Attachment 1. Partnership agreement.

PARTNERSHIP AGREEMENT

Protection and Enhancement of the Kalamazoo River Watershed

This document is a non-regulatory Partnership Cooperation Agreement between various units of government, businesses and private sector organizations dedicated to long-term, sustainable protection and enhancement of the broad range of values found within the Kalamazoo River Watershed. The partnership is not a contract. It is a statement of intent, support and willingness to participate at a level appropriate to the respective interests of the individual partners.

The groups committed to this partnership jointly recognize the need for improving, maintaining and protecting the quality of the Kalamazoo River Watershed. They share a desire to protect and enhance the designated and desired uses of the watersheds. The parties do so in the unanimous belief that restoring these assets to their full potential will provide significant aesthetic, recreational, economic and environmental benefits to the area for years to come.

BACKGROUND

The Kalamazoo River is a major feature of southwest Michigan, and has played a crucial role in the exploration, settlement, and economic growth of our region. It remains among our most valuable resources. Presenting unparalleled cultural, recreational, aesthetic, and ecological benefits, the land and water resources within the watershed contribute immeasurably to the quality of life for all Michigan citizens and visitors, present and future.

The watershed has had a history of pollution problems, many of which still linger today. Working with and for, local communities, business and industry, state and federal agencies, educational institutions and non-profit organizations, local citizens have shown great commitment and significant success in enhancing the quality of the watershed's resources. Recent efforts to address water quality concerns of the Kalamazoo River system are nationally recognized for their watershed-wide, community based approach stressing voluntary, cooperative strategies.

While there are numerous organizations working on a particular watershed issue, or a portion of the watershed, there really is no single organization that attempts to deal with all issues throughout the watershed, or that speaks on behalf of the entire watershed. Through a series of public forums, workshops and other discussions in recent years, there is strong support for an overall, watershed wide "umbrella" organization. After many meetings of a wide variety of concerned citizens, the following outlines what this organization should, and should not, be:

It should:

- Provide a common, single voice for the entire watershed and its citizens;
- Serve as an information clearing house on all watershed related issues, including action alerts when appropriate;
- In certain circumstances, serve as the fiduciary agent for those organizations without that capability;
- Coordinate overall educational and watershed planning efforts; and,
- Provide overall watershed leadership.

It should not:

- Attempt to be a “super” or “supervisory” organization;
- Hinder, conflict or interfere with other organizations working on behalf of the watershed; or,
- Attempt to speak for another organization, unless requested by that organization and/or part of an overall agreed upon watershed strategy.
- This partnership agreement is intended to provide structure to this coordinated effort to provide long-term, sustainable protection and enhancement to the environmental, economic, aesthetic, recreational and environmental values of the Kalamazoo River Watershed.

PRINCIPAL ENTITIES AND THEIR ROLES

Umbrella organization

The Kalamazoo River Watershed Council (Council) has agreed to serve as the overall “umbrella” organization. The Kalamazoo River Watershed Council* is a public, non-profit 501(c)3 organization whose mission is to work collaboratively with the community, government agencies, local officials and businesses to improve and protect the health of the Kalamazoo River, its tributaries, and its watershed. The goals of the Kalamazoo River Watershed Council are to: 1) Promote wise stewardship and use of the natural resources of the Kalamazoo River and its watershed through education about its environmental, social, and economic issues; 2) Promote and celebrate the river as a recreational, aesthetic, and economic resource; 3) Facilitate, support, and provide technical assistance to partners addressing river and watershed issues, management planning, and funding; 4) Develop and implement resource protection and ecological enhancement projects; and, 5) Continue to function as the Public Advisory Council for all matters related to the problem of contaminated sediments in the Kalamazoo River system, advocating long-term solutions that will help produce a cleaner and safer river environment.

* The Kalamazoo River Watershed Council is the assumed name of this organization, which was incorporated under the name of the Kalamazoo River Public Advisory Council.

Stephen K. Hamilton, President

Kalamazoo River Watershed Council

PARTNER ORGANIZATIONS

What follows is a description, in their own words, of each of the partner organizations:

Who they are, what they do and how they do it; and
How they envision interacting with, serving and being served by the Watershed Council acting as the "umbrella" organization.

1) Kalamazoo River/Lake Allegan Total Maximum Daily Load (TMDL) Implementation Committee (Committee)

The Committee is an informal, voluntary, stakeholder based gathering of citizens, coming together to reduce phosphorus within the watershed. Its purpose is to provide watershed wide leadership in the implementation of the Phosphorus TMDL Implementation Plan developed in 2002. This includes: overall coordination and communication; convening and facilitation of stakeholders; assist in reporting and tracking; encourage and support appropriate regulatory activities; identify watershed needs and sources of funding; nurture and support existing community organizations; and examine and analyze other successful watershed protection efforts for possible use within this watershed.

The Committee and the Council agree to the following: 1) jointly participate in governance and participation in activities of both groups; 2) assist the Council in serving as the center for watershed communications; 3) develop a long-term repository for watershed information and data, and serve as an information clearing house; and 4) provide assistance in promotion and support of activities, issues and areas of mutual interest.

Thomas Dunn, Chair Date

Attachment 2. Crosswalk table of subwatersheds as defined by project, agency, and management unit.

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
1	*30100 10*	*201*	2	S Br Kalamazoo River	at Mosherville Road	3	05S	02W	30	14.3	14.3			TMDL
2	*30100 20*	*201*	3	S Br Kalamazoo River	at Unnamed Trib	31	04S	02W	30	24.7	39.1			TMDL
3	*30100 30*	*202*	4	S Br Kalamazoo River	at Unnamed Trib	11	05S	03W	30	22.0	61.1			TMDL
4	*30100 40*	*203*	5	S Br Kalamazoo River	at Beaver Creek	30	04S	03W	38	29.2	90.3			TMDL
5	*30100 50*	*204*	7	S Br Kalamazoo River	at Swains Lake Drain	12	04S	04W	13	17.3	107.6			TMDL
6	*30100 60*	*205*	7	Lampson Run Drain	at Mouth	8	04S	04W	13	21.7	21.7			TMDL
7	*30100 70*	*206*	8	S Br Kalamazoo River	at Gage #04102850	20	03S	04W	13	18.4	147.7			TMDL
8	*30100 80*	*206*	12	S Br Kalamazoo River	at Mouth	35	03S	04W	13	5.5	153.2			TMDL

SUB	HUC - NRCS 14 digit	HUC - NRCS 12 digit and 303d	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
9	*3010090*	*101*	11	North Kalamazoo River	at Cross Lake	32	03S	02W	38	33.3	33.3			TMDL
10	*3010100*	*102*	11	Spring Arbor and Concord	at Mouth	9	03S	03W	38	20.9	20.9			TMDL
11	*3010110*	*103*	12	N Br Kalamazoo River	at Spring Arbor and Concord Drain	9	03S	03W	38	25.2	79.3			TMDL
12	*3010120*	*104 & 406*	20	Kalamazoo River	at Gage #04103010	26	02S	05W	13	37.1	269.6			TMDL
13	*3020010*	*404*	14	Wilder Creek	at Huckleberrry Drain	15	03S	05W	13	15.1	15.1			TMDL
14	*3020020*	*404*	20	Wilder Creek	at Mouth	33	02S	05W	13	14.8	29.9			TMDL
15	*3020030*	*401*	16	S Br Rice Creek	at State Route 99	18	02S	03W	38	16.9	16.9	Rice Creek		TMDL
16	*3020040*	*402*	19	S Br Rice Creek	at Mouth	14	02S	05W	13	22.5	39.4	Rice Creek		TMDL
17	*3020050*	*403*	18	N Br Rice Creek	at Gordon Lake	26	01S	04W	13	21.6	21.6	Rice Creek		TMDL
18	*3020060*	*403*	19	N Br Rice Creek	at Mouth	14	02S	05W	13	14.5	36.1	Rice Creek		TMDL
19	*3020070*	*405*	20	Rice Creek	at Mouth	25	02S	06W	13	21.0	96.5	Rice Creek		TMDL
20	*3020080*	*406*	21	Kalamazoo River	at Gage #04103500	25	02S	06W	13	15.4	411.5			TMDL

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
21	*3020090*	*407*	22	Kalamazoo River	at Squaw Lake Drain	33	02S	06W	13	24.6	436.1			TMDL
22	*3020100*	*408*	23	Kalamazoo River	at Pigeon Creek	25	02S	07W	13	21.5	457.6			TMDL
23	*3020110*	*411*	42	Kalamazoo River	at Dickinson Creek	15	02S	07W	13	14.6	472.2			TMDL
24	*3020120*	*409*	25	Harper Creek	at Mouth	19	02S	07W	13	26.6	26.6			TMDL
25	*3020130*	*410*	42	Minges Brook	at Mouth	18	02S	07W	13	27.6	54.2			TMDL
26	*3030010*	*301*	28	Battle Creek	Above Hogle and Miller Drain	20	01N	04W	23	20.6	20.6	Battle Creek		TMDL
27	*3030020*	*301*	28	Hogle and Miller Drain	at Mouth	20	01N	04W	23	6.6	6.6	Battle Creek		TMDL
28	*3030030*	*302*	30	Battle Creek	at Unnamed Trib	28	02N	04W	23	15.9	43.0	Battle Creek		TMDL
29	*3030050*	*303*	30	Big Creek	at Mouth	15	01N	05W	23	18.0	18.0	Battle Creek		TMDL
30	*3030040*	*306*	33	Battle Creek	at Big Creek	15	01N	05W	23	27.4	88.5	Battle Creek		TMDL
31	*3030060*	*304*	32	Indian Creek	at State and Indian Creek	13	01S	05W	13	33.1	33.1	Battle Creek		TMDL
32	*3030070*	*305*	33	Indian Creek	at Mouth	18	01N	05W	23	16.7	49.7	Battle Creek		TMDL
33	*3030080*	*306*	34	Battle Creek	at Indian Creek	18	01N	05W	23	9.7	147.9	Battle Creek		TMDL

SUB	HUC - NRCS 14 digit	HUC - NRCS 12 digit and 303d	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
34	*3030090*	*307*	35	Battle Creek	at Gage #04104500	29	01N	06W	23	23.7	171.6	Battle Creek		TMDL
35	*3030100*	*308*	36	Battle Creek	at Ackley Creek	6	01S	06W	13	18.7	190.3	Battle Creek		TMDL
36	*3030110*	*309*	40	Battle Creek	at Unnamed Trib	13	01S	07W	13	16.8	207.0	Battle Creek		TMDL
37	*3030120*	*310*	38	Wanadoga Creek	at Ellis Creek	23	01N	07W	8	26.0	26.0	Battle Creek		TMDL
38	*3030130*	*311*	39	Wanadoga Creek	at Gage #04104945	9	01S	07W	13	22.3	48.3	Battle Creek		TMDL
39	*3030140*	*311*	40	Wanadoga Creek	at Mouth	21	01S	07W	13	5.9	54.3	Battle Creek		TMDL
40	*3030150*	*312*	41	Battle Creek	at Gage #04105000	5	02S	07W	13	12.8	274.0	Battle Creek		TMDL
41	*3030160*	*312*	42	Battle Creek	at Mouth	1	02S	08W	13	6.4	280.4	Battle Creek		TMDL
42	*3030170*	*411*	45	Kalamazoo River	at Gage #04105500	1	02S	08W	13	12.5	819.3			TMDL
43	*3040010*	*501*	44	Wabascon Creek	at Luce Road	36	01N	08W	8	27.4	27.4			TMDL
44	*3040020*	*502*	45	Wabascon Creek	at Mouth	29	01S	08W	13	19.5	46.9			TMDL
45	*3040030*	*503*	52	Kalamazoo River	at Wabascon Creek	29	01S	08W	13	24.5	890.8			TMDL
46	*3040040*	*504*	52	Sevenmile Creek	at Mouth	25	01S	09W	39	16.3	16.3			TMDL
47	*3040050*	*505*	48	Augusta Creek	at Unnamed Trib	3	01S	09W	39	19.1	19.1	Four Townships		TMDL

SUB	HUC - NRCS 14 digit	HUC - NRCS 12 digit and 303d	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
48	*3040060*	*506*	49	Augusta Creek	at Gage #04105700	27	01S	09W	39	17.7	36.8	Four Townships		TMDL
49	*3040070*	*506*	52	Augusta Creek	at Mouth	34	01S	09W	39	1.0	37.8	Four Townships		TMDL
50	*3040080*	*507*	51	Gull Creek	at Gage #04105800	7	02S	09W	39	35.7	35.7	Four Townships		TMDL
51	*3040090*	*507*	52	Gull Creek	at Mouth	17	02S	09W	39	1.8	37.5	Four Townships		TMDL
52	*3040100*	*508*	53	Kalamazoo River	at Gull Creek	17	02S	09W	39	30.6	1012.9		Mainstem 3	TMDL
53	*3040110*	*509*	55	Kalamazoo River	at Morrow Lake Dam	21	02S	10W	39	23.9	1036.8		Mainstem 3	TMDL
54	*3040120*	*601*	55	Comstock Creek	at Mouth	20	02S	10W	39	18.3	18.3	Four Townships		TMDL
55	*3040130*	*604*	63	Kalamazoo River	at Gage #04106000	20	02S	10W	39	4.4	1059.5		Mainstem 3	TMDL
56	*3050010*	*604*	63	Davis Creek	at Mouth	24	02S	11W	39	14.5	14.5	Davis Creek	Mainstem 3 overlap	TMDL
57	*3050020*	*603*	58	Portage Creek	at Gage #04106180	16	03S	11W	39	14.9	14.9	Portage/Arcadia		TMDL
58	*3050030*	*603*	61	Portage Creek	at Gage #04106300	34	02S	11W	39	5.4	20.3	Portage/Arcadia		TMDL
59	*3050040*	*602*	60	W Fork Portage Creek	at Gage #04106320	6	03S	11W	39	14.5	14.5	Portage/Arcadia		TMDL
60	*3050050*	*602*	61	W Fork Portage Creek	at Gage #04106400	6	03S	11W	39	6.7	21.2	Portage/Arcadia		TMDL
61	*30500*	*603*	62	Portage	at Gage	27	02S	11W	39	6.2	47.7	Portage/Arc		TMDL

SUB	HUC - NRCS 14 digit	HUC - NRCS 12 digit and 303d	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
	60			Creek	#04106500							adia		
62	*3050070*	*603*	63	Portage Creek	at Mouth	15	02S	11W	39	4.0	51.7	Portage/Arcadia		TMDL
63	*3050080*	*604*	65	Kalamazoo River	at Portage Creek	15	02S	11W	39	6.0	1131.7		Mainstem 3	TMDL
64	*3050090*	*605*	65	Spring Brook	at Mouth	27	01S	11W	39	38.6	38.6	Four Townships		TMDL
65	*3050100*	*606*	66	Kalamazoo River	at Spring Brook	27	01S	11W	39	40.5	1210.7	Portage/Arcadia portion	Mainstem 3 portion	TMDL
66	*3050110*	*607*	67	Kalamazoo River	at Silver Creek	4	01S	11W	39	36.8	1247.6	Four Townships		TMDL
67	*3050120*	*607*	74	Kalamazoo River	at Plainwell Dam	24	01N	12W	3	17.5	1265.1			TMDL
68	*3060010*	*701*	69	Gun River	at Gun Lake Outlet	6	02N	10W	8	34.2	34.2	Gun River		TMDL
69	*3060020*	*702*	70	Gun River	at Culver Drain	26	02N	11W	3	46.2	80.5	Gun River		TMDL
70	*3060030*	*703*	74	Gun River	at Mouth	24	01N	11W	3	34.0	114.5	Gun River		TMDL
71	*3060040*	*901*	73	Sand Creek	at Mouth	30	01S	12W	39	21.2	21.2			TMDL
72	*3060050*	*902*	73	Base Line Creek	at Mouth	31	01N	12W	3	36.6	36.6			TMDL
73	*3060060*	*903*	74	Pine Creek	at Mouth	21	01N	12W	3	33.3	91.0			TMDL
74	*3060070*	*905*	76	Kalamazoo River	at Otsego Dam	17	01N	12W	13	17.8	1488.4			TMDL
75	*3060080*	*904*	76	Schnable Brook	at Mouth	7	01N	12W	3	36.2	36.2			TMDL

SUB	HUC - NRCS 14 digit	HUC - NRCS 12 digit and 303d	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
76	*3060090*	*905*	77	Kalamazoo River	at Trowbridge Dam	12	01N	13W	3	7.3	1531.9			TMDL
77	*3060100*	*906*	78	Kalamazoo River	at Unnamed Dam	28	02N	13W	3	19.5	1551.4			TMDL
78	*3060110*	*907*	80	Kalamazoo River	at Unnamed Dam	28	02N	13W	3	44.8	1596.2			TMDL
79	*3060120*	*908*	80	Swan Creek	at Mouth	9	02N	14W	3	49.1	49.1			
80	*3060130*	*909*	93	Kalamazoo River	at Gage #04108500	32	03N	14W	3	8.1	1653.4			
81	*3070010*	*806*	82	Little Rabbit River	at Dorr and Nichols Drain	17	04N	12W	3	25.6	25.6	Rabbit River		
82	*3070020*	*807*	89	Little Rabbit River	at Mouth	29	04N	13W	3	23.5	49.0	Rabbit River		
83	*3070030*	*804*	88	Bear Creek	at Mouth	17	03N	12W	3	20.1	20.1	Rabbit River		
84	*3070040*	*801*	85	Green Lake Creek	at Mouth	31	04N	11W	3	28.2	28.2	Rabbit River		
85	*3070050*	*802*	86	Rabbit River	at Green Lake Creek	31	04N	11W	3	21.4	49.6	Rabbit River		
86	*3070060*	*805*	88	Rabbit River	at Gage #04108600	16	03N	12W	3	15.5	65.1	Rabbit River		
87	*3070070*	*803*	88	Miller Creek	at Mouth	20	03N	12W	3	30.3	30.3	Rabbit River		
88	*3070080*	*805*	89	Rabbit River	at Bear Creek	17	03N	12W	3	2.7	118.3	Rabbit River		

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
89	*3070090*	*808*	91	Rabbit River	at Little Rabbit River	29	04N	13W	3	32.5	199.9	Rabbit River		
90	*3070100*	*809*	91	Black Creek	at Mouth	25	04N	14W	3	35.1	35.1	Rabbit River		
91	*3070110*	*810*	92	Rabbit River	at Silver Creek	35	04N	14W	3	20.4	255.4	Rabbit River		
92	*3070120*	*811*	93	Rabbit River	at Mouth	16	03N	15W	3	37.2	292.6	Rabbit River		
93	*3070130*	*909*	95	Kalamazoo River	at Rabbit River	16	03N	15W	3	26.9	1972.9			
94	*3070140*	*910*	95	Mann Creek	at Mouth	17	03N	15W	3	17.4	17.4			
95	*3070150*	*911*	96	Kalamazoo River	at Peach Orchid Creek	22	03N	16W	3	23.5	2013.8			
96	*3070160*	*912*	0	Kalamazoo River	at Mouth	5	03N	16W	3	17.3	2031.1			

SUB – Subwatershed number from Michigan Geospatial Data Library watershed dataset
HUC - Hydrologic Unit Code, NRCS – Natural Resource Conservation Service
DRAIN_TO – Subwatershed drains to, WCOURSE – Watercourse
SEC – Section, TN – Township, RNG – Range, CO – County
AREA_MI – Area in square miles, TDA_MI – Total drainage area in square miles
Sub-WMP – Subwatershed management planning area
SWWMP – Stormwater watershed management planning area
TMDL – Total Maximum Daily Load, for Lake Allegan

Attachment 3. Build-out analysis and urban cost scenarios (63 pages).

BUILD-OUT ANALYSIS AND URBAN COST SCENARIOS

FOR THE KALAMAZOO RIVER WATERSHED MANAGEMENT PLAN

Prepared for:
Kalamazoo River Watershed Council
408 E. Michigan Avenue
Kalamazoo, Michigan 49007

Prepared by:
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September 30, 2010

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1.0 Introduction

The Kalamazoo River watershed drains approximately 2,000 square miles of land that discharges into Lake Michigan at Saugatuck, Michigan. This 8-digit HUC watershed (#04050003) has numerous water quality issues resulting from historic and current land use decisions. One of the major problems in the watershed is nutrient enrichment of Lake Allegan, a reservoir on the Kalamazoo River mainstem west of the City of Allegan. Lake problems associated with the over-enrichment of phosphorus include nuisance algal blooms, low oxygen levels, poor water clarity, and a fish community heavily unbalanced and dominated by exotic carp.

Agriculture and forested land cover approximately 70% of the Kalamazoo River watershed, while developed urban lands represent only 8%. A 2001 watershed pollutant loading study found that urban land covers (transportation, industrial, and residential) may represent up to 50% of the overall nonpoint source phosphorus load to the Kalamazoo River (K&A, 2001). Where new development pressures exist, pollutant loads will increase unless policies are in place to mitigate impacts of new development. In Kalamazoo County, for example, land is being developed at 2.5 times the population growth, resulting in loss of farmland and forested areas (MSU, 2007). Despite a phosphorus TMDL that addresses existing nonpoint source loads as of 1998, these new development pressures and potentially negative impacts on hydrology, water quality, TMDL or watershed management goals in the Kalamazoo River watershed are not explicitly being addressed[1]. A statistical analysis of the last ten years of monitoring data since 1998 shows no progress had been made towards these load reduction goals (K&A, 2007)[2].

In the last ten years, several nonpoint source modeling studies have been conducted in major subwatersheds of the Kalamazoo River watershed and for the Lake Allegan/Kalamazoo River TMDL (K&A, 2001). However, no study has yet modeled the Kalamazoo River watershed in its entirety, and pollutant loading information is lacking for several areas including the mouth and headwaters of the Kalamazoo River. The development of a Kalamazoo River Watershed Management Plan (WMP) requires the quantification of current pollutant loads. It also needs an assessment of potential load changes resulting from future land development and land use change in the watershed.

To address these two WMP needs, a watershed-wide, nonpoint source empirical model was run by K&A as part of the WMP to estimate runoff volumes and pollutant loads from existing land cover. Runoff volumes and pollutant loads were calculated using average runoff depth values produced by the Long-term Hydrologic Impact Assessment model (L-THIA) and available pollutant event mean concentration (EMC) values. Loads and volumes were calculated for “current” conditions (2001 land use; the most recent and comprehensive set of land cover data) and for future conditions in 2030 using a land use layer produced by the Land Transformation Model[3] (LTM). The LTM data layer was used at three different scales: watershed, subwatershed and municipal/township levels. These modeling results were used to assess the impact of

[1] *The phosphorus Total Maximum Daily Load (TMDL) developed for Lake Allegan, which includes the entire watershed area upstream of Lake Allegan, requires a 43% reduction for nonpoint source phosphorus load for the April-June season, and a 50% reduction for the July-September season (Heaton, 2001). These reductions can only be achieved through the implementation of not only agricultural best management practices, but urban best management practices and policies, as well.*

[2] *A copy of this presentation can be downloaded at: http://kalamazooriver.net/tmdl/docs/M-89%20NPS%20Loading%201998-2007.pdf*

[3] *LTM developed by Bryan Pijanowski, et al. and currently hosted by Purdue University (Pijanowski, et al., 2000, 2002).*

future potential urban development on water quality and to estimate the costs necessary to achieve water quality goals. This report presents the methodology and results of this watershed-wide modeling effort.

2.0 Methods

The methods used in this analysis provide WMP stakeholders with information on current and predicted future runoff from the landscape within the watershed, nutrient loading from specific land cover, and potential costs to offset phosphorus loads now and in the future. Explanations of these models, input values, and assumptions are outlined below.

2.1 Model Descriptions

The build-out analysis for the Kalamazoo River WMP was developed by coupling a GIS-based runoff model with regionally recognized event mean concentration (EMC) values from the Michigan Trading Rules (Part 30), future land use data, and runoff data. L-THIA GIS, a simple rainfall-runoff model, was used to generate runoff values for both current and future build-out conditions. The future land use layers used in the build-out analysis were produced by the LTM, a GIS-based land use change model developed by researchers from Michigan State University and currently hosted by Purdue University (Pijanowski, *et al.,* 2000, 2002)[4]. The first step in this modeling effort coupled values from the L-THIA model with EMC values for Michigan to establish baseline pollutant loads and runoff volume in the Kalamazoo River watershed. The second modeling step incorporated predicted land use in 2030 from the LTM to calculate pollutant load and runoff volume changes that may result from projected changes in land cover in the future.

LONG-TERM HYDROLOGIC IMPACT ASSESSMENT

L-THIA WAS DEVELOPED AS A SIMPLE-TO-USE, ONLINE ANALYSIS TOOL PROVIDING AN ASSESSMENT OF THE IMPACT OF LAND USES ON RUNOFF. L-THIA CALCULATES AVERAGE ANNUAL RUNOFF FOR EACH UNIQUE LAND USE/SOIL CONFIGURATION USING LONG-TERM CLIMATE DATA FOR A SPECIFIED AREA. L-THIA USES THE SCS CURVE NUMBER METHOD TO ESTIMATE RUNOFF, A WIDELY APPLIED METHOD ORIGINALLY DEVELOPED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE (USDA, 1986). THE ARCVIEW EXTENSION L-THIA GIS[1] WAS USED IN THIS ANALYSIS.

LAND TRANSFORMATION MODEL

THE LAND TRANSFORMATION MODEL IS A GIS-BASED MODEL THAT PREDICTS LAND USE CHANGES BY COMBINING SPATIAL RULES WITH ARTIFICIAL NEURAL NETWORK ROUTINES. SPATIAL RULES TAKE INTO ACCOUNT A VARIETY OF GEOGRAPHICAL, POLITICAL, AND DEMOGRAPHIC PARAMETERS SUCH AS POPULATION DENSITY, POPULATION GROWTH PROJECTIONS, LOCATION OF RIVERS AND PUBLIC LANDS, DISTANCE FROM ROADS, AND TOPOGRAPHY (PIJANOWSKI *ET AL*., 2002). THE MODEL AND ADDITIONAL INFORMATION ARE AVAILABLE FROM PURDUE UNIVERSITY'S WEBSITE. LTM WAS RUN FOR WISCONSIN, ILLINOIS, AND MICHIGAN AS PART OF THE EPA STAR ILWIMI PROJECT AND THE 2000-2030 TIME SERIES LAYERS ARE AVAILABLE ON THE LTM WEBSITE. THE LTM MICHIGAN LAND USE LAYERS FOR 2000 AND 2030 WERE SELECTED FOR USE IN THIS ANALYSIS.

[4] *Information on the land transformation model and data for download is available at:* http://ltm.agriculture.purdue.edu/ltm.htm.

The LTM layer for the year 2000 actually used the 2001 Integrated Forest Monitoring Assessment Prescription (IFMAP) land use/land cover dataset[5] as a base layer. For consistency purposes, this project references all analyses done using the LTM 2000 layer as 2001. The LTM land use categories are based on a reclassification of IFMAP categories using the USGS Gap Analysis Program (GAP) land use coding system (see Purdue University's LTM website). The build-out analysis was conducted using the LTM land use categories. Due to variation in land use category descriptions between the datasets, categories equivalent to the LTM descriptions were matched. The category equivalents for IFMAP, L-THIA and LTM are provided in Table 1. It should be noted that LTM layers have a 100-m resolution.

Table 1. Equivalence of land use categories between L-THIA, LTM and IFMAP datasets.

LTM Land Use Code	LTM Land Use Category	L-THIA Land Use Category	Equivalent 2001 IFMAP Land Use Category
11	Urban -commercial	Commercial	High Intensity Urban Runways
12	Urban-Residential	LD Residential	Low Intensity Urban
13	Other Urban	Open Spaces	Parks/Golf Courses
14	Urban - Roads and Parking Lots	Parking & Paved Spaces	Roads, Parking Lots
21	Agriculture - Non-row Crops	Agricultural	Forage Crops Non-tilled Herbaceous Orchards
22	Agriculture - Row Crops	Agricultural	Non-vegetated Farmland (plowed) Row Crops
30	Open - non-forested	Grass/pasture	Herbaceous Openland
41	Forest - Deciduous (upland)	Forest	Northern Hardwoods Aspen Forest Oak forest Other Upland Deciduous Mixed Upland Forest
42	Forest - Coniferous (upland)	Forest	Pines Other Upland Conifers Mixed Upland Conifers
43	Forest - Mixed Deciduous / Coniferous (upland)	Forest	Upland Mixed Forest Shrub/Low Density Forest
50	Open Water	Water/Wetlands	Open Water
610	Wetland - Wooded - shrubland	Water/Wetlands	Lowland Shrub
611	Wetland - Wooded - Lowland deciduous forest	Water/Wetlands	Lowland Deciduous
612	Wetland - Wooded - Lowland coniferous forest	Water/Wetlands	Lowland Coniferous
613	Wetland - Wooded - lowland mixed forest	Water/Wetlands	Lowland Mixed
62	Wetland - Nonwooded	Water/Wetlands	Emergent Wetland Floating Aquatic Mixed non-forested
70	Barren	Grass/Pasture	Sand/soil/rock/mud flats

[5] *2001 IFMAP land use map available at the Michigan Geographic Data Library:* http://www.mcgi.state.mi.us/mgdl/?rel=ext&action=sext

2.2 L-THIA Load Prediction Methodology

L-THIA calculates average annual runoff using a number of datasets, including long-term precipitation records, soil data, curve number values, and land use of the area modeled. To customize the analysis for the Kalamazoo River watershed, the following data layers were used as model inputs for L-THIA:

- Soil Survey Geographic (SSURGO) database[6]
- Layers from the LTM land use model results for 2001 and 2030
- Long-term precipitation data available for two National Oceanic and Atmospheric Administration co-op stations: Allegan (#200128) and Battle Creek (#200552)[7]

The default curve number values for a given land use/soil combination listed in the L-THIA manual were used for this analysis (Table 2). Average runoff depth was calculated using L-THIA for both the 2001 and 2030 land use layers.

The model was designed as a simple runoff estimation tool and as such, it contains a number of limitations. It is important to note the following:

- L-THIA only models surface water runoff
- It assumes that the entire area modeled contributes to runoff
- Factors such as contributions of snowfall to precipitation, the effect of frozen ground that increases stormwater runoff during cold months, and variations in antecedent moisture conditions are not modeled (L-THIA manual, 2005)

L-THIA is not designed to assess the requirements of a stormwater drainage system and other such urban planning practices, nor to model complex groundwater or fate and transport processes. However, the model clearly answered the needs of a simple loading analysis required in this project. A graphic description of the model process is presented in Figure 1.

Regionally recognized EMC values were used in the analysis to determine pollutant loading. These EMC values were calculated through the Rouge River National Wet Weather Demonstration Project. The project conducted an extensive assessment of stormwater pollutant loading factors per land use class (Cave *et al*., 1994) and recommended EMC values for 10 broad land use classes. These EMC values have since been incorporated into the Michigan Trading Rules (Part 30) to calculate pollutant loads from urban stormwater nonpoint sources. EMC values used in this analysis are presented in Table 2.

These EMCs, along with runoff depth grids produced through L-THIA, were used to calculate current and future pollutant loads using GIS spatial analysis functions. Pollutant loads and runoff volumes were calculated using the following equations (Michigan Trading Rules, 2002):

a) $R_L \times A_L \times 0.0833 = R_{Vol}$

b) $EMC_L \times R_L \times A_L \times 0.2266 = L_L$

[6] *SSURGO soil data for each county within the Kalamazoo River Watershed were downloaded from NRCS Soil Mart: http://soils.usda.gov/survey/geography/ssurgo/*

[7] *NOAA data for each station downloaded from: http://lwf.ncdc.noaa.gov/oa/climate/stationlocator.html*

Where:

EMC_L =	Event mean concentration for land use L in mg/l
R_{vol} =	Runoff volume in acre-feet/year
R_L =	Runoff per land use L from L-THIA in inches/year
A_L =	Area of land use L in acres
0.2266 =	Unit conversion factor (to convert mg-in-ac/yr to lbs/ac-yr)
L_L =	Annual load per land use L, in pounds

Using this equation, annual loads (with values presented in the form of GIS grids) were calculated for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) for both the 2001 and 2030 land use layers at the watershed, subwatershed, and municipality level.

Table 2. Curve numbers and event mean concentrations used in L-THIA and the build-out analysis.

LTM Land Use Categories	Curve Numbers for Soil Group				Event Mean Concentration (mg/L)			MI Trading Rules Land Use Category
	A	B	C	D	TSS	TN	TP	
Urban -Commercial	89	92	94	95	77	2.97	0.33	Commercial
Urban-Residential	54	70	80	85	70	5.15	0.52	Low Density Residential
Other Urban	49	69	79	84	51	1.74	0.11	Urban Open
Urban - Roads and Parking Lots	98	98	98	98	141	2.65	0.43	Highways
Agriculture - Non-Row Crops	64	75	82	85	145	5.98	0.37	Agricultural
Agriculture - Row Crops	64	75	82	85	145	5.98	0.37	Agricultural
Open - Non-Forested	39	61	74	80	51	1.74	0.11	Forest/Rural Open
Forest - Deciduous (upland)	30	55	70	77	51	1.74	0.11	Forest/Rural Open
Forest - Coniferous (upland)	30	55	70	77	51	1.74	0.11	Forest/Rural Open
Forest - Mixed Deciduous / Coniferous (upland)	30	55	70	77	51	1.74	0.11	Forest/Rural Open
Open Water	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Shrubland	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Lowland Deciduous Forest	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Lowland Coniferous Forest	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Lowland Mixed Forest	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Non-Wooded	0	0	0	0	6	1.38	0.08	Water/Wetlands
Barren	39	61	74	80	51	1.74	0.11	Forest/Rural Open

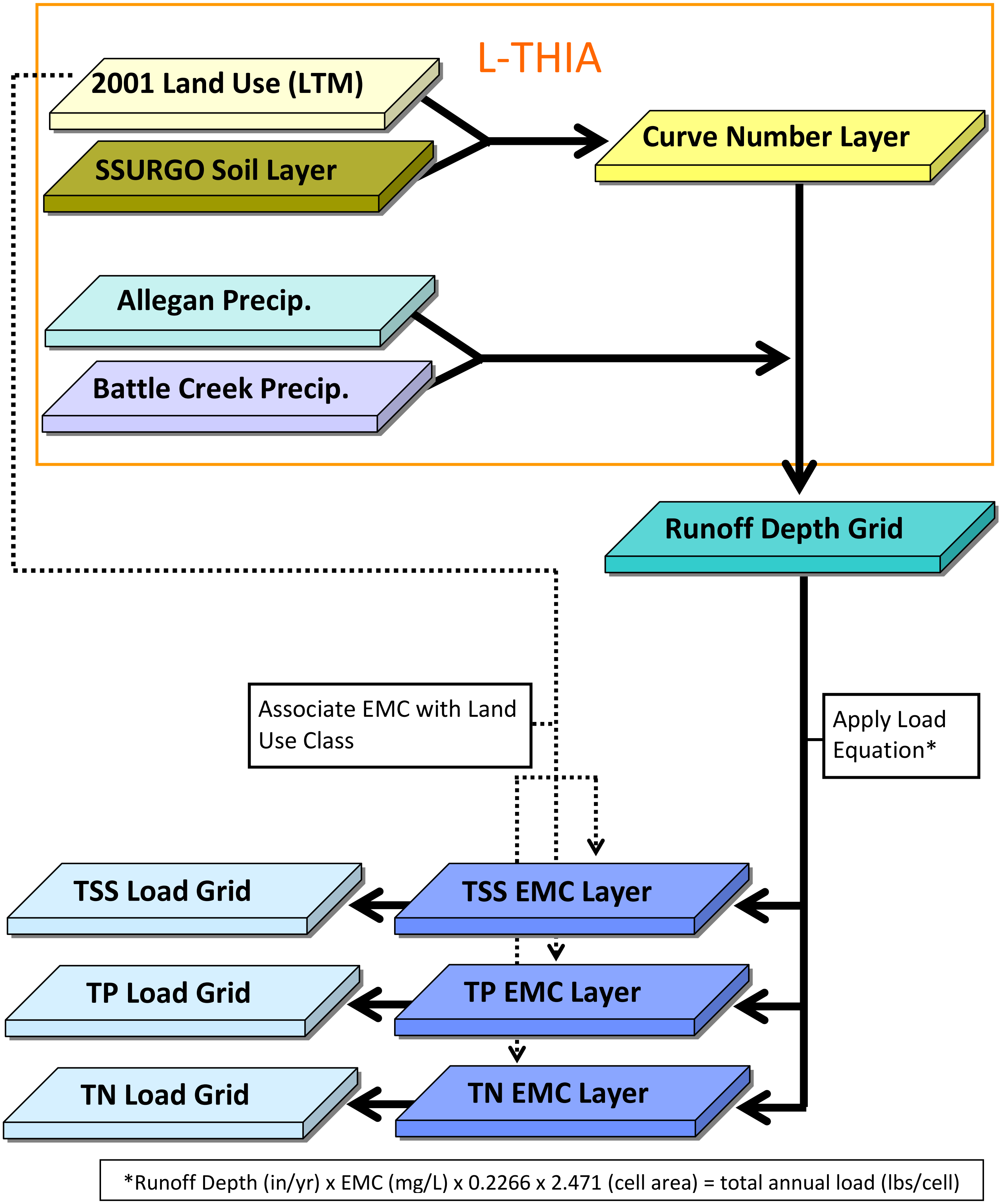

Figure 1. Conceptual flow chart of L-THIA nonpoint source modeling used to calculate runoff depth grids and additional datasets used to calculate annual nutrient and sediment loads in the watershed (where TP is total phosphorus, TN is total nitrogen and TSS is total suspended solids).

3.0 Results

Modeling results for the 2001 LTM layer were defined as the baseline for loading and runoff volume conditions. These may be considered generally comparable to the 1998 TMDL nonpoint source baseline load from which 50% reduction in TP loads are required. Predicted phosphorus loading results were within an acceptable range when compared to other available loading data for the Kalamazoo River watershed. As such, results obtained from the L-THIA/EMC model were deemed reasonable for the purposes of this evaluation. Modeling results for the 2030 LTM layer represented the build-out condition. The build-out analysis was conducted at three different scales, the entire Kalamazoo River watershed, 12-digit HUC subwatersheds, and municipalities/townships to support decision-making in the watershed management planning process. Land use throughout the watershed generally predicts an increase in urban land use and a decrease in forested, agricultural and wetland land cover.

3.1 Land Use Change Analysis

In order to compare current watershed loading to the predicted future loading scenario, land use layers from the LTM for the baseline year 2001 and predicted 2030 were analyzed. A comparison of land cover distribution in 2001 and 2030 for the entire Kalamazoo River watershed is presented in Figure 2. From 2001 to 2030, the most substantial change in land use is an increase in both urban land covers (commercial/high intensity and residential). From the model results, urban areas in the Kalamazoo River watershed could increase by more than 172,000 acres, corresponding to a 3.5 fold increase in urban areas compared to 2001. This growth of urban areas by 2030, as modeled would correspond to a loss of over 86,000 acres of farmland, 60,000 acres of forest and open land, and 20,000 acres of wetlands throughout the watershed.

It is important to note that the LTM layers used in this analysis modeled both urban and forest growth, although forest growth in the watershed is minor compared to forest lost to development. While the LTM model is programmed to exclude existing urban areas, water and designated public lands from future development, a small number of cells classified as water actually changed to urban categories (one-tenth of one percent). However, this error is minor and does not affect loading results in the build-out analysis.

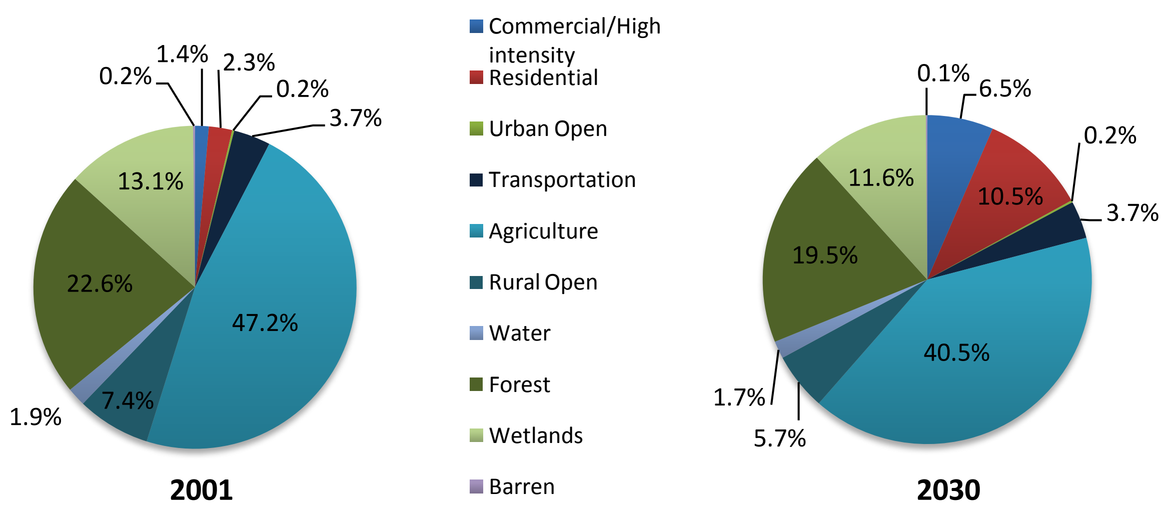

Figure 2. Comparison of land use breakdowns for the Kalamazoo River watershed in 2001 and 2030 (as predicted by the Land Transformation Model).

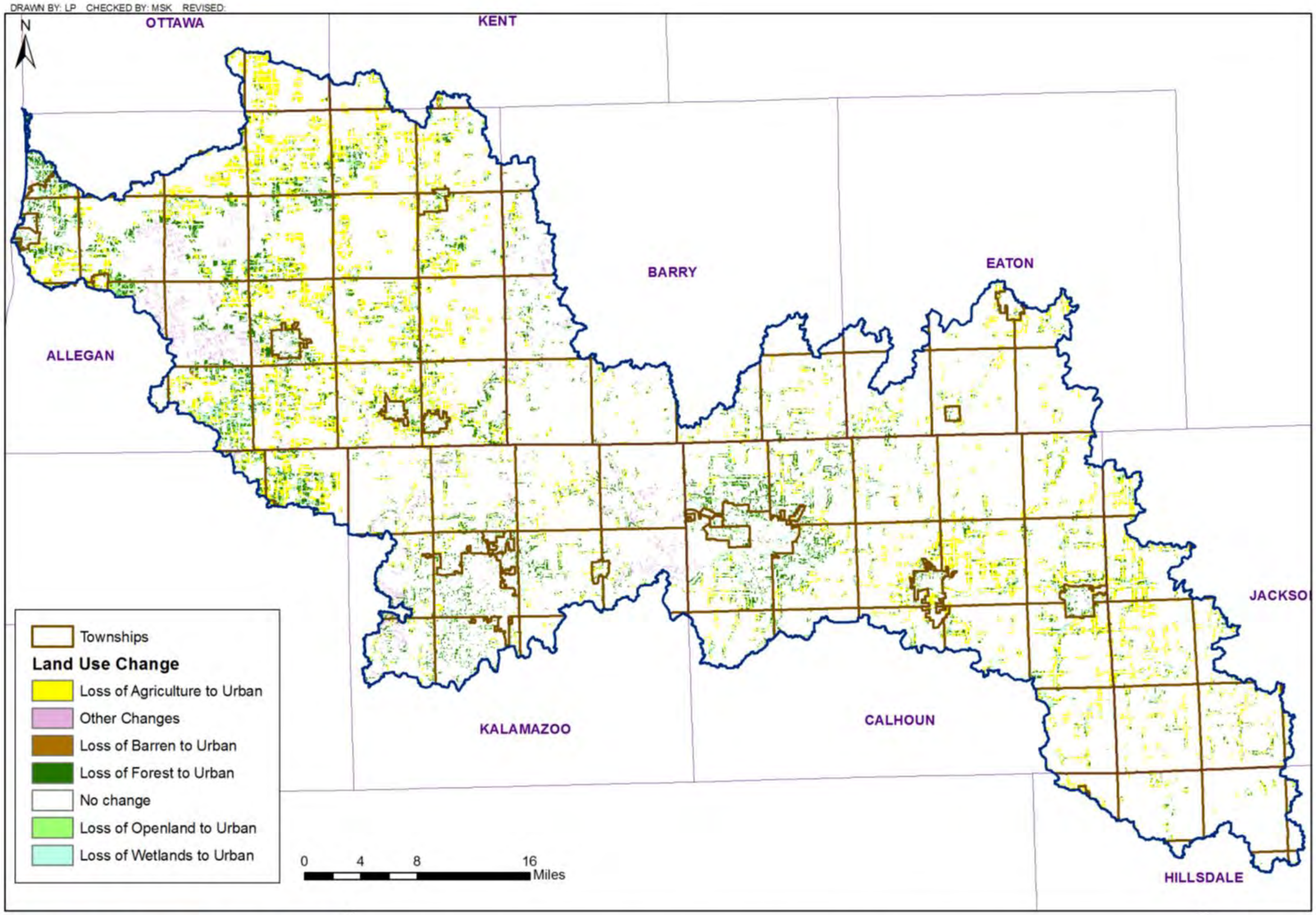

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Figure 3. Land use change from 2001 to 2030 in the Kalamazoo River watershed as predicted by the Land Transformation Model.

