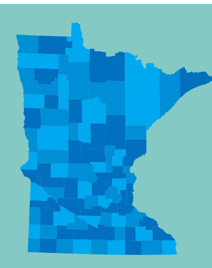
Grant

June 2023

Amity Creek Watershed Nine Key Element Plan

Section 319 Small Watershed Program plan that meet's the EPA's Nine Key Elements of watershed-based planning.

MINNESOTA POLLUTION CONTROL AGENCY



Authors

Anne Thompson, S. St. Louis SWCD
Cindy Osborn, MPCA
Greg Johnson, MPCA
Karen Evens, MPCA
Linsey Krumrie, MPCA
Karl Kohler, DNR

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

This report is available in alternative formats upon request, and online at www.pca.state.mn.us.

Document number: wq-cwp2-27

Contents

Contents i
List of figures ii
List of tables iii
Executive summary 1
Water quality conditions 3
Land use in Amity Creek Watershed 4
Total maximum daily load 5
Implementation strategies 11
Element a. Sources identified 16
Nonpoint source 16
Temperature 18
Point Sources 18
Element b. Estimated reductions 20
Element c. Best management practices 21
Nonpoint source BMPs 21
Point source BMPs 22
Element d. Expected costs and technical assistance 24
Element e. Education and outreach 25
Element f. Reasonably expeditious schedule 26
Element g. Milestones 27
Element h. Assessment criteria 28
Element i. Monitoring 29
Adaptive management 31
References 33

List of figures

Figure 1. Map Amity Creek Watershed with locator inset (WHAF, 2022) 3

Figure 2. Land use map of Amity Creek Watershed (WHAF, 2023) 5

Figure 3. TSS load duration curve, Amity Creek (04010102-511) 6

Figure 4. TSS load duration curve, Amity Creek, East Branch (04010102-540) 8

Figure 5. Amity Creek Watershed Reach Definitions and Level of Concern Determined from the Rapid Assessment (from Jennings and Geenen, 2017) 17

List of tables

Table 1. Impairments in Amity Creek Watershed 3

Table 2. Land use by acre in Amity Creek Watershed (PLET, 2022) 4

Table 3. TMDL summary, Amity Creek (04010102-511), HSPF developed 6

Table 4. TSS TMDL summary, Amity Creek, East Branch (04010102-540), HSPF developed 8

Table 5. Reductions in loading Amity Creek TMDL using PLET loading (MPCA, 2020) 10

Table 6. Planned implementation, activities, schedule, milestones, assessment criteria, costs, and estimated reductions (PLET) by practice, for the Amity Creek Watershed 12

Table 7. Summary of nitrogen, phosphorus, and sediment loading by land use (PLET, 2022) 16

Table 8. Relative Streambank Erosion Rates for Amity Creek Watershed Reaches (from Jennings and Geenen, 2017) 17

Table 9. The percentage of road crossings acting as barriers in Amity Creek Watershed (adapted from SSLSWCD, 2022, Appendix B) 18

Table 10. Historic and predicted average maximum July temperatures (from MPCA WRAPS) 18

Table 11. List of MS4 permits in Amity Creek Watershed 19

Table 12. Industrial and construction stormwater permits in Amity Creek 19

Table 13. Estimated reductions for stormwater practices in the Amity Creek Watershed, calculated using PLET 20

Table 14. Estimated reductions associated with streambank restoration in the Amity Creek Watershed, calculated using PLET 20

Table 15. Overview of conceptual designs for the four highest-priority stream reaches in the Amity Creek watershed (Jennings and Geenen 2017) 21

Table 16. Partnerships in the Amity Creek Watershed 24

Table 17. Monitoring activities for the Amity Creek watershed(these tasks also included in Table 6) 29

Executive summary

Amity Creek is an important stream in the Duluth, Minnesota, area and has been the subject of extensive studies about its ecological health and water quality. This document synthesizes the various reports in identifying the water quality and other stressors affecting the aquatic life and aquatic recreation uses of the stream and its tributaries. The document then identifies the restoration activities and best management practices needed to restore and protect the water quality standards present for the streams and address the geomorphic and habitat stressors present in the watershed to meet the stream stability, sediment load, and biological condition goals for the streams.

The approach to restore and protect Amity Creek, its tributaries, and watershed addresses the five components of watershed health: hydrology, geomorphology, connectivity, biology, and water quality. Objectives for the five components include:

Hydrology

- Improve and restore watershed runoff, streamflow, and groundwater interactions to create a more resilient system. This is especially important to address the increasing magnitude of storm events and length of drought periods.

Geomorphology

- Protect stream reaches that are providing healthy ecological functions that support all life stages of brook trout and associated coldwater aquatic organisms.
- Restore unstable stream reaches where degraded ecological functions exist.

Connectivity

- Lateral
    - Restore stream floodplain connectivity (bank height ratio = 1) where the channel is incised.
    - Reestablish and protect healthy, diverse riparian areas.
- Longitudinal
    - Restore stream and floodplain longitudinal connectivity and continuity for aquatic organism passage and sediment transport continuity.
- Vertical
    - Protect known coldwater sources and inputs.
    - Maximize groundwater and floodplain storage, while enhancing infiltration.
- Temporal
    - Protect natural areas that will enable healthy ecosystems over time and that are essential to native species.
    - Ensure actions in the watershed are developed with long-term, natural, and holistic goals.
    - Improve resilience by considering each of the 5 components of a healthy watershed when taking action in the watershed.

Water quality

- Reduce water temperatures in currently stressed reaches.
- Protect coldwater reaches and sources.

- Reduce sediment input to the stream to sufficiently meet water quality standards and to remove the TSS impairment.

Biology

- Protect and improve current brook trout populations and coldwater aquatic organism assemblages.
- Improve the coldwater fish and invertebrate assemblages of the stream as measured by IBI scores.

Funding of projects proposed in this plan may be restricted to funding source. Only projects and practices that are allowable by EPA's 2014 program guidelines and Minnesota's Nonpoint Source Program Management Plan (except where noted in the MPCA's NPSMPP) will be funded by the Federal Clean Water Act Section 319 funds. Match funds and activities must also be eligible under the guidelines and plan.

Water quality conditions

Amity Creek Watershed is hydrologic unit code (HUC)12 040101020403 in the Lester River Watershed. It is in the Northeast edge of Duluth, Minnesota (Figure 1). The trout stream is recognized as one of the highest quality trout fisheries and is a popular recreational area in the City of Duluth. Both the main stem and the East Branch of Amity Creek are listed as impaired by turbidity (Table 1). Recent watershed efforts by local agencies have focused on outreach, tree planting, hydrology, trail impacts, and bluff stabilization. It is well understood that negative effects of bank erosion are impacting the watershed but there has been little work to date to map and diagnose the magnitude of such impacts.

Figure 1. Map Amity Creek Watershed with locator inset (WHAF, 2022)

Impairments in the Amity Creek Watershed are summarized in Table 1. The impairments were addressed in the *Duluth Urban Area Streams TMDL Report* (2020).

Table 1. Impairments in Amity Creek Watershed

Water body name	Water body description	Year listed	AUID	Use Class	Affected designated use	Pollutant or stressor	Year TMDL plan approved

Amity Creek	Unnamed cr to Lester R	2004	04010102-511	1B, 2Ag, 3B	Aquatic Life	Turbidity	2020
Amity Creek, East Branch	Unnamed cr to Amity Cr	2014	04010102-540	1B, 2Ag, 3B	Aquatic Life	Turbidity	2020

Land use in Amity Creek Watershed

Land use in Amity Creek is mostly forestry and urban land uses (Table 2).

