Saint Mary's University of Minnesota

GeoSpatial Services

Wetland Functional Assessment and Wetland Restoration Prioritization Framework

Marengo River Watershed. Wisconsin

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Marengo River Watershed. Wisconsin

Kevin M. Benck, Kevin J. Stark, and Andy Robertson

Saint Mary's University of Minnesota
GeoSpatial Services
700 Terrace Heights, Box #7
Winona, MN 55987

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Acronyms and Abbreviations

CTI	Compound Topographic Index
DC LSB	Douglas County Lake Superior Basin
DEM	Digital Elevation Model
ELU	Ecological Landscape Unit
EPA	Environmental Protection Agency
GIS	Geographic Information System
LiDAR	Light Detection and Ranging
LLWW	Landform Type, Landscape Position, Waterbody Type, and Waterflow Path
LSB	Lake Superior Basin
NWI	National Wetland Inventory
PRW	Potentially Restorable Wetland
SPI	Stream Power Index
SURRGO	Soil Survey Geographic Database
WDNR	Wisconsin Department of Natural Resources
WFA	Wetland Functional Assessment

1. Introduction

1.1. Project Area

The study area for this project is the Marengo River watershed. The Marengo River watershed is situated in northern Wisconsin, and covers portions of Bayfield and Ashland Counties (Figure 1-1). The majority of the watershed is located within Ashland County, with a total combined area of 217.5 mi^2.

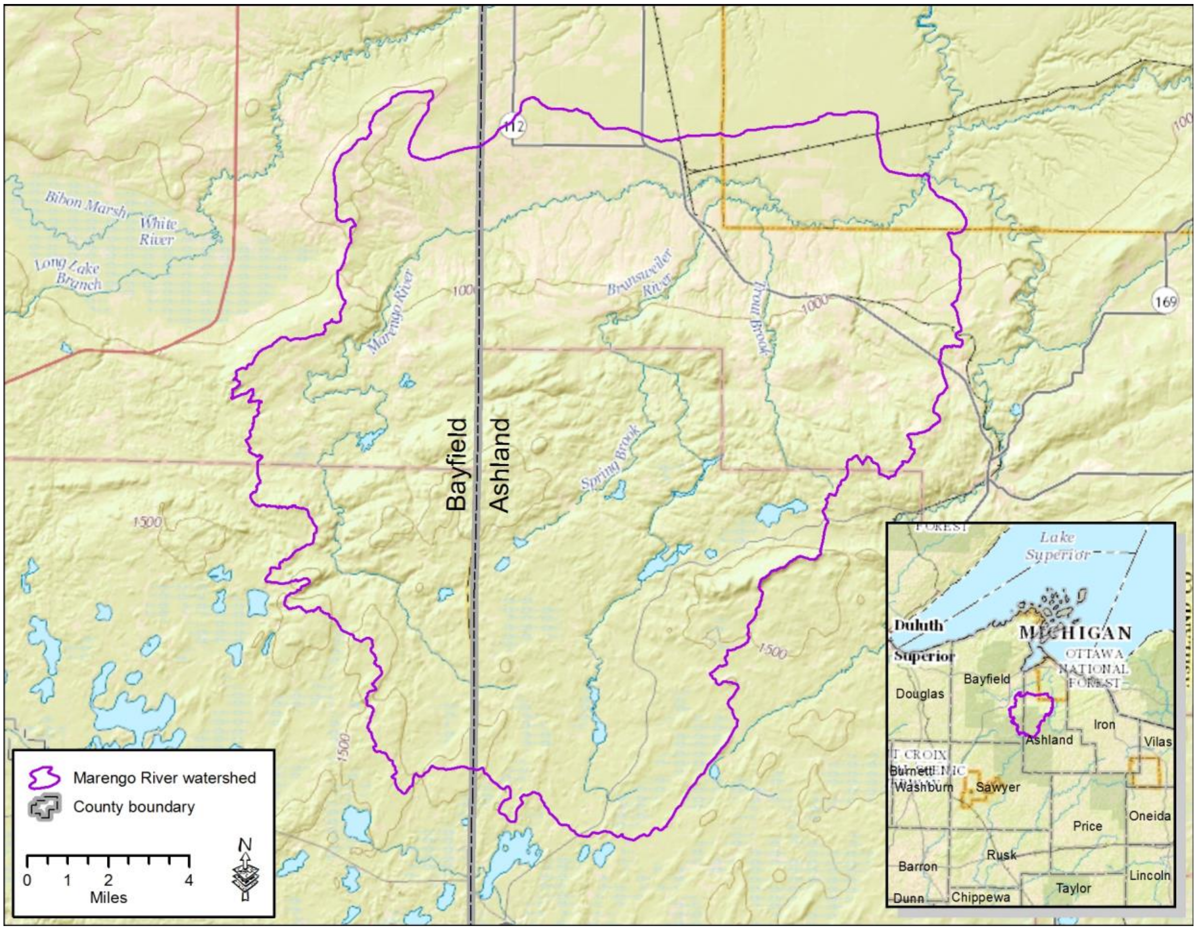

Figure 1-1. The Marengo River Watershed Study Area (purple outline) shown with area rivers, roads, and county boundaries. The inset map of shows location of watershed in relation to Bayfield and Ashland Counties and a portion of Lake Superior.

The Marengo River watershed is comprised of two ecological landscape units (ELUs), the Superior Coastal Plain and the North Central Forest (WDNR 2015a) (Figure 1-2).

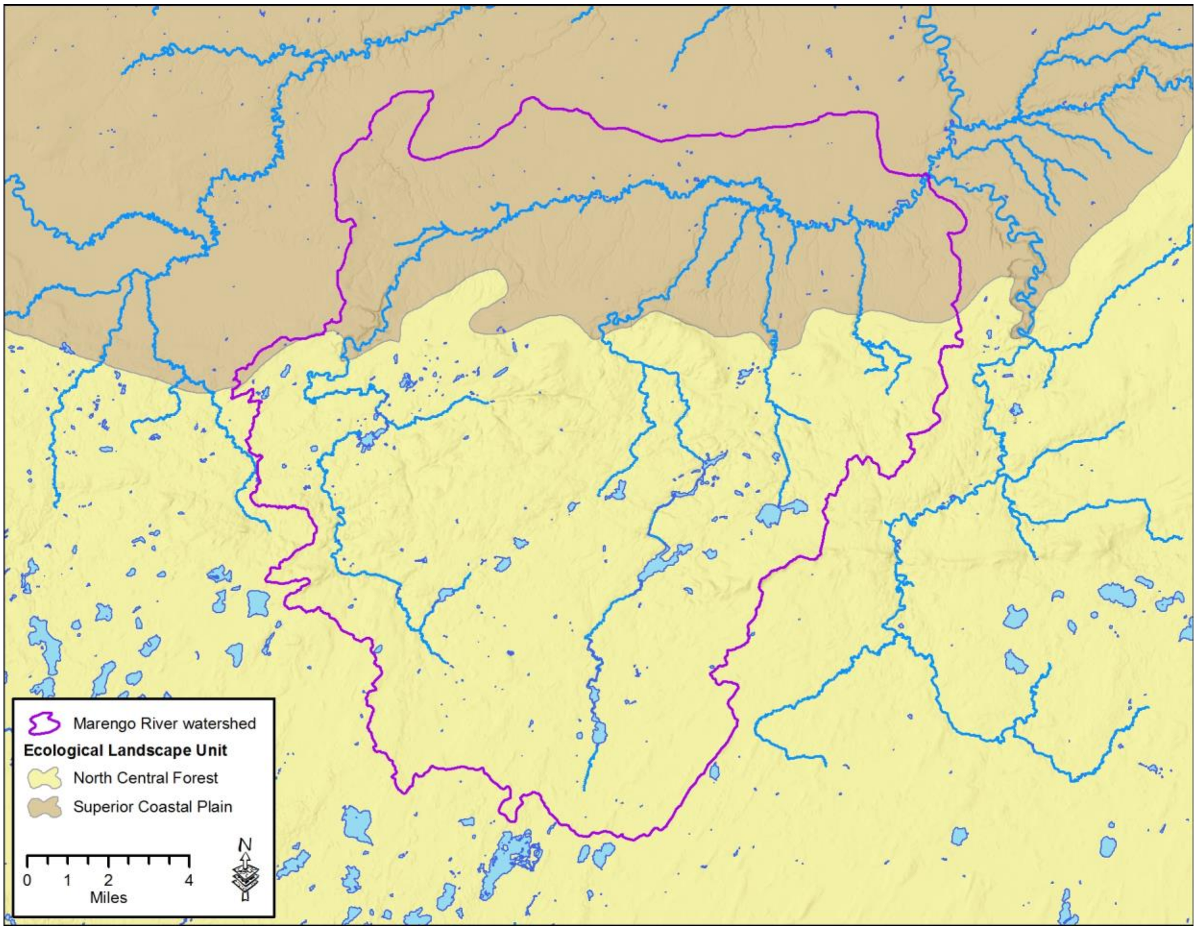

Figure 1-2. Ecological Landscape Units within the Marengo River watershed.

Superior Coastal Plain Ecological Landscape Unit
Only a small portion of the watershed is located within this unit, roughly the northern third (Figure 1-2). This is the northernmost of Wisconsin's ecological landscapes, bordered on the north by Lake Superior and on the south by the Northwest Sands, Northwest Lowlands, and North Central Forest ecological landscapes. The proximity to Lake Superior strongly influences the climate of this unit. The climate is characterized by cooler summers, warmer winters, and greater precipitation as compared to more inland ELU locations. Exposed areas along the coast of Lake Superior are subject to significant disturbance regimes (i.e. windstorms, waves, ice, currents, and periodic water level fluctuations). These disturbance regimes are determining factors in maintaining the characteristic landforms and vegetation types of shoreline ecosystems (WDNR 2015c).

Historically, this area was almost entirely forested. A mixture of eastern white pine (*Pinus strobus*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), white birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*), quaking aspen (*Populus tremuloides*), and northern white-cedar (*Thuja* *occidentalis*) grew on the fine-textured glacio-lacustrine deposits that border much of the Lake Superior coast. At present, this climax coastal forest has been fragmented through historical or current agricultural uses. Approximately one-third of this ELU is now non-forested (or sparsely forested with new growth). Open-land areas are dominated by grass cover, having been cleared then pastured or plowed. Nearly 40% of the remaining forested area is comprised of aspen and birch forests that are managed for pulp (WDNR 2015c).

Important soils include deep, poorly-drained reddish lacustrine clays on either side of the Bayfield Peninsula. The clay deposits include lenses of sand or coarse-textured till; these areas are especially erosion-prone when they are subjected to flowing water and down-cutting by streams. The tills covering the Bayfield Peninsula and Apostle Islands are variable in composition, but include clays, silts, loams and sands. Organic soils are limited in extent, occurring mostly in association with the peatlands on the margins of the coastal lagoons and to a lesser extent in basins underlain by impermeable tills (WDNR 2015c).

Lake Superior has had an enormous influence on the climate, landforms, soils, vegetation, and economy of the Superior Coastal Plain. Freshwater estuaries are present along the coast. Inland lakes are rare, but lagoons, some of them quite large, occur behind the coastal sandpits. Coldwater streams originate in the aquifers at the northern edge of the Northwest Sands in Bayfield County and flow north across the Superior Coastal Plain before emptying into Lake Superior. Many of the streams flowing across the clay plain suffered severe damage to their banks and beds during the era of heavy logging in the late 19th and early 20th centuries. Some of them have not yet recovered and their slumping banks continue to dump sediments into the main channels, and ultimately, into Lake Superior (WDNR 2015c).

North Central Forest Ecological Landscape Unit

The majority of the Marengo River watershed is located within this ELU. Overall, the North Central Forest Ecological Landscape most of the northern third of the state. The landforms within this ELU are characterized by end and ground moraines with some pitted outwash and bedrock controlled areas. In the northern portion of the ELU, kettle depressions and steep ridges are found. Two prominent areas in this ecological landscape are the Penokee-Gogebic Iron Range in the northern part of the ecological landscape, extending into Upper Michigan, and Timm's Hill, the highest point in Wisconsin (1,951 feet), in the southern part of the ELU. Soils consist of sandy loams, sands, and silts. Organic soils (peats and mucks) are common in poorly drained lowlands (WDNR 2015b).

The climate within this ELU is typical of northern Wisconsin, with cold winters and warm summers. Lake Superior influences climate in the northern portion of the North Central Forest, especially during the winter season when greater snowfall occurs here than in most areas in Wisconsin. Precipitation in this ELU is similar to the state average and almost 1 inch more than other northern ELUs. Annual snowfall is relatively high, exceeded only in the Superior Coastal Plain and Northern Highland ELUs. Typical of northern Wisconsin, the mean growing season in the ELU is 115 days, the shortest growing season of all ecological landscapes. The cool temperatures coupled with the short growing season are not conducive to supporting agricultural row crops (WDNR 2015b).

The climate, however, is especially favorable for the growth of forests. Forest cover in this ELU is extensive, containing over 28% of the state's forests. The historical vegetation here was primarily mesic hemlock-hardwood forest dominated by eastern hemlock (*Tsuga canadensis*), sugar maple (*Acer saccharum*), and yellow birch (*Betula alleghaniensis*). There were smaller areas of eastern white pine and red pine (*Pinus resinosa*) forest scattered throughout the ecological landscape, and individual eastern white pine trees were a component of the hemlock hardwood forest. Harvesting eastern hemlock to support the tanneries was common at the turn of the 20th century, and the species soon became a minor component of forests due to overharvesting and the lack of regeneration (WDNR 2015b).

Currently, forests cover cover approximately 81% of the ELU. Northern hardwood forest is dominant comprising 47% of the forested area. These stands are comprised of second-growth stands of sugar maple, American basswood (*Tilia americana*), and red maple (*Acer rubrum*), with scattered individuals or pockets of eastern hemlock, yellow birch, northern red oak (*Quercus rubra*), white ash (*Fraxinus americana*), balsam fir, and eastern white pine. Aspen-birch forests are also relatively dominant comprising 24% of all forested area in the ELU. Throughout the North Central Forest, there has been a substantial decrease of former dominants such as eastern hemlock, yellow birch, and eastern white pine, while sugar maple and early successional species, especially quaking aspen, have increased. A variety of forested and non-forested wetland community types are also present, and wet-mesic forests dominated by northern white-cedar and/or ashes (*Fraxinus* spp.) are more numerous here than anywhere else in the state (WDNR 2015b).

Rivers, streams, and springs are found throughout this ecological landscape. Major rivers include the Wisconsin, Chippewa, Flambeau, Jump, Wolf, Peshtigo, Pine, and Popple. Large lakes include Namekagon, Lac Courte Oreilles, Owen, Round, Butternut, North Twin, Metonga, Pelican, Pine, Kentuck, Pickerel, and Lucerne. Several large man-made flowages occur in the North Central Forest, including the Chippewa, Turtle-Flambeau, Gile, Pine, and Mondeaux. There are several localized but significant concentrations of glacial kettle lakes associated with end and recessional moraines (e.g., the Perkinstown, Bloomer, Winegar, Birchwood Lakes, and Valhalla/Marenisco moraines). In southern Ashland and Bayfield counties, the concentrations of lakes are associated with till plains or outwash over till. Lakes here are due to dense till holding up the water table. Rare lake types include marl and meromictic lakes and ultra-oligotrophic, deep seepage lakes (WDNR 2015b).

1.2. Project Background

Changes in land use and loss of wetlands in the Lake Superior Basin (LSB) have had an impact on the region's freshwater resources as a result of reduction in water storage capacity and increased volume and velocity of surface water runoff (LWCD 2016). This is a result of erosion and weathering of the geologically young red clay deposits left during the regions last glacial period (Verry and Kolka 2003). These soils are of low permeability, highly erodible, and prone to extensive mass wasting along stream banks, tributaries, and intermittent drainages (Verry and Kolka 2003, Stable Solutions LLC and Community GIS Inc. 2007). Due to this watersheds in the LSB have experienced increases in runoff volume and velocities which result in flashy stream flow condition that erode and further incise stream channels, undercut bluffs, and create turbidity and sedimentation problems (Stark and Conner 2013). Conservation efforts in the LSB have been focused on improving water quality through restoring and protecting the regions natural hydrology. This "slow-the-flow" (STF) philosophy has resulted in restoration and preservation efforts aimed at reducing peak flows and restoring the lost storage capacity in the LSB (Stable Solutions LLC and Community GIS Inc. 2007, Wheeler et al. In Press).

