Watershed

July 2021

Marsh River Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique waterbody identifier for each river reach comprised of the U.S. Geological Survey (USGS) eight-digit HUC plus a three-character code unique within each HUC.

Aquatic life use impairment: The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation use impairment: Streams are considered impaired for impacts to aquatic recreation if fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus and either chlorophyll-a or Secchi disc depth standards are not met.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Red River Basin is assigned a 4-digit HUC (4-HUC) of 0902 and the Marsh River Watershed is assigned an 8-HUC of 09020107.

Impairment: Waterbodies are listed as impaired if water quality standards are not met for designated uses including aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic Integrity (IBI): A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or pollutant source): This term is distinguished from 'stressor' to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stressor (or biological stressor): This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Executive summary

The Marsh River Watershed (MRW) is identified by an 8-digit hydrologic unit code (8-HUC), 09020107. It encompasses approximately 362 square miles in northwest Minnesota along the Minnesota/North Dakota boarder. The watershed extends across portions of Norman (91% of the watershed), Clay (8%), and Polk (1%) Counties and contains the cities of Ada, Halstad, Hendrum (partially), Perley, and Shelly.

The area that is now the MRW was once covered with glaciers that formed glacial Lake Agassiz as they retreated and melted. The glaciers and subsequent lake left behind flat terrain and rich soils that characterize much of the larger Red River of the North (Red River) Basin. Early settlers to the area took advantage of the rich soils to grow crops. Beginning before the turn of the 20th century, widespread flood management in the form of drainage projects were undertaken to remove surface water and excess soil moisture to promote crop growth. These projects modified many natural stream channels and altered the hydrology of the landscape, draining approximately 95% of the wetland area that gave the Marsh River and associated watershed its name. Currently, approximately 88% of the land area in the watershed is devoted to crops. Major crops include (in descending order of cultivated land area) soybeans, small grains, corn, and sugar beets.

In 2014, the Minnesota Pollution Control Agency (MPCA) began its intensive watershed monitoring (IWM) within the MRW, completing it at the end of the field season in 2015 (MPCA, 2017). Data were collected from six of the uniquely identified stream reaches in the watershed (not including reaches of the Red River, which are being addressed with a separate project) during the two field seasons of sampling (2014-2015). Those six stream reaches, which include the Marsh River (assessment unit identifier [AUID] 09020107-503, hereafter identified by the unique 3 digit suffix), Judicial Ditch 51 (-518), County Ditch (CD) 11 (-517), CD 45 (-521), Spring Creek (-508), and CD 66 (-516), are located in two of the five 12-HUC subwatersheds in the MRW. The remaining three 12-HUC subwatersheds had no monitored streams, because they contain highly channelized, largely ephemeral streams, which prevented the collection of assessable data.

Data collected in 2006 through 2015 (including IWM data) were assessed in 2016 to determine whether streams were supportive of the beneficial uses of aquatic life use and aquatic recreation use. To determine whether a stream can support aquatic life, data on parameters such as biological life (fish and aquatic macroinvertebrates), dissolved oxygen (DO), and pollutants such as total suspended solids (TSS), chloride, total phosphorus (TP) (as it relates to eutrophication), and unionized ammonia are compared against state standards (i.e., acceptable limits) for that parameter/pollutant. To determine whether a stream can support aquatic recreation (i.e., direct contact of humans with the water), *Escherichia coli* (*E. coli*) data are compared against state standards (elevated *E. coli* is an indication that human health may be at risk from pathogens associated with fecal contamination in the water). If any parameter/pollutant does not meet state standards, it identifies/causes an impairment of the waterbody's beneficial use and is listed on Minnesota's impaired waters list (MPCA, 2019). Of the six AUIDs with sufficient aquatic life use data, four fully supported the beneficial use. The two streams that did not support aquatic life (Marsh River [-503] and CD 11 [-517]) were both listed as impaired for aquatic life use, as indicated by poor fish communities; additionally, the Marsh River is listed as impaired for aquatic life use because aquatic macroinvertebrate communities were poor, turbidity/TSS were high, and DO was low. Only one of the six sampled streams, the Marsh River (-503), had enough *E. coli* data to assess aquatic recreation use, and it was found to be impaired for aquatic recreation use as *E. coli* concentrations are chronically (and sometimes severely) elevated. Occasional periods of little-to-no flow prevented some water quality samples from being collected in the assessed streams. This resulted in many assessment decisions having insufficient information to confidently determine use status for aquatic life or aquatic recreation use.

While aquatic consumption use is not a focus in this report, there is an existing aquatic consumption use impairment in the Marsh River (-503), as indicated by high levels of mercury in fish tissue. This impairment is addressed by the Minnesota statewide mercury TMDL.

The stressors that contribute to poor fish and aquatic macroinvertebrate populations within the MRW include flow regime instability, loss of longitudinal connectivity (i.e., blocked fish passage), high suspended sediment, insufficient physical habitat, and low DO. Flow regime instability was identified as the most impactful stressor to fish and macroinvertebrate communities in the Marsh River (-503), while loss of longitudinal connectivity and insufficient physical habitat were identified as the stressors causing the most harm to fish communities in CD 11 (-517). A notable connectivity issue for fish passage in CD 11 is a high gradient culvert. Upstream habitat for fish species are completely inaccessible due to the culvert.

Some of the primary conditions leading to poor water quality and stressors in the MRW are the widespread drainage networks, shortage of long-term water storage, and lack of vegetative cover on cropland. All three of these conditions cause water to move through the watershed quickly, leading to higher and quicker peak flows in streams during wet times of the year followed by lower or no flow in streams for extended periods of time during dry times of the year (particularly true for tributaries of the Marsh River, as many of them dry up entirely in late summer). Rain and snowmelt flowing over land with little to no vegetation, such as cropland, moves very quickly and also causes sediment and particles, including applied manure which may have high levels of *E. coli*, to be exposed and dislodged. Nutrients such as nitrogen (N) and phosphorus (P) that have been applied to cropland and from manure can also get carried with overland flow of water. The water and pollutants flow quickly to drainage networks and streams where the high volume of water continues to move quickly due to straight channels and lack of water storage areas. These higher and quicker peak flows further exacerbate elevated sediment loads in streams due to increased bank erosion. During extended periods of lower flow, several adverse conditions exist, including decreased DO, increased temperature, disconnected streams, and loss of physical habitat from sediment settling and embedding objects that would otherwise be suitable for use by aquatic life.

The reduction of pollutants, non-pollutants, and stressors to improve conditions for aquatic life and the reduction of *E. coli* to improve conditions for aquatic recreation will require a long-term, coordinated effort to restore the impaired waters. Great care will also be needed to protect currently non-impaired waterways from becoming degraded to an impaired condition.

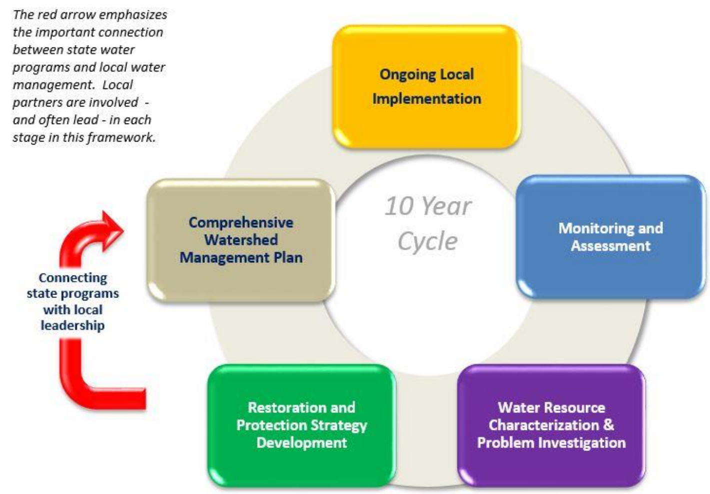
To mitigate and correct impairments and prevent further degradation of the streams within the MRW, an increase in the implementation of best management practices (BMPs) or engineered Conservation Practices (CPs) will be required on the landscape and along the waterways. Landscape-focused BMPs and CPs may include, but are not limited to, nutrient management, cover crops and perennial vegetation, residue management, or creating/strengthening buffers along the riparian zone of streams and ditches using native perennial vegetation and trees. Examples of BMPs or CPs specifically designed for managing the water include stream channel restoration, regional water retention such as multi-purpose flood control structures, engineered hydrologic controls, and restoration of unconnected streams. Many engineered CPs and BMPs are already in use within the watershed; however, more widespread implementation will be necessary to reach water quality goals.

Although multiple impairments have been identified throughout the watershed and water quality is generally considered poor, the data does suggest that the potential for higher quality fish and macroinvertebrate habitat within the MRW exists if continuous flow can be restored. The Marsh River and its tributaries support extensive fish and macroinvertebrate populations. Thirty-six unique fish species and over 119 unique macroinvertebrate taxa were sampled during the 2014-2015 survey.

This WRAPS report summarizes past surface water monitoring, water quality assessments, and other water quality studies, such as TMDL studies, that have been conducted in the MRW. A TSS and an *E. coli* TMDL study were developed for the Marsh River (AUID -503) and compiled into the *Marsh River Watershed TMDL Report* (MPCA, 2020). The TMDL calculations show that required reductions of TSS within the Marsh River range from 0% at lower flows, to a 50% reduction during the highest flows. Required reductions for *E. coli* in the Marsh River (AUID -503) range from 0% to 21%, depending on stream flow conditions. In addition, this WRAPS report outlines strategies for local groups to use in local water planning to prioritize projects that can be implemented in the watershed to improve water quality.

What is the WRAPS Report?

Minnesota has adopted a watershed approach to address the state's 80 major watersheds. The Minnesota watershed approach incorporates **water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results** into a cycle that addresses both restoration and protection.



As part of the watershed approach, the MPCA developed a process to identify and address threats to water quality in each of these major watersheds. This process is called Watershed Restoration and Protection Strategy (WRAPS) development. The WRAPS reports have two parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.

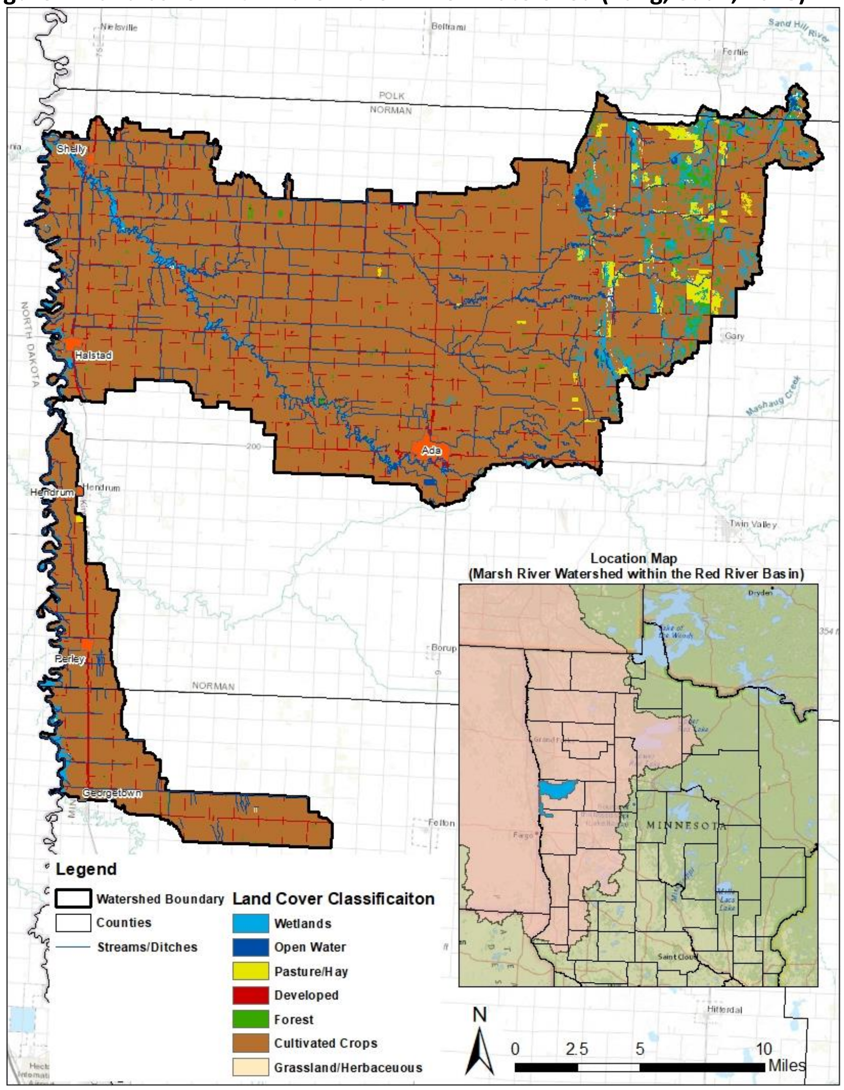
Waters not meeting state standards are listed as impaired, and total maximum daily load (TMDL) studies are developed for them. The TMDLs are incorporated into the WRAPS reports. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and use watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, the WRAPS report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. The WRAPS report also serves as a building block for addressing the U.S. Environmental Protection Agency's (EPA) Nine Minimum Elements of watershed plans, to help qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

Purpose	•Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning •Summarize watershed approach work done to date including the following reports: •*Marsh River Watershed Monitoring and Assessment Report* •*Marsh River Watershed Stressor Identification Report*
Scope	•Impacts to aquatic recreation and aquatic life in streams
Audience	•Local working groups (SWCDs, watershed districts, watershed groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed background and description

The MRW is identified by the 8 digit HUC 09020107 and occupies 361.7 square miles in northwest Minnesota, extending across portions of Norman (91% of the watershed), Clay (8%), and Polk (1%) Counties. This area of Minnesota was once covered with continental glaciers that, as they retreated and melted, formed glacial Lake Agassiz. The glaciers and subsequent lake left behind flat terrain and rich soils that characterize the Lake Agassiz Plains Ecoregion (Level III) and much of the Red River of the North (Red River) Basin. Early settlers to the area took advantage of the rich soils to grow crops. Beginning before the turn of the 20th century, widespread drainage projects were undertaken to promote crop growth and flood management by removing excess soil moisture. These projects modified many natural stream channels and altered the hydrology of the landscape, draining the wetlands that gave the river its name.

Figure 1: Land cover within the Marsh River Watershed (Yang, et al., 2018).



As a result of the fertile soils, a majority of the land cover in the MRW (88%) is cultivated crops (**Figure 1**). Crop data from 2015 (USDA-NASS, 2015) shows that the agricultural acreage in the watershed is dominated by soybeans (34.5%), small grains (24.3%), corn (12.1%), and sugar beets (8.2%). Approximately 3.8% of the land area in the watershed is developed and holds over half of the reported watershed population of 3,735 (U.S. Department of Commerce, 2010). Ada and Halstad are the only cities with populations greater than 500. The remaining land area within the watershed is split between (in descending order of area) wetlands, forest, rangeland, open water, and barren land. There are no lakes of notable size within the watershed, and the few small lakes that are present are all located in the northeast corner. The largest of these is Raff Lake, covering 95 acres. Other features within the watershed include Prairie Smoke Dunes Scientific and Natural Area, Agassiz-Olson Wildlife Management Area, and the Agassiz ATV trail.

The Marsh River originates approximately 2 miles southeast of Ada at the connection with the Wild Rice River. From there it flows northwest for 51.4 miles until it reaches the Red River. During the era of productive logging in the area, the headwaters of the Marsh River were channelized to connect the Marsh River to the nearby Wild Rice River so that logs could be floated from the Wild Rice River to a sawmill near the town of Ada along the Marsh River. There is currently a dike that separates the two rivers, but when the Wild Rice River reaches 95% of maximum flow, water will overflow the dike and send excess water from the Wild Rice River into the Marsh River. With the exception of the headwaters of the Marsh River, much of the Marsh River has not been channelized or greatly altered.

There is also an area of approximately 76 square miles (37 square miles in the city of Halstad – Red River 12-HUC and 39 square miles in the city of Perley – Red River 12-HUC [**Figure 2**]) within the MRW that consists of direct drainage into the Red River. All of the tributary streams in this area have been channelized and tend to be ephemeral.

Additional Marsh River Watershed resources

Minnesota Department of Natural Resources (DNR) Context Report:
http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_59.pdf

Minnesota Department of Natural Resources (DNR) Report Card:
http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_59.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework map:
http://arcgis.dnr.state.mn.us/ewr/whaf/Explore/

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Elm-Marsh Watershed:
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_021582.pdf

Minnesota Pollution Control Agency (MPCA) Red River of the North – Marsh River:
https://www.pca.state.mn.us/water/watersheds/red-river-north-marsh-river

Minnesota Pollution Control Agency (MPCA) Minnesota Nutrient Reduction Strategy:
https://www.pca.state.mn.us/water/nutrient-reduction-strategy

Minnesota Nutrient Planning Portal – Marsh River Watershed:
https://mrbdc.mnsu.edu/mnnutrients/watersheds/red-river-north-marsh-river

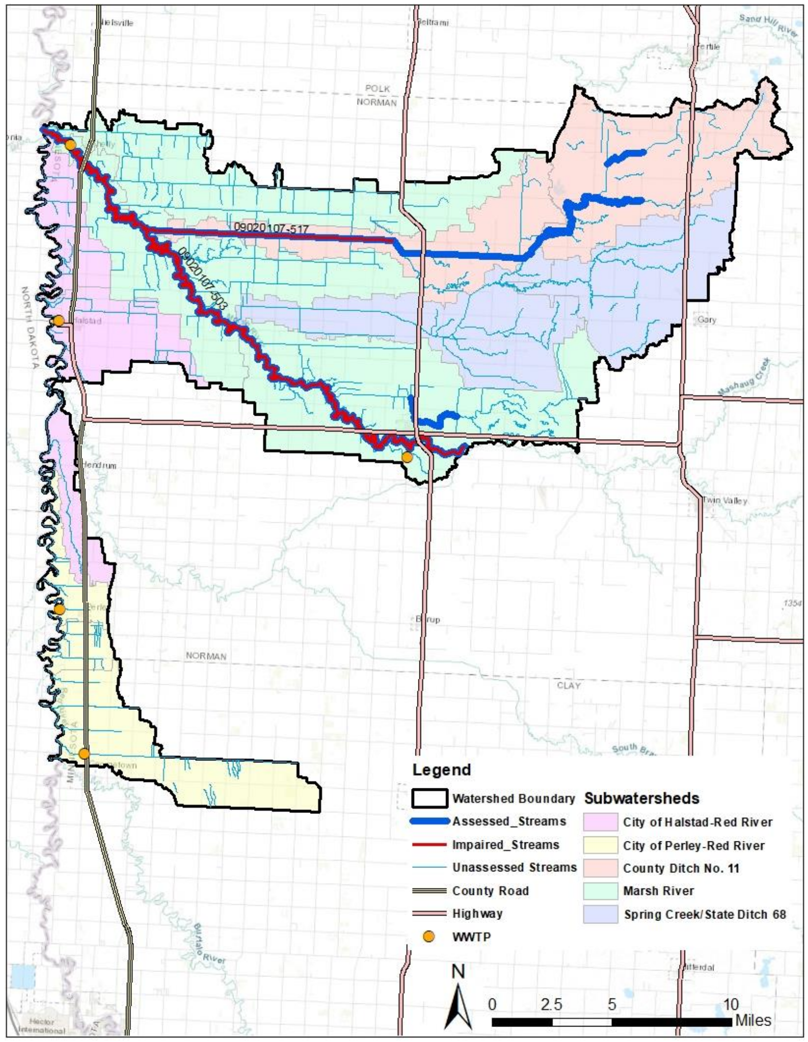
Wild Rice Watershed District:
http://www.wildricewatershed.org/

Soil and water conservation districts:
Norman County - http://www.normancountyswcd.org/index.html
Clay County - https://claycountymn.gov/272/Soil-Water-Conservation-District
East Polk County - http://eastpolkswcd.org

2. Watershed conditions

The MRW includes a portion of the Red River, many tributaries to the Red River, and an extensive network of drainage channels. Excluding the mainstem of the Red River, there are approximately 570 miles of stream and drainage channel within the MRW (MPCA, 2013). Eighteen stream reaches in the MRW are currently defined by the State of Minnesota (i.e., have an AUID), totaling 198.55 miles of combined stream length within the watershed; 2 of the 18 stream reaches are the Red River, which total 60.07 miles. Although the MRW does include a portion of the mainstem of the Red River, any impairments related directly to the Red River will be addressed at a later date in a different report.

Figure 2: Marsh River Watershed streams, ditches, and 12-HUC subwatersheds.



In 2014, the MPCA began its IWM within the MRW, completing it at the end of the field season in 2015 (MPCA, 2017). The vast majority of the streams and channels in the watershed tend to be ephemeral. This prevented the collection of data within most of the streams in the watershed. The data that were collected in 2006 through 2015 (including IWM data) were assessed in early 2016 to determine whether streams were supportive of their beneficial uses. Waterbodies that are determined to not support a beneficial use are listed as impaired on Minnesota's impaired waters list which is updated every other year.

Of the 16 individual identified stream reaches (i.e., AUIDs) in the MRW that are not portions of the Red River mainstem, six were assessed (Marsh River, AUID 09020107-503; Spring Creek, -508; County Ditch [CD] 66, -516; CD 11, -517; Judicial Ditch [JD] 51, -518; and CD 45, -521) for aquatic life use and only one (Marsh River, -503) had enough data for assessment of aquatic recreation use. The six stream reaches constitute 82.3 miles of combined stream length. Two of the six stream reaches assessed for aquatic life do not support the beneficial use and -503 did not support aquatic recreation use. Impairments seen within the stream reaches are common to highly modified landscapes and are identified/caused by poor fish and aquatic macroinvertebrate communities, high suspended sediment in the water column, and high concentrations of *E. coli*. There are no lakes of notable size within the MRW, so no lakes were monitored or assessed.

There are five wastewater treatment facilities within the MRW, located in the towns of Ada, Georgetown, Halstad, Perley, and Shelly (MPCA, 2019). None of the communities within the watershed are large enough to be subject to Municipal Separate Storm Sewer System (MS4) permitting. The annual average area under construction in Norman County (which encompasses 91% of the MRW) is 0.014% based on construction activity covered under the Construction Stormwater General Permit (MNR100001) from 2015 through 2019 (MPCA, 2020). The annual average area under industrial activities in Norman County from 2015 through 2019 is assumed to be the same as what has undergone construction activities (0.014%). The MPCA lists 96 currently active environmental permitted locations or contaminated sites within the MRW. Active sites identified include: 31 tanks and leaks, 23 hazardous waste sites, 19 animal feedlots sites (that are active, registered, and have more than 0 animal units), 17 water quality sites, 2 air quality sites, 1 investigation and cleanup site, and 1 solid waste site (MPCA, 2019).

Nonpoint sources and stressors in the watershed are typical of the agricultural setting of the Red River Basin.

A more detailed analysis of the quality of the waters within the MRW can be found in the *Marsh River Watershed Monitoring and Assessment Report* (MPCA, 2017) and the *Marsh River Stressor Identification Report* (MPCA, 2018). The conditions and associated pollutant sources of these individual streams are summarized in the following sections.

2.1 Condition status

This section describes the streams within the MRW that are impaired and in need of restoration, or not impaired and in need of protection. Impairment classification is based on determining if a waterbody can meet aquatic life use and/or aquatic recreation use standards. To determine whether a stream can support aquatic life, data on parameters such as biological life (fish and aquatic macroinvertebrate indices of biological integrity [F-IBI and M-IBI]) and DO and pollutants such as TSS, chloride, and TP (as it relates to eutrophication) are compared against state standards (i.e., acceptable limits) for that parameter/pollutant. To determine whether a stream can support aquatic recreation (i.e., direct contact of humans with the water), *E. coli* data are compared against state standards (elevated *E. coli* is an indication that human health may be at risk from pathogens associated with fecal contamination in the water. Streams considered impaired for either aquatic life use or aquatic recreation use will be targeted with restoration practices, while the waterbodies that currently meet aquatic life use and aquatic recreation use criteria will be the focus of protection efforts.

Water quality conditions in the MRW are generally poor and reflect the highly altered landscape. Much of the land in the watershed has been converted to agricultural use. Most of the waterways have been channelized, and as a result the hydrology of the watershed has been modified. Excess *E. coli*, elevated TSS concentrations, and reduced biological assemblages are problems in the assessed waterways.

One of the waterbodies in the MRW (not including the Red River) is impaired for aquatic consumption use, caused by high mercury levels. For the most part, mercury concentrations in fish tissue were relatively low in samples from 2014, except for in the tissues of sampled Northern Pike (MPCA, 2017).

The Marsh River (-503) was listed in 2016 as impaired for aquatic consumption use due to the high levels of mercury in fish tissue (MPCA, 2019), but this impairment is addressed by the statewide mercury TMDL. Aquatic consumption use impairments and toxic pollutants are not discussed further as they are not covered in this report. For more information on mercury impairments, see the statewide mercury TMDL documents on MPCA's statewide mercury reduction plan website (MPCA, 2020).

Streams

A wide range of parameters were used in an effort to determine if streams within the MRW support aquatic life use and aquatic recreation use, including, but not limited to, F-IBI and M-IBI, DO concentration, TSS, and *E. coli* measurements. Water quality measures were compared to the state standards that are applicable to where the watershed is located.

Excluding the mainstem of the Red River, the MRW contains 16 stream reaches with unique AUIDs, 6 of which have been assessed for aquatic life use and 1 for aquatic recreation use (**Table 1** and **Figure 2**). Information used to create **Table 1** was summarized using the MPCA's *Marsh River Watershed Monitoring and Assessment Report* (MPCA, 2017), as well as the MPCA's *Marsh River Watershed Stressor Identification Report* (MPCA, 2018).

Of the streams with sufficient data, the Marsh River and CD 11 (AUID -503 and -517, respectively) do not support aquatic life use, and the Marsh River (-503) also does not support aquatic recreation use (**Table 1** and **Table 2**). During previous assessments within the MRW (prior to the one in early 2016 as part of the WRAPS project), the Marsh River was listed as impaired for aquatic life use due to high turbidity (2008) and low DO (2010). Neither impairment classification was changed as a results of assessments in 2016.

Table 1: Status of stream reaches in the Marsh River Watershed based on assessments of 10 years of data (2006-2015) (MPCA, 2017).

				Aquatic life use					Aquatic rec. use
12-HUC subwatershed	AUID (Last 3 digits)	Stream name	Reach description	Fish Index of biotic integrity (FIBI)	Macroinvertebrate Index of biotic integrity (MIBI)	Dissolved oxygen (DO)	Turbidity/TSS	Un-ionized ammonia [a]	*E. coli*
City of Perley-Red River (090201070101)	507	County Ditch 6	Headwaters to Red R	NA	NA	NA	NA	NA	NA
Marsh River (090201070501)	503	Marsh River	Headwaters to Red River	Imp	Imp	IF	Imp	Sup	Imp
	506	Unnamed Ditch	Headwaters to Marsh R	NA	NA	NA	NA	NA	NA
	518	Judicial Ditch 51	County Ditch 26 to Unnamed Ditch	Sup	NA	IF	IF	IF	IF

12-HUC subwatershed	AUID (Last 3 digits)	Stream name	Reach description	Aquatic life use					Aquatic rec. use
				Fish Index of biotic integrity (FIBI)	Macroinvertebrate Index of biotic integrity (MIBI)	Dissolved oxygen (DO)	Turbidity/TSS	Un-ionized ammonia [a]	*E. coli*
	519	Judicial Ditch 51	Unnamed ditch to Marsh R	NA	NA	NA	NA	NA	NA
County Ditch 11 (090201070502)	508	Spring Creek	T146 R45W S24 east line to County Ditch 38	Sup	Sup	IF	IF	IF	NA
	511	County Ditch 5	CD 45 to Spring Cr	NA	NA	NA	NA	NA	NA
	516	County Ditch 66	County Ditch 38 to County Ditch 11	Sup	Sup	IF	IF	IF	NA
	517	County Ditch 11	County Ditch 66 to Marsh River	Imp	Sup	IF	Sup	Sup	IF
	520	County Ditch 45	Headwaters to -96.3235 47.4726	NA	NA	NA	NA	NA	NA
	521	County Ditch 45	-96.3235 47.4726 to County Ditch 5	Sup	Sup	IF	IF	IF	NA
Spring Creek/State Ditch 68 (090201070503)	509	Spring Creek/State Ditch 68	Unnamed cr to Marsh R	NA	NA	NA	NA	NA	NA
	512	Unnamed creek	Headwaters to Unnamed cr	NA	NA	NA	NA	NA	NA
	513	Unnamed creek	Headwaters to Unnamed cr	NA	NA	NA	NA	NA	NA
	514	Unnamed creek	Unnamed cr to Unnamed cr	NA	NA	NA	NA	NA	NA
	515	Unnamed creek	Unnamed cr to Spring Cr	NA	NA	NA	NA	NA	NA

Sup = found to meet the water quality standard (supporting); Imp = does not meet the water quality standard and therefore, is impaired; IF = the data collected was insufficient to make a finding; NA = not assessed.

Existing impairment prior to assessments in 2016, new impairment as of 2016, meets water quality standard(s), insufficient information.

Note: The table does not include the two identified stream reaches that are mainstem sections of the Red River of the North.

[a] This is the form of nitrogen that is harmful to aquatic life and for which there are state standards for class 2 waters.

Table 2: Impaired stream reaches in the Marsh River Watershed on the draft 2020 impaired waters list (MPCA, 2019), specifically the 305(b) list.

AUID (last 3 digits)	Waterbody [a]	Impairment cause	Designated Class	Impaired beneficial use [b]	Listing Year	Target Completion
-503	Marsh River, Headwaters to Red River	Fish bioassessments	2B, 3C	AQL	2018	2028
		Benthic macroinvertebrates bioassessments	2B, 3C	AQL	2018	2028
		Turbidity [c]	2B, 3C	AQL	2008	2028
		Dissolved oxygen	2B, 3C	AQL	2010	2028
		E. coli	2B, 3C	AQR	2018	2028
		Mercury in fish tissue	2B, 3C	AQC	2016	N/A category 4A
-517	County Ditch 11, County Ditch 66 to Marsh River	Fish bioassessments	2B, 3C	AQL	2018	2028

[a] Excludes the Red River of the North main stem.

[b] AQL = aquatic life, AQR = aquatic recreation, AQC = aquatic consumption.

[c] As of 2015, Total suspended solids standards have replaced turbidity standards.

Lakes

There are no lakes of notable size within the MRW. As a result, no water quality samples were collected and no assessments were completed on lakes.

2.2 Water quality trends

Streamflow measurements taken for the Marsh River between 1995 and 2014 show no statistically significant trend in streamflow during the recent decades. Water quality data within the MRW are insufficient to perform trend analysis. Although there are monitoring locations along the Red River that lie within the MRW that have long-term data records (some dating back to 1962), the Red River is not being considered in this report. The mainstem portion of the Red River is part of a separate project.

2.3 Stressors and sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the biological stressors and/or sources of contaminants or stressors impacting or threatening those waterbodies must be identified and evaluated. Biological stressor identification (SID) was conducted for streams with impairments caused by poor assemblages of fish and/or macroinvertebrate biota and encompassed the evaluation of both pollutant (e.g., TSS) and non-pollutant (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. Pollutant source assessments were conducted where a biological SID process identified a pollutant as a stressor, as well as for the typical pollutant impairment listings. **Section 3** provides further detail on stressors and pollutant sources.

Due to the absence of specific pollutant sources and/or biological stressors within the watershed, not all candidate causes were evaluated as stressors for the assessed streams. The small proportion of urbanized land and minimal industrial or mining activity minimizes the potential for related biological stressors. Candidate causes such as impervious land area were minimal, and sources of certain types of pollutants that are specific to urban, industrial, or mining were negligible, such as salt and effluent from roads. Data collected over an extended period of time for nitrate-nitrite, temperature, and pH show no evidence of the potential of those pollutants to cause stress to the biological community.

As a result of this preliminary analysis, the number of candidate causes examined was limited to the five more likely causes of stress to the aquatic biological community, and they are listed below.

Stressors of biologically impaired stream reaches

The candidate causes analyzed as potential stressors to fish and aquatic macroinvertebrates within the assessed stream reaches in the MRW include loss of longitudinal connectivity, flow regime instability, insufficient physical habitat, high suspended sediment, and low DO. (**Table 3**). All five were determined to be stressors to some degree. Flow regime instability was identified as the most impactful stressor to fish and macroinvertebrate communities in the Marsh River (-503), while loss of longitudinal connectivity and insufficient physical habitat were identified as the stressors causing the most harm to fish communities in CD 11 (-517). A notable connectivity issue for fish passage in CD 11 is a high gradient culvert. Upstream habitat for fish species is completely inaccessible due to the culvert.

Table 3: Primary stressors to aquatic life in biologically impaired reaches in the Marsh River Watershed (MPCA, 2018).

12-HUC subwatershed	AUID (Last 3 digits)	Stream	Reach description	Biological impairment	Primary stressor: Loss of longitudinal connectivity	Primary stressor: Flow regime instability	Primary stressor: Insufficient physical habitat	Primary stressor: High suspended sediment	Primary stressor: Low dissolved oxygen
Marsh River	503	Marsh River	Headwaters to Red River	Fish	0	+++	+	++	0
				Macroinvertebrates	NE	+++	++	++	+
County Ditch 11	517	County Ditch 11	County Ditch 66 to Marsh River	Fish	+++	++	+++	++	++

+++ the available evidence convincingly supports the case for the candidate cause as a stressor, ++ the available evidence strongly supports the case for the candidate cause as a stressor, **+** the available evidence somewhat supports the case for the candidate cause as a stressor, 0 neither supports nor weakens the case for the candidate cause as a stressor, and NE no evidence is available.

Pollutant sources

Pollutant sources vary by subwatershed and ecoregion depending on National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permitted discharges, upstream loading conditions, and nonpoint sources within the watershed. Point and nonpoint sources of pollutants are identified in **Table 4** and **Table 5**, respectively, which are summarized from the MPCA's SID Report (MPCA, 2018) and the MRW TMDL Report (MPCA, 2020).

The vast majority of poor water quality and stressors discussed in **Section 2** are the result of nonpoint sources in **Table 5** and related conditions such as widespread drainage networks, shortage of long-term water storage, and lack of vegetative cover. All three of these conditions cause water to move through the watershed quickly, leading to higher and quicker peak flows in streams during wet times of the year, followed by lower or no flow in streams for extended periods of time during dry times of the year (particularly true for tributaries of the Marsh River, as many of them dry up entirely in late summer). Rain and snowmelt flowing over land with little to no vegetation (particularly cropland) moves very quickly and also causes sediment and particles, including manure which may have high levels of *E. coli*, to be exposed and dislodged. Nutrients such as TN and TP that have been applied to cropland and from manure can also get carried with overland flow of water. The water and pollutants flow quickly to drainage networks and streams where the high volume of water continues to move quickly due to straight channels and lack of water storage areas. These higher and quicker peak flows further exacerbate elevated sediment loads in streams through increased bank erosion. During extended periods of lower flow, adverse conditions include decreased DO, increased temperature, disconnected streams, and loss of physical habitat caused by sediment settling and embedding objects that would otherwise be suitable for use by aquatic life.

More specific information regarding the geographic location of nonpoint source locations and prioritization is detailed in **Section 3** where various methods of targeting and evaluating geographic areas are described.

Table 4: NPDES-permitted, point sources in the Marsh River Watershed.

