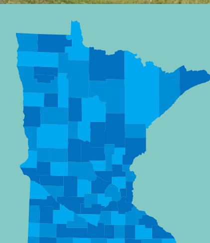
Grant

April 2024

Hay Creek Watershed NKE Plan

This nine key element (NKE) plan addresses the water quality concerns in the Hay Creek Watershed. If implemented as written, this plan will achieve the estimated reductions to achieve water quality standards and goals in ten years.

MINNESOTA POLLUTION CONTROL AGENCY



Authors

Greg Johnson, MPCA
Tracy Halstensgard, Roseau River Watershed District

Contributors/acknowledgements

Erik Jones, Houston Engineering, Inc.
Moriya Rufer, Houston Engineering, Inc.
Chris Lundeen, MPCA
Cary Hernandez, MPCA

Editing and graphic design

Paul Andre
Lori McLain

Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

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Document number: wq-cwp2-39

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Executive summary

Hay Creek is one of four stream reaches in the Roseau River Watershed identified by the Roseau River Watershed District (RRWD) for water quality restoration. The RRWD identified the stream for restoration given its identification as being impaired for aquatic life and aquatic recreation uses by the Minnesota Pollution Control Agency (MPCA). The goals for restoration are to achieve the water quality criteria for fish index of biotic integrity (F-IBI), macroinvertebrate index of biotic integrity (M-IBI), total suspended solids (TSS), and *Escherichia coli* (*E. coli*). The total maximum daily loads (TMDL) completed for the TSS and *E. coli* impairments are the only TMDLs needed in the Roseau River Watershed.

In addition to the water quality concerns, flooding and water quantity impacts on land productivity and water quality are significant concerns of the landowners in the watershed. The water quantity impacts across the watershed have been exacerbated over the course of the last 30 years with increases in both frequency and intensity of precipitation events. In March 2023, the Minnesota Department of Natural Resources released an Evaluation of Hydrologic Change (EHC) for the Roseau River Watershed (MNDNR, Evaluation of Hydrologic Change (EHC) Technical Summary: Roseau River Watershed, 2023). Some of the key findings of the EHC include:

- 1992 is identified as the year of the greatest hydrologic change at the outlet of the Roseau River Watershed,
- The Roseau River Watershed receives 4.3 more inches of precipitation per year when compared to the pre-change point going back to 1973,
- Based upon hydrologic change evaluations for other major Minnesota watersheds, the Roseau River Watershed had the highest increase in precipitation for similar time periods,
- The average yearly peak flows for the Roseau River Watershed have increased by 40%, and
- The amount of water flowing through the Roseau River Watershed during the largest floods (those occurring only 10% or less) has increased by 99%.

This Nine Key Element (NKE) plan will address the sources of the excess TSS and *E. coli* in the Hay Creek Watershed along with poor habitat conditions and related biological stressors affecting the fish and macroinvertebrate communities. The RRWD's roles, as well as the roles of the partners identified in Table 21, for drainage and flood damage reduction are integral to the overall management of the watershed.

The RRWD is actively pursuing the watershed's management needs and opportunities through partnerships ranging from the federal flood damage reduction program for the Red River Basin, MPCA monitoring and reports, Board of Water and Soil Resources (BWSR) watershed planning, Department of Natural Resources (DNR) water, fish, and wildlife programs in addition to their own and other state and federal programs. The NKE plan demonstrates the mission statement of the RRWD which states "The Roseau River Watershed District (RRWD) is committed to a leadership role in protecting, improving, and managing the surface waters and affiliated groundwater resources within the District, including their relationships to the ecosystems of which they are an integral part, through regulation, capital projects, education, cooperative endeavors, and other programs based on sound science, innovative thinking, an informed and engaged constituency, and cost effective use of public funds."

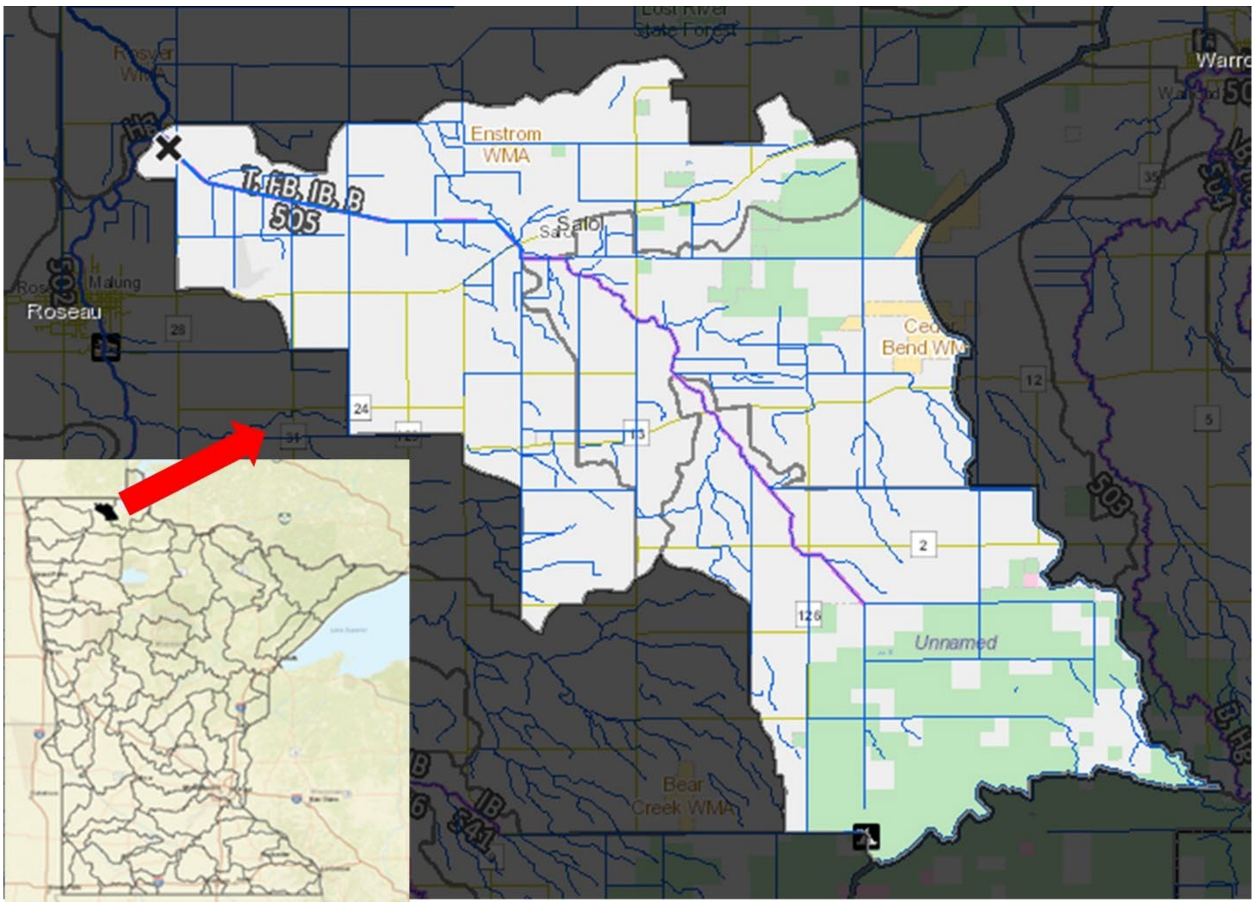
The Hay Creek Watershed is a hydrologic unit code (HUC) 10 subwatershed (0902031403) located in the Roseau River HUC-8 major watershed (09020314). The Hay Creek watershed is comprised of the three HUC-12 subwatersheds listed in Table 1. The drainage area of the Hay Creek Watershed is approximately 67,840 acres.

Table 1. HUC-12 subwatersheds located in the Hay Creek Watershed

Watershed	HUC#
Upper Hay Creek	090203140301
Middle Hay Creek	090203140302
Lower Hay Creek	090203140303

A map of the Hay Creek watershed is shown in Figure 1.

Figure 1. Hay Creek Watershed streams and altered waterways (WHAF, 2023)



The NKE plan (in collaboration with other reports and documentation) is addressing pollutants, sources and solutions in the Hay Creek Watershed. For the purposes of the Section 319 grant program, only practices and activities eligible for funding under the United States Environmental Protection Agency (EPA) 2014 Section 319 program guidance and Minnesota's Nonpoint Source Pollution Program Management Plan (NPSPPMP) are eligible for Section 319 funding. All match activities must be eligible for Section 319 funding, except where noted in the NPSPPMP.

Water quality conditions

Hay Creek and Bemis Hill Creek/County Ditch (CD) 9 were assessed for aquatic life and aquatic recreation uses in the Hay Creek Watershed. Descriptions of the reaches are shown in Table 2.

