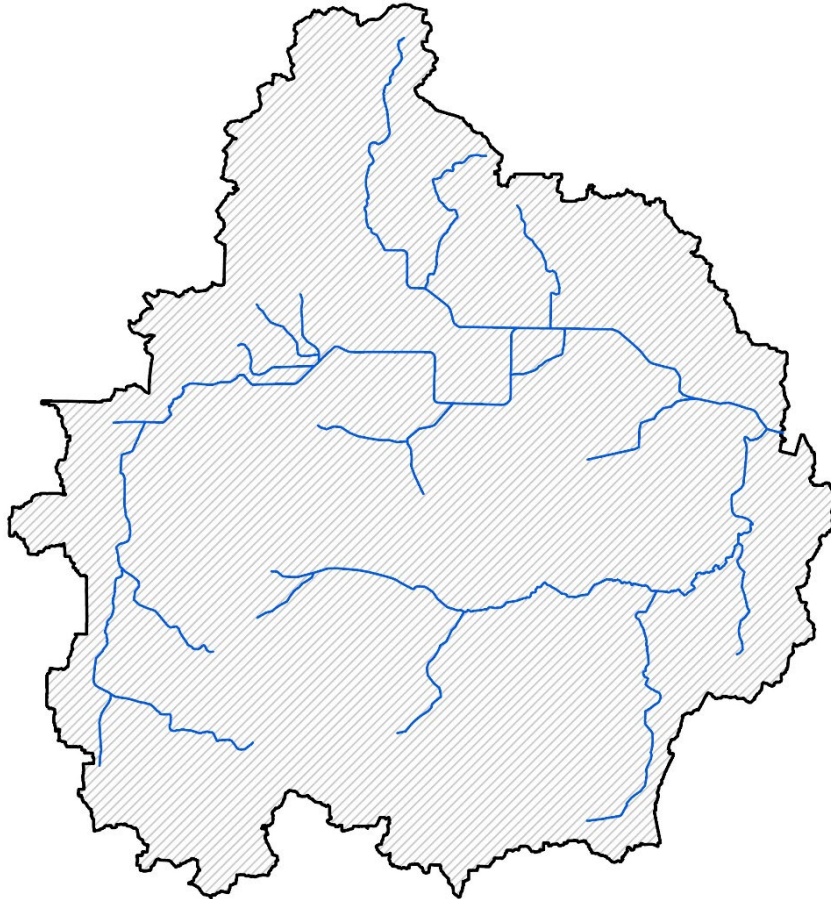


VERMILLION RIVER HEADWATERS

Subwatershed Assessment



Prepared by Scott Soil and Water Conservation District with financial support from Clean Water, Land and Legacy Amendment and the Vermillion River Watershed Joint Powers Organization

May 23, 2025



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List of Acronyms

BMP('s)	Best Management Practice(s)
BWSR	Board of Water and Soil Resources
EQIP	Environmental Quality Incentives Program
GIS	Geographic Information System
HEI	Houston Engineering Inc.
LiDAR	Light Detection and Ranging
MCD	Metro Conservation Districts
MNDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MSHA	Minnesota Stream Habitat Assessment
NRCS	Natural Resource Conservation Service
PTMApp	Prioritize Target and Measure Application
PRP's	Priority Resource Points
RUSLE	Revised Universal Soil Loss Equation
SWA	Subwatershed Assessment
SWCD	Soil and Water Conservation District
TN	Total Nitrogen
TP	Total Phosphorus
TS	Total Sediment
USDA	United States Department of Agriculture
VRWJPO	Vermillion River Watershed Joint Powers Organization
WASCOB	Water and Sediment Control Basin

Executive Summary

This report presents the results of a comprehensive assessment of potential sediment, nitrogen and phosphorus reduction BMP projects within the watershed areas of the two stream branches in Scott County that together form the headwaters of the Vermillion River, the largest geographical watershed in the seven-county Twin Cities metro area. The southern branch is considered the western-most segment of the main stem of the Vermillion River; the northern branch is considered a tributary, the majority of which constitute the recently abandoned County Ditch 12. The various practices identified were prioritized based on predicted catchment area pollutant loading and the feasibility and cost effectiveness of implementation. Priority catchments and, subsequently, potential projects were identified using BWSR's Prioritize, Target, and Measure Application (PTMApp) toolbar in ESRI's ArcGIS Pro software, considering pollutant delivery efficiency and site-specific constraints. Potential BMP types were identified based on their potential pollutant load reduction following implementation. These included:

- Water and Sediment Control Basins
- Grade Stabilization Structures
- Grassed Waterways
- Filter Strips
- Wetland Restorations
- Native Grasses

This report includes maps of the proposed location and aerial extent of recommended BMP projects within each tributary subwatershed. In addition, it describes potential pollutant reductions including sediment, phosphorus and nitrogen associated with the individual BMP's. If a specific project outlined in this report is selected for installation, site specific designs, landowner agreements, and funding sources must be secured to implement the BMP. The collection of projects listed in this report should be updated on a regular basis as new projects or new technologies are identified.

Document Overview

The Vermillion River Headwaters Subwatershed Analysis is a watershed management tool developed to proactively identify and prioritize BMP projects based on performance and cost effectiveness. This process is intended, ultimately, to assist local water management agencies, soil and water conservation districts and their partners maximize the cost-effective use of public funding for watershed protection and improvement.

The methodology behind this document provides the ability to rapidly assess subwatersheds for locations where the most appropriate and feasible BMP's can be implemented based on actual site conditions. While accurate and sufficient for the intended purposes of this analysis, final costs and pollutant removals must be refined once projects are selected for construction. Construction projects should be considered as only one part of an overall watershed restoration plan that includes, but is not limited to, educational outreach, discharge prevention, and pollutant source control.

This document is organized into three sections including Methods, Headwaters Tributary Subwatershed BMP's and Cost/Benefit Analysis Ranking for the proposed BMP's. Each section is briefly described below.

Methods

The Methods section outlines the general procedures used when assessing the watershed. It details the processes of Project Scoping, Desktop Analysis, Cost/Treatment Analysis, and Project Ranking. This protocol provides the detail necessary to rapidly assess issues and opportunities at variable scales within a defined watershed. It further allows for narrowing down multiple potential remediation options to a point where the resource manager can select the most appropriate BMP based on site-specific characteristics and defined goals.

Vermillion River Headwaters Tributary Subwatersheds and BMP's

BMP's were proposed by the Prioritize Target and Measure Application (PTMApp) toolbar, titled by name and numbered as an identifier which is then referenced when comparing results across the watershed. Detailed information relating to each site-specific BMP proposed is provided below:

Description of Existing Site Conditions

Proposed BMP existing site conditions are discussed related to soils, land cover, and agricultural farming practices.

Site Selection

A rendered aerial photo highlights locations identified for suitable BMP projects. Additional field inspections will be required to confirm project feasibility, but the most ideal locations for BMP project installations are identified here based on best available desktop data.

BMP Recommendations

The BMP Recommendation section describes the conceptual BMP's selected for the area. In most instance multiple BMP's were reviewed with the most feasible ones being recommended based on their compatibility with current land use, predicted pollutant reduction efficiency, and estimated costs.

Cost/Benefit Analysis

A summary table provides for the direct comparison of the expected amount of treatment of the proposed BMP that can be expected per invested dollar.

Cost/Benefit Analysis Ranking

Projects that are 1) most suited to address the project goals, 2) compatible with current land use and 3) predicted to have reasonable design, installation and maintenance costs were chosen for a cost/benefit analysis and ranked (Table 2). The list is sorted by modeled volume of sediment reduction (tons per year) by BMP. The typical minimum maintenance period for most publicly funded projects on private land is 10 years, with the exception of grade stabilization structures and wetland restoration which have a design life of 15 years, consistent with local cost share policies.

Residue Management including mulch till, strip till, and no till, were identified during the field reconnaissance portion of this SWA as the most feasible BMP's for cropland with moderate to steep slopes throughout the entire watershed. These were not specifically modeled in this assessment due to the lack of an accurate treatment analysis model for pollutant reduction. Scott SWCD's annual countywide tillage transect survey, however, reveals that over the past 10 years an average of 82% of all cropland already has residue levels that exceed fifteen percent (15%). Results of the same survey also show that the percentage of cropland with thirty percent (30%) or more residue remains slightly less than fifty percent (<50%), suggesting there is significant opportunity for increased adoption of high residue management practices. Despite not being modeled, promotion of these practices throughout all agricultural lands in the Vermillion Headwaters Subwatershed will continue to be a priority for the Scott SWCD due to their widely accepted cost effectiveness and the water quality improvement they generate by reducing soil erosion and improving soil health. These efforts will range from broad outreach campaigns using print and social media to one-on-one technical support with individual producers.

Methods

Step #1: Project Scoping

Identifying an impaired water body and its contributing watershed are the first steps in the assessment process. MPCA's impaired waters list (referred to as the "303(d)" list) is used for this purpose. Certain segments of the tributary streams that form the Vermillion River Headwaters have struggled historically with excessive *Escherichia coli* (*E. coli*) and Chlorides, and, during high flows, Total Suspended Solids. DNA testing in 2016 and 2017 revealed both human and cattle sources of *E. coli*. Ongoing water quality monitoring by the VRWJPO shows the

headwaters continue to struggle with high levels of Chloride pollution relative to the rest of the watershed, and the entire southern branch (Vermillion River main stem) and a portion of the northern branch tributary (up to Interstate 35) are on MPCA's 2024 303(d) impaired waters list for E. coli.

While the headwaters of the Vermillion River are located in southeastern Scott County, most of the watershed is located in Dakota County. The total area of the portion of in Scott County is approximately 11,500 acres, the majority of which is in some form of agricultural use. When this study commenced the 2019 National Land Cover Database (NLCD) was the most current and comprehensive data set available for evaluating land cover, which is one of the key inputs used in the PTMApp model. As shown in Figure 1, 53% or 6,508 acres of the watershed is identified as cultivated crops or hay/pasture, 20% or 2,430 acres is herbaceous/shrub/forest land cover, 17% or 2,116 acres is considered developed or barren land which includes road rights of way, and open water and wetlands constitute the remaining 10% or 1,150 acres.

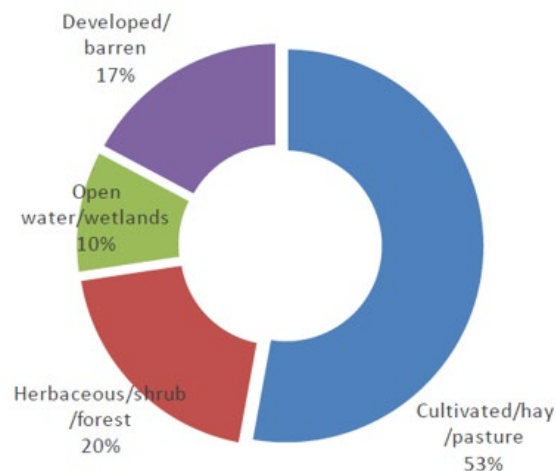


Figure 1 Vermillion Headwaters land use by type (NLCD 2019)

Step 2: Desktop Analysis – PTMApp Model

The purpose of the desktop analysis was to narrow the amount of field reconnaissance and other time-consuming tasks that would be needed to complete the SWA by identifying and prioritizing those areas within the watershed that likely yield the greatest pollutant loads. ArcGIS Pro was used with the help of BWSR's PTMApp Toolbar. It was assumed that areas having the highest soil erosion rates were also the areas that generated the greatest nutrient loadings.

To calculate watershed nutrient loading the PTMApp tool combines several different inputs to produce the most accurate representation of the watershed. Local area rainfall rates help the model derive the rate at which nutrients will move through the watershed. Elevation and planimetric datasets help the model determine flow patterns and travel times, which enable the model to map the path of pollutant runoff and perform a decay function to represent natural processes. Another element of the model uses soil type and curve number information to adjust for runoff and infiltration rates. Finally, the tool utilizes Revised Universal Soil Loss Equation (RUSLE) inputs to calculate soil erosion rates.

The tool generates multiple outputs that can graphically display and quantify loading potentials throughout the watershed, predict optimal conservation practice locations and types, and calculate corresponding pollutant reduction and costs. After the watershed is segmented into roughly 40-acre parcels all inputs are linked to the PTMApp toolbar through specific folder assignments. The tool calculates loading for nitrogen, phosphorus, and sediment. Flow (accumulation) over the watershed is calculated using the Stream Power Index (SPI). The SPI, which is calculated using the formula $\ln[(\text{flow accumulation}) \times (\text{slope})]$, is used to simulate surface water flow irrespective of land cover, land use, soil type or other factors that may otherwise influence potential rates of erosion or pollutant runoff. Sediment yield is calculated using the Revised Universal Soil Loss Equation (RUSLE) of $R \times K \times L \times S \times C \times P$, where R is the rainfall rate, K is soil erodibility factor, LS is slope-length factor, C is the cover or management factor, and P is the support practice factor. After sediment yield is determined the sediment delivery ratio (SDR) is calculated using the formula $0.41 \times \text{Catchment Drainage Area (sq.km)}^{-0.3}$. Final accumulations at priority resource points (PRP's) are estimated after adjustment and decay factors are applied. Similar techniques are used to calculate total phosphorus, except values are driven by land cover associations ratios and decay factors are applied for final loading values. Loading totals are represented at several different levels. The amount of loading can be examined on an event basis with the results showing both 2-yr and 10-yr rainfall results. The results are also broken down into

quartiles so products will show every option from minimum to maximum loading results. The flexibility of the model allows the user to examine multiple scenarios for watershed loading while also offering suggestions to help with nutrient reductions.

To utilize the PTMApp tool a number of products created in ArcGIS Pro are prerequisite. The process to run the tool followed the *PTMApp Desktop Toolbar User's Guide* developed by Houston Engineering Inc., using their default tool parameters. The default unit costs for the BMP practices in PTMApp are 25% of total project costs, based on 2020 USDA-NRCS EQIP cost estimates for installation and implementation of new conservation practices in Minnesota. An adjustment to the default unit costs was applied to generate more current total project costs based on local SWCD staff knowledge and experience that account for significant inflation cost increases experienced since the pandemic (Table 1). The adjustment resulted in a doubling of the default unit costs. Prior to running the model, the watershed had to be hydro-conditioned to ensure the 2022 digital elevation model accurately represented the watershed's flow. Following hydro-conditioning PRP's were identified to provide a more discrete loading model. Additional priority points were added to the main channels, at known historic and potential future monitoring sites, to improve discretization of pollutant loading outputs. Model runs using the PTMApp toolbar were performed by Houston Engineering Inc.

The BMP's modeled in PTMApp are based on Natural Resources Conservation Services (NRCS) practice codes. The model utilizes several BMP selection criteria for each practice to identify the most practical locations for each practice. This report focused on the practices that are commonly used by the SWCD and are included in the Scott County 2025 Conservation Practice Financial Assistance Program Policy Manual. Tables 1 lists and describes the BMP's within the PTMApp tool, and Table 2 summarizes the criteria it uses for BMP selection.

Table 1: PTMApp default unit costs and BMP naming as grouped in PTMApp.

BMP Group	BMP (BWSR Naming)	BWSR ID	NRCS ID	BMP Handbook Group	Unit Cost	Unit Cost Value
Storage	Farm Pond/Wetland	378	378	-	1624.10	\$/acre
	Drainage Water Management	554	554	Controlling	11.08	\$/acre
	Water and Sediment Control Basin	638	638	Trapping	9000.00	\$/each
	Regional Wetland/Pond	-	656_1*	Trapping	24439.57	\$/acre
	Large Wetland Restoration	-	656_2*	Trapping	24439.57	\$/acre
Filtration	Riparian Buffer	390	390	Controlling	2131.74	\$/acre
	Filtration Strip	393	393	Trapping	992.16	\$/acre
Biofiltration	Saturated Buffer	-	604	Trapping	2735.56	\$/acre
	Denitrifying Bioreactor	-	605	Trapping	76.04	\$/cu yd
Infiltration	Infiltration Trench/Small Infiltration Basin	350	350**	Trapping	72.90	\$/sq yd
	Multi-stage Ditch (open channel)	-	582	Controlling	4036.56	\$/acre
Protection	Critical Area Planting	342	342	-	587.54	\$/acre
	Grade Stabilization	410	410	Avoiding	290.13	\$/sq yd
	Grassed Waterway	412	412	Controlling	18700.00	\$/acre
	Lake and Wetland Shoreline Restoration	580	580	Controlling	37.98	\$/sq yd
Source Reduction	Perennial Crops (Conservation Cover)	327	327	Avoiding	480.80	\$/acre
	No till (Conservation Tillage)	329	329	Controlling	50.00	\$/acre
	Cover Crops	340	340	Avoiding	67.04	\$/acre
	Reduced till (Conservation Tillage)	-	345	Controlling	22.06	\$/acre
	Forage / Biomass Planting	512	512	-	89.68	\$/acre
	Prescribed Grazing	528	528	Controlling	13.00	\$/acre
	Nutrient Management of Groundwater	590	590_1*	Avoiding	13.68	\$/acre
	Nutrient Management of Phosphorus	590	590_2*	Avoiding	13.68	\$/acre
	Nutrient Management of Nitrogen	590	590_3*	Avoiding	13.68	\$/acre

Table 2: PTMAApp BMP selection criteria.