Facility	Permit Number	Discharge / facility type	Receiving AUIDs (09020107-###)	Average wet weather design flow (mgd)	Secondary pond size (acres)	*E. coli* WLA (billion org/day) [b]	TSS	
							Discharge Limits (mg/L)	WLA (tons/day)
Ada WWTP	MNG585095	Controlled / pond	-506	0.448	14	**10.8793**	45	**0.4283**
Shelly WWTP	MNG585227	Controlled / pond	-503	0.042	4.93	**3.8311**	45	**0.1508**
Georgetown WWTP	MNG585132	Controlled / pond	-507	0.0185	1.5	**1.1656**	45	**0.0459**
Halstad WWTP	MN0020770	Continuous / mechanical	-502	0.114	N/A	**0.5437**	30	**0.0143**
Perley WWTP	MNG585326	Controlled / pond	-999 [a]	0.02	1.08	**0.8393**	45	**0.0330**

[a] -999 is a catchall AUID for all other waterbodies in a watershed that do not have an assigned, unique AUID.

Table 5: Nonpoint sources of impaired waterbodies in the Marsh River Watershed. Relative magnitudes of contributing sources are indicated.

			Pollutant sources											
Aggregated 12-HUC watershed	**AUID (Last 3 digits)**	**Pollutant**	**Fertilizer and/or manure run-off**	**Livestock overgrazing in riparian**	**Failing septic systems**	**Wildlife**	**Poor riparian vegetation cover**	**Upland soil erosion**	**Bank Erosion/excessive peak flow**	**Channelization**	**Upstream influences**	**Farmed-through headwater streams**	**Poor shoreline buffer**	**Internal sources**
Marsh River	Marsh River (-503)	*E. coli*	◎	○	○	○								
		TSS						◎	●	●	●	●		
		DO	◎							◎	◎	◎		
County Ditch 11	County Ditch No. 11 (-517)	TSS						◎	●	●	●	●		
		DO	◎				○			◎	◎	◎		

Key: ● = High ◎ = Moderate ○ = Low

2.4 TMDL summary

The Marsh River (-503) had two TMDL studies developed to address four impairments. The river is impaired as a result of elevated concentrations of TSS, requiring a TMDL and reductions in the current loading to achieve the numeric water quality standards, and therefore, the water quality goals. The TSS TMDL also addresses the two biological impairments in the Marsh River. The Marsh River also has *E. coli* measurements that are above allowable levels, which requires an additional TMDL. The following tables (**Table 6** through **Table 9**) show the maximum allowable load of the specified pollutant in the Marsh River to bring the river into compliance (loading capacity), and the allowable amount of that pollutant, which can come from nonpoint sources (load allocation) and point sources (wasteload allocation). A portion of the allowable load (10%) is placed in the "margin of safety" category, reflecting a level of uncertainty in the analysis.

Total Suspended Solids (TSS)

In January 2015, the EPA issued an approval of the adopted amendments to the state water quality standards, replacing the historically used turbidity standard with TSS standards. The existing TSS load, along with the calculated load allocation and wasteload allocation necessary to meet the water quality standard for the MRW are shown in the following tables. The analysis is based on using the concentrations of TSS from load duration curves. The critical flow condition is established using the flow zone requiring the greatest estimated load reduction.

Table 6 provides the measured and allowable loading of TSS to the Marsh River broken down by flow zones in the rivers. **Table 7** provides the critical flow condition and representative load reduction that is an overall estimated percent reduction across all flow zones.

Table 6: TSS TMDL summary for Marsh River, Headwaters to Red River (AUID 09020107-503).

- Listing year: 2008
- Baseline years: 2010-2011
- Numeric standard used to calculate TMDL: 65 mg/L TSS

Total Suspended Solids		Flow zones				
		Very High	High	Mid-Range	Low	Very Low
		[US tons/day]				
Wasteload Allocation	**Total WLA**	**0.60**	**0.582**	**0.5803**	***	***
	Ada WWTP (MNG585095)	0.43	0.43	0.43	***	***
	Shelly WWTP (MNG585227)	0.15	0.15	0.15	***	***
	Construction/Industrial Stormwater	0.02	0.002	0.0003	***	***
Load Allocation	**Total LA**	**56.1**	**4.818**	**0.3197**	**0.153**	**0.00**
Margin of Safety (MOS)		**6.3**	**0.60**	**0.10**	**0.017**	**0.00**
Loading Capacity		**63**	**6.0**	**1.0**	**0.17**	**0.00**
Observed Load		125	8.1	0.42	0.05	N/A
Estimated Percent Reduction		49.6%	25.9%	0%	0%	N/A
Existing 90th percentile concentration (mg/L)		92				
Overall estimated percent reduction		29%				

*** = flow-derived WLA, calculated as *Point Source Discharge X Water Quality Standard Concentration*.

Table 7: Critical flow condition and load reduction for the Marsh River (-503) TSS TMDL.

AUID (last 3 digits)	Waterbody name, reach description	LDC Load Reduction Range	Critical Flow Condition	Critical Condition Load Reduction	Representative Load Reduction
-503	Marsh River, Headwaters to Red R	0% - 50%	Very High	50%	29%

Escherichia coli (*E. coli*)

The existing *E. coli* contributions, along with the wasteload and load allocations to meet the standard for the Marsh River, are shown in the following tables. The analysis is based on the load duration curve method. The critical flow condition is established using the flow zone requiring the greatest estimated load reduction.

Table 8 provides the measured and allowable loading of *E. coli* to the Marsh River, broken down by flow zones in the river. **Table 9** provides the critical flow condition and estimated representative load reduction.

Table 8: *E. coli* TMDL summary for Marsh River, Headwaters to Red River (AUID 09020107-503).

- Listing year: 2018
- Baseline years: 2010-2011
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*

E. coli		Flow zones				
		Very High	High	Mid-Range	Low	Very Low
		(billion org/day)				
Wasteload Allocation	**Total WLA**	**14.8**	**14.8**	***	***	***
	Ada WWTP (MNG585095)	11	11	***	***	***
	Shelly WWTP (MNG585227)	3.8	3.8	***	***	***
Load Allocation	**Total LA**	**892.4**	**71.6**	**14.4**	**1.53**	**0.00**
Margin of Safety (MOS)		**100.8**	**9.6**	**1.6**	**0.17**	**0.00**
Loading Capacity		**1,008**	**96**	**16**	**1.7**	**0.00**
Observed Load		626	100	20	1.4	N/A
Estimated Percent Reduction		0%	4%	20%	0%	N/A
Highest Observed Monthly Geometric Mean		147.4 org/100 mL				
Estimated representative percent reduction		14.5%				

*** = flow-derived WLA, calculated as *Point Source Discharge X Water Quality Standard Concentration*.

Table 9: Critical flow conditions and load reduction for the Marsh River (-503) *E. coli* TMDL.

AUID (last 3 digits)	Waterbody name, reach description	LDC Load Reduction Range	Critical Flow Condition	Critical Condition Load Reduction	Representative Load Reduction
-503	Marsh River, Headwaters to Red R	0% - 20%	Mid-range	20%	14.5%

2.5 Protection considerations

The MPCA has developed a 'Streams Protection Strategy' to help watershed stakeholders set protection goals for streams that meet standards for fish and/or macroinvertebrates. In addition to how close fish and macroinvertebrate IBIs are to the standards, the 'Streams Protection Strategy' considers other water "values" such as the density of roads, percent of disturbed land, and percent of public or easement protected land. While the 'Streams Protection Strategy' and a 'Stream Prioritization Spreadsheet' are available from MPCA to manually determine stream protection, a shapefile was created that has already determined stream prioritization for waterbodies that do not have impairments caused by poor biota (DNR and MPCA, 2019). **Table 10** shows the stream protection prioritization results for the four stream reaches that support aquatic life. While all four AUIDs were determined to have the highest priority class, the priority rank suggests that Spring Creek (-508) is the highest priority for protection, followed by CD 45 (-521), JD 51 (-518), and CD 66 (-516), which is the lowest priority for protection.

Table 10: Stream protection prioritization for streams in the MRW not impaired for biota.

Stream name, AUID (last 3 digits)	TALU [a]	Vulnerable? [b]	Cold or warm	Biota nearly impaired?	Riparian risk [c]	Watershed risk [c]	Current protection risk [d]	Priority rank [e]	Priority class [f]
Spring Creek (-508)	General	Yes	warm	both	high	med/high	low	3.5	A
CD 66 (-516)	Modified	No	warm	neither	med/high	high	low	10.5	A
JD 51 (-518)	Modified	No	warm	neither	high	high	low	9	A
CD 45 (-521)	General	No	warm	both	medium	med/high	low	4.5	A

[a] The 3 possible tiered aquatic life use (TALU) designations are exceptional, general, and modified.

[b] Indicates whether the fish and/or macroinvertebrate biota were determined to be vulnerable to causing an impairment.

[c] low = low density of roads and low percent disturbed land, med = both risk factors intermediate or one factor high and one low, and high = high density of roads and high percent disturbed land.

[d] low = high percent of public and easement protected land in riparian and watershed area, med - both protective factors intermediate or one factor high and one low, high = low percent of public and easement protected land in riparian and watershed area

[e] The lower the value, the higher the priority.

[f] Possible priority classes are A (highest priority), B, and C (lowest priority).

Since the MPCAs 'Streams Protection Strategy' is based primarily on biological data for waterbodies that support aquatic life, another separate analysis was done for stream reaches that are currently impaired. The Marsh River (-503) and CD 11 (-517) were prioritized and classified based on existing water quality criteria.

Designation of streams as candidates for protection or restoration is important in aligning with the Board of Water and Soil Resources' (BWSR) Nonpoint Priority Funding Plan for Clean Water Funding Implementation and Minnesota's Clean Water Roadmap. For this reason, assessed streams are designated as either "protection" or "restoration" based on water quality data. Streams within the "protection" category are subdivided into three subcategories: Above Average Quality, Potential Impairment Risk, and Threatened Impairment Risk. Streams within the "restoration" category are subdivided into two subcategories: Low Restoration Effort and High Restoration Effort. This more refined categorization reflects priorities in the Nonpoint Priority Funding Plan for Clean Water Funding Implementation. Each stream reach receives a classification for each measured water quality parameter (e.g., TP– low restoration effort, *E. coli* – potential impairment risk, etc.).

All unassessed streams currently supporting aquatic life and aquatic recreation in the MRW are also candidates for protection. Over time, if these waters are not subject to protection strategies, they may become impaired. For these streams, the protection strategy consists of working toward ensuring the existing loads for the critical duration periods are not exceeded. Protection strategies include improving upland and field surface runoff (RO) controls and improving livestock and manure management. Strategies for addressing protection of these waters are discussed in more detail in **Section 3** of this report.

A brief summary of the protection or restoration classification for the impaired stream reaches in the MRW is shown in **Table 11**. A more detailed explanation for determining protection and restoration designations for impaired streams within the MRW is included as **Appendix A**.

Table 11: Protection and restoration classification in impaired streams in the Marsh River Watershed.

AUID (last 3 digits)	Waterbody, reach description	Protection			Restoration	
		Above Average Quality [a]	Probable Impairment Risk [a]	Threatened Impairment Risk [a]	Low Restoration Effort [a]	High Restoration Effort [a]
-503	Marsh River, Headwaters to Red R	Ammonia		DO	*E. coli*	TP, TSS
-517	County Ditch 11, CD 66 to Marsh R	*E. coli*, Ammonia, TP, TSS	DO			

[a] DO = dissolved oxygen, *E. coli* = *Escherichia coli*, TP = total phosphorus, and TSS = total suspended solids.

3. Prioritizing and implementing restoration and protection

This WRAPS report summarizes priority areas for targeting actions to improve water quality, and identifies point sources and nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, an implementation table of strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources is included.

Provided in the following subsections are the results of such prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and residents of the watershed, it is imperative to create social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement BMPs. Thus, effective and ongoing public participation or civic engagement is a crucial part of local planning and implementation efforts.

The successful implementation of restoration and protection strategies also requires a combined effort from multiple entities within the MRW, including local and state partners (e.g., soil and water conservation districts [SWCDs], the watershed district, MPCA, Minnesota Department of Natural Resources [DNR], BWSR). Continuing to bring these groups together in the decision-making process will increase the transparency and eventual success of the implementation. Resource management organizations should also work with landowners within the MRW through typical outreach programs to help identify implementation priorities. Collaboration and compromise will also ensure that identified priorities and strategies are incorporated into local plans, future budgeting, and grant development.

Implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and professional judgment based on what is known at this time, and therefore should be considered approximate. Furthermore, many strategies are predicated on securing needed funding. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

The MRW WRAPS effort was led by the Wild Rice Watershed District (WRWD). The WRWD has a long history of collaborating with local and state partners to prioritize, implement, and fund restoration and protection activities within its jurisdiction. Future restoration and protection work in the area will benefit from these relationships, building on previous successes.

3.1 Targeting of geographic areas

Significant amounts of effort have been invested in monitoring and protecting the MRW over the past several decades. Major leaders in this effort have been the WRWD and the SWCDs of Clay, Norman, and Polk Counties. Clay and Norman Counties each have one SWCD while Polk County has two, East Polk County SWCD and West Polk County SWCD; the MRW is within the boundary of East Polk County SWCD but not West Polk County SWCD.

Pursuant to Minnesota Statute, the WRWD and SWCDs are required to prepare Watershed or Water Management Plans (WMPs) for the Wild Rice River Watershed ([WRRW] which includes the entirety of the MRW) or respective county, and to periodically update and revise the plans (typically every 5 to 10-years). A WMP is an important tool for identifying problems and issues, goals, and short and long-term strategies to address these issues and attain the goals. A WMP also inventories resources, assesses resource quality, and establishes regulatory controls, programs, or infrastructure improvements needed to manage the resources within the watershed or county. The WMPs provide guidance for the WRWD and counties to manage the water and natural resources throughout the MRW.

The WMPs were most recently updated by the WRWD in 2003, Clay County SWCD in 2017, Norman County SWCD in 2017, and East and West Polk County SWCDs in 2012. A comprehensive WMP was written for the Wild Rice – Marsh planning region as part of the One Watershed, One Plan (1W1P) program. It was led by the WRWD, but the aforementioned SWCDs have also taken a very active role in the process. The comprehensive WMP was completed at the end of 2020.

Additional tools used for determining restoration and protection strategies

As part of past and current local planning within the watershed, water quality models and enhanced geospatial water quality products (EGWQP) were developed. Advances in watershed assessment tools allows for the rapid identification of at-risk areas for natural resource degradation, as well as feasible placement locations for cost-effective BMPs and structural CPs. These models will be used to analyze RO quantity; target sources of sediment, TN, and TP; and identify opportunities for BMP and CP implementation.

The watershed-based results developed under this WRAPS effort utilized the following geospatial products to assess water quality:

- Hydrological Simulation Program – FORTRAN (HSPF) model and its Scenario Application Manager (SAM) tool
- Prioritize, Target, and Measure Application (PTMApp) model
    - Light Detection and Ranging (LiDAR) terrain analysis
    - EGWQP
    - BMP Suitability Analysis

Future use and updates of WMPs will continue to include integration of these resources in conjunction with additional modeled water quality and quantity data. This breadth of available resources will be used to efficiently and effectively manage the waterbodies and contributing lands within the MRW. The

WMPs will provide the management and guidance framework under which these resources can be used to the greatest benefit.

Hydrological Simulation Program – FORTRAN (HSPF) model

A HSPF model was chosen as one of the primary watershed modeling tools to simulate hydrology and water quality for this WRAPS effort. HSPF makes use of meteorological data, agricultural tillage information, and a host of additional land use and management information. Products from the HSPF model include a temporal history (1996 through 2009 for this model) of water quantity; RO flow rate; and concentration, load, and yield estimates for sediment and nutrients (among other parameters).

The Marsh River (AUID -503) and CD 11 (AUID -517) are impaired due to excessive sediment and/or sediment is a stressor to aquatic life. As such, the HSPF model created for the MRW was used to help identify major subwatersheds and stream reaches that have higher potential for exporting nutrients and sediment to downstream resources. Subwatersheds were prioritized by ranking the area-averaged yields (mass/acre/year) for TP, TN, TSS, and RO (volume/acre/year). This can aid in the effort to identify areas within the MRW where restoration and protection strategies would be most beneficial.

Figure 3 through **Figure 6** demonstrate the use of this product (the methods and more HSPF priority maps are available in **Appendix B**). The Highest Priority (Highest 90% - darkest green) areas are the catchments delivering the highest yield (mass or volume per unit area) of the listed water quality parameter (RO, total sediment (TS), TP, TN) to the MRW outlet. This map and associated data can be used to target general locations that deliver the largest amount of the specified water quality parameter to the watershed outlet, the allowing watershed managers more effectively place practices within the drainage area.

Figure 3: Map of prioritized subwatersheds for implementation to address altered hydrology in the Marsh River Watershed, based on average (1996-2009) annual runoff (of water).

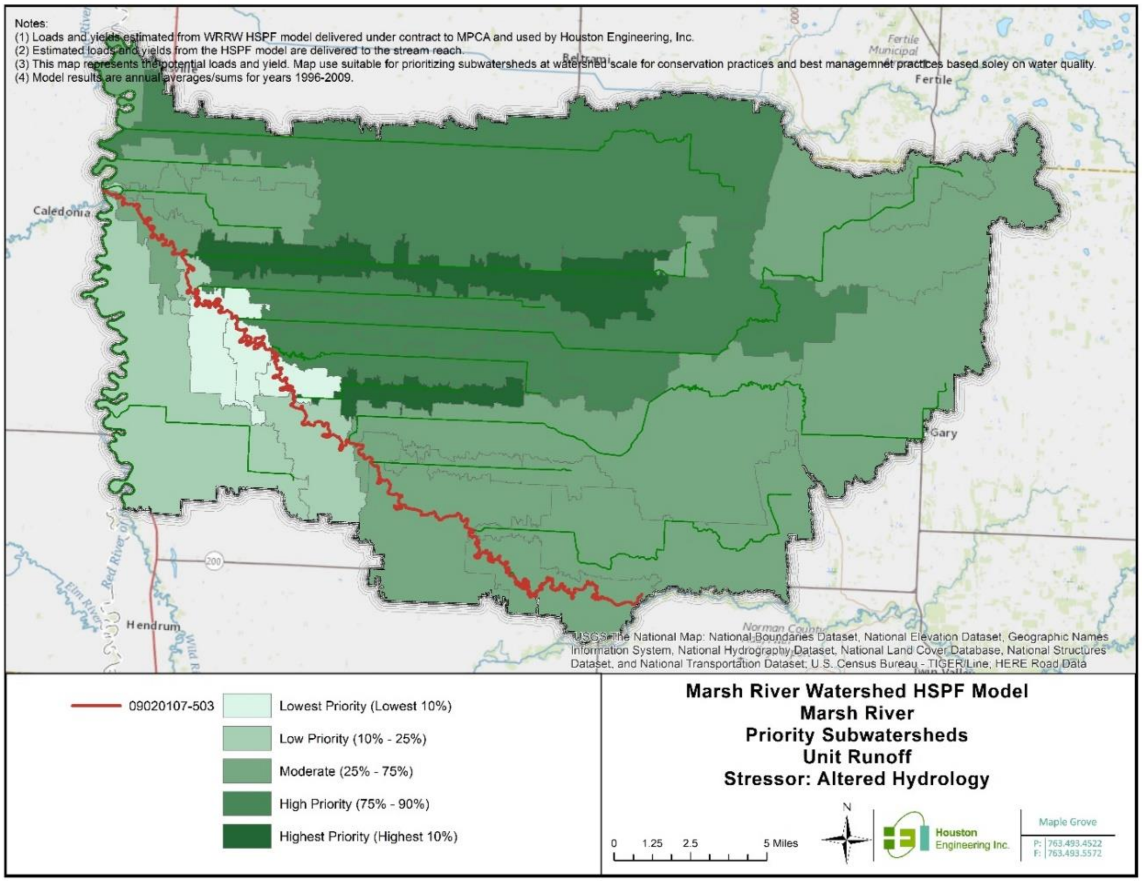


Figure 4: Map of prioritized subwatersheds for implementation to address elevated turbidity and loss of habitat in the Marsh River Watershed, based on average (1996-2009) annual total sediment yields.

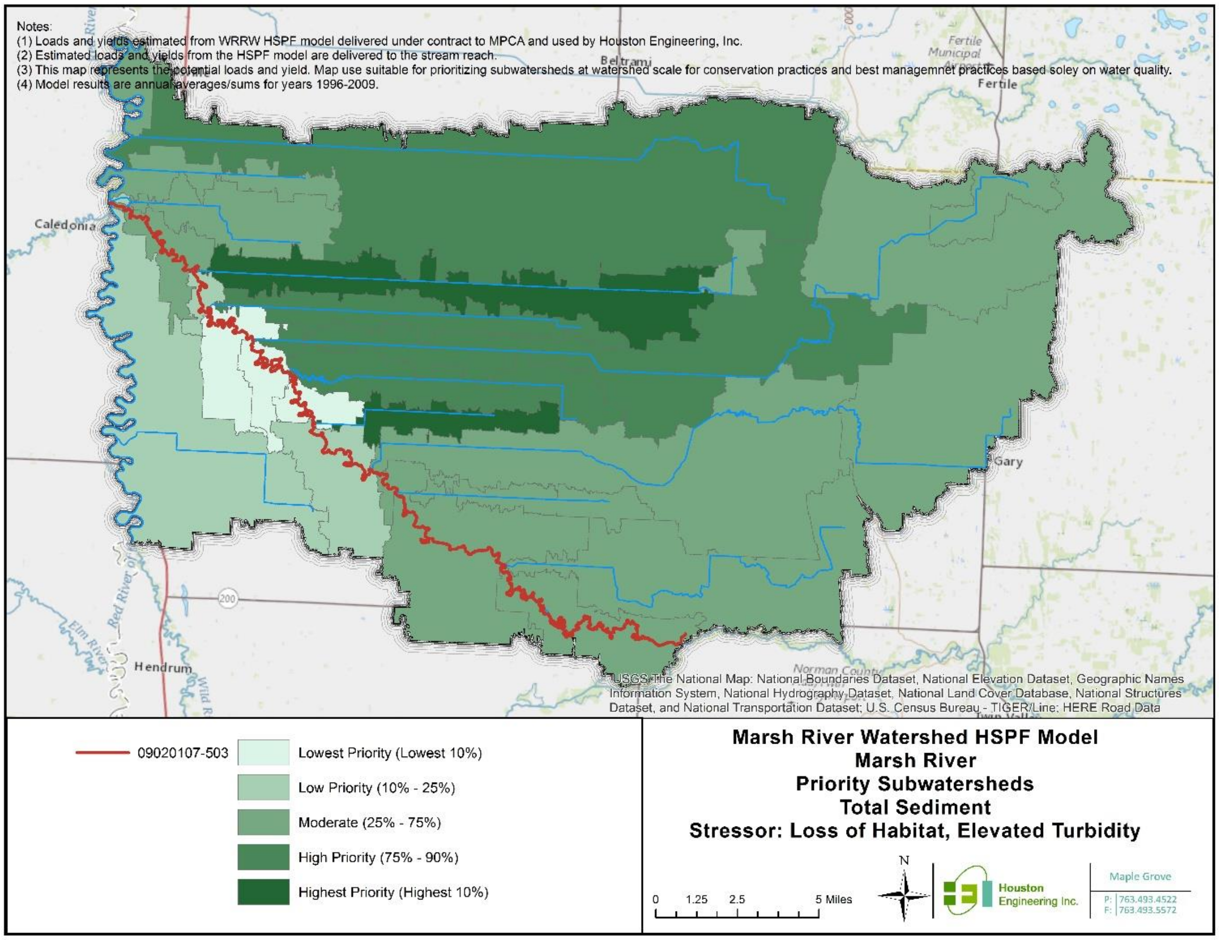


Figure 5: Map of prioritized subwatersheds for implementation to address excessive nutrients in the Marsh River Watershed, based on average (1996-2009) annual total phosphorus yields.

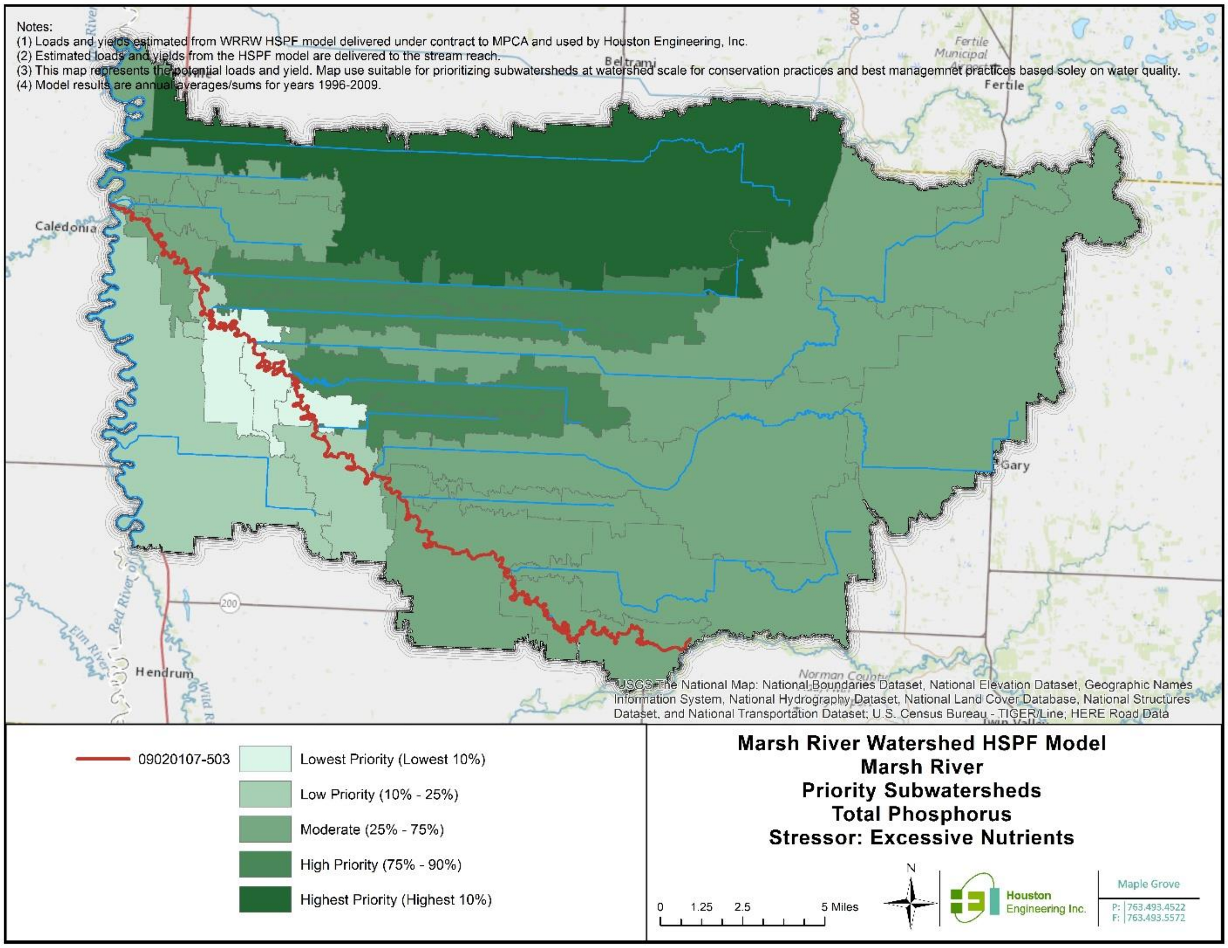
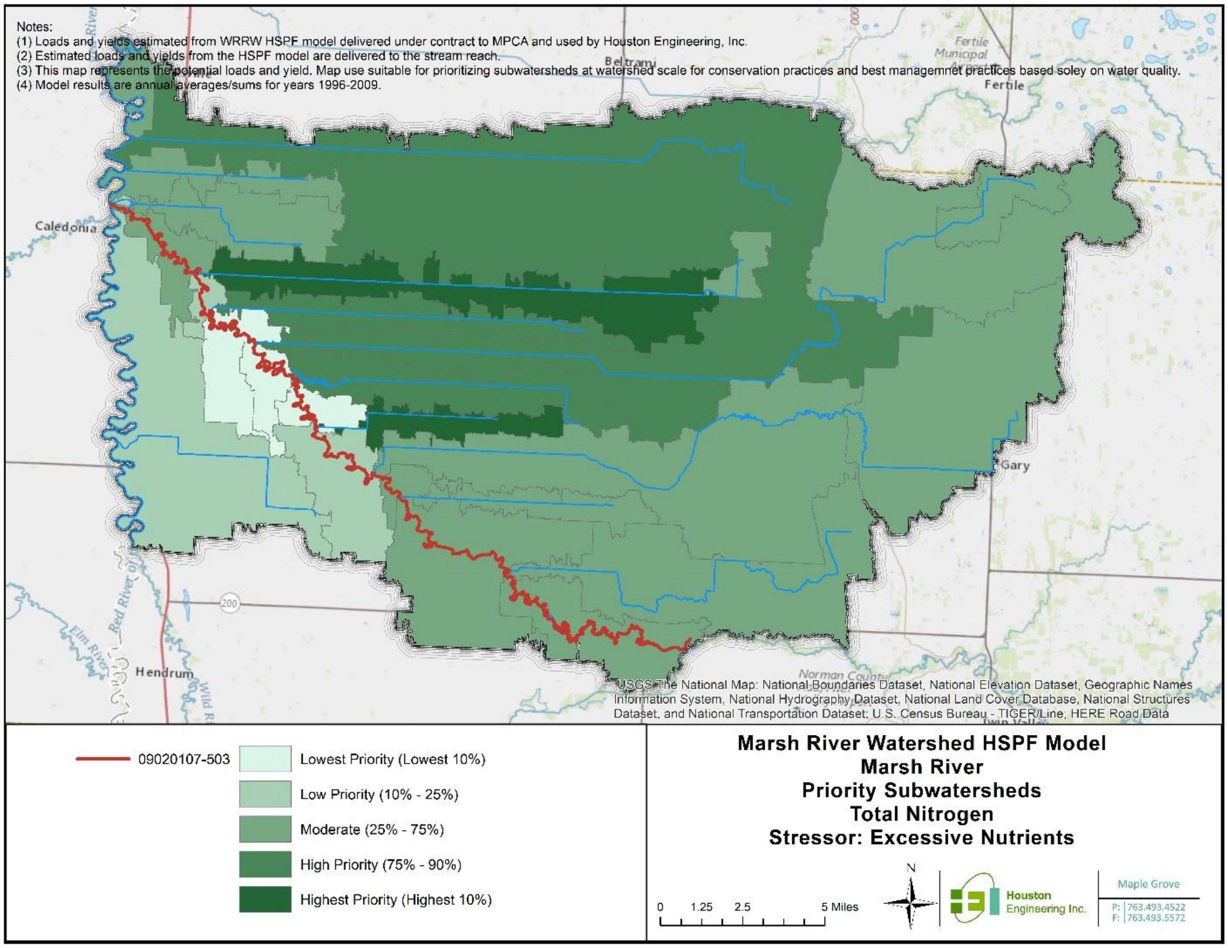


Figure 6: Map of prioritized subwatersheds for implementation to address excessive nutrients in the Marsh River Watershed, based on average (1996-2009) annual total nitrogen yields.



Prioritize, Target, Measure Application (PTMApp)

In addition to generically targeting areas within the watershed for restoration and protection based solely on the yield of water quality constituents (e.g., TS, TP) delivered to the stream outlet, a field-scale analysis was also completed to identify opportunities to place specific types of BMPs based on the feasibility and estimated benefit of those BMPs. For instance, a field may deliver a moderate to high amount of sediment to a stream but have limited opportunities to implement BMPs to reduce sediment delivery because of the physical setting, landowner interest/ability, or productivity of land. For this reason, the Prioritize, Target, Measure Application (PTMApp) was also included as part of the Marsh River WRAPS Report.

PTMApp results can be used to locate areas within the watershed where BMPs and CPs are feasible and will be the most beneficial to water quality goals while also being the most cost-effective (i.e., provide the highest water quality benefit for the lowest dollar investment).

PTMApp utilizes LiDAR information to create a digital elevation model (DEM) for GIS analysis within the application. For use with PTMApp, the DEM is first hydro-conditioned, a process that analyzes and modifies the original DEM to ensure that hydrologic flow lines generated through the use of PTMApp match the observed flow of water on the landscape. Infrastructure items such as culverts are not identified during the LiDAR data collection, and thus are not represented in the DEM. The absence or presence of a culvert can have a dramatic effect on water flow and accumulation within a watershed. Hydro-conditioning artificially adds flow diversions (like culverts) to the original DEM, resulting in a more hydrologically accurate DEM (hDEM).

The hDEM, along with Soil Survey Geographic Database (SSURGO) data, RO curve number estimates, Revised Universal Soil Loss Equation (RUSLE) parameters, and land cover data are used to rank and classify portions of the watershed that are suitable for BMP and CP installation to improve water quality by reducing sediment and nutrient loss to streams. The high spatial resolution of the hDEM and additional input parameters makes it possible to identify locations to place BMPs and CPs at the sub-field (<40 acre) scale.

Any PTMApp analysis focuses on identifying potential locations believed suitable for BMPs and CPs based on NRCS design criteria guidelines, topographic characteristics, soil type, and land use (i.e., the model identifies preliminary locations to target BMP placement). Many other factors such as landowner willingness and the presence of existing BMPs and CPs are also important criteria affecting the final placement of BMPs and CPs. The analysis performed in the MRW did not factor in the potential of existing practices on the landscape due to a lack of a complete record of existing BMPs and CPs. The PTMApp feasible BMP and CP locations can then be reviewed, screened, and field verified by management personnel to assist in targeting the implementation of practices.

For the MRW, PTMApp BMP suitability analysis was purposefully focused on a subset of possible BMPs and CPs that are used most often within the MRW.

The full results of the PTMApp analysis have been provided in **Appendix C**. **Figure 7** and **Figure 8** show examples of field scale locations that have been targeted for opportunities for infiltration related practices (e.g., Two-stage ditch - **Figure 7**) and water storage practice (e.g., water and sediment control basin – **Figure 8**). Infiltration and storage practices are identified as recommended actions to improve flow regime stability and reduce excess sedimentation and nutrient transport.

The PTMApp data products can be used to precisely locate areas on the landscape where various types of management practices will be the most beneficial at reducing sediment, P, or N. HSPF results can then be used to determine the areas that may be better suited for in-stream management practices. Together, the results from HSPF and PTMApp, as well as professional local knowledge and experience can used to inform placement of protection and restoration strategies within the MRW (further explained in **Section 3.3**).

Additional tools available for refining restoration and protection strategies are available in **Table 12**.

Figure 7: Infiltration Practice Opportunities in the Marsh River Watershed.