An important feature in the Marengo River watershed, and much of the LSB of Wisconsin, is the Lake Superior clay plain (hereafter referred to as the red clay plain) (Figure 1-3). This feature can be found in the lower portion of the Marengo River watershed at elevations 750–1,150 feet above sea level (Stable Solutions LLC and Community GIS Inc. 2007). This band cuts across the entire Wisconsin portion of the LSB and is highly erodible. Soils are typically comprised of clayey tills that were deposited across the landscape by glaciers and glacial Lake Duluth.

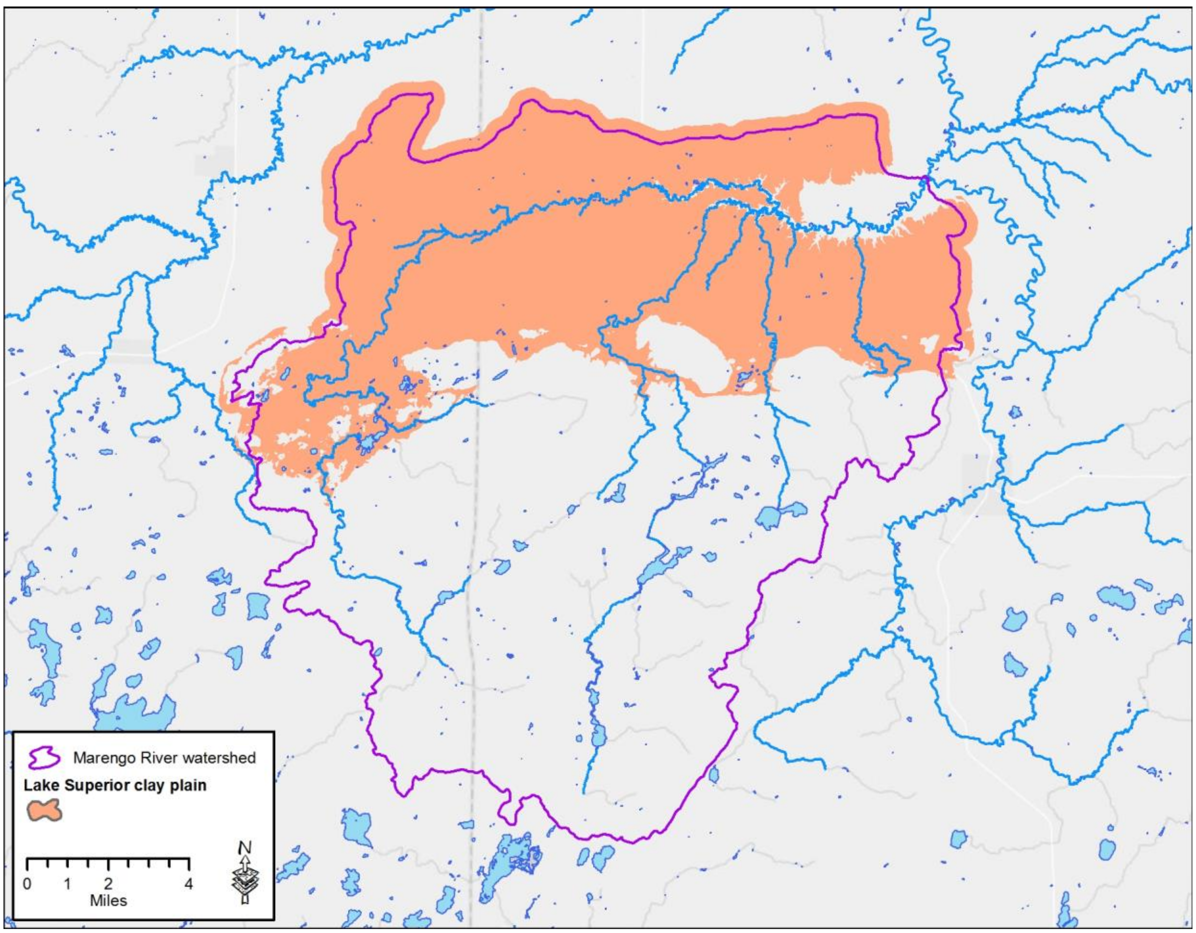

Figure 1-3. Location of the Lake Superior clay plain (red clay plain) within the Marengo River watershed.

Entrenched, alluvial valleys are found throughout this feature. Areas near the floodplains of the Marengo River are also frequently farmed, due to the loamier soil deposits that have built up from flood events (Stable Solutions LLC and Community GIS Inc. 2007).

The Marengo River Watershed has been identified as a key watershed for restoration efforts funded through the Great Lakes Restoration Initiative. Stable Solutions LLC and Community GIS Inc. (2007) conducted a test case to determine which hydrologic factors had the most influence on the timing, quality, and quantity of water in the Marengo River watershed. The intent was to use the results of this analysis to help identify and prioritize restoration projects in the watershed. The hydrologic assessment identified the following specific concerns or areas of concern in the Marengo River watershed:

- areas with more than 50 or 60% open land or young forest;
- sand deposition in the lower reaches of the watershed and at the confluence with the Bad River, filling in and channelizing flow and restricting access to floodplains;
- cropland tillage, rotation and surface drainage;
- water channeled by road and ditch systems; and
- drained wetlands contributing to the overall volume and velocity of water added to the river system during major runoff events.

Further assessments conducted in the watershed have identified other areas of concern including; the red clay plain areas mentioned earlier and a stretch of the Marengo River located between Kyster Road and County Highway C (Stable Solutions LLC and Community GIS Inc. 2007). This reach was identified through a cooperative study by the US Geological Survey and the Bad River Tribe Natural Resources Department, as having a high risk area for suspended sediment contributions.

In general the infrastructure and a strong support network for watershed conservation activities exists within the Lake Superior Basin Partnership, the Chequamegon Bay Partnership and the Bad River Watershed. However, some of the detailed current wetland information needed to prioritize wetland restoration and conservation is not available.

1.3. Purpose

The objective of this project is to identify and supply information and data that can be incorporated in a decision support matrix to help inform the public and local-level planning efforts. Specifically this project will produce data that represents the following wetland-related topics within the Marengo River watershed:

- Predicted wetland functions of existing, mapped wetlands,
- Locations of potential wetland restoration (i.e., wetland re-establishment) opportunities, and
- Production of supplemental spatial data that can be used to characterize the watershed in terms of potential sediment loads, the impact of open lands on overland flows, and barriers to natural flow.

Wetlands perform a number of ecological functions that help improve and maintain environmental quality. Stark and Robertson (2013) conducted a wetland functional assessment (WFA) that predicted the ability of a wetland to perform a given set of functions at a "significant" level relative to the ability of a watershed to provide the function. Significance in this context is used to identify wetlands that are likely to perform a given function at level relative to how other wetlands are performing. Assignment of wetland function predicted condition for each of the wetland polygons was based on a method that employs the National Wetland Inventory (NWI) or Cowardin classification and the Landform Type, Landscape Position, Waterbody Type, and Waterflow Path (LLWW) classification system (together referred to as NWIplus) for a given wetland that was developed by Tiner (2011). The assessment method used by Stark and Robertson (2013) included refinements to the mapping process and classification code to function performance correlations built of WFA conducted by (Miller et al. 2012, Richtman et al. 2012, Stark and Conner 2013).

The Environmental Protection Agency (EPA) defines three tiers of wetlands assessments; level 1) landscape-scale assessments; level 2) rapid wetland assessments; and level 3) intensive site-level assessments (EPA 2013). The wetland functional assessment conducted for this project is a level 1 assessment. The purpose of a level 1 assessment is to:

"…evaluate indicators for a landscape view of watershed and wetland condition. Level 1 wetland assessment methods do not involve a site visit and use the types of information that can be reviewed in the office at a desk, such as maps, soil inventories, and remote sensing-generated data such as GIS models, wetland inventories, and land use datasets." (EPA 2013, p. 22)

The WFA conducted for this project followed the methodology used by Stark and Robertson (2013). This included all assumptions and classification codes to wetland function correlations. The delineation of wetland boundaries and classification attribution was informed primarily through remotely-sensed information such as digital elevation models (DEMs), aerial photography, and other spatial datasets. It also relied on best profession judgment of local and regional wetland and soils experts. While the data are not intended to provide site-level specificity, they can be used to better understand the present-day distribution wetlands, which wetlands are predicted to be significant for performing certain ecological functions in the study area and provide an initial assessment of locations to be considered for the re-establishment of former wetlands. These areas may have drained some former wetlands or were otherwise altered from pre-settlement conditions based on their topographic position, their soils, and other visual evidence visible on high-resolution aerial photography.

This document provides a review of the findings of the WFA conducted for the Marengo River watershed. Descriptions of a select set of additional datasets that help to inform watershed planning decisions are also included.

2. Results

2.1. Current Wetlands

The tables in the following sections contain data summaries for both classification systems (NWI and LLWW), wetland function and availability of potentially restorable wetlands (PRWs). The NWI and LLWW summaries list the acreage for each of the major wetland classification parameters. In cases where there are dual attributes the dominant attribute was used for the summary. For example, wetlands with the NWI code PFO4/SS3B are summarized as PFO4B. The WFA summary lists acreage for each of the ecological functions predicted.

2.1.1. National Wetland Inventory System Classification

A general summary and breakdown of NWI System, Class, Water Regime, and Modifiers applied in the Marengo River watershed can be found in Table 2-1. Approximately 25,150 acres (or 18%) of the watershed is classified as wetland. Palustrine system wetlands accounted for the vast majority (94%) of the wetland area, lacustrine systems account for approximately 5%, and riverine systems account for approximately 2%. The majority of wetland area was dominated by forest (58%) or scrub shrub (20%) vegetation. Emergent wetlands account for approximately 14% of all wetlands with unconsolidated bottom wetlands (i.e., ponds, lakes and rivers) accounted for 7% of the total wetland area. Aquatic bed and unconsolidated shore wetlands account for remaining 1%

Table 2-1. Summary of the NWI codes found within the Marengo watershed.

	No. of polygons	Area (acres)	Percent of Watershed	Percent of All Wetlands
General				
Marengo Watershed	--	139,219	--	--
Wetlands	9,998	25,149	18.1%	--
Uplands	--	114,069	81.9%	--
NWI System				
P – palustrine	9,856	23,591	16.9%	93.8%
L – lacustrine	24	1,128	0.8%	4.5%
R – riverine	118	430	0.3%	1.7%
NWI Class				
FO – forested	6,427	14,435	10.4%	57.4%
SS – scrub shrub	1,402	5,054	3.6%	20.1%
EM – emergent	1,615	3,575	2.6%	14.2%
UB – unconsolidated bottom	396	1,839	1.3%	7.3%
AB – aquatic bed	56	225	0.2%	0.9%
US – unconsolidated shore	102	21	0.0%	0.1%
NWI Water Regime				
B – saturated	3,437	13,949	10.0%	55.5%
C – seasonally flooded	5,641	8,259	5.9%	32.8%
H – permanently flooded	48	1,615	1.2%	6.4%

Table 2-1 (continued). Summary of the NWI codes found within the Marengo watershed.

	No. of polygons	Area (acres)	Percent of Watershed	Percent of All Wetlands
NWI Water Regime (continued)				
F – semi-permanently flooded	459	708	0.5%	2.8%
G – intermittently exposed	250	328	0.2%	1.3%
A – temporarily flooded	161	290	0.2%	1.2%
K – artificially flooded	2	0	0.0%	> 0.05%
NWI modifiers				
g – organic soil	2,351	3,677	2.6%	14.6%
b – beaver	295	1,899	1.4%	7.6%
h – impounded	87	423	0.3%	1.7%
bg – beaver, organic soil	43	155	0.1%	0.6%
f – farmed	29	34	0.0%	0.1%
x – excavated	111	28	0.0%	0.1%
xg – excavated, organic soil	20	5	0.0%	> 0.05%
d – partially drained	2	1	0.0%	> 0.05%
hg – impounded, organic soil	1	1	0.0%	> 0.05%

The (B) and (C) water regimes accounted for just over 88% of the wetland area. The saturated (B) water regime occurred in 56% of wetlands with the seasonally flooded (C) water regime found in approximately 33%. Permanently flooded (H) regimes accounting for just over 6% of wetland area with semi-permanently flooded (F) regimes covering approximately 3% of the watershed. Intermittently exposed (G), temporarily flooded – freshwater tidal (S), and artificially flooded (K) water regimes made up the remaining area percentages.

Special modifiers were assigned to approximately 25% of the wetlands in the watershed. Organic soil wetland (g) was a common special modifier in the NWI wetland data which accounted for 15% of the total wetland area. It should be noted that only wetlands that were mostly coincident with organic soil map units in SSURGO were given the “g” modifier. It is likely that many other small bogs exist in the dataset that do not have the “g” modifier, but may well contain organic soils. Wetlands dominated by species such as tamarack (*Larix laricina*, NWI subclass 2), black spruce (*Picea mariana*, NWI subclass 4), and leatherleaf (*Chamaedaphne calyculata*, NWI subclass 3) are likely to be organic soils. These wetlands were not all identified as organic because of scale limitation of the soils data, specifically the inclusions not identified by a distinct soil map unit. Beaver activity also appears to be having a significant influence on many wetlands. At least 338 wetlands were considered beaver ponds in the watershed.

2.1.2. Landscape Position, Landform, Water Flow Path, Waterbody Classification

The summary for the LLWW data is presented in Table 2-2. Terrene was the most common landscape position comprising approximately 68% of the total wetland area in the watershed. In terms of LLWW Inland landform, flat (FL) was the most common classification at approximately 44% by area, with basin (BA) the second most abundant at 34% by total wetland area. Outflow (OU) was the most common water flow path with 36% of the wetland area, with outflow-intermittent (OI) accounting for 29% of the wetland area in the watershed. The headwater modifier (hw, ≈30%) and discharge to stream (ds, ≈28%) were the most frequently applied modifiers. Waterbodies (LK, PD, and RV) accounted for approximately 8% of the mapped wetland area, with lakes (LK) accounting for approximately 5% of the wetland area. However, ponds (PD) were the most frequently occurring of the waterbodies representing 92% of the total number of waterbodies mapped.

Table 2-2. Summary of the NWI codes found within the Marengo watershed.

	No. of polygons	Area (acres)	Percent of Watershed	Percent of All Wetlands
General				
Marengo Watershed	--	139,219	--	--
Wetlands	9,998	25,149	18.1%	--
Uplands	--	114,069	81.9%	--
Landscape Position				
LE – Lentic	65	191	0.1%	0.8%
LR – Lotic River	704	1,774	1.3%	7.1%
LS – Lotic Stream	1,214	4,077	2.9%	16.2%
TE – Terrene	7,564	17,050	12.2%	67.8%
Landform				
IL – island	5	2	0.0%	0.0%
FR – fringe	26	32	0.0%	0.1%
FP – floodplain	881	2,458	1.8%	9.8%
BA –basin	6,396	8,649	6.2%	34.4%
FL – flat	1,923	10,938	7.9%	43.5%
SL – slope	313	1,008	0.7%	4.0%
Waterbody Type				
LK – Lake	20	1,120	0.8%	4.5%
PD – Pond	414	529	0.4%	2.1%
RV – River	17	409	0.3%	1.6%
Waterflow Path				
BI – bidirectional flow	25	54	0.0%	0.2%
IS – isolated (now considered vertical flow)	2,012	704	0.5%	2.8%
TI – throughflow-intermittent	556	1,382	1.0%	5.5%
TH – throughflow	1,681	6,620	4.8%	26.3%
TB – bidirectional throughflow	40	139	0.1%	0.6%
OU – outflow	923	9,026	6.5%	35.9%
OI – outflow-intermittent	4,761	7,225	5.2%	28.7%

Table 2-2. Summary of the NWI codes found within the Marengo watershed.

