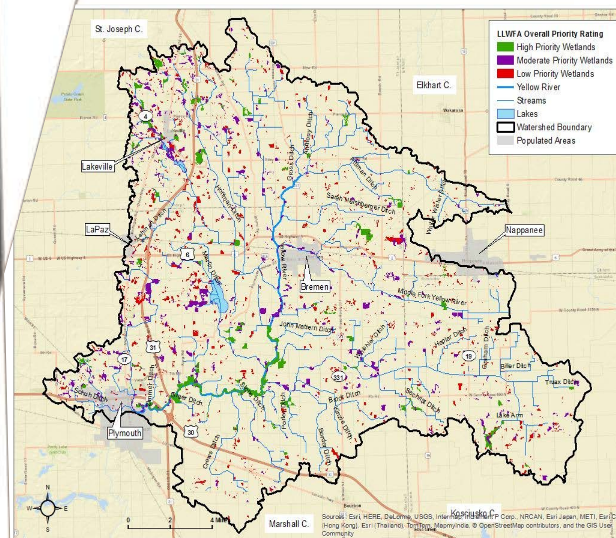
Landscape-Level Wetland Functional Assessment

Headwaters Yellow River Watershed

15X107600



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Document Information

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Acronyms

CRP	Conservation Reserve Program
CREP	Conservation Reserve Enhancement Program
DEM	Digital elevation model
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
HUC	Hydrologic Unit Code
IGIC	Indiana Geographic Information Council
LLWFA	Landscape-level Wetland Functional Assessment
NHD	National Hydrography Data
NRCS	Natural Resources Conservation Service
NRI	National Resources Inventory
NWI	National Wetland Inventory
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Executive Summary

In September of 2015, the Marshall County Soil and Water Conservation District (SWCD) received an Environmental Protection Agency (EPA) Region 5 Wetland Program Development Grant to complete a Landscape-Level Wetland Functional Assessment (LLWFA) to develop a better understanding of the functional value of wetlands in the Headwaters Yellow River watershed. The LLWFA assessment utilized the United States Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) 2016 dataset as the baseline data for the study. The NWI is a resource that accurately describes the location and size of wetlands in the watershed, but the database does not describe the function of each wetland. Results of the LLWFA assessment provide valuable information to local, regional, and state agencies regarding the future prioritization of restoration and conservation efforts in the Headwaters Yellow River watershed. Tasks completed during this study include the following: development of a NWI+ data base, LLWFA functional analysis of the NWI+ database, desktop review of NWI wetlands, targeted windshield survey of priority wetlands, overall functional wetland prioritization, and specific wetland restoration/enhancement site identification and conceptual plan development.

The landscape-scale changes that have taken place in the Headwaters Yellow River watershed since European settlement have greatly impacted the wetlands of the watershed. At least 1,887 wetlands totaling 1,353.4 acres have been lost to land-use changes; however, there are 3,182 remaining wetlands totaling 10,847 acres, which have been mapped as part of the NWI. The LLWFA utilized geospatial data in ArcGIS 10.4 to perform complex analyses of existing databases to determine the functional significance of the wetlands in the Headwaters Yellow River watershed. Wetland function was determined using relationships between the properties described in the NWI+ database and established wetland functions. The NWI+ database was used to identify wetlands with potential to perform a variety of functions at high or moderate levels. The nine functions that were used to evaluate wetlands include surface water detention, streamflow maintenance, nutrient transformation, sediment and particulate retention, bank and shoreline stabilization, fish and aquatic invertebrate habitat, waterfowl and waterbird habitat, habitat for other wildlife, and conservation of biodiversity. For each of the 3,182 wetlands investigated a final LLWFA score was calculated using the cumulative score developed from the correlations determined from each of the nine functional metrics. From the final LLWFA scores there were determine to be 184 high priority wetlands totaling 2,690 acres, 1,087 moderate priority wetlands totaling 3,993 acres, and 1,911 low priority wetlands totaling 4,163 acres. High priority wetlands had the largest average size at 14.6 acres, followed by moderate (3.7 acres) and low (2.2 acres).

Following the development of the NWI+ database and initial wetland functional assessments using the LLWFA, the wetland polygons within the watershed were prioritized during a desktop review for future investigation during a windshield survey. The windshield survey was conducted on November 15-17 and November 20, 2017. During the windshield survey wetland characteristics were field verified by driving throughout the watershed and conducting rapid visual surveys of wetlands visible from public roads. During the windshield survey data was collected documenting any habitat alterations, upland buffers, adjacent land-uses, and presence of invasive species for each of the surveyed wetlands. Results of the windshield survey included the investigation/designation of a total of 282 sites across the Headwaters Yellow River watershed. A site, as identified during the windshield survey could be defined as a single NWI wetland if that individual wetland was isolated or a site could include multiple NWI wetlands in close vicinity to each other such that they were part of the same wetland complex.

The results of the windshield survey were used to help identify specific sites within the Headwaters Yellow River watershed where wetland priority management activities could take place in the future. The sites highlighted during the windshield survey were given further analysis using Google Maps Pro and Arc Maps 10.4. This was done by analyzing historical aerials and hydric soils maps. The list of sites was limited to

the top 25 sites for possible wetland restoration (Appendix C). From there the list of sites was taken down to the top 10 sites ranked by how much of an impact a site would potentially improve water quality of the watershed. This was determined by considering multiple attributes for each site, along with professional experience in preforming wetland restoration and mitigation. The attributes analyzed during the ranking of potential sites were as follows: adjacency to woodland and open waterways, dominant soil types, ease of restoration, ease of site access, potential wetland to parcel size ratio, number of landowners of particles with potential wetlands, estimated restoration cost, location within critical areas identified in the Headwaters Yellow River Watershed Management Plan and any additional considerations observed. A KMZ file was created for the 25 sites listed in Appendix C and allows for the quick location of each site using Google Earth application.

It is important to note that a significant amount of data has been generated as a result of the various analysis completed during this study. Landowner discussions/permissions were not included in this study and therefore will be a significant driver for future wetland work in the Headwaters Yellow River watershed. The various analysis completed have created a better understanding of the functional connections/differences between existing wetlands and provides specific starting locations for future wetland work. Resources that can be used for future wetland projects in the Headwaters Yellow River watershed include the NWI+ GIS shapefile, NWI+ excel database document (Appendix A), windshield survey excel database document (Appendix B), the priority site specific wetland restoration/enhancement excel database document (Appendix C) and the supporting KMZ Google Earth file which shows the location of the sites outlined in Appendix C. All documents will be supplied to the Marshall County SWCD staff at the completion of the study and will be retained at the Plymouth Indiana office.

1 Introduction

1.1 Introduction

The Marshall County Soil and Water Conservation District (SWCD) received an Environmental Protection Agency (EPA) Region 5 Wetland Program Development Grant in September of 2015 to complete a Landscape–Level Wetland Functional Assessment (LLWFA) for the Headwaters Yellow River watershed. The goal of the LLWFA assessment was to work in conjunction with the development of the Headwaters Yellow River Watershed Management Plan (WMP) to identify wetlands within the watershed of greatest value for future protection, restoration and enhancement.

1.2 Ecological Significance of Wetlands

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils.

The hydrology, soils, and hydrophytes of wetlands create unique wetlands that perform essential ecosystem functions. These ecosystem functions include surface water detention, streamflow maintenance, nutrient transformation, sediment retention, shoreline stabilization, fish habitat, waterfowl habitat, wildlife habitat, and conservation of biodiversity.

1.3 Project Location

The Kankakee River watershed (HUC: 07120001) spans 5,165 square miles of northwest Indiana and northeast Illinois. Approximately, 2,996 square miles of the watershed are in Indiana and 2,169 square miles are in Illinois (Ivens et al. 1981). The Kankakee River watershed was once the location of a complex network of swamps and marshes called the “Grand Marsh” (Ivens et al. 1981). Prior to disturbance the Grand Marsh encompassed approximately 400,000 acres and ranged from three to five miles in width (Ivens et al. 1981). Efforts began in the late 19th century in Indiana to channelize the Kankakee River and drain the adjacent wetlands in order to convert the land to agricultural land (Ivens et al. 1981). Unfortunately, the Grand Marsh was not the only portion of the Kankakee River watershed impacted during the early 1900’s.

Eighteen 10-digit HUC watersheds comprise the Kankakee River watershed, one of which is the Headwaters Yellow River watershed. The Headwaters Yellow River watershed (HUC: 0712000103) encompasses 293 square miles (187,300 acres) of land in northern Indiana and is spread across portions of Marshall, St. Joseph, Elkhart, and Kosciusko Counties (Figure 1-1). Surface water from the Headwaters Yellow River watershed drains a network of open and closed drains to the mainstem of the Yellow River, which flows southwest from Bremen through Plymouth. The Yellow River continues to flow west through Starke County and drains into the Kankakee River near Knox.

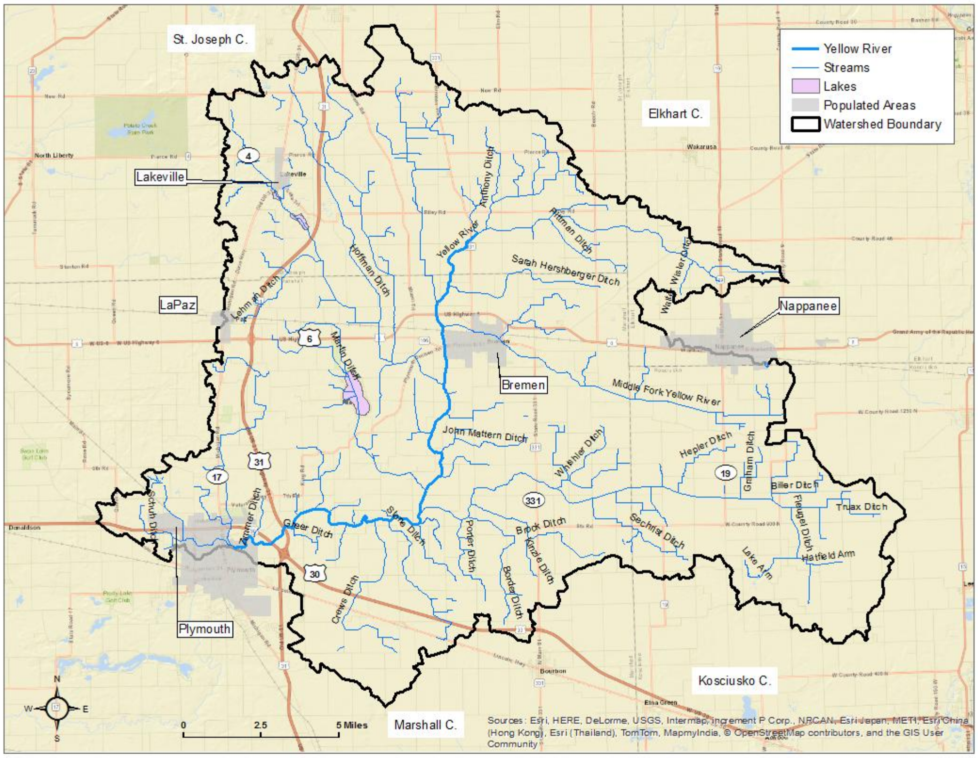

Figure 1-1. Headwaters Yellow River watershed general location map.

The landscape-scale changes that have taken place in the Headwaters Yellow River watershed since European settlement have greatly impacted the wetlands of the watershed. According the United States Fish and Wildlife (USFWS), National Wetlands Inventory (NWI) dataset (2017) for historical wetlands, at least 1,887 wetlands totaling 1,353.4 acres have been lost to land-use changes (Figure 1-2). The USFWS 2016 NWI dataset of existing wetlands in the Headwaters Yellow River watershed identifies 3,182 wetlands totaling 10,847 acres. These wetlands are categorized into three separate wetland types in the NWI database and include emergent wetlands, forested/shrub wetlands and ponds. Forested/shrub wetlands account for the majority (66 percent) of the wetlands in the watershed followed by emergent wetlands (28 percent), and ponds (6 percent; Figure 1-3). There are also three lakes within the Headwaters Yellow River watershed which cover 518 acres and include Pleasant Lake (24 acres), Riddles Lake (74 acres) and Lake of the Woods (420 acres). Of the 3,182 wetlands totaling 10,847 acres in the watershed, approximately 764 wetlands (24 percent) accounting for 2,124 acres (19.5 percent) are listed as being partially drained/ditched or modified by human disturbance by excavation. Additionally, 348 wetlands of the 3,182 wetlands (11 percent) in the watershed are listed as "farmed" wetlands. Farmed wetlands cover 1,523 acres or 14 percent of the overall NWI wetland dataset.

