are used to judge whether a project reaches the target and is developing toward site capacity.

Red flag features: Features of a wetland or the surrounding landscape to which special recognition or protection is assigned on the basis of objective criteria. The recognition or protection may occur at a Federal, state, regional, or local level and may be official or unofficial.

Reference domain: All wetlands within a defined geographic area that belong to a single regional wetland subclass.

Reference standards: Conditions exhibited by a group of reference wetlands that correspond to the highest level of functioning (highest sustainable capacity) across the suite of functions of the regional wetland subclass. By definition, highest levels of functioning are assigned an index of 1.0.

Reference wetlands: Wetland sites that encompass the variability of a regional wetland subclass in a reference domain. Reference wetlands are used to establish the range of conditions for construction and calibration of functional indices and to establish reference standards.

Region: A geographic area that is relatively homogeneous with respect to large-scale factors such as climate and geology that may influence how wetlands function.

Regional wetland subclass: Regional hydrogeomorphic wetland classes that can be identified based on landscape and ecosystem scale factors. There may be more than one regional wetland subclass for each of the hydrogeomorphic wetland classes that occur in a region, or there may be only one.

Site potential: The highest level of functioning possible, given local constraints of disturbance history, land use, or other factors. Site capacity may be equal to or less than levels of functioning established by reference standards for the reference domain, and it may be equal to or less than the functional capacity of a wetland ecosystem.

Soil surface: The soil surface is the top of the mineral soil; or, for soils with an "O" horizon, the soil surface is the top of the part of the "O" horizon that is at least slightly decomposed. Fresh leaf or needle fall that has not undergone observable decomposition is excluded from soil.

Value of wetland function: The relative importance of wetland function or functions to an individual or group.

Variable: An attribute or characteristic of a wetland ecosystem or the surrounding landscape that influences the capacity of the wetland to perform a function.

Variable condition: The condition of a variable as determined through quantitative or qualitative measure.

Variable index: A measure of how an assessment model variable in a wetland compares to the reference standards of a regional wetland subclass in a reference domain.

Wetland: See **Wetland ecosystems**.

Wetland ecosystems: In 404: "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Corps Regulation 33 CFR 328.3 and EPA Regulations 40 CFR 230.3). In a more general sense, wetland ecosystems are three-dimensional segments of the natural world where the presence of water at or near the surface creates conditions leading to the development of redoximorphic soil conditions, and the presence of a flora and fauna adapted to the permanently or periodically flooded or saturated conditions.

Wetland assessment area (WAA): The wetland area to which results of an assessment are applied.

Wetland functions: The normal activities or actions that occur in wetland ecosystems, or simply, the things that wetlands do. Wetland functions result directly from the characteristics of a wetland ecosystem and the surrounding landscape, and their interaction.

Wetland restoration: The process of restoring wetland function in a degraded wetland. Restoration is typically done as mitigation.

Appendix B
Reference Data

Site ID	Type	County	Rating[1]	Depth of surface "O" Horizon, in.	Mineral or Organic Soil?	Stream Alteration	Site Alteration(s)
CF1	Flood	Cook	2	15	both	severe	none observed
CI15	Flood	Cook	3	0	both	N/O	none observed
LF4	Flood	Lake	1	11.5	both	moderate	none observed
LF6	Flood	Lake	3.5	12	both	moderate	culverts
LI4	Flood	Lake	3.5	10.8	both	N/O	none observed
CF2	Flood	Cook	2	0	mineral	none	culvert
CF4	Flood	Cook	1.5	0	mineral	moderate	none observed
CF5	Flood	Cook	1.5	0	mineral	N/O	none observed
CF9	Flood	Cook	4.5	4	mineral	none	none observed
CI5	Flood	Cook	2	0	mineral	N/O	culvert
LF3h	Flood	Lake	4.5	3.8	mineral	none	adjacent ditch
LF3m	Flood	Lake	4	8	mineral	none	none observed
LF7h	Flood	Lake	3.5	6.5	mineral	N/O	none observed
LF11	Flood	Lake	3	1	mineral	moderate	none observed
LF12	Flood	Lake	2.5	0	mineral	moderate	none observed
LF15	Flood	Lake	4	3.3	mineral	moderate	none observed
LF16	Flood	Lake	3	0	mineral	none	none observed
LI5	Flood	Lake	2.5	3	mineral	N/O	beaver activity, culverts
CF6	Flood	Cook	4	55	organic	N/O	none observed
KF9	Flood	Kenosha	2.5	28	organic	N/O	none observed
KF12	Flood	Kenosha	2.5	33.5	organic	moderate	natural dam
KF25	Flood	Kenosha	2	27.5	organic	moderate	none observed
KF31	Flood	Kenosha	3	N/A	organic	N/O	cattle
LF5	Flood	Lake	3	55	organic	none	none observed
LF7m	Flood	Lake	2.5	37.5	organic	N/O	none observed
LF10	Flood	Lake	3.5	27	organic	none	ditch along road