	No. of polygons	Area (acres)	Percent of Watershed	Percent of All Wetlands
Select LLWW modifiers				
bv – beaver	259	1,856	1.3%	7.4%
ds – discharge to stream	4,533	7,066	5.1%	28.1%
hw – headwaters	1,511	7,446	5.3%	29.6%

2.1.3. Wetland Functional Assessment

The WFA conducted for wetlands in the Marengo River watershed used the same assumptions and correlation tables applied by Stark and Robertson (2013) in Douglas County, Wisconsin. The correlation table and assumptions are provided as Appendix A and Appendix B of this document. In general a matrix was used to correlate the NWIplus characteristics and identified spatial relationships between wetlands to other wetlands, streams, rivers, or lakes to determine if the performance of a given function was significant. Significance was assessed in terms of three categories; high, moderate, or no prediction was given. Wetlands identified as highly significant are predicted to be more significant in performing a given function than those assessed as moderate. Any wetland not predicted to be significant for a given function (not designated as high or moderate in the geospatial data table) are either not predicted to perform the function or may simply perform the function less efficiently and therefore are not predicted to be a significant wetland type for that function.

The summary for the WFA is presented in Table 2-3. Overall, habitat support for the suite of species was provided by less than 30% (with the exception of Other Wildlife Habitat) of the wetlands in the watershed. In general, the wetlands performed these functions as the “High” level, with the exceptions of Fish Habitat and Shorebird Habitat. Nearly every wetland in the watershed provides some level of habitat for mammal, reptile, or songbird species as is reflected by the Other Wildlife Habitat results. These wetlands are also predominantly functioning at the “High” level (≈82%), However, this is result should be interpreted with caution, as there are significantly fewer criteria for selection as “High” or “Moderate”, than some of the other habitat provisioning functions (see Appendix B). The overall low numbers of wetlands performing these functions at a significant level, does suggest that there is potential wetland enhancement, whereby management actions could be implemented to increase the predicted performance of these wetlands. Further investigation including field-level reconnaissance and data collection is required to verify this assumption.

In contrast to the low performance numbers for the Habitat Provisioning functions, the functions considered as Physical/Chemical Processes were provided by the majority of the wetlands in the watershed, mainly at the “High” level. The Sediment and Other Particulate Retention and Shoreline Stabilization functions were provided by the least number of wetlands. This is somewhat expected, due to the nature of the watershed and the issues with erosion and sediment loadings associated with the watersheds within the Lake Superior clay plain. With the exceptions of Carbon Sequestration and Surface Water Detention, “High” performing wetlands outnumbered their “Moderate” counterparts. While the results show that the Physical/Chemical Processes functions are being performed by more wetlands throughout the watershed than the Habitat Provisioning functions, the results of the WFA also can be interpreted to indicate the potential for management actions to improve the predicted performance of these functions, through enhancement of existing wetlands. As was the case above, the same caveats on this interpretation also apply.

Table 2-3. Summary of predicted wetland functional performance for wetlands in the Marengo watershed

	No. of polygons	Area (acres)	Percent of Watershed	Percent of All Wetlands
General				
Marengo Watershed	--	139,219	--	--
Wetlands	9,998	25,149	18.1%	--
Uplands	--	114,069	81.9%	--
Habitat Provisioning				
Amphibian Habitat (AMH)	**2,839**	**3,884**	**2.8%**	**15.4%**
High	2,723	3,723	2.7%	14.8%
Moderate	116	161	0.1%	0.6%
Fish Habitat (FIS)	**1,491**	**5,280**	**3.8%**	**21.0%**
High	365	2,250	1.6%	8.9%
Moderate	1,126	3,030	2.2%	12.0%
Migratory Bird Habitat (MBIRD)	**160**	**554**	**0.4%**	**2.2%**
High	160	554	0.4%	2.2%
Moderate	0	0	0.0%	0.0%
Shorebird Habitat (SBH)	**450**	**291**	**0.2%**	**1.2%**
High	102	21	0.0%	0.1%
Moderate	348	270	0.2%	1.1%
Waterfowl and Waterbird Habitat (WBIRD)	**2,295**	**5,766**	**4.1%**	**22.9%**
High	1,462	4,738	3.4%	18.8%
Moderate	833	1,029	0.7%	4.1%
Woodcock Habitat (WCK)[1]	**1,757**	**6,815**	**4.9%**	**27.1%**
Other Wildlife Habitat (OWH)	**9,790**	**25,052**	**18.0%**	**99.6%**
High	3,586	20,584	14.8%	81.8%
Moderate	6,204	4,468	3.2%	17.8%
Physical/Chemical Processes				
Carbon Sequestration (CAR)	**9,526**	**23,307**	**16.7%**	**92.7%**
High	2,648	3,920	2.8%	15.6%
Moderate	6,878	19,387	13.9%	77.1%
Nutrient Transformation (NT)	**9,264**	**22,883**	**16.4%**	**91.0%**
High	7,800	19,563	14.1%	77.8%
Moderate	1,464	3,320	2.4%	13.2%
Sediment and Other Particulate Retention (SR)	**6,328**	**9,380**	**6.7%**	**37.3%**
High	3,422	6,540	4.7%	26.0%
Moderate	2,906	2,840	2.0%	11.3%

Table 2-4 (continued). Summary of predicted wetland functional performance for wetlands in the Marengo watershed

	No. of polygons	Area (acres)	Percent of Watershed	Percent of All Wetlands
Shoreline Stabilization (SS)	**2,346**	**10,666**	**7.7%**	**42.4%**
High	1,880	6,032	4.3%	24.0%
Moderate	466	4,634	3.3%	18.4%
Streamflow Maintenance (SM)	**7,503**	**18,146**	**13.0%**	**72.2%**
High	3,842	10,293	7.4%	40.9%
Moderate	3,661	7,854	5.6%	31.2%
Surface Water Detention (SWD)	**9,405**	**23,922**	**17.2%**	**95.1%**
High	2,452	8,848	6.4%	35.2%
Moderate	6,953	15,074	10.8%	59.9%

[1] - Woodcock habitat was identified as only present/absent. No qualifier was determined

2.2. Potential Restorable Wetlands

2.2.1. Data Development

Stark and Robertson (2013) reviewed existing landscape-scale methods used to identify the locations of PRWs and apply those methodologies to Douglas County, Wisconsin. This analysis showed that the current method of intersecting hydric soils with topographic indices under-estimated the occurrence of PRWs within the red clay plain area. This was due, in part, to the complex nature of the soils in this area and in part to the way the soils were represented in digital map form. There weren't soil map units considered hydric by soil taxonomic rules and soil types were aggregated into soil map units (i.e., soil complexes), thereby excluding them from this type of query. In many cases, soil map units (MUs) contained multiple soil components with coverage percentages split across several components. For example, a given soil map unit might be made up of component A at 40%, component B at 30%, component C at 20%, and component D at 10%.

Stark and Robertson (2013) addressed this issue by refining the process of identifying PRWs in the clay plain through a process of disaggregating the soil map unit data so that only soils with some wetland potential based on SSURGO soil map unit characteristics coincident with areas of higher compound topographic index (CTI) values were identified. CTI is designed to represent soil wetness; it is a function of the slope and the upstream contributing area per unit width orthogonal to the flow direction. PRW polygons were created using a query of soil map units combined with areas of high CTI values. First, criteria for identifying which soils would be useful for predicting wetland restoration sites. For this, the description of all SURRGO soil map units in the county were reviewed. In order to capture soils that aren't considered hydric by soil taxonomic rules and certain components within a soil map unit (polygon), all soils with a drainage class of "somewhat poorly drained" or wetter were subset from the SURRGO database. Second, a threshold of which CTI values are relevant to predicting wetland restoration sites was needed. Due to the nature of the soil complexes in the red clay plain, separate CTI thresholds were established for areas in the red clay plain versus outside the red clay plain. The soil polygons and CTI data were combined to produce an initial "population" of areas likely to support wetlands. Next, the known wetlands were removed in order to locate possible former wetlands (aka potential wetland re-establishment sites). A detailed review of the method by Stark and Robertson (2013) is provided in Appendix C.

Stark and Robertson (2013) reported that additional datasets could be included in the development of a former (or historic) wetlands layer. The hypothesis was that the inclusion of additional data would produce a more realistic representation of the location and extent of pre-settlement wetlands. In reviewing the available pre-settlement land cover data (Finley 1976), it was determined that the land cover was mapped at too course a level to provide additional clarification to the location of wetlands. Land cover data (ca. 1930) was also available from the Border surveys. This mapping part of the Wisconsin Land Economic Survey maps. The land cover conditions depicted in the maps for Douglas County represent conditions found in 1933, at the peak of agricultural conversion in the county (Butcher 2016). Much of the current surface drainage network was in place at the time of this survey (Butcher 2016). Based on the surface drainages mapped by Stark and Robertson (2013), an interpretation of the areas drained by this network was developed and included in the historic wetland development. This dataset is based on the assumption that the ditch drainage network was established to drain wetland areas in order to allow farming. In addition the current wetland data layer was included as the final data input to the historic wetland layer.

In addition to the collateral data inputs, a slight modification was made to how the datasets were combined to create the historic wetland dataset. For this analysis, all data was converted to raster, or gridded cell data. This allows for the incorporation of map algebra, where the output data is based on scored input data using a mathematical formula. The same assumptions for developing select soil map units and topographic characteristics as were determined by Stark and Robertson (2013) were used to create input data in relation to the clay plain area. An additional scored attribute was included that would be part of the confidence level associated with each raster cell in the final output. The locations of current wetlands and drained areas were similarly coded with values. The final steps in the development of this data layer were to identify the total number of raster cells associated with each wetland complex and remove those that were less than the minimum mapping unit used in the original Stark and Robertson (2013) wetland mapping. The potentially restorable wetland dataset was created from this layer through the removal of current wetlands and developed areas, using the same method as Stark and Robertson (2013). The resultant data (Figure 2-1) also includes the confidence level information that can be used in prioritizing restoration opportunities.

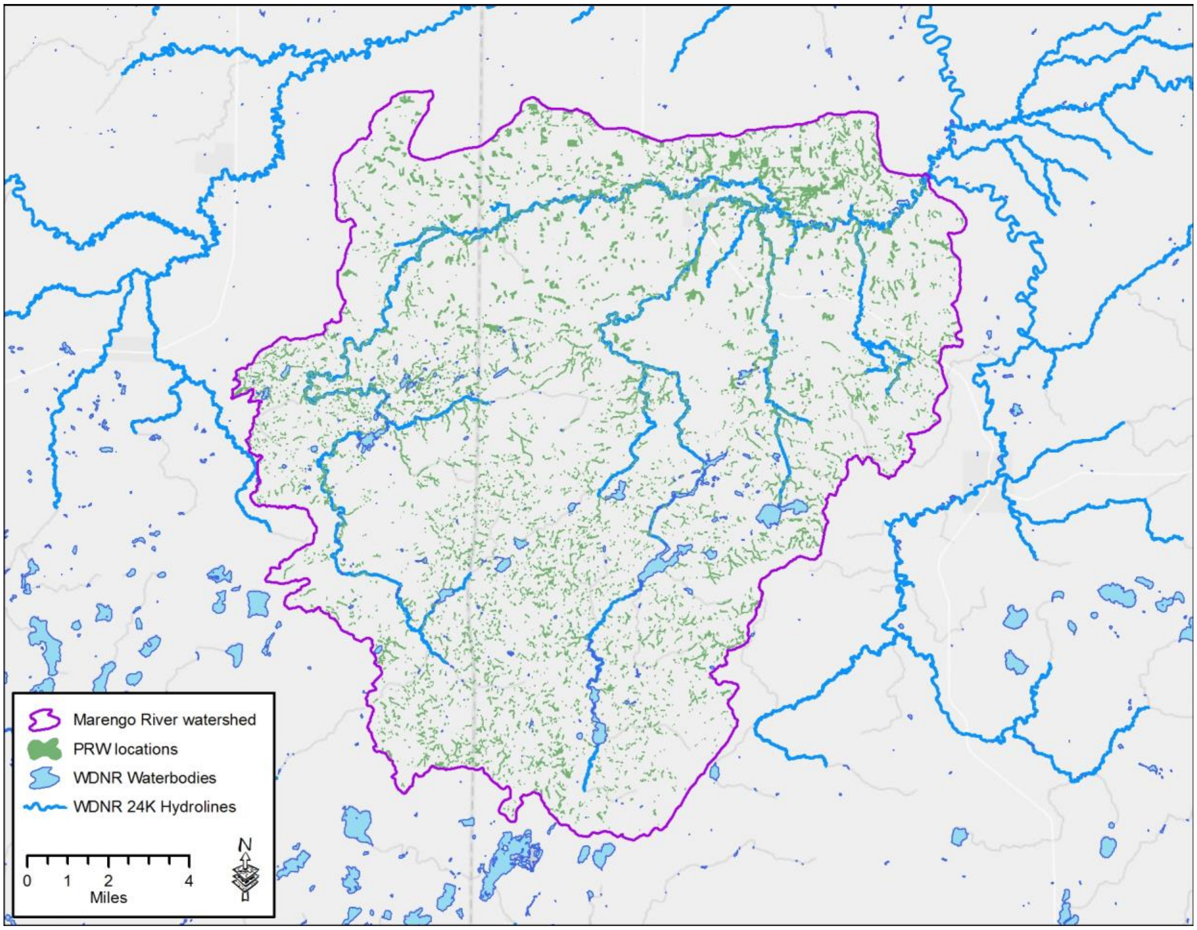

Figure 2-1. Distribution of locations within the watershed that were identified as potentially restorable wetlands.

2.2.2. Summary

The analysis identified over 52,000 locations that satisfied the criteria used to establish PRW locations. In an effort to narrow this list, a selection was made to show only those locations that are ≥5 acres in size (Figure 2-2). This analysis identified 54 locations. The dataset also includes a confidence level factor that can be used to further narrow this list. This confidence level is based on the contributing datasets used to create the PRW dataset. The larger the number, the more likely the identified location was previously a wetland.

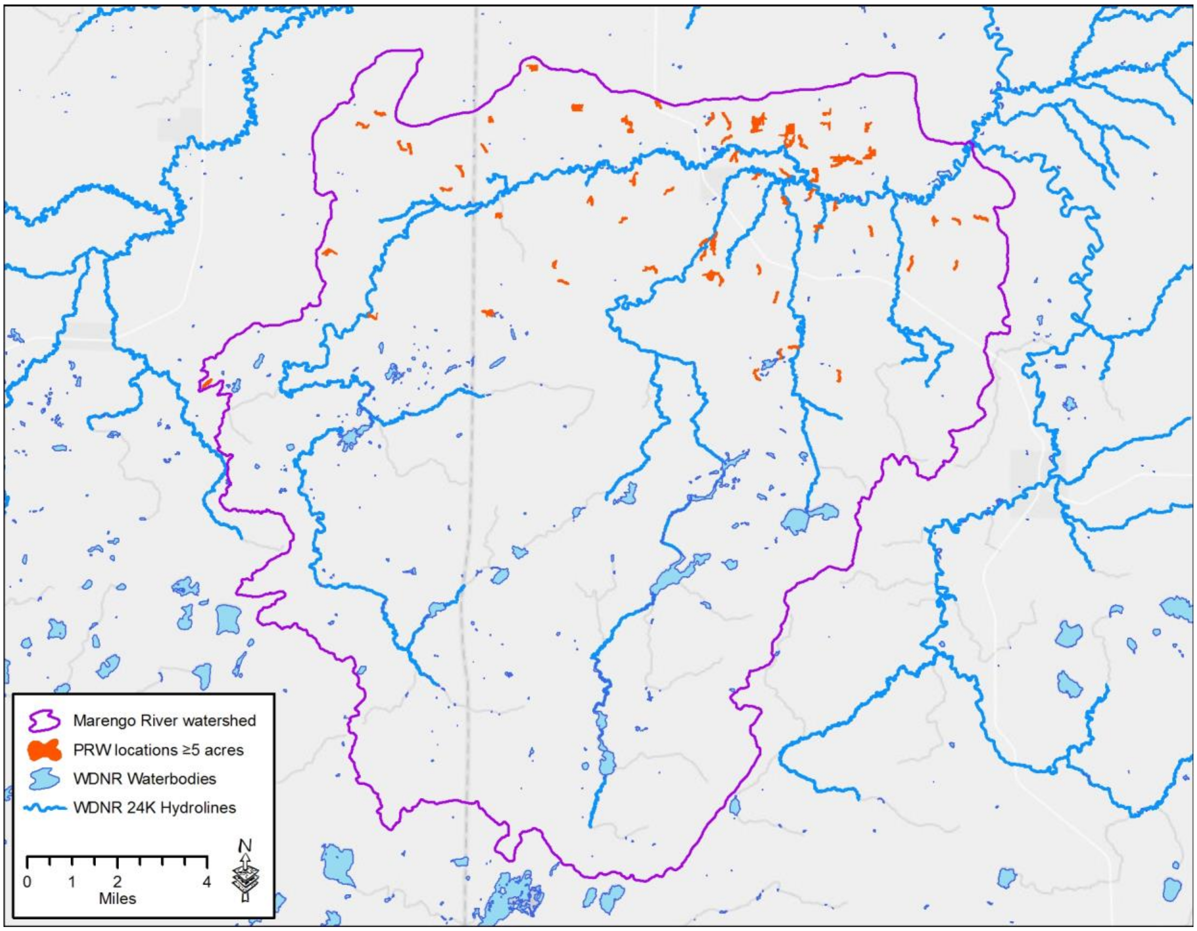

Figure 2-2. PRW representative that are ≥5 acres in size.