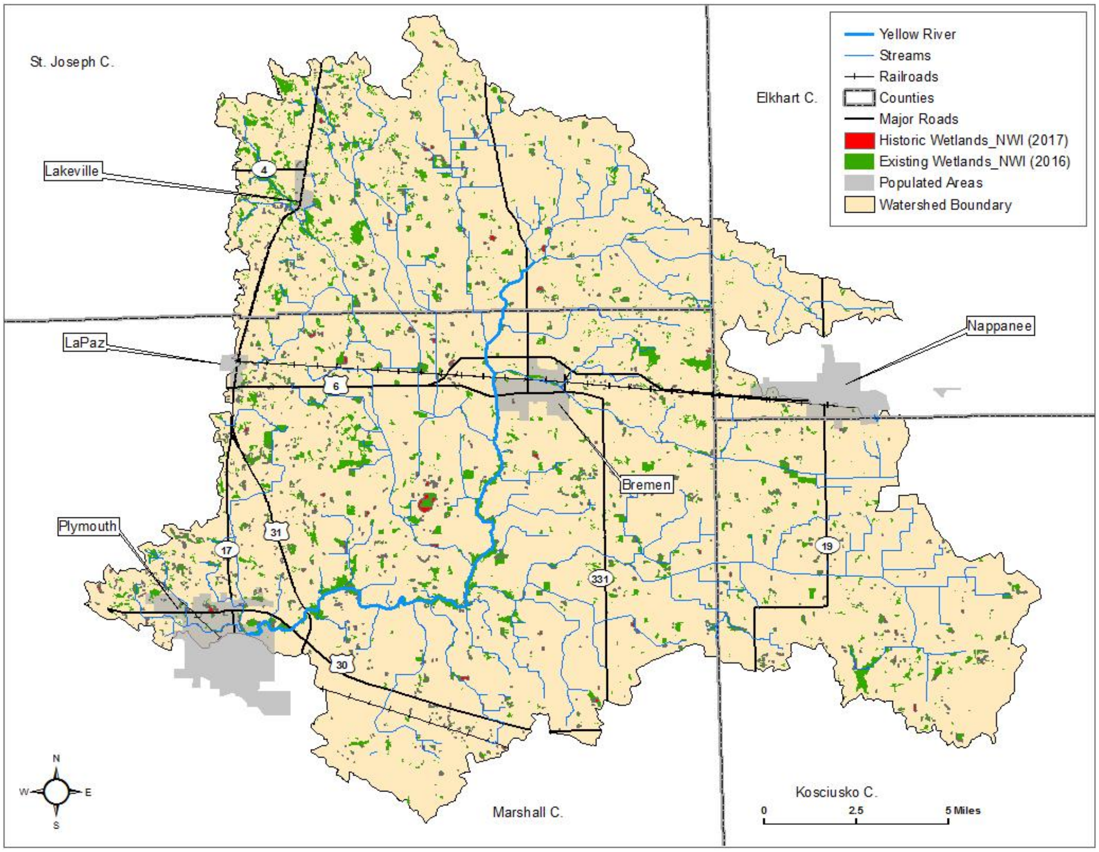

Figure 1-2. NWI existing and historical wetlands within the Headwaters Yellow River watershed.

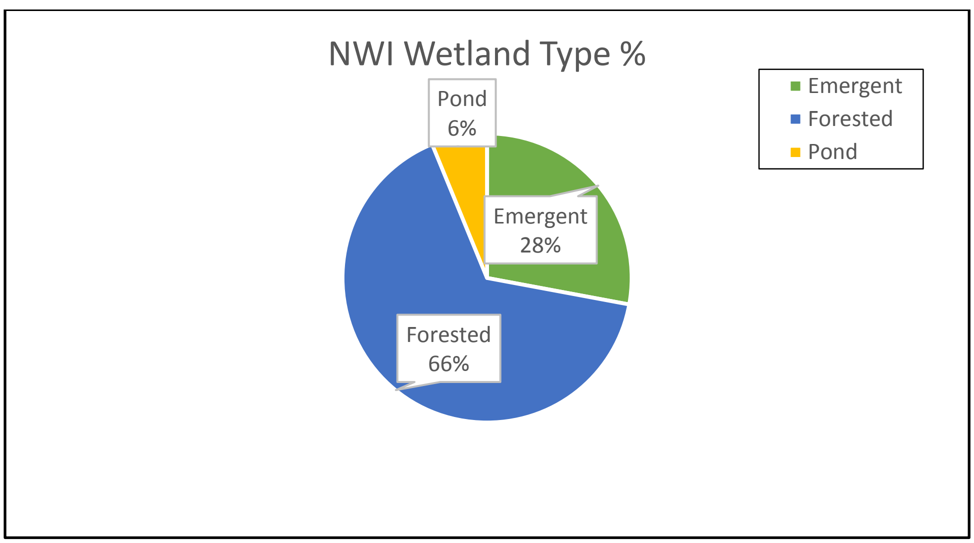

Figure 1-3. Percentage of each NWI wetland type in the Headwaters Yellow River watershed.

1.4 Project Justification

The landscape-scale changes that have taken place in the Headwaters Yellow River watershed since European settlement have greatly impacted the wetlands of the watershed. At least 1,887 wetlands totaling 1,353.4 acres have been lost to land-use changes; however, there are 3,182 remaining wetlands totaling 10,847 acres, which have been mapped as part of the NWI. The NWI is a resource that accurately describes the location and size of wetlands in the watershed, but the database does not describe the function of each wetland. Unfortunately, the resources available to both state and local agencies limit the conservation actions that can be implemented to protect, restore, and enhance wetlands. Therefore, an understanding of the functions each wetland in the Headwaters Yellow River watershed is essential to accomplishment stakeholder goals. An understanding of the functions each wetland performs will provide guidance and refine how wetland protection, restoration, and enhancement opportunities are addressed in the future.

Wetlands provide valuable services to the watershed including surface water detention, streamflow maintenance, nutrient transformation, sediment and other particulate retention, carbon sequestration, bank and shoreline stabilization, provision for fish and aquatic invertebrate habitat, provision for waterfowl and waterbird habitat, provision of habitat for other wildlife, and provision for highly diverse plant communities (Tiner, McGuckin, and Herman 2015). A better understanding of the functional value of each wetland in the Headwaters Yellow River watershed will provide valuable information to local, regional, and state agencies regarding the prioritization of restoration and conservation efforts.

2 Wetland Functions

2.1 Surface Water Detention

Streams throughout the Midwestern United States experience flooding as a result of modifications to the hydrology of upstream waterbodies. Watersheds have been modified in ways that promote the expedient delivery of stormwater downstream, resulting in increased peak discharges (Figure 2-1). These modifications include increased impervious surfaces, gray infrastructure, and subsurface tile drain systems. In the Headwaters Yellow River watershed impervious surfaces and gray infrastructure are primarily located in Plymouth, Bremen, La Paz, Lakeville, and Nappanee. Subsurface drainage tile systems are common in the Headwaters Yellow River watershed and may be used on as much as 20-60 percent of the row-crop land in the watershed (Figure 2-2). Wetlands reduce downstream flooding by detaining and slowly releasing water to receiving waters. Watersheds with at least 40 percent coverage of wetlands and lakes have 80 percent lower flood flows than comparable watersheds (Novitzki 1979). Wetlands and lakes cover approximately six percent of the Headwaters Yellow River watershed.

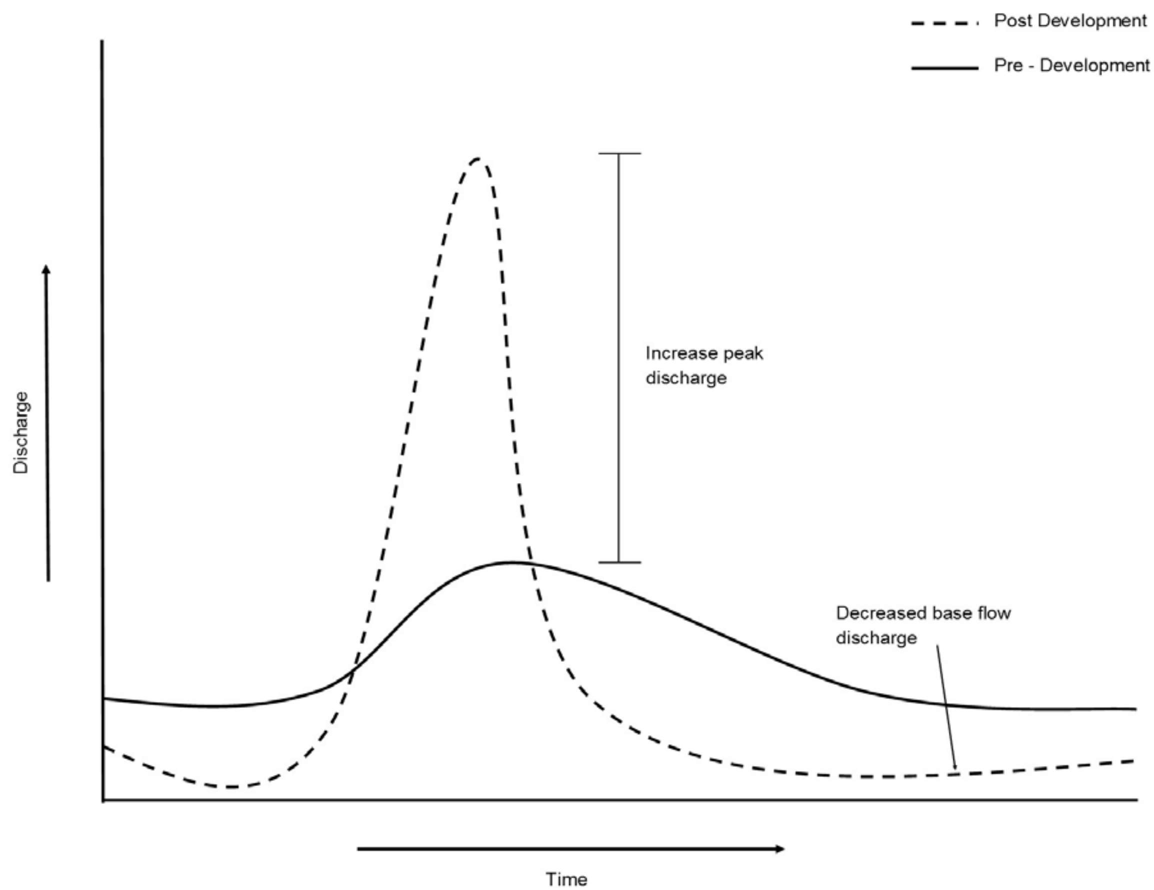

Figure 2-1. Typical discharge patterns of streams in developed and undeveloped watersheds.

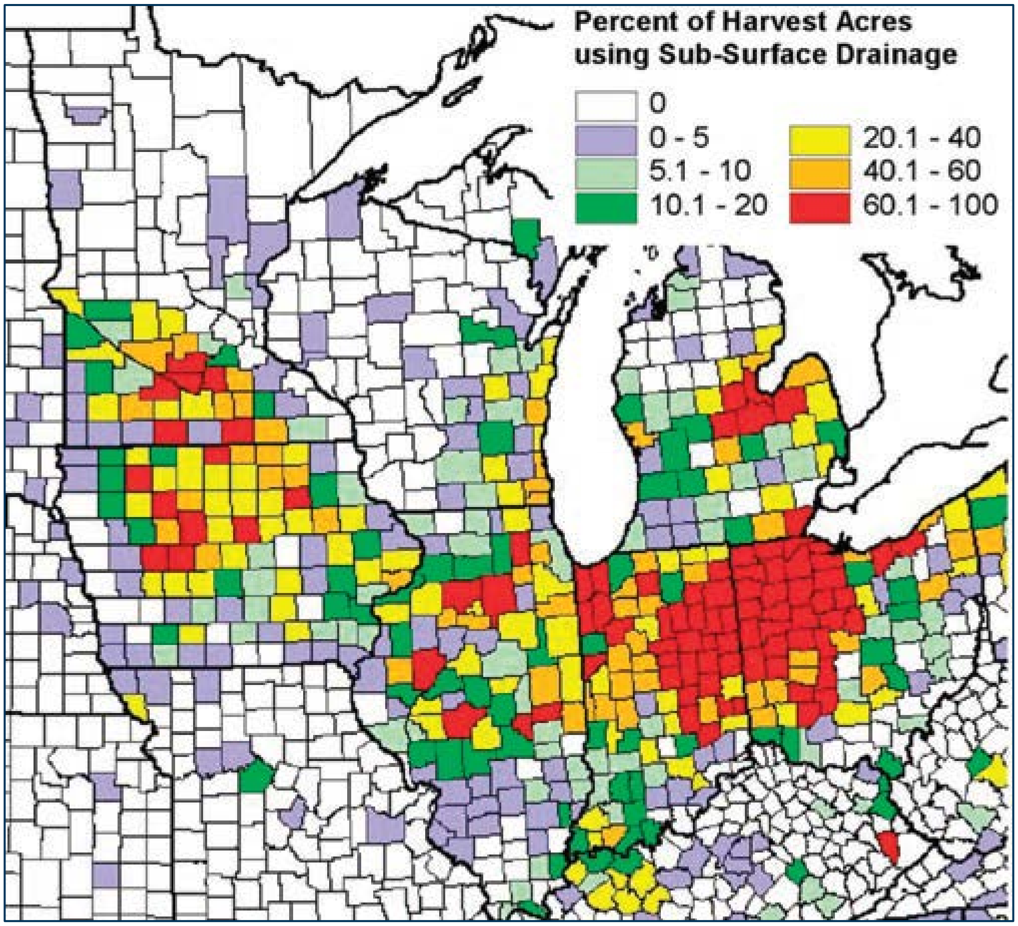

Figure 2-2. Percentage of harvest acres using sub-surface drainage tile Midwestern states (NRI 1992; Census of Agriculture 1992).