Table 2. Stream reaches assessed in the Hay Creek Watershed

Stream name	WID	Reach description	Reach length (miles)	Use class*
Hay Creek	09020314-505	Headwaters to Roseau R	17	WWg
County Ditch 9	09020314-512	T161 R37W S29, south line to Hay Cr	3	CWg

* Use class abbreviations: WWg – warmwater general, CWg – coldwater general

Assessment indicators

Table 3 and Table 4 provide summaries of the assessment indicators and use support status for Hay Creek and County Ditch 9, respectively. Each stream is identified as a single stream reach and identified by its Water Unit Identification (WID) number. Tables 3 and 4 include assessment results for Dissolved Oxygen (DO) and Index of Biological Integrity (IBI) for fish (F-IBI) and macroinvertebrates (M-IBI).

Table 3. Aquatic life and recreation use indicators and assessments for Hay Creek, Headwaters to Roseau R (WID 09020314-505)

Indicators	Indicator evaluation	Aquatic life use support status	Aquatic recreation use support status
F-IBI	Below threshold	Not supported	N/A
M--IBI	Below threshold		
DO	Insufficient information		
TSS	Exceeds standard		
Chloride	Meets standard		
pH	Meets standard		
Ammonia	Meets standard		
Eutrophication	Insufficient information		
Bacteria	Exceeds standard	N/A	Not supported

Table 4. Aquatic life and recreation use indicators and assessments for County Ditch 9, T161 R37W S29, south line to Hay Cr (WID 09020314-512)

Indicators	Indicator evaluation	Aquatic life use support status	Aquatic recreation use support status
F-IBI	Above threshold	Fully supported	N/A
M-IBI	Above threshold		
DO	No data		
TSS	Insufficient information		
Chloride	No data		
pH	No data		
Ammonia	No data		

Indicators	Indicator evaluation	Aquatic life use support status	Aquatic recreation use support status
Eutrophication	Insufficient information		
Bacteria	No data	N/A	Not assessed

Table 5 shows the 2015 and 2016 biological monitoring F-IBI and M-IBI scores used to assess the aquatic life use support status of Hay Creek.

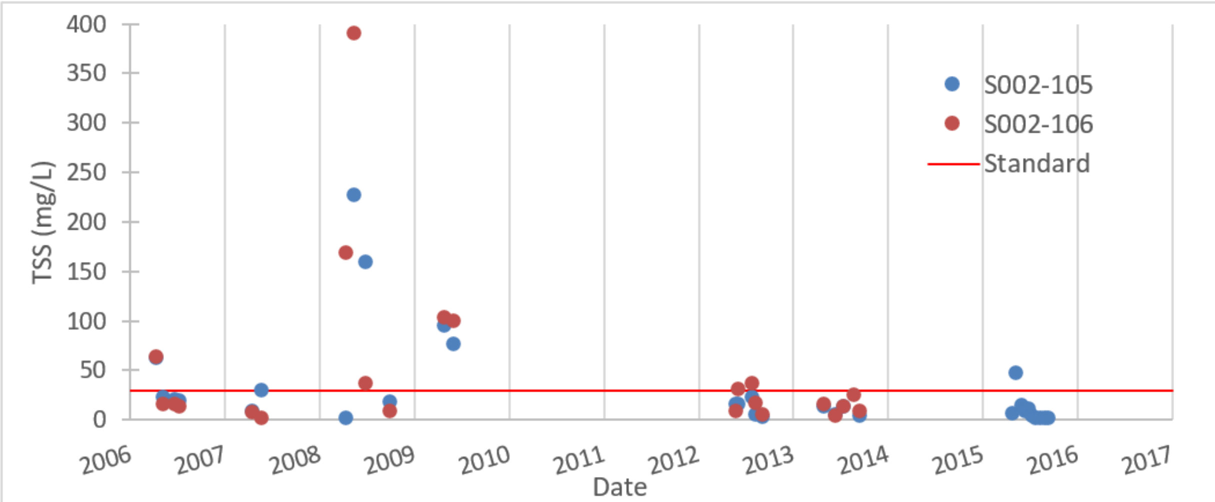
Table 5. F-IBI and M-IBI scores for the two monitoring stations along Hay Creek

	Hay Creek		**Bemis Hill Creek (County Ditch 9)**
	05RD043	**05RD044**	**15RD017**
Fish class	Northern streams	Northern headwaters	Northern coldwater
Fish use	General use	General use	General use
F-IBI impairment threshold	47	42	35
Mean F-IBI score	43	60	50
Macroinvertebrate class	Northern forest streams – riffle/run habitat	Northern forest streams – riffle/run habitat	Northern coldwater
Macroinvertebrate use	General use	General use	General use
M-IBI impairment threshold	53	20	32
Mean M-IBI score	53	15	29

Total suspended solids

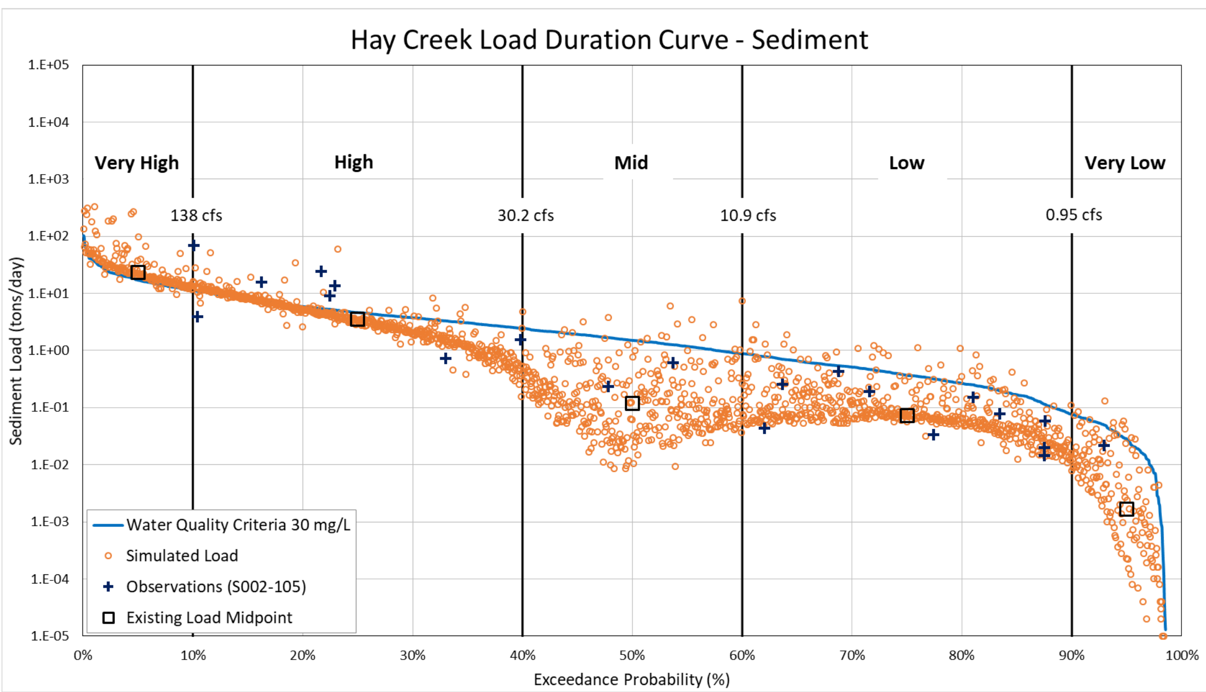
Figure 2 shows the TSS data used for assessing the exceedance of the TSS water quality standard for Hay Creek. The figure represents the results of once-a-month water sampling at two sites on the stream (two samples per month in 2015). The S002-105 site is located near the mouth of the Hay Creek at CR-28 and S002-106 site is located approximately three miles upstream at 460th Avenue (township road northwest of MN Hwy 11). The TSS concentrations at the two sites were generally similar except for two samples collected in 2008.

Figure 2. TSS data for Hay Creek from 2006 through 2015 (TMDL information)



Hay Creek was listed as impaired for aquatic life use due to high TSS concentrations, given that greater than 10% of the samples at each site exceeded the regional TSS standard of 30 milligrams per liter (mg/L) TSS for the stream. Given the limited data available and the lack of streamflow data, the TMDL load duration curve was developed using the Hydrologic Simulation Program – FORTRAN (HSPF) model for the Roseau River Watershed (Figure 3).

Figure 3. TSS load duration curve for Hay Creek



The TSS TMDL summary table is shown in Table 6.

Table 6. TSS TMDL summary

		Flow condition *				
		Very high	**High**	**Mid**	**Low**	**Very low**
Hay Creek – Total suspended solids		**Tons per day**				
Loading Capacity (LC)		**17.0**	**4.62**	**1.51**	**0.37**	**0.028**
Wasteload allocations	**Total WLA**	0.99	0.96	0.95	**	**
	Roseau WWTP (MNG580039)	0.95	0.95	0.95	**	**
	Construction Stormwater (MNR100001)	0.02	0.005	0.002	**	**
	Industrial Stormwater (MNR500000)	0.02	0.005	0.002	**	**
Load allocations	**Total LA**	**14.29**	**3.20**	**0.41**	**	**
Margin of safety (10%)		1.70	0.46	0.15	**	**
Existing load		**23.10**	**3.48**	**0.12**	**0.07**	**0.002**
Estimated load reduction		**6.10**				
Percent reduction		**27%**				

*HSPF-simulated flow was used to develop the flow zones and loading capacities for this reach.
**The WLA for the permitted wastewater discharger is based on a facility design flow. The WLA exceeded the very low-flow and low-flow zones total daily LC (minus the MOS). For these flow zones, the WLA and LAs are determined by the following formula: Allocation = (flow contribution from a given source) X (*E. coli* concentration limit or standard).