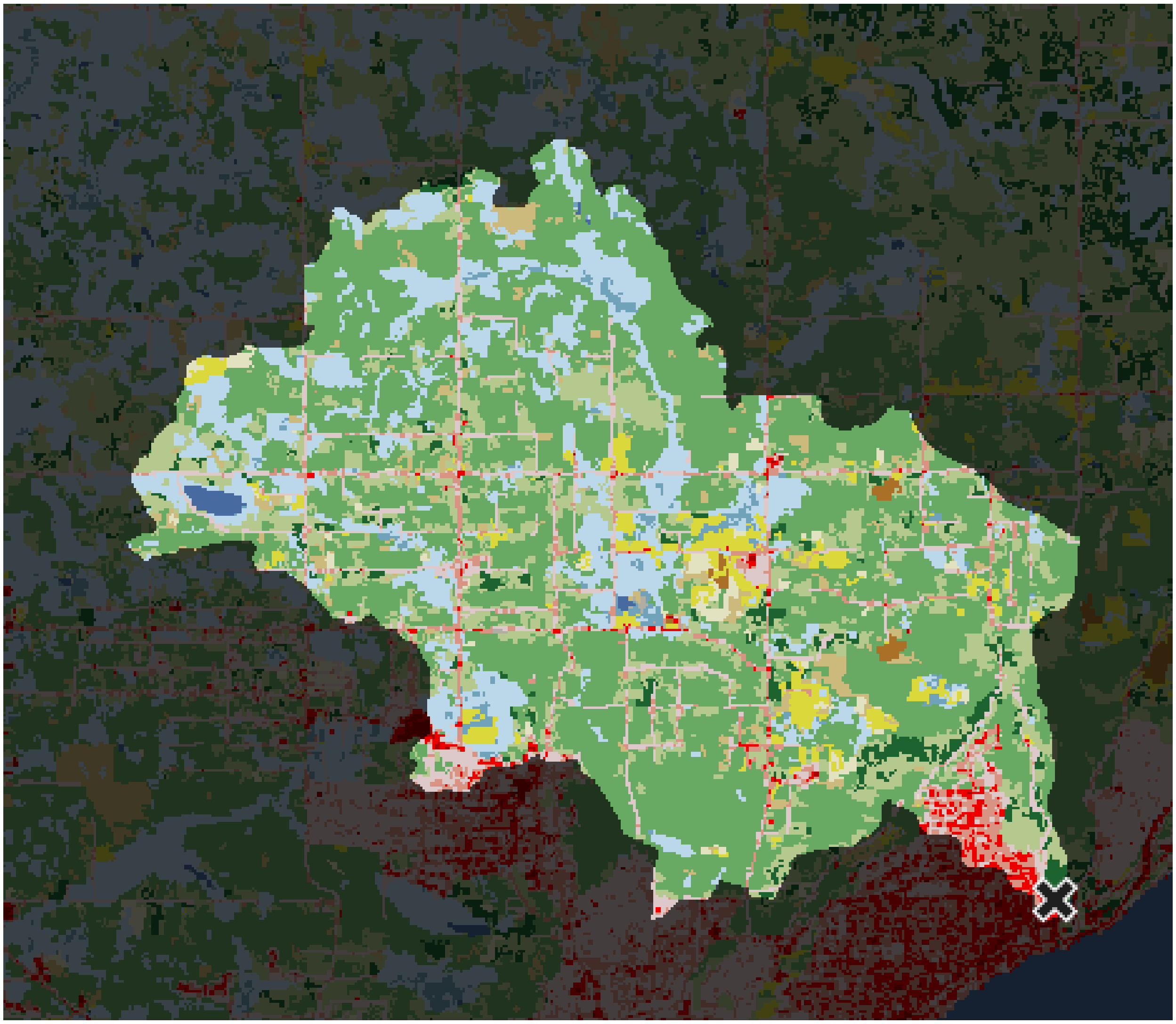
The Amity Creek watershed is mostly rural with a land use history of timber logging and some agriculture. Changes in hydrology associated with land clearing have resulted in increased peak stream flows and sediment transport competence and capacity. Streambank erosion, channel incision, and hillslope erosion are evident in many locations in the watershed. Many stream reaches are actively adjusting toward new equilibrium conditions associated with altered watershed boundary conditions and forcing functions. (Jennings & Geenen, 2017).

Table 2. Land use by acre in Amity Creek Watershed (PLET, 2022)

Urban	Cropland	Pastureland	Forest	Feedlots	Total acres
1226.06	73.39	730.57	8614.23	0.04	10644.29

Land use is illustrated in Figure 2.

Figure 2. Land use map of Amity Creek Watershed (WHAF, 2023)



Total maximum daily load

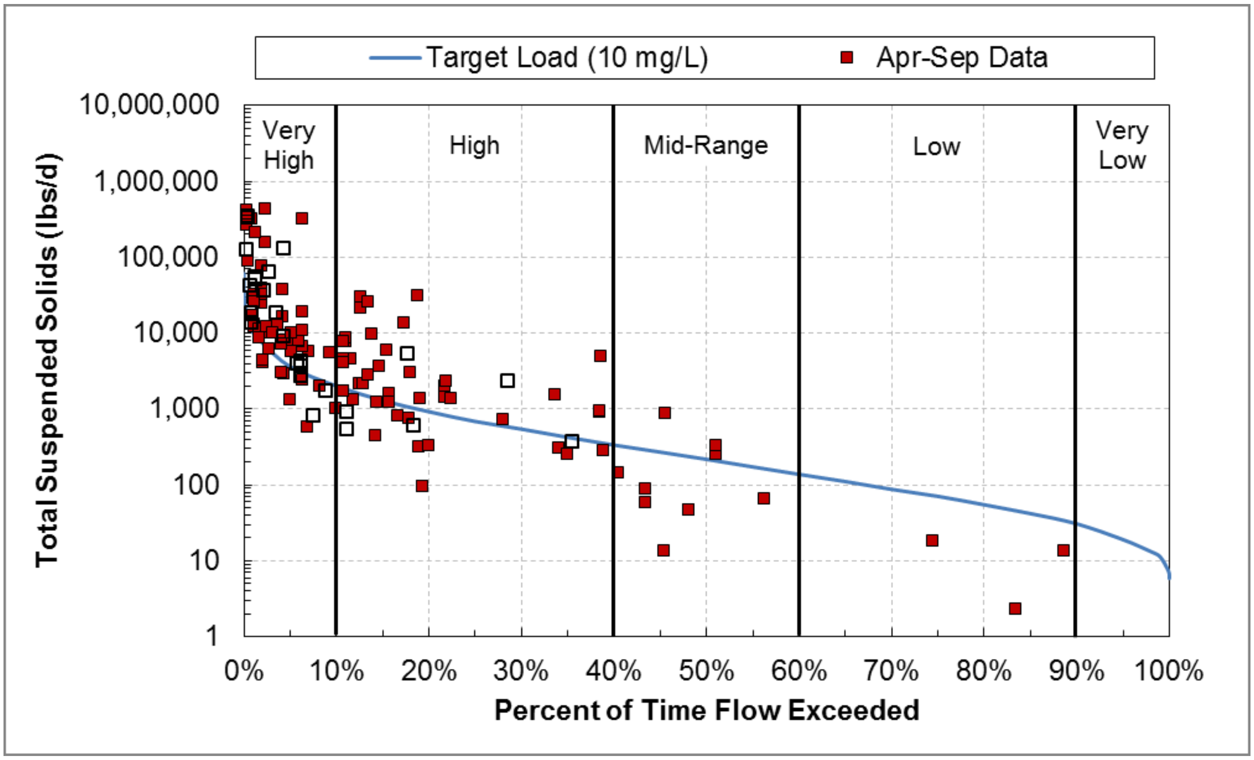
The water quality data for Amity Creek and East Branch Amity Creek indicate elevated TSS concentrations such that the two streams were listed as impaired for aquatic life based on the TSS criterion in Minnesota Water Quality Standards. Average annual TSS concentrations ranged from 12 to 124 mg/L between 2007 and 2017 at two sites on Amity Creek. The TSS standard was exceeded in 30 to 89 percent of the samples collected each year. Average annual TSS concentrations for the East Branch Amity Creek ranged from 7 to 33 mg/L between 2008 and 2013 at two sites on the creek. The TSS standard was exceeded in 14 to 50 percent of the samples collected each year. Exceedances generally occurred under high to very high flow levels.

The Hydrological Simulation Program – FORTRAN (HSPF) was used to calculate the loads for the development of the TMDLs for Amity Creek. The Pollution Load Estimation Tool (PLET) developed by the EPA will be used for the purposes of this plan. These numbers are proportionate; however, the PLET numbers are higher loads than the HSPF model.

