

**LANDSCAPE LEVEL WETLAND FUNCTIONAL ASSESSEMENT
(LLWFA)
Version 1.0**

Methodology Report



July 12, 2011

WPDG 2008: Landscape Level Wetland Functional Assessment Final Report

Abstract: The emergence of watershed management planning is driving an interest in understanding the relationship between wetland loss and degraded surface water quality. In addition to quantifying wetland loss, there has been a strong push recently to interpret loss of wetland function on a landscape level, and to incorporate that information into a watershed management context. In a 1990 report to Congress, The Michigan Department of Natural Resources (MDNR) and the U.S. Department of the Interior estimated that Michigan had lost approximately 50% of its original wetland resource base.

Though calculations on wetland quantity can give us an idea of overall impact, studies in the Northeast have shown the available spatial information can be enhanced to estimate qualitative loss of wetland function. Based on a technique developed in the US Fish and Wildlife Service' Northeast Region (USFWS-NE), additional information can be added to the National Wetland Inventory (NWI) database to characterize 13 general wetland functions at a landscape level. In cooperation with the Michigan Non-Point Source unit, this technique was applied to assist with watershed management plans with wetland conservation and restoration strategies for their watershed projects. Thirty separate 319 watershed groups around the state have either completed LLWFA analysis, or are slated for completion in the next 2 years. Several municipalities have incorporated these efforts into part of their master planning process.

As part of the LLWFA efforts, watershed stakeholders receive the latest in GIS technology, allowing groups that formerly had no GIS expertise in house to make the best possible use of the wetland mapping information.

Working closely with an advisory group of Michigan biologists, ecologists, and other specialists from numerous other relevant wetland-related fields, the Landscape Level Wetland Functional Assessment (LLWFA) methods have been refined and updated to reflect the regional differences in wetland ecosystems from the northeast to the Midwest.

Training of local watershed planners, GIS outputs, and refining of documentation have been a major focus of this project.

INTRODUCTION

The U.S. Fish and Wildlife Service (USFWS) have been conducting the National Wetlands Inventory (NWI) for over 25 years. The NWI Program has produced wetland maps for 91% (78% final) of the lower 48 states, all of Hawaii, and 35% of Alaska. Wetlands are classified according to the Service's official wetland classification system (Cowardin et al. 1979). This classification describes wetlands by ecological system (Marine, Estuarine, Lacustrine, Riverine, and Palustrine), by subsystem (e.g., water depth, exposure to tides), class (vegetative life form or substrate type), subclass, water regimes (hydrology), water chemistry (pH and salinity), and special modifiers (e.g., alterations by humans). The availability of digital data and geographic information system (GIS) technology make it possible to use NWI data for various geospatial analyses.

In the 1990s, the NWI Program for the Northeast Region recognized the potential application of NWI data for watershed assessments, but realized that other attributes would have to be added to the data to facilitate functional analysis. Dr. Mark Brinson had recently developed a hydrogeomorphic (HGM) approach to wetland functional assessment (Brinson 1993a). This approach provided the impetus for developing other attributes to expand the NWI database and make it more useful for functional assessment.

In the mid-1990s, a set of HGM-type descriptors were developed to describe a wetland's landscape position, landform, and water flow path (Tiner 1995, 1996a,b). These projects were watershed characterizations that included a preliminary assessment of wetland functions as a main component or the prime component of the study. Of the 4 LLWW descriptors, as they're referred to in Tiner's Nanticoke Watershed study in Maryland (Tiner, 2005), three were derived from the three core components in Brinson's (Brinson, 1993) approach to wetland functional classification. Geomorphic Setting (Landscape position) refers to the topographic location of the wetland within the surrounding landscape. Water source and its transport (relates to Landform) refers to the hydrologic input into a given wetland, which has been adapted and refined in this analysis. Hydrodynamics (Water Flow Path) refers to the motion of water and the capacity of that water to do work (i.e., transport sediments, transport nutrients to root surfaces) (Brinson, 1993).

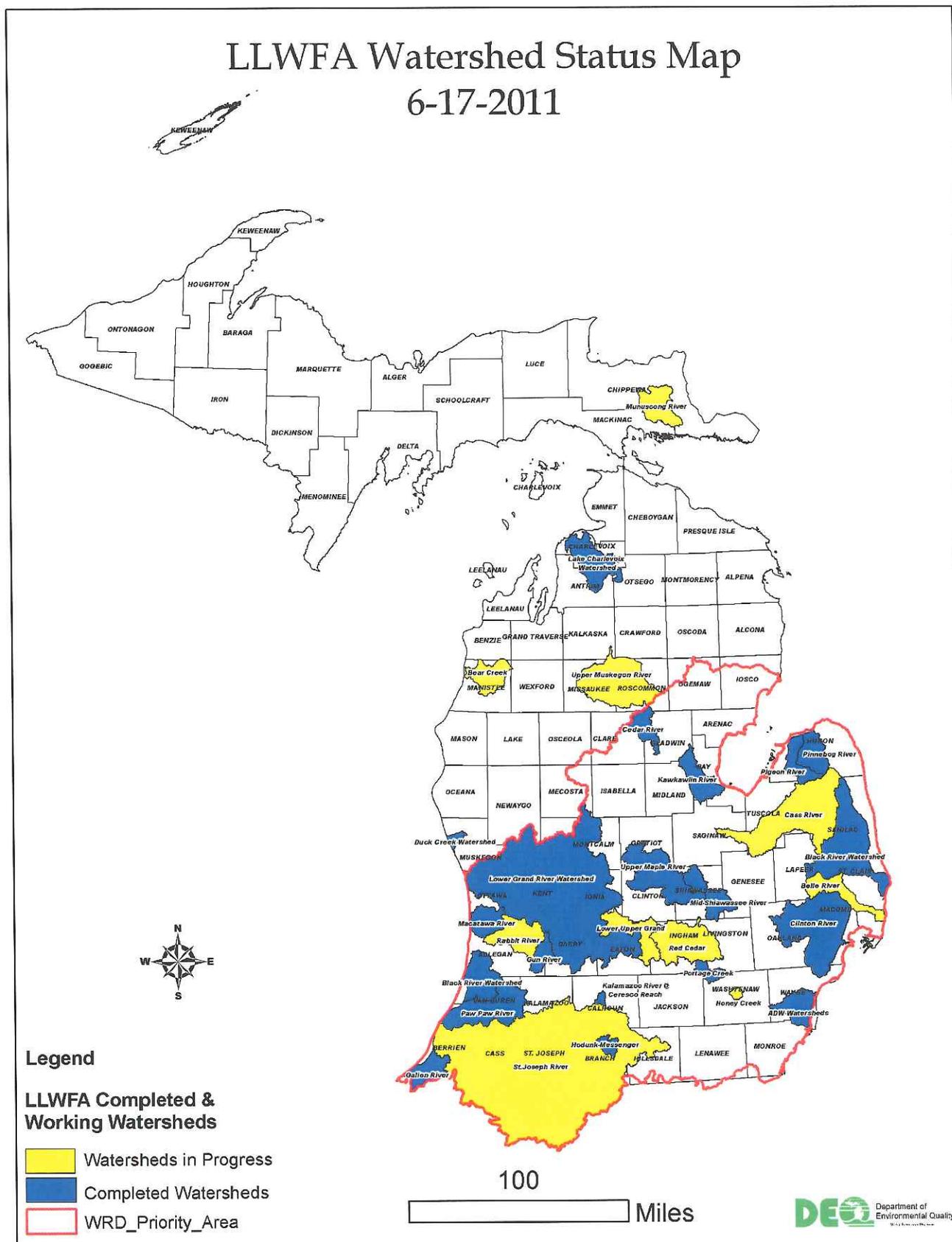
In conducting these studies, USFWS worked with local and regional wetland experts to develop correlations between these wetland characteristics as recorded in the database and wetland functions. These correlations

reflect the best approximation of what types of wetlands are likely to perform certain functions at significant levels based on the characteristics we have in the wetland database (Tiner, 2003b). Given that the functional correlations were developed for the Northeast Region of the country, an advisory group was convened in Michigan to address regional differences and develop functional correlations that better fit Michigan's diverse wetland resource base. Though the information contained within a LLWFA analysis is intended to be an approximation of wetland function across a landscape, there is defensible logic in connecting fundamental wetland properties with ecological significance (Brinson, 1993). This type of analysis assumes that given sufficient information on geomorphic setting, water source, and water movement, it should be possible to make reasonable judgments on how these physical properties can be translated into wetland functions.

Background

The Michigan Department of Environmental Quality (MDEQ) has been working since 2006 on refining and expanding the use of the Landscape Level Wetland Functional Assessment (LLWFA) across much of the state. Each year, the DEQ Non-Point Source Unit is the main entity which distributes 319 watershed planning funds to local units of government, non-profit organizations, and numerous other state, federal, and local partners to reduce nonpoint source pollution statewide. Their yearly prioritization of watershed planning efforts directly influenced the completion of LLWFA efforts, and the scale at which they work is a perfect fit for this landscape level wetland information. Twenty watersheds have been thru the complete LLWFA process, and another ten watersheds are in some phase of completion. This approach addresses both a current (2005) wetland inventory and a Pre-European Settlement inventory, to approximate change over time, and provide the best information possible on wetland status and trends from original condition thru today. These watershed planning organizations have utilized these tools to help them better evaluate projects for preserving or enhancing their current wetland resources and planning for restoration of lost resources. Restoring lost wetland functionality shows great promise in addressing the systemic cause of much of the non-point source pollution occurring in the State. The following map illustrates completed watersheds, and those in various phases of completion:

Figure 1: LLWFA Status Map as of 6/13/11



METHODS-General

The Landscape Level Wetland Functional Assessment involved the completion of 5 major tasks:

1. Spatial Data Collection and Integration
2. Classification and Enhancement of NWI data with LLWW descriptors
3. Functional Correlations and Assessment
4. GIS Tool Development and Status and Trends Report
5. Training and Outreach

The first task assigned was to collect and integrate all GIS spatial data for the watershed that could be used to attempt an automated classification of the NWI polygons from a HGM and functional perspective. This data collection included:

Layer Name	Data Source	Description
National Wetlands Inventory	US Fish and Wildlife Service, National Wetlands Inventory	2005 National Wetland Inventory compiled by Ducks Unlimited (GLARO)
National Hydrography Dataset-High Resolution	US Geological Survey and EPA	Based upon Digital Line Graph (DLG) hydrography at 1:24,000 scale
Digital Raster Graphic (DRG) topography and DEM	US Geological Survey	Scanned USGS Topo quads
SSURGO Soil Surveys	Natural Resource Conservation Service	Digitized from Paper Soil Surveys at 1:24000
NAPP 1998 Digital Orthophoto Mosaics	US Geological Survey	Color Infra-Red Aerial Imagery
NAIP 2005 & 2010 Digital Orthophoto Mosaics	Natural Resource Conservation Service (NRCS)	Natural Color Aerial Imagery
CGI Framework Data	MI Center for Geographic Information	Includes roads, political boundaries, hydrography, census figures, etc
MI Natural Features Inventory Land Cover 1800	MI Natural Features Inventory (MNFI)	Land Cover data derived from GLO Surveys from early to mid 1800's
DARCY Groundwater Movement Model	DNR Institute for Fisheries Research	Predicts groundwater recharge/discharge based on topography and soils
MI Natural Features Inventory Biorarity Index	MI Natural Features Inventory (MNFI)	Known sightings of threatened, endangered, or special concern species and high quality natural communities based on a 40 acre grid

Each dataset was necessary to complete one piece of the HGM classification. Of these datasets, topography and hydrography were the most utilized to determine the LLWW descriptors for each wetland in NWI. Results of this classification were then checked against the NAPP and NAIP photography to ensure consistency with

current conditions. These datasets were integrated into a Geodatabase for use in ESRI ArcINFO 9.3 software. A geodatabase is a GIS data format that allows integration of disparate data sources into one centralized database, from which, all data can be accessed independently. This approach eases the difficulty in managing multiple GIS datasets concurrently.

The second task involved the actual LLWW classification of NWI polygons for various watersheds. Classification of hydrogeomorphic (LLWW) descriptors included populating the NWI database with information on; landscape position, landform, water flow path, and waterbody type. (Appendix X for Simplified Keys to the LLWW classification). Rivers, lakes, and ponds present in the NWI spatial data were classified in terms of waterbody type, and waterflow path. The method for classifying these LLWW descriptors involves a trained interpreter individually analyzing each and every polygon within each of the wetland inventories. The general methodology for determining values for each of the LLWW descriptors are determined as follows:

LANDFORM

Landform values are derived explicitly from Cowardin water regime information. A detailed breakdown of this classification is explained in more detail in Figure 7.

