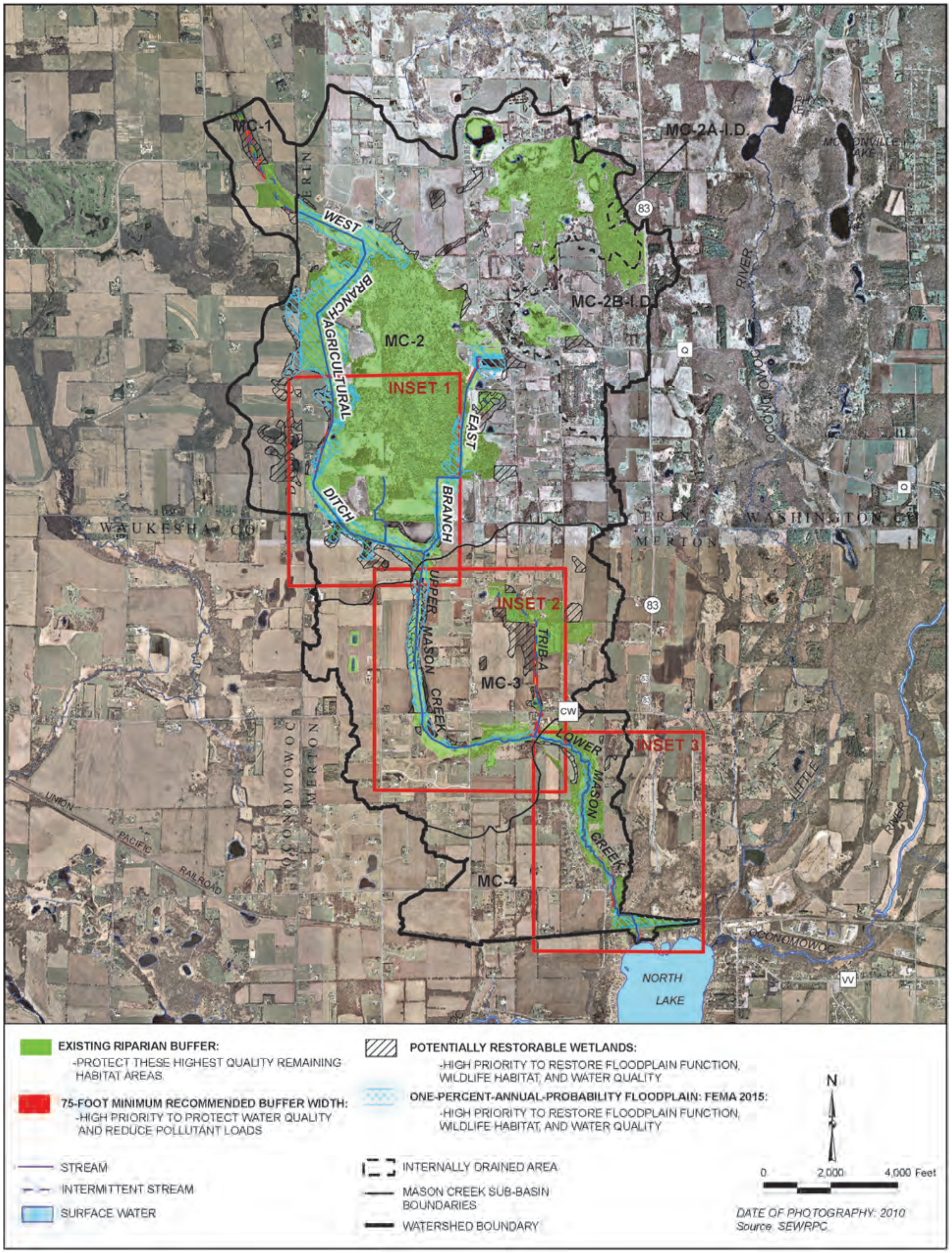
Map III-2

HIGH PRIORITY RIAPRIAN BUFFER PROTECTION AREAS TO IMPROVE WATER QUALITY AND WILDLIFE WITHIN THE MASON CREEK WATERSHED: 2016



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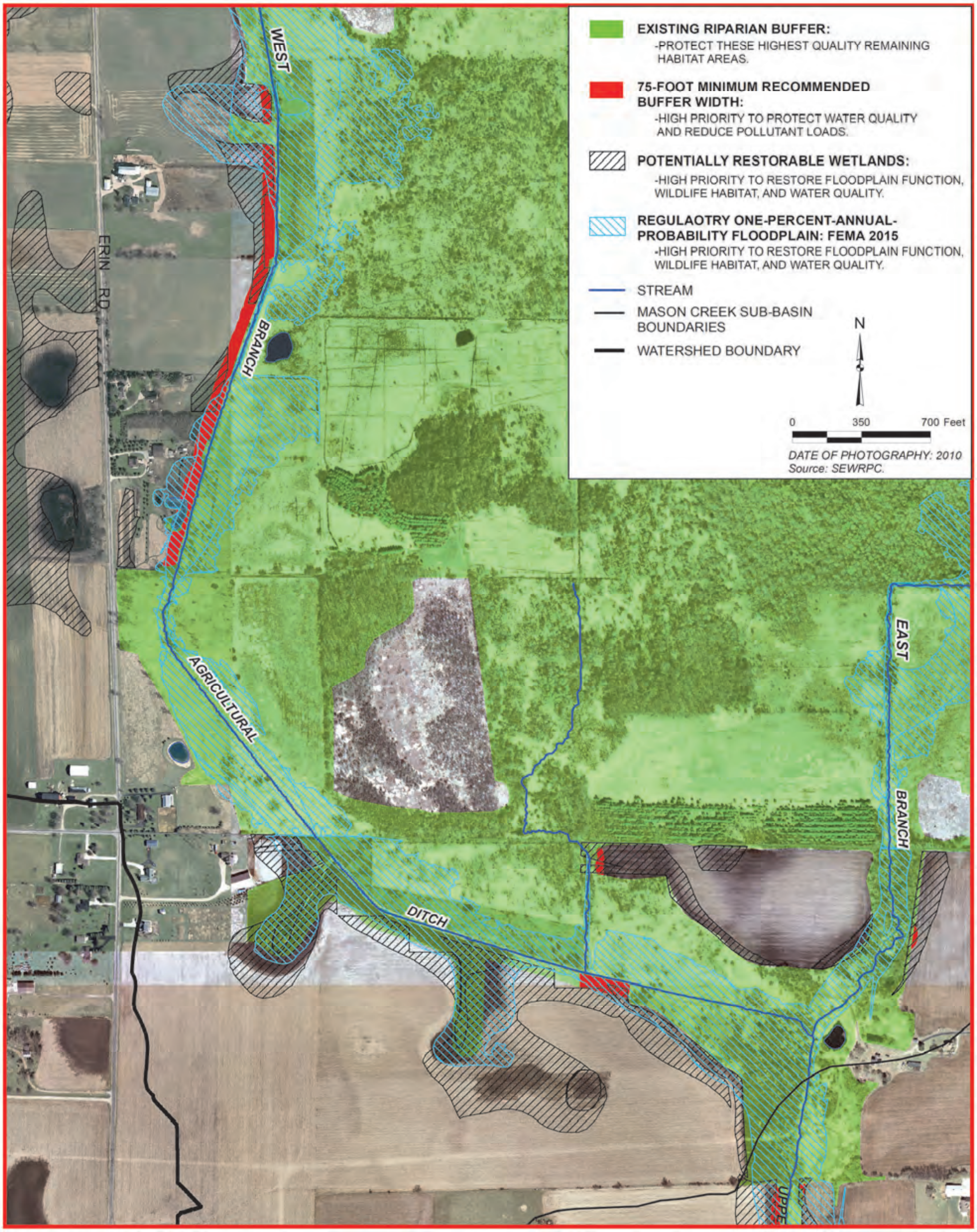
HIGH PRIORITY RIAPRIAN BUFFER PROTECTION AREAS TO IMPROVE WATER QUALITY AND WILDLIFE WITHIN THE MASON CREEK WATERSHED: 2016



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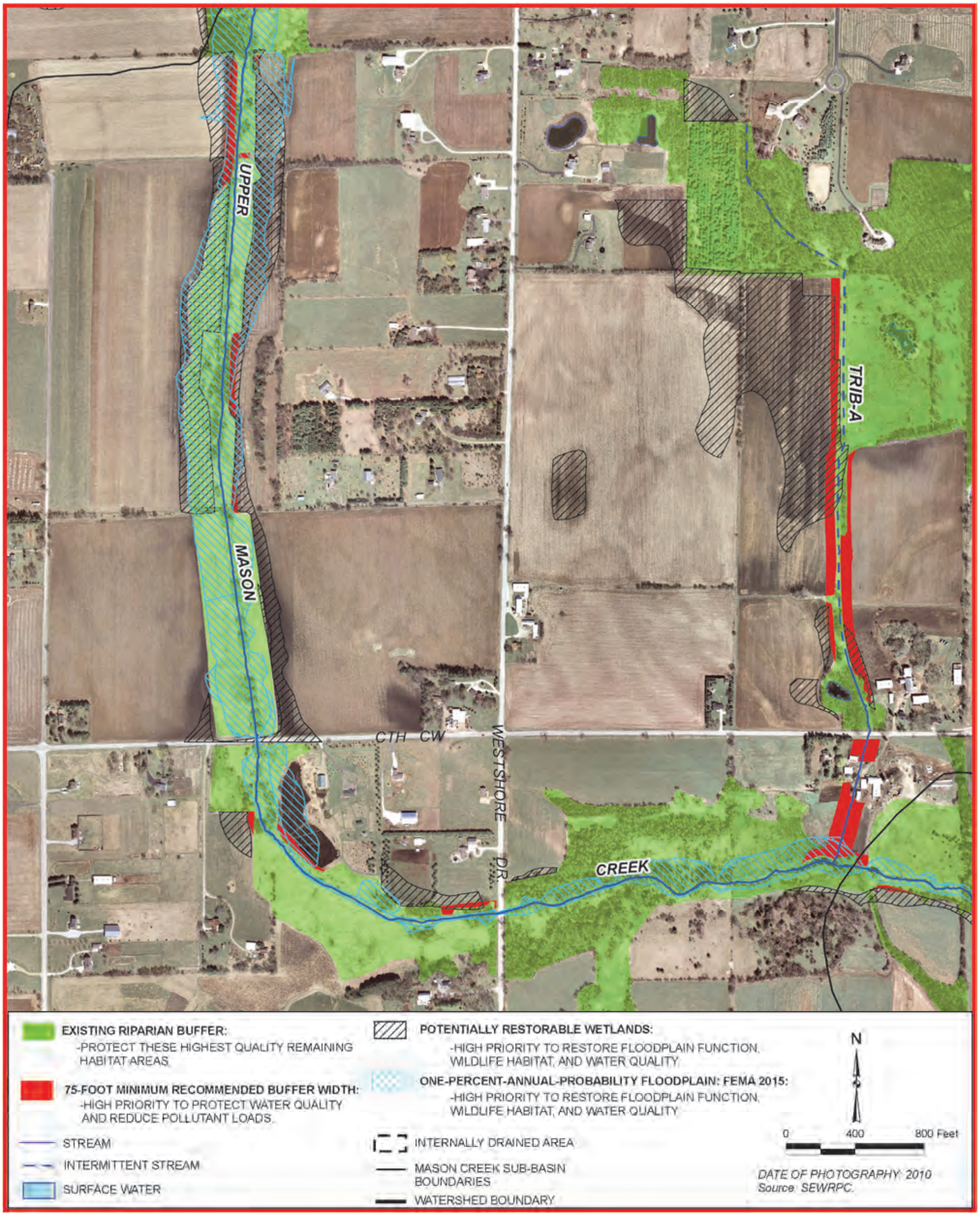
HIGH PRIORITY RIAPRIAN BUFFER PROTECTION AREAS TO IMPROVE WATER QUALITY AND WILDLIFE WITHIN THE MASON CREEK WATERSHED: 2016



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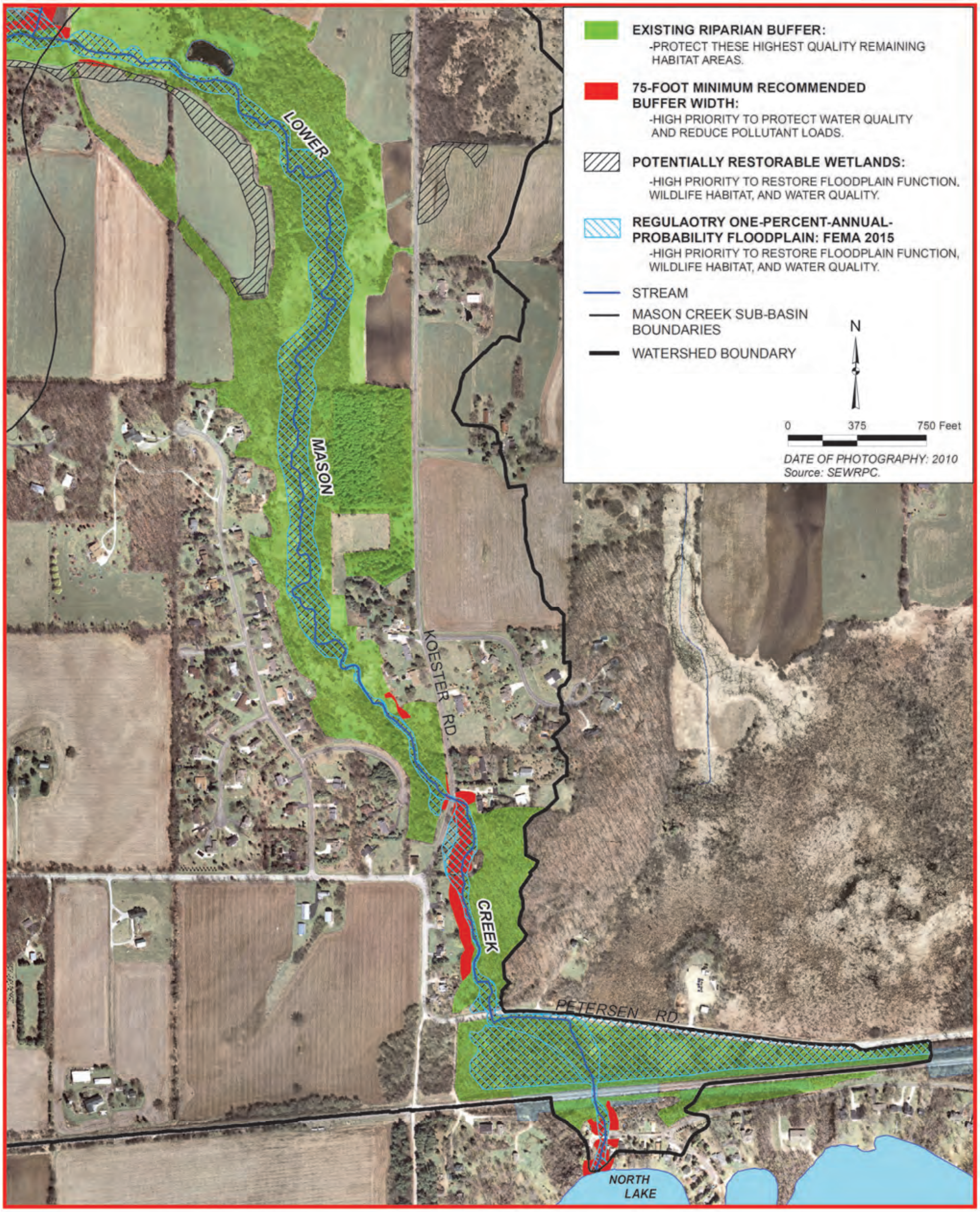
HIGH PRIORITY RIAPRIAN BUFFER PROTECTION AREAS TO IMPROVE WATER QUALITY AND WILDLIFE WITHIN THE MASON CREEK WATERSHED: 2016



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APPENDICES

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Appendix A

INFORMATIONAL MEETING ATTENDEES, WORK GROUP MEMBERS, TECHNICAL ASSISTANCE, AND GRANT PARTNERS CONTRIBUTING TO DEVELOPMENT OF THE MASON CREEK WATERSHED PROTECTION PLAN

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Figure A-1

INFORMATIONAL/COMMUNITY MEETING DATES AND LOCATIONS:

March 19, 2013	**Town Hall Library, North Lake** N76 W1429. HWY VV North Lake, WI 53064
July 23, 2013	**Town Hall Library, North Lake** N76 W1429. HWY VV North Lake, WI 53064
April 28, 2014	**Tall Pines Conservancy Office** N44 W32882 Watertown Plank Rd. Nashotah, WI 53058
September 29, 2014	**Southeastern Wisconsin Regional Planning Commission** W239 N1812 Rockwood Dr. Waukesha, WI 53187
July 28, 2015	**Merton Town Hall** W314 N7624. HWY 83 North Lake, WI 53064

INFORMATIONAL MEETING ATTENDEES AND WORK GROUP PLAN CONTRIBUTORS

Name	Affiliation
Dave Arnot	Rueckert Mielke
Megan Beauchaine	Southeastern Wisconsin Regional Planning Commission
Jill Bedford	Tall Pines Conservancy
Ben Benninghoff	Wisconsin Department of Natural Resources
Nick Besasie	USDA Natural Resources Conservation Services
Susan Buchanan	Tall Pines Conservancy
Lisa Conley	Rock River Coalition
Dave Cox	Village of Hartland
Andrew Craig	Wisconsin Department of Natural Resources
Kenneth Denow	Consultant for Oconomowoc Watershed Protection Program
Karen Doyle	Waukesha County
Jason Freund	Carroll University
Don Gallo	Reinhart Law
Amy Garbe	Faye Gehl Foundation
John Gehl	Wisconsin Department of Natural Resources
Ellen Gennrich	Waukesha County Land Conservation
Marilyn Haroldson	Town of Merton
Lori Hazel	Concerned Citizen
Mike Hazel	Concerned Citizen
Don Heilman	Concerned Citizen
Jerry Heine	North Lake Management District

INFORMATIONAL MEETING ATTENDEES AND WORK GROUP PLAN CONTRIBUTORS (CONT.)

Name	**Affiliation**
Eric Hyde	Washington County
Ken Lane	Concerned Citizen
James Jackley	Wisconsin Department of Natural Resources
Ben Johnson	Concerned Citizen
Marlin Johnson	Waukesha County Land Conservation
Mike Lawton	Concerned Citizen
Perry Lindquist	Waukesha County
Michelle Lehner	Wisconsin Department of Natural Resources
Jon McAnolly	Concerned Citizen
Maureen McBroom	Wisconsin Department of Natural Resources
John Muehl	North Lake Management District
Zofia Noe	Southeastern Wisconsin Regional Planning Commission
Tom Oasen	Natural Resources Conservation Services
Mark Olsen	Concerned Citizen
Matt Otto	Natural Resources Conservation Services
Aaron Owens	Southeastern Wisconsin Regional Planning Commission
Brian Pehl	Short Elliot Hendrickson Inc.
Brad Pfaff	Farm Service Agency
Mary Rampolla	City of Oconomowoc
Mark Riedel	Wisconsin Department of Natural Resources
Rachel Sabre	Wisconsin Department of Natural Resources
Jim Schneider	North Lake Management District
Tim Sear	Short Elliot Hendrickson Inc.
Paul Sebo	Waukesha County Conservationist
Richard Simmons	Concerned Citizen
Tom Slawski	Southeastern Wisconsin Regional Planning Commission- Special Biologist
Jim Smith	Applied Technology
Tom Steinbach	City of Oconomowoc
Tim Thompson	Wisconsin Department of Natural Resources
Tom Weik	Tall Pines Conservancy
Steve Werster	Rueckert Mielke
Andy Yencha	University of Wisconsin Extension Basin Educator (Former)

TECHNICAL ASSISTANCE CONTRIBUTORS

Name	Affiliation
Andrew Craig	Wisconsin Department of Natural Resources
Perry Lindquist	Waukesha County
Maureen McBroom	Wisconsin Department of Natural Resources
Matt Otto	Natural Resources Conservation Services
Mark Riedel	Wisconsin Department of Natural Resources
Rachel Sabre	Wisconsin Department of Natural Resources
Paul Sebo	Waukesha County Conservationist
Tom Steinbach	City of Oconomowoc
Andy Yencha	University of Wisconsin Extension Basin Educator (Former)

GRANT PARTNER/SUPPORTERS

City of Oconomowoc
Natural Resources Conservation Services
North Lake Management District
Southeastern Wisconsin Regional Planning Commission
Tall Pines Conservancy
University of Wisconsin-Extension
Washington County
Waukesha County
Wisconsin Department of Natural Resources

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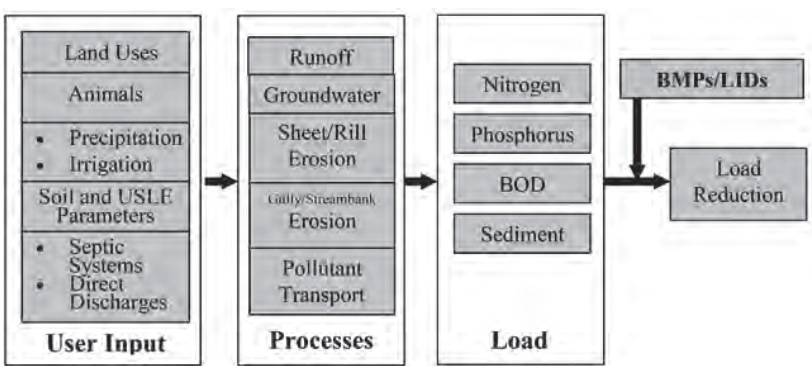
Appendix B

STEPL LOADING RESULTS FOR THE MASON CREEK WATERSHED

Spreadsheet Tool for the Estimation of Pollutant Load *(excerpt from STEPL 4.1 User's Guide)*:
The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). It computes surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. The land uses considered are urban land, cropland, pastureland, feedlot, forest, and a user-defined type. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. The types of animals considered in the calculation are beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys, and ducks. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

The input data include state name, county name, weather station, land use areas, agricultural animal numbers, manure application months, population using septic tanks, septic tank failure rate, direct wastewater discharges, irrigation amount/frequency, and BMPs for simulated watersheds. When local data are available, users may choose to modify the default values for USLE parameters, soil hydrologic group, nutrient concentrations in soil and runoff, runoff curve numbers, and detailed urban land use distribution. Pollutant loads and load reductions are automatically calculated for total nitrogen, total phosphorus, BOD5, and sediment.



STEPL is designed for the Grants Reporting and tracking System of the U.S. Environmental Protection Agency.