Amity Creek -511

The load duration curve for the Amity Creek (-511) illustrates most exceedances occur at the very high and high flow regimes (Figure 3).

Figure 3. TSS load duration curve, Amity Creek (04010102-511)



The Amity Creek -511 TMDL summary (Table 3) describes the maximum daily loading of sediment by type and by flow regime.

Table 3. TMDL summary, Amity Creek (04010102-511), HSPF developed

TMDL Parameter		Flow Regime				
		Very High (37–1,128 cfs)	High (6–37 cfs)	Mid-Range (3–6 cfs)	Low (0.6–3 cfs)	Very Low (0.1–0.6 cfs)
		TSS Load (lbs/day)				
Wasteload Allocation	Duluth City MS4 (MS400086)	135	26	8.2	2.7	0.71
	Rice Lake City MS4 (MS400151)	124	24	7.5	2.4	0.65
	St. Louis County MS4 (MS400158)	5.6	1.1	0.34	0.11	0.030
	Industrial Stormwater (MNR050000) [a]	0.32	0.062	0.020	0.0064	0.0017
	Construction Stormwater (MNR100001) [a]	0.32	0.062	0.020	0.0064	0.0017
	Near-channel	1,030	197	62	20	5.4

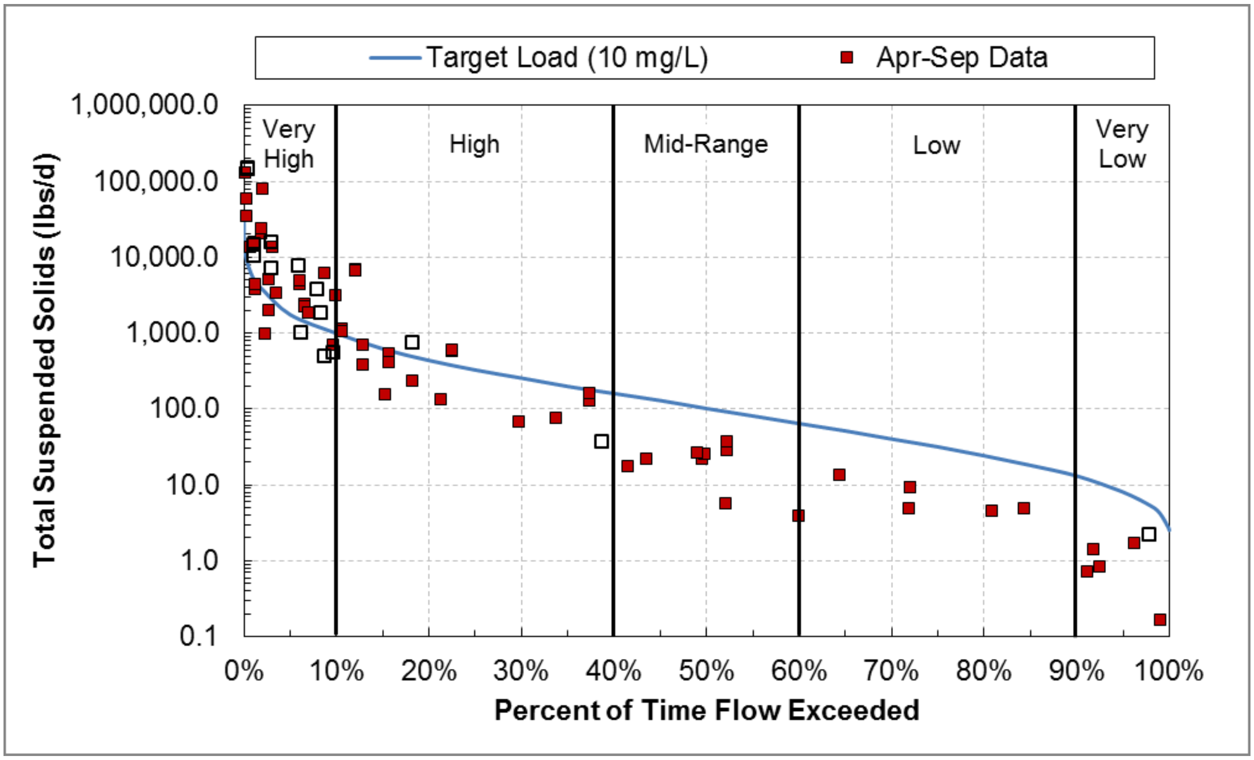
Load Allocation	Non-MS4 watershed runoff	1,955	373	118	38	10
MOS		361	69	22	7.1	1.9
Loading Capacity		**3,611**	**689**	**218**	**71**	**19**

a. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.
-: No data

Amity Creek, East Branch -540

Amity Creek, East Branch, load duration curve shows that most of the exceedances of the water quality standard for TSS occur in the very high flow regime (Figure 4).

Figure 4. TSS load duration curve, Amity Creek, East Branch (04010102-540)



The Amity Creek, East Branch, -540 TMDL summary (Table 4Table 3) describes the maximum daily loading of sediment by type and by flow regime.

Table 4. TSS TMDL summary, Amity Creek, East Branch (04010102-540), HSPF developed

TMDL Parameter		Flow Regime				
		Very High (18–540 cfs)	High (3–18 cfs)	Mid-Range (1–3 cfs)	Low (0.2–1 cfs)	Very Low (0.05–0.2 cfs)
		TSS Load (lbs/day)				
Wasteload Allocation	Duluth City MS4 (MS400086)	24	4.6	1.4	0.44	0.11
	Rice Lake City MS4 (MS400151)	90	17	5.2	1.6	0.42
	St. Louis County MS4 (MS400158)	1.9	0.35	0.11	0.034	0.0086
	Industrial Stormwater (MNR050000) [a]	0.16	0.030	0.0092	0.0029	0.00073
	Construction Stormwater (MNR100001) [a]	0.16	0.030	0.0092	0.0029	0.00073
	Near-channel	332	62	19	6.0	1.5

Load Allocation	Non-MS4 watershed runoff	1,133	211	66	21	5.2
MOS		176	33	10	3.2	0.81
Loading Capacity		**1,758**	**328**	**102**	**32**	**8.1**

a. It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.

The TMDL reductions for both Amity Creek and Amity Creek, East Branch, are summarized in Table 5. There is a needed 60% reduction for stormwater runoff and streambank reductions. The estimated load reductions were calculated using the PLET model. All reduction estimates are rounded to the nearest whole number.

Table 5. Reductions in loading Amity Creek TMDL using PLET loading (MPCA, 2020)

Source	Annual reduction %	Needed reduction t/yr
Near-channel & NPS runoff	60%	8075
Stormwater runoff	60%	85

Implementation strategies

The implementation strategies, schedule, milestones, assessments, costs, and estimated reductions by practice are described in the following table and estimated to yield the reductions needed to reach water quality standards within 10 years. The estimated reductions were calculated using the PLET model and run by practice type. For the final reductions of activities, as completely implemented, were calculated using the PLET Combined Efficiencies Calculator tool. Those are described in Element b. and summarized in Table 5, Table 13, and Table 14.

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 a final verification at time of any financial award and must meet all current and necessary rules and guidelines for eligibility. Any stormwater activities that take place in an 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 BMPs implemented is eligible for Section 319 funding. General diagnostic and exploratory monitoring activities are not eligible for funding or match purposes.