LANDSCAPE POSITION

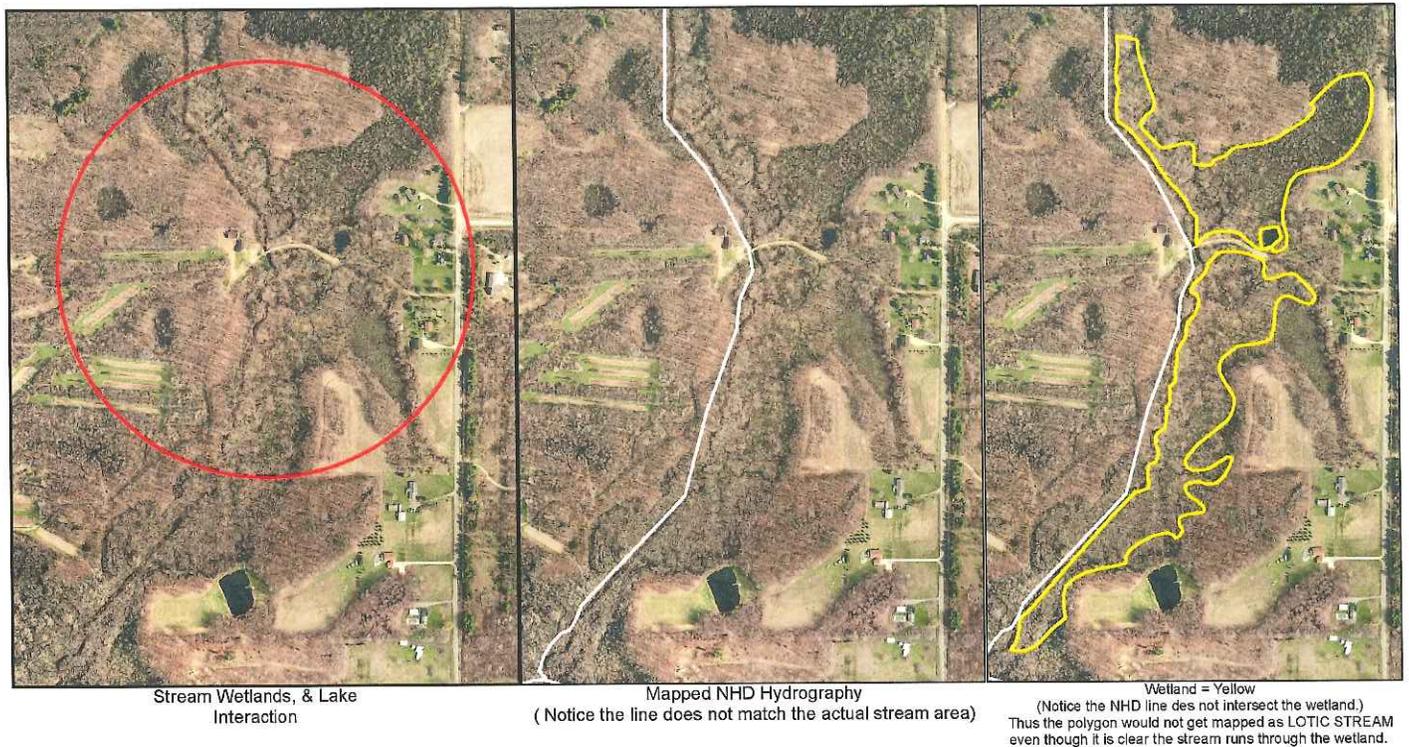
Landscape Position values are determined by cross referencing NWI with hydrology and topography. NWI polygons that spatially intersect a stream/river in NHD are classified as LOTIC. LOTIC type wetlands can be further refined to indicate their adjacency to a stream or a river (LOTIC STREAM or LOTIC RIVER). High Resolution NHD data was used to differentiate rivers from streams in this analysis. A NHD classification completed by DNR-IFR separated rivers by temperature gradient (cold, cool, warm) and size, based on average water flows (Cubic Feet per Second or CFS). This dataset was used in the LLWFA analysis to mark this distinction. An example of a lotic stream wetland is shown in Figure 2 below.

Figure 2: Lotic Stream Wetland Example



NWI Polygons that are determined to be within the basin of a lake are classified as LENTIC. Identifying the extent of a lake basin, and thus which wetlands fall within it, is done with the assistance of digital elevation models (DEM). An example of a lake basin shown on a DEM and wetlands falling within and outside of that basin is illustrated in Figure 3 below:

Figure 5: Hydrologic Mapping Error Resulting in Misclassification of a Wetland

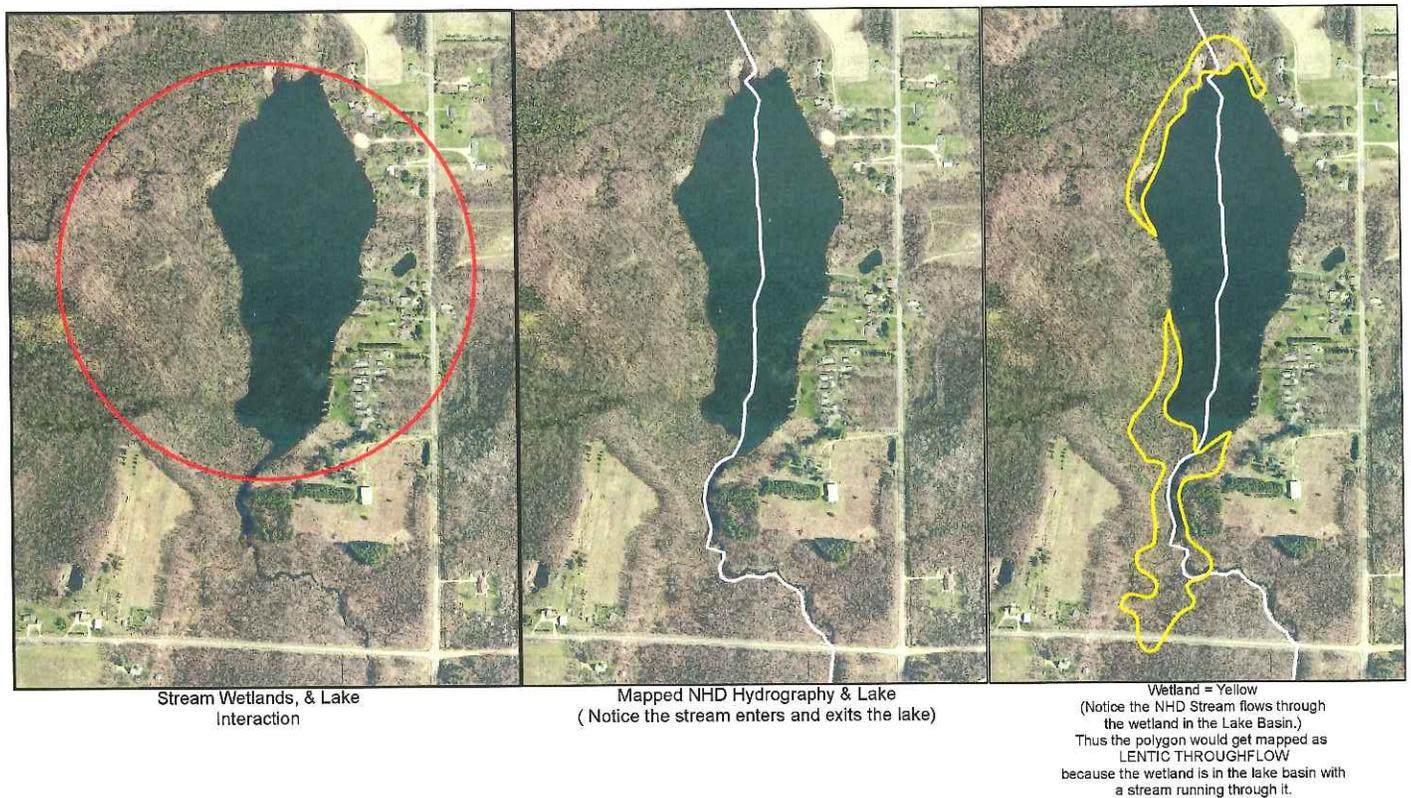


WATER FLOW PATH

Water flow path, otherwise known as Hydrodynamics, is classified by automated and manual interpretation of the intersection of NHD surface water features and NWI. Automated methods include intersecting NHD and NWI to capture THROUGHFLOW wetlands (in-stream wetlands), both natural and artificial. A distinction is drawn in NHD between natural Stream/River features and artificial Canal/Ditch features. Vegetated NWI wetlands that don't intersect any surface water body are classified as ISOLATED. Detailed coding was developed in an effort to differentiate intermittent, artificial, and perennial connections between wetlands and other surface waterbodies. Any wetland classified as LENTIC (Landscape Position) is automatically assigned a Water Flow Path of BIDIRECTIONAL, accounting for the tidal effects of lakes on adjacent wetlands.

Wetlands located at the terminus of a stream entering a lake are a special exception in that they are coded as Lentic THROUGHFLOW to account for the hydrologic influence the stream is having on that wetland, even though the wetland is also located in the lake basin. See Figure 6 for a detailed explanation of this exception:

Figure 6: LENTIC THROUGHFLOW



WATERBODY TYPE

Waterbody type classification is the simplest of the 4 LLWW descriptors. Ponds, Lakes, and Rivers are classified as such based explicitly on NWI Cowardin code. Lakes and ponds were separated at the 5 acre mark, all open-water polygons less than or equal to 5 acres were classified as ponds, while all open-water polygons larger than 5 acres were classified as lakes. The 5 acre cutoff was chosen to remain consistent with previously existing DEQ regulations. High Resolution NHD data was used to differentiate rivers from streams in this analysis. A NHD classification completed by DNR-IFR separated rivers by temperature gradient (cold, cool, warm) and size, based on average water flows (Cubic Feet per Second or CFS). This dataset was used in the LLWFA analysis to mark this distinction.

Figure 7: LLWW Classification Detail

Landscape Position	Landform	Waterbody Type	Waterflow Path
<p><u>Terrene (TE)</u> Wetland that is: 1. Surrounded by upland 2. Borders a pond that is surrounded by upland. (<i>Modifier pd</i>) 3. Is adjacent to but is not affected by the stream/river.</p>	<p><u>Slope (SL)</u> Wetlands occurring on a slope of 5% or greater.</p>	<p><u>Natural Pond (PD1)</u> A natural pond that is less than 5 acres in size.</p>	<p><u>Isolated (IS)</u> Wetland is typically surrounded by upland (non-hydric soil); receives precipitation and runoff from adjacent areas with no apparent outflow.</p>
<p><u>Lentic (LE)</u> Wetland lies along a lake or within its basin (i.e., the relatively flat plain contiguous to the lake).</p>	<p><u>Island (IL)</u> A wetland completely surrounded by water.</p>	<p><u>Dike/Impounded Pond (PD2)</u> A pond that is dike/impounded and less than 5 acres in size.</p>	<p><u>Inflow (IN)</u> Wetland is a sink receiving water from a river, stream, or other surface water source, lacking surface-water outflow.</p>
<p><u>Lotic River (LR)</u> Wetland that is periodically flooded by a river.</p>	<p><u>Fringe (FR)</u> Wetland occurs in the shallow water zone of a permanent waterbody. <i>*NWI water regime F, G, and H</i></p>	<p><u>Excavated Pond (PD3)</u> A pond that is excavated and less than 5 acres in size.</p>	<p><u>Outflow (OU)</u> Water flows out of the wetland naturally, but does not flow into this wetland from another source.</p>
<p><u>Lotic Stream (LS)</u> Wetland that is periodically flooded by a stream.</p>	<p><u>Floodplain (FP)</u> Wetland occurs on an active alluvial plain along a river and some streams. <i>*Modifiers FPba (Basin) and FPF1 (Flat)</i></p>	<p><u>Natural Lake (LK1)</u> A natural lake that is greater than 5 acres in size.</p>	<p><u>Outflow Intermittent (OI)</u> Water flows out of the wetland intermittently, but does not flow into this wetland from another source.</p>
	<p><u>Basin (BA)</u> Wetland occurs in a distinct depression. <i>*NWI water regime C and E</i></p>	<p><u>Dammed River Valley (LK2)</u> A lake created by damming a river valley and greater than 5 acres in size.</p>	<p><u>Outflow Artificial (OA)</u> Water flows out of the wetland, in a channel that was manipulated or artificially created.</p>
	<p><u>Flat (FL)</u> Wetland occurs on a nearly level landform. <i>*NWI water regime A and B</i></p>	<p><u>Excavated Lake (LK3)</u> A lake that is excavated and is greater than 5 acres in size.</p>	<p><u>Throughflow (TH)</u> Water flows through the wetland, often coming from upstream sources (typically wetlands along rivers and streams).</p>
		<p><u>River (RV)</u> A polygonal feature on a U.S. Geological Survey map (DRG) or a National Wetlands Inventory Map.</p>	<p><u>Throughflow Intermittent (TI)</u> Water flows through the wetland intermittently, often coming from upstream sources (typically wetlands along streams).</p>
			<p><u>Throughflow Artificial (TA)</u> Water flows through the wetland, in a channel that was manipulated or artificially created.</p>
<p>*** <i>hw Modifier: Any landscape position or waterbody type associated with a 1st order stream</i></p>			<p><u>Bidirectional (BI)</u> Wetland along a lake and not along a river or stream entering this type of waterbody; its water levels are subjected to the rise and fall of the lake levels</p>

Task number three involved connecting the HGM-coded NWI polygons with the functional correlations prepared by MDEQ with input from the Advisory Group. Certain functions rely solely on the LLWW descriptors, others rely mainly on the NWI (Cowardin) Classification, and a third subset relies on a combination of the two. The functional correlations and the Watershed-based Preliminary Assessment of Wetland Functions (W-PAWF) will be discussed in greater detail later in this report.