Note: In the map above, the category "Other Changes" refer to non-urban changes, such as open land to forest, or wetland to forest.

THE TOWNSHIPS PREDICTED TO HAVE THE GREATEST URBAN GROWTH IN THE NEXT 20 YEARS ARE SCATTERED ACROSS THE WATERSHED, BUT A LARGE MAJORITY ARE CONCENTRATED IN THE WEST IN ALLEGAN COUNTY WHERE THE LANDSCAPE IS MORE RURAL WITH PLENTY OF OPEN SPACE AND AGRICULTURE. THESE TOWNSHIPS SHOW GROWTH BECAUSE OF THEIR PROXIMITY TO RECREATION, OPEN LAND, AND MAJOR TRANSPORTATION ROUTES. A SUBSTANTIAL AMOUNT OF ACREAGE IS PREDICTED TO BE CONVERTED TO URBAN LAND USE BY 2030 IN THE TOWNSHIPS LISTED IN TABLE 3. ALL OF THE TOWNSHIPS CURRENTLY HAVE LESS THAN 1,000 URBAN ACRES, AND SOME HAVE FEWER THAN 500 ACRES. THE PREDICTED CHANGE RESULTS IN AN 8 FOLD TO OVER 35 FOLD INCREASE IN URBAN LAND COVER IN THESE AREAS.

A detailed breakdown of land use changes by township is presented in Appendix A. Table 3 below presents the ten townships with the highest potential for future urban development (i.e., greater than 2.5% increase). As modeled by LTM, the western portion of the watershed and the east side of the City of Marshall could experience the strongest urban expansion. Urban development in the west could be explained by the proximity of recreational and natural areas (such as the Allegan State Game Area) and the availability of land for development (Figure 4). The urbanization of such a large, contiguous area could likely have a strong negative impact on water quality, increase runoff and stream bank erosion, and generally degrade natural habitat in this currently rural part of the watershed. Urban development by the City of Marshall could be explained as suburban development and/or expansion and the high availability of agricultural land for development. Again, an increase in urban land cover without proper stormwater controls or regulation would result in higher nutrient loading, increased erosion, and an overall degradation of habitat and water quality.

Table 3. Townships in the Kalamazoo River watershed with the highest modeled increase in urban development by the year 2030.

Township	Total increase in urban areas (in acres)	% of total urban increase for the Kalamazoo River watershed
Cheshire	6,934	4.01
Salem	5,911	3.42
Trowbridge	5,911	3.42
Pine Grove	5,478	3.17
Allegan	5,253	3.04
Dorr	5,140	2.97
Marengo	4,930	2.85
Otsego	4,603	2.66
Monterey	4,470	2.58
Watson	4,351	2.52

Note: All township locations are shown in Figure 4, except for Marengo Township which is located east of the City of Marshall.

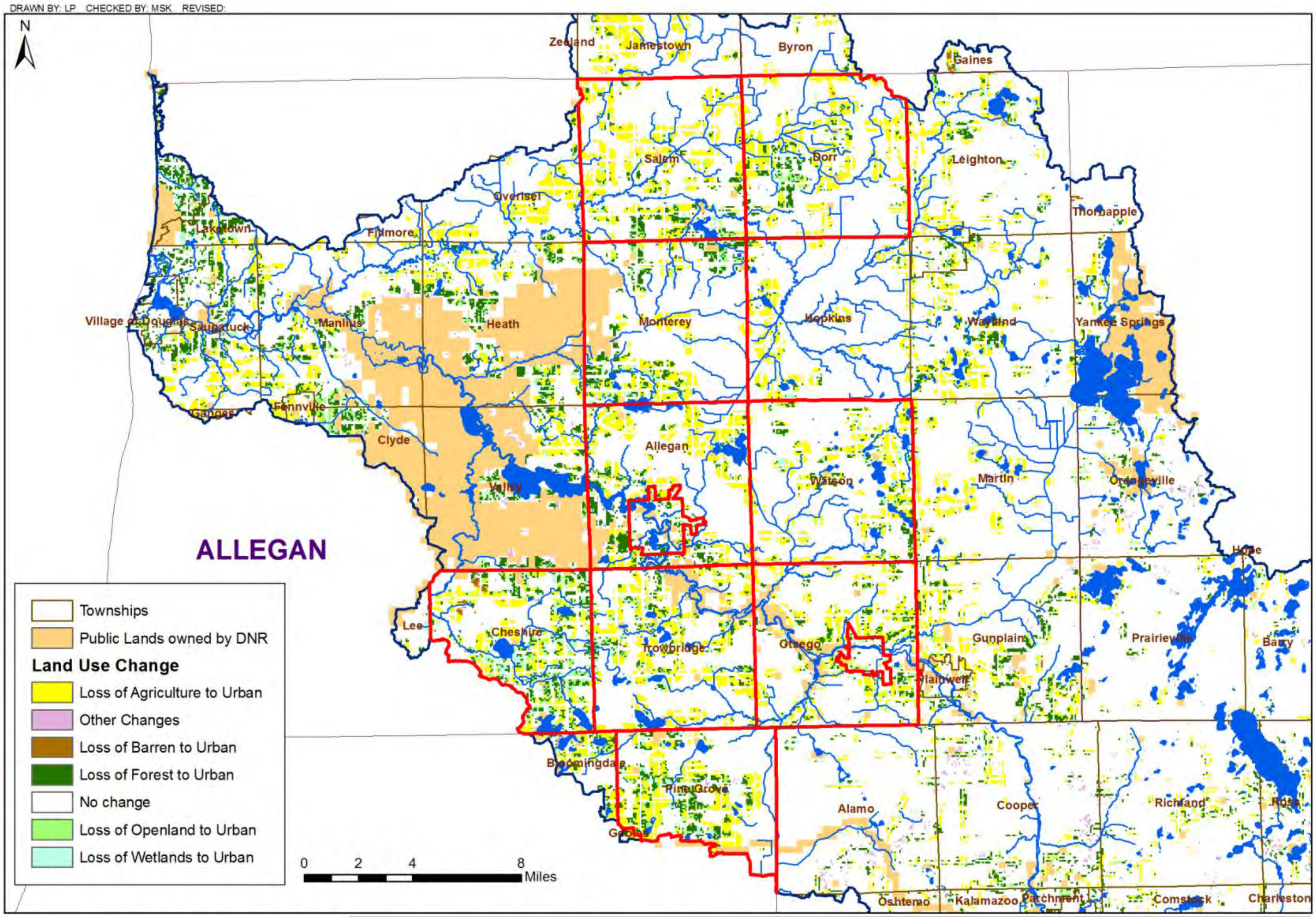

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Figure 4. Townships outlined in red located in the western section of the Kalamazoo River watershed have the largest predicted increase in urban area from the Land Transformation Model.

3.2 Pollutant Load and Runoff Volume Analysis at the Watershed Scale

Total runoff volume and pollutant loads for the Kalamazoo River watershed were calculated both for the baseline year 2001 and for the build-out year 2030 (Figure 5). It should be noted that loading and runoff calculations do not take into account the fact that municipalities may already have ordinances controlling stormwater runoff and/or phosphorus fertilizers or other regulations reducing runoff and phosphorus loading. Results show that the growing urbanization of the watershed by 2030 would lead to a 25% increase in runoff volume and TP load, 12% for TSS and 18% for TN load. These increases are related to the increase in impervious areas and land conversion from agricultural to urban uses.

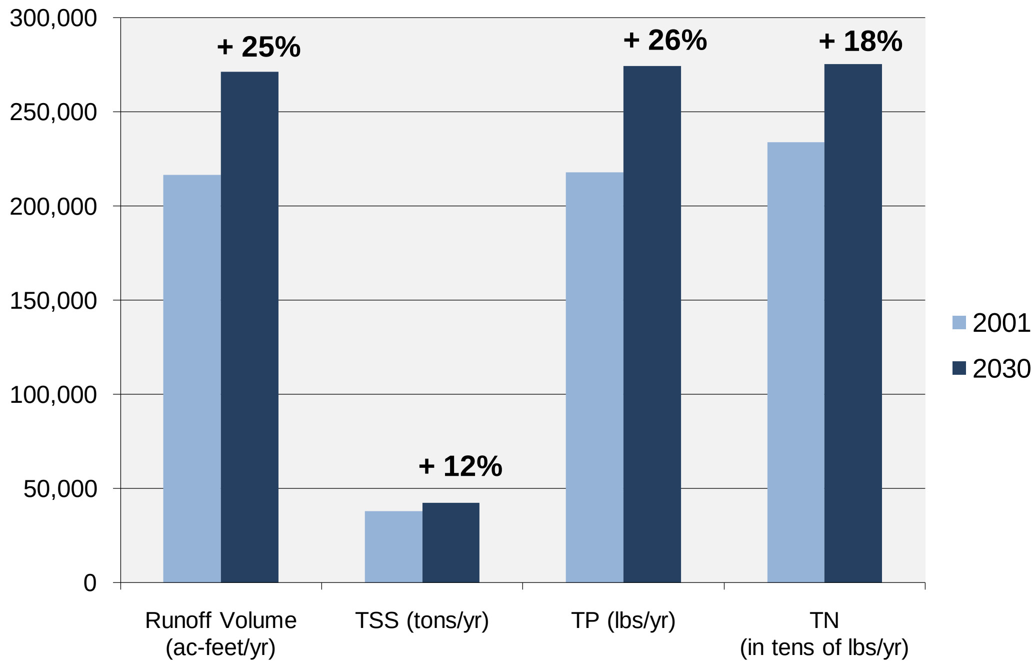

Figure 5. Nutrient load, sediment load and runoff volume comparisons between 2001 and 2030 for the Kalamazoo River watershed.

The 1999 Lake Allegan/Kalamazoo River Phosphorus TMDL requires a 43% reduction in TP load from nonpoint sources for the period April-June and a 50% reduction for July-September (Heaton, 2001). Figure 6 shows 2001 and 2030 loading compared to these TMDL goals. Nonpoint sources in the watershed include agricultural runoff (not regulated under the NPDES program) and urban sources, such as lawn fertilizers and stormwater runoff. Several counties in the watershed have recently passed ordinances limiting or banning the use of phosphorus fertilizers. However, it is difficult to quantify the impact of such regulations on future phosphorus loads. Agricultural nonpoint source remains a relatively high source of phosphorus to the entire watershed (40% of the total load to the watershed in 2001), yet the agricultural TP load is currently 30% lower than the total TP load from urban areas. In 2030, the model predicts that the phosphorus load from agriculture will represent only 27% of the total load and will be 60% lower than the total urban load (Figure 7). (These estimates reflect no changes in the level of best management practice [BMP] applications in either source category). Therefore, achieving the goals set in the Lake Allegan TMDL will not be possible unless measures are taken to mitigate the impact of urban development on water quality and quantity, both current and future. The implementation of stormwater BMPs and ordinances will become an important tool in reaching the TMDL nonpoint source load allocation.

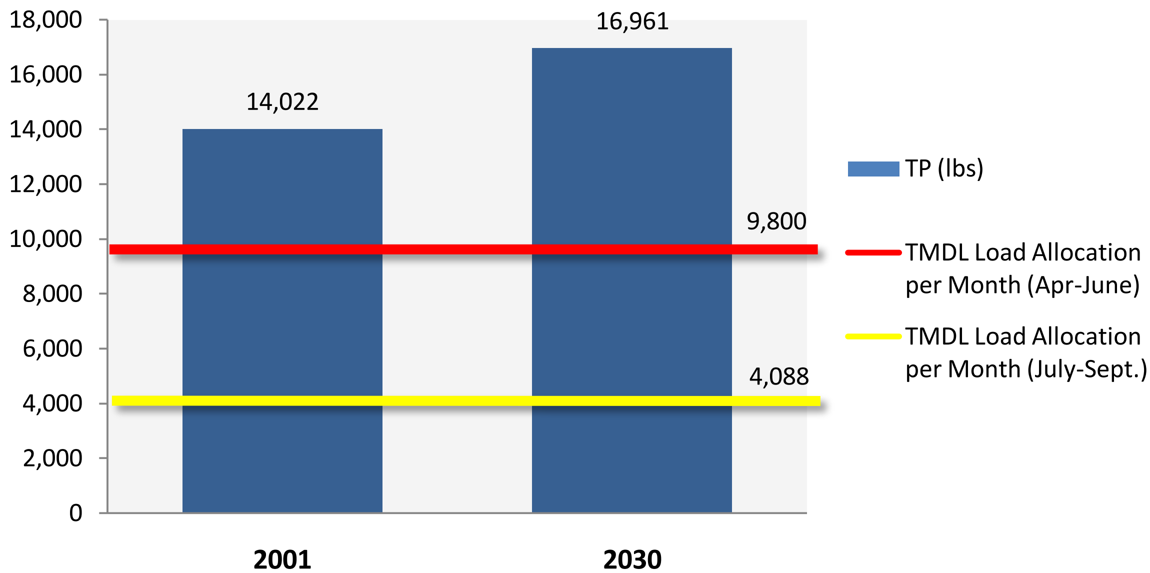

Figure 6. Comparison of NPS TP load (per month) in 2001 and 2030 with TMDL load allocation for the Lake Allegan/ Kalamazoo River TMDL area.

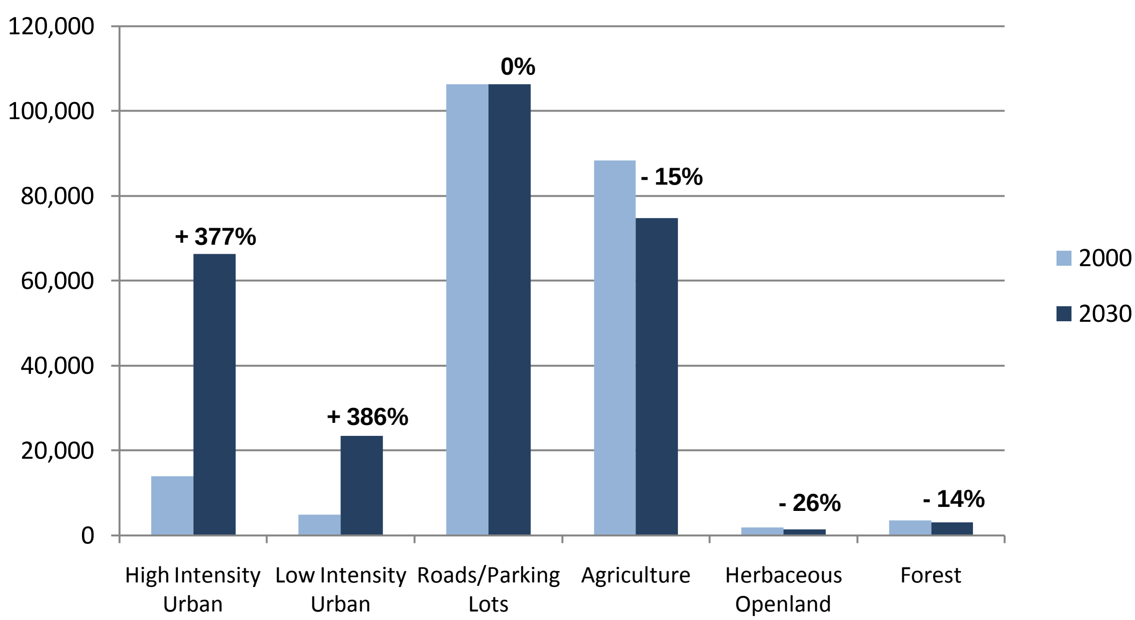

Figure 7. Total phosphorus load (in lbs/year) per land use in the Kalamazoo River watershed.

USING THE LAND TRANSFORMATION MODEL TO PREDICT FUTURE LAND USE IN THE WATERSHED, RESULTING LOAD INCREASES IN TOTAL PHOSPHORUS FROM HIGH INTENSITY AND LOW INTENSITY URBAN LAND USES ARE PREDICTED TO INCREASE BY OVER 375% AND 385%, RESPECTIVELY. WHEN PAIRED WITH PROACTIVE STORMWATER MANAGEMENT PRACTICES AND CONTROLS, GROWTH OF THESE URBAN AREAS DOES NOT HAVE TO RESULT IN EXTREME INCREASES IN TOTAL PHOSPHORUS LOADING TO THE RIVER. SECTION 4.0 DISCUSSES THE POTENTIAL STORMWATER COSTS ASSOCIATED WITH THE PREDICTED LOAD INCREASE.

3.3 Pollutant Load and Runoff Volume Analysis at the Subwatershed Scale

While all subwatersheds will experience an increase in runoff and loading to a varying extent, figures in Appendix B clearly show the trend by 2030 toward a larger increase in runoff and pollutant loading in the western part of the Kalamazoo River watershed, consistent with the land use change analysis in Section 3.1. The central area in the watershed between the Cities of Battle Creek and Kalamazoo and eastern parts of the watershed will be least impacted by urban development and the resulting environmental impacts. Annual average runoff and pollutant loads per subwatershed[8] are presented as maps in Appendix B and runoff volumes and pollutant loads for current baseline and future build-out are compared in Table B-1 in Appendix B.

In 2001, the subwatersheds with the highest runoff and pollutant loads are those located either in dense urban areas in the Cities of Kalamazoo, Portage and Battle Creek or in large agricultural areas, such as the Gun and Rabbit River subwatersheds (Table 4). Results are similar for 2030, in that the same urban and agricultural subwatersheds will continue to have the highest runoff and loading values. This is primarily due to predicted urban expansion in these areas of the watershed, as agricultural land is converted to residential and commercial uses (Table 5). In addition, two new subwatersheds (-0905, -0906) along the Kalamazoo River between Plainwell and Allegan are predicted to have some of the highest loadings in 2030, confirming the environmental impact of urbanization in this area (see Section 3.1 above).

These findings clearly highlight the difficulty of achieving TMDL goals in the long term when many high-loading subwatersheds are located upstream of Lake Allegan and directly along the Kalamazoo River. If land use changes occur as predicted without intervention, future loads will have to be offset in addition to the loads already in exceedence of the nonpoint source load allocation set by the TMDL. Areas outside of the TMDL area also have reason to be involved in watershed management planning as several rural subwatersheds around the City of Allegan (-0908, -0907, -0902) will experience the largest increases in pollutant loads as large acreages of agricultural and forested land are converted to urban land use (Table 6). In addition, the mouth of the watershed around the city of Saugatuck will also see large increases in loading as the attraction of the Lake Michigan shoreline leads to suburban sprawl. These areas do not currently fall under NPDES Phase II regulations, but future growth in the western portion of the watershed may result in regulation.

[8] *The subwatershed analysis was done using the recent 12-digit HUC subwatershed layer available from the USDA Geospatial Data Gateway (http://datagateway.nrcs.usda.gov).*

In these high-growth subwatersheds, urban development will have to be managed in a sustainable manner if water quality is to be protected from further degradation. Permitted municipalities in high-loading, urban subwatersheds will need to consider all possible stormwater management options to limit increases in runoff from future development. Efforts to reduce stormwater impacts include retrofitting current residential and commercial impervious surfaces for stormwater retention or infiltration, as well as developing construction rules or ordinances promoting on-site retention for new developments.

Table 4. Subwatersheds contributing the largest nutrient and sediment loads to the watershed in 2001.

Subwatershed	HUC	Mean Runoff Depth (in/yr)	TSS (lbs/ac/yr)	TP (lbs/ac/yr)	TN (lbs/ac/yr)	% urban/ agriculture
Portage Creek	040500030603	4.21	112.12	0.37	2.93	40 / 15
Davis Creek-Kalamazoo River	040500030604	3.72	98.27	0.33	2.68	32 / 30
Harts Lake-Kalamazoo River	040500030503	3.56	97.18	0.32	2.30	27 / 8
Battle Creek	040500030312	3.49	97.69	0.32	2.33	27 / 13
Averill Lake-Kalamazoo River	040500030606	4.06	96.18	0.31	2.33	32 / 18
Kalamazoo River	040500030912	3.15	81.76	0.26	2.16	20 / 15
Fales Drain-Rabbit River	040500030802	2.90	85.19	0.24	2.87	7 / 53
Gun River	040500030703	2.79	83.40	0.23	2.87	5 / 58
Headwaters Little Rabbit River	040500030806	2.58	77.64	0.22	2.65	8 / 72
Black Creek	040500030809	2.54	80.06	0.22	2.67	5 / 80
Pigeon Creek-Rabbit River	040500030808	2.64	77.15	0.22	2.68	6 / 59
Little Rabbit River	040500030807	2.64	77.13	0.22	2.80	6 / 66
West Fork Portage Creek	040500030602	3.39	65.15	0.21	1.63	22 / 19

Table 5. Subwatersheds predicted to contribute the largest nutrient and sediment loads to the watershed in 2030.

Subwatershed	HUC	Mean Runoff Depth (in/yr)	TSS (lbs/ac/yr)	TP (lbs/ac/yr)	TN (lbs/ac/yr)	% urban/ agriculture
Portage Creek	040500030603	4.64	118.83	0.41	3.25	51 / 14
Kalamazoo River	040500030912	4.83	109.76	0.41	3.43	48 / 10
Harts Lake-Kalamazoo River	040500030503	4.17	107.34	0.37	2.75	43 / 6
Battle Creek	040500030312	4.04	106.59	0.36	2.75	43 / 11
Davis Creek-Kalamazoo River	040500030604	3.98	102.34	0.35	2.86	39 / 28
Averill Lake-Kalamazoo River	040500030606	4.55	102.50	0.35	2.62	46 / 15
Tannery Creek-Kalamazoo River	040500030906	3.94	90.67	0.33	3.04	40 / 24
Little Rabbit River	040500030807	3.86	91.17	0.32	3.50	32 / 49
Fales Drain-Rabbit River	040500030802	3.65	95.08	0.31	3.35	22 / 46
Trowbridge Dam-Kalamazoo River	040500030905	3.49	83.95	0.29	2.88	31 / 34
Gun River	040500030703	3.52	92.60	0.29	3.31	22 / 50
Pigeon Creek-Rabbit River	040500030808	3.50	88.46	0.29	3.23	24 / 50
Black Creek	040500030809	3.40	89.38	0.29	3.09	27 / 62

Table 6. Subwatersheds predicted to experience the largest changes in runoff volume, nutrient load and sediment load from 2001 to 2030.

		Runoff		TSS		TP		TN	
Subwatershed	HUC	Change in volume (acre-feet/yr)	% of total change	Change in load (tons/yr)	% of total change	Change in load (lbs/yr)	% of total change	Change in load (lbs/yr)	% of total change
Swan Creek	030908	3,207	5.9	288	6.5	3,373	6.0	26,866	6.4
Lake Allegan-Kalamazoo R.	030907	2,702	4.9	238	5.4	2,803	5.0	21,868	5.2
Base Line Creek	030902	1,582	2.9	124	2.8	2,119	3.8	14,353	3.4
Pigeon Creek-Rabbit River	030808	1,463	2.7	116	2.6	1,566	2.8	11,327	2.7
Rabbit River	030811	1,461	2.7	108	2.4	1,588	2.8	11,085	2.7
Black Creek	030809	1,586	2.9	104	2.3	1,543	2.8	9,513	2.3
Little Rabbit River	030807	1,524	2.8	105	2.4	1,590	2.8	10,424	2.5
Kalamazoo R.	030912	1,869	3.4	142	3.2	1,505	2.7	12,945	3.1
Tannery Creek-Kalamazoo R.	030906	1,460	2.7	128	2.9	1,504	2.7	11,683	2.8

3.4 Pollutant Load and Runoff Volume Analysis at the Township Scale

The results of runoff volume and pollutant load changes by township or city (municipality level) were very similar to results at the subwatershed level presented in Section 3.3 (i.e. the same areas were highlighted as high loading areas). Therefore, another statistic was calculated for each township/city and presented in Figures C-1 to C-4 in Appendix C. These tables present the change in each township/city's runoff volume and pollutant load as a percentage of the total watershed's change in runoff or loading in 2030. Total runoff volume and pollutant load values for the current baseline and future build-out years per township/city are presented in Table C-1 in Appendix C.

Changes in pollutant loads and runoff volume are consistent with land use changes discussed in Section 3.1. The townships or cities experiencing the largest increase in runoff volume and loads are the same municipalities forecasted to experience the largest urban development (refer to Table 3). They are located in the western section of the Kalamazoo River watershed, between the Cities of Allegan and Otsego (Table 7). Saugatuck Township, at the mouth of the watershed, and townships around the city of Battle Creek will also experience significant increases in runoff and pollutant loads according to the results of this modeling analysis. The municipal management level was chosen as part of this analysis because of the jurisdictional relevance of townships and cities. Townships and cities have the ability to pass ordinances and laws and use tax revenues to implement stormwater retrofits. Modeling future runoff and pollutant loading may be most useful in approaching municipalities and promoting early implementation of stormwater policies and BMPs. As runoff volume and pollutant loading changes over time, so do the resulting costs associated with reducing the loads and their resulting impacts. An example of this is provided in Section 4.0.

Table 7. Townships with greatest changes in runoff volume and pollutant loads as a percentage of the total watershed change in runoff volume and pollutant loads from 2001 to 2030.

	Runoff		TSS		TP		TN	
Name	**Change in volume (acre-feet/yr)**	**% of total change**	**Change in load (tons/yr)**	**% of total change**	**Change in load (lbs/yr)**	**% of total change**	**Change in load (lbs/yr)**	**% of total change**
Cheshire Twp	2,782	5.1	249	5.7	2,900	5.2	23,080	5.5
Salem Twp	2,217	4.0	151	3.4	2,330	4.2	15,238	3.7
Trowbridge Twp	1,920	3.5	154	3.5	1,916	3.4	13,932	3.3
Dorr Twp	1,844	3.4	133	3.0	1,894	3.4	12,748	3.1
Allegan Twp	1,848	3.3	155	3.5	1,884	3.4	14,089	3.4
Heath Twp	1,697	3.1	150	3.4	1,856	3.3	14,601	3.5
Monterey Twp	1,772	3.2	155	3.5	1,861	3.3	14,500	3.5

4.0 Stormwater Controls Cost Analysis

A simple cost analysis was conducted as an additional illustration for decision-makers to emphasize the importance of implementing stormwater runoff controls and policies as early as possible to meet TMDL load allocation requirements and protect overall water quality. Townships outside the TMDL area were also included in this analysis because they may eventually face similar requirements as the US EPA looks to expand the NPDES Phase II program or as more TMDLs are developed for impaired waters. Urban growth is predicted to increase to varying degrees throughout the entire watershed; therefore, costs for reducing the increased loading associated with this urban growth will increase, as well. The trend is for less developed townships and smaller municipalities to experience more rapid growth compared to larger cities that have already experienced full build-out in many areas. A simple cost analysis of stormwater controls was performed as part of analysis. The purpose of the analysis was to capture: 1) the current cost to reduce phosphorus loading in half to satisfy the TMDL baseline load level, and 2) the future predicted costs to reduce the future phosphorus loading, if urban growth continues without stormwater controls.

The cost analysis used several assumptions in order to calculate a conservative, generalized cost for loading reductions in each municipality. These assumptions were limited by the lack of site-specific data available for the watershed, the large scale of the watershed and large number of individual municipalities, and the general project scope. Therefore, assumptions used in the cost analysis are as follows:

- Only TP load from Commercial/High Density land use was considered in the cost calculation as this land use is most likely subject to current and future regulation.

- A value of $10,000 per pound of phosphorus reduced was used as a coarse, conservative estimate.

- No adjustments were made to account for cost inflation by 2030, land value, or operation and maintenance (which to a certain degree are implicitly covered in the $10,000/lb assumption).

- Retrofitting of existing commercial developments was not taken into account. A certain percentage of commercial properties are retrofitted each year to meet new standards and provide increased retention/infiltration. These retrofits would reduce the total load for 2030.

- The TP load from the 2001 loading analysis in this report is used in place of the 1998 TMDL baseline level for simplification purposes (again, any existing controls or treatment systems are not taken into account in this analysis).

Three scenarios were defined in order to compare the current load and future load as it relates to the TMDL, with the associated costs for each. The scenarios used in the analysis are:

Scenario 1: Stormwater ordinance passed in 2001 - A stormwater ordinance requiring all new commercial developments to infiltrate or retain 100% of stormwater runoff on-site is passed by the municipality at the start of TMDL implementation (i.e., there is no increase in load from commercial development between 2001 and 2030). Therefore, the cost to the municipality is only for stormwater retrofit BMPs to reduce the 2001 load by 50% (to meet TMDL requirements).

Scenario 2: Reducing new 2030 loading by 50% - The municipality is required to reduce the new 2030 load resulting from increased development by 50% (representative of a theoretical Phase II regulation that may apply in the future and require municipalities to implement retrofits).

Scenario 3: Retrofitting in 2030 to meet TMDL - The municipality waits until 2030 to address the Kalamazoo River phosphorus TMDL and is now required to reduce the new 2030 load to 50% below the loading level in 2001 (which represents the existing TMDL load allocation).

The cost analysis was conducted both at the township and subwatershed level to be consistent with other analyses presented in this report. The cost analysis results for all townships and municipalities are presented in Appendix D. While stormwater management can be implemented within both township and watershed boundaries, only townships have the authority to pass ordinances controlling stormwater BMP requirements. To provide a comparison with other municipalities, the City of Portage and Oshtemo Township are highlighted in the table in the appendix. They have substantially lower future loads and associated costs because both have already passed stormwater ordinances requiring on-site stormwater management[9] (Table D-1). Information was not available at the time of this analysis regarding other townships that may have passed similar ordinances. In the City of Portage, for example, it was assumed that the baseline urban-commercial phosphorus load would not increase over time, as the ordinance requires on-site stormwater infiltration for new development. The cost to reduce half of their baseline load is just over $5 million. The costs for scenarios 2 and 3 remain at the $5 million level since it can be assumed that the city's loading will not likely increase.

In contrast, Table 8 shows that municipalities and townships without current ordinances have a rising trend in stormwater control costs over time and under increasingly stringent regulatory scenarios. The table shows an excerpt from Table D-1 (Appendix D) of six major municipalities in the watershed within the TMDL area. Due to the built-out condition of these cities currently, somewhat limited urban growth is predicted for 2030 when compared to more rural areas with greater open areas for potential development. Nevertheless, costs for stormwater controls are not insignificant. The City of Battle Creek, for example, could expect stormwater control costs to more than double between 2001 and 2030 if action is postponed. Costs for the City of Marshall could be almost seven times greater in 2030 when compared to the Scenario 1 cost (early action) at only $500,000.

In addition, Table 8 includes six townships located from the eastern and western portions of the watershed as an example of how costs are impacted by large increases in urban-commercial loading. Since these townships have ample area for development and relatively low baseline loads, the substantial increase in future loading greatly increases stormwater control costs by 2030. In the case of Albion and Allegan Townships, which are located within the TMDL area, costs increase nearly 10 times between Scenario 1 and Scenario 3. Differences between Scenario 1 and 3 costs for the other four townships listed in Table 8 are much greater. For example, Cheshire Township's stormwater costs are expected to be over 100 times greater in 2030 when compared to Scenario 1 costs at only $200,000.

[9] *Oshtemo Township's final stormwater ordinance (78.520) requires all owners or developers of property to construct and maintain on-site stormwater management facilities designed for a 100-year storm. The full text of the ordinance is available at: http://www.oshtemo.org/*
The City of Portage has adopted 9 stormwater BMP performance standards for development and redevelopment sites, including stormwater infiltration/retention on-site (FTCH, 2003).

Table 8. Stormwater control scenarios in cities and townships with high stormwater treatment costs related to increases in urban loading.

	TP Load (lbs/yr)		Cost of Stormwater Controls ($)		
Name	2001 TP from urban-commercial	2030 TP from urban-commercial	Scenario 1 (in millions)	Scenario 2 (in millions)	Scenario 3 (in millions)
City of Allegan	506	789	$2.5	$3.9	$5.4
City of Battle Creek	1,642	2,589	$8.2	$12.9	$17.7
City of Kalamazoo	1,822	2,231	$9.1	$11.2	$13.2
City of Marshall	106	382	$0.5	$1.9	$3.3
City of Otsego	199	334	$1.0	$1.7	$2.3
City of Plainwell	174	279	$0.9	$1.4	$1.9
Albion Twp	15	739	$0.75	$3.7	$7.3
Allegan Twp	417	2,225	$2.0	$11.1	$20.1
Cheshire Twp	37	2,574	$0.2	$12.9	$25.6
Dorr Twp	330	2,253	$1.6	$11.3	$20.9
Salem Twp	331	2,648	$1.7	$13.2	$24.8
Trowbridge Twp	93	2,007	$0.5	$10.0	$19.6

The scenarios used for this stormwater control cost analysis were based largely on the current requirements under the phosphorus TMDL, which applies to the area upstream of Lake Allegan in the western part of the watershed. Under the most stringent TMDL requirement, nonpoint source phosphorus loading is required to be reduced by half during certain months of the year (July-September) and by 43% from April-June. Over the past 10 years since the TMDL was developed, overall watershed phosphorus loading goals have not been met. Since point source loading contributions have stayed within their allocation, it has been determined that nonpoint sources are still discharging above the set load allocation. Results from this limited cost analysis suggest that the costs associated with reducing just the urban-commercial baseline loading to half within the TMDL area may total as much as $55 million (Figure 8). If the urban-commercial build-out and, therefore, phosphorus load are allowed to increase without implementing stormwater policies now, the costs to retrofit are predicted to soar above $380 million[10] by 2030 within the TMDL area[11]. For the entire TMDL watershed, waiting to implement stormwater controls on new and expanding development will equate to an almost 700% increase in the cost to meet the TMDL load allocation.

It is important to note that lower cost BMPs may be available for implementation in certain areas. For example, stormwater retention basins in areas where existing build-out is not prohibitive may generate a pound of phosphorus reduction at a price lower than the $10,000 assumption used in this analysis. For this reason, costs for Scenario 1 may be slightly lower than what is predicted here, although urban-residential loading is not taken into account in this analysis and would likely add additional costs. Conversely, urban areas that already have substantial build-out may find that stormwater retrofit projects may come at a

[10] *Future phosphorus load reduction costs have not been adjusted for inflation and are presented in 2009 dollars.*
[11] *When calculating stormwater control costs for retrofits in 2030, the build-out loading values that were used did not compensate for areas within the watershed that already have stormwater ordinances in place. Data for existing stormwater ordinances were not available at the time of this analysis and assumed to be limited in scope.*

greater cost than $10,000/pound of phosphorus reduced. The values presented as part of this analysis are meant for illustrative purposes and should not be considered an accurate cost for the scenarios presented herein.

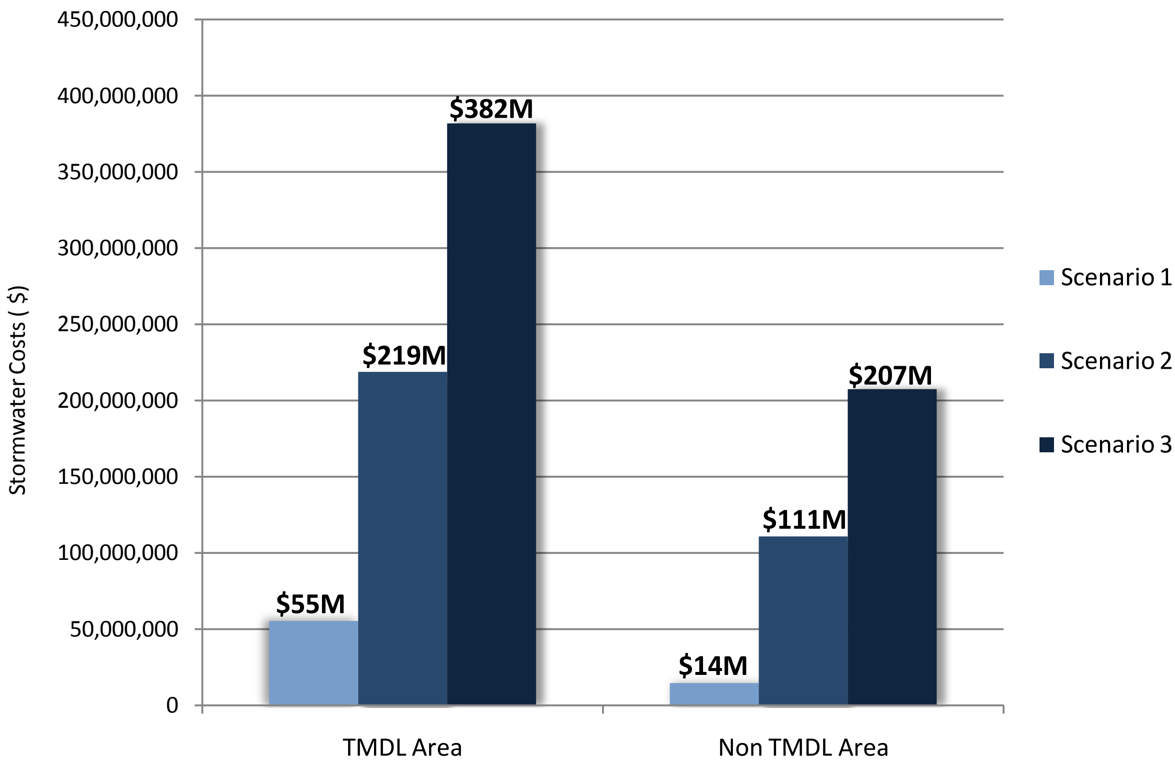

Figure 8. Increasing costs for stormwater controls to treat increasing urban phosphorus loads from 2001 to 2030 in both the TMDL area and the non TMDL area of the watershed.

In general, results show that stormwater retrofits in 2030 would be extremely expensive for municipalities, costing on average almost seven times the cost of controlling stormwater at 2001 loading values. In comparison, municipalities such as the City of Portage and Oshtemo Township have already passed stormwater ordinances that require new development to control TP loading, most often in the form of stormwater retention BMPs. The ordinance will work to limit TP loading from future build out, and therefore decrease the cost to retrofit developed areas with no stormwater controls. These townships will see substantial costs savings by 2030 in terms of stormwater controls. Their future costs are considerably lower when compared to townships with similar TP loads that will likely face the prospect of stormwater retrofits in 2030. In terms of the existing phosphorus TMDL, it is important to note that this limited analysis only calculates costs associated with urban-commercial loading and not other sources of nonpoint source runoff and pollutant loading. While urban-commercial loading is the largest contributing nonpoint source load in many areas within the watershed, municipalities must consider all nonpoint sources when implementing stormwater ordinances and regulations. For instance, many of the townships (e.g., Allegan Township) in the watershed are expected to have large increases in urban-residential land use, which may result in increased storm sewer infrastructure and, therefore, exponential increases in loading and retrofitting costs.

A SEPARATE URBAN BMP SCREENING TOOL AND SUPPORTING DOCUMENTATION DEVELOPED FOR THE KALAMAZOO RIVER WATERSHED AS PART OF THIS PROJECT IS AVAILABLE FROM THE KALAMAZOO RIVER WATERSHED COUNCIL. THE TOOL WAS DESIGNED TO ASSIST MUNICIPALITIES, TOWNSHIPS, AND WATERSHED MANAGERS IN ESTIMATING THE COST-EFFICIENCY AND REDUCTION POTENTIAL OF SEVERAL COMMONLY USED STORMWATER BMPS. THIS TOOL PROVIDES MUNICIPALITIES AND TOWNSHIPS WITH INFORMATION MORE SPECIFIC TO THEIR NEEDS TO SATISFY WMP REQUIREMENTS FOR COST AND REDUCTION POTENTIAL OF BMPS RECOMMENDED IN THE PLAN. THE PURPOSE OF THIS TOOL AND THE ANALYSIS PROVIDED IN THIS REPORT IS TO SUPPORT IMPLEMENTATION OF STORMWATER BMPS AT THE MOST COST-EFFECTIVE RATE.

5.0 Conclusions

This report presented the first comprehensive effort to estimate runoff and pollutant loads within the entire Kalamazoo River watershed. A simple runoff/loading model was developed using commonly accepted methods and equations, such as the Long-Term Hydrologic Impact Assessment model for estimating runoff and pollutant event mean concentrations referenced in the Michigan Trading Rules. Runoff volumes and pollutant loads were calculated for both current (baseline) conditions, using the most recent land use available from 2001, and future (build-out) conditions, using the 2030 land use map, produced by the Land Transformation Model. Modeling results for baseline and build-out conditions were analyzed at three geographic scales: entire watershed, 12-digit HUC subwatershed, and municipality.

Results from this analysis highlight a few areas within the watershed that are predicted to experience increasing urban development, and consequently large increases in stormwater runoff and pollutant loads. These critical areas include the western section of the Kalamazoo River watershed around the cities of Allegan, Otsego and Saugatuck; the area surrounding the City of Battle Creek; and the eastern side of the City of Marshall. It must be noted that the western part of the watershed contains the Allegan State Game Area. This currently rural area is expected to experience the largest change within the entire watershed. Urbanization could seriously impact the hydrology and water quality of this natural area. In addition, results clearly emphasize the increasing importance of stormwater as a non-point source of pollution while the proportion of TP load from agricultural activities is predicted to decrease from 40% to 27% by 2030. Implementation of stormwater runoff control practices will be required throughout the watershed to preserve water quality, prevent stream channel erosion and flashiness, and in particular to achieve the goals set in the Lake Allegan/Kalamazoo River TMDL. In fact, municipalities could face very high costs to control stormwater and achieve the reductions required in the TMDL as time progresses. Results from the stormwater cost analysis indicate that limiting the increase in stormwater runoff through ordinance may be an easy and less expensive option.

In conclusion, the loss of agricultural land and open space to urban areas within the next 30 years, as modeled in this report, predicts a 25% increase in runoff volume and phosphorus load, a 12% increase in total suspended solids load and an 18% increase in total nitrogen. These predicted increases conflict with the 40-50% TP load reduction goals set in the Lake Allegan/Kalamazoo River TMDL. Preserving water quality and implementing the current TMDL will not only require a concerted effort among all partners within the watershed, but also the extensive implementation of multiple practices and regulations. Such practices include stormwater BMPs and ordinances promoting infiltration, retention, and reduction in impervious surfaces; zoning regulations promoting mixed land uses and smart growth, including adoption of low impact development practices; preservation of open space and critical areas; and broad adoption of agricultural BMPs. The costs associated with these BMPs vary from project to project, although overall costs throughout the watershed likely range in the hundreds of millions of dollars. Early adoption of stormwater policies and implementation of stormwater controls can greatly reduce the price of load reductions required by the TMDL and other regulatory programs.

RESULTS PRESENTED IN THIS REPORT ARE NOT INTENDED TO PRESENT AN ACCURATE PREDICTION OF THE CURRENT OR FUTURE CONDITIONS IN THE KALAMAZOO RIVER WATERSHED. THEY ARE INSTEAD MEANT TO BE USED AS ESTIMATES TO GUIDE THE DEVELOPMENT AND IMPLEMENTATION OF THE WATERSHED MANAGEMENT PLAN, SUPPORT THE SELECTION OF CRITICAL AREAS WITHIN THE WATERSHED, AND PROVIDE A BASIS FOR EDUCATIONAL AND PROMOTIONAL EFFORTS. THESE RESULTS COULD BE USED TO INFORM DISCUSSIONS AND DECISIONS FROM LOCAL UNITS OF MANAGEMENT AND WATERSHED MANAGERS REGARDING ZONING AND LAND USE MANAGEMENT.

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Appendix A

Land Use Change Analysis per Township

APPENDIX A - Land Use Change Analysis per Township

Table A-1: Land Use Breakdown per Township for 2001 and 2030 (in acres).