Table 6. Planned implementation, activities, schedule, milestones, assessment criteria, costs, and estimated reductions (PLET) by practice, for the Amity Creek Watershed

Type	Eligibility	Activity	Milestones					Assessment	Cost	Reductions		
			2-year (2024)	4-year (2026)	6-year (2028)	8-year (2030)	10 year (2032)			N (lbs/yr)	P (lbs/yr)	TSS (t/yr)
Streambank	Y	Stream Restoration AM-7 (1,892 ln ft) design and implementation		Design	Implement 1,892 linear feet of restoration			# feet restored	$250,000			18381
	Y	Stream Restoration AM-9 (4,417 ln feet) design and implementation			Design	Implement 4,417 linear feet of restoration		# feet restored	$525,000			2580
	Y	Stream Restoration EB-1 (9,409 ln ft) design and implementation	Design and Implement 9,409 linear feet of restoration					# feet restored	$1,270,000			2060
	Y	Stream Restoration EB-2 (8,347 ln ft) design and implementation	Design	Implement 8,347 linear feet of restoration				# feet restored	$265,000			1828
	Y	Stream Restoration AM -2 (2,233 ln ft) design and implementation				Design	Implement 2, 233 ln ft of restoration	# feet restored	$670,000			489
	Y	Water storage from connecting floodplains (calculated based on linear feet of restoration x floodplain width of 100 feet x 1 foot depth) (As part of the stream restoration plans - cost included in restoration)	11.6 acres	2.4 acres	2.3 acres	4.8 acres		# acres	--	3	1	0.03
Outreach	Y	10 Partner Collaboration Meetings	2 meetings	2 meetings	2 meetings	2 meetings	2 meetings	# meetings # new attendees	$4,800			
		Meet with MS4 permit holders	2 meetings	2 meetings	2 meetings	2 meetings	2 meetings	# meetings # new attendees	$4,800			
	Y	Create mailings for citizens promoting forestry and riparian management, stormwater BMPs, and explaining streambank restoration for community members.	1 mailing		1 mailing		1 mailing	# mailing # follow ups from mailing	$1,320			
	Y	Post information signage following implementation	1 sign	1 sign	1 sign	1 sign	1 sign	# signs	$2,200			
	Y	Conduct Outreach for landowners regarding forest and riparian vegetation health	2 events	2 events	2 events	2 events	2 events	# events	$3,600			
	Y	Meet with individual landowners to provide technical assistance for stream mechanics and forest health	4 meetings	4 meetings	4 meetings	4 meetings	4 meetings	# meetings # new attendees	$7,200			
	Y	Support education and outreach to recreation users	4 posters at trailheads	4 posters at trailheads	4 posters at trailheads	4 posters at trailheads	4 posters at trailheads	# posters	$3,420			
Administration	Y	Watershed Plan Coordinator: design, permit and oversee implementation of projects; complete outreach; coordinate with partners	1 FTE	1 FTE	1 FTE	1 FTE	1 FTE	# FTEs # implementation projects	$286,000			
	N	Enroll lands with high water resource value into the Duluth Natural Areas Program		research and map	apply for designation			# application accepted # acres enrolled	$20,000			

Type	Eligibility	Activity	Milestones					Assessment	Cost	Reductions		
			2-year (2024)	4-year (2026)	6-year (2028)	8-year (2030)	10 year (2032)			N (lbs/yr)	P (lbs/yr)	TSS (t/yr)
	N	Construction and Industrial stormwater permit coverage and compliance	Permits issued, inspected, and enforced as needed	Permits issued, inspected, and enforced as needed	Permits issued, inspected, and enforced as needed	Permits issued, inspected, and enforced as needed	Permits issued, inspected, and enforced as needed	# permits # inspections # enforcements	$120,000			
Stormwater	Y	Protect and restore vegetation	2 acres	2 acres	2 acres	2 acres	2 acres	# acres	$7,240			
	Y	Vegetate riparian buffers	3 acres	3 acres	3 acres	3 acres	3 acres	# acres	$11,100	19.56	4.02	0.81
	Y	Address trail runoff and erosion through establishing vegetation and buffers, trail repair/upgrades, and erosion control.	2500 linear feet	2500 linear feet	2500 linear feet	2500 linear feet	2500 linear feet	# ln ft trails treated	$362,500		2.71	1.2
	Y	Address invasive species and declining forest stands	2 acres	2 acres	2 acres	2 acres	2 acres	# acres invasive species removed	$7,240	0.99	0.44	0.01
	Y	Rain gardens in non-residential developed land uses, 180 gardens	36 raingardens	36 raingardens	36 raingardens	36 raingardens	36 raingardens	# rain gardens	$21,000	9.78	1.93	0.28
	Y	45,000 ln ft of filter strips in non-residential developed land uses, approximately 15 acres	9,000 feet of filter strips	9,000 feet of filter strips	9,000 feet of filter strips	9,000 feet of filter strips	9,000 feet of filter strips	# ft filter strips	$60,000	148.32	26.76	4.64
	Y	15,000 ft of filter strips along roads in Amity Creek	3,000 feet of filter strips	3,000 feet of filter strips	3,000 feet of filter strips	3,000 feet of filter strips	3,000 feet of filter strips	# feet	$20,000	98.72	18.93	3.01
	N	20 Rain gardens in transportation areas, curb cut, to treat stormwater from streets	4 raingardens in road/transportation land use	4 raingardens in road/transportation land use	4 raingardens in road/transportation land use	4 raingardens in road/transportation land use	4 raingardens in road/transportation land use	# acres	$30,000	37.08	6.69	1.16
	Y	20 rain gardens in residential areas (approximately 5 acres)	4 raingardens in residential areas	4 raingardens in residential areas	4 raingardens in residential areas	4 raingardens in residential areas	4 raingardens in residential areas	# acres	$30,000	19.56	3.86	0.56
	Y	Detention basins (4) in Residential developments approx. 1.5 acres	Detention basin .5 acres		Detention basin .5 acres	Detention basin .5 acres	Detention basin .5 acres	# basins # acres	$90,000	4.8	1.09	0.19
	N	Weekly street sweeping on all paved roads (approx. 26 weeks of sweeping dependent on snow cover)	52 weeks of street sweeping	52 weeks of street sweeping	52 weeks of street sweeping	52 weeks of street sweeping	52 weeks of street sweeping	# sweep events	$21,250	0	15.15	6.06
	Y	Changing to pervious pavement (sidewalks, parking lots, etc.) 9 acres in non-residential land uses	1.8 acres of pervious pavement (gridded concrete, etc.)	1.8 acres of pervious pavement (gridded concrete, etc.)	1.8 acres of pervious pavement (gridded concrete, etc.)	1.8 acres of pervious pavement (gridded concrete, etc.)	1.8 acres of pervious pavement (gridded concrete, etc.)	# acres	$2,500,000	44.27	6.18	0.92
	Y	Improving the understory of wooded/forestry areas 10 acres	2 acres understory managed, planted, cultivated	2 acres understory managed, planted, cultivated	2 acres understory managed, planted, cultivated	2 acres understory managed, planted, cultivated	2 acres understory managed, planted, cultivated	# acres	$200,000	0.99	0.44	0.01
	Y	Improving/restoring, creating 7 acres of wetlands	1.4 acres of wetlands restored/created	1.4 acres of wetlands restored/created	1.4 acres of wetlands restored/created	1.4 acres of wetlands restored/created	1.4 acres of wetlands restored/created	# acres	$350,000	3	1.36	0.03
	Y	Stream road crossings - 5 upgraded, repaired, right sized	Stream road crossing upgraded/repaired	Stream road crossing upgraded/repaired	Stream road crossing upgraded/repaired	Stream road crossing upgraded/repaired	Stream road crossing upgraded/repaired	# crossings	$1,600,000	9.09	0.23	0.23
	Y	Improving trail runoff by implementing forestry road practices	Manage 2 acres of trail runoff	Manage 2 acres of trail runoff	Manage 2 acres of trail runoff	Manage 2 acres of trail runoff	Manage 2 acres of trail runoff	# acres	$30,000		2.71	1.2
	Y	Planting vegetative buffers to capture stormwater runoff in residential areas (approximately 15000 ft)	3,000 feet of vegetated buffers	3,000 feet of vegetated buffers	3,000 feet of vegetated buffers	3,000 feet of vegetated buffers	3,000 feet of vegetated buffers	# feet	$60,000	48.92	10	2.05