PTMAApp Treatment Group (PTMAApp Group Number)	BMP Name (NRCS practice code)	PTMAApp BMP Selection Criteria	BMP Raster/Layer Name
Storage (1)	Water and Sediment Control Basin (638)	- Accumulated sed. delivered to flowline percentile rank >0.75 - Contributing drainage area <40 acres - NLCD land cover must be Cultivated Crops - Stream power index (SPI) percentile rank >0.80 - Must have greater than 4,356 ft3 (0.1 ac-ft) upstream storage per WASCOB	wascob_bin
Filtration (2)	Riparian Buffer (390)	- NLCD land cover must be Cultivated Crops - Practices must be within a 100ft buffers surrounding drainage pathways >20 acres OR a 100ft buffer of NHD high resolution waterbodies that intersect drainage pathways larger >20 acres	riparian_bin
	Filtration Strip (393)	- Contributing drainage area <124 acres - NLCD land cover must be Cultivated Crops - Sediment mass accumulated at the catchment outlet <8.1 tons/year - Include areas within 33m of flowline where flowline is defined as drainage area greater than 124 acres - Slope greater than 1%	filtst_bin
Protection (5)	Critical Planting Area (342)	- NLCD land cover must be Cultivated Crops - Stream Power Index (SPI) percentile rank must be greater than or equal to 0.50 - Flow accumulation, or drainage area, to the cell must be between 5-100 acres - Apply Expand 10m (33ft) to include typical buffer around planting area	crit_plant_bin
	Grade Stabilization (410)	- NLCD land cover must be Cultivated Crops - Stream Power Index (SPI) percentile rank must be greater than or equal to 0.50 - Drainage area to the BMP must be between 40 and 250 acres - Slope of the individual raster cell must be greater than or equal to 4% - Velocity of flow (estimated using Manning's equation) at the cell generated from the 2yr 24hr storm event must be greater than or equal to 4ft/sec	protect_bin
	Grassed Waterway (412)	- NLCD land cover must be Cultivated Crops - Slope of the individual raster cell must be between 3-12% - Using the Expand tool, if any cells within 50m cells have drainage area >1000 acres, remove cell from inclusion - flow accumulation, or drainage area, to the cell must be between 5-100 acres - Apply Expand tool to make minimum width 15m (100ft), meeting typical installed width plus small buffer - Grassed waterway BMP raster generated in both filtration and protection groups. User has the option to summarize results for this BMP in either group	Gwater_bin
	Lake and Wetland Shoreline Restoration (580)	BMP's considered within 5m of areas where bank heights are greater than 1.524m (5ft) on a perennial flowline (defined as drainage area of 1000 acres or more)	shore_bin
		Within 100ft of lakes (in lakes route) and wetlands (from NWI in base.gdb)	
		Can be placed on any land cover types with exception to open water and wetlands; often times adjacent to fields on fallow ground	
		- Stream Power Index (SPI) percentile rank must be greater than or equal to 0.80 - Expand BMP 5m (16ft) to include typical buffer around planting area	
Source Reduction (6)	Perennial Crops (327)	- NLCD land cover must be Cultivated Crops (1) When the crop productivity index is unavailable in the soil data, assume the index value is 0 AND (2) only consider a BMP when the index is equal to or below 0.61 - No drainage pathways within practice larger than 640 acres (1 square-mile)	peren_bin
	No-till (329)	- NLCD land cover must be Cultivated Crops - No drainage pathways within practice larger than 640 acres (1 square-mile)	no_till_bin
	Cover Crops (340)	- NLCD land cover must be Cultivated Crops - No drainage pathways within practice larger than 640 acres (1 square-mile)	CovCrop_bin

Step 3: Desktop Reconnaissance

As a complementary effort, Scott SWCD staff performed a desktop GIS-based reconnaissance of the entire watershed to validate the thoroughness and accuracy PTMAApp model results. This analysis was performed at the 40-acre grid level and relied on available information including LiDAR contours, historical aerial photography, and flow accumulation and slope raster data sets, in addition to local knowledge of the land use, land cover, and agricultural activity in the watershed. Potential locations that would benefit from BMP treatment were based on observed patterns of erosion, proximity to sensitive resources, and slope characteristics. Utilizing local knowledge and experience, staff identified 49 sites where BMP's were not captured in PTMAApp modeling but would be likely feasible. Selected BMP's types, which included grassed waterways, grade stabilization structures, wetland restoration, and conservation cover, were based on site-specific characteristics, project feasibility, and ability to address the resource concern in a cost-effective manner. The types of BMP considered are listed in table 3 below, and their specific locations are shown in Map 6 and in figures associated with detailed analyses presented on pages

24 through 33. It is worth noting that in some locations, PTMApp selected the WASCOD practice but upon close analysis staff determined grassed waterways would likely be the more feasible option based on evident topography.

Table 3: BMPs considered for each site.

Pollutant Source/Feature	Potential BMP Practice
Ephemeral Erosion	Grassed Waterway Critical Area Planting Water and Sediment Control Basin Grade Stabilization Structure
Sheet & Rill Erosion	Conservation Cover Filter Strip
Farmed Wetland	Wetland Restoration

Step 4: Benefit Ranking

After PTMApp BMP projects were identified by SWCD staff, potential sediment reductions were calculated within the tool itself along with preliminary cost estimates. Highest rankings were applied to those BMP's in the top 10% of sediment contributing catchments, and those that had the potential to produce the greatest nutrient removal over a 10- or 15-year life cycle. It is important to note that actual cost will likely differ from PTMApp's estimated costs due to the toolbar's inability to indicate precise locations and specific design features for identified BMP's. The final value for the cost per pound of treatment includes estimated cost to plan, design, construct, operate, maintain and finance the practice over its entire lifespan.

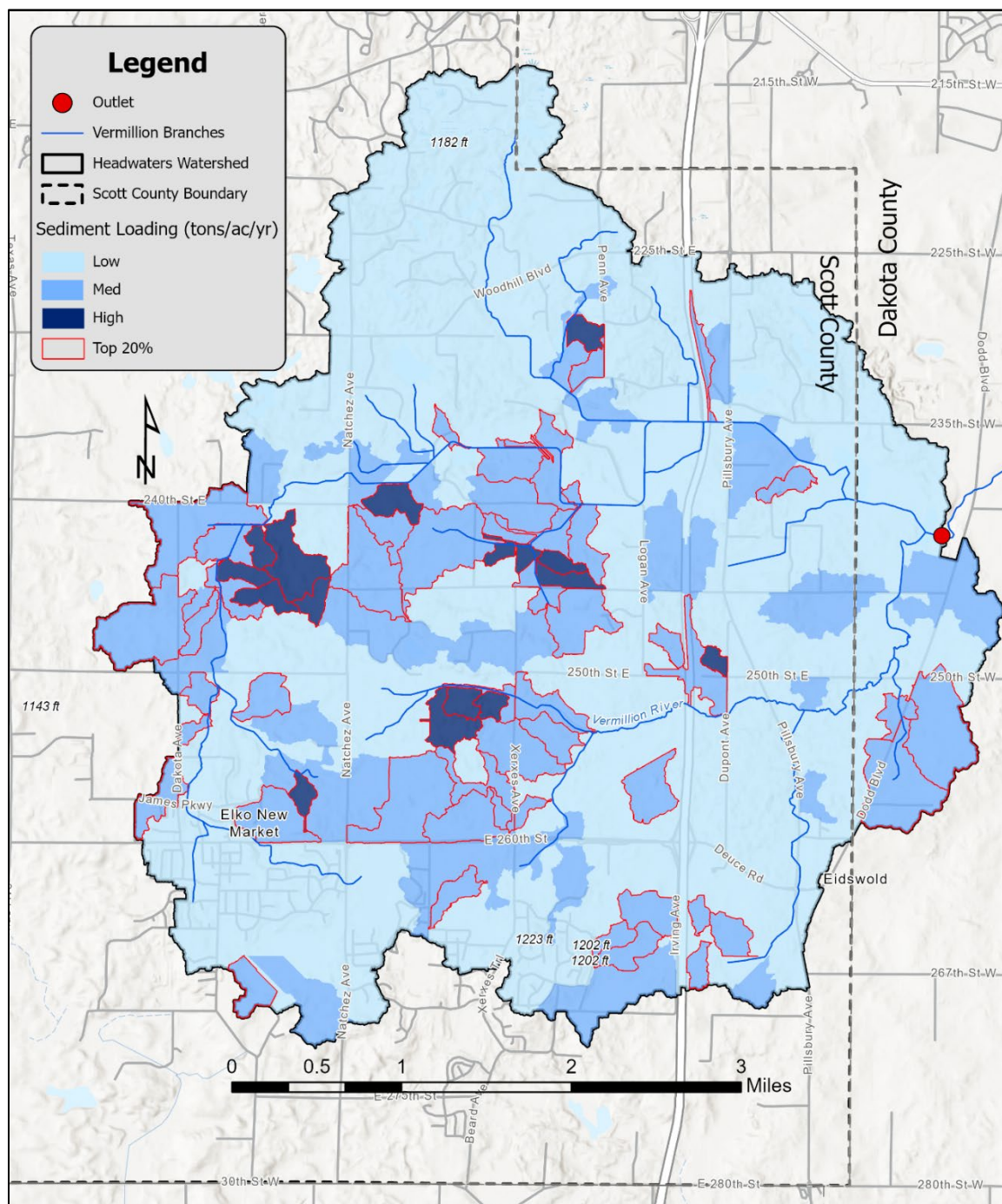
The sediment, nitrogen, and phosphorus reduction estimates associated with the installation of each project should be considered as pollutant reduction to the Headwaters of the Vermillion River. It is important to note that reported treatment levels are dependent upon optimal site selection and sizing. Not all locations and sizes will yield the same results.

Results

The PTMApp analysis for the Vermillion Headwaters calculated potential sediment, phosphorus, and nitrogen loading. The vulnerability of each 40-acre (+/-) parcel delineated by PTMApp is scaled and then ranked relative to all other parcels. The average annual catchment loading predicted by PTMApp was approximately 27 tons of sediment, 153 Lbs. of nitrogen, and 12 Lbs. of phosphorus. The top 20% of the 302 catchments generated by PTMApp are listed in Tables 4 through 6 and shown in Maps 1 through 3, below.

Table 4: PTMAApp predicted top 20% of sediment contributing catchments ranked by yield at field edge.

Catchment	acres	Sediment Load (tons/yr)	Sediment Yield (tons/ac/yr)
500642	15.59	82.10	5.27
500731	24.80	113.86	4.59
500683	21.39	81.38	3.80
500567	67.82	257.28	3.79
500672	20.24	72.49	3.58
500486	32.64	116.75	3.58
501186	16.43	47.85	2.91
501516	22.66	61.57	2.72
500626	17.59	46.03	2.62
500891	11.45	29.69	2.59
500945	21.03	54.36	2.59
500176	21.25	54.87	2.58
500742	19.32	49.77	2.58
500968	15.10	38.83	2.57
501027	39.48	97.20	2.46
501249	65.08	141.49	2.17
501211	10.08	21.23	2.10
501215	10.97	22.87	2.08
387	56.43	112.51	1.99
500935	123.36	242.75	1.97
582	41.58	81.11	1.95
501422	18.61	35.29	1.90
501400	12.74	24.06	1.89
501145	121.42	225.55	1.86
500599	32.75	59.89	1.83
691	23.35	42.30	1.81
501458	30.78	55.61	1.81
501099	72.09	129.43	1.80
501471	33.42	58.88	1.76
501530	39.31	67.50	1.72
501197	61.88	104.86	1.69
501005	37.19	62.43	1.68
501184	39.47	65.88	1.67
501529	13.98	23.00	1.65
500485	22.40	36.58	1.63
914	54.90	89.59	1.63
500890	16.88	27.49	1.63
500575	38.51	62.57	1.62
500579	14.32	22.47	1.57
500824	21.25	33.29	1.57
1397	43.62	68.19	1.56
501438	32.68	50.91	1.56
501071	121.44	186.38	1.53
500233	18.56	28.42	1.53
476	53.59	80.82	1.51
500624	95.68	141.92	1.48
500600	123.54	181.16	1.47
501514	36.73	53.83	1.47
501488	17.39	24.69	1.42
501358	27.53	38.95	1.41
500756	68.95	96.59	1.40
500251	18.69	25.79	1.38
501528	44.08	60.13	1.36
501520	31.34	40.07	1.28
1071	21.81	25.77	1.18
501097	51.76	60.76	1.17
500553	117.74	137.27	1.17
501517	27.53	32.00	1.16
500725	122.37	141.42	1.16
501068	34.02	38.74	1.14



Map 1: Map showing sediment loading as predicted by PTMap, in tons/ac/yr; top 20% of catchments are outlined in red.

Table 5: PTMAApp predicted top 20% of Nitrogen contributing catchments ranked by yield at field edge.

Catchment	Acres	Nitrogen Load (Lbs./yr)	Nitrogen Yield (Lbs./ac/yr)
501278	105.66	755.31	7.15
501273	10.06	69.45	6.90
501396	50.62	338.24	6.68
501358	27.53	182.52	6.63
500683	21.39	139.09	6.50
500642	15.59	101.22	6.49
501422	18.61	120.01	6.45
501274	40.11	258.06	6.43
500742	19.32	123.25	6.38
500731	24.80	156.00	6.29
1382	25.42	159.38	6.27
500599	32.75	204.32	6.24
501516	22.66	139.29	6.15
501272	102.02	625.71	6.13
501290	75.12	457.69	6.09
501145	121.42	737.45	6.07
500935	123.36	745.71	6.05
1232	23.48	141.84	6.04
501391	12.09	72.58	6.00
501197	61.88	367.40	5.94
501468	11.43	67.78	5.93
501211	10.08	59.35	5.89
501438	32.68	190.27	5.82
501370	18.51	107.44	5.81
501400	12.74	73.85	5.80
501488	17.39	100.47	5.78
500233	18.56	106.54	5.74
500343	52.97	302.23	5.71
500739	19.44	110.00	5.66
501027	39.48	222.66	5.64
501215	10.97	61.80	5.63
501458	30.78	172.84	5.62
501099	72.09	400.42	5.55
1388	25.57	139.32	5.45
501230	16.16	87.87	5.44
500579	14.32	77.66	5.42
500803	16.41	88.84	5.42
501229	89.98	486.74	5.41
500672	20.24	107.20	5.30
500486	32.64	171.81	5.26
1397	43.62	229.42	5.26
500567	67.82	355.70	5.24
501071	121.44	635.63	5.23
914	54.90	285.26	5.20
501524	37.05	189.65	5.12
500945	21.03	107.59	5.12
1401	10.55	53.77	5.09
501068	34.02	173.32	5.09
501108	115.75	586.65	5.07
1022	15.27	77.06	5.05
500891	11.45	57.74	5.04
501288	98.22	493.38	5.02
500756	68.95	343.58	4.98
500626	17.59	87.58	4.98
501249	65.08	322.54	4.96
500725	122.37	604.11	4.94
500257	35.73	174.54	4.88
501457	122.65	598.37	4.88
501309	18.03	87.84	4.87
500251	18.69	90.85	4.86