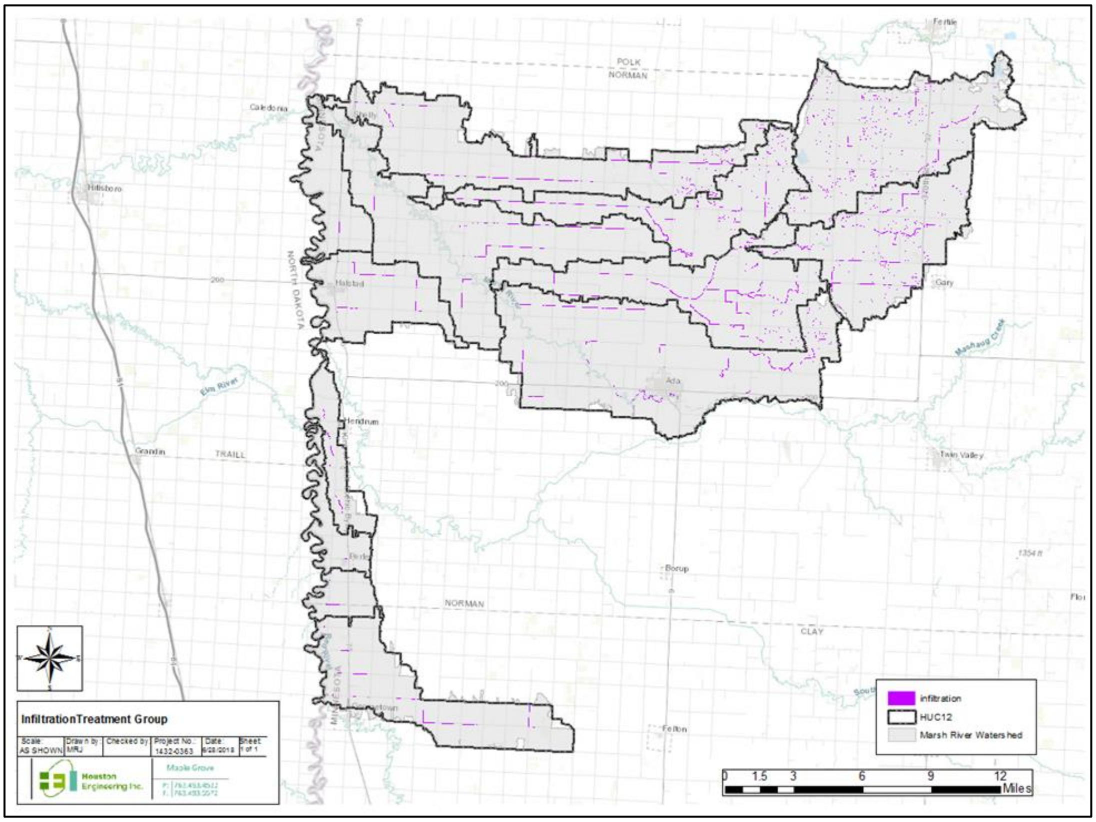


Figure 8: Storage practice opportunities in the Marsh River Watershed.

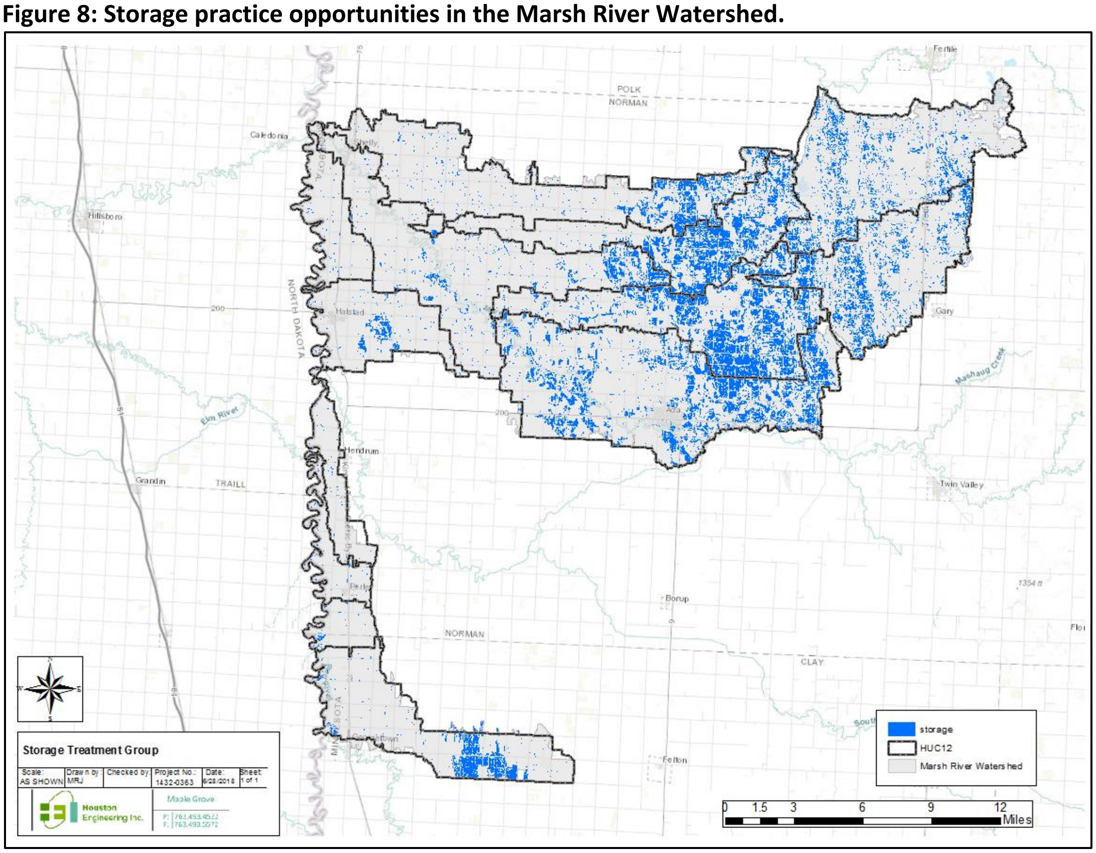


Table 12: Additional tools available for restoration and protection of impaired and non-impaired waters.

Tools	Description	How can the tool be used?	Notes	Link to information and data
Environmental Benefit Index – (EBI)	The EBI is the aggregation of three Geographic Information System (GIS) raster data layers including soil erosion risk, water quality risk, and habitat quality. The 30-meter grid cells in each layer contain scores from 0-100. The sum of all three scores is the EBI score (max of 300). A higher score indicates a higher priority for restoration or protection.	The three data layers can be used separately, or the sum of the layers (EBI) can be used to identify priority areas for restoration or protection projects. The layers can be weighted or combined with other layers to better reflect local values.	A GIS data layer that shows the 5% of each 8-digit watershed in Minnesota with the highest EBI scores is available for viewing in the MPCA 'water quality targeting' web map, and download from MPCA.	MPCA Web Map[1] MPCA download[2]
Zonation	This tool serves as a framework and software for large-scale spatial conservation prioritization, and a decision support tool for conservation planning. The tool incorporates values-based priorities to help identify areas important for protection and restoration.	Zonation produces a hierarchical prioritization of the landscape based on the occurrence levels of features in sites (grid cells). It iteratively removes the least valuable remaining cell, accounting for connectivity and generalized complementarity in the process. The output of Zonation can be imported into GIS software for further analysis. Zonation can be run on very large data sets (with up to ~50 million grid cells).	The software allows balancing of alternative land uses, landscape condition and retention, and feature-specific connectivity responses.	Software[3] Examples Pine River watershed[4] Cannon River Watershed[5]
Restorable wetland inventory	A GIS data layer that shows potential wetland restoration sites across Minnesota. Created using a compound topographic index (CTI) (10-meter resolution) to identify areas of ponding, and USDA NRCS SSURGO soils with a soil drainage class of poorly drained or very poorly drained.	Identifies potential wetland restoration sites with an emphasis on wildlife habitat, surface and groundwater quality, and reducing flood damage risk.	The GIS data layer is available for viewing and download on the Minnesota 'Restorable Wetland Prioritization Tool' website.	Restorable Wetlands[6]
National Hydrography Dataset (NHD) and Watershed Boundary Dataset (WBD)	The NHD is a vector GIS layer that contains features such as lakes, ponds, streams, rivers, canals, dams and stream gages, including flow paths. The WBD is a companion vector GIS layer that contains watershed delineations.	General mapping and analysis of surface-water systems. These data have been used for fisheries management, hydrologic modeling, environmental protection, and resource management. A specific application of this data set is to identify riparian buffers around rivers.	The layers are available on the USGS website.	USGS[7]

Tools	Description	How can the tool be used?	Notes	Link to information and data
Light Detection and Ranging (LiDAR)	Elevation data in a DEM GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth.	General mapping and analysis of elevation/terrain. These data have been used for erosion analysis, water storage and flow analysis, siting and design of BMPs, wetland mapping, and flood control mapping. A specific application of the data set is to delineate small catchments.	The layers are available on the Minnesota Geospatial Information Office (MGIO) website.	MGIO[8]
Hydrological Simulation Program – Fortran (HSPF) Model	Simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants from pervious and impervious land. Typically used in large watersheds (greater than 100 square miles).	Incorporates watershed-scale and nonpoint source models into a basin-scale analysis framework. Addresses RO and constituent loading from pervious land surfaces, RO and constituent loading from impervious land surfaces, and flow of water and transport/ transformation of chemical constituents in stream reaches.	Local or other partners can work with MPCA HSPF modelers to evaluate at the watershed scale: 1) the efficacy of different kinds of adoption rates of BMPs 2) effects of proposed or hypothetical land use changes. A simplified option to run HSPF models is a graphical interface called the Scenario Application Manager (SAM).	EPA Models[9] USGS[10]

1 http://mpca.maps.arcgis.com/apps/Viewer/index.html?appid=0b76cfbbd4714b1ba436fdc707be479c

2 https://gisdata.mn.gov/dataset/env-ebi-top-5

3 https://www.helsinki.fi/en/researchgroups/digital-geography-lab/software-developed-in-cbig

4 https://www.pca.state.mn.us/water/watersheds/pine-river5 https://www.pca.state.mn.us/water/watersheds/cannon-river

6 http://www.mnwetlandrestore.org/links-contact/data-download/

7 https://www.usgs.gov/core-science-systems/ngp/national-hydrography

8 http://www.mngeo.state.mn.us/chouse/elevation/lidar.html

9 http://www.epa.gov/ceam/hydrological-simulation-program-fortran-hspf

10 http://water.usgs.gov/software/HSPF/

3.2 Public participation

A key prerequisite for successful strategy development and on-the-ground implementation is meaningful public participation. A specific goal of the public participation process for this WRAPS was to work closely with the residents, cities, counties, businesses and other stakeholders to ensure that their ideas, concerns and visions for future conditions were understood and utilized throughout the WRAPS study process. The WRAPS process is most likely to be successful when average citizens play a greater role in helping to frame the water quality issues in their own community, as well as in the creation of the solutions to those problems. This is particularly true in the MRW, as nearly all of the land is privately owned. Given this, the public participation process included two primary components: technical stakeholder engagement and citizen engagement.

There are a large number of technical stakeholder groups within the MRW that work with the WRWD and SWCD (hereafter, referred to as local government units [LGUs]) personnel and are already involved in restoration efforts throughout the watershed. Technical stakeholder organizations include The Nature Conservancy; Ducks Unlimited; Red River Basin Commission; Red River Basin Institute; and many more wildlife, conservation, and sportsman organizations. The WRWD has also worked alongside the Minnesota Center for Environmental Advocacy to prioritize natural resource issues in the watershed (MCEA, 2005; WRWD, 2002). The LGUs make a great effort to continue working closely with these groups in an effort to develop projects that are mutually beneficial.

The LGUs recognize the importance of informing citizens of current MRW activities and educating the citizens on the benefits of conservation, preservation, and enhancement of natural resources. They also realize that optimum water management practices result when affected people are sufficiently educated on water issues. For this reason, the LGUs have taken an active position in publicizing their activities and educating the public; for example, a professional publicist has been retained by the Board to prepare press releases on WRWD activities. From the standpoint of education, staff and managers of the LGUs have appeared before other governmental boards and organizations to inform them about activities and programs that are being implemented within the watershed. The LGU Boards actively participate in state, regional, and basin functions associated with LGU activities. The LGUs also maintain a considerable amount of printed information concerning watershed and county activities and water-related issues.

The LGUs have also been instrumental in garnering citizen involvement. Stakeholder groups are used to identify natural resource problems within the MRW (and surrounding areas). Garnering support and gathering information from the public is often accomplished through a series of mailers, workshops, discussions, and meetings. The LGUs also have the goal of involving citizens in water quality monitoring across the watershed. A number of local citizens are also part of River Watch, a program that engages citizens to help with monitoring the health of the watershed. River Watch also works closely with LGU staff, local schools, and other local and regional groups in the area to monitor waters within the Red River Basin (some sites are within the MRW), and to educate the general public on water related issues affecting their community.

The public participation efforts related to the MRW WRAPS have been overseen and carried out by the WRWD. A public meeting and open house event for the WRAPS project was held at the Twin Valley

Community Hall on May 30, 2018. This event took place during the early stages of the WRAPS process to update stakeholders on the WRAPS efforts, as well as receive input and guidance on water quality values and concerns in the area. A 1W1P kickoff meeting for the Wild Rice – Marsh planning region was held at the WRWD office in July 2019. At this meeting, participants indicated priority areas on wall maps and completed a survey to share their priority issues and concerns. This public survey was also shared online via email for anyone who could not attend the meeting. These priorities were incorporated into the WRAPS report which was being drafted at the time of the kickoff meeting. In addition, the WRWD posts project information on their website (http://www.wildricewatershed.org/projects/).

Accomplishments and future plans

Since water quality is among the priorities of the LGU's management activities, future public participation will continue to be coordinated by them. The LGUs will update, inform, and engage stakeholders on water quality issues through the typical LGU communications, including watershed or county plan update events and website communication. A primary objective of this public participation effort is to create understanding of water quality problems and solutions that are available, and to build motivation to make changes with those who will be needed to voluntarily implement BMPs. As trusted authorities on water issues in the area, the LGUs are uniquely suited to provide information and leadership on this topic; for example, the WRWD has a professional publicist on retainer to help effectively broadcast pertinent news and information to the public.

The LGUs are currently in the planning process of many projects to alleviate impairments within, and downstream of the MRW. One such project is the 19.6-million-dollar Green Meadow Water Management Project. This project will provide 11,000 acre-ft of water storage within the MRW, reducing local flood volume by 40% to 45% and overall Red River flood volume by approximately 5%. Extended retention of water on the landscape will reduce stream bank erosion and turbidity/suspended sediment concentration in the affected streams. It will also create an estimated 400 to 600 acres of permanent wildlife habitat. The project is currently in the design and land acquisition phase.

Expectations are that future project implementation will be guided by the comprehensive WMP as a result of the 1W1P program. However, projects and management will also be guided by the information gained from this WRAPS report and associated TMDL report; and/or through partnerships with adjacent SWCDs and watershed districts, the Red River Watershed Management Board, and other organizations.

Public notice for comments

The opportunity for public comment on the draft WRAPS report was provided via a public notice in the State Register from April 12, 2021 through May 12, 2021. There were no comments received during the public comment period.

3.3 Restoration and protection strategies

The MRW has numerous areas and waterbodies in need of protection or restoration. Collaborative efforts between local and state partners (i.e., SWCDs, WRWD, MPCA, DNR, and BWSR) led to a list of water quality restoration and protection strategies for the watershed. Restoration strategies are targeted at decreasing stressors and sources related to the measured impairments within the watershed. Due to the somewhat homogeneous nature of the watershed, most of the suggested strategies are applicable throughout the watershed. **Table 13** briefly lists major stressors within the MRW, prioritizing the importance of working to alleviate that stressor.

Table 13: Recommended prioritization of TMDLs relative to the stressors contributing to the biological impairments in the Marsh River Watershed.

Stressor	Priority	Comment
Sedimentation	High	TMDL should focus on reducing sediment input from riparian corridor and immediate stream channel (stream banks) in AUID -503 (Marsh River) and -517 (County Ditch 11).
Riparian disturbance	High	Restoration efforts should aim to re-establish quality riparian corridor to increase woody debris, coarse particulate organic matter inputs, and stream shading in AUID -517.
Flow alteration	High	AUID -503 and -517 would benefit from detention/retention of water on the landscape in order to mitigate stressors caused by flow alteration.
Low DO	Medium	DO enhancement efforts should be focused on AUID -517. Low DO does not appear to be limiting the biological community in AUID -503. More information and further sampling is recommended to determine the effects of eutrophication on DO.

Restoration of impaired waterways within the MRW will not be an easy task. Soil erosion and channel degradation are believed to be the primary sources of sediment to impaired waterways. The drainage ditch networks increase flow volume during high flow events that result in bank erosion and an increase in sediment load. The resulting excess sediment load fills the interstitial spaces (spaces between gravel particles) of the coarse substrate that is utilized by sensitive gravel spawning fish and macroinvertebrates. During periods of low flow, crucial habitat may not be available to aquatic animals, and DO and stream temperature may undergo severe fluctuations.

Restoring the upstream-downstream link in CD 11 would provide the most influence on mitigating the declining biological integrity. Access into upper portions of CD 11 will allow migratory fish species to gain access to spawning grounds and will facilitate certain life history traits that require longitudinal connectivity.

Re-establishment of the riparian zones and use of BMPs for cultivated lands within the MRW could greatly reduce soil loss and suspended sediment concentration within the streams of the watershed. Additionally, detention/retention of water over the landscape would especially help with flow regime instability and subsequently, erosion/sedimentation.

Eutrophication does not seem to be influencing DO dynamics in MRW; however, TP has been documented at very high levels often well above the TP standard for streams in the area. Augmenting (i.e., increasing) baseflow would help to maintain DO concentrations above the standard and reduce DO flux (high and low swings). Reducing TP loads, although not currently causing DO to flux by more than 5 mg/L on days with available data, would prevent greater flux in DO as a result of eutrophication.

In addition to the aquatic life use impairments, the Marsh River is also listed as impaired by *E. coli*. *E. coli* concentrations are elevated, sometimes severely, indicating the potential for fecal contamination pathogens, which could pose a risk to human health. Reducing *E. coli* concentrations within the waterbodies of the MRW will require livestock to be kept away from waterbodies, appropriate manure management (proper storage and application methods), and replacement or maintenance of noncompliant subsurface sewage treatment systems.

Although multiple impairments have been identified throughout the watershed, the Marsh River and its tributaries do support extensive fish and macroinvertebrate populations. Thirty-six unique fish species and over 119 unique macroinvertebrate taxa were observed during an extensive sampling survey. The actions implemented to restore impaired waters can also be implemented in areas with unimpaired waters in an effort to keep the unimpaired waters from becoming impaired. The data does suggest that the potential for higher quality fish and macroinvertebrate habitat within the Marsh River exists if continuous flow can be restored.

Table 14 and **Table 15** contain a more complete list of the strategies to restore impaired streams and protect streams of the MRW that are not impaired. Included in the tables are water quality goals for restoration, suggested implementation strategies to achieve those goals, estimated necessary adoption rates, units/metrics to track progress towards goals, governmental unit(s) responsible for implementation, and the timeline to achieve those goals. All other waters (lakes included) in the watershed are assumed to be unimpaired and, therefore, subject to protection strategies. Given the homogeneity of the watershed, protection strategies are identified on a watershed-wide basis and generalized for all unimpaired streams and lakes.

Interim 10-year milestones are identified in **Table 14** so that incremental progress is measured and achieved. Ongoing water quality monitoring data will be used in future components of the WRAPS process to judge the effectiveness of the proposed strategies and inform adaptive implementation toward meeting the identified long-term goals. **Table 14** references 10-HUC subwatersheds and two AUIDs (09020107-503 and 09020107-517), the locations of which can be seen in **Figure 9**.

Figure 9: Marsh River Watershed 10-HUC subwatersheds.

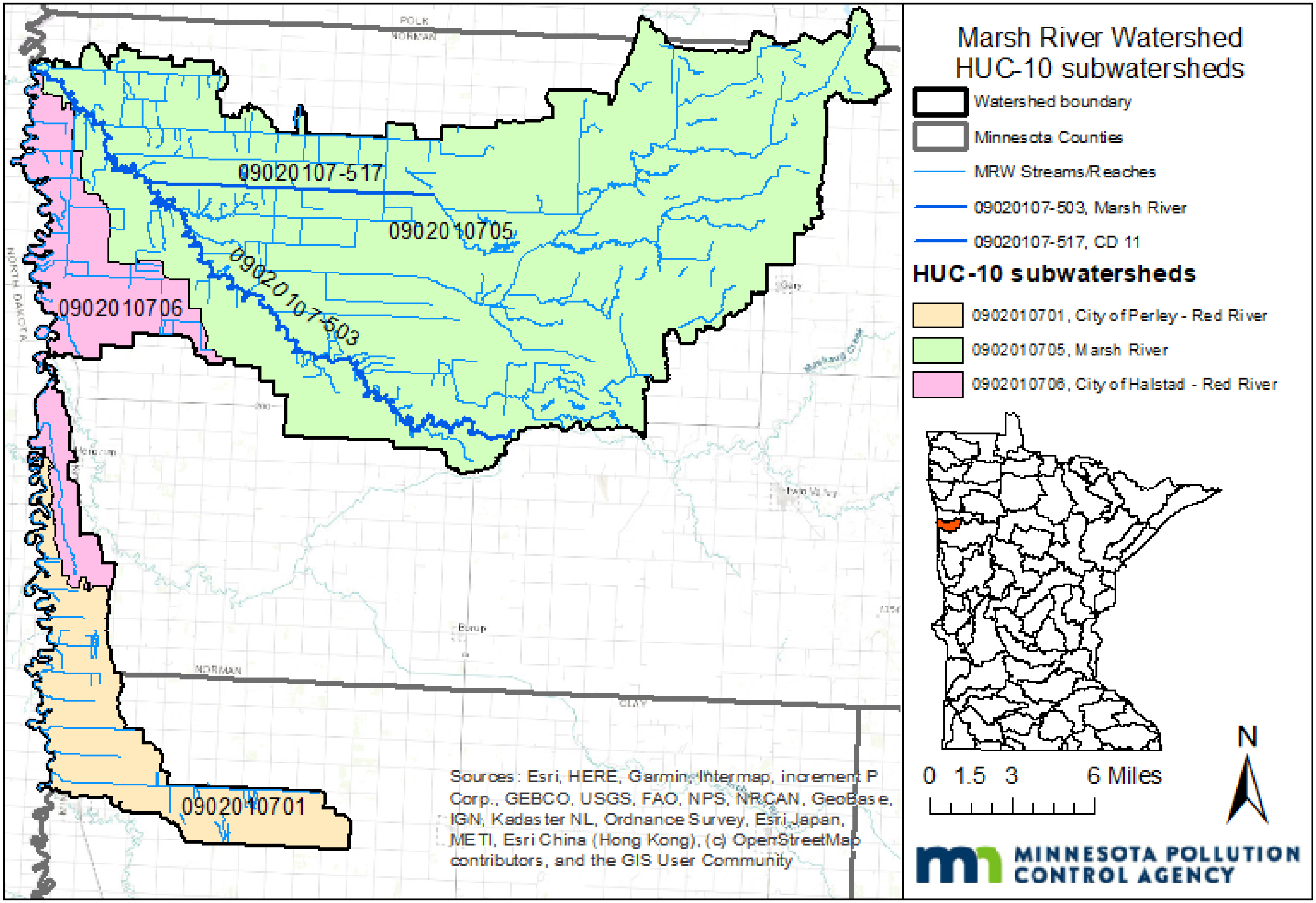


Table 14: Strategies and actions proposed for the Marsh River Watershed.

Parameter / stressor	Planning region (1W1P)	10-HUC subwatershed	Impaired waterbody (AUID)	Identified conditions [a]	Water quality goal (summarized)	Pollutant / stressor sources		Watershed-wide goal for parameter / stressor	10-yr target to meet by 2029	Restoration and protection strategies estimated rate of adoption: All= >90% Most= >60% Many/much= >30% Some= >10% Few= <10%	Estimated years to reach goal from 2019
						Land Use	Pathway				
Sediment	Marsh River	0902010701 0902010705 0902010706	09020107-503	•-503 is impaired •-517 meets standards •IF in 4 streams •Stressing aquatic life in -503 and -517	90% of stream concentrations are below 65 mg/L in class 2 waterbodies. Aquatic life populations are not stressed by sediment.	Stream bank erosion		29% Reduction (50% Reduction during very high flow and 26% Reduction during high flow)	4% Reduction	**Most** fields use surface sediment controls to prevent sediment mobilization and transport including conservation tillage, removing open intakes, cover crops, etc. **Many** fields trap/settle eroded sediment with grassed waterways or water and sediment control basins, etc. **Most** pastures are managed to prevent overgrazing and direct stream access by livestock. **All** waterbodies have adequate and well-maintained filtration buffers. **Some** larger streambank stabilization/buffer enhancement - those that threaten high value property. Address altered hydrology in contributing areas as discussed below under 'Habitat.'	50
						Riverine Erosion					
						Crop Agriculture (not tiled)	Surface RO				
						Crop Agriculture (tiled)	Surface RO; Open tile intakes				
Hydrology	Marsh River	0902010701 0902010705 0902010706	09020107-503 09020107-517	•Stressing aquatic life in -503 and -517	Increase flow during drier times of the year to ensure that low flow periods do not stress aquatic life populations. Decrease flows during wet times of the year to ensure that increased TSS does not stress (as a result of habitat loss, increased suspended sediment) aquatic life populations. Hydrology is not accelerating other parameters (excessive sedimentation, low DO, high temperature, etc.)	Crop Agriculture (not tiled)	Excess surface RO, lack of groundwater recharge	Maintain flow in all major streams (streams with AUIDs)	Measurable increase in flow during drier periods (typically late summer)	**Most** fields improve vegetative cover by using cover crops, buffers, grassed waterways, etc. **Many** fields have increased soil water holding capacity from increased soil organic matter due to conservation/no tillage, increased vegetation, etc. **Most** field drainage incorporates conservation drainage principles and/or is intercepted by ponds, wetlands, etc. that allow for infiltration. **Most** drainage projects are hydrologically mitigated to protect from further degradation. **Most** drainage and ditch projects incorporate multiple benefits including maintaining vegetation and natural stream features. **Some** non-ag land use areas add wetlands, perennial vegetation, and urban/ residential stormwater management. **Some** channel restorations and floodplain reconnection projects, starting in headwaters.	50
						Crop Agriculture (tiled)	Tile drainage, lack of groundwater recharge				
						All	Excess surface RO, lack of groundwater recharge				
Unionized Ammonia	Marsh River	0902010701 0902010705 0902010706		•Meets standards in -503 and -517 •IF in 4 streams •Not stressing aquatic life in -503 and -517	Aquatic life populations are not stressed by unionized ammonia. Reduce to support statewide and downstream goals.	Crop Agriculture	Surface RO, tile drainage, and groundwater infiltration	13 % Reduction	5% Reduction	**All** fields incorporate nutrient management principles for fertilizer and manure use. Hydrology practices as discussed above are implemented, including design parameters for N removal. Sediment practices as discussed above are implemented, including design parameters for N removal.	25
Total Phosphorus (TP)	Marsh River	0902010701 0902010705 0902010706		•IF in 6 streams	Summer stream mean concentration remains below 150 ug/L and aquatic life uses are not stressed by TP as assessed by the response stress for river eutrophication. Reduce to support statewide and downstream goals.	Stream Bank Erosion		10% Reduction	4% Reduction	**All** fields incorporate nutrient management principles for fertilizer and manure use. **Some** ditch/stream water has improved treatment via stream/ditch vegetative improvements. **All** failing SSTSs are fixed.	25
						Crop Agriculture	Surface RO				
						Pasture	Surface RO				
						Developed	Sanitation (WWTPs and SSTS)				
E. coli	Marsh River	0902010701 0902010705 0902010706	09020107-503	•-503 is impaired •IF in 1 stream	Average monthly geometric mean of samples in class 2 streams is below 126 org/100mL.	Crop Agriculture (with manure application);	Surface and feedlot RO	20% Reduction during mid-range flows	7% Reduction	**All** manured fields incorporate best manure management practices. **Many** manured fields incorporate infield and edge of field vegetative	20

Parameter / stressor	Planning region (1W1P)	10-HUC subwatershed	Impaired waterbody (AUID)	Identified conditions [a]	Water quality goal (summarized)	Pollutant / stressor sources: Land Use	Pollutant / stressor sources: Pathway	Watershed-wide goal for parameter / stressor	10-yr target to meet by 2029	Restoration and protection strategies estimated rate of adoption: All= >90% Most= >60% Many/much= >30% Some= >10% Few= <10%	Estimated years to reach goal from 2019
						Pasture (overgrazed)	Pasture RO			practices to capture manure RO including cover crops, buffer strips, etc. **Much** of the pastureland is to be managed to reduce surface manure RO. **Most** manure feed lot pile RO is controlled. **All** failing SSTSs are fixed.	
						Developed	Sanitation (WWTPs and SSTS)				
Habitat	Marsh River	0902010701 0902010705 0902010706	09020107-503 09020107-517	•Stressing aquatic life in -503 and -517	Maintain habitat connectivity by addressing altered hydrology and sediment strategies (above). Remove barriers to fish passage (high gradient culvert)	Degraded riparian corridor		10% Increase	4% Increase	**Many** streams have adequate buffer size and vegetation to meet shading, woody debris, geomorphology, and other habitat needs. Implement hydrology and sediment practices as discussed above.	30
						Altered hydrology					
Dissolved oxygen (DO)	Marsh River	0902010701 0902010705 0902010706	09020107-503	•-503 is impaired [b] •IF in 6 streams [b] •Stressing aquatic life in -503 and -517	Concentrations are above 5 mg/L, with DO flux not excessive.	Land use stressors (phosphorus, altered hydrology, degraded riparian corridor)		Meet eutrophication standard (function of TP, hydrology, and habitat)	Meet P, hydrology, and habitat goals	Address hydrology, P, and habitat practices as discussed above.	25

[a] Note that **IF** means **Insufficient Information** where some data were available but were too limited for assessments.

[b] While data was too limited to assess -503 for dissolved oxygen in 2016, -503 has been listed as impaired for aquatic life use due to low dissolved oxygen since 2010.

Table 15: Strategies that can be implemented to meet help meet water quality goals in the Marsh River Watershed.

Land use	Restoration and Protection Strategies [a] Common management practices by land use	BMP mode of action (By pollutant or stressor [b]): Sediment	Hydrology	Nitrogen	Phosphorus	*E. coli*	Habitat	Responsibility (Practice design, construction, and maintenance): Farm Owners	Farm Operators	Residents	Conservation Non-profit	Businesses	Municipalities	Ag Industry/Groups	Watershed Org.	Drainage Auth	SWCD	P&Z/Environ.	Feedlot Staff	Elected Officials	Transportation Auth.	MPCA	DNR	BWSR	MDA	MDH	U of M Extension	USDA	USFWS	Corps of Eng.
Cultivated Crops	Improved fertilizer management	-	-	X	X	-		•	•		•			•			•		•			•		•	•	•	•	•		
	Grassed waterway	X	-	X	-	-		•	•		•						•	•				•		•	•			•		
	Conservation tillage	X	-	-	X			•	•		•			•			•							•	•		•	•		
	Crop rotation (including small grain)			X	-			•	•		•			•			•		•					•	•		•	•		
	Improved manure field application	-	-	X	-	-		•	•		•			•			•	•	•	•		•		•			•	•		
	Cover crops	X	-	-	X	-		•	•		•			•			•						•	•	•		•	•		
	WASCOBS, terraces, flow-through basins	X	X	-	X	-		•	•						•		•					•		•	•			•		
	Buffers, border filter strips		-	X	-	X	X	•	•	•	•			•		•	•	•		•		•	•	•	•		•	•	•	
	Contour strip cropping (50% crop in grass)	X	X	X	X	X	-	•	•					•			•							•	•		•	•		

Land use	Restoration and Protection Strategies [a] Common management practices by land use	BMP mode of action By pollutant or stressor [b]						Responsibility Practice design, construction, and maintenance																						
		Sediment	Hydrology	Nitrogen	Phosphorus	*E. coli*	Habitat	Farm Owners	Farm Operators	Residents	Conservation Non-profit	Businesses	Municipalities	Ag Industry/Groups	Watershed Org.	Drainage Auth	SWCD	P&Z/Environ.	Feedlot Staff	Elected Officials	Transportation Auth.	MPCA	DNR	BWSR	MDA	MDH	U of M Extension	USDA	USFWS	Corps of Eng.
	Wind Breaks	-			-			•	•	•	•						•							•				•		
	Conservation cover (replacing marginal farmed areas)	X	X	X	X	X	-	•	•		•						•			•		•	•	•				•	•	
	In/near ditch retention/treatment	-	-	-	-	-		•	•		•		•	•	•	•	•							•				•		
	Alternative tile intakes	X			X	-		•	•		•			•		•	•		•	•		•		•	•		•	•		
	Treatment wetland (for tile drainage system)		-	X	-			•	•	•	•		•			•	•	•		•		•	•	•	•	•	•	•	•	
	Controlled drainage, drainage design		X	X	-			•	•		•			•		•	•							•				•		
	Saturated buffers		-	X	-			•	•		•					•	•							•	•			•		
	Wood chip bioreactor			X	-			•	•		•					•	•							•	•			•		
	Wetland Restoration	X	X	X	X	X	X	•	•	•	•					•	•						•	•				•	•	•
	Retention Ponds	X	X	X	X	X	-	•	•	•	•						•							•				•		
	Mitigate agricultural drainage projects	X	X	X	X	X	-	•	•		•						•	•					•	•				•		•
	Maintenance and new enrollment of BMPs, CRP, RIM, etc.	X	X	X	X	X	-	•	•	•	•						•	•					•	•				•	•	
Pastures	Rotational grazing/improved pasture vegetation management	X			X	X	X	•	•		•						•	•	•				•	•	•			•	•	
	Livestock stream exclusion and watering facilities	X			X	X	X	•	•		•						•	•	•				•	•	•			•	•	
Cities & yards	Nutrient/fertilizer and lawn mgt.	-	-	-	-	-				•	•	•	•				•	•		•					•		•			
	Infiltration/retention ponds, wetlands	-	-	X	-					•	•	•	•					•		•	•				•		•			•
	Rain gardens, rain barrels		-							•	•	•	•					•		•		•		•			•			
	Street sweeping & storm sewer mgt.	-								•	•	•	•					•		•	•	•					•			
	Trees/native plants	-			-					•	•	•	•				•						•				•		•	
	Snow pile management		-							•		•	•					•		•	•									

Land use	Restoration and Protection Strategies [a] Common management practices by land use	BMP mode of action By pollutant or stressor [b]						Responsibility Practice design, construction, and maintenance																						
		Sediment	Hydrology	Nitrogen	Phosphorus	*E. coli*	Habitat	Farm Owners	Farm Operators	Residents	Conservation Non-profit	Businesses	Municipalities	Ag Industry/Groups	Watershed Org.	Drainage Auth	SWCD	P&Z/Environ.	Feedlot Staff	Elected Officials	Transportation Auth.	MPCA	DNR	BWSR	MDA	MDH	U of M Extension	USDA	USFWS	Corps of Eng.
	Permeable pavement for new construction	-	-							•		•	•							•	•									
	Construction site erosion control	X	X	-	X		-			•		•	•		•			•		•	•	•								
SSTS	Maintenance and replacement/upgrades			X	X	X		•		•		•	•	•				•		•	•	•	•	•	•	•	•			
Feedlots	Feedlot RO controls including: buffer strips, clean water diversions, etc. on feedlots with RO			X	X	X		•	•		•			•			•	•	•	•		•		•	•	•	•	•		
Streams, ditches, & ravines	Protect and restore buffers, natural features	X	X	X			X	•	•	•	•	•	•	•	•	•	•	•		•	•		•	•			•	•		
	Reduce or eliminate ditch clean-outs	X		X			X	•					•		•	•	•	•		•			•	•						
	Bridge/culvert design	X	X				X										•			•	•		•							•
	Streambank stabilization	X		X	X		-	•	•		•		•	•	•	•	•			•	•		•	•			•	•		
	Ravine/stream (grade) stabilization	X		X	X			•	•		•		•	•	•	•	•			•	•		•	•			•	•		
	Stream channel restoration and floodplain reconnection	X		X	X		X	•	•		•		•	•	•	•	•			•	•		•	•			•	•		•
Lakes & Wetlands	Near-water vegetation protection and restoration	X		X	X		X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	In-water management and species control			X	-		X			•	•	•					•	•		•		•	•	•			•		•	
Grassland & Forest	Protect and restore areas in these land uses, increase native species populations	X	-	X	X		X	•	•	•	•		•	•		•	•	•		•	•		•	•	•	•	•	•	•	

[a] Table 16 includes additional information regarding specific restoration and protection strategies.