STEPL Version 4.2 released in April 2013 was used to model the pollutant loads (see website at http://it.tetratech-ffx.com/steplweb/)

STEPL Data Inputs:
State: Wisconsin
County: Waukesha
Weather Station: WI Milwaukee WSO Airport
Land Use Area (Acres)
AUTHOR

Existing Conditions: Year 2010

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total
MC-1	1	144	0	0	0	0	0-24%	145
MC-2	378	775	544	144	0	2	0-24%	1843
MC-3	273	707	185	34	0	14	0-24%	1213
MC-4	135	292	122	39	0	0	0-24%	588
MC-2a	2	0	0	6	0	0	0-24%	8
MC-2b	103	56	154	47	0	0	0-24%	360

8. Input or modify urban land use distribution

Watershed	Urban Area (ac.)	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivated	Vacant (developed)	Open Space %	Total % Area
MC-1	1	0	0	0	100	0	0	0	0	0	100
MC-2	378	0.7	0	0	19.5	0	79.8	0	0	0	100
MC-3	273	0.4	0	0	19	0	64.4	0	0	16.2	100
MC-4	135	0	0	0	36	0	64	0	0	0	100
MC-2a	2	0	0	0	0	0	100	0	0	0	100
MC-2b	103	1	0	0	30.6	0	68.4	0	0	0	100

Planned Conditions: Year 2035

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total
MC-1	11	126	0	7	0	0	0-24%	144
MC-2	435	740	516	151	0	2	0-24%	1844
MC-3	211	767	185	34	0	14	0-24%	1211
MC-4	147	287	120	39	0	0	0-24%	593
MC-2a	1	0	0	6	0	0	0-24%	7
MC-2b	103	56	154	47	0	0	0-24%	359

8. Input or modify urban land use distribution

Watershed	Urban Area (ac.)	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivated	Vacant (developed)	Open Space %	Total % Area
MC-1	11	0	0	0	37	0	63	0	0	0	100
MC-2	435	0.8	0	0	18.3	0	79.7	0	0	1.2	100
MC-3	211	0.4	0	0	24.6	0	75	0	0	0	100
MC-4	147	0	0	0	36.5	0	63.5	0	0	0	100
MC-2a	1	0	0	0	0	0	100	0	0	0	100
MC-2b	103	1.1	0	0	29.8	0	68.5	0	0	0.6	100

Agricultural Animals

Data Source: Agricultural animal distribution is based on USDA Census of Agriculture 2012 and consultation with local NRCS and Waukesha and Washington County staff. It is important to note that these numbers were not changed when modelling for the planned 2035 land use load conditions.

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	# of months manure applied
MC-1	1	3	1	0	1	1	0	0	8
MC-2	13	50	10	5	20	20	1	1	8
MC-3	6	24	5	3	10	10	0	1	8
MC-4	3	12	2	1	5	5	0	0	8
MC-2a	0	0	0	0	0	0	0	0	8
MC-2b	1	6	1	1	3	3	0	0	8
Total	24	95	19	10	39	39	1	2	

Septic Systems

Data Source: The total number of septic systems were provided by the model default, but were distributed amongst the subwatershed based on area of rural lands. These numbers were not changed for the planned 2035 estimated pollutant loads.

3. Input septic system and illegal direct wastewater discharge data

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	Wastewater Direct Discharge, # of People	Direct Discharge Reduction, %
MC-1	8	3	0.96	0	0
MC-2	142	3	0.96	0	0
MC-3	68	3	0.96	0	0
MC-4	34	3	0.96	0	0
MC-2a	1	3	0.96	0	0
MC-2b	20	3	0.96	0	0

Hydrologic Soil Group

Data Source: Hydrological soil group is based on STATSGO database and the most dominant soil type was chosen for each subwatershed.

5. Select average soil hydrologic group (SHG), SHG A = highest infiltration and SHG D = lowest infiltration

Watershed	SHG A	SHG B	SHG C	SHG D	SHG Selected	Soil N conc.%	Soil P conc.%	Soil BOD conc.%
MC-1	○	◉	○	○	B	0.080	0.031	0.160
MC-2	○	◉	○	○	B	0.080	0.031	0.160
MC-3	○	◉	○	○	B	0.080	0.031	0.160
MC-4	○	◉	○	○	B	0.080	0.031	0.160
MC-2a	○	◉	○	○	B	0.080	0.031	0.160
MC-2b	○	◉	○	○	B	0.080	0.031	0.160

STEPL EXISTING 2010 VERSUS PLANNED 2035 LAND USE LOAD COMPARISONS BY SUBWATERSHED FOR NITROGEN (N), PHOSPHORUS (P), BIOLOGICAL OXYGEN DEMAND (BOD), AND SEDIMENT

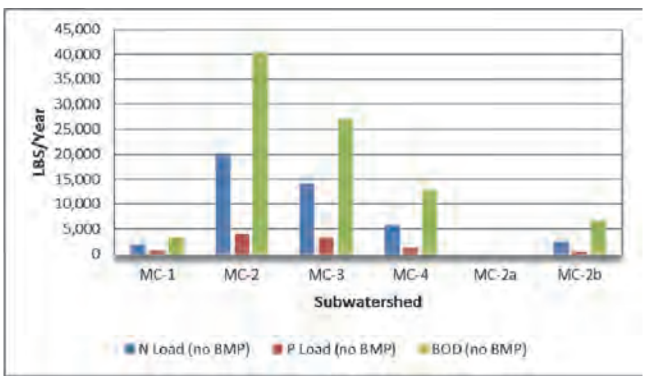
Existing Land Use: 2010

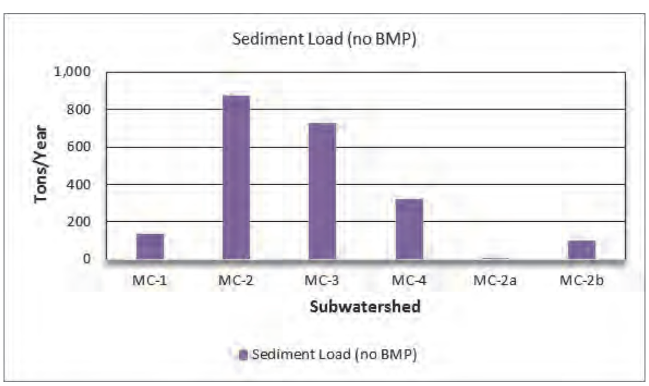
1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)
	lb/year	lb/year	lb/year	t/year
MC-1	2012.0	540.2	3391.2	133.8
MC-2	19872.3	4053.1	40260.0	873.0
MC-3	14199.9	3214.9	27234.4	725.7
MC-4	5829.7	1354.8	12701.7	320.0
MC-2a	7.9	1.9	33.0	0.2
MC-2b	2413.0	438.2	6715.9	99.4
Total	44334.7	9603.1	90336.2	2152.2

2. Total load by land uses (no BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	5556.67	948.18	20100.16	134.07
Cropland	27311.26	7350.81	45611.25	1828.19
Pastureland	5651.39	608.52	17622.42	186.15
Forest	60.77	29.00	145.91	3.75
Feedlots	5654.04	627.19	6445.69	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	100.59	39.40	410.73	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00
Total	44334.72	9603.10	90336.16	2152.16





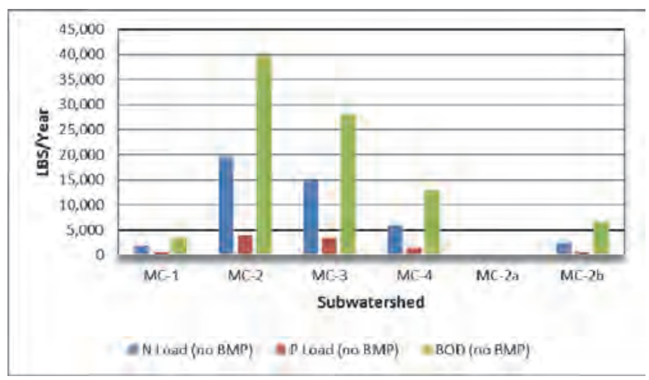
Planned Land Use: 2035

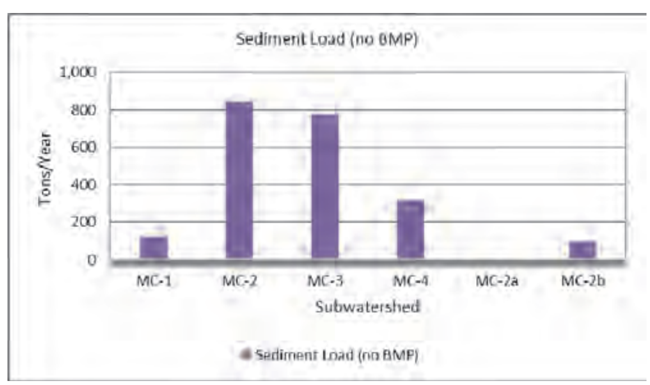
1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)
	lb/year	lb/year	lb/year	t/year
MC-1	1838.9	486.8	3238.7	119.1
MC-2	19486.5	3950.2	39954.3	841.6
MC-3	14887.1	3418.9	28138.8	777.8
MC-4	5859.9	1354.1	12919.1	317.9
MC-2a	5.5	1.5	21.7	0.2
MC-2b	2395.6	435.2	6664.1	98.8
Total	44473.4	9646.6	90936.8	2155.4

2. Total load by land uses (no BMP)

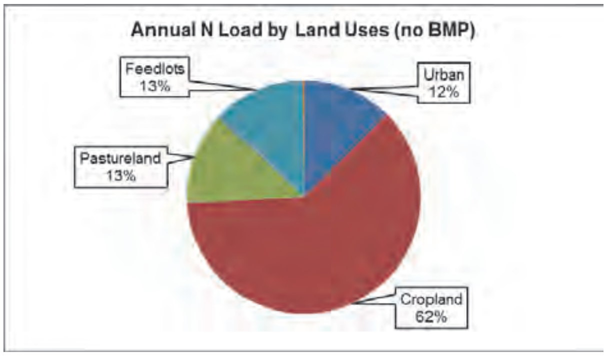
Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	5832.07	1000.46	21172.91	140.76
Cropland	27341.32	7358.86	45661.33	1830.11
Pastureland	5481.53	590.22	17092.79	180.55
Forest	63.87	30.48	153.37	3.94
Feedlots	5654.04	627.19	6445.69	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	100.59	39.40	410.73	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00
Total	44473.43	9646.62	90936.82	2155.36

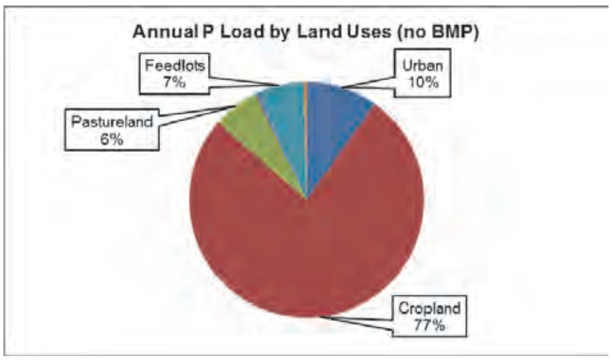


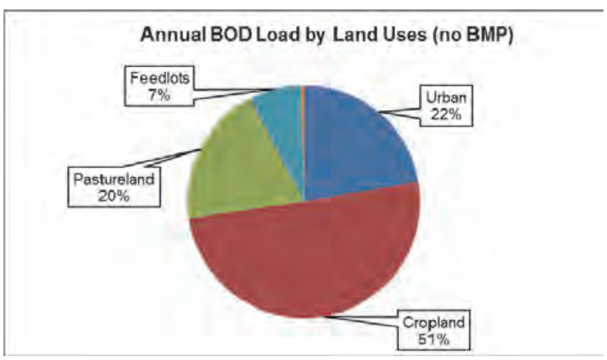


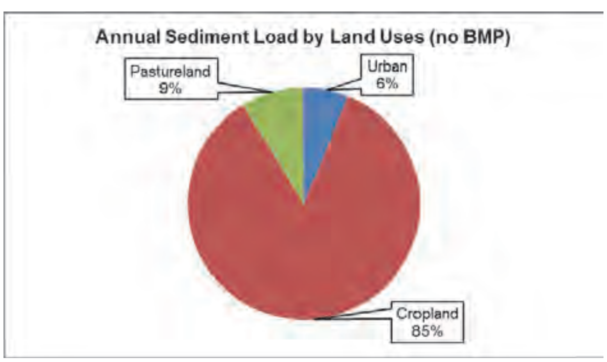
STEPL EXISTING 2010 VERSUS PLANNED 2035 LAND USE LOAD COMPARISONS BY SUBWATERSHED FOR NITROGEN (N), PHOSPHORUS (P), BIOLOGICAL OXYGEN DEMAND (BOD), AND SEDIMENT (cont.)

Existing Land Use: 2010

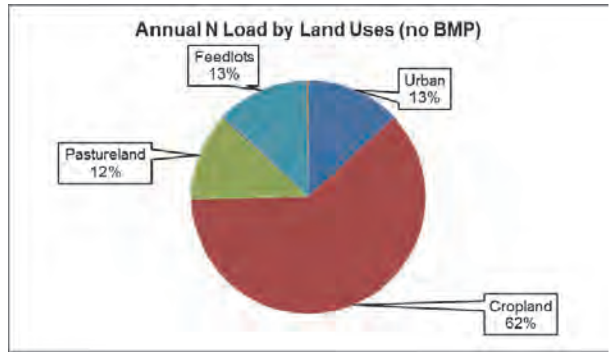


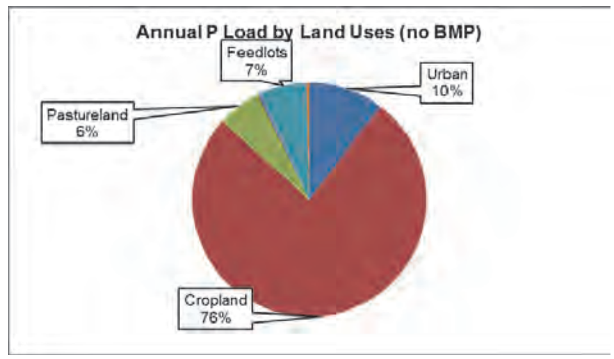


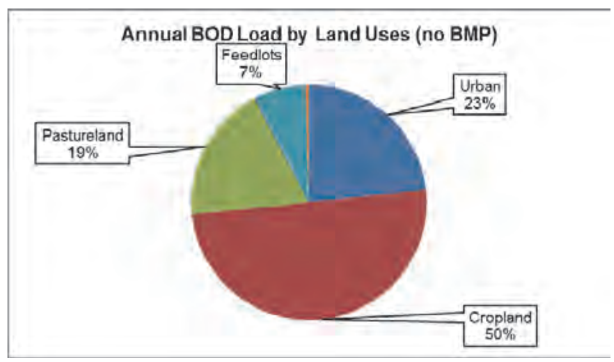


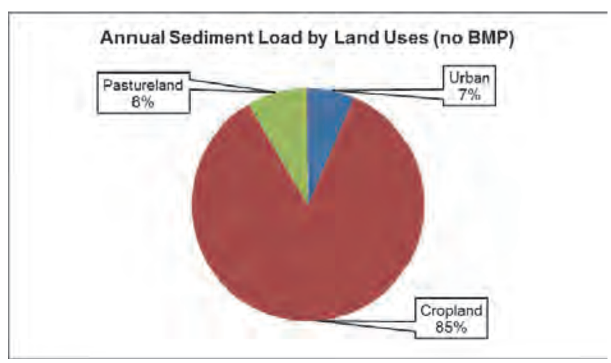


Planned Land Use: 2035









STEPL LOAD REDUCTION RESULTS FOR AGRICULTURAL BEST MANAGEMENT PRACTICES (BMPs) FOR CROPLAND

Upland Practices applied to Cropland:
Individual BMP efficiency values for nitrogen, phosphorus, biological oxygen demand, and sediment were based on values used by the Chesapeake Bay Model (CBM) and data from the Minnesota Department of Agriculture (MDA) as well as input from Waukesha and Washington County and NRCS staff.[1] Although it is well established that combined BMP efficiencies can greatly increase the overall percent reduction for pollutants such as detailed in the Plum-Kankaput Creek Watershed Plan,[2] it was beyond the scope of this project to determine the proportions of each of these practices being applied to each field in the Mason Creek watershed. However, estimates of the overall proportions of existing and proposed BMPs for fields throughout the Mason Creek watershed were provided by Perry Lindquist, Waukesha County Land Resources Manager, and Paul Sebo, Washington County Conservationist. Therefore, each practice was modelled separately to show existing load reductions and feasible planned load reductions as summarized below.

Table 1

STEPL BMP PRACTICES AND EFFICIENCIES USED IN THE MASON CREEK WATERSHED MODELLING

MASON CREEK WATERSHED SLAWSKI, THOMAS M. COMMUNITY ASSISTANCE PLANNING REPORT MULTIPLE MULTIPLE	Existing Practices Implemented (percent of agricultural lands)	Proposed Practices Implemented (percent of agricultural lands)	Efficiency				Data Source
			N	P	BOD	Sediment	
Reduced Tillage	5%	75% No Till	0.55	0.45	ND	0.55	MDA
No Till	50%	75%	0.59	0.69	ND	0.78	MDA
Nutrient Management	50%	100%	0.08	0.15	ND	0.25	CBM
Cover Crop	0%	50%	0.30	0.25	ND	0.35	MDA

Source: SEWRPC.

[1] *Simpson, Thomas, and Sarah Weammert, Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed. University of Maryland Mid-Atlantic Water Program, 2009; Minnesota Department of Agriculture, Miller, T. P., J. R. Peterson, C. F. Lenhart, and Y. Nomura,* The Agricultural BMP Handbook for Minnesota, *, September 2012, http://www.leg.state.mn.us/lrl/lrl.asp*

[2] *Outagamie County Land Conservation Department,* Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds, *Appendix D, STEPL load reduction results for combined BMP's for cropland & pastureland practices, streambank restoration, riparian buffer, and wetland restoration, 2014.*

STEPL LOAD REDUCTION RESULTS FOR REDUCED TILLAGE PRACTICES

Existing Conditions: 5 percent Reduced Tillage

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	2012.0	540.2	3391.2	133.8	54.8	12.9	23.5	3.7	1957.2	527.3	3367.8	130.1
MC-2	19872.3	4053.1	40260.0	873.0	294.9	69.4	126.3	19.7	19577.4	3983.7	40133.6	853.3
MC-3	14199.9	3214.9	27234.4	725.7	269.0	63.3	115.2	18.0	13930.9	3151.6	27119.2	707.7
MC-4	5829.7	1354.8	12701.7	320.0	111.1	26.1	47.6	7.4	5718.6	1328.7	12654.1	312.6
MC-2a	7.9	1.9	33.0	0.2	0.0	0.0	0.0	0.0	7.9	1.9	33.0	0.2
MC-2b	2413.0	438.2	6715.9	99.4	21.3	5.0	9.1	1.4	2391.7	433.2	6706.7	97.9
Total	44334.7	9603.1	90336.2	2152.2	751.1	176.7	321.8	50.3	43583.7	9426.4	90014.4	2101.9

Proposed Conditions: 75 Percent No Till (see below)

STEPL LOAD REDUCTION RESULTS FOR NO TILL PRACTICES

Existing Conditions: 50 percent No Till

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	2012.0	540.2	3391.2	133.8	628.3	192.4	332.9	52.0	1383.7	347.8	3058.3	81.8
MC-2	19872.3	4053.1	40260.0	873.0	3381.3	1035.4	1791.5	279.9	16490.9	3017.6	38468.4	593.1
MC-3	14199.9	3214.9	27234.4	725.7	3084.7	944.6	1634.3	255.4	11115.2	2270.3	25600.1	470.4
MC-4	5829.7	1354.8	12701.7	320.0	1274.0	390.1	675.0	105.5	4555.7	964.7	12026.7	214.6
MC-2a	7.9	1.9	33.0	0.2	0.0	0.0	0.0	0.0	7.9	1.9	33.0	0.2
MC-2b	2413.0	438.2	6715.9	99.4	244.3	74.8	129.5	20.2	2168.6	363.4	6586.4	79.1
Total	44334.7	9603.1	90336.2	2152.2	8612.6	2637.4	4563.2	713.0	35722.1	6965.7	85773.0	1439.2

Proposed Conditions: 75 percent No Till

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	2012.0	540.2	3391.2	133.8	942.4	288.6	499.3	78.0	1069.6	251.6	2891.9	55.8
MC-2	19872.3	4053.1	40260.0	873.0	5072.0	1553.2	2687.3	419.9	14800.3	2499.9	37572.7	453.2
MC-3	14199.9	3214.9	27234.4	725.7	4627.0	1416.9	2451.5	383.0	9572.9	1798.0	24782.9	342.7
MC-4	5829.7	1354.8	12701.7	320.0	1911.0	585.2	1012.5	158.2	3918.7	769.6	11689.3	161.8
MC-2a	7.9	1.9	33.0	0.2	0.0	0.0	0.0	0.0	7.9	1.9	33.0	0.2
MC-2b	2413.0	438.2	6715.9	99.4	366.5	112.2	194.2	30.3	2046.5	326.0	6521.7	69.0
Total	44334.7	9603.1	90336.2	2152.2	12918.9	3956.1	6844.7	1069.5	31415.8	5647.0	83491.4	1082.7

STEPL LOAD REDUCTION RESULTS FOR NUTRIENT MANAGEMENT PLAN PRACTICES

Existing Conditions: 50 percent Nutrient Management Plan

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	2012.0	540.2	3391.2	133.8	116.0	48.4	106.7	16.7	1896.0	491.7	3284.5	117.1
MC-2	19872.3	4053.1	40260.0	873.0	624.1	260.7	574.2	89.7	19248.1	3792.4	39685.8	783.3
MC-3	14199.9	3214.9	27234.4	725.7	569.4	237.8	523.8	81.8	13630.5	2977.1	26710.6	643.9
MC-4	5829.7	1354.8	12701.7	320.0	235.2	98.2	216.3	33.8	5594.5	1256.6	12485.4	286.2
MC-2a	7.9	1.9	33.0	0.2	0.0	0.0	0.0	0.0	7.9	1.9	33.0	0.2
MC-2b	2413.0	438.2	6715.9	99.4	45.1	18.8	41.5	6.5	2367.9	419.4	6674.4	92.9
Total	44334.7	9603.1	90336.2	2152.2	1589.7	663.9	1462.6	228.5	42745.0	8939.2	88873.6	1923.6

Proposed Conditions: 100 percent Nutrient Management Plan

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	2012.0	540.2	3391.2	133.8	231.9	96.9	213.4	33.3	1780.1	443.3	3177.8	100.4
MC-2	19872.3	4053.1	40260.0	873.0	1248.3	521.3	1148.4	179.4	18624.0	3531.8	39111.5	693.6
MC-3	14199.9	3214.9	27234.4	725.7	1138.7	475.6	1047.6	163.7	13061.1	2739.3	26186.8	562.0
MC-4	5829.7	1354.8	12701.7	320.0	470.3	196.4	432.7	67.6	5359.4	1158.4	12269.1	252.4
MC-2a	7.9	1.9	33.0	0.2	0.0	0.0	0.0	0.0	7.9	1.9	33.0	0.2
MC-2b	2413.0	438.2	6715.9	99.4	90.2	37.7	83.0	13.0	2322.8	400.6	6632.9	86.4
Total	44334.7	9603.1	90336.2	2152.2	3179.4	1327.9	2925.1	457.0	41155.3	8275.2	87411.1	1695.1

STEPL LOAD REDUCTION RESULTS FOR COVER CROP PRACTICES

Existing Conditions: 0 percent Cover Crop (see STEPL Loads for Existing Land Use: 2010 on page 4 of this Appendix)

Proposed Conditions: 50 percent Cover Crop

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	2012.0	540.2	3391.2	133.8	309.5	75.2	149.4	23.3	1702.5	464.9	3241.9	110.4
MC-2	19872.3	4053.1	40260.0	873.0	1665.8	405.0	803.9	125.6	18206.5	3648.1	39456.1	747.4
MC-3	14199.9	3214.9	27234.4	725.7	1519.6	369.4	733.3	114.6	12680.2	2845.5	26501.1	611.2
MC-4	5829.7	1354.8	12701.7	320.0	627.6	152.6	302.9	47.3	5202.1	1202.2	12398.9	272.7
MC-2a	7.9	1.9	33.0	0.2	0.0	0.0	0.0	0.0	7.9	1.9	33.0	0.2
MC-2b	2413.0	438.2	6715.9	99.4	120.4	29.3	58.1	9.1	2292.6	409.0	6657.8	90.3
Total	44334.7	9603.1	90336.2	2152.2	4242.9	1031.5	2047.6	319.9	40091.8	8571.6	88288.6	1832.2

STEPL LOAD REDUCTION RESULTS FOR EXISTING RIPARIAN BUFFERS, 75 FOOT RIPARIAN BUFFER EXPANSION AREAS, CONVERSION OF FARMED POTENTIAL RESTORABLE WETLANDS, AND CONVERSION OF FARMED STEEP SLOPES

Based upon discussions with Santina Wortman, U.S. Ecological Protection Agency (EPA), Tetra Tech staff, and, Peter Vincent and Ralph Reznick from the Michigan Department of Environmental Quality (DEQ), it was determined that we utilize the wetland BMP efficiency applied only to the converted cropland area approach. This approach uses the acres of cropland to be converted to wetland and applies a wetland detention BMP efficiency to calculate reductions.