The TMDL indicates that a 27% reduction in TSS load during very high-flow conditions is needed to meet the TSS water quality standard (MPCA Final Roseau River Watershed Total Maximum Daily Load Study, 2020). The average annual TSS load to Hay Creek is estimated at 1,295 tons/year, as calculated using the EPA Pollutant Load Estimation Tool (PLET). The assumption for the NKE plan is that a load reduction of 27% of the estimated annual TSS load will achieve the reductions needed to meet the TMDL and achieve the water quality standard for TSS. The 27% reduction equals 350 tons per year. The load values are summarized in Table 7.

Table 7. Hay Creek current TSS load and load reduction needed to meet the TSS water quality standard based on the PLET model (2023).

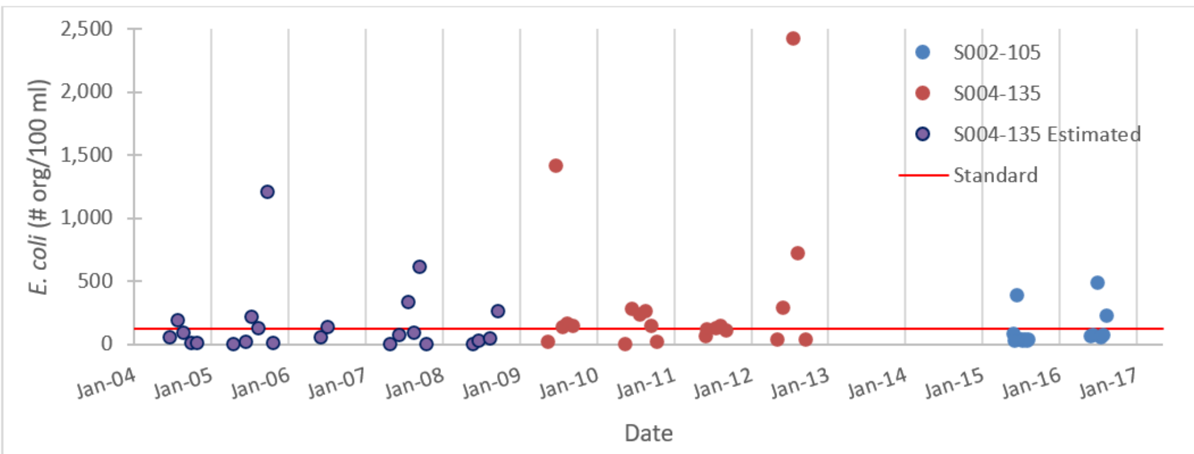
	TSS (tons/year)
Existing load estimate	1,295
Load reduction target	350
Percent reduction	27

Escherichia coli (E. coli)

Hay Creek was listed as impaired for aquatic recreation use due to elevated *E. coli* levels, given that greater than 10% of the samples at each site exceeded the *E. coli* criteria of 126 organisms per milliliter (org./mL) for the stream.

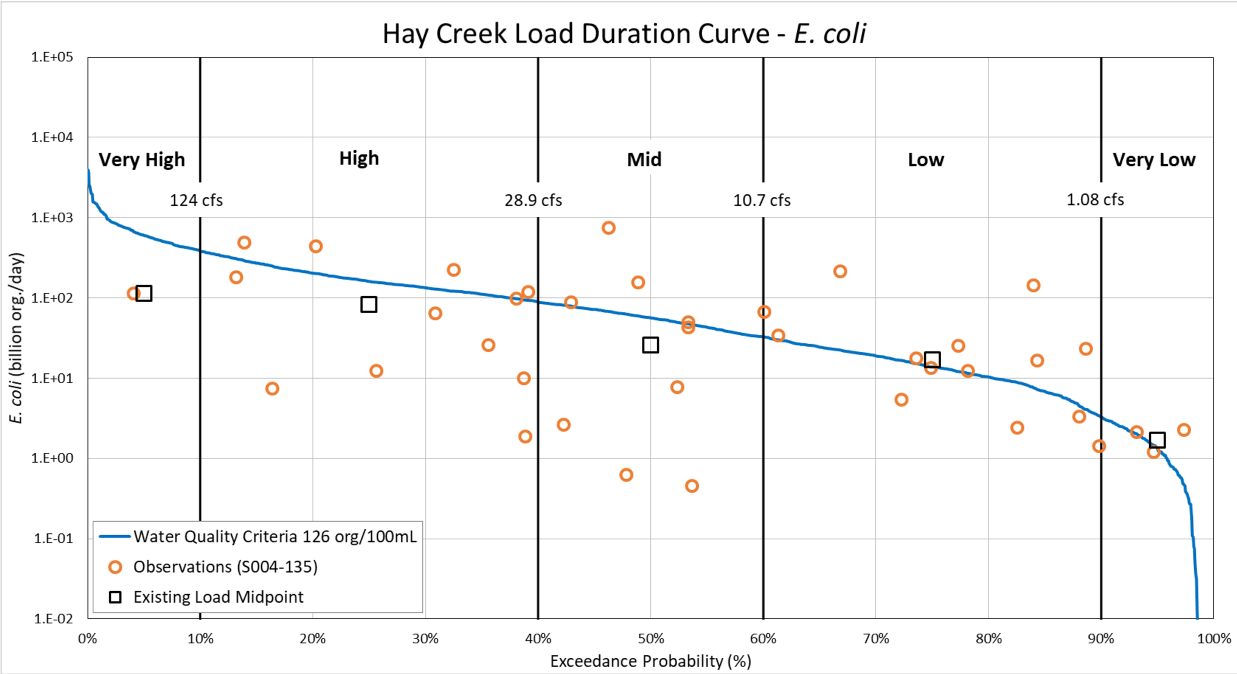
Figure 4 shows the Hay Creek *E. coli* data. The 2004 through 2008 data are estimated *E. coli* concentrations based on the conversion of fecal coliform data to *E. coli* values. The 2004 through 2012 data were used for assessing the exceedance of the *E. coli* water quality standard for Hay Creek. The 2015 and 2016 data were collected after the assessment period. The figure represents the results of once-a-month water sampling at S002-105 near the mouth of Hay Creek and S004-135 at CR-12 approximately 11 miles upstream of S002-105 (two or three samples per month in 2015 and 2016).

Figure 4. E. coli data for Hay Creek from 2009 through 2016



The TMDL load duration curve for E. coli was developed using the predicted streamflow data from the HSPF model for the Roseau River Watershed multiplied by the E. coli criteria (Figure 5). Only the observed bacteria loads are shown given that the HSPF model does not include bacteria.

Figure 5. Load duration curve for *E. coli* in Hay Creek



The *E. coli* TMDL summary table is shown in Table 8.

Table 8. *E. coli* TMDL summary

Hay Creek – *E. coli*		**Flow condition ***				
		Very high	**High**	**Mid**	**Low**	**Very low**
		Billion organisms per day				
Loading Capacity		**602**	**161**	**56.5**	**13.8**	**1.3**
Wasteload allocations	**Total WLA**	**24.1**	**24.1**	**24.1**	**	**
	Roseau WWTP (MNG580039)	24.1	24.1	24.1	**	**
Load Allocations	**Total LA**	**518**	**120**	**26.8**	**	**
Margin of safety (10%)		1.70	0.46	0.15	**	**
Existing load		**114**	**81.9**	**25.6**	**16.8**	**1.68**
Estimated load reduction					**3.06**	**0.35**
Percent reduction					**18%**	**21%**

*HSPF-simulated flow was used to develop the flow zones and loading capacities for this reach.
**The WLA for the permitted wastewater discharger is based on a facility design flow. The WLA exceeded the very low-flow and low-flow zones total daily LC (minus the MOS). For these flow zones, the WLA and LAs are determined by the following formula: Allocation = (flow contribution from a given source) X (*E. coli* concentration limit or standard).

The TMDL indicates that 18% and 21% reductions in *E. coli* loads during low- and very low-flow conditions are needed to meet the *E. coli* water quality standard (MPCA Final Roseau River Watershed Total Maximum Daily Load Study, 2020). For the purposes of the NKE, the annual load reduction needed to achieve the *E. coli* standard is assumed to be 21% of the estimated annual load estimated (Table 9). The reduction represents a conservative approach to setting a reduction goal to meet the water quality standard in all flow categories of the load duration curves based on the observed average monthly geometric mean and the monthly geometric mean standard for *E. coli*. The estimated existing annual load and annual load reductions needed are also shown in the table. The loads represent estimates based on the load duration curve TMDL daily loads and duration of the flow categories.

Table 9. *E. coli* reductions needed to meet the TMDL for Hay Creek.