Type	Eligibility	Activity	Milestones					Assessment	Cost	Reductions		
			2-year (2024)	4-year (2026)	6-year (2028)	8-year (2030)	10 year (2032)			N (lbs/yr)	P (lbs/yr)	TSS (t/yr)
	Y	Critical planting, e.g., natives, pollinators, etc. on vacant urban areas - 10 acres	2 acres of critical planting	2 acres of critical planting	2 acres of critical planting	2 acres of critical planting	2 acres of critical planting	# acres	$8,000	6	0.8	0.33
Monitoring	Y*	Stream stability: longitudinal profile survey/stream and facet slope and length. Complete 8 surveys	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # analysis	$30,720			
	Y*	• Stream stability: complete qualitative. Complete a Pfankuch form and the level 3 forms at 3 reaches for 8 surveys.										
	Y*	• Stream stability: cross sections/stream width, depth and width, 18 cross sections (6 at 3 reaches) 8 surveys										
	Y*	• Stream stability: Wolleman pebble count 9 pebble counts (2 riffles and 1 reach count as 3 reaches)										
	Y*	• Floodplain connection/storage: Bank height ratios - 8 surveys to determine the bank height ratio/level of disconnect of the stream from the floodplain.										
	Y*	Stream stability: embeddedness survey. Determine embeddedness in key reaches by completing a field survey	Plan, survey, and analysis to repeat what was done on East Branch and continue to mainstem					# plan # embeddedness analysis	$5,400			
	Y*	Sediment input from bank erosion (BANCS model) -- 7 surveys, one survey every other year in specific reaches.	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	1 survey and data analysis	2 surveys and data analysis	# surveys # reaches identified for restoration/protection # improvements	$6,720			
	Y*	Pool habitat: pool volume and area, survey in 3 reaches, 8 surveys	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # analysis	$7,680			
	Y*	Visual changes: photo points. Establish picture locations including a compass bearing for direction and take pictures every 3 years. 20 points at each of 3 reaches	1 event		1 event		1 event	# photo points	$2,880			
	Y*	Large woody debris: LWDI method, 8 surveys	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # projects IDed # improvements	$7,680			
	Y*	Water temperature: deploy continuous water temperature loggers. Deploy 8 (assume that 3 are lost/replaced due to weather/stream) loggers within and between the 3 monitoring reaches. Collect data from June 1st to September 30th each year.	deploy 5 loggers and analyze data each year	deploy 5 loggers and analyze data each year	deploy 5 loggers and analyze data each year	deploy 5 loggers and analyze data each year	deploy 5 loggers and analyze data each year	# data points # temperature analysis # improvements	$7,000			
	Y*	Water quality: Collect synoptic Secchi tube readings during spring runoff and summer rain events.	2 sampling events	2 sampling events	2 sampling events	2 sampling events	2 sampling events	# Secchi readings # trend analysis # improvements	$6,000			

Type	Eligibility	Activity	Milestones					Assessment	Cost	Reductions		
			2-year (2024)	4-year (2026)	6-year (2028)	8-year (2030)	10 year (2032)			N (lbs/yr)	P (lbs/yr)	TSS (t/yr)
	Y*	Fish abundance and presence/absence: electrofisher sampling at 3 sites (game/nongame fishes), 8 surveys completed	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # species improved	$23,040			
	Y*	Habitat Features: habitat type and quantity. Survey 3 reaches using DNR methods. 8 surveys.	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # analyses # habitat improved	$7,680			
	Y*	Tributary fish habitat potential for designation as a public water: measure water temperature and fish community use in small tributaries. Place continuous temp loggers and complete electro fishing sampling in 7 tributary or headwater reaches. Complete 8 surveys	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # species improved	$7,680			
	Y*	Invertebrate abundance and presence/absence. Take 2 kicknet samples at 3 sites for 8 surveys	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # analyses # invert improvements	$15,360			
	Y*	Invasive Species: Inventory the location and type of invasive species throughout the watershed	plan	survey	analyze data			# inventories # invasive species addressed # improvements	$7,200			
	Y*	Angler use: survey. Place a survey box with paper forms at the upstream and downstream end of the section of East Amity on City of Duluth land.	install box and review data	review data	review data	review data	review data	# fisher surveys # analysis # suggestions adopted	$4,320			
	Y*	Riparian vegetation: determine the health, cover, and plant community type and the precent of invasive species. Use SQT methods at 3 sites for 8 surveys	1 survey and data analysis	1 survey and data analysis	2 surveys and data analysis	2 surveys and data analysis	2 surveys and data analysis	# surveys # projects IDed # improvements	$7,680			
	Y*	Stormwater: Inventory and inspect stormwater outfalls throughout the watershed. Utilize City of Duluth inventory methods	plan the inventory method and the inspection method and map the outfalls	survey 1/3rd of the outfalls	survey 1/3rd of the outfalls	survey 1/3rd of the outfalls	resurvey any outfalls addressed	# outlets improved # outlets surveyed # projects IDed	$12,000			
	Y*	Forest type and health: Inventory and create a database of forest type and health throughout the watershed			plan	survey	analyze data	# surveys # improvements # projects IDed	$7,200			
	Y*	Inspect repaired road crossings to ensure continued performance	Conduct inspections seasonally	Conduct inspections seasonally	Conduct inspections seasonally	Conduct inspections seasonally	Conduct inspections seasonally	# inspections	$1,000			
		Total cost as planned							$8,219,580	454	105	25361

Total reductions rounded to nearest unit.

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).*
>
> *EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters*

The primary sources of sediment loading in Amity Creek are from streambank erosion. In addition, urban development is the second most significant source of loading to the stream. The TMDL identified the sources of sediment in the streams as both near-channel and watershed sources. Watershed sources include permitted and non-permitted sources. Permitted sources include stormwater from municipal separate storm sewer systems (MS4s), industrial stormwater, and construction stormwater.

Nonpoint source

The overwhelming TSS loading area in the Amity Creek Watershed is streambanks. Loads by land use are summarized in Table 7.

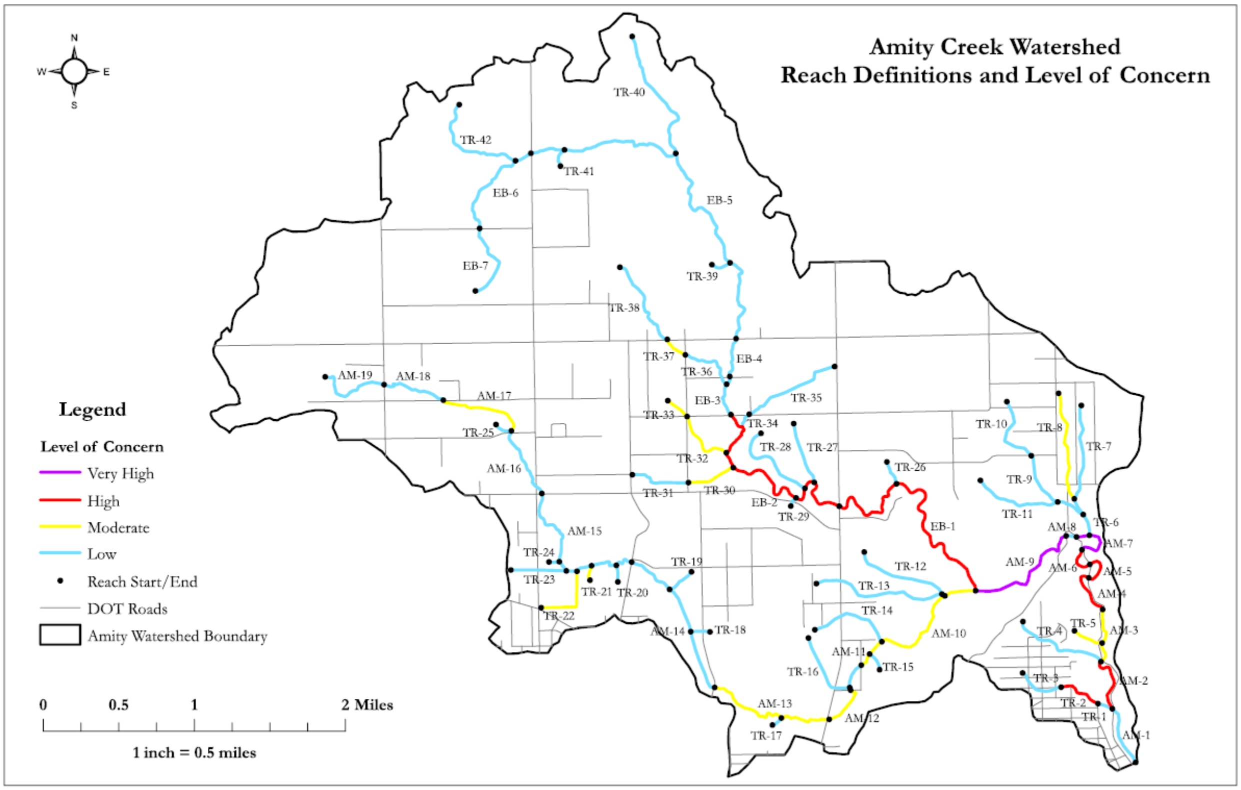
Table 7. Summary of nitrogen, phosphorus, and sediment loading by land use (PLET, 2022)