[b] "X" = strong benefit to water quality improvement as related to the specified parameter, "-" = moderate benefit to water quality as related to the specified parameter, blank = little benefit to water quality as related to the specified parameter.

Table 16: Additional information for restoration and protection strategies.

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
Total Suspended Solids (TSS)	**Improve upland/field surface RO controls:** Soil and water conservation practices that reduce soil erosion and field RO, or otherwise minimize sediment from leaving farmland.	Cover crops
		Water and sediment basins, terraces
		Rotations including perennials
		Conservation cover easements
		Grassed waterways
		Strategies to reduce flow – some of flow reduction strategies should be targeted to ravine sub-watersheds
		Residue management – conservation tillage
		Forage and biomass planting
		Open tile inlet controls – riser pipes, french drains
		Contour farming
		Field edge buffers, borders, windbreaks and/or filter strips
		Strip-cropping
	Protect/stabilize banks/bluffs: Reduce collapse of bluffs and erosion of streambank by reducing peak river flows and using vegetation to stabilize these areas.	Strategies for altered hydrology (reducing peak flow)
		Streambank stabilization
		Riparian forest buffer
		Livestock exclusion – controlled stream crossings
	Stabilize ravines: Reducing erosion of ravines by dispersing and infiltrating field RO and increasing vegetative cover near ravines. Also may include earthwork/regrading and revegetation of ravine.	Field edge buffers, borders, windbreaks and/or filter strips
		Contour farming and contour buffer strips
		Diversions
		Water and sediment control basin
		Terrace
		Conservation crop rotation
		Cover crop
		Residue management – conservation tillage
	Stream channel restoration	Addressing road crossings (direct erosion) and floodplain cut-offs
		Clear water discharge: urban areas, ag tiling etc. – direct energy dissipation
		Two-stage ditches

Parameter (include non-pollutant stressors)	Strategy key	
	Description	Example BMPs/actions
		Large-scale restoration – channel dimensions match current hydrology and sediment loads, connect the floodplain, stable pattern, (natural channel design principals)
		Stream channel restoration using vertical energy dissipation: step pool morphology
	Improve forestry management	Proper water crossings and road construction
		Forest roads - cross-drainage
		Maintaining and aligning active forest roads
		Closure of inactive roads and post-harvest
		Location and sizing of landings
		Riparian Management Zone Widths and/or filter strips
	Improve urban stormwater management [to reduce sediment and flow]	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
Nitrogen (N) or Nitrate	**Increase fertilizer and manure efficiency:** Adding fertilizer and manure additions at rates and ways that maximize crop uptake while minimizing leaching losses to waters	N rates at maximum return to N (U of MN rec's)
		Timing of application closer to crop use (spring or split applications)
		Nitrification inhibitors
		Manure application based on nutrient testing, calibrated equipment, recommended rates, etc.
	Store and treat tile drainage waters: Managing tile drainage waters so that nitrate can be denitrified or so that water volumes and loads from tile drains are reduced	Saturated buffers
		Restored or constructed wetlands
		Controlled drainage
		Woodchip bioreactors
		Two-stage ditch
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and capturing of soil nitrate by roots during the spring, summer and fall.	Conservation cover (easements/buffers of native grass and trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
		Crop conversion to low nutrient-demanding crops (e.g., hay).
Phosphorus (P)	**Improve upland/field surface RO controls:** Soil and water conservation practices that reduce soil erosion and	Strategies to reduce sediment from fields (see above - upland field surface RO)
		Constructed wetlands
		Pasture management

Parameter (include non-pollutant stressors)	Strategy key	
	Description	Example BMPs/actions
	field RO, or otherwise minimize sediment from leaving farmland	
	Reduce bank/bluff/ravine erosion	Strategies to reduce TSS from banks/bluffs/ravines (see above for sediment)
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and minimize erosion and soil losses to waters, especially during the spring and fall.	Conservation cover (easements/buffers of native grass and trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
	Preventing feedlot RO**:** Using manure storage, water diversions, reduced lot sizes and vegetative filter strips to reduce open lot P losses	Open lot RO management to meet Minn. R. 7020 rules
		Manure storage in ways that prevent RO
	Improve fertilizer and manure application management: Applying P fertilizer and manure onto soils where it is most needed using techniques that limit exposure of P to rainfall and RO.	Soil P testing and applying nutrients on fields needing P
		Incorporating/injecting nutrients below the soil
		Manure application meeting all 7020 rule setback requirements
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Sewers around lakes
		Eliminating straight pipes, surface seepages
	Reduce in-water loading: Minimizing the internal release of P within lakes	Rough fish management
		Curly-leaf pondweed management
		Alum treatment
		Lake drawdown
		Hypolimnetic withdrawal
	Improve forestry management	See forest strategies for sediment control
	Reduce Industrial/Municipal wastewater TP	Municipal and industrial treatment of wastewater P
		Upgrades/expansion. Address inflow/infiltration.

Parameter (include non-pollutant stressors)	Strategy key	
	Description	Example BMPs/actions
	Treat tile drainage waters: Treating tile drainage waters to reduce P entering water by running water through a medium which captures P	P-removing treatment systems, including bioreactors
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
E. coli	**Reducing livestock bacteria in surface RO:** Preventing manure from entering streams by keeping it in storage or below the soil surface and by limiting access of animals to waters.	Strategies to reduce field TSS (applied to manured fields, see above)
		Improved field manure (nutrient) management
		Adhere/increase application setbacks
		Improve feedlot RO control
		Animal mortality facility
		Manure spreading setbacks and incorporation near wells and sinkholes
		Rotational grazing and livestock exclusion (pasture management)
	Reduce urban bacteria: Limiting exposure of pet or waterfowl waste to rainfall	Pet waste management
		Filter strips and buffers
		See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Replace failing septic (SSTS) systems
		Maintain septic (SSTS) systems
	Reduce industrial/municipal wastewater bacteria	Reduce straight pipe (untreated) residential discharges
		Reduce WWTP untreated (emergency) releases
Dissolved Oxygen	Reduce P	See strategies above for reducing P
	Increase river flow during low flow years	See strategies above for altered hydrology
	In-channel restoration: Actions to address altered portions of streams.	Goal of channel stability: transporting the water and sediment of a watershed without aggrading or degrading.
		Restore riffle substrate
Chloride	Road salt management	[Strategies currently under development within Twin Cities Metro Area Chloride Management Plan]

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
Altered hydrology; peak flow and/or low base flow (Fish/Macroinvertebrate IBI)	**Increase living cover:** Planting crops and vegetation that maximize vegetative cover and evapotranspiration especially during the high flow spring months.	Grassed waterways
		Cover crops
		Conservation cover (easements and buffers of native grass and trees, pollinator habitat)
		Rotations including perennials
	Improve drainage management: Managing drainage waters to store tile drainage waters in fields or at constructed collection points and releasing stored waters after peak flow periods.	Treatment wetlands
		Restored wetlands
	Reduce rural RO by increasing infiltration: Decrease surface RO contributions to peak flow through soil and water conservation practices.	Conservation tillage (no-till or strip till w/ high residue)
		Water and sediment basins, terraces
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve irrigation water management: Increase groundwater contributions to surface waters by withdrawing less water for irrigation or other purposes.	Groundwater pumping reductions and irrigation management
Poor habitat (Fish/Macroinvertebrate IBI)	**Improve riparian vegetation:** Planting and improving perennial vegetation in riparian areas to stabilize soil, filter pollutants and increase biodiversity	50' vegetated buffer on waterways
		One rod ditch buffers
		Lake shoreland buffers
		Increase conservation cover: in/near water bodies, to create corridors
		Improve/increase natural habitat in riparian, control invasive species
		Tree planting to increase shading
		Streambank and shoreline protection/stabilization
		Wetland restoration
		Accurately size bridges and culverts to improve stream stability
	Restore/enhance channel: Various restoration efforts largely aimed at	Retrofit dams with multi-level intakes
		Restore riffle substrate
		Two-stage ditch

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
	providing substrate and natural stream morphology.	Dam operation to mimic natural conditions
		Restore natural meander and complexity
Water temperature	Maintain adequate flow	Address altered hydrology to increase baseflow
	Improve riparian vegetation: Actions primarily to increase shading, but also some infiltration of surface RO.	Riparian vegetative buffers
		Tree planting to increase shading
Connectivity (Fish IBI)	**Remove fish passage barriers:** Identify and address barriers.	Remove impoundments
		Properly size and place culverts for flow and fish passage
		Construct by-pass
All [protection-related]	**Implement volume control/limited-impact development:** This is aimed at development of undeveloped land to provide no net increase in volume and pollutants	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php

4. Monitoring plan

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. Accordingly, as a very general guideline, progress benchmarks are established for this watershed that assume that improvements will occur, resulting in a water quality pollutant concentration decline each year. Improvement is assumed to occur at a rate of 0.5% to 1% improvement (reduction or increase) per year. For instance, if the overall TP reduction goal is 13% and the 10-year reduction goal is a 5%, the desired load reduction for year one would be a 0.5% reduction, with equivalent reductions occurring year over year.

Again, this is a general guideline. Factors that may lead to slower progress include limits in funding or landowner acceptance, challenging fixes (e.g., unstable bluffs and ravines, invasive species) and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur. Progress toward water quality goals can be monitored and compared against modeled results from an existing HSPF-SAM study (**Appendix C**). HSPF-SAM was used to estimate improvements in water quality based on three scenarios representing different levels of BMP implementation. Scenario 1 represents the most conservative implementation (suggesting slower progress toward water quality goals), whereas Scenario 3 represents an aggressive implementation of BMPs (suggesting more rapid progress toward water quality goals).

The foundation of effective water quality monitoring is the collection and analysis of water samples. Although the historical water quality measurement record for the MRW dates back to 1962, the available data is sparse, both spatially and temporally. The MRW WRAPS focuses on the 10-year assessment period (2006 through 2015). During the final years of the WRAPS assessment period (2014 to 2015), an IWM program was performed to fill in several data gaps. In spite of this effort, more data is still needed to initially assess impairment within a majority of reaches in the watershed.

Stream monitoring within the MRW will continue primarily through the efforts of the WRWD and the MPCA. As outlined in the Section 5.2.3 of the WRWD WMP, the WRWD has established current and future monitoring goals for water quality throughout the watershed. This effort is aimed at collecting current measurements of water quality parameters and building a more robust data set for analyzing long-term trends in water quality within the watershed. This includes the district's involvement in the River Watch program, which involves citizens in monitoring local waterbodies. In addition to the stream monitoring supported by the WRWD, the MPCA also has ongoing monitoring in the watershed.

The MPCA has three water quality monitoring programs with the purpose of collecting data to create a long-term data set to track progress towards water quality goals and enable water quality condition assessments to be completed. These programs will continue (or hopefully begin, as is the case for the citizen monitoring program) to collect and analyze data in the MRW as part of Minnesota's Water Quality Monitoring Strategy (MPCA, 2011). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. The three monitoring programs are the IWM Program, Watershed Pollutant Load Monitoring Network, and Citizen Stream and Lake Monitoring Program.

IWM (MPCA, 2017) data provides a periodic but intensive "snapshot" of water quality throughout the watershed. This program collects water quality and biological data at stream monitoring stations across the watershed for a period of 1 to 2 years, on a 10-year cycle. The most recent IWM occurred in 2014 and 2015. To measure pollutant trends and conditions across the watershed, the MPCA will re-visit and re-assess the watershed, as well as monitoring new sites in areas of interest. This work is scheduled to start its second iteration in the MRW in 2024.

Watershed Pollutant Load Monitoring Network (MPCA, 2019) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, sediment, and nutrient loads. In the MRW, not including sites on the mainstem of the Red River, there is one load monitoring site (W59007001) on the Marsh River near Shelly, Minnesota.

Citizen Stream and Lake Monitoring Programs (MPCA, 2020) data provide a continuous record of waterbody transparency throughout many of the watersheds in the state. This program, much like the district River Watch Program, relies on a network of private citizen volunteers who make monthly lake and river measurements. However, there are no citizens currently enrolled in these monitoring programs in the MRW.

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6. Appendices

Appendix A: Protection and Restoration in the Marsh River Watershed.

Based on a technical memorandum by Houston Engineering, Inc. provided to MPCA on August 6, 2019.

Introduction

All streams currently supporting aquatic life and aquatic recreation in the MRW are candidates for protection. Over time, these waters could be subjected to land uses or stressors that could cause them to become impaired. Watershed managers and stakeholders should seek opportunities to identify and implement protection strategies on all unimpaired waterbodies. For streams, rivers, and lakes, the protection strategy consists of working toward ensuring that the existing loads for the critical duration periods are not exceeded.

Designation of streams as candidates for protection or restoration is important in aligning with the Board of Soil and Water Resources' (BWSR) Nonpoint Priority Funding Plan for Clean Water Funding Implementation (BWSR, 2018) and Minnesota's Clean Water Roadmap (Minnesota Interagency Team, 2014). For this reason, assessed streams are designated as either "protection" or "restoration" based on water quality data. Once designated as protection or restoration, streams and lakes are further divided into subcategories based on water quality monitoring data to reflect priorities in the Nonpoint Priority Funding Plan for Clean Water Funding Implementation.

Streams

Stream reaches were prioritized and classified into Protection or Restoration classes based on existing water quality data. Both protection and restoration classes are further divided into subclasses. Streams within the "protection" category are subdivided into three subcategories: Above Average Quality, Potential Impairment Risk, and Threatened Impairment Risk. Streams within the "restoration" category are subdivided into two subcategories: Low Restoration Effort and High Restoration Effort.

Stream Protection and Restoration Categories

Stream protection and restoration categories were determined based on 10 years of water quality data from 2007 through 2016 for five parameters, DO, TSS, TP, unionized ammonia, and *E. coli*. The lower limit on the number of samples required for this analysis is five for DO, TSS, TP, and unionized ammonia and three in a given month for *E. coli*. This is lower than what is required for MPCA to assess streams against state standards in order to categorize more stream reaches and parameters into protection/restoration subcategories. Depending on the parameter, there may be further limitations and requirements for MPCA assessments that were not considered for this analysis (which also allowed for more streams and parameters to be categorized). The standards (i.e., concentrations) for each parameter that are used for MPCA assessments are the same ones used for this analysis.

The following is a sampling of some of the limitations and requirements needed for MPCA assessments. Class 2 stream assessments require 12 (for TP) or 20 (for DO and TSS) samples over two years and at least five samples in a given month for *E. coli*. Determining whether an impairment caused by eutrophication is present requires assessment of not only TP, but response parameters as well (chlorophyll-a, five-day biochemical oxygen demand [BOD_5], diel DO flux, or pH levels).

Due to there being so many differences between methods used for this analysis and those used for assessments, a restoration classification may not mean a waterbody is impaired for a specific parameter.

Descriptions of the stream categories and water quality attributes for each class are provided below, followed by a list of MRW classification results in **Table A-1**.

Protection Categories

All streams currently supporting aquatic life and aquatic recreation are candidates for protection. Over time, these waters could be subjected to land uses or stressors that could cause them to become impaired. For purposes of this analysis, streams within the "protection" category are subdivided into three subcategories: Above Average Quality, Potential Impairment Risk, and Threatened Impairment Risk.

Above Average Quality

A reach of a stream (i.e., Assessment Unit Identification Number [AUID]) is exhibiting Above Average Quality for a water quality parameter if one of the following conditions are met:

- The data requirements of MPCA assessment methods are met, there's no impairment, and the 90^{th} percentile (TSS, DO, unionized ammonia), average (TP), or the geometric mean (*E. coli*) of concentrations is less than 75% of the numeric water quality standard; or
- The data requirements of MPCA assessment methods are not met (have less than the required number of samples over the required timeframe for example) yet there is a minimum of five samples (or three samples per month for *E. coli*), no samples exceed the numeric water quality standard, and the 90^{th} percentile (TSS, DO, unionized ammonia), average (TP), or geometric mean (*E. coli*) of concentrations is less than 75% of the numeric water quality standard.

Table A-1 lists the water quality parameters classified as Above Average Quality by AUID.

Potential Impairment Risk

An AUID is exhibiting Potential Impairment Risk for a water quality parameter if water quality conditions are "near" but not exceeding the numeric water quality standard as determined by meeting one of the following conditions:

- The data requirements of MPCA assessment methods are met and the 90^{th} percentile (TSS, DO, unionized ammonia), average (TP), or the geometric mean (*E. coli*) of concentrations exceeds 75% , but is less than 90% of the numeric water quality standard; or
- The data requirements of MPCA assessment methods are not met (have less than the required number of samples over the required timeframe for example) yet there is a minimum of five samples (or three samples per month for *E. coli*), and the 90^{th} percentile (TSS, DO, unionized ammonia), average (TP), or geometric mean (*E. coli*) of concentrations exceeds 75% of the

numeric water quality standard, but does not exceed 90% of the numeric water quality standard.

Table A-1 lists the water quality parameters classified as Potential Impairment Risk by AUID.

Threatened Impairment Risk

An AUID is exhibiting Threatened Impairment Risk for a water quality parameter if water quality conditions are "very near" and which periodically exceed the numeric water quality standard as determined by meeting at least one the following conditions:

- The data requirements of MPCA assessment methods are met and the 90th percentile (TSS, DO, unionized ammonia), average (TP), or geometric mean (*E. coli*) of concentrations exceeds 90% , but is less than the numeric water quality standard; or
- The data requirements of MPCA are not met but there are 25% or more of the data requirements of MPCA (i.e., five or more sample for TSS and DO and three or more samples of TP and *E. coli*) and the 90th percentile (TSS, DO, unionized ammonia), average (TP), or geometric mean (*E. coli*) of concentrations is less than the numeric water quality standard, but greater than 90% , of the water quality standard; or

Table A-1 lists the water quality parameters classified as Threatened Impairment Risk by AUID.

For streams and rivers, the protection strategy consists of working toward ensuring the existing loads for the critical duration periods are not exceeded. Strategies for addressing protection of these waters were discussed previously in the main body of the *Marsh River WRAPS Report*.

Restoration Categories

AUIDs in the "restoration" categories fail to achieve some minimum threshold water quality condition. Example minimum threshold conditions include failure to achieve numeric water quality standards or a condition considered degraded or unstable such as areas of accelerated stream bank erosion, which can further contribute to degradation of water quality. Restoration classifications are further divided into Low Restoration Effort and High Restoration Effort.

Low Restoration Effort

Low Restoration Effort is defined as a degraded condition but a condition near the designated minimum threshold, for a given parameter. An example is an AUID where the numeric water quality standard is exceeded (and therefore is "impaired"), but with restoration has a high probability of attaining the numeric water quality standard for the parameter as determined by meeting at least one of the following conditions:

- The data requirements of MPCA assessment methods are met and the 90th percentile (TSS, DO, unionized ammonia), average (TP), or geometric mean (*E. coli*) of concentrations exceeds the numeric water quality standard but is less than 125% of the numeric standard; or
- The data requirements of MPCA assessment methods are not met (have less than the required number of samples over the required timeframe for example) yet there is a minimum of five samples (or three samples per month for *E. coli* and TP) and the 90th percentile (TSS, DO,

unionized ammonia), average (TP), or geometric mean (*E. coli*) of concentrations exceeds the numeric water quality standard but is less than 125% of the numeric standard.

Table A-1 lists the water quality parameters classified as Low Restoration Effort by AUID.

High Restoration Effort

High Restoration Effort are degraded and are no longer near the designated threshold for a given parameter. These surface waters have a lower probability of attaining the numeric water quality standard and may require a large effort to attain water quality compliance. Classifying a parameter for an AUID as High Restoration Effort is contingent on meeting at least one of the following conditions:

- The data requirements of MPCA assessment methods are met, there is an impairment, and the 90^{th} percentile (TSS, DO, unionized ammonia), average (TP), or geometric mean (*E. coli*) exceeds 125% of the water quality standard.
- The data requirements of MPCA assessment methods are not met (have less than the required number of samples over the required timeframe for example) yet there is a minimum of five samples (or three samples per month for *E. coli* and TP) and the 90^{th} percentile (TSS, DO, unionized ammonia), average (TP), or geometric mean (*E. coli*) exceeds 125% of the water quality standard or 25% of those samples exceed the water quality standard.

Table A-1 lists the water quality parameters classified as High Restoration Effort by AUID.

Table A-1: Protection and restoration classification of water quality parameters in stream reaches in the Marsh River Watershed.

AUID (last 3 digits)	Waterbody, reach description	Above Average Quality	Potential Impairment Risk	Threatened Impairment Risk	Low Restoration Effort	High Restoration Effort
-503	Marsh River, Headwaters to Red R	Ammonia		DO	*E. coli*	TP, TSS
-517	County Ditch 11, CD 66 to Marsh R	*E. coli*, Ammonia, TP, TSS	DO			

*DO = dissolved oxygen, *E. coli* = *Escherichia coli*, TP = total phosphorus, and TSS = total suspended solids.

Appendix B: Marsh River HSPF Priority maps

Based on a technical memorandum by Houston Engineering, Inc. provided to MPCA on March 26, 2018.

Introduction

Using results from WRRW and MRW HSPF models, areas within the MRW were prioritized to identify subwatersheds where restoration and protection strategies would be most beneficial. Subwatersheds were prioritized by ranking the area-averaged yields (pounds/acre/year) from the HSPF for RO, TP, TN, and TS. Prioritization is based solely on the potential mass leaving the landscape; considerations of other factors across the landscape (e.g., existing BMPs, Travel Time) could change the outcome of prioritizations.

The HSPF model combines both the WRRW and MRW into one model and will be referred to as the WRRW HSPF model for the remainder of this document. In HSPF, a watershed is divided into “model segments”, usually called hydrozones (**Figure B-1**), based on the location of the climate stations. Each model segment uses a unique set of climate data. Each model segment is further divided into subwatersheds with each subwatershed containing one hydrologic reach (lake, reservoir, or river). Each modeling segment is composed of multiple land segments called PERLNDs (pervious areas) and IMPLNDs (impervious areas). These PERLNDs and IMPLNDs are typically based on land uses and soil types and a subwatershed can be composed of multiple PERLND/IMPLND types. RO and water quality loadings are simulated for each PERLND/IMPLND in a modeling segment, i.e., the same flows and loadings are used across all subwatersheds in a modeling segment for each individual PERLND/IMPLND type. The amount of RO and loading differ between subwatersheds based on differing acreage of each PERLND/IMPLND type. The WRRW HSPF model is composed of eleven modeling segments (**Figure B-1**), or hydrozones, with ten covering the WRRW and three covering the MRW with two representing areas in both watersheds. The model is further divided into 172 subwatersheds with 144 subwatershed in the WRRW and 28 in the MRW. Each modeling segment, and therefore subwatershed, is divided by up to 10 landuse/soil classes (PERLNDs), or land segments, and one impervious land segment class (IMPLND), for a total of 120 possible land segments in the HSPF model (see **Figure B-2**).

Figure B-1: Set-up for the Wild Rice River Watershed's and Marsh River Watershed's HSPF model.

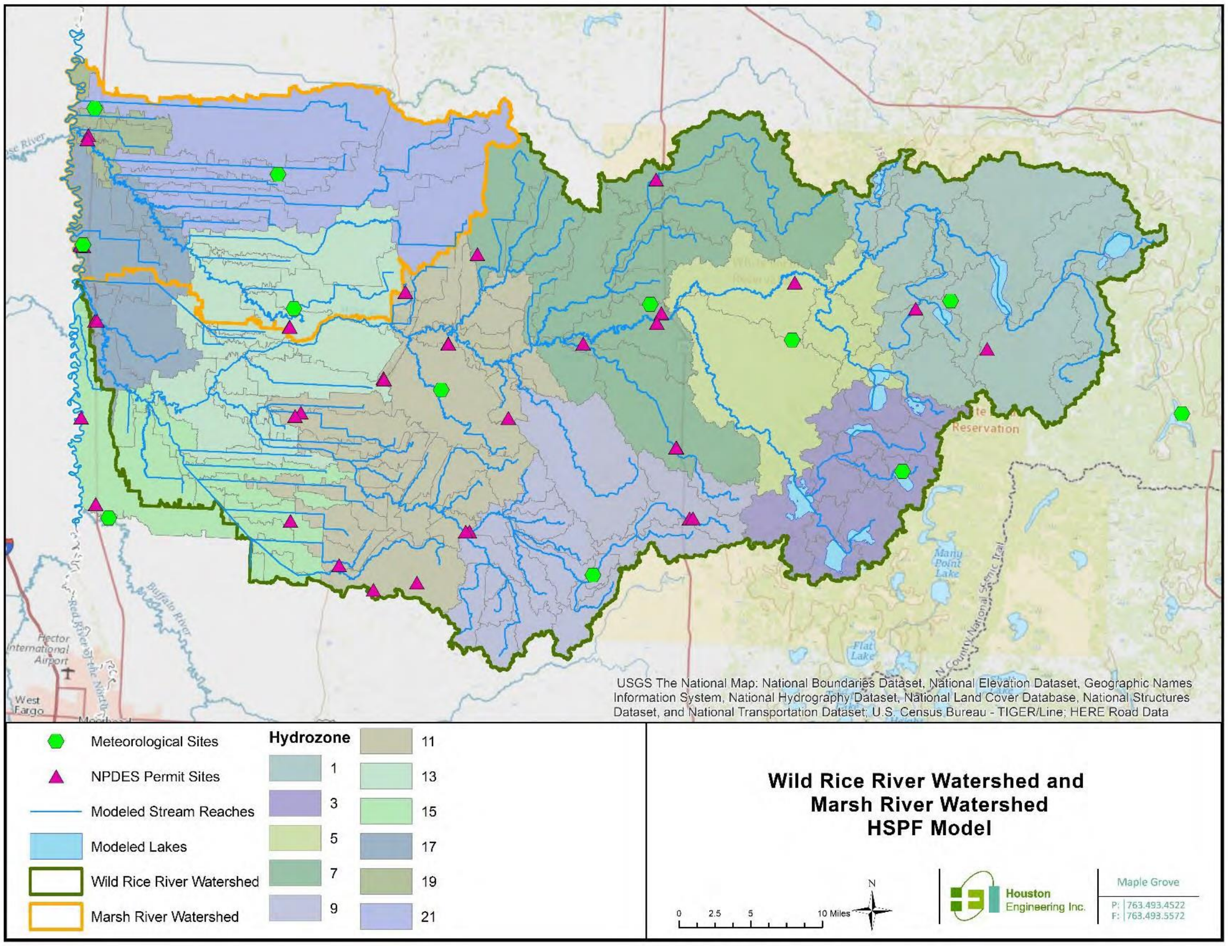
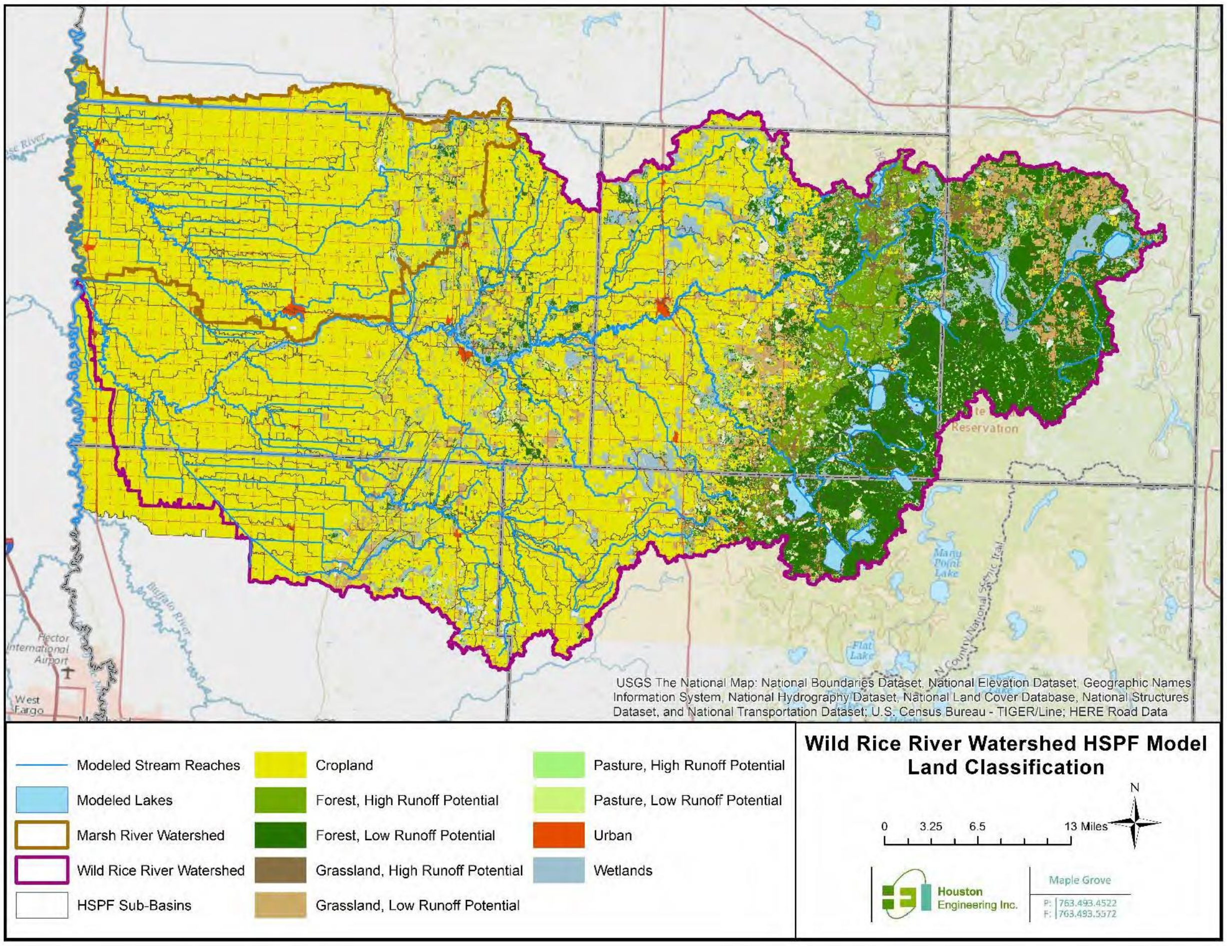


Figure B-2: Land classifications (pervious lands [PERLNDs] / impervious lands [IMPLNDs]) in the WRRW HSPF model.



The land segment classes include urban, forest-low RO potential (A/B soils), forest-high RO potential (C/D soils), cropland-high till, cropland- low till, pasture-low RO potential (A/B soils), pasture-high RO potential (C/D soils), grasslands-low RO potential (A/B soils), grassland-high RO potential (C/D soils), and wetland.

Using the HSPF model output for prioritization

Subwatershed priority rankings were developed for several stressors including altered hydrology (expressed as RO), excess nutrients (TP, TN) and turbidity and habitat alteration/geomorphology (TS). **Table B-1** shows the required outputs, by constituent and land class (PERLND, IMPLND, or RCHRES), in the HSPF model. The following is a brief description of the components used to develop the maps and shown in **Table B-1**.

In HSPF, RO from a land segment has three components: surface RO, interflow, and active groundwater flow. For PERLNDs, RO is taken as the sum of the three flow components and is outputted. RO from IMPLNDs only has a surface RO component. In-channel (RCHRES) streamflow was not used in this analysis.

Overland TP loading is the sum of inorganic P loading and organic P loading. Inorganic P is simulated directly using the PQUAL group. Inorganic P is taken as a fraction of the organic material simulated as biological oxygen demand (BOD). For pervious land segments (PERLNDs), differing factions of organic P is used for surface RO, interflow, and active groundwater flow (see **Table B-1**). In-channel TP loading has various forms but can be extracted from HSPF as TP using the PLANK group. In-channel TP flux is taken as the difference between TP inflow and TP outflow for the hydrologic reach.

Like TP, overland TN has multiple forms and is taken as the summation of unionized ammonia (NH3), nitrate-nitrite (NO2/NO3), and organic N loadings. NH3 and NO2/NO3 are simulated directly using the PQUAL group. Organic N is taken as a fraction of the organic material simulated as BOD with varying fractions for different flow types (surface RO, interflow, and active groundwater) (see **Table B-1**). In-channel TN loading has various forms but can be extracted from HSPF as TN using the PLANK group. In-channel TN flux is taken as the difference between TN inflow and TN outflow for the hydrologic reach.

Overland sediment can be extracted directly from the HSPF model as TS from overland sources using the SEDMNT group for PERLNDs and SOLIDS group for IMPLNDs. In-channel sediment loading and sediment flux can be extracted directly using the SEDTRN group. In-channel sediment flux can be taken as the change in bed storage.

Table B-1: HSPF model outputs for RO, TP, TN, and TS used to prioritize subwatersheds for implementation.

Parameter	Description	Volume	Group	Variable	x1	x2	Factor
Runoff (RO)	Total runoff from pervious areas	PERLND	PWATER	PERO	1	1	
	Surface water runoff for impervious areas	IMPLND	IWATER	SURO	1	1	
Total Phosphorus (TP)	Total flux of inorganic P (PO4)	PERLND	PQUAL	POQUAL	3	1	
	Portion of BOD composed of organic P in Surface runoff	PERLND	PQUAL	SOQUAL	4	1	0.0005
	Portion of BOD composed of organic P in active groundwater	PERLND	PQUAL	AOQUAL	4	1	0.0004
	Portion of BOD composed of organic P in interflow	PERLND	PQUAL	IOQUAL	4	1	0.0005
	Total flux of inorganic P (PO4)	IMPLND	IQUAL	SOQUAL	3	1	
	Portion of BOD composed of organic P in Surface runoff	IMPLND	IQUAL	SOQUAL	4	1	0.0005
	Total inflow of TP	RCHRES	PLANK	TPKIF	5	1	
	Total outflow of TP	RCHRES	PLANK	TPKCF1	5	1	
Total Nitrogen (TN)	Total flux of Unionized Ammonia (NH3)	PERLND	PQUAL	POQUAL	2	1	
	Total flux of Nitrate-Nitrite (NO2NO3)	PERLND	PQUAL	POQUAL	3	1	
	Portion of BOD composed of organic N in Surface runoff	PERLND	PQUAL	SOQUAL	4	1	0.0407
	Portion of BOD composed of organic N in active groundwater	PERLND	PQUAL	AOQUAL	4	1	0.0488
	Portion of BOD composed of organic N in interflow	PERLND	PQUAL	IOQUAL	4	1	0.0407
	Total flux of Unionized Ammonia (NH3)	IMPLND	IQUAL	SOQUAL	2		
	Total flux of Nitrate-Nitrite (NO2NO3)	IMPLND	IQUAL	SOQUAL	3		
	Portion of BOD composed of organic N in Surface runoff	IMPLND	IQUAL	SOQUAL	4	1	0.0407
	Total inflow of TN	RCHRES	PLANK	TPKIF	4	1	

Parameter	Description	Volume	Group	Variable	x1	x2	Factor
	Total outflow of TN	RCHRES	PLANK	TPKCF1	4	1	
Total Sediment (TS)	Total Sediment	PERLND	SEDMNT	SOSED	1	1	
	Total Solids	IMPLND	SOLIDS	SOSLD	1	1	
	Inflow of Sediment	RCHRES	SEDTRN	ISED	4	1	
	Outflow Sediment	RCHRES	SEDTRN	ROSED	4	1	
	Sediment Flux/Change in Storage	RCHRES	SEDTRN	DEPSCR	4	1	

Developing subwatershed priority maps using yields

The prioritization of subwatersheds occurred at two scales; i.e., the entire watershed and major tributary (see **Figure B-19**). Prioritization at multiple scales is necessary because the results change depending upon the location of the impaired resource in the watershed. Prioritization maps were generated using results extracted from the WRRW HSPF model for the period 1996 through 2009. Average yields and loads were extracted, summarized, and used to generate the prioritization maps. Prioritization maps were developed for RO, TP, TN, and TS based on related stressors used in the SID work for biological impairments. The stressors include altered hydrology (using RO), excessive nutrients (using TN and TP), loss of habitat (using TS), and elevated turbidity (using TS).