The fourth task in the LLWFA process involves the products and reports that accompany the GIS classification and functional correlation, and present this information to an audience that typically has little to no exposure to these types of wetland concepts. Final deliverables for this effort include hard-copy maps illustrating wetland extent during Pre-European Settlement and 2005 eras, and predicted wetlands of significance for 13 functions. A status and trends document contrasting Pre-European Settlement wetlands to 2005 wetlands are also created for each watershed. A final statistical report is also included in the Status and Trends document illustrating approximate functional loss, wetland loss, and general information on how the LLWFA work was completed. Also provided for each watershed is a customized Geographic Information Systems (GIS) tool that presents the totality of the information generated during the LLWW classification, functional correlations, and all source data used to complete the effort. This mapping tool allows for customized map creation utilizing aerial photography, hydrography, and any other relevant data to be overlain and utilized along with the wetland information. This free GIS product gives users the freedom to utilize the data for creation of maps intended for site specific application. Given the high cost of GIS software, and the expertise necessary to operate a full blown GIS, this particular piece of the LLWFA effort is a simple, valuable, and informative tool to local planning groups that are too often short of resources, monetary and otherwise.

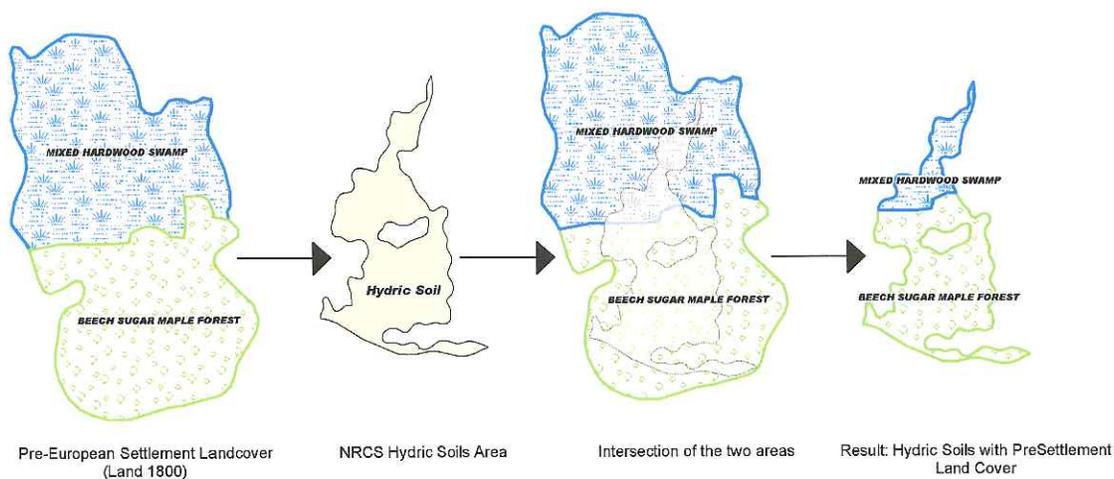
Finally, training and outreach has been an integral part of the LLWFA process. Given the relative complexity of this type of wetland assessment effort, significant time has been spent presenting the results of this analysis to watershed groups and other interested organizations, as well as in-depth training given to stakeholders likely to utilize this type of tool in their professional capacity. Twenty watersheds have been presented with information about their watershed and many have found this to be helpful on a planning scale as well as helpful in educating local stakeholders on the benefits of wetland functions and values. In 2010, a presentation was given at the semi-annual drain commissioner's conference, to highlight the potential of this type of landscape level assessment in restoring and protecting hydrologic condition. This audience was receptive to this type of planning tool, and showed significant interest in adapting this sort of approach in their activities. These types of additional applications for the LLWFA process are still being cultivated and explored, and represent part of the potential future for this tool.

METHODS - Pre-European Settlement Wetland Inventory (Presettlement NWI)

Estimating the extent of historic wetlands was completed through the use of several data sources, all of which required a level of assumption to ascertain the information needed for a useful and accurate functional classification. Given that fact, it is obvious that this dataset represents a best-guess approximation of wetland extent and condition in Pre-European Settlement times. The location and condition of Pre-European Settlement wetlands were derived from two major sources: 1) soil survey data from the U.S.D.A. Natural Resource Conservation Service (NRCS) based on 1:15,840 soil maps and 2) Michigan Natural Features Inventory Pre-European Settlement vegetation maps derived from General Land Office Survey (GLO) maps created between 1816 and 1856. The former source was relied upon much more heavily with the secondary source filling in gaps in the classification of wetland type.

Hydric soil map units were culled from the soil survey data, including all major hydric units as well as complexes where hydric soils were deemed to be a significant part of the soils series (<15%). All hydric soil polygons were deemed historic wetland polygons for the purposes of this analysis. These polygons were then cross-referenced (overlain) with the Presettlement Land Cover so that differing vegetation types were denoted as separate polygons within a single hydric soil unit. This intersection between the two layers is shown in Figure 8:

Figure 8: Diagram illustrating intersection of Hydric Soil Polygons with Presettlement Land Cover



The process shown in Figure 8 was automated using GIS tools and programming expertise to simplify and accelerate the speed at which this lengthy geoprocessing technique could be completed. This automation method is shown in detail in **Appendix 1**.

Because the spatial location of presettlement wetlands are derived from soil polygons that have no accompanying Cowardin classification codes, these codes had to be created to facilitate comparison with the current NWI. Completion of this 'Presettlement Cowardin code' was possible thru the use of auxiliary data sources, including; Presettlement Land Cover, GLO Survey Plats, current hydrology, and topography. The methodology for creating this attribution is outlined below.

Vegetative Class of presettlement wetland polygons is determined using the Presettlement Land Cover dataset. A crosswalk between Land Cover types in the Presettlement Land Cover dataset and NWI Cowardin Vegetative Classes is provided in an **Appendix 2** at the end of this report. Water Regime (flooding/ponding frequency) information for presettlement polygons is derived from a crosswalk document prepared for the LLWFA process by the State Soil Scientist. This document assigns a Cowardin water regime to each unique Map Unit Symbol (Soil Type) that is considered by NRCS to be hydric. This document creates a crosswalk from one dataset to the other, allowing an 'apples to apples' comparison of current NWI and our derived presettlement NWI. This crosswalk is essential in the LLWW coding process, as water regime is directly utilized to arrive at landform. This document is presented in a spreadsheet, and attached to this report digitally on the accompanying DVD. For a generalized Correlation Legend Scheme of the NWI Water Regime - NRCS Hydric Soils Map Unit List prepared by NRCS, see **Appendix 3**.

Presettlement hydrology was approximated using current surface water data, topography, and checked against GLO Surveys. Original GLO survey plats were obtained from MNFI, and georectified to section corners to be spatially explicit in the LLWFA system. This allowed original stream course locations to be verified with current hydrology and topography information. Streams that appeared to occupy their original undisturbed channel, or were denoted as undisturbed in the attribution were included in the Pre-European Hydrology dataset.

Once the 'Presettlement Cowardin Code' has been created for each presettlement wetland polygon, the LLWW process could be applied to each in the same manner it is applied to the current NWI. Because of assumptions made during the presettlement attribution process, there are some issues of scale created when comparing 'Presettlement NWI' with Current NWI. The result of these assumptions is a dataset that is very simplified in comparison to the 2005 NWI, however it provides an adequate base at the landscape level to perform a basic assessment of lost wetland function.

METHODS-2005 Enhanced National Wetland Inventory

The distribution, extent, and classification of 2005 wetlands were based on NWI mapping. Wetlands were classified according to the FWS's official wetland classification system (Cowardin et al. 1979). The LLWW descriptors were added to the digital NWI database to provide HGM-type information for each wetland polygon. In addition to the 4 LLWW descriptors, information was gathered on wetlands in a headwater position relative to the watershed as a whole. Wetlands polygons adjacent to ponds had this relationship noted in the database. A distinction was drawn when dealing with floodplain wetlands in terms of landform. Depending on the assigned water regime of the NWI polygon, the floodplain wetland was further classified as either basin or flat.

When enhancing the current NWI with the LLWW descriptors, significant effort goes into mapping hydrologic connection between wetlands, and connections between wetlands and other surface water features. Extensive artificial drainage networks have been added to the landscape since pre European settlement, many times in former wetland areas. This has resulted in formerly isolated wetlands being connected to the overall hydrologic network, significantly changing the functional role that wetland plays in the overall watershed. These types of functional changes are important to note in this type of analysis.

As part of this effort, while the HGM descriptors were being added to the NWI database, DEQ-WRD staff also performed QA/QC on the Ducks Unlimited 2005 NWI update. This resulted in significant acreage of wetland being added to the updated NWI, and erroneous mapping being corrected in many instances.

DEQ-WRD also made every effort to add features to the NHD surface water inventory if a feature was located that was not otherwise mapped in the NHD hydrology dataset. Due to the scale at which the interpreters are working on this effort, significant stream miles have been added to NHD that were otherwise omitted. These features were generally mapped only if they had a hydrologic impact on wetlands within the watershed.

Preliminary Assessment of Wetland Functions

This study employed a landscape-level wetland assessment approach called "Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF). W-PAWF applies general knowledge about wetlands and their functions to produce a watershed profile highlighting wetlands of potential significance for numerous functions. The method was developed to predict wetland functions for large geographic areas, particularly watersheds, from NWI data. To do this, two steps must be undertaken: 1) the digital NWI database must be expanded by adding LLWW descriptors, and 2) correlations between wetland characteristics in the database and wetland functions must be developed. Many wetland functions are related to physical properties, while others are dependent on a combination of biological and physical characteristics. For example, floodplain and depressional wetlands temporarily store surface water, whereas slope wetlands do not; wetlands that are sources of streams are vital for streamflow maintenance; marshes provide habitat for waterfowl and waterbirds (Tiner, 2003b).

Once the digital databases had been constructed for both eras, including LLWW descriptors, correlations were applied to both datasets to produce a preliminary assessment of wetlands performing functions at significant levels. The correlations are applied to the databases with analyses that take into account NWI classification as well as HGM codes constructed from the LLWW descriptors.

13 total functions are evaluated in the W-PAWF approach; 1) Flood Water Storage, 2) Streamflow Maintenance, 3) Nutrient Transformation, 4) Sediment and Other Particulate Retention, 5) Shoreline Stabilization, 6) Fish Habitat, 7) Stream Shading, 8) Waterfowl and Waterbird Habitat, 9) Shorebird Habitat, 10) Interior Forest Bird Habitat, 11) Amphibian Habitat, 12) Conservation of Rare and Imperiled Wetlands and Species, 13) Ground Water Influence. Each of the functions are discussed in more detail below. Many of the criteria were initially developed by Ralph Tiner from the U.S. Fish and Wildlife Service based on his knowledge of wetland characteristics and functions, while others have been devised by DEQ and incorporated into the analysis. An advisory group was formed of Michigan biologists, wetland specialists, and others to modify the criteria to better fit the characteristics of Michigan wetlands.

The Enhanced National Wetland Inventory provides knowledge about each wetland area and the significance at which each particular wetland performs one or more of the thirteen evaluated functions. The functional characteristics of each wetland help to provide valuable information on what ecological services an existing wetland is providing on the landscape as well as what services could be replaced by wetland restoration activities. In evaluating each of the functions, upland conditions adjacent to the wetland are not considered, and it should be emphasized that this preliminary assessment should be viewed as a first cut at identifying wetlands performing various functions at a significant rate based on the identified criteria and detailed information established for each wetland.