Reach	% Reduction	Estimated existing load (billion MPN/yr)	Load reduction (billion MPN/yr)
Hay Creek (09020314-505)	21	16,900	3,500

The TMDL load duration curve indicates that elevated E. coli levels occur in the low- and very low- flow conditions suggesting that bacteria sources may include failing septic systems and near channel sources (i.e., cattle in or near streams), and less from watershed runoff in storm runoff. The repair and/or replacement of Subsurface Sewage Treatment Systems (SSTS) that are failing or nonconforming and implementation of pasture management practices will achieve the necessary E. coli reductions to achieve the standard.

Nutrients

Nutrient (phosphorus [P] and nitrogen [N]) loading from the Hay Creek contributes to excess nutrient loads flowing to Lake Winnipeg through the Red River of the North. Nutrient reduction goals to address the eutrophication problems of Lake Winnipeg have been drafted by the International Joint Commission (IJC, 2019). The nutrient reduction goal for the Hay Creek NKE plan is calculated from the IJC goals as presented in the updated nutrient reduction strategy goals for Minnesota (MPCA, 2022). The current load, goal, and percent load reduction needed for the Minnesota portion of the Red River of the North and Roseau River Watersheds are shown in Table 10 (MPCA, 2022).

Table 10. Load estimates for the Minnesota portion of the Red River of the North and the Minnesota portion of the Roseau River (adapted from MPCA, 2022).

	P Load (metric tons/year)			N Load (metric tons /year)		
Watershed	Existing	Final goal	% reduction	Existing	Final goal	% reduction
Red River	991	700	29	8,247	4,763	42
Roseau River	21	16.8	20	147	47	32

The existing Hay Creek nutrient load was estimated using PLET (2023). The reduction goals are the percent reductions in P and N loads identified for the Roseau River. The existing loads and reduction targets for the Hay Creek Watershed are shown in Table 11.

Table 11. Load reductions for the Hay Creek Watershed to meet the Hay Creek portion of the nutrient reduction goals for Lake Winnipeg based on the PLET model (2023).

	P Load (lbs/year)	N Load (lbs /year)
Existing load estimate	14,921	85,616
Load reduction target	2,984	27,374
Percent reduction	20	32

Implementation strategies

The implementation strategies, schedule, milestones, assessments, costs, and the estimated pollutant reductions by practice are described in Table 12. The plan is estimated to yield the reductions needed to meet the water quality standards for TSS and *E. coli* within ten years. The plan will also achieve the P and N reduction goals identified for the Hay Creek Watershed as a portion of the goals for Lake Winnipeg. Estimated pollutant reductions by practice were calculated per practice using the EPA's PLET for decision-making purposes. The complete reductions for this plan were calculated using the PLET combined efficiencies; therefore, the summation of individual practice estimates may not equal the reductions estimated for the entire plan. Complete plan reductions are summarized in Table 12.

Eligibility for funding refers to current practice eligibility in 2023, as described in the EPA's 2014 Guidance and Minnesota's 2021 NSPMP. Practices are subject to final verification at the time of any financial award and must meet all current and necessary rules and guidelines for eligibility. Any stormwater activities that take place in a Municipal Separate Storm Sewer System (MS4) permitted conveyance system are not eligible for Section 319 grant funding, nor can they be used for match funding. Monitoring to determine the effectiveness of this plan and the best management practices (BMPs) implemented is eligible for Section 319 funding. General diagnostic and exploratory monitoring activities are not eligible for funding or match purposes.

Table 12. Implementation types, eligibility, activities, schedule, milestones, assessment criteria, costs, and estimated per practice pollutant reductions (PLET, 2022)

Type	319 Eligible	Activity	Milestones 2-year (2025)	4-year (2027)	6-year (2029)	8-year (2031)	10-year (2033)	Assessment	Cost	Reductions TSS (t/yr)	P (lbs/yr)	N (lbs/yr)
Cropland	Y	Cover crops - 2,450 acres	490	490	490	490	490	# acres	$490,000	6	83	1,363
Cropland	Y	Wetland restoration - 2,150 acres	430	430	430	430	430	# acres # restorations # acres treated	$5,375,000	33	541	3,626
Cropland	Y*	Riparian buffers, above the buffer law requirement - 257 acres	50	51	52	52	52	# buffers # feet of buffers # acres treated	$642,500	24	379	1,798
Cropland	Y	Conservation cover - 3,000 acres	600	600	600	600	600	# producers # acres treated	$6,000,000	46	759	5,086
Cropland	Y	Side inlet improvement - 3,150 acres	630	630	630	630	630	# producers # side inlets # acres treated	$200,000	20	305	1,521
Cropland	Y	Grade stabilization structures - 3,150 acres	630	630	630	630	630	# producers # grade stabilizations # acres treated	$1,575,000	20	305	1,521
Cropland	Y	Tillage/residue management - 5,500 acres	1,100	1,100	1,100	1,100	1,100	# producers # acres treated	$1,100,000	69	1,178	2,741
Cropland	Y	Grassed waterways - 150 acres	30	30	30	30	30	# producers # waterways # acres treated	$75,000	1	15	73
Cropland	Y	Water and sediment control basins (WASCOBs) - 200 acres	40	40	40	40	40	# producers # WASCOBs # acres treated	$300,000	1	19	97

Type	319 Eligible	Activity	Milestones					Assessment	Cost	Reductions		
			2-year (2025)	4-year (2027)	6-year (2029)	8-year (2031)	10-year (2033)			TSS (t/yr)	P (lbs/yr)	N (lbs/yr)
Stream restoration	Y	Stream restoration including drainage ditch modifications, channel stabilization, two-stage ditch development, and channel bank vegetation - 5.5 miles				5.5		# miles # feet # acres	$1,650,000	348	215	558
Pasture	Y	Pasture management systems, each including rotational grazing, livestock access control (exclusion), alternative water supply, and critical area planting - 6 operations, 2,300 acres treated	460	460	460	460	460	# access controls # acres treated	$1,150,000	14	210	3,518
Septic System Improvement	N*	SSTS upgrades and replacements - 30 systems	6	6	6	6	6	# systems	$600,000	-	19	48

Habitat/ connectivity	Y	Modify/replace dams, culverts & fish passage barriers - 3 barriers		1	1	1		# barriers removed	$300,000			
	Y	Re-meander channelized stream reaches - 4 projects		1	1	1	1	# projects # feet	$400,000			
	Y	Restore riffle substrate - 4 projects		1	1	2		# projects # riffles	$40,000	Reductions assumed with the 5.5 miles of stream restoration		
Education & Outreach	Y	Soil health / water quality workshop	1	1	1	1	1	# workshops	$5,000			
	Y	Ag BMP Program sign-up events	1	1	1	1	1	# events	$5,000			
	Y	Landowner mailings	2	2	2	2	2	# mailings # landowners	$12,000			
	Y	County Fair booth to promote program	2	2	2	2	2	# visitors # people expressing interest	$15,000			
	Y	Individual landowner meetings	10	10	10	10	10	# meetings # landowners	$10,000			
Total costs									$19,944,500			

* Final determination of Section 319 funding eligibility will be made based on the most current Section 319 guidelines and the NSPMP.

Element a. Sources Identified

An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

The pollutant sources of TSS, *E. coli*, and nutrients are primarily nonpoint sources from land cover and use and hydrological characteristics of the watershed. Point sources are generally very small contributors of the pollutants.