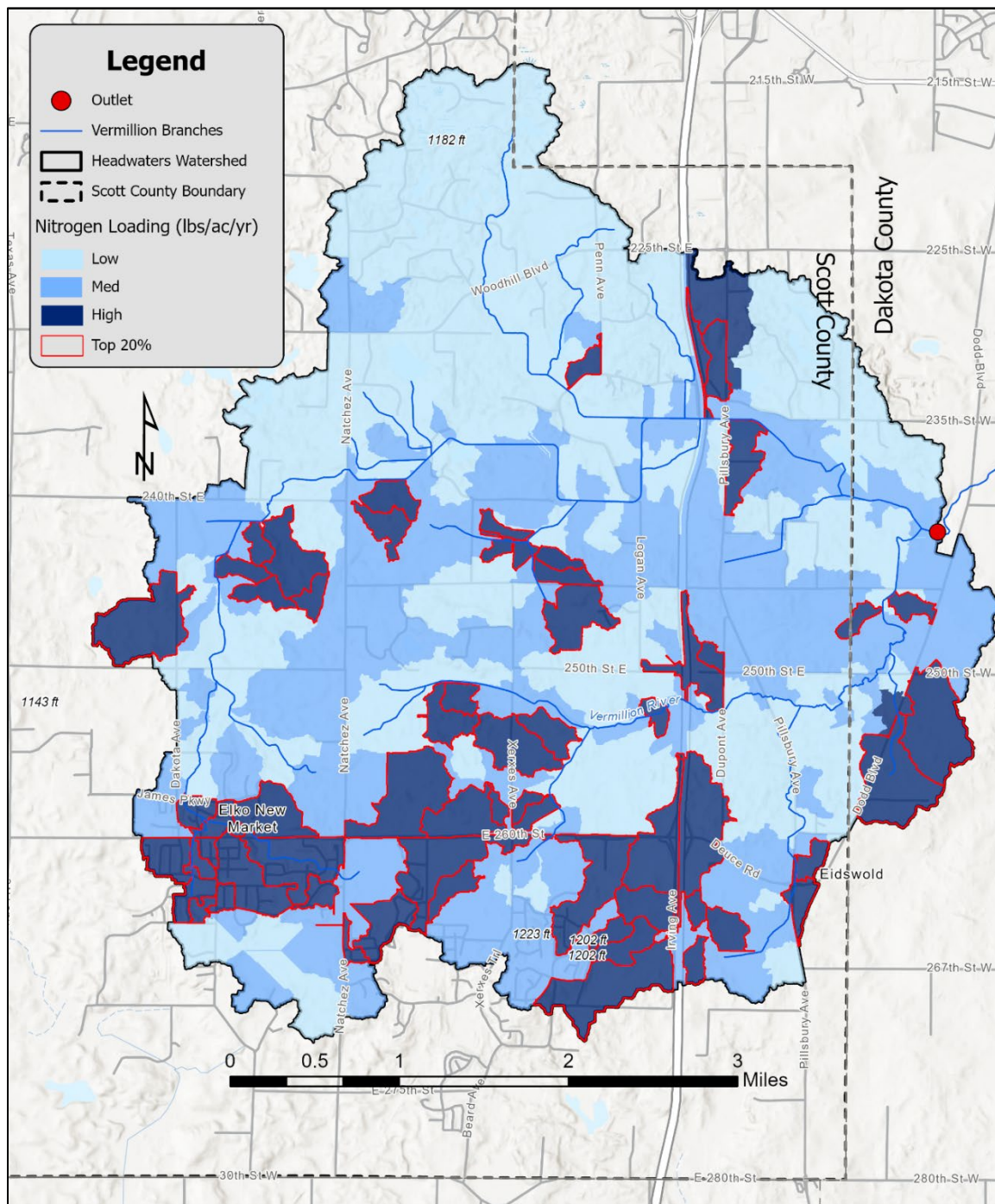
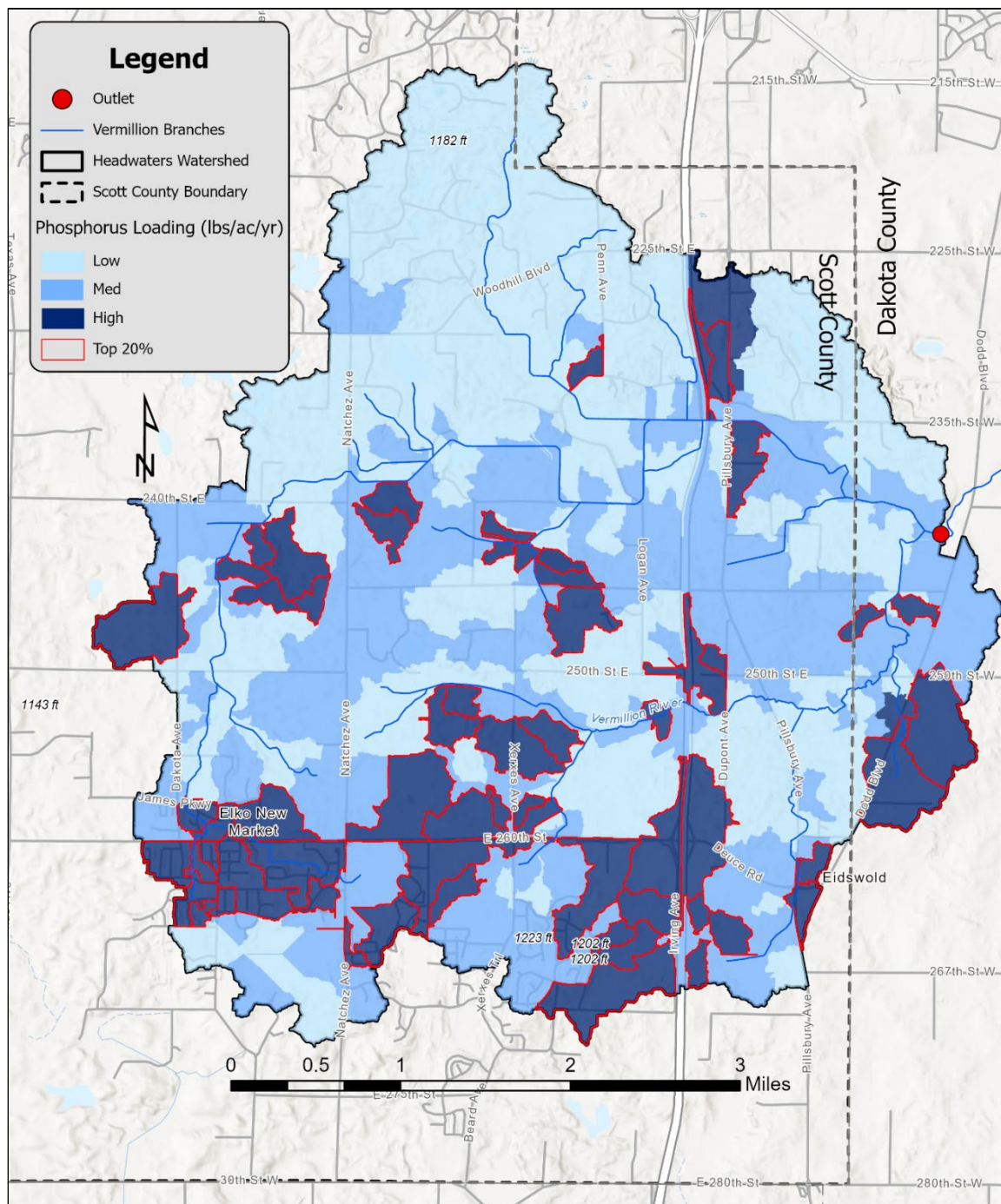


Table 6: PTMAApp predicted top 20% of phosphorus contributing catchments ranked by yield at field edge.

Catchment	acres	Phosphorus Load (Lbs./yr)	Phosphorus Yield (Lbs./ac/yr)
1382	25.42	24.08	0.95
501273	10.06	9.34	0.93
501290	75.12	68.99	0.92
501274	40.11	35.62	0.89
1232	23.48	20.70	0.88
501370	18.51	16.25	0.88
501391	12.09	10.55	0.87
501524	37.05	30.28	0.82
501468	11.43	9.22	0.81
501396	50.62	40.57	0.80
501481	111.36	81.47	0.73
501288	98.22	71.39	0.73
501272	102.02	74.11	0.73
1302	10.55	6.61	0.63
501278	105.66	65.76	0.62
501425	13.56	8.38	0.62
1401	10.55	6.45	0.61
501379	36.61	21.87	0.60
501229	89.98	50.87	0.57
501482	73.66	40.04	0.54
1388	25.57	13.86	0.54
501526	44.81	24.06	0.54
500207	95.85	50.96	0.53
501100	65.69	34.54	0.53
501192	10.16	5.29	0.52
501527	14.95	7.69	0.51
500233	18.56	9.48	0.51
501108	115.75	55.86	0.48
1407	19.96	9.59	0.48
914	54.90	26.35	0.48
355	25.08	11.27	0.45
501309	18.03	8.01	0.44
501411	12.07	5.34	0.44
501422	18.61	8.15	0.44
500184	25.10	10.68	0.43
1447	43.39	18.46	0.43
501267	17.48	7.34	0.42
501184	39.47	16.34	0.41
501378	107.06	43.62	0.41
501286	46.87	18.98	0.40
500551	15.22	6.12	0.40
501258	13.96	5.55	0.40
500565	12.30	4.85	0.39
1430	45.50	17.69	0.39
500529	123.61	47.19	0.38
500343	52.97	19.94	0.38
501533	5.96	2.24	0.38
501457	122.65	45.92	0.37
501249	65.08	23.79	0.37
500623	120.18	43.86	0.36
500251	18.69	6.81	0.36
93	19.23	6.85	0.36
500683	21.39	7.61	0.36
500309	19.21	6.78	0.35
500101	10.21	3.59	0.35
501197	61.88	21.62	0.35
500448	16.94	5.90	0.35
500457	35.53	12.27	0.35
501519	12.36	4.24	0.34
501386	83.62	28.65	0.34

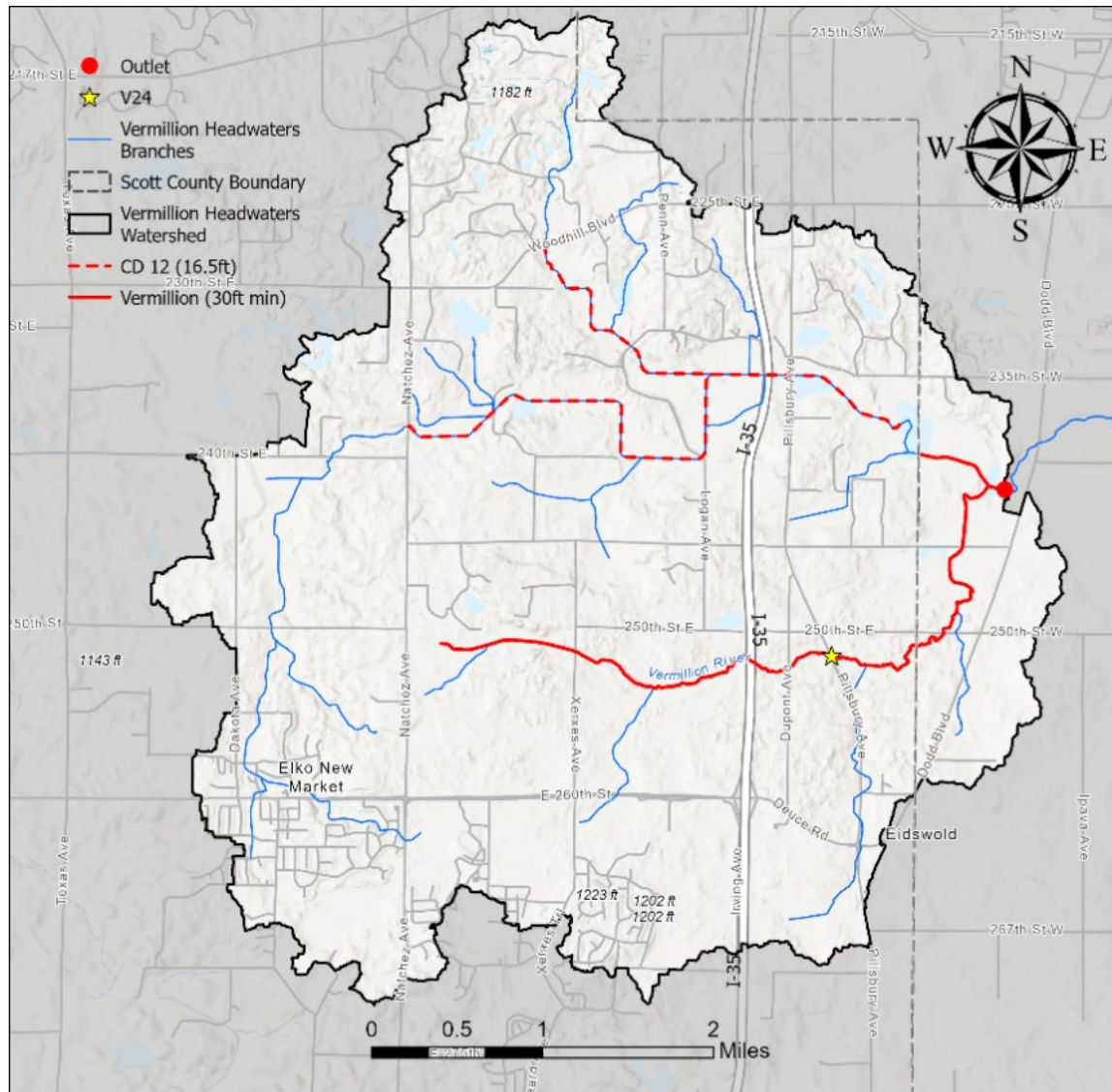


Map 3: Map showing phosphorus loading as predicted by PTMAApp, in Lbs./ac/yr; top 20% of catchments are outlined in red.

Predicted BMP's

The PTMAApp model predicted the placement of BMP's at 1,758 sites throughout the Vermillion River Headwaters watershed. Among these include a total of 526 storage, 133 filtration, 397 protection, and 835 source reduction BMP's. The model produces significant overlap among practices; in most cases however a single practice or a single practice with one or two cohort practices will sufficiently address any given specific concern. Ultimately, the model results provide resource managers with the ability to prioritize efforts geographically, evaluate multiple different BMP's options, and determine which practice or practices would be most feasible based on site-specific conditions, pollutant reduction potential, and opportunity.

To sort through the 1,758 proposed BMP's, the catchments were ranked based on their predicted sediment, phosphorus, and nitrogen loading, and the top 20% contributing (priority) catchments were selected for BMP assessment. The BMP's identified within those priority catchments were ranked based on sediment reduction modeled using the 2-year, 24-hour rainfall event at the catchment outlet. It was assumed there is a close relationship between sediment reduction and corresponding phosphorus and nitrogen reductions, such that practices having the highest sediment load reductions would similarly yield the highest phosphorus and nitrogen reductions.



Map 4: Required buffer sections (in red).

One conclusion reached from the SWCD's desktop analysis is that areas that were predicted by PTMApp to potentially benefit from perennial conservation cover correlate closely with areas that would benefit from the application of filter strips. Minnesota Statutes 103F.48 requires 16.5' of continuous perennially rooted vegetation along public drainage systems and 50' average/30' minimum for all other public waters. The results of Scott SWCD's annual review of buffer compliance show there is a 99% compliance rate in both the northern tributary (County Ditch 12) and southern branch (Vermillion River), respectively (Map 4). Based on PTMApp's accuracy for predicting locations of conservation cover in riparian areas and the level of buffer compliance that currently exists, it was determined that using PTMApp to predict filter strip and riparian buffer BMP's was unnecessary.

The SWCD's desktop analysis also revealed that PTMAApp often failed to identify potential large wetland restoration sites. This may be attributed to several toolbar constraints and consequently the areas identified by PTMAApp for potential wetland restoration were relatively small and associated mostly with the farm pond BMP (Map 7).

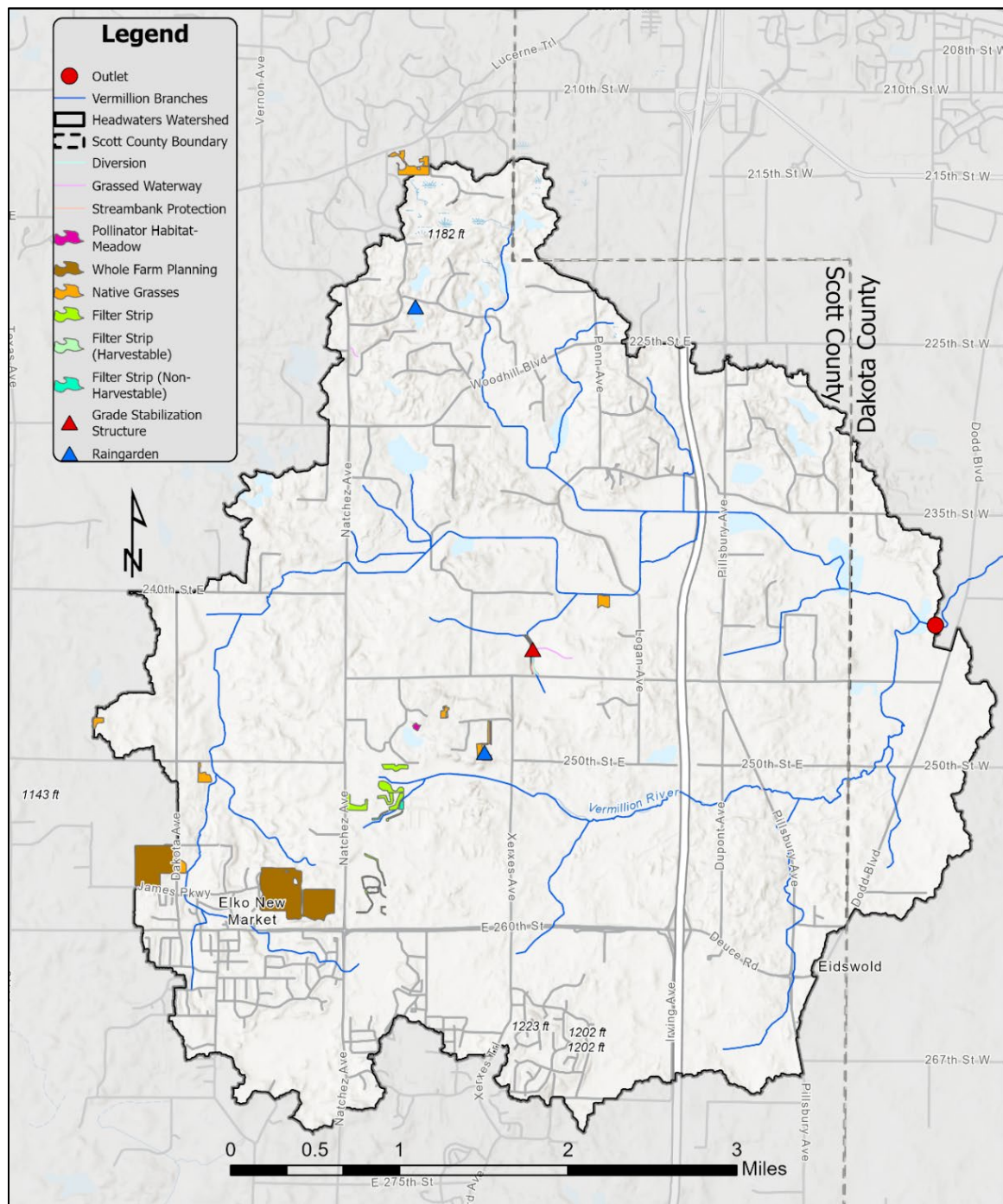
One other of PTMAApp's limitations detected through the SWCD's desktop review pertains to its identification of potential WASCOB BMP's. WASCOB's identified by PTMAApp are shown as linear features following lines of concentrated flow as opposed to single point structures (i.e. berms) placed across concentrated flow paths at periodic intervals. This significance of this linear display is that it greatly overestimates quantities and thus limits the ability to predict potential costs with reasonable accuracy or confidence. The apparent assumption is the location and number of berms ultimately needed, and therefore costs, would be determined by project designer following site-specific evaluations.

The practices identified and prioritized in this report are limited to those that a) were identified through PTMAApp modeling and b) are located within the top 10% of contributing catchments. It is important to point out, however, that there are sites outside the top catchment areas where, due to site-specific conditions, BMP's capable of providing significant sediment and nutrient load reductions could be applied and contribute just as much if not more to water quality improvement as any given BMP in a top 10% catchment. Cost effective BMP's that address significant source of sediment are considered high priority whenever the opportunity to implement them arises.