The priority rankings maps are developed ranking the average subwatershed yields to identify specific priority subwatersheds which should be preferentially considered for targeting fields for practice implementation. The rankings are from largest to smallest yields and are used to calculate their percentile rank. The ranks are then summarized as the lowest priority (lowest 10%), low priority (10% to 25%), moderate priority (25% to 75%), high priority (75% to 90%), and highest priority (highest 10%). The highest priority subwatersheds with the highest yields and most likely would benefit the most from implementation and protective strategy management. For the major tributary maps, the yields were re-ranked, only using the subwatersheds draining to the tributary.

In addition to the priority rankings maps, an overall water quality index (WQI) map was generated. The WQI (e.g., **Figure B-15**) represents the combined importance of nutrients and sediment and is estimated using:

WQI = 0.5*Sediment Ranking + 0.25*TP Ranking + 0.25*TN Ranking

These maps should be used when the practitioner wishes to consider establishing priority based on both excess nutrients and sediment as stressors.

The priority mapping in MRW is divided into three sections: (1) MRW Yields Maps, which provides watershed-scale maps of the average yields used to develop the prioritizations maps for the landscape yields (land segment scale) and average subwatershed scale (average yields across the subwatershed or delivered to the channel); (2) MRW Prioritization mapping, which provide prioritization maps at the watershed-scale and field-stream index mapping; and (3) Major Tributary Scale Prioritization mapping, which provide prioritization maps for the drainage are of impaired reaches.

Marsh River Watershed yields

The following maps provide the yields for the MRW extracted from the WRRW HSPF model, including yield leaving the land scape (at the land segment or PERLND scale) (**Figure B-3** through **Figure B-6**) and yields entering the channel (at the subwatershed scale) (**Figure B-7** through **Figure B-10**). The yields leaving the landscape are the annual average yields by land segment (PERLND/IMPLND) for RO, TP, TN, and TS. The yields entering the channel (subwatershed scale) are the area-weighted average landscape yields within the subwatershed. The yield maps can be used to complete pollutant sources assessments. They show which subwatersheds are the largest sources of RO, nutrients and sediment per area delivered to the channel (edge of field). The yield maps are used to generate the prioritization maps.

Figure B-3 provides the average annual (1996 through 2009) RO (in/yr) yield leaving the landscape for each land segment in the HSPF model. **Figure B-4** provides the average annual (1996 through 2009) TP (lbs/ac/yr) yield leaving the landscape for each land segment in the HSPF model. **Figure B-5** provides the average annual (1996 through 2009) TN (lbs/ac/yr) yield leaving the landscape for each land segment in the HSPF model. **Figure B-6** provides the average annual (1996 through 2009) TS (lbs/ac/yr) yield leaving the landscape for each land segment in the HSPF model. **Figure B-7** provides the average annual (1996 through 2009) RO (in/yr) yield entering the channel for each subwatershed in the HSPF model. **Figure B-8** provides the average annual (1996 through 2009) TP (lbs/ac/yr) yield entering the channel for each subwatershed in the HSPF model. **Figure B-9** provides the average annual (1996 through 2009) TN (lbs/ac/yr) yield entering the channel for each subwatershed in the HSPF model. **Figure B-10** provides the average annual (1996 through 2009) TS (lbs/ac/yr) yield entering the channel for each subwatershed in the HSPF model.

The numeric values extracted from HSPF for each land segment and subwatershed used to develop the yield maps are provided in **Table B-2**.

Figure B-3: Average (1996-2009) runoff (of water) leaving the landscape for the Marsh River Watershed portion of WRRW HSPF model.

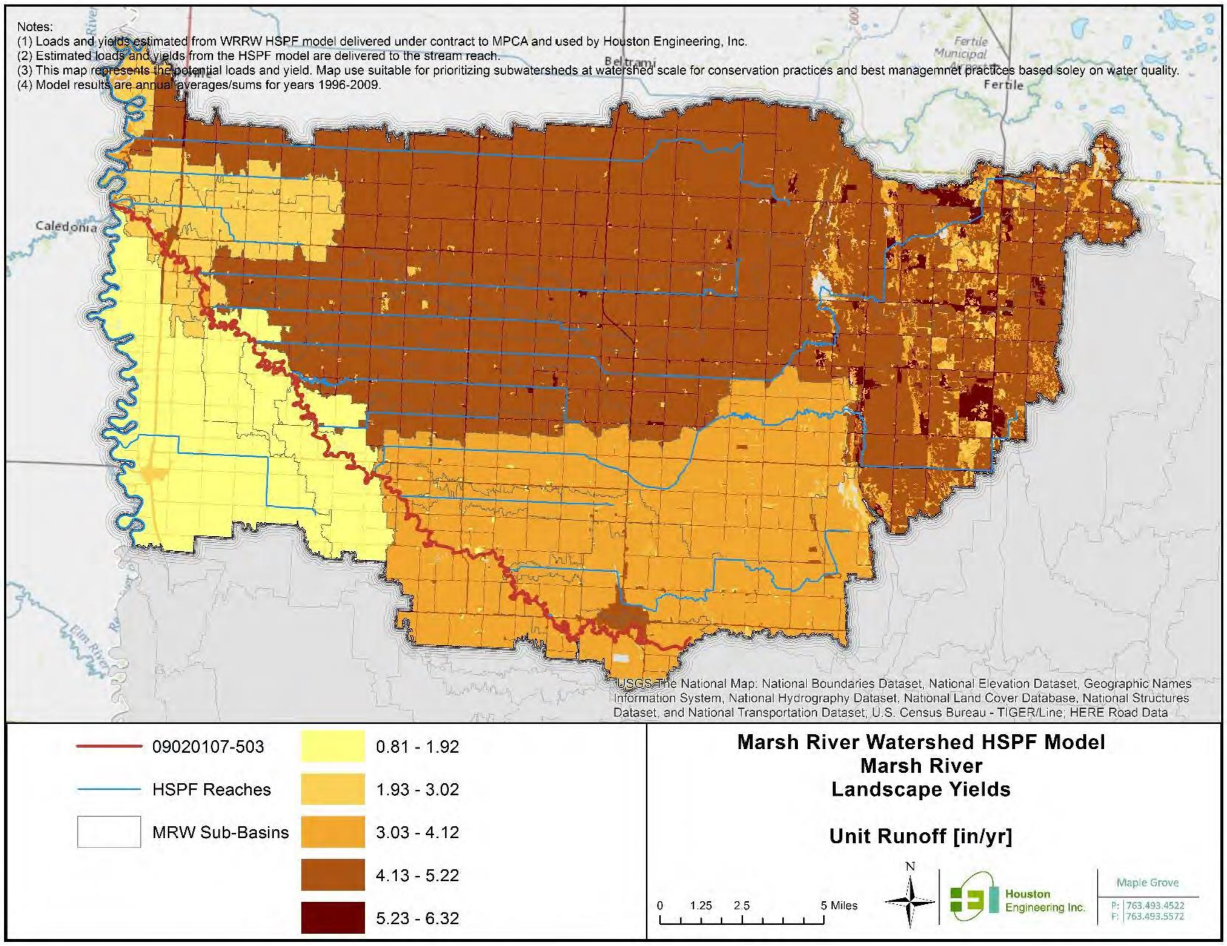


Figure B-4: Average (1996-2009) total phosphorus yield leaving the landscape for the Marsh River Watershed portion of the WRRW HSPF model.

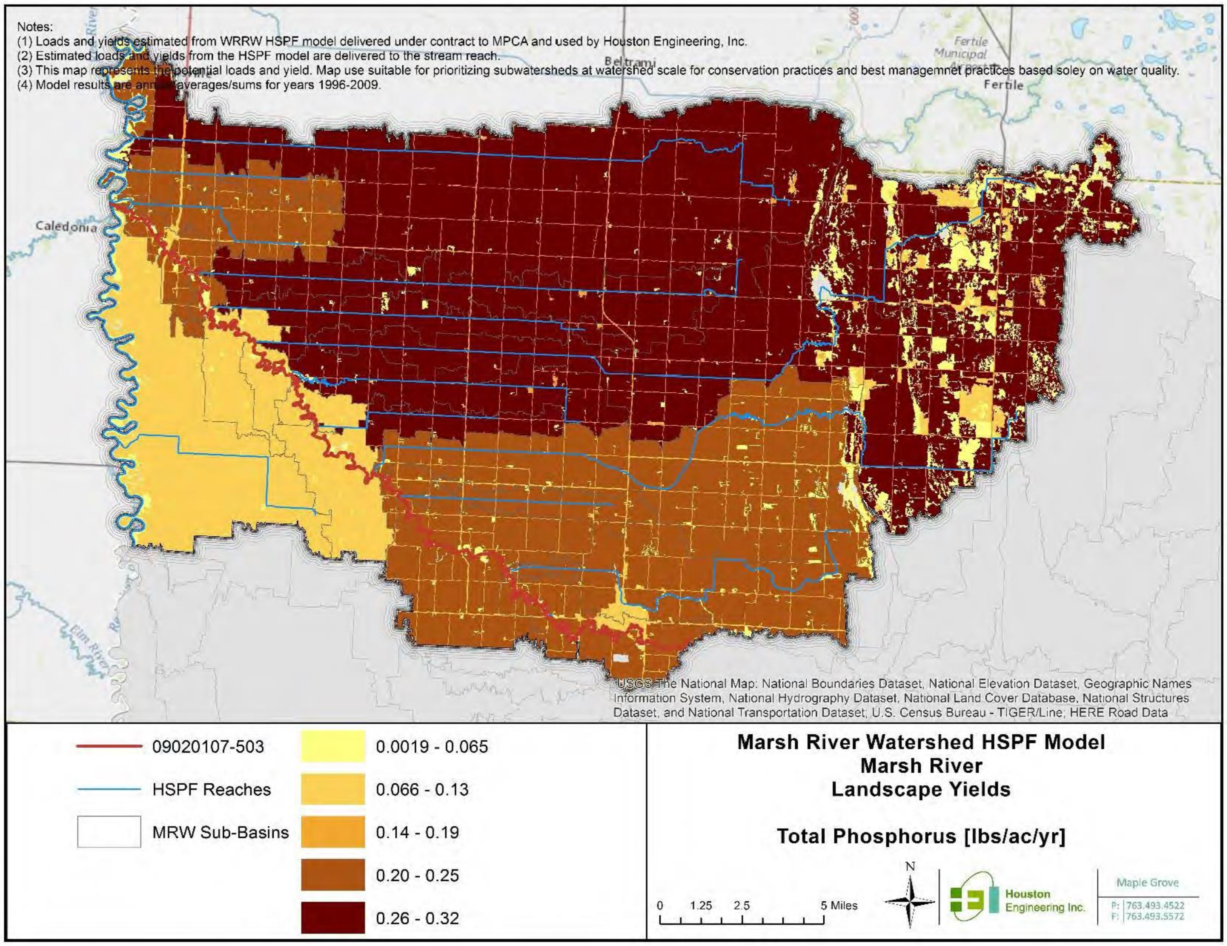


Figure B-5: Average (1996-2009) total nitrogen yield leaving the landscape for the Marsh River Watershed portion of the WRRW HSPF model.

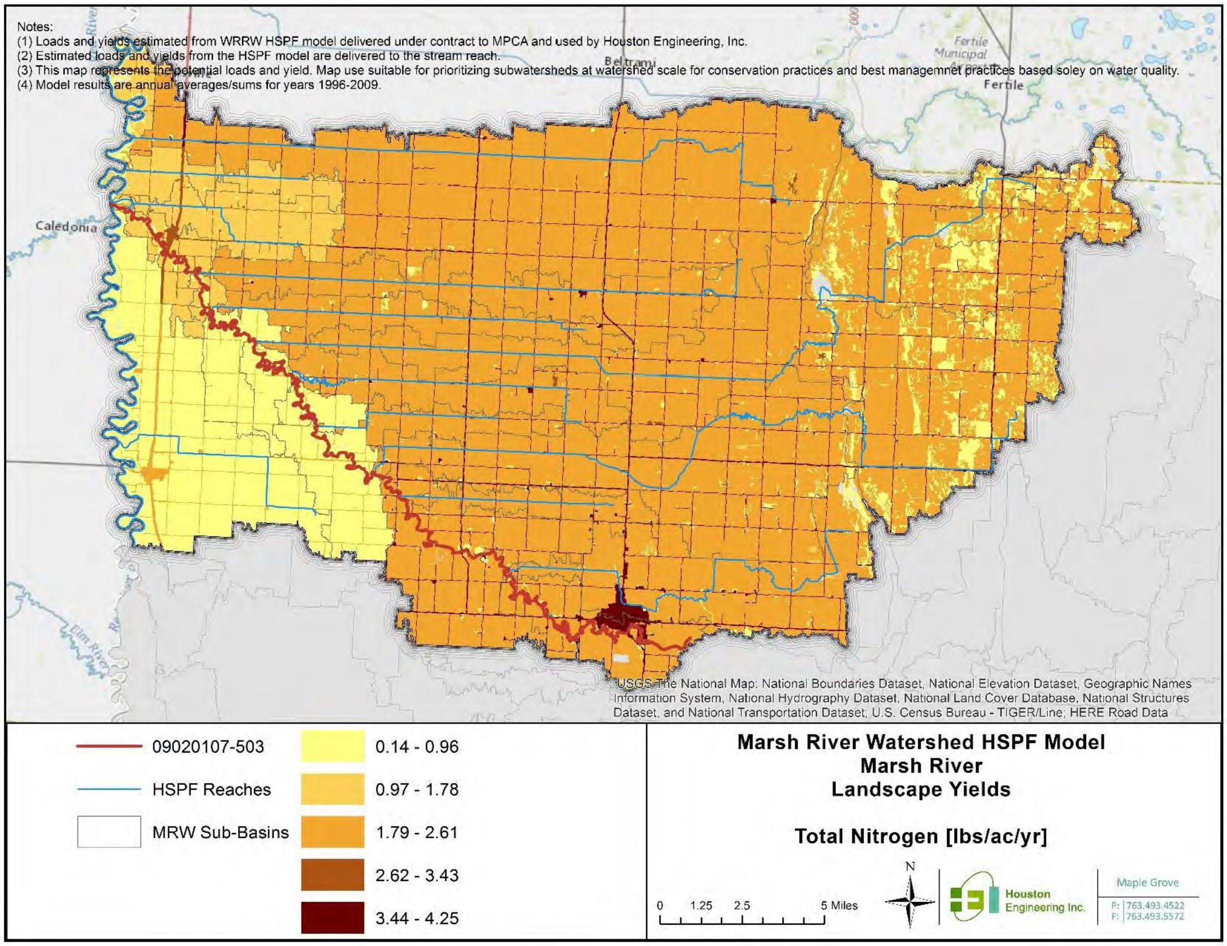


Figure B-6: Average (1996-2009) total sediment yield leaving the landscape for the Marsh River Watershed portion of the WRRW HSPF model.

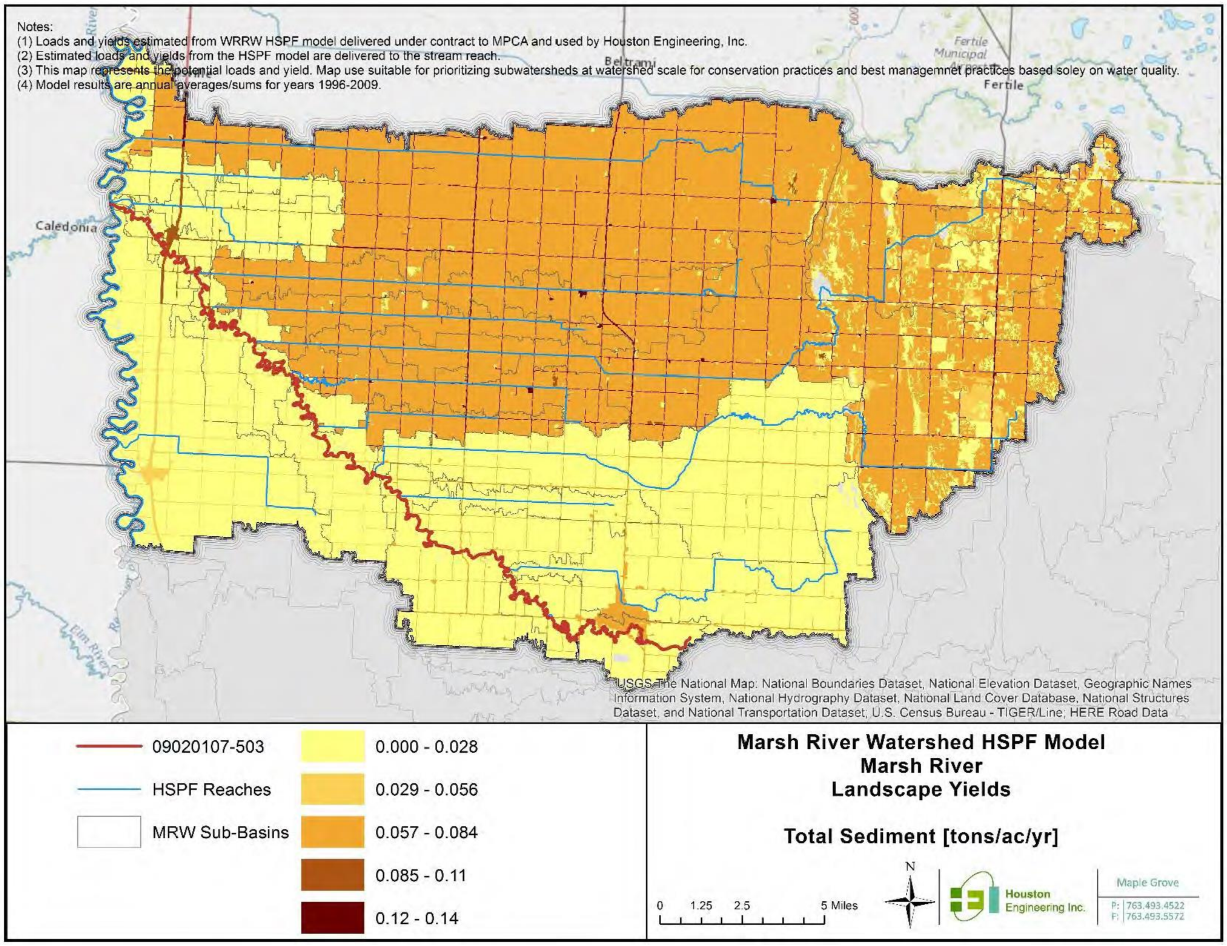


Figure B-7: Average (1996-2009) runoff (of water) delivered to the channel by subwatershed for the Marsh River Watershed portion of the WRRW HSPF model.

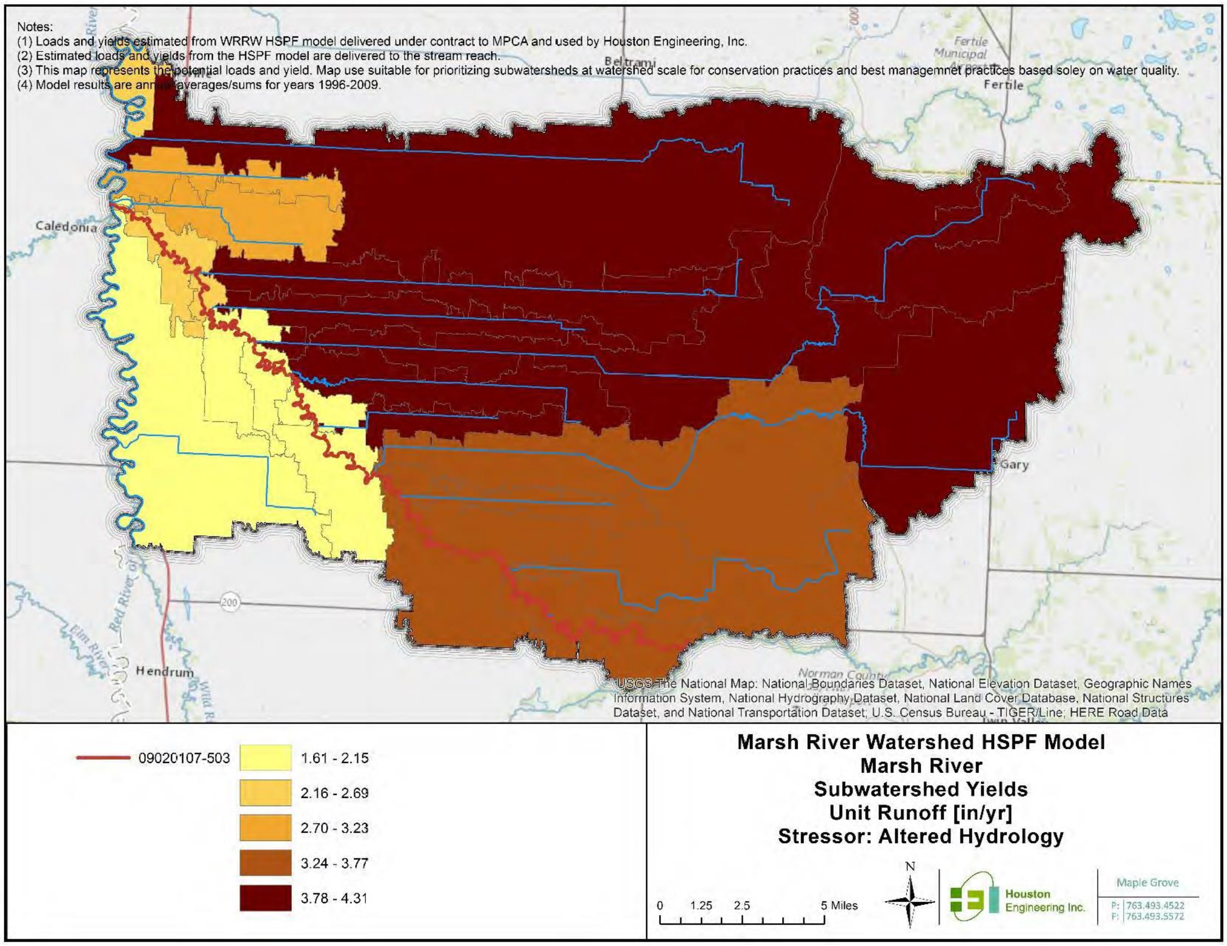


Figure B-8: Average (1996-2009) total phosphorus yield delivered to the channel by subwatershed for the Marsh River Watershed portion of the WRRW HSPF model.

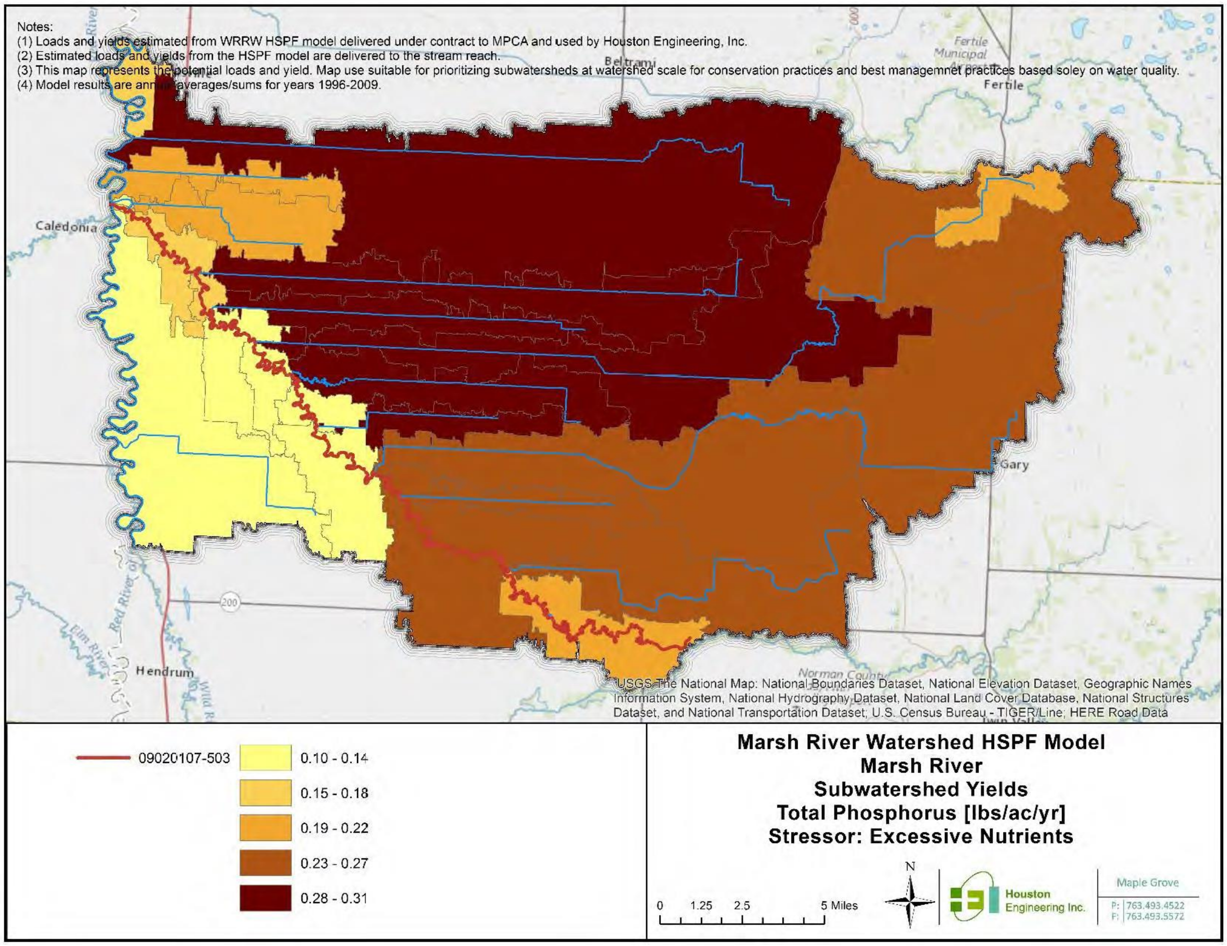


Figure B-9: Average (1996-2009) total nitrogen yield delivered to the channel by subwatershed for the Marsh River Watershed portion of the WRRW HSPF model.

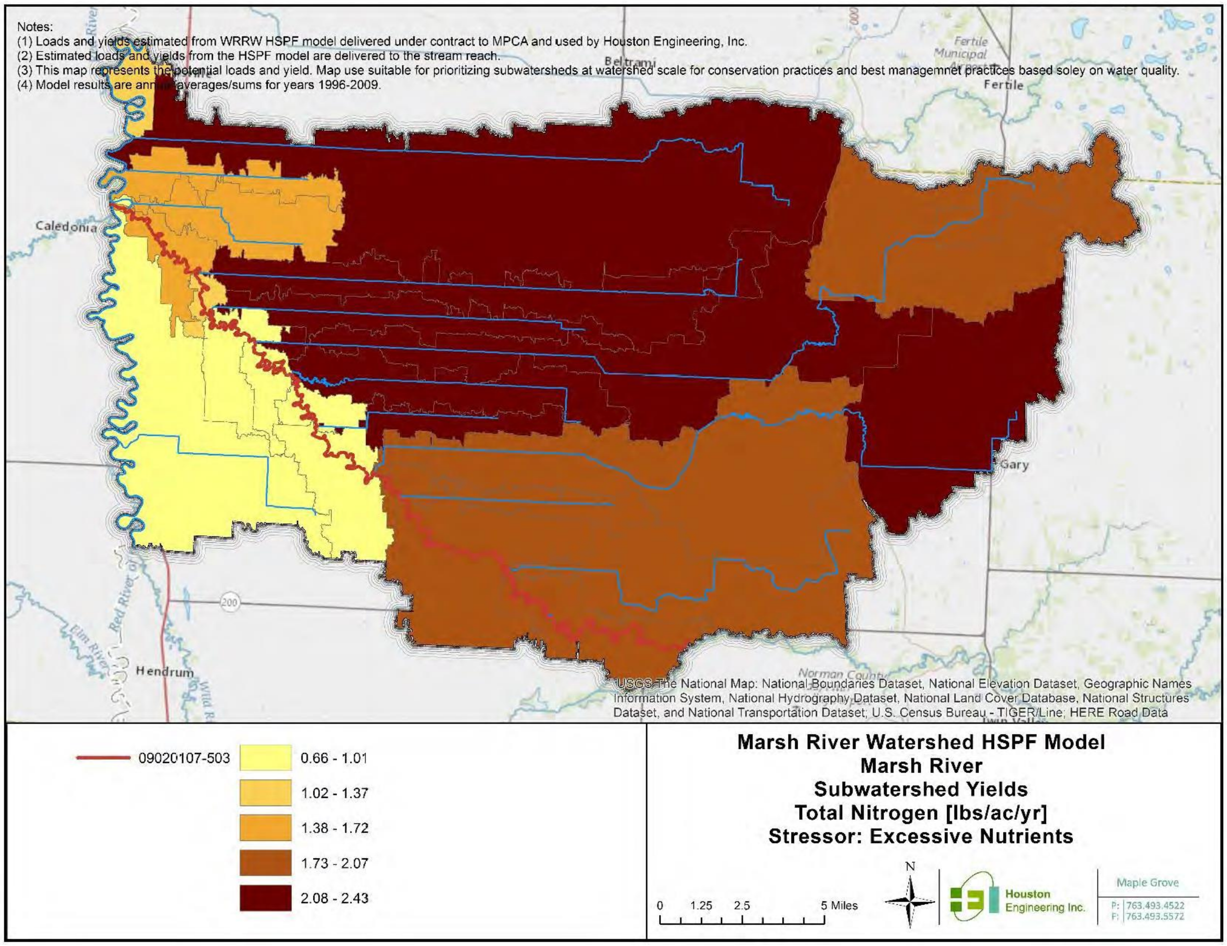
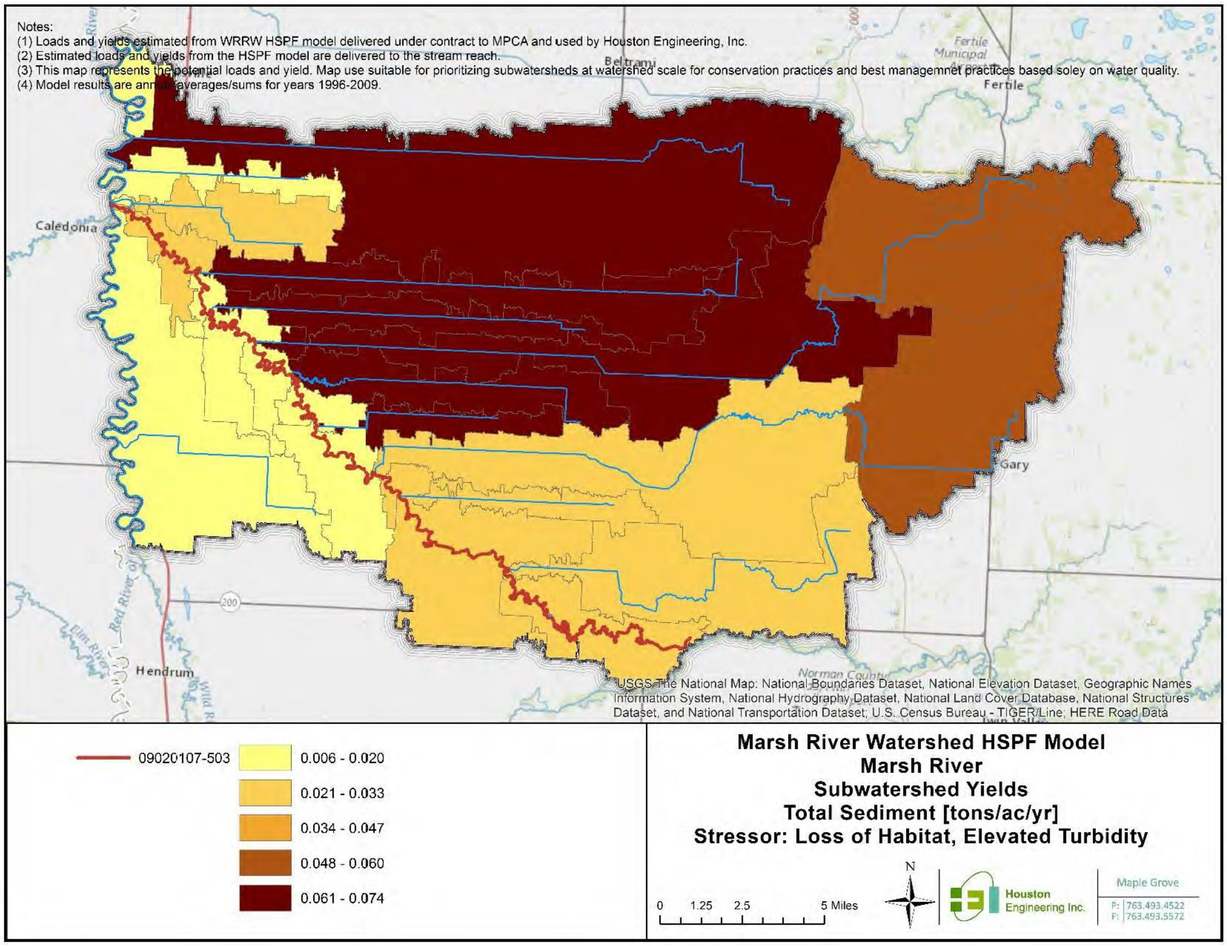


Figure B-10: Average (1996-2009) total sediment yield delivered to the channel by subwatershed for the Marsh River Watershed portion of the WRRW HSPF model.



Marsh River Watershed prioritization

The following maps provide subwatershed prioritization at the watershed scale for RO, TP, TN, and TS based on the subwatershed yields and represent different stressors which can lead to impairments. The priority rankings maps are developed by ranking the average subwatershed yields to identify specific priority subwatersheds which should be preferentially considered for targeting fields for practice implementation. The rankings are from largest to smallest yields and are used to calculate their percentile rank. The ranks are then summarized as the lowest priority (lowest 10%), low priority (10%-25%), moderate priority (25%-75%), high priority (75%-90%), and highest priority (highest 10%). The highest priority subwatersheds with the highest yields and most likely would benefit the most from implementation and protective strategy management. In addition, a watershed scale WQI is included to summarize the watershed conditions.

Figure B-11 provides the subwatershed prioritization for the stressor altered hydrology using average annual (1996-2009) RO entering the channel. **Figure B-12** provides the subwatershed prioritization for the stressor excessive nutrients using average annual (1996-2009) TP yield delivered to the channel. **Figure B-13** provides the subwatershed prioritization for the stressor excessive nutrients using average annual (1996-2009) TN yield delivered to the channel. **Figure B-14** provides the subwatershed prioritization for the stressor loss of habitat and elevated turbidity using average annual (1996-2009) TS yield delivered to the channel. **Figure B-15** provides the watershed scale subwatershed prioritization from the WQI. The dark green in the figures represent the highest priority subwatersheds (top 10%) with the highest yields and most likely would benefit the most from implementation and protective strategy management. The lightest green in the figures represent the lowest priority subwatersheds (bottom 10%) with the lowest yields and most likely would benefit the least from implementation and protective strategy management at the watershed scale.