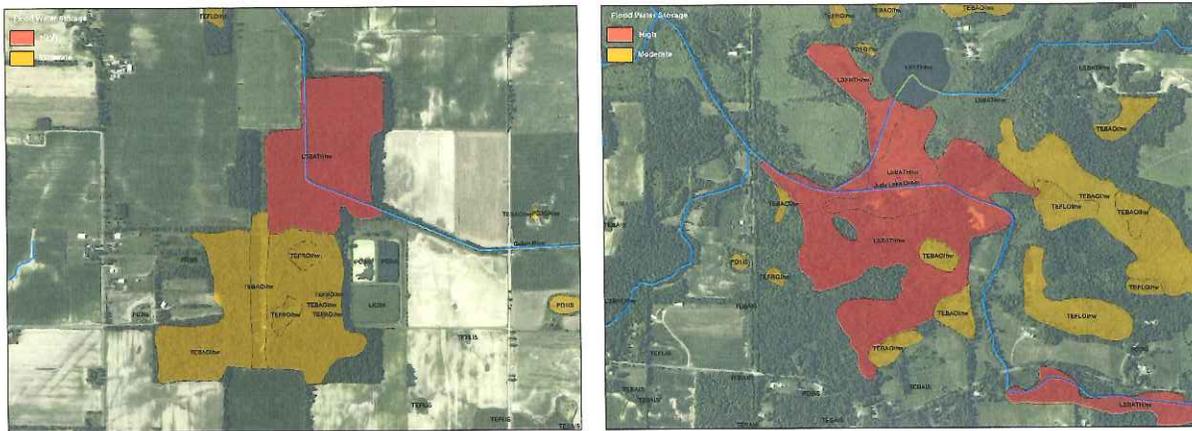
After completing the NWI Enhancement and the Functional Correlation analyses, maps can be produced to highlight wetlands that are performing these functions at significant levels. Two classes of significance were used to cull out wetlands performing functions at high and moderate levels based on their physical and biological characteristics. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a level above that of wetlands not designated (Tiner, 2003b).

Flood Water Storage

This function is important for reducing downstream flooding and lowering flood heights, both of which aid in minimizing property damage and personal injury from such events (Tiner, 2003b). All wetlands perform some type of flood water storage; however we have tried to identify areas that are performing this function at a significant level. Wetlands capturing flood water at significant levels would include wetlands along streams and rivers. These wetland types hold excess water until the river or stream can re-stabilize and move the excess water down stream. Once the water levels recede the water stored in these wetlands also recedes back to normal levels. Wetlands located on islands in lakes or rivers also provide this function significantly, as do ponds that are not being artificially drained. Isolated basin wetlands are also a very important wetland type for this function. These depressions or "bowl shaped" wetlands provide a storage area for adjacent upland run off during rain events preventing the water from flooding surrounding areas. Wetlands performing this function at a moderate level include wetlands with natural hydrologic connections as opposed to wetlands that are being drained artificially. Ponds that are not ranked as high for this function are included in the moderate category, as are wetlands adjacent to lakes. This function does not take into consideration the size of the wetland being analyzed, although generally accepted principles would indicate that size should make a difference in the amount of water stored.

<i>Flood Water Storage</i>	<i>High</i>	<ul style="list-style-type: none"> • Wetlands along Streams and Rivers • Island Wetlands • Ponds that are Throughflow & Throughflow Intermittent • Terrene Basin Isolated
	<i>Moderate</i>	<ul style="list-style-type: none"> • Terrene & Outflow or Outflow Intermittent wetlands • Other Ponds • Terrene wetlands that are associated with Ponds • All Lake side wetlands not already High

Figure 9: Examples of NWI Wetlands Rated High and Moderate for Flood Water Storage

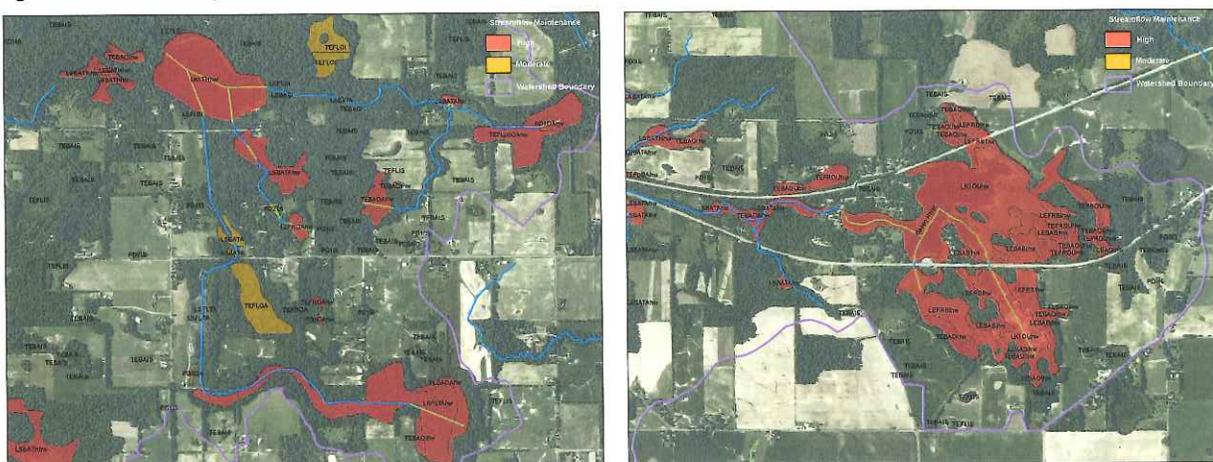


Streamflow Maintenance

Wetlands that are sources of groundwater discharge that sustain streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams. All wetlands classified as headwater wetlands are important for streamflow (*Tiner*). Headwater wetlands are very important when it comes to maintaining base flows of streams. All wetlands classified as headwater are rated as performing this function at a significant rate. Specific wetland types also perform this function, but generally at a more moderate rate. Wetlands that are adjacent to rivers or streams, and are located within the floodplain, store water during flooding events and then release water slowly into the stream or river, maintaining flow. Ponds and lakes that have a stream or river flowing through them are also important in supplying and regulating streamflow as well. Other wetlands that discharge groundwater at varying degrees also provide streamflow but at a more moderate rate.

Streamflow Maintenance	High	<ul style="list-style-type: none"> • All Headwater Wetlands (hw) <ul style="list-style-type: none"> ▪ 1st order perennial streams and above ▪ 2nd order perennial streams
	Moderate	<ul style="list-style-type: none"> • Lotic Floodplain Wetlands • Lotic Stream Fringe Wetlands • Throughflow & Outflow Ponds & Lakes • Terrene Outflow Wetlands associated with a Pond • Terrene Outflow Wetlands Outflowing to streams

Figure 10: Examples of NWI Wetlands Rated High and Moderate for Streamflow Maintenance

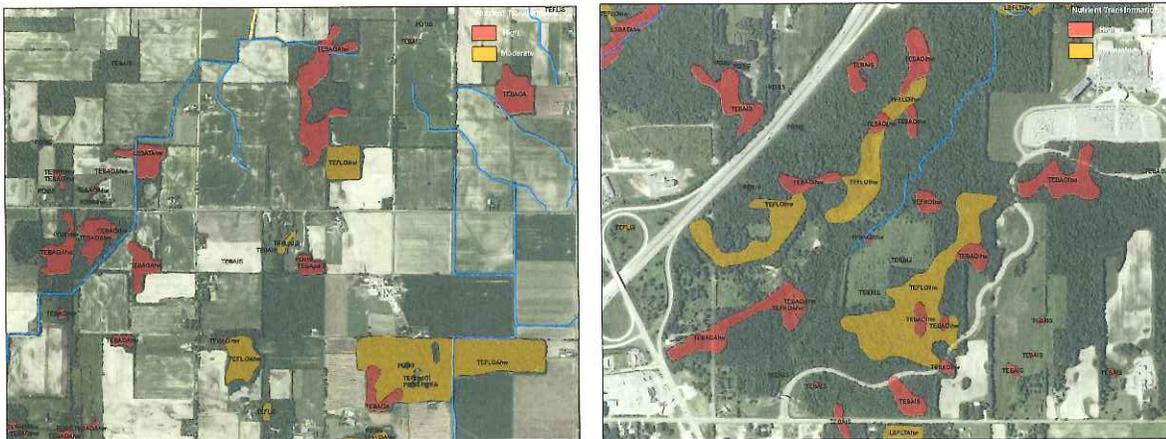


Nutrient Transformation

All wetlands recycle nutrients in some capacity, but wetlands that have a fluctuating water table are best able to capture and recycle nutrients. Natural wetlands performing this function help improve local water quality of streams and other watercourses by capturing and filtering these nutrients. Heavily vegetated wetlands are uniquely suited to slow water flows causing soils, minerals, and other materials to precipitate out of the water column and be deposited in the wetland. Wetland types that are vegetated and fall on the wetter end of the water regime scale perform this function significantly, where as vegetated wetlands on the dryer end of that scale perform this function at a slightly less significant level. From the water quality stand point wetlands that are associated with a stream or river are in the correct Landscape Position to provide this function at a significant level. Generally speaking, when evaluating this particular function, vegetative class and water regime are the most important considerations.

Nutrient Transformation	High	<ul style="list-style-type: none"> • Vegetated Wetlands from NWI P_ (AB, EM, SS, FO, and mixes) with water regime C, E, F, H, G. No Open Water types.
	Moderate	<ul style="list-style-type: none"> • Seasonally Saturated and Temporarily Flooded Vegetated Wetlands from NWI P_ (AB, EM, SS, FO, and mixes) with A, B water regime. • Lacustrine vegetated wetlands (no open water)

Figure 11: Examples of NWI Wetlands Rated High and Moderate for Nutrient Transformation

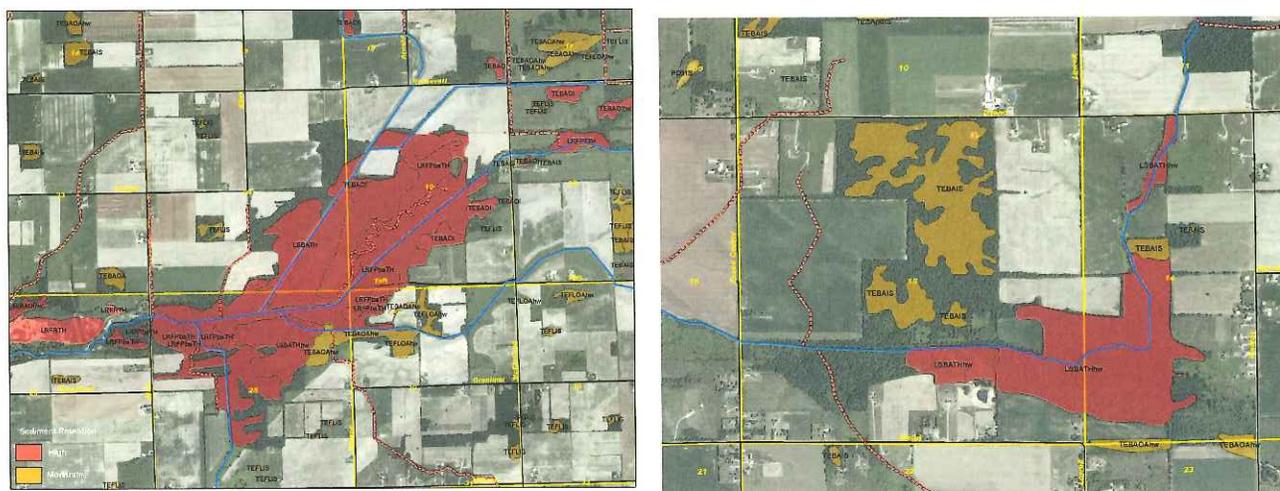


Sediment and Other Particulate Retention

This function supports water quality maintenance by capturing sediments with bonded nutrients or heavy metals. Vegetated wetlands will perform this function at higher levels than those of non-vegetated wetland types (Tiner, 2003b). Specifically wetlands that are considered lentic, or wetlands along streams, and rivers that have natural watercourses (not agricultural ditches) are likely to trap and retain sediments and particulates at more significant levels. In-stream ponds are also important for this function and are rated high. These ponds slow the waterflow and allow the sediments to precipitate out and settle to the pond floor. Basin wetlands surrounded by upland also tend to perform this function highly, trapping sediments entering in runoff from adjacent upland. Other ponds are also significant in retaining such materials and are rated moderate. Basin wetlands that outflow also perform sediment and other particulate retention at a moderate rate.