To determine the load reductions from the existing riparian buffer areas, it was assumed that areas of buffer would be converted to either cropland, pasture, or urban land uses (Determination of land use was based on 2010 land use designations. Wetland and woodland land uses were assumed to be lost to cropland).

Table 2

STEPL BMP PRACTICES AND EFFICIENCIES USED IN THE MASON CREEK WATERSHED MODELLING

Conservation Practice	Acres (percent of total land area in watershed)	Acres (percent of total land area in watershed)	Efficiency				Data Source
			N	P	BOD	Sediment	
Existing Riparian Buffers	1,418 (26.9%)	1,418 (26.9%)	0.675	0.66	ND	0.625	MDA
75 foot buffer expansion areas	- -	25 (0.5%)	0.675	0.66	ND	0.625	MDA
Convert Currently Farmed Potentially Restorable Wetlands	- -	205 (3.9%)	0.675	0.66	ND	0.625	MDA
Convert Farmed Steep Slopes to Filter Strips	- -	125 (2.4%)	0.7	0.75	ND	0.65	STEPL
	Subtotal	1,773 (33.6%)					

Source: SEWRPC

Existing Conditions: Load Reductions from Existing Riparian Buffers (see Map B-1)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	193.0	53.3	395.7	31.4	125.3	33.8	125.7	19.6	67.8	19.5	270.0	11.8
MC-2	7638.4	2003.6	16387.7	1161.4	4968.3	1272.3	4643.8	725.9	2670.1	731.3	11743.9	435.5
MC-3	998.5	250.1	2224.8	142.6	650.7	158.9	569.9	89.1	347.8	91.2	1654.9	53.5
MC-4	665.4	177.1	1448.6	101.8	431.1	112.5	405.1	63.6	234.3	64.6	1043.5	38.2
MC-2a	50.0	13.8	102.6	8.1	32.5	8.8	32.6	5.1	17.6	5.1	70.0	3.1
MC-2b	307.2	80.0	684.8	45.4	199.1	50.8	180.6	28.4	108.1	29.1	504.2	17.0
Total	9852.5	2577.9	21244.3	1490.8	6406.8	1637.2	5957.7	931.8	3445.6	940.7	15286.5	559.1

Proposed Conditions: Additional Load Reductions for Installation of 75 Foot Width Riparian Buffers (see Map B-1)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	49.0	15.9	99.5	11.3	31.3	10.0	45.0	7.0	17.7	5.9	54.4	4.2
MC-2	118.5	36.0	253.7	25.0	76.0	22.7	100.0	15.6	42.5	13.3	153.7	9.4
MC-3	77.5	23.5	166.3	16.3	49.7	14.8	65.2	10.2	27.8	8.7	101.1	6.1
MC-4	9.7	1.9	39.9	0.5	6.5	1.3	1.4	0.3	3.2	0.7	38.5	0.2
MC-2a	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MC-2b	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	254.8	77.3	559.4	53.1	163.5	48.7	211.7	33.2	91.3	28.6	347.7	19.9

Proposed Conditions: Additional Load Reductions for Conversion of Currently Farmed Potentially Restorable Wetlands (see Map B-2)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	190.3	62.4	385.7	44.5	121.3	39.3	178.0	27.8	69.0	23.1	207.7	16.7
MC-2	1236.7	357.0	2695.5	239.8	796.4	225.3	959.2	149.9	440.3	131.7	1736.3	89.9
MC-3	671.1	212.5	1374.6	147.7	429.4	133.9	590.9	92.3	241.7	78.6	783.7	55.4
MC-4	88.4	29.4	178.9	21.2	56.3	18.5	84.8	13.2	32.1	10.9	94.1	7.9
MC-2a	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MC-2b	75.0	25.0	151.7	18.1	47.7	15.7	72.3	11.3	27.3	9.3	79.4	6.8
Total	2261.4	686.2	4786.4	471.3	1451.0	432.6	1885.1	294.6	810.4	253.6	2901.2	176.7

Proposed Conditions: Additional Load Reductions for Conversion of Currently Farmed Steep Slopes to Filter Strips (see Map B-2)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-1	257.0	83.8	521.1	59.5	170.4	55.5	247.3	38.6	86.6	28.3	273.7	20.8
MC-2	490.3	157.9	995.0	110.8	325.5	104.8	460.8	72.0	164.8	53.1	534.3	38.8
MC-3	332.6	107.9	674.5	76.2	220.6	71.5	317.1	49.5	112.0	36.4	357.4	26.7
MC-4	491.5	158.3	997.3	111.0	326.3	105.0	461.8	72.2	165.2	53.2	535.5	38.9
MC-2a	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MC-2b	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1571.4	507.9	3187.9	357.4	1042.8	336.9	1487.0	232.3	528.6	171.0	1700.9	125.1

STEPL LOAD REDUCTION RESULTS FOR CONCENTRATED FLOW DITCHES/GULLIES CONVERTED TO GRASSED WATERWAYS

Load Reductions from seven concentrated flow ditches/gullies that are proposed to be converted to grassed waterways were calculated with the STEPL Model Spreadsheet, which is the same as the Region 5 Model Spreadsheet. A BMP efficiency of 70 percent was used for the 7 concentrated flow ditches/gullies, as shown in the tables below. Both of these models estimate the annual tons of gross erosion as sediment delivered at the edge of field. Since this plan is looking at load reductions to the stream system, a delivery ratio needs to be applied.[3] Ephemeral gully delivery rates for an integrated (connected) system are typically 50 to 90 percent.[4] A delivery ratio of 70 percent was assumed for concentrated flow ditch load delivery to calculate actual loads delivered to Mason Creek, which was the same used for gully erosion in the Plum-Kankaput Plan.[5] Widths and depths of each concentrated flow ditch/gully along Mason Creek were determined from direct assessment by SEWRPC staff in the summer and fall of 2014. Total lineal feet of drainages was determined by GIS methods. Measurements were used for inputs into the STEPL model. The 'years to form' input was estimated to be one year. Locations of the concentrated flow ditches/gullies are located on Map B-3.

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[3]*Outagamie County Land Conservation Department,* Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds*, Appendix D. Region 5 Model Inputs for gully stabilization, 2014.*

[4]*Natural Resources Conservation Services (NRCS),* Erosion and Sediment Delivery. Field Office Technical Guide, *March 1998, http://efotg.sc.egov.usda.gov/references/public/IA/Erosion_and_sediment_delivery.pdf*

[5]*Outagamie County Land Conservation Department, 2014, Op. cit.*

Proposed Conditions: Total load reductions for proposed priority grassed waterways

1. Gully dimensions

Gully	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Length (ft)	Years to Form	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
Gully1	14	8	0.8	525	1	0.7	Silt Loam	0.0425	1	196.3500	137.4450
Gully2	10	8	0.6	434	1	0.7	Silt Loam	0.0425	1	99.6030	69.7221
Gully3	9.5	7	0.6	595	1	0.7	Organic	0.011	1.5	32.3978	22.6784
Gully4	13	7	1	1396	1	0.7	Organic	0.011	1.5	153.5600	107.4920
Gully5	8	6	1	610	1	0.7	Organic	0.011	1.5	46.9700	32.8790
Gully6	8	6	0.9	472	1	0.7	Organic	0.011	1.5	32.7096	22.8967
Gully7	8	6	0.8	360	1	0.7	Organic	0.011	1.5	22.1760	15.5232

Existing Load From Gullies					Existing Load Delivered to Stream (Accounting for 70% Delivery Ratio)				Load Reduction From BMP Installation (70% BMP Efficiency Applied)				Total Load Delivered to Stream After BMP Installation (70% BMP Efficiency Applied)			
Gully ID	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Load Delivered (no BMP)	P Load Delivered (no BMP)	BOD Load Delivered (no BMP)	Sediment Load Delivered (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
Gully1	314.2	121.0	628.3	196.4	219.9	84.7	439.8	137.4	153.9	59.3	307.9	96.2	66.0	25.4	131.9	41.2
Gully2	159.4	61.4	318.7	99.6	111.6	42.9	223.1	69.7	78.1	30.1	156.2	48.8	33.5	12.9	66.9	20.9
Gully3	77.8	29.9	155.5	32.4	54.4	21.0	108.9	22.7	38.1	14.7	76.2	15.9	16.3	6.3	32.7	6.8
Gully4	368.5	141.9	737.1	153.6	258.0	99.3	516.0	107.5	180.6	69.5	361.2	75.2	77.4	29.8	154.8	32.2
Gully5	112.7	43.4	225.5	47.0	78.9	30.4	157.8	32.9	55.2	21.3	110.5	23.0	23.7	9.1	47.3	9.9
Gully6	78.5	30.2	157.0	32.7	55.0	21.2	109.9	22.9	38.5	14.8	76.9	16.0	16.5	6.3	33.0	6.9
Gully7	53.2	20.5	106.4	22.2	37.3	14.3	74.5	15.5	26.1	10.0	52.2	10.9	11.2	4.3	22.4	4.7
Total	1164.3	448.2	2328.6	583.8	815.0	313.8	1630.0	408.6	570.5	219.6	1141.0	286.0	244.5	94.1	489.0	122.6

STEPL LOAD REDUCTION RESULTS FOR STREAMBANK RESTORATION PRACTICES

Total length, height, and severity of each eroding streambank site along Mason Creek were determined from direct assessment by SEWRPC staff in the summer and fall of 2014. Measurements were used for inputs into the STEPL model. The tables below indicate impaired streambank inputs as well as pollutant loads and load reductions. All of the streambank erosion sites are located on Map B-3. A BMP efficiency of 75 percent was used to calculate load reductions for these eroding sites.

2. Impaired streambank dimensions in the different watersheds

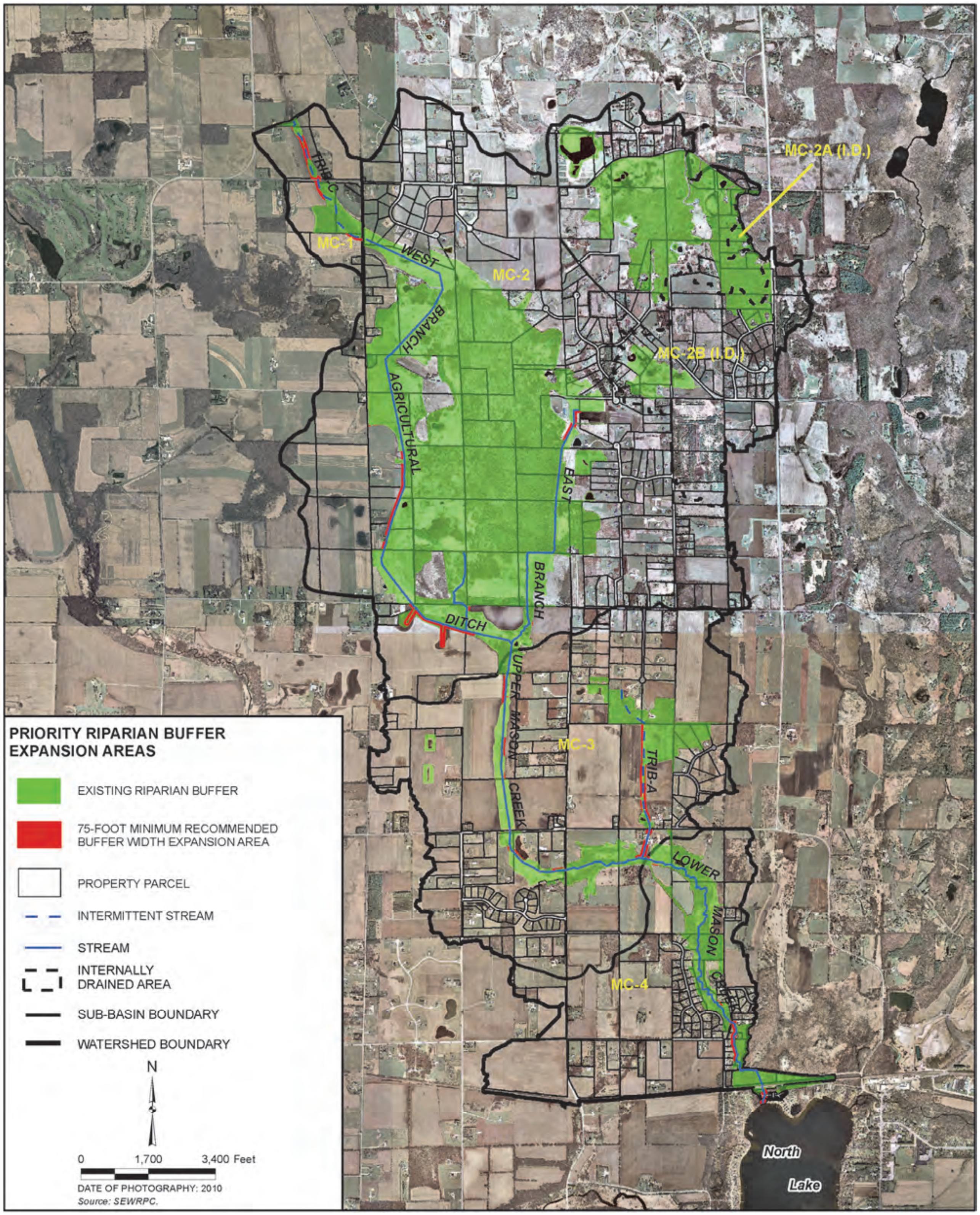
Subbasin	Strm Bank	Length (ft)	Height (ft)	Lateral Recession	Rate Range (ft/yr)	Rate (ft/yr)	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
MC-4	1	51.9	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.8602	0.6452
	2	58.8	2	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.6497	0.4873
	3	113.8	4	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	7.7384	5.8038
	4	58	2	1. Slight	0.01 - 0.05	0.03	0.75	Silt Loam	0.0425	1	0.1479	0.1109
	5	163	2	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.8012	1.3509
	6	52.1	2	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5757	0.4318
	7	240.3	2	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	2.6553	1.9915
	8	37	1	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2044	0.1533
	9	116.5	2	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.2873	0.9655
	10	60.6	2	1. Slight	0.01 - 0.05	0.03	0.75	Silt Loam	0.0425	1	0.1545	0.1159
	11	87.1	1	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4812	0.3609
	12	91.2	1.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.7558	0.5669
MC-3	13	49.6	1.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4111	0.3083
	14	65.6	1.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5437	0.4077
	15	88	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.4586	1.0940
	16	46.4	1.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3845	0.2884
	17	57	2	1. Slight	0.01 - 0.05	0.03	0.75	Silt Loam	0.0425	1	0.1454	0.1090
	18	38.4	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.6365	0.4774
MC-2	19	70.6	1	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3901	0.2925
	20	113.8	2	1. Slight	0.01 - 0.05	0.03	0.75	Silt Loam	0.0425	1	0.2902	0.2176
	21	55.9	1	1. Slight	0.01 - 0.05	0.03	0.75	Silt Loam	0.0425	1	0.0713	0.0535
	22	53.8	2	1. Slight	0.01 - 0.05	0.03	0.75	Organic	0.011	1.5	0.0355	0.0266
	23	160.6	1	3. Severe	0.3 - 0.5	0.4	0.75	Organic	0.011	1.5	0.7066	0.5300
	24	73.4	3	2. Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5	0.3149	0.2362
	25	31.6	2	2. Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5	0.0904	0.0678
	26	51.3	2	2. Moderate	0.06 - 0.2	0.13	0.75	Organic	0.011	1.5	0.1467	0.1100
	27	58.4	2.5	1. Slight	0.01 - 0.05	0.03	0.75	Silt Loam	0.0425	1	0.1862	0.1396
	28	24.7	2	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2729	0.2047

1. Total load by subwatershed(s)

Subbasin	Erosion ID	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
		lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
MC-4	1	1.4	0.5	2.8	0.9	1.0	0.4	2.1	0.6	0.3	0.1	0.7	0.2
	2	1.0	0.4	2.1	0.6	0.8	0.3	1.6	0.5	0.3	0.1	0.5	0.2
	3	12.4	4.8	24.8	7.7	9.3	3.6	18.6	5.8	3.1	1.2	6.2	1.9
	4	0.2	0.1	0.5	0.1	0.2	0.1	0.4	0.1	0.1	0.0	0.1	0.0
	5	2.9	1.1	5.8	1.8	2.2	0.8	4.3	1.4	0.7	0.3	1.4	0.5
	6	0.9	0.4	1.8	0.6	0.7	0.3	1.4	0.4	0.2	0.1	0.5	0.1
	7	4.2	1.6	8.5	2.7	3.2	1.2	6.4	2.0	1.1	0.4	2.1	0.7
	8	0.3	0.1	0.7	0.2	0.2	0.1	0.5	0.2	0.1	0.0	0.2	0.1
	9	2.1	0.8	4.1	1.3	1.5	0.6	3.1	1.0	0.5	0.2	1.0	0.3
	10	0.2	0.1	0.5	0.2	0.2	0.1	0.4	0.1	0.1	0.0	0.1	0.0
	11	0.8	0.3	1.5	0.5	0.6	0.2	1.2	0.4	0.2	0.1	0.4	0.1
	12	1.2	0.5	2.4	0.8	0.9	0.3	1.8	0.6	0.3	0.1	0.6	0.2
MC-3	13	0.7	0.3	1.3	0.4	0.5	0.2	1.0	0.3	0.2	0.1	0.3	0.1
	14	0.9	0.3	1.7	0.5	0.7	0.3	1.3	0.4	0.2	0.1	0.4	0.1
	15	2.3	0.9	4.7	1.5	1.8	0.7	3.5	1.1	0.6	0.2	1.2	0.4
	16	0.6	0.2	1.2	0.4	0.5	0.2	0.9	0.3	0.2	0.1	0.3	0.1
	17	0.2	0.1	0.5	0.1	0.2	0.1	0.3	0.1	0.1	0.0	0.1	0.0
	18	1.0	0.4	2.0	0.6	0.8	0.3	1.5	0.5	0.3	0.1	0.5	0.2
MC-2	19	0.6	0.2	1.2	0.4	0.5	0.2	0.9	0.3	0.2	0.1	0.3	0.1
	20	0.5	0.2	0.9	0.3	0.3	0.1	0.7	0.2	0.1	0.0	0.2	0.1
	21	0.1	0.0	0.2	0.1	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.0
	22	0.1	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	23	1.7	0.7	3.4	0.7	1.3	0.5	2.5	0.5	0.4	0.2	0.8	0.2
	24	0.8	0.3	1.5	0.3	0.6	0.2	1.1	0.2	0.2	0.1	0.4	0.1
	25	0.2	0.1	0.4	0.1	0.2	0.1	0.3	0.1	0.1	0.0	0.1	0.0
	26	0.4	0.1	0.7	0.1	0.3	0.1	0.5	0.1	0.1	0.0	0.2	0.0
	27	0.3	0.1	0.6	0.2	0.2	0.1	0.4	0.1	0.1	0.0	0.1	0.0
	28	0.4	0.2	0.9	0.3	0.3	0.1	0.7	0.2	0.1	0.0	0.2	0.1
Total		38.5	14.8	76.9	23.4	28.9	11.1	57.7	17.5	9.6	3.7	19.2	5.8