2.2 Streamflow Maintenance

Many wetlands are sources of groundwater discharge and some may be in a position to sustain streamflow in the watershed. Wetlands that sustain streamflow can be important for supporting aquatic life in streams (Tiner 2003). All headwater wetlands provide streamflow maintenance, unless they are ditched. Ditched headwater wetlands have decreased streamflow maintenance functionality due to the faster release of water, reducing the period of outflow (Tiner 2003). Floodplain wetlands store water in the form of bank storage. Bank storage is any water that is absorbed and stored in the void in the soil cover in the bed and banks of a stream, lake, or reservoir (NOAA Glossary). Bank storage provides the release of water to streams during periods of baseflows (Whiting 1998). The degree of bank storage is affected by the porosity and permeability of bank material, the width of the floodplain, and the hydraulic gradient (Tiner 2003).

2.3 Nutrient Transformation

The export of phosphorus and nitrogen from streams is an issue throughout the Midwestern United States. Excess nutrients are responsible for numerous water quality issues including the eutrophication of many waterbodies, toxic algae blooms, and the Gulf of Mexico Dead Zone. However, wetlands with fluctuating water tables recycle nutrients very well. Wetlands filter phosphorus laden runoff via plant uptake and have been documented to remove as much as 59 percent of the total phosphorus (Lu et al. 2009).

2.4 Retention of Sediments and Other Particulates

Wetlands can form as sediments are deposited into aquatic basins in floodplains, estuaries, or other habitats (Tiner 2003). As the water body slowly fills in, it morphs into a shallower, and often vegetated, wetland habitat. The wetland, in turn, functions as a catch basin for additional sediments being deposited into or from the main body of water. Wetlands capturing sediment that would otherwise flow into streams and rivers can help reduce turbidity and improve the overall water quality of riparian habitat. Furthermore, wetlands can capture pollutants, including heavy metals, before they reach riparian bodies of water (Kahn et al. 2009).

2.5 Shoreline Stabilization

Vegetated wetlands situated along lake, river, and estuarine shorelines prevent erosion by breaking up wave action and reducing impacts incurred along the margins of these habitats. Shorelines experiencing less wave action, such as those associated with terrene vegetated ponds, provide moderate protection against erosion. However, shorelines located along water bodies experiencing greater wave action, including estuarine wetlands, estuarine rocky shores, marine rocky shores, lotic wetlands, and lentic wetlands, provide a higher level of protection against erosion (Tiner 2003).

2.6 Provision of Habitat for Fish and Other Aquatic Animals

Wetlands that have been identified as significant for streamflow maintenance are considered vital to sustaining the watersheds ability to provide in-stream fish habitat. While these wetlands are not significant habitats themselves, they provide water that is essential for all aquatic life (Tiner 2003). Terrene outflow wetlands and lotic basin wetlands along low order streams discharge cool groundwater to the receiving stream, which provides cooler stream temperatures for cold water species.

2.7 Provision of Waterfowl and Waterbird Habitat

Wetlands are significant waterfowl and waterbird habitat if they are used for nesting, reproduction, or feeding. Shorebirds will use a variety of wetland habitats, including river floodplains, natural and managed wetlands, gravel and sand bars, lake shorelines, reservoirs, and even flooded agricultural fields (Potter et al. 2007). Waterfowl also use wetland habitats for foraging, nesting, and brood rearing. For this type of study, wetlands containing greater amounts of water and those that are frequently flooded for long periods may be of greater emphasis (Tiner 2003).

2.8 Provision of Other Wildlife Habitat

Wetlands provide habitat for a variety of wildlife, and may be used in all stages of an organism’s life cycle, from egg and juvenile though adulthood. On a regional level, the diverse wildlife using wetlands are reflected through recent assessments conducted at large-scale wetland restoration sites in both southern (Goose Pond) and northern (Eagle Marsh) Indiana (Karns et al. 2012, Ruch et al. 2016). The type and amount of wildlife that will use a wetland habitat is, to some extent, contingent upon a number of variables, including the site type (bottomland, upland, or association with nearby waterbodies), surrounding habitat type (natural versus developed), degree of vegetative interspersion, and proximity/distance to other wetlands (Golet 1972). Because certain wildlife species are dependent on large, continuous tracts of forest, wetlands associated with large forest stands are of particular value. Some species of amphibians require seasonal or fishless wetlands for successful reproduction; thus small, seemingly insignificant, wetlands may be critical for their ongoing survival.

2.9 Conservation of Biodiversity

The structure of a wetland as it relates to vegetation density, wetland depth, and drying regime can greatly influence the diversity and types of organisms that utilize a habitat. For example, shallow water mudflats provide foraging habitat for wading shorebirds, but greater water depth, area, and vegetation has shown a positive influence on diving ducks (Webb et al. 2010). A wetland complex containing a matrix of wetlands with varying hydrology (seasonal, semi-permanent, and permanent) can help ensure the persistence of amphibian populations during years of drought; as seasonal and semi-permanent wetlands dry, permanent wetlands become the only habitat available for reproduction (Lannoo 1998). Essentially, different types of wetlands provide habitat for different types of organisms. Thus, wetlands containing varied wetland habitats or those that contribute to a heterogeneous landscape improve opportunities for increased biological diversity and may be considered to be of higher value in a watershed analysis. Unique or uncommon wetlands (such as bogs or fens) may be especially critical for the survival of organisms with specialized habitat requirements or unique life histories. These types of wetlands may be considered to be of high value when identifying important wetland types within a watershed.

3 Methods

3.1 Existing Geospatial Datasets

There were four primary geospatial datasets utilized to conduct the LLWFA. The location of waterbodies in the watershed were displayed using USGS NHD from 2008. Topography and elevation were displayed using USGS elevation contours at a scale of 1:24,000 in combination with DEM data. The location of wetlands in the watershed were displayed using the 2016 USFWS NWI dataset.

3.2 Geospatial Analysis

All geospatial analysis was done in ArcGIS 10.4. GIS data created during the Headwaters Yellow River watershed LLWFA followed the naming convention recommendations of the IGIC. The IGIC recommended naming convention incorporates a keyword, steward, extent, and date component. The keyword provides a description of the contents of the data, the steward identifies the creator of the dataset, the extent describes the geographic extent of the dataset, and the date describes the date the dataset was created or modified. Below is the structure of the recommended naming convention that was utilized:

keyword_steward_extent_date

3.3 NWI+ Database & Data Analysis

The LLWFA utilized geospatial data in ArcGIS 10.4 to perform complex analyses of existing databases to determine the functional significance of the wetlands in the Headwaters Yellow River watershed. This will allow for a refined prioritization of future wetland protection, restoration, and enhancement in the watershed. Wetland function was assessed using techniques developed by the USFWS (USFWS 2013). This technique uses the NWI data to characterize and assess the function of wetlands at a watershed-scale. First, hydrogeomophic-type descriptors were added to the NWI dataset creating a “NWI+ database”. This technique takes into account the landscape position, landform, and water flow path of NWI wetlands (Tiner 2011). Landscape position describes the location of wetlands relative to the location of other waterbodies including lotic, lentic, and terrene systems (Figure 3-1). Landform describes the physical shape of the each wetland including basin, flat, floodplain, fringe, island, and slope shaped wetlands. Water flow path describes the direction of the flow of water associated with each wetland including outflow wetlands, through-flow wetlands, inflow wetlands, isolated wetlands, and bidirectional-nontidal wetlands (Figure 3-2) ; USFWS 2013).

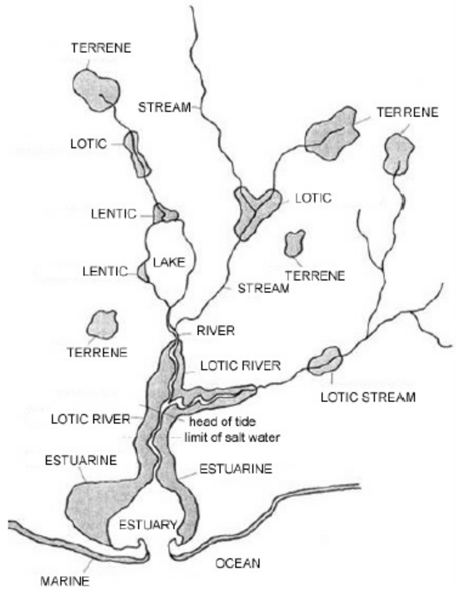

Figure 3-1. Example of wetlands classified by landscape position (Tiner, McGuckin, and Herman 2015).

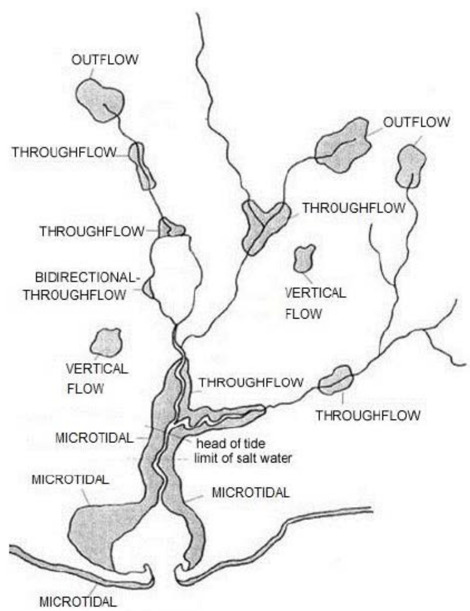

Figure 3-2. Example of wetlands classified by water flow path (Tiner, McGuckin, and Herman 2015).

Wetland function was determined using relationships between the properties described in the NWI+ database and established wetland functions. The NWI+ database was used to identify wetlands with potential to perform a variety of functions at high or moderate levels. The nine functions that were used to evaluate wetlands include surface water detention, streamflow maintenance, nutrient transformation, sediment and particulate retention, bank and shoreline stabilization, fish and aquatic invertebrate habitat, waterfowl and waterbird habitat, habitat for other wildlife, and habitat for unique wetland plant communities.

Wetlands were assigned high correlations, moderate correlations, or no correlations with each of the nine functions based on wetland function correlations described in Tiner 2003.

To determine the overall LLWFA priority of each wetland an overall LLWFA score was calculated. The score was determined by assigning all high correlations with metrics a score of "3", moderate a score of "1" and no correlation a score of "0." For each wetland the cumulative score was then calculate and based on the scores of the nine metrics. Wetlands that received a score of < 11 received a "low" priority, 11-17 a "moderate" priority and 18 or greater a "high" priority.

The NWI+ database, functional metric correlations and LLWFA overall scoring can be found in Appendix A.

3.4 Windshield Survey Planning

Following the development of the NWI+ database and initial wetland functional assessments using the LLWFA, the wetland polygons within the watershed were prioritized. This was completed by viewing the NWI data over satellite imagery in Google Earth. Utilizing the historical aerials, each polygon was analyzed to determine its priority to survey during the windshield survey. Wetlands that were excluded, included manmade ponds and retention basins, heavily fragmented wetlands within agricultural and urban areas, and small depressions within farm fields. These excluded areas serve a purpose for recharging groundwater, but do not offer significant ecological functions. Wetlands that were to be surveyed were given a rank of low, medium, and high priority. A more detailed description of the windshield survey planning is available in Section 5.

3.5 Windshield Survey

The windshield survey was conducted by Cardno on November 15-17 and November 20, 2017. During the windshield survey wetland characteristics were field verified by driving throughout the watershed and conducting rapid visual surveys of wetlands visible from public roads. During the windshield survey an excel spreadsheet was completed documenting any habitat alterations, upland buffers, adjacent land-uses, and presence of invasive species for each of the surveyed wetlands (Appendix B). In the event that data could not be collected on a wetland, the wetland number(s) and date of the survey was documented, as well as the reason the wetland could not be surveyed. A more detailed description of the windshield survey is available in Section 5.

4 Results

4.1 Surface Water Detention

The watershed contains 702 wetlands totaling 5,267 acres that are categorized as being highly functioning for surface water detention. Twenty-five percent of the total acreage of the highly functioning wetlands in the watershed are located in the floodplain of the mainstem of the Yellow River (Figure 4-1). There are another 2,481 wetlands totaling 5,613 acres that are categorized as being moderately functioning for surface water detention. The distribution of wetlands categorized as a moderate function for surface water detention are evenly distributed through the Headwaters Yellow River Watershed (Figure 4-1).