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Adams Twp	0	7	5	30	47	47	1,159	1,142	99	91	158	151	0	0	109	109	32	0.02	0.12
Alamo Twp	86	489	309	1,164	788	788	10,139	9,501	1,722	1,473	5,859	5,649	183	178	4,045	3,897	1,258	0.73	1.79
Albion, City	198	539	410	902	566	566	583	371	477	304	820	497	10	7	240	121	833	0.48	0.25
Albion Twp	25	1,119	215	2,347	477	477	13,744	11,703	1,245	1,048	3,588	2,992	20	15	1,727	1,339	3,227	1.87	1.62
Allegan, City	549	887	146	593	339	339	279	163	274	136	625	339	279	195	314	163	786	0.45	0.22
Allegan Twp	450	2,666	289	3,326	680	680	10,712	7,798	1,258	788	4,178	2,871	872	773	1,814	1,374	5,253	3.04	1.56
Assyria Twp	109	983	109	1,124	514	514	9,671	8,856	1,539	1,381	5,837	5,256	188	173	5,187	4,865	1,890	1.09	1.78
Barry Twp	136	576	170	568	494	494	10,339	9,953	1,253	1,176	3,820	3,622	776	724	4,008	3,884	838	0.48	1.61
Battle Creek, City	2,219	3,598	2,965	5,402	3,165	3,165	4,156	3,378	3,343	2,580	7,892	6,417	507	484	3,304	2,661	3,815	2.21	2.15
Bedford Twp	143	1,278	618	2,555	773	773	3,472	3,032	2,320	1,668	7,971	6,405	220	208	3,314	2,916	3,071	1.78	1.46
Bellevue Twp	131	820	170	860	677	677	10,193	9,555	1,166	1,028	3,573	3,259	77	64	3,662	3,417	1,379	0.80	1.51
Bloomingdale Twp	5	304	86	998	119	119	1,278	724	334	205	731	437	215	138	539	383	1,211	0.70	0.25
Brookfield Twp	27	255	54	309	465	465	12,068	11,693	660	657	1,920	1,880	156	156	2,429	2,392	482	0.28	1.37
Byron Twp	77	297	111	361	121	121	4,082	3,739	252	252	759	687	10	10	230	208	469	0.27	0.44
Carmel Twp	52	393	69	442	321	321	7,561	7,035	405	353	1,245	1,164	25	7	1,035	1,001	714	0.41	0.82
Charleston Twp	126	361	163	638	539	539	4,448	4,216	1,668	1,218	8,710	9,027	378	371	2,380	2,046	709	0.41	1.42
Charlotte, City	264	388	190	314	284	284	351	235	213	198	267	198	7	5	109	82	247	0.14	0.13
Cheshire Twp	40	2,963	299	4,309	442	442	6,474	3,926	2,056	1,161	4,075	2,256	588	504	3,459	2,051	6,934	4.01	1.35
Clarence Twp	42	712	84	1,381	442	442	11,169	9,886	974	882	2,864	2,523	810	796	4,050	3,818	1,967	1.14	1.57
Climax Twp	0	0	0	0	10	10	195	195	5	5	17	17	0	0	7	7	0	0.00	0.02
Clyde Twp	42	390	89	623	240	240	200	82	1,142	482	3,062	3,071	5	5	279	166	882	0.51	0.39

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Comstock Twp	677	1,317	1,147	2,444	1,134	1,134	7,848	7,272	1,715	1,401	5,733	4,863	1,201	1,166	1,717	1,586	1,937	1.12	1.63
Concord Twp	72	1,248	178	2,343	638	638	13,801	11,288	1,668	1,475	3,714	3,333	42	42	3,057	2,807	3,341	1.93	1.78
Convis Twp	138	687	163	1,161	726	726	8,354	7,752	1,616	1,769	5,525	5,066	331	329	6,170	5,861	1,547	0.89	1.80
Cooper Twp	72	759	556	2,006	628	628	9,237	8,350	2,498	2,024	7,816	7,257	170	170	2,286	2,123	2,137	1.24	1.80
Dorr Twp	383	2,572	717	3,667	635	635	15,590	12,054	1,137	739	2,916	2,044	7	5	1,268	956	5,140	2.97	1.74
Eaton Twp	32	571	32	618	294	294	4,119	3,299	341	373	1,122	974	5	5	988	904	1,124	0.65	0.54
Eckford Twp	10	534	79	961	371	371	11,223	10,319	652	568	1,900	1,653	91	89	1,957	1,789	1,406	0.81	1.25
Emmett Twp	462	1,700	754	2,856	1,208	1,208	8,305	7,361	1,564	1,151	5,599	4,099	272	222	2,646	2,231	3,341	1.93	1.60
Fayette Twp	15	22	15	42	20	20	339	321	67	59	178	170	5	5	158	156	35	0.02	0.06
Fennville, City	84	198	89	235	96	96	259	96	59	40	89	47	22	2	27	15	259	0.15	0.06
Fillmore Twp	49	104	42	136	74	74	1,700	1,576	35	32	106	99	0	0	37	35	148	0.09	0.16
Fredonia Twp	12	264	37	529	235	235	3,314	2,901	467	390	1,144	1,025	208	195	1,994	1,871	744	0.43	0.57
Gaines Twp	5	119	2	106	79	79	870	806	67	89	205	178	7	7	195	153	217	0.13	0.12
Galesburg	25	86	89	255	49	49	259	166	94	67	269	198	17	15	126	94	227	0.13	0.07
Ganges Twp	7	49	32	84	5	5	217	143	27	15	25	17	0	0	0	0	94	0.05	0.02
Gobles, City	0	22	5	106	5	5	89	17	22	5	42	7	0	0	0	0	124	0.07	0.01
Gunplain Twp	198	2,031	269	2,726	880	880	11,248	9,111	1,369	934	5,500	4,072	195	158	2,147	1,942	4,290	2.48	1.69
Hanover Twp	30	726	257	1,433	519	519	10,257	9,167	2,444	2,246	5,369	4,942	255	252	3,084	2,928	1,873	1.08	1.71
Heath Twp	230	1,917	368	2,800	576	576	4,183	2,735	3,380	2,389	10,509	9,461	156	143	3,632	3,037	4,119	2.38	1.77
Homer Twp	37	773	131	1,478	516	516	13,455	12,073	1,077	961	1,777	1,554	15	2	2,644	2,293	2,083	1.20	1.51
Hope Twp	2	5	0	2	0	0	0	0	7	7	35	32	0	0	2	0	5	0.00	0.00
Hopkins Twp	158	1,112	203	1,579	672	672	17,435	15,646	588	521	2,113	1,858	114	99	1,777	1,581	2,330	1.35	1.77
Jamestown Twp	74	1,404	133	1,651	546	546	10,450	7,855	183	156	862	736	22	15	395	311	2,847	1.65	0.97
Johnstown Twp	30	576	82	692	329	329	4,831	4,282	684	598	2,691	2,352	67	59	2,123	1,947	1,156	0.67	0.83
Kalamazoo, City	2,451	3,029	3,576	4,883	2,538	2,538	596	427	1,520	1,114	3,907	2,918	292	190	845	672	1,885	1.09	1.23
Kalamazoo	726	1,070	1,436	2,113	892	892	949	744	899	756	2,029	1,537	44	32	492	393	1,021	0.59	0.58

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Twp																			
Kalamo Twp	7	30	12	30	49	49	2,422	2,394	170	166	309	304	5	5	571	571	40	0.02	0.27
Laketown Twp	116	1,030	329	1,490	250	250	410	250	514	227	2,800	1,589	47	17	872	489	2,076	1.20	0.41
Lee Twp-Allegan	2	20	12	126	5	5	358	334	163	151	529	487	0	0	363	311	131	0.08	0.11
Lee Twp-Calhoun	74	381	69	635	526	526	14,856	14,312	1,085	1,025	3,217	3,062	203	203	3,237	3,126	872	0.50	1.79
Leighton Twp	304	1,502	284	1,824	578	578	12,313	10,573	951	937	2,550	2,090	403	383	2,016	1,725	2,738	1.58	1.51
Leroy Twp	10	334	124	857	319	319	5,434	4,917	833	704	2,041	1,782	292	279	2,639	2,498	1,058	0.61	0.90
Liberty Twp	7	69	20	131	44	44	610	487	77	74	119	94	136	136	180	158	173	0.10	0.09
Litchfield, City	2	15	2	62	20	20	138	72	2	0	5	2	0	0	0	0	72	0.04	0.01
Litchfield Twp	17	133	12	277	190	190	3,803	3,459	104	91	252	245	0	0	306	289	381	0.22	0.36
Manlius Twp	153	1,507	316	2,192	373	373	6,699	5,377	2,419	1,658	7,191	6,430	425	420	5,088	4,791	3,230	1.87	1.75
Maple Grove Twp	10	52	27	77	119	119	3,546	3,501	264	250	717	709	12	12	712	689	91	0.05	0.42
Marengo Twp	15	1,772	126	3,299	746	746	14,376	10,875	1,114	855	3,195	2,530	57	57	3,242	2,738	4,930	2.85	1.76
Marshall, City	151	539	376	1,129	398	398	1,161	633	356	220	932	605	64	52	573	457	1,142	0.66	0.31
Marshall Twp	84	974	175	1,984	1,117	1,117	11,619	9,889	1,112	959	3,138	2,669	119	99	2,874	2,548	2,698	1.56	1.56
Martin Twp	190	1,085	141	1,505	591	591	18,130	16,422	828	680	1,754	1,525	116	114	1,265	1,124	2,258	1.31	1.77
Monterey Twp	185	2,034	336	2,958	591	591	12,785	10,803	1,616	1,171	5,538	4,099	116	101	1,853	1,287	4,470	2.58	1.77
Moscow Twp	44	128	74	301	487	487	12,093	11,925	1,374	1,322	3,420	3,366	10	10	2,123	2,088	311	0.18	1.51
Newton Twp	15	116	37	232	114	114	2,031	1,955	425	408	1,107	1,006	5	2	1,282	1,218	297	0.17	0.40
Olivet, City	42	104	57	138	57	57	84	47	69	47	225	170	0	0	106	77	143	0.08	0.05
Orangeville Twp	215	736	373	1,006	262	262	4,161	3,818	1,547	1,238	7,057	6,852	1,021	956	2,718	2,488	1,154	0.67	1.33
Oshtemo Twp	432	944	638	1,700	806	806	4,047	3,516	1,465	1,003	4,754	4,309	52	49	373	252	1,574	0.91	0.98
Otsego, City	203	353	183	363	220	220	245	131	131	79	230	141	44	27	82	27	331	0.19	0.10
Otsego Twp	215	2,088	331	3,062	675	675	11,545	8,836	1,470	1,097	4,524	3,430	390	343	2,520	2,170	4,603	2.66	1.67
Overisel Twp	57	848	190	1,275	403	403	8,604	7,047	242	185	687	529	2	2	1,028	929	1,875	1.08	0.86

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Parchment, City	69	94	180	269	89	89	12	5	79	30	124	84	2	2	27	15	114	0.07	0.05
Parma Twp	40	1,245	156	2,197	561	561	9,407	7,230	1,144	937	2,258	1,742	0	0	2,422	2,076	3,247	1.88	1.23
Pavilion Twp	10	40	35	96	96	96	2,343	2,278	161	163	507	497	52	52	588	573	91	0.05	0.29
Pennfield Twp	188	1,441	546	2,936	823	823	6,244	5,110	2,199	1,754	8,841	7,267	198	161	3,267	2,871	3,642	2.11	1.73
Pine Grove Twp	27	1,349	119	4,275	442	442	7,794	4,930	1,396	865	4,171	2,639	67	59	2,305	1,762	5,478	3.17	1.26
Plainwell, City	173	282	188	363	190	190	301	185	138	99	245	163	42	25	47	27	284	0.16	0.10
Portage, City	1,282	1,814	3,235	4,359	1,460	1,460	1,090	887	1,273	857	3,746	2,918	12	12	1,391	1,206	1,656	0.96	1.05
Prairieville Twp	131	697	208	744	623	623	12,016	11,540	1,396	1,285	5,402	5,167	1,547	1,391	1,922	1,811	1,102	0.64	1.79
Pulaski Twp	15	566	116	1,137	544	544	13,445	12,432	1,950	1,833	3,956	3,667	109	109	3,262	3,109	1,572	0.91	1.81
Richland Twp	96	554	339	1,332	667	667	12,214	11,483	1,574	1,423	5,570	5,108	1,035	1,021	1,468	1,396	1,450	0.84	1.79
Ross Twp	126	516	366	1,327	541	541	5,925	5,523	1,715	1,386	8,814	8,569	1,431	1,332	3,689	3,412	1,352	0.78	1.77
Salem Twp	358	2,832	341	3,778	650	650	14,265	10,351	1,238	828	3,526	2,417	168	163	2,355	1,920	5,911	3.42	1.77
Sandstone Twp	0	5	0	0	2	2	72	67	10	10	27	27	0	0	2	2	5	0.00	0.01
Saugatuck, City	59	111	96	163	91	91	0	0	52	49	282	193	151	146	69	49	119	0.07	0.06
Saugatuck Twp	195	1,824	472	2,728	551	551	4,374	2,970	1,206	793	3,788	2,271	642	603	2,239	1,740	3,884	2.25	1.05
Scipio Twp	40	279	86	596	566	566	10,143	9,738	1,295	1,216	2,718	2,587	74	62	2,503	2,387	749	0.43	1.34
Sheridan Twp	52	1,129	180	2,286	546	546	9,536	7,887	1,401	1,102	4,015	3,274	64	59	4,015	3,526	3,183	1.84	1.53
Somerset Twp	27	62	15	126	49	49	1,292	1,213	163	141	427	410	0	0	213	185	146	0.08	0.17
Spring Arbor Twp	35	341	166	603	220	220	4,122	3,660	764	689	1,362	1,253	15	15	1,095	996	744	0.43	0.60
Springfield, City	321	489	277	526	534	534	25	15	425	294	581	390	15	15	205	121	418	0.24	0.18
Springport Twp	22	381	32	712	114	114	3,968	3,180	269	235	467	371	2	0	472	363	1,038	0.60	0.41
Texas Twp	188	709	526	1,616	474	474	4,028	3,403	1,320	845	4,984	4,631	514	477	773	660	1,611	0.93	0.99
Thornapple Twp	27	54	32	84	69	69	2,204	2,189	136	334	371	346	35	35	138	131	79	0.05	0.25
Trowbridge	114	2,597	193	3,620	635	635	12,634	8,962	1,441	1,006	4,119	2,992	578	519	3,183	2,567	5,911	3.42	1.76

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Twp																			
Valley Twp	96	1,025	257	1,576	339	339	1,386	766	3,395	1,871	12,491	12,913	1,651	1,576	2,978	2,535	2,249	1.30	1.74
Village of Douglas	84	188	163	314	158	158	15	15	210	84	282	163	119	116	72	64	255	0.15	0.09
Walton Twp	82	573	101	672	927	927	13,961	13,282	996	932	2,898	2,750	131	128	3,598	3,437	1,063	0.61	1.75
Watson Twp	153	1,960	175	2,721	773	773	12,847	10,274	1,273	1,030	4,428	3,526	343	324	3,000	2,431	4,351	2.52	1.77
Wayland, City	272	474	173	494	156	156	588	383	208	116	316	151	30	25	153	111	524	0.30	0.15
Wayland Twp	178	1,544	210	2,263	749	749	11,633	9,714	1,132	941	4,127	3,281	346	319	3,012	2,592	3,420	1.98	1.65
Wheatland Twp	0	5	0	10	2	2	220	210	40	40	67	64	0	0	104	101	15	0.01	0.03
Yankee Springs Twp	156	610	168	628	348	348	1,772	1,478	801	655	4,094	4,038	2,523	2,392	1,841	1,574	914	0.53	0.90
Zeeland Twp	12	148	5	156	30	30	1,584	1,302	5	5	27	25	0	0	10	7	287	0.17	0.13
Total	**19,881**	**86,682**	**32,345**	**138,538**	**50,126**	**50,155**	**616,131**	**529,208**	**97,720**	**77,393**	**296,468**	**255,162**	**26,279**	**24,454**	**172,451**	**152,427**	**172,935**	**100**	**100**

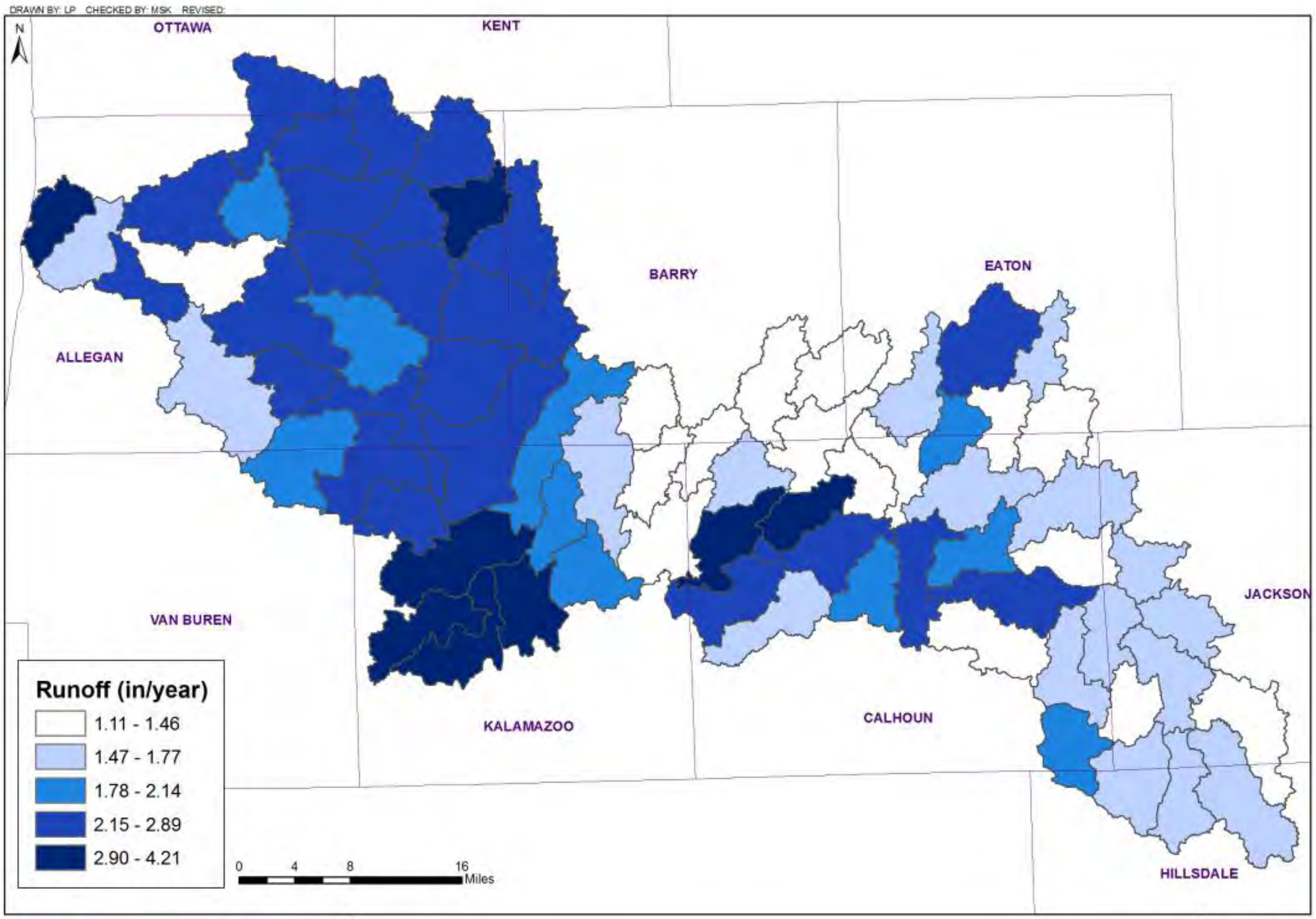
Note: The category “Urban Open” was removed for the table for practical reasons. It represents a small portion of the watershed and does not change during build-out.

Appendix B

Runoff and Loading Comparison per 12-Digit HUC Subwatershed

APPENDIX B - Runoff and Loading Comparisons per 12-digit HUC Subwatershed

Figure B-1a and 1b: Average Annual Runoff (in/yr) per Subwatershed.



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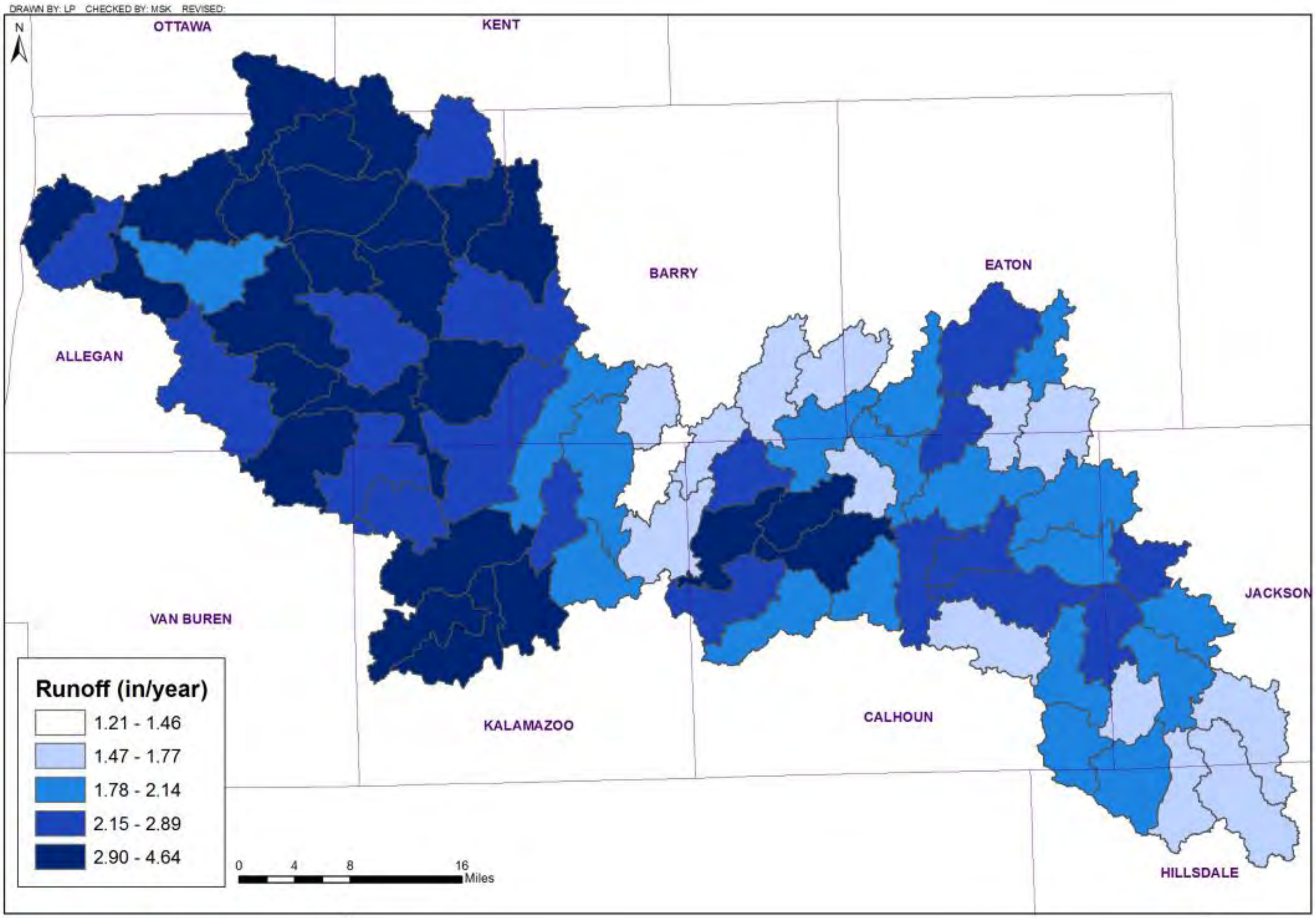
Average Annual Runoff per Subwatershed (2001)

FIGURE 1a



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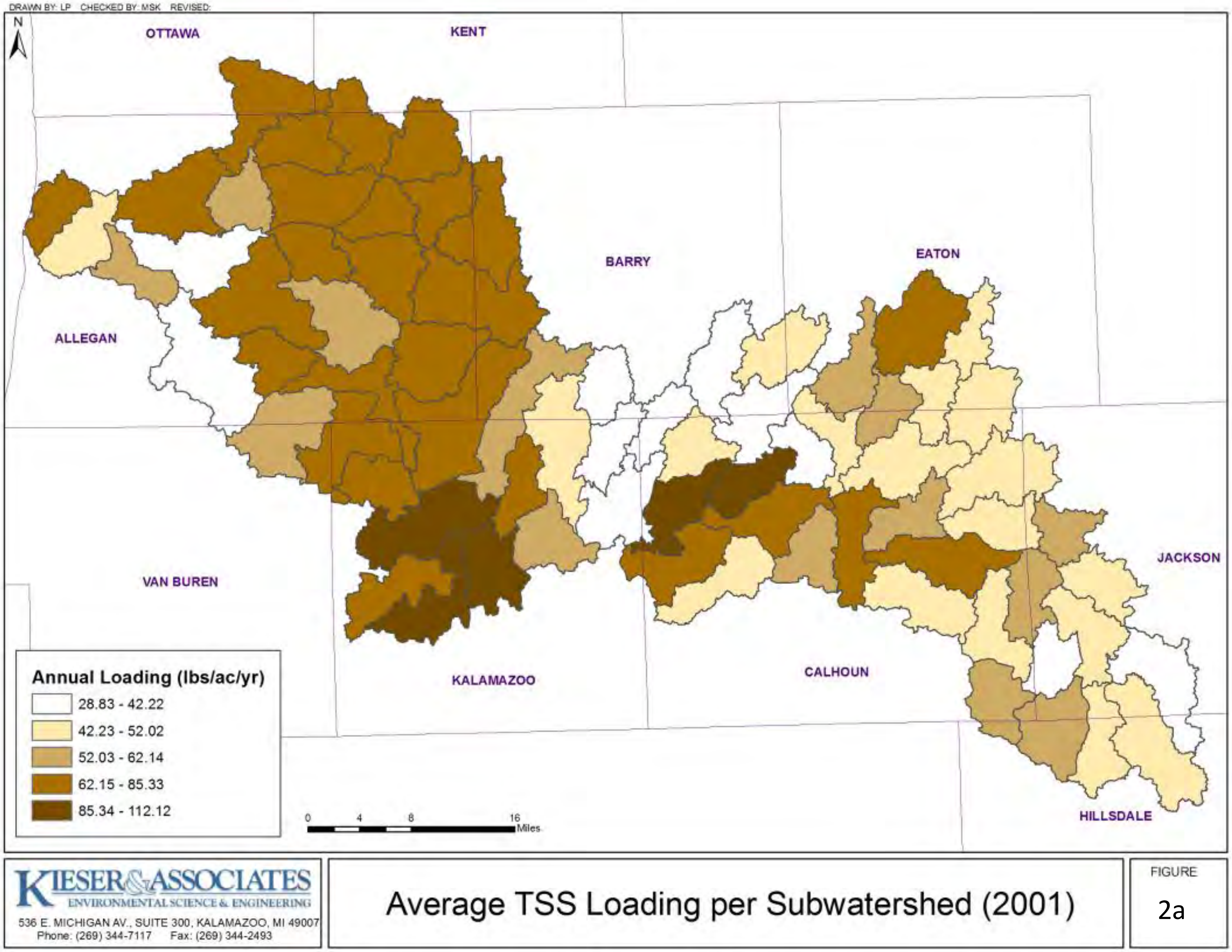
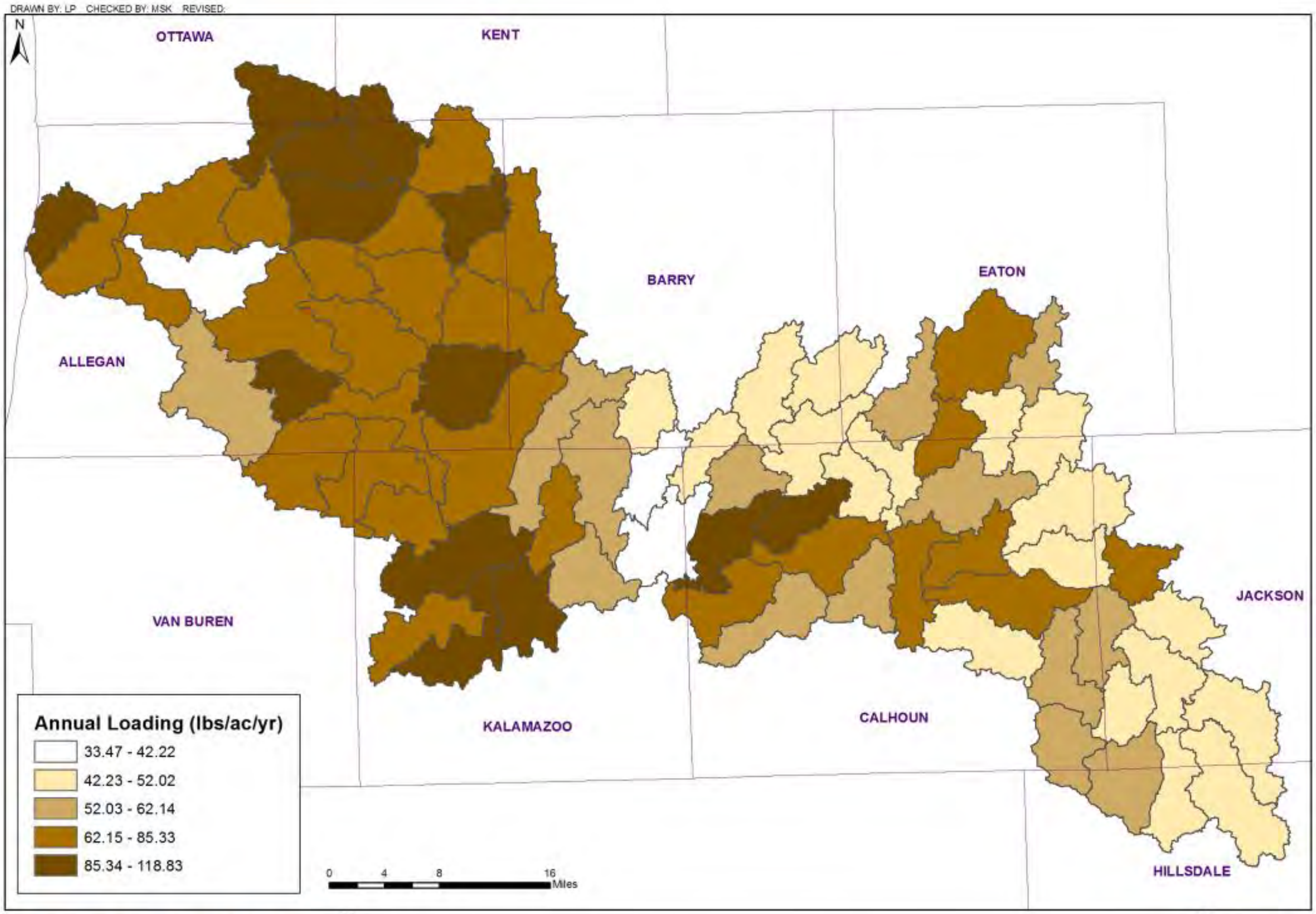
Average Annual Runoff per Subwatershed (2030)

FIGURE
1b

Figure B-2a and 2b: Average TSS Loading (lbs/ac/yr) per Subwatershed.





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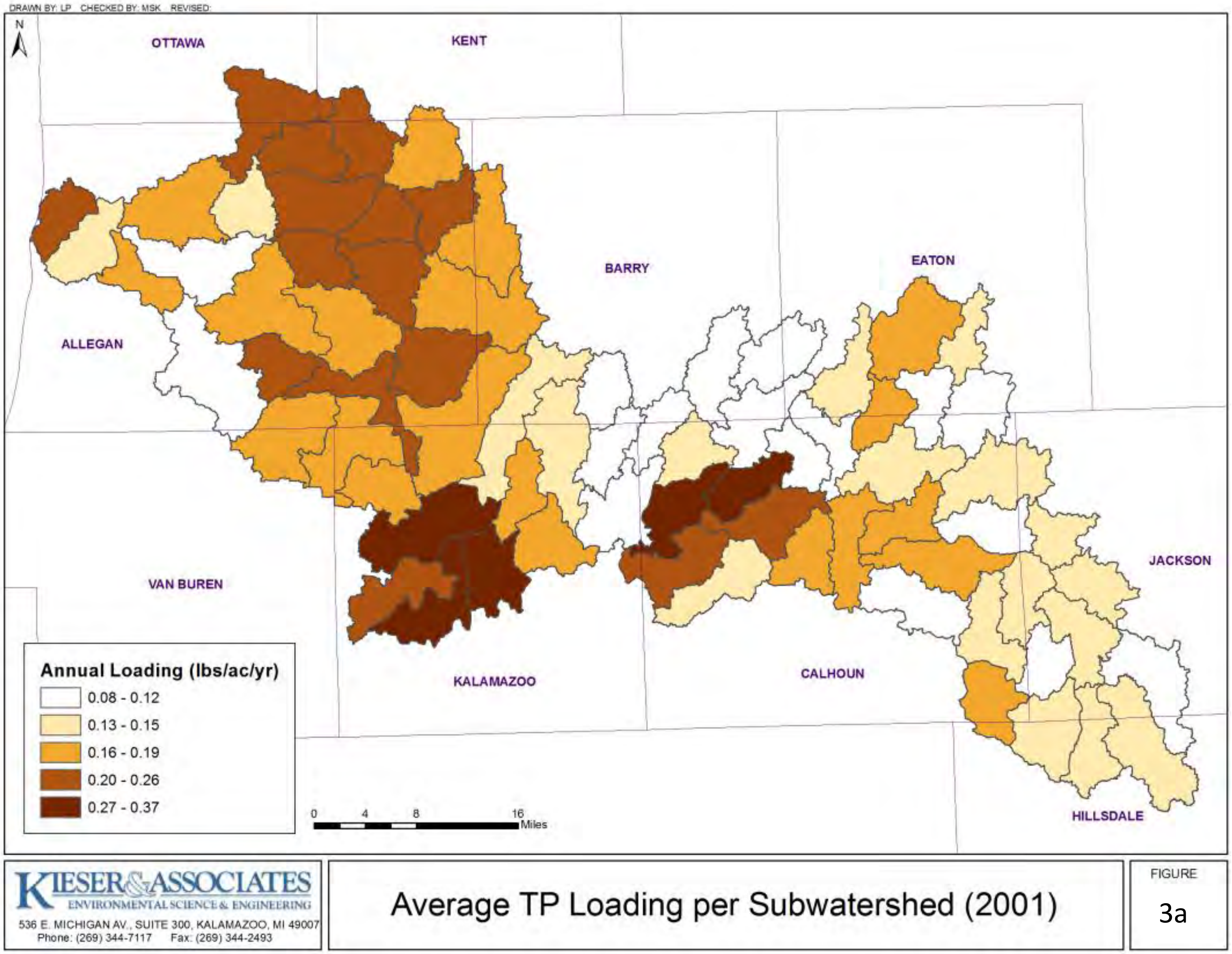
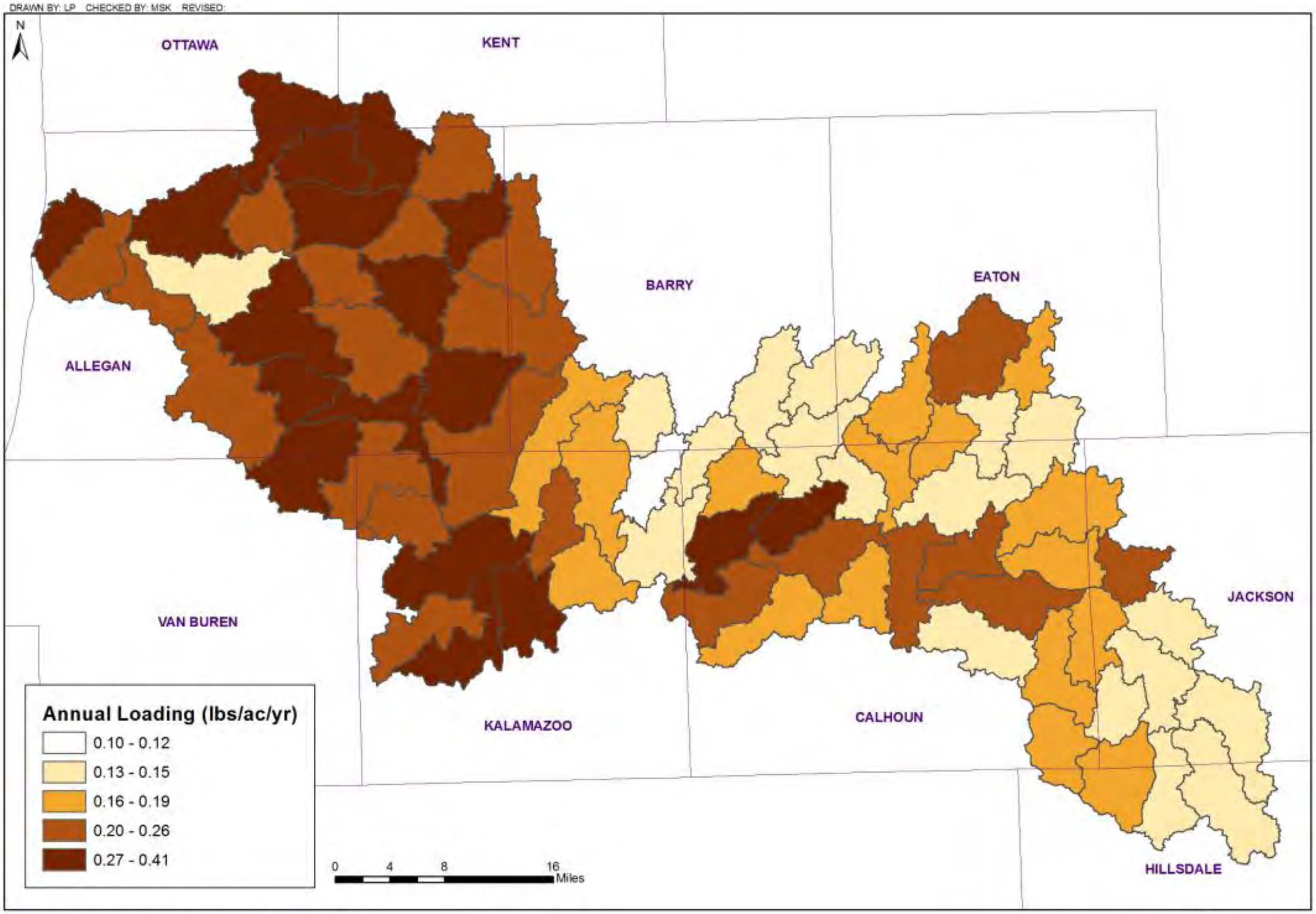
Average TSS Loading per Subwatershed (2030)

FIGURE

2b

Figure B-3a and 3b: Average TP Loading (lbs/ac/yr) per Subwatershed.





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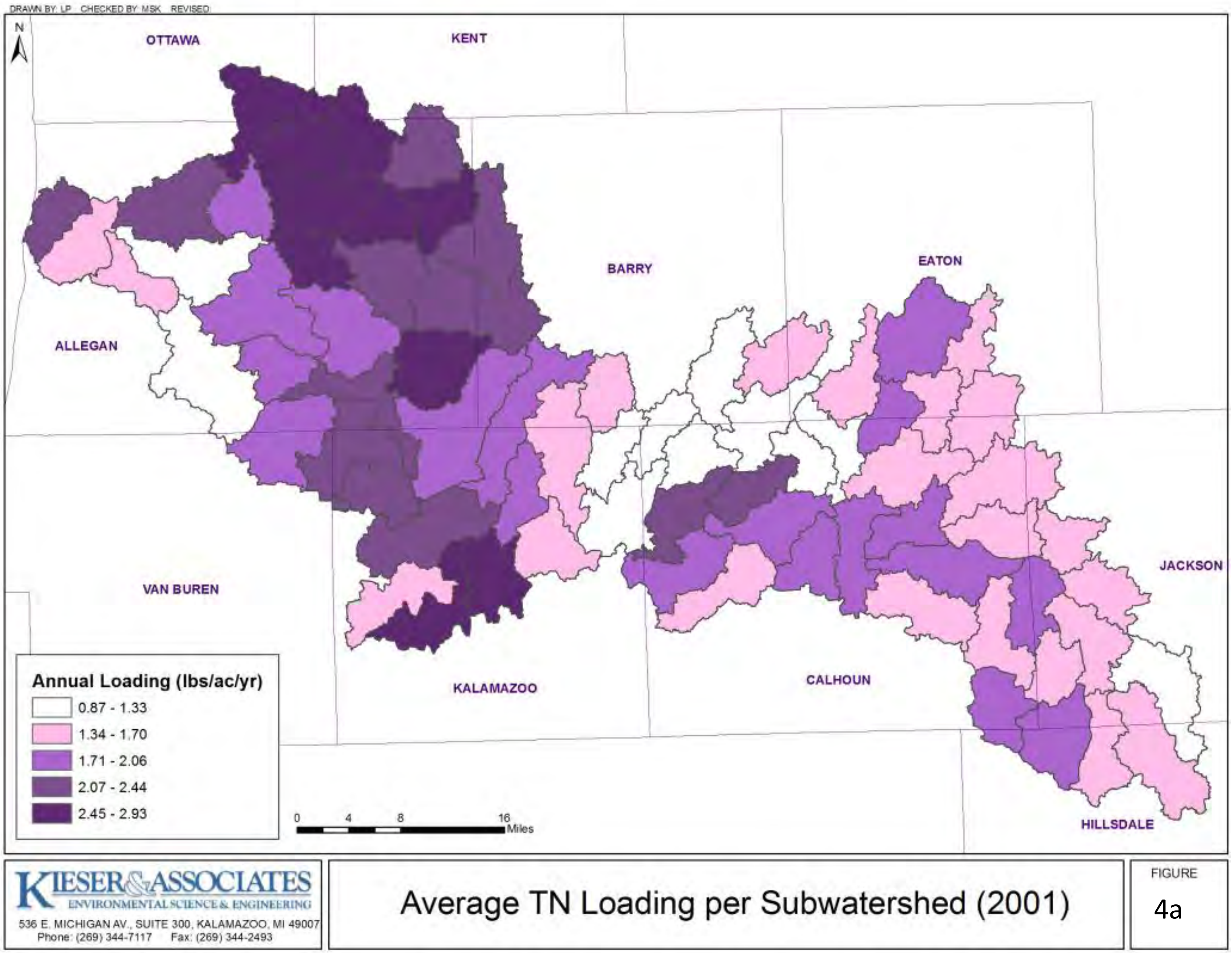
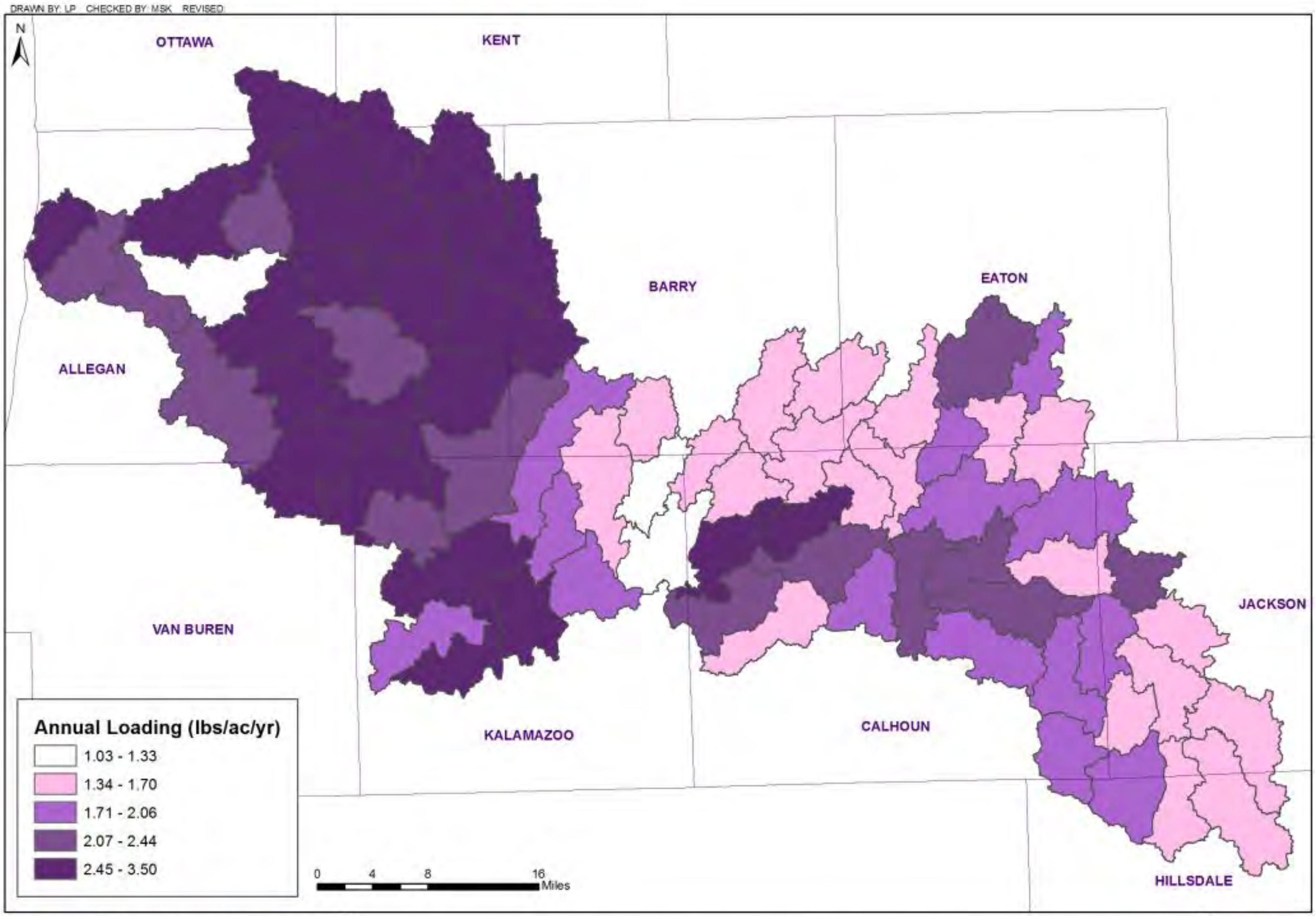
Average TP Loading per Subwatershed (2030)

FIGURE 3b

Figure B-4a and 4b: Average TN Loading (lbs/ac/yr) per Subwatershed.