2.3. Other Data Analysis

In addition to the WFA, a number of other datasets were developed that would provide additional information on conditions in the watershed. These datasets include layers that would be beneficial in understanding the watersheds surface water hydrology and identify potential locations of wetland restoration/enhancement/preservation opportunities.

2.3.1. Surface Water Flow

In an effort to improve understanding of surface flow in the watershed, features that convey or in some cases cause a barrier to flow are important to identify and incorporate in both hydrologic and terrain analyses used to better understand the complex erosion and sedimentation issues within the watershed.

Ditch and Drainage Path Network

Drainage ditches, drainage paths, swales, and in some cases ephemeral streams not captured in the Wisconsin Department of Natural Resources (WDNR) 24K flow line dataset, act to convey water into the intermittent and perennial stream network of the watershed. These features were delineated using interpretation of several landscape-scale datasets including, aerial imagery, DEM derived hillshades, and the existing 24K flow network. The digitized drainage features were then snapped to the existing WDNR 24K Hydroline dataset.

The ditches and drainage paths were found to be most concentrated in the northern portion of the watershed, within the red clay plain (Figure 2-3). They often drain agricultural fields to the nearest roadside ditch or stream (Figure 2-4). In an attempt to characterize the ditch and drainage paths in order to differentiate between channelized ditches and natural or semi-natural drainage paths, the data was attributed with codes reflecting the type of ditch. The ditch types in the dataset are; in-field (within agricultural fields), roadside ditches[1], culverts, channelized flow through wetlands, natural flow paths through wetlands, natural connections to a 24K hydro flowlines, and artificial flow paths through open water. The agricultural ditches are particularly relevant for providing indications of potential wetland restoration, specifically wetland re-establishment, sites; visible ditching is evidence of hydrologic alteration and therefore, possible wetland drainage. In addition, in some cases it was found that drainages might even be intermittent streams not captured in the WDNR 24K hydro flowline data.

[1] that roadside ditches were only digitized when enhanced in-field flow paths (shallow ditches) flowed into them. The downstream path would be digitized until it found it's way downstream to an existing WDNR 24K hyroflowline feature (typically an intermittent or perennial stream).

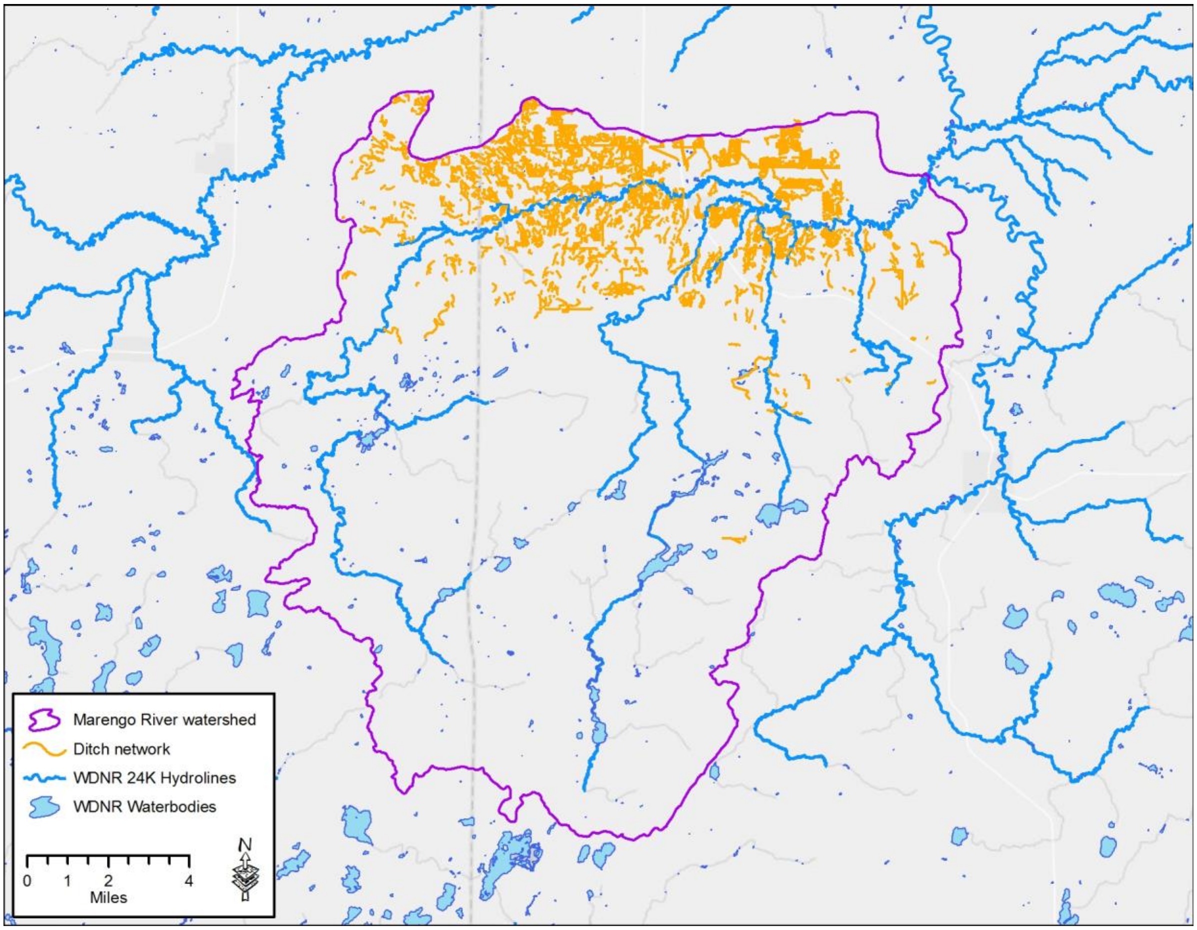

Figure 2-3. General distribution of ditches in the Marengo River watershed. Note: some of these “ditches” are likely relatively shallow and include some semi-natural drainage paths that have been enhanced in order to reduce surface ponding.

Figure 2-4. Aerial view of a network of agricultural (in-field) drainage and their interpreted connection to the existing WNDR 24K flowlines.

Barriers to Flow

A variety of features on the landscape can be barriers to the natural surface flow within the watershed. These features include culverts (undersized or blocked), abandoned rail beds, logging roads, private drives and trails; and natural features such as beaver dams. In many cases, these features can be interpreted from the same collateral datasets used to create the ditch and drainage path network.

Potential barriers to flow were identified through aerial photo interpretation using a variety of collateral datasets and the wetland polygon layer to supplement and inform the determination of the presence/absence of a potential barrier. A linear dataset was created, with the polylines denoted the locations where anthropogenic influences were felt to have altered a normal flow or path of a wetland. These features tended to be fairly evenly distributed throughout the watershed (Figure 2-5). The majority of the features identified tended to be barriers caused by raised roadbeds and railroad grades (Figure 2-6). Naturally occurring alterations, such as beaver dams or impounded farm ponds were not included in the dataset.

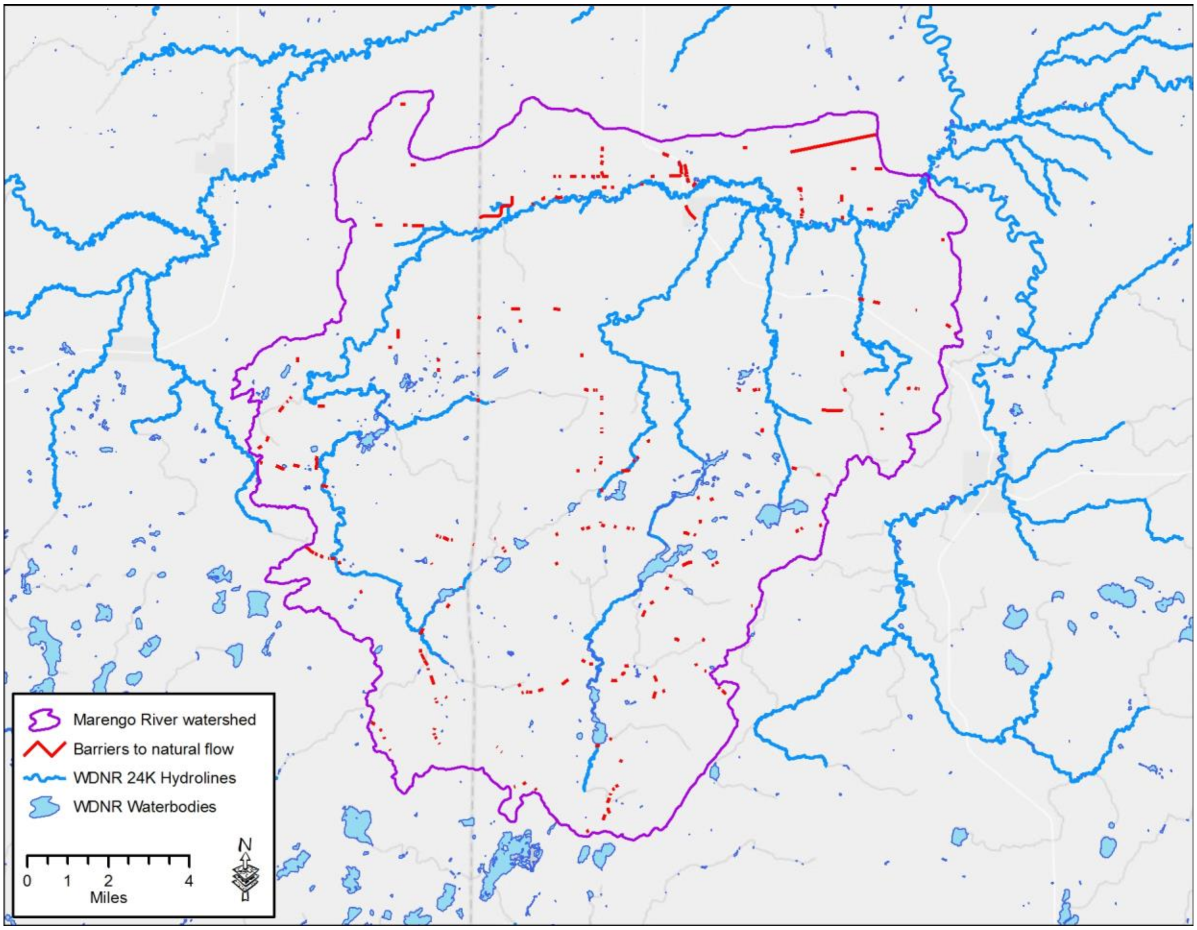

Figure 2-5. Distribution of features that have the potential to be barriers to natural waterflow in the Marengo River watershed.

Figure 2-6. Aerial view of a location where a road has created an artificial barrier to the natural surface flow. The barrier is indicated by the red line.

2.3.2. Terrain Analysis

Terrain analysis is a landscape modeling technique that uses DEM data in a geographic information system (GIS) to describe the hydrologic processes that are related to erosion and sedimentation. This is done through calculations and modeling techniques incorporating DEM, DEM-derived datasets and corollary datasets.

A stream power index (SPI) can be used to describe potential flow erosion and related landscape processes. The SPI is a calculated value of upstream catchment area, the erosive power of flowing water, and the slope of each individual cell in the raster and can be used to identify suitable locations for soil conservation measures to reduce the effect of concentrated surface runoff. An SPI raster was developed for the Marengo Watershed and analyzed in conjunction with the existing WDNR 24K hydro flowlines, and with an open lands analysis and an overland flow accumulation model. The results of these two analyses are provided below.

Combining the SPI with the stream segments in the WDNR hydrology layer identifies segments with highest stream power. These stream segments are more likely to be contributing disproportionate sediment loads compared with other stream segments. Streams in the lower portion of the watershed tend to exhibit a higher level of stream power and are potentially more susceptible erosion Figure 2-7).

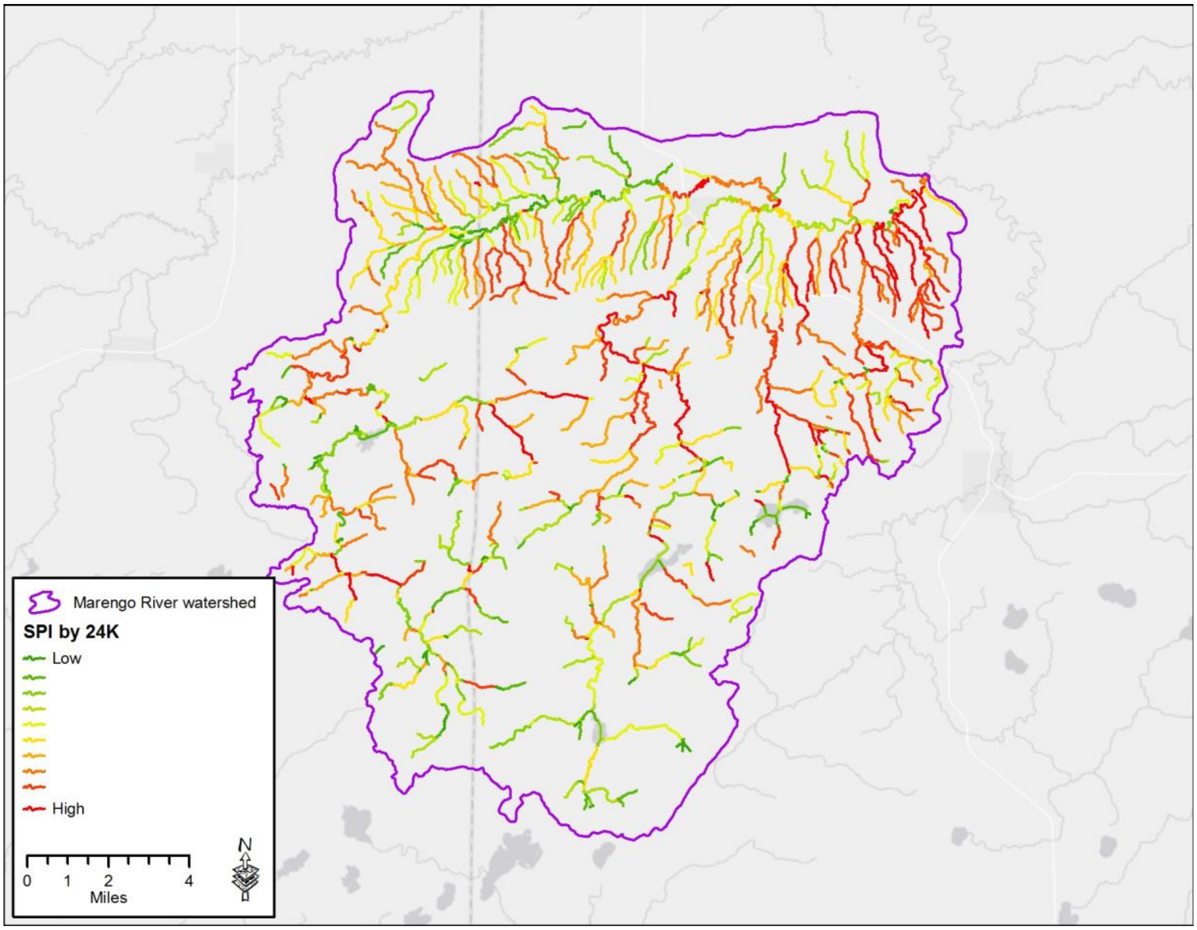

Figure 2-7. Stream Power Index analysis for the WDNR 24K hydro flowline. Streams with lower index value are shown in green, with the streams with the highest index shown in red.