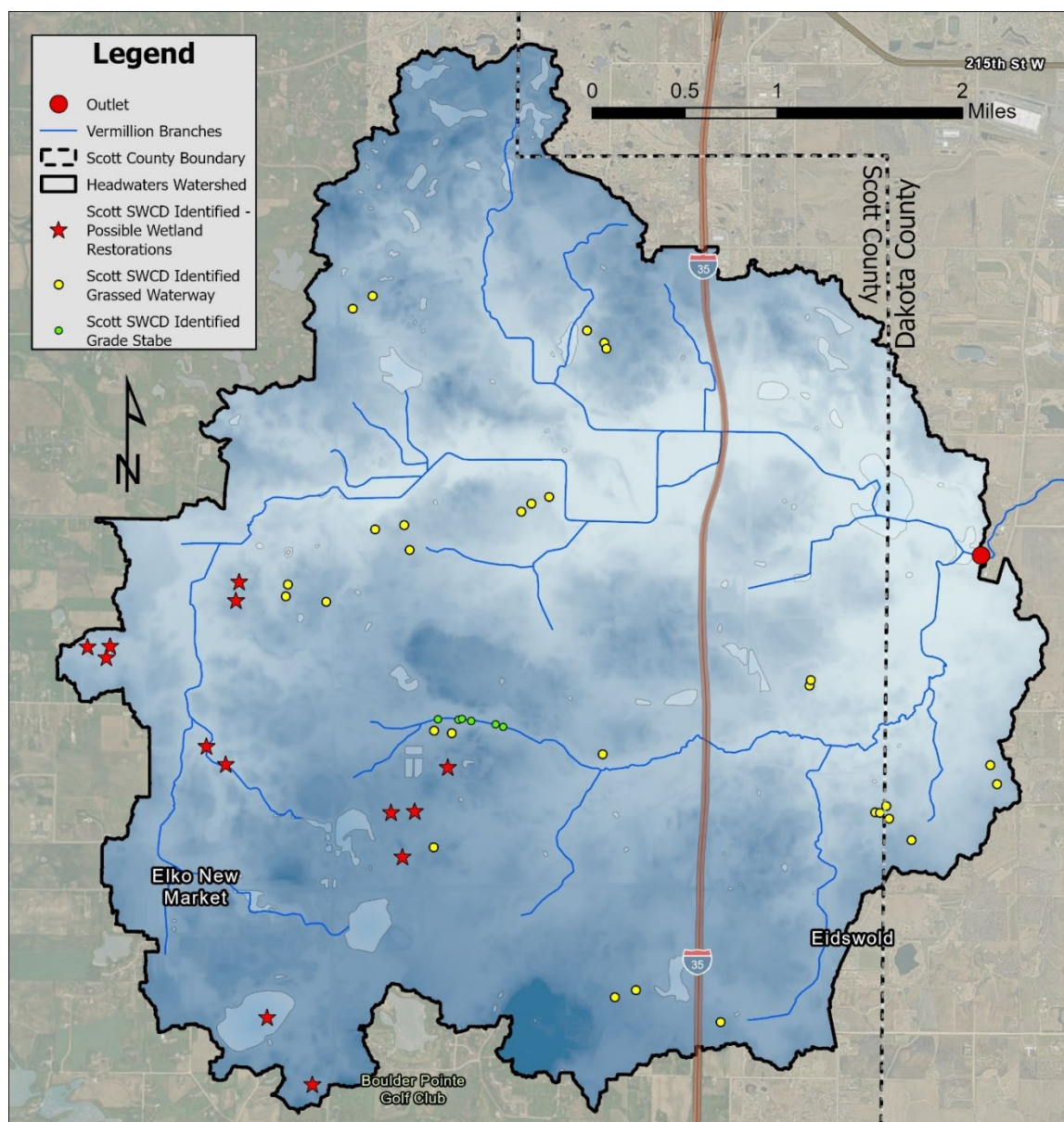
The remainder of this report provides an overview of historic practices that have been installed. Followed by maps of all the feasible BMP locations based on Scott SWCD staff review and PTMAApp predicted BMP's.

Existing Conservation Practices

The Scott SWCD maintains an inventory of all conservation practices that have been installed since 2010. Practices installed in the Vermillion Headwaters watershed include raingardens (2), a grade stabilization structure, a grassed waterway (1,678 Lin ft), streambank protection (460 Lin ft), a diversion (530 Lin ft), filter strip (21.06 acres), conservation cover (29 acres), pollinator habitat (1.06 acres) and whole farm planning under the MN Agricultural Water Quality Certification Program (89.5 acres).



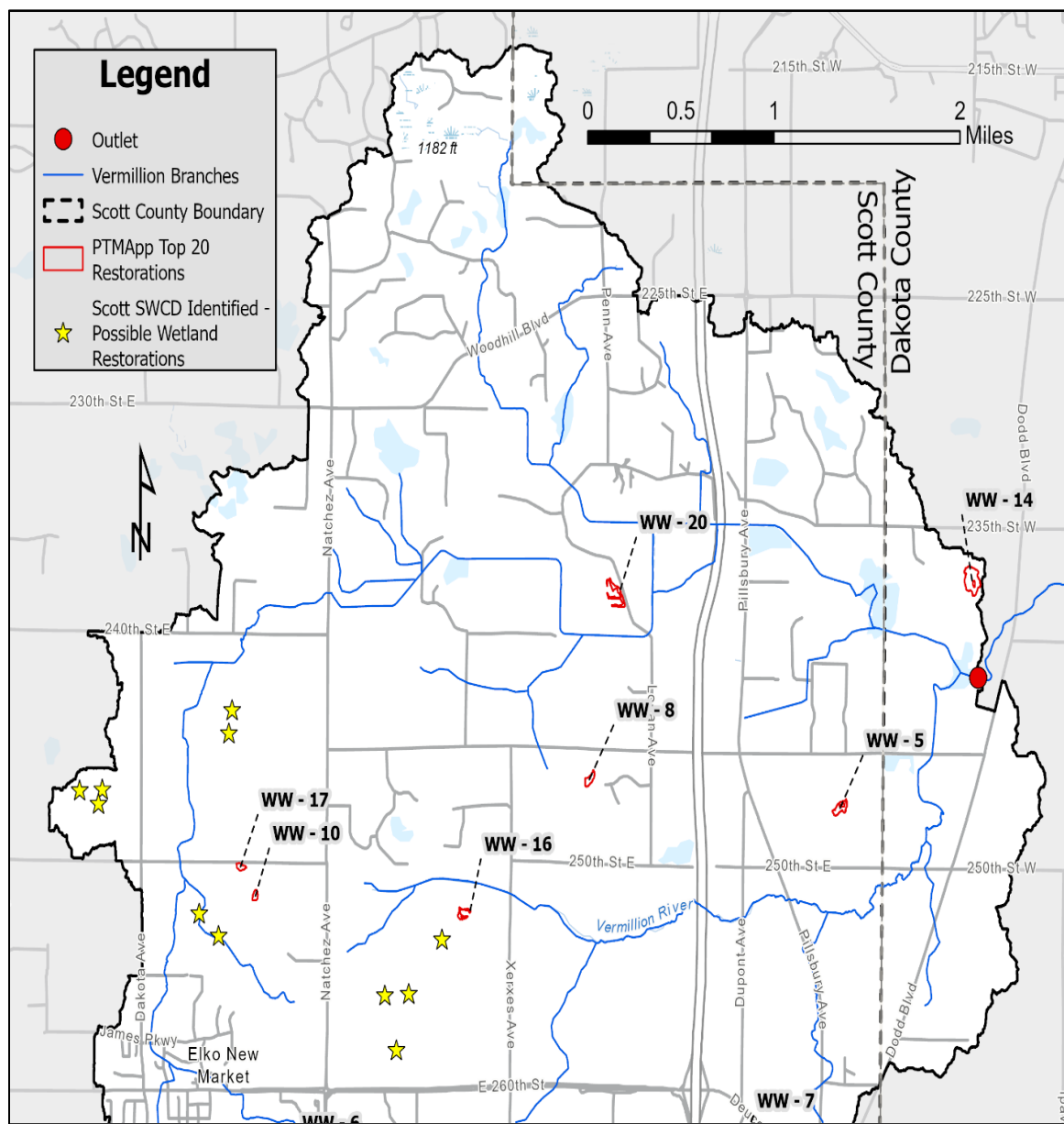
Map 5: BMP's installed within the Headwaters watershed since 2010.



Map 6: Locations of potential BMP's identified during Scott SWCD's GIS-based desktop reconnaissance.

Wetland Restoration Identification

Using the PTMApp toolbar, 160 sites were identified for possible wetland restoration. After reviewing the identified locations, the number restorations deemed feasible by staff was determined to be 63 based on current land use, ownership, and topography. As discussed further in the next section, Scott SWCD identified 13 additional wetland restoration sites that were not identified by the PTMApp toolbar. All are located in the south and southwest portions of the watershed corresponding to the area of predominantly agricultural land use (Map 7). Sediment and nutrient reductions, water treatment (storage), and estimated costs for wetland restoration BMP's identified by PTMApp can be found in Table 7. Corresponding values for projects identified by SWCD staff were not calculated but are assumed to be proportionally similar. Calculations would be performed through onsite feasibility if/when the opportunity for a project arises based on landowner interest.



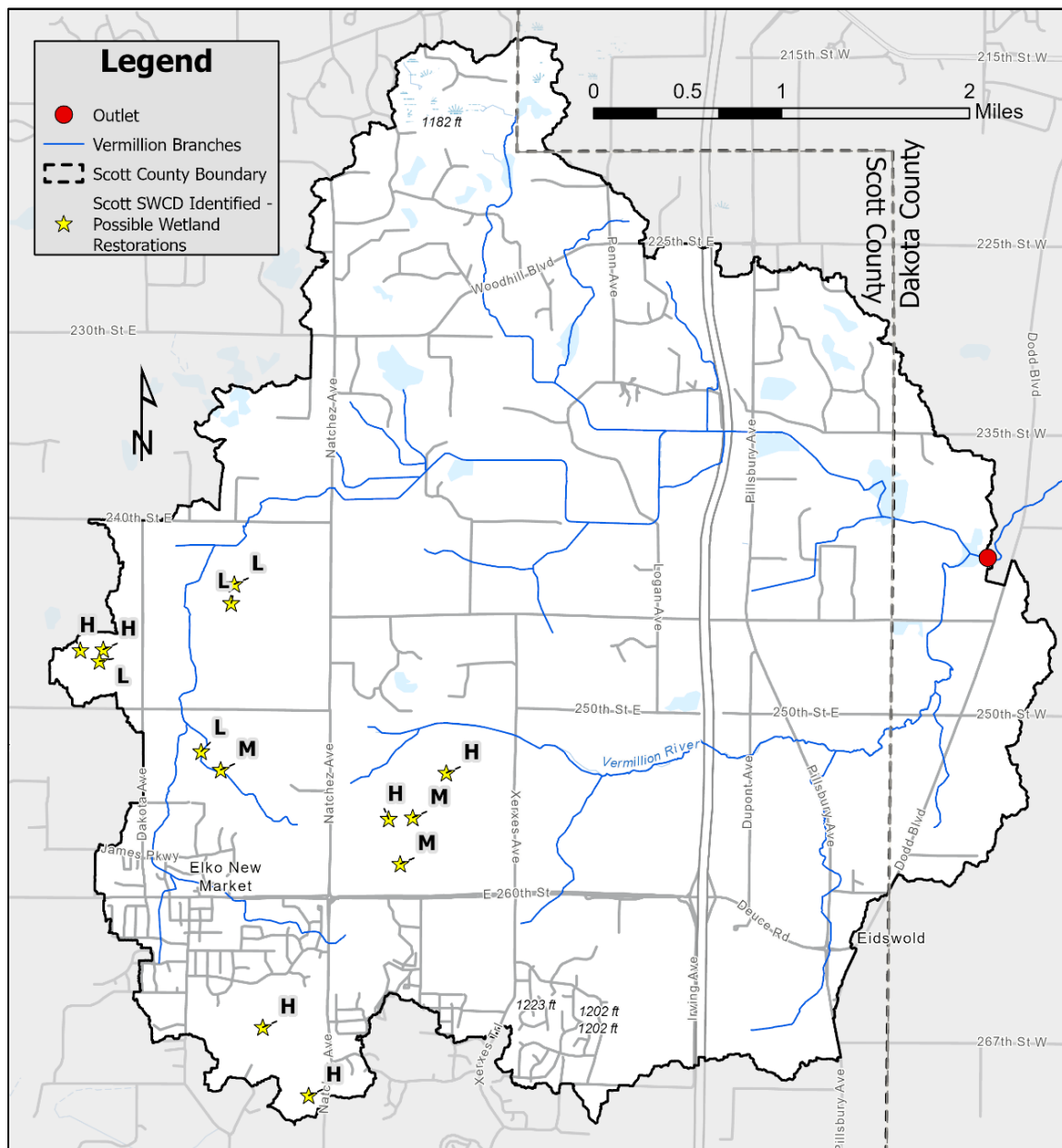
Map 7: Potential wetland restoration sites identified by PTMApp (top 20, in red) and Scott SWCD staff (13, in yellow).

Table 7: PTMAApp predicted BMP benefits for top 20 wetland restoration sites based on sediment reduction.

BMP ID	Watershed (acres)	Water Treated (cu-ft)	BMP Area (acres)	Sediment Reduction at BMP (tons/yr)	Phosphorus Reduction at BMP (Lbs./yr)	Nitrogen Reduction at BMP (Lbs./yr)	Term (years)	Total Cost	Annual Cost
WW - 1	426.35	20,571.90	0.12	58.65	126.26	1040.77	25	\$4,645.62	\$185.82
WW - 2	83.22	50,013.25	0.16	45.87	9.78	156.41	25	\$5,838.98	\$233.56
WW - 3	36.72	102,248.92	1.42	42.30	5.13	89.13	25	\$35,528.26	\$1,421.13
WW - 4	53.94	122,436.75	1.50	39.97	6.91	115.96	25	\$37,118.30	\$1,484.73
WW - 5	7.42	152,496.37	1.66	15.57	1.59	36.04	25	\$40,320.21	\$1,612.81
WW - 6	212.82	2,617,958.47	11.04	11.54	85.31	833.67	25	\$162,320.29	\$6,492.81
WW - 7	8.88	63,905.01	1.67	10.68	2.14	50.04	25	\$40,490.87	\$1,619.63
WW - 8	10.27	91,449.85	1.13	10.22	1.84	28.66	25	\$29,680.40	\$1,187.22
WW - 9	52.29	1,877,407.68	7.72	9.05	24.35	178.19	25	\$127,389.06	\$5,095.56
WW - 10	2.85	25,163.72	0.64	5.27	0.69	16.20	25	\$18,712.11	\$748.48
WW - 11	1.25	10,878.79	0.36	4.36	0.30	7.06	25	\$11,510.29	\$460.41
WW - 12	1.62	17,992.95	0.41	3.73	0.80	7.35	25	\$12,752.34	\$510.09
WW - 13	11.60	29,316.03	0.18	3.45	2.26	36.75	25	\$6,316.77	\$252.67
WW - 14	7.22	1,017,781.38	4.69	2.70	0.88	15.65	25	\$89,242.19	\$3,569.69
WW - 15	25.09	180,036.75	0.81	2.63	2.66	48.98	25	\$22,458.06	\$898.32
WW - 16	4.41	39,020.72	0.70	2.38	0.53	13.39	25	\$20,085.63	\$803.43
WW - 17	3.04	24,006.60	0.71	2.14	0.97	15.34	25	\$20,190.27	\$807.61
WW - 18	1.40	21,704.73	0.55	1.60	0.32	7.53	25	\$16,381.89	\$655.28
WW - 19	10.71	105,114.99	0.36	1.48	1.49	21.42	25	\$11,510.29	\$460.41
WW - 20	20.69	152,906.00	1.83	1.42	3.83	42.39	25	\$43,564.78	\$1,742.59

Scott SWCD Identified Wetland Restorations – Feasibility Rank

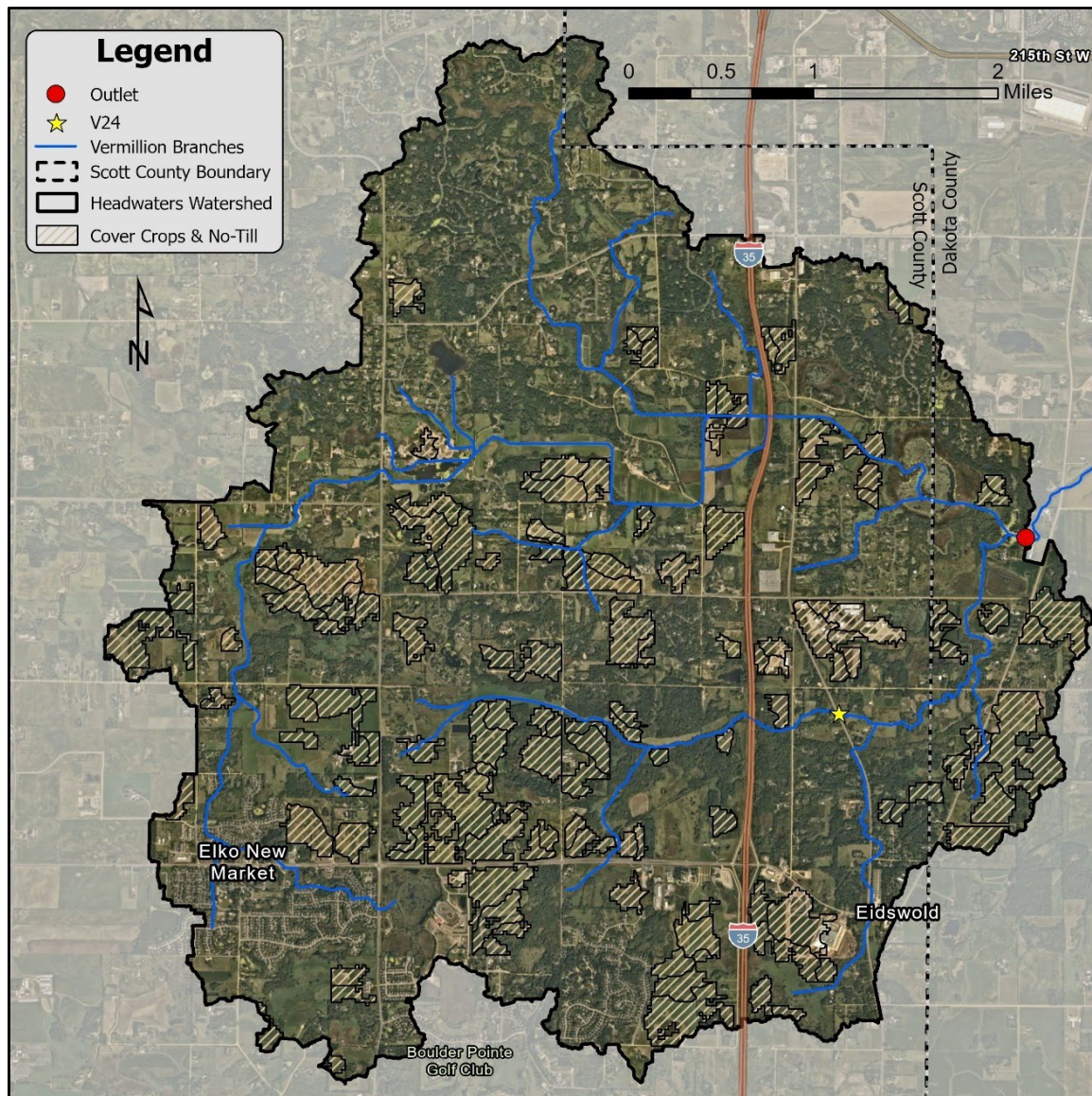
The 13 potential wetland restoration sites identified by Scott SWCD staff were prioritized based on land ownership, compatibility with surrounding land use, and estimated project cost and complexity. A ranking system of High (H), Medium (M) or Low (L) feasibility was used, with those projects that would involve fewer (e.g. 1-2) landowners, yield great sediment reduction, and have lower projected cost being ranked higher. In SWCD's experience, the more landowners involved in a potential wetland restoration project the less likely it is to be constructed due to incompatible interests and conflicting priorities.