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Average TN Loading per Subwatershed (2030)

FIGURE
4b

Table B-1: Load and Volume Comparisons per 12-Digit HUC Subwatershed.

Stream	HUC	Runoff Volume (acre-feet/yr) 2001	Runoff Volume 2030	Runoff Volume Change	% of total change	TSS (tons/yr) 2001	TSS 2030	TSS Change	% of total change	TP (lbs/yr) 2001	TP 2030	TP Change	% of total change	TN (lbs/yr) 2001	TN 2030	TN Change	% of total change
Upper North Branch Kalamazoo River	030101	2,179	2,608	430	0.8	403	437	34	0.8	2,228	2,656	428	0.8	26,524	29,655	3,131	0.8
Spring Arbor and Concord Drain	030102	1,674	1,953	279	0.5	314	333	20	0.4	1,739	2,006	267	0.5	20,595	22,315	1,719	0.4
Middle North Branch Kalamazoo River	030103	1,929	2,331	402	0.7	360	390	29	0.7	2,010	2,404	393	0.7	22,900	25,548	2,648	0.6
Lower North Branch Kalamazoo River	030104	1,981	2,574	593	1.1	378	419	41	0.9	2,116	2,696	580	1.0	23,670	27,413	3,744	0.9
Horseshoe Lake-South Branch Kalamazoo River	030201	3,041	3,221	180	0.3	573	587	14	0.3	3,161	3,342	181	0.3	36,875	38,162	1,286	0.3
Cobb Lake-South Branch Kalamazoo River	030202	1,827	1,952	125	0.2	341	350	9	0.2	1,887	2,017	131	0.2	22,039	22,988	949	0.2
Beaver Creek-South Branch Kalamazoo River	030203	2,640	2,796	156	0.3	504	514	10	0.2	2,780	2,936	156	0.3	32,736	33,691	955	0.2
Swains Lake Drain-South Branch Kalamazoo River	030204	1,199	1,439	240	0.4	225	243	18	0.4	1,235	1,475	240	0.4	14,761	16,458	1,697	0.4
Lampson Run Drain	030205	2,038	2,348	310	0.6	394	414	19	0.4	2,158	2,462	303	0.5	26,052	27,884	1,832	0.4
South Branch Kalamazoo River	030206	1,966	2,643	677	1.2	372	427	55	1.2	2,084	2,755	671	1.2	23,576	28,546	4,970	1.2
Narrow Lake-Battle Creek	030301	1,941	2,250	309	0.6	364	389	25	0.6	2,010	2,318	308	0.5	23,466	25,746	2,280	0.5
Relaid Mills Drain-Battle Creek	030302	1,315	1,577	262	0.5	250	270	21	0.5	1,369	1,623	254	0.5	16,305	18,149	1,845	0.4
Big Creek	030303	1,325	1,404	79	0.1	250	257	7	0.2	1,356	1,430	74	0.1	17,247	17,798	551	0.1
Headwaters Indian Creek	030304	2,827	3,122	295	0.5	527	552	25	0.6	2,896	3,193	297	0.5	34,840	37,134	2,295	0.5
Indian Creek	030305	1,697	1,948	251	0.5	312	333	21	0.5	1,798	2,050	252	0.4	17,772	19,698	1,925	0.5
Dillon Relaid Drain-Battle Creek	030306	4,389	4,927	538	1.0	811	854	43	1.0	4,680	5,193	513	0.9	47,071	50,743	3,672	0.9
Townline Brook Drain-Battle Creek	030307	2,096	2,369	273	0.5	386	410	24	0.5	2,189	2,457	268	0.5	22,900	24,979	2,079	0.5
Ackley Creek-Battle Creek	030308	1,347	1,773	426	0.8	238	278	40	0.9	1,369	1,797	428	0.8	13,603	17,165	3,562	0.9
Clear Lake-Battle Creek	030309	1,075	1,423	348	0.6	191	223	32	0.7	1,065	1,436	371	0.7	12,215	15,295	3,080	0.7
Headwaters	030310	1,868	2,045	177	0.3	351	366	15	0.3	1,936	2,101	166	0.3	22,855	24,118	1,263	0.3

		Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
Stream	HUC	2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change
Wanadoga Creek																	
Wanadoga Creek	030311	1,989	2,632	643	1.2	350	408	57	1.3	1,963	2,624	660	1.2	21,985	27,236	5,251	1.3
Battle Creek	030312	3,441	3,984	542	1.0	581	634	53	1.2	3,748	4,323	575	1.0	27,690	32,679	4,988	1.2
Headwaters South Branch Rice Creek	030401	1,536	2,161	625	1.1	291	338	47	1.1	1,618	2,231	614	1.1	18,176	22,462	4,285	1.0
South Branch Rice Creek	030402	1,658	2,310	653	1.2	307	359	52	1.2	1,699	2,355	656	1.2	19,337	24,156	4,820	1.2
North Branch Rice Creek	030403	2,840	3,515	675	1.2	529	578	50	1.1	2,877	3,567	690	1.2	35,901	40,725	4,824	1.2
Wilder Creek	030404	2,241	2,687	446	0.8	427	461	34	0.8	2,319	2,764	445	0.8	29,196	32,344	3,148	0.8
Rice Creek	030405	2,065	2,717	652	1.2	388	432	44	1.0	2,195	2,837	641	1.1	23,558	27,668	4,110	1.0
Montcalm Lake-Kalamazoo River	030406	3,422	4,314	892	1.6	639	711	73	1.6	3,688	4,565	877	1.6	37,186	43,660	6,473	1.6
Buckhorn Lake-Kalamazoo River	030407	2,849	3,618	769	1.4	522	582	60	1.3	3,043	3,828	785	1.4	29,228	34,907	5,680	1.4
Pigeon Creek-Kalamazoo River	030408	2,077	2,290	213	0.4	396	411	14	0.3	2,208	2,421	213	0.4	24,670	26,028	1,358	0.3
Harper Creek	030409	2,106	2,659	553	1.0	384	434	50	1.1	2,202	2,767	565	1.0	22,006	26,608	4,602	1.1
Minges Brook	030410	3,390	3,983	593	1.1	610	664	54	1.2	3,662	4,257	595	1.1	33,063	37,874	4,811	1.2
Willow Creek-Kalamazoo River	030411	3,321	4,065	744	1.4	577	648	72	1.6	3,531	4,296	766	1.4	31,097	37,616	6,520	1.6
Headwaters Wabascon Creek	030501	1,895	2,364	469	0.9	335	379	44	1.0	1,843	2,318	476	0.9	21,869	25,777	3,908	0.9
Wabascon Creek	030502	1,524	2,263	738	1.3	261	333	73	1.6	1,554	2,310	755	1.3	13,732	20,229	6,497	1.6
Harts Lake-Kalamazoo River	030503	4,560	5,333	773	1.4	749	827	78	1.8	4,871	5,666	795	1.4	35,396	42,365	6,968	1.7
Sevenmile Creek	030504	1,127	1,413	286	0.5	200	225	25	0.6	1,116	1,400	283	0.5	12,662	14,848	2,186	0.5
Headwaters Augusta Creek	030505	1,337	1,438	101	0.2	245	254	9	0.2	1,349	1,447	98	0.2	16,193	16,965	773	0.2
Augusta Creek	030506	1,073	1,168	94	0.2	186	194	8	0.2	1,042	1,137	95	0.2	11,216	11,963	748	0.2
Gull Creek	030507	2,827	3,195	368	0.7	521	554	33	0.7	2,943	3,313	370	0.7	32,551	35,490	2,938	0.7
Eagle Lake-Kalamazoo River	030508	2,028	2,367	339	0.6	324	357	33	0.7	1,980	2,324	344	0.6	16,311	19,263	2,952	0.7
Morrow Lake-Kalamazoo River	030509	2,179	2,506	327	0.6	400	428	29	0.6	2,320	2,653	332	0.6	22,698	25,313	2,615	0.6
Comstock Creek	030601	1,899	2,135	236	0.4	354	374	19	0.4	2,039	2,275	236	0.4	20,935	22,690	1,755	0.4
West Fork Portage Creek	030602	4,262	4,970	708	1.3	494	529	35	0.8	3,167	3,576	409	0.7	24,775	28,093	3,318	0.8
Portage Creek	030603	5,801	6,386	585	1.1	929	985	56	1.3	6,199	6,820	621	1.1	48,515	53,827	5,312	1.3

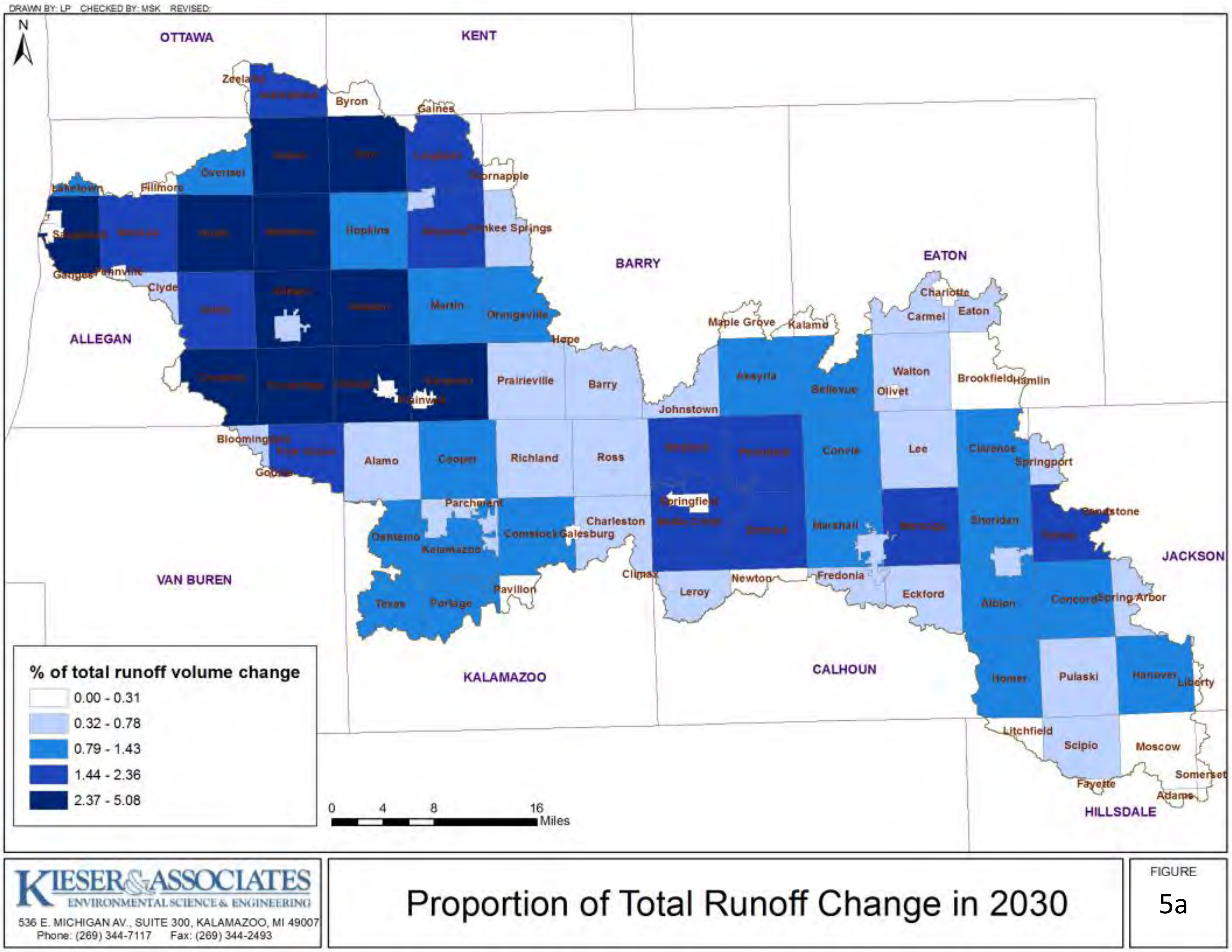
		Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
Stream	**HUC**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**
Davis Creek-Kalamazoo River	030604	4,783	5,114	331	0.6	760	791	31	0.7	5,039	5,382	343	0.6	41,393	44,272	2,879	0.7
Spring Brook	030605	3,457	3,939	482	0.9	613	655	42	0.9	3,391	3,874	483	0.9	40,822	44,546	3,724	0.9
Averill Lake-Kalamazoo River	030606	8,516	9,550	1,034	1.9	1,216	1,296	80	1.8	7,933	8,790	857	1.5	58,941	66,248	7,307	1.8
Silver Creek-Kalamazoo River	030607	6,087	7,385	1,299	2.4	1,074	1,183	109	2.5	6,146	7,475	1,329	2.4	66,054	76,092	10,038	2.4
Gun Lake-Gun River	030701	3,712	4,349	638	1.2	616	672	55	1.2	3,485	4,153	667	1.2	39,662	44,901	5,239	1.3
Fenner Creek-Gun River	030702	5,524	6,359	835	1.5	963	1,027	63	1.4	5,278	6,160	881	1.6	69,295	75,475	6,181	1.5
Gun River	030703	5,025	6,347	1,322	2.4	905	1,005	100	2.2	4,992	6,371	1,380	2.5	62,303	71,938	9,635	2.3
Green Lake Creek	030801	3,220	4,137	916	1.7	585	661	76	1.7	3,302	4,204	902	1.6	37,698	44,399	6,701	1.6
Fales Drain-Rabbit River	030802	3,199	4,022	823	1.5	566	632	66	1.5	3,192	4,073	881	1.6	38,092	44,567	6,476	1.6
Miller Creek	030803	3,715	4,828	1,113	2.0	687	771	84	1.9	3,880	5,001	1,122	2.0	42,692	50,569	7,877	1.9
Bear Creek	030804	2,554	3,170	617	1.1	490	525	36	0.8	2,671	3,281	611	1.1	33,885	37,394	3,509	0.8
Buskirk Creek-Rabbit River	030805	2,485	2,904	419	0.8	441	471	30	0.7	2,562	2,994	432	0.8	28,460	31,396	2,937	0.7
Headwaters Little Rabbit River	030806	3,484	4,512	1,027	1.9	631	700	69	1.5	3,611	4,632	1,021	1.8	43,159	49,604	6,445	1.5
Little Rabbit River	030807	3,279	4,802	1,524	2.8	577	683	105	2.4	3,224	4,814	1,590	2.8	41,957	52,391	10,434	2.5
Pigeon Creek-Rabbit River	030808	4,488	5,951	1,463	2.7	790	906	116	2.6	4,418	5,983	1,566	2.8	54,829	66,156	11,327	2.7
Black Creek	030809	4,708	6,293	1,586	2.9	892	996	104	2.3	4,917	6,460	1,543	2.8	59,423	68,936	9,513	2.3
Silver Creek-Rabbit River	030810	2,244	3,202	957	1.7	358	435	77	1.7	1,979	3,013	1,034	1.8	23,989	31,632	7,643	1.8
Rabbit River	030811	4,777	6,239	1,461	2.7	826	934	108	2.4	4,617	6,205	1,588	2.8	55,293	66,378	11,085	2.7
Sand Creek	030901	2,613	2,939	326	0.6	456	480	24	0.5	2,566	2,917	351	0.6	28,666	31,166	2,499	0.6
Base Line Creek	030902	3,818	5,687	1,869	3.4	698	822	124	2.8	3,851	5,970	2,119	3.8	45,073	59,426	14,353	3.4
Pine Creek	030903	3,917	4,564	646	1.2	709	744	35	0.8	3,892	4,612	720	1.3	47,414	51,702	4,289	1.0
Schnable Brook	030904	3,639	5,020	1,381	2.5	677	785	108	2.4	3,819	5,180	1,361	2.4	41,449	51,153	9,704	2.3
Trowbridge Dam-Kalamazoo River	030905	3,249	4,515	1,266	2.3	556	655	99	2.2	3,268	4,582	1,314	2.3	35,563	44,984	9,421	2.3
Tannery Creek-Kalamazoo River	030906	2,446	3,906	1,460	2.7	414	542	128	2.9	2,444	3,948	1,504	2.7	24,635	36,318	11,683	2.8
Lake Allegan-Kalamazoo River	030907	5,159	7,861	2,702	4.9	829	1,067	238	5.4	4,960	7,763	2,803	5.0	50,582	72,450	21,868	5.2
Swan Creek	030908	3,968	7,175	3,207	5.9	620	908	288	6.5	3,444	6,817	3,373	6.0	39,656	66,522	26,866	6.4

		Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
Stream	**HUC**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**
Bear Creek-Kalamazoo River	030909	2,383	3,482	1,099	2.0	316	418	102	2.3	1,758	2,968	1,210	2.2	19,148	28,936	9,788	2.3
Mann Creek	030910	2,153	3,032	879	1.6	299	383	85	1.9	1,794	2,782	988	1.8	16,288	24,397	8,110	1.9
Peach Orchid Creek-Kalamazoo River	030911	2,010	3,294	1,283	2.3	349	464	115	2.6	1,995	3,314	1,318	2.4	21,619	32,015	10,397	2.5
Kalamazoo River	030912	2,650	4,061	1,411	2.6	414	556	142	3.2	2,642	4,147	1,505	2.7	21,843	34,788	12,945	3.1
Total		216,737	271,399	54,751	100	37,866	42,306	4,440	100	218,313	274,285	55,973	100	2,337,823	2,755,016	417,193	100

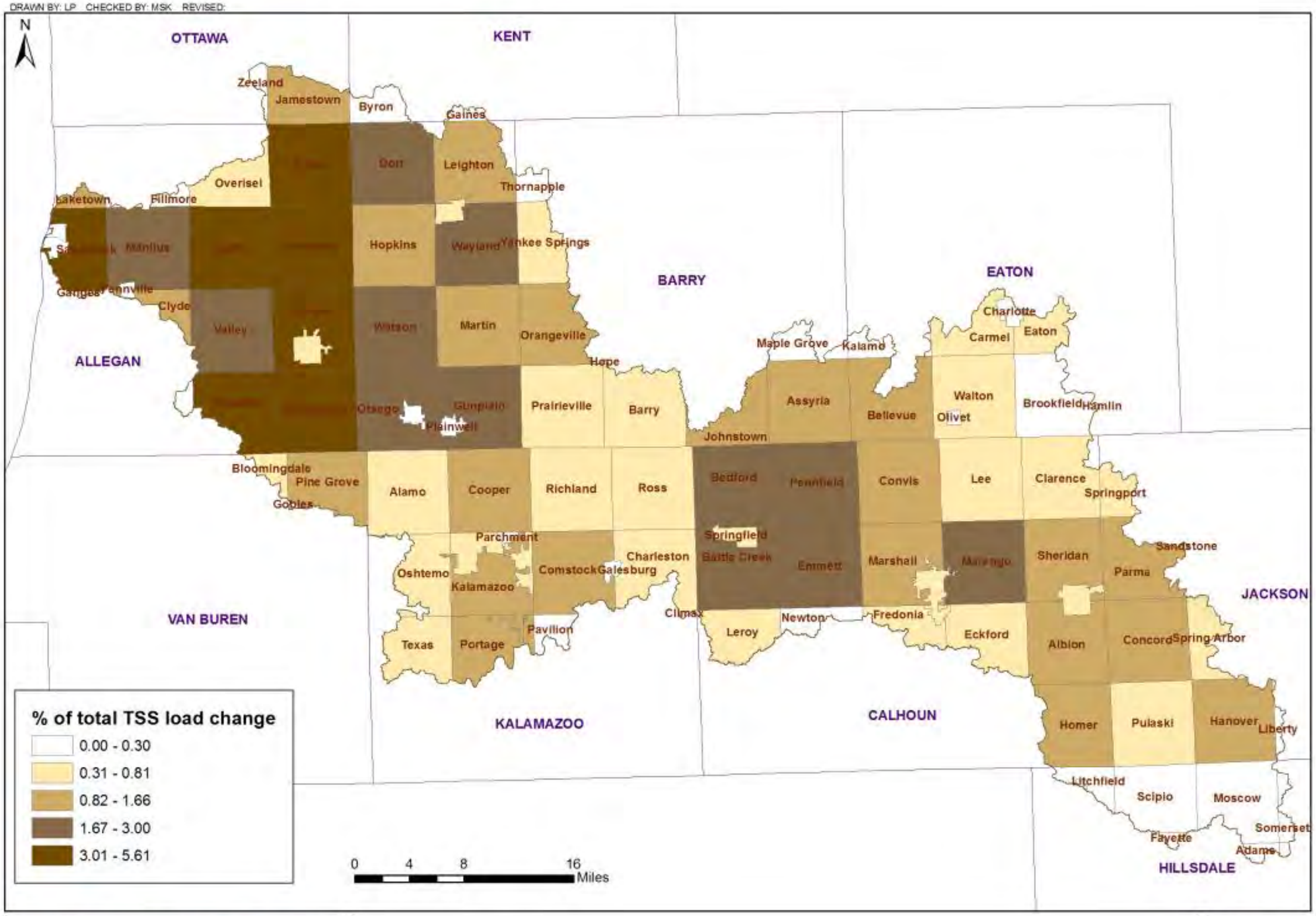
Appendix C

Changes in Volume and Load per Township for Build-out Scenario

APPENDIX C - Changes in Volume and Load per Township for Build-out Scenario



DRAWN BY: LP CHECKED BY: MSK REVISED:



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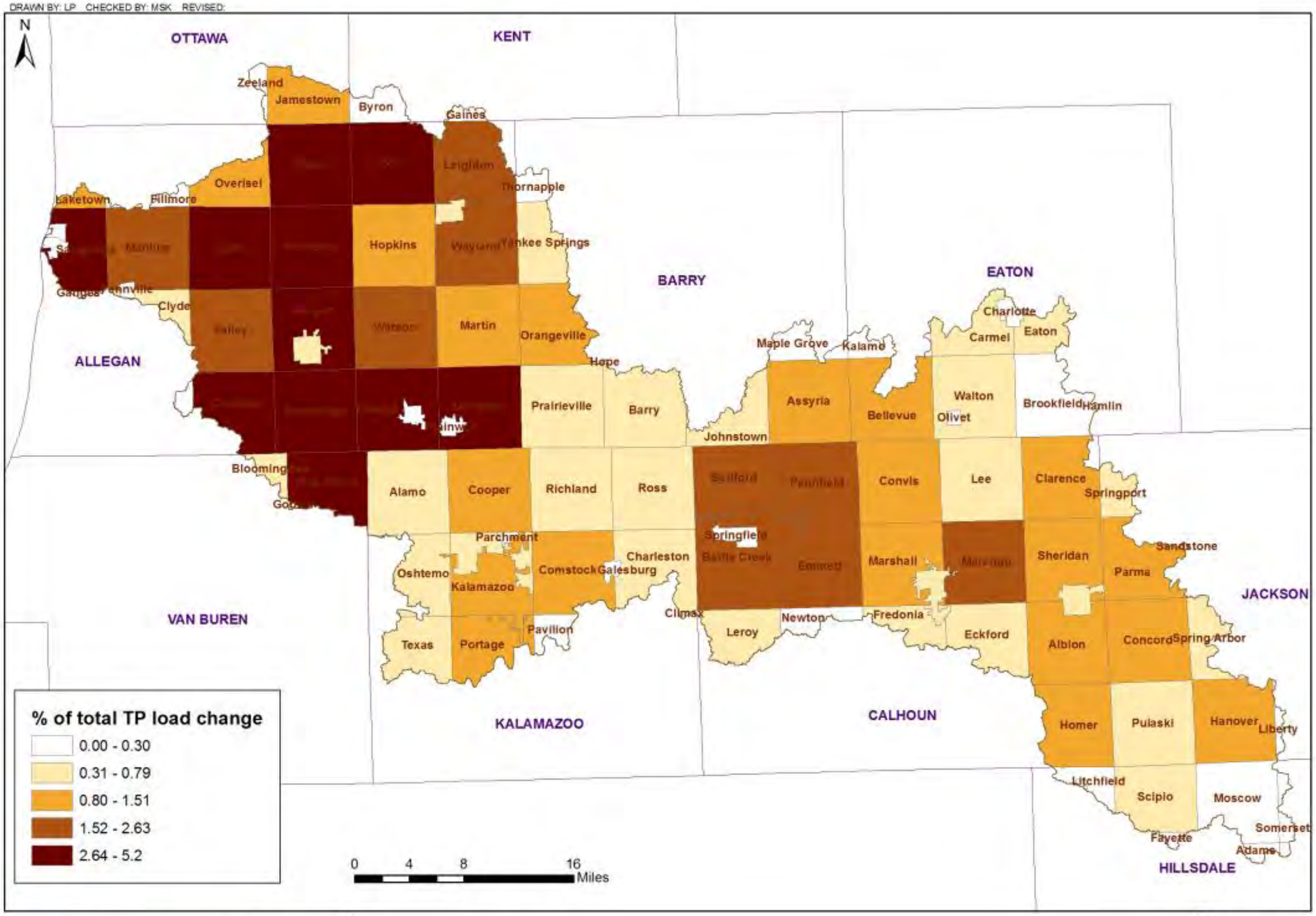
Proportion of Total TSS Change in 2030

FIGURE 5b



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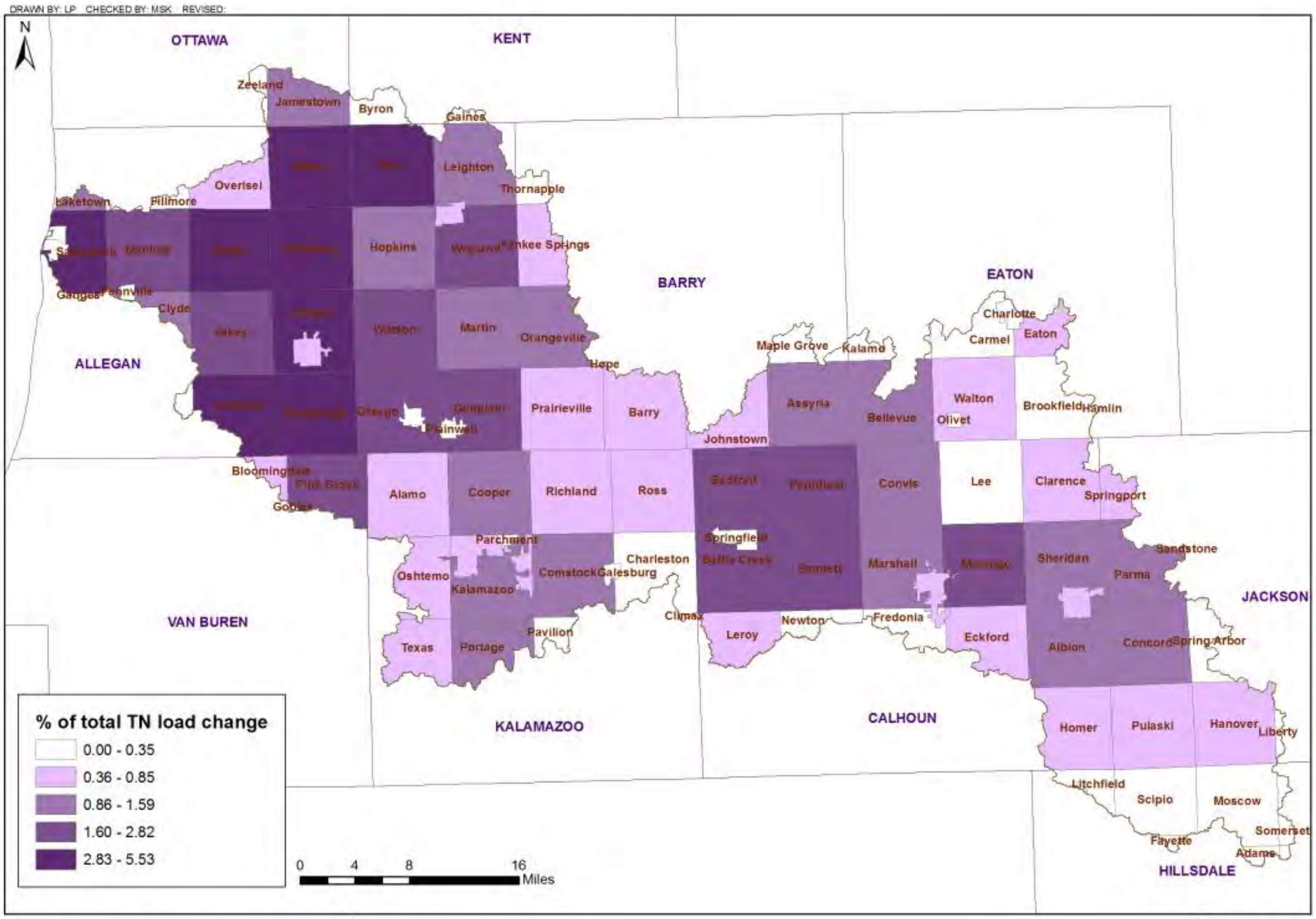
Proportion of Total TP Change in 2030

FIGURE
5c



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Proportion of Total TN Change in 2030

FIGURE
5d

Table C-1: Total Loads and Runoff Volume per Township for Years 2001 and 2030.

		RUNOFF VOLUME (ACRE-FEET/YR)				TSS LOAD (TONS/YR)				TP LOAD (LBS/YR)				TN LOAD (LBS/YEAR)			
NAME	% of total watershed area	2001	2030	Change in Volume	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change
Adams Twp	0.12	222	228	6	0.0	43	43	0	0.0	235	241	6	0.0	2,809	2,853	43	0.0
Alamo Twp	1.82	4,446	4,830	384	0.7	785	812	27	0.6	4,371	4,803	432	0.8	50,549	53,529	2,980	0.7
Albion	0.26	1,264	1,533	269	0.5	225	251	26	0.6	1,418	1,682	265	0.5	10,002	12,239	2,237	0.5
Albion Twp	1.64	2,516	3,239	723	1.3	481	534	54	1.2	2,630	3,346	716	1.3	32,325	37,302	4,977	1.2
Allegan	0.20	1,382	1,708	326	0.6	206	239	33	0.7	1,413	1,756	343	0.6	11,020	13,983	2,962	0.7
Allegan Twp	1.53	3,516	5,364	1,848	3.4	605	759	155	3.5	3,542	5,426	1,884	3.4	37,461	51,550	14,089	3.4
Assyria Twp	1.79	2,626	3,327	701	1.3	463	526	64	1.4	2,560	3,273	714	1.3	29,950	35,691	5,741	1.4
Barry Twp	1.57	2,524	2,852	328	0.6	458	488	29	0.7	2,561	2,878	317	0.6	29,764	32,261	2,497	0.6
Battle Creek	2.15	8,397	9,548	1,151	2.1	1,397	1,510	113	2.5	9,064	10,250	1,186	2.1	67,729	77,921	10,192	2.4
Bedford Twp	1.47	2,274	3,249	975	1.8	387	485	98	2.2	2,316	3,315	999	1.8	19,999	28,722	8,723	2.1
Bellevue Twp	1.53	2,524	3,035	511	0.9	464	511	47	1.0	2,626	3,128	502	0.9	28,013	32,041	4,027	1.0
Bloomingdale Twp	0.24	488	725	237	0.4	89	106	17	0.4	509	770	261	0.5	5,226	7,066	1,840	0.4
Brookfield Twp	1.40	2,299	2,439	141	0.3	437	448	11	0.2	2,395	2,528	132	0.2	28,801	29,721	920	0.2
Byron Twp	0.45	1,189	1,362	173	0.3	219	231	12	0.3	1,204	1,373	169	0.3	15,864	16,961	1,097	0.3
Carmel Twp	0.84	1,506	1,711	205	0.4	285	301	16	0.4	1,573	1,768	194	0.3	18,472	19,823	1,351	0.3
Charleston Twp	1.39	1,836	2,018	182	0.3	312	328	16	0.4	1,802	1,981	179	0.3	17,403	18,855	1,452	0.3
Charlotte	0.13	760	846	85	0.2	127	135	8	0.2	827	910	83	0.1	6,037	6,708	671	0.2
Cheshire Twp	1.33	2,577	5,359	2,782	5.1	445	694	249	5.6	2,476	5,376	2,900	5.2	28,657	51,736	23,079	5.5
Clarence Twp	1.55	2,290	2,752	462	0.8	427	462	35	0.8	2,334	2,802	468	0.8	28,324	31,663	3,338	0.8
Climax Twp	0.02	41	41	0	0.0	8	8	0	0.0	44	44	0	0.0	504	504	0	0.0
Clyde Twp	0.40	987	1,372	385	0.7	137	177	40	0.9	811	1,254	443	0.8	6,761	10,546	3,785	0.9
Comstock Twp	1.57	3,796	4,309	513	0.9	658	705	47	1.1	4,032	4,552	520	0.9	36,437	40,696	4,259	1.0
Concord Twp	1.80	2,851	3,577	726	1.3	538	588	50	1.1	2,987	3,693	706	1.3	34,673	39,200	4,527	1.1
Convis Twp	1.78	2,728	3,185	457	0.8	489	530	41	0.9	2,785	3,265	480	0.9	28,967	32,837	3,870	0.9
Cooper Twp	1.79	3,493	4,101	609	1.1	610	660	49	1.1	3,405	4,055	650	1.2	39,321	44,170	4,849	1.2
Dorr Twp	1.79	4,640	6,485	1,844	3.4	826	959	133	3.0	4,708	6,602	1,894	3.4	57,070	69,819	12,748	3.1
Eaton Twp	0.54	1,025	1,372	346	0.6	191	219	28	0.6	1,081	1,412	331	0.6	11,250	13,645	2,395	0.6
Eckford Twp	1.28	2,053	2,419	366	0.7	393	420	27	0.6	2,139	2,504	365	0.7	26,722	29,261	2,539	0.6
Emmett Twp	1.61	3,741	4,746	1,005	1.8	662	757	95	2.1	3,983	5,011	1,027	1.8	36,158	44,784	8,626	2.1

		RUNOFF VOLUME (ACRE-FEET/YR)				TSS LOAD (TONS/YR)				TP LOAD (LBS/YR)				TN LOAD (LBS/YEAR)			
NAME	% of total watershed area	2001	2030	Change in Volume	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change
Fayette Twp	0.06	92	98	6	0.0	16	16	0	0.0	93	98	5	0.0	1,010	1,045	35	0.0
Fennville	0.06	369	452	83	0.2	60	66	6	0.1	396	481	85	0.2	3,316	3,870	553	0.1
Fillmore Twp	0.16	316	350	34	0.1	57	60	3	0.1	339	372	33	0.1	3,398	3,616	218	0.1
Fredonia Twp	0.57	912	1,108	196	0.4	169	184	16	0.4	944	1,146	202	0.4	10,292	11,787	1,495	0.4
Gaines Twp	0.11	321	380	60	0.1	56	62	6	0.1	316	375	59	0.1	3,398	3,889	490	0.1
Galesburg	0.07	154	202	48	0.1	26	30	4	0.1	164	217	52	0.1	1,431	1,833	401	0.1
Ganges Twp	0.02	37	65	27	0.1	7	9	2	0.0	39	64	25	0.0	469	643	174	0.0
Gobles	0.01	41	63	22	0.0	7	8	0	0.0	40	70	30	0.1	517	664	147	0.0
Gunplain Twp	1.72	4,838	6,424	1,586	2.9	875	1,002	127	2.9	4,908	6,533	1,624	2.9	56,310	68,092	11,782	2.8
Hamlin Twp	0.00	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	2	2	0	0.0
Hanover Twp	1.73	2,319	2,808	489	0.9	430	469	39	0.9	2,385	2,866	482	0.9	27,528	31,036	3,508	0.8
Heath Twp	1.80	3,578	5,275	1,697	3.1	525	675	150	3.4	2,998	4,854	1,856	3.3	32,159	46,759	14,601	3.5
Homer Twp	1.55	2,591	3,101	510	0.9	497	535	38	0.9	2,726	3,230	504	0.9	33,048	36,544	3,496	0.8
Hope Twp	0.00	3	6	2	0.0	0	1	0	0.0	2	5	2	0.0	23	43	20	0.0
Hopkins Twp	1.82	4,357	5,101	743	1.4	820	865	44	1.0	4,521	5,269	748	1.3	55,613	60,043	4,430	1.1
Jamestown Twp	1.00	2,780	3,672	892	1.6	530	589	59	1.3	2,953	3,799	847	1.5	33,947	39,116	5,168	1.2
Johnstown Twp	0.85	1,437	1,867	430	0.8	259	297	38	0.9	1,446	1,871	424	0.8	16,324	19,643	3,319	0.8
Kalamazoo	1.24	7,785	8,316	531	1.0	1,227	1,275	48	1.1	8,218	8,711	493	0.9	58,527	62,854	4,328	1.0
Kalamazoo Twp	0.58	2,775	3,090	316	0.6	459	490	31	0.7	3,023	3,353	330	0.6	22,551	25,351	2,800	0.7
Kalamo Twp	0.28	432	447	16	0.0	81	82	1	0.0	431	445	14	0.0	5,894	5,990	96	0.0
Laketown Twp	0.19	584	1,067	483	0.9	89	137	48	1.1	571	1,077	506	0.9	5,029	9,381	4,351	1.0
Lee Twp-Allegan	0.11	113	143	30	0.1	17	19	3	0.1	88	126	39	0.1	1,255	1,594	339	0.1
Lee Twp-Calhoun	1.84	2,864	3,063	198	0.4	535	551	16	0.4	2,929	3,124	194	0.3	35,860	37,265	1,405	0.3
Leighton Twp	1.51	3,620	4,552	932	1.7	659	732	74	1.7	3,697	4,623	926	1.7	43,867	50,523	6,656	1.6
Leroy Twp	0.91	1,312	1,569	256	0.5	244	265	21	0.5	1,361	1,629	267	0.5	15,177	17,226	2,049	0.5
Liberty Twp	0.08	153	192	39	0.1	28	31	3	0.1	159	198	39	0.1	1,800	2,062	262	0.1
Litchfield	0.01	53	59	5	0.0	10	10	0	0.0	59	65	6	0.0	533	539	6	0.0
Litchfield Twp	0.37	811	878	67	0.1	157	160	3	0.1	869	935	66	0.1	9,971	10,289	318	0.1
Manlius Twp	1.78	2,840	4,116	1,275	2.3	431	548	117	2.6	2,414	3,798	1,384	2.5	28,360	39,403	11,043	2.6
Maple Grove Twp	0.43	567	599	32	0.1	107	110	3	0.1	591	622	31	0.1	6,986	7,247	261	0.1

		RUNOFF VOLUME (ACRE-FEET/YR)				TSS LOAD (TONS/YR)				TP LOAD (LBS/YR)				TN LOAD (LBS/YEAR)			
NAME	**% of total watershed area**	**2001**	**2030**	**Change in Volume**	% of total change	**2001**	**2030**	**Change in Load**	% of total change	**2001**	**2030**	**Change in Load**	% of total change	**2001**	**2030**	**Change in Load**	% of total change
Marengo Twp	1.78	3,182	4,356	1,173	2.1	604	688	84	1.9	3,343	4,504	1,161	2.1	38,465	46,256	7,791	1.9
Marshall	0.31	1,043	1,338	294	0.5	185	209	25	0.6	1,147	1,449	302	0.5	9,167	11,466	2,299	0.6
Marshall Twp	1.59	3,614	4,235	621	1.1	681	725	44	1.0	3,889	4,516	627	1.1	38,942	43,208	4,266	1.0
Martin Twp	1.82	5,299	5,993	694	1.3	997	1,041	44	1.0	5,394	6,098	704	1.3	71,582	75,917	4,334	1.0
Monterey Twp	1.81	4,051	5,823	1,772	3.2	707	862	155	3.5	3,932	5,792	1,861	3.3	47,498	61,998	14,500	3.5
Moscow Twp	1.54	2,422	2,477	55	0.1	458	462	4	0.1	2,514	2,572	58	0.1	30,167	30,573	406	0.1
Newton Twp	0.41	511	597	86	0.2	92	100	8	0.2	512	603	91	0.2	5,778	6,541	763	0.2
Olivet	0.05	162	218	56	0.1	27	32	5	0.1	172	229	57	0.1	1,323	1,813	490	0.1
Orangeville Twp	1.28	2,408	2,950	542	1.0	361	411	50	1.1	2,068	2,652	584	1.0	25,004	29,719	4,715	1.1
Oshtemo Twp	1.00	3,136	3,608	472	0.9	316	337	21	0.5	1,958	2,201	242	0.4	16,578	18,539	1,961	0.5
Otsego	0.10	814	962	148	0.3	130	143	13	0.3	868	1,025	157	0.3	6,894	8,112	1,217	0.3
Otsego Twp	1.69	3,690	5,271	1,581	2.9	660	780	120	2.7	3,748	5,378	1,630	2.9	42,421	53,879	11,458	2.7
Overisel Twp	0.89	2,766	3,419	654	1.2	522	555	32	0.7	2,866	3,541	674	1.2	35,898	39,482	3,584	0.9
Parchment	0.05	264	290	26	0.0	44	46	3	0.1	293	322	28	0.1	2,067	2,318	251	0.1
Parma Twp	1.26	2,306	3,149	843	1.5	435	499	64	1.4	2,427	3,258	831	1.5	27,191	33,031	5,840	1.4
Pavilion Twp	0.29	438	461	23	0.0	83	84	2	0.0	459	484	25	0.0	5,335	5,509	173	0.0
Pennfield Twp	1.73	2,605	3,600	995	1.8	460	551	91	2.1	2,703	3,722	1,019	1.8	25,405	33,793	8,389	2.0
Pine Grove Twp	1.27	3,122	4,419	1,297	2.4	564	635	71	1.6	3,061	4,636	1,575	2.8	38,335	48,334	9,998	2.4
Plainwell	0.10	738	850	111	0.2	117	126	9	0.2	779	904	125	0.2	6,447	7,356	910	0.2
Portage	1.07	4,804	5,322	518	0.9	761	814	53	1.2	5,190	5,744	554	1.0	38,883	43,755	4,872	1.2
Prairieville Twp	1.68	3,455	3,865	410	0.7	633	669	36	0.8	3,516	3,913	397	0.7	41,112	44,168	3,057	0.7
Pulaski Twp	1.84	2,648	3,015	367	0.7	501	528	27	0.6	2,744	3,105	361	0.6	32,903	35,387	2,484	0.6
Richland Twp	1.75	3,361	3,720	359	0.7	611	640	28	0.6	3,408	3,779	372	0.7	39,124	41,843	2,719	0.7
Ross Twp	1.67	2,026	2,307	281	0.5	350	375	25	0.6	2,014	2,309	294	0.5	20,385	22,776	2,391	0.6
Salem Twp	1.81	5,279	7,496	2,217	4.0	938	1,089	151	3.4	5,223	7,553	2,330	4.2	65,527	80,765	15,238	3.7
Sandstone Twp	0.01	14	17	3	0.0	2	3	0	0.0	13	16	3	0.0	166	187	21	0.0
Saugatuck	0.05	256	313	56	0.1	39	45	6	0.1	267	329	62	0.1	1,972	2,539	566	0.1
Saugatuck Twp	1.02	2,336	3,865	1,529	2.8	383	529	146	3.3	2,294	3,899	1,605	2.9	21,707	35,036	13,330	3.2
Scipio Twp	1.37	2,525	2,709	183	0.3	476	489	14	0.3	2,634	2,824	191	0.3	30,421	31,769	1,348	0.3
Sheridan Twp	1.55	2,301	3,089	788	1.4	424	488	64	1.4	2,368	3,171	802	1.4	26,499	32,528	6,029	1.4

		RUNOFF VOLUME (ACRE-FEET/YR)				TSS LOAD (TONS/YR)				TP LOAD (LBS/YR)				TN LOAD (LBS/YEAR)			
NAME	**% of total watershed area**	**2001**	**2030**	**Change in Volume**	% of total change	**2001**	**2030**	**Change in Load**	% of total change	**2001**	**2030**	**Change in Load**	% of total change	**2001**	**2030**	**Change in Load**	% of total change
Somerset Twp	0.16	236	250	15	0.0	43	44	1	0.0	239	256	17	0.0	2,794	2,913	119	0.0
Spring Arbor Twp	0.61	987	1,197	209	0.4	183	200	17	0.4	1,025	1,226	202	0.4	11,695	13,145	1,450	0.3
Springfield	0.18	1,207	1,350	143	0.3	206	221	15	0.3	1,335	1,480	144	0.3	9,063	10,368	1,304	0.3
Springport Twp	0.42	744	990	246	0.4	140	157	17	0.4	757	1,004	246	0.4	9,771	11,394	1,623	0.4
Texas Twp	0.95	2,469	2,967	497	0.9	239	257	19	0.4	1,420	1,687	267	0.5	14,569	16,524	1,955	0.5
Thornapple Twp	0.25	662	691	29	0.1	121	124	3	0.1	657	689	32	0.1	8,702	8,978	276	0.1
Trowbridge Twp	1.76	3,292	5,212	1,920	3.5	602	756	154	3.5	3,363	5,279	1,916	3.4	38,269	52,200	13,932	3.3
Valley Twp	1.67	2,514	3,434	921	1.7	301	389	89	2.0	1,683	2,704	1,020	1.8	17,657	26,027	8,370	2.0
Village of Douglas	0.08	469	566	97	0.2	76	87	10	0.2	501	608	107	0.2	3,569	4,532	963	0.2
Walton Twp	1.78	3,588	3,940	353	0.6	674	703	29	0.7	3,779	4,126	347	0.6	41,286	43,867	2,581	0.6
Watson Twp	1.79	3,722	5,197	1,475	2.7	686	805	119	2.7	3,857	5,329	1,472	2.6	42,665	53,531	10,866	2.6
Wayland	0.15	845	1,049	204	0.4	126	144	18	0.4	849	1,082	232	0.4	7,621	9,423	1,801	0.4
Wayland Twp	1.66	4,661	5,897	1,236	2.3	844	937	93	2.1	4,678	5,978	1,300	2.3	55,990	65,164	9,174	2.2
Wheatland Twp	0.03	26	29	2	0.0	5	5	0	0.0	27	29	2	0.0	378	396	17	0.0
Yankee Springs Twp	0.71	1,731	2,141	410	0.7	263	299	36	0.8	1,532	1,950	418	0.7	15,791	19,101	3,309	0.8
Zeeland Twp	0.13	283	375	92	0.2	54	59	5	0.1	293	381	88	0.2	3,945	4,428	483	0.1
Total	100	217,061	271,812	54,751	100	37,866	42,306	4,440	100	218,313	274,285	55,972	100	2,337,823	2,755,016	417,193	100

Appendix D

Stormwater Controls Cost Analysis

APPENDIX D – Stormwater Controls Cost Analysis

Table D-1: Cost scenarios for implementation of stormwater controls per township.

	TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
NAME	2001	2001 Load from Urban-Commercial	2030	2030 Load from Urban-Commercial	Ordinance passed in 2001	50% reduction in 2030	Retrofitting in 2030
Adams Twp	235	0	241	5	0	27,495	54,990
Alamo Twp	4,371	70	4,803	442	352,221	2,208,820	4,065,419
Albion	1,418	139	1,682	375	693,585	1,872,500	3,051,415
Albion Twp	2,630	15	3,346	739	75,168	3,697,475	7,319,782
Allegan	1,413	506	1,756	789	2,528,005	3,947,070	5,366,135
Allegan Twp	3,542	417	5,426	2,225	2,086,150	11,124,450	20,162,750
Assyria Twp	2,560	81	3,273	716	405,734	3,580,795	6,755,857
Barry Twp	2,561	97	2,878	415	486,259	2,076,455	3,666,651
Battle Creek	9,064	1,642	10,250	2,589	8,211,300	12,943,400	17,675,500
Bedford Twp	2,316	108	3,315	923	541,955	4,613,815	8,685,675
Bellevue Twp	2,626	73	3,128	552	364,199	2,761,925	5,159,651
Bloomingdale Twp	509	3	770	220	13,748	1,100,165	2,186,582
Brookfield Twp	2,395	16	2,528	165	80,000	826,475	1,572,950
Byron Twp	1,204	65	1,373	256	322,786	1,280,220	2,237,655
Carmel Twp	1,573	28	1,768	243	140,210	1,213,950	2,287,690
Charleston Twp	1,802	82	1,981	230	409,794	1,147,965	1,886,137
Charlotte	827	177	910	256	883,540	1,280,650	1,677,760
Cheshire Twp	2,476	37	5,376	2,574	183,400	12,869,850	25,556,300
Clarence Twp	2,334	24	2,802	472	121,252	2,362,110	4,602,969
Climax Twp	44	0	44	0	0	0	0
Clyde Twp	811	47	1,254	382	236,275	1,909,430	3,582,586
Comstock Twp	4,032	490	4,552	951	2,450,890	4,753,210	7,055,530
Concord Twp	2,987	45	3,693	827	222,575	4,135,625	8,048,675
Convis Twp	2,785	94	3,265	490	469,281	2,449,680	4,430,080
Cooper Twp	3,405	47	4,055	620	234,590	3,101,095	5,967,600
Dorr Twp	4,708	330	6,602	2,253	1,648,505	11,263,700	20,878,895
Eaton Twp	1,081	19	1,412	372	92,611	1,859,025	3,625,439
Eckford Twp	2,139	8	2,504	377	39,866	1,886,450	3,733,034
Emmett Twp	3,983	329	5,011	1,201	1,645,540	6,007,300	10,369,060
Fayette Twp	93	11	98	14	52,551	69,255	85,959
Fennville	396	79	481	167	393,335	834,915	1,276,495
Fillmore Twp	339	36	372	73	180,712	365,397	550,082
Fredonia Twp	944	8	1,146	192	39,866	958,985	1,878,104
Gaines Twp	316	0	375	55	0	276,250	552,499
Galesburg	164	17	217	60	85,959	300,108	514,256
Ganges Twp	39	6	64	34	30,396	168,120	305,844
Gobles	40	0	70	22	0	110,441	220,882
Gunplain Twp	4,908	200	6,533	1,765	1,001,185	8,823,950	16,646,715
Hanover Twp	2,385	24	2,866	508	118,332	2,537,550	4,956,769
Heath Twp	2,998	208	4,854	1,771	1,039,830	8,853,650	16,667,470
Homer Twp	2,726	21	3,230	534	106,064	2,672,100	5,238,137

	TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
NAME	2001	2001 Load from Urban-Commercial	2030	2030 Load from Urban-Commercial	Ordinance passed in 2001	50% reduction in 2030	Retrofitting in 2030
Hope Twp	2	2	5	4	9,775	19,549	29,324
Hopkins Twp	4,521	134	5,269	944	668,800	4,720,745	8,772,690
Jamestown Twp	2,953	57	3,799	1,055	282,903	5,274,050	10,265,198
Johnstown Twp	1,446	22	1,871	427	107,541	2,136,480	4,165,419
Kalamazoo	8,218	1,822	8,711	2,231	9,110,650	11,154,400	13,198,150
Kalamazoo Twp	3,023	538	3,353	811	2,689,935	4,053,430	5,416,925
Kalamo Twp	431	5	445	19	22,543	97,397	172,251
Laketown Twp	571	111	1,077	981	553,555	4,905,675	9,257,795
Lee Twp-Allegan	88	2	126	18	9,775	89,432	169,088
Lee Twp-Calhoun	2,929	55	3,124	252	275,449	1,261,295	2,247,142
Leighton Twp	3,697	222	4,623	1,158	1,107,760	5,788,550	10,469,340
Leroy Twp	1,361	8	1,629	238	41,760	1,188,790	2,335,820
Liberty Twp	159	3	198	45	16,704	225,505	434,305
Litchfield	59	2	65	10	8,352	50,112	91,872
Litchfield Twp	869	12	935	93	58,464	465,568	872,672
Manlius Twp	2,414	129	3,798	1,308	644,070	6,541,400	12,438,730
Maple Grove Twp	591	7	622	36	34,914	180,546	326,178
Marengo Twp	3,343	10	4,504	1,221	50,112	6,106,450	12,162,788
Marshall	1,147	106	1,449	382	529,530	1,908,355	3,287,180
Marshall Twp	3,889	64	4,516	684	319,148	3,420,815	6,522,482
Martin Twp	5,394	154	6,098	915	767,560	4,576,010	8,384,460
Monterey Twp	3,932	165	5,792	1,819	826,540	9,093,850	17,361,160
Moscow Twp	2,514	30	2,572	83	150,262	417,139	684,015
Newton Twp	512	11	603	84	57,429	419,917	782,405
Olivet	172	29	229	77	144,423	386,704	628,985
Orangeville Twp	2,068	207	2,652	696	1,034,325	3,479,400	5,924,475
Oshtemo Twp	1,958	256	2,201	256	1,280,580	1,280,580	1,280,580
Otsego	868	199	1,025	334	994,915	1,671,495	2,348,075
Otsego Twp	3,748	190	5,378	1,780	949,245	8,899,100	16,848,955
Overisel Twp	2,866	48	3,541	802	241,688	4,011,775	7,781,862
Parchment	293	53	322	72	263,914	361,660	459,406
Parma Twp	2,427	23	3,258	871	116,929	4,355,695	8,594,462
Pavilion Twp	459	6	484	27	30,895	135,138	239,381
Pennfield Twp	2,703	126	3,722	986	629,755	4,930,365	9,230,975
Pine Grove Twp	3,061	22	4,636	1,236	111,698	6,177,950	12,244,203
Plainwell	779	174	904	279	868,250	1,396,750	1,925,250
Portage	5,190	1,026	5,744	1,026	5,131,850	5,131,850	5,131,850
Prairieville Twp	3,516	90	3,913	497	451,924	2,487,135	4,522,346
Pulaski Twp	2,744	8	3,105	384	41,760	1,918,810	3,795,860
Richland Twp	3,408	70	3,779	415	349,600	2,077,020	3,804,441
Ross Twp	2,014	80	2,309	320	400,897	1,602,385	2,803,873
Salem Twp	5,223	331	7,553	2,648	1,656,100	13,240,650	24,825,200
Sandstone Twp	13	0	16	3	0	16,704	33,408
Saugatuck	267	49	329	93	244,544	464,345	684,147
Saugatuck Twp	2,294	163	3,899	1,534	813,205	7,669,250	14,525,295

	TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
NAME	2001	2001 Load from Urban-Commercial	2030	2030 Load from Urban-Commercial	Ordinance passed in 2001	50% reduction in 2030	Retrofitting in 2030
Scipio Twp	2,634	27	2,824	204	136,071	1,022,190	1,908,309
Sheridan Twp	2,368	28	3,171	764	141,985	3,818,395	7,494,806
Somerset Twp	239	12	256	24	58,464	121,806	185,148
Spring Arbor Twp	1,025	22	1,226	235	108,577	1,173,765	2,238,954
Springfield	1,335	196	1,480	332	978,960	1,661,630	2,344,300
Springport Twp	757	16	1,004	270	77,607	1,348,210	2,618,813
Texas Twp	1,420	132	1,687	350	661,320	1,751,490	2,841,660
Thornapple Twp	657	25	689	49	124,373	243,128	361,883
Trowbridge Twp	3,363	93	5,279	2,007	465,563	10,037,150	19,608,737
Valley Twp	1,683	104	2,704	940	520,075	4,701,365	8,882,655
Village of Douglas	501	77	608	149	383,541	744,845	1,106,150
Walton Twp	3,779	60	4,126	403	301,735	2,017,285	3,732,836
Watson Twp	3,857	107	5,329	1,537	537,300	7,686,550	14,835,800
Wayland	849	277	1,082	463	1,383,225	2,317,170	3,251,115
Wayland Twp	4,678	166	5,978	1,365	827,605	6,824,300	12,820,995
Wheatland Twp	27	0	29	2	0	11,678	23,356
Yankee Springs Twp	1,532	119	1,950	505	593,595	2,524,710	4,455,825
Zeeland Twp	293	9	381	116	45,972	580,490	1,115,008

Table D-2: Cost scenarios for implementation of stormwater controls per subwatershed.

		TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
Watershed Name	**HUC**	**2001**	**2001 Load from Urban-Commercial**	**2030**	**2030 Load from Urban-Commercial**	**Ordinance passed in 2001**	**2030**	**Retrofitting in 2030**
Upper North Branch Kalamazoo River	030101	2,228	43	2,656	462	216,043	2,312,465	4,408,887
Spring Arbor and Concord Drain	030102	1,739	36	2,006	339	177,832	1,692,760	3,207,689
Middle North Branch Kalamazoo River	030103	2,010	34	2,404	454	170,024	2,269,280	4,368,536
Lower North Branch Kalamazoo River	030104	2,116	20	2,696	652	100,225	3,261,695	6,423,166
Horseshoe Lake-South Branch Kalamazoo River	030201	3,161	21	3,342	202	102,663	1,008,215	1,913,767
Cobb Lake-South Branch Kalamazoo River	030202	1,887	26	2,017	140	130,158	700,600	1,271,042
Beaver Creek-South Branch Kalamazoo River	030203	2,780	33	2,936	203	167,041	1,016,135	1,865,230
Swains Lake Drain-South Branch Kalamazoo River	030204	1,235	3	1,475	239	16,704	1,196,305	2,375,906
Lampson Run Drain	030205	2,158	8	2,462	349	39,247	1,746,390	3,453,533
South Branch Kalamazoo River	030206	2,084	25	2,755	673	125,281	3,364,195	6,603,110
Narrow Lake-Battle Creek	030301	2,010	28	2,318	325	139,083	1,626,710	3,114,337
Relaid Mills Drain-Battle Creek	030302	1,369	6	1,623	267	29,001	1,336,685	2,644,369
Big Creek	030303	1,356	18	1,430	99	89,664	496,048	902,432
Headwaters Indian Creek	030304	2,896	55	3,193	327	276,142	1,635,430	2,994,719
Indian Creek	030305	1,798	74	2,050	310	371,756	1,552,385	2,733,015
Dillon Relaid Drain-Battle Creek	030306	4,680	240	5,193	795	1,200,140	3,974,925	6,749,710
Townline Brook Drain-Battle Creek	030307	2,189	59	2,457	320	293,438	1,600,690	2,907,942
Ackley Creek-Battle Creek	030308	1,369	63	1,797	438	315,565	2,192,100	4,068,636
Clear Lake-Battle Creek	030309	1,065	26	1,436	308	131,350	1,540,130	2,948,911
Headwaters Wanadoga Creek	030310	1,936	36	2,101	209	179,041	1,047,000	1,914,960
Wanadoga Creek	030311	1,963	70	2,624	654	350,662	3,267,935	6,185,209
Battle Creek	030312	3,748	530	4,323	958	2,649,200	4,791,020	6,932,840
Headwaters South Branch Rice Creek	030401	1,618	13	2,231	649	66,816	3,244,005	6,421,194
South Branch Rice Creek	030402	1,699	12	2,355	635	58,464	3,176,455	6,294,446
North Branch Rice Creek	030403	2,877	25	3,567	684	127,405	3,418,620	6,709,835
Wilder Creek	030404	2,319	6	2,764	450	31,514	2,251,010	4,470,506
Rice Creek	030405	2,195	43	2,837	740	217,153	3,698,040	7,178,928
Montcalm Lake-Kalamazoo River	030406	3,688	150	4,565	1,021	752,050	5,106,400	9,460,750
Buckhorn Lake-Kalamazoo River	030407	3,043	130	3,828	868	652,245	4,338,095	8,023,945
Pigeon Creek-Kalamazoo River	030408	2,208	12	2,421	236	58,464	1,180,590	2,302,716
Harper Creek	030409	2,202	55	2,767	541	273,546	2,702,850	5,132,155
Minges Brook	030410	3,662	267	4,257	797	1,334,620	3,985,310	6,636,000
Willow Creek-Kalamazoo River	030411	3,531	399	4,296	1,024	1,994,250	5,119,800	8,245,350

		TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
Watershed Name	**HUC**	**2001**	**2001 Load from Urban-Commercial**	**2030**	**2030 Load from Urban-Commercial**	**Ordinance passed in 2001**	**2030**	**Retrofitting in 2030**
Headwaters Wabascon Creek	030501	1,843	29	2,318	448	147,093	2,241,790	4,336,488
Wabascon Creek	030502	1,554	76	2,310	705	377,843	3,524,540	6,671,238
Harts Lake-Kalamazoo River	030503	4,871	926	5,666	1,574	4,628,095	7,871,550	11,115,005
Sevenmile Creek	030504	1,116	23	1,400	293	115,034	1,465,490	2,815,946
Headwaters Augusta Creek	030505	1,349	26	1,447	120	128,985	601,180	1,073,375
Augusta Creek	030506	1,042	16	1,137	96	77,607	480,629	883,650
Gull Creek	030507	2,943	74	3,313	409	370,905	2,045,875	3,720,845
Eagle Lake-Kalamazoo River	030508	1,980	246	2,324	528	1,227,745	2,641,385	4,055,025
Morrow Lake-Kalamazoo River	030509	2,320	64	2,653	362	317,745	1,810,155	3,302,566
Comstock Creek	030601	2,039	53	2,275	280	263,364	1,400,275	2,537,187
West Fork Portage Creek	030602	3,167	459	3,576	802	2,292,690	4,008,365	5,724,040
Portage Creek	030603	6,199	1,125	6,820	1,592	5,623,000	7,961,950	10,300,900
Davis Creek-Kalamazoo River	030604	5,039	1,412	5,382	1,694	7,057,950	8,469,250	9,880,550
Spring Brook	030605	3,391	104	3,874	568	519,505	2,839,325	5,159,145
Averill Lake-Kalamazoo River	030606	7,933	1,286	8,790	1,982	6,432,400	9,908,600	13,384,800
Silver Creek-Kalamazoo River	030607	6,146	302	7,475	1,554	1,511,370	7,768,750	14,026,130
Gun Lake-Gun River	030701	3,485	208	4,153	783	1,039,000	3,913,955	6,788,910
Fenner Creek-Gun River	030702	5,278	248	6,160	1,085	1,241,210	5,427,400	9,613,590
Gun River	030703	4,992	216	6,371	1,555	1,079,965	7,774,100	14,468,235
Green Lake Creek	030801	3,302	189	4,204	1,092	944,500	5,460,750	9,977,000
Fales Drain-Rabbit River	030802	3,192	192	4,073	981	961,900	4,905,625	8,849,350
Miller Creek	030803	3,880	157	5,001	1,272	785,935	6,358,750	11,931,565
Bear Creek	030804	2,671	47	3,281	735	236,698	3,676,450	7,116,202
Buskirk Creek-Rabbit River	030805	2,562	283	2,994	707	1,413,610	3,536,645	5,659,680
Headwaters Little Rabbit River	030806	3,611	241	4,632	1,358	1,207,295	6,792,000	12,376,705
Little Rabbit River	030807	3,224	257	4,814	1,854	1,282,600	9,271,650	17,260,700
Pigeon Creek-Rabbit River	030808	4,418	273	5,983	1,717	1,365,110	8,582,750	15,800,390
Black Creek	030809	4,917	103	6,460	1,854	513,625	9,268,950	18,024,275
Silver Creek-Rabbit River	030810	1,979	81	3,013	998	406,824	4,989,185	9,571,547
Rabbit River	030811	4,617	242	6,205	1,684	1,209,485	8,420,800	15,632,115
Sand Creek	030901	2,566	60	2,917	373	301,888	1,864,130	3,426,373
Base Line Creek	030902	3,851	14	5,970	1,774	68,146	8,870,250	17,672,354
Pine Creek	030903	3,892	72	4,612	741	361,007	3,706,320	7,051,633
Schnable Brook	030904	3,819	96	5,180	1,480	478,055	7,398,750	14,319,446
Trowbridge Dam-Kalamazoo River	030905	3,268	307	4,582	1,565	1,534,445	7,825,100	14,115,755
Tannery Creek-Kalamazoo River	030906	2,444	264	3,948	1,648	1,317,550	8,239,550	15,161,550
Lake Allegan-Kalamazoo River	030907	4,960	788	7,763	3,338	3,938,040	16,691,800	29,445,560
Swan Creek	030908	3,444	83	6,817	3,009	413,577	15,046,600	29,679,623
Bear Creek-Kalamazoo River	030909	1,758	74	2,968	1,069	370,422	5,345,500	10,320,578
Mann Creek	030910	1,794	175	2,782	975	875,565	4,876,335	8,877,105

		TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
Watershed Name	HUC	2001	2001 Load from Urban-Commercial	2030	2030 Load from Urban-Commercial	Ordinance passed in 2001	2030	Retrofitting in 2030
Peach Orchid Creek-Kalamazoo River	030911	1,995	82	3,314	1,284	412,258	6,420,400	12,428,543
Kalamazoo River	030912	2,642	353	4,147	1,570	1,763,425	7,849,000	13,934,575

Attachment 4. Road stream crossing data for the Kalamazoo River Watershed & streambank erosion sites

The Michigan Department of Environmental Quality (MDEQ) conducted road-stream crossing (RSX) surveys from 2000-2003 on approximately 80% of the crossings within the Kalamazoo River watershed (Kirkwood email, 2007). Approximately 500 road stream crossing sites were surveyed using the MDEQ Road Stream Crossing Survey Form, although not all data fields were completed. The following information summarizes the RSX surveys performed.

Survey Year(s)	2000-2003
Approximate Number of Sites	500
Sub-watersheds without RSX Surveys	Rice Creek Greater Battle Creek Area Kalamazoo Zone B
Concentrated Poor Scores	Mainstem 3 Corridor Mainstem Zone A Rabbit River

Table 1 provides a summary for the scores of RSXs by rating and percent. Table 2 provides information on the approximate subwatershed location of each RSX. MDEQ ranked each site as either poor, fair, or good. Thirty seven RSXs were not given scores or missing location data.

Table1. Rating and associated percent of road-stream crossings

Rating of Road-Stream Crossings in the Kalamazoo River Watershed

Rating	RSX	Percent
Poor	30	6
Fair	191	38
Good	242	49
None	34	7

Table 2. Location of road-stream crossings and number of crossings with poor ratings

Road-Stream Crossings and Poor Ratings in the Kalamazoo River Watershed Per Subwatershed

Subwatershed	RSX	Poor Rating	Percent
Rabbit River	163	4	2
Lower Kalamazoo (Zone A)	109	12	11
Mainstem 3	47	6	13
North Branch Kalamazoo	46	0	0
South Branch Kalamazoo	45	0	0
Battle Creek	14	5	36
Gun River	9	0	0
Portage Creek	9	4	44
Davis Creek	0	0	0
Four Townships Area	0	0	0
Rice Creek	0	0	0

Sites with poor ratings occur in the lower portion of the watershed with no poor ratings appearing in the upper reaches. All of the RSXs in the North and South Branches of the Kalamazoo River have a good or fair rating and no poor ratings. Overall, the MDEQ data appears to have few surveys on RSXs in the middle portion of the watershed.

Attachment 5. Common pollutants, sources and water quality standards.

Sources of water pollution are broken down into two categories: point source pollution and nonpoint source pollution. Point source pollution is the release of a discharge from a pipe, outfall or other direct input into a body of water. Common examples of point source pollution are factories and wastewater treatment facilities. Facilities with point source pollution discharges are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit to ensure compliance with water quality standards under the Clean Water Act. They are also required to report to the Michigan Department of Natural Resources and Environment on a regular basis. This process assists in the restoration of degraded water bodies and drinking water supplies.

Presently, most surface water pollution comes from wet weather, non-point source pollution. Polluted runoff is caused when rain, snowmelt, or wind carries pollutants off the land and into water bodies. Roads, parking lots, driveways, farms, home lawns, golf courses, storm sewers, and businesses collectively contribute to nonpoint source pollution.

Nonpoint source pollution, also known as polluted runoff, is not as easily identified. It is often overlooked because it can be a less visible form of pollution.

The State of Michigan's Part 4 Rules (of Part 31, Water Resources Protection, of Act 451 of 1994) specify water quality standards, which shall be met in all waters of the state. Common water pollutants and related water quality standards are described below. Note that not all water quality pollutants have water quality standards established.

Sediment

Sediment is soil, sand, and minerals that can take the form of bedload (particles transported in flowing water along the bottom), suspended or dissolved material. Sediment harms aquatic wildlife by altering the natural streambed and increasing the turbidity of the water, making it "cloudy". Sedimentation may result in gill damage and suffocation of fish, as well as having a negative impact on spawning habitat. Increased turbidity from sediment affects light penetration resulting in changes in oxygen concentrations and water temperature that could affect aquatic wildlife. Sediment can also affect water levels by filling in the stream bottom, causing water levels to rise. Lakes, ponds and wetland areas can be greatly altered by sedimentation. Other pollutants, such as phosphorus and metals, can bind themselves to the finer sediment particles. Sedimentation provides a path for these pollutants to enter the waterway or water body. Finally, sediment can affect navigation and may require expensive dredging.

Related water quality standards

Total Suspended Solids (TSS) - Rule 50 of the Michigan Water Quality Standards (Part 4 of Act 451) states that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. This kind of rule, which does not establish a numeric level, is known as a "narrative standard." Most people consider water with a TSS concentration less than 20 mg/l to be clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary.

Nutrients

Although certain nutrients are required by aquatic plants in order to survive, an overabundance can be detrimental to the aquatic ecosystem. Nitrogen and phosphorus are generally available in limited supply in an unaltered watershed but can quickly become abundant in a watershed with agricultural and urban development. In abundance, nitrogen and phosphorus accelerate the natural aging process of a water body and allow exotic species to better compete with native plants. Wastewater treatment plants and combined sewer overflows are the most common point sources of nutrients. Nonpoint sources of nutrients include fertilizers and organic waste carried within water runoff. Excessive nutrients increase weed and algae growth impacting recreational use on the water body. Decomposition of the increased weeds and algae lowers dissolved oxygen levels resulting in a negative impact on aquatic wildlife and fish populations.

Related water quality standards

Phosphorus - Rule 60 of the Michigan Water Quality Standards (Part 4 of Act 451) limits phosphorus concentrations in point source discharges to 1 mg/l of total phosphorus as a monthly average. The rule states that other limits may be placed in permits when deemed necessary. The rule also requires that nutrients be limited as necessary to prevent excessive growth of aquatic plants, fungi or bacteria, which could impair designated uses of the surface water.

Dissolved Oxygen - Rule 64 of the Michigan Water Quality Standards (Part 4 of Act 451) includes minimum concentrations of dissolved oxygen, which must be met in surface waters of the state. This rule states that surface waters designated as coldwater fisheries must meet a minimum dissolved oxygen standard of 7 mg/l, while surface waters protected for warmwater fish and aquatic life must meet a minimum dissolved oxygen standard of 5 mg/l.

Temperature/Flow

Removal of streambank vegetation decreases the shading of a water body, which can lead to an increase in temperature. Impounded areas can also have a higher water temperature relative to a free-flowing stream. Heated runoff from impervious surfaces and cooling water from industrial processes can alter the normal temperature range of a waterway. Surges of heated water during rainstorms can shock and stress aquatic wildlife, which are adapted to "normal" temperature conditions. Increased areas of impervious surfaces, such as parking lots and driveways, and reduced infiltration from other land use types, such as lawns and bare ground, leads to an increase in runoff. Increased runoff reduces groundwater recharge and leads to highly variable flow patterns. These flow patterns can alter stream morphology and increase the possibility of flooding downstream.

Related water quality standards

Temperature - Rules 69 through 75 of the Michigan Water Quality Standards (Part 4 of Act 451) specify temperature standards which must be met in the Great Lakes and connecting waters, inland lakes, and rivers, streams and impoundments. The rules state that the Great Lakes and connecting waters and inland lakes shall not receive a heat load which increases the temperature of the receiving water more than 3 degrees Fahrenheit above the existing natural water temperature (after mixing with the receiving water). Rivers, streams and impoundments shall not receive a heat load which increases the temperature of the receiving water more than 2 degrees Fahrenheit for coldwater fisheries, and 5 degrees Fahrenheit for warmwater fisheries.

These waters shall not receive a heat load which increases the temperature of the receiving water above monthly maximum temperatures (after mixing). Monthly maximum temperatures for each water body or grouping of water bodies are listed in the rules.

The rules state that inland lakes shall not receive a heat load which would increase the temperature of the hypolimnion (the dense, cooler layer of water at the bottom of a lake) or decrease its volume. Further provisions protect migrating salmon populations, stating that warmwater rivers and inland lakes serving as principal migratory routes shall not receive a heat load which may adversely affect salmonid migration.

Bacteria/Pathogens

Bacteria are among the simplest, smallest, and most abundant organisms on earth. While the vast majority of bacteria are not harmful, certain types of bacteria cause disease in humans and animals. Concerns about bacterial contamination of surface waters led to the development of analytical methods to measure the presence of waterborne bacteria. Since 1880, coliform bacteria have been used to assess the quality of water and the likelihood of pathogens being present. Combined sewer overflows in urban areas and failing septic systems in residential or rural areas can contribute large numbers of coliforms and other bacteria to surface water and groundwater. Agricultural sources of bacteria include livestock excrement from barnyards, pastures, rangelands, feedlots, and uncontrolled manure storage areas. Stormwater runoff from residential, rural and urban areas can transport waste material from domestic pets and wildlife into surface waters. Land application of manure and sewage sludge can also result in water contamination. Bacteria from both human and animal sources can cause disease in humans.

Related water quality standards

Bacteria - Rule 62 of the Michigan Water Quality Standards (Part 4 of Act 451) limits the concentration of microorganisms in surface waters of the state and surface water discharges. Waters of the state which are protected for total body contact recreation must meet limits of 130 Escherichia coli (E. coli) per 100 milliliters (ml) water as a 30-day average and 300 E. coli per 100 ml water at any time. The total body contact recreation standard only applies from May 1 to October 1. The limit for waters of the state which are protected for partial body contact recreation is 1000 E. coli per 100 ml water. Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 ml water as a monthly average and 400 fecal coliform bacteria per 100 ml water as a 7-day average. For infectious organisms which are not addressed by Rule 62 The Department of Natural Resources and

Environment has the authority to set limits on a case-by-case basis to assure that designated uses are protected.

Chemical Pollutants

Chemical pollutants such as gasoline, oil, and heavy metals can enter surface water through runoff from roads and parking lots, or from boating. Sources of chemical pollution may include permitted applications of herbicides to inland lakes to prevent the growth of aquatic nuisance plants. Other chemical pollutants consist of pesticide and herbicide runoff from commercial, agricultural, municipal or residential uses. Impacts of chemical pollutants vary widely with the chemical.

Related water quality standards

pH - Rule 53 of the Michigan Water Quality Standards (Part 4 of Act 451) states that the hydrogen ion concentration expressed as pH shall be maintained within the range of 6.5 to 9.0 in all waters of the state.

Attachment 6. Individual water body assessment.

Several subwatersheds of the Kalamazoo River watershed have undergone watershed planning exercises, typically funded by Clean Water Act Section 319 grants. In most cases, the following subwatersheds have complete, or nearly completed, USEPA approved watershed plans, making these areas eligible for implementation project funding through the 319 program.

MDEQ Surface Water Quality Division has conducted biosurveys of a number of streams in the Kalamazoo River watershed over the years. See most recent subwatershed management plans for more details linked at www.kalamazooriver.net.

Portage and Arcadia creeks

Portage Creek is a first- to third-order coldwater stream that flows into the Kalamazoo River in the city of Kalamazoo. A survey conducted in 1993 indicated that macroinvertebrate communities were moderately impaired, with the majority of taxa being those that are relatively tolerant of poor water quality and habitat. Designated uses for a coldwater fishery were being met, as indicated by a fish community containing greater than 1% salmonids, however, the physical habitat was rated as severely to moderately impaired. Arsenic concentrations in water samples at two of four locations exceeded those typically found in streams in this ecoregion.

The Portage-Arcadia Creek Watershed is composed of four subwatersheds: Arcadia Creek, Axtell Creek, Portage Creek and the West Fork of Portage Creek. Axtell Creek and the West Fork of Portage Creek flow into Portage Creek, which meets the Kalamazoo River in the City of Kalamazoo.

Arcadia Creek also discharges into the Kalamazoo River in Kalamazoo, just north of the Portage Creek outlet. The dominant soils are Urban Complex and Oshtemo Sandy Loam. Urban lands are those areas that are so obscured by urban work and structures that identification of the soil is not possible. Though the lower reaches of the watershed are largely urban, 44% of the whole watershed is composed of forested land cover. The Arcadia Creek Subwatershed lies within portions of Oshtemo Township and the City of Kalamazoo. This subwatershed flows mostly in an easterly direction, with the headwaters of Arcadia Creek starting west of 11th Street, in the southeastern portion of Oshtemo Township. The watercourse then flows through the western portion of the City of Kalamazoo, roughly parallel with Stadium Drive and on through to the downtown area before finally discharging to the Kalamazoo River. Within the City of Kalamazoo portion of the subwatershed, curb and gutter systems direct storm water from 1,862 acres to storm sewers that collect, transport and discharge approximately 2,362 acre-feet per of storm water into the creek annually. Virtually all 5.5 miles of the creek receive storm water contributions from lightly to heavily urbanized areas within the City of Kalamazoo.

The Axtell Creek Subwatershed lies entirely inside of the City of Kalamazoo. There are 1,519 acres in this subwatershed, located within the west-southwest portion of the city. Greater than half of these acres, including the areas surrounding Pikes Pond, Kleinstuck Marsh, Whites Lake and Woods Lake, contribute no surface water flow to the creek. The land uses of the drainage area are approximately 48% urban, 45% open space and forest, 4% water/wetlands and 3% agriculture. The artesian headwaters of Axtell Creek are found within the City of Kalamazoo Well Field #4, at the intersection of Maple Street and Crosstown Parkway. Pressure relief overflow from active wells provides a significant contribution to the base flow of the creek. The stream flows 1.24 miles from the well field through a channel along Crosstown Parkway to a series of large, shallow storm water detention ponds before discharging to Portage Creek. Over portions of its length, small sections of the creek are piped underground, especially under roadways. Much of the watershed is commercial with several mowed parks surrounding the ponds. Storm water drainage units contribute an approximate 815 acre-feet of runoff annually to the creek.

The Portage Creek Subwatershed lies within the Cities of Portage and Kalamazoo and in Texas Township, with the majority flowing through the City of Portage. This 12.5-mile creek begins to flow west of US-131 in Texas Township to Hampton Lake. After exiting this lake the creek then curves, flowing generally in a northeast direction, through most of the City of Portage before coursing sinuously almost due north through the City of Kalamazoo, and into the Kalamazoo River. Both the West Branch of Portage Creek and Axtell Creek (each considered as separate sub-watersheds in this project) flow into Portage Creek within the City of Kalamazoo. The drainage area includes land uses of approximately 21.3% urban, 52.4% open space and forest, 3.1% water/wetlands and 23.2% agriculture. In the City of Kalamazoo, storm sewers directly drain 2,215 acres into the creek and contribute 3,346 acre-feet of runoff annually.

Battle Creek River

The Battle Creek River Watershed covers 196,750 acres (307 square miles) in northern Calhoun, southeastern Barry, and southern Eaton counties. Land use consists primarily of agriculture followed with forestland, wetland, and urban/rural/non-farm. The headwaters of the Battle Creek River begin at the Duck Lake/Narrow Lake areas as the Battle Creek Drain. As it leaves Narrow Lake, it heads north through the City of Charlotte, southwest through the Village of Bellevue, and finally south towards the City of Battle Creek to where it empties into the Kalamazoo River.

The MDEQ has identified the Battle Creek River as one of the leading tributaries contributing sediment and phosphorus to the Kalamazoo River. It is also one of the flashiest gauged tributaries in the Kalamazoo River Watershed. Through a rigorous inventory of the watershed, the main source of sediment was found to be stream bank erosion resulting from historic dredging.

The dredged channel sediments are often deposited as “berms” along the drainage ditches and may be reintroduced to the drainage system over time through bank erosion. Bank erosion has been suggested as being the largest portion of the sediment budget for the Battle Creek River, but there has not been enough data collected to properly estimate the contribution of sediment from bank erosion, though efforts are ongoing at the Calhoun Conservation District. These sources may represent large components of sediment budgets at the local and watershed scale.

Davis Creek

Davis Creek, also sometimes referred to in whole or in part as Allen Creek or the Olmsted-Davis Drain, is a highly modified, predominately urban drainage corridor in the urban and urbanizing core of Kalamazoo County. Recent water quality tests and biological assessments have shown that the creek is stressed from development and land use impacts associated with continued urbanization of the watershed.

Davis Creek originates at East Lake in Pavilion Township of Kalamazoo County, Michigan. The creek and its watershed are located entirely in Kalamazoo County. The creek joins the Kalamazoo River at a point upstream of the City of Kalamazoo. Davis Creek flows northwest from its origin at East Lake, through agricultural areas of Pavilion Township, and into the City of Portage. The creek then flows north through a densely populated mobile home park, and into eastern parts of the City of Kalamazoo and Kalamazoo Township.

Based on a 1994 MDNR aquatic habitat quality varied widely in the Davis Creek watershed.In an unnamed tributary near Lexington Green Park habitat conditions were rated as severely impaired because of the regular dredging maintenance and industrial storm water discharges. Silt deposition was more than three feet deep, and a petroleum sheen was discharging from a storm sewer outfall. The aquatic macroinvertebrate community was rated as moderately impaired.

At Sprinkle Road habitat quality was rated as unimpaired and the macroinvertebrate community was slightly impaired. However, from Kilgore Road to the confluence of Davis Creek with the Kalamazoo River, habitat and macroinvertebrate communities were rated as moderately impaired. Fish community structure throughout the Davis Creek basin was rated as slightly impaired. The results of this survey suggest that there have been no improvements in water quality and the biological health of Davis Creek as compared to previous surveys in 1977, 1979 and 1985.

The creek suffers from the following known types of pollution:

Suspended Solids and Sediments- The creek contains high concentrations of muck, dirt, sand and other grit which are washed in from roads, streambanks, bare urban lots and agricultural fields. Often other pollutants find their way to the creek by attaching to eroding soil. Sediments can also cause a stream to become wide and shallow which increases flooding problems.

Bacteria- Fecal coliform bacteria have been found in unhealthy amounts in the creek waters. Fecal coliform bacteria are associated with human and animal waste and probably come from septic tank leakage, runoff from manure-fertilized fields, and/or pet wastes, but can also come from warm-blooded wild animals including deer, ducks and geese.

Chemicals- Water samples have shown that Davis Creek contains high levels of phosphate and nitrogen compounds, both of which are found in most lawn fertilizers. Oil and grease remain a localized problem despite past attempts at remediation.

Trash- The creek contains a great deal of garbage in the form of glass bottles, tires, metal drums, plastic, styrofoam and cans.

Unstable hydrology- Large portions of the Davis Creek corridor have been modified by dredging and straightening. It is assumed these changes were made to (1) improve drainage of lands within the watershed, (2) to control seasonal flooding, and (3) to claim additional land for other uses by removing the natural creek meander and reducing the width of the natural drainage corridor. Historically, Davis Creek was known as a trout stream and cold water fishery.

The Kalamazoo County Drain Commission has a current American Recovery and Reinvestment Act grant to study hydrology and devise an engineering plan for stabilizing streambanks and culverts (February 2010 – September 2011).

Rice Creek

The Rice Creek Watershed covers 58,200 acres (90.9 square miles) in western Jackson and eastern Calhoun Counties. Rice Creek includes a North and South Branch and main stem. Flowing from east to west, its headwaters are a network of small, vegetated channels located in western Jackson County. Flowing west into Calhoun County, these smaller tributary channels merge to form the North and South Branches of Rice Creek, which then combine to form the main stem in Marengo Township. Rice Creek then joins with the Kalamazoo River in Marshall. The North Branch of Rice Creek is approximately nineteen miles long. The character of the North Branch is marked by several popular lakes, including Prairie Lake and the Gang Lakes, some of which are impacted by seasonal nuisance algal and weed growth stemming from excess nutrients. These lakes act as a sediment trap, often to the point of needing to be dredged in order to maintain their recreational and habitat functions. The amount of sediment in the lakes is a direct result of streambank erosion and the lack of floodplain or wetland depositories for those sediments. The lakes in the North Branch increase the amount of surface water exposed to sun, thereby heating the waters.

The South Branch of Rice Creek is approximately seventeen miles long. It has fewer lakes than the North Branch and also high groundwater contribution to the creek. The South Branch is a designated trout stream. Sediment and nutrient problems, as well as a lack of cover for shade and temperature control, are prevalent issues. From the main stem of Rice Creek, the point where the North and South Branches merge, to the outlet at the Kalamazoo River, the Creek is approximately another six miles long.

Rice Creek suffers from impairments to designated water uses. Generally, though, water quality is acceptable and much of the Creek retains rural charm. Those factors that occasionally and locally rise above or near regulatory levels of concern are poor macroinvertebrate communities, excess fecal coliforms, and suspended solids and turbidity. The probable root causes for these impairments include livestock in the stream and instability of sediments caused by a long history of drain work. Variable daily cycles in turbidity demonstrate the abundance of easily mobilized sediments in the Creek.

Gull Lake, Augusta Creek, and nearby watersheds

This area is denoted as the "Four Townships Watershed Area" and has been the topic of a parallel watershed planning process (FTWRC, 2010). The Augusta Creek and Gull Lake watersheds include a number of high quality streams and lakes as well as abundant wetlands, and are important sites from a biodiversity standpoint. The focus of watershed management in these subwatersheds is oriented to protection and preservation, with some attention to localized stormwater issues and a general concern about row-crop and animal agriculture. Future residential and urban development, as well as intensification of agriculture, presents the most important challenges for the protection of water resources. To maintain and enhance the presently good water quality in area lakes and streams, priority is given to riparian buffers of 1000-foot width along all significant streams as well as 8 lakes with the most residential development.

Augusta Creek and other area streams tend to carry low concentrations of phosphorus and ammonium, but many do have high concentrations of nitrate, reflecting the elevated concentrations in local groundwater. The stream waters are usually clear and low in suspended sediments, although they may carry considerable amounts of sediment as sand that moves along the stream bottom. Most of these streams originate in or pass through lakes and wetlands, which effectively remove sediment and nutrients and thereby improve the downstream water quality.

Augusta Creek is particularly important for recreational opportunities because there is public access at the W.K. Kellogg Experimental Forest (owned by Michigan State University) and at the Augusta Creek Hunting and Fishing Area (managed by the MDNR). Fly fishing is popular in the stream, which is annually stocked with trout. The outflows from Gilkey and Fair Lakes supply water to the headwaters of the Augusta Creek system, and several smaller lakes also drain into the creek system. The extensive riparian wetlands all along the stream courses in Augusta Creek and its tributaries help to stabilize the flow of water in the creek by absorbing excess water during high flow and slowly returning this excess water over ensuing periods of lower flow.

Spring Brook is a cold water tributary to the Kalamazoo River immediately downstream of the city of Kalamazoo. A 1991 MDEQ biological survey conducted on Spring Brook indicated that this stream had the highest habitat quality for fish and other aquatic life of any cold water stream of similar size that was sampled in southwestern Michigan. Brown trout of varying sizes were observed as well as high numbers and diversity of aquatic insects. A more recent biosurvey, conducted in 2004, found that approximately one mile of the riparian zone had been completely removed and replaced by subdivisions and lawns near Riverview Drive. A survey conducted further upstream, at DE Avenue, found a largely unimpacted riparian zone and an excellent macroinvertebrate community. Pollutants associated with development including sediment, phosphorus, and thermal inputs are the primary threats to this watershed.

Gull Creek, a second order warmwater stream that originates at the Gull Lake outflow, was sampled in MDEQ biosurveys in 1986 and 1994. Both surveys indicated the stream to be high quality. Fish and macroinvertebrate communities were rated "acceptable". Habitat conditions were slightly impaired to non-impaired. Most water quality parameters were within the normal ranges for streams in this ecoregion. Nitrite (0.014 mg/L), nitrate-nitrite (0.142 mg/L), and ammonium (0.132 mg/L) were elevated on one sampling date in 1994 compared with a second sampling date and with other sites in the watershed.

Gull Lake is one of the largest inland lakes in Michigan, with an area of 2040 acres and a maximum depth of over 110 feet. This lake is unusual in southern Michigan because it supports a diverse fishery, including both warm- and cold-water species. Gull Lake serves as an important public recreational site for the region. Residential development lines the lake. After the early 1970's, lakeside homes were put on a sewer system to reduce septic inputs and residents were urged to apply fertilizers sparingly if at all, and these measures apparently led to reductions in summer algal blooms and improvements in water clarity in later years (Tessier and Lauff 1992).

Gun River

The Gun River Watershed encompasses an area of 73,272 acres in Allegan and Barry Counties, The Gun River flows from Gun Lake through agricultural land into the urbanizing area of Otsego Township, Allegan County, where it joins the Kalamazoo River. The watershed has been significantly altered from its presettlement conditions, primarily due to agricultural development including extensive tile drainage of muck soils. Sedimentation and excessive nutrient inputs have resulted in areas of the watershed exhibiting degraded aquatic habitat, decline of biodiversity, and reduced fish populations.

The MDEQ has focused on restoration of two Gun River subwatersheds that have identified impairments: Fenner Creek, and an upstream stretch of the Gun River between Gun Lake and Orangeville Creek.