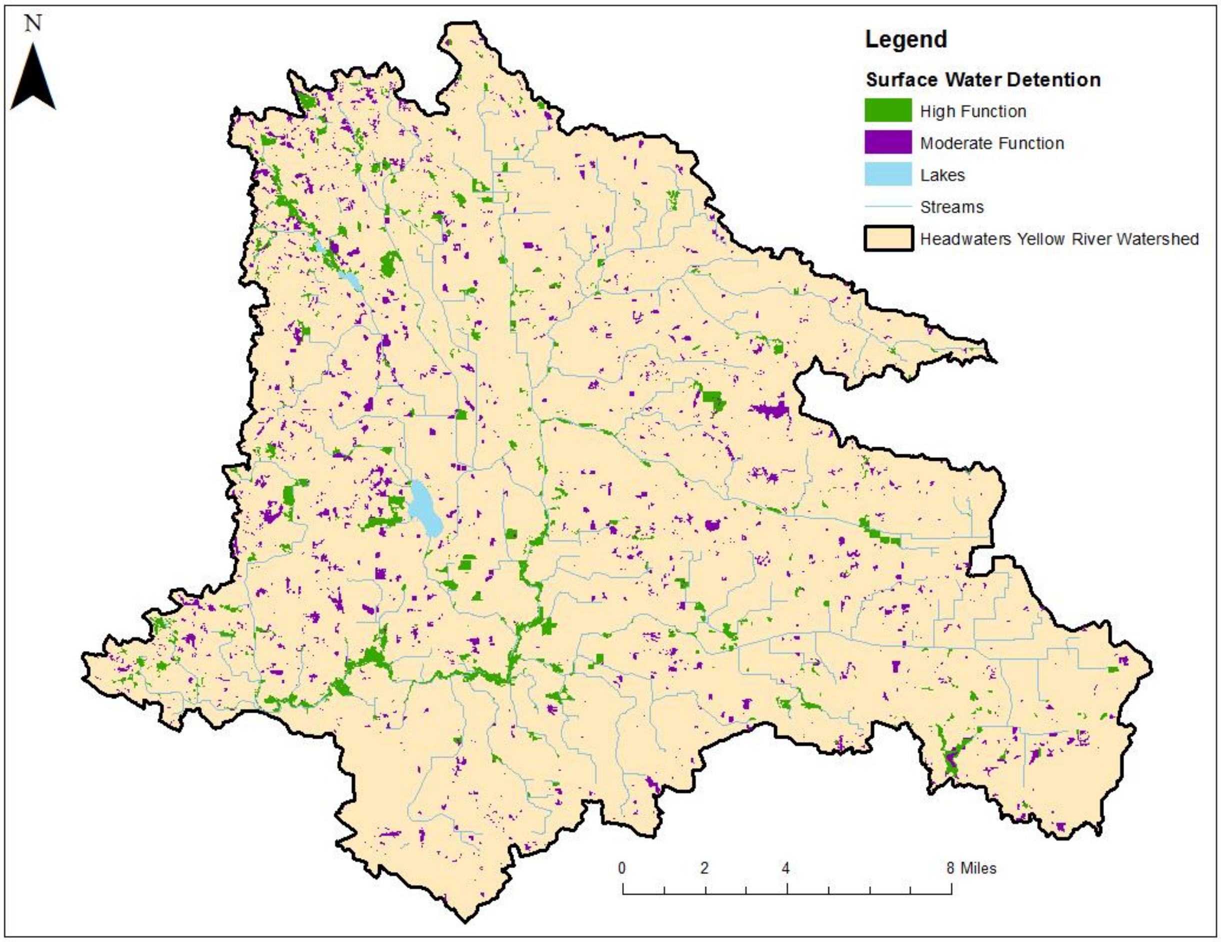

Figure 4-1. Existing high and moderate surface water detention wetlands in Headwaters Yellow River Watershed.

4.2 Streamflow Maintenance

The watershed contains 2,674 wetlands totaling 7,756 acres that are categorized as being highly functioning for streamflow maintenance. These highly functioning wetlands are evenly distributed across the Headwaters Yellow River watershed (Figure 4-2). There are 509 wetlands totaling 3,124 acres categorized as being moderately functioning for streamflow maintenance. Of the 3,161 acres of moderately functioning wetlands in the watershed, 572 acres are located along the floodplain of the mainstem of the Yellow River (Figure 4-2).

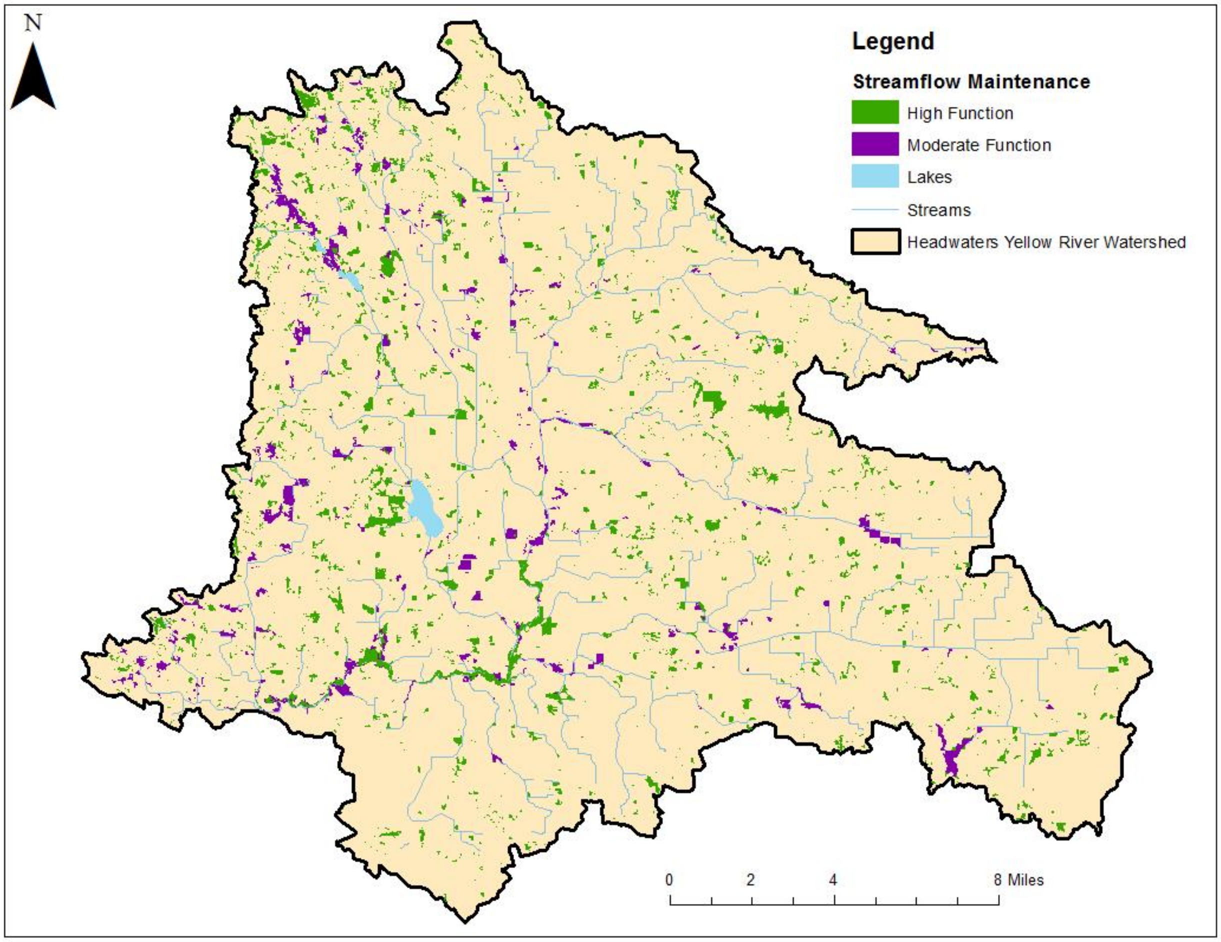

Figure 4-2. Existing high and moderate streamflow maintenance wetlands in Headwaters Yellow River Watershed.

4.3 Nutrient Transformation

There are 1,514 wetlands totaling 5,127 acres that are categorized as being highly functioning for nutrient transformation. The majority of these wetlands are forested wetlands (80 percent), followed by emergent wetlands (15 percent), and ponds (4 percent). The few ponds categorized as highly functioning for nutrient transformation are categorized as high because they share a boundary with another wetland that is categorized as highly functioning. Eighteen percent of the total acreage of the highly functioning wetlands in the watershed are located in the floodplain of the mainstem of the Yellow River (Figure 4-3). The Headwaters Stock Ditch and West Bunch Branch subwatersheds also contain 481 wetlands totaling 1,419 acres categorized as highly functioning for nutrient transformation (Figure 4-3). There are another 1,175 wetlands totaling 5,313 acres that have been categorized as a moderately function wetland for nutrient transformation. The wetlands categorized as moderately functioning are scattered and evenly distributed throughout the watershed (Figure 4-3). Lastly, there are 494 ponds totaling 440 acres in the watershed that perform negligible nutrient transformation.

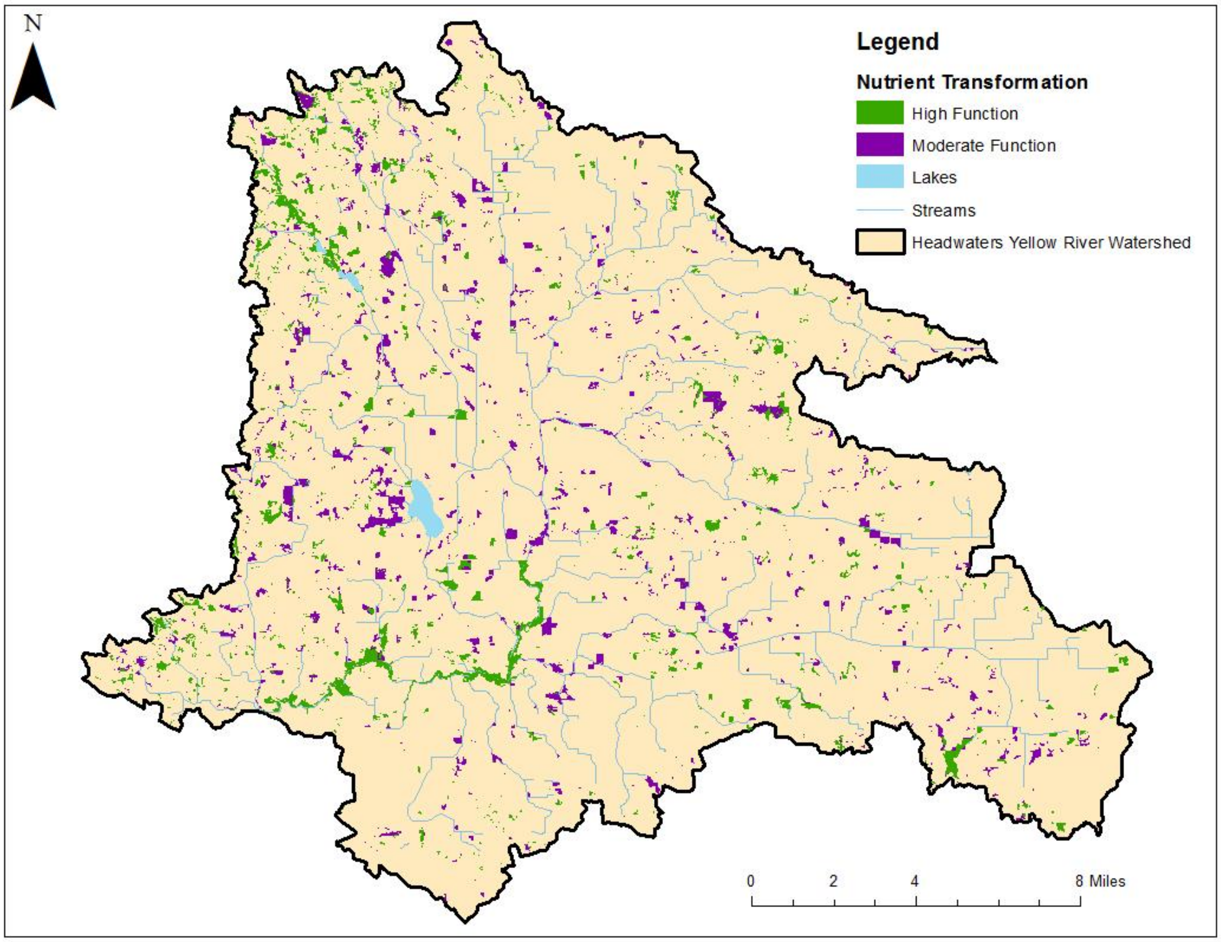

Figure 4-3. Existing high and moderate nutrient transformation wetlands in Headwaters Yellow River Watershed.

4.4 Retention of Sediment and Other Particulates

The watershed contains 710 wetlands totaling 5,277 acres that are categorized as being highly functioning for the retention of sediment and other particulates. The majority of these wetland are forested wetlands (71 percent), followed by emergent wetlands (26 percent), and ponds (3 percent). Twenty-five percent of the total acreage of the highly functioning wetlands are spatially distributed along the mainstem of the Yellow River in the floodplain and in the northwest portion of the watershed (Figure 4-4). However, there are a limited number of highly functioning wetlands for the retention of sediment and other particulates in the eastern portion of the watershed (Figure 4-4). There are another 2,465 wetlands totaling 5,579 acres that are moderately functioning for the retention of sediment and other particulates. These moderately functioning wetlands are scattered and evenly distributed throughout the watershed.