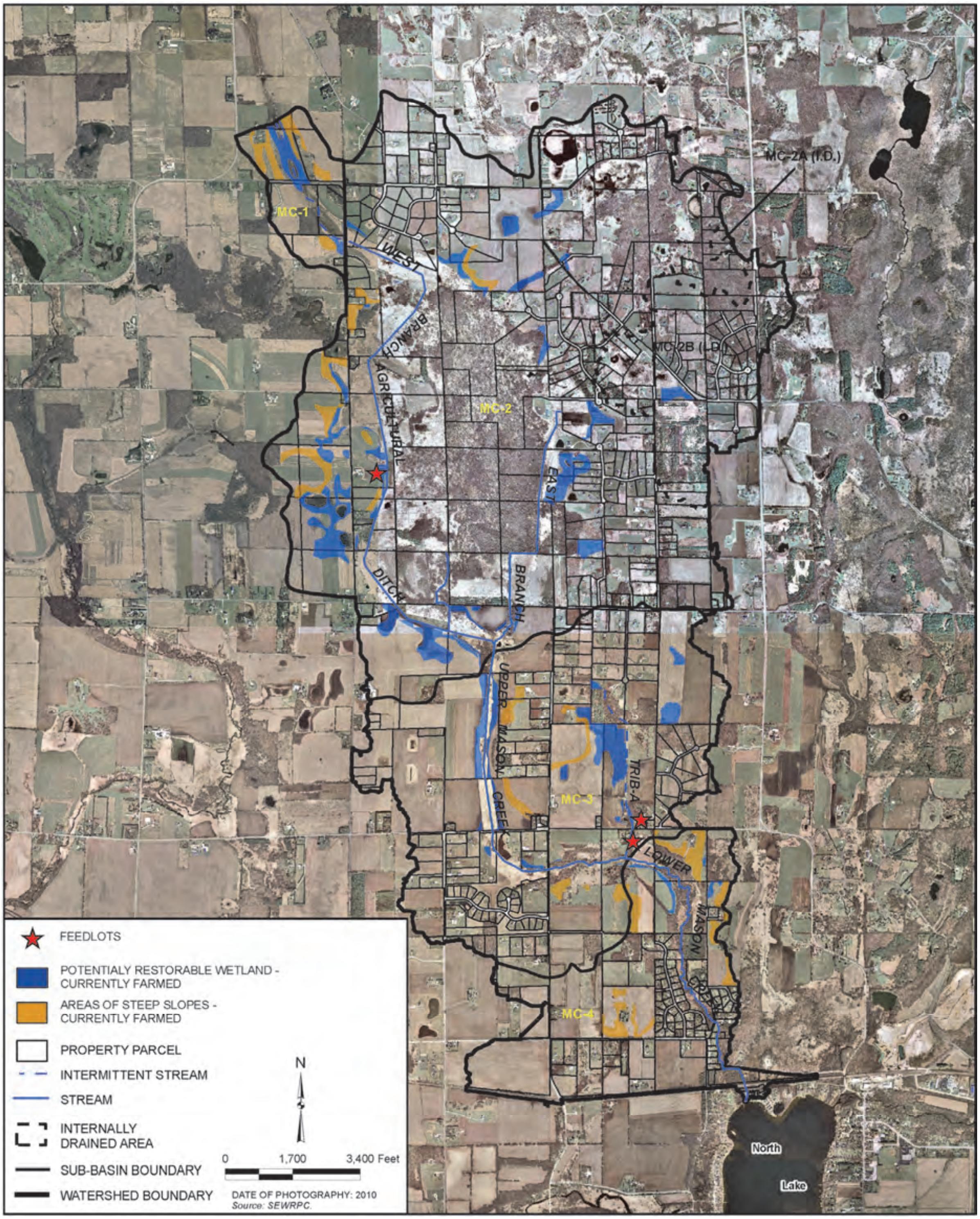
Map B-1

EXISTING RIPARIAN BUFFERS AND 75-FOOT BUFFER EXPANSION AREAS WITHIN MASON CREEK: 2014



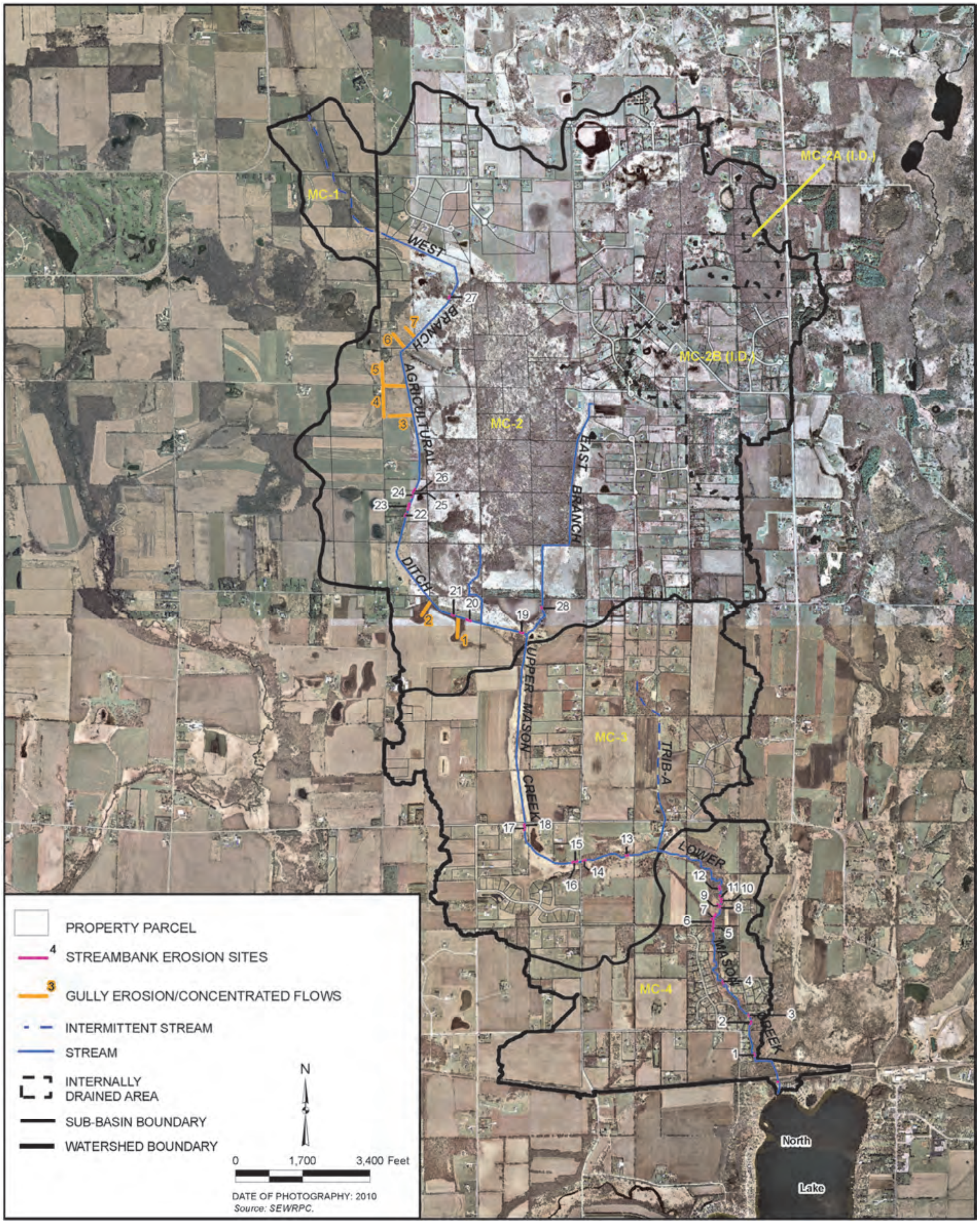
Map B-2

POTENTIALLY RESTORABLE WETLANDS AND STEEP SLOPES THAT ARE CURRENTLY FARMED WITHIN THE MASON CREEK WATERSHED: 2014



Map B-3

BANK EROSION SITES AND CONCENTRATED FLOW DITCHES ALONG MASON CREEK: 2014



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SEWRPC Community Assistance Planning Report No. 321

MASON CREEK WATERSHED
PROTECTION PLAN

Appendix C

SEWRPC RIPARIAN BUFFER GUIDE NO. 1
"MANAGING THE WATER'S EDGE"

PRELIMINARY DRAFT

Managing the Water's Edge

Making Natural Connections

Problem Statement:

Despite significant research related to buffers, there remains no consensus as to what constitutes optimal riparian buffer design or proper buffer width for effective pollutant removal, water quality protection, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental corridors, augmentation of stream baseflow, and water temperature moderation.

Southeastern Wisconsin Regional Planning Commission

Our purpose in this document is to help protect and restore water quality, wildlife, recreational opportunities, and scenic beauty.

This material was prepared in part with funding from the U.S. Environmental Protection Agency Great Lakes National Program Office provided through CMAP, the Chicago Metropolitan Agency for Planning.

Introduction

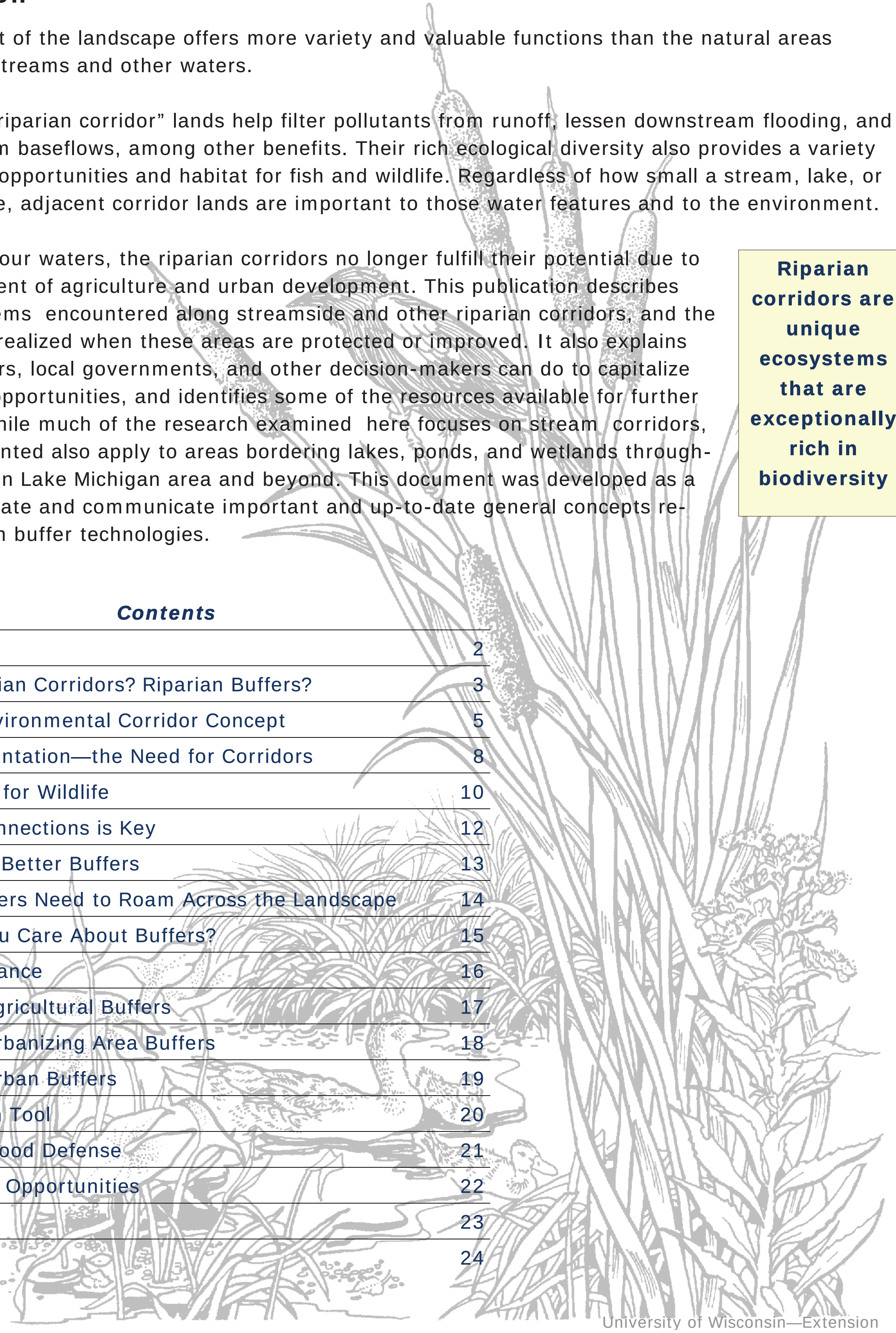
Perhaps no part of the landscape offers more variety and valuable functions than the natural areas bordering our streams and other waters.

These unique "riparian corridor" lands help filter pollutants from runoff, lessen downstream flooding, and maintain stream baseflows, among other benefits. Their rich ecological diversity also provides a variety of recreational opportunities and habitat for fish and wildlife. Regardless of how small a stream, lake, or wetland may be, adjacent corridor lands are important to those water features and to the environment.

Along many of our waters, the riparian corridors no longer fulfill their potential due to the encroachment of agriculture and urban development. This publication describes common problems encountered along streamside and other riparian corridors, and the many benefits realized when these areas are protected or improved. It also explains what landowners, local governments, and other decision-makers can do to capitalize on waterfront opportunities, and identifies some of the resources available for further information. While much of the research examined here focuses on stream corridors, the ideas presented also apply to areas bordering lakes, ponds, and wetlands throughout the southern Lake Michigan area and beyond. This document was developed as a means to facilitate and communicate important and up-to-date general concepts related to riparian buffer technologies.

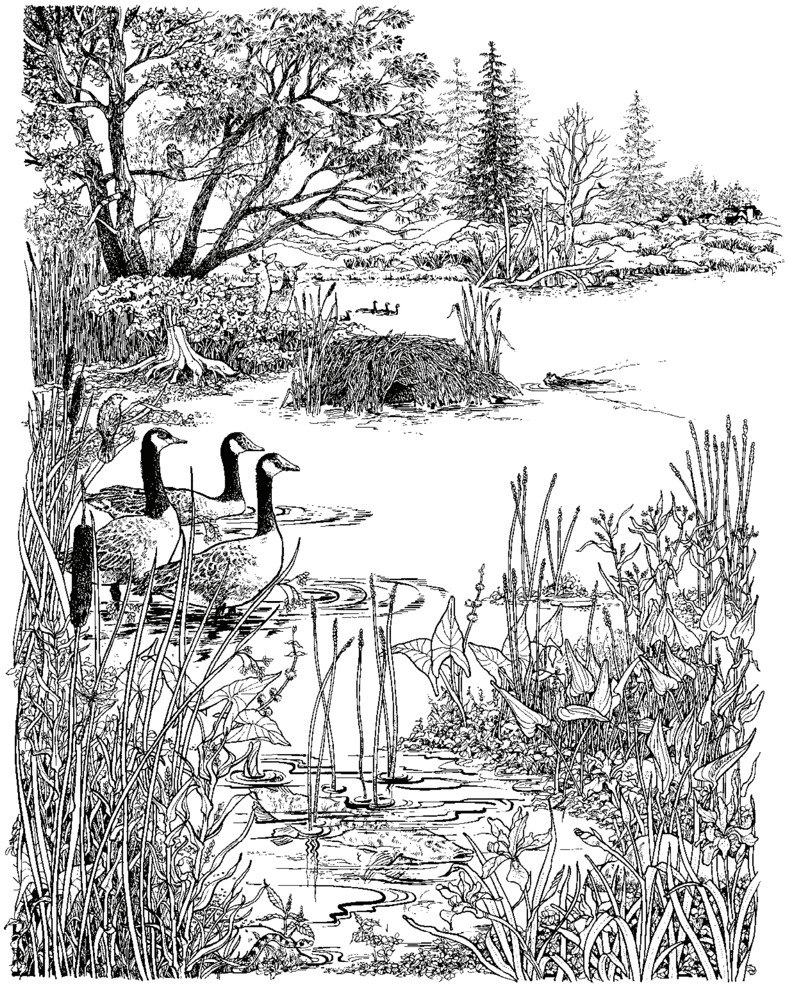
Riparian corridors are unique ecosystems that are exceptionally rich in biodiversity

Contents



What Are Riparian Corridors? Riparian Buffer Zones?

The word riparian comes from the Latin word *ripa*, which means bank. However, in this document we use riparian in a much broader sense and refer to land adjoining any water body including ponds, lakes, streams, and wetlands. This term has two additional distinct meanings that refer to 1) the "natural or relatively undisturbed" corridor lands adjacent to a water body inclusive of both wetland and upland flora and fauna and 2) a buffer zone or corridor lands in need of protection to "buffer" the effects of human impacts such as agriculture and residential development.


University of Wisconsin—Extension

The word buffer literally means something that cushions against the shock of something else (noun), or to lessen or cushion that shock (verb). Other useful definitions reveal that a buffer can be something that serves to separate features, or that is capable of neutralizing something, like filtering pollutants from stormwater runoff. Essentially, buffers and buffering help protect against adverse effects.

Riparian buffer zones function as core habitat as well as travel corridors for many wildlife species.

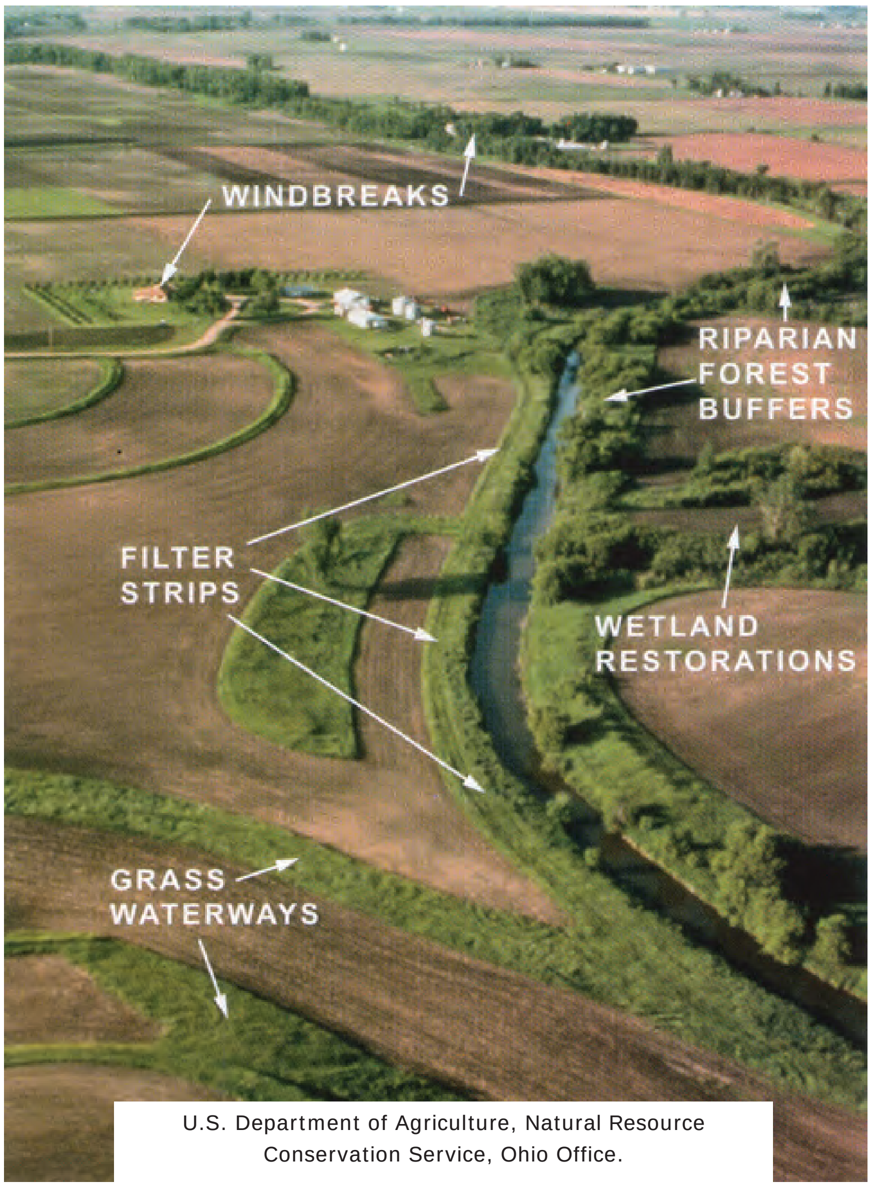
Riparian buffers are zones adjacent to waterbodies such as lakes, rivers, and wetlands that simultaneously protect water quality and wildlife, including both aquatic and terrestrial habitat. These zones minimize the impacts of human activities on the landscape and contribute to recreation, aesthetics, and quality of life. **This document summarizes how to maximize both water quality protection and conservation of aquatic and terrestrial wildlife populations using buffers.**

What Are Riparian Corridors? Riparian Buffer Zones?

Buffers **can** include a range of complex vegetation structure, soils, food sources, cover, and water features that offer a variety of habitats contributing to diversity and abundance of wildlife such as mammals, frogs, amphibians, insects, and birds. Buffers can consist of a variety of canopy layers and cover types including ephemeral (temporary-wet for only part of year) wetlands/seasonal ponds/spring pools, shallow marshes, deep marshes, wetland meadows, wetland mixed forests, grasslands, shrubs, forests, and/or prairies. Riparian zones are areas of transition between aquatic and terrestrial ecosystems, and they can potentially offer numerous benefits to wildlife and people such as pollution reduction and recreation.

In the water resources literature, riparian buffers are referred to in a number of different ways. Depending on the focus and the intended function of a buffer, or a buffer-related feature, buffers may be referred to as stream corridors, critical transition zones, riparian management areas, riparian management zones, floodplains, or green infrastructure.

It is important to note that within an agricultural context, the term buffer is used more generally to describe filtering best management practices most often at the water's edge. Other practices which can be interrelated may also sometimes be called buffers. These include grassed waterways, contour buffer strips, wind breaks, field border, shelterbelts, windbreaks, living snow fence, or filter strips. These practices may or may not be adjacent to a waterway as illustrated in the photo to the right. For example, a grassed waterway is designed to filter sediment and reduce erosion and may connect to a riparian buffer. These more limited-purpose practices may link to multipurpose buffers, but by themselves, they are not adequate to provide the multiple functions of a riparian buffer as defined here.



U.S. Department of Agriculture, Natural Resource Conservation Service, Ohio Office.

Beyond the Environmental Corridor Concept

The term "environmental corridors" (also known as "green infrastructure") refers to an inter-connected green space network of natural areas and features, public lands, and other open spaces that provide natural resource value. Environmental corridor planning is a process that promotes a systematic and strategic approach to land conservation and encourages land use planning and practices that are good for both nature and people. It provides a framework to guide future growth, land development, and land conservation decisions in appropriate areas to protect both community and natural resource assets.

Environmental corridors are an essential planning tool for protecting the most important remaining natural resource features in Southeastern Wisconsin and elsewhere. Since development of the environmental corridor concept, there have been significant advancements in landscape ecology that have furthered understanding of the spatial and habitat needs of multiple groups of organisms. In addition, advancements in pollutant removal practices, stormwater control, and agriculture have increased our understanding of the effectiveness and limitations of environmental corridors. In protecting water quality and providing aquatic and terrestrial habitat, there is a need to better integrate new technologies through their application within riparian buffers.

SEWRPC has embraced and applied the environmental corridor concept developed by Philip Lewis (Professor Emeritus of Landscape Architecture at the University of Wisconsin-Madison) since 1966 with the publication of its first regional land use plan. Since then, SEWRPC has refined and detailed the mapping of environmental corridors, enabling the corridors to be incorporated directly into regional, county, and community plans and to be reflected in regulatory measures. The preservation of environmental corridors remains one of the most important recommendations of the regional plan. Corridor preservation has now been embraced by numerous county and local units of government as well as by State and Federal agencies. The environmental corridor concept conceived by Lewis has become an important part of the planning and development culture in Southeastern Wisconsin.

Beyond the Environmental Corridor Concept

Environmental corridors are divided into the following three categories.

- **Primary environmental corridors** contain concentrations of our most significant natural resources. They are at least 400 acres in size, at least two miles long, and at least 200 feet wide.