The Gun River and its tributaries are impaired by nonpoint source pollution. Previous studies have identified pathogens, phosphorus, polychlorinated biphenyls (PCBs), mercury, nutrients, and poor macroinvertebrate communities as degrading the water quality in certain waterbodies within its watershed. Other significant water quality impairments include degraded indigenous aquatic habitat, a decline of biotic diversity, and reduced fish populations caused by sedimentation.

Best Management Practices (BMPs) to address non-point source pollution have been identified to accomplish goals listed in the Watershed Plan. Land use planning is recognized as critical to improve water quality through conservation easements, farmland preservation, model ordinances, and low impact development techniques such as reducing impervious surfaces to increase infiltration. Currently, no townships in the Gun River Watershed have a comprehensive ordinance designed to protect water quality. Township ordinances have the greatest potential for future protection of resources in the Watershed.

Rabbit River

The Rabbit River is a tributary of the Kalamazoo River located primarily in Allegan County with a watershed that encompasses 187,200 acres. Land use in the watershed is primarily agricultural, but forested and urban areas are also represented. The Rabbit River originates east of Wayland, MI, in Leighton Township, and flows westerly to join the Kalamazoo River at New Richmond, which then flows on to Lake Michigan. The Rabbit River is a State Designated Trout Stream, as are several of its tributaries.

The Rabbit River Watershed is ranked third out of twenty-eight in the state of Michigan as a Conservation Priority Area for the USDA's Environmental Quality Incentive Program (EQIP) to reduce non-point source pollution. Significant water quality impairments include degraded indigenous aquatic habitat and biotic diversity, reduced fish populations and flooding. Major NPS pollutants include sediment, excessive nutrients, and high flow. Occasional spikes in fecal coliform bacteria have also been noted, raising concerns about water-body contact. Development is steadily increasing in the watershed as open space and agricultural land is re-zoned to residential and industrial. The Rabbit River Watershed Management Plan states that water quality threats and impairments are caused by sedimentation, nutrient inputs, and high-flow occurrences. The sources of sediment include stream banks, cropland, construction sites, and road crossings/road ditches.

In 1989 an agricultural pesticide spray (endosulfan) contaminated the Rabbit River west of 2nd Street near Wayland and resulted in fish and macroinvertebrate kills. Brown trout and other fish were severely impacted for more than 3 miles downstream. Macroinvertebrate communities were severely impacted for more than 10 miles downstream. Biosurveys conducted in 1989 and 1990 to assess impacts and recovery from the pesticide discharge indicated that macroinvertebrate communities had substantially recovered by the following year. Brown trout populations were still depleted but recovering. These biosurveys also indicated that habitat and biological communities in the Rabbit River were significantly degraded because of agricultural activities apart from the pesticide incident, primarily due to erosion and sedimentation from runoff and cattle access, and river channelization. River quality did not appear to be affected by permitted point source discharges from Dean Foods and Northbrook Mobile Home Park Estates.

In 1993 another biosurvey of this reach of the Rabbit River indicated further recovery of stream communities from the pesticide incident. However, overall biological and habitat integrity of the upper Rabbit River was still considered poor. Fish communities of Green Lake outlet and Miller Creek were evaluated as slightly impaired. Community structure in both tributaries was considered typical of first to second order warm water systems.

The Red Run Drain system forms the headwaters of the Little Rabbit River. Based on a 1991 survey, the overall biological quality in the Red Run Drain, Dorr/Byron Drain and near the confluence of the Red Run Drain with the Little Rabbit River was assessed as moderately to severely impaired. Impairments appeared to result from farming practices. Little or no buffer areas existed between active fields and stream banks, and significant sedimentation has resulted in degraded habitat quality. Total phosphorus concentrations were higher than normal for streams in this area of Allegan County, ranging from 127 to 430 ppb in the Red Run Drain and Byron/Dorr Drain.

Nutrients enter the stream from agricultural production and residential area runoff. Damaging high flows result from uncontrolled storm water runoff due to development and past drainage practices. The MDEQ staff effort focuses on restoration of three Rabbit River subwatersheds that have identified impairments: Green Lake Creek (Tollenbar Drain), Headwaters Little Rabbit River (Red Run Drain), and Black Creek.

The Upper Rabbit River Watershed, located in rural Allegan, Barry, and Ottawa Counties encompasses 91,210 acres of agricultural, urban and forested land. The Upper Rabbit River Watershed is approximately 60 percent agricultural land. Streams in the Upper Rabbit River Watershed have suffered impairments due to human derived land based activities.

The Rabbit River has a Watershed Management Plan that seeks to improve water quality and reduce non-point source pollution through implementation of land-use planning, zoning, ordinance review strategies and by increasing awareness of water quality and watershed issues through information and education. Land use planning needs are similar to the Gun River. Recent projects have enjoyed some success in this area:

- Updated master plans to reflect water quality protection in all seven municipalities
- Riparian Overlay District Ordinance adopted by all seven municipalities within the Watershed
- Funnel Ordinance for water quality protection adopted by three municipalities
- Water Quality Zoning in Review Document
- The Watershed Project partnered with Monterey Township to disseminate a Land Use Planning Survey for Water Quality. Results were in full support of preserving water quality and in full support of land preservation.

Other notable water quality issues in tributaries

Comstock Creek, also sampled in 1994, is a second order warmwater stream and the outlet of Campbell Lake. The area is still largely wetland, which has buffered the creek from impacts. The City of Kalamazoo operates a well field along the stream below Campbell Lake as part of its water supply network. The fish and macroinvertebrate communities were rated as non-impaired, and had a very diverse community of molluscs. The habitat was rated as slightly impaired. Ammonium concentrations were elevated (96 ppb) compared to other sampling stations in the tributaries of the lower Kalamazoo River watershed. All other water quality parameters were within normal ranges for streams in this ecoregion.

Allen Creek is a small coldwater stream originating west of Parchment and flowing for approximately one mile to the Kalamazoo River. Four fish surveys conducted in the 1980s documented impacts of dewatering and dredging in the headwaters from Westnedge Avenue to Allen Street by Kalamazoo Township in 1981, 1982 and 1984. These operations resulted in a reduction of the native Brook trout population by 97% from 1981 to 1984, and impacts to the macroinvertebrate communities because of heavy siltation. In 1984 MDNR Fisheries Division initiated a three year restocking program of brook trout; a 1987 survey indicated slow recovery.

A 1994 biosurvey indicated moderate impairment of the macroinvertebrate community, and habitat conditions were degraded. Allen Creek was not meeting the designated uses for coldwater fishery. No brook trout were collected, and heavy siltation was still very prevalent. All water quality parameters were within the normal ranges for streams in this ecoregion.

Cooper Creek (Collier Creek, Coopers Glen Creek, Trout Run).   Cooper Creek, a first order coldwater stream, originates north of Parchment and flows along a very steep gradient in the Kalamazoo Nature Center to the Kalamazoo River. In a 1994 survey, biological quality was non-impaired based on the aquatic macroinvertebrate community. The creek was meeting the designated uses for coldwater fishery. Ninety-eight percent of the fish collected were salmonids, primarily brook trout. All water quality parameters were within the normal ranges for streams in this ecoregion.

Dumont Creek. Dumont Creek is a first order warmwater stream originating at Dumont Lake, flowing approximately 4 miles along a fairly steep gradient, to the Kalamazoo River. In a 1994 the macroinvertebrate community and habitat were rated as non-impaired. All water quality parameters were within the normal ranges for streams in this ecoregion.

Swan Creek. This is a third order warmwater stream from the outlet of Swan Lake to 109th Avenue. The stream then becomes a largely groundwater fed coldwater stream within the Kalamazoo State Game Area to the Kalamazoo River. A 1989 fish survey indicated recent declines in the trout fishery because of increasing sedimentation. A 1994 survey rated biological quality of Swan Creek severely impaired based on fish and macroinvertebrate communities. The designated uses for coldwater fishery were being met in the coldwater portion of Swan Creek (2.9% salmonids). Habitat conditions ranged from moderately impaired to slightly impaired. Many of the pool and riffle areas were affected by significant amounts of shifting sand. The loss of habitat appears to be attributable to the extensive sand bedload from eroding road crossings and forested areas.

Chart Creek. The overall biological quality of the East Branch, West Branch and main branch of Chart Creek was rated as severely impaired to slightly impaired based on the assessment of the macroinvertebrate community and habitat conditions in 1993. Impairments were attributed to nutrient enrichment from nonpoint sources and groundwater discharges from Murco, Inc. Improvements in treatment have occurred and natural attenuation is currently being used as an approved interim remedial action plan. Lack of suitable substrate was attributed to drain maintenance projects.

Species diversity in the West Branch and mainstem were good, and indicative of a cold water system. The fish community on the East Branch was severely degraded because of low oxygen, elevated ammonia and poor habitat.

Attachment 7. Buffer analysis memo (16 pages)

To: Jeff Spoelstra, KRWC **Date:** September 20, 2010

From: Kieser & Associates, LLC **cc:** Project files

Re: Buffer Analysis for the Kalamazoo Watershed Management Plan

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Introduction

Riparian buffers play an important role in preserving water quality in rivers and streams. The functions of riparian buffers are well established and include filtering pollutants from stormwater and agricultural runoff, stabilizing streambanks to prevent erosion, moderating the microclimate of a stream or waterbody, and protecting fish and wildlife habitat (Johnson and Ryba, 1992). Because of these beneficial functions, the area along a river corridor can be considered a critical area for water resource protection and restoration. As part of the Kalamazoo River watershed management planning project, the project team determined that a simple analysis of the buffer area around tributaries and lakes in the Kalamazoo River watershed would illustrate potential water quality impacts associated with land cover and land use changes in the riparian corridor. Since land use influences the quality and quantity of runoff in a watershed, this analysis provides information that can be used in: a) recommendations for future land use planning decisions; b) prioritizing best management practices (BMPs); and, c) informing watershed stakeholders on future loading that would adversely impact the Kalamazoo River in the context of the phosphorus Total Maximum Daily Load (TMDL).

As part of this buffer analysis, Kieser & Associates, LLC (K&A) used model output data to estimate pollutant loading for areas within the 100-meter buffer that are predicted to change to urban land use in the future (i.e., future build-out). K&A used model results from the Land Transformation Model[1], which is a Geographic Information System (GIS) and neural network-based model that predicts future land change in the year 2030. This buffer analysis provides stakeholders with a simplistic model of the potential increase in pollutant loading to the river if a portion of the land use in the river corridor becomes developed. To further support decision-making and BMP recommendations, agricultural management scenarios were also applied within the 100-meter buffer boundary. The agricultural scenarios included modeling runoff and pollutant loading to the river under scenarios where 25%, 50% and 75% of the agricultural land in the 100-meter buffer was permanently planted in grass or hay buffers. These scenarios were applied to riparian areas that are currently defined as agriculture in the 2001 land cover. These loading results can then be compared with the predicted loading increases due to future build-out.

The results from the buffer analysis and agricultural buffer scenarios are summarized in table format in this memorandum. These results, along with information obtained from the Kalamazoo River watershed

[1] *More information about the Land Transformation Model and data for download are available at:* [*http://ltm.agriculture.purdue.edu/ltm.htm*](http://ltm.agriculture.purdue.edu/ltm.htm)

build-out analysis report by K&A, will be used by the project team in developing recommendations for BMPs included as part of the watershed management plan.

GIS Buffer Methodology

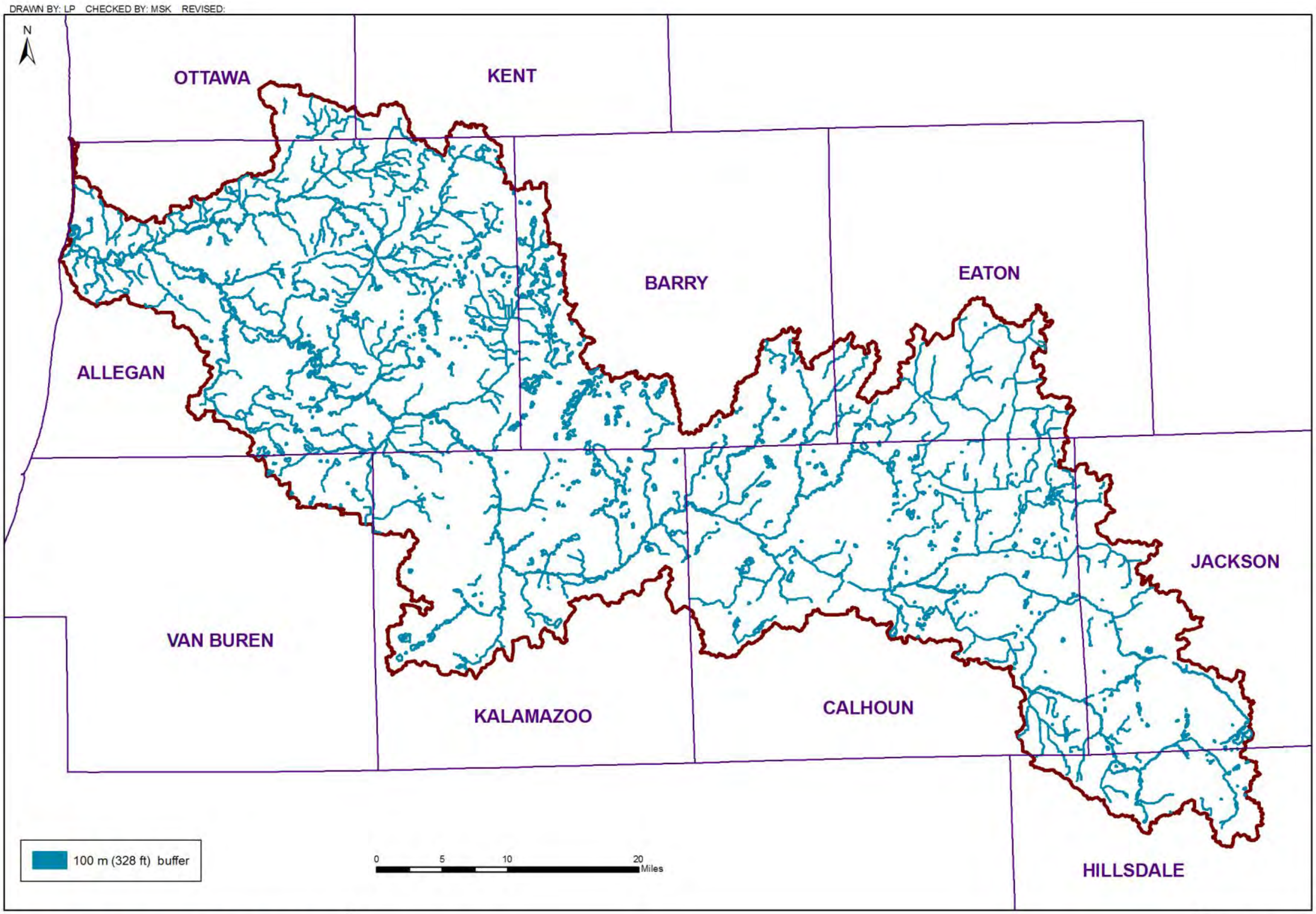
Geographic information system (GIS) software allows for the definition of a distance buffer around geographic features. For this analysis, the Kalamazoo River stream network (available from the Michigan Geographic Data Library) was used as the baseline feature for defining the buffer. Using the "Buffer" function within ArcGIS Spatial Analyst, a 100-meter buffer (i.e. 50-meter on each side of a stream line) was created around the entire stream network in the Kalamazoo River watershed. Lakes in the available stream network data layer are not modeled as polygons but are defined by a line around the shoreline. Because of this fact, buffers around lakes also included a 50-meter portion on the water inside of the lake. This buffer area on surface water was deleted from the analysis for practical purposes since surface water land cover cannot be converted to vegetated buffer. This deleted surface water area did not affect the agricultural buffer analysis since only agricultural land use in the 2001 data layer was used to calculate runoff and pollutant loading. Therefore, any LTM considerations for land conversion from water are excluded from results. Figure 1 presents the overall view of the buffer in the entire Kalamazoo River watershed. At this large scale, it is not possible to view the land area within the buffer area, which only appears as a line in the image. Figures 2 and 3 show a semi-transparent close-up view of the buffer overlaid on an aerial photograph within an agricultural and an urban location, respectively.

The decision to use a 100-meter buffer was based on the land use data resolution used in the build-out analysis (100x100 meter). A 100-meter resolution is the minimum scale for the land use change and loading analysis used in GIS. The 2001 and 2030 predicted land use areas within the 100-m buffer were calculated using the "Tabulate Area" function[2] and compared. Pollutant loads were calculated using the "Raster Calculator" function with raster[3] layers for runoff (calculated using the Long-Term Hydrologic Impact Assessment or L-THIA tool[4]) and coupled with event mean concentrations. To evaluate the affects of these buffers on adjacent, upland areas, a 300-meter buffer was delineated around the stream network in the Kalamazoo River watershed in the same way the 100-meter buffer was created. This buffer represents a theoretical area treated by the 50-meter riparian buffer and extends 100-meters beyond each riparian buffer on either side of the river.

[2] *This GIS function internally converts the buffer from a vector to a raster format in order to match the land use format and cell resolution.*

[3] *Raster data model is a regular "grid cell" approach to defining space. Usually square cells are arranged in rows and columns (as defined in Bolstad, 2005).*

[4] *The L-THIA GIS extension is available for download at: http://www.ecn.purdue.edu/runoff/lthianew/Index.html*



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Delineated 100-meter riparian buffer in the Kalamazoo River Watershed (hydrographic network downloaded from the Michigan Geographic Data Library).

FIGURE 1

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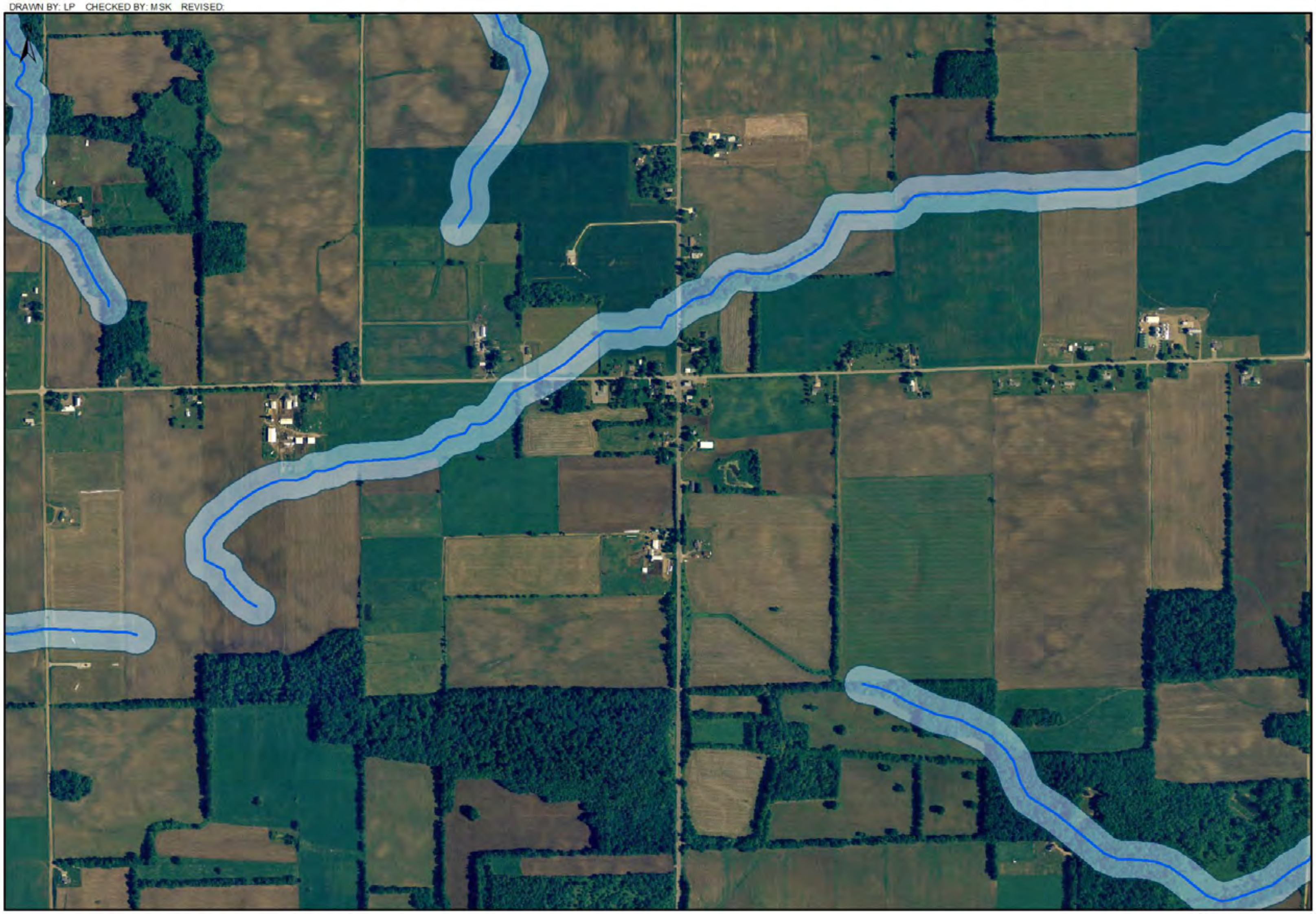

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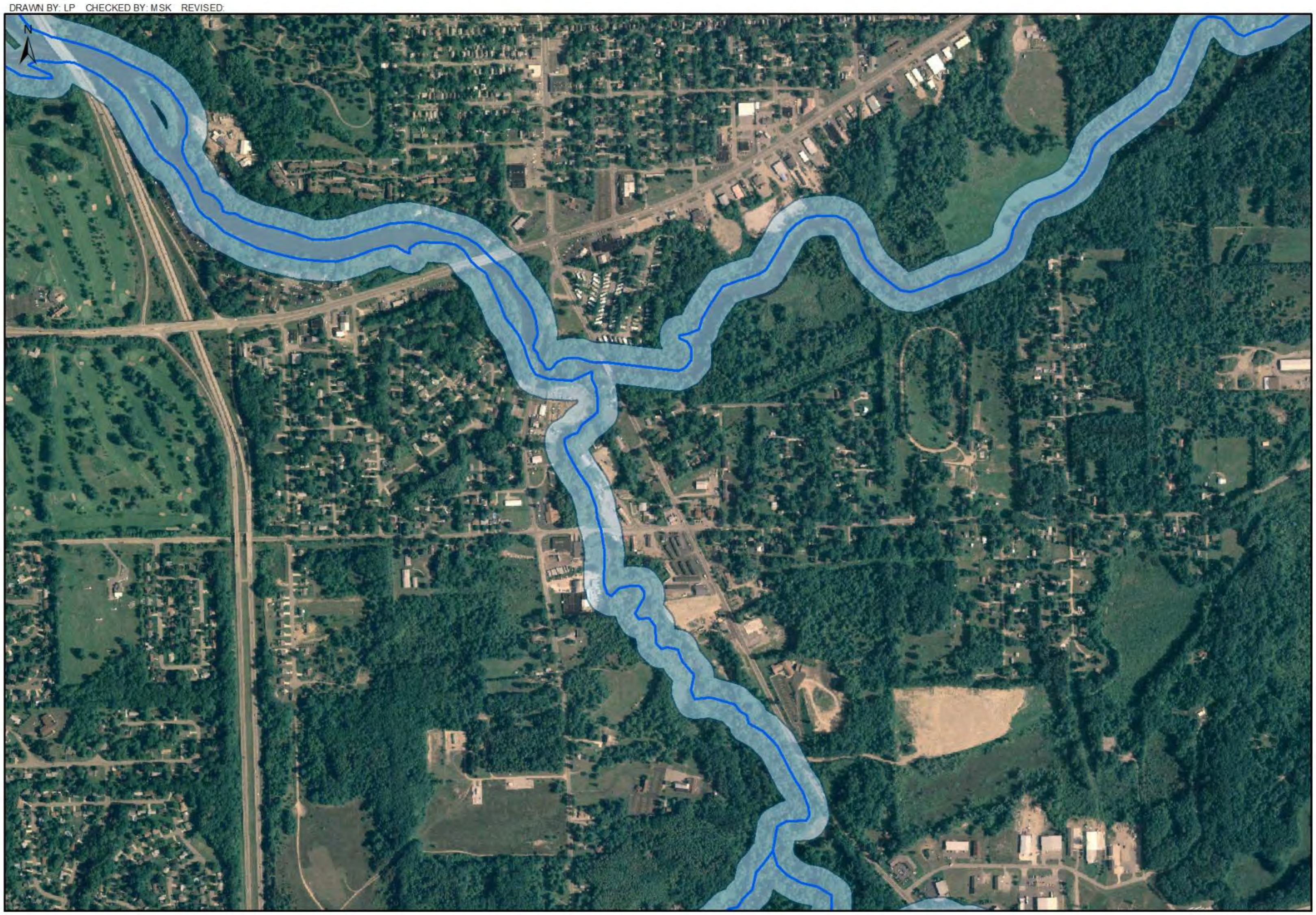
Small scale image of 100-meter buffer in a non-urban setting within the Rabbit River subwatershed (dark blue represents the stream network and lighter blue represents the 100 meter buffer).

FIGURE 2



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Small scale image of 100-meter buffer in an urban setting within the Battle Creek River subwatershed (dark blue represents the stream network and lighter blue represents the 100-meter buffer).

FIGURE
3

Buffer Land Use Change

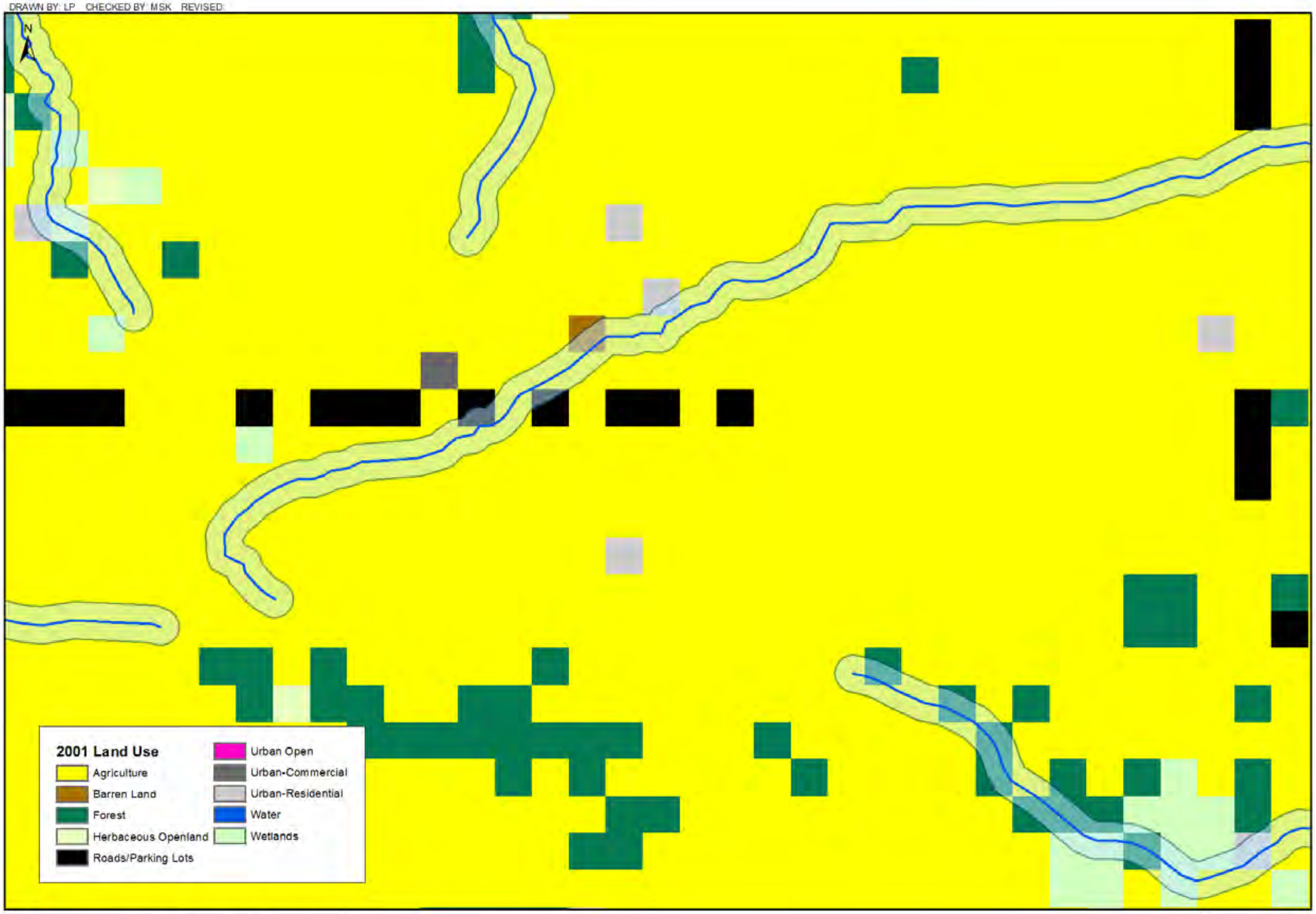
Between 2001 and 2030, commercial and residential land uses within the riparian buffer are expected to increase by over 250%, as predicted by the Land Transformation Model or LTM (Pijanowski *et al*., 2002). The LTM is a GIS-based model that predicts land use changes by combining spatial rules with artificial neural network routines. Spatial rules take into account a variety of geographical, political and demographic parameters such as population density, population growth projections, location of rivers and public lands, distance from roads, and topography. As a part of the Kalamazoo River buffer analysis, K&A used the 2030 LTM layer created for the Kalamazoo River watershed and compared it to the current (2001) land use in the watershed to determine overall land use change within the 100-meter buffer area between 2001 and 2030. Figures 4 and 5 illustrate the land use in 2001 and 2030 within the smaller scale section of the buffer example area in the Rabbit River subwatershed. A comparison of the two layers reveals that much of the agricultural land use along the river corridor and to the east in 2001 is predicted to change to urban land use by 2030 (both commercial and resident urban land use).

Predicted land use change from 2001 to 2030 within the 100-meter buffer area is provided in Table 1. Land use for commercial and residential urban use is predicted to have the greatest increase in change between 2001 and 2030 within the riparian corridor. As a result of this increase, the watershed is predicted to lose nearly 12% of rural open areas, 10% of forested areas, and 8% of wetland areas within the 100-meter buffer area along the river corridor. This increase in urban areas, together with the loss of rural, open forest and wetlands could have a substantial impact on runoff and pollutants delivered to the river in the future, as well as an increase in future channel erosion. In order to better gauge how this land use change might affect nutrient and sediment loading to the river, K&A used an empirical calculation to estimate the new load resulting from the 2030 land use breakdown as described below.

Table 1: Land use change within 100-meter buffer from 2001 to 2030 in the Kalamazoo River watershed.

	Area (acres)			
Land use category	**2001**	**2030**	**Change in Value**	**Percent Change**
Urban-Commercial	991	3,610	2,619	264.3
Urban-Residential	1,426	5,550	4,124	289.3
Urban Open	54	54	0	0.0
Transportation	1,858	1,858	0	0.0
Agriculture	18,916	17,631	-1,285	-6.8
Rural Open	4,665	4,094	-571	-12.2
Forest	13,242	11,955	-1,287	-9.7
Wetlands	31,950	29,296	-2,654	-8.3
Barren	40	27	-12	-31.3
Total	*81,017*	*81,017*		

Note: The 2030 LTM land use layer contains an error where 934 acres of surface water in the buffer area (1.2% of total buffer area) were changed to “other urban” and “non-urban” land uses. However, this error does not impact the loading analysis. No load was calculated for those erroneous cells because the SSURGO soil layer used in the build-out analysis does not include data for lake areas and consequently, runoff and load cannot be calculated.



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2001 land use within 100-meter buffer example area located in the Rabbit River subwatershed.

FIGURE 4

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Predicted 2030 land use within the 100-meter buffer example area located in the Rabbit River subwatershed.

FIGURE 5

Buffer Loading Analysis

As a component of the Kalamazoo River watershed buffer analysis, runoff volume and pollutant loads were calculated using the same methodology presented in the Kalamazoo River Watershed Build-out Analysis Report (K&A, 2010). Using EMC values for each land use category, runoff volume and loading for total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN) were calculated for 2001 and predicted 2030 land use. Table 2 provides the difference between 2001 and 2030 loading values due to watershed build-out (using LTM-predicted land use change).

From this analysis, runoff volume and the TP load are predicted to increase by more than 20% between 2001 and 2030 in the 100-meter buffer area; this increase is directly correlated to the increase in impervious land use (Table 2). This predicted increase in TP would add an additional 2,200 pounds of TP to the watershed annually, above and beyond the current TP loading already in exceedence of the TMDL load allocation. In addition, the 2030 predicted loading from the buffer area could contribute almost 19,000 additional pounds of TN and 200 tons of TSS per year.

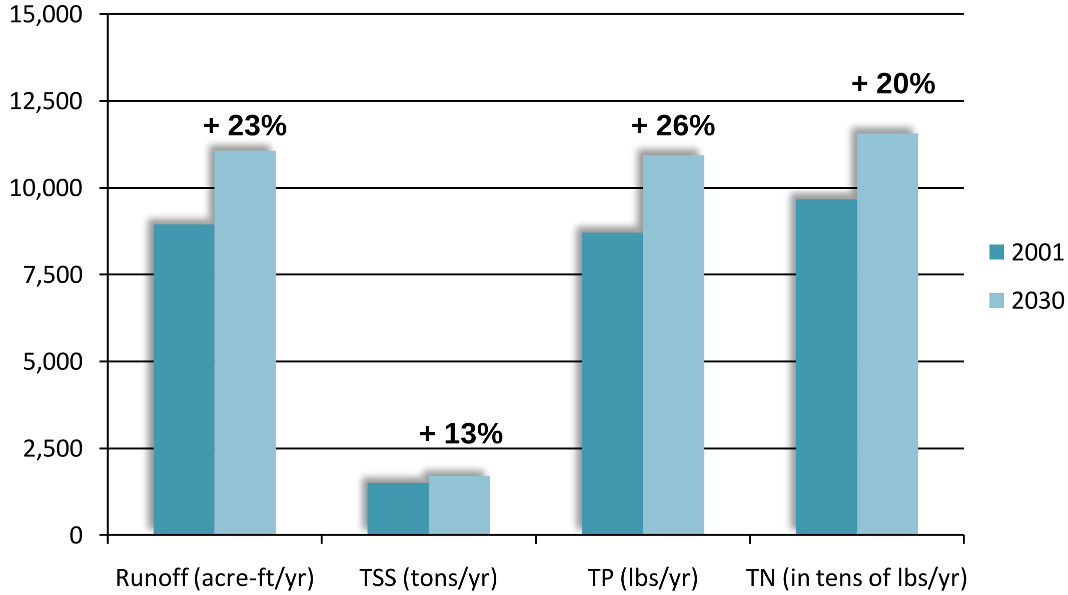
Table 2: Pollutant load comparison between 2001 and 2030 land uses within 100-m buffer area in the Kalamazoo River watershed.

Loading	2001	2030	Change in Value	Percent Change
Runoff (acre-feet/yr)	8,945	11,066	2,121	23.7
TSS (tons/yr)	1,508	1,705	197	13.1
TP (lbs/yr)	8,713	10,950	2,237	25.7
TN (lbs/yr)	96,813	115,717	18,904	19.5

When comparing the buffer area to the entire watershed, runoff volume and loading changes predicted between 2001 and 2030 are very similar. Figure 1 provides a comparison of increases in runoff and pollutant loading for the buffer area and entire watershed. Runoff for the entire watershed is predicted to increase by approximately 25%, TSS by 12%, TP by 26%, and TN by 18% (Figure 1b). It is important to note a distinction, however, between loads associated with riparian areas and loads associated with lands more distant from surface waters. Areas within the 100-meter buffer will have a much greater delivery rate than those areas located further from surface water. For this reason, the potential impact of changing land use within the 100-meter buffer may have a greater overall impact on water quality than is captured by this analysis. This should be noted in watershed management plan recommendations for protecting and managing future land uses.

One major land use category impacting water quality in the 100-meter buffer area is agriculture. The loading analysis revealed that approximately 40% of the TP load generated within the watershed-wide 100-meter buffer comes from agricultural land use. Due to this large load, recommending agricultural BMPs that include buffer protections or new buffers should be considered in the watershed management plan. Buffers or filter strips are one of the agricultural BMPs promoted by the Natural Resources Conservation Service (NRCS) conservation programs. NRCS's electronic Field Office Technical Guide (eFOTG) for the state of Michigan describes filter strips as vegetated areas used to treat runoff

1a: Predicted Change in Loading from 2001 to 2030 within the Riparian Buffer Area



1b: Predicted Change in Loading from 2001 to 2030 within the Entire Kalamazoo River Watershed

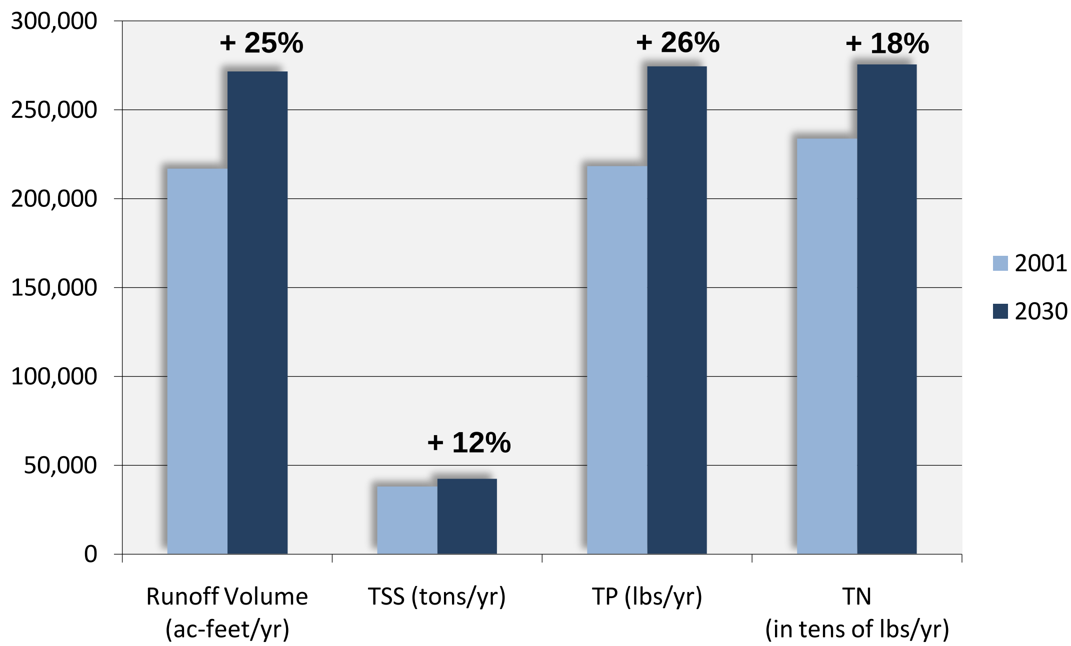


Figure 1a-b: Percent change in runoff and loading values for the Kalamazoo River buffer area (1a) and entire Kalamazoo River watershed (1b) are predicted to increase at similar rates as urban land use increases from 2001 to 2030. It is important to note that modeling in this analysis does not factor in delivery; therefore, loading from the buffer area will have a higher rate of delivery than loading from areas in the watershed not directly adjacent to surface water.

that is not part of the adjacent cropland rotation. The filter strips must be established to permanent herbaceous vegetation consisting of a single species or a mixture of grasses, legumes, and/or other forbs adapted to the soil, climate, nutrients, chemicals, and practices used in the current management system. Filter strips must be managed to maximize vegetation density and can be mowed under an approved management plan (which functions to remove nutrients and increase plant growth).

Buffer Cost Analysis

As part of the cost calculation component of the watershed management plan, K&A performed a limited analysis of agricultural filter strips on a portion of the 100-meter buffer area[5]. This limited analysis involved changing a portion of land use within the 100-meter buffer area that was agricultural land in 2001 to herbaceous open land. This change represents the resulting load change that might be expected from farmers installing buffer strips as part of the Farm Bill or other incentive program. The higher percentages of land converted from agriculture to filter strip (50%-75%) is likely too ambitious for any conservation incentive programs, but provides watershed planners with an estimate of the potential benefits of applying other BMPs with similar benefits to the riparian buffer area. The following simple scenarios were run to quantify the impact of restoring agricultural areas to filter strips (i.e., herbaceous open land):

Scenario 1: 25% of 2001 agricultural land in the buffer area is converted to grass filter strip

Scenario 2: 50% of 2001 agricultural land in the buffer area is converted to grass filter strip

Scenario 3: 75% of 2001 agricultural land in the buffer area is converted to grass filter strip

In order to calculate the TP load change from typical agricultural land use to filter strips, an annual unit area load was calculated for each land use. The unit area loads are shown in Table 3 and were derived from GIS analysis of the total area in the 100-meter buffer and the resulting total TP load using empirical calculations and event mean concentrations (MI-ORR, 2002). On an annual per acre basis, the average load is 0.19 pounds of TP/acre/year for agriculture and only 0.03 pounds of TP/acre/year for open land (open land category was used because it most closely represents the vegetation of a grass or hay filter strip used in agricultural conservation practices). The unit area loads were applied to the land conversion in the 100-meter buffer for the three scenarios. Results from these calculations are presented in Table 4 and show that conversion of land in the 100-meter buffer from agriculture to filter strips would yield a TP reduction of approximately 795 lbs TP/year in Scenario 1, 1,591 lbs TP/year in Scenario 2, and 2,836 lbs TP/year in Scenario 3.

[5] *It must be stated that this analysis is strictly limited to buffer strip considerations using relatively simplistic empirical loading calculations. No other modeling has been conducted for other agricultural or urban areas which might otherwise suggest a host of other BMPs necessary to control and/or reduce associated runoff. Mechanistic modeling using the Soil Water & Assessment Tool (SWAT) would yield a more detailed analysis of effective BMPs for subwatershed agricultural practices. The Hydrological Simulation Program - FORTRAN (HSPF) is a similarly sophisticated water quality model that would be suitable for detailed assessment of urban BMP selection. This level of sophisticated modeling is expensive and beyond the current K&A scope and budget.*

Table 3: Total phosphorus loads and unit area loads for land use categories within 100-meter buffer.

	Total area within 100-m buffer area (in acres)	Total TP load (in lbs/year)	Average TP load (in lbs/acre/year)
Agricultural	18,916	3,364	0.19
Open land, non-forested (i.e., filter strip)	4,665	119	0.03

In addition, it was assumed that the riparian filter strip filters runoff and nutrients from an upstream area about twice the size of vegetated area (i.e., the filter strip treats runoff from an additional 100 meters of agricultural land above the filter strip on each side of the stream). The 1999 Michigan Department of Environmental Quality's Pollutants Controlled Manual estimates that filter strips reduce TP loads from agricultural land by 85% (MDEQ, 1999). To better estimate the full load reduction potential of the filter strip, the TP load from the 300-meter buffer in each scenario (by percentage) was reduced by 85%. This simulates the treatment affect of the riparian filter strip. By quantifying this additional load reduction, a better estimate of the efficiency of the scenarios could be calculated. The total estimated TP loading reduction potential when accounting for additional treatment above the filter strip is summarized in Table 4. In total, conversion of agricultural land adjacent to streams to vegetated filter strips could potentially reduce TP loading by 2,471 lbs TP/year in Scenario 1, 4,943 lbs TP/year in Scenario 2, and 7,865 lbs TP/year in Scenario 3.

A cost analysis was also conducted to provide an estimate for the watershed management plan. Using NRCS filter strip implementation costs for 2009 provided by the Allegan County Conservation District, installing filter strips on 25% of agricultural land within the 100-meter buffer would cost approximately $2.1 million. If filter strips were installed on 50% or 75% of agricultural land in the 100-meter buffer, the resulting cost would be $4.3 and $6.4 million, respectively. In terms of the cost per benefit, or cost per pound of TP reduction, the total load reduction from both the land use change and the runoff treated in the 600-meter buffer beyond the filter strip were added together and the costs divided over the total TP load reduction. The resulting cost per pound for TP reductions in the riparian buffer using filter strips is approximately $392.

One factor not included in the cost analysis for the TP load reduction from filter strips is the potential income from a commodity grown in the filter strip, such as hay. The potential gross income that would result from producers haying the filter strip following NRCS standards was calculated using 2009 NRCS payment values. These dollar values represent some of the benefits from installing filter strips for producers. Using the average commodity prices for 2009 from the Allegan Conservation District and assuming all of the filter strips installed would be planted in hay, the potential income from hay sales from $1.9-8.5 million depending on the scenario applied.

Table 4: Buffer scenarios and cost analysis for agricultural land conversion to grass plantings/filter strips.