2.3.3. Open Land Effects on Flow Accumulation

To further analyze erosion potential within the watershed, the results of the flow accumulation model were combined with the open lands dataset. The open lands dataset was created to measure the proportion of open land and impervious surface within the watershed, where open land is land that has been cleared for one purpose or another such as timber harvest or residential development, and has no or limited forest canopy cover). The flow accumulation model produces a dataset that represents the cumulative area that contributes flow to any point across a contiguous landscape. The flow accumulation model also takes into account the direction of flow across a given landscape. The result of combining these two layers is a dataset that can be used to quickly identify areas where the potential for erosion is high.

For the purposes of this project, this dataset has been aggregated at the HUC-12 level (Figure 2-8). This figure shows areas that are potentially more susceptible to erosion, due to high total percent of the watershed being open land and also characterized by high levels of flow accumulation. Regions in the upper portions of the watershed exhibit low levels of susceptibility, while predictable the potential susceptibility increases in the lower regions of the watershed. The areas with the highest susceptibility are the HUC-12's associated with the Marengo River.

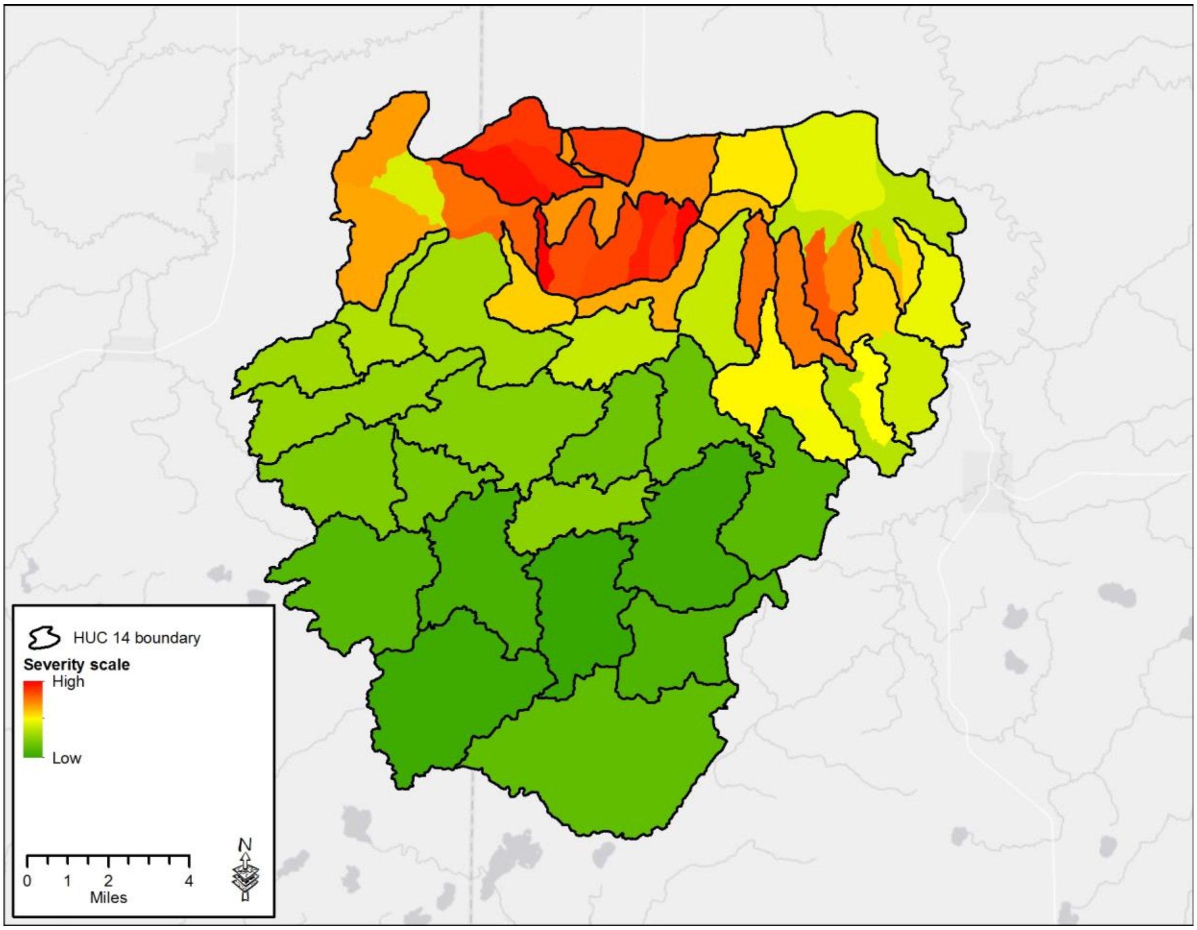

Figure 2-8. Severity index that combines total percent open land and maximum flow accumulation by HUC-12. The severity scale ranges from green (low) to high (red).

3. Future Data Recommendations

3.1. LiDAR-derived Elevation Data

Light Detection and Ranging (LiDAR) is a remote sensing data collection method which incorporates the use of light in the form of laser pulses to measure ranges or variable distances to the surface of the earth. When this distance information is combined with airborne global positioning information, the data are used to create precise three-dimensional surfaces (i.e., digital topographic or elevation information or other surface characteristics like vegetation height). LiDAR data was available for only the Bayfield County portion of the watershed.

As compatible LiDAR data becomes available for the remainder of the watershed, incorporation of a complete bare ground DEM derived from the LiDAR would greatly enhance the precision in mapping existing wetlands, predicting wetland functions, and identifying potentially restorable wetland locations. Specifically the data could further understanding about the surface hydrology characteristics, increasing hydrologic modeling precision by, for example, locating old ditches under forested or scrub-shrub canopies undetectable in even the high resolution aerial photography.

It is worth noting, however, that the high resolution DEMs resulting from most LiDAR collected elevation data also present other challenges not especially problematic in coarser resolution DEMs. Before performing hydrologic analysis on the high resolution LiDAR-derived DEMs, a process known as hydro-enforcement must be completed. Due to the high resolution of the LiDAR, artificial flow impediments like roads bridge decks, and some course vegetation, need to be removed from the data. The hydro-enforcement process removes these artificial digital dams and prepares the surface to simulate the surface flow connectivity important in many hydrological modeling exercises. The hydro-enforcement can require significant technical knowledge and time to complete.

3.1.1. Stream/River Bank Assessment – LiDAR Data

Potential stream bank and riparian zone issues can also be more readily assessed through terrain analysis techniques supported by LiDAR. These analyses can be used to identify river banks that are potentially susceptible to mass wasting and erosion. These areas are not discernable in the high resolution aerial photography and the 10 meter DEM is to coarse for using terrain analysis to identify these locations. Any effort to identify these erosion prone areas would be greatly enhanced by the elevation precision provided in many LiDAR-derived DEMs.

3.1.2. Springs and Seep Locations

If additional wetland work is to be completed in the future, it is recommended that known locations of springs and seeps in the study area be incorporated into the LLWW attribution in order to more accurately determine which wetlands might be spring-fed (sf), or their Water Flow Path is ground water dominated (gd).

3.2. Possible Future Additions to the Wetland Database (NWIplus wetlands)

Additional fields might be added to the NWIplus wetland dataset to further enhance data users' ability to query different information from it. For example, the inclusion of an attribute for wetlands that are considered to be ecologically significant. Such a feature might be a considered as a possible first cut of wetlands that would receive prioritization in terms of preservation or enhancement. Another enhancement that could be incorporated directly into the NWIplus codes, specifically in the LLWW codes is the use of an additional special modifier called abandoned agriculture (former farmed wetland now regenerating), coded as “aa”. This might be completed in a semi-automated fashion by using the transitional agriculture codes.

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Appendix A. Overview of Douglas County, Wisconsin Wetland Functional Assessment

Wetlands perform a number of ecological functions that help improve and maintain environmental quality. For each wetland function a list of possible NWIplus codes and, in some cases, spatial relationships are listed for those wetland types that are predicted to be significant in performing that function. These wetland types and spatial relationships are split into two categories, high and moderate. Wetlands identified as highly significant are predicted to be more significant in for performing a given function.

The following is an overview of the wetland functions assessed for Douglas County, Wisconsin by Stark and Robertson (2013). Wetlands perform a number of ecological functions that help improve and maintain environmental quality. These functions were separated into two categories, Habitat Provisioning and Physical/Chemical Processes, for the sake of discussion. For each wetland function a list of possible NWIplus codes and, in some cases, spatial relationships are listed for those wetland types that are predicted to be significant in performing that function. These wetland types and spatial relationships are split into two categories, high and moderate. Wetlands identified as highly significant are predicted to be more significant in for performing a given function.

Habitat provisioning functions provide an indication of the level at which these wetlands are able to provide cover/refugia, foraging, and nesting habitat. Habitat provisioning functions assessed for the Lake Superior Basin in Douglas County (DC LSB) are as follows:

- Amphibian Habitat (AMH) – wetlands provide habitat for a number of amphibian and turtle species.
- Fish Habitat (FIH) - wetlands serve as habitat for a variety fish. Within this function is a special category containing those factors such as stream shading that keep water temperatures low enough for cold water species such as trout.
- Migratory Bird Habitat (MBIRD) – wetlands provide valuable stop-over locations during migration seasons.
- Shorebird Habitat (SHB) – wetlands provide habitat for a wide-variety of shorebirds
- Waterfowl and Waterbird Habitat (WBIRD) – wetlands provide habitat for local and migration waterfowl and waterbird species.
- Woodcock Habitat (WCK) – forested and scrub-shrub wetlands provide nesting and rearing habitat
- Other Wildlife Habitat (OWH) – wetlands provide habitat for a variety of mammal, reptile, and songbird species.

Physical/chemical process functions provide an indication on the level at which wetlands are providing habitat forming processes and water quality. Physical/chemical process unctions assessed for the Lake Superior Basin in Douglas County (DC LSB) are as follows:

- Carbon Sequestration (CAR) - wetlands serve as carbon sinks that help trap atmospheric carbon.
- Nutrient Transformation (NT) - wetlands through natural chemical processes break down nutrients from natural sources as well as fertilizers and other pollutants essentially treating the runoff.
- Sediment Retention (SR) - wetlands act as filters to physically trap sediment particles before they are carried further downstream.
- Shoreline Stabilization (SS) - wetland plants help hold the soil to prevent erosion.
- Streamflowr Maintenance (SM) - During drought conditions and periods of low discharge, wetlands provide a source of water to keep streams from drying up.
- Surface Water Detention (SWD) - storage of runoff from rain events and spring melt waters which attenuates peak flood levels downstream.

After the LLWW classification codes were interpreted from aerial photography and additional topographic and hydro-layers were consulted, wetland functions were correlated using predicted wetland functions based on wetland characteristics contained within the Cowardin classification, the LLWW classification, and/or upon spatial relationships of the wetlands to other wetlands, streams, rivers, or lakes. The wetlands (polygons) that are considered significant for each function are split into two levels, high and moderate. All wetlands not predicted to be significant for each function (not designated as high or moderate in the geospatial data table) are either not predicted to perform the function or may simply perform the function less efficiently and therefore are not predicted to be a significant wetland type for that function. For example, most vegetated wetlands have some ability to detain and slowly release surface water through evaporation, transpiration, infiltration, or slowed overland flow, but some wetland types are just more significant for this function. Conversely some wetlands act as predicted habitat for certain species or guilds of species while some wetlands are virtually non-habitat based on their vegetation structure. For example, open water and fringe wetland habitats are significant for waterfowl, while saturated forested wetlands might be considered to have no direct habitat value to most waterfowl. In the latter case, the forested wetland would not be identified as high or moderate for waterfowl habitat.

To determine which wetland classes (i.e., which codes) were to be identified as being significant for each function, technical committee meeting members carefully reviewed existing code lists (often referred to as correlation tables) and made minor adjustments or modifications to them to meet the unique characteristics of this particular project area. The beginning point for these correlation tables were based on tables used in Miller et al. (2012), Richtman et al. (2012), Stark and Robertson (2013).

From the existing correlation tables ArcGIS models (using Model Builder ™) were written to automatically populate the NWIplus wetland database with high and moderate. The models consist of a series of queries, both tabular (i.e., attribute) and spatial (i.e., location), to assign high and moderate for each function. Several different wetland functions were assessed based on the codes and spatial relationships in the NWIplus database.

The following is a brief overview of the wetland functions assessed in the DC LSB.. These wetland functions were individually selected through a series of queries, both tabular (i.e., classification codes) and spatial (i.e., location), to assign features (polygons) that are predicted to be significant at high and moderate levels. Refer to Appendix B for the specific correlation of classification codes and location in the watershed or in reference to other wetlands or habitat types used to determine high or moderate functional performance.. The resultant wetland dataset provides the location of different wetland types and, based on their classification, whether their predicted to be significant for a particular function at a high or moderate level. Woodcock habitat was an exception where it was either considered potential woodcock habitat or not (WDK, 1 = yes, NULL = no).

Habitat Functions

<u>Amphibian Habitat (AMH)</u>
Amphibians such as frogs, toads, and salamanders are commonly found in floating vegetation and wild rice. Some amphibian species require a variety of habitats for their life cycle, while others tend to stay in much wetter areas throughout their lives. Typically seasonally flooded to permanently flooded wetlands provide amphibian habitat. Shallower water habitats tend to be best for amphibians. As might be expected most wetlands classifications providing amphibian habitat are palustrine or lacustrine littoral. Table 14 contains the codes for APH.

Palustrine and lacustrine littoral aquatic beds (PAB#, L2AB#) function highly as amphibian habitat. Seasonally flooded or wetter emergent palustrine and lacustrine littoral wetlands also provide excellent amphibian habitat ([P, L2]EM[C, F, G, H]). If organic soils are present the palustrine classifications providing the amphibian habitat become much broader including all classes with seasonally flooded or wetter water regimes (P[AB, EM, SS, FO, US, UB][C, F, G, H]g). Fens are a special habitat type of this group (PEM1Bg). Wild rice beds ([L2, R2, P]EM2#) are also considered highly functional for amphibian habitat. From a water body perspective woodland ponds (PD1[b, c]) provide high quality amphibian habitat.

All permanently flooded and intermittently exposed palustrine and lacustrine littoral wetlands ([P, L2]#,#) are considered moderately functioning regardless of water regime. Water body types providing moderately functioning amphibian habitat include all natural ponds not already classified as highly functioning, impoundments, and excavated ponds (PD1[not b OR c], PD2#, PD3#).

<u>Fish (FIS)</u>
Wetlands performing the function of fish habitat provide areas vital for various parts of their life cycle. Many organisms on which fish feed need wetlands to survive. Wetlands also provide spawning and nursery areas. Wetland plants provide cover essential to small and young fish avoiding predators. The shade provided by wetland trees and shrubs helps to maintain cooler water temperatures for cold

water species. Determining wetland functioning for fish habitat requires using a combination of the LLWW and NWI codes.