[1] This was the rating initially assigned to the site based on the field visit.

Site ID	FQI (native)	Mean c (native)	W/Adventives	% Non Native Species	% GVC	% TSSC	% INV
CF1	13.3	3.1	-1.9	21	>95	<5	50
CI15	20.7	3.7	-3.4	14	>95	<5	20
LF4	5.2	3	-3.6	25	>95	<5	90
LF6	23.1	4.4	-3.3	11	>95	<5	40
LI4	19.8	3.5	-3.3	13	>95	<5	40
CF2	13.4	2.5	-2.1	15	>95	<5	25
CF4	13.2	3	-0.8	30	>95	<5	95
CF5	17.7	4.1	-3.9	14	>95	<5	60
CF9	27	4.2	-1.9	18	>95	<5	12.5
CI5	10.9	2.6	-2.3	26	>95	<5	30
LF3h	42.4	4.9	-2.8	1	> 95	<5	55
LF3m	28	4.1	-3.5	8	> 95	<5	35
LF7h	30.6	4.2	-2.9	12	>95	<5	7.5
LF11	19.6	3.3	-3.1	10	80	30	25
LF12	17.7	3.1	-1.2	16	65	30	30
LF15	32.6	5	-1.2	4	>95	7.5	25
LF16	16.8	3.2	-3	10	>95	10	10
LI5	15.8	3	-2.4	29	80	10	50
CF6	24.2	4.1	-3.5	15	>95	10	30
KF9	15.4	3.1	-2.3	11	90	<5	10
KF12	21.4	3.8	-2.2	11	>95	<5	10
KF25	12.7	3	-2.3	18	100	<5	95
KF31	17.4	3.9	-3.4	20	>95	<5	15
LF5	21.2	4.2	-3.7	7	>95	5	10
LF7m	25	4	-3.4	13	>95	<5	7.5
LF10	20.9	3.6	-2.6	19	>95	<5	80