Map 8: Wetlands identified by Scott SWCD as potentially restorable, with feasibility rankings: H - high (6), M - Medium (3), and L - Low (4)

PTMApp Proposed Cover Crop & No-Till BMP's

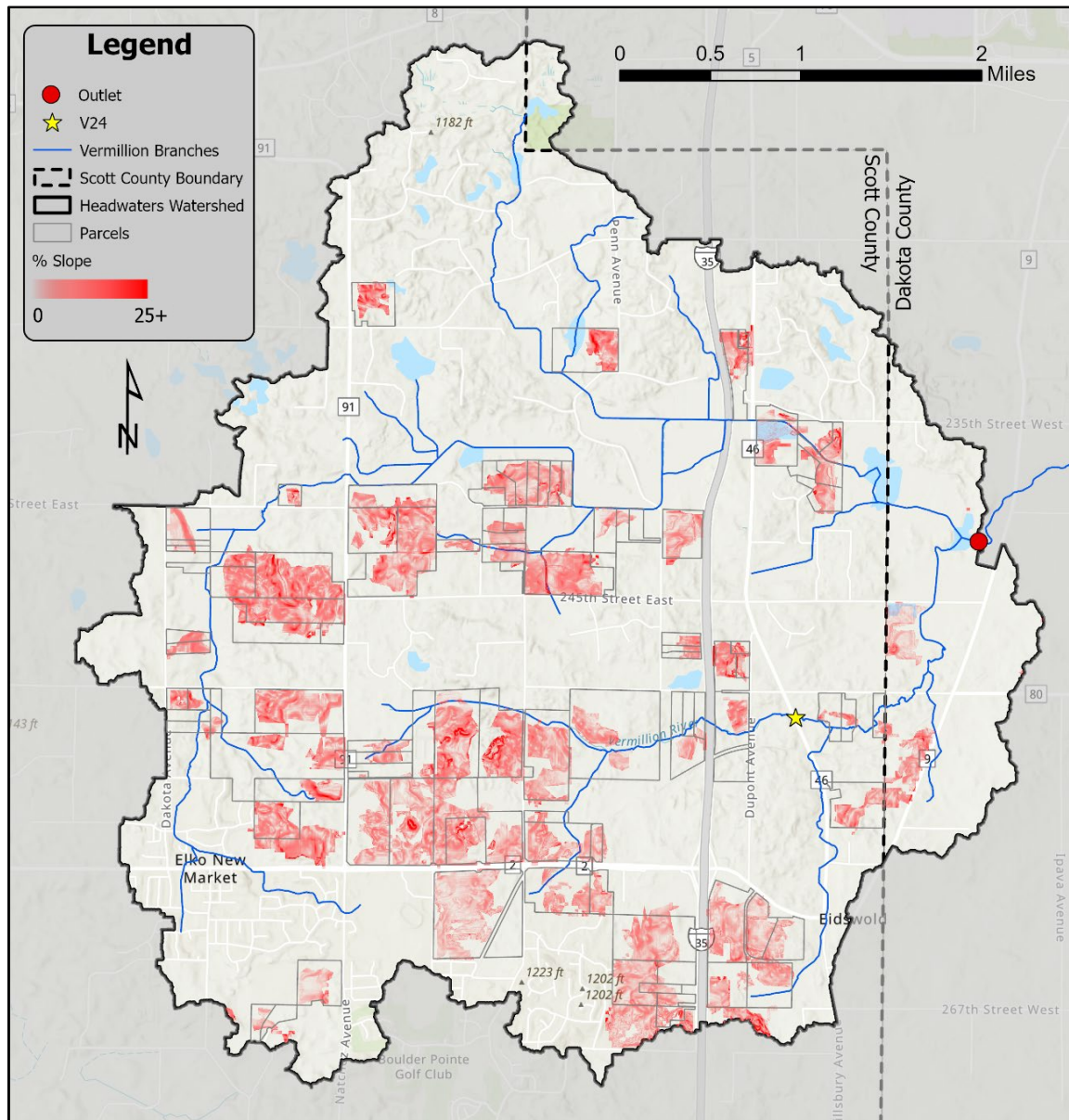
PTMApp predicted areas of agricultural land that would benefit from the use of cover crops and no-till practices (Map 9). These were not, however, included in the ranking of BMP's for two main reasons. First, soil health practices including cover crops and no-till are and will remain a high priority for implementation in the Vermillion River watershed, due to their well-documented environmental benefits and excellent cost effectiveness. And second, countywide tillage transect surveys conducted annually by Scott SWCD since the 1990's shows that 82% of all cropland already has residue levels of at least 15%. That said, less than 50% of cropland has residue levels at or above 30%, suggesting there is significant opportunity for increasing adoption of high residue management practices..



Map 9: PTMApp proposed cover crop and no-till BMP locations.

Perennial Conservation Cover - High Priority Locations

In addition to structural BMP's, non-structural BMP's that involve the establishment of perennial vegetative cover, such as Conservation Cover (Practice Code 327) are better identified using certain products created for PTMAApp than the model itself. These include the slope raster file, land cover layer, and flow accumulation file. The slope raster file was used to identify slope steepness, the land use layer was used to determine where slopes occurred on agricultural land, and the flow accumulation file was used to determine where agricultural lands occur within 300 feet of significant concentrated runoff. The results of this analysis are shown on Map 10. Within the areas shown, approximately 436 acres occur on lands with an average slope of 6-10%, and 225 acres occur on lands with an average slope 10% or greater. Both represent areas deemed high priority for conversion from crop production to perennial cover (preferably native prairie or native trees and shrubs) due to higher cost effectiveness for runoff and pollution reduction compared to areas with flatter slopes and/or which are more distal to concentrated flows.



Map 10: Priority areas of perennial conservation cover. Agricultural lands that are within 300 feet of concentrated flow and have slopes of 6% or greater are deemed high priority, with highest priority given to slopes of 10% or greater.

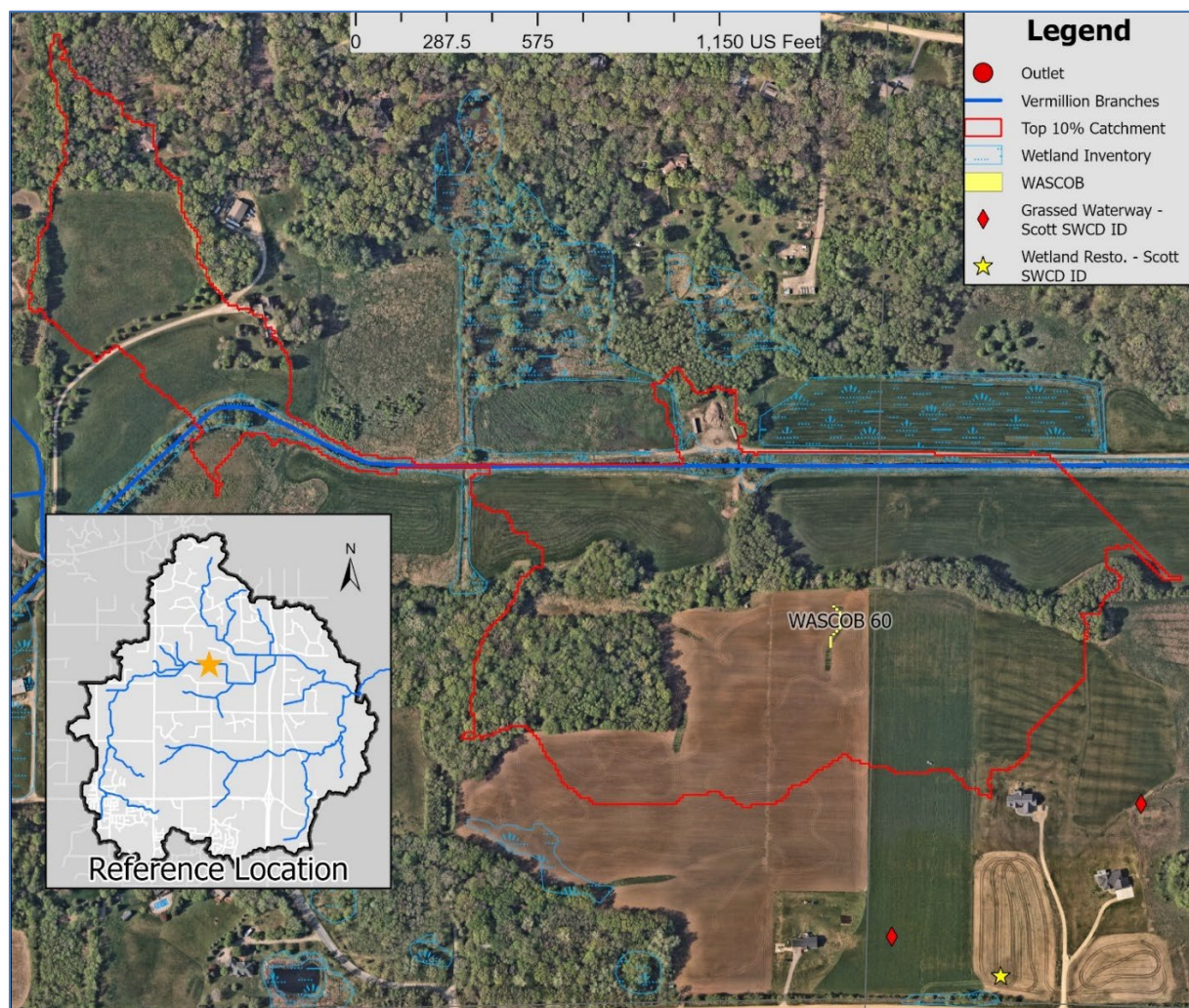
Top 10% Sediment Catchment BMP's

The following site descriptions and maps focus on the top 10% of sediment loading catchments and the associated BMP's PTMAApp identified highest reduction potentials, and in addition any BMP's identified by Scott SWCD staff through their GIS-based desktop analysis.

Catchment Rank #19 – Central Upper CD 12 branch

DESCRIPTION of EXISTING SITE CONDITIONS

This site consists of an agricultural field with conventional tillage practices of corn/soybean rotations. There is an existing grassed waterway in need of maintenance. Hayden loams with slopes of 6% - 10%, moderately erodible are the predominant soils of this field with an existing wetland located to the east which is the receiving waters for runoff. Ephemeral erosion is occurring in the concentrated flow areas depositing sediment south of the CD 12 Vermillion branch.



BMP RECOMMENDATIONS

The suggested BMP in this area is a *WASCOB* (#60) to reduce sediment transport and subsequent Phosphorus loading. Scott SWCD also identified two grassed waterways and a wetland restoration just south of the identified catchment that would also aid in the reduction of nutrient loading.

BMP COST BENEFIT ANALYSIS

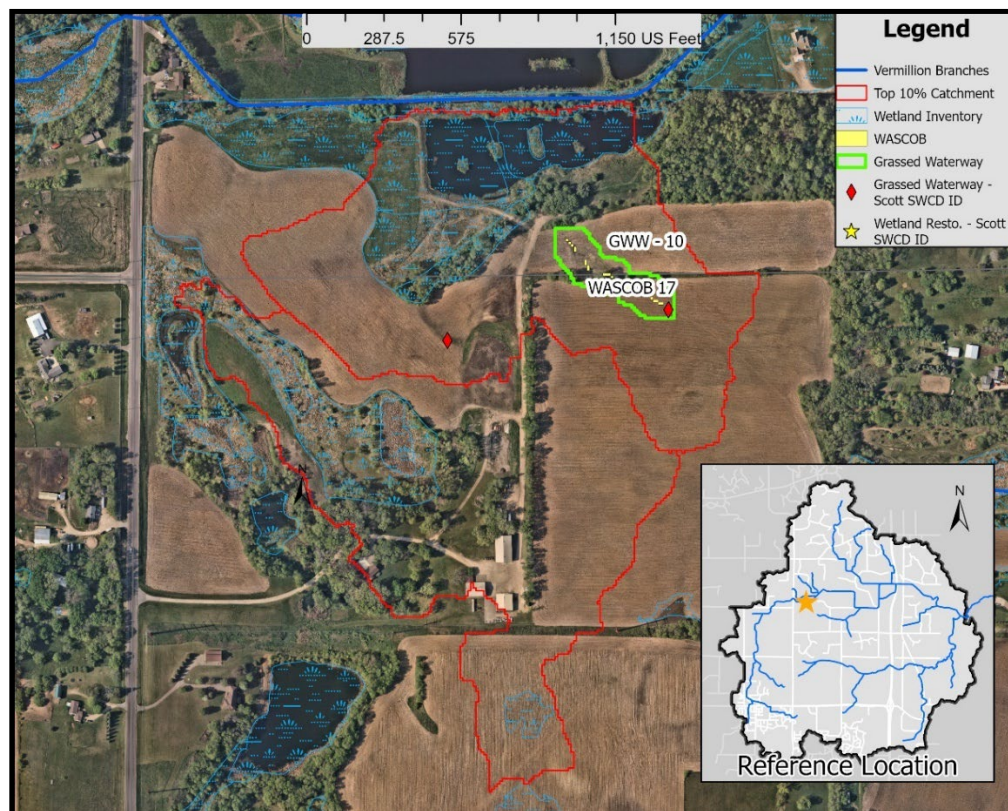
The following table shows anticipated phosphorus, nitrogen and sediment reductions based on PTMAApp BMP practices and their associated costs with term years for each practice identified.

Practice	Term (years)	P Load (Lbs./yr.)		Total P Reduction (Lbs./yr)	N Load (Lbs./yr.)		Total N Reduction (Lbs./yr)	S Load (tons/yr)		Total Sed. Reduction (Tons/yr)	Estimate Cost Per Year	Estimated Total Cost
		Before	After		Before	After		Before	After			
WASCOB #60	10	1.41	0.34	1.07	28.90	12.43	16.47	14.46	1.73	12.73	\$922.39	\$9,224

Catchment Rank #6 & #5 – West Central CD 12 Upper Branch

DESCRIPTION of EXISTING SITE CONDITIONS

Proposed grassed waterway and WASCOB are located in the west central area of the watershed. Soils at the waterway and WASCOB location is Hayden loams with slopes of 10 to 22%. Scott SWCD also identified the same area as PTMAApp for the same practices. Conventional tillage practices of corn/soybean rotations are utilized in this area with ephemeral erosion occurring in the concentrated flow areas due to the steep slopes.



BMP RECOMMENDATIONS

The concentrated ephemeral erosion sites observed are proposed to be corrected with *Grassed Waterway (10)* and *WASCOB (17)* as suggested BMP's by PTMAApp in this area to reduce sediment transport and subsequent Phosphorus loading. Scott SWCD also identified a location for a grassed waterway to the west of the proposed practice areas, that would also aid in the reduction of nutrient loading.

BMP COST BENEFIT ANALYSIS

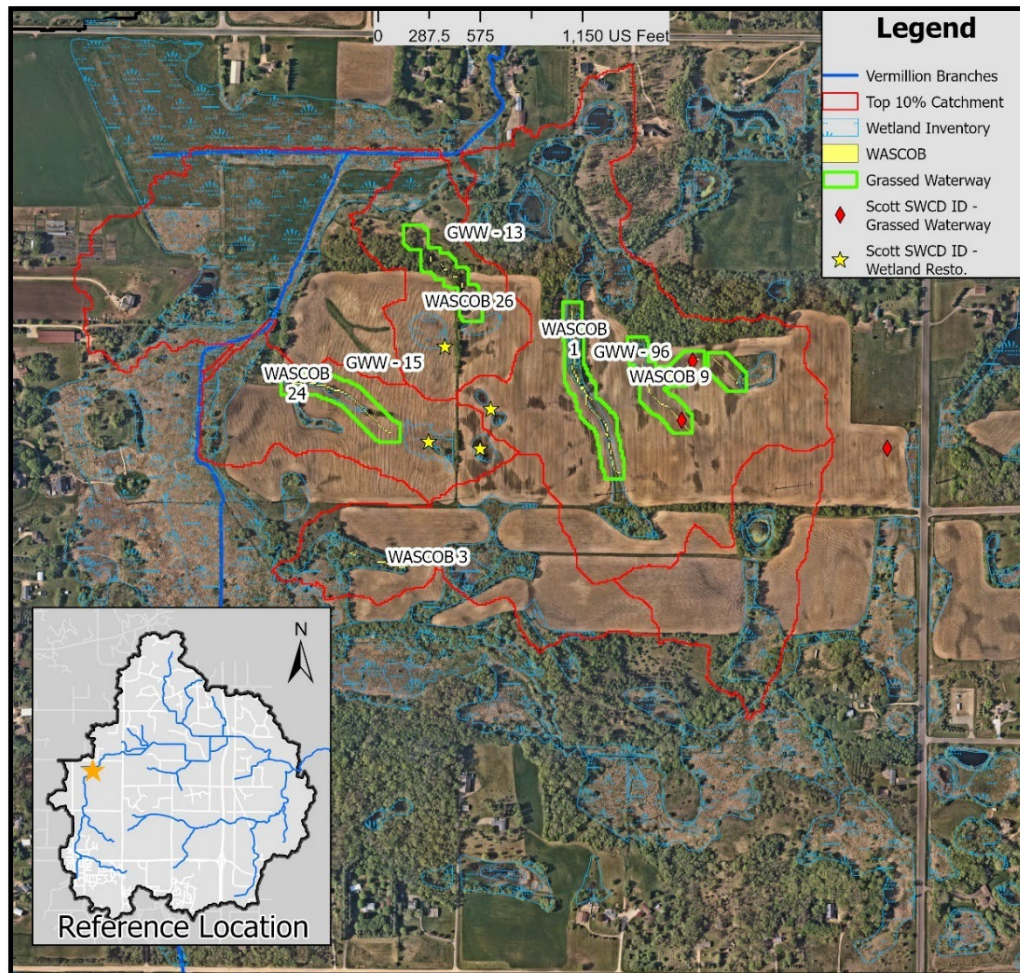
The following table shows anticipated phosphorus, nitrogen and sediment reductions based on PMTApp BMP practices and their associated costs with term years for each practice identified.