Conversion Scenarios							Cost Analysis	
	Agricultural Area Converted to Grass (acres)	TP Load from Grass (lbs/year) (1)	Original TP Load(1) from Agriculture (lbs/year)	TP Load Reduction from Land Conversion (in 100-m buffer) (lbs/year)	TP Load Reduction from Treated Area Above Buffer (lbs/year)	Total Load Reduction (lbs/year)	Implementation Costs (in 2009 $) (NRCS) (2)	Estimated Cost per Pound of Load Reduction (in 2009 $)
Scenario 1 25%	4,729	121	916	795	1,676	2,471	$2,137,508	$865
Scenario 2 50%	9,458	241	1,832	1,591	3,352	4,943	$4,275,016	$865
Scenario 3 75%	14,187	362	2,748	2,836	5,029	7,865	$6,412,524	$865

Note:

(1) TP loads in the table above were calculated using average annual loading values (see Table 3).

(2) Cost calculations were done using a value of $452/acre for buffer strip installation (Communication with Allegan Conservation District).

Conclusions

From the information provided by this buffer analysis, it appears that land use change within the 100-meter buffer area over the next 20 years will be similar to predictions throughout the Kalamazoo River and its tributaries. Generally, urban land use will increase while forest, wetland and rural open area will decrease. The resulting watershed impacts will be increased runoff and pollutant loading to the Kalamazoo River. Due to the geographic nature of the buffer area, delivery of pollutants will be greater in this area than in other areas throughout the watershed. In the context of the phosphorus TMDL, this predicted load increase will need to be addressed in order to meet water quality goals, on top of existing load reductions that are required under the TMDL. For this reason, a number of BMPs and land use planning will need to be included as part of the watershed management plan.

Overall, implementing agricultural BMPs in the 100-meter buffer area, such as restoring grass buffers on agricultural lands within the riparian zone, could provide a significant phosphorus load reduction depending on the extent of the BMP implementation. Added incentives for producers may involve allowing cutting of hay in order to generate some income from the property. While the cost per pound of TP reduction for riparian filter strips appears relatively high for an agricultural practice, it provides a great cost savings when compared to urban BMP costs (which can be greater than $10,000 per pound of TP reduction[6]). For this reason, stakeholders should seek out the lowest cost reductions in order to maximize TP reductions and reach TMDL goals. Other agricultural BMPs should be examined and recommended as part of the watershed management plan.

From this analysis, the 100-meter buffer is one critical area in the watershed that should be prioritized due to the high delivery rate of runoff and pollutants to the river. In particular, agricultural BMP recommendations and implementation will be particularly important as agriculture comprises almost one-quarter of the total acreage within the 100-meter buffer area. A second important priority within the critical area will be protection of undeveloped areas, including forests, wetlands and rural open areas. Much of the acreage in these land use categories is predicted to be developed in the next 20 years. As urban land use increases, runoff and pollutant loading to the Kalamazoo River will also likely increase if best management practices and other protective measures are not applied to this critical area.

Implementing agricultural BMPs, retrofitting urban areas within the 100-meter buffer, and strategic land use planning are all important factors in reducing the predicted increase in runoff and pollutant loading to the Kalamazoo River. Invariably, these actions will require robust funding to increase implementation and efficacy. The information generated in this analysis, while limited in scope, should inform the Kalamazoo River watershed management planning project on the general impact and range of cost estimates for various levels of agricultural BMP application. In addition, results from this memorandum highlight the future conditions that are predicted through various modeling efforts that all conclude the

[6] *See Kalamazoo River Build-out Report, 2010 in the Kalamazoo River Watershed Management Plan for more information.*

current trajectory of land use change will have an overall negative impact on water quality if left on course.

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Attachment 8. Kalamazoo River BMP screening tool (8 pages)

Six Ways to Use the Kalamazoo River BMP Screening Tool

1. To calculate general stormwater treatment costs in your township:
   - Tab A: Select your township or city, enter entire township or city acreage per land use (refer to LOOKUP Tables)
   - Tab B: Select appropriate BMPs for all areas/acres generating urban stormwater in your township or city
   - Tab C: Review & print summary of BMP cost estimates

2. To selectively calculate TP loading from specific portions of your township and estimate BMP implementation costs:
   - Tab A: Select your township or city, enter acreage per land use for the specific area in your township or city you are interested in treating stormwater
   - Tab B: Select BMPs you are interested in implementing to treat stormwater in that specific area
   - Tab C: Review & print summary of site-specific BMP cost estimates*

3. To compare and select the most cost effective reductions by selecting different BMPs:
   - Tab A: Select your township or city, enter acreage per land use for the area of interest
   - Tab B: Select one set of BMPs to determine cost estimates and reduction efficiency
   - Open and save a second workbook, under Tab B select a different set of BMPs to compare cost estimates and reduction efficiencies
   - Tab C: Review & print summary of estimated costs for each workbook/set of BMPs

4. To track progress toward TMDL NPS load allocation goals using installed BMPs in your township:
   - Open and save two separate workbooks
   - Tab A: For both workbooks, select your township and city, enter entire township or city acreage per land use (refer to LOOKUP Table)
   - Tab B: In workbook one, enter the BMPs (or equivalent stormwater treatment by area) that were present in your township or city in 1998; in workbook two, enter all current BMPs that are presently implemented in your township or city
   - Tab C: Review & print both summary sheets to compare "future load with BMP application" for workbook one and "future load with BMP application" for workbook two (these figures will show 1998 "baseline" TP load in lbs/yr and 2010 "current" TP load in lbs/yr**)

5. To calculate BMP costs to reduce current TP load in order to comply with TMDL NPS load allocation:
   - Using workbook one created in Step #4, divide the "future load with BMP application" TP value in half to get your TMDL goal allocation
   - Subtract this TP load value from the 2010 "future load with BMP application" TP value in workbook two created in #4, this is the remaining TP load that must be offset to comply with the TMDL

- Open and save a third workbook, under Tab A enter the area of all untreated acreage generating urban stormwater (you can use information from workbook two, Tab B, column J "Area Not Treated by BMPs")
- Tab B: Enter a variety of appropriate BMPs for areas that generate stormwater until the "total load reduction" cell (L32) equals the number of pounds of TP required for TMDL compliance calculated above

6. To estimate the potential pollutant loading "prevention" from areas in the township that are permanently protected from development:

- Open and save a new workbook, under Tab A/Step 1 select the appropriate township or municipality
- Enter in the appropriate acreage for each land use in the area of interest (or area where permanent protection is being considered) and record the current loading in row 34
- Open and save a second workbook, under Tab A/Step 1 select the appropriate township or municipality
- Enter the identical number of acres from the first workbook, but place these under the low density, medium density or high density residential land use categories instead of the current land use
- Record the current load from this new land use category and compare to the loading calculated in the first workbook (where the current existing land use category was used)

*The BMP Screening Tool should be used for screening purposes only. For more accurate BMP design and cost estimates, a user should consult an environmental engineering firm.

**These figures are gross estimates of 1998 baseline loading and 2010 current loading to provide a general trend of whether TP loading is increasing, decreasing or remaining the same over time, depending on land use changes over time and stormwater BMPs employed for new or existing development. Variability is introduced by accuracy of acreages associated with each land use, location to surface waters, efficiencies of BMPs, annual average rainfall, and other general assumptions used in the BMP Screening Tool.

READ ME

INSTRUCTIONS AND REFERENCES FOR THE KALAMAZOO RIVER URBAN STORMWATER BMP SCREENING TOOL

Version 1.0- October 2009

This workbook contains the Urban Stormwater BMP Screening Tool developed by Kieser & Associates, LLC for the Kalamazoo River Watershed Council as part of the Kalamazoo River Watershed Management Plan. It is constructed only for applications in the Kalamazoo River Watershed.

The BMP Tool is designed to provide an estimate of current Total Phosphorus (TP) and Total Suspended Solids (TSS) loads and runoff volume using regional event mean concentrations (MDEQ, 2002) and average annual precipitation. It can also be used to estimate cost-effectiveness of common urban best management practices using national construction cost averages and efficiency values. It should not be used for site design, or for calculating site-specific BMP costs or pollutant loads.

The empirical model requires the following inputs to be provided by the user:

- land use breakdown of the area of interest,
- appropriate BMP(s) for the area,
- area of each land use category draining to the selected BMP(s).

Cells requiring user's input are in yellow. All other cells are automatically calculated.

The BMP Tool workbook is divided into 3 worksheets:

A- Calculate current pollutant load

Pollutant loads and stormwater volume are calculated for current land use footprints using equations and event mean concentrations provided in the Michigan Trading Rules (Rule 323.3013) (see LOOKUP TABLE 3).

Average annual precipitation values were calculated using long-term average precipitation data from cooperative stations in Allegan, Gull Lake, Battle Creek and Hillsdale. Look-up tables with land use breakdowns (by township or city only) and average annual precipitation for that area are provided to facilitate user input.

Please note that this simple tool was designed to be used to support TMDL implementation and watershed management in the Kalamazoo River Basin. By default, the tool will only model land use conditions without including the impact of previously installed urban or agricultural BMPs. New BMPs are only applicable to urban stormwater applications.

B- Apply stormwater best management practice(s)

This worksheet allows a user to select urban stormwater treatment BMPs. The BMPs selected represent general applications of BMP systems and do not necessarily represent a site-specific BMP. The selection process should be guided by best professional judgment and treatment efficiency. It should also be noted that this tool does not model the combined efficiency of multiple BMPs. Each BMP is modeled individually and may not reflect actual site conditions when multiple BMPs are installed together.

Related costs are for general comparison purposes; they should not to be used for site-specific applications.

C- Print results

All results are compiled in this worksheet to allow the user to print one summary page for a scenario.

These results can be used as a screening tool to assess loading issues from urban stormwater and generalized options (costs and benefits) to address these issues.

This document should be used as a template. Users can save this worksheet using a separate file name for each modeled scenario.

References:

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KALAMAZOO RIVER URBAN STORMWATER BMP SCREENING TOOL
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A- Calculate Current Pollutant Load

Step 1 Select municipality or township of modeled catchment (for default rainfall data).

Richland Twp

Only enter values in yellow cells:

Step 2 Enter land use area (in acres) of catchment to be modeled in Table A below (yellow cells, column C).
(For reference, the 2001 land use breakdown per township is provided in the LOOKUP TABLES worksheet)

Step 3 OPTIONAL: The load calculations use default imperviousness values for each land use (see LOOKUP TABLE 3).
Users have the option of entering a more specific land use imperviousness value (LOOKUP TABLE 3/Column U) based on their local knowledge of the area modeled.

TABLE A

	2				
Land Cover of Modeled Area	**Area (acres)**	**Average Annual Precipitation (in/yr)**	**Current Load**		
			TP (lbs/yr)	**TSS (lbs/yr)**	**Runoff Volume (acre-feet/yr)**
Low Density Residential		37.63	0.0	0	0.0
Medium Density Residential		37.63	0.0	0	0.0
High Density Residential		37.63	0.0	0	0.0
Industrial		37.63	0.0	0	0.0
Commercial		37.63	0.0	0	0.0
Roads/Parking Lots		37.63	0.0	0	0.0
Airport		37.63	0.0	0	0.0
Parks/Golf Courses		37.63	0.0	0	0.0
Agriculture (Row Crops, Orchards, Forage crops)		37.63	0.0	0	0.0
Herbaceous Openland		37.63	0.0	0	0.0
Forest		37.63	0.0	0	0.0
Water		37.63	0.0	0	0.0
Wetlands		37.63	0.0	0	0.0
Other (Sand, Rock, Bare soil)		37.63	0.0	0	0.0
TOTAL	**0.00**		**0.0**	**0**	**0.0**

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B- Apply Stormwater Best Management Practices

Step 4 Enter the area for each land use that will be treated by selected BMP(s).
Note: The total area entered in the BMP columns should be less or equal to the total land use area entered in Table A (The current land use area from Table A automatically populates Column C).

Total loads after BMP application are presented in Columns L & M.
BMP cost estimates are presented below Table B. Please note that land costs are not included in the BMP cost calculations.

BMP definitions are provided in the LOOKUP TABLES worksheet.

Note: Professional judgment should be used when selecting BMPs for the area selected. For instance, rain gardens and constructed wetlands are more appropriate for residential neighborhoods, retention and detention ponds are more appropriate for commercial or transportation areas.

This tool does not model the combined efficiency of multiple BMPs. Each BMP is modeled individually and may not reflect actual site conditions when multiple BMPs are installed.

TABLE B

Land Use (Zoning) of Modeled Area	Total Area (acres)	Average Annual Precipitation (in/yr)	BMP Coverage Projections						Future Load (lbs/yr) with BMP		
			Area Treated by Grass Swale	Area Treated by Extended Dry Detention Basin	Area Treated by Wet Detention Pond	Area Treated by Rain Garden	Area Treated by Constructed Wetlands	Area Not Treated by BMPs	Total Load TP	Total Load TSS	Runoff Volume (acre-feet/yr)
Low Density Residential	0.00	37.63						0.0	0.0	0	0.0
Medium Density Residential	0.00	37.63						0.0	0.0	0	0.0
High Density Residential	0.00	37.63						0.0	0.0	0	0.0
Industrial	0.00	37.63						0.0	0.0	0	0.0
Commercial	0.00	37.63						0.0	0.0	0	0.0
Roads/Parking Lots	0.00	37.63						0.0	0.0	0	0.0
Airport		37.63						0.0	0.0	0	0.0
Parks/Golf Courses	0.00	37.63						0.0	0.0	0	0.0
Agriculture (Row Crops, Orchards, Forage crops)	0.00	37.63						0.0	0.0	0	0.0
Herbaceous Openland	0.00	37.63						0.0	0.0	0	0.0
Forest	0.00	37.63						0.0	0.0	0	0.0
Water	0.00	37.63						0.0	0.0	0	0.0
Wetlands	0.00	37.63						0.0	0.0	0	0.0
Other (Sand, Rock, Bare soil)	0.00	37.63						0.0	0.0	0	0.0

Total area treated by BMP type (in acres)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0**

Total Load TP	Total Load TSS	Runoff Volume	
0.0	**0.0**	**0.0**	**Total Load/Volume with BMP application**
0.0	**0.0**	**0.0**	**Total Load/Volume with BMP no application**
0.0	**0.0**	**0.0**	**Load reduction from BMP application**
			Average cost per lb (or acre-feet) of reduction

BMP Cost Estimate	**Base BMP Cost**	**$0**	**$0**	**$0**	**$0**	**$0**
	Engineering & Planning / Landscaping Cost *(25% of base cost for retention/detention/swales/wetlands, 3% of base cost for rain gardens)*	**$0**	**$0**	**$0**	**$0**	**$0**
	Total BMP Cost	**$0**	**$0**	**$0**	**$0**	**$0**

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Summary

Date:	1/6/2011 8:41	
Name of area/project (optional):		
Total area modeled	0.00	acres

TOTAL POLLUTANT LOADS

	Runoff Volume *(acre-feet/yr)*	TP *(lbs/yr)*	TSS *(lbs/yr)*
Current Load/Volume	0.0	0.0	0
Future Load/Volume with BMP Application	0.0	0.0	0
Load/Volume Reduction from BMP Application	0.0	0.0	0

BMP APPLICATION

	Total Area Treated *(acres)*	Base BMP Cost *($)*	Engineering & Planning Cost *($)*	Total Cost *($)*
Grass Swales	0.00	0	0	0
Extended Dry Detention Basins	0.00	0	0	0
Wet Detention Ponds	0.00	0	0	0
Rain Gardens	0.00	0	0	0
Construction Wetlands	0.00	0	0	0
Total	0.00	0	0	0

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TABLE 1- BMP DATA

BMP	% Efficiency (1) TP	TSS	Runoff	Base Cost(2) ($ per acre treated)	Cost Adjustment for Small Project (2)
Grass Swale	40%	80%	15%	3,000	3.00
Extended Dry Detention	30%	90%	15%	3,000	2.10
Wet Detention Pond	90%	90%	0%	3,000	2.10
Rain Garden (Neighborhood)	50%	90%	50%	69,914	n/a
Constructed Wetlands	49%	76%	0%	42,254	n/a

(1) Efficiency values (for TP and TSS) for extended detention basin, wet de/retention pond and grass swale are taken from the Michigan Trading Rules. Efficiency values (for TP and TSS) for constructed wetlands were taken from EPA (2005), rain garden efficiencies were taken CSN Technical Bulletin No. 4 and MA DEP Stormwater Drainage Report (2009).

Runoff volume efficiency values were taken from the Chesapeake Bay Stormwater Network (Schueler, 2008). Level 1 runoff reductions (baseline BMP design) are used here to provide conservative estimates. Level 2 design (i.e. more innovative) would provide a greater runoff reduction (see reference for more information).

(2) Base cost and cost adjustment values are provided in WERF's BMP and LID Whole Life Cost Worksheets (2009b). The medium value of $3,000 per acre is used for retention, detention and swale.

For rain gardens, the cost per area treated is $16.05 (cost per sq. ft of rain garden) x 20% (rain garden area ratio to drainage area) =$3.21 per sq. foot treated (or $139,828 per acre treated). The assumption used in this tool is that rain gardens will be installed at a neighborhood scale, therefore providing economies of scale. The WERF neighborhood discount factor (50%) was applied to give a value per acre treated of $69,914.

The base BMP cost of $42,254 per acre (effective drainage area) for curb-contained bioretention is used for constructed wetlands.

See full references in READ ME worksheet

BMP DEFINITIONS

Extended Dry Detention: Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Wet Detention Pond: Wet ponds (a.k.a. stormwater ponds, wet retention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming stormwater runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as stormwater runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Traditionally, wet ponds have been widely used as stormwater best management practices.

Swales: The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to a vegetated, open-channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows along these channels, it is treated through vegetation slowing the water to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Rain garden: Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system.

Constructed wetlands: Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic and habitat value. Although natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

All definitions above were taken from the EPA "National Menu of Stormwater Best Management Practices" website (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm).

TABLE 2- PRECIPITATION AND LAND USE DATA PER TOWNSHIP

Note: Only land use area located within the Kalamazoo River Watershed is provided in the table below.

Township	Average Annual Precipitation (in/yr)	2001 Land Use (in acres) (1) Low Density Residential	Commercial	Airport	Road/parking lot	Agriculture	Herbaceous Open land	Parks/Golf Course	Forest	Water	Wetlands	Sand/Bare Soil
Adams Twp	36.50	10.5	2.4	0.0	40.0	1,164.9	116.3	0.0	149.7	0.0	117.0	0.7
Alamo Twp	39.16	246.0	80.3	0.0	702.5	10,176.1	2,091.4	71.2	5,505.0	184.4	4,151.8	4.7
Albion	36.50	401.4	206.8	0.0	496.6	595.8	536.2	0.0	789.9	11.1	259.3	6.7
Albion Twp	36.50	166.1	34.0	0.0	505.7	13,809.1	1,356.4	0.0	3,448.8	20.7	1,680.6	10.5
Allegan, City of	39.16	159.0	447.7	96.7	339.4	265.5	340.3	0.0	557.1	277.1	296.2	34.2
Allegan Twp	39.16	271.8	430.3	18.9	660.5	10,740.5	1,832.3	0.0	3,638.5	875.8	1,790.2	36.5
Assyria Twp	34.44	129.0	73.4	0.0	543.1	9,571.4	1,948.1	0.0	5,450.6	189.7	5,233.1	9.6
Barry Twp	37.63	164.6	109.4	0.0	607.8	10,267.3	1,518.7	0.0	3,610.3	803.7	3,968.3	9.3
Battle Creek	34.44	2,791.7	1,763.6	332.0	3,411.9	4,176.9	3,558.7	249.1	7,650.9	515.7	3,291.1	196.4
Bedford Twp	34.44	620.5	145.4	0.0	714.5	3,403.7	2,668.7	133.0	7,706.7	229.3	3,343.2	5.3
Bellevue Twp	34.44	152.1	127.7	0.0	720.1	10,173.5	1,478.2	0.0	3,302.9	75.6	3,679.2	32.2
Bloomingdale Twp	39.16	65.6	4.2	0.0	113.9	1,318.3	421.4	0.0	690.7	205.5	554.4	0.4
Brookfield Twp	34.44	57.2	28.9	0.0	527.3	12,102.5	787.7	0.0	1,728.4	143.9	2,436.9	41.8
Byron Twp	39.16	107.4	67.4	0.0	193.3	4,054.6	346.0	0.0	678.1	13.1	232.4	25.1
Carmel Twp	34.44	62.3	50.0	0.0	326.5	7,610.4	504.8	0.4	1,143.5	24.2	1,025.2	4.0
Charleston Twp	37.63	147.9	119.0	0.0	601.3	4,557.0	1,922.1	0.0	8,405.9	375.8	2,291.5	32.9
Charlotte	34.44	183.0	248.0	0.0	285.5	362.7	246.9	10.9	279.5	13.1	90.1	23.4
Cheshire Twp	39.16	250.4	47.4	0.0	538.6	6,397.9	2,466.1	0.0	3,556.2	562.6	3,590.0	182.6
Clarence Twp	34.44	85.0	44.0	0.0	498.2	11,138.2	1,179.1	0.0	2,690.7	811.3	4,010.1	8.7
Climax Twp	34.44	0.0	0.0	0.0	1.3	215.7	5.6	0.0	7.6	0.0	2.4	0.0
Clyde Twp	39.16	79.8	33.8	0.0	120.5	198.8	1,431.5	0.0	2,917.1	2.2	337.1	0.7
Comstock Twp	37.63	1,157.1	732.3	0.0	1,094.4	7,808.6	1,959.3	6.9	5,512.6	1,176.9	1,674.4	91.2
Concord Twp	36.50	164.3	57.4	0.0	628.9	13,886.5	1,799.4	0.0	3,531.8	43.1	3,044.3	14.9
Convis Twp	34.44	139.7	118.1	0.0	763.7	8,395.9	1,862.7	0.0	5,188.4	351.6	6,161.5	367.4
Cooper Twp	39.16	509.3	86.1	0.0	661.8	9,298.3	2,884.6	106.3	7,454.7	177.7	2,187.4	70.5
Dorr Twp	39.16	664.5	360.0	0.0	811.3	15,500.1	1,460.2	0.0	2,589.3	11.8	1,232.7	41.8
Eaton Twp	34.44	42.7	42.0	0.0	310.0	4,139.6	429.9	0.0	1,046.6	8.0	977.2	116.8
Eckford Twp	34.44	62.5	12.2	0.0	405.2	11,246.3	785.5	0.0	1,728.2	99.9	1,966.4	2.7
Emmett Twp	34.44	747.5	431.7	0.0	1,225.6	8,331.2	1,857.0	2.2	5,408.1	272.0	2,530.8	42.3
Fayette Twp	36.50	7.1	3.6	0.0	16.7	389.8	76.7	0.0	180.1	9.6	161.2	2.4
Fennville	39.16	115.6	78.9	0.0	61.8	261.5	78.5	0.0	74.1	22.2	33.1	2.4
Fillmore Twp	39.16	35.8	30.9	0.0	65.4	1,746.0	58.9	0.0	82.3	1.1	25.8	14.0
Fredonia Twp	34.44	34.7	9.1	0.0	203.7	3,390.6	525.3	0.0	1,107.9	208.8	1,966.6	1.1
Gaines Twp	39.16	7.8	7.6	0.0	48.0	881.1	81.8	0.0	210.2	5.6	222.6	113.2
Galesburg	37.63	59.8	25.8	0.0	95.4	263.5	104.1	0.0	219.7	33.8	124.8	2.7
Ganges Twp	39.16	5.1	0.9	0.0	19.6	241.3	32.0	0.0	27.6	0.2	4.0	0.0
Gobles	39.16	8.9	0.7	0.0	7.8	88.5	17.3	0.0	40.3	0.0	0.7	0.0
Gunplain Twp	39.16	276.4	213.7	0.0	771.2	11,343.9	1,837.2	76.7	5,095.2	186.8	2,102.3	62.9
Hamlin Twp	34.44	0.2	0.0	0.0	1.8	3.6	0.4	0.0	0.0	0.0	0.0	0.0
Hanover Twp	36.50	230.8	41.6	0.0	548.0	10,235.7	2,618.9	0.0	5,171.0	257.8	3,132.4	5.1
Heath Twp	39.16	368.1	250.2	0.0	587.1	4,205.4	3,918.1	0.0	9,868.8	167.7	3,570.7	44.7
Homer Twp	36.50	110.5	41.1	0.0	531.1	13,492.6	1,086.6	0.0	1,742.6	12.2	2,588.6	8.7
Hope Twp	37.63	0.4	0.7	0.0	0.0	3.3	9.1	0.0	42.5	0.0	2.0	0.0
Hopkins Twp	39.16	187.7	168.6	0.0	676.1	17,331.1	928.7	0.0	1,903.7	109.4	1,719.7	21.8
Jamestown Twp	39.16	130.5	65.8	0.0	394.5	10,656.9	331.4	0.0	742.8	14.9	354.0	18.7

TABLE 3- LAND USE CATEGORIES AND ASSOCIATED COEFFICIENTS FROM MICHIGAN TRADING RULES

2001 IFMAP Land use categories (1)	Equivalent Land Use - MI trading (1)	User-defined fractional imperviousness (2)	Defaullt Coefficients from MI Trading Rules IMP_L	C_I	C_P	Event Mean concentrations (mg/L) TSS	TP
Low intensity urban	Low density residential		0.1	0.95	0.2	70	0.52
High density urban	Commercial		0.9	0.95	0.2	77	0.33
Not applicable	Medium Density Residential		0.3	0.95	0.2	70	0.52
Not applicable	High Density Residential		0.85	0.95	0.2	97	0.24
Not applicable	Industrial		0.8	0.95	0.2	149	0.32
Airports	Highways		0.9	0.95	0.2	141	0.43
Road/Parking Lots	Highways		0.9	0.95	0.2	141	0.43
Agriculture (Non-vegetated farmland, row crops, forage crops, orchards/vineyards)	Agricultural		0.05	0.95	0.2	51	0.37
Herbaceous Openland/Shrub-scrub	Forest/rural open		0.05	0.95	0.2	51	0.11
Parks/Golf courses	Urban open		0.05	0.95	0.2	51	0.11
Forest	Forest/rural open		0.05	0.95	0.2	51	0.11
Water	Water/Wetlands		1	0.95	0.2	6	0.08
Wetlands (Lowland forest, emergent wetlands, non-forest wetlands)	Water/Wetlands		1	0.95	0.2	6	0.08
Sand/Bare soil	Forest/rural open		0.05	0.95	0.2	51	0.11

(1) Land use categories used in this Tool are a combination of IFMAP categories and MI Trading Rules categories. The most representative terms v used to give users a better understanding of each land use category.

(2) Users have the option of defining a land use imperviousness value (as a ratio) based on their local knowledge of the area modeled. If no value is entered, calculations will use the default imperviousness coefficient (IMP_L)

Definitions:

IMP_L Fractional imperviousness of land use L
C_I Impervious area runoff coefficient
C_P Pervious area runoff coefficient

Equations used in the Tool

$R_L \times A_L \times 0.0833 = R_{Vol}$
$EMC_L \times R_L \times A_L \times 0.2266 = L_L$
Where:
EMC_L = Event mean concentration for land use L in mg/l
R_{vol} =Runoff volume in acre-feet/year
R_L = Runoff per land use L in inches/year
A_L = Area of land use L in acres
0.2266 = Unit conversion factor (to convert mg-in-ac/yr to lbs/ac-yr)
L_L = Annual load per land use L, in pounds

Johnstown Twp	37.63	75.4	39.4	0.0	307.8	4,887.0	937.6	0.0	2,454.1	62.5	2,119.6	9.1
Kalamazoo, City of	37.63	3,459.9	2,167.0	307.1	2,673.6	597.3	1,661.7	271.3	3,725.5	282.2	768.8	109.9
Kalamazoo Twp	37.63	1,361.7	714.5	0.0	926.7	940.9	949.6	0.0	2,103.8	68.5	407.6	99.0
Kalamo Twp	34.44	11.3	5.1	0.0	89.4	2,413.4	181.0	0.0	298.7	4.2	556.2	2.2
Laketown Twp	39.16	152.6	99.4	0.0	144.1	390.7	333.6	0.2	853.3	18.0	256.2	215.9
Lee Twp-Allegan	39.16	5.6	1.1	0.0	34.7	362.7	171.5	0.0	532.6	0.0	347.2	0.7
Lee Twp-Calhoun	34.44	65.8	73.4	0.0	584.4	14,768.5	1,366.6	0.0	2,922.0	180.6	3,309.4	9.8
Leighton Twp	39.16	232.4	318.7	0.0	656.7	12,282.2	1,178.4	0.0	2,300.2	416.1	2,026.0	215.3
Leroy Twp	34.44	140.8	10.5	0.0	306.7	5,517.9	883.6	0.0	1,976.2	281.5	2,643.1	2.4
Liberty Twp	36.50	20.5	7.3	0.0	55.4	612.7	78.7	0.0	127.9	139.7	167.0	0.2
Litchfield	36.50	2.9	1.6	0.0	8.9	161.7	3.6	0.0	4.2	0.0	0.4	0.0
Litchfield Twp	36.50	15.3	13.1	0.0	145.7	3,939.6	123.6	0.0	248.4	0.0	295.8	2.7
Manlius Twp	39.16	368.1	176.1	0.0	468.8	6,669.3	3,027.0	0.0	6,487.1	427.4	5,053.8	94.5
Maple Grove Twp	34.44	26.0	18.0	0.0	115.0	3,581.1	373.6	0.0	633.6	10.0	703.9	3.8
Marengo Twp	34.44	124.8	32.7	0.0	673.6	14,415.3	1,329.4	0.0	2,988.7	80.9	3,206.0	2.4
Marshall	34.44	423.4	172.6	0.0	373.6	1,107.9	379.2	0.0	943.8	49.4	560.2	37.8
Marshall Twp	34.44	198.1	81.4	0.0	956.3	11,741.5	1,330.3	0.0	2,916.2	129.2	2,877.1	15.8
Martin Twp	39.16	154.3	175.0	0.0	669.8	17,955.8	956.5	0.0	1,653.0	102.5	1,273.0	70.9
Monterey Twp	39.16	311.1	179.0	0.0	569.3	12,636.6	2,225.2	0.0	4,996.2	138.5	1,932.6	36.0
Moscow Twp	36.50	92.5	36.5	0.0	544.0	12,213.2	1,520.9	0.0	3,235.6	5.8	1,981.7	7.8
Newton Twp	34.44	43.1	8.2	0.0	113.6	2,031.3	478.4	123.0	1,101.1	5.3	1,175.3	142.1
Olivet	34.44	39.6	37.1	0.0	70.3	92.1	91.2	0.0	211.5	0.2	110.3	2.4
Orangeville Twp	39.16	342.5	201.5	0.0	397.2	4,154.0	1,977.3	0.0	6,597.2	1,006.5	2,700.9	4.7
Oshtemo Twp	39.16	682.5	413.4	0.0	690.1	4,113.3	1,691.9	163.9	4,588.1	45.4	363.8	47.1
Otsego	39.16	178.8	167.7	0.0	252.4	233.3	151.4	0.0	219.9	44.7	96.7	12.2
Otsego Twp	39.16	322.0	221.1	0.0	775.3	11,499.6	2,013.3	0.0	3,950.8	373.6	2,477.9	45.8
Overisel Twp	39.16	228.2	49.4	0.0	319.6	8,649.2	372.5	0.0	595.8	0.7	1,017.4	7.1
Parchment	37.63	155.9	80.1	0.0	105.6	13.1	64.7	0.0	122.1	18.5	35.6	3.8
Parma Twp	36.50	152.1	43.4	0.0	528.0	9,507.8	1,227.6	0.9	2,150.3	0.7	2,423.6	9.1
Pavilion Twp	37.63	41.1	21.8	0.0	110.8	2,335.1	203.7	0.0	433.0	49.1	630.0	9.1
Pennfield Twp	34.44	556.6	173.7	0.0	868.7	6,247.6	2,628.6	100.5	8,357.9	180.1	3,280.5	59.2
Pine Grove Twp	39.16	144.8	21.3	0.0	432.1	7,902.4	1,737.5	0.0	3,742.8	64.0	2,303.1	7.8
Plainwell	39.16	168.8	141.4	0.0	236.2	288.0	150.6	0.0	233.5	46.5	42.5	18.0
Portage	37.63	3,359.6	1,203.6	41.8	1,321.7	1,133.5	1,392.8	85.6	3,642.3	17.6	1,341.7	69.2
Prairieville Twp	37.63	202.8	113.9	0.0	549.3	12,145.6	1,793.4	0.0	4,949.1	1,565.8	2,006.2	12.2
Pulaski Twp	36.50	121.4	17.8	0.0	519.3	13,560.2	2,167.0	80.5	3,626.5	113.4	3,268.0	1.6
Richland Twp	37.63	357.8	99.6	0.0	698.3	12,271.0	1,742.2	255.1	5,315.1	931.8	1,446.6	29.4
Ross Twp	37.63	324.9	118.5	0.0	604.7	5,891.8	1,889.6	432.8	8,565.4	1,470.2	3,717.9	6.4
Salem Twp	39.16	344.0	333.8	0.0	698.7	14,158.9	1,670.4	36.5	3,195.1	169.0	2,337.1	58.0
Sandstone Twp	36.50	0.0	0.0	0.0	1.1	67.6	10.7	0.0	22.7	0.4	4.2	0.0
Saugatuck	39.16	94.7	51.4	0.0	91.0	0.0	89.4	0.4	230.2	162.1	51.6	24.2
Saugatuck Twp	39.16	508.6	167.5	0.0	516.6	4,398.7	1,642.8	218.6	3,358.1	651.4	2,021.7	210.4
Scipio Twp	36.50	94.3	38.5	0.0	502.6	10,231.9	1,416.6	0.0	2,517.0	74.9	2,531.9	10.5
Sheridan Twp	34.44	166.6	76.9	0.0	650.3	9,473.8	1,573.0	91.2	3,757.3	66.9	4,055.5	6.4
Somerset Twp	36.50	12.5	25.6	0.0	68.9	1,272.7	215.3	0.0	373.4	0.2	244.2	0.4
Spring Arbor Twp	36.50	164.3	35.6	0.0	203.0	4,149.6	824.4	0.0	1,274.1	19.6	1,173.3	2.9
Springfield	34.44	303.8	302.0	40.5	452.3	15.6	508.6	0.0	555.8	9.8	191.7	8.5
Springport Twp	34.44	29.1	32.5	0.0	143.7	3,959.0	261.3	0.0	457.2	5.3	490.8	8.2
Texas Twp	37.63	497.0	167.0	0.0	463.9	4,136.7	1,440.0	0.0	4,876.6	524.0	783.3	21.1
Thornapple Twp	39.16	29.6	20.9	0.0	85.6	2,188.1	175.2	0.0	379.6	34.7	145.7	239.3
Trowbridge Twp	39.16	211.9	120.1	0.0	661.8	12,602.2	1,927.2	0.0	3,654.8	570.9	3,131.3	16.9
Valley Twp	39.16	252.0	107.2	0.0	477.7	1,359.2	4,157.8	0.0	11,770.2	1,612.1	2,913.3	26.0
Village of Douglas	39.16	155.5	92.5	0.0	152.1	8.0	270.2	103.6	248.0	86.5	72.3	9.6
Walton Twp	34.44	96.3	96.3	0.0	985.9	13,832.4	1,259.4	0.0	2,706.3	134.3	3,582.0	12.0
Watson Twp	39.16	173.2	165.7	0.0	604.9	12,972.9	1,832.5	0.0	3,907.4	334.0	3,051.4	44.0
Wayland	39.16	164.3	254.0	0.0	174.4	602.5	247.1	0.0	268.9	35.8	156.6	18.5
Wayland Twp	39.16	188.6	198.8	0.0	714.5	11,586.1	1,575.6	0.0	3,717.5	353.4	3,025.4	43.6
Wheatland Twp	36.50	0.9	0.0	0.0	5.3	227.7	52.9	0.0	68.5	0.0	93.8	0.0
Yankee Springs Twp	39.16	178.6	178.6	0.0	363.8	1,777.8	953.6	0.0	3,876.7	2,564.2	1,846.5	34.5
Zeeland Twp	39.16	19.3	9.3	0.0	64.5	1,541.6	12.2	0.0	26.5	0.7	6.9	2.7

(1) The land use categories used here correspond to the equivalent Michigan Trading Rules categories, and not to the original IFMAP categories.

Attachment 9. BMP descriptions, costs, and load reductions per area treated.

Vegetated Filter Strips: Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice.

Extended Dry Detention: Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, and extended detention ponds) are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Wet Detention: Wet ponds (a.k.a. stormwater ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming stormwater runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as stormwater runoff resides in this pool. Pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Traditionally, wet ponds have been widely used as stormwater best management practices.

Infiltration Basin: An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater into the soil. Infiltration basins typically have a high pollutant removal efficiency, and can also help recharge the groundwater, thus restoring low flows to stream systems. Infiltration basins need to be applied very carefully, as their use is often sharply restricted by concerns over groundwater contamination, site feasibility, soils, and clogging at the site. In particular, designers need to ensure that the soils on the site are appropriate for infiltration. Infiltration basins have been used as regional facilities, providing both water quality and flood control in some communities.

Swales: The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to vegetated, open-channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows along these channels, it is treated through vegetation slowing the water to allow sediment to settle and water to filter through a subsoil matrix (mulch mix), and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Rain garden: Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system (depending on soil permeability or level of contamination).

Constructed wetlands: Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic and habitat value. Although natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

All definitions above were taken from the EPA "National Menu of Stormwater Best Management Practices" website (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm).

Table 1 contains BMP average overall cost, engineering cost, and annual operations and maintenance costs (O&M) based on the area (land acreage or rooftop) treated by the practice. Load reductions are estimated for total phosphorus, total suspended solids and runoff using the Kalamazoo River Watershed BMP Tool (2010) for areas treated by BMPs under three different, typical land uses in the watershed. It should be noted that these costs are averages for construction of BMPs by professional engineers and developers in new build and retrofit development situations. It is likely that a homeowner could construct a stormwater treatment BMP (e.g., rain garden) at lower cost than estimated in Table 1, but it should be noted that proper BMP performance is more likely when technical considerations are made such as elevations, soil infiltration rates, soil organic content, proximity to utilities, appropriate plant species, soil compaction during construction, etc.

Table 1. BMP costs and loads reductions.

	BMP Base Cost	BMP Engineering Costs	Annual O&M***	Load Reduction per Acre Treated (Low Density Residential)			Load Reduction per Acre Treated (High Density Residential)			Load Reduction per Acre Treated (Roads/Parking Lots)		
	($/acre treated)	*($/acre treated)*	*(percent of base costs)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*
Filter Strips*	$13,800	$3,450	2% ($320)	0.5	164	0	0.7	693	0	1.3	1052	0
Grass Swale	$7,800	$1,950	5%-7% ($390-546)	0.5	131	0.1	0.7	554	0.4	1.3	842	0.4
Extended Dry Detention	$6,270	$1,568	1% ($63)	0.4	148	0.1	0.5	623	0.4	1	947	0.4
Wet Detention	$6,270	$1,568	3%-6% ($118-376)	1.1	148	0	1.5	623	0	2.9	947	0
Constructed Wetland	$42,254	$10,564	2% ($845)	0.6	125	0	0.8	527	0	1.6	800	0
	BMP Base Cost	**BMP Engineering Costs**	**Annual O&M***	**Load Reduction per Rooftop Treated (Low Density Residential)**								
	($/rooftop treated)	*($/rooftop treated)*	*(percent of base costs)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*						
Rain Garden**	$3,496	$105	($175-$343)	0.06	8.2	0.02						
	BMP Base Cost	**BMP Engineering Costs**	**Annual O&M**	**Removal Efficiencies**								
Infiltration Basin****	$2 per cubic foot of storage for a 0.25 acre basin	NA	5%-10% of constructio n costs	TSS 75%	TP 60-70%	Bacteria 90%		Runoff 100% assumed				

*Data Sources: costs from EPA, 1999, Preliminary Data Summary of Urban Stormwater BMPs, EPA-821-R-99-D12; load reduction estimates from NREPA of 1994, PA 451, Part 30 - Water Quality Trading
**The average size residential roof is about 2,000 sq. ft. which equates to about 0.05 acres
***Annual O&M costs from: EPA, 1999, Preliminary Data Summary of Urban Stormwater BMPs, EPA-821-R-99-D12
(All remaining calculations were done using the Kalamazoo River Urban Stormater BMP Screening Tool); citations are included under the READ ME tab (Loading=NREPA of 1994, PA 451, Part 30; costs=WERF tool)
****Infiltration basins are a good option and common BMP in southwestern Lower Michigan. Design requirements are highly variable and do not lend themselves to standardization for comparison to other listed BMPs. Estimates are taken from www.stormwatercenter.net.

1. Michigan Department of Environmental Quality. 2002. Part 30 Water Quality Trading. Available at: http://www.state.mi.us/orr/emi/arcrules.asp?type=Numeric&id=1999&subId=1999-036+EQ&subCat=Admincode
2. Schueler T. 2008. Technical Support for the Bay-wide Runoff Reduction Method Version 2.0. Chesapeake Stormwater Network.
3. US Environmental Protection Agency. 2005. National Management Measures to Control Nonpoint Source Pollution from Urban Areas.
4. Water Environment Research Foundation. 2009a. User's Guide to the BMP and LID Whole Life Cost Models version 2.0. Available at: http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08
5. Water Environment Research Foundation. 2009b. BMP and LID Whole Life Cost Models Excel Worksheets for Extended Detention Ponds, Retention Ponds, Swales. Available for download at: http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08

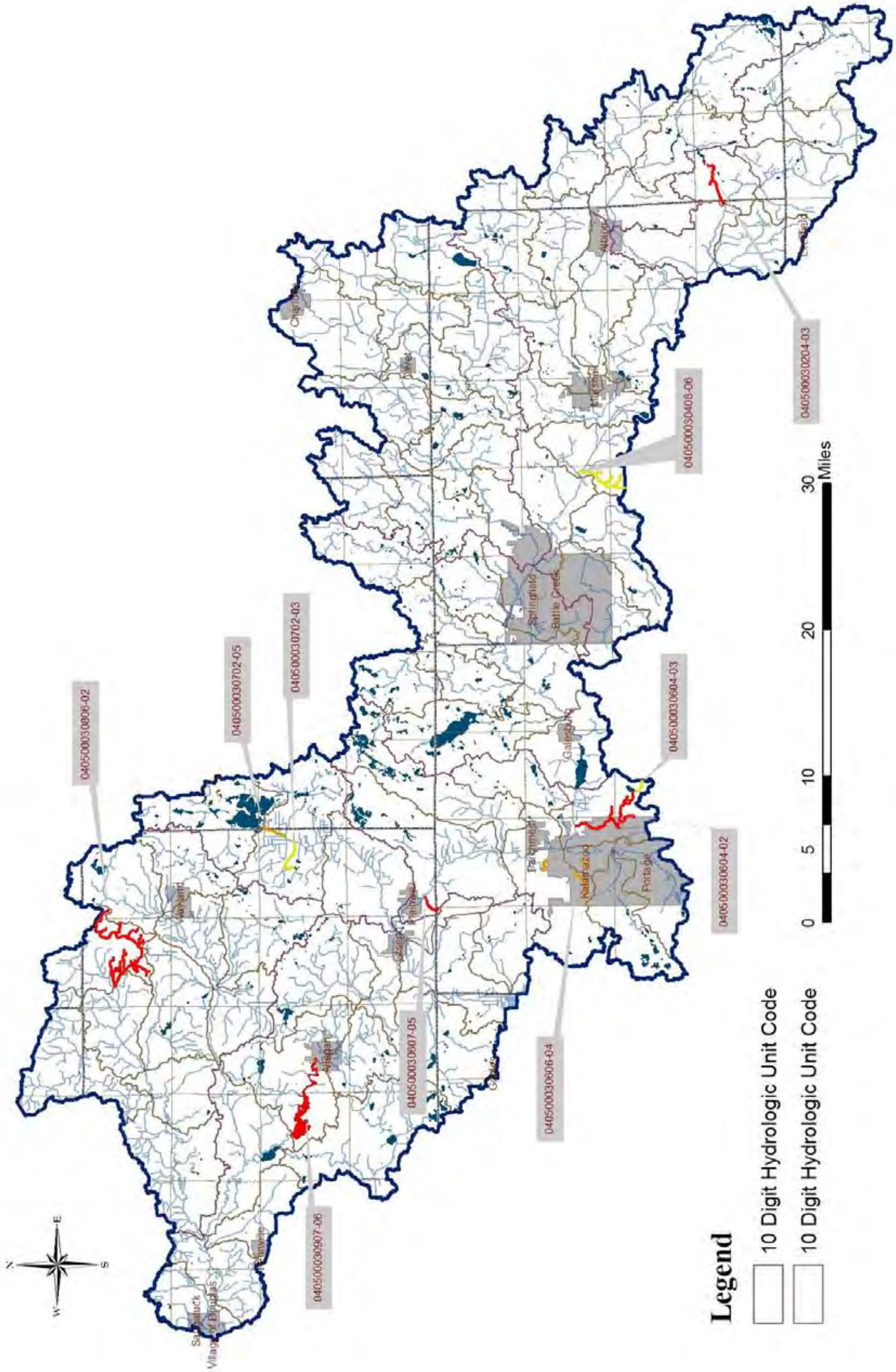
Attachment 10. Public comment.