Site ID	% Cattail	Snags	Wetland Area/ Catchment Ratio	Wetlands Within 500 m Score	Catchment LU Score	300 m Buffer LU Score	% of Wetland Perimeter that is Buffered
CF1	51-80	no	0.51	12.0	3.18	3.66	83
CI15	51-80	no	0.28	12.5	2.79	1.93	100
LF4	0-20	no	0.38	12.0	2.95	2.73	78
LF6	51-80	no	0.12	5.5	3.20	3.00	66
LI4	81-100	no	0.24	4.0	2.98	2.69	59
CF2	51-80	no	0.34	6.0	2.82	3.62	100
CF4	0-20	no	0.05	14.0	1.20	1.50	100
CF5	21-50	no	0.08	15.0	1.65	2.30	75
CF9	0-20	no	0.20	16.5	1.57	2.19	100
CI5	81-100	no	0.05	9.5	1.58	1.42	93
LF3h	51-80	no	1.04	32.5	2.32	2.12	80
LF3m	0-20	no	1.04	32.5	2.32	2.12	80
LF7h	81-100	no	0.39	14.5	3.19	2.46	16
LF11	81-100	yes	0.16	10.5	3.41	2.82	93
LF12	0-20	no	0.34	6.0	3.08	3.02	96
LF15	0-20	no	0.34	14.5	1.71	1.98	100
LF16	81-100	no	0.01	11.5	4.15	3.20	100
LI5	51-80	yes	0.15	34.0	3.72	3.70	3
CF6	51-80	no	0.32	6.0	1.72	1.67	100
KF9	81-100	no	0.02	6.0	3.10	3.06	62
KF12	81-100	no	0.53	17.0	2.29	2.39	89
KF25	0-20	no	0.23	12.0	2.55	2.38	39
KF31	81-100	no	0.25	17.5	2.63	2.41	95
LF5	0-20	no	0.54	9.0	1.31	1.84	92
LF7m	81-100	no	0.39	14.5	3.19	2.46	16
LF10	0-20	no	1.15	11.5	3.36	2.88	86

Site ID	Type	County	Rating[1]	Depth of surface "O" Horizon, in.	Mineral or Organic soil?	Site Alteration(s)
CI2	Isolated	Cook	1	0	both	none observed
CI6	Isolated	Cook	3.5	0	both	ditch
KI27	Isolated	Kenosha	3.5	13.5	both	none observed
KI34	Isolated	Kenosha	4	5	both	none observed
KI36	Isolated	Kenosha	3	30.3	both	culvert
LI11	Isolated	Lake	3.5	39.8	both	none observed
LI16	Isolated	Lake	4.5	10	both	none observed
CI8	Isolated	Cook	2	2	mineral	none observed
CI11	Isolated	Cook	4	0	mineral	none observed
CI14	Isolated	Cook	3	0	mineral	none observed
CI16	Isolated	Cook	4	1.5	mineral	none observed
CI17	Isolated	Cook	2	1.5	mineral	culvert
KI24	Isolated	Kenosha	4	2.5	mineral	culvert
KI50	Isolated	Kenosha	3	8	mineral	none observed
LF8	Isolated	Lake	1.5	0	mineral	plowed/tiled
LF13	Isolated	Lake	2.5	6.3	mineral	boardwalk
LI1	Isolated	Lake	1	4	mineral	dirt road
LI3	Isolated	Lake	1	0	mineral	site no longer wetland
LI7	Isolated	Lake	3.5	6.3	mineral	ditch along road
LI14	Isolated	Lake	3.5	0	mineral	none observed
LI15	Isolated	Lake	4	6.8	mineral	none observed
LI21	Isolated	Lake	3.5	11.5	mineral	none observed
LI22	Isolated	Lake	4	8.3	mineral	none observed
LI26	Isolated	Lake	4.5	2	mineral	none observed
CI1	Isolated	Cook	3	55	organic	none observed
CI4	Isolated	Cook	1.5	0	organic	none observed
CI10	Isolated	Cook	4	28.5	organic	none observed
CI12	Isolated	Cook	5	55	organic	none observed
KF1	Isolated	Kenosha	4	14.3	organic	none observed
KI21	Isolated	Kenosha	2	55	organic	none observed
KI37	Isolated	Kenosha	3.5	32	organic	none observed
KI40	Isolated	Kenosha	2	55	organic	none observed
KI42	Isolated	Kenosha	2.5	12.5	organic	none observed
LI2	Isolated	Lake	2	55	organic	old drain tile, site planted
LI12	Isolated	Lake	2.5	55	organic	old drain tile, site planted
LI25	Isolated	Lake	3.5	55	organic	none observed
LI27	Isolated	Lake	2.5	19.3	organic	none observed
LI28	Isolated	Lake	2.5	24.7	organic	none observed

[1]This was the rating initially assigned to the site based on the field visit.