Sources	N Load (lb/yr)	% N load	P Load (lb/yr)	% P load	Sediment Load (t/yr)	% TSS load
Urban	6193.13	18%	958.91	0%	141.35	1%
Cropland	305.81	1%	60.77	0%	17.18	0.13%
Pastureland	3928.62	11%	318.67	0%	24.22	0.18%
Forest	1812.29	5%	898.33	0%	21.4	0.16%
Feedlots	125.08	0.37%	25.02	0.00%	0	0%
Septic	353.87	1%	138.6	0%	0	0%
Streambank	21534.02	63%	8290.6	0%	13458.76	99%
Total	**34252.83**	**100%**	**10690.88**	**100%**	**13662.9**	**100%**

Streambank

Jennings and Geenen (2017) provides an evaluation of near-channel sediment sources to the streams. The project identified Rosgen stream types and reach lengths for 68 stream reaches comprising Amity Creek, East Amity Creek, and their tributaries. The project identified a level of concern for bank erosion and channel stability through a rapid assessment and estimated relative streambank erosion rates. Figure 5 shows the results of the rapid assessment. Level of concern was rated as “Low”, “Moderate”, “High”, and “Very High”. “Very High” and “High” ratings indicate reaches that are likely to be major sources of sediment loading in the watershed.

Figure 5. Amity Creek Watershed Reach Definitions and Level of Concern Determined from the Rapid Assessment (from Jennings and Geenen, 2017)



The project then completed a Bank Assessment for Non-point source Consequences of Sediment (BANCS) assessment to estimate streambank erosion rates. Using the information in the BANCS assessment, a relative streambank erosion rate was assigned to each of the 68 reaches. The first four reaches in the table were identified as the highest priority reaches comprising about two-thirds of the total streambank erosion. These levels of concern are based on sediment input and stream stability. The average erosion rate in EB-1 and EB-2 is less than the very high reaches but are still important to address. The report indicated that the other stream reaches contributing more than one percent of the total should also be included for consideration as potential restoration projects.

Table 8. Relative streambank erosion rates for Amity Creek Watershed reaches (from Jennings and Geenen, 2017)

Rank	Reach	Concern	Category	L (ft)	Ht (ft)	ft/yr	ton/yr	%
1	AM-7	VERY HI	4	1,892	10	2	1,892	11.4
2	AM-9	VERY HI	4	4,417	8	2	3,534	21.3
3	EB-1	HIGH	3	9,409	6	1	2,823	17.0
4	EB-2	HIGH	3	8,347	6	1	2,504	15.1
5	AM-2	HIGH	3	2,233	6	1	670	4.0
6	AM-4	HIGH	3	1,744	6	1	523	3.1
7	AM-5	HIGH	3	1,214	6	1	364	2.2
8	AM-6	HIGH	3	1,042	6	1	313	1.9
9	TR-2	HIGH	3	1,557	4	1	311	1.9

Upland nonpoint sources

While near-channel sediment loads predominate in the watershed, upland sources of sediment are present. Watershed hydrologic processes, especially in the form of runoff during snowmelt and storm events, also play a role in exacerbating the large bank instabilities resulting in the large near-channel sediment loads.

Amity Creek contains 29 total stream crossings or an average of 1.1 stream crossings per stream mile, all of which are potential sources of sediment (SSLSWCD 2017). Erosion from road crossings include culvert erosion, road washouts, and contribute to connectivity problems. Five road crossings have been identified as critical loading areas for sediment loading. Other road crossings have been identified and will be considered for future work.

Table 9. The percentage of road crossings acting as barriers in Amity Creek Watershed (adapted from SSLSWCD, 2022, Appendix B)

Total number of crossings	29 (100%)
Percent Barriers	45%
Percent Low Priority	3%
Percent Medium Priority	17%
Percent High Priority	24%

Impervious areas, residential lawns, land disturbance, trails, and roadways contribute to the sediment loading.

Temperature

The HSPF model provided an analysis of how the stream may be affected by climate change using projected conditions. Without changing the land cover/land use in the Amity Creek Watershed, water temperature is expected to increase by 2.7 degrees F (Amity Creek) and 3.2 degrees F (East Branch) (Table 10). Although Amity is relatively cooler to other Duluth area streams, temperatures fall between stressful (68.0°F – 76.9°F) and lethal (>77.0°F) levels for brook trout habitats. It is assumed the lower impervious area in the watershed, about 3.5%, keeps the stream temperature low. Restoration includes the need to address current impervious areas and minimize future increases (MPCA, 2020). Stream restoration, including creating an appropriate channel size, connecting to the floodplain to allow for infiltration and lifting of the water table, and increasing shade to the channel and deep pool habitat, will also help to address water temperatures.

Table 10. Historic and predicted average maximum July temperatures (from MPCA WRAPS)

Stream	Historic average maximum July temperature (degrees F)	Predicted average maximum July temperature (degrees F)	Change (degrees F)
Amity Creek	69.2	71.9	2.7
E Br Amity Creek	71.0	74.2	3.2

Point Sources

Point sources in the Amity Creek Watershed include MS4 stormwater, industrial, and construction permits.

Municipal separate storm sewer system

Table 11 summarizes the MS4 permitted entities in the watershed. Stormwater from the conveyance system that is untreated (e.g., street runoff) contributes to sediment loading in the system. BMPs to improve the stormwater conveyance system are not eligible to be funded with Section 319 grant funds.

Table 11. List of MS4 permits in Amity Creek Watershed

Entity	Permit #
City of Duluth	MS400086
City of Rice Lake	MS400151
St. Louis County	MS400158

Construction and industrial entities that could contribute to sediment loading are described in Table 12. It is assumed that these permit requirements are met, and these meet the TMDL for the permits.

Table 12. Industrial and construction stormwater permits in Amity Creek

Entity	Permit #
Industrial	MNR050000
Construction	MNR1000001

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).*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

The TMDLs for Amity Creek and East Branch Amity Creek identify a 60% reduction in TSS load from each of the MS4 entities, upland nonpoint sources, and near-channel erosion as being needed to achieve the TMDL load capacity for the streams. HSPF reduction scenarios estimate that achieving the 60% reductions in developed land cover areas and near-channel sources will achieve the water quality standard of an exceedance rate of less than 10% of the time.

The implementation activities described in Table 6 have estimated reductions needed to meet the TMDLs and other goals for the Amity Creek Watershed.

Stormwater practices are identified in Table 6 were estimated using the BMP calculator in PLET. All reduction estimates are rounded to the nearest whole number. Most of the stormwater activities will occur in the developed areas of the watershed near Lake Superior. The reductions from stormwater are summarized in Table 13.

Table 13. Estimated reductions for stormwater practices in the Amity Creek Watershed, calculated using PLET

	N reduction (lbs/yr)	P reduction (lbs/yr)	TSS reductions (t/yr)
Combined stormwater	2932	486	88

Estimated reductions resulting from streambank restorations on both Amity Creek and Amity Creek, East Branch are summarized in Table 14. These are the top four critical loading areas for the watershed, as referenced in Table 8.

Table 14. Estimated reductions associated with streambank restoration in the Amity Creek Watershed, calculated using PLET

	N reduction (lbs/yr)	P reduction (lbs/yr)	TSS reductions (t/yr)
Streambank restoration	13342	5137	8339

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.*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

Nonpoint source BMPs

Streambank erosion is the largest critical load source. The top sources are identified in Table 14.