In addition to the watershed scale prioritization maps, watershed scale Field Stream Index (FSI) maps are provided. The FSI maps provide guidance, subject to field verification, about where field practices rather than in-stream implementation activities, provide the largest benefit. These maps show the magnitude of field source loads relative to in-stream sources and are taken as the overland field load divided by the in-channel flux. Positive numbers represent a source of in-stream materials and a negative number represents a sink for in-stream materials. If the FSI is between -1 and 1, the dominate processes in the subwatershed are in-channel, meaning the in-channel flux is larger than the overland sources. If the FSI is less than -1 or greater than 1, field sources are larger than the in-stream sources. **Figure B-16** provides the FSI for the stressor excessive nutrients based on TP. **Figure B-17** provides the FSI for the stressor excessive nutrients based on TN. **Figure B-18** provides the FSI for the stressor loss of habitat and elevated turbidity based on TS. The information showed in the FSI mapping does not change for the major tributary prioritization mapping, therefore it’s only included for the watershed-scale prioritization mapping.

Figure B-11: Map of prioritized subwatersheds for implementation to address altered hydrology in the Marsh River Watershed, based on average (1996-2009) annual runoff (of water).

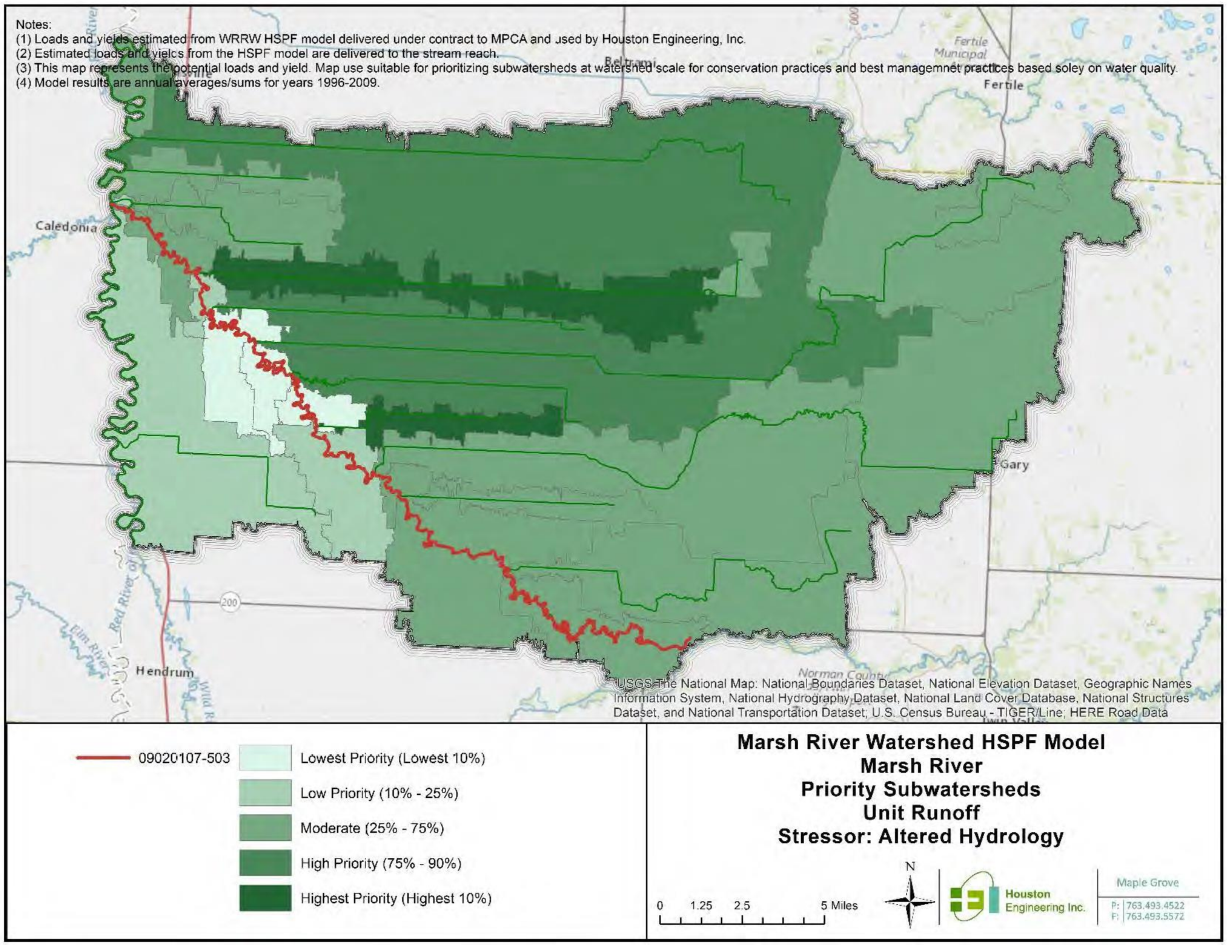


Figure B-12: Map of prioritized subwatersheds for implementation to address excessive nutrients in the Marsh River Watershed, based on average (1996-2009) annual total phosphorus yields.

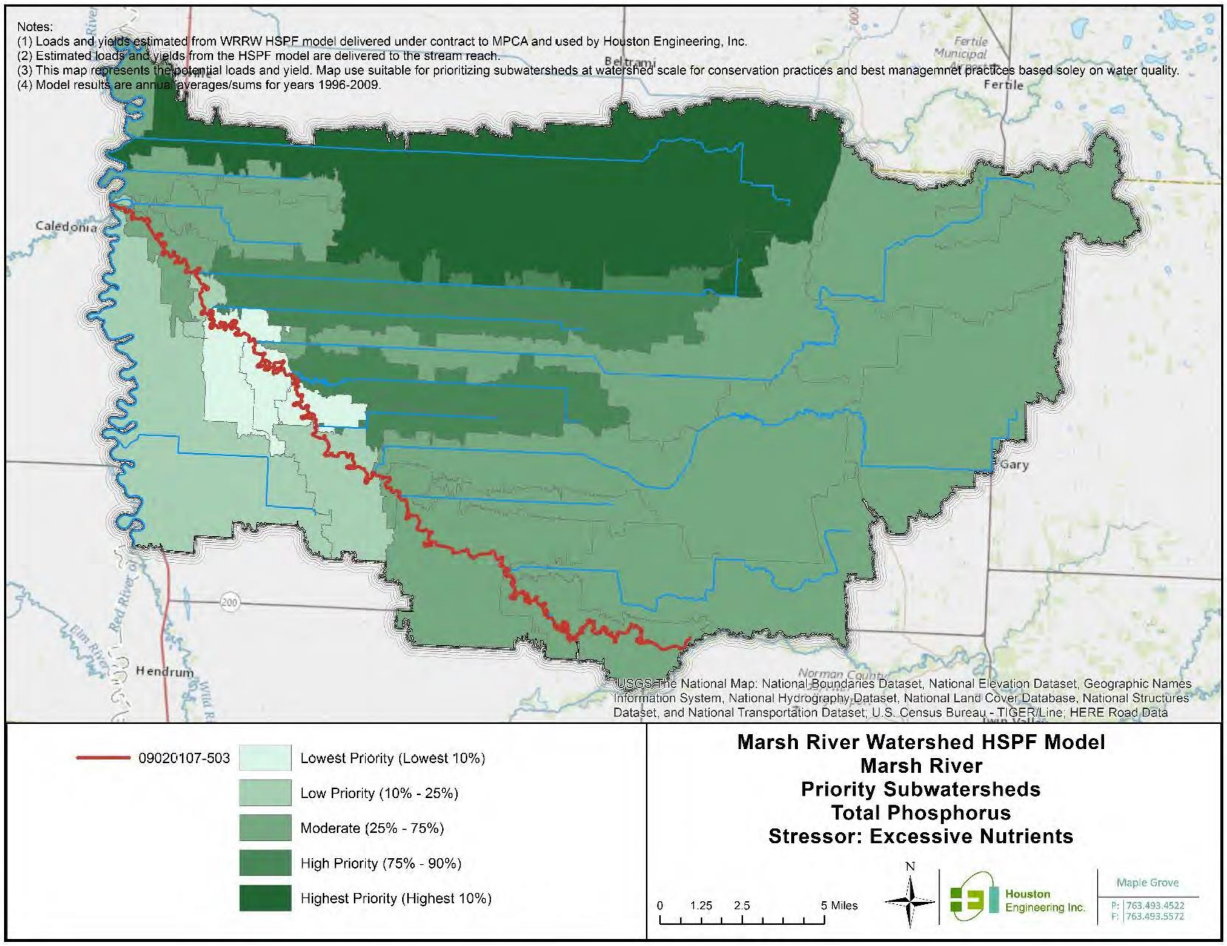


Figure B-13: Map of prioritized subwatersheds for implementation to address excessive nutrients in the Marsh River Watershed, based on average (1996-2009) annual total nitrogen yields.

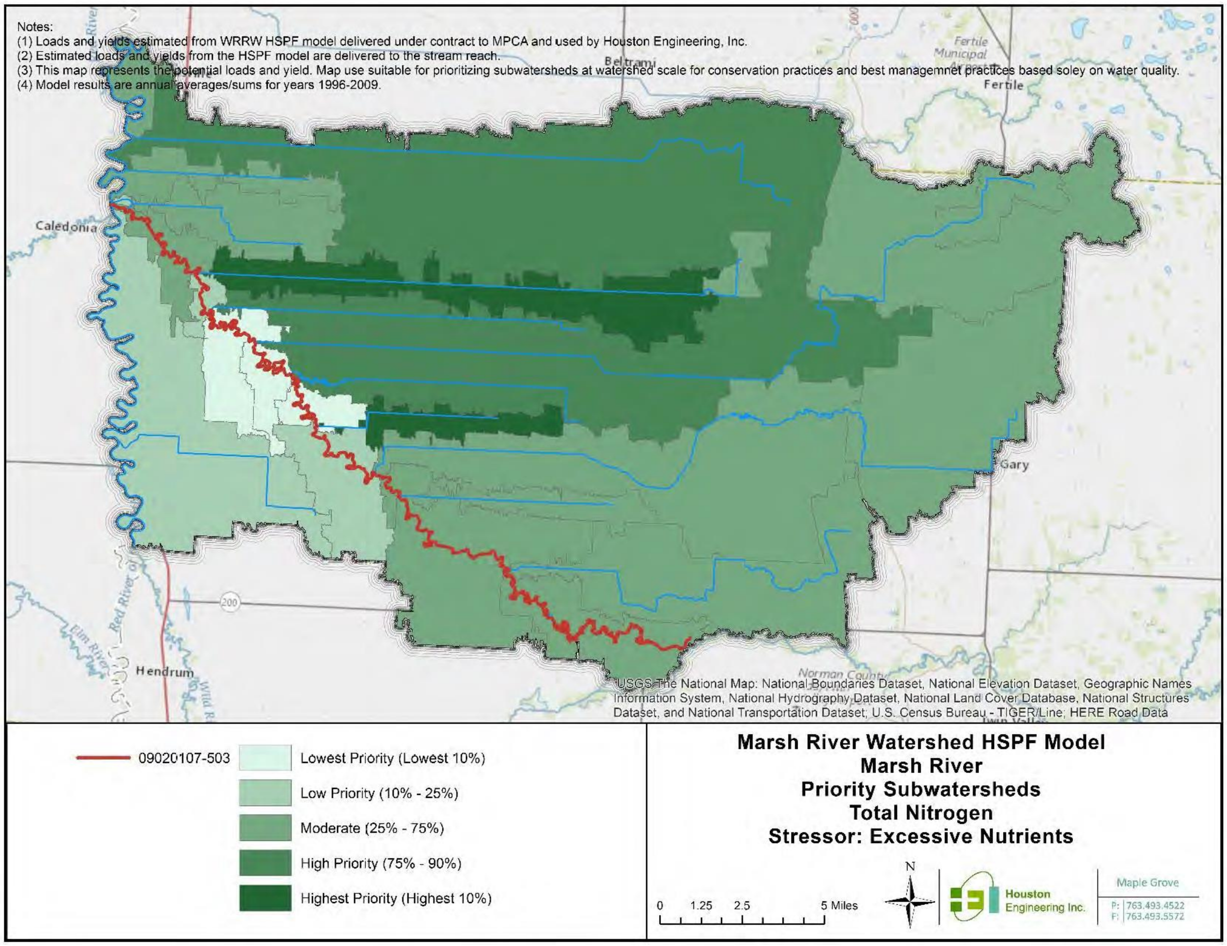


Figure B-14: Map of prioritized subwatersheds for implementation to address elevated turbidity and loss of habitat in the Marsh River Watershed, based on average (1996-2009) annual total sediment yields.

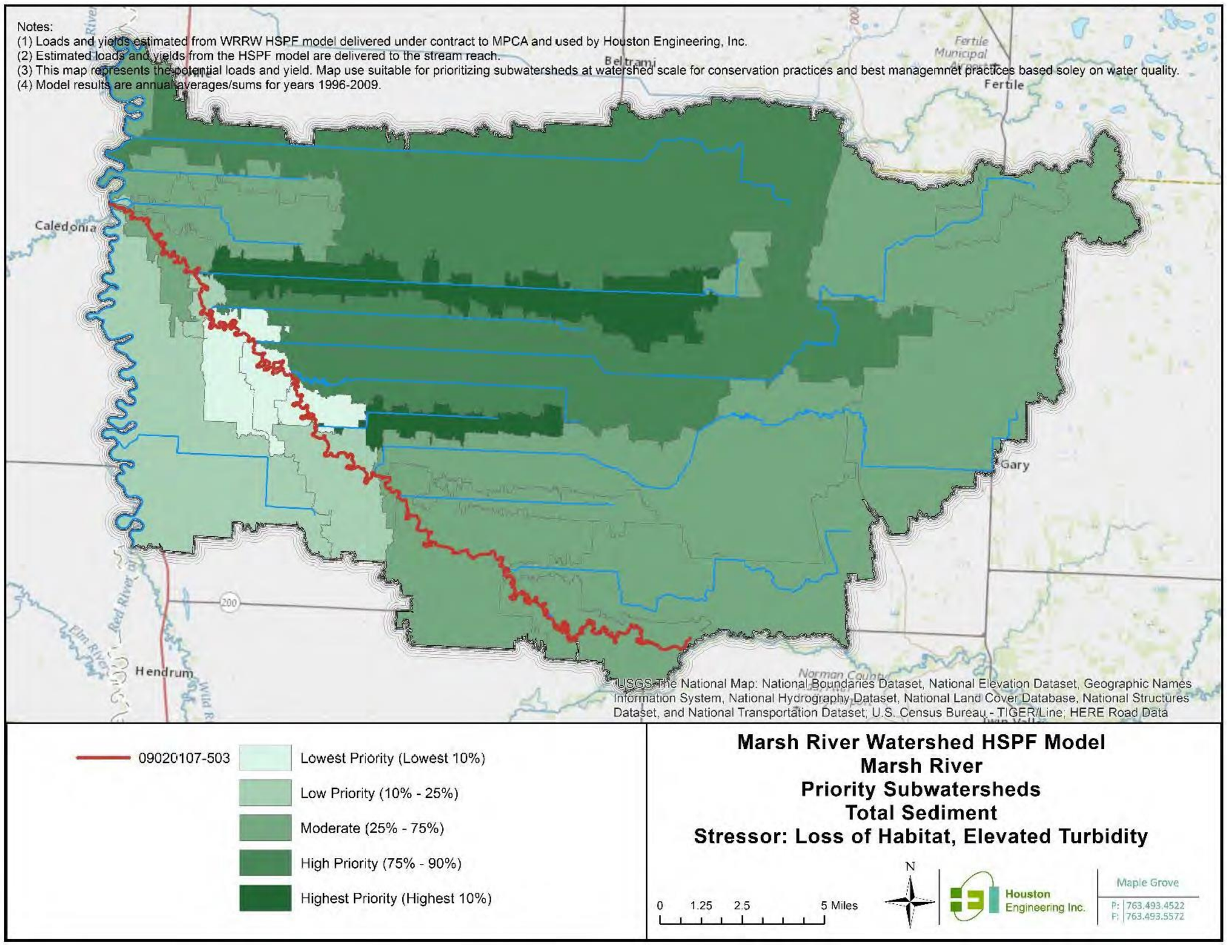


Figure B-15: Map of prioritized subwatersheds for implementation in the Marsh River Watershed, using the average (1996-2009) water quality index.

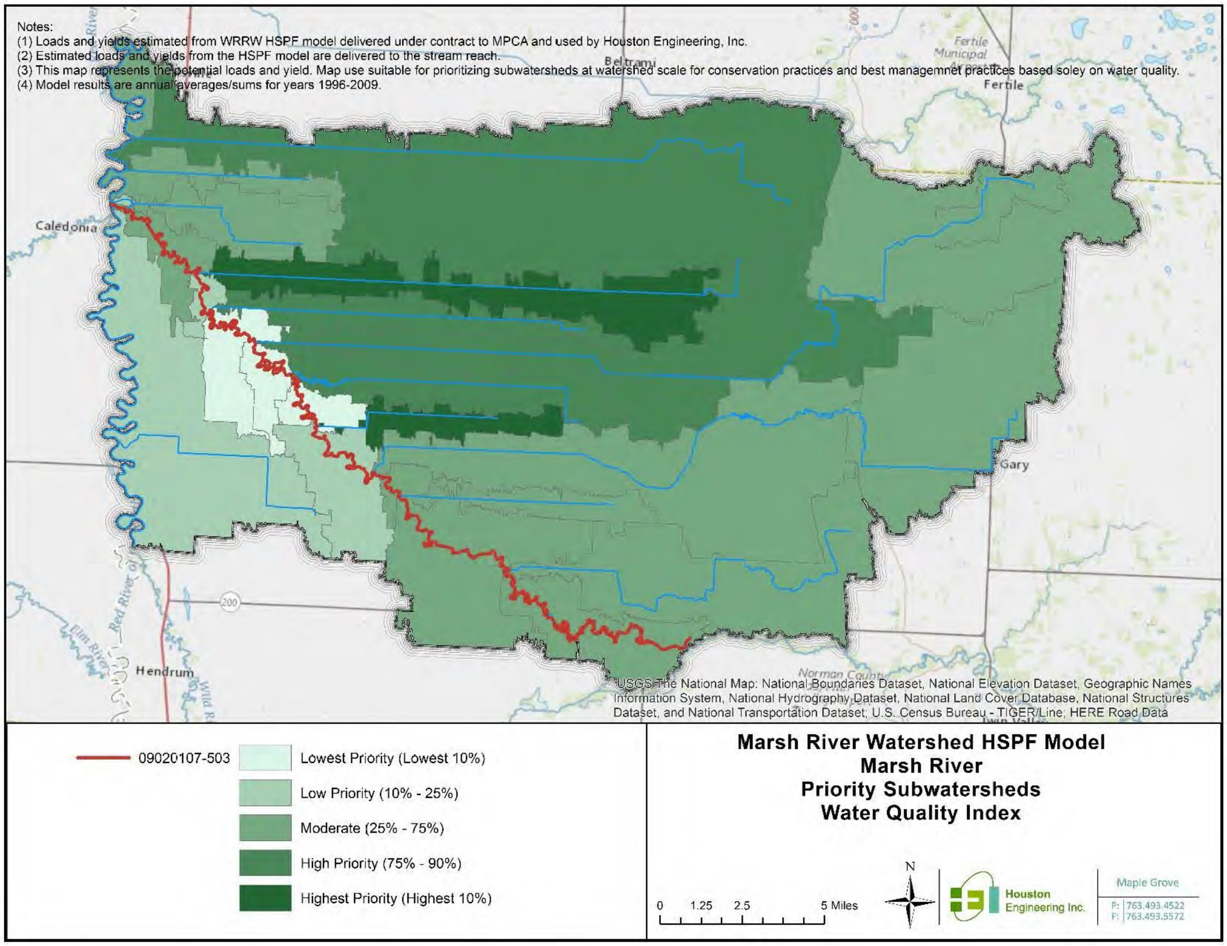


Figure B-16: Map of prioritized subwatersheds for implementation of field and stream practices (Field Stream Index) to address excessive nutrients, based on average (1996-2009) annual total phosphorus load.

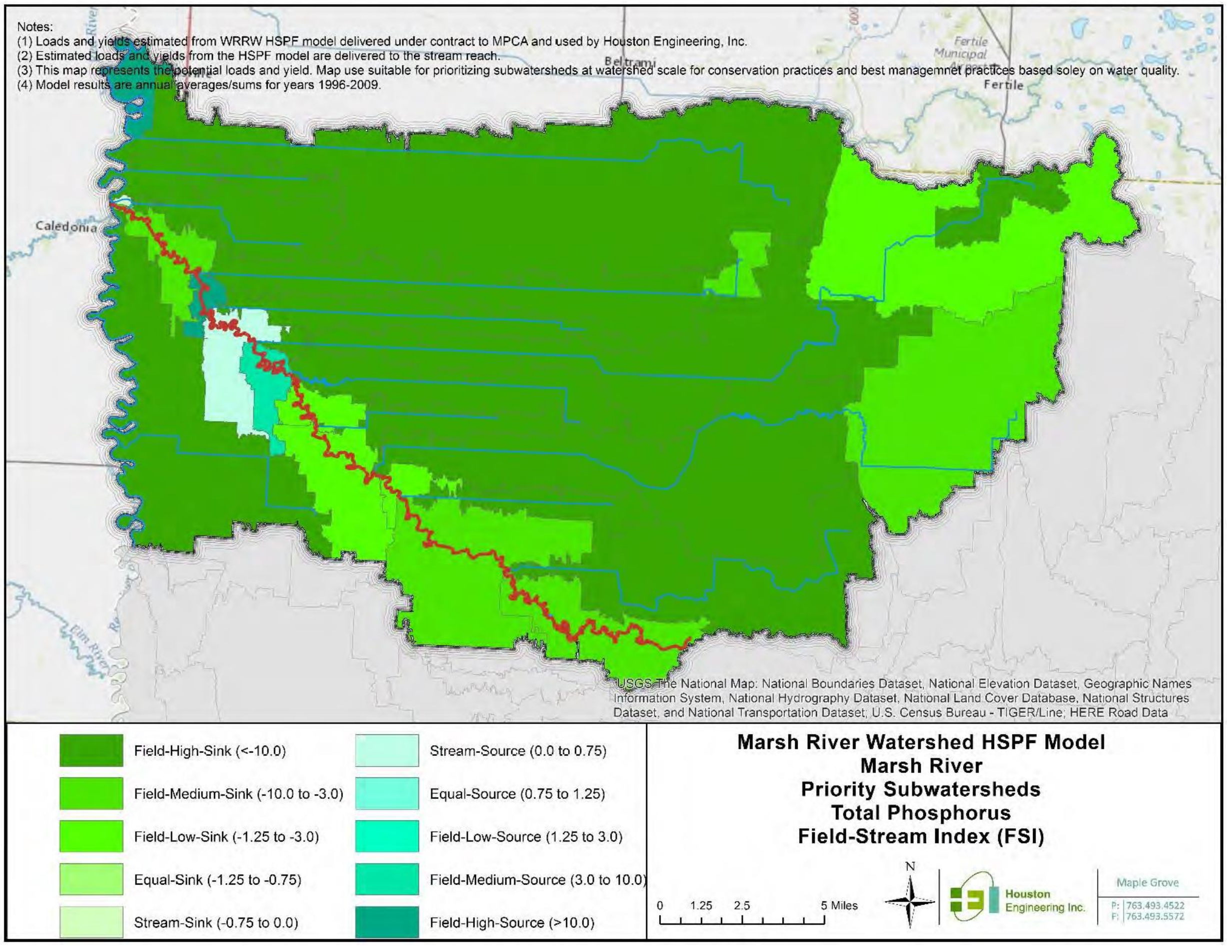


Figure B-17: Map of prioritized subwatersheds for implementation of field and stream practices (Field Stream Index) to address excessive nutrients, based on average (1996-2009) annual total nitrogen load.

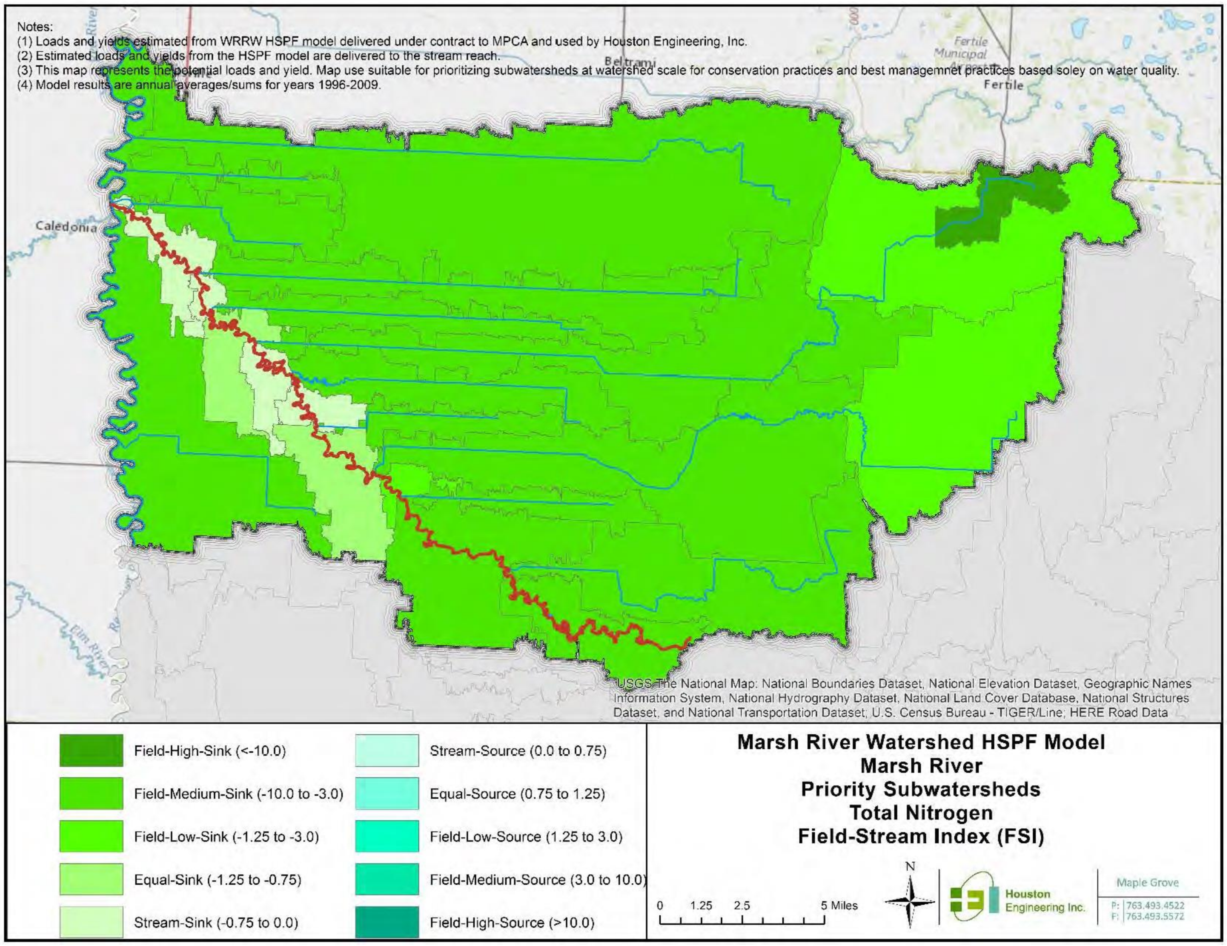
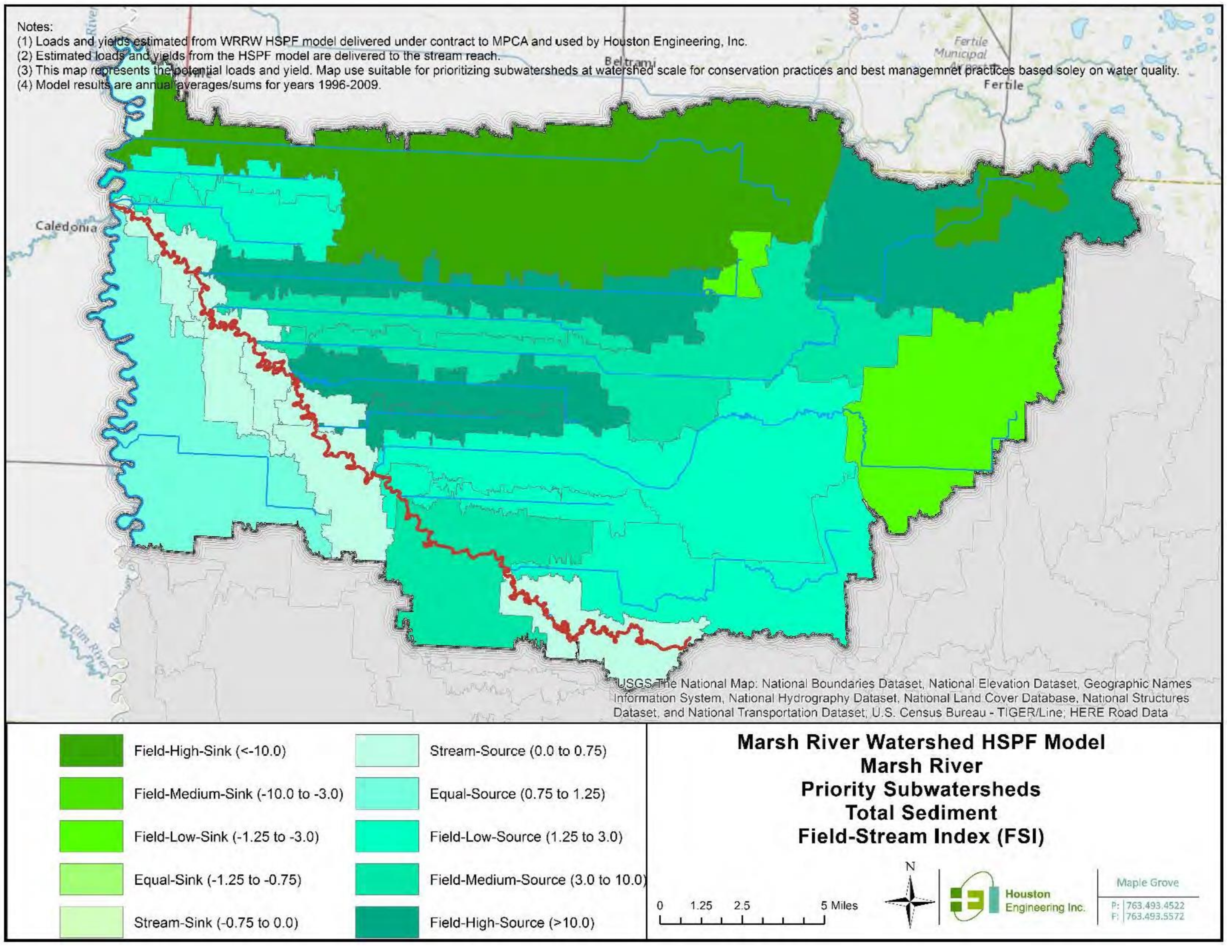


Figure B-18: Map of prioritized subwatersheds for implementation of field and stream practices (Field Stream Index) to address loss of habitat and elevated turbidity, based on total sediment (1996-2009).



Tributary scale prioritization

The prioritization mapping changes based on the subwatershed included in the drainage area. Therefore, prioritization maps were produced for the drainage areas of each conventional water quality parameter (i.e., turbidity, TSS, and/or nutrients) in the MRW. This will be referred to as major tributary prioritization. **Figure B-19** provides the drainage areas for the only major tributary in the MRW.

Similar to the watershed scale maps, the following maps provide subwatershed prioritization at the tributary scale for RO, TP, TN, and TS based on the subwatershed yields and represent different stressors which can lead to impairments. In addition, a tributary scale WQI is included for the drainage area.

Marsh River, Headwaters to Red R (AUID 09020107-503)

Figure B-20 provides the subwatershed prioritization for the stressor altered hydrology using average annual (1996-2009) RO entering the channel for AUID 09020108-503. **Figure B-21** provides the subwatershed prioritization for the stressor excessive nutrients using average annual (1996-2009) TP yield delivered to the channel for AUID 09020108-503. **Figure B-22** provides the subwatershed prioritization for the stressor excessive nutrients using average annual (1996-2009) TN yield delivered to the channel for AUID 09020108-503. **Figure B-23** provides the subwatershed prioritization for the stressor loss of habitat and elevated turbidity using average annual (1996-2009) TS yield delivered to the channel for AUID 09020108-503. **Figure B-24** provides the tributary scale subwatershed prioritization from the WQI.

Figure B-19: Drainage area for the major tributary (Marsh River, AUID 09020107-503) in the Marsh River Watershed.

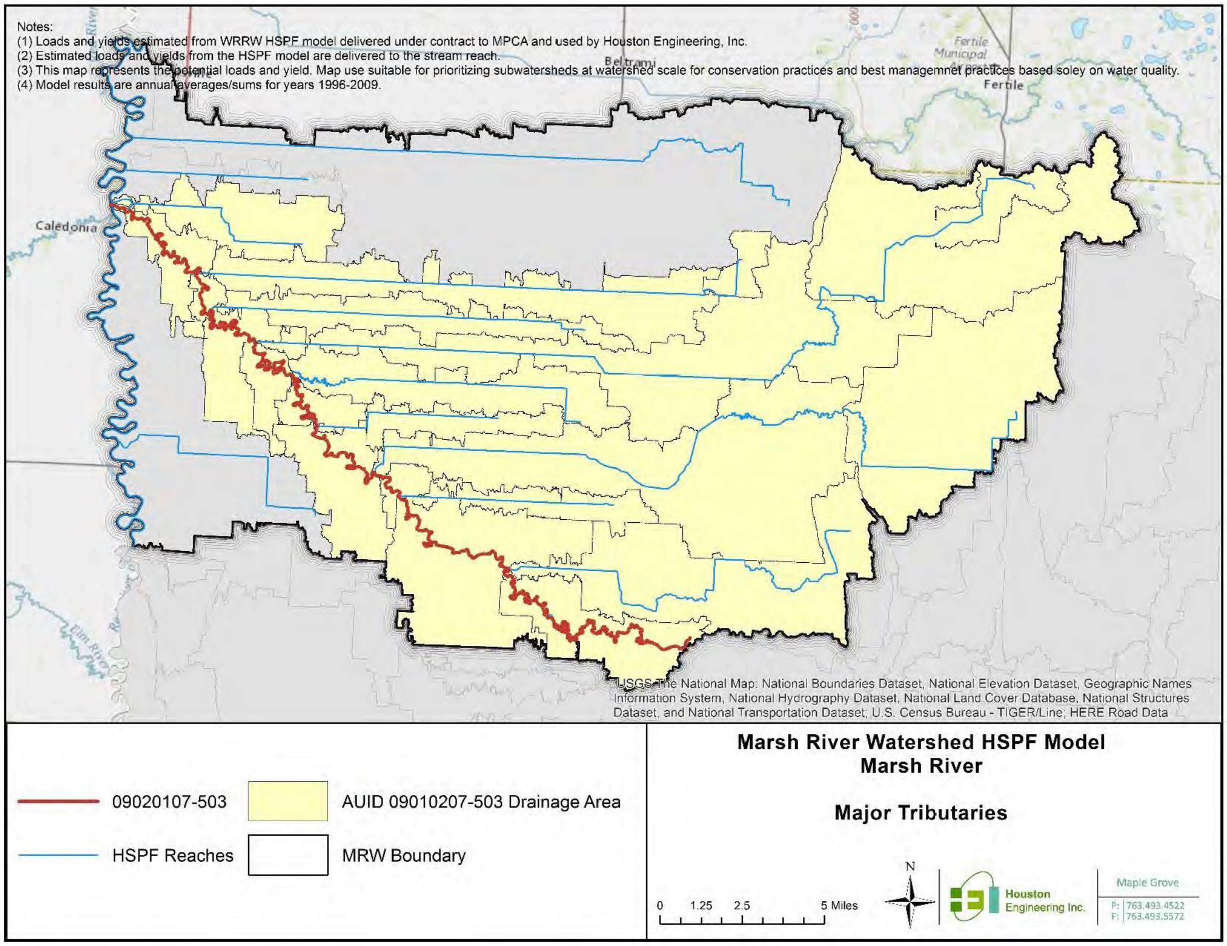


Figure B-20: Map of prioritized subwatersheds for implementation to address altered hydrology in the Marsh River (AUID 09020107-503), based on average (1996-2009) annual runoff.