Site ID	FQI (native)	Mean c (native)	W/Adventives	% Non Native Species	% GVC	% TSSC	% INV
CI2	4.5	1.7	-0.7	13	>95	<5	95
CI6	21.7	3.4	-2.2	16	>95	10	5
KI27	18.1	3.3	-1.7	20	>95	<5	20
KI34	22.6	3.4	-1.0	15	>95	<5	10
KI36	22.7	3.6	-3.2	17	>95	<5	7.5
LI11	14.1	3	-1.5	33	>95	<5	25
LI16	24.4	4.6	-2.6	15	>95	<5	7.5
CI8	9.8	2.8	-1.9	29	>95	<5	10
CI11	19.5	4.3	-3.8	15	>95	10	17.5
CI14	19.2	3.8	-3.3	7	>95	<5	50
CI16	21	3.8	-2.2	16	>95	<5	5
CI17	14.2	3.8	-2.2	13	10	20	5
KI24	18	3.3	-2.1	19	>95	20	20
KI50	18.8	3.7	-2.4	28	>95	<5	7.5
LF8	10.3	2.7	-1.1	35	>95	<5	55
LF13	20.6	3.9	-2.7	13	>95	<5	75
LI1	8.8	2.4	-1.7	26	>95	0	90
LI3	1.5	0.8	2.3	56	>95	<5	5
LI7	28.2	4.4	-2.4	19	>95	30	10
LI14	23.3	3.8	-3.2	10	70	30	30
LI15	20.1	3.6	-0.9	23	>95	<5	7.5
LI21	23.4	4.4	-3.8	7	>95	<5	10
LI22	24.1	3.7	-1.9	7	>95	<5	7.5
LI26	21	4	-2.4	13	>95	<5	7.5
CI1	17.9	3.9	-2	25	>95	7.5	17.5
CI4	10.4	3	-2.5	25	60	<5	22.5
CI10	25.8	5	-3.8	13	>95	7.5	7.5
CI12	38.1	5.6	-3.8	4	>95	10	5
KF1	23.8	3.6	-3.4	20	>95	<5	5
KI21	14.3	3	-1.3	19	>95	<5	7.5
KI37	25.4	4.4	-3.2	11	>95	<5	30
KI40	22.3	4.1	-1.6	15	>95	<5	25
KI42	25.4	4.4	-2.9	6	>95	<5	80
LI2	15.3	3.3	-2.1	16	85	<5	40
LI12	24.1	3.8	-1.8	18	80	<5	20
LI25	34.5	5.1	-3.6	10	>95	10	25
LI27	16.4	3.1	-2.3	18	>95	<5	7.5
LI28	23	4.1	-2.3	24	>95	<5	10