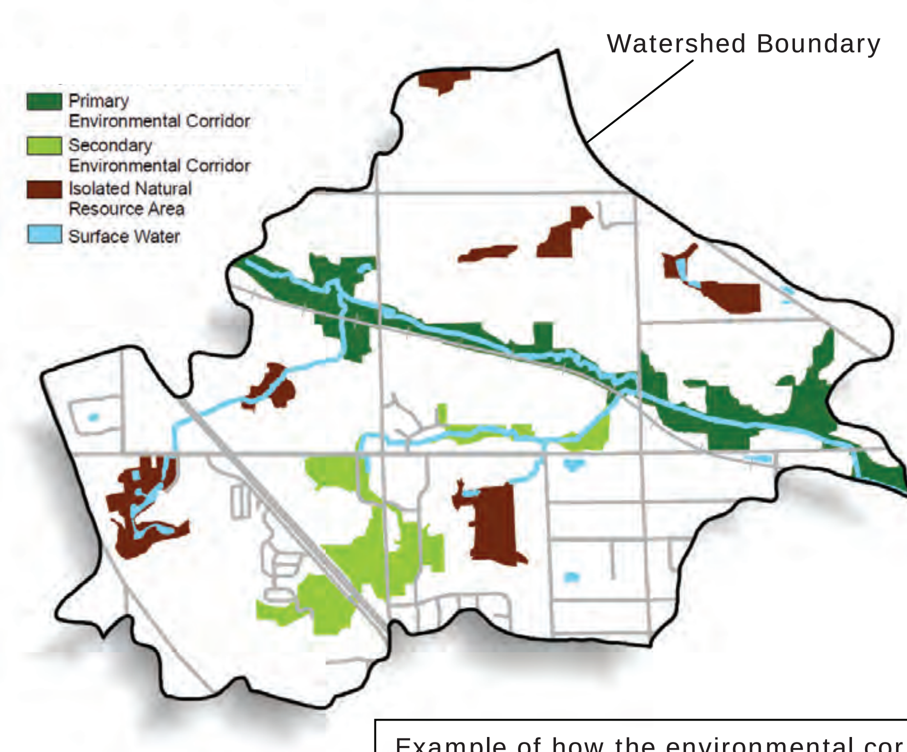
- **Secondary environmental corridors** contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and at least one mile long, unless serving to link primary corridors.

- **Isolated natural resource areas** contain significant remaining resources that are not connected to environmental corridors. They are at least five acres in size and at least 200 feet wide.

Key Features of Environmental Corridors

- Lakes, rivers, and streams
- Undeveloped shorelands and floodlands
- Wetlands
- Woodlands
- Prairie remnants
- Wildlife habitat
- Rugged terrain and steep slopes
- Unique landforms or geological formations
- Unfarmed poorly drained and organic soils
- Existing outdoor recreation sites
- Potential outdoor recreation sites
- Significant open spaces
- Historical sites and structures
- Outstanding scenic areas and vistas

Beyond the Environmental Corridor Concept

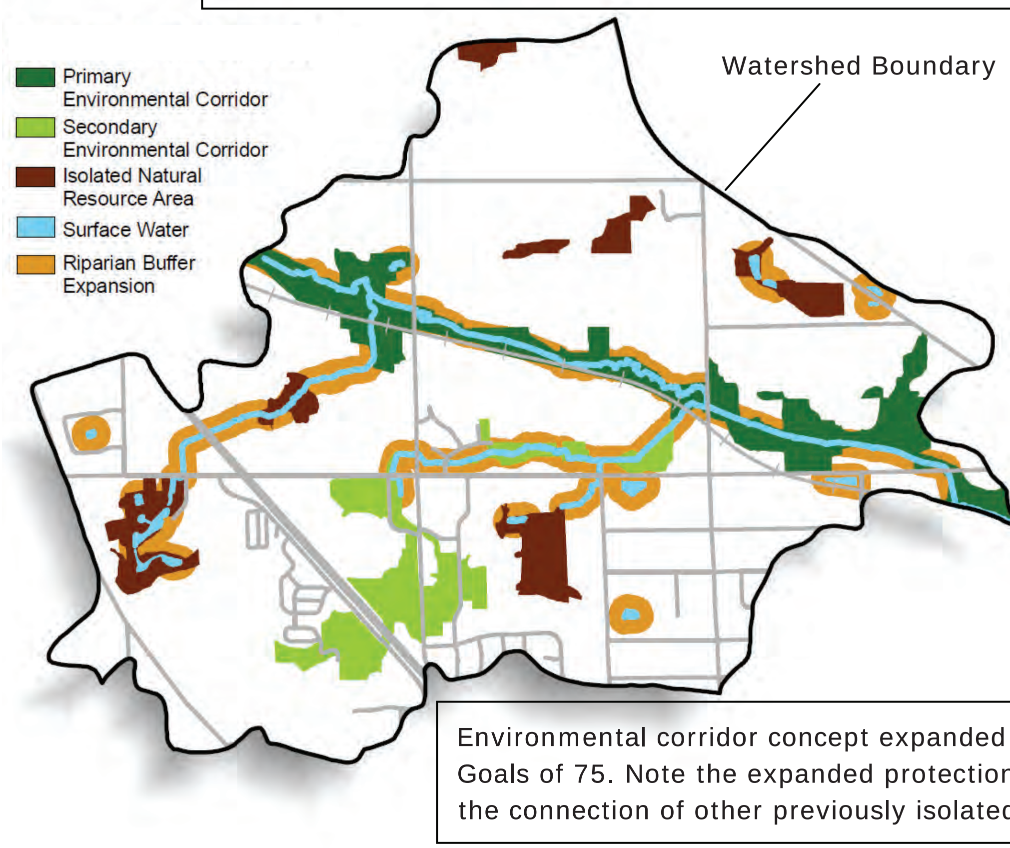


The Minimum Goals of **75** within a Watershed

75% minimum of total stream length should be naturally vegetated to protect the functional integrity of the water resources. (Environment Canada, How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Great lakes Areas of Concern, Second Edition, 2004)

75 foot wide minimum riparian buffers from the top edge of each stream bank should be naturally vegetated to protect water quality and wildlife. (SEWRPC Planning Report No 50, A Regional Water Quality Management Plan for the Greater Milwaukee Watersheds, December 2007)

Example of how the environmental corridor concept is applied on the landscape. For more information see "Plan on It!" series **Environmental Corridors: Lifelines of the Natural Resource Base** at http://www.sewrpc.org/SEWRPC/LandUse/EnvironmentalCorridors.htm



Environmental corridor concept expanded to achieve the Goals of 75. Note the expanded protection in addition to the connection of other previously isolated areas.

Habitat Fragmentation—The Need for Corridors

Southeastern Wisconsin is a complex mosaic of agricultural and urban development. Agricultural lands originally dominated the landscape and remain a major land use. However, such lands continue to be converted to urban uses. Both of these dominant land uses fragment the landscape by creating islands or isolated pockets of wetland, woodland, and other natural lands available for wildlife preservation and recreation. By recognizing this fragmentation of the landscape, we can begin to mitigate these impacts.

New developments should incorporate water quality and wildlife enhancement or improvement objectives as design criteria by looking at the potential for creating linkages with adjoining lands and water features.

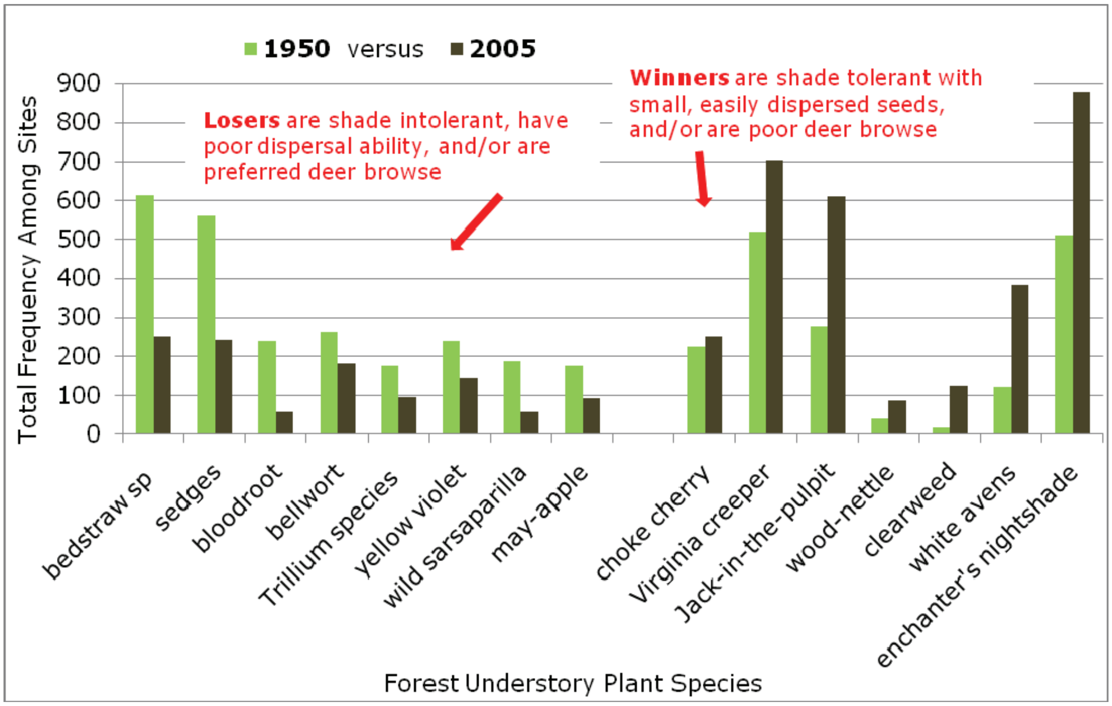
At the time of conversion of agricultural lands to urban uses, there are opportunities to re-create and expand riparian buffers and environmental corridors reconnecting uplands and waterways and restoring ecological integrity and scenic beauty locally and regionally. For example, placement of roads and other infrastructure across stream systems could be limited so as to maximize continuity of the riparian buffers. This can translate into significant cost savings in terms of reduced road maintenance, reduced salt application, and limited bridge or culvert maintenance and replacements. This simple practice not only saves the community significant amounts of money, but also improves and protects quality of life. Where necessary road crossings do occur, they can be designed to provide for safe fish and wildlife passage.

Overland travel routes for wildlife are often unavailable, discontinuous, or life endangering within the highly fragmented landscapes of Southeastern Wisconsin and elsewhere.

State Threatened Species: Blanding's turtle

Habitat Fragmentation—The Need for Corridors

Forest understory plant species abundance among stands throughout Southern Wisconsin



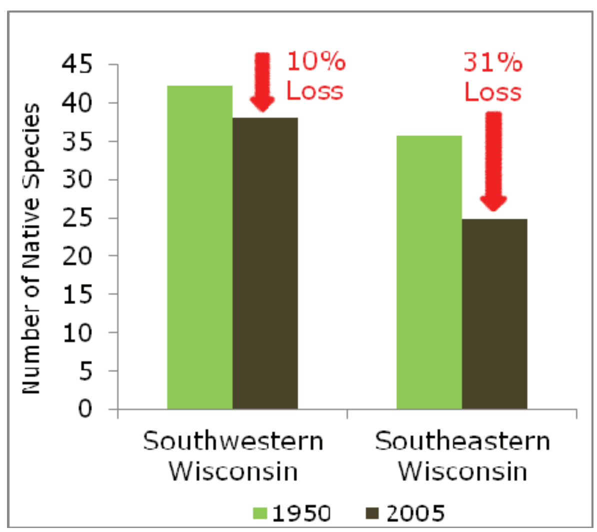
Forest fragmentation has led to significant plant species loss within Southern Wisconsin

(Adapted from David Rogers and others, 2008, Shifts in Southern Wisconsin Forest Canopy and Understory Richness, Composition, and Heterogeneity, Ecology, 89 (9): 2482-2492)

"...these results confirm the idea that large intact habitat patches and landscapes better sustain native species diversity. It also shows that people are a really important part of the system and their actions play an increasingly important role in shaping patterns of native species diversity and community composition. Put together, it is clear that one of the best and most cost effective actions we can take toward safeguarding native diversity of all types is to protect, enhance and create corridors that link patches of natural habitat."
Dr. David Rogers, Professor of Biology at the University of Wisconsin-Parkside

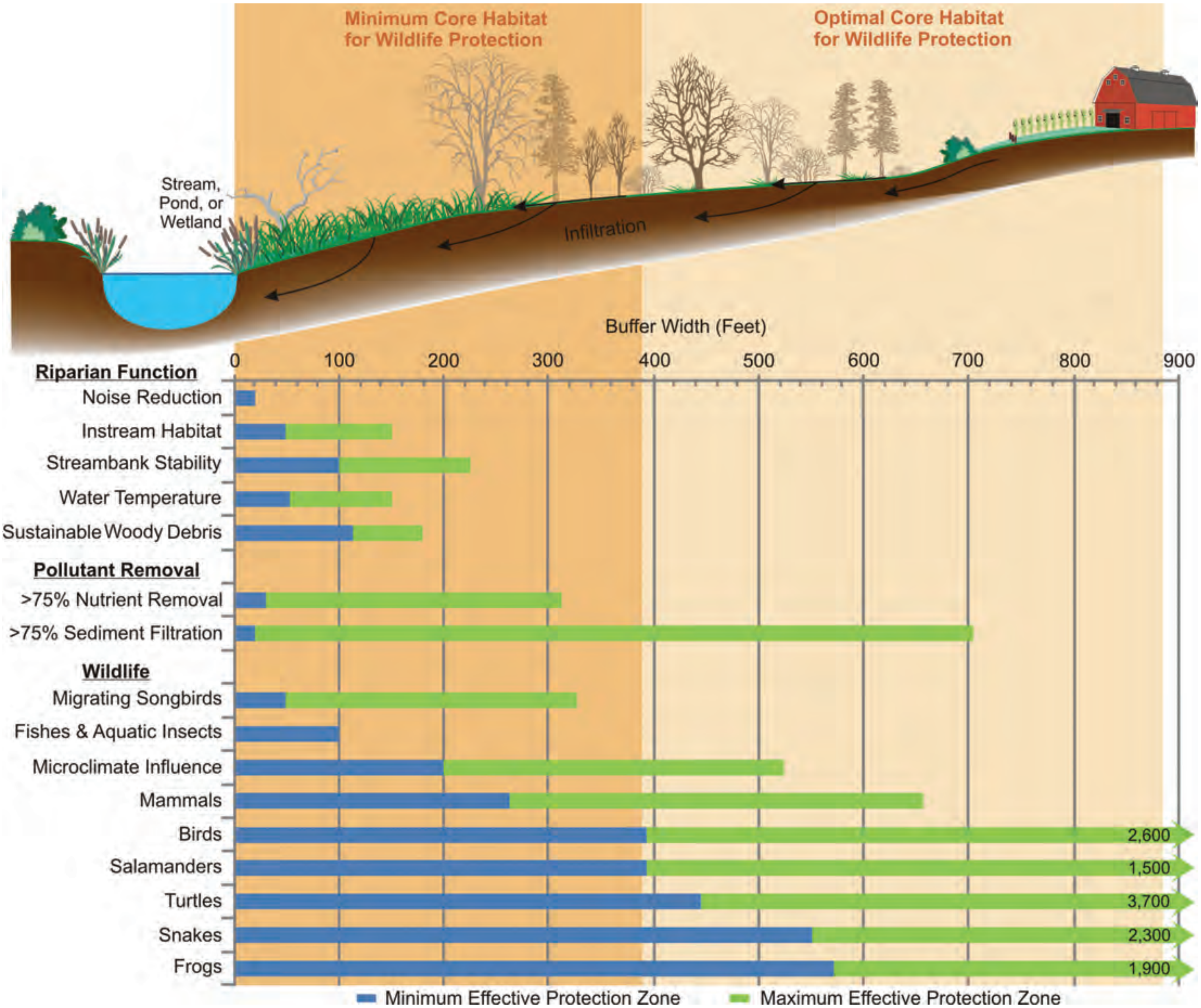
Since the 1950s, forests have increasingly become more fragmented by land development, both agricultural and urban, and associated roads and infrastructure, which have caused these forests to become isolated "islands of green" on the landscape. In particular, there has been significant loss of forest understory plant species over time (shrubs, grasses, and herbs covering the forest floor.) It is important to note that **these forests lost species diversity even when they were protected as parks or natural areas**.

One major factor responsible for this decline in forest plant diversity is that routes for native plants to re-colonize isolated forest islands are largely cut-off within fragmented landscapes. For example, the less fragmented landscapes in Southwestern Wisconsin lost fewer species than the more fragmented stands in Southeastern Wisconsin. In addition, the larger-sized forests and forests with greater connections to surrounding forest lands lost fewer species than smaller forests in fragmented landscapes.



Wider is Better for Wildlife

Why? Because buffer size is the engine that drives important natural functions like food availability and quality, access to water, habitat variety, protection from predators, reproductive or resting areas, corridors to safely move when necessary, and help in maintaining the health of species' gene pools to prevent isolation and perhaps extinction.



One riparian buffer size does not fit all conditions or needs. There are many riparian buffer functions and the ability to effectively fulfill those functions is largely dependent on width. Determining what buffer widths are needed should be based on what functions are desired as well as site conditions. For example, as shown above, water temperature protection generally does not require as wide a buffer as provision of habitat for wildlife. Based on the needs of wildlife species found in Wisconsin, the minimum core habitat buffer width is about 400 feet and the optimal width for sustaining the majority of wildlife species is about 900 feet. Hence, the value of large undisturbed parcels along waterways which are part of, and linked to, an environmental corridor system. The minimum effective buffer width distances are based on data reported in the scientific literature and the quality of available habitats within the context of those studies.

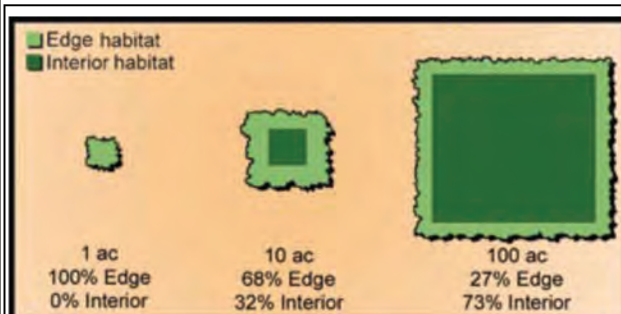
Wider is Better for Wildlife

Wildlife habitat needs change within and among species. **Minimum Core Habitat and Optimum Core Habitat distances were developed from numerous studies to help provide guidance for biologically meaningful buffers to conserve wildlife biodiversity.** These studies documented distances needed for a variety of biological (life history) needs to sustain healthy populations such as breeding, nesting, rearing young, foraging/feeding, perching (for birds), basking (for turtles), and overwintering/dormancy/hibernating. These life history needs require different types of habitat and distances from water, for example, one study found that Blanding's turtles needed approximately 60-foot-wide buffers for basking, 375 feet for overwintering, and up to 1,200 feet for nesting to bury their clutches of eggs. Some species of birds like the Blacked-capped chickadee or white breasted nuthatch only need about 50 feet of buffer, while others like the wood duck or great blue heron require 700-800 feet for nesting. Therefore, **understanding habitat needs for wildlife species is an important consideration in designing riparian buffers.**

Although *Ambystoma* salamanders require standing water for egg laying and juvenile development, most other times of the year they can be found more than 400 feet from water foraging for food.

Wisconsin Species	Mimimum Core Habitat (feet)	Optimum Core Habitat (feet)	Number of Studies
Frogs	571	1,043	9
Salamanders	394	705	14
Snakes	551	997	5
Turtles	446	889	27
Birds	394	787	45
Mammals	263	No data	11
Fishes and Aquatic Insects	100	No data	11
Mean	388	885	

This approach was adapted from *R.D. Semlitsch and J.R. Bodie, 2003, Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibian and Reptiles, Conservation Biology, 17(5):1219-1228*. These values are based upon studies examining species found in Wisconsin and represent mean linear distances extending outward from the edge of an aquatic habitat. The Minimum Core Habitat and Optimum Core Habitat reported values are based upon the mean minimum and mean maximum distances recorded, respectively. Due to a low number of studies for snake species, the recommended distances for snakes are based upon values reported by *Semlitsch and Bodie.*



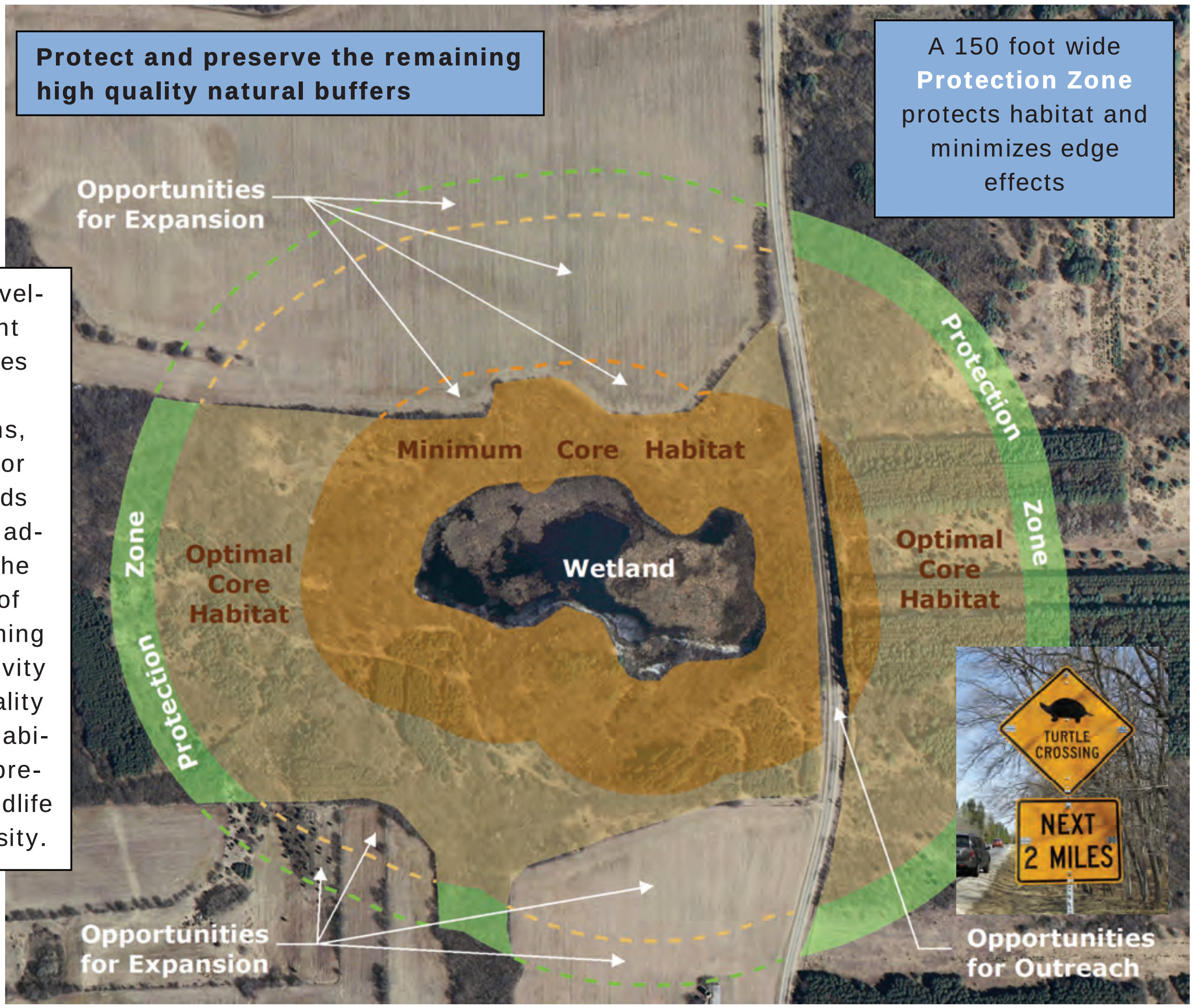
*"**Large patches typically conserve a greater variety and quality of habitats, resulting in higher species diversity and abundance.**" Larger patches contain greater amounts of interior habitat and less edge effects, which benefits interior species, by providing safety from parasitism, disease, and invasive species.*

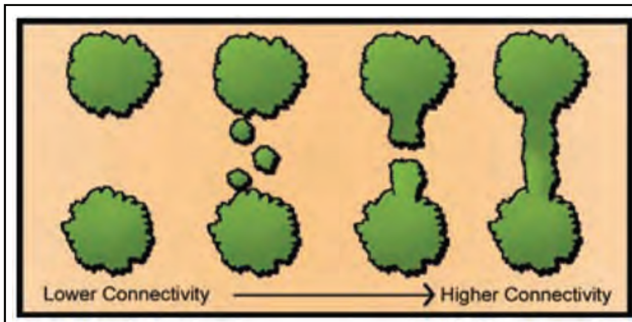
(Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station)

Maintaining Connections is Key

Like humans, all forms of wildlife require access to clean water. Emerging research has increasingly shown that, in addition to water, more and more species such as amphibians and reptiles cannot persist without landscape connectivity between quality wetland and upland habitats. Good connectivity to upland terrestrial habitats is essential for the persistence of healthy sustainable populations, because these areas provide vital feeding, overwintering, and nesting habitats found nowhere else. Therefore, both aquatic and terrestrial habitats are essential for the preservation of biodiversity and they should ideally be managed together as a unit.