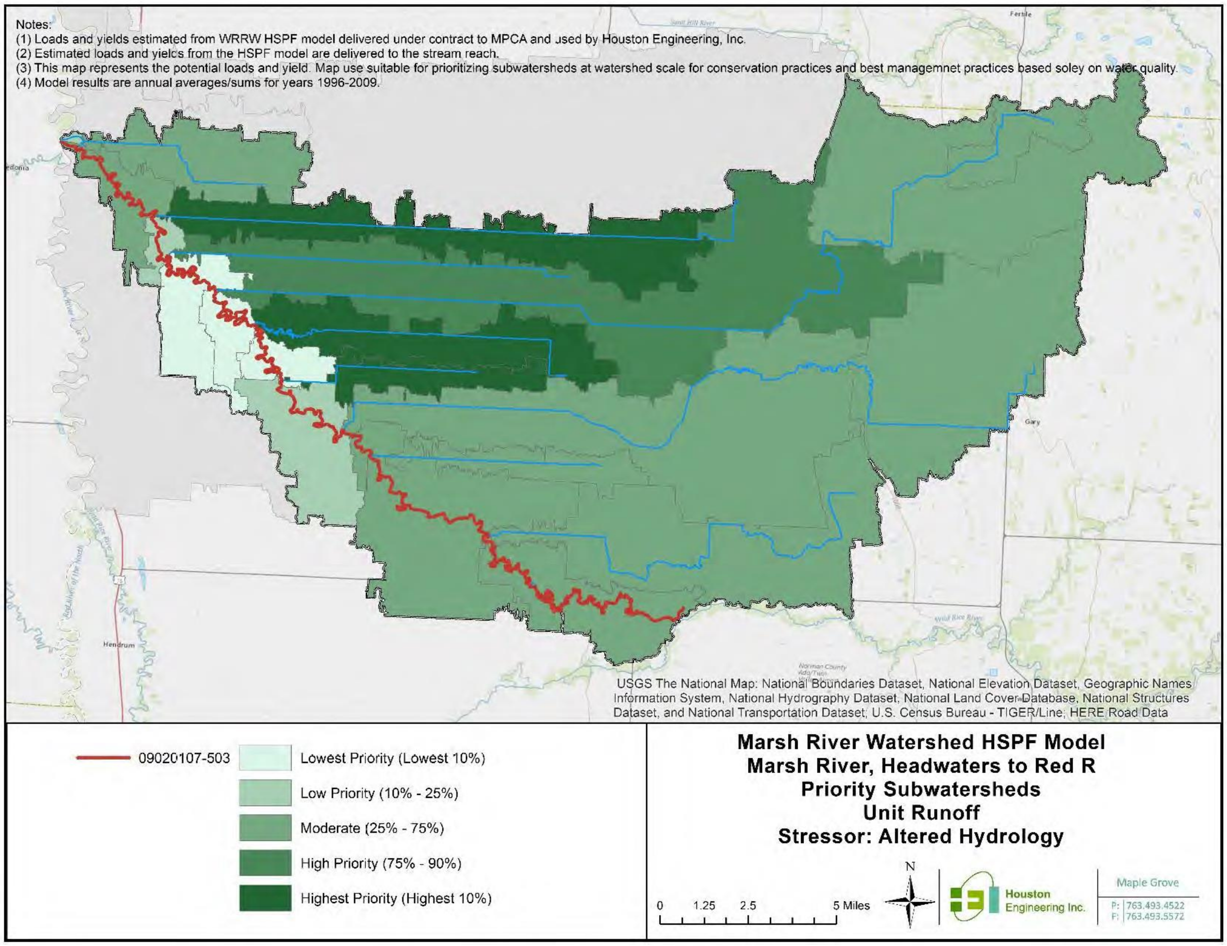


Figure B-21: Map of prioritized subwatersheds for implementation to address excessive nutrients in the Marsh River (AUID 09020107-503), based on average (1996-2009) annual total phosphorus yields.

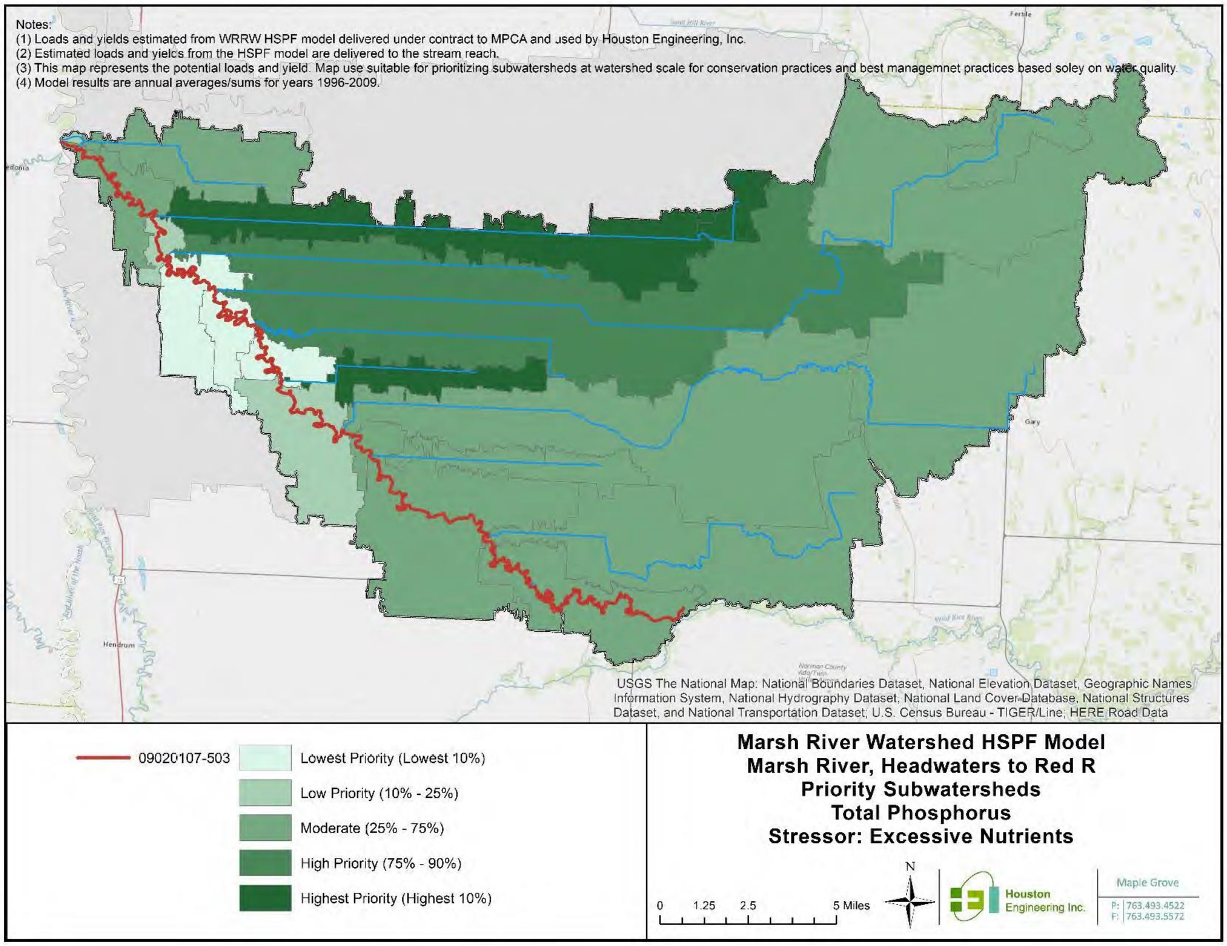


Figure B-22: Map of prioritized subwatersheds for implementation to address excessive nutrients in the Marsh River (AUID 09020107-503), based on average (1996-2009) annual total nitrogen yields.

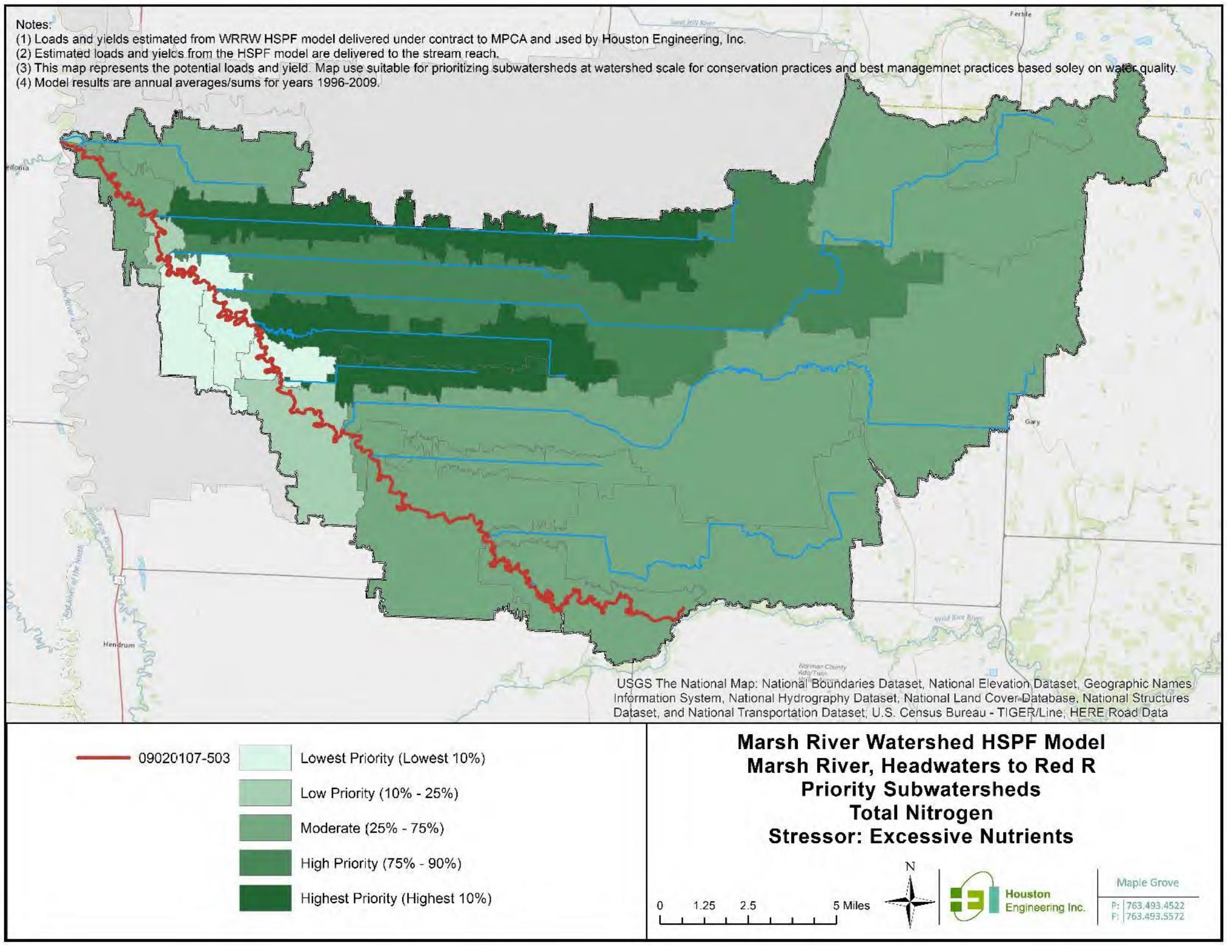


Figure B-23: Map of prioritized subwatersheds for implementation to address elevated turbidity and loss of habitat in the Marsh River (AUID 09020107-503), based on average (1996-2009) annual total sediment yields.

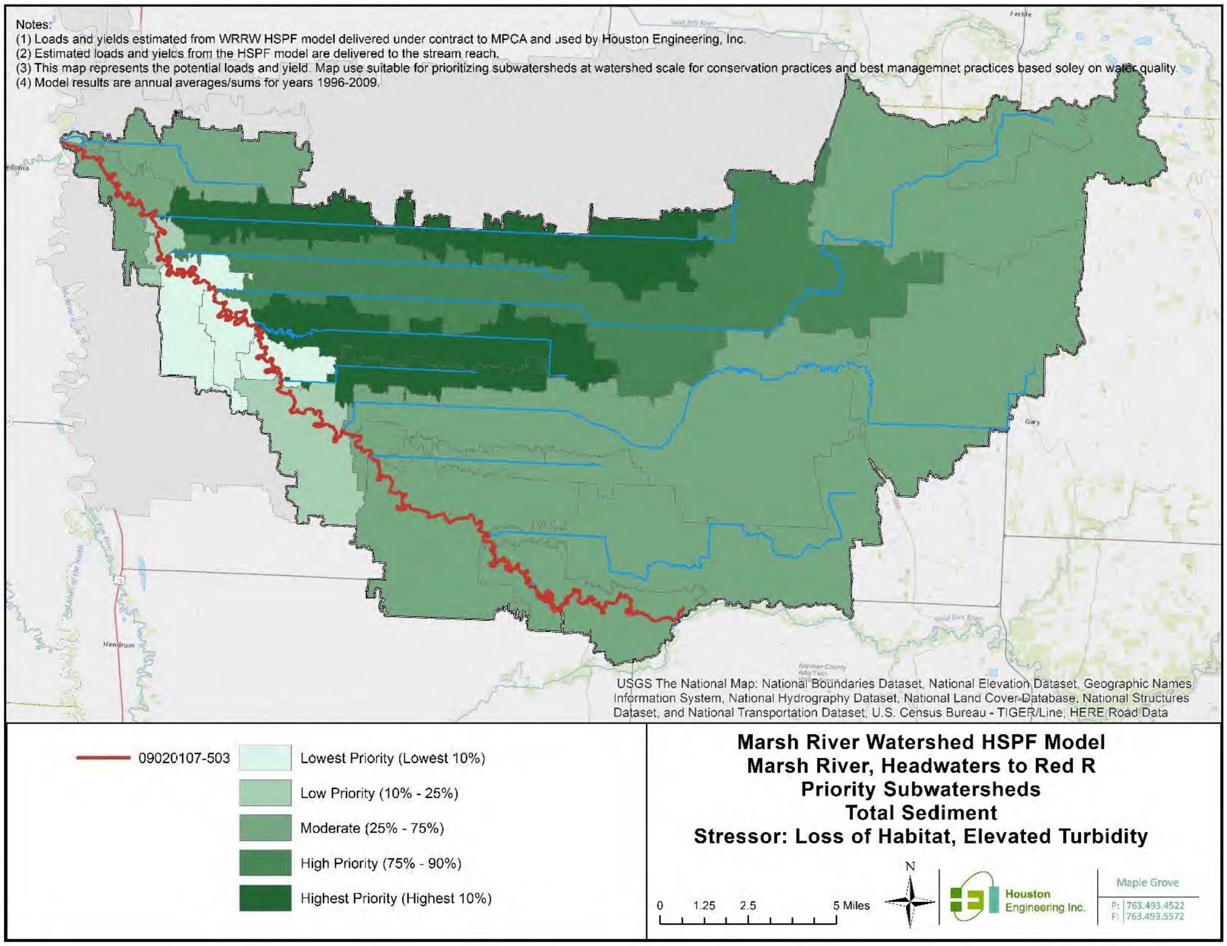


Figure B-24: Map of prioritized subwatersheds for implementation in the Marsh River (AUID 09020107-503), based on the average (1996-2009) water quality index.

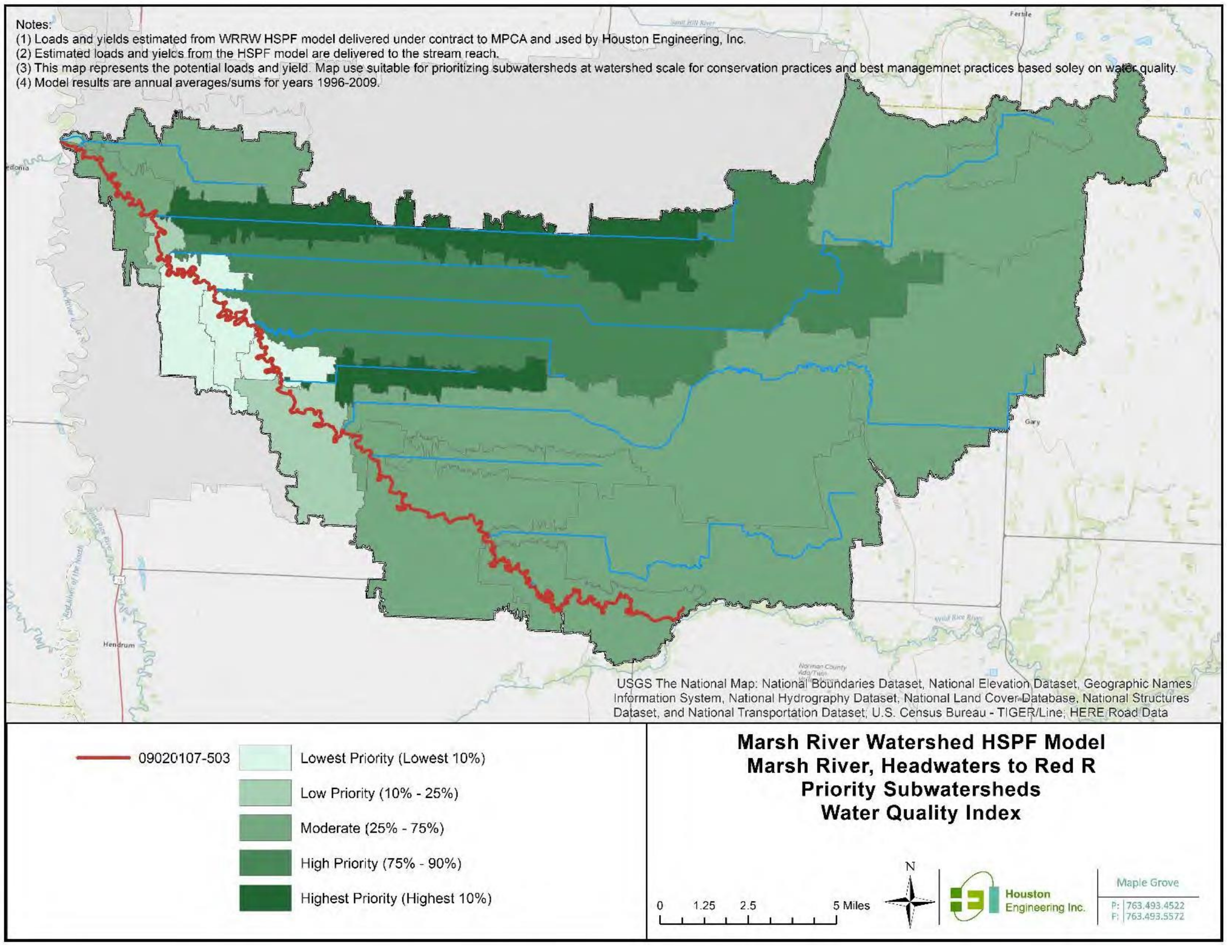


Table B-2: Water quality yields by subwatershed from the Marsh River Watershed portion of the WRRW HSPF model.

HSPF RCHRES	Runoff [in/yr]	Total Nitrogen [lbs/ac/yr]	Total Phosphorus [lbs/ac/yr]	Total Sediment [tons/ac/yr]	WQI	FSI TN	FSI TP	FSI TS
810	3.67	1.92	0.229	0.028	0.14	-5.76	-12.38	1.57
829	3.72	1.98	0.222	0.030	0.16	-3.19	-4.32	0.62
830	3.63	1.88	0.235	0.027	0.12	-4.87	-6.83	4.08
849	3.64	1.89	0.240	0.027	0.13	-7.03	-18.06	1.74
850	3.64	1.89	0.225	0.028	0.14	-1.39	-1.84	1.45
867	4.18	2.10	0.240	0.060	0.21	-2.97	-4.78	-2.23
869	3.63	1.88	0.236	0.026	0.12	-5.38	-10.56	2.50
870	1.63	0.70	0.108	0.007	0.03	-0.95	-2.29	0.15
889	4.31	2.43	0.303	0.074	0.25	-8.71	-21.33	36.24
890	1.61	0.66	0.102	0.006	0.01	-0.44	-1.41	0.04
909	4.29	2.40	0.301	0.073	0.24	-5.77	-11.97	16.80
910	1.62	0.66	0.099	0.006	0.01	-0.38	5.02	0.02
925	4.00	1.85	0.197	0.050	0.18	-11.72	-29.67	-260.56

HSPF RCHRES	Runoff [in/yr]	Total Nitrogen [lbs/ac/yr]	Total Phosphorus [lbs/ac/yr]	Total Sediment [tons/ac/yr]	WQI	FSI TN	FSI TP	FSI TS
927	4.14	2.07	0.238	0.059	0.21	-1.32	-2.09	28.53
929	4.27	2.36	0.296	0.071	0.23	-5.13	-11.23	7.50
930	1.62	0.68	0.106	0.007	0.02	-0.94	0.71	0.01
949	4.28	2.40	0.301	0.073	0.24	-5.94	-13.61	8.38
950	2.28	1.15	0.155	0.015	0.05	-0.60	37.59	0.05
967	4.24	2.36	0.307	0.071	0.23	-5.09	-6.33	-1.74
969	4.30	2.42	0.303	0.073	0.25	-5.30	-10.49	15.88
970	2.65	1.42	0.165	0.022	0.07	-0.45	-4.51	0.04
979	2.92	1.50	0.194	0.021	0.07	-8.03	-21.56	2.08
980	1.67	0.85	0.106	0.012	0.05	-0.06	-0.10	0.02
989	4.34	4.20	0.316	0.305	0.46	-25.22	-28.04	-3.16
991	1.68	0.76	0.109	0.008	0.04	-6.27	-21.23	0.85
993	2.84	1.44	0.193	0.019	0.06	-8.55	-30.84	1.42
995	4.28	2.39	0.303	0.072	0.24	-5.67	-10.89	-10.12
997	2.45	1.26	0.160	0.018	0.06	-3.60	52.44	0.26

Appendix C: 3 HSPF – SAM/PTMApp Scenarios

Based on a technical memorandum by Houston Engineering, Inc. provided to the MPCA on August 12, 2019.

Introduction

This appendix describes estimated load reduction benefits for three BMP scenarios in the MRW. The benefits of the scenarios were evaluated using the HSPF-SAM[1], informed by the BMP suitability processes in the PTMApp.

The BMP scenarios were developed, and the benefits estimated, to guide local implementation efforts for use in the WRAPS. The intent of preparing this appendix is to provide 1) greater clarity with regard to the technical feasibility of achieving various nutrient and sediment load reductions, and therefore, the MRW water quality goals (i.e., load allocations); 2) more detailed guidance to those responsible for implementing the TMDL including the numbers and types of BMPs which should be placed on the landscape; and 3) the information expectations memorialized in the Clean Water Accountability Act (https://www.revisor.leg.state.mn.us/statutes/?id=114D&view=chapter).

The three scenarios developed and simulated using HSPF-SAM are intended to represent a range of potential strategies and include: (1) a Low BMP Implementation Scenario; (2) an Intermediate BMP Implementation Scenario, and (3) a High BMP Implementation Scenario. The Low BMP Implementation scenario represents a targeted implementation approach where BMPs are located and constructed to treat 5% to 10% of cropland acres in subwatersheds where practices are feasible. The Intermediate BMP Implementation scenario also represents a targeted implementation approach where BMPs are located and constructed to treat 10% to 25% of cropland acres in subwatersheds where practices are feasible. The High BMP Implementation scenario represents an upper limit on what can be achieved in terms of the load reduction by assuming up to half of the cropland acres in the watershed are treated with BMPs. Further discussion of the scenarios is provided below.

Scenario Development

Three BMP scenarios were developed and simulated using two programs, PTMApp to develop BMP feasibility, and the HSPF-SAM, a BMP scenario tool for the watershed-wide HSPF model.

PTMApp Best Management Practices Feasibility

BMP feasibility was conducted utilizing PTMApp, a hydrologically-conditioned digital elevation model (hDEM) and a suite of water quality datasets were generated to help identify and target locations at the field-scale for BMPs and CPs. PTMApp is used in rural settings to: 1) identify the field-scale source locations and amounts of TSS, TP, and TN that leave the landscape and enter a downstream lake or river; 2) target specific fields on the landscape (based upon NRCS design standards, landscape

[1] https://www.respec.com/product/scenario-application-manager/

characteristics, land productivity, and/or landowner preference) for the potential implementation of nonpoint source BMPs and CPs; and 3) estimate the benefits of single or multiple BMPs and CPs to one or more streams, rivers, and lakes within a watershed, where the benefits are expressed as the downstream load reduction and the annual estimated cost/unit load reduction. These tools allow water quality practitioners to target solutions to the identified priorities and develop tailor-made implementation plans. Products developed by using PTMApp are also useful in making day-to-day implementation decisions and communicating needs and benefits with landowners.

BMP Suitability

The feasibility of placing a BMP or CP on the landscape depends on several factors. These factors include land use, the size of the contributing drainage area, the land slope, the type of flow regime, and local topography. Detailed information on the theory and criteria for evaluating practice feasibility are documented in the BMP Suitability Enhancement Technical Memorandum (HEI, 2018). Practice feasibility is based solely on technical factors largely based on field office technical guides developed by the NRCS and excludes social factors like landowner willingness. Locations shown as “feasible” are candidates for implementing practices and require further technical evaluation to confirm feasibility. BMPs and CPs are categorized into five treatment groups consisting of structural practices and one treatment group of management practices. Treatment groups and a sampling of BMP types in each group are shown in **Table C-1**.

Table C-1: Treatment groups included in PTMApp and types of practices each treatment group represents.

Treatment Group	Primary Treatment Process	Form of Treatment	Practices
Structural Practice Groups			
Storage	Sedimentation	Particulate	WASCOB Wetland Restoration Pond for Water Use
Filtration	Sedimentation	Particulate	Grassed Waterways Filter Strips Conservation Cover Easements
Biofiltration	Sedimentation & biological	Particulate	Saturated buffers Denitrifying Bioreactor
Infiltration	Volume abstraction	Dissolved	Alternative Tile Intakes
Protection	Physical protection of the landscape	Total (Dissolved & Particulate)	Grade Stabilization Structure Critical Area Planting Streambank and Shoreline Protection
Management Practice Group			
Source Reduction	Reduction of Mass Potential	Total (Dissolved & Particulate)	Conservation Tillage Nitrogen Management Plan

Table C-2 shows the total number of locations feasible for each treatment group at the field scale with a drainage area treated by the BMP is greater than one acre. It should be noted, the BMPs listed in **Table C-2** and shown in **Figure C-1** through **Figure C-6**, are opportunities were the landscape fits design criteria of each treatment group and field verification may be necessary if a BMP area is selected for implementation.

Table C-2: Number of practices in Marsh River Watershed.

PTMApp Structural Practice Treatment Group	Total Number of Practices
Biofiltration	79
Filtration	3,442
Infiltration	224
Protection	8,038
Storage	2,694
PTMApp Management Practice Treatment Group	**Total Acres of Practices**
Source Reduction	240,317

Figure C-1: Feasible locations for PTMApp's Biofiltration Practices Treatment Group in the Marsh River Watershed.

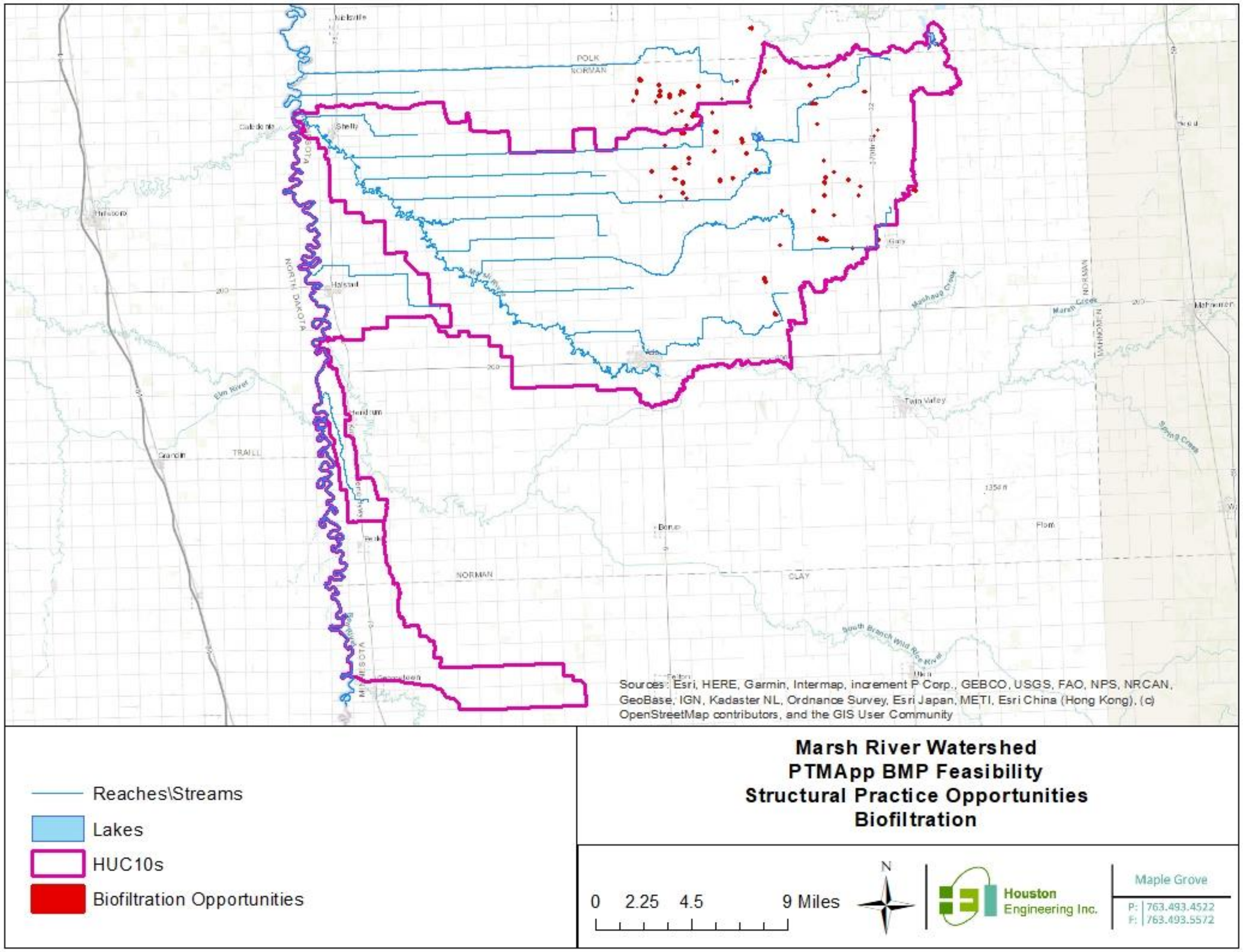


Figure C-2: Feasible locations for PTMApp's Filtration Practices Treatment Group in the Marsh River Watershed.

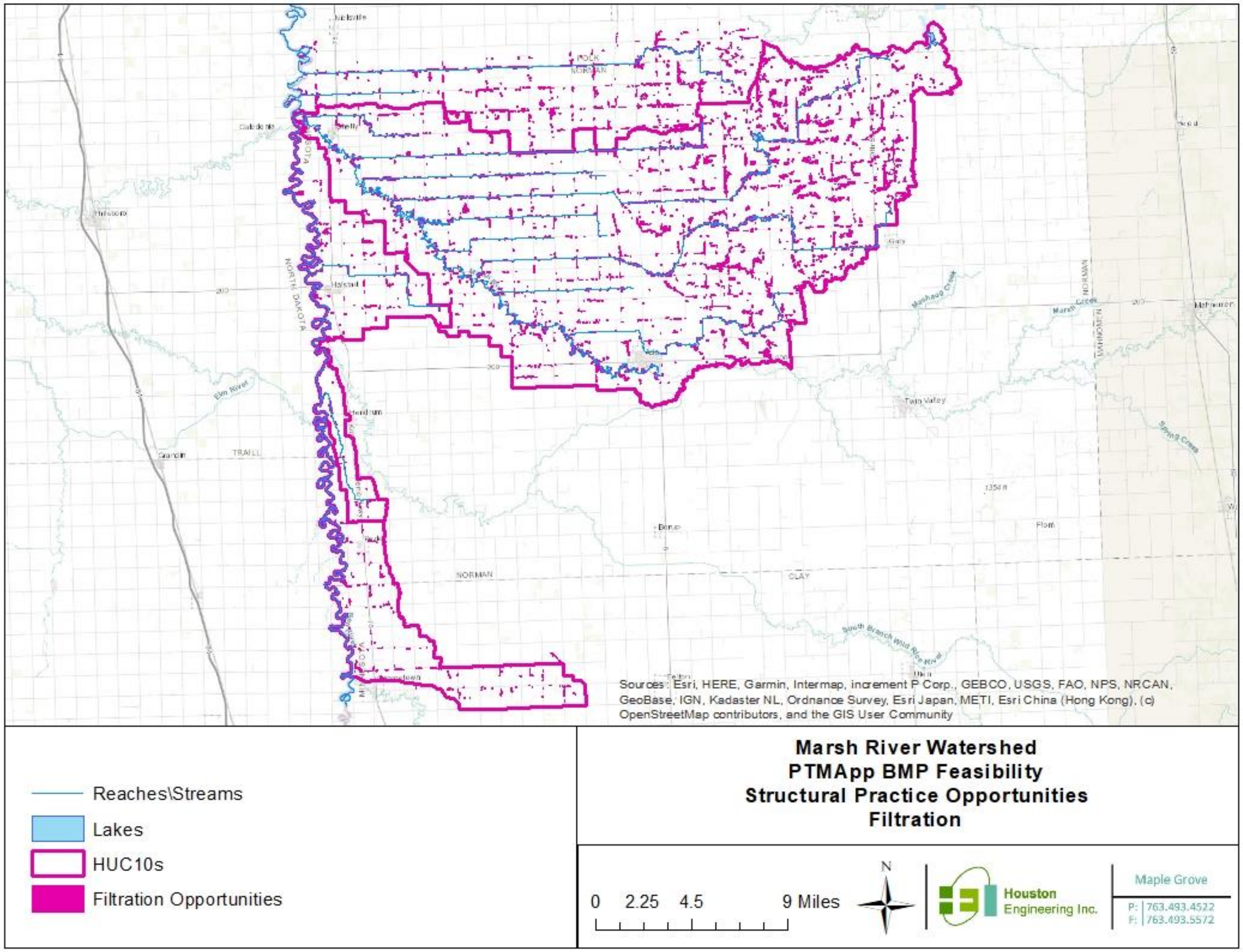


Figure C-3: Feasible locations for PTMApp's Infiltration Practices Treatment Group in the Marsh River Watershed.