Site ID	% Cattail	Snags	Wetland Area/ Catchment Ratio	Wetlands Within 500 m Score	Catchment LU Score	300 m Buffer LU Score	% of Wetland Perimeter that is Buffered
CI2	0-20	no	0.14	4.0	1.92	1.97	100
CI6	51-80	no	0.03	1.0	1.13	2.66	84
KI27	81-100	no	0.29	27.5	2.98	2.83	18
KI34	21-50	no	0.19	20.0	3.23	3.12	0
KI36	81-100	no	0.58	12.0	2.76	2.75	75
LI11	81-100	no	0.23	18.0	4.27	3.97	68
LI16	81-100	yes	0.38	22.0	2.16	1.95	91
CI8	81-100	yes	0.34	5.0	2.28	1.98	92
CI11	0-20	no	0.06	9.0	1.82	1.69	100
CI14	0-20	no	0.05	14.0	1.13	1.91	100
CI16	0-20	no	0.10	4.5	1.25	1.08	100
CI17	0-20	no	0.16	3.5	1.29	1.63	100
KI24	0-20	no	0.05	12.5	2.88	3.16	0
KI50	51-80	yes	0.39	4.5	4.03	3.79	0
LF8	0-20	no	0.09	10.0	2.94	2.69	15
LF13	0-20	no	0.24	13.5	2.16	2.02	87
LI1	0-20	no	0.07	14.5	3.61	3.99	0
LI3	0-20	no	0.07	20.0	3.23	3.05	0
LI7	0-20	yes	0.37	2.0	1.13	1.93	81
LI14	0-20	yes	0.02	9.0	2.02	1.23	81
LI15	21-50	yes	0.24	17.0	2.06	2.36	100
LI21	0-20	no	0.08	23.5	1.00	1.79	100
LI22	21-50	no	0.11	26.0	1.49	1.81	90
LI26	0-20	no	0.1	13.5	1.63	1.64	100
CI1	0-20	no	0.09	15.0	1.11	1.38	100
CI4	0-20	yes	0.12	7.0	2.75	1.76	100
CI10	0-20	no	0.02	6.5	1.00	1.22	100
CI12	0-20	yes	0.16	17.5	1.00	1.04	100
KF1	81-100	no	0.11	4.5	2.95	2.38	61
KI21	81-100	no	0.09	11.5	3.66	2.96	17
KI37	21-50	no	0.22	2.0	2.67	2.98	66
KI40	81-100	no	0.82	5.5	3.52	3.79	24
KI42	0-20	no	0.02	21.0	2.17	1.76	100
LI2	0-20	yes	0.21	16.5	3.02	3.18	100
LI12	0-20	yes	0.28	19.5	3.19	3.32	100
LI25	21-50	no	0.38	12.0	1.66	2.29	80
LI27	81-100	no	0.82	16.5	3.06	3.20	31
LI28	81-100	no	0.28	9.5	3.35	3.36	44

Appendix C
Functional Capacity Units[1]

In the 404 Regulatory Program, the primary application of FCI is to compare different wetland areas, such as project alternatives, or pre- or post-project condition. However, comparing two wetland areas on the basis of a functional capacity index alone can lead to erroneous conclusions. For example, consider the following scenario. A new highway is being planned, and there are two alternative routes under consideration. The first route will impact 5 acres of wetland with an FCI of 0.8 for a particular wetland function. The second route will impact 25 acres of wetland, also with an FCI of 0.8 for the same function. In comparing the two alternatives based on functional capacity, it would be correct to say that on a per unit area basis there was no difference between the alternatives. However, when incorporating the size of each wetland area into the comparison, a conclusion of no difference would be erroneous. The comparison of the two alternatives, based on the functional capacity index and size of wetland, would lead to a more appropriate conclusion that the first alternative is the least damaging to the selected wetland function.

The functional capacity indices resulting from the assessment phase can be applied in a variety of ways during the application phase using *functional capacity units (FCUs)*. Functional capacity units provide a measure of the ability of a wetland area to perform a function, and are calculated by multiplying a functional capacity index by the area of wetland the FCI represents. For example:

$$FCU = FCI \times \text{size of wetland area}$$

where:

FCU = Functional capacity units for wetland area

FCI = Functional capacity index for wetland area

Once the functional capacity of a wetland area is expressed in terms of FCUs, a number of the comparison necessary in the 404 permit review process can be made. For example:

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[1] The following is adapted from an article written by R. Daniel Smith in the USACE Wetlands Research Program Bulletin, Volume 4, No. 3, October 1994.

a. Comparing the same wetland area at different points in time (e.g., pre- or post-project conditions).

b. Comparing WAAs in the same hydrogeomorphic wetland class at the same point in time.

c. Comparing WAAs in different hydrogeomorphic wetland classes at the same point in time.