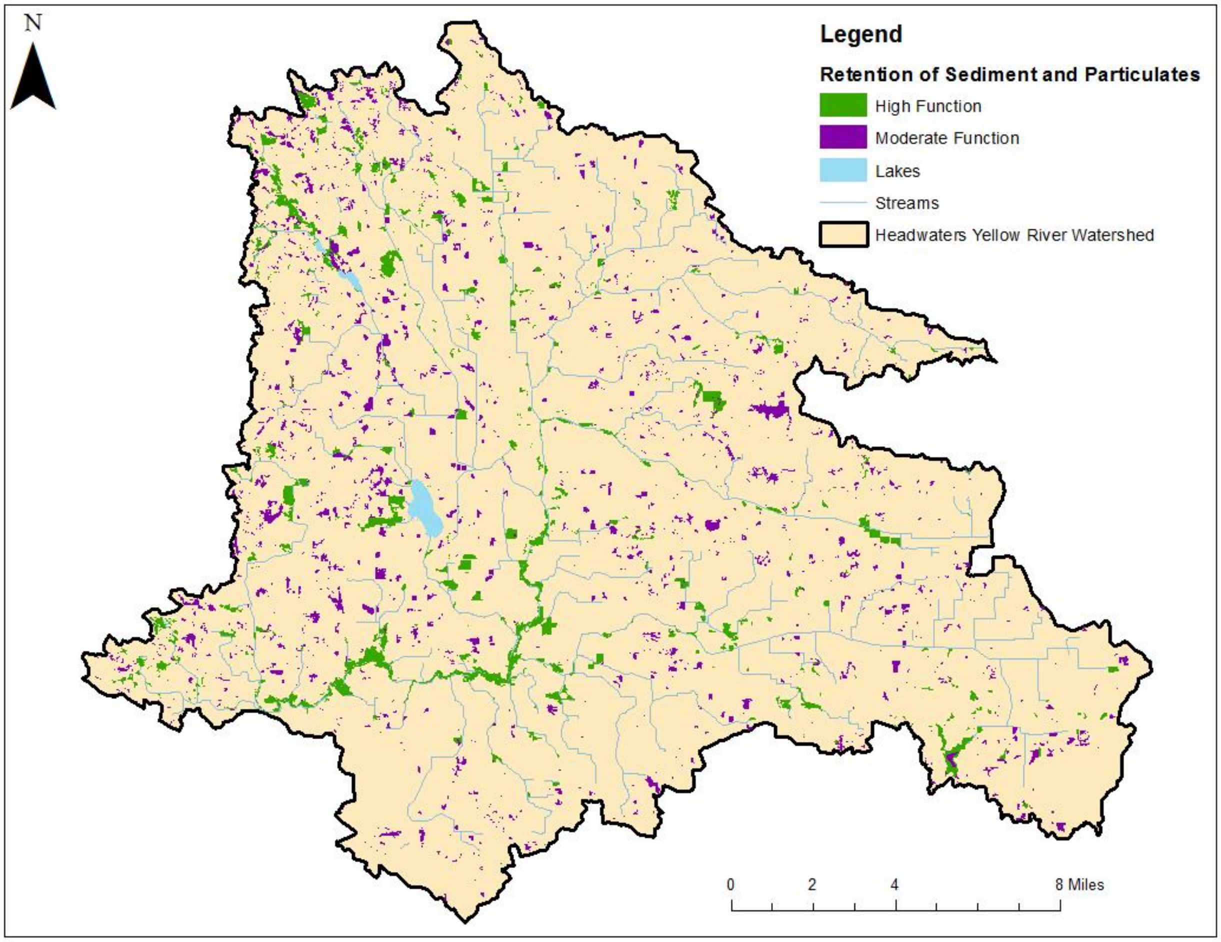

Figure 4-4. Existing high and moderate sediment retention wetlands in Headwaters Yellow River Watershed.

4.5 Shoreline Stabilization

There are 702 wetlands totaling 5,267 acres categorized as highly functioning for shoreline stabilization. The majority of the highly functioning wetlands are forested wetlands (71 percent), followed by emergent wetland (26 percent), and ponds (2 percent). Each of these wetlands shares a boundary with a lentic or lotic waterbody and therefore protects the shoreline. Historically, streambank erosion from the mainstem of the Yellow River has been believed to be a major source of sediment into the Kankakee River. Therefore, the forested floodplain wetlands located along the mainstem of the Yellow River are an important component of the ecosystem (Figure 4-5). Lastly, there are another 779 wetlands totaling 536 acres categorized as moderately functioning for shoreline stabilization. These moderately functioning wetlands are primarily wetlands that are associated with the shoreline stabilization of ponds (Figure 4-5).

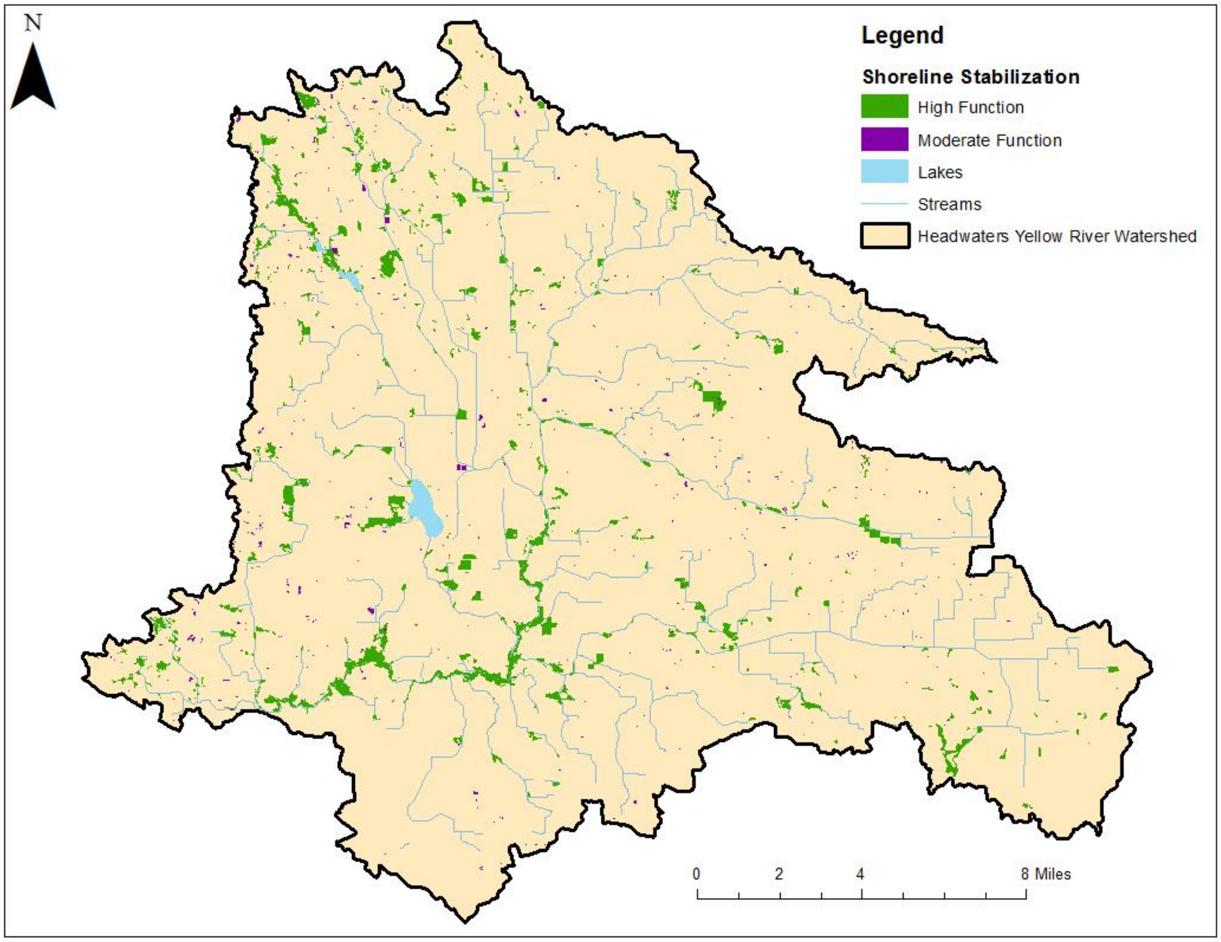

Figure 4-5. Existing high and moderate shoreline stabilization wetlands in Headwaters Yellow River Watershed.

4.6 Provision of Habitat for Fish and Other Aquatic Animals

The watershed contains 936 wetlands totaling 831 acres categorized as highly functioning for the provision of habitat for fish and other aquatic animals. The majority of the highly functioning wetlands in the watershed are forested wetlands (42 percent), followed by emergent wetlands (31 percent), and ponds (27 percent). While many of the forested and emergent wetlands do not provide actual habitat for fish, they provide water to headwater streams and maintain baseflows that are necessary for fish communities. The highly functioning wetlands are evenly scattered throughout the watershed (Figure 4-6). There are another 354 wetlands totaling 3,948 acres categorized as moderately functioning, of local importance, or important for stream shading. The wetlands categorized as moderately functioning, of local importance, or important for stream shading, are located primarily in the floodplain of the mainstem of the Yellow River (Figure 4-6).

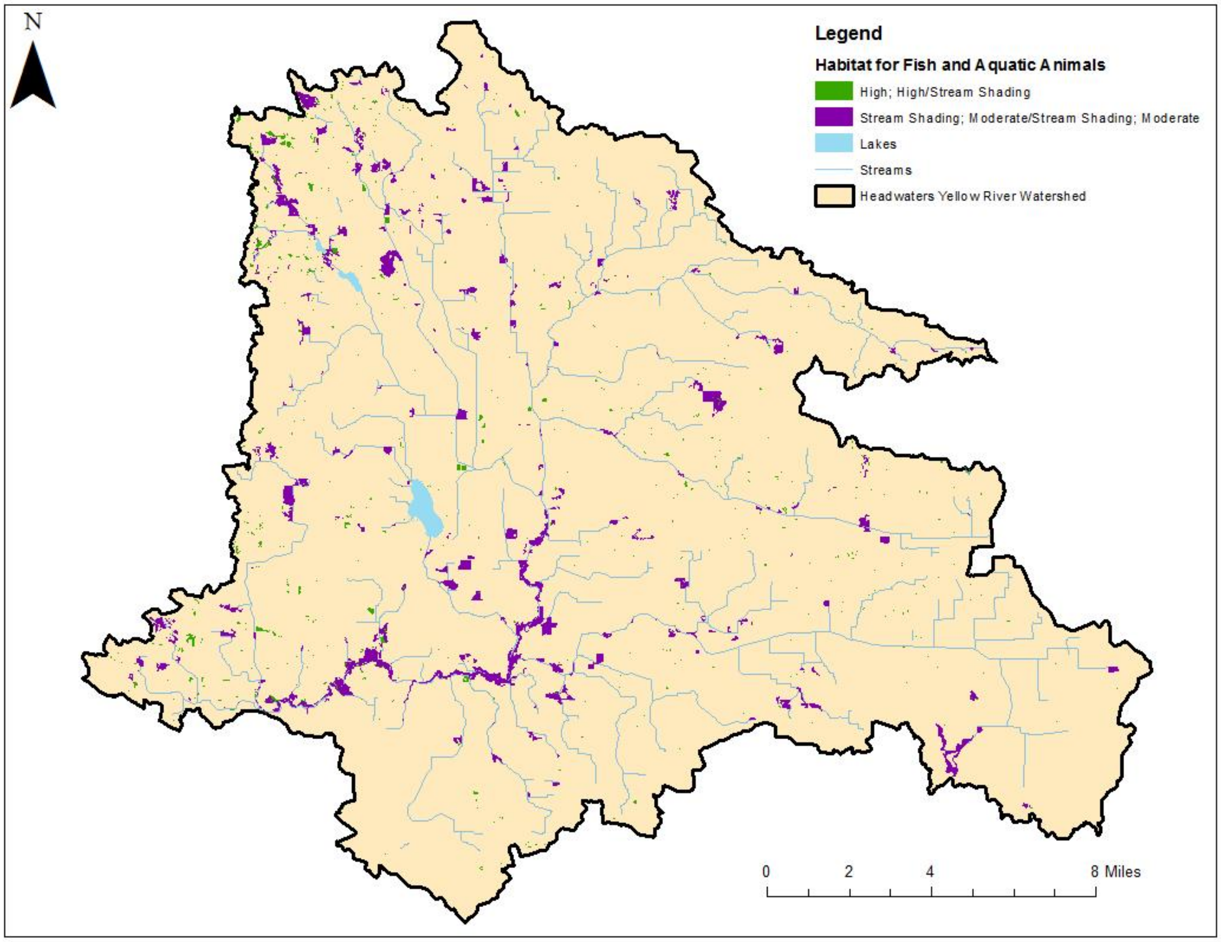

Figure 4-6. Existing high and moderate fish habitat wetlands in Headwaters Yellow River Watershed.