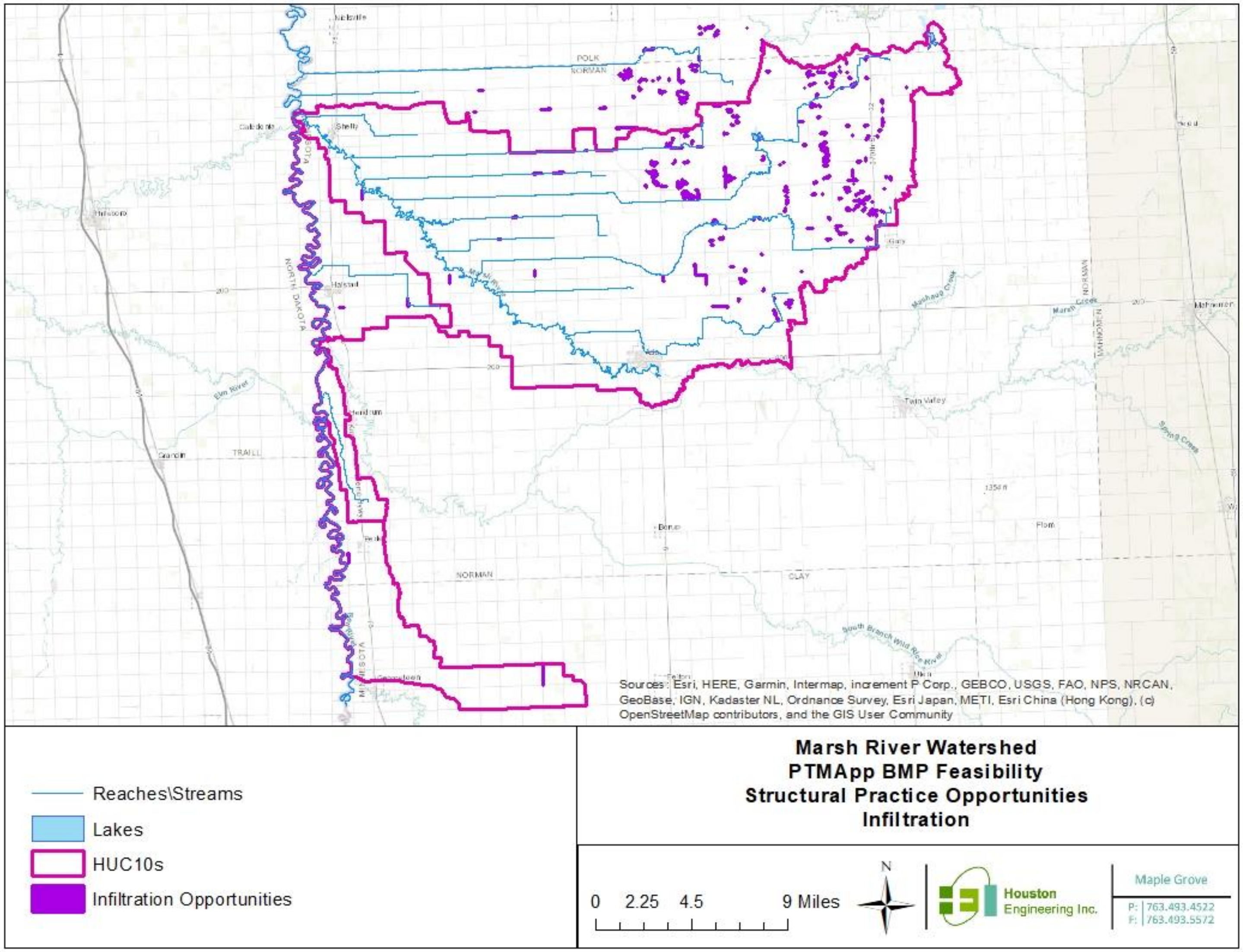


Figure C-4: Feasible locations for PTMApp's Protection Practices Treatment Group in the Marsh River Watershed.

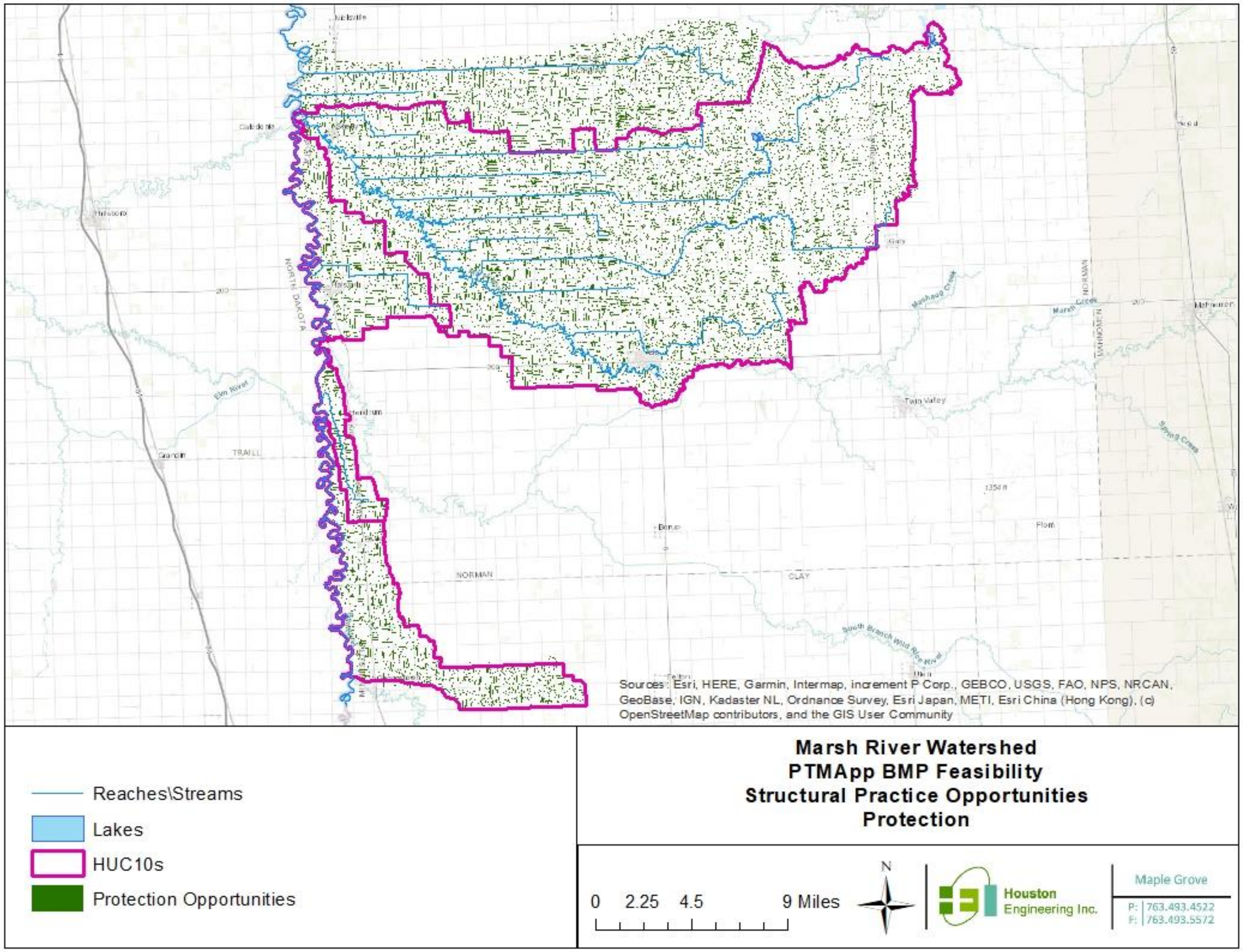


Figure C-5: Feasible locations for PTMApp's Storage Practices Treatment Group in the Marsh River Watershed.

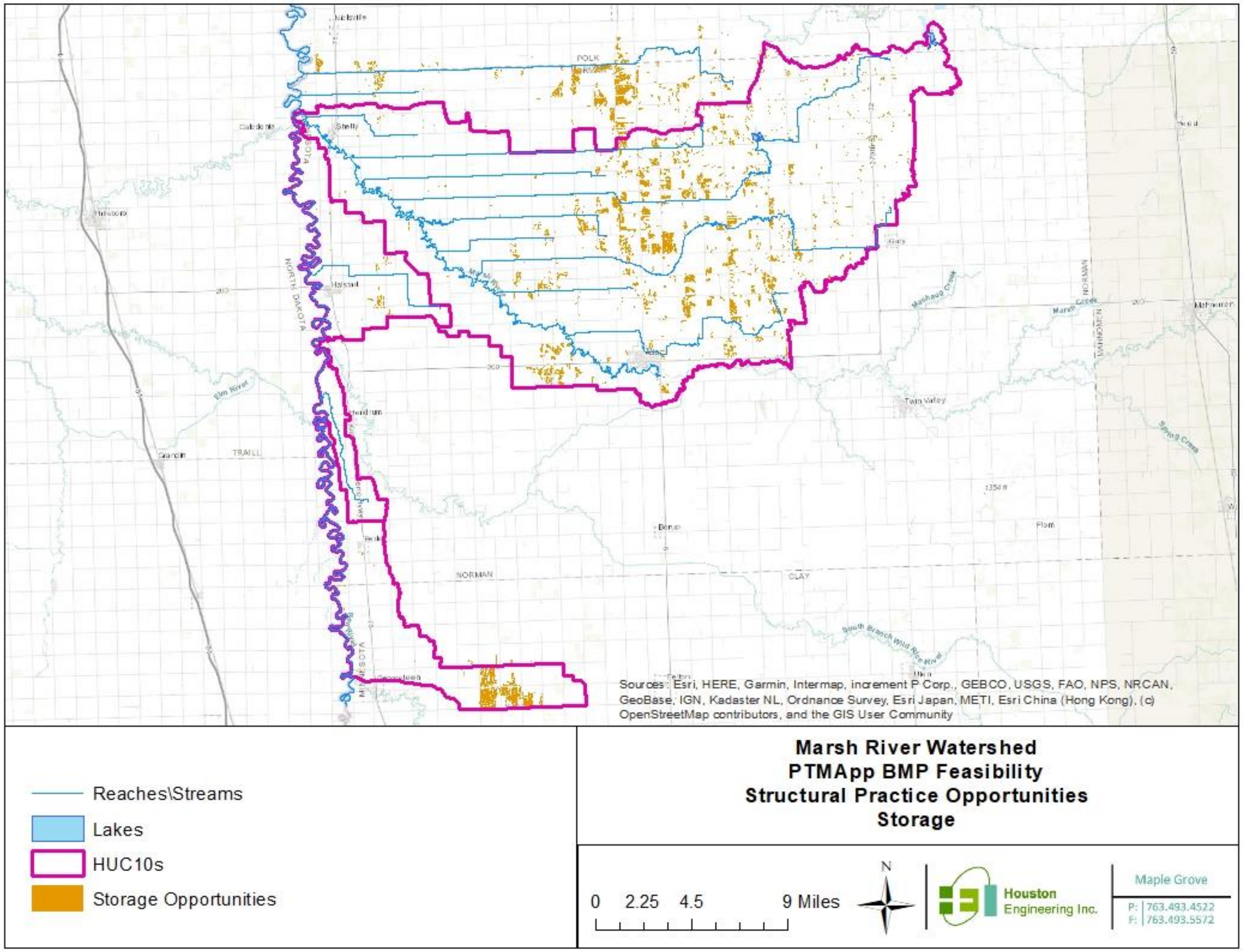
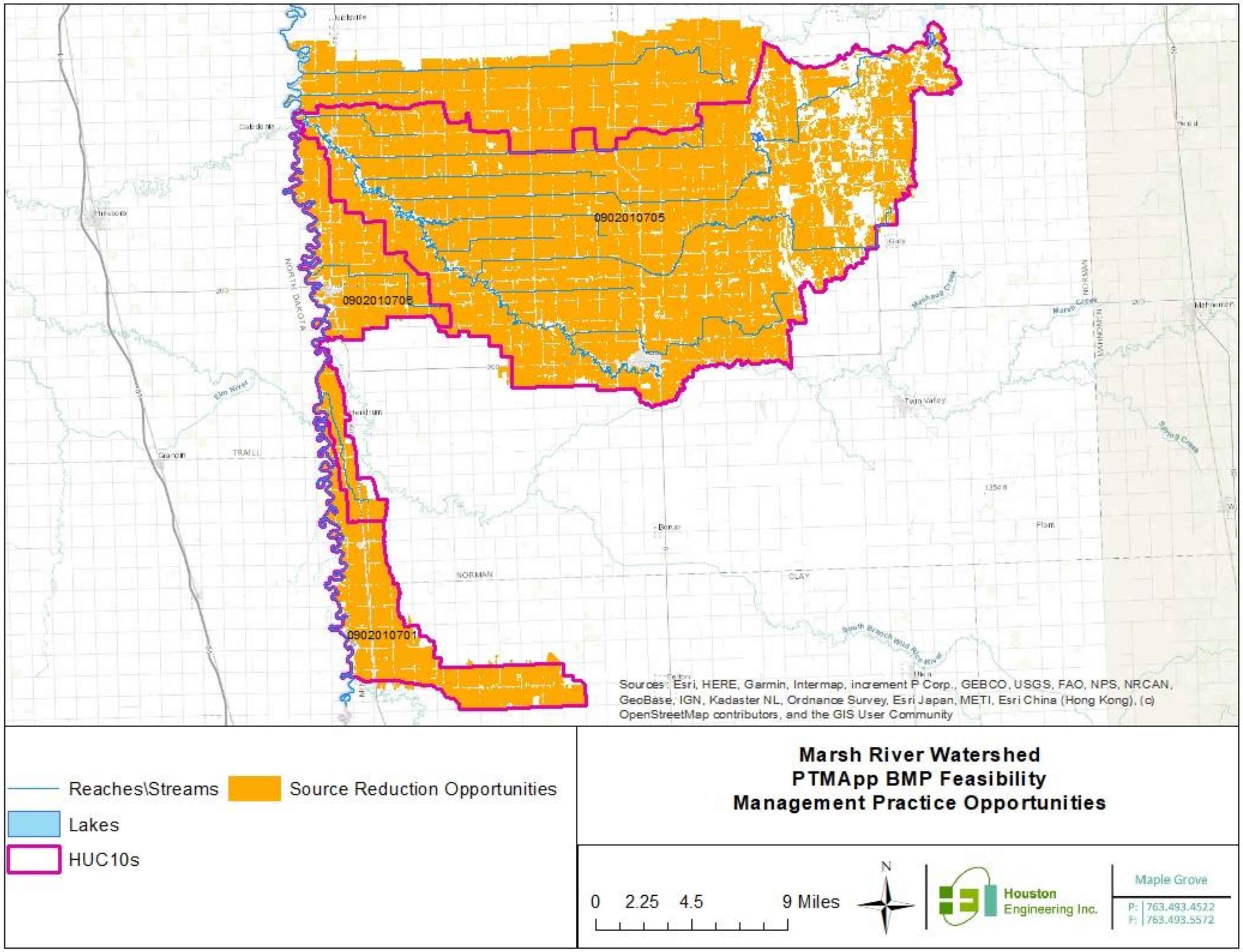


Figure C-6: Feasible locations for PTMApp's Management Practices Treatment Group in the Marsh River Watershed.



Scenario Application Manager

HSPF-SAM is a watershed scale tool that consists of GIS for subwatershed selection, HSPF to simulate the transport and fate of pollutants, and a BMP database. The tool assists in developing custom implementation plans by combining individual and/or suites of BMPs that are simulated and applying reduction efficiencies to the appropriate source loads represented in the HSPF model. **Table C-3** lists the BMPs included in the HSPF-SAM software and their associated PTMApp treatment group.

Table C-3: HSPF-SAM BMPs and associated PTMApp Treatment groups.

SAM BMP Name	Minnesota Agricultural BMP Handbook Practice	NRCS EQIP Practice	NRCS Practice Code	PTMApp Treatment Group[1]
Nutrient Management	Nutrient Management (590)	Nutrient Management	590	6
Nutrient Management + Manure Incorporation	Nutrient Management (590)	Nutrient Management	590	6
Restore Tiled Wetlands (cropland)	Wetland Restoration (651)	Wetland Restoration	657	6
Tile Line Bioreactors	Woodchip Bioreactor (Denitrification Beds)	Denitrifying Bioreactor	747	3
Controlled Tile Drainage	Controlled Drainage (554)	Drainage Water Management	554	1
Riparian Buffers, 16 ft wide (replacing row crops)	Riparian and Channel Vegetation (322/390)	Conservation Cover	327	2
Riparian Buffers, 50 ft wide (replacing row crops)	Riparian and Channel Vegetation (322/390)	Conservation Cover	327	2
Riparian Buffers, 100 ft wide (replacing row crops)	Riparian and Channel Vegetation (322/390)	Conservation Cover	327	2
Filter Strips, 50 ft wide (cropland field edge)	Filter Strips (393) and Field Borders (386)	Conservation Cover	327	2
Conservation Crop Rotation	Conservation Crop Rotation (328)	Conservation Crop Rotation	328	6
Conservation Cover Perennials	Conservation Cover (327)	Conservation Cover	328	6
Corn & Soybeans to Cover Crop	Cover Crops (340)	Cover Crop	340	6
Reduced Tillage (30% + residue cover)	Cover Crops (340)	Cover Crop	340	6
Short-Season Crops to Cover Crop	Conservation Tillage (329, 345, and 346)	Residue and Tillage Management-Reduced Till	329	6
Reduced Tillage (no till)	Conservation Tillage (329, 345, and 346)	Residue and Tillage Management-Reduced Till	329	6
Alternative Tile Intakes	Alternative Tile Intakes	Subsurface Drain	606	4
Riparian Buffers, 50 ft wide (replacing pasture)	Riparian and Channel Vegetation (322/390)	Conservation Cover	327	2
Corn & Soybeans to Rotational Grazing	Rotational Grazing	Conservation Cover	327	6
Water and Sediment Control Basin (cropland)	Water and Sediment Control Basin (638)	Water and Soil Control Basin	638	1

[1]PTMAP Treatment Groups: 1-Storage, 2-Filtration, 3-Biofiltration, 4-Infiltration, 5-Protection, and 6-Source Reduction.

The three BMPs highlighted in green were used to develop the three scenarios. The three scenarios represent an increasing implementation of BMPs and are used to gage the level of effort needed to meet the TMDL reduction goals and aid watershed managers in developing implementation strategies. The three BMP scenarios are:

Scenario 1-Low BMP Implementation:

- Nutrient Management strategies are applied to 10% of the cropland within the watershed, equaling 21,851 treated acres.
- Water and Sediment Control Basins treat 5% of the cropland in subwatersheds where they are feasible, equaling 160 treated acres (see **Figure C-5**).
- Filter Strips, 50ft wide, treat 10% within the watershed, equaling 21,851 treated acres.

Scenario 2-Intermidiate BMP Implementation:

- Nutrient Management strategies are applied to 25% of the cropland within the watershed, equaling 54,633 treated acres.
- Water and Sediment Control Basins treat 10% of the cropland in subwatersheds where they are feasible, equaling 320 treated acres (see **Figure C-5**).
- Filter Strips, 50ft wide, treat 25% of the cropland within the watershed, equaling 54,633 treated acres.

Scenario 3-High BMP Implementation:

- Nutrient Management strategies are applied to 50% of the cropland within the watershed, equaling 109,265 treated acres.
- Water and Sediment Control Basins treat 20% of the cropland in subwatersheds where they are feasible, equaling 640 treated acres (see **Figure C-5**).
- Filter Strips, 50ft wide, treat 50% of the cropland within the watershed, equaling 109,265 treated acres.

Scenario Results

The following provides a summary of the base conditions and the percent load reductions for the three BMP scenarios for TSS, TP, and TN. The base conditions are represented as the simulated annual average loads for 1996 through 2009 that are contributed directly to each reach (**Figure C-7**) and the annual average loads at the outlets of each 10-digit HUC (**Table C-4**). For each scenario, the percent load reductions in each reach is shown in **Figure C-8** through **Figure C-10** and percent load reductions at the 10-digit HUC outlets are summarized in **Table C-5** through **Table C-7**.

Base

Figure C-7: Base conditions of TSS, TP, and TN (in-channel annual average loads) for each reach in the MRW portion of the HSPF model for 1996-2009.

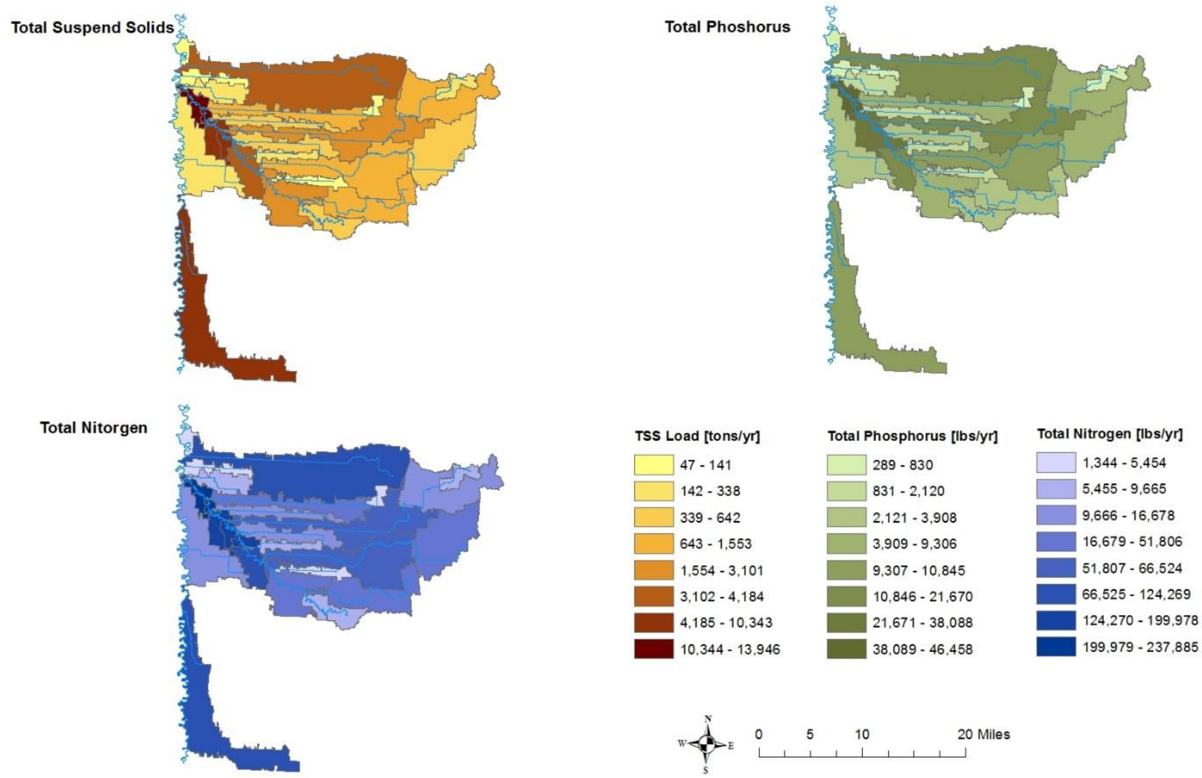


Table C-4: Base conditions of TSS, TP, and TN (in-channel annual average loads) at each 10-HUC outlet from the MRW portion of the HSPF model for 1996-2009.

10-HUC	HSPF Sub-basin	TSS Load [tons/yr]	TP Load [lbs/yr]	TN Load [lbs/yr]
0902010705	980	13,946	46,458	237,885
0902010706	991	338	2,211	11,655
0902030101	995	3,139	15,355	89,676

Scenario 1

Figure C-8: Scenario 1's percent load reductions of TSS, TP, and TN for each reach in the MRW portion of the HSPF model for 1996-2009.

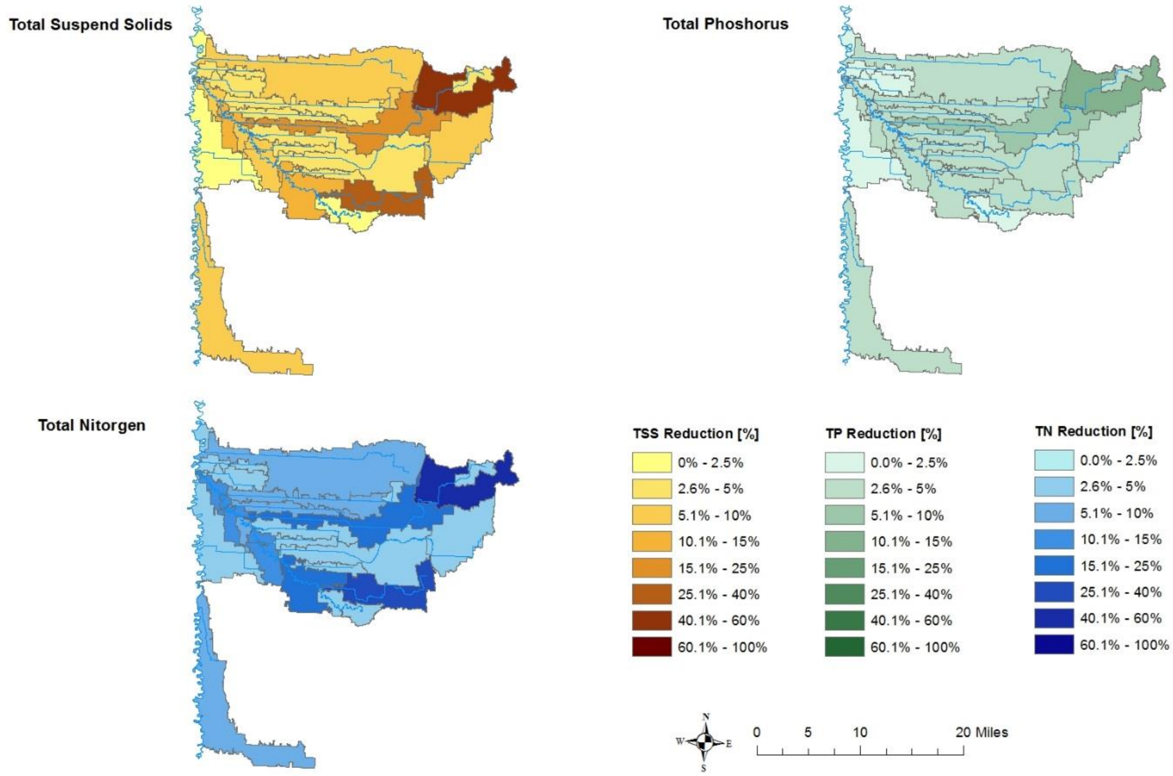


Table C-5: Scenario 1's percent load reductions of TSS, TP, and TN at each 10-HUC outlet from the MRW portion of the HSPF model for 1996-2009.

10-HUC	HSPF Subbasin	TSS Reduction [%]	TP Reduction [%]	TN Reduction [%]
0902010705	980	8.8%	3.5%	11.0%
0902010706	991	1.4%	2.1%	3.2%
0902030101	995	5.6%	3.1%	5.2%

Scenario 2

Figure C-9: Scenario 2's percent load reductions of TSS, TP, and TN for each reach in the MRW portion of the HSPF model for 1996-2009.

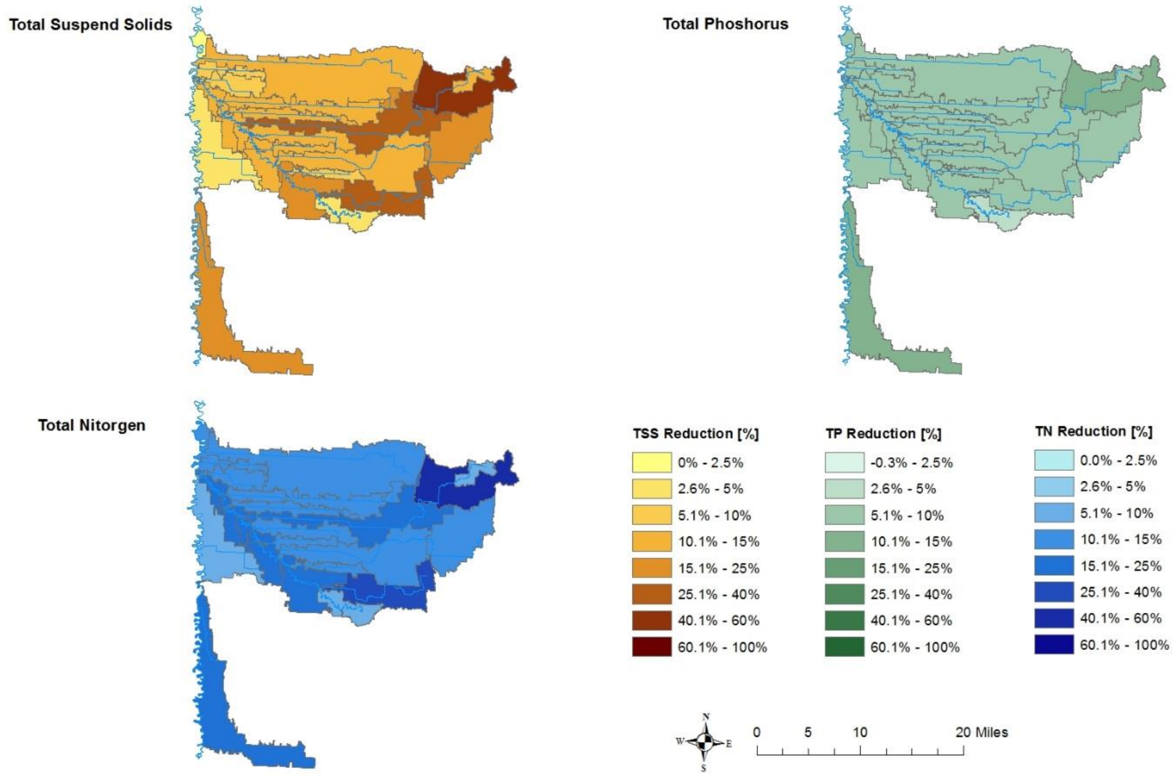


Table C-6: Scenario 2's percent load reductions of TSS, TP, and TN at each 10-HUC outlet from the MRW portion of the HSPF model for 1996-2009.

10-HUC	HSPF Subbasin	TSS Reduction [%]	TP Reduction [%]	TN Reduction [%]
0902010705	980	12.3%	7.0%	17.4%
0902010706	991	3.4%	5.4%	8.1%
0902030101	995	14.1%	7.7%	13.0%

Scenario 3

Figure C-10: Scenario 3's percent load reductions of TSS, TP, and TN for each reach in the MRW portion of the HSPF model for 1996-2009.

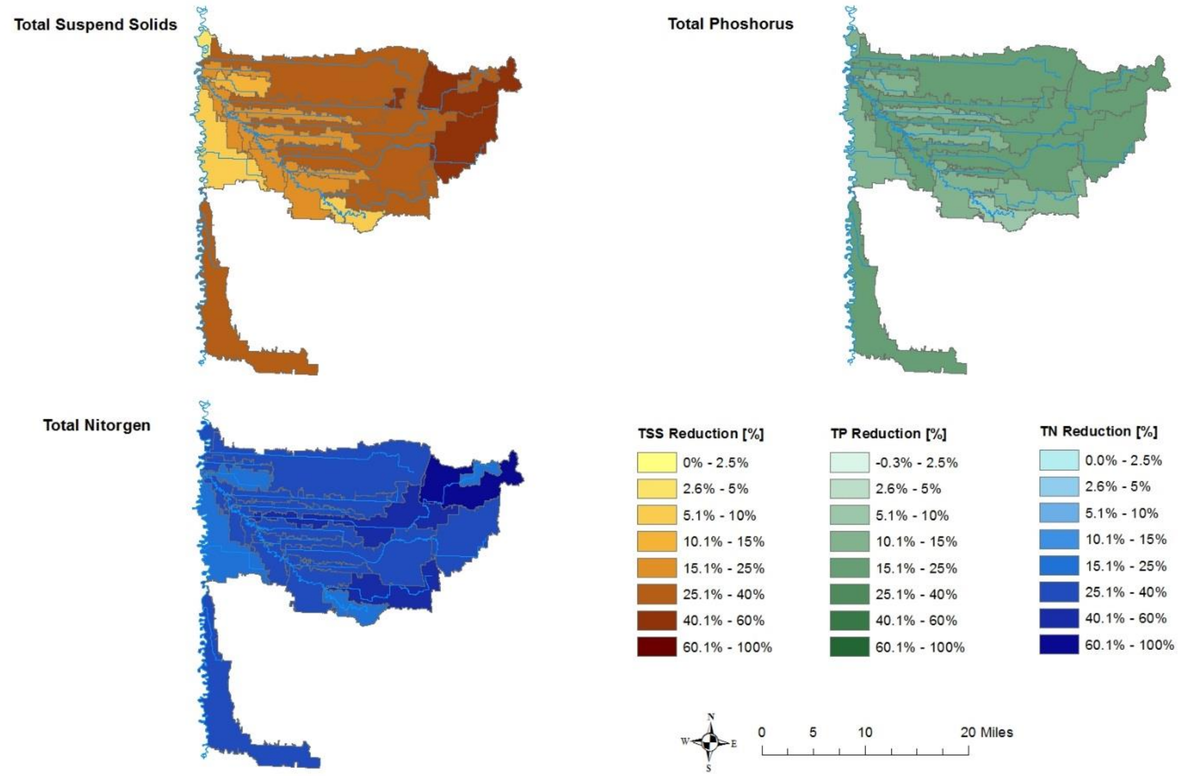


Table C-7: Scenario 3's percent load reductions of TSS, TP, and TN at each 10-HUC outlet from the MRW portion of the HSPF model for 1996-2009.

10-HUC	HSPF Subbasin	TSS Reduction [%]	TP Reduction [%]	TN Reduction [%]
0902010705	980	20.2%	16.2%	32.6%
0902010706	991	6.8%	10.9%	16.3%
0902030101	995	35.2%	20.9%	33.1%

Impaired Reaches

The following provides information for TSS impaired reaches or impaired reaches with TSS as a stressor in the MRW. **Table C-8** provides the needed load reduction in TSS, the modeled average annual load in tons per year, and load reduction for each BMP scenario.

Table C-8: Percent load reductions for BMP scenarios in impaired reaches.

AUID	HSPF sub-basin	Need Load Reduction	Base TSS Load [tons/yr]	Scenario 1	Scenario 2	Scenario 3
09020107-503	970	20%	13,716	8.9%	12.4%	20.3%

Discussion

HSPF-SAM provides limited implementation practices to treat overland sources of pollutants and does not allow for near channel or in-channel implementation strategies to be simulated. The three scenarios show increasing treatment in the watershed as the area of treatment increases. As the treatment area doubles from Scenario 1 to Scenario 2, the load reductions nearly double in load reduction percentages, same with the doubling of treatment area from Scenario 2 to Scenario 3. This means a large portion of the sediment in the MRW stems from overland sources and increased implementation of practices will provide the roughly same magnitude of treatment. Additional implementation practices not included in HSPF-SAM that target other sources (i.e., streambank erosion and in-channel sources) may provide additional load reductions in the Marsh River.

For the impaired reach of the Marsh River, the 20% load reduction in sediment can be achieved with Scenario 3, with 20% of cropland treated with WASCOBs and 50% treated with filter strips. Nutrient Management strategies, as simulated in HSPF-SAM, do not provide sediment treatment.