Streambank restoration

Jennings and Geenen (2017) recommended that streambank and hillslope erosion be addressed using a systematic geomorphic approach to improve watershed stability while optimizing water quality and biological conditions. Restoration plans using such an approach "should integrate hydrology, geomorphology, connectivity, water quality, and biology as a framework for setting objectives and implementing specific efforts. Hydrology considerations include baseflow, bankfull, and flood discharges. Geomorphology considerations include channel and floodplain dimensions to transport watershed flows and sediment, meander patterns that are appropriate for valley conditions, and bedforms that optimize energy dissipation and habitats. Connectivity considerations include ground and surface water, floodplain functions, and aquatic organism passage issues. Water quality and biology considerations include erosion control, healthy riparian vegetation, stormwater management, appropriate in-stream wood, and watershed stability" (Jennings & Geenen 2017).

To advance this approach, Jennings and Geenen (2017) provided planning-level conceptual designs for the five highest-priority stream reaches in appendices of the report. These streambank restorations are identified in Table 6.

Table 15. Overview of conceptual designs for the four highest-priority stream reaches in the Amity Creek watershed (Jennings and Geenen 2017)

Reach	Length of restoration (ft)	Cost	Percent sediment reduction
Amity Creek Reach 7	986	$271,000 – 320,000	73
Amity Creek Reach 9	2,100	$525,000 – 630,000	73
East Branch Reach 1	5,080	$1,115,000 – 1,300,000	73
East Branch Reach 1	1,060	$330,000 – 435,000	73
Amity Creek Reach 2 9	2,233	$525,000 – 630,000	73

Temperature

Amity Creek and East Branch Amity Creek should be prioritized for protection efforts to ensure that anthropogenic effects are minimized and that climate change mitigation strategies are put in place when appropriate. Increased impervious coverage in these watersheds risks increases in water temperatures and potential loss of suitable trout habitat. Increased canopy cover can provide shade for the streams, helping to keep the water cooler. Forest health can be improved by managing understory growth and invasive species. Practices that protect the floodplain and riparian corridor canopy and understory improve the microclimate and effective stream shade and prepare for future climate change impacts (Jennings & Geenen, 2017). The headwaters of the creek show increasing temperatures and should be targeted as critical areas for protection efforts. Streambank restorations will also improve conditions to prevent warming.

Stormwater control in developed areas

Stormwater runoff from residential and other developed areas contribute about 1% of the sediment loading. Stormwater runoff outside the conveyance systems include BMPs such as green infrastructure. Adding pervious pavement in parking lots, sidewalks, parks, trails, and residential areas will help decrease the runoff by improving infiltration. By extension, this mitigates sediment loading. Increased impervious surfaces are correlated to the increase of stream temperatures by increasing warmer stormwater runoff entering the stream. Providing buffers to the trails, managing forested areas appropriately, addressing stream/road crossings, encouraging raingardens, adopt a drain, increasing riparian buffers, and other infiltration BMPs will help mitigate stormwater runoff.

Stream/road crossings can also negatively impact habitat by creating stream connectivity issues. The two road crossings are Woodland Avenue over Amity Creek and West Tischer Road over East Branch Amity Creek are critical stormwater loading areas. These road crossings are recommended for replacement, removal, and/or repair.

Point source BMPs

Construction stormwater

Best management practices and other stormwater control measures to address the WLA for construction stormwater are defined in the State's NPDES/SDS General Stormwater Permit for

Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs, and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. All local construction stormwater requirements must also be met.

MS4s

Implementation strategies that can be used to meet WLAs include education and outreach, stormwater BMPs to reduce TSS and *E. coli* loading, pet waste management programs, disconnecting impervious areas, retrofitting of stormwater practices in untreated areas, and implementing BMPs that provide water quality treatment and reduce peak flows. Examples of stormwater conveyance system BMPs could include sediment trap structures, enhanced street sweeping, ditch checks, curb-cut rain gardens, and filtration basins. MS4 entities can ensure new developments address sediment reduction needs and mitigate flows that could potentially contribute to stream flashiness by reviewing and updating ordinances as needed. Citizens can be involved through adopt-a-drain program to reduce loading to the conveyance system.

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.

EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters

The cost to implement this plan fully is estimated at approximately $8.2 million. Costs by practices and activities are itemized in Table 6. This estimate includes implementation of BMPs, staff time, education and outreach, studies, inventories, and monitoring. The implementation of this plan will be funded by local funding, state and federal grants, and support from private organizations. Section 319 grant funding will serve as the foundation for implementing this plan. Additional funding includes local SWCD operational funding, State Clean Water Funds through BWSR, USDA NRCS EQIP funding, federal Great Lakes Restoration Initiative funds, and support through state and local funding from MN Trout Unlimited and the City of Duluth and City of Rice Lake. Landowners will contribute funds for grant match requirements. Private organization and foundation funding opportunities will also be pursued.

The Amity Creek Watershed works with multiple partners to achieve their goals. A list of major partners is listed in Table 16.

Table 16. Partnerships in the Amity Creek Watershed

Partner	Role
Minnesota DNR	Tech support, design work, monitoring
University of Minnesota – Duluth	Tech support
City of Duluth	Funding, landowner, outreach
City of Rice Lake	Funding, landowner, outreach
Minnesota PCA	Tech support, design work, monitoring
EPA – Duluth lab	Tech support and monitoring
St. Louis County	Funding, landowner
Minnesota Trout Unlimited	Funding, project partner
Minnesota BWSR	Funding

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.*
>
> *EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters*

Specific outreach activities, schedule, milestones, assessment criteria, and costs are listed in Table 6.

The education and outreach component of this plan will focus on the engagement of the stakeholder group through stakeholder group meetings, partner organizations meetings, and planned informal conversations. The information shared with the stakeholder group will also be shared with the public to build awareness of the watershed and stream resources, encourage use and appreciation for the natural environment, and participate in individual and community activities to implement BMPs or protect land use changes from degrading the streams.

Activity within the Duluth Urban Area community is highly integrated with its local water resources as evident from the numerous trout streams that run through the city, the popular Duluth Lakewalk and attractions in Canal Park and surrounding areas, beaches, and much more. Despite this, some lack of understanding of the connection between human activity on the land and resulting water quality remains. Education and outreach activities can work to fill this gap and ensure the protection of the watershed.

Many organizations and efforts exist in the watershed to engage citizens in the watershed with water quality improvements and protection efforts. Examples of existing groups that are conducting water quality-based public participation include:

- South St. Louis SWCD
- Duluthstreams.org: https://www.lakesuperiorstreams.org/streams/duluthStream_selector.html
- Duluth Streams Corps: https://www.communityactionduluth.org/post/learn-more-about-our-duluth-stream-corps-projects
- Minnesota Sea Grant: http://seagrant.umn.edu/
- Environmental centers: Hartley Nature Center, Great Lakes Aquarium
- Fish and wildlife groups: Trout Unlimited, Steelhead Club, Arrowhead Fly Fishers
- Sustainable Twin Ports: https://www.facebook.com/Sustainable-Twin-Ports-157955860884394/
- Lake Superior Cold Water Coalition: http://www.lrcd.org/lake-superior-coldwater-coalition.html
- Non-profit groups: Izaak Walton League, St. Louis River Alliance, NERR/Lake Superior Reserve
- Duluth Urban Watershed Advisory Committee: https://www.lakesuperiorstreams.org/communities/DuluthWRAPS/index.html
- Regional Stormwater Protection Team: http://www.lakesuperiorstreams.org/stormwater/rspt.html (MPCA, 2020, p. 48) wraps

Element f. Reasonably expeditious schedule

> *A schedule for implementing the activities and NPS management measures identified in this plan that is reasonably expeditious.*
>
> *EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters*

The schedule for this watershed plan is designated in 2-year increments described in Table 6. When implemented as planned, the activities and BMPs described will reach the estimated reductions needed to meet water quality standards in 10 years.