Appendix D Summary of Variables and Functional Capacity Indices

All Variables Used

V_{ALT}: Presence of hydrologic alteration
$V_{ALT\text{-}OEX}$: Presence of hydrologic alteration (stream portion)
V_{BUFFER}: Wetland buffer
V_C: Native mean c score
V_{CAT}: Cover of *Typha spp.*
V_{CATCH}: Ratio of wetland area to catchment area
V_{FQI}: Native FQI score
V_{GVC}: Ground vegetation cover
V_{INV}: Invasive species cover (excluding *Typha spp.*)
$V_{LANDUSE}$: Land use within 300 m of site
V_{LUC}: Land use of the catchment area
V_{NAT}: Percent of plant species that are native
V_{OHOR}: Thickness of surface "O" horizon
V_{SOIL}: Soil structure
V_{TSSC}: Tree-shrub-sapling percent cover
V_W: Plant wetness score
V_{W500}: Wetlands within 500 m score

Functional Capacity Indices

Maintain characteristic hydrologic regime

a. *Isolated Depressions*:

$$FCI = \frac{\left[\dfrac{\dfrac{\left(V_{GVC} + V_{SOIL} + V_W\right)}{3} + V_{CATCH}}{2} + V_{ALT} + V_{LUC}\right]}{3}$$

b. Floodplain Depressions:

$$FCI = \frac{\left[\frac{\frac{(V_{GVC} + V_{SOIL})}{2} + V_{CATCH}}{2} + V_{ALT} + V_{LUC}\right]}{3}$$

Maintain characteristic biogeochemical processes

Isolated and Floodplain Depressions

$$FCI = \frac{\left[\frac{\left(V_{OHOR} + V_{GVC} + V_{BUFFER}\right)}{3} + V_{SOIL} + V_{LUC}\right]}{3}$$

Export organic carbon

Floodplain Depressions

$$FCI = \frac{\left(V_{GVC} + V_{OHOR}\right)}{2} \times V_{ALT-OEX}$$

Maintain characteristic plant communities

Isolated and Floodplain Depressions

$$FCI = \left\{ \frac{\left(\frac{V_{NAT} + V_{FQI} + V_{C}}{3}\right) + \sqrt{\left(V_{INV} \times V_{CAT}\right) \times \left(\frac{V_{ALT} + V_{LUC}}{2}\right)}}{2} \right\}$$

Maintain characteristic fauna

a. *Isolated and Floodplain Depressions:*

$$FCI = \frac{\sqrt{V_{INV} \times \frac{\left(V_{NAT} + V_{ALT}\frac{\left(V_{GVC} + V_{TSSC}\right)}{2}\right)}{3}} + \frac{\left(V_{W500} + V_{BUFFER} + V_{LANDUSE}\right)}{3}}{2}$$

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* May 2006	**2. REPORT TYPE** Final report	**3. DATES COVERED** *(From - To)*
4. TITLE AND SUBTITLE A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Depressional Wetlands in the Upper Des Plaines River Basin		**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) Jeff P. Lin		**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Environmental Laboratory U.S. Army Engineer Research and Development Center 3909 Halls Ferry Road, Vicksburg, MS 39180-6199		**8. PERFORMING ORGANIZATION REPORT NUMBER** ERDC/EL TR-06-4
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Corps of Engineers Washington, DC 20314-1000		**10. SPONSOR/MONITOR'S ACRONYM(S)** **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This Regional Guidebook characterizes the wetlands in the Upper Des Plaines River Basin using the hydrogeomorphic (HGM) approach. The HGM approach is a collection of concepts and methods used to develop functional indices to assess the capacity of a particular wetland to perform functions relative to similar wetlands in a region. Specifically, this report describes the rationale that was used to select functions for two subclasses of herbaceous freshwater depressions, the Isolated Depression subclass and the Floodplain Depression subclass. The report also describes the process used to select model variables and metrics and to develop assessment models. Data from reference wetlands are provided and used to calibrate model variables and assessment models. Protocols for applying functional indices to the assessment of wetland functions are provided.

15. SUBJECT TERMS

	Functional assessment	Watershed
Depression	HGM	Wetland
Des Plaines River	Hydrogeomorphic approach	

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT UNCLASSIFIED	**b. ABSTRACT** UNCLASSIFIED	**c. THIS PAGE** UNCLASSIFIED		120	**19b. TELEPHONE NUMBER** *(include area code)*