Sediment and other Particulate Retention	High	<ul style="list-style-type: none"> • Basin Wetlands associated with Lakes • Fringe and Island Wetlands associated with Lakes • Floodplain Wetlands • Lotic Stream basin, flat, and fringe wetlands that are Throughflow or Throughflow Intermittent • Lotic River Floodplain or Fringe Throughflow wetlands • Throughflow or Throughflow Intermittent Ponds • Island Wetlands • Terrene Basin wetlands that are Isolated
	Moderate	<ul style="list-style-type: none"> • Terrene Basin wetlands that are Outflow, Outflow Intermittent or Outflow Artificially • Natural Ponds not already "High" • All Wetlands associated with a Pond

Figure 12: Examples of NWI Wetlands Rated High and Moderate for Sediment Retention

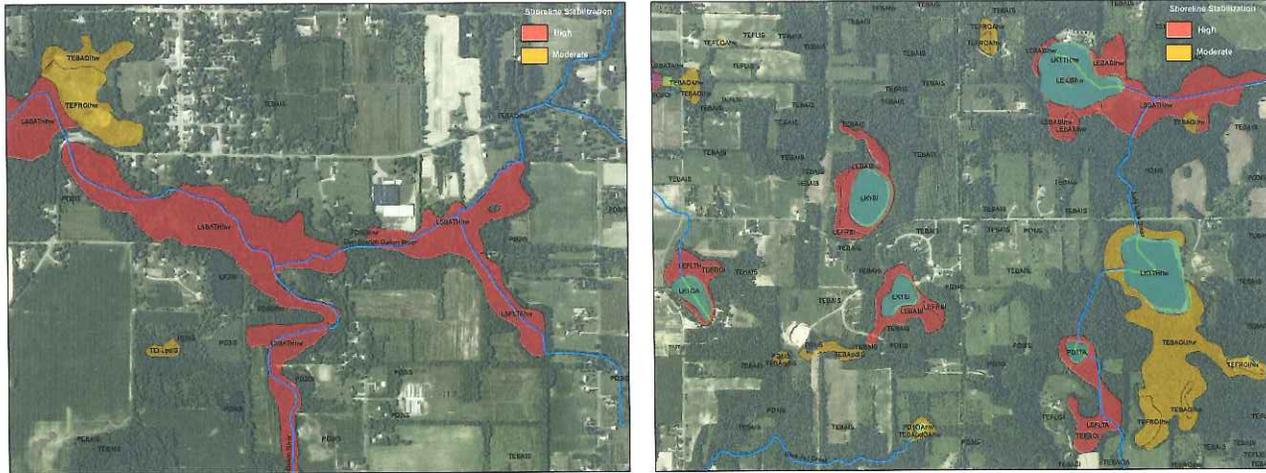


Shoreline Stabilization

Vegetated wetlands along all water bodies (e.g. estuaries, lakes, rivers, and streams) provide this function. Vegetation stabilizes the soil or substrate and diminishes wave action, thereby reducing shoreline erosion potential (*Tiner*). Vegetated wetlands along lakes, streams, or rivers provide a buffer to shorelines that would otherwise be more vulnerable to erosion. Wetlands that are along rivers, streams, and lakes that are vegetated perform this function at a highly significant level. Wetlands in a headwater position within a watershed, that are outflowing to other surface water, perform this function at a more moderate rate.

Shoreline Stabilization	High	<ul style="list-style-type: none"> • Vegetated (except island types) along water bodies <ul style="list-style-type: none"> ▪ Rivers, Lakes, Streams
	Moderate	<ul style="list-style-type: none"> • Terrene Vegetated Wetlands along Ponds • Terrene Outflow, Outflow Intermittent, Outflow Artificial Wetlands that are Headwater

Figure 13: Examples of NWI Wetlands Rated High and Moderate for Shoreline Stabilization

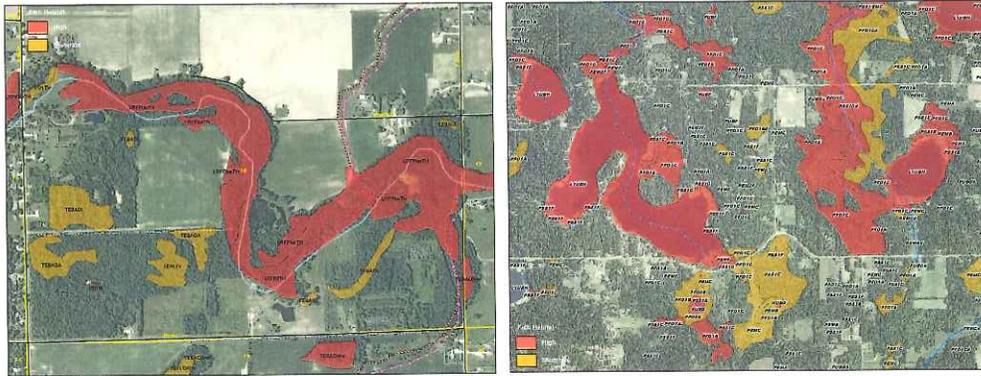


Fish Habitat

The fish habitat function looks at wetlands that are considered essential to one or more parts of fish life cycles. Wetlands designated as important for fish are generally those used for reproduction, or feeding. These wetland types include; lentic wetlands, throughflow wetlands adjacent to streams and rivers, ponds (excluding isolated, artificial ponds) and adjacent wetlands, aquatic bed wetlands that are outflowing to other surface water, and all headwater wetlands that have not been artificially modified. Wetlands that provide habitat at a moderate level include; aquatic bed wetlands not otherwise rated as high for this function, artificially created lakes and ponds, and wetlands that are intermittently connected to other surface water.

Fish Habitat	High	<ul style="list-style-type: none"> • Lentic Wetlands • Stream and River Wetlands that are only Throughflow • Wetlands associated with a pond • Ponds that are associated with a Wetland • Palustrine Aquatic Bed outflowing • Natural Ponds that are Isolated • Natural Lakes • Lakes that are throughflow, throughflow intermittent, or artificial, outflow, outflow intermittent or artificial • Headwater wetlands except artificial types
	Moderate	<ul style="list-style-type: none"> • Palustrine aquatic bed that are outflowing Artificially, or intermittently, Isolated and are not coded H • Diked impounded ponds not H • Throughflow ponds • Palustrine aquatic bed throughflows • Lotic Stream wetlands that are intermittent throughflow • Terrene that outflow intermittently or artificially • Excavated isolated Lakes

Figure 14: Examples of NWI Wetlands Rated High and Moderate for Fish Habitat

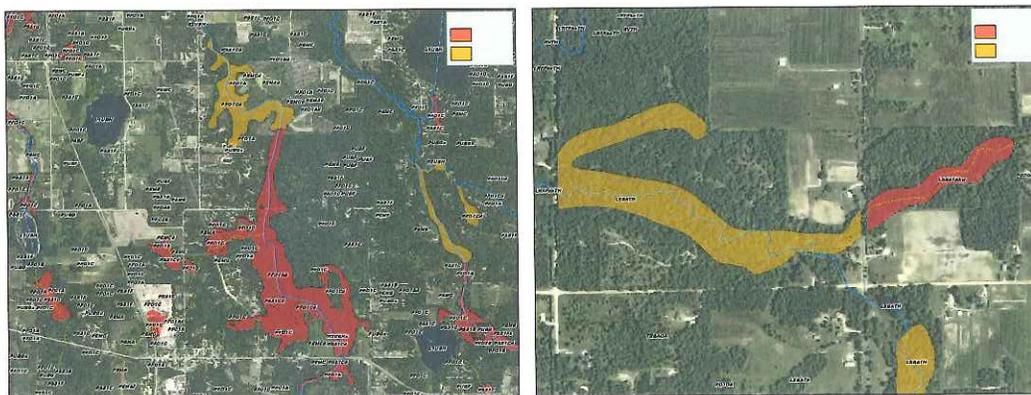


Stream Shading

Wetlands providing this ecological service regulate water temperature due to the proximity to streams and waterways. These wetlands generally are Palustrine Forested or Scrub-Shrub. Wetlands performing this function at a high level are adjacent to a headwater stream, and are forested or shrub-scrub. Wetlands performing this function at a moderate level are non-headwater, lotic wetlands that are forested and shrub-scrub. This function is particularly important for aquatic life in and around coldwater streams and the wetlands adjacent to them.

Stream Shading	High	<ul style="list-style-type: none"> Stream Wetlands that are Palustrine Forested and Palustrine Scrub-Shrub and Headwater
	Moderate	<ul style="list-style-type: none"> Stream Wetlands that are Palustrine Forested and Palustrine Scrub-Shrub and not Headwater

Figure 15: Examples of NWI Wetlands Rated High and Moderate for Stream Shading

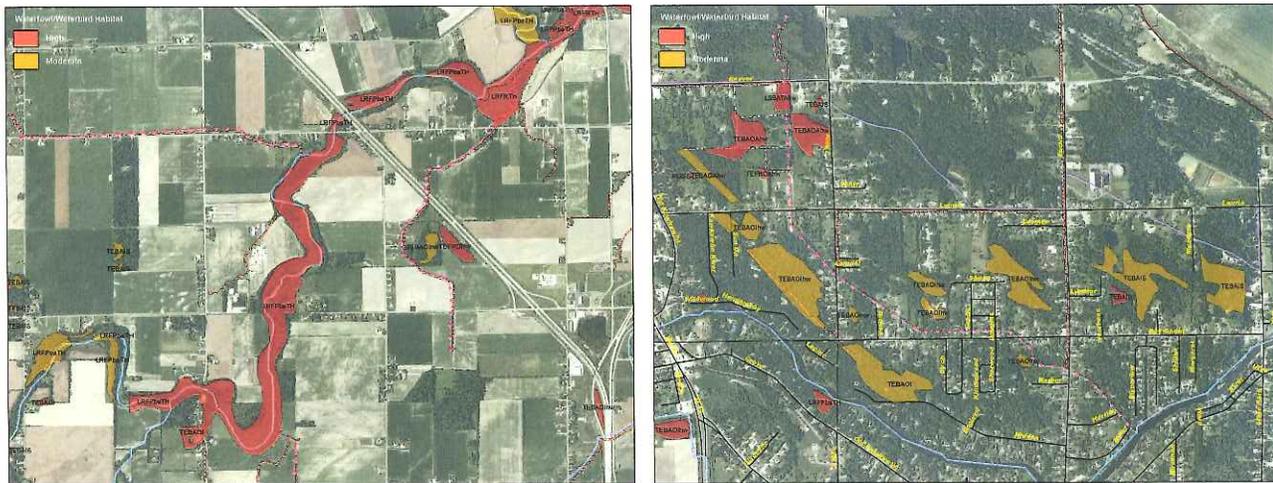


Waterfowl and Waterbird Habitat

Wetlands designated as important for waterfowl and waterbirds are generally those used for nesting, reproduction, or feeding. The emphasis is on the wetter wetlands and ones that are frequently flooded for long periods (Tiner, 2003b). For this function, the analysis prioritizes projected habitat for these species. Vegetation types include; aquatic bed, emergent, and shrub-scrub wetlands with associated water regimes including; seasonally flooded, semi-permanently flooded, and permanently flooded. Wetlands performing the above function at a moderate rate tend to be the deciduous forested wetland types that are seasonally flooded to permanently flooded. These could include floodplains or forested basins.

Waterfowl and Waterbird Habitat	High	<ul style="list-style-type: none"> Palustrine aquatic bed emergent and scrub-shrub wetlands that are seasonally flooded, seasonally flooded/saturated, Semi permanently flooded, intermittently exposed, and permanently flooded. No coniferous.
	Moderate	<ul style="list-style-type: none"> Palustrine Forested wetlands that are seasonally flooded, seasonally flooded/saturated, Semi permanently flooded, intermittently exposed, and permanently flooded. No coniferous.

Figure 16: Examples of NWI Wetlands Rated High and Moderate for Waterfowl/Waterbird Habitat

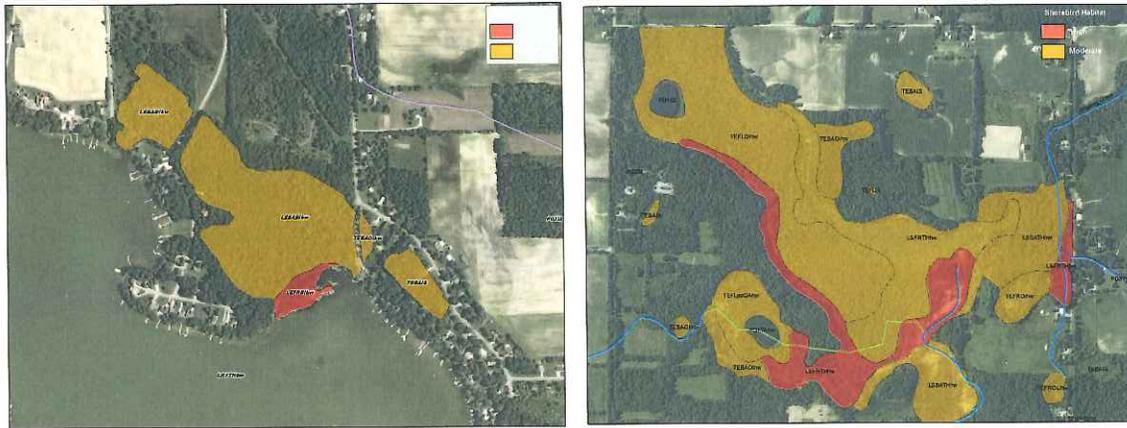


Shore Bird Habitat

Shorebirds generally inhabit open areas of beaches, grasslands, wetlands, and tundra and undertake some of the longest migrations known. Along their migration pathway, many shorebirds feed in coastal and inland wetlands where they accumulate fat reserves needed to continue their flight. Common species include; plovers, oystercatchers, avocets, stilts, and sandpipers. This function attempts to capture wetland types most likely to provide habitat for these species. Wetland types that provide this function at a high rate include aquatic bed wetlands that are permanently flooded to intermittently exposed, wetlands with non-persistent vegetation, and Lacustrine unconsolidated shore. Wetlands performing this function at a moderate rate of significance are the more common wetland types such as emergent, shrub-scrub, and forested areas that are not permanently flooded.