Land development practices near streams, lakes, or wetlands need to address the issue of maintaining connectivity with quality upland habitats to preserve wildlife biodiversity.



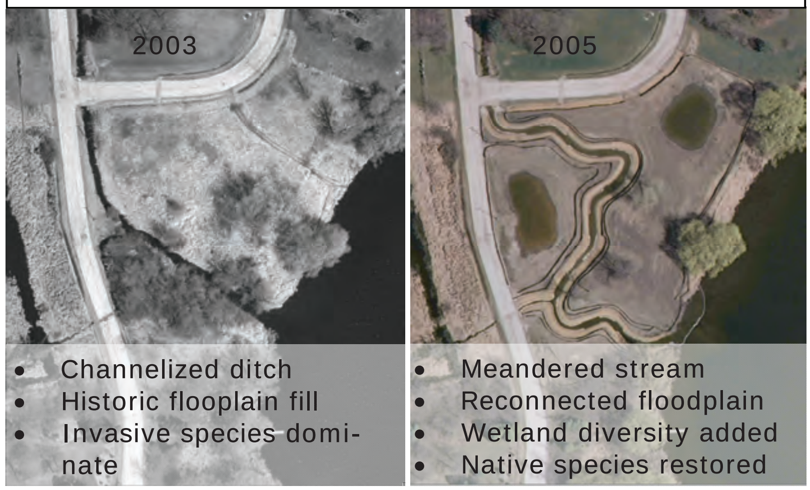


Increasing connectivity among quality natural landscapes (wetlands, woodlands, prairies) can benefit biodiversity by providing access to other areas of habitat, increasing gene flow and population viability, enabling recolonization of patches, and providing habitat (Bentrup 2008).

Basic Rules to Better Buffers

Protecting the integrity of native species in the region is an objective shared by many communities. The natural environment is an essential component of our existence and contributes to defining our communities and neighborhoods. Conservation design and open space development patterns in urbanizing areas and farm conservation programs in rural areas have begun to address the importance of maintaining and restoring riparian buffers and connectivity among corridors.

There are opportunities to improve buffer functions to improve water quality and wildlife habitat, even in urban situations

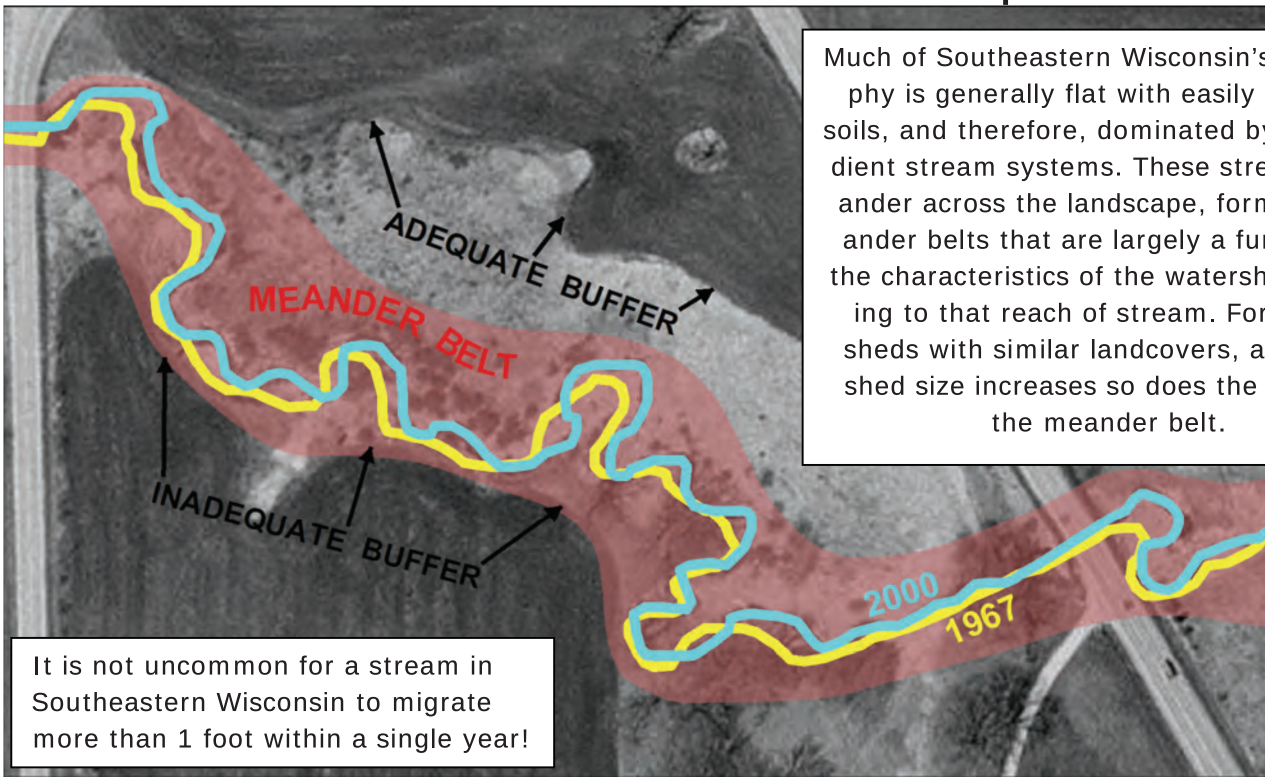


How wide should the buffer be? Unfortunately, there is no one-size-fits all buffer width adequate to protect water quality, wildlife habitat, and human needs. Therefore, the answer to this question depends upon the predetermined needs of the landowner and community objectives or goals.
As riparian corridors become very wide, their pollutant removal (buffering) effectiveness may reach a point of diminishing returns compared to the investment involved. However, the prospects for species diversity in the corridor keep increasing with buffer width. For a number of reasons, 400- to 800-foot-wide buffers are not practical along all lakes, streams, and wetlands within Southeastern Wisconsin. Therefore, communities should develop guidelines that remain flexible to site-specific needs to achieve the most benefits for water resources and wildlife as is practical.

Key considerations to better buffers/corridors:

- Wider buffers are better than narrow buffers for water quality and wildlife functions
- Continuous corridors are better than fragmented corridors for wildlife
- Natural linkages should be maintained or restored
- Linkages should not stop at political boundaries
- Two or more corridor linkages are better than one
- Structurally diverse corridors (e.g., diverse plant structure or community types, upland and wetland complexes, soil types, topography, and surficial geology) are better than corridors with simple structures
- Both local and regional spatial and temporal scales should be considered in establishing buffers
- Corridors should be located along dispersal and migration routes
- Corridors should be located and expanded around rare, threatened, or endangered species
- Quality habitat should be provided in a buffer whenever possible
- Disturbance (e.g. excavation or clear cutting vegetation) of corridors should be minimized during adjacent land use development
- Native species diversity should be promoted through plantings and active management
- Non-native species invasions should be actively managed by applying practices to preserve native species
- Fragmentation of corridors should be reduced by limiting the number of crossings of a creek or river where appropriate
- Restoration or rehabilitation of hydrological function, streambank stability, instream habitat, and/or floodplain connectivity should be considered within corridors.
- Restoration or retrofitting of road and railway crossings promotes passage of aquatic organisms

Creeks and Rivers Need to Roam Across the Landscape



Much of Southeastern Wisconsin's topography is generally flat with easily erodible soils, and therefore, dominated by low gradient stream systems. These streams meander across the landscape, forming meander belts that are largely a function of the characteristics of the watershed draining to that reach of stream. For watersheds with similar landcovers, as watershed size increases so does the width of the meander belt.

It is not uncommon for a stream in Southeastern Wisconsin to migrate more than 1 foot within a single year!

Healthy streams naturally meander or migrate across a landscape over time. Streams are transport systems for water and sediment and are continually eroding and depositing sediments, which causes the stream to migrate. When the amount of sediment load coming into a stream is equal to what is being transported downstream—and stream widths, depths, and length remain consistent over time—it is common to refer to that stream as being in a state of **"dynamic equilibrium."** In other words the stream retains its physical dimensions (equilibrium), but those physical features are shifted, or migrate, over time (dynamic).

Room to Roam

Riparian buffer widths should take into account the amount of area that a stream needs to be able to self-adjust and maintain itself in a state of dynamic equilibrium. … These are generally greater than any minimum width needed to protect for pollutant removal alone.

Streams are highly sensitive, and they respond to changes in the amounts of water and sediment draining to them, which are affected by changing land use conditions. For example, streams can respond to increased discharges of water by increased scour (erosion) of bed and banks that leads to an increase in stream width and depth—or "degradation." Conversely, streams can respond to increased sedimentation (deposition) that leads to a decrease in channel width and depth—or "aggradation."

Why Should You Care About Buffers?

Economic Benefits:

- Increased value of riparian property
- Reduced lawn mowing time and expense
- Increased shade to reduce building cooling costs
- Natural flood mitigation protection for structures or crops
- Pollution mitigation (reduced nutrient and contaminant loading)
- Increased infiltration and groundwater recharge
- Prevented loss of property (land or structures) through erosion
- Greater human and ecological health through biodiversity

Recreational Benefits:

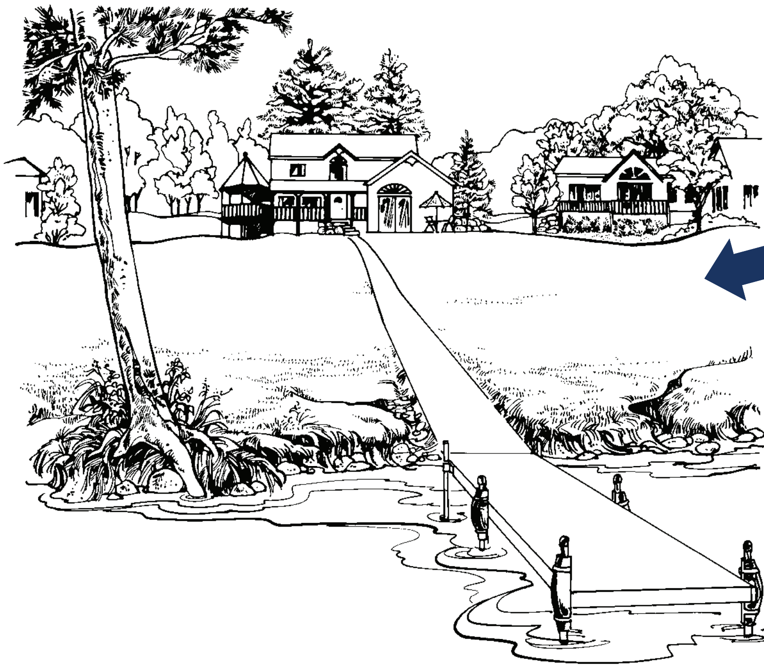
- Increased quality of the canoeing/kayaking experience
- Improved fishing and hunting quality by improving habitat
- Improved bird watching/wildlife viewing quality and opportunities
- Increased potential for expansion of trails for hiking and bicycling
- Opportunities made available for youth and others to locally reconnect with nature

Riparian buffers make sense and are profitable monetarily, recreationally, and aesthetically!

Social Benefits:

- Increased privacy
- Educational opportunities for outdoor awareness
- Improved quality of life at home and work
- Preserved open space/balanced character of a community
- Focal point for community pride and group activities
- Visual diversity
- Noise reduction

A Matter of Balance



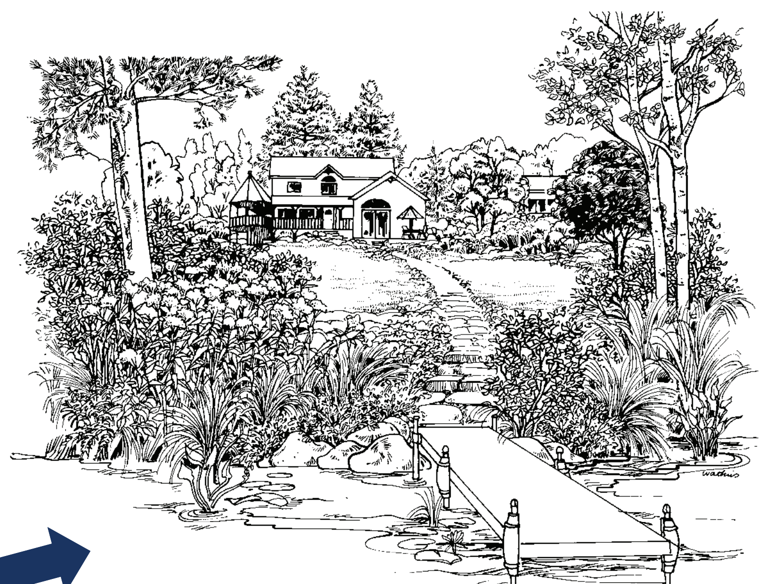
University of Wisconsin—Extension

Although neatly trimmed grass lawns are popular, these offer limited benefits for water quality or wildlife habitat. A single house near a waterbody may not seem like a "big deal," but the cumulative effects of many houses can negatively impact streams, lakes, and wetlands.

All the lands within Southeastern Wisconsin ultimately flow into either the Mississippi River or the Great Lakes systems. The cumulative effects of agriculture and urban development in the absence of mitigative measures, ultimately affects water quality in those systems. Much of this development causes increases in water runoff from the land into wetlands, ponds, and streams. This runoff transports water, sediments, nutrients, and other pollutants into our waterways that can lead to a number of problems, including flooding that can cause crop loss or building damage; unsightly and/or toxic algae blooms; increased turbidity; damage to aquatic organisms from reduced dissolved oxygen, lethal temperatures, and/or concentrations of pollutants; and loss of habitat.

Riparian buffers are one of the most effective tools available for defending our waterways. Riparian buffers can be best thought of as forming a living, self-sustainable protective shield. This shield protects investments in the land and all things on it as well as our quality of life locally, regionally, and, ultimately, nationally. Combined with stormwater management, environmentally friendly yard care, effective wastewater treatment, conservation farming methods, and appropriate use of fertilizers and other agrichemicals, **riparian buffers complete the set of actions that we can take to minimize impacts to our shared water resources.**

Lakeshore buffers can take many forms, which require a balancing act between lake viewing, access, and scenic beauty. Lakeshore buffers can be integrated into a landscaping design that complements both the structural development and a lakeside lifestyle. Judicious placement of access ways and shoreline protection structures, and preservation or reestablishment of native vegetation, can enhance and sustain our use of the environment.



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Case Study—Agricultural Buffers

Agricultural nonpoint source pollution runoff continues to pose a threat to water quality and aquatic ecosystems within Wisconsin and elsewhere. In an effort to address this problem, the Wisconsin Buffer Initiative was formed with the goal of designing a buffer implementation program to achieve science-based, cost-effective, water quality improvements (report available online at http://www.soils.wisc.edu/extension/nonpoint/wbi.php).

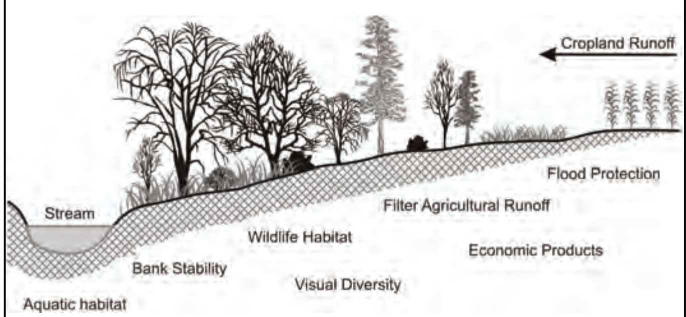
While it is true that riparian buffers alone may not always be able to reduce nutrient and sediment loading from agricultural lands, WBI researchers found that "...***riparian buffers are capable of reducing large percentages of the phosphorus and sediment that are currently being carried by Wisconsin streams. Even in watersheds with extremely high loads (top 10%), an average of about 70% of the sediment and phosphorus can be reduced through buffer implementation***." (*Diebel, M.J. and others, 2009, Landscape planning for agricultural nonpoint source pollution reduction III: Assessing Phosphorus and sediment reduction potential, Environmental Management, 43:69-83.*).

Challenge:
Buffers may take land out of cultivated crop production and require additional cost to install and maintain. Cost sharing, paid easements, and purchase of easements or development rights may sometimes be available to offset costs.

Benefits:
Buffers may offset costs by producing perennial crops such as hay, lumber, fiber, nuts, fruits, and berries. In addition, they provide visual diversity on the landscape, help maintain long-term crop productivity, and help support healthier fish populations for local enjoyment.

Federal and state natural resource agencies have long recognized the need to apply a wide range of Best Management Practices on agricultural lands to improve stream water quality. Although there are many tools available in the toolbox to reduce pollutant runoff from agricultural lands, such as crop rotations, nutrient and manure management, conservation tillage, and contour plowing, riparian buffers are one of the most effective tools to accomplish this task. Their multiple benefits and inter-connectedness from upstream to downstream make riparian buffers a choice with watershed-wide benefits.

Determine what benefits are needed.



The USDA in *Agroforestry Notes* (AF Note-4, January 1997) outlines a four step process for designing riparian buffers for Agricultural lands:

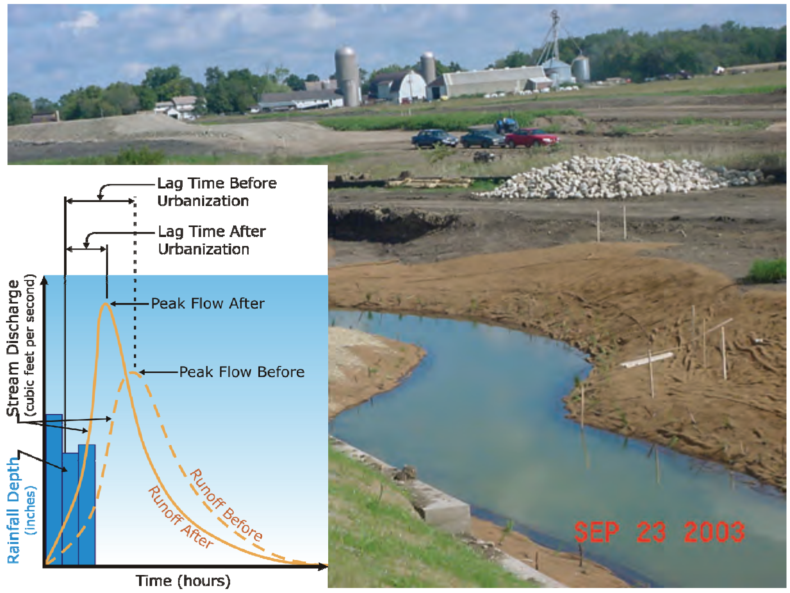
1-Determine what buffers functions are needed
2-Identify the best types of vegetation to provide the needed benefits
3-Determine the minimum acceptable buffer width to achieve desired benefits
4-Develop an installation and maintenance plan

Drain tiles can bypass infiltration and filtration of pollutants by providing a direct pathway to the water and "around" a buffer. This is important to consider in design of a buffer system which integrates with other agricultural practices.

Case Study—Urbanizing Area Buffers

When development occurs near a waterbody, the area in driveways, rooftops, sidewalks, and lawns increases, while native plants and undisturbed soils decrease. As a result, the ability of the shoreland area to perform its natural functions (flood control, pollutant removal, wildlife habitat, and aesthetic beauty) is decreased. In the absence of mitigating measures, one the consequences of urban development is an increase in the amount of stormwater, which runs off the land instead of infiltrating into the ground. Therefore, **urbanization impacts the watershed, not only by reducing groundwater recharge, but also by changing stream hydrology** through increased stormwater runoff volumes and peak flows. This means less water is available to sustain the baseflow regime. The urban environment also contains increased numbers of pollutants and generates greater pollutant concentrations and loads than any other land use. This reflects the higher density of the human population and associated activities, which demand measures to protect the urban water system.

Mitigation of urban impacts may be as simple as not mowing along a stream corridor or changing land management and yard care practices, or as complex as changing zoning ordinances or widening riparian corridors through buyouts.

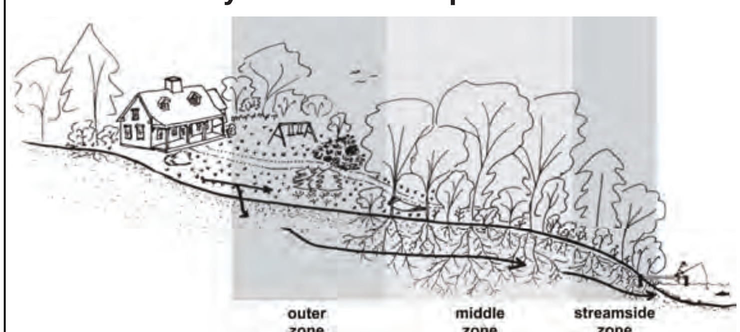


Comparison of hydrographs before and after urbanization. Note the rapid runoff and greater peak streamflow tied to watershed development. (Adapted from Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, October 1998)

Challenge:
Urban development requires balancing flood protection, water quality protection, and the economic viability of the development.

Opportunities:
Buffers may offset costs by providing adequate space for providing long-term water quantity and water quality protection. In addition, they provide visual diversity on the landscape, wildlife habitat and connectedness, and help maintain property values.

Anatomy of an urban riparian buffer



The most effective urban buffers have three zones:

Outer Zone-Transition area between the intact buffer and nearest permanent structure to capture sediment and absorb runoff.

Middle Zone-Area from top of bank to edge of lawn that is composed of natural vegetation that provides wildlife habitat as well as improved filtration and infiltration of pollutants.