Practice	Term (years)	P Load (Lbs./yr.)		Total P Reduction (Lbs./yr)	N Load (Lbs./yr.)		Total N Reduction (Lbs./yr)	S Load (tons/yr)		Total Sed. Reduction (Tons/yr)	Estimate Cost Per Year	Estimated Total Cost
		Before	After		Before	After		Before	After			
WASCOB #17	10	3.32	0.8	2.52	68.17	29.31	38.86	49.53	5.94	43.59	\$1,085.96	\$10,859.56
Grassed Waterway #10	20	1.19	0	1.19	26.2	0	26.2	8.79	0.36	8.43	\$699.67	\$13,993.35

Catchment Rank #2, #4, #5, #9 #13 & #21 – West Central Upper Branch

DESCRIPTION of EXISTING SITE CONDITIONS

This area is located in the west central region of the watershed of the upper branch. Wetlands identified through the Scott County Wetland Inventory Map and interspersed moderate, agricultural fields where conventional tillage practices are utilized. Hayden loams are the predominant soil in the upland areas with Webster soils in the lower elevations and Peat and Muck in the wetland areas; average slopes of 6 to 10%. This location includes a good amount of the highest ranked sediment contributing catchments.



BMP RECOMMENDATIONS

Water & Sediment Control Basins and grassed waterways are the primary BMP's proposed by PTMApp. These practices would be installed to eliminate ephemeral erosion identified aerial reconnaissance to reduce sediment transport and subsequent phosphorus loading. Scott SWCD also identifies four wetland restoration locations and three grassed waterways, two that overlap with PTMApp predictions.

BMP COST BENEFIT ANALYSIS

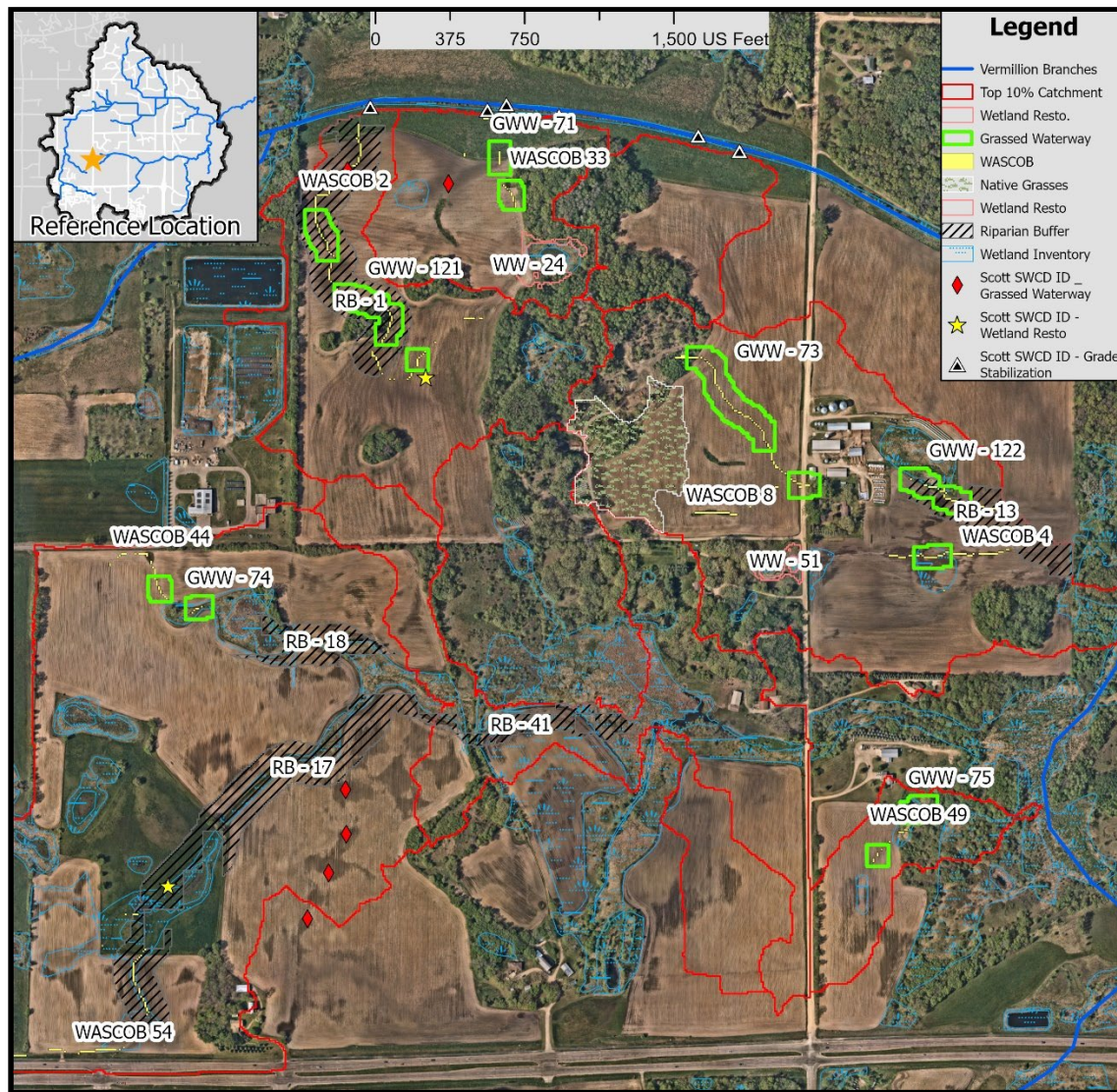
The following table shows anticipated phosphorus, nitrogen and sediment reductions based on PMTApp BMP practices and their associated costs with term years for each practice identified.

Practice	Term (years)	P Load (Lbs./yr.)		Total P Reduction (Lbs./yr)	N Load (Lbs./yr.)		Total N Reduction (Lbs./yr)	S Load (tons/yr)		Total Sed. Reduction (Tons/yr)	Estimate Cost Per Year	Estimated Total Cost
		Before	After		Before	After		Before	After			
WASCOB #1	10	7.73	1.86	5.87	158.7	68.24	90.46	166.19	19.94	146.25	\$1,583.76	\$15,837.61
WASCOB #3	10	6.7	1.61	5.09	137.24	59.02	78.22	90.68	10.89	79.79	\$1,462.44	\$14,624.38
WASCOB #9	10	6.03	1.45	4.58	124.24	53.42	70.82	67.9	8.15	59.75	\$1,410.38	\$14,103.75
WASCOB #24	10	3.43	0.83	2.6	70.34	30.25	40.09	42.33	5.08	37.25	\$1,097.32	\$10,973.23
WASCOB #26	10	3.36	0.8	2.56	68.55	29.48	39.07	40.03	4.8	35.23	\$1,111.52	\$11,115.19
Grassed Waterway #13	20	0.79	0	0.79	16.22	0	16.22	8.1	0.32	7.78	\$404.64	\$8,092.79
Grassed Waterway #15	20	0.21	0	0.21	4.5	0	4.5	7.79	0.31	7.48	\$165.53	\$3,310.55
Grassed Waterway #96	20	0.2	0	0.2	4.06	0	4.06	0.65	0.02	0.63	\$106.63	\$2,132.64

Catchment Rank #11, #15, #17, #24, #28 & #30 – Western Main

DESCRIPTION of EXISTING SITE CONDITIONS

Aerial reconnaissance of this area revealed significant ephemeral erosion occurring within the agricultural areas. The erosion is due to the significant slopes of the Hayden loams are the predominant soil in the upland areas with Webster soils in the lower elevations and Peat and Muck in the wetland areas; average slopes of 6 to 10%. Sediment and subsequent phosphorus from these fields outlet directly into the Vermillion Headwaters main stem.



BMP RECOMMENDATIONS

Suggested BMP's in this area include multiple *Grassed Waterways* and the installation of *Water & Sediment Control Basins* to reduce sediment transport and subsequent Phosphorus loading to the open water channel. Grassed waterways or WASCOBS are overlapping and depend on agricultural practices to determine best fitting practice for those areas. PTMAApp wetland restorations identified in this area are to expand the existing wetlands, as outlined. Riparian buffers are recommended along tributary channels where there are no buffer requirements. Scott SWCD also identified six grade stabilizations along the main channel that would reduce the continuation of sediment eroding into the stream. The only native grasses or perennial cover location identified by PTMAApp consists of a 6.67-acre area, to assist with nutrient loading and provide habitat for wildlife.

BMP COST BENEFIT ANALYSIS

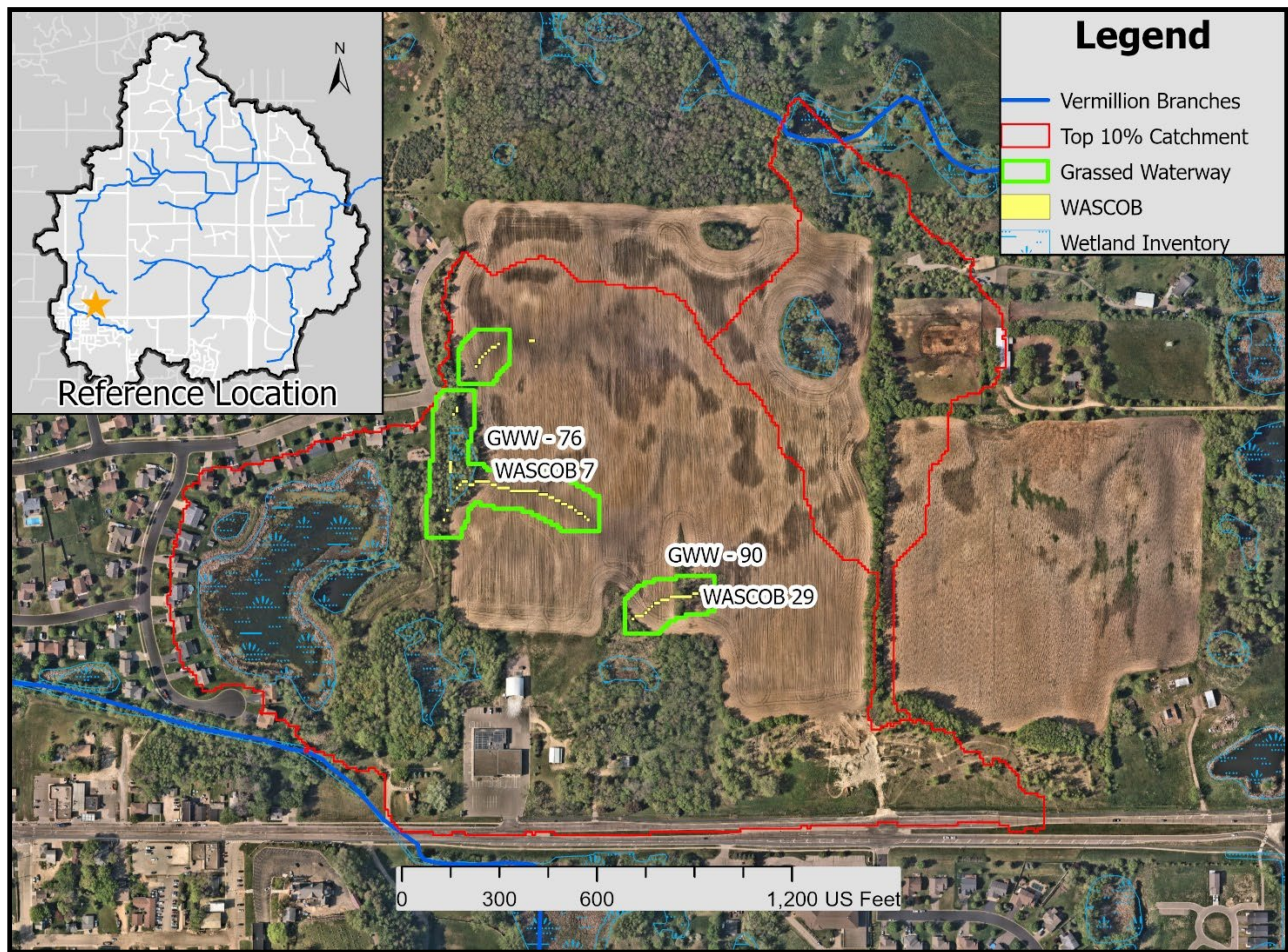
The following table shows anticipated phosphorus, nitrogen and sediment reductions based on PMTApp BMP practices and their associated costs with term years for each practice identified.

Practice	Term (years)	P Load (Lbs./yr.)		Total P Reduction (Lbs./yr)	N Load (Lbs./yr.)		Total N Reduction (Lbs./yr)	S Load (tons/yr)		Total Sed. Reduction (tons/yr)	Estimate Cost Per Year	Estimated Total Cost
		Before	After		Before	After		Before	After			
WASCOB #2	10	10.10	2.43	7.67	214.64	92.30	122.34	91.03	10.92	80.11	\$2,457.08	\$24,570.80
WASCOB #4	10	14.23	3.41	10.82	241.73	103.94	137.79	84.73	10.17	74.56	\$2,588.05	\$25,880.51
WASCOB #8	10	8.60	2.08	6.52	176.92	76.08	100.84	71.73	8.59	63.14	\$1,778.81	\$17,788.05
WASCOB #33	10	3.33	0.80	2.53	68.58	29.49	39.09	33.50	4.02	29.48	\$1,096.48	\$10,964.77
WASCOB #44	10	4.95	1.19	3.76	103.63	44.56	59.06	22.98	2.76	20.22	\$1,354.58	\$13,545.82
WASCOB #49	10	2.79	0.67	2.12	43.98	18.91	25.07	21.57	2.59	18.98	\$1,001.48	\$10,014.80
WASCOB #54	10	12.08	2.90	9.18	167.87	72.18	95.68	19.51	2.34	17.17	\$1,786.71	\$17,867.11
Grassed Waterway #71	20	0.27	0.00	0.27	5.35	0.00	5.35	1.19	0.05	1.14	\$142.33	\$2,846.52
Grassed Waterway #73	20	0.36	0.00	0.36	7.29	0.00	7.29	1.16	0.05	1.12	\$222.15	\$4,442.94
Grassed Waterway #74	20	0.26	0.00	0.26	5.29	0.00	5.29	1.16	0.05	1.11	\$160.56	\$3,211.23
Riparian Buffer #1	10	10.09	6.41	3.69	214.64	150.81	63.83	91.03	79.45	11.58	\$2,235.53	\$22,355.31
Riparian Buffer #13	10	22.82	0.00	22.82	389.30	0.00	389.30	126.43	125.97	0.46	\$1,021.54	\$10,215.38
Riparian Buffer #17	10	26.70	22.71	4.00	465.50	434.33	31.16	117.35	117.05	0.31	\$2,910.77	\$29,107.67
Riparian Buffer #18	10	8.58	7.10	1.48	181.24	165.94	15.29	50.74	50.50	0.24	\$788.38	\$7,883.78
Riparian Buffer #41	10	48.58	44.54	4.04	910.28	887.53	22.75	285.60	285.54	0.06	\$695.49	\$6,954.86
Wetland Resto #24	25	0.74	0.21	0.53	16.33	2.94	13.39	3.09	0.71	2.38	\$803.43	\$20,085.63
Wetland Resto #51	25	1.27	0.36	0.91	15.59	2.81	12.78	0.70	0.16	0.54	\$481.84	\$12,046.12
Perennial Cover #1	25	2.25	0.36	1.89	46.10	30.89	15.21	16.72	5.01	11.71	\$2,062.38	\$20,623.81

Catchment Rank #7 & #16 – Southwest Area

DESCRIPTION of EXISTING SITE CONDITIONS

This site is located adjacent to the City of New Market and is currently farmed in a conventional corn/soybean crop rotation. The portion of the agricultural field drains to an open water wetland complex identified through the Scott County Wetland Inventory Maps. Past aerial photos indicate Grassed Waterways were present in the areas of ephemeral erosion. Soil types vary from Hayden Loams with slopes of 6% - 10%.



BMP RECOMMENDATIONS

Ephemeral erosion is occurring along the concentrated flow paths transporting sediment from the steeper slopes ranging from 6% to 10%. Suggested BMP's in these areas include the installation of *WASC OB's* (#7, & #29), *grassed waterways* (#76 & #90) or a combination of both to reduce sediment transport.