Element g. Milestones

> *A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.*
>
> *EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters*

The planned milestones for this watershed are designated in 2-year increments and will take place over the next 10 years (2022-2032). Specific milestones for each activity are captured in Table 6. The accomplishment of these milestones will be used to evaluate the implementation of this plan.

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.*
>
> *EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters*

The assessment criteria for this watershed are designated in 2-year increments and the unit of measure is described in Table 6. The assessment criteria and achievement of milestone goals will be used to measure the accomplishment of this NKE plan.

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.*
>
> *EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters*

Monitoring and evaluation for the Amity Creek Watershed NKE Plan emphasizes each of the five components of watershed health: hydrology, geomorphology, connectivity, biology, and water quality. Hydrology will be monitored with the re-establishment of a stream gage site. Past streamflow monitoring resulted in poor daily flow measurements due to shifting bed conditions with storm events.

Geomorphic monitoring includes stream stability measures including stream cross-sections, bed and channel material, and aquatic habitat features. Connectivity monitoring will include bridge and culvert assessments and floodplain assessments. Biological monitoring will include fish and macroinvertebrate sampling and angler use surveys. Habitat will be monitored in conjunction with the geomorphic monitoring and include measures of large woody debris, stream substrate, and pool and riffle conditions. Water quality monitoring will include Secchi transparency tube measurements, water column sediment sampling and laboratory analysis, sediment input monitoring using the BANCS model along with photo point surveys, and continuous sensors for stream temperature and turbidity.

Table 17 summarizes the activities, measures, timeline, and cost for monitoring. The costs in this table are also captured in Table 6.

Table 17. Monitoring activities for the Amity Creek watershed (these tasks also included in Table 6)

Monitoring/evaluation activity	Method	Description	Frequency	Ten-year cost
Streamflow	Continuous stage and rating curve	Re-establish gage site.	Every year	$150,000
Stream stability	Longitudinal profile survey/ stream and facet slope and length	Complete surveys at three reaches.	Every year	$30,720
Stream stability	Cross sections/stream width, depth and width	18 cross sections (six cross sections at three reaches)	Every year	included above
Stream substrate	Wolleman pebble count	Nine pebble counts (two riffles and one reach count at three reaches)	Every year	included above
Floodplain connection/storage	Bank Height Ratio	Survey three reaches to determine the bank height ratio and level of disconnect of the stream from the floodplain.	Every year	included above

Monitoring/evaluation activity	Method	Description	Frequency	Ten-year cost
Habitat features	Pfankuch method	Complete qualitative forms in the field and the level 3 forms at three reaches.	Every year	included above
Stream substrate	Embeddedness survey	Determine embeddedness in key reaches by completing a field survey	Every year	$5,400
Habitat features	Habitat type and quantity	Survey three reaches using DNR methods	Every year	$7,680
Pool habitat	Pool volume and area	Survey pools in three reaches	Every year	$7,680
Large woody debris	Large Woody Debris Index (LWDI) method	Complete at three reaches.	Every year	$7,680
Sediment input from bank erosion	BANCS model	Complete at three reaches.	Every year	$6,720
Visual changes	Photo points	Establish picture locations including a compass bearing for direction and take pictures every 3 years. Take photos at 20 points at each of 3 reaches.	Once every three years	$2,880
Water temperature	Continuous water temperature sensors and data loggers	Deploy 5 loggers within and between the 3 monitoring reaches. Collect data from June 1st to September 30th each year.	Every year	$7,000
Fish abundance and presence/absence	Electrofisher sampling	Sample game and non-game fish at 3 sites.	Every year	$23,040
Invertebrate abundance and presence/absence	Determine the make-up of the aquatic invertebrate community	Take two kicknet samples at three sites during the summer	Every year	$15,360
Water quality	Transparency	Collect synoptic Secchi tube readings during spring runoff and summer rain events.	Every year	$6,000
Water quality	Continuous turbidity	Operate turbidity sensor at streamflow gage site.	Every year	$20,000
Water quality	Total suspended solids, suspended sediment concentration, and bedload	Sampling to develop sediment-turbidity relationship for sediment load calculations.	Every year	$20,000
Angler use	Surveys	Place a survey box with paper forms at the upstream and downstream end of the section of East Amity on City of Duluth land.	Install first year and review data every year	$4,320

Monitoring/evaluation activity	Method	Description	Frequency	Ten-year cost
Riparian vegetation	Determine the health, cover, and plant community type and the precent of invasive species	Use stream quantification tool (SQT) methods at three sites	Annually	$7,680
Stormwater	Inventory and inspect stormwater outfalls throughout the watershed	Utilize City of Duluth inventory methods	Every 6 years	$12,000
Tributary fish habitat potential for designation as a public water	Measure water temperature and fish community use in small tributaries	Place continuous temp loggers and complete electro fishing sampling in seven tributary or headwater reaches	Annually	$7,680
Invasive Species	Inventory the location and type of invasive species throughout the watershed		Every 10 years	$7,200
Forest type and health	Inventory and create a database of forest type and health throughout the watershed		Every 10 years	$7,200

Adaptive management

Adaptive management is an approach to water quality restoration efforts where BMP implementation efforts are combined with an on-going evaluation of the 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 in the TMDL, 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).

Uncertainties related to the water quality criteria, TMDL numbers, sediment sources and aquatic life stressors are present in the Duluth Urban Area Streams TMDL even though much was learned through the TMDL study. 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 life goals for the river. As this work is completed, the TMDL implementation goals, priorities and BMPs will be examined and revised, as needed.

The Amity Creek Watershed partners anticipate a biennial review process including an assessment of partnership operations and self-assessment of workload and delivery of implementation actions. The MPCA requires grantees to evaluate their progress through semi-annual reporting. At the biennial point of the project grant (halfway point) the watershed partners will have enough tracking to determine whether the implementation and effectiveness of the implementation is heading in the correct direction to help meet water quality goals. The biennial assessment will consider the pace of progress toward the plan goals and will provide additional data that may impact plan priorities and help define future implementation activities. A more thorough evaluation of plan progress will take place toward the end of the first grant. Over the life of the nine-key element plan, information may arise that warrant revisions to the plan. New priority issues may emerge, or strategies may need to be adjusted. The relative importance of existing issues may change based on monitoring data, modeling results, or shifting priorities of the partners.

The following prompts and associated responses will help guide the adaptive management approach:

- Are the streambank erosion sources being adequately prioritized for restoration?
    - If not: re-evaluate streambank restoration sites to determine whether different priorities for restoration are needed or if upland sources need higher prioritization for implementation.
- Is voluntary BMP adoption meeting the targets in the plan?
    - If not: Consider putting additional funds toward outreach staff for making one on one connections with community members, increase development of outreach materials to targeted areas to better communicate the issues and the need to work collaboratively to meet water quality goals.
- Are the installed BMPs performing as intended?
    - If not: Consider an assessment of what other BMPs would have a larger impact for this area.
- Are risks to under-represented populations being mitigated?
    - If not: Consider putting additional funding into outreach staffing and development of materials for communicating risks and working together on solutions with other agencies and partners.

References

Jennings, G. and Geenen, M. (2017). Amity Creek Stressor Identification. Prepared for South St. Louis Soil and Water Conservation District. http://www.lakesuperiorstreams.org/communities/DuluthWRAPS/docs/Appendix%20B.%20Amity.pdf

Shabman, L., K. Reckhow, M.B. Beck, J. Benaman, S. Chapra, P. Freedman, M. Nellor, J. Rudek, D. Schwer, T. Stiles and C. Stow. 2007. *Adaptive Implementation of Water Quality Implementation Plans: Opportunities and Challenges*. Nicholas School of the Environment and Earth Sciences, Nicholas Institute, Duke University. NI R 07-03. 98 pp.

Tetra Tech. (2020). *Final Duluth Urban Area Watershed Restoration and Protection.* https://www.pca.state.mn.us/sites/default/files/wq-ws4-42a.pdf

Tetra Tech. (2020). *Duluth Urban Area Streams Total Maximum Daily Load.* https://www.pca.state.mn.us/sites/default/files/wq-iw10-11e.pdf