Shorebird Habitat	High	<ul style="list-style-type: none"> Palustrine Aquatic Bed wetlands that is not intermittently exposed or permanently flooded. Non-Persistent wetlands (PEM2) Lacustrine Unconsolidated shore that is parentally flooded.
	Moderate	<ul style="list-style-type: none"> Palustrine emergent, scrub-shrub, and forested wetlands including mixed types that are not intermittently exposed or permanently flooded.

Figure 17: Examples of NWI Wetlands Rated High and Moderate for Shorebird Habitat

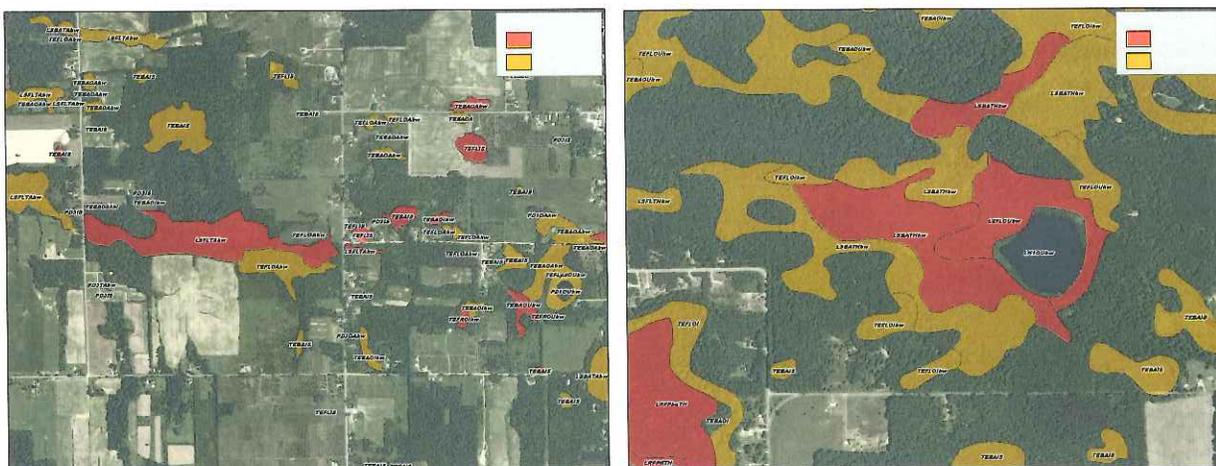


Interior Forest Bird Habitat

Interior Forest Birds require large forested areas to breed successfully and maintain viable populations. This diverse group includes colorful songbirds such as; tanagers, warblers, vireos that breed in North America and winter in the Caribbean, Central and South America, as well as residents and short-distance migrants such as; woodpeckers, hawks, and owls. They depend on large forested tracts, including streamside and floodplain forests. It is important to note that adjacent upland forests to these riparian areas are critical habitat for these species as well. This function attempts to capture wetland types most likely to provide habitat for these species. Habitat that rates highly significant for interior forest birds includes forested floodplains and shrub-scrub wetlands. Moderately significant wetlands are all other forested wetlands that have not already been ranked as high. This function is evaluated in more general terms to include the multiple forest bird species.

Interior Forest Bird Habitat	High	<ul style="list-style-type: none"> • Palustrine Forested wetlands that are along Rivers • Palustrine scrub-shrub wetlands and those mixed with other wetlands types
	Moderate	<ul style="list-style-type: none"> • Palustrine Forested wetlands that are not already H

Figure 18: Examples of NWI Wetlands Rated High and Moderate for Interior Forest Bird Habitat

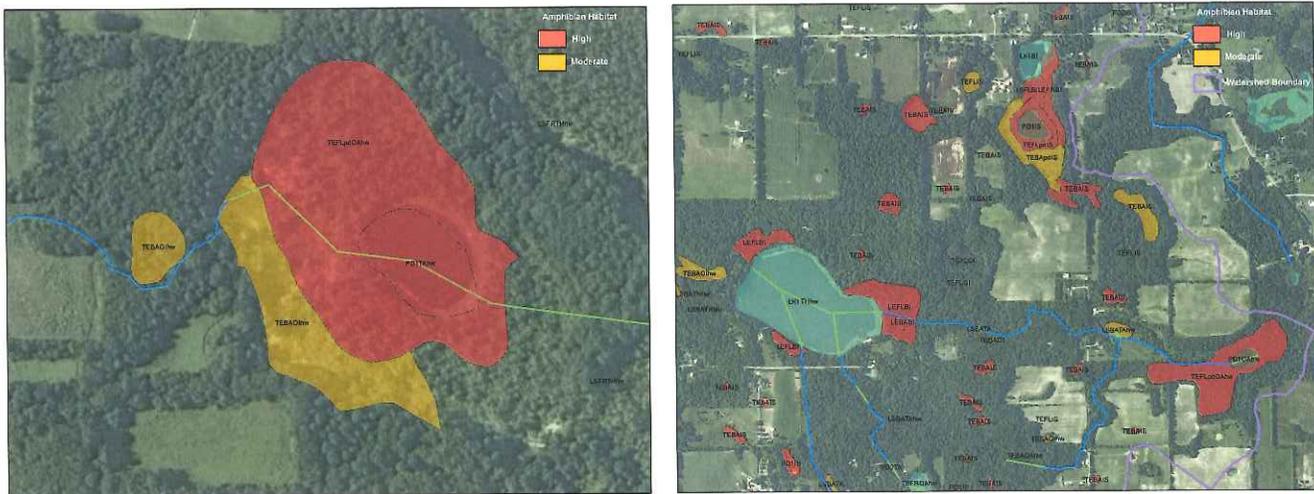


Amphibian Habitat

Amphibians share several characteristics in common including wet skin that functions in respiration and gelatinous eggs that require water or moist soil for development. Most amphibians have an aquatic stage and a terrestrial stage and thus live in both aquatic and terrestrial habitats. Aquatic stages of these organisms are often eaten by fish and so for certain species, successful reproduction may occur only in fish-free ponds. Common sub-groups of amphibians are salamanders, frogs, and toads. This function attempts to capture wetland types most likely to provide habitat for these species. For this function, wetland size is actually taken into consideration. Wetlands that are less than five acres in size, vegetated, and isolated are ranked high for amphibian habitat. Naturally outflowing wetlands are also ranked high for this function. Floodplain wetlands and lentic wetlands are significant wetland types for amphibian habitat as are natural ponds and isolated aquatic beds. Vegetated wetlands that are less than 5 acres in size that are either throughflow, or outflowing artificially or intermittently fall into the moderate range for this function. Other wetland types that are significant but don't fall into the high category include rivers, forested and shrub-scrub wetlands smaller than five acres and isolated vegetated wetlands that have not already been ranked highly.

Amphibian Habitat	High	<ul style="list-style-type: none"> • Palustrine emergent, scrub-shrub, and forested wetlands along with those mixed types that are less than 5 acres and Isolated and only seasonally flooded, seasonally flooded/saturated, or semi-permanently flooded. • Outflowing wetlands • Palustrine Aquatic beds that is isolated and not intermittently exposed or permanently flooded. • Wetlands adjacent to rivers • Lakeside wetlands • Natural ponds and any wetlands that are associated with those ponds
	Moderate	<ul style="list-style-type: none"> • Palustrine emergent, scrub-shrub, and forested wetlands with those mixed types that are less than 5 acres and adjacent to a stream (throughflow) and only seasonally flooded, seasonally flooded/saturated, or semi-permanently flooded. • Palustrine emergent, scrub-shrub, and forested wetlands along with those mixed types that are less than 5 acres and outflowing artificially or intermittently and only seasonally flooded, seasonally flooded/saturated, or semi-permanently flooded. • Palustrine emergent, scrub-shrub, and forested wetlands along with those mixed types that are isolated and only seasonally flooded, seasonally flooded/saturated, or semi-permanently flooded. • Palustrine Aquatic bed isolated wetlands that are permanently flooded. • Scrub-shrub and forested wetlands less than 5 acres (must be PFO1) • Rivers • Ponds and the wetlands associated with them unless already H

Figure 19: Examples of NWI Wetlands Rated High and Moderate for Amphibian Habitat

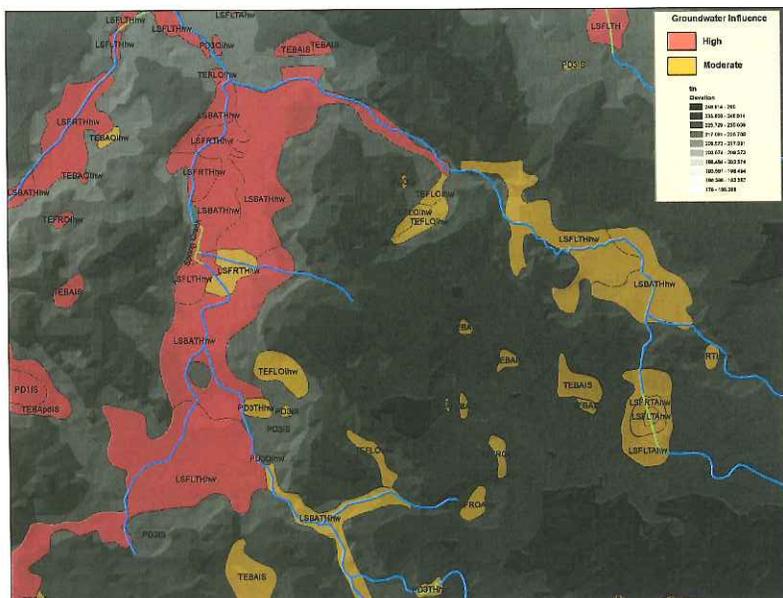


Ground Water Influence

Wetlands categorized as high or moderate for Groundwater Influence are areas that receive some or all of their hydrologic input from groundwater reflected at the surface. The Darcy (Darcy's Law) model was the data source utilized to determine this wetland/groundwater connection, which is based upon soil transmissivity and topography. Groundwater movement is tracked as meters/day – 1 by cell. The ranges that were used in this analysis to differentiate between high and moderate groundwater influence are listed in the 'GIS Users Version of the Functional Correlations' document included with Appendix 4. Wetlands rated for this function are important for maintaining streamflows and temperature control in water bodies. The Darcy output was then intersected with wetlands on the ground to identify areas of potential wetland/groundwater connection. Using the models output data wetlands were ranked either highly likely or moderately likely to provide this function.