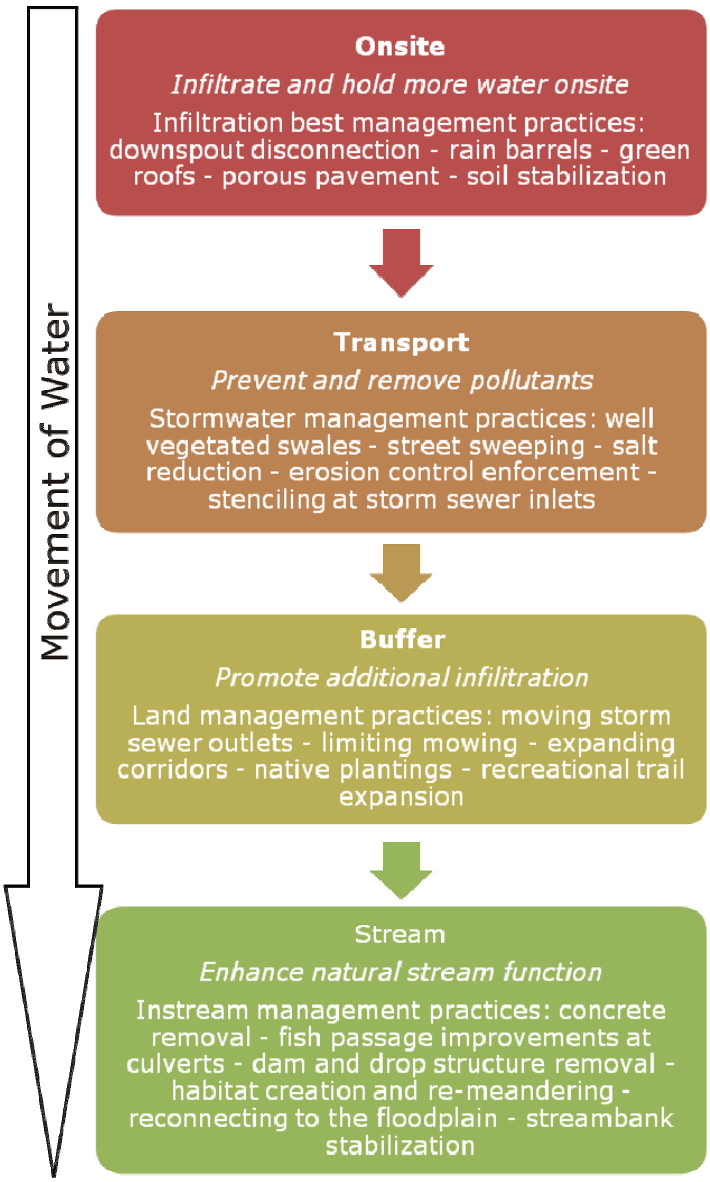
Streamside Zone-Area from the water's edge to the top of the bank or uplands that provides critical connection between water, wetland, and upland habitats for wildlife as well as protect streams from bank erosion

(Fact sheet No. 6 Urban Buffer in the series Riparian Buffers for Northern New Jersey)

Case Study—Urban Buffers

Placement of riparian buffers in established urban areas is a challenge that requires new and innovative approaches. In these areas, historical development along water courses limits options and requires balancing flood management protection versus water quality and environmental protection needs. Consequently, some municipalities have begun to recognize the connections between these objectives and are introducing programs to remove flood-prone structures and culverts from the stream corridors and allow recreation of the stream, restoring floodplains, and improving both the quality of life and the environment.

In urban settings it may be necessary to limit pollution and water runoff before it reaches the buffer.



Challenge:
There are many potential constraints to establishing, expanding, and/or managing riparian buffers within an urban landscape. Two major constraints to establishment of urban buffers include:

1) **Limited or confined space to establish buffers** due to encroachment by structures such as buildings, roadways, and/or sewer infrastructure;

2) **Fragmentation of the landscape** by road and railway crossings of creeks and rivers that disrupt the linear connectedness of buffers, limiting their ability to provide quality wildlife habitat.

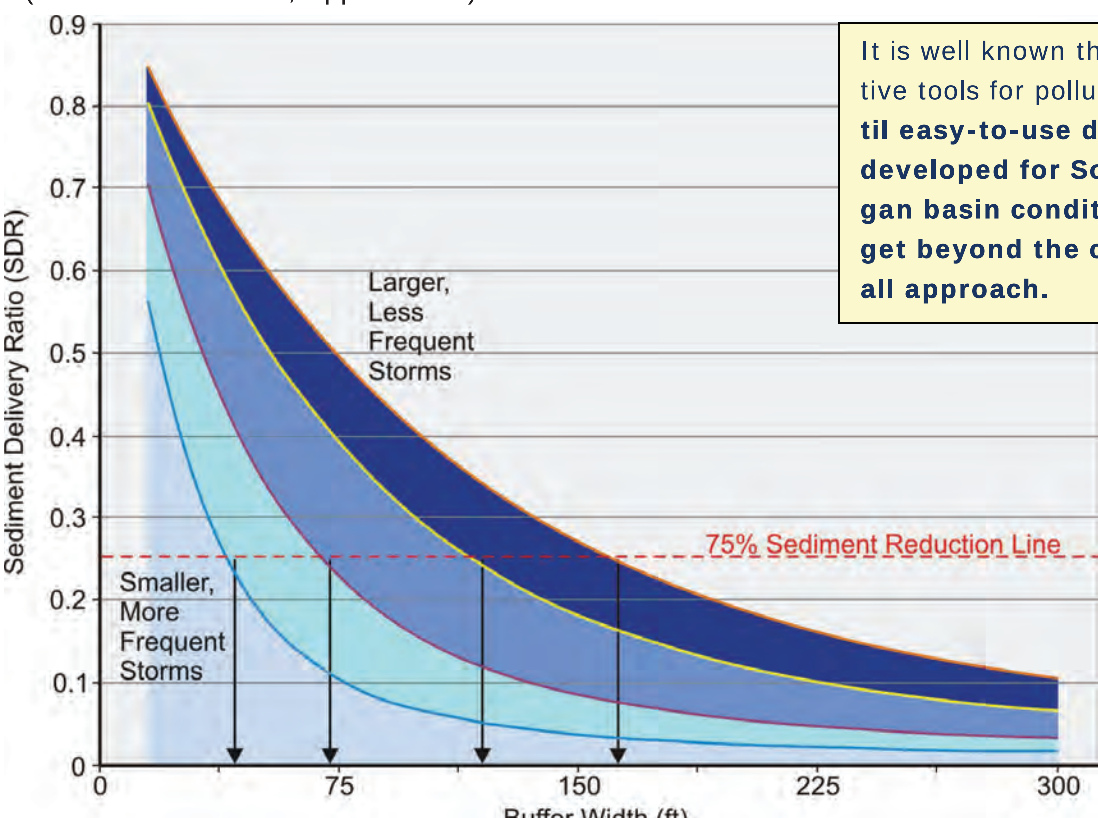
Much traditional stormwater infrastructure intercepts runoff and diverts it directly into creeks and rivers, bypassing any benefits of buffers to infiltrate or filter pollutants. This is important to consider in design of a buffer system for urban waterways, which begin in yards, curbsides, and construction sites, that are figuratively as close to streams as the nearest storm sewer inlet.

A Buffer Design Tool

Design aids are needed to help municipalities, property owners, and others take the "guesswork" out of determining adequate buffer widths for the purpose of water resource quality protection. While there are various complex mathematical models that can be used to estimate sediment and nutrient removal efficiencies, they are not easily applied by the people who need them including homeowners, farmers, businesses and developers.

To fill this gap, design aid tools are being developed using factors such as slope, soils, field length, incoming pollutant concentrations, and vegetation to allow the user to identify and test realistic buffer widths with respect to the desired percent pollutant load reduction and storm characteristics. By developing a set of relationships among factors that determine buffer effectiveness, the width of buffer needed to meet specific goals can be identified.

In the example below, 50-foot-wide buffers are necessary to achieve 75 % sediment removal during small, low intensity storms, while buffers more than 150 feet wide are necessary to achieve the same sediment reduction during more severe storms. Based on this information, decision-makers have the option of fitting a desired level of sediment removal into the context of their specific conditions. Under most conditions, a 75-foot width will provide a minimum level of protection for a variety of needs (SEWRPC PR No. 50, Appendix O.)



It is well known that buffers are effective tools for pollutant removal, but **until easy-to-use design aid tools are developed for Southern Lake Michigan basin conditions, we can never get beyond the current one size fits all approach.**

This generalized graph depicts an example of model output for an optimal buffer width to achieve a 75% sediment reduction for a range of soil and slope, vegetation, and storm conditions characteristic of North Carolina. *(Adapted from Muñoz-Carpena R., Parsons J.E.. 2005. VFSMOD-W: Vegetative Filter Strips Hydrology and Sediment Transport Modeling System v.2.x. Homestead, FL: University of Florida. http://carpena.ifas.ufl.edu/vfsmod/citations.shtml)*

Buffers Are A Good Defense

Today's natural resources are under threat. These threats are immediate as in the case of chemical accidents or manure spills, and chronic as in the case of stormwater pollution carrying everything from eroded soil, to fertilizer nutrients, to millions of drips from automobiles and other sources across the landscape. Non-native species have invaded, and continue to invade, key ecosystems and have caused the loss of native species and degradation of their habitats to the detriment of our use of important resources.

> ***"Riparian ecosystems are naturally resilient,*** *provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife: all characteristics that can contribute to ecological adaptation to climate change."*
>
> *(N. E. Seavy and others, Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research, 2009, Ecological Restoration 27(3):330-338)*

A more subtle, but growing, concern is the case of stresses on the environment resulting from climate change. Buffers present an opportunity for natural systems to adapt to such changes by providing the space to implement protective measures while also serving human needs. **Because riparian buffers maintain an important part of the landscape in a natural condition, they offer opportunities for communities to adjust to our changing world.**

Well-managed riparian buffers are a good defense against these threats. In combination with environmental corridors, buffers maintain a sustainable reserve and diversity of habitats, plant and animal populations, and genetic diversity of organisms, all of which contribute to the long-term preservation of the landscape. Where they are of sufficient size and connectivity, riparian buffers act as reservoirs of resources that resist the changes that could lead to loss of species.

Refuge or protection from increased water temperatures as provided by natural buffers is important for the preservation of native cold-water, cool-water, and warm-water fishes and their associated communities.

Buffers Provide Opportunities

River, lake, and wetland systems and their associated riparian lands form an important element of the natural resource base, create opportunities for recreation, and contribute to attractive and well-balanced communities. These resources can provide an essential avenue for relief of stress among the population and improve quality of life in both urban and rural areas. Such uses also sustain industries associated with outfitting and supporting recreational and other uses of the natural environment, providing economic opportunities. Increasing access and assuring safe use of these areas enhances public awareness and commitment to natural resources. Research has shown that property values are higher adjoining riparian corridors, and that such natural features are among the most appreciated and well-supported parts of the landscape for protection.

We demand a lot from our riparian buffers!

Sustaining this range of uses requires our commitment to protect and maintain them.

Summary

The following guidance suggestions highlight key points to improve riparian corridor management and create a more sustainable environment.

Riparian corridors or buffers along our waters may contain varied features, but all are best preserved or designed to perform multiple important functions.

Care about buffers because of their many benefits. Riparian buffers make sense and are profitable monetarily, recreationally, aesthetically, as well as environmentally.

Enhance the environmental corridor concept. Environmental corridors are special resources which deserve protection. They serve many key riparian corridor functions, but in some cases, could also benefit from additional buffering.

Avoid habitat fragmentation of riparian corridors. It is important to preserve and link key resource areas, making natural connections and avoiding habitat gaps.

Employ the adage "wider is better" for buffer protection. While relatively narrow riparian buffers may be effective as filters for certain pollutants, that water quality function along with infiltration of precipitation and runoff and the provision of habitat for a host of species will be improved by expanding buffer width where feasible.

Allow creeks and rivers room to roam across the landscape. Streams are dynamic and should be buffered adequately to allow for natural movement over time while avoiding problems associated with such movement.

Consider and evaluate buffers as a matter of balance. Riparian buffers are a living, self-sustainable shield that can help balance active use of water and adjoining resources with environmental protection.

Agricultural buffers can provide many benefits. Riparian buffers in agricultural settings generally work well, are cost-effective, and can provide multiple benefits, including possibly serving as areas to raise certain crops.

Urban buffers should be preserved and properly managed. Though often space-constrained and fragmented, urban buffers are important remnants of the natural system. Opportunities to establish or expand buffers should be considered, where feasible, complemented by good stormwater management, landscaping, and local ordinances, including erosion controls.

A buffer design tool is needed and should be developed. Southeastern Wisconsin and the Southern Lake Michigan Basin would benefit from development of a specific design tool to address the water quality function of buffers. Such a tool would improve on the currently available general guidance on dimensions and species composition.

Buffers are a good defense. Combined with environmental corridors, riparian buffers offer a good line of defense against changes which can negatively impact natural resources and the landscape.

Managing the Water's Edge

MORE TO COME

Future editions in a riparian buffer planning series are being explored with the intent of focusing on key elements of this critical land and water interface. Topics may include:

- Information sharing and development of ordinances to integrate riparian buffers into existing land management plans and programs
- Integration of stormwater management practices and riparian buffer best management practices
- Application of buffers within highly constrained urban corridors with and without brownfield development
- Installation of buffers within rural or agricultural lands being converted to urban uses
- Utilization of buffers in agricultural areas and associated drainage systems
- Integration of riparian buffers into environmental corridors to support resources preservation, recreation and aesthetic uses
- Preservation of stream courses and drainageways to minimize maintenance and promote protection of infrastructure
- Guidance for retrofitting, replacement, or removal of infrastructure such as dams and road crossings, to balance transportation, recreation, aesthetic, property value, and environmental considerations.
- Protection of groundwater recharge and discharge areas
- Protection of high quality, sensitive coastal areas, including preservation of recreational potential

MORE INFORMATION

This booklet can be found at http://www.sewrpc.org/RBMG-no1 . Please visit the website for more information, periodic updates, and a list of complementary publications.

* * *

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May 7, 2010

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Appendix D

MASON CREEK POTENTIALLY RESTORABLE WETLAND EVALUATION

Mason Creek Potentially Restorable Wetland Evaluation

Step 1. Information to Help Determine Appropriate Restoration Targets

A. Pre-Settlement Vegetation (see Map I-3 in Chapter I of this report) - Pre-settlement vegetation in the Mason Creek sub-watershed consisted primarily of forested plant community types. These included maple-basswood-red oak forest, oak forest, conifer swamp/bog, and lowland hardwoods. There was a small area of relatively open oak savanna in the northern part of the sub-watershed. Significant areas of non-forested wetland were also present in the northern and western parts of the sub-watershed.

Historical Aerial Imagery - Agricultural land use was already extensive in 1940 (Figure D-1). Trees occurred primarily in the northeastern portion of the watershed in areas where pre-settlement vegetation was mapped as oak forest and maple-basswood-red oak forest and in the central portion of the sub-watershed where pre-settlement vegetation was mapped as conifer swamp/bog. Other wetland areas were predominantly open, particularly in the western and northwestern portion of the sub-watershed. Figure D-2 shows how portions of the western and northwestern part of the Mason Creek sub-watershed appeared in 1940, with patches of trees and shrubs (dark gray) visible to the far right with more open wetlands immediately to their west (lighter gray). Portions of some of the open wetlands were farmed.

Figure D-1

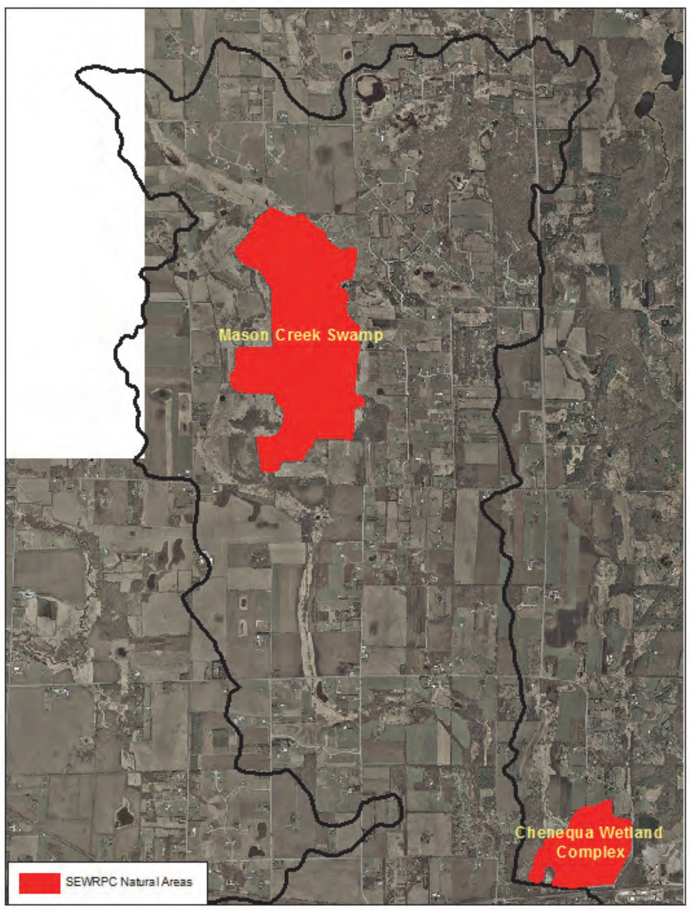
1940 AERIAL PHOTOGRAPH THAT INCLUDES A PORTION OF THE MASON CREEK SUB-BASIN AREA

Source: University of Wisconsin-Madison

B. Natural Areas and Rare Species Records–The 425-acre Mason Creek Swamp (SEWRPC NA-3, Figure D-2) is the only SEWRPC- or State-designated natural area in the sub-watershed. Much of this swamp is mapped as conifer swamp/bog in the pre-settlement vegetation, but it appears to be dominated by lowland hardwoods presently. There is no vegetation inventory for this natural area, and its designation is based on its size and relative lack of disturbance inferred from historical aerial photographs. The Chenequa Wetland Complex (SEWRPC NA-3, Figure D-2) is located immediately adjacent to the far southeastern portion of the Mason Creek sub-watershed. This wetland consists of tussock sedge wet meadow, Midwest cattail deep marsh, dogwood-mixed willow shrub meadow, and central tamarack-red maple rich swamp. Tubercled orchid, a State threatened species, was collected there in 1855, but it has not been observed since. Inventories by SEWRPC staff occurred in 1992 and 1999. Including the orchid, 90 native plant species have been recorded from this natural area.

Figure D-2

NATURAL AREAS IN AND ADJACENT TO THE MASON CREEK WATERSHED



Source: SEWRPC.

Step 2. Appropriate Restoration Targets

The pre-settlement vegetation mapping is coarse, but a large portion of the potentially restorable wetlands in the western and northern portion of the sub-watershed are mapped as open wetland in the pre-settlement vegetation inventory and should be restored to open, herbaceous plant communities. Other potentially restorable wetlands to south are mapped as forested plant community types in the pre-settlement vegetation, and some are mapped as upland community types. Those potentially restorable wetlands mapped as upland plant community types were likely too small to constitute dominant community types in the initial land surveys. However, given both present and historical (1940) forested cover in nearby or adjacent areas, these potentially restorable wetlands were likely dominated by hardwood swamp.

Potential restorable wetlands that have soils that are saturated to the surface or that are inundated with water up to six inches deep for most of the growing season should be restored to shallow marsh (Table D-1). Historically open wetlands that are typically only saturated or inundated in the spring or following heavy rain events should be restored to sedge meadow (Table D-2); most potentially restorable wetlands likely fall into this category. Wetlands that were forested prior to settlement could be restored using lowland hardwoods (Table D-3). The ongoing death of green and black ash trees as the emerald ash borer spreads across the Region and the historical decimation of American elms by Dutch elm disease have caused/are causing lowland hardwood swamps dominated by these species to be replaced by other wetland community types. Restoration of lowland hardwood swamps using ash and elm is not advised. The restoration of hardwood swamps involves the initial planting of only woody vegetation, because most appropriate herbaceous species require the shading from the canopy. In all cases the appropriate restoration target community in a given location depends upon the hydrologic regime in place upon the cessation of agricultural practices, removal of tile, and any earth moving activities that may occur. Small elevation gradients (less than one foot) can separate different wetland plant communities. Establishing communities dominated by native lowland hardwood swamp species (e.g. silver maple), sedge meadow species (e.g. tussock sedge) or shallow marsh species (e.g. broad-leaved cattail) are reasonable goals for the restoration of the respective plant community types.

Table D-1

A PARTIAL LIST OF SPECIES THAT ARE OFTEN EITHER CO-DOMINANT OR ABUNDANT IN SHALLOW MARSHES WITHIN SOUTHEASTERN WISCONSIN

Latin Name	Common Name	Vegetation Type
Carex atherodes	Slough sedge	Sedge
Carex lacustris	Lake sedge	Sedge
Eleocharis palustris and E. erythropoda	Spike rush	Sedge
Glyceria grandis	Giant manna grass	Grass
Juncus torreyi	Torrey's rush	Rush
Leersia oryzoides	Rice cut-grass	Grass
Sagittaria latifolia	Arrowhead	Forb
Schoenoplectus fluviatilis	River bulrush	Sedge
Schoenoplectus tabernaemontani	Soft-stem bulrush	Sedge
Sparganium eurycarpum	Bur-reed	Forb
Stachys tenuifolia	Smooth hedge-nettle	Forb
Typha latifolia	Broad-leaved cattail	Forb

Source: SEWRPC.

Table D-2

A PARTIAL LIST OF SPECIES THAT ARE OFTEN EITHER CO-DOMINANT OR ABUNDANT IN SEDGE MEADOWS. WITHIN SOUTHEASTERN WISCONSIN

Latin Name	Common Name	Vegetation Type
Asclepias incarnate	Marsh milkweed	Forb
Calamagrostis canadensis	Canada blue-joint	Grass
Carex lacustris	Lake sedge	Sedge
Carex pellita	Broad-leaved woolly sedge	Sedge
Carex stipata	Awlfruit sedge	Sedge
Carex stricta	Tussock sedge	Sedge
Carex trichocarpa	Hairy-fruited sedge	Sedge
Cicuta maculate	Water hemlock	Forb
Eutrochium maculatum	Spotted Joe-Pye weed	Forb
Helianthus grosseserratus	Saw-tooth sunflower	Forb
Impatiens capensis	Jewelweed	Forb
Iris virginica	Blue flag iris	Forb
Juncus dudleyi	Common rush	Rush
Lycopus americanus	Common bugleweed	Forb
Salix bebbiana	Bebb's willow	Shrub
Salix discolor	Pussy willow	Shrub
Scirpus cyperinus	Woolgrass sedge	Sedge
Solidago gigantean	Giant goldenrod	Forb
Stachys tenuifolia	Smooth hedge-nettle	Forb
Symphyotrichum puniceum (syn. S. lucidulum and S. firmum)	Marsh aster	Forb
Verbena hastate	Blue vervain	Forb

Source: SEWRPC.