4.7 Provision of Waterfowl and Waterbird Habitat

The watershed contains 651 wetlands totaling 1,823 acres categorized as highly functioning for the provision of waterfowl and waterbird habitat. Highly functioning wetlands for the provision of waterfowl and waterbird habitat are relatively small with an average size of 2.8 acres. There are 300 wetlands totaling 2,974 acres categorized as moderately functioning. While there are relatively few wetlands that are highly functioning, or moderately functioning, for the provision of waterfowl and waterbird habitat, there is a significant quantity of wetland area in the watershed that is appropriate wood duck habitat. Wood ducks prefer wetlands, rivers, lakes, and ponds that are surrounded by deciduous forest (Dugger and Fredrickson 1992). Therefore, the 1,094 acres of primarily forested wetlands along the mainstem of the Yellow River are valuable wood duck habitat (Figure 4-7). In fact, these wetlands alone account for approximately 30 percent of all of the wood duck habitat in the Headwaters Yellow River watershed.

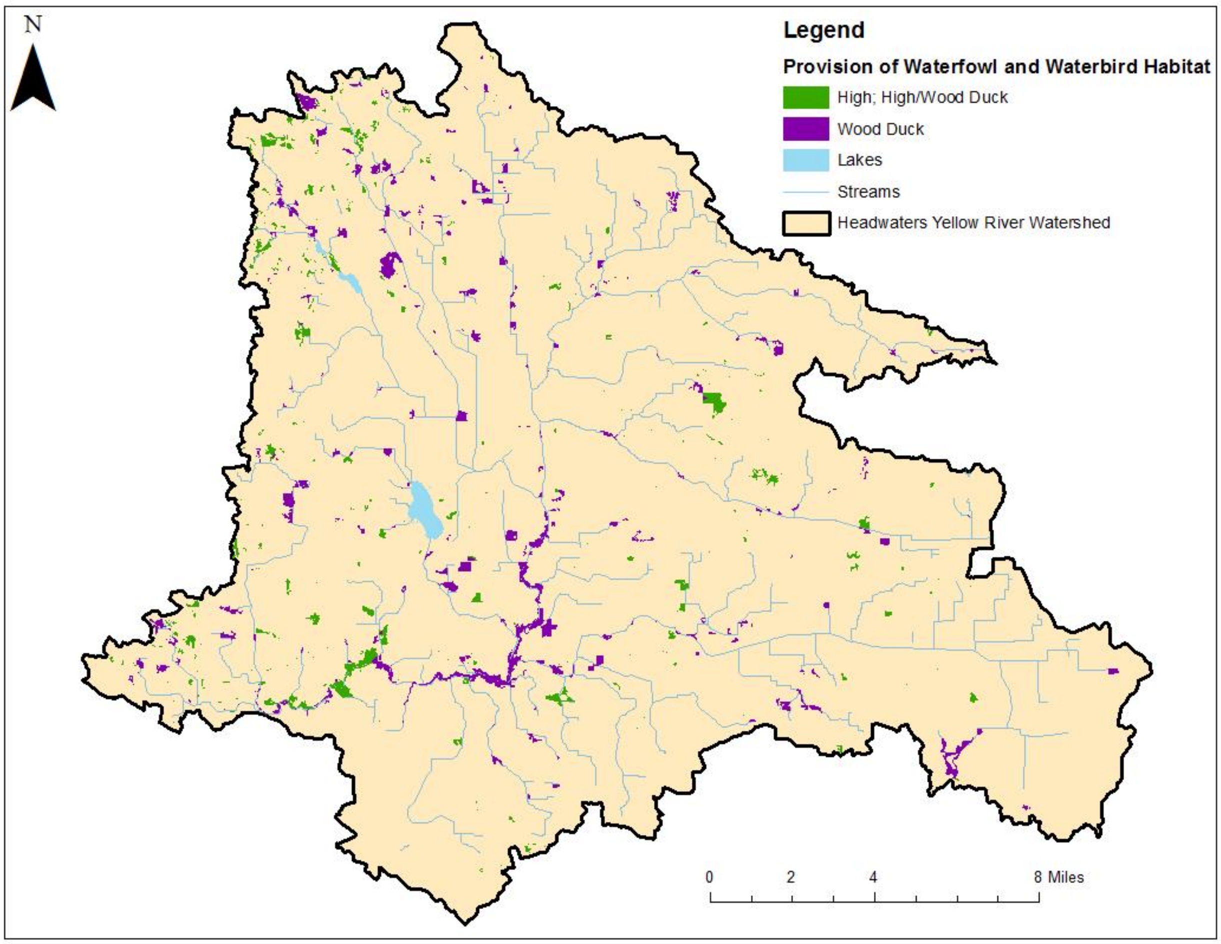

Figure 4-7. Existing high and moderate waterfowl habitat wetlands in Headwaters Yellow River Watershed.

4.8 Provision of Other Wildlife Habitat

The watershed contains 255 wetlands totaling 5,397 acres categorized as highly functioning for the provision of other wildlife habitat. Seventeen percent of the total acreage of the highly functioning wetlands are spatially distributed along the mainstem of the Yellow River in the floodplain and in the northwest portion of the watershed (Figure 4-8). There are 2,928 wetlands totaling 5,482 acres categorized as moderately functioning from the provision of other wildlife habitat. These moderately functioning wetlands are scattered evenly throughout the Headwaters Yellow River watershed.

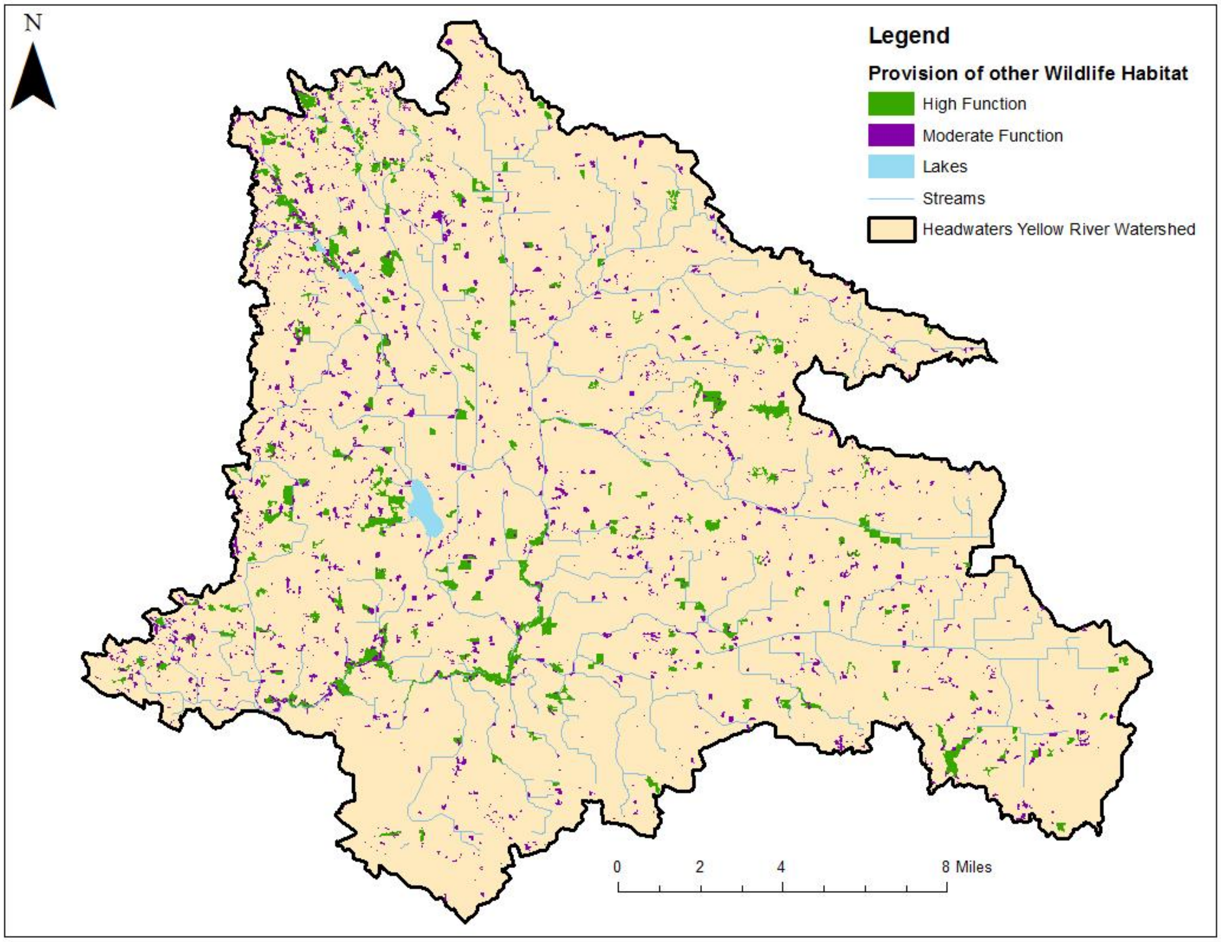

Figure 4-8. Existing high and moderate wildlife habitat wetlands in Headwaters Yellow River Watershed.

4.9 Conservation of Biodiversity

The watershed contains 50 wetlands totaling 2,093 acres categorized as significant for the function of the conservation of biodiversity. There are two wetlands totaling 135 acres categorized as regionally significant for the function of conservation of biodiversity. For the purposes of this assessment, wetlands were identified as significant for the conservation of biodiversity if a wetland was 25 acres or larger and was a forested/shrub or emergent wetland type. The two wetlands listed as regionally significant for the conservation of biodiversity are associated with a rare bog habitat, the only one of its kind within the watershed. The two wetlands are associated with the Glennwood Nature Preserve managed by Acres Land Trust and located in Kosciusko County (Figure 4-9). Significant wetlands for the conservation of biodiversity are spread throughout the watershed but there are a number wetlands located along the Yellow River, south of Bremen (Figure 4-9).

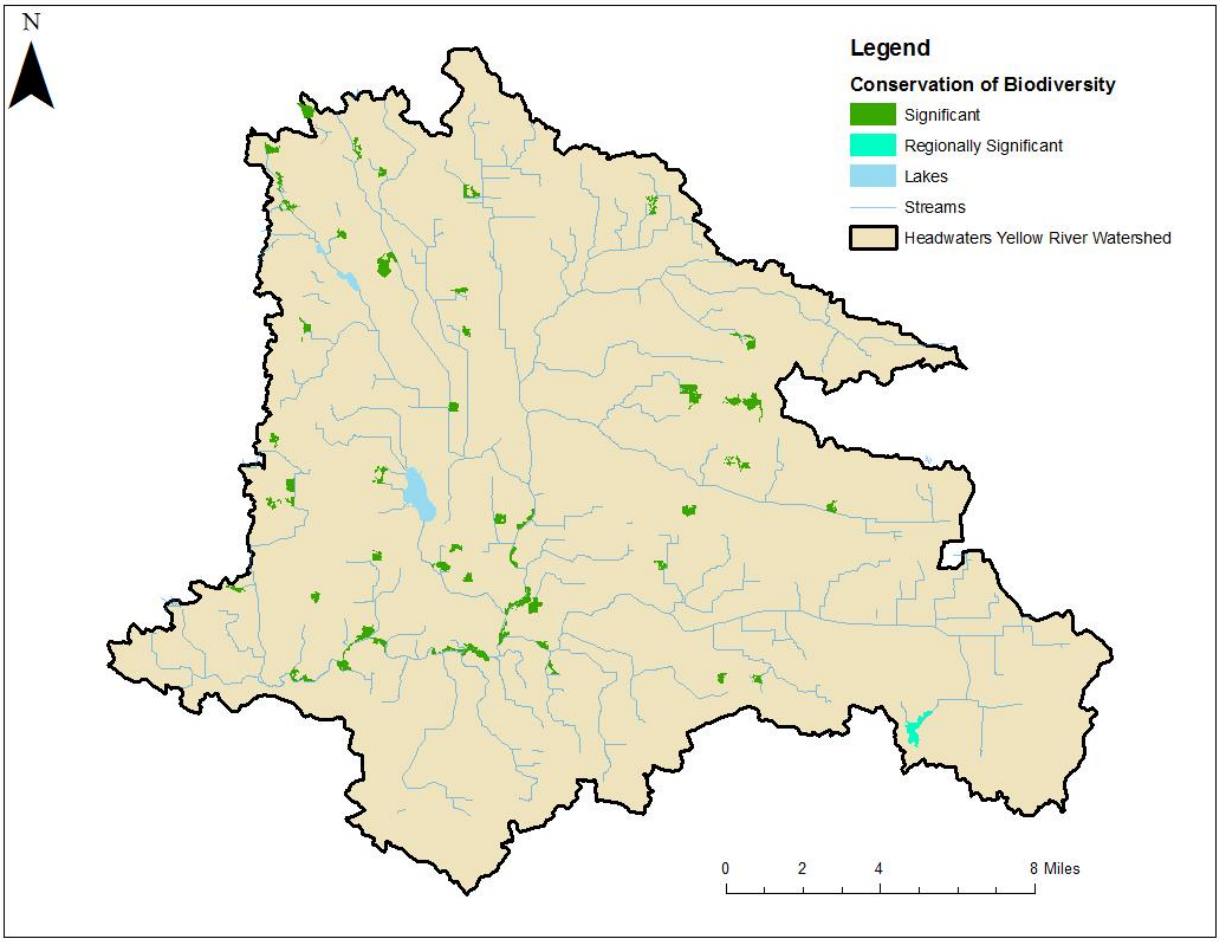

Figure 4-9. Existing significant and regionally significant conservation of biodiversity wetlands in Headwaters Yellow River Watershed.