Nonpoint sources

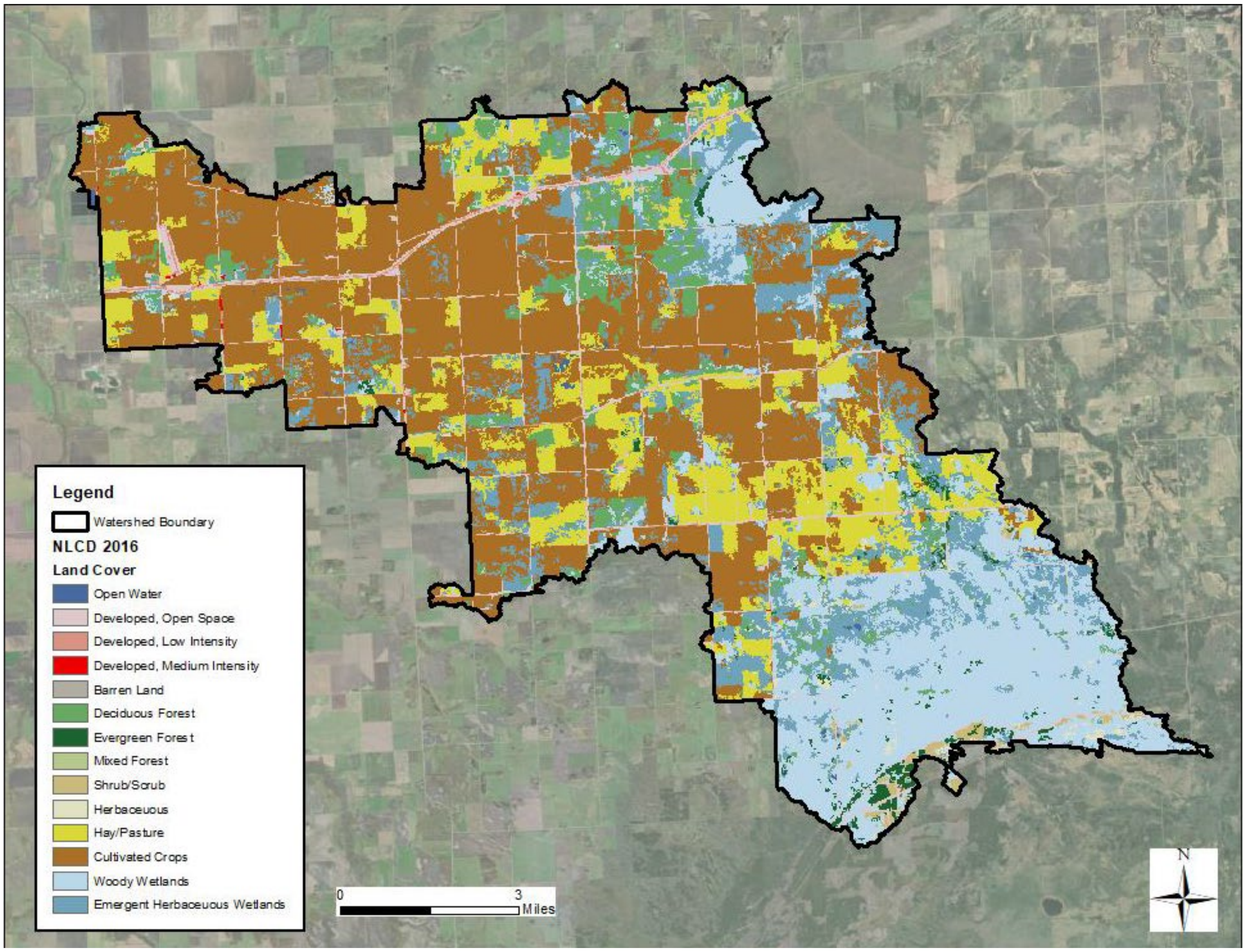
Most of the pollutant loading in the Hay Creek Watershed comes from nonpoint source (NPS) pollution. The primary loading is from stream bed and bank erosion (streambank) and watershed land uses, primarily agriculture cropland. Overland and riparian runoff resulting from watershed land use are important factors affecting streambank erosion in addition to in-channel characteristics.

The watershed sources are largely characterized by the land use and cover distribution in the watershed (Table 13 and Figure 6).

Table 13. Percent land use and cover in the Hay Creek Watershed (NLCD, 2011)

Open water	Urban	Forest/shrub	Pasture/hay/ grassland	Cropland	Wetland
0.2%	4.6%	8.9%	14.5%	38.4%	33.4%

Figure 6. Land use and cover in the Hay Creek Watershed (Houston, 2016)



TSS sources

A large portion of the sediment load comes from stream channel and bank erosion along Hay Creek and adjoining drainage ditches. Sediment loads also come from upland erosion and sediment delivery from cropland, forests, and developed areas. A large portion of the sediment load also comes from stream channel and bank erosion along Hay Creek and adjoining drainage ditches. The TSS load estimates were identified in the Hay Creek TSS TMDL using the HSPF watershed model for the Roseau River Watershed. The primary loads are summarized in Table 14.

Table 14. Nonpoint source TSS loads to Hay Creek based on HSPF-SAM (TMDL report, 2020)

	Bed/bank	Cropland – high till	Cropland – low till	Developed	Other	Total
Load (tons/yr)	728	291	149	114	16	1,298
Percent	56%	22%	11%	9%	1%	99%

A comparable TSS load was computed for the Hay Creek Watershed using the EPA PLET model. The loads estimated using the PLET model are summarized in Table 15. For the purposes of this plan, the PLET-modeled loads, and load reductions associated with practices will be used.

Table 15. NPS pollution loads to Hay Creek Watershed estimated using PLET (2023)

Source	TSS load (t/yr)	P load (lb/yr)	N load (lb/yr)
Developed areas	64	344	2,764
Cropland	451	8,595	52,361
Pastureland	55	1,125	14,273
Forest	28	2,321	4,663
Feedlots	0	2,069	10,344
Septic	0	38	96
Streambank	697	429	1,115
TOTAL	**1,295**	**14,921**	**85,616**

The predominate source of sediment to Hay Creek was identified as bank and bed erosion from streams and ditches. Upland runoff and erosion are a secondary source of pollutants followed by small contributions from developed and other areas. A geospatial bank erosion assessment was completed to identify the stream reaches with the highest potential bed and bank erosion (Houston Engineering, Inc., undated). The analysis identified stream reaches using sinuosity, estimated sediment discharge rating, stream power index, and bank erosion risk based on average bank slope and height (Table 16). The study evaluated the banks of Hay Creek (Figure 1) to determine the cause of streambank loading. The study indicates that various areas of the stream reach are vulnerable to different types of erosion. This study is described in Element c. BMPs.

Table 16. Summary of riparian area sediment sources along Hay Creek reach -505 (Houston Engineering, Inc., undated)

Source	Indicator	Length of stream (mi)
Bed and bank erosion due to channel alteration	Sinuosity	14.7
Bank erosion from direct runoff	Sediment discharge rating	8.0
Direct overland and gully erosion	Stream power index	10.5
Bank erosion due to unstable banks	Bank erosion risk	5.5

The hydrologic alteration of much of the stream through channelization changes water speed and flow, increases the rate of erosion, and degrades aquatic habitat. A primary indicator of the alteration is the lack of natural sinuosity due to ditching. Unstable banks along the stream and ditches result in higher erosion rates and increased sediment loading.

Upland runoff and erosion primarily occur from the cropland in the watershed. Cropland area contributing the most sediment to Hay Creek was estimated using the Prioritize, Target, and Measure Application (PTMApp). Poor soil health and agricultural runoff contributes to sediment and nutrient loading through overland runoff and the formation of gullies. Runoff from pastures in the riparian area also acts as a source of sediment, nutrient, and bacteria loading.

E. coli sources

Nonpoint sources of *E. coli* in the watershed include human waste from noncompliant SSTS, animal waste from livestock, pets, wildlife, and naturalized populations in sediment and water. The bacteria source assessment completed for the *E. coli* TMDL is summarized in Table 17. The predominate source of bacteria was identified as cattle followed by wildlife, other livestock, and finally by humans and pets. Satellite imagery has shown indications that livestock in the channel is an issue.

Table 17. Estimated *E. coli* production estimates in Hay Creek Watershed (TMDL report, 2020)

Source category	Sub-source	*E. coli* (billion org./day)	Percent of total
Humans	**All**	**260**	**0.4%**
	WWTP	20	0.0%
	SSTS	40	0.1%
	Pets	200	0.3%
Livestock	**All**	**64,490**	**91.8%**
	Cattle	60,800	86.6%
	Hogs	3,110	4.4%
	Sheep and goats	560	0.8%
	Other	20	0.0%
Wildlife	**All**	**5,480**	**7.8%**
	Deer	200	0.3%
	Geese	4,510	6.4%
	Ducks	770	1.1%
Total		**70,230**	**100.0%**

Nutrient sources

The phosphorus and nitrogen loading estimated by the PLET model are listed in Table 15. The predominate source is cropland runoff with elevated sources paralleling the sediment runoff pathways. The estimated loads from forested areas are a result of the large acreage of forest in the watershed and is generally not a pollutant concern. The estimated loads from feedlots in the PLET model are likely considerably greater than actual loading given that most of the cattle operations are pasture-based. With that consideration, pasture loads are likely higher than estimated in the model especially with pastures located near waterways.

Point sources

Point sources of TSS and *E. coli* include the Roseau Wastewater Treatment Plant (WWTP) and construction and industrial stormwater. The Roseau WWTP is operated under a National Pollutant Discharge Elimination System (NPDES) and State Disposal System (SDS) permit that requires *E. coli* concentrations in discharges to be less than 126 org/100 mL. The permitted discharge and TSS and *E. coli* loads are shown in Table 18. Actual loads are generally lower than the permitted loads. The facility is a stabilization pond system that discharges treated effluent in the spring (March through June) and fall (September through December).

Table 18. Roseau WWTP permitted discharge and pollutant loads to Hay Creek (TMDL report, 2020)

System type	Discharge (million gallons/day)	Bacteria load as *E. coli* (bill. org./day)	TSS load (ton/day)
Pond	5.05	24.1	0.95

The annual wastewater discharge and pollutant load for 2022 from the Roseau WWTP were obtained and calculated from the discharge monitoring reports submitted to MPCA by the facility. The annual values are shown in Table 19. The 2022 effluent pollutant loads show how small a contribution the point source is to the Hay Creek loads.

Table 19. Annual discharge and pollutant load for the Roseau WWTP in 2022

	Discharge (million gallons/yr)	TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)	Bacteria load as *E. coli* (mill. org./yr)*
2022	10.5	0.3	219	475	14.0

* *E. coli* calculated from Fecal Coliform reported by the WWTP assuming 126 organisms/100 mL *E. coli* = 200 organisms/100 mL Fecal Coliform

Permitted construction and industrial stormwater sources of pollutants were also identified as very small contributors to the TSS and bacteria loads in the watershed given that they comprise a very small fraction of the watershed.