Table D-3

A PARTIAL LIST OF TREES AND SHRUBS APPROPRIATE FOR HARDWOOD SWAMP RESTORATION WITHIN SOUTHEASTERN WISCONSIN

Latin Name	Common Name	Vegetation Type
Acer rubrum	Red maple	Tree
Acer saccharinum	Silver maple	Tree
Betula allegheniensis	Yellow birch	Tree
Cornus alba	Red-osier dogwood	Shrub
Cornus obliqua	Silky dogwood	Shrub
Populus deltoides	Cottonwood	Tree
Quercus bicolor	Swamp white oak	Tree
Quercus palustris[a]	Pin oak	Tree
Salix amygdaloides	Peach leaf willow	Tree
Sambucus nigra subsp, canadensis	Elderberry	Shrub
Viburnum lentago	Nannyberry	Shrub

[a] *Native but rare and generally of more southerly distribution.*

Source: SEWRPC.

Areas outside of the wetlands should generally be restored to maple-basswood-red oak forest or oak forest, with the latter on areas with better drainage from steeper slopes or well-drained soils. Restoration of oak savanna where it historically occurred (Figure D-2) or prairie would enhance wildlife value. In general, upland restoration adjacent to existing or restored wetlands would minimize disturbances near the wetland edge that would otherwise promote the establishment and spread of invasive species and reduce the amount of sediment and surface-runoff entering wetlands from surrounding uplands after heavy rain events (sediment and nutrients carried by runoff also promote invasive species).

Step 3. Prioritizing sites

Consider, at least qualitatively, the below factors in order to maximize potential for successfully establishing native-dominated communities and conserving existing native plant communities.

A. **Parcel size -** Large and/or adjacent parcels should be priorities, because restored areas that maximize interior versus perimeter will be the easiest to manage and experience less pressure from invasive species.

B. **Within-parcel ecological considerations -** Parcels that can offer greater habitat complexity (i.e. marsh, sedge meadow, hardwood or conifer swamps, and/or upland community types) rather than just one community type have the potential to support more species and more ecological functions. Candidate parcels should be surveyed for invasive species, so that likely future actions and costs for invasive species management can be determined, at least on a relative basis among candidate parcels. Those parcels where the boundary between planned restoration activities and invasive species (e.g. reed canary grass) are minimized should be given priority.

C. **High-quality existing natural communities –** Besides Mason Creek, the most valuable natural feature in the Mason Creek sub-watershed is Mason Creek Swamp (SEWRPC NA-3). The integrity of Mason Creek Swamp would be improved by the restoration of potentially restorable wetlands and uplands between Mason Creek to the West and the drainage ditch to the east and potentially restorable wetlands and adjacent uplands to the north. While there has been no inventory, aerial photography shows that Mason Creek Swamp has been extensively ditched and drained and has large areas where the color of dormant season vegetation is consistent with buckthorn and reed canary grass. A site visit would be necessary to determine the locations of relatively high-quality remnant natural communities, the impacts and extent of invasive species, and any restoration or management needs.

Step 4. Implementation of Restoration and Management Process

A. **Seeding or Planting Herbaceous Plants -** What follows is a brief summary of the applicable restoration process. The Minnesota Board of Soil and Water Resources and the Minnesota Department of Transportation have produced an excellent, detailed restoration guide for wetlands[1]. Ensure that no herbicide with residual activity (e.g. atrazine) has been used for at least one year on agricultural lands. Ideally, cultivated land is farmed through the growing season that precedes restoration planting in order to prevent the proliferation of weeds. Restoration may then be attempted with seed broadcast on to bare, agricultural land. Seeding of herbaceous species should occur from mid-November through December, or otherwise over shallow snow or bare ground before February 15. This is because many species require a cool, moist period prior to germination, and many wetland species will even germinate in the cool weather of early spring, which gives them a good head start. Seeding at the appropriate time may be risky in areas that are likely to be inundated early in the spring, because this may lift seed and carry it away. In such locations, plugs and/or pre-vegetated mats may be planted instead. Many of herbaceous species spread extensively by rhizomes, so planting plugs spaced a foot or two apart can achieve native plant coverage rather quickly. Plugs can be planted when the soil is moist and expected to remain so, and pre-vegetated mats can be staked into standing water, but planting in autumn should occur early enough that adequate root development can occur to prevent frost heave. The annual weeds that grow in fallow farm fields have the potential to kill native seedlings by robbing them of light. If soils are firm enough to allow it, areas that develop closed canopies of annual weeds should be mowed to a height of eight inches as needed to prevent native seedling mortality. This is time sensitive, and an implementation plan should be in place before it is needed. Mowing is best performed by a sickle mower, which lays down cut material in an even layer that quickly dries and deteriorates. Rotary mowers tend to leave clumps that can smother seedlings, but mowing with a rotary mower is still preferred to not mowing vigorous annual weeds.
Planting Trees and Shrubs – Plant trees in early spring following guidelines from the Natural Resource Conservation Service[2]. Fall planting in wet soils can lead to frost heave.

B. **Invasive Species -** Wetland plant communities are extremely vulnerable to invasive species, because water can disperse the seeds or vegetative parts of invasive plants, and because nutrients and sediments that are funneled from surrounding agricultural and developed lands diminish the relative competitive abilities of both existing and establishing native wetland vegetation. Even if native species are sown or transplanted into former agricultural lands, the end result is likely to be large areas dominated by reed

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[1]*Robert L. Jacobson*, Restoring & Managing Native Wetland & Upland Vegetation, *Minnesota Board of Soil & Water Resources, Minnesota Department of Transportation*, *http://www.shootingstarnativeseed.com/documents/BWSR-wetland-guide.pdf*

[2]*Natural Resources Conservation Service*, Hand-Planting Guidelines for Bareroot Trees and Shrub, *http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1167617.pdf*

canary grass (*Phalaris arundinacea*) or other invasive species unless plans are in place to detect and control invasive species from the beginning. Once an area becomes dominated by reed canary grass, reversal of the situation is costly and time-consuming. Invasion is also promoted by disturbance, so control efforts that create disturbance and negatively impact desired vegetation can be counter-productive. Especially troublesome wetland invasive plants aside from reed canary grass in SE Wisconsin include giant reed (*Phalaris australis* subsp. *australis*), narrow-leaved and hybrid cattails (*Typha angustifolia* and *Typha x glauca*), giant manna grass (*Glyceria maxima*), hairy willow-Herb (*Epilobium hirsutum*), common and glossy buckthorns (*Rhamnus cathartica* and *Rhamnus frangula*) and purple loosestrife (*Lythrum salicaria*).

C. **Other Long-Term Management** –Prescribed fire or mechanical and chemical removal of common and glossy buckthorns and/or thinning of other woody species may be necessary to maintain the open nature of sedge meadows. Without monitoring and timely response most natural community types in southeast Wisconsin are vulnerable to invasion and subsequent dominance by exotic species.

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Appendix E

SOIL QUALITY INDICATORS

Source: U.S. Department of Agriculture, National Resources Conservation Service, see website for more information, http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/assessment/?cid=stelprdb1237387

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USDA Natural Resources Conservation Service

Indicator	Test	Function
?	?	?

Soil Quality Indicators

Physical, Chemical, and Biological Indicators for Soil Quality Assessment and Management

A series of information sheets for physical, chemical, and biological indicators is available to help conservationists and soil scientists with soil quality assessment. Use this guide to learn more about selecting appropriate soil quality indicators to assess specific soil functions. Visit http://go.usa.gov/zUAH for more information and to download copies of the information sheets.

What is soil quality?

Concise definitions for soil quality include "fitness for use" and "the capacity of a soil to function." Combining these, soil quality is the ability of a soil to perform the functions necessary for its intended use.

Soil functions include:

- sustaining biological **D**iversity, activity, and productivity
- regulating **W**ater and solute flow
- **F**iltering, buffering, degrading organic and inorganic materials
- storing and cycling **N**utrients and carbon
- providing physical **S**tability and support

TIP: *The* ***Function*** *icon at the top right corner of each information sheet uses* ***D, W, F, N, or S*** *to show the function(s) that is most affected by the subject indicator.*

How is soil quality measured?

The quality of a soil, or its capacity to function, is evaluated using ***inherent*** and ***dynamic*** soil properties. These properties serve as ***indicators*** of soil function because it is difficult to measure function directly and observations may be subjective.

Inherent, or use-invariant, soil properties change very little or not at all with management. Inherent soil properties form over thousands of years and result primarily from the soil forming factors: climate, topography, parent material, biota, and time. Examples of inherent properties are soil texture, type of clay, depth to bedrock, and drainage class.

Dynamic, or management dependent, soil properties are affected by human management and natural disturbances over the human time scale, i.e., decades to centuries. Significant changes in dynamic soil properties can occur in a single year or growing season. There are many dynamic soil properties, several of which are the subjects of this information sheet series.

Soil indicators are often divided into **P**hysical, **C**hemical and **B**iological categories depending on how they affect soil function. However, these categories are not always clearly defined since a soil property or indicator can affect multiple soil functions or categories.

TIP: *The* ***Indicator*** *icon at the top right corner of each information sheet uses* ***P, C, or B*** *to show the category in which the indicator best fits.*

Depending on the indicator and the method used to evaluate it, properties are assessed in the **F**ield, **L**aboratory, or even an **O**ffice when no special equipment is required.

TIP: *The* ***Test*** *icon at the top right corner of each information sheet uses* ***F, L, or O*** *to show where indicator assessment takes place for the method highlighted on the information sheet.*

Helping People Help the Land

Selecting soil quality indicators

A soil function – indicator matrix (fig. 1) can be used to select appropriate indicators for assessing a particular soil function. Additionally, if an indicator is already being measured, the matrix reveals the indicator's relationship to other soil functions, thus maximizing the usefulness of the collected data.

Each indicator listed in the matrix below is linked to its accompanying information sheet. The information sheets:

- define and describe the indicator
- relate the indicator to soil function
- discuss inherent and dynamic factors influencing it
- suggest management practices to improve soil function
- provide a reference for an assessment method

Figure 1. Soil function – indicator matrix: when a direct relationship exists between the function and indicator, increasing reliability and ease of use of the associated assessment method is shown with increasing stars.

	Soil Function				
Soil Quality Indicator	**Sustain biological diversity, activity, and productivity "D"**	**Regulate and partition water and solute flow "W"**	**Filter, buffer, degrade, detoxify organic and inorganic materials "F"**	**Store and cycle nutrients and carbon "N"**	**Physical stability and support for plants and structures associated with human habitation "S"**
Aggregate Stability [a,c,f]	★★	★★	—	★★	★★½
Available Water Capacity [a,g]	★★★	★★½	—	★★	—
Bulk Density [a,h]	★★½	★★★	—	★	★★★
Earthworms [b,d]	★★★	—	★★★	★★★	★★★
Infiltration [b,e,i]	—	★★	★	—	—
Particulate Organic Matter [a,c]	★★★	★★★	★★★	★★★	★★★
Potentially Mineralizable Nitrogen [a,c]	★★★	—	—	★★★	—
Reactive Carbon [a]	★★	★	★★★	★★	★★
Slaking [b,e,i,j]	★	★★½	—	—	—
Soil Crusts [b,d]	—	★★½	—	—	—
Soil Electrical Conductivity [b]	—	★★★	—	—	—
Soil Enzymes [a]	★★★	—	—	★★★	—
Soil Nitrate [b]	★	★	—	—	—
Soil pH [b,d]	★★	★★★	★★★	★★★	—
Soil Respiration [a,b,c]	★★★	—	★	★★★	★★
Soil Structure and Macropores [b,d]	★½	★½	★	★	★★
Total Organic Carbon [a]	★★★	★★★	★★★	★★★	★★★

[a] laboratory/office method
[b] field method
[c] time consuming
[d] simple visual observation
[e] variability requires large sample number
[f] perhaps the most informative physical indicator
[g] important for drought prone areas
[h] important for weight to volume conversions, small sampling errors result in significant interpretation problems
[i] effective educational method
[j] qualitative

Appendix F

MASON CREEK CROSS-SECTION AND POINT FEATURE DATA DESCRIPTION OF FIELD MEASUREMENTS AND LOCATIONS: SUMMER 2014

CROSS-SECTION DATA

STREAM BANK CHARACTERISTICS

Bankfull Width: The stream channel that is formed by the dominant discharge, also referred to as the active channel, which meanders across the floodplain as it forms pools and riffles. Defined by the discharge that occurs when water just begins to leave the channel and spread onto the floodplain.

Bank Height: Height of the bank from the streambed to the top edge of the lateral scour line as shown in Figure F-1.

Undercut Depth: A bank that has had its toe of slope, or base, cut away by the water action creating overhangs in the stream as shown in Figure F-1.

Slope: Ratio of horizontal distance divided by the vertical height of the streambank as shown in Figure F-2.

Instream habitat characteristics

Width: The width of the existing water surface measured at a right angle to the direction of flow from shore to shore.

Maximum Depth: The vertical height of the water column from the existing water surface level to the lowest point of the streambed.

Habitat Type: An aquatic unit, consisting of an aggregation of habitats having equivalent structure, function, and responses to disturbance. Pool, riffle, and run habitat types were observed in the Jackson Creek watershed.

- A pool is that area of the water column that has slow water velocity and is usually deeper than a riffle or run (Figure F-3). Pools usually form around bends or around large-scale obstructions that laterally constrict the channel or cause a sharp drop in the water surface profile.
- Riffles are portions of the water column where water velocity is fast, stream depths are relatively shallow, and the water surface gradient is relatively steep (Figure F-4).
- A run is that area of the water column that does not form distinguishable pools or riffles, but has a rapid nonturbulent flow. A run is usually too deep to be a riffle and has flow velocities too fast to be a pool.

Figure F-1

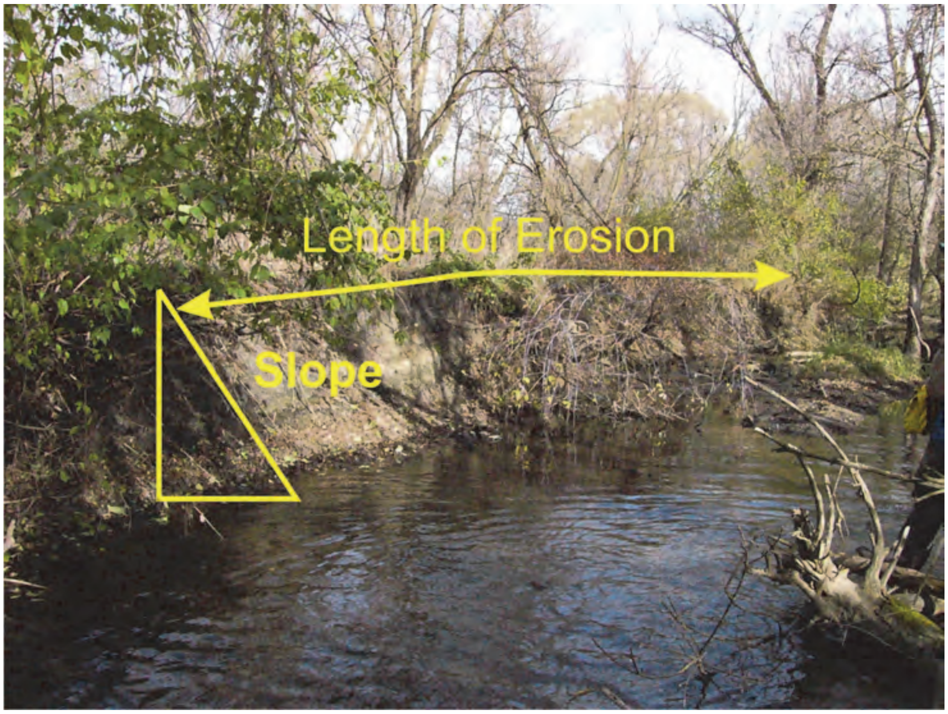
EXAMPLE OF BANK HEIGHT AND UNDERCUT DEPTH MEASURED AT AN ACTIVELY ERODING SITE

NOTE: These photos were not taken within the Mason Creek watershed and are for illustrative purposes only.

Source: SEWRPC.

Figure F-2

EXAMPLE OF LENGTH OF EROSION AND BANK SLOPE MEASURED AT AN ACTIVELY ERODING SITE



NOTE: This photo was not taken within the Mason Creek watershed and is for illustrative purposes only.

Source: SEWRPC.

Figure F-3

TYPICAL DEEP WATER/LOW VELOCITY POOL HABITATS IN THE MASON CREEK WATERSHED: 2014

Source: SEWRPC.

Figure F-4

TYPICAL SHALLOW WATER/HIGH VELOCITY RIFFLE HABITATS IN THE MASON CREEK WATERSHED: 2014

Source: SEWRPC.

Substrates: Refers to the materials that make up the streambed. Substrate composition in the streams of the Mason Creek watershed was determined visually by recording the dominant substrate types within the transect. The following categories of substrate type were used.

- Bedrock: Solid rock forming a continuous surface.
- Boulder: Rocks with a diameter of 10 to 20 inches.
- Cobble: Rocks with a diameter of 2.5 to 10 inches.
- Gravel: Rocks with a diameter of 0.07 to 2.5 inches.
- Sand: Inorganic particles smaller than gravel, but coarser than silt with a diameter of 0.002 to 0.07 inch.
- Silt: Fine inorganic particles, typically dark brown in color. Feels greasy and muddy in hands. The material is loose and does not retain shape when compacted into a ball and will not support a person's weight when it makes up the stream bottom. Silt particles have a diameter of less than 0.0001 inch.
- Peat: A fibrous mass of organic matter in various stages of decomposition, generally dark brown to black in color and of spongy consistency.
- Clay: Very fine, inorganic, dark brown or gray particles. Individual particles are barely visible or not visible to the unaided eye. The particles feel gummy and sticky and slippery underfoot. Clay particles retain shape when compacted and partially or completely support a person's weight when they comprise the stream bottom. Clay particles have a diameter of less than 0.0001 inch.

Sediment Depth: The depth of fine sediments (usually silt) that overlay or comprise the streambed. Sediment depth is an indicator of sediment deposition and was measured to the nearest 0.5 inch.

Woody Debris: Large pieces or aggregations of smaller pieces of wood (e.g., logs, large tree branches, root tangles) located in, or in contact with, the water surface.

Cover: This can be one, or any combination, of characteristics that include undercut banks, overhanging vegetation, water velocities, logs or woody debris, deep pools, boulders and other substrates, aquatic macrophytes, and algae that provide 1) protection from predators, 2) feeding areas, 3) spawning habitat, or 4) some other benefit such as shading.

POINT FEATURE DATA

Crossing: A structure (e.g., bridge or culvert) that crosses over is lying within the stream channel.

Drain Tile: A subsurface drainage system (plastic or metal corrugated pipe) that allows excess water from agricultural and urban lands to discharge into a drainage ditch, stream or wetland.

Pool: A single maximum depth is recorded within a pool habitat (See Habitat Type above and Figure F-3).

Riffle: A single maximum depth is recorded within a riffle habitat (See Habitat Type above and Figure F-4).

Stormwater Outlet: Any culvert or drainage system that allows for excess storm water to discharge into a certain location. *It should be noted that in 2014 the SEWRPC field staff did not identify any stormwater outlets along Mason Creek.*

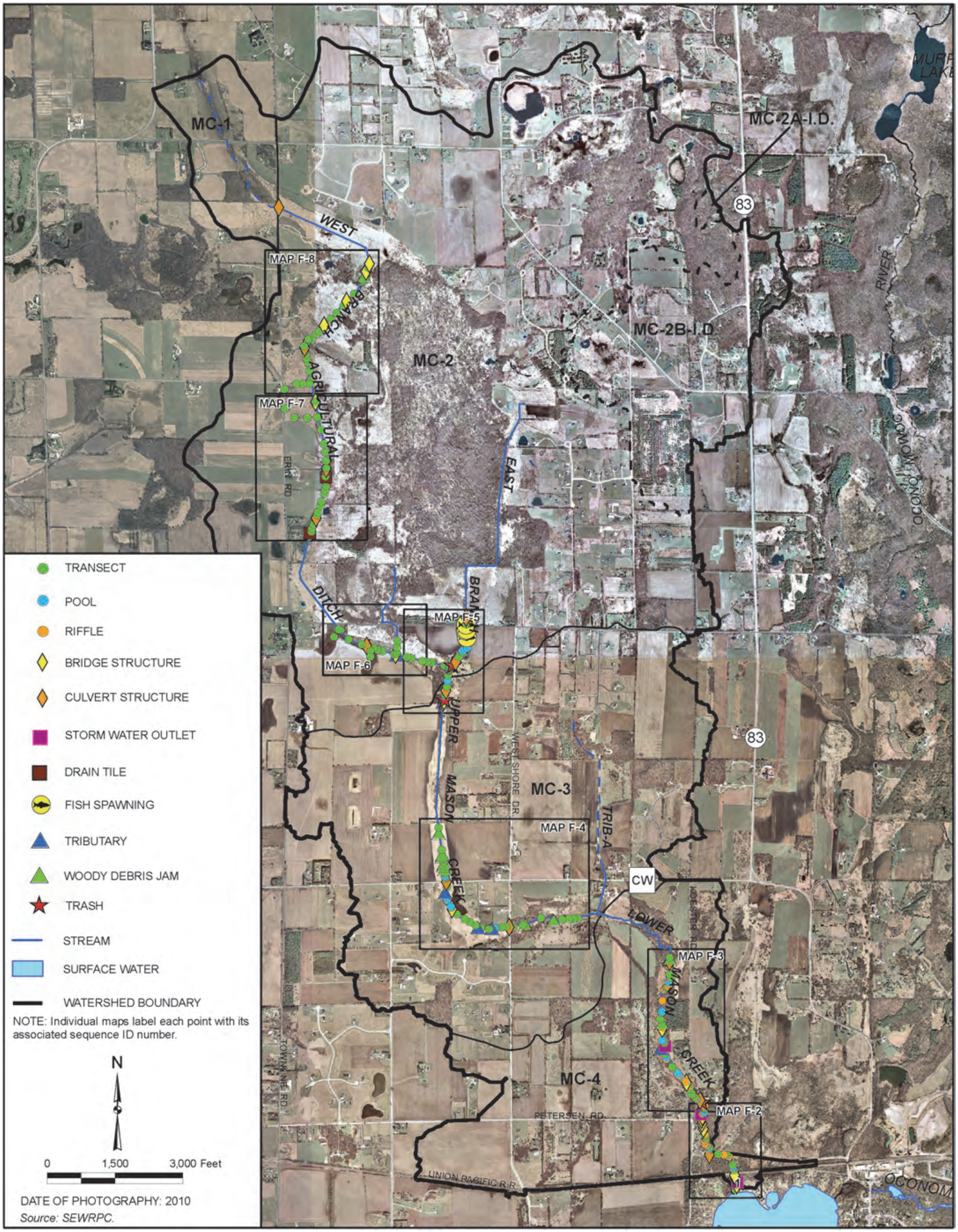
Trash: Identify and describe trash or any debris that is within or adjacent to the stream channel.

Woody debris Jam: Identify and describe the extent of the obstruction in the channel (See description above).

The transect and point feature data within the Mason Creek watershed are shown on Maps F-1 through F-8 below. Table F-1 below lists the data and measurements collected at each transect along with a description detailing how each measurement is taken as well as description of the point features mapped.
Note that all of this data, site locations, and associated shape files are available on a CD in the inside back cover of this report or available to download from the SEWRPC website at http://www.sewrpc.org/SEWRPC/DataResources.htm

Map F-1

MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014



PRELIMINARY DRAFT

Map F-2

MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014