BMP COST BENEFIT ANALYSIS

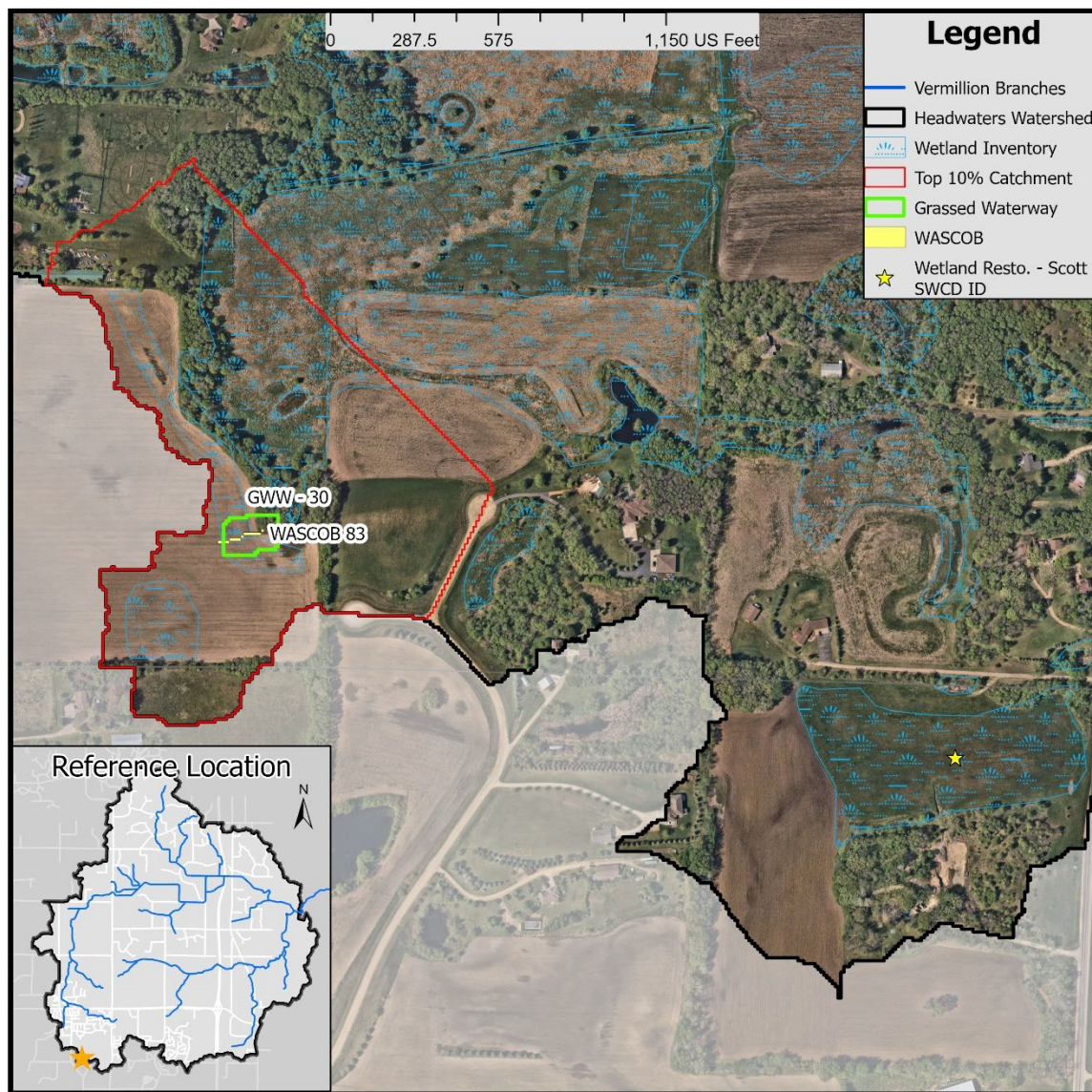
The following table shows anticipated phosphorus, nitrogen and sediment reductions based on PTMAApp BMP practices and their associated costs with term years for each practice identified.

Practice	Term (years)	P Load (Lbs./yr.)		Total P Reduction (Lbs./yr)	N Load (Lbs./yr.)		Total N Reduction (Lbs./yr)	S Load (tons/yr)		Total Sed. Reduction (tons/yr)	Estimate Cost Per Year	Estimated Total Cost
		Before	After		Before	After		Before	After			
WASC OB #7	10	6.94	1.64	5.3	129.27	55.59	73.68	74.27	8.91	65.36	\$1,419.93	\$14,199.30
WASC OB #29	10	2.05	0.5	1.55	42.04	18.08	23.96	37.88	4.55	33.33	\$974.74	\$9,747.44
Grassed Waterway #76	20	0.38	0	0.38	7.14	0	7.14	1.09	0.04	1.05	\$287.90	\$5,758.03
Grassed Waterway #90	20	0.08	0	0.08	1.8	0	1.8	0.72	0.03	0.69	\$76.85	\$1,537.18

Catchment Rank #29 - Southwest

DESCRIPTION of EXISTING SITE CONDITIONS

This area of the North Tributary Watershed consists of a well-defined drainage channel which flows to a natural channel carrying sediment and subsequent phosphorus to the Vermillion River complex and several wetlands. Ephemeral erosion was identified through the field reconnaissance of this area due to the significant slopes of the Hayden loam soils which have slopes of 6% to 18% within the concentrated flow areas. Sediment carried from the site travels into either an identified wetland or the drainage channel located in lower elevation areas consisting of Palms Muck and Peat soils.



BMP RECOMMENDATIONS

The significant areas of ephemeral erosion transporting sediment to the existing wetlands and drainage channel would be improved with *Water & Sediment Control Basins*. The installation of a combination of these practices will provide phosphorus and sediment reduction thus improving water quality.

BMP COST BENEFIT ANALYSIS

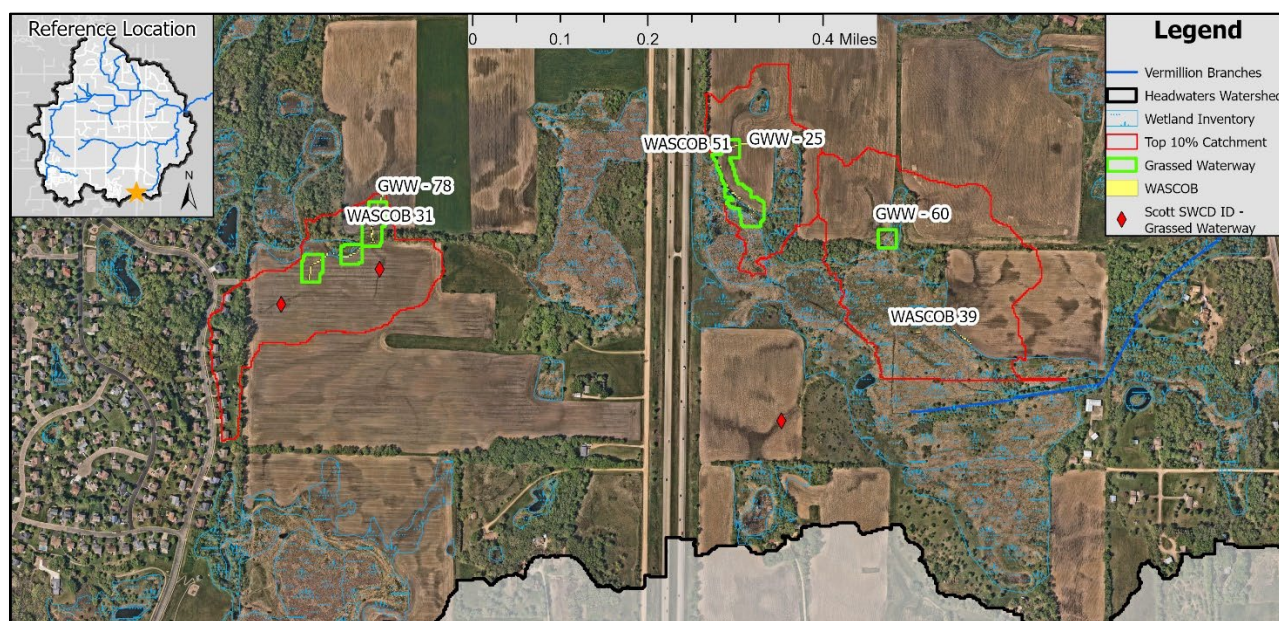
The following table shows anticipated phosphorus, nitrogen and sediment reductions based on PMTApp BMP practices and their associated costs with term years for each practice identified.

Practice	Term (years)	P Load (Lbs./yr.)		Total P Reduction (Lbs./yr)	N Load (Lbs./yr.)		Total N Reduction (Lbs./yr)	S Load (tons/yr)		Total Sed. Reduction (tons/yr)	Estimate Cost Per Year	Estimated Total Cost
		Before	After		Before	After		Before	After			
WASCOB #83	10	2.28	0.55	1.73	46.84	20.14	26.7	5.05	0.61	4.44	\$996.15	\$9,961.51
Grassed Waterway #30	20	0.52	0	0.52	10.62	0	10.62	4.43	0.18	4.25	\$287.85	\$5,757.08

Catchment Ranks #22, #23 & 27 – South Central

DESCRIPTION of EXISTING SITE CONDITIONS

Aerial Reconnaissance identified sheet & rill erosion as well as isolated areas of ephemeral erosion all moving sediment to a system of wetlands. Conventional tillage practices of corn/soybean rotations are utilized on these fields. Flowing through areas of identified wetlands shown on the Scott County Wetland Inventory Maps, these catchments would also benefit from riparian buffers along the agricultural field edges.



BMP RECOMMENDATIONS

Both WASCOBS and Grassed Waterways are overlapping and would be site dependent for which practice is more feasible. Not identified, a buffer along agricultural field edges to reduce loading levels produced by overland flows from the crop fields. Scott SWCD also identified grass waterways that overlap in the area of WASCOB – 31 & GWW – 78, with a Scott SWCD identified grassed waterway adjacent to WASCOB 39 which was missed by PMTApp. After the start of this analysis, the agricultural area to the North of GWW-25 & 60 has been changed to commercial and may impact the hydrology of these catchment.

BMP COST BENEFIT ANALYSIS

The following table shows anticipated phosphorus, nitrogen and sediment reductions based on PMTApp BMP practices and their associated costs with term years for each practice identified.

Practice	Term (years)	P Load (Lbs./yr.)		Total P Reduction (Lbs./yr)	N Load (Lbs./yr.)		Total N Reduction (Lbs./yr)	S Load (tons/yr)		Total Sed. Reduction (Tons/yr)	Estimate Cost Per Year	Estimated Total Cost
		Before	After		Before	After		Before	After			
WASCOB #31	10	8.15	1.95	6.2	119.99	51.6	68.39	35.28	4.24	31.04	\$1,400.62	\$14,006.19
WASCOB #39	10	4.44	1.07	3.37	87.28	37.53	49.75	29.97	3.59	26.38	\$1,293.99	\$12,939.91
WASCOB #51	10	3.04	0.73	2.31	61.6	26.49	35.11	20.32	2.44	17.88	\$1,078.72	\$10,787.22
Grassed Waterway #25	20	0.59	0	0.59	9.85	0	9.85	4.72	0.19	4.53	\$247.58	\$4,951.56
Grassed Waterway #60	20	0.31	0	0.31	3.68	0	3.68	1.79	0.07	1.72	\$88.80	\$1,775.90
Grassed Waterway #78	20	0.18	0	0.18	3.85	0	3.85	1	0.04	0.96	\$127.19	\$2,543.89

Stream Habitat Assessment

Purpose

To gain a more thorough understanding of the condition of the Vermillion Headwaters, Scott SWCD utilized MPCA's Minnesota Stream Habitat Assessment Worksheet (Appendix A) to evaluate the habitat quality and integrity of both the main stem and tributary streams. This habitat assessment focused on the physical habitat evaluation whilst considering historic water quality monitoring at various sites throughout the watershed to assess the water quality portion.

Data Collection/Methods

The Vermillion River Headwaters was inspected by Scott SWCD through onsite inspections where physical access could be reasonable gained (Map 8). These sections were visually inspected by walking the channel and banks to record the physical conditions of the system beyond the routinely visited water monitoring location (V24). The two main branches of the headwaters inspected are the upper branch, composed primarily of Scott County Ditch 12 (now abandoned) and the lower, main Vermillion River Headwaters branch. Physical conditions recorded as listed in the MSHA worksheet include surrounding land use, riparian land use, instream zone, channel morphology, and aquatic vegetation. The maximum (and ideal) score for stream systems is 100. Scoring instructions from the *MPCA Stream Habitat Assessment Protocol for Stream Monitoring Sites (May 2017, p. 9 D.)* section are as follows:

D.1. Surrounding Land Use: Average the scores of the two banks. For example, if residential/park was the land use selected on the left bank and forest, wetland, prairie, shrub was selected on the right bank, then use the land use score would be $(2+5)/2 = 3.5$. In the case of two land uses selected for one bank, the two scores are averaged together and then averaged with the score of the other bank. The maximum land use score is 5.

D.2. Riparian Zone: Average the scores of the two banks for Riparian Width, Bank Erosion, and Shade; then add the three scores. For example, if moderate riparian width (3) was chosen for the left bank and very narrow (1) on the right bank; little erosion (4) on the left bank, and moderate (3) on the right bank; heavy shade (5) on the left bank, and substantial (4) on the right bank; the riparian zone score would be: $[(3+1)/2] + [(4+3)/2] + [(5+4)/2] = 10$. The maximum riparian score is 14.

a) *Substrate, Embeddedness, Siltation, and Substrate Types* – Add the scores of substrate, embeddedness, siltation and substrate type. The substrate score is calculated by adding the two substrate scores for each channel type, multiplying by the percentage of the channel type, then adding the scores for each channel type present. If only one substrate type is chosen because it makes up more than 80% of the channel type, multiply the one substrate score by 2 before multiplying it by the percentage of the channel type. The maximum substrate score is 28.

D.4. Channel Morphology: Add the scores of Depth Variability, Channel Stability, Velocity Types, Sinuosity, Pool Width/Riffle Width, Channel Development, and Modifications. The modifications score can range from -8 to 3. The maximum channel morphology score is 35.

Legend

- Outlet
- ★ V24 WQM Site
- Vermillion Branches
- ▭ Headwaters Watershed
- - - Scott County Boundary
- - - Sections Scored

The map displays the Vermillion River Watershed in Scott County, North Dakota. The Vermillion River is shown in blue, with its branches also in blue. The watershed boundary is outlined in black. The Scott County boundary is indicated by a dashed line. The sections scored are highlighted in red. The V24 WQM Site is marked with a yellow star. The outlet is marked with a red dot. The map includes a north arrow and a scale bar (0 to 2 miles). Key locations and features include:

- Highways:** 91, 35, 46, 2, 9, 80, 7.
- Streets:** 230th Street East, 245th Street East, 267th Street West, 335th Street West, 34th Street East, 35th Street East, 36th Street East, 37th Street East, 38th Street East, 39th Street East, 40th Street East, 41st Street East, 42nd Street East, 43rd Street East, 44th Street East, 45th Street East, 46th Street East, 47th Street East, 48th Street East, 49th Street East, 50th Street East, 51st Street East, 52nd Street East, 53rd Street East, 54th Street East, 55th Street East, 56th Street East, 57th Street East, 58th Street East, 59th Street East, 60th Street East, 61st Street East, 62nd Street East, 63rd Street East, 64th Street East, 65th Street East, 66th Street East, 67th Street East, 68th Street East, 69th Street East, 70th Street East, 71st Street East, 72nd Street East, 73rd Street East, 74th Street East, 75th Street East, 76th Street East, 77th Street East, 78th Street East, 79th Street East, 80th Street East, 81st Street East, 82nd Street East, 83rd Street East, 84th Street East, 85th Street East, 86th Street East, 87th Street East, 88th Street East, 89th Street East, 90th Street East, 91st Street East, 92nd Street East, 93rd Street East, 94th Street East, 95th Street East, 96th Street East, 97th Street East, 98th Street East, 99th Street East, 100th Street East.
- Landmarks:** Elmo New Market, Boulder Pointe Golf Club, Eidsvold.
- Elevations:** 1182 ft, 1223 ft, 1202 ft, 1202 ft, 1143 ft.

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The results of this assessment will be split between the two sections, including the north tributary/CD12 branch and the southern/Vermilion Main stem branch.

Results

The CD12 portion of the Vermillion Headwaters serves as a county ditch that was constructed in 1656. The ditch runs approximately 5.2 miles in length, flowing west to east where it drains into Rice Lake. This portion of the stream lacks normal, healthy channel development due to being dredged for purposes of efficient drainage. Throughout the MSHA inspections, this portion of the watershed showed significant maintenance issues consisting of bank erosion, sediment accumulation, periods of interstitial flow and blockages from trees or beavers. Inspections were completed over the course of three separate days and are identified below as U-1, U-2, and U-3 during the overview of inspection findings.

U-1

This section was inspected in the fall of 2022 and showed signs of little erosion with moderate shade. Being a county ditch, it is a priority to have the streams buffers tree free in this area and would impact the shade score even more if the trees are removed. This means that there is a significant amount of tree cover. The instream zone consisted of cobble, gravel and sand with mainly runs of flow and light substrate embeddedness. Low siltation with moderate cover of overhanging vegetation, logs and woody debris, as well as rootwads. The overall MSHA assessment score for this section was 47. Due to the condition of existing riparian cover and limited flow, stream restoration and riparian habitat practices through this section would provide minimal improvement benefits.



Figure 1: Looking downstream near the headwaters of CD12 Main Branch.



Map 12: Location and overview of scored reach, U-1.

U-2

This section of the MSHA was completed with two worksheets, completed in the fall of 2022. Many of the issues in this section consist of channel sloughing, sediment deposition and wildlife (beaver) presence. Riparian widths range from moderate to extensive, with moderate bank erosion. Significant reaches west of Beard Ave are heavily shaded while little to no shade was found east of Beard Ave. Being a county ditch, it is a priority to have the streams buffers tree free in this area and would impact the shade score even more if the trees are removed. No water was observed immediately east of Beard Ave, due to the presence of a beaver dam (Figure 3). Heavy siltation with no coarse substrate. Sinuosity and channel development are lacking west of Beard Ave but begins to develop east of Beard Ave. A large portion of the immediate surrounding land use east of Beard Ave consists of turf grass farming, which may contribute to nutrient loading. Invasive vegetation of cattails and reed canary grass are heavily present in this section. This section would benefit from bank stabilizations (approx. 800 Ln Ft) and channel revetment to improve the sinuosity of the channel. MSHA scores for this section ranged from 35 and 42, with an average of 38.5. Similar to other sections that have been altered for drainage purposes, this section would benefit from stabilization practices (approx. 800 Ln ft), riparian buffer improvement, and potentially remeandering to improve sinuosity and aquatic habitat quality.