Habitat

The stressor identification completed for biological impairments on Hay Creek evaluated available data and evidence to determine the likely stressors affecting the fish and macroinvertebrate communities in the stream. The evidence suggests that inadequate habitat and elevated sediment levels are the most likely stressors with flow regime instability being a likely lesser stressor for the fish community. The same stressors appear to be affecting the macroinvertebrate community with a possible added stressor of low dissolved oxygen. The inadequate habitat and elevated sediment level stressors are directly associate to the factors influencing the TSS loads and transport in the stream for the purposes of this NKE plan.

Element b. Estimated reductions

An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded stream banks).

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The implementation activities described in Table 12 will exceed the TSS load reduction needed to achieve the TSS TMDL for Hay Creek. The activities will provide TP load reductions that are greater than and TN load reductions slightly less than the proportional load reduction goals from Hay Creek toward meeting the nutrient reduction goals for the Red River of the North and Lake Winnipeg. The loads and reductions were calculated using the EPA's PLET model. Table 12 lists the practices and individual estimated reductions by practice. The reductions in this section are calculated using the combined efficiencies calculator to calculate the impact of this plan as a system (Table 20).

Table 20. Load reduction targets and estimated combined efficiencies load reductions for implementation activities (PLET, 2023).

	TSS (tons/yr)	P Load (lbs/year)	N Load (lbs /year)
Load reduction target	350	2,984	27,374
Estimated load reductions	609	4,383	26,318

The NKE plan will also achieve the 21% load reduction goal (3,500 Billion most probable number [MPN]/year) for *E. coli* to meet the *E. coli* standard for Hay Creek. The primary reductions will be achieved through the implementation of pasture management and the replacement/upgrades of failing SSTS. It is expected that the *E. coli* water quality standard will be met when this plan is fully implemented.

Element c. Best management practices

A description of the BMPs (NPS management measures) that are expected to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas (by pollutant or sector) in which those measures will be needed to implement this plan.

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The BMPs and associated implementation activities are described in Table 12. Core activities will include the stream channel restoration, streambank stabilization, upland activities to reduce runoff, pasture management near waterways, and SSTS improvements.

Critical areas for each pollutant source were identified by Houston Engineering, Inc. in a targeted implementation profile assessment for the Hay Creek Subwatershed (Houston, n.d.). Critical areas associated with channel alteration and streambed and bank erosion were identified using a rapid geospatial assessment technique and are shown in Figure 7 and Figure 8.

Figure 7. Locations of high risk for erosion due to channel alteration and potential areas for two-stage ditch implementation (Houston, n.d.).

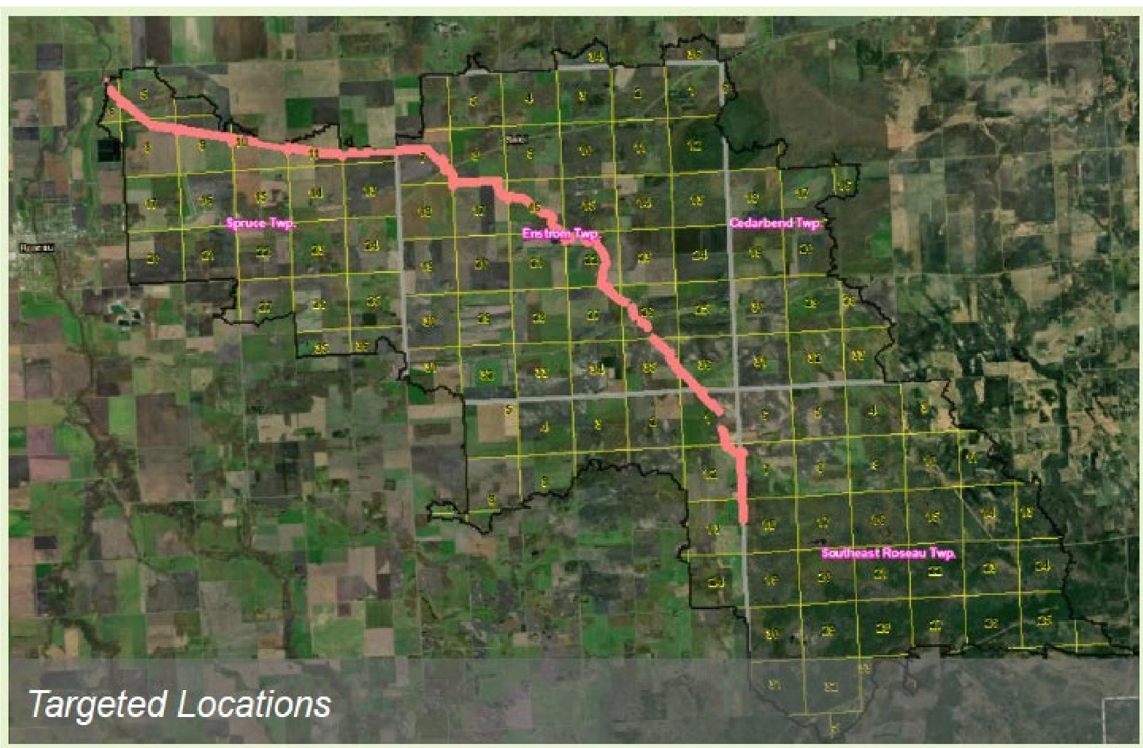
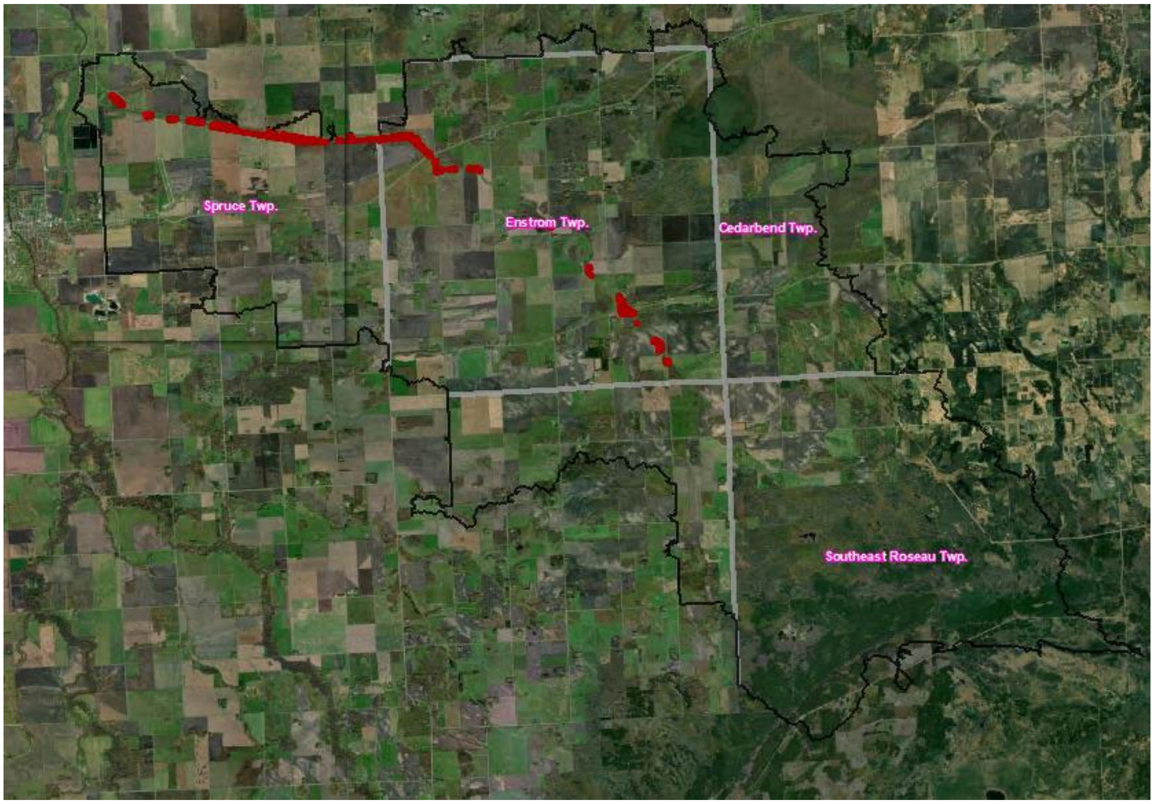
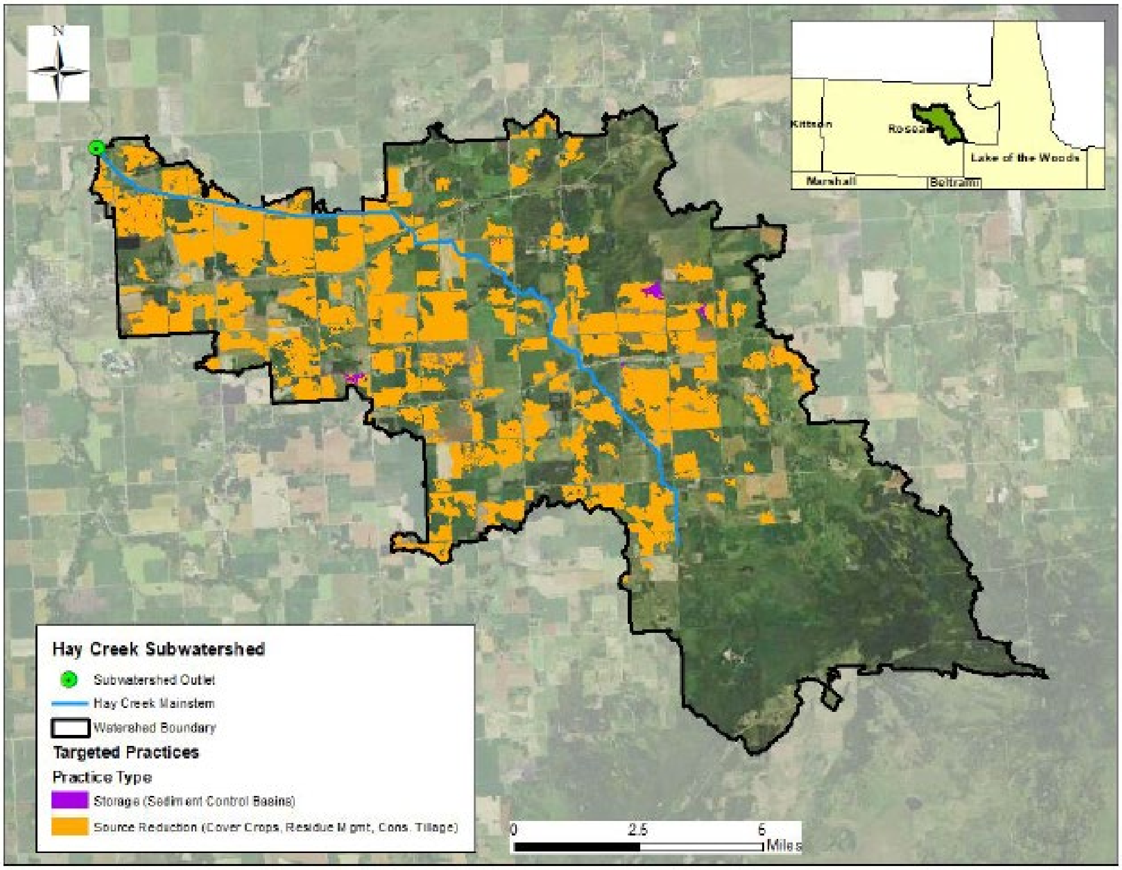