Wetlands functioning highly for fish habitat tend to have wetter water regimes and are mostly associated with large or moving bodies of water. Headwater wetlands also function highly as fish habitat. Specifically, lentic, lotic stream, and lotic river wetlands (**LE#, LS#, LR#**) that are semi-permanently flooded, intermittently exposed, or permanently flooded *(##F#, ##G#, ##H#)* are highly functioning for fish habitat. Terrene outflow headwater (**TE#OUhw**) wetlands and any wetlands hydrologically connected to them with semi-permanently flooded or wetter water regimes *(##F#, ##G#, ##H#)* are included in highly functioning as well. Water bodies providing this function include all lakes (**LK##**) and rivers (**RV##**).

Wetlands performing the function of fish habitat to a moderate degree are typically LLWW lotic types. Seasonally flooded *(##C#)* basins classified as low gradient lotic streams (**LS1BA#**) are moderately functioning for fish habitat. Similarly, seasonally flooded *(##C#)* lotic river floodplain basins (**LR#FPba**), oxbows for example, are also moderately functioning as fish habitat. In terms of waterbody, all throughflow ponds (**PD#TH**) are classified as moderately functioning.

Due to the very specific habitat conditions required for trout and other cold water species to thrive, a third level of performance specifically for trout is added to this function. The wetland types included typically contribute to maintaining cooler water temperature through stream shading. Forested palustrine wetlands *(PFO#)* associated with natural high, middle, and low gradient stream wetlands (**LS1#, LS2#, LS3#**) that are not ponded (**###pd**) perform this function. Similarly, scrub-shrub palustrine wetlands *(PSS#)* associated with the same lotic stream types, partly drained or not, also perform this function.

Wetlands that are not considered for the fish habitat function are shrub bog types. Specifically, wetlands classified as saturated palustrine broad leaf evergreen scrub-shrub bogs *(PSS3Ba)* are never considered.

<u>Migratory Bird Habitat (MBIRD)</u>
This function is intended to identify wetlands that are predicted to act as significant stop-over locations for migratory birds during migration. Migratory birds are considered non-game birds that fly between summer breeding grounds and non-breeding wintering areas. During their migration, they must stop to feed and rest. Some areas are considered especially important as stop-over locations based on the availability of food, water, and shelte they provide to various migratory birds.

For this assessment we simply focused on all wetter wetlands are near Lake Superior. Specific sites identified by the Wisconsin Stopover Inititive (WISI) that occur in the DC LSB include the St. Louis River Estuary wetlands and Wisconsin Point. WISI states that the St. Louis River Estuary wetlands (large marshes, shrub swamps, and wet meadows) and coniferous (upland) forests provide stop-over habitat for migrating waterbirds waterfowl and songbirds. The St. Louis River Estuary is important for waterfowl, waterbird, landbirds, and raptors during both spring and fall. Shorebird habitat is important in the fall here.Wisconsin Point is a long spit of sand (these beaches are mapped as lacustrine unconsolidated shore wetlands) and with backshore dunes and some interdunal wetlands that provide stop-over habitat for songbirds, raptors, waterfowl, aterbirds, and shorebirds. Wisconsin Point is specifically notable for waterfowl and raptor stopover habitat during spring and fall and spring time waterbird and landbird stop-over habitat. Lastly, the entire shoreline of Lake Superior in the DC LSB is known for supporting waterfowl and raptors as migratory stop-over areas during both spring and fall migration.

Shorebird Habitat (SHB)

Birds including: herons, cranes, egrets, and sandpipers are shorebirds, and are commonly referred to as wading birds. They require shallow open water areas of lakes or ponds, sometimes mixed with emergent vegetation for feeding on invertebrates, fish, and amphibians. Nesting occurs on sandy beaches and bars and mudflats. Classifying wetlands functioning as shorebird habitat is relatively straight forward as compared to some of the other functions because it depends entirely on the NWI Cowardin classification system. Table 13 contains the codes and conditions providing the determination for SBH. Figure 17 shows features performing SBH.

Highly functioning wetlands for shorebird habitat are seasonally or temporarily flooded unconsolidated shore areas *([P, L2,]US[A, C])* and mixes of unconsolidated shore and emergent vegetation *([P,L2][[US,EM]/[US,EM]][A, C])*.

Wetlands moderately functioning for shorebird habitat are palustrine and littoral lacustrine wetlands with unconsolidated bottom or aquatic beds ([P,L2][UB,AB][F, G]). Unconsolidated bottom and aquatic bed mixes and either type mixed with emergent ([P, L2][[UB,AB,EM]/[UB,AB,EM]][F,G]) are also included as moderately functioning.

Waterfowl & Waterbird Habitat (WBIRD)

Ducks, geese and swans are most commonly thought of as waterfowl, but a number of other types of birds, such as loons, coots and grebes also rely on similar habitats for survival. Their highly functioning habitat is typically associated in some way with open water. Depending on the species, habitats can range from large open littoral areas, to forested ponds and streams. Much of the functioning of wetlands for WFH is dependent on a combination of specific LLWW and NWI classifications. Table 12 contains the codes and conditions for (WFH), and Figure 16 shows the features that are classified as WFH.

As might be expected, due to the variety of waterfowl and waterbird species there are a variety of classifications that function at a high level. Vegetated wetlands and wetlands with mixes of vegetation and non-vegetated classes that are semi-permanently flooded or wetter are considered highly functioning for waterfowl habitat *([L2,R2,P][AB,EM,SS,FO][F,G,H]), ([L2,R2,P][AB,EM,SS,FO]/[UB/US][F,G,H])*. Basin and fringe wetlands associated with streams (**LSFR#, LSBA#**) are considered highly functioning waterfowl habitat provided they are seasonally or semi-permanently flooded *(###C)(###F)*. Similarly, lotic river floodplain basin and fringe wetlands (**LRFPba#, LRFR#**) function highly, again provided they are semi-permanently, or seasonally flooded *(###C)(###F).* Of special note are oxbows that have through flow

(**LRFPbaoxTH**) which are considered highly functioning regardless of water regime. All natural (**PD1#**) and beaver ponds (**PD4**) are also considered highly functioning.

Moderately functioning wetlands for waterfowl habitat as the term implies do not perform the function as well as the highly functioning wetlands. In many cases this is the result of drier conditions or a different position within the landscape. All littoral open water wetlands *(L2UB#)* are moderately functioning, as well as littoral unconsolidated shore *(L2US[A,C])* Isolated terrene basins (**TEBAIS#**) that are classified as palustrine emergent wetlands which are semi-permanently flooded or wetter *(PEM[F ,G, H])* function at the moderate level. All temporarily flooded wetlands (###A) are moderately functional as waterfowl habitat. All impounded and excavated ponds (**PD2#, PD3#**) are included as moderately functioning. Other water bodies that are included are lakes (**LK#**) and rivers (**RV#**).

Wetlands classified with the saturated water regime *(###B)* are not considered to perform the function of waterfowl/waterbird habitat.

<u>Woodcock Habitat (WCK)</u>

Woodcock prefer a variety of habitats depending on time of day, activity, and season, but generally prefer younger forested areas for nesting and brood rearing and scrub shrub with saturated soils for feeding. To identify the wetlands considered potential woodcock habitat from the NWIplus dataset, all deciduous scrub shrub palustrine wetlands or deciduous forested palustrine wetlands adjacent to deciduous scrub shrub wetlands with a water regime of C, B, or A were selected as potential woodcock habitat.

<u>Other Wildlife Habitat (OWH)</u>

General wildlife in this case includes mammals, reptiles, and songbirds. All vegetated wetlands, and only vegetated wetlands, perform this function to some degree. The size and whether there are multiple vegetation types in a complex determine the level at which a wetland complex is functioning for GHW. It needs to be emphasized that this function is dependent on wetland complexes that may be made up of many different interconnected wetlands types. In other words it is the size of the entire wetland complex that determines its level of function and not the size of the individual wetlands making up the complex.

All vegetated wetland complexes *([L#,P][AB, EM, SS, FO]#)* greater than or equal to 20 acres in size are highly functioning for GHW. Wetland complexes of greater than or equal to 10 acres are highly functioning if composed of multiple vegetative types. For example, a monotypic patch of wild rice *(#EM2#)* that is 14 acres in size would not be highly functioning, but if the complex is 14 acres in size and made up of a mixture of wild rice and water lilies *(#AB#)* it is highly functioning.

All other vegetated wetlands not already classified as highly functioning are moderately functioning. For monotypic wetlands this includes all wetlands less than 20 acres in size. For wetland complexes with multiple vegetation types this includes all wetlands less than 10 acres in size.

Physical / Chemical Functions

Carbon Sequestration (CAR)

Carbon sequestration occurs when wetlands act as carbon sinks through chemical and biological processes such as photosynthesis. Typically, wetlands performing carbon sequestration are vegetated to some degree. Therefore, NWI classifications become the major source of information in making determinations regarding carbon sequestration. Soil and water regime information are also important in determining whether a wetland functions at a high or moderate level for this function.

Lacustrine and palustrine aquatic beds *([L2,P]AB[F, G, H]])* perform this function at a high level. Bog and northern white cedar wetlands are also major contributors to carbon sequestration. NWI classifications identifying bogs include palustrine and littoral limnetic wetlands dominated by broad leaf evergreen shrubs with a saturated water regime, acidic water chemistry modifier, and organic soil modifier *([L2/P]SS3Bag).* Similarly, scrub-shrub and forested bogs dominated by needle leaf evergreens with the saturated water regime and organic soils modifier *([L2/P][SS,FO]4Bg)* are included as highly functioning as well.In NWI, wild rice is given the non-persistent *(#EM2#)* designation. There are several wetland types containing wild rice that function highly for CAR. Lower perennial riverine with an intermittently exposed or permanently flooded water regime *(R2EM2[G, H]* are included, as well as littoral lacustrine and palustrine wetlands that are semi-permanently flooded or wetter *([L2,P]EM2[,F,G,H]).*

Moderately functioning wetlands for CAR include all wetlands and water bodies not already specified as highly functioning. All wetlands perform carbon sequestration to some degree.

Nutrient Transformation (NT)

Nutrient transformation refers to the natural chemical processes that remove or recycle compounds in the environment. In the case of wetlands, nitrates and phosphorous from agricultural runoff are the primary nutrients of concern. Wetlands performing this function are sinks for excess nutrients. The nutrients are prevented from moving further through the watershed through either storage or by wetland vegetation using the nutrients for their own life cycle.

For nutrient transformation, landscape position is less important than the other factors such as vegetation and soil type. For this reason the NWI classification becomes the primary system that defines the functioning of a wetland for nutrient transformation. Vegetated lacustrine littoral and palustrine wetlands that are seasonally flooded, semi-permanently flooded, intermittently exposed, or permanently flooded *(L2[AB, EM, SS, FO][C,F,G,H], P[AB, EM, SS, FO][C,F,G,H]),* function highly for nutrient transformation. Any mixes of vegetated and non-vegetated NWI classes also function highly if the they are semi-permanently flooded or wetter *(L2[[AB, EM, SS, FO]/[US,UB]][F,G,H], P[[AB, EM, SS, FO]/[US,UB]][F,G,H]).* Vegetated palustrine wetlands with organic saturated soil *(P[EM, SS, FO]Bg)* provided they are not on a coastal or glaciolacustrine plain are also considered to be highly functional.

For moderate nutrient transformation activity vegetation is important, but moderately functioning wetlands tend to be drier than their highly functioning counterparts. Vegetated palustrine wetlands that are temporarily flooded as defined by NWI, *(P[EM, SS, FO]A),* function moderately for nutrient transformation. Any mixes containing vegetated NWI classes also function highly if the they are temporarily flooded,*(P[EM, SS, FO]/[US,UB]A).* Vegetated palustrine wetlands with saturated soil *(P[EM, SS, FO]B)* that are on coastal or glaciolacustrine plains are also considered to be moderately functioning. Finally, any vegetated, palustrine wetland with saturated soil is considered to be moderately functioning if it has the mineral soil modifier *(P#Bm).*

Wetland types that do not provide a nutrient transformation function include bogs, *(P[SS2, SS3, SS4, FO2, FO3, FO4]#).* Similarly, any wetland with acidic water chemistry *(P[EM, SS, FO]Bag)* is excluded. Open water wetlands *(#UB#)* and unconsolidated shore *(#US#)* also do not perform this function.

Sediment & Other Particulate Retention (SR)

Wetlands that physically trap particles that affect water quality have sediment retention properties. In contrast to nutrient transformation which involves chemical processes, SR is a physical process where the suspended particles are filtered by the soil and plant roots. The removal of suspended particles helps to improve water clarity and help maintain cooler temperatures on cold water streams. Due to the physical nature of sediment retention LLWW is the primary system used to make SR determinations with the NWI vegetation classes and water regime also factoring into the process.

In general, wetlands functioning highly for SR tend to be vegetated. However, lentic basins (**LEBA#)** and lotic river fringes (**LRFR#**) perform sediment retention to a high degree regardless of the presence of vegetation. Lentic fringe, and island wetlands (**LEFR#, LEIL#**) that are vegetated *([L, P][AB, EM, SS, FO])* or vegetated mixes *([L, P][[AB, EM, SS, FO]/[UB/US]])* perform well in removing particulates. Vegetated lotic stream basins and fringe wetlands (**LSBA#, LSFR#**) are included as well as vegetated lotic river basin, floodplain, fringe, and island wetlands (**LRBA#, LRFP#, LRIL#**). Several terrene wetlands types function highly for sediment retention. All ponded terrene throughflow wetlands are included (**TE#pdTH**). Terrene basins with throughflow (**TEBATH**) and terrene interfluve basins with both regular and intermittent throughflow (**TEIFbaTH, TEIFbaTI**) also perform SR to a high degree. In terms of waterbody type, all ponds with throughflow (**PD#TH**) provide this function to a high level. Any wetland classified as severely human induced **(####hi**) in LLWW and impounded *(###h)* in NWI functions highly for sediment retention as well.

Wetlands that moderately perform the sediment retention function include some non-vegetated types. Lentic fringe (**LEFR#**), lotic stream flats (**LSFL#**), lotic stream fringe (**LSFR#**), lotic river fringes (**LRFR#**) and lotic river islands (**LRIL#**) with non-vegetated NWI classes *(#[UB, US]#)* all fit this category. However, lentic flat wetlands (**LEFL#**) classified with vegetated NWI classes *(#[AB,EM,SS,FO]#)* also moderately perform the SR function. Ponded terrene wetlands (**TE#pd#**) not classified with a throughflow waterflow path are considered to moderately perform sediment retention as well. Non-saturated *(P#B#)* terrene basins (**TEBA#**) with waterflow path other than throughflow (**##TH#**) or intermittent through flow **(##TI#**) function moderately. Terrene flat wetlands (**TEFL#**) with the temporarily flooded *(P#A#)* water regime also fall into the moderately performing category. Natural ponds classified as bogs (**PD1a**), woodland-wetland (**PD1b**), or sinkhole-woodland (**PD1h**) are the only water body types that moderately function in sediment retention. All lacustrine unconsolidated shore and unconsolidated bottom *(L2US#, L2UB#)* wetlands that are not already classified as highly functioning are considered to be moderately functioning. In terms of LLWW water body, any pond without through flow (**PD#**) that is not listed as an exception is moderately functioning as well.

There are several universal exceptions of wetland types that do not function as sediment retention areas, which are never considered to perform the sediment retention function. First, the saturated NWI water regime *(##B#)* is removed from any consideration. Sediment retention only applies to the flooded water regimes. Secondly, floating mat wetlands as designated by the LLWW **(##fm**) code are not considered to provide the sediment/particle retention function. Finally, several types of ponds never perform the sediment retention function. Woodland-dry land (**PDc**) and prairie – dry land (**PDe**) are the two types relevant to the SMWSA that never perform the sediment retention function.

<u>Shoreline Stabilization (SS)</u>
Natural shoreline stabilization structures and vegetation prevent erosion or remediate erosion that has already occurred by binding soils. Vegetation and mixed vegetation along lake, river, stream, and pond shorelines prevent soil from being washed or blown away.