5 LLWFA Windshield Survey

5.1 Windshield Survey Planning

Prior to conducting the windshield survey, the wetland polygons located within the Yellow River watershed were prioritized for viewing during the windshield survey effort. This was accomplished by viewing the NWI wetlands data over satellite imagery in Google Earth. By doing so, historical aerial images could be utilized to observe and note significant features within and around each wetland. Based on this information, each wetland was then ranked based on its priority to view during the windshield survey. Prioritization of the wetlands allowed for a greater focus on wetlands that performed multiple functions listed in section four, while reducing time spent on impacted and manmade wetlands, and wetlands located too far from public roads. These assigned rankings were low, medium, and high priority, while some were excluded entirely (Figure 5-1).

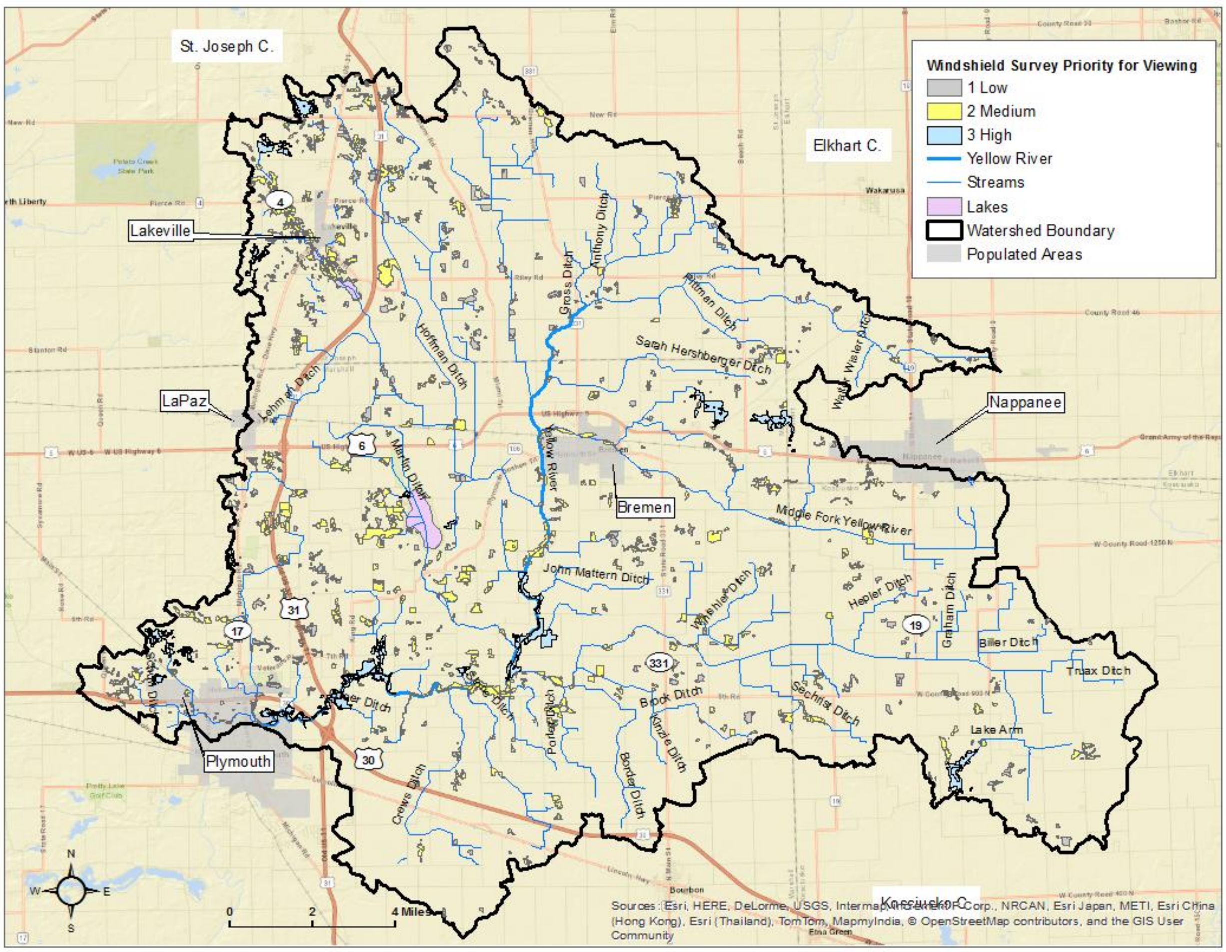

Figure 5-1. Windshield Survey viewing priority ranking developed from satellite imagery review.

5.1.1 <u>Excluded Wetlands</u>

Wetlands that were excluded, included manmade ponds and retention basins, heavily fragmented and impacted wetlands within agricultural and urban areas, and small, isolated, depressions within agricultural areas. An example of an excluded wetland is a row crop field that the hydrology has been altered through the use of drainage tile allowing for the regular growth of crops. The NWI numbers associated with these wetlands were included on the field survey map for any potential notes regarding potential restoration.

5.1.2 Low Priority Wetlands

Low priority wetlands were ranked as such based on the ease of viewing during the survey, the manipulations to the wetland or surrounding area, and if they were impacted as a result of the surrounding land-use. Some that fell within this priority level may serve a higher number of the wetland functions, but the greater distance of these wetlands from public roads would not allow for this to be confirmed without landowner access.

5.1.3 Medium Priority Wetlands

Medium priority wetlands were those that were larger, isolated wetlands that were visible from public roads. Wetlands given this priority level provide some of the wetland functions, but the surrounding land-use, and/or hydrological manipulation, has reduced the number of functions that the wetland originally served. An example of a medium priority wetland is a forested wetland that has been isolated by the surrounding construction of commercial and/or residential properties.

5.1.4 High Priority Wetlands

High priority wetlands were large wetland complexes and other wetlands that were directly associated with the watershed. These were wetlands that were located along the Yellow River, or those that were associated with the headwaters of the ditches within the watershed. As such, these areas potentially provide a large portion of the wetland functions. An example of a high priority wetland is a forested floodplain wetland located along the Yellow River. While the surrounding area may have been developed in some way, these potential remnant wetlands have had minimal impact from the surrounding land-uses.

5.2 Windshield Survey

Utilizing a created map of the Yellow River watershed, the windshield survey was divided between four field days, November 15-17 and November 20, 2017, and was performed entirely from public roads. During this survey an excel spreadsheet (Appendix B) was completed documenting upland buffers, habitat alteration, adjacent land-uses, and the presence of invasive plant species for each wetland. The date, associated NWI FID numbers, and additional comments were documented as well. In the event a wetland was not visible from the road, and accurate notes could not be documented, the NWI number was recorded and notes were taken regarding the reason(s) that no other information was collected. Each available selection on the field spreadsheet is expanded upon in the following sections.

5.2.1 Upland Buffers

An upland buffer is an area of upland vegetation directly adjacent to a wetland (Chase et al. 1995). During the survey it was determined only if an upland buffer was present or not.

5.2.2 Habitat Alteration

Over the course of the survey it was noted if habitat alteration was present or not. For the purposes of this study, habitat alteration was defined as any alteration to the hydrology, or any other change to the wetland that likely had a negative impact to the number of functions that it served. The primary means of alteration for the area was the creation of ditches and installation of drainage tiles to reduce the amount of water in a given area.

5.2.3 Adjacent Land-uses

The adjacent land use consisted of eleven separate types of land-use, with multiple that could be noted for each wetland. The selections available for agriculture were row crop, pasture, and confined feed operation. The two choices for residential were rural and urban, and urban was expanded upon with commercial and industrial uses. The remaining selections that could be chosen were forested, scrub-shrub, prairie, and open water to describe the surrounding natural area. Since it was possible to have more than one land-use around any wetland, multiple options could be selected to describe the adjacent land-use accurately.

5.2.4 Invasive Plant Species

The choices for invasive plant species consisted of six specific options. These options encompassed the main invasive species that are encountered throughout the watershed, as well as the option to note other prevalent invasive species in the wetland and the upland buffer. The species that could be selected from in the field were common reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), cattail (*Typha* spp.), buckthorn (*Rhamnus* spp.), purple loosestrife (*Lythrum salicaria*), and teasel (*Dipsacus* spp.).

5.2.5 Additional Comments

The additional comments area was available to expand upon adjacent land-uses and invasive plant species in the event that a selection was not available to accurately document a wetland. Also, this section was used to add comments as to why some wetlands could not be documented, and if there were potential restoration or enhancement activities that could be performed to restore wetland functions.

5.3 Summary of Windshield Survey Efforts

Results of the windshield survey included the investigation/designation of a total of 282 sites across the Headwaters Yellow River watershed (Appendix B). A site, as identified during the windshield survey (Appendix B) could be defined as a single NWI wetland if that individual wetland was isolated or a site could include multiple NWI wetlands in close vicinity to each other such that they were part of the same wetland complex. Most often a site as investigated during the windshield survey would include multiple NWI wetlands (Appendix B). The results of the windshield survey were used to help identify specific sites within the Headwaters Yellow River watershed where wetland priority management activities could take place in the future and are explained in more detail in Section 6.

6 Prioritized Management Actions

6.1 High Priority Wetlands

Wetland prioritization can be performed by any agencies and organizations using any of the functional categories described in section four. Functional categories can be more or less weighted based on the goals and objectives of the organization. However, the goal of this document is to provide guidance to organizations to maximize the benefits of future wetland protection, restoration, and enhancement opportunities. In order to maximize the benefit from future wetland protection, restoration, and enhancement opportunities a wetland ranking system has been utilized. This ranking system takes into account the functional value of each category equally, and therefore prioritizes all of the wetlands in the watershed based on their overall functional significance to the Headwaters Yellow River watershed at an ecosystem scale.

For each of the 3,182 wetlands identified in the Headwaters Yellow River watershed a final LLWFA score was calculated using the cumulative score developed from the correlations determined from each of the nine functional metrics. Each of the nine metrics for each wetland was given a score of 3, 1 or 0 depending on correlation of the wetland to the metric (Appendix A). High correlations received a score of 3, moderate a 1 and no correlation a 0. The overall cumulative score for each wetland was determined as high priority if the score was 18 or higher, moderate for scores of 11 through 17 and low for scores below 11.

There were a total of 184 high priority wetlands totaling 2,690 acres identified throughout the Headwaters Yellow River watershed (Figure 6-1). A total of 1,087 wetlands were identified as moderate priority and totaled 3,993 acres (Figure 6-1). A total of 1,911 wetlands were identified as low priority wetlands and totaled 4,163 acres (Figure 6-1). High priority wetlands had the greatest average size at 14.6 acres, followed by moderate (3.7 acres) and low (2.2 acres).

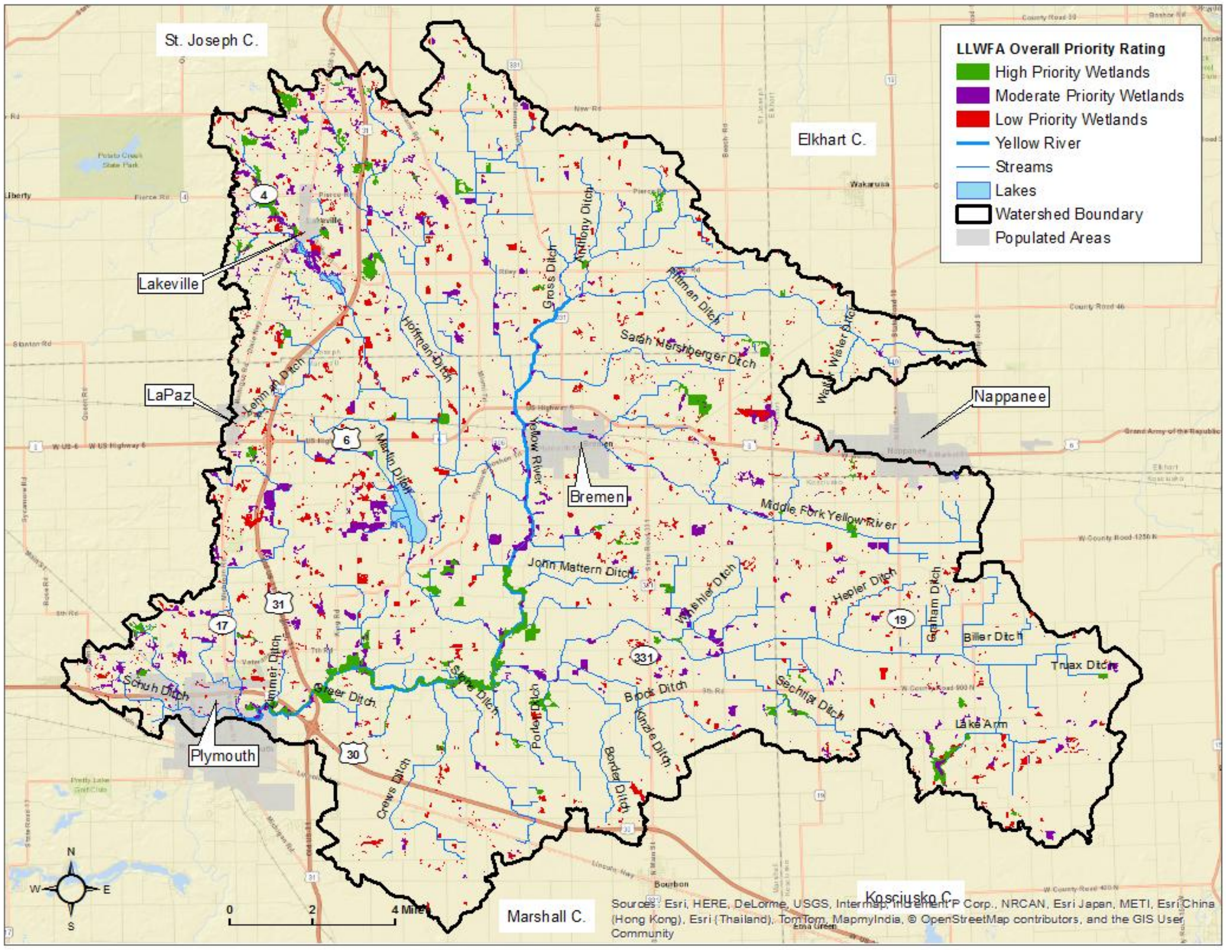

Figure 6-1. Overall LLWFA score priority rating within the Headwaters Yellow River watershed.