Figure 8. Targeted locations (critical areas) for streambank erosion controls (Houston, n.d.).



Critical cropland areas were identified using the Prioritize, Target, and Measure Application (PTMApp) by evaluating the areas with the greatest potential for sediment reductions with the adoption of storage and source reduction BMPs in Houston (n.d.) (Figure 9).

Figure 9. Critical cropland areas with the largest estimated overland erosion and sediment delivery to Hay Creek shown as areas targeted for storage and source reduction practices in PTMApp (Houston Engineering, Inc., n.d.).

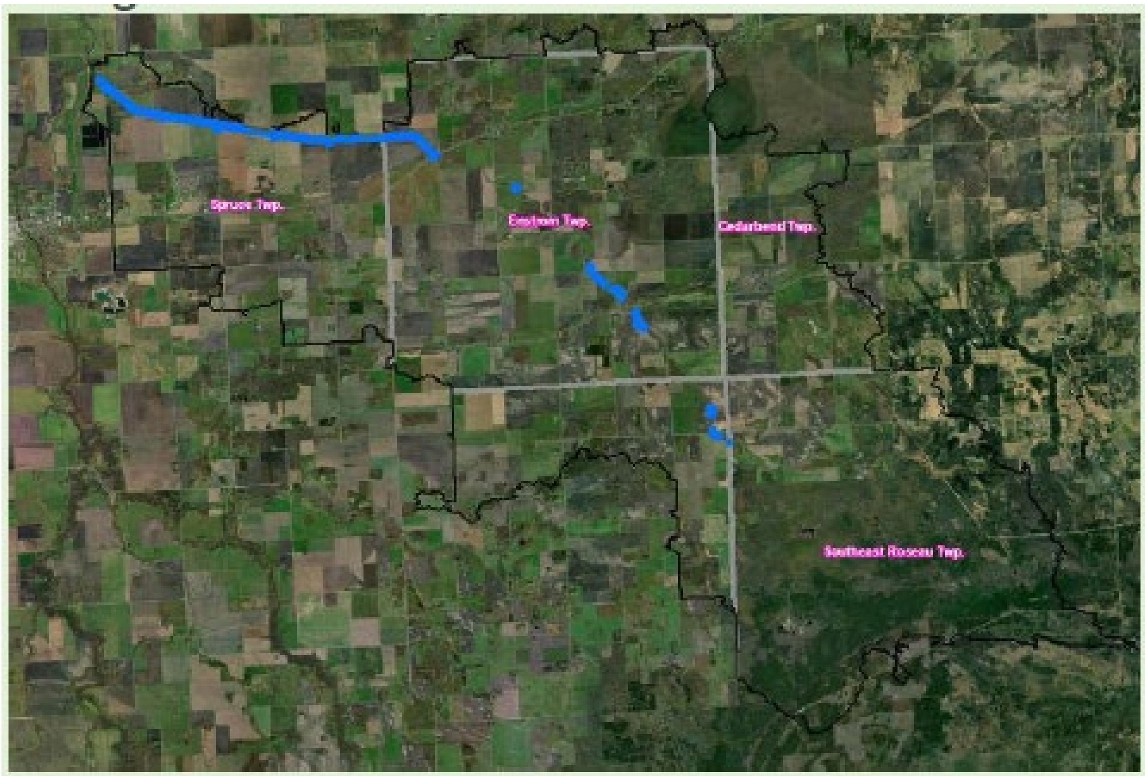


Stream reaches with elevated risk of upland runoff causing riparian area erosion are identified as critical areas for the implementation riparian and upland practices to reduce overland erosion are shown in Figure 10.

Figure 10. Locations of high risk for overland runoff in riparian areas and potential for riparian area structural practices (Houston, n.d.)

Stream reaches with elevated risk of upland runoff in association with the critical cropland areas for upland management and structural practices are shown in Figure 11.

Figure 11. Stream reaches with high risk of sediment loading from upland runoff and potential for soil health management and water storage/infiltration practices (Houston, n.d.)



Element d. Expected costs and technical assistance

> *An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement the entire plan (include administrative, Information and Education, and monitoring costs). Expected sources of funding, States to be used Section 319, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds to assist in implementing this plan.*
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The estimated costs of the activities in this plan are shown in Table 12. The costs to implement this NKE plan are estimated at $19,944,500 when fully implemented.

Funding for this plan will be through Section 319 funding, BWSR One Watershed One Plan (1W1P) funding, implementation grants, NRCS/EQIP funding, Conservation Stewardship Program, and other opportunities.

Implementation of the activities in this plan will occur with a wide range of people and organizations beginning with watershed landowners and residents and extending through local government units, state agencies, and federal agencies (Table 21).

Table 21. Partners' Potential Roles and Responsibilities

	Partner	**General Roles**	**Potential Responsibilities**
Citizen Groups	Landowners and Residents	Provide input, information & feedback Share information Provide leadership Collaborate on projects development	Provide local perspectives Share information Monitor or allow monitoring of projects Implement resource improvement projects
	Roseau River International Watershed (facilitated by the Red River Basin Commission)	Provide a forum for broad implementation and management discussions Help coordinate implementation efforts	Maintain record of discussions Organize meetings Discuss implementation priorities
Non-Profit Organizations	Conservation Corps of Minnesota	Provide conservation project implementation services	Support implementation projects

	Partner	General Roles	Potential Responsibilities
Local Government	Roseau River Watershed Joint Powers Board	Develop Comprehensive Water Management Plan for the Roseau River Watershed	Attend meetings
		Maintain record of meetings and discussions	Share information
		Organize public meetings	Support implementation projects
		Engage stakeholders; solicit input on priority resource concerns	Organize watershed meetings/events
		Discuss implementation priorities	Provide project funding as agreed to in the governing documents
	Roseau County Soil & Water Conservation District (Assisted by Technical Service Area VIII)	Serve on many state and local conservation-based committees	Maintain list of potential and finished projects
		Design and implement technical conservation projects, forest management plans, invasive species control, shoreline stabilization, tree planting, water sampling, soil sampling, etc.	Provide technical assistance to landowners/projects
		Manage grant projects	Provide cost-share opportunities
		Pursue and develop funding proposals	Write funding requests
		Conduct landowner outreach and community engagement	Contractor facilitation and project management
		Initiate and maintain landowner contacts and relationships	Conservation project development
		County weed inspection	Design and create outreach materials
			GIS mapping and data collection
	Roseau County (Highway and Environmental Services)	Serve on the 1W1P Policy and Advisory Committees	Maintain and construct transportation infrastructure
		Oversee county roads	Consult implementation plan in zoning decisions