Vegetation is the main factor that contributes to wetlands functioning highly for shoreline stabilization. Non-island lentic, lotic river and lotic stream wetlands ([**LE,LR,LS][BA,FL,FP,FR,IF,SL]##**), with vegetated NWI classes *([L2,R2,P][AB,EM,SS,FO]#)* all function highly with respect to shoreline stabilization. Similarly wetlands with the same LLWW attributes and vegetation dominant mixes are also included as highly functioning *([L2,R2,P][AB,EM,SS,FO]/[UB/US]#).* The only LLWW water body type that provides SS are ponds (**PD##**) adjacent to streams. Island (**#IL#**) and floating mat (**##fm**) wetlands never perform the shoreline stabilization function.

Wetlands performing shoreline stabilization at a moderate level are vegetated with terrene LLWW attributes. Terrene ponded wetlands (**TE#pd**) attributed as vegetated and dominant vegetated mixes NWI wetlands *([L2,R2,P][AB,EM,SS,FO]#), ([L2,R2,P][[AB,EM,SS,FO]]/[UB,US]]#)* perform this function to a moderate degree. Terrene, outflow, headwater wetlands (**TE#Ouhw**) and consisting of vegetated and vegetated mixes like the terrene ponded wetland previously described also provide this function if they are hydrologically connected to a stream. Connectivity in the case of the SMWSA was determined by intersecting wetlands data with a stream data set extracted from the National Hydrography Dataset as provided by the Wisconsin DNR. Lower perennial river wetlands *(R2EM1#)* which are not wild rice beds are also included as moderately functioning for shoreline stabilization.

Wetlands that are never considered to be performing the wetland function include all island wetlands (**#IL##**), isolated wetlands (**##IS#**), inflow wetlands (**##IN#**), floating mat wetlands (**##fm**), and unconsolidated shore wetlands *(#US#).*

<u>Streamflow Maintenance (SM)</u>
Surface water maintenance is the ability of a watershed to keep water traveling through the drainage system. Wetlands that help maintain stream flow are those that contribute water to the interconnected

conduits within a watershed. Wetlands providing highest surface water maintenance are headwater wetlands. Most other wetland types that provide surface water maintenance are throughflow and outflow types, although in some cases isolated and inflow wetlands also provide this function to a moderate degree.

All headwater wetlands **(###hw**) provide surface water maintenance to a high degree. Lentic wetlands with throughflow or outflow (**LE#TH, LE#OU**) provide SWM to a high degree. Similarly terrene wetlands with throughflow and outflow provide this function to a high degree if they are associated with a pond (**TE#THpd, TE#Oupd**). Water body types functioning highly for SWM are ponds and lakes, provided again that they have throughflow or outflow (**PDTH#, PDOU#, LKTH#, LKOU#**). All wetlands and wetland complexes adjacent to rivers (**RV#**) and streams (**ST#**) function highly as well. All wetlands with organic soils *(###g)* adjacent to third order streams or higher (further downstream) are highly functioning as well.

There are two types of lentic wetlands that moderately function for SWM. Lentic wetlands with bidirectional flow (**LE#BI#**) provide SWM to a moderate degree. Also, lentic wetlands with throughflow (**LE#TH#**) that are adjacent to lakes (**LK#**) also provide this function. Low gradient river floodplain (**LR1FP#**) wetlands and lotic stream basins (**LS#BA#**) perform surface water maintenance to a moderate level as well. Several types of terrene wetlands provide SWM to a moderate degree. The broadest terrene category is terrene wetlands with throughflow (**TE#TH#**). Isolated and inflow terrene wetlands associated with ponds (**TE#Ispd, TE#Inpd**) also function moderately. Terrene wetland flats with outflow (**TEFLOU#**) consisting of saturated soils *(##B#)* that are adjacent to third order streams or higher are moderately functioning. In terms of water bodies, ponds and lakes that are with inflow or isolated water flow paths (**PDIS#, PDIN#, LK#IS#, LK#IN#**) are considered moderately functioning.

<u>Surface Water Detention (SWD)</u>
Wetlands trap and store surface water. Surface water can take the form of precipitation or in colder climates spring snow melt. The wetlands then release the water slowly over time through surface or underground hydrologic networks. From the human perspective, this process equates to lower peak flood levels. In fact, wetlands in a watershed can diminish and even desynchronize peaks flows. Generally, depressional wetlands that capture and store precipitation and runoff are significant for performing the function of surface water detention. They provide ground water recharge points and include wetlands found along stream and river floodplains, in lake basins, fringes, and islands.

There are a number of LLWW classifications that indicate a wetland performs this function at a high level. Lentic basins (**LEBA#**) (# = wild card or a character used as a substitute for any of a class of characters in a search) and lentic fringe (**LEFR#**) wetlands are two major examples. Flat wetlands associated with dammed lakes (**LE2FL#**, **LE3FL#**) also function highly in this capacity. Lentic islands (**LEIL#**) are the final Lentic classification performing this function at a high level. Lotic classifications providing highly functioning SWD include basins (**LSBA#**, **LRBA#**), fringe wetlands (**LSFR#**, **LRFR#**), and lotic river island wetlands (**LRIL#**). Non-vegetated lotic fringe wetlands such as gravel bars do not perform this function. Terrene basins, terrene ponded basins, and terrene fringe wetlands perform this function to a high degree provided there is throughflow present

(**TEBATH#, TEBApdTH**, **TEFRpdTH**). In terms of LLWW water body type, all types (**PD#, LK#, ST#, RV#**) contribute highly to this function as well. Finally, any wetland with organic soils, as indicated by the lower case g NWI *(###g)* modifier that is adjacent to a LLWW lake (**LK#**), river (**RV#**), or stream (**ST#**) is highly functioning for surface water detention. All wetlands not specifically listed as highly functioning or as an exception perform the function of surface water detention to a moderate level.

Wetlands considered to never perform this function are terrene sloped wetlands, (**TESL#**) and sewage treatment ponds (**PD2f**). Also, non-vegetated banks and bars along rivers (**R2US#**) do not provide any SWD. The final and relatively uncommon exceptions are flat wetlands on a drainage divide **(#FL#dd**).

Appendix B. Wetland function correlation matrix developed for the Douglas County, Wisconsin WFA. Correlation matrix was used to determine functional performance in the Marengo River watershed.

Amphibian Habitat (AMH) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	PEM_C or wetter (and mixes where EM is dominant), Any P__Cg or wetter water regime, PD1b and c (forest upland context = vernal pool), PEM1B_g (fen), PEM2_, L2AB, L2EM2_, PAB, R_EM2 (wild rice)	NA
Moderate	P__H or G (not rated as High), _AB_F & _UB_F (not rated as High), L2__H or G (not rated as High)	NA
Carbon Sequestration (CAR) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	P__ (AB,EM, SS, FO, and mixes)F, P__ (AB,EM, SS, FO, and mixes)G, P__ (AB,EM, SS, FO, and mixes)H, P__ (AB,EM, SS, FO, and mixes)Cg, P___Ba (and mixes), PFO4Bg (and mixes), R_EM2, L2EM2__, PEM2_, R_EMF, L1AB, P___g	Exclude _FO2/_, _SS2/_
Moderate	All remaining vegetated wetlands not selected as High	

Fish Habitat (FIS) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	LE and F or wetter; LS and LR F or wetter water regime; TE_OUhw and TEFROUhw F or wetter wetlands; PD_OU F or wetter, PD_TH F or wetter, Any LK_ or RV_,	Shrub bogs (e.g., PSS3Ba) and commercial bogs (PSSf) should be excluded
Moderate	PD1_TH, PD2_TH, PD4_TH, LS_BA_TH (C water regime), LR_FPbaTH (C water regime), PUBG or PUBH or split classes of these	Shrub bogs (e.g., PSS3Ba) and commercial bogs (PSSf) should be excluded
Stream Shading	LS (not LS4 or not LS__pd) and PFO, LS (not LS4) and PSS (not PSS_Ba or not PSSf)	Shrub bogs (e.g., PSS3Ba) and commercial bogs (PSSf) should be excluded

Nutrient Transformation (NT) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	P__(AB, EM, SS, FO and mixes)C, P__(AB, EM, SS, FO and mixes)H (except impoundments), P__(AB, EM, SS, FO and mixes)B (not on coastal plain or glaciolacustrine plain), Wetlands with “Bg” (except “Bag” or beaver impoundments (b)), PD3fv	
Moderate	P__(AB, EM, SS, FO and mixes including __/UB and UB/__, etc.)F except farmed (f) and non semipermanently flooded and excavated (x) associated with UB, P__(EM, SS, FO)A, P__(AB, EM, SS, FO and mixes)B (e.g., on coastal plain or glaciolacustrine plain; excluding bogs such as PSS3Ba and beaver impoundments (b)), Wetlands with “Bm”	

Other Wildlife Habitat (OWH) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	Any vegetated wetland complex > 20 acres, wetlands 10-20 acres with 2 or more vegetated classes (excluding EM5), small isolated wetlands in dense cluster in a forest matrix (restrict to forest regions of U.S. with woodland vernal pools currently unable to delineate), Vegetated wetlands and wetland complexes < 10 acres and directly adjacent to RV or part of chain of wetlands adjacent to RV	
Moderate	Other vegetated wetlands	

Sediment and Other Particulate Retention (SR) Function Performance Correlations

Level of Function	**Wetland Type**	**Notes**
High	LEBA (veg), LEFR (vegetated and mixes, not “fm”-floating mat), LEIL(veg and mixes, not “fm”), LSFR(veg), LRFR (veg, not “fm”), LRIL (veg), LSBA, LRBA, LRFP, PDTH, TEBATH, TEBATI, TEBAIS, TEBAIN, TEIFbaTH, TEIFbaTI, TE_FR_TH, TE__pdTH (including __pq), All impounded (h) wetlands, “Moderate” wetlands with _IN_ or _TH_ and adjacent or intersect ditcches	Floating mats (fm) and no “B” wetlands should be identified as significant for this function
Moderate	LEBA (nonveg), LEFR (nonveg), LRIL (nonveg), LRFR (nonveg), LSFR (nonveg), LEFL (veg), LSFL or LRFL (not P___B_), Other TE__pd (not P__B_), Other TEBA (not P__B_), TEFL__ (P__A, not P__B_), PD (not c, d, e, f, g, j types)	Floating mats (fm) and no “B” wetlands should be identified as significant for this function

Shorebird Habitat (SBH) Function Performance Correlations

Level of Function	**Wetland Type**	**Notes**
High	PUS_C or A; L2US_C or A, R2US_C or A	
Moderate	L2UB_G, L2UBF (and mixes with EM if mapped), PUBG, PUBF	

Shoreline Stabilization (SS) Function Performance Correlations

Level of Function	**Wetland Type**	**Notes**
High	LR_(AB, EM, SS, FO and mixes; not LRIL), LS_(AB, EM, SS, FO and mixes, not LSIL), LE__(AB, EM, SS, FO and mixes; not LEIL and not “fm”), PD’s adjacent to streams, vegetated wetlands adjacent to Streams	Exclude __Fh, __Gh, & __Hh
Moderate	TE__pd (AB, EM, SS, FO and mixes), TE%TI% or TE%TH%, TE__OUhw (AB, EM, SS, FO and mixes, no __IN or __IS) associated with Streams, vegetated wetlands adjacent to Ponds (PD)	Exclude __Fh, __Gh, & __Hh

Surface Water Detention (SWD) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	LEBA(ba), LEIL(il), LEFL (in reservoir and dammed areas only: LE2FL and LE3FL), LEFR, LE_ox_, LRBA(ba), LRIL(il), LRFPba, LRFR (excluding non-vegetated gravel bars/banks), LR_ox_, LSBA(ba), LSIL(il), LRFPba , LSFR (excluding non-vegetated gravel bars/banks), LS_ox_, PDBI (and adjacent to PDBI), PDIL(il), PD_ox_, PDTH, (excluding PD2f), TEBApdTH, TEBATH, TEIL(il), TEFRpdTH, TH_ox_, wetlands with "organic" soils associated with waterbodies, Small wetlands (buffered points) within floodplain of 3rd order streams, TE wetlands adjacent ditches	Exclude all sloped wetlands. Retained floating mat bogs such as LEFR because their area will store surface water when lake levels rise.
Moderate	LRFPfl, LSFL, PD (other except PD2f), LE1FL, TEBA (other than above, includes TEBA_IS), TE__pd (other, excluding slope wetlands TESLpd__), TEBATI, Temporarily Flooded Terrene Flat Outflow wetlands (TEFLOU__ + P___A_), all non-headwaters Saturated Terrene Flats Outflow (TEFLOU + P___B), Lotic sandbars and mudflats (TEFLOU + R_USA) (TEBAOU + R_USC), Temporarily Flooded Lentic wetlands adjacent to "natural lakes" (LE1_FLBI + P___A) and wetlands adjacent to "other dammed lakes" (LE3_FLBI + P___A),	Exclude all sloped wetlands. Retained floating mat bogs such as LEFR because their area will store surface water when lake levels rise.

Stream-flow Maintenance (SM) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	_hw_ (all headwater wetlands), _gd_ (groundwater dominated), PD_ (all ponds, excluding sewage treatment), all wetlands associated with waterbodies (excluding _IS_ and _IN_), Wetlands with "organic" soils	Exclude all sloped wetlands
Moderate	LR1FP, LS_BA, PDTH, TE__pdTH, PDOU, TE__pdOU, TEOU , LE wetlands associated with through-flow lakes (LK__TH), outside red clay plain wetlands connected to intermittent streams	Exclude all sloped wetlands

Waterfowl and Waterbird Habitat (WBIRD) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	LS(1,2, or 5)BA and P__ (FO or SS and mixes; not PSS3Ba or SSf), LS(1,2)FR and P__ (FO or SS and mixes; not PSS3Ba or PSSf), LR(1,2)FPba and P__(FO or SS and mixes; not PSS3Ba or PSSf), LR(1,2)BA and P__(FO or SS and mixes; not PSS3Ba or PSSf), LRFPba and PFO/EM, LRFPba and PUB/FO, L2AB (and mixes with non-vegetated), L2US_(F), L2UB_F, L2_F (vegetated, AB, EM, SS, FO and mixes with non-vegetated), L2_H or G (vegetated, AB, EM, SS, FO and mixes with non-vegetated), PAB, PUB__b, R_EMF, P__H or G (vegetated, EM, SS, FO including mixes with UB), P__F and adjacent to PD, LK, RV(not LR4) ST(not LS4), or is a waterbody; PEM1C__ (including mixes) and associated with PD, LK, RV(not LR4), or ST(not LS4), PD associated with P__(AB, EM,SS, FO)F	Shrub bogs (e.g., PSS3Ba) and commercial bogs(PSSf) should be excluded
Moderate	other L2UB (not listed as high), PD1, PD2 a3, b, h, PD3, or PD4, Other PEMF,PEMCs that are TEBA% or split classes (e.g., PEM/SS1C TEBAOIhw)	Shrub bogs (e.g., PSS3Ba) and commercial bogs(PSSf) should be excluded

Migratory Bird Habitat (MBIRD) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
High	All palustrine environments with an F or wetter water regime within 3 miles of Lake Superior and within 100 meters of a river. Also the River itself if mapped as a wetland (i.e., R2UBH)	
Moderate	All palustrine wetlands with an F or wetter water regime within 3 miles of Lake Superior not already identified as High in the above selection	

Woodcock Habitat (WCK) Function Performance Correlations		
Level of Function	**Wetland Type**	**Notes**
Function performed	All deciduous scrub shrub palustrine wetlands or deciduous forested palustrine wetlands adjacent to deciduous scrub shrub wetlands with a water regime of C, B, or A	

Appendix C. Development of the Potentially Restorable Wetland Data for Douglas County, Wisconsin

Background – Existing Methods & GIS layers

Wetland restoration, particularly "potential" restoration, in this context is to apply to the idea of finding areas with the potential for the re-establishment of wetlands. These locations are predicted to have once supported wetlands and have since been altered so they are no longer map-able wetlands by NWI landscape-scale standards. Two existing GIS datasets represent potential restorable wetlands in this context and for this assessment additional steps were taken to create customized PRW layers for the study area.