6.2 Specific High Priority Sites for Future Wetland Work

During the windshield survey, sites for possible wetland restorations and mitigations were identified (Appendix B). Following the completion of the survey, the identified sites were given further analysis using Google Maps Pro and Arc Maps 10.4. This was done by analyzing historical aerials and hydric soils maps. The list of sites was limited to the top 25 sites for possible wetland restoration (Appendix C). From there the list of sites was taken down to the top 10 sites ranked by how much of an impact a site would potentially improve water quality of the watershed. This was determined by considering multiple attributes for each site, along with professional experience in preforming wetland restoration and mitigation. The attributes analyzed during the ranking of potential sites were as follows: adjacency to woodland and open waterways, dominant soil types, ease of restoration, ease of site access, potential wetland to parcel size ratio, number of landowners of particles with potential wetlands, estimated restoration cost, critical areas identified in Yellow River Watershed Management Plan and any additional considerations observed (Appendix C). The preferred sites were adjacent to woodlands and especially open waterways. The majority of potential sites had some variety of muck soil type predominate. Ease of restoration and site access were assigned numbers, with lower numbers representing a better score. Potential wetland size was determined through analyzing topography and soil maps. This in turn determined which property parcels would have to be obtained for a wetland restoration to be completed. The sites that had a higher ratio of potential wetland acres to parcel acres were favored. Determining the ownership of parcels was important in ranking the top 10 wetlands. If a site had only one land owner it was considered more desirable. Sites located in critical areas identified in the Headwaters Yellow River WMP were given a higher ranking due to their potential for improving water quality in the watershed and availability for future funding sources. Estimated cost for restoration of each wetland was based solely on previous projects completed and best professional judgement. A KMZ file was created for the 25 sites listed in Appendix C and allows for the quick location of each site using Google Earth application. This KMZ file will be available from the Marshal County SWCD for future site inquiries. The latitude and longitude of each site is also available for each site in Appendix C.

6.3 Future Technical and Funding Resources

Available in Table 6-1 below is a list of potential technical and funding resources that could be utilized in future wetland work. The programs and grants listed are not the only options for the Headwaters Yellow River watershed but does include many of the common technical and funding sources used in this area.

Table 6-1. List of available technical and funding resources for wetland protection, restoration, and enhancement.

Agency	Program	Overview	Assistance
USDA	Wetland Reserve Program	A voluntary program that provides landowners with financial incentives to restore and protect wetlands in exchange for retiring marginal agricultural land.	Permanent Easement 30-year Easement Restoration Cost-Share Agreement
USDA	Conservation Reserve Program	Voluntary program that offers long-term rental payments and cost-share assistance to establish long-term, resource-conserving cover on environmentally sensitive cropland, or, in some cases, marginal pastureland.	50 percent of the cost of establishing a CRP practice
USDA	Farmable Wetlands Program	Designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow.	
USDA	Conservation Reserve Enhancement Program	The CREP is an offshoot of the CRP, targets high-priority conservation issues identified by local, state, or tribal governments or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation practices, farmers, ranchers, and agricultural land owners are paid an annual rental rate.	

USDA	Environmental Quality Incentives Program	The EQIP is a voluntary program that provides financial and technical assistance to agricultural producers to plan and implement conservation practices that improve soil, water, plant, animal, air and related natural resources on agricultural land and non-industrial private forestland.	Payments are made on completed practices or activities identified in an EQIP contract that meet NRCS standards.
USFWS	North American Wetlands Conservation Act Grants Program	Provides matching grants to carry out wetland conservation projects in the United States for the long-term protection of wetland and upland habitats which waterfowl and other migratory birds depend upon.	Project Grants - $50,000 to $1,000,000 1:1 non-federal cost - share
USFWS	Partners for Fish and Wildlife	Provides technical and financial assistance to private landowners, tribes and schools on a voluntary basis to restore, enhance and manage private land to improve fish and wildlife habitats.	
EPA	Five-Star and Urban Waters Restoration Program	Seeks to develop nationwide-community stewardship of local natural resources, preserving them for future generations and enhancing habitat for local wildlife. Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development.	Grants - $20,000 to $50,000 1:1 non-federal cost - share
IDEM	Nonpoint Source Implementation Grants (319 Program)	Nonpoint source pollution reduction project can be used to protect water resource areas and the general water resources in a watershed by implementing BMP's	Organizations are usually required to provide 40% of the total project cost.
IDNR	Lake and River Enhancement (LARE) Grants	Engineering Design/Build Projects Engineering Feasibility Studies	LARE will provide funds for 80% of the total project cost.

7 Summary

The Marshall County SWCD received an EPA Region 5 Wetland Program Development Grant in September of 2015 to complete a Landscape–Level Wetland Functional Assessment for the Headwaters Yellow River watershed. The goal of the LLWFA assessment was to work in conjunction with the development of the Headwaters Yellow River Watershed Management Plan (WMP) to identify wetlands within the watershed of greatest value for future protection, restoration and enhancement. A better understanding of the functional value of each wetland in the Headwaters Yellow River watershed will provide valuable information to local, regional, and state agencies regarding the prioritization of restoration and conservation efforts.

The landscape-scale changes that have taken place in the Headwaters Yellow River watershed since European settlement have greatly impacted the wetlands of the watershed. At least 1,887 wetlands totaling 1,353.4 acres have been lost to land-use changes. However, there are 3,182 remaining wetlands totaling 10,847 acres, which have been mapped as part of the NWI. Forested wetlands account for the majority of the wetlands in the watershed (66 percent) followed by emergent wetlands (28 percent), and ponds (6 percent). Of the 3,182 wetlands covering 10,847 acres in the watershed, approximately 764 wetlands (24 percent) accounting for 2,124 acres (19.5 percent) are listed as being partially drained/ditched or modified by human disturbance by excavation. Additionally, 348 wetlands (11 percent) in the watershed are listed as “farmed” wetlands. Farmed wetlands cover 1,523 acres or 14 percent of the overall watershed NWI dataset.

The LLWFA utilized geospatial data in ArcGIS 10.4 to perform complex analyses of existing databases to determine the functional significance of the wetlands in the Headwaters Yellow River watershed. There were a total of 184 high priority wetlands totaling 2,690 acres identified throughout the Headwaters Yellow River watershed. A total of 1,087 wetlands were identified as moderate priority and totaled 3,993 acres. A total of 1,911 wetlands were identified as low priority wetlands and totaled 4,163 acres. High priority wetlands had the greatest average size at 14.6 acres, followed by moderate (3.7 acres) and low (2.2 acres). Critical areas as identified in the Headwaters Yellow River WMP, contain a significant percentage of high and moderate priority wetlands identified in the LLWFA analysis. Critical areas contain 83% of the high priority wetlands, totaling 2,319 acres and 76% of the moderate priority wetlands, totaling 3,004 acres.

The windshield survey included the investigation/designation of a total of 282 sites across the watershed and was used to help identify specific sites within the Headwaters Yellow River watershed where wetland priority management activities could take place in the future. During the windshield survey sites for possible wetland restorations and mitigations were identified and a list of a top 25 sites was developed. The attributes analyzed during the ranking of potential sites included adjacency to woodland and open waterways, dominant soil types, ease or restoration, ease of site access, potential wetland to parcel size ratio, number of landowners of particles with potential wetlands, estimated restoration cost, critical areas identified in Yellow River Watershed Management Plan and any additional considerations observed.

It is important to note that a significant amount of data has been generated as a result of the various analysis completed including the development of the NWI+ database, landscape functional assessment of wetland attributes, windshield survey, and development of specific wetland restoration sites. Landowner discussions/permissions were not included in this study and therefore will be a significant driver for future wetland work in the Headwaters Yellow River watershed. The various analysis completed have created a better understanding of the functional connections/differences between existing wetlands and provides specific starting locations for future wetland work.

8 Literature Cited

Chase, V., Deming, L., Latawiec, F.. *Buffers for Wetlands and Surface Waters: a Guidebook for New Hampshire Municipalities*. N.H. Office of State Planning, 1995.

Dugger, K.M., and L.H. Fredrickson. 13.1.6. Life History and Habitat Needs of the Wood Duck. *Waterfowl Management Handbook*, Jan. 1992, pp. 1–8.

“Glossary of Hydrologic Terms.” *NOAA*, National Oceanic and Atmospheric Administration, www.nws.noaa.gov/om/hod/SHManual/SHMan014_glossary.htm.

Golet, F.C. 1972, Classification and Evaluation of Freshwater Wetlands as Wildlife Habitat in the Glaciated Northeast. University of Massachusetts, Amherst, MA. Ph. D. dissertation.

Ivens BJL, Bhowmik NG, Brigham AR, Gross DL. 1981. The Kankakee River Yesterday and Today. Champaign.

Lu SY, Wu FC, Lu YF, Xiang CS, Zhang PY, Jin CX. 2009. Phosphorus removal from agricultural runoff by constructed wetland. Ecol. Eng. 35:402–409.

Kahn, S., I. Shmad, M.T. Shah, S. Rehman, and A. Khaliq. 2009. Use of constructed wetland for the removal of heavy metals from industrial wastewater. Journal of Environmental Management 90:3451–3457.

Karns, D.R., D.G. Ruch, B. Simpson, B. Feaster, L. Sterrenburg, A. Bellian, B.E. Fisher, D. Gorney, J.D. Holland, R.P. Jean, W.W. Jones, M. McCarty, W.N. McKnight, W.J. Murphy, S. Namestnik, L.P. Tedesco, and J.O. Whitaker, Jr. 2012. Results of a biodiversity survey at Goose Pond Fish and Wildlife Area, Greene County, Indiana. Proceedings of the Indiana Academy of Science 121:45–53.

Lannoo, M.J. 1998. Amphibian conservation and wetland management in the upper Midewest: a catch-22 for the Cricket Frog? Pages 330–339 *in* M.J. Lannoo, editor. Status and Conservation of Midwest Amphibians. University of Iowa Press, Iowa City, Iowa.

Novitzki, R.P. 1979. The hydrologic characteristics of Wisconsin wetlands and their influence on floods, streamflow, and sediment. In: P.E. Greeson et al. (editors). Wetland Functions and Values: The State of Our Understanding. Amer. Water Resources Assoc., Minneapolis, MN. pp. 377-388.

Potter, B.A., R.J. Gates, G.J. Soulliere, R.P. Russel, D.A. Granfors, and D.N. Ewert. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Shorebird Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, MN. 101 pp.

Ruch, D.G., J. Nelsen, R. Carlson, B. Fisher, A.H. Fleming, D. Gorney, J.D. Holland, M. Jordan, B. Kingsbury, B. Murphy, P. McMurray, K. Roth, P. Rothrock, S. Russel, C. Strang, J. Whitaker Jr., B. Yankowiak. 2016. Results of the 2014 Eagle Marsh Biodiveristy Survey, Allen County, Indiana. Proceedings of the Indiana Academy of Science 125:40-49.

Tiner RW. 2003. Correlating Enhanced National Wetlands Inventory Data with Wetland Functions for Watershed Assessments : A Rationale for Northeastern U. S. Wetlands.

Tiner, R.W. 2011. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors: Version 2.0. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. 51 pp.

Tiner RW, McGuckin K, Herman J. 2015. Wetland Characterization and Landscape-level Functional Assessment for Long Island, New York.

Webb, Elisabeth B., et al. “Effects of Local and Landscape Variables on Wetland Bird Habitat Use During Migration Through the Rainwater Basin.” *Journal of Wildlife Management*, vol. 74, no. 1, Jan. 2010, pp. 109–119., DOI:10.2193/2008-577.

Whiting, P.J. 1998. Bank storage and its influence on streamflow. Stream Notes July 1998. Stream Systems Technology Center, Rocky Mountain Research Station, Fort Collins, CO.

APPENDIX

A

NWI+ DATABASE AND WETLAND FUNCTIONAL CORRELATIONS

APPENDIX

B

WINDSHIELD SURVEY DATASET

APPENDIX

C

PRIORITY WETLAND RESTORATION SITES