	Partner	General Roles	Potential Responsibilities
		Enforce planning & zoning	Keep partners aware of opportunities
		Enforce wetland rules, construction setbacks and lot width, and SSTS.	Provide project management
		Jurisdictional drainage authority	Manage and maintain drainage systems under their jurisdiction in accordance with MN Statute 103E.
State Government	Minnesota Board of Water and Soil Resources	Serve on the 1W1P Advisory Committee	Keep partners aware of opportunities
		Administer MN Clean Water Fund Projects	Provide project management
		Provide technical assistance	
		Lead HUC-8 based Landscape Stewardship Planning efforts	
		Serves on County Technical Evaluation Panels for wetland permits	
	Minnesota Department of Natural Resources (Divisions of Fisheries, Forestry, Wildlife, and Ecological and Water Resources)	Serve on the 1W1P Advisory Committee	Review/approve projects under Minnesota DNR programs
		Administer DNR programs, issue Public Waters Permits, conduct wetland rule enforcement	Provide cost-share assistance for conservation projects
		Provide technical assistance for hydrology, fisheries, geomorphology, and forestry	Provide technical comments on project design
		Assist in development and evaluation of project proposals	Assist landowners with design and implementation of conservation projects
	Minnesota Pollution Control Agency	Serve on the 1W1P Advisory Committee	Oversee implementation plan
		Administer MPCA and Section 319 funding programs	Keep partners aware of opportunities
		Provide technical assistance for hydrology, geomorphology and water quality	Provide data administration
		Assist in development and evaluation of project proposals	

	Partner	General Roles	Potential Responsibilities
	Minnesota Department of Transportation	Oversee state highway	Maintain Highway 11 corridor
Federal Government	Environmental Protection Agency (Region 5)	Provide Section 319 grants and guidance	
	Natural Resources Conservation Service	Serve on the 1W1P Advisory Committee Provide technical review Administer U.S. Department of Agriculture (USDA) funding programs	Make Committee aware of funding opportunities Landowner engagement and education Provide cost-share assistance for conservation projects Assist landowners with design and implementation of conservation projects
	US Army Corps of Engineers	Provide watershed modeling	Update models with new data Explain & educate local stakeholders
	Federal Emergency Management Agency	Provide floodplain mapping Provide hazard mitigation funding and assistance	Updated floodplain maps Hazard mitigation planning and grants

Element e. Education and outreach

> *An information/education component that will be implemented to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, implementing and maintaining the NPS management measures that will be implemented.*
>
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Education and outreach have been initiated with landowners by postcard mailers and meetings. The RRWD held a meeting with landowners in the Hay Creek Subwatershed in 2021 to introduce them to the "Hay Creek Subwatershed Targeted Implementation Profile." Since then, the RRWD has engaged landowners across the district in the development of the Roseau River Comprehensive Water Management Plan. Landowner engagement will continue using social media, mailings, and events promoting prioritized practices. Out of those efforts, staff will meet individually with landowners to provide assistance in project development and contractual requirements.

The RRWD will promote the programs and practices at their booth at the Roseau County Fair. The fair provides an excellent opportunity to engage with the public in an informal setting.

We will also provide information at other events sponsored by organizations such as grower associations, MN Farm Bureau, Red River Watershed Management Board, township annual meetings, the Roseau County Fair, the Roseau River International Watershed, and the Red River Basin Commission.

Outreach activities are listed in Table 12.

Element f. Reasonably expeditious schedule

> *A schedule for implementing the activities and NPS management measures identified in this plan that is reasonably expeditious.*
>
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Timelines for the proposed implementation are shown in Table 12.

Implementation activities described in Table 12 will yield estimated reductions greater than estimated reductions desired to reach water quality standards and nutrient reduction goals within 10 years. This schedule will be updated using adaptive management as funding, partnerships, effectiveness of implementation, and new information becomes available.

Element g. Milestones

> *A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.*
>
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The milestones column in Table 22 provide interim, measurable milestones for determining successful implementation of practices in Table 12. The milestones in this plan serve the purpose of measuring continuous progress toward the restoration of the Hay Creek Watershed.

Table 22 Milestone table Hay Creek Watershed (PLET, 2023).

		Milestones			
Hay Creek Watershed	Indicator	Short Term (Yrs 0-4)	Mid Term (Yrs 4-8)	Long Term (Yrs 8-10)	Total
	Total Suspended Solids (t/yr)	93	442	47	582
	Phosphorus (lbs/yr)	1524	1742	763	4029
	Nitrogen (lbs/yr)	8558	9123	4283	21964

Element h. Assessment criteria

> *A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.*
>
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The milestones columns in Table 12 provide interim, measurable milestones for determining successful implementation of practices and progress toward executing this plan. The assessment criteria focuses on measuring the forward progress of the implementation of practices and BMPs.

It is difficult to anticipate the response of the stream to BMPs within a 10-year period. While water chemistry and other water quality monitoring is considered the gold standard, to encourage the continued adoption and support of these efforts, alternative and additional measures must be employed. The connection of BMPs on the landscape to the response in chemistry changes can be difficult to communicate to the public. The milestones described in Table 12 offer alternative means of measuring, and importantly, communicating the successes to support the forward momentum of implementation adoption. There are estimated reductions associated with these practices which will allow watershed professionals to have an approximate idea of the loading changes to be expected. These milestones are to ensure that the expected reductions are taking place. Traditional water quality monitoring (chemical, sediment, and biological) and the visual inspections of the watershed will demonstrate success. Visual inventories of streambank erosion, gullies, and field runoff can be the leading indicator of the success of implementation.

Element i. Monitoring

> *The monitoring & evaluation component to track progress and evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.*
>
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Water quality monitoring in the Hay Creek Subwatershed will be conducted at two established MPCA stream sampling stations: 1) S004-135 located mid-length of the reach, and 2) S002-105 located near the outlet into the Roseau River. Each station will be sampled at least once each month from May to September for the full 10-year timeline of the project. The sampling regime will include both field and laboratory measurements. Field measurements include DO, temperature, pH, conductivity, and Secchi tube readings. Upstream and downstream photos will be taken. Laboratory analysis will consist of TSS, TP, nitrite + nitrate (NO_2+NO_3-N), *E. coli*, and pheophytin corrected chlorophyll-a.

Historically, the MPCA has four established stream sampling stations on Hay Creek (Table 23). Both of the stations selected (S004-135 and S002-105) for this project have several years of prior TSS and *E. coli* data from which to establish baselines for monitoring the project's effectiveness.

Table 23. MPCA established stream stations on Hay Creek

Station ID	Location	Years Sampled	Total Sampling Visits
S014-895	Beltrami Island State Forest Boundary	2017	1
S004-135	County Road 12	2003-2012, 2017	54
S002-106	460th Ave. (County Road 9)	2002-2013, 2018	68
S002-105	County Road 28	2001-2013, 2015, 2016, 2018	115

In addition to the 10-year monitoring plan proposed above, the Roseau River Watershed's second cycle of intensive watershed monitoring (IWM) under Minnesota's HUC-8 Watershed Approach is scheduled to begin in 2026. Under this effort, the MPCA conducts 2 years of intensive watershed monitoring in all 80 watersheds in Minnesota on a 10-year cycle (i.e., every major watershed is sampled for 2 years, once every 10 years. The selection of IWM sites will be a collaborative effort between the MPCA and local partners. During the site selection process, the MPCA will use information gathered from the first cycle to establish long-term 'Core' (water chemistry) and 'Anchor' (biological) stations and provide local partners an opportunity to request monitoring to support projects or investigate problems. The final selection of the Core, Anchor, and locally requested sites will not occur until approximately nine months before the start of IMW.

Adaptive management

Adaptive management is an approach to water quality protection efforts where BMP implementation efforts are combined with an on-going evaluation of water quality issues. Effects of implemented BMPs are reflected by adjustments to the resource goals, implementation plan and/or implementation efforts when needed. Adjustments are made to incorporate the knowledge gained through the combined efforts. Adaptive management—sometimes referred to as adaptive implementation—is critical when various uncertainties are significant in a watershed (Shabman et al., 2007). This approach is essentially a "learning while doing" approach. It means that uncertainty is not forgotten once implementation begins. Rather, a focus is placed on reducing the uncertainty present through implementation, monitoring and evaluation, research, and experimentation. The knowledge gained through these efforts is then focused on reducing the uncertainties the implementation approaches and/or water uses and criteria. The approach goes beyond just asking “when” in implementation to include “where, what, how and why” (Shabman et al., 2007).

Through an adaptive management approach, this initial implementation plan has been developed to begin implementation activities, continue survey and inventory efforts, and evaluate the progress toward meeting the aquatic recreation goals for Hay Creek Subwatershed. As this work is completed, the implementation goals, priorities, and BMPs will be examined and revised, as needed.

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