Figure 3: Beaver Dam observed approx. 3000' downstream of Natchez Ave. Photo taken facing upstream (west).



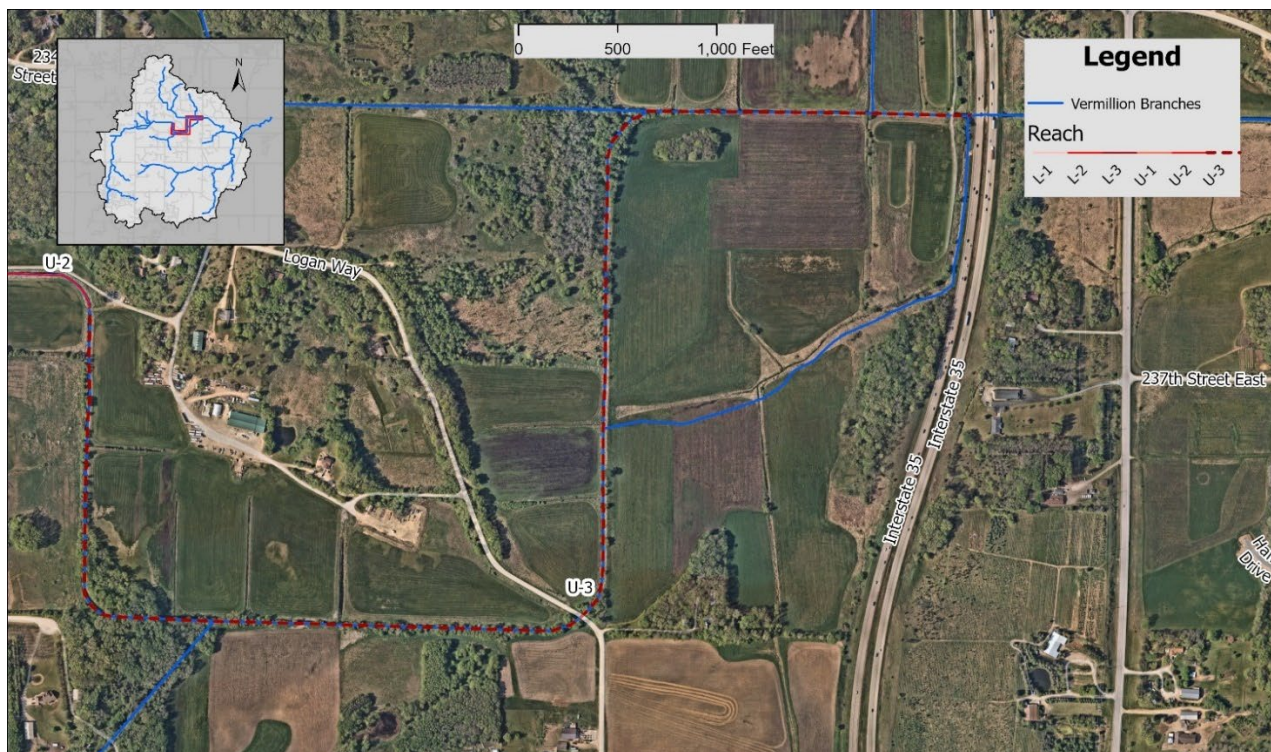
Map 13: Location and overview of scored reach, U-2

U-3

The final MSHA for the upper branch was collected through four scoring sheets on the same day during the late fall/early winter of 2022. The surrounding land use consists of forest and sod farming. Riparian buffer widths range from narrow to wide with moderate to no shade. The instream zone was primarily run channel type with cobble, sand, moderate siltation and detritus substrate with severe embeddedness. Cover type consisted of moderate undercut banks, overhanging vegetation, logs or woody debris root wads, and emergent macrophytes. Channel morphology scored the lowest in this section as the channel represents the typical drainage ditch profile with moderate stability. Sinuosity ranked fair to poor with no pooling and channel modifications of leveed and dredged. MSHA scores for this section ranged from 27.1 to 43.5, with an average of 37.3. Similar to U-2, this section would benefit from stabilization practices, riparian buffer improvement, and potentially, remeandering to improve aquatic habitat quality.



Figure 2: Typical channel conditions for reach U-3. Photo facing downstream (east).



Map 14: Location and overview of scored reach, U-3.

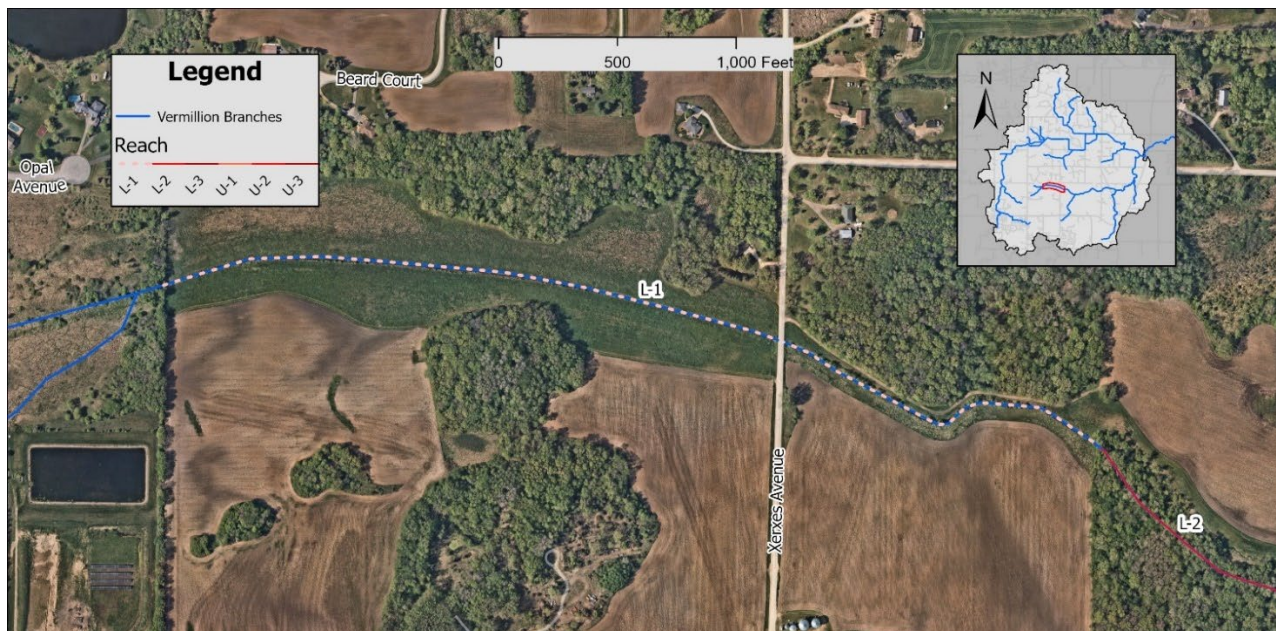
The main Vermillion Headwaters branch runs nearly 2.5 miles flowing west to east where it eventually enters Dakota county near 250th St West. The two branches of the Vermillion Headwaters merge near the outlet of Rice Lake and continue flowing east. This portion of the headwaters does encounter intermittent flow at times, depending on precipitation. Unlike the northern branch, flow in the Vermillion main branch is not influenced by water levels in Rice Lake. It is, however, a flashy system that reacts quickly to large rain event and spring snowmelt events. Data for this branch was collected on three separate occasions and scoring sheets are grouped L-1, L-2 and L3.

Reach L-1

The surrounding land use is predominantly forest, wetland, prairie and shrub with portions of row crop to the south of the stream. The riparian zone width was viewed as wide with light to occasionally heavy shade. Vegetation consisted of an abundance of Reed Canarygrass, stinging nettle, and thistle. The instream zone consisted of run channel types with pool areas and little to no embeddedness. Substrate in this portion of the stream found to range from sand, silt, muck and detritus. Stream cover in this area is overhanging vegetation at a moderate (25-50%) level. This section showed moderate to high channel stability with low depth variability and slow to no velocity. The stream found to have poor sinuosity and channel development, while improving downstream in stretch L-2. With an overall MSHA score of 41, this section like U-2 and U-3 would benefit from a combination of stabilization practices, riparian buffer improvement, and potentially, remeandering to improve aquatic habitat quality.



Figure 3: Typical channel conditions for reach L-1. Facing downstream (east)



Map 15: Location and overview of scored reach, L-1.

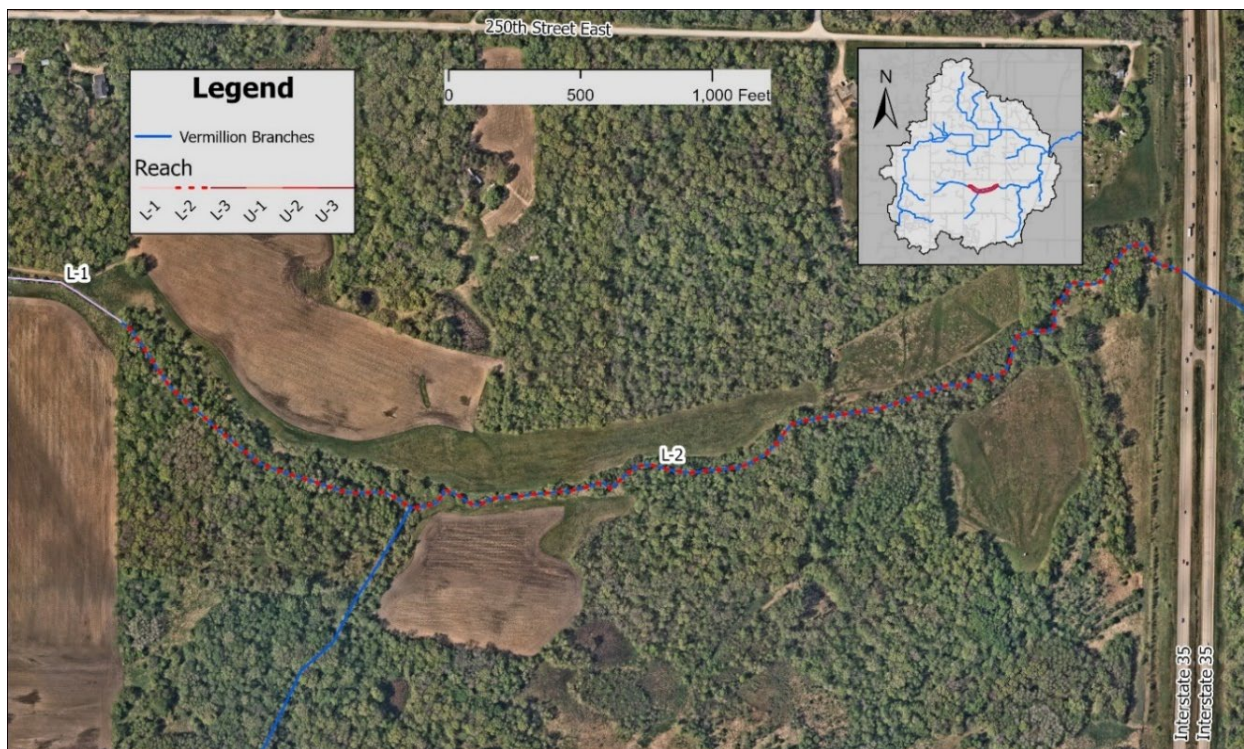
Reach L-2:

This reach held the most forest and hayfield surrounding land use with occasional row crop. Areas where row crop land use was present showed good vegetative buffer establishment. The riparian zone width scored moderate to wide but had a moderate amount of bank erosion. Water levels in this stretch were low to intermittent and nearly completely dry. A private 20- to 30-foot-long culvert was inspected in this stretch and showed substantial amount of undermining on both sides and a large washout immediately downstream (figure 6). Channel type in this area was predominantly run with sand, silt, and detritus substrate. No embeddedness was found and low to moderate siltation. Cover



Figure 4: Typical channel conditions for reach L-2. Facing upstream.

amount is moderate to extensive with cover types in this area of large undercuts, overhanging vegetation, logs or woody debris with root wads and emergent macrophytes. Channel morphology was viewed as having moderate stability with good sinuosity, resulting in fair channel development. Most sections were dry with pockets of stream pooling. It is assumed the interstitial is due to excessive sediment loading from bank erosion that is impeding flow. This section had a MSHA score of 45.5 and would benefit from bank stabilizations (approx. 1500 Ln ft) and near-channel grade stabilization.



Map 16: Location and overview of scored stretch, L-2.

Reach L-3:

Due to land accessibility, sections for the Vermillion between the east side of 35W and Dupont Ave were not able to be inspected for this MSHA. Scott SWCD collects water quality samples at V24 (Map) biweekly, during spring melt, and rain events. Being a routinely visited site, around 850' of this reach was inspected in fall of 2024. Surrounding land use consists of forest, wetland and residential area routinely mowed. Riparian width is considered narrow to moderate with moderate bank erosion and moderate to light shade. The instream zone showed mainly run channel types with some riffle of sand and silt substrate. Cover amount is moderate comprised of undercut banks, overhanging vegetation, logs or woody debris and floating leaf macrophytes. Channel morphology showed moderate to high but areas of significant cutting on banks from overland flow during spring melts and wet seasons. Channel sinuosity and development rank as good with some bank stabilization and use of rip rap. Reed canary and duckweed present in stream. This section had an overall MSHA score of 79.5, and like L-2 it would benefit from bank stabilizations (approx. 300 Ln ft) and near-channel grade stabilization. A bank stabilization was completed previously for the single landowner in this stretch, within the right of way on the west side of Pillsbury Ave.



Figure 5: Spring melt showing overland flow to the Vermillion. Facing upstream, about 315' west of Pillsbury Ave.



Map 17: Location and overview of scored reach, U-3.

MSHA Summary

Aspects identified the stream habitat and condition of the Vermillion Headwaters can affect downstream temperature and overall nutrient concentrations. The average score for the Vermillion Headwaters was 42.4 out of 100 using the MSHA. Based on this average, the stream reach would score as fair. From year to year, it is not uncommon for reaches to be dry depending on the precipitation. Most reaches would benefit from bank stabilization and/or riparian vegetation improvement practices, while sections that have been channelized for drainage purposes would potentially benefit additionally from full restoration including but not limited to re-meandering. In addition, the implementation of upland conservation BMP's as identified in this report would help reduce the volume and rate of water and sediment entering the stream, further improving habitat quality.

Intermittent periods of low flow within the streambed prevent aquatic species' ability to travel further upstream through its tributaries. Pooled areas with little to no cover or shade warm up and contribute to temperature fluctuations during times of higher precipitation. About 49 miles of the Vermillion Rivers main stem and tributaries are Minnesota Department of Natural Resources (DNR), designated trout streams (MNDNR). These class 2a cold-water stretches are mainly in Dakota County, while continuous temperature is recorded every 15-minutes at the V24 location in Scott County. There are no temperature standards for the reaches of Vermillion River in Scott County, but flow from these reaches can significantly impact water quality further downstream where standards do exist.



Figure 6: Facing east from Pillsbury Ave near Rice Lake Inlet during spring melt.



Figure 7: Facing east from Pillsbury Ave near Rive Lake Inlet during dry season.

Works Cited

Minnesota Department of Natural Resources. 2025. The Minnesota Department of Natural Resources Website (online). Accessed Feb. 11, 2025, at mndnr.gov/copyright
Minnesota Department of Natural Resources 500 Lafayette Road St. Paul, MN 55155-4046

Minnesota Pollution Control Agency (MPCA). May 2017. *Stream Habitat Assessment (MSHA) Protocol For Stream Monitoring Sites*. Wq-bsm.02

Minnesota Pollution Control Agency (MPCA). 2024. *2024 Impaired Waters List*. Wq-iw1-81

Houston Engineering Inc. March 2016. *(PTMAPP): Theory and Development Documentation*.
HEI No. 6059_051

Houston Engineering Inc. March 2021. *Prioritize, Target, Measure Application (PTMAPP) Desktop Toolbar User's Guide*.

Houston Engineering Inc. June 2019. *Workshop Section 2 Manual: Running PTMApp-Desktop*.

Houston Engineering Inc. June 2018. *Workshop Section 3 Manual: Using PTMApp-Desktop Output Data to Build Products*.

(revised April 2017)

Aquatic Vegetation (indicate as follows for observed abundance: Abundant=[3]; Moderate=[2]; Sparse=[1])

A. Beneficial Aquatic Vegetation

☐ Pond Lilies (<i>Nymphaea/Nuphar</i>)	☐ Sedge (<i>Carex</i>)	☐ Wild Celery (<i>Vallisneria</i>)
☐ Wild Rice (<i>Zizania</i>)	☐ Pond Weed (<i>Potamogeton</i>)	☐ Bulrush (<i>Scirpus</i>)
☐ Waterweed (<i>Elodea</i>)	☐ Coontail (<i>Ceratophyllum</i>)	☐ Water Cress (<i>Nasturtium</i>)
☐ Water Milfoil (<i>Myriophyllum</i>)	☐ Arrowhead (<i>Sagittaria</i>)	

B. Invasive and Negative Aquatic Vegetation

☐ Eurasian Milfoil (<i>Myriophyllum</i>)	☐ Purple Loosestrife (<i>Lythrum</i>)	☐ Reed Canary Grass (<i>Phalaris</i>)
☐ Cattails (<i>Typha</i>)	☐ Duckweed (<i>Lemna</i>)	

C. Algae

☐ Algae (Floating Mats)	☐ Algae (Planktonic)	☐ Algae (Benthic)
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No Vegetation Noted ☐

MSHA / Veg Comments: _____