Wisconsin DNR – PRW layer

In recent years the WI DNR created multiple versions of a state-wide PRW GIS dataset. For this version of the PRW GIS layer, the process involved querying each of the state's county-level NRCS SURRGO databases for hydric soil map units. From this selection, existing (mapped wetlands) were removed. Then, all incompatible land uses such as roads, urban, commercial, residential, etc. were also removed from consideration as a PRW. With some post processing to rid the layer of some "noise" (i.e., sliver polygons and very small polygons), the remaining polygons were then considered PRWs. A more detailed step-wise description of the process the WI DNR used to create this dataset is as follows:

- SSURGO soils data polygons were queried to find hydric soils[2] with ≥ 85% hydric component(s) of a given soil polygon (map unit);
- Wetland polygon data were intersected (ESRI Analysis tool) with the hydric soil polygons to determine where hydric soils exist outside of existing mapped wetlands. These might be potential restorable wetland areas, however, some land uses are not conducive to restoration;
- The resulting polygon data were then intersected with a roads layer and a land use layer to determine where hydric soils have been permanently converted to land use not compatible for wetland reestablishment (e.g., not possible or practical to remove a road or convert developed, urban land back to wetlands).
- The resulting layer was edited to reduce superfluous or erroneous polygons; this involved removing polygons that had larger perimeters than areas (i.e., shape length > shape area). These "sliver polygons" appear to be primarily the result of mapping discrepancies between

[2] According to the NRCS (Federal Register Doc. 2012-4733 Filed 2-28-12) Hydric soil means a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. This definition includes soils that developed under anaerobic conditions in the upper part but no longer experience these conditions due to hydrologic alteration such as those hydric soils that have been artificially drained or protected (e.g., ditches or levees).

wetland data and soils data layers developed as these data were created with different mapping methodologies and geographic scales. Once these slivers were removed, all hydric soil polygons that were not located within an existing wetland and did not overlap roads or urban land use were considered potentially restorable wetlands (PRW).

Virtually No Hydric Soil in the Red Clay Plain

Following examination of the WI DNR PRW 2012 version 2 GIS layer in the study area, it was found that PRWs were nearly completely lacking in the clay plain portion of the county (Figure C-1). That is, there were very few polygons indicating potential wetland restoration sites in approximately the first 6-8 miles inland of Lake Superior. This was due, in part, to the complex nature of the soils in this area and in part to the way the soils were represented in digital map form. There weren't soil map units considered hydric by soil taxonomic rules and soil types were aggregated into soil map units (i.e., soil complexes), thereby excluding them from this type of query. In many cases, soil map units (Mus) contained multiple soil components with coverage percentages split across several components. For example, a given soil map unit might be made up of component A at 40%, component B at 30%, component C at 20%, and component D at 10%. If less than 85% of the map unit was a hydric soil, then the map unit would not be selected for consideration as a PRW, or if the soil taxonomy didn't allow for the soil to be truly considered hydric despite having evidence of hydric conditions, then the map unit also would not be considered as a PRW. This pointed to a need to look for another approach or the need to incorporate some additional data into a PRW GIS model.

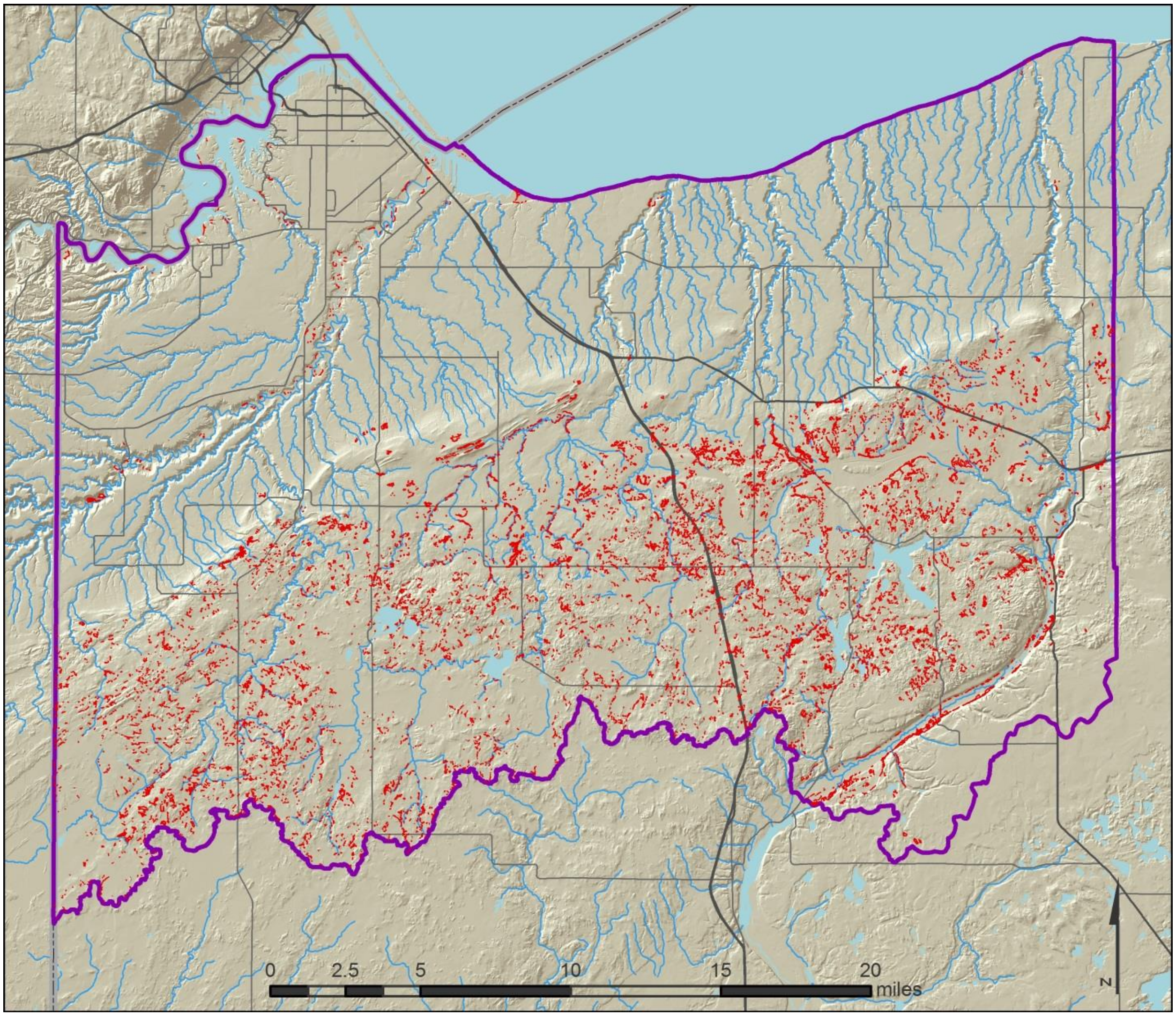

Figure C-1. WI DNR 2012 version 2 PRWs (red polygons) in the DC LSB. Notice a concentration of PRWs in the southern portion of the study area (outside of the clay plain) where soil map units are more distinct (i.e., not aggregated or treated as soil complexes made up of mutlitple components in each map unit) like in the clay plain area.

Potential Wetland Soil Landscapes (PWSL) – USDA-NRCS

Another soils dataset made available to the project team near the beginning of the project was the Potential Wetland Soil Landscape (PWSL) GIS layer. The PWSL layer is a nation-wide gridded version of NRCS's SURRGO soils data (referred to as gSURRGO). This layer is intended for the identification of areas with a "hydric" soil as a dominant or named component not already mapped as a wetland. The data contain a tabular field called PWSL that provides an indication of grid cells likely to support wetlands.

The PWSL shows some areas in the red clay plain area of Douglas County as 50% in the PWSL field, but none greater. That is 50% of a given soil map unit contains hydric soils. It is presumed that the same “problem” exists in the data that a lower percentage of the map units are considered hydric because of these “complexes” and therefore don’t get captured as a high percentage.

Refined PPW Identification Methods

In order to locate potential wetland restoration opportunities, more accurately, potential wetland re-establishment opportunities in the clay plain, it became clear that a different approach was necessary. First, the problem of aggregated soils data needed to be addressed. That is, the soils information needed to be disaggregated or split by some other covariate (factor) to find the sites with soils that likely supported wetlands but have since been drained or otherwise hydrologically altered. After discussions with local wetland experts including Greg Larsen, a former State of Minnesota Soil Scientist, it was discussed that topography is a major determinant for the position of wetlands in the clay plain. That is, many of the soils have low permeability and even a slight depression or accumulation area is likely to hold water and support hydrophytes (i.e., become or re-establish as a wetland). Therefore it was decided during technical committee meetings that the methods for identifying PRWs in the clay plain would be different than those outside the clay plain in the southern portion of the study area.

Within the clay plain

The identification of potential restorable wetlands (PRWs) in the clay plain involved a process of disaggregating the SURRGO soil map unit data so that only soils with some wetland potential based on soil map unit characteristics coincident with areas of higher compound topographic index (CTI) values were identified. CTI is designed to represent soil wetness; it is a function of the slope and the upstream contributing area per unit width orthogonal to the flow direction. This provides an estimation, based on the best available DEM, where water is likely to accumulate and have a higher probability creating wet soil conditions. From this, additional photo-interpretive effort was taken to examine the largest of the resulting PRWs (polygons) and determine, based on evidence such as land use, visual evidence of hydrologic alteration (namely surface ditching), if a given area might be a more likely viable wetland re-establishment site. If this type of evidence came together in the same site, the area was considered a viable site worthy of further consideration. That is, a preponderance of evidence exists indicating there was likely wetlands removed from the site and the site is likely to still receive enough water that wetlands could be re-established given some reversal of hydrologic alterations. For sites (PRW polygons) that were considered viable, points were digitized through photo interpretation in order to represent likely pour points of the viable PRW area. The following sections further explain each of the resulting potential restoration site layers.

PRW Polygons

PRW polygons for the clay plain area were created using a query of soil map units combined with areas of high CTI values. First, criteria for identifying which soils would be useful for predicting wetland restoration sites. For this, the description of all SURRGO soil map units in the county were reviewed. In order to capture soils that aren’t considered hydric by soil taxonomic rules and certain components within a soil map unit (polygon), all soils with a drainage class of “somewhat poorly drained” or wetter were subset from the SURRGO database. Second, a threshold of which CTI values are relevant to predicting wetland restoration sites was needed. During the continual refinement of the PRW GIS modeling process the WDNR is engaged in, field testing of relevant CTI values (i.e., thresholds) indicate that a CTI threshold (i.e., values equal to or greater) 10.0 is reasonable. However, for this process, the threshold was expanded slightly to accommodate for the generally low permeability of the clay plain soils; areas with a CTI $\geq$ 9.5 were grouped.

The soil polygons and CTI data (polygons converted from gridded data) meeting the afore-mentioned criteria were combined in a GIS (ESRI ArcGIS Intersect Tool). The resultant layer represents an initial "population" of areas (polygons) likely to support wetlands. Next, the known wetlands were removed in order to locate possible former wetlands (aka potential wetland re-establishment sites). The existing (mapped) mapped wetlands were removed using ESRI's ArcGIS Erase tool.

NOTE: Initially these soil map units were ranked for their relative likelihood to support wetlands according to an interpretation of hydrologic characteristics of the soil map components making up each soil map unit (a discrete polygon). Various hydrologic properties contained in each map unit description were reviewed for this process. The MUs' symbol, name, percent slope range, drainage class(es) and notable hydrologic variables taken from each map unit description that were considered relevant for determining the relative rank number. This assigned rank (the "Rank" column) is intended to represent the relative probability (1-20) that an MU might spatially define wetlands or former wetlands, where the higher the number the higher the probability.

The layer resulting from the combination of soil CTI information is an initial representation of potential restorable wetlands (PRWs). It contained well over 10 thousand polygons. Therefore some additional steps were required to clean-up some of the results considered superfluous. For example, the layer contained many very small and some very narrow polygons. These polygons are considered superfluous because they are likely the result of mapping discrepancies or scale issues between the various data sources. Polygons < 0.25 acres were deleted from the layer, then all polygons with shape perimeter > shape area were also deleted, as these were too small or too much of a sliver respectfully.

Initial PRW Viability Filtering – Clay Plain

The top 300 largest PRW polygons (sorted by acreage) from the clay plain were individually examined in a GIS to begin to filter the results of the thousands (over nine thousand) of individual polygons into an initial subset of potentially viable wetland re-establishment locations. Additional polygons were examined by panning for areas with a concentration of PRW polygons and evidence of ditching. For each of these polygons, over 500 in total, a preliminary interpretation of the viability of wetland re-establishment was captured in the data table, with polygons considered either "likely", "possibly", or "not likely" viable. All polygons not specifically reviewed were labeled "not examined". This viability was based on review of the aerial photography and additional GIS data such as the WI DNR Hydro layer, interpreted ditches layer, and land use/cover layer (open/impervious lands layer created by Community GIS Inc.). This subset of locations might be further filtered or prioritized using additional data or criteria and should be visited in field. From the PRW polygons that were considered "likely viable" or "possibly viable", pour points were digitized / interpreted. These pour points were to represent major points where the, "viable" wetland re-establishment sites drain to.

PRW Pour Points
A preponderance of evidence approach was used by the photo interpreter/GIS analyst includes sites that that have certain soils conditions (e.g., somewhat poorly drained or wetter), hydrologic position (high CTI values), conducive land use (e.g., active or "transitional" agriculture), and visual evidence of ditching (i.e., ditches visible in aerial photography).In areas where a "preponderance of evidence" suggested that a site might have once supported wetlands, representative pour points were digitized. Note, a more accurate and inclusive representation of ditches in the study area might be found in the future with high resolution elevation data created (e.g., a LiDAR-derived DEM).

PRW Catchments
From the pour points (locations representing drainage from areas worthy of further investigation as viable wetland re-establishment sites), catchments were delineated using the Watershed Tool in ESRI's ArcGIS 10.2 Spatial Analyst toolset. These catchments were intended to represent the drainage areas that capture the largest, primary wetland re-establishment areas in the study area. It is recommended that the watershed tool or similar be re-run once high resolution elevation data are made available.

<u>Outside the clay plain</u>
The identification of PRW polygons in the clay plain of DC LSB utilized existing methods of the WI DNR PRW layer with some minor refinements. The WI DNR's method uses soil map units with 85% or more of the components being hydric or partially hydric. The approach was considered by the technical committee to be a reasonable approach as soil map units in this area were not aggregated into soil complexes and therefore were more spatially explicit than map units in the clay plain. The major steps of refining the existing WI DNR GIS layer are as follows:

Update the WI DNR 2012 v2 PRW layer with new wetland boundaries
Starting with the WI DNR 2012 v2 PRW layer (an unpublished GIS layer received from the WI DNR), all wetlands contained in the NWIplus wetlands database were used to erase or remove any portion of a hydric soil map unit not already "erased" by the last version (circa 1993) WWI data.

Erase all remaining hydric soil polygons with incompatible land uses
Open/Impervious Lands – Community GIS Inc. Data, Type = "Open" & Sub_Type = "Residential" OR Sub_Type = "Urban Areas" OR Sub_Type = "Commercial Industrial" OR Sub_Type = "Utilities"; OR Type = "Impervious" & Sub_Type = "Roads Driveways" OR Sub_Type = "Rail Line" OR Sub_Type = "Structures".

Erase all polygons with shape area > shape length
This cleans up some of the very thin "sliver-like" polygons that are assumed to be a result of horizontal registration and very minor mapping scale discrepancies.

Erase all polygons less than 0.25 acres
This assumes that most of very small polygons are the result of mapping error/discrepancy and if they aren't error, than it is assumed that the polygons are too small to represent a cost effective

wetland restoration opportunity. All remaining polygons <0.5 acres were labeled as “small 0.25-0.5 ac” in the PRWstatus field.

Saint Mary's Unversity of Minnesota
GeoSpatial Sevices
700 Terrace Heights #7
Winona, MN 55987

www.smumn.edu/

www.geospatialservices.org/