Ground Water Influence	High and Moderate	<ul style="list-style-type: none"> • Uses Darcy to determine areas of ground water influence
-------------------------------	--------------------------	---

Figure 20: Examples of NWI Wetlands Rated High and Moderate for Groundwater Influence

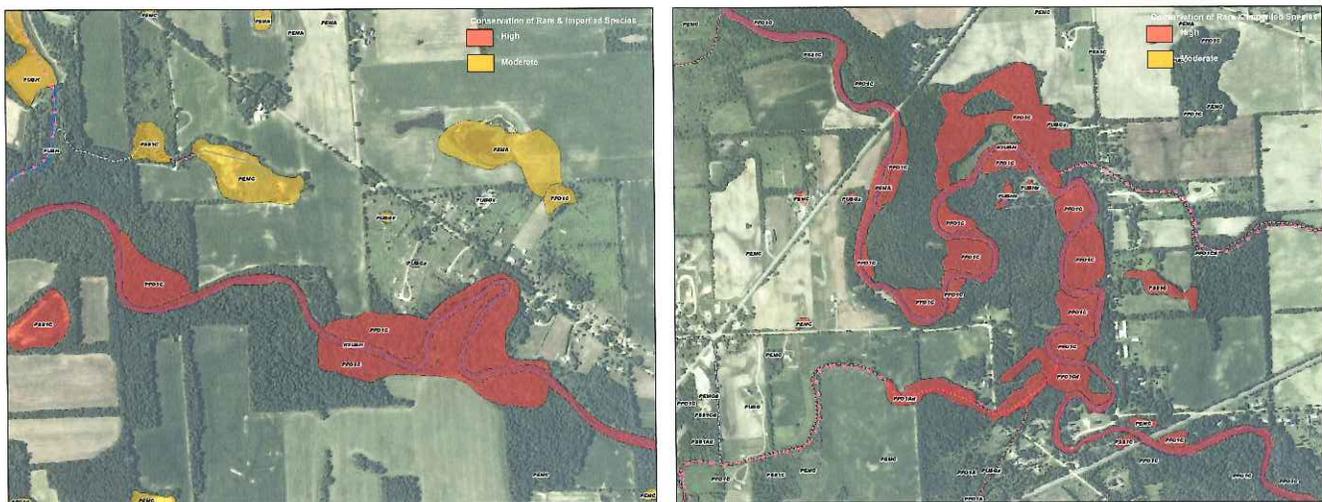


Conservation of Rare and Imperiled Wetlands and Species

Wetlands that are considered rare either globally or at the state level are identified for this function. They are likely to contain a wide variety of flora and fauna, or contain threatened or endangered species. This function is derived from the Michigan Natural Features Dataset (MNFI) of known sightings of threatened, endangered, or special concern species and high quality natural communities. The model values are reported on a 40 acre polygon grid for the state of Michigan, or a subset of MI. Due to this the dataset should not be used as a comprehensive inventory of Rare and Imperiled wetlands. This data set is intersected with the current wetlands layer only to identify wetlands currently on the landscape that have potential to either be habitat for a threatened or endangered species or be a wetland that is of rare nature.

<p>Conservation of Rare and Imperiled Wetlands</p>	<p>High</p>	<ul style="list-style-type: none"> • MNFI's Biological Rarity Index and Probability value layer to identify wetlands and species of rarity.
---	--------------------	--

Figure 21: Examples of NWI Wetlands Rated High and Moderate for Conservation of Rare and Imperiled Wetlands and Species



Michigan LLWFA Advisory Council

It was apparent to DEQ-WRD staff upon completion of the Paw Paw River LLWFA pilot project, that changes would need to be made to help the LLWFA better reflect the wetland resources of Michigan. To address this need, an advisory council of Michigan wetland biologists, specialists, and individuals familiar with Michigan's wetland resources was convened and tasked with reviewing the functional correlations created by Ralph Tiner of USFWS and modifying them to apply to Midwestern conditions. The council analyzed each correlation and either made adjustments or agreed with the correlation as USFWS originally devised it. The Advisory council was pivotal in helping MDEQ staff compile and create the functional correlations as well as the various documents needed to continue work on the Landscape Level Assessment in Michigan. To help educate the advisory council MDEQ staff created training materials and detailed presentations to help explain the LLWW descriptors as well as the LLWFA. These documents are included on a DVD attached as (Appendix 4). A full listing of advisory group members and their respective organizations is included at the end of this report.

RESULTS

The wetland spatial data produced as a result of this effort can be used for a multitude of purposes. The addition of the LLWW information to the original NWI database facilitates a greater ability to subset the data. This gives the end user the ability to craft the data to the specific needs of the organization, and produce maps that highlight wetlands of significance for one specific function or multiple. Because of the scalability of the final datasets, watershed-scale maps can be produced as quickly and easily as maps showing sub-watersheds or local communities.

Several watersheds across the state have found innovative ways to utilize the landscape level assessment information. An example of this would be the Black River Watershed in Allegan and Van Buren Counties, a link to the approved watershed plan can be found here: (http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714_31581-120463--,00.html). The watershed planners performed interesting analyses on the connections between inland lakes and wetland resources, in addition to creating a prioritization process (utilizing the LLWFA data) meant to inform decision making on the siting of wetland restoration projects.

The Gun River Watershed is another strong example of how this type of landscape level assessment information can be incorporated into watershed planning efforts. A link to the approved watershed management plan can be found here: (http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714_31581-104278--,00.html). The watershed coordinator for this project utilized the LLWFA in combination with his local knowledge of landowners to prioritize wetland restoration efforts down to actual properties using parcel data. He then met with local landowners to gauge their interest in completing a wetland restoration project on their property, assisting interested landowners with the procedural aspects of working thru the various requirements of state/federal restoration programs (WRP, Partners for Fish and Wildlife, etc) to help address the needs of the overall watershed.

The most essential piece of any successful LLWFA project is a strong, stable watershed coordinator, with local knowledge. A local champion has the ability and connections to utilize these tools where they are most likely to be implemented. Unfortunately, many watershed planning organizations, conservation districts and municipalities just don't have the resources to provide a lasting position to work on watershed related issues. In these instances, the department attempts to put more effort into working with the permanent fixtures at the local level; city/township planners, municipal employees, and planning commissions are all appropriate audiences for this type of assessment.

GENERAL LIMITATIONS OF THE STUDY

Historical wetland data produced from existing soils surveys, are obvious approximations of wetland extent and condition. NWI Coding for Pre-European Settlement wetland polygons was derived from soil characteristics, and checked against Pre-European Settlement vegetation maps produced by interpreting GLO Surveys from the early 1800's. This required an approximation of flooding and ponding frequency (water regime), as well as vegetative cover. Given that landform information in this analysis was derived from NWI water regime, certain types of landform (fringe, slope, etc) may be underrepresented in the Pre-European Settlement coverage. Pre-European Settlement hydrology was approximated using current surface water data, and checked with GLO Surveys. Streams that appeared to have a natural channel, were major courses, or were denoted as undisturbed in the attribution were included in the Pre-European Settlement analysis.

The 2005 NWI data should be an accurate reflection of wetland extent and condition within the State of Michigan. However, given the inherent limitations of using a data source that is mainly derived from aerial photo interpretation, care should be exercised when using the results of this analysis. Issues with photo quality, scale, and variable environmental conditions should be taken into consideration when interpreting this information (Tiner, 1997 and 1999). Also, errors of omission and commission are possible. Drier-end wetlands tend to be difficult to interpret on aerial photos, as are forested wetlands where canopy can obscure hydrology below. Because water regime information was interpreted from one snapshot in time, it may not always be reliable in determining seasonal saturation. Many times, the seasonal saturation of wetlands can vary widely over long time periods which can be difficult to account for in this type of mapping effort.

This analysis produces a planning tool that can assist in identifying potential wetlands of significance for certain functions. However, no effort was made to compare the relative significance of two wetlands predicted to perform the same function. The W-PAWF also does not consider the condition of adjacent upland or the relative water quality of adjacent waterbodies, which may be considered important factors in determining the overall health and condition of a wetland (Tiner, 2005).

No assessment technique on wetland function is likely to be robust enough to first evaluate the level of a particular function and then further distinguish whether the function is part of a human-based value system (Brinson, 1993). Also, it should be noted, that this type of analysis is not intended for a user to take it to the field for the purpose of matching indicators with functions. Rather, this type of analysis is intended to show how some fundamental knowledge about water flows and sources and geomorphic setting can be interpreted to illustrate ecological functioning (Brinson, 1993).

APPROPRIATE USE OF THIS TYPE OF ANALYSIS

At the watershed or regional level, an understanding of the status and trends of wetland ecosystems is essential for the establishment of policies, strategies, and priorities for action (Ramsar Convention on Wetlands 2005).

The U.S. EPA considers the development of a State comprehensive wetland monitoring and assessment program as a top priority to determine the causes, effects and extent of pollution to wetland resources, and to improve pollution prevention, reduction and elimination strategies (Fennessy et. al. 2004). This is used to enhance wetland inventory and assessment techniques at a watershed scale and should assist local planners in a monitoring strategy if that goal is identified at a local level. Also, wetland assessment is the identification of the status of, and threats to, wetlands as a basis for the collection of more specific monitoring activities (Apfelbeck, 2006).

Wetland inventories can be carried out at different levels of detail and a sequential inventory, starting simple and subsequently undertaking more detailed work, should be undertaken (Ramsar Convention on Wetlands 2005). With the development of the Michigan Rapid Assessment Method (MiRAM), a field-based assessment method, opportunities exist to enhance landscape level wetland inventory and assessment. Really, this type of rapid assessment method should be paired with landscape level assessment to ensure proper management decisions. For example, degrees of landscape-level stress and wetland functions are best determined by also considering landscape-level information (Apfelbeck, 2006). Field-based assessments are necessary to accurately assess wetland functions. However, remote assessments are important when evaluating wetland functions at the watershed scale since it is often necessary to have some way to screen wetlands to target for further assessment (Apfelbeck, 2006).

This type of analysis is meant to be an initial screening of the overall status and trends of the wetland resource base within a watershed. When paired with Pre-European Settlement information, cumulative impacts of wetland functional degradation can be evaluated. Given limited public understanding of the functions and values of wetlands, this analysis can serve as an effective illustration of the role of wetlands within the larger landscape and the role that wetland destruction and degradation has played in reduced surface-water quality, habitat, and flood control over time.

The overall results of this effort provide many possibilities and unlimited potential for future use of these datasets within Michigan's 404 Program, and 319 Program. WRD staff involved in this project envision myriad applications of this assessment within not only the non-regulatory arena, but also regulatory applications. Given the use of "best professional judgment" as a basis for permitting and enforcement/compliance decisions, data that can speak to wetland functions and values within a watershed will be extremely useful to regulatory staff. In a non-regulatory sense, this analysis can help to pinpoint potential restoration, enhancement, and protection activities to appropriate areas of the watershed that are most in need of a particular wetland function. From a regulatory perspective, wetlands should be inventoried, assessed, monitored, and managed in the context of the entire watershed to supplement the site-by-site regulatory-based assessments which are often necessary for addressing direct impacts such as dredging, filling, and draining. A watershed approach

can also integrate indirect wetland impacts that are caused by land use practices that require a broader understanding of how wetlands function on the landscape and the benefits that they provide. For this reason, watershed planning allows communities to make better choices on preserving the highest quality wetlands by protecting the most vulnerable wetlands and for prioritizing sites for restoration (Cappiella et al. 2006). Given the recent push to incorporate and understand the 'watershed context' of a wetland resource in Clean Water Act guidance involving mitigation efforts, landscape level assessment of this type will continue to play an increasingly large role in wetland regulatory actions.

The usefulness of this data will also depend on the goals of the partnering watershed management authority. For example; in a watershed undergoing problems with excessive sedimentation in waterways, this data could be used to pinpoint wetlands which are currently performing that function at a significant rate. In a highly urbanized watershed, this analysis can be used to pinpoint wetlands of significance for flood control AND sediment retention. The high level of scalability of this analysis is what makes it so versatile for use in a Wetland Management Program. Watershed groups and local governments should consider using landscape assessments to identify priority areas, probable stressors, and wetland restoration and conservation opportunities (Apfelbeck, 2006).

When taken a step further, a set of profiles and reference wetlands could be developed based on this approach. By studying in detail the functioning of various reference wetland types, one should be able to extrapolate to other similar wetlands on the assumption that wetlands with similar landscape position and landform, similar location with respect to water sources, and similar slope and catchment area will also have similar functions (Brinson, 1993). The array of key wetland types that emerge as reference wetlands can be used not only for the purposes of characterizing and quantifying various aspects of wetland function, but also as standards to evaluate wetland construction and restoration projects. In this sense they become the standards of success in contrast to relying on endless lists of design criteria and performance standards. One of the most valuable uses may be in the training of wetland scientists who will be involved in work on permit review, assessment of functions, construction of new wetlands, and restoration of degraded ones (Brinson, 1993).

In Michigan, wetlands are just beginning to be considered in the context of watershed management planning and the creation of municipal master plans. Wetland restoration and enhancement are increasingly becoming popular tools, in lieu of traditional best management practices, to enhance the overall ecological health and surface water quality of a watershed. Understanding the overall historic impact of wetland loss and degradation can assist local planners and resource managers in sighting future development as it lends new importance to the wetlands that remain.

CONCLUSIONS

The findings of this analysis provide an estimate of the extent of wetland area and associated functionality since Pre-European Settlement times. Given that any landscape level analysis is a 'first-cut' approach to understanding wetland loss and its impacts, this type of assessment should be used as one piece to a larger wetland restoration/management plan and field work should be done to verify specific wetland functions predicted as part of this effort. However, understanding at a small scale the changes in wetland extent and functionality that have occurred throughout various watersheds over time should be a valuable tool to resource managers on the ground.

With the recent release of the FGDC Draft Wetland Mapping Standard, it is expected that all Federal efforts to map wetlands in the future will include the LLWW attribution explained in this report. This development ensures that information collected on wetlands at a landscape level will include the data necessary to produce a functional assessment for large geographic areas. The methodology employed in this study provides a consistent approach to assessing wetland function, which as a concept is being incorporated more and more into resource management of all kinds in Michigan. In the future, perhaps this information can be obtained at a statewide level, and give the first glimpse into the status and trends of Michigan's wetlands from a functional qualitative perspective.

ACKNOWLEDGEMENTS

Acknowledgement is due to the staff of the US Fish and Wildlife Service, Region 3, who were instrumental in the completion of this work. Specifically, Ralph W. Tiner provided conceptual support, documentation on the methodology, and assistance with construction of the presettlement wetlands inventory. Herbert Bergquist provided GIS and database support over the term of the project. Robert Zbiciak provided knowledge of local wetland ecology and associated functions, as well as application for this analysis within a wetland restoration framework. Peter Vincent of MDEQ assisted with the initial research into this effort and its techniques. Todd Losee provided an ecology/biology perspective to this effort and helped craft the methodology related to open waterbodies in the NWI database, as well as assistance with the presettlement wetlands inventory.

LLWFA Advisory Council

Ed Schools, Conservation Scientist, Michigan Natural Features Inventory (MNFI), DNR

Rob Zbiciak, Wetland Restoration Coordinator, DEQ -517-241-9021

Robert Goodwin, GIS Professional, MSU-RSGIS

Bradley Potter, Biologist, USFWS

Amy Lounds, Wetlands Specialist, DEQ

Jim Hudgins, State Coordinator, USFWS

James Sallee, Soil Specialist, DEQ

Jim Hazelman, Assistant State Coordinator, USFWS

Doug Pearsall, Senior Conservation Scientist, TNC

Robb Macleod, GIS Manager, Ducks Unlimited

Steve Sobaski, GIS Manager, TNC

Chad Kotke, 319 and CMI Grants Management, DEQ

Peter Vincent, Watershed Planning Coordinator, DEQ

Todd Losee, Wetlands Specialist, DEQ

Paul Seelbach, Fisheries Biologist, USGS

Barb Avers, Wildlife Biologist, DNR

Greg Souliere, Science Coordinator, USFWS

Chris Freiburger, Fisheries Habitat Biologist, DNR

David Mifsud, Herpetological/Ecosystems Specialist, Herpetological Resources & Management, LLC

Amy Derosier, Wildlife Action Plan Coordinator, DNR

William Bowman, State Soil Scientist, NRCS

REFERENCES

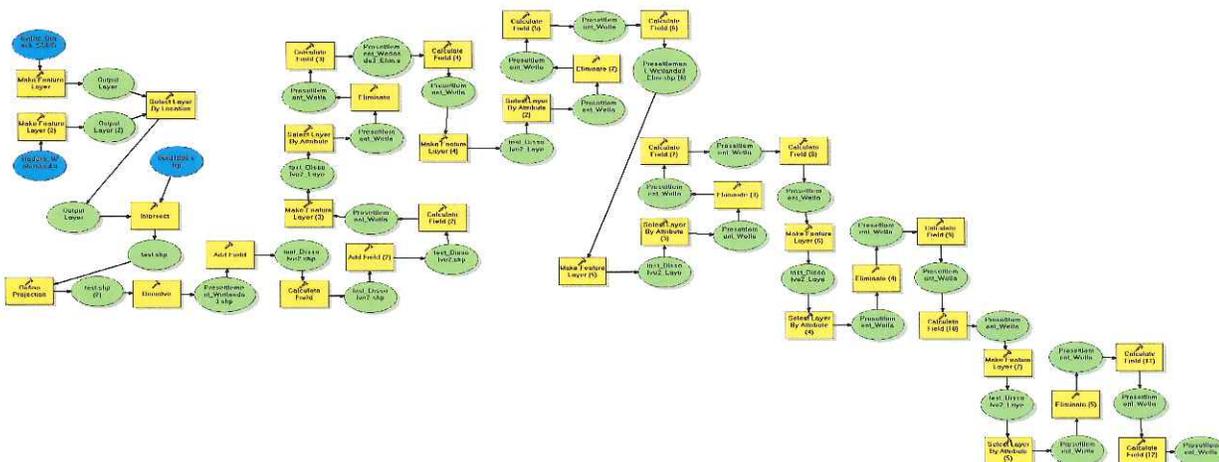
- Apfelbeck, R. 2006. "Integrating Wetland Inventory, Assessment and Monitoring into Local Watershed Plans and Montana's State Water Monitoring and Assessment Strategy," Montana Department of Environmental Quality, Helena, MI 59602
- Brinson, M. M. 1993. "A hydrogeomorphic classification for wetlands," Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. NTIS No. AD A270 053.
- Cappiella, K., A. Kitchell and T. Schueler. 2006. Using local watershed plans to protect wetlands. Center for Watershed Protection. Ellicott City, MD 21043. www.cwp.org
- Comer, Patrick J. 1996. Wetland Trends in Michigan since 1800: A Preliminary Assessment. Michigan Natural Features Inventory, Lansing, MI.
- Cowardin, L.M., Carter, V., Golet, F.C., and LaRoe, E.T. (1979). "Classification of wetlands and deepwater habitats of the United States," U.S. Fish and Wildlife Service, Washington, DC.
- Fennessy, M.S., A.D. Jacobs and M.E. Kentula. 2004. Review of rapid methods for assessing wetland condition. EPA/620/R-04/009. U.S. Environmental Protection Agency, Washington, DC. <http://www.epa.gov/owow/wetlands/monitor>
- Ramsar Convention on Wetlands. 2005. An integrated framework for wetland inventory, assessment and monitoring (IF-WIAM). Ramsar COP9 DR1 Annex E.
- Tiner, R. W, 2002, Enhancing wetlands inventory for watershed-based wetland characterizations and preliminary assessment of wetland functions. p. 17-39. *in*
- Tiner, R. W. 2003a. Dichotomous keys and mapping codes wetland landscape position, landform, water flow path, waterbody type descriptors. U.S. Fish and Wildlife Service, National Wetlands Inventory Northeast Region, Hadley, MA, USA,
- Tiner, R, W. 2003b. Correlating enhanced National Wetlands Inventory data with wetland functions for watershed assessments: a rationale for northeastern U.S. wetlands. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA, USA.
- Tiner, R. W, 2004, Remotely-sensed indicators for monitoring the general condition of in watersheds: an application for Nanticoke River watershed. Ecological Indicators 4:227-243. Tiner, R. W. and H, C Bergquist. 2003, Historical analysis of wetlands and their functions for the Nanticoke River watershed: a comparison between pre-settlement and 1998 conditions. U,S. Fish & Wildlife Service, Northeast Region, Hadley, MA, USA.. National Wetlands Inventory
- Tiner, R, W.. H. C. Bergquist. J, Q. Swords, and B, J. McClain. 2001. Watershed-based wetland characterization for Delaware's Nanticoke River watershed: a preliminary assessment report. U.S. Fish and Wildlife Service, Northeast Region, Hadley. MA, USA. National Wetlands Inventory report.
- Vance Linda, Kudray, Gregory M. and Stephen V. Cooper. 2006. Crosswalking National Wetland Inventory attributes to hydrogeomorphic functions and vegetation communities: a pilot study in the Gallatin Valley, Montana. Report to the Montana Department of Environmental Quality and the United States Environmental Protection Agency. Montana Natural Heritage Program, Helena, Montana 37 pp. plus appendices.

Appendix 1: Automation for Presettlement Spatial Data Creation

Pre-Settlement Wetland Coverage Creation

In Order to create the Pre-settlement Wetland layer some well thought out GIS processes had to be conducted.

1. Layers: State wide Hydric Soils data, Watershed boundary. These two layers were used to select all hydric soils polygons that intersected the watershed boundary.
2. The result of process one was then intersected with the land cover 1800 dataset in order to create polygons that contained hydric soils data along with the land cover type that they fell onto from the land 1800 data layer. These areas are then "Dissolved" based on landcover type so that any adjacent areas with the same covertype and musym code are merged together.
3. With the resulting polygons the idea now is to limit as many "smaller/or sliver" polygons as possible. The acreage is calculated for each of the polygons within the layer and then a selection done to select all wetlands ≥ 1 acre. These selected polygons are then "Eliminated" into neighboring polygons to remove the entire sliver or smaller poly's created during the intersect/dissolve process.
4. The "Eliminate Process is done a total of 5 times. After each time the acreage is recalculated and then the attributes reselected for 1 acre, 2 acre, 3 acre, 4 acre, 5 acre polygons. This allows for many small sliver, or inconsistent polygons to be incorporated into the neighboring polygon.
5. The final Dissolve leaves you with a polygon shapfile containing hydric soils codes, cover type, and finally updated acreage.



6. The next step is to cross walk the cover type and convert that into the NWI coding system (See Pre-Settlement NWI coding document). This step simply selects out cover types that are the same and then classes them to a NWI code based on this cover type. The water regime will come from the hydric soils data in the next step.
7. The polygons should contain a MUSYM soil code which will allow for the NWI water regime to be assigned to the correct wetland.
 - a. See the Hydric soils excel spreadsheet to locate the county in which the watershed falls.
 - b. Select out and convert the chosen county to a dbf file.
 - c. Add the table to your ArcMap mxd and Join that table with the table for your wetlands based on the MUSYM code.
 - d. Export out your joined shapefile.
8. You should now have a Pre-European Settlement wetland shapefile that contains NWI cover type polygons with a NWI attribute and a separate field for the water Regime. You then need to add the water regime to the end of the NWI attribute to complete your final NWI code.
9. Keep in mind that some watersheds cross multiple counties. When this happens you must break the Pre-European Settlement polygons up by county in order to get the correct MUSYM codes for each county.
10. Fill in the remaining water regimes that do not have a match by searching the hydric soils table to find the musym code and a location similar to the one your working in and assign it that water regime.

Appendix 2: 1800 Land Cover Codes to Cowardin Class Conversion

Pre-Settlement Land Cover Classes Conversion Table to Cowardin NWI Vegetative Classes

Uplands

CoverType: Beach-Sugar Maple Forest
Beach-Sugar Maple-Hemlock Forest
PFO1

CoverType: Black Oak Barren
Aspen Birch Forest
PFO1

CoverType: Mixed Oak Forest
Mixed Oak Savanna
Oak-Hickory Forest
Oak-Pine Barrens
PFO1

CoverType: Sand Dune
Grassland
PEM1

Cover Type: White Pine-Mixed Hardwood Forest
White Pine-White Oak Forest
White Pine-Red Pine Forest
Hemlock White Pine Forest
Pine Barrens
Spruce-Fir-Cedar Forest
PFO4

Wetlands

CoverType: Black Ash Swamp
PFO1

CoverType: Lake/River
River (Use Riverpoly) R2UB
Lakes (Use Lakepoly) L1UB

CoverType: Mixed Conifer Swamp
PFO4

CoverType: Mixed Hardwood Swamp
Cedar Swamp
PFO1

CoverType: Shrub Swamp/Emergent Marsh
PSS/EM

CoverType: Wet Prairie
Muskeg/Bog
PEM1

Appendix 3: NRCS Water Regime Definitions

Correlation Legend Scheme Of the NWI Water Regime - NRCS Hydric Soils Map Unit List

[A] Temporarily Flooded – “Non-hydric”, Moderately Well, Moderately Wet and Somewhat Poorly Drained Soils on Floodplain Terraces

Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime.

[B] Saturated – All Non-flooding, Poorly Drained Mineral Soils

The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present. (*Note: Farmed areas of these soils are not saturated to the surface. In some counties five to ten percent of the NRCS map units are on flood plains and in drainageways.*)

[C] Seasonally Flooded – Flooding, Poorly Drained, Coarse Soils with Fluctuating Water Tables

Surface water is present for extended periods especially early in the growing season, but is absent by the end of the season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.

[E] Seasonally Flooded/Saturated – Flooding, Very Poorly Drained, Mineral Soils

Surface water is present for extended periods especially early in the growing season and when surface water is absent, substrate remains saturated near the surface for most of the growing season.

[F] Semi-permanently Flooded – Flooding Marshes, Mucks, Mucky Soils and Very Poorly Drained Mineral Soils

Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface. (*Note: In some counties from 10 to 35 percent of these map units are in non-flooding, upland areas.*)

[G] Intermittently Exposed – Non Flooding Marshes, Mucks, Mucky Soils and Very Poorly Drained Mineral Soils

Surface water is present throughout the year except in years of extreme drought. (*Note: In some counties from 5 to 30 percent of the NRCS map units are on floodplains and in drainageways.*)

[H] Permanently Flooded – Subaqueous Soils along the Great Lakes, Bays and Major Rivers

Water covers the land surface throughout the year in all years.

by: William Bowman, NRCS, State Soil Scientist

9-26-08