1) The Southwest Michigan Land Conservancy (SWMLC) offered clarification in Section 4 regarding preserved lands in the watershed as well as SWMLC functions. A new figure was provided by SWMLC for Figure 10. An implementation task was added to Table 28 calling for the development of a watershed wide conservation plan.

2) Watershed Council Board members offered editorial comments throughout the text.

3) The Michigan Department of Environmental Quality offered numerous comments that have been incorporated throughout the text. Key items included a reorganization of Section 8 including adding more information from attachments, a calculation of phosphorus loading reduction goals from agricultural and urban lands now described in Section 10 and documented in Attachment 12, and a request for a map of impaired waterbodies now included as Attachment 11.

Attachment 11. Impaired waterbodies.



Attachment 12. Watershed and TMDL phosphorus load reduction goal calculations.

Land Use	Acres of Land Use	Goal of 10% of Total area for BMP	Goal 30% of Area Total area for BMP	BMP Efficiency Min Value Table 34- pg 157	Load reductions for 10%	Load Reduction for 30%
	Numbers based on table 3			extended detention tp-lbs/acre/yr		
Low Density Urban	29,786	2,978.60	8,935.80	0.3	893.58	2,680.74
High Density Urban	16,800	1,680.00	5,040.00	0.8	1,344.00	4,032.00
Transportation	49,803	4,980.30	14,940.90	2.3	11,454.69	34,364.07
					13,692.27	**41,076.81**
Agriculture	100 meter buffer	area above 100 meter buffer	Total Reduction			
Based on Table 25						
25%	795	1,676	**2,471.00**			
50%	1,591	3,352	**4,943.00**			
75%	2,836	5,029	**7,865.00**			

Total Load Reduction from 75% Ag & 30% LDU, HDU & Transportation	**48,941.81**					
TMDL Load	**Present Load**	**Goal**	**Reduction per month**	**Total Reduction**		
April/June	17,218	9,800	7,418	22,254		
July/Sept	8,135	4,088	4,047	12,141		
total reduction needed to meet TMDL	**34,395**					
Lake Allegan WS sq miles	1551.4					
Whole WS sq miles	2031.1					
% of WS under TMDL	0.763822559					
Total Load Reduction from 75% Ag & 30% LDU, HDU & Transportation in TMDL portion of watershed	**37,382.86**					

Attachment 13. Kalamazoo River Watershed Land Conservation Plan: Priority subwatersheds where land conservation will protect local water quality

In 2013 a team of graduate students from the University of Michigan's School of Natural Resources and Environment (SNRE), under the supervision of Dr. J. David Allan at SNRE worked with the Kalamazoo River Watershed Council (KRWC) and Southwest Michigan Land Conservancy (SWMLC) to develop a land conservation plan for the entire Kalamazoo River watershed. The overall purpose of the plan is to direct future conservation activities in a strategic way that would best protect the overall health of waterbodies in the watershed.

The graduate student team completed a GIS-analysis of the watershed on the basis of parcels based on their natural features and contribution to water quality protection. The full analysis and key criteria are described in the attached technical document. The graduate student team worked closely with KRWC and SWMLC, state agencies, and convened several stakeholder sessions with local conservation and natural resources professionals to guide the project.

The KRWC and SWMLC used the results from the *Kalamazoo River Watershed Land Conservation Plan* to develop an Executive Summary that can be used for outreach to both local governments and landowners (see below). The priority sub-watersheds that had the highest number of high-ranking parcels in terms of conservation value are identified on the map in the Executive Summary. The high priority sub-watersheds were grouped, in some cases to come up with eight priority areas for land conservation. Natural resources professionals and state agencies were consulted to make the final selections shown in the Executive Summary.

Developing the Plan

With the Watershed Management Plan as its foundation, the planning team convened local experts to develop a list of criteria that would help identify the highest quality land in the watershed. The final criteria included: land use; wetlands; proximity to water bodies and conserved lands; presence of cold water streams; and threatened or endangered species. The model emphasized conservation of existing high-quality landscapes, as opposed to restoration of degraded landscapes. Then, based on these criteria, the team undertook a geographic information systems (GIS) analysis to prioritize the lands in the Kalamazoo River Watershed based on their conservation value.

The analysis revealed the eight sub-watersheds with the highest density of priority land for conservation. The protection of these high-priority lands (shown and described on the map inside) is the most important for improvement of water quality, the health of the Kalamazoo River, and ultimately, Lake Michigan. The landscapes in these areas are extremely diverse, with everything from forested floodplains to prairie fen wetlands to coldwater trout streams.

The Plan will be adopted by the Michigan Department of Environmental Quality as the Land Conservation component of its Kalamazoo River Watershed Management Plan.

This large parcel along the Kalamazoo River floodplain near Augusta was ranked among the top 20 parcels to protect. It is a candidate for conservation grant funding in 2016.

photo by Emily Wilke

Plan Next Steps

SWMLC and KRWC, along with other organizations active in the watershed, will use this land conservation plan to secure funding and guide land protection efforts, reaching out to landowners with high-ranking properties. We will send informational mailings to policymakers and high-priority landowners, and host meetings and workshops for those landowners interested in learning more about land conservation. Working together to permanently protect these important lands will ensure the long-term viability and continued improvement of the health of the Kalamazoo River system.

Kalamazoo River Watershed Land Conservation Plan Project Partners

Southwest Michigan Land Conservancy and the Kalamazoo River Watershed Council would like to thank all of the organizations and planning team members who made this project possible:

- Dr. J. David Allan and graduate students from the School of Natural Resources and the Environment at the University of Michigan: Kyle Alexander, Jamie Jackson, Fumi Kikuyama, Ben Sasamoto, and Allison Stevens
- Kalamazoo Community Foundation; Frey Foundation
- Michigan Department of Environmental Quality, Water Resources Division
- Michigan Department of Environmental Quality, Office of the Great Lakes

And we are grateful to all partner organizations that participated in our planning meetings and provided invaluable support and input.

Kalamazoo River WATERSHED COUNCIL

A Clean Water Legacy for the Kalamazoo River

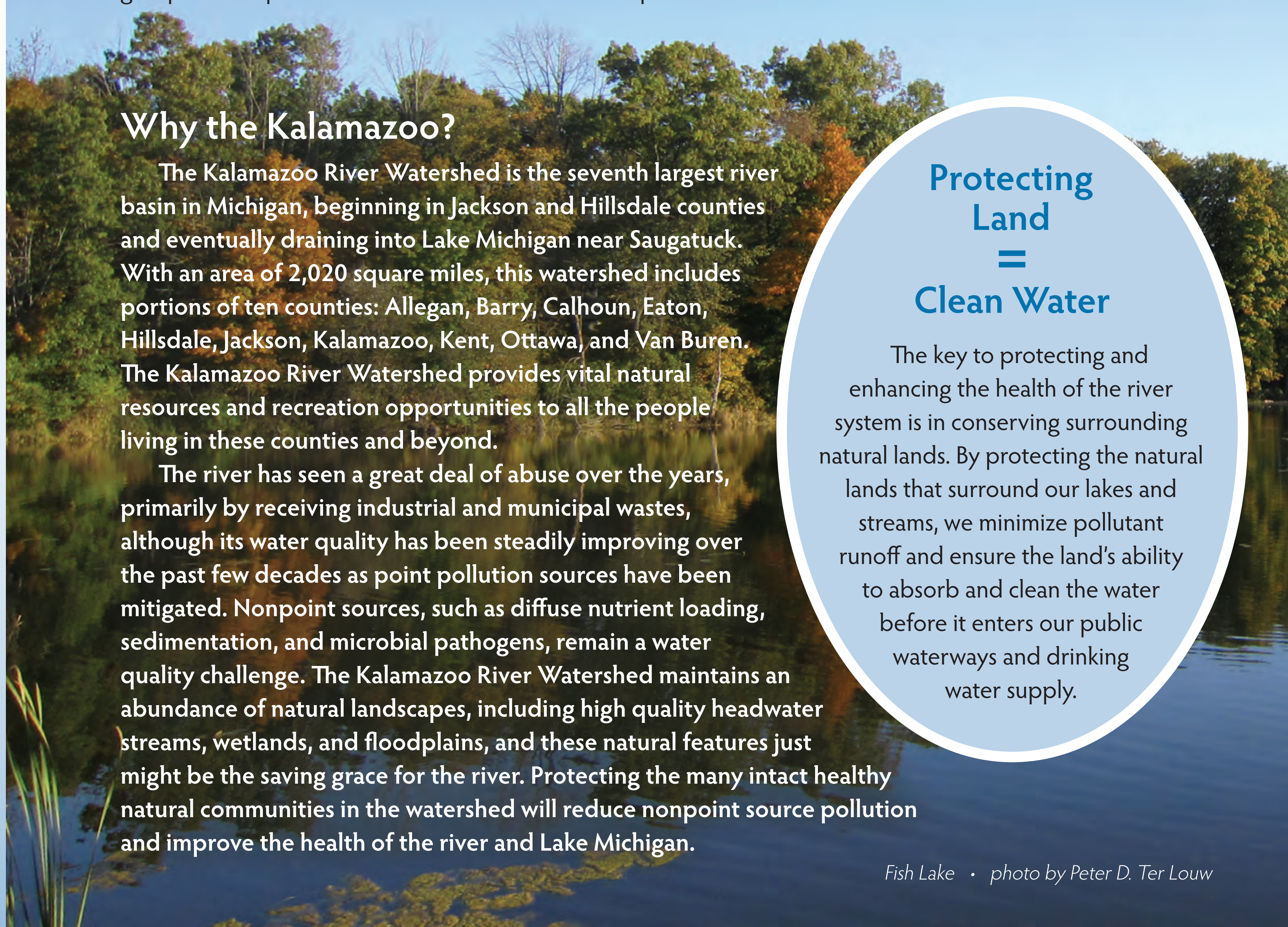
SWMLC SOUTHWEST MICHIGAN LAND CONSERVANCY

A Strategic Plan for Land Conservation in the Kalamazoo River Watershed

Introduction

The Kalamazoo River Watershed Management Plan was completed in 2011 to develop a unified vision for water resource management within the watershed. This plan, however, did not provide location-specific guidance for land conservation to improve water quality.

To address this missing piece, the Southwest Michigan Land Conservancy (SWMLC) and the Kalamazoo River Watershed Council (KRWC) worked in partnership with over 40 governmental and conservation groups to complete the first-ever land conservation plan for the Kalamazoo River Watershed.



Why the Kalamazoo?

The Kalamazoo River Watershed is the seventh largest river basin in Michigan, beginning in Jackson and Hillsdale counties and eventually draining into Lake Michigan near Saugatuck. With an area of 2,020 square miles, this watershed includes portions of ten counties: Allegan, Barry, Calhoun, Eaton, Hillsdale, Jackson, Kalamazoo, Kent, Ottawa, and Van Buren. The Kalamazoo River Watershed provides vital natural resources and recreation opportunities to all the people living in these counties and beyond.

The river has seen a great deal of abuse over the years, primarily by receiving industrial and municipal wastes, although its water quality has been steadily improving over the past few decades as point pollution sources have been mitigated. Nonpoint sources, such as diffuse nutrient loading, sedimentation, and microbial pathogens, remain a water quality challenge. The Kalamazoo River Watershed maintains an abundance of natural landscapes, including high quality headwater streams, wetlands, and floodplains, and these natural features just might be the saving grace for the river. Protecting the many intact healthy natural communities in the watershed will reduce nonpoint source pollution and improve the health of the river and Lake Michigan.

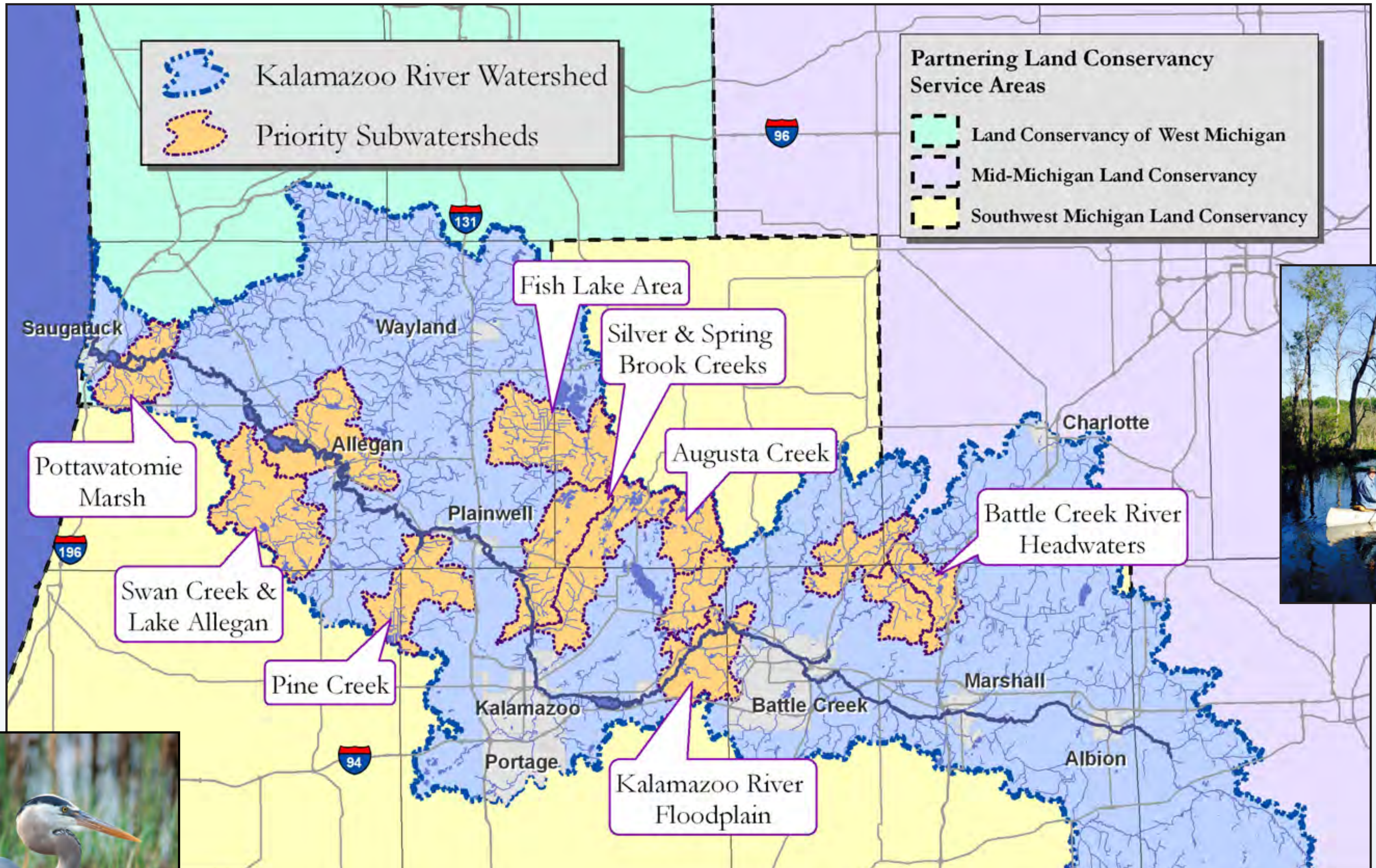
Protecting Land = Clean Water

The key to protecting and enhancing the health of the river system is in conserving surrounding natural lands. By protecting the natural lands that surround our lakes and streams, we minimize pollutant runoff and ensure the land's ability to absorb and clean the water before it enters our public waterways and drinking water supply.

Fish Lake • photo by Peter D. Ter Louw

Highest Priority Sub-Watersheds

A 2014 assessment model, created by watershed experts and local stakeholders, identified the top 10% priority parcels for conservation. The sub-watersheds with the greatest concentration of these parcels were combined into eight priority areas for protection.



Pottawatomie Marsh

Before draining into Lake Michigan, the Kalamazoo River flows through a large wetland complex and forms Kalamazoo Lake. Marshes in this area serve as important habitat for waterfowl and migratory birds. This area is also notable for its remarkable, yet fragile, sand dunes. Protecting land in this area is important to conserving large tracts of wetland and paleodune habitat.

Swan Creek & Lake Allegan

Swan Creek flows north into the Kalamazoo River below the Lake Allegan dam. The headwaters area consists primarily of farmland, with the downstream portion of the creekshed permanently conserved and surrounded by the Allegan State Game Area and designated as a Natural River under the Natural Rivers Act.

Pine Creek

This small creek is located at the intersection of Kalamazoo, Van Buren, and Allegan Counties and flows north into the Kalamazoo River, downstream of Otsego. Land use consists of small headwater lakes, with associated wetlands surrounded by farmland. The creek's documented fish community has remained unchanged for over 50 years with some natural reproduction of brown trout in the headwaters.

Fish Lake Area

Set in Barry County, this small creekshed contains the Fish Lake section of the Barry State Game Area that flows west into Gun River. While most of the Gun River watershed consists of agriculture, pockets of important wetlands and forested floodplain can be found around Fish Lake. Much of the area has natural land cover and a variety of unique plant and animal species.

Great Blue Heron

photo courtesy KRWC

Wanadoga Creek

photo by Peter D. Ter Louw

Kalamazoo River-Augusta Floodplain

In this central region, the floodplain consists of large tracts of land containing a mix of agriculture and riparian forest and wetlands adjacent to the Fort Custer State Recreation Area, one of the largest tracts of protected land in the watershed. The forested floodplain is documented as extremely botanically diverse and is essential for flood storage.

Augusta Creek

This spring-fed creek flows south through Barry and Kalamazoo counties on the eastside of Gull Lake, a primarily rural area dotted by residential homes, conserved parcels of land, and agricultural fields. Augusta Creek contains a rich diversity of habitats, especially wetlands, and a variety of rare and uncommon plants and animals – including at least 16 different species of fish, two of which are species of greatest conservation need, the lake chubsucker and the tadpole madtom. A focus for conservation, over 1,800 acres have been conserved between MSU, DNR and SWMLC.

Gilkey Lake Headwaters of Augusta Creek

photo by Emily Wilke

Silver Creek & Spring Brook

Silver Creek and Spring Brook are two separate - yet adjacent tributaries - to the Kalamazoo River, located in the corner where Allegan and Kalamazoo Counties meet. Both are recognized as high quality trout streams with top-quality coldwater designation. The headwaters are a combination of fallow farmland and scrub shrub wetland; the lower reaches are dominated by active farmland and the Kalamazoo River floodplain.

Battle Creek River Headwaters

This headwaters area includes Ackley Creek, Big Marsh Lake, Wanadoga Creek & Clear Lake. The area boasts numerous lakes and wetlands, including Big Marsh Lake, home to a sandhill crane migration stopover site that is largely protected by Michigan Audubon's 898-acre Bernard W. Baker Sanctuary. Portions of Wanadoga Creek and the area surrounding Clear Lake have tracts of undeveloped forests and wetland complexes. Wanadoga Creek is characterized as a cool to cold water system supporting mottled sculpin, blacknose dace, and white sucker.

Kalamazoo River Watershed Land Conservation Plan

April 22, 2014

Prepared for: Kalamazoo River Watershed Council & Southwest Michigan Land Conservancy

Prepared by: Kyle Alexander, Jamie Jackson, Fumi Kikuyama, Ben Sasamoto, and Alison Stevens of the University of Michigan, School of Natural Resources and Environment

Abstract: The Kalamazoo River Watershed Land Conservation Plan was developed to select for conservation targets among ownership parcels in the Kalamazoo River Watershed (MI). The watershed, while historically degraded, features large areas of preserved Midwestern habitats. To facilitate for the permanent protection of these lands, this plan was developed using an ArcGIS-based analysis that scored ownership parcels based on the following conservation criteria: land cover, presence of wetlands, proximity to hydrology, proximity to existing conserved lands, presence of cold lands, and presence of threatened and endangered species habitat. These criteria were developed using a literature review of existing conservation plans and Kalamazoo River Watershed stakeholder input. The results from this analysis were used to identify conservation priorities, including: the top 100 scoring parcels in the basin, a database of the top 20% scoring parcels and their contact information, and priority subwatersheds for conservation.

Table of Contents

Acronyms

AOC – Area of Concern
BUI – Beneficial Use Impairment
C-CAP – Coastal Change Analysis Program
CERCLA – Comprehensive Environmental Response, Compensation and Liability Act
FEMA – Federal Emergency Management Agency
GIS – Geographic Information System
GLWQA – Great Lakes Water Quality Agreement
HI – Habitat Index
HUC – Hydrologic Unit
IBI – Index of Biotic Integrity
KRWC – Kalamazoo River Watershed Council
KRWLCP – Kalamazoo River Watershed Land Conservation Plan
KRWMP – Kalamazoo River Watershed Management Plan
KRWPAC – Kalamazoo River Watershed Public Advisory Council
MDEQ – Michigan Department of Environmental Quality
MDNR – Michigan Department of Natural Resources
MI – Michigan
MiGDL – Michigan Geographic Data Library
MNFI – Michigan Natural Features Inventory
NPL – National Priority List
NWI – National Wetlands Inventory
OGL – Office of the Great Lakes
OU – Operable Unit
PCB – Polychlorinated-biphenyl
RAP – Remedial Action Plan
ROD – Records of Decision
SNRE – University of Michigan School of Natural Resources and Environment
SWMLC – Southwest Michigan Land Conservancy
TCRA- Time Critical Removal Actions
TMDL – Total Maximum Daily Load
USEPA – United States Environmental Protection Agency
WRD – Michigan Department of Environmental Quality, Water Resources Division

Tables

Figures

Attachments

1.0-Introduction

The Kalamazoo River Land Conservation Plan (KRWLCP) is organized into the following sections:

- Introduction and Background
- Conservation Criteria
- Ranking and Weighting
- GIS Methods
- Conservation Model Results
- Area of Concern Conservation Strategy and Results
- Discussion and Community Outreach

1.1 Background (The Kalamazoo River)

The Kalamazoo River Watershed drains a total area of 2,020 square miles in southwestern Michigan (MI) and includes portions of ten counties (Figure-1): Allegan, Barry, Calhoun, Eaton, Hillsdale, Jackson, Kalamazoo, Kent, Ottawa, and Van Buren (Kalamazoo River Watershed Council (KRWC), 2011). This drainage area makes the watershed the seventh largest river basin in the State of Michigan (Wesley, 2005). The main stem of the Kalamazoo River forms near Albion, MI at the confluence of the North and South Branches of the river and flows west for 123 miles before discharging into Lake Michigan near Saugatuck, MI (Kalamazoo River Watershed Public Advisory Council (KRWPAC), 1998). The North and South Branches of the river originate further upstream in southern Jackson County and northeastern Hillsdale County, respectively (KRWC, 2011). Measured from the headwaters of the South Branch to Lake Michigan, the river has a total length of 175 miles; additionally, the basin features 899 miles of tributaries (Wesley, 2005).

The Kalamazoo River and its basin have been significantly shaped by human activities. Archeological evidence suggests that there has been a human presence in the area for over 11,000 years (KRWPAC, 1998). However, it was during the 19th century that the watershed began to see major human impacts; during this era, the cities of Battle Creek, Kalamazoo, Parchment, Plainwell, and Otsego developed into commercial centers and began hosting industries such as cereal, pharmaceuticals, automobile parts, and paper production (KRWC, 2011). Over this period, the basin saw further alterations in the form of dam and impoundment construction. Currently, there are over 100 dams in the watershed, including 15 on the Kalamazoo River mainstem (Wesley, 2005). By the mid-20th century, industrial contamination and other human stressors rendered the Kalamazoo River severely degraded. During this period, the river was considered an “eyesore” and largely avoided by the public (KRWPAC, 1998). However, since the passage of the Clean Water Act in the early 1970s, major efforts have been taken in the United States to restore surface waters. The Kalamazoo River is no exception and is much cleaner today than it was during this previous era. Thanks to regulation of point-sources and efforts to restore the river, the Kalamazoo River Watershed has seen an improvement in water quality, both in terms of clarity and safety, and is witnessing a return of diverse fish and clam communities (KRWC, 2011).

Today, the Kalamazoo River Watershed faces a different set of challenges. Despite the recovery that has been made, the legacy of industrial contamination still looms large over the river, most notably in the form of polychlorinated-biphenyl (PCB) contamination from earlier de-inking practices utilized by the paper industry. This legacy is epitomized by the Kalamazoo River’s status as an Area of Concern (AOC) under the 1987 Great Lakes Water Quality Agreement (GLWQA) and the designation of an 80-mile stretch of the river from Morrow Lake dam to Lake Michigan as a federal “Superfund” site (KRWC, 2011). Additionally, while point-source pollution has largely been controlled by the Clean Water Act, non-point source pollution still threatens the integrity of the basin’s surface waters. For example, Lake Allegan, a large lake formed by an impoundment west of Allegan, MI, suffers from eutrophication and has a Total Maximum Daily Load (TMDL) for total phosphorous due to non-point nutrient loading; several other TMDLs are also being targeted for development as a result of non-point source pollution. In addition to phosphorus, sediments and microbial pathogens are non-point source pollutants of concern within the watershed (KRWC, 2011). Addressing these diffuse sources of pollution is of primary concern for the health of the Kalamazoo River Watershed moving forward.

1.2 Purpose (The Land Conservation Plan)

In March 2011, the KRWC completed the *Kalamazoo River Watershed Management Plan* (KRWMP) to provide a unified vision for water resource management in the Kalamazoo River Watershed. In doing so the KRWMP “sets a direction for policy and management decisions over at least the next decade and should be used as a guide for policy setting, decision-making and prioritizing actions originating from funding agencies, governmental units, private entities, organizations, and individuals" (KRWC, 2011). In order to provide for effective implementation, the KRWMP outlines a number of specific goals to be achieved; these goals not only promote the health of the watershed, but are also intended to serve as guideposts to assess progress and keep watershed stakeholders moving in the same direction. These goals are split into two categories: goals and objectives for restoring and protecting the **designated uses** of water bodies as required by state and federal water quality programs, and goals for achieving **desired uses** which have been identified by watershed stakeholders and do not necessarily pertain to water quality.

A prominent component of the vision presented in the KRWMP, and featured specifically in its goals, is land conservation. The conservation of critical natural features present in the watershed is emphasized as an important strategy for preventing non-point source water pollution and protecting important ecosystem functions. Goals related to this strategy call for a watershed-wide conservation planning effort to prioritize lands to conserve. Specifically, the first designated use goal of the KRWMP calls for the development of a "watershed-wide land conservation vision" in an effort to "preserve and restore wetlands and open space". Additionally, KRWMP "desired use" goals include the following:

- Goal 1. Promote and implement coordinated land use planning in the Kalamazoo River Watershed
- Goal 3. Protect open space and promote sustainable agricultural practices
- Goal 4. Protect habitat for native aquatic and terrestrial wildlife
- Goal 6. Improve recreation infrastructure along river while respecting natural features

Thus, the purpose of the *Kalamazoo River Watershed Land Conservation Plan* (KRWLCP) is to address these goals and direct future conservation activities in the basin. To do so, **the KRWLCP identifies lands in the watershed that are of the highest priority for conservation based on their natural features and contribution to the overall health of water bodies in the watershed.** These high priority areas were identified using a geographic information system (GIS) overlay analysis that incorporated a set of conservation criteria derived from stakeholder input and the aforementioned goals detailed in the KRWMP. The KRWLCP is intended to serve as an appendix to the KRWMP and provide a watershed-wide conservation strategy for the Kalamazoo River basin.

1.3 KRWLCP Strategy

There is a real opportunity to promote the health of the Kalamazoo River Watershed through land conservation. Despite its history of pollution, the watershed maintains an abundance of natural landscapes, including high quality headwater streams, wetlands, and floodplains. Additionally, the watershed features several large patches of contiguous forest and grassland areas and a number of state parks and game areas; in total, there are about 55,000 acres of publically owned land in the basin (KRWC, 2011). Conserving critical areas will benefit the watershed by preserving important ecosystem functions that promote water quality and the overall condition of the basin. Additionally, conservation will prevent development in environmentally important areas, such as floodplains and wetlands. According to an analysis conducted by Kieser & Associates, LLC for the KRWMP, urban land cover only makes up 8% of the watershed's area but may be responsible for up to 50% of overall non-point source phosphorous loading to the Kalamazoo River (Kieser & Associates, LLC, 2010). This figure speaks to significant contribution of developed land to non-point source pollution. Land conservation can mitigate this contribution by directing development away from particularly important natural areas.

To identify these high priority areas for conservation, the KRWLCP utilized ArcGIS software to perform an overlay analysis of the watershed. Overlay analysis is conducted by superimposing different types of spatial information regarding a location in order to study relationships (ESRI, n.d.). In the KRWLCP, GIS is used to "stack" a set of conservation criteria on top of each other to reveal areas in the watershed that, if conserved, stand to contribute positively to overall water quality. GIS overlay has been widely applied within the practice of land use management to provide decision support in a wide variety of contexts including agriculture, forestry, recreation, and transportation (Hamerlinck, 2010). Common applications involve solving site selection and site suitability problems (Armenakis & Nirupama, 2012). Using GIS to identify candidate areas for conservation is also a well-established practice (Foody, 2008), as is its use in watershed management; for example, Zhang et al. (2011) describe the development of the Watershed Management Priority Indices which uses web-based GIS software to assist in watershed planning decisions.

Conservation of existing high quality landscapes, as opposed to the restoration of degraded landscapes, is the mainspring behind the KRWLCP GIS model. Identified below, and discussed further in Section 2.2, are the six conservation criteria utilized in the KRWLCP GIS analysis to identify high priority areas to focus future land conservation efforts. Unlike many conservation models, the KRWLCP utilizes criteria that emphasize the conservation of lands highly contributable to improved water quality within the watershed.

- Current Land Cover
- Presence of Wetlands
- Hydrology Buffer
- Proximity to Conserved Lands
- Presence of Cold Streams
- Threatened and Endangered Species

A weighting and ranking scheme is used in the GIS conservation model to give emphasis to the most important of these conservation criteria. Weighting is a common practice in multi-criteria overlay evaluations such as this and is used to assign more importance to some criteria over others based on the objective of the analysis (Walke, Obi Reddy, Maji, & Thayalan, 2012). The weighting and ranking schemed utilized in the KRWLCP is detailed in Section 3.

The conservation emphasis of the KRWLCP is in no way intended to devalue the restoration potential of lands identified by the conservation model. On the contrary, many of the Recovery Potential Indicators identified by the United States Environmental Protection Agency (USEPA) overlap with the conservation criteria identified by the KRWLCP and are utilized by the conservation model (USEPA, 2012). Restoration remains an important strategy in the management of the Kalamazoo River Watershed but is not the primary focus of this plan.

2.0- Conservation Criteria

In order to prioritize lands in the Kalamazoo River Watershed, the GIS conservation model identified ownership parcels in the watershed that exhibited high conservation values based on six conservation criteria:

- Current Land Cover
- Presence of Wetlands
- Hydrology Buffer
- Proximity to Conserved Lands
- Presence of Cold Streams
- Threatened and Endangered Species

2.1 Criteria Selection

In a collaborative effort, a planning team comprised of five students from the University of Michigan-School of Natural Resources and Environment (SNRE), the Southwest Michigan Land Conservancy (SWMLC), and the KRWC convened over an approximate six month period to discuss and ultimately decide on the conservation criteria used in the GIS conservation model. Throughout the process, experts in the field and stakeholders from within the Kalamazoo River Watershed were solicited for their local knowledge and understanding of conservation values and threats within the watershed.

The conservation criteria used in the model were largely derived from protection priorities identified in the KRWMP. Specifically, section four of the plan entitled "Natural Features and their Protection" provides a list of natural features that are of particular importance for management and protection. Broadly, these natural features of importance include:

- Terrestrial Ecosystems
- Streams and Rivers
- Lakes
- Wetlands and Floodplains
- Rare Species and Features

- Invasive Species

Because this is a conservation plan, mitigation of invasive species already present in the watershed is not represented in the GIS conservation model. However, the remaining emphasized natural features are represented by one or more layer. Table-1 illustrates conservation criteria, aligned against KRWMP natural features of importance. The GIS methodology used in this plan is discussed in detail in Section 4.

Table-1: Criteria and Natural Features Comparison

Criteria	Data Layer	KRWMP Natural Features
Land Cover	C-CAP 2006	Terrestrial Ecosystems
Wetlands	NWI 2005	Wetlands
Hydrology Buffer	MiGDL 2009	Floodplain, Streams and Rivers, Lakes
Proximity to Conserved Lands	CARL	Terrestrial Ecosystems
Cold Streams	WWAT Rivers and Streams	Streams and Rivers
Threatened and Endangered Species	MNFI	Rare Features and Species

The conservation criteria were also influenced by input from a variety of watershed stakeholders. In June 2013, a watershed stakeholder meeting was held to begin the conservation planning process; this meeting was well-attended by representatives of numerous organizations and agencies active in watershed management in the basin. A list of stakeholder attendees at this meeting is included in Attachment-1. Attendees were given the opportunity to identify conservation ideals that should guide the KRWLCP as well as threats to water quality in the basin. The ideals and threats identified by stakeholders were used in the development of the conservation criteria; concerns were closely related to the natural features highlighted in the KRWMP. Table-2 illustrates how the GIS model criteria approximate certain conservation values and threats that were identified at this meeting.

Table-2: Stakeholder Values and Threats

Criteria	Stakeholder Conservation Values	Stakeholder Conservation Threats
Land Cover	Landscape perspective, Ecosystem functions	Stormwater, Nutrient runoff
Wetlands	Water quality, Groundwater recharge	Wetland loss, Nutrient Runoff
Hydrology Buffer	Tourism, Flood control, Water quality abatement	Stormwater, Nutrient runoff
Proximity to Conserved Lands	Wildlife corridors, connectivity, recreation	Fragmentation of habitat
Cold Streams	Recreation, Tourism, Habitat preservation	Water Withdrawals, Temperature
Threatened and Endangered Species	Threatened Species protection, Habitat protection	Fragmentation of habitat

2.2 Criteria Descriptions

The subsequent sections detail the six conservation criteria used in the GIS conservation model to identify high priority parcels within the Kalamazoo River Watershed.

2.2.1 Land Cover

According to the USEPA, State reporting has identified non-point source pollution as the leading cause of water quality problems in the United States (USEPA, 2012). Because contaminated runoff from non-natural land covers is a principal component of non-point source pollution to surface waters, land cover is intimately linked with water quality. Scientific literature confirms that there is a strong relationship between land cover and water quality, with numerous studies documenting a correlation between water quality parameters and the proportion of different land covers within a watershed (Lee, Hwang, Lee, Hwang, & Sung, 2009). For example, Roth et al were able to use GIS-derived estimations of land cover within the River Raisin Watershed (MI) to predict variations in index of biotic integrity (IBI) and habitat index (HI) scores at downstream sites (Roth, Allan, & Erickson, 1996). A number of mechanisms through which land cover affects stream ecosystems have been identified and studied, including: sedimentation, nutrient enrichment, contaminant pollution, hydrologic alteration, riparian clearing, and loss of large woody debris (Allan, 2004).

In general, non-natural land covers have been associated with degraded water quality while natural land covers such as forest and grasslands have been linked to healthy watersheds. Within the Kalamazoo River Watershed, two land covers, urban and agriculture, have been found to produce runoff that significantly contributes to water quality problems (Wesley, 2005). Currently, by land cover, the watershed is approximately 47% farmland, 21% forest, 9% open land, and 7% developed (KRWC, 2011); conserving key natural land covers in the watershed will prevent land cover-related water quality degradation as a result of conversion to a non-natural land use. Agriculture, urban, and natural land covers in particular have a dramatic impact on watershed health and thus, have been given special consideration in the KRWLCP GIS analysis. Current land cover for the Kalamazoo River Watershed is illustrated in Figure-2.

Agriculture

Agricultural lands have been found to contribute to nutrient loading, bank instability, erosion, pesticides, pathogens, and lower levels of biodiversity in surface waters (USEPA Office of Water, 2011). It is believed that agricultural lands are accountable for approximately 46% of sediment, 47% of total phosphorus, and 52% of total nitrogen discharges into U.S. waterways (Allan & Castillo, 2007). Case studies confirm these findings and indicate that watersheds with a high proportion of agricultural land are likely to be subject to degraded water quality. A study of North Carolina streams found that the percentage of agriculture at the watershed scale was strongly related to poorer water quality as measured by benthic macroinvertebrate community structure (Potter, Cubbage, & Blank, 2004). Similarly, an analysis of 103 Wisconsin streams found that agricultural land cover was negatively correlated with IBI scores and habitat quality (Wang, Lyons, Kanehl, & Gatti, 1997).

Urban

Urbanization is accompanied by the proliferation of impervious surfaces such as buildings and pavement which do not allow precipitation to infiltrate into the ground. These impervious surfaces increase the volume of stormwater runoff, which has the potential to carry sediment, nutrients, toxic chemicals, road salts, heavy metals and other harmful pollutants into surface waters (USEPA, 2013). Streams suffering from the impacts of urbanization are often afflicted with what has come to be known as “urban stream syndrome”, symptoms of which include: flashier hydrographs, increased levels of nutrients and contaminants, and reduced biotic richness and diversity (Wallace, Croft-White, & Moryk, 2013). Consequently, the proportion of urban land within a watershed has been statistically linked with changes in biological communities within streams. For example, of several land cover categories studied, percent urban land was found to be most strongly associated with benthic macroinvertebrate IBI scores in a study conducted in Western Washington (Morley & Karr, 2002). Additionally, impervious surfaces have the potential to alter both the hydrology and geomorphology of streams as they are forced to respond to altered amounts of runoff and decreased infiltration (Paul & Meyer, 2001).

Natural Land Covers

While agriculture and urban land covers are correlated with water quality degradation, natural land covers including forest, wetlands, and grasslands exhibit the opposite relationship. In the River Raisin Watershed, IBI and HI scores were found to be higher in sites that contained a higher proportion of natural vegetated land (Roth, Allan, & Erickson, 1996). Likewise, the proportion of forest cover within a watershed has been correlated with better stream conditions in North Carolina (Potter, Cubbage, & Blank, 2004). In general, natural land covers have been associated with reduced pollutant runoff and normal flow dynamics and their presence within a watershed has been used as an indicator for ecological health (USEPA, 2012).

GIS Layer

Land cover is represented in the KRWLCP GIS model through the layer 2006 Coastal Change Analysis Program (C-CAP).

2.2.2 Wetlands

While various natural land cover types, including forests and grasslands, are linked to overall watershed health, wetlands have been widely recognized for their added contributions to improved water quality. Important wetland functions include an ability to store large volumes of water, filtration capabilities, and enhanced biological productivity (USEPA, 2001). Increasingly, these ecosystem services are being recognized and quantified for their economic benefits, including flood control, contributions to improved drinking water, fisheries health, recreational benefits and more (USEPA, 2006).

Water Storage and Water Quality

Wetlands, especially those located within floodplains or in close proximity to open water bodies, are recognized for their ability to act as sponges, providing water storage capacity and mitigating the effects of flash floods and extreme runoff events (Carter, 1997). While a single wetland's water storage capacity varies depending on its physical, chemical, and biological attributes, an average one-acre wetland can store approximately one million gallons of water (USEPA, 2006). Additionally, many wetlands are able to function as sediment, nutrient, and pollutant sinks, though the ability of a wetland to perform any of these functions varies depending on its specific features. However, in general, watersheds with more wetlands tend to have lower concentrations of nutrients, suspended solids, and other pollutants when compared to watersheds with few or no wetlands (Carter, 1997).

Biological Productivity

Wetlands are recognized as being biologically productive ecosystems, providing habitat for both terrestrial and aquatic life (USEPA, 2001). The biological significance of wetlands is compounded by their relatively low abundance when compared to historic land cover data. Many wetlands serve as home to threatened and endangered species of both flora and fauna within Michigan, and exist as unique environments in and of themselves.

Wetland Trends in Michigan

Historically, southern Michigan has lost an approximated 66% of wetlands (roughly 3,320,000 acres) when compared to pre-European land cover data (MDEQ, n.d.). Currently, wetlands make up approximately 13% of the Kalamazoo River Watershed land cover which is comparable to the statewide average for Michigan's Lower Peninsula (KRWC, 2011). Figure-3 illustrates the current distribution of wetlands in the Kalamazoo River Watershed.

GIS Layer

The GIS conservation model utilizes the 2005 National Wetlands Inventory (NWI) layer to represent the wetlands conservation criteria.

2.2.3 Hydrology Buffer

For the purpose of the KRWLCP, the hydrology buffer criterion is included to capture the value of those lands which, because of their spatial relationship to surface water bodies, act as riparian buffer zones. The criterion also serves to capture the value of those lands that reside within the 100-year floodplain of the Kalamazoo River and its tributaries.

Riparian Buffer

Riparian buffers, for the purpose of the KRWLCP, are vegetated lands (lands dominated by natural land cover) that are located adjacent to or within some proximity to surface water bodies such as rivers, streams, lakes, and open wetlands. Riparian vegetative buffer strips are valued for their contributions to adjacent water bodies, including stream temperature moderation, sediment reduction, and nutrient reduction (Osborne & Kovacic, 1993). Given the dynamic nature of non-point source pollution within the Kalamazoo River Watershed, there is no "one size fits all" prescription for riparian buffer size or location. Specific site conditions, such as topography, geology, hydrology, and land use need to be taken into consideration when determining the most effective riparian buffer width and location for any given site. While buffer strips as small as 1-25 meters in width have been found to be effective at removing nutrients, some studies suggest land covers as far as 4,000 meters away are directly linked to sediment and nutrient levels in adjacent water bodies (Houlahan & Findlay, 2004). These findings suggest that small scale solutions, only focusing on individual sites within a close proximity to open water, may be unsuccessful in addressing water quality problems at the watershed scale. Thus, those natural lands located both directly adjacent to water bodies, as well as those located many thousands of feet away, should be recognized for their potential ability to influence the overall water quality within a watershed.

Floodplains

The Federal Emergency Management Agency (FEMA) defines the 100-year floodplain as the area that has a one-percent chance of being inundated by a flood during any given year (FEMA). Within the context of the KRWLCP, this area is recognized for its potential to contain lands with many of the qualities associated with riparian buffers. Additionally, it is acknowledged that the conservation of lands within the 100-year floodplain may have economic benefits to communities, including the mitigation of costly flood damage, recreational opportunities, and aesthetics (Kousky & Walls, 2013).

GIS Layer

The hydrology buffers used in the KRWLCP GIS model were created using the Stream Rivers Assessment Units and Inland Lake Assessment Units layers downloaded from the Michigan Geographic Data Library. These two layers were combined to represent all surface water bodies.

2.2.4 Proximity to Conserved Lands

Parcels that are in close proximity to existing conserved lands in the watershed are given priority in the KRWLCP for logistical reasons. With over 55,000 acres of land already in a state of preservation, the watershed features a vast network of conserved and recreational lands (Figure-4). For the organizations and agencies tasked with managing these lands, adding additional acreage in close proximity to these preserves makes practical sense. Maintaining additional preserves will require significant work but can be made easier for land managers by prioritizing areas near existing conserved lands. Additionally, prioritizing parcels near existing conserved lands allows for the expansion of the watershed's existing recreational infrastructure and will provide the public with greater opportunity to utilize them.

From a landscape-level perspective, the KRWLCP seeks to identify opportunities where adjacent parcels can be added onto already conserved lands. While the focus of this plan is water quality, conserving contiguous patches of natural land can provide significant benefits to terrestrial ecosystems and opportunities to do so should be considered. Habitat fragmentation, broadly, occurs when human-induced land conversion results in disjointed patches where contiguous habitat once existed (Lewis, Plantinga, & Wu, 2009). Such fragmentation is thought to threaten biodiversity and compromise the integrity of ecological systems through a variety of mechanisms such as edge effects, creating conditions that encourage exotic species invasion, and general habitat loss and isolation (Collinge, 1996). Using spatial models to simulate landscape management decisions, Huxel and Hastings (1999) found that restoring habitats adjacent to existing habitat can increase the efficacy of species recovery projects. This study speaks to the importance of considering adjacency in land use management decisions. To this end, the KRWLCP prioritizes parcels that are near existing conserved lands.

GIS Layer

Conserved lands are incorporated into the GIS model using the Conserved and Recreational Lands (CARL) layer developed by Ducks Unlimited (Ducks Unlimited, n.d.). For Michigan, this data includes conserved and recreational lands owned or protected by a variety of public and private organizations (The Nature Conservancy, 2007).

2.2.5 Cold Streams

Cold streams are a unique feature of the Kalamazoo River Watershed that warrant special consideration in the KRWLCP. As defined by the Michigan Department of Natural Resources (MDNR) - Fisheries Division, cold streams are those which typically have drainage areas of less than 80 square miles and maintain mean water temperatures of less than 63.5 degrees Fahrenheit during July (Institute of Water Research, Michigan State University, 2008). Cold streams in the Kalamazoo River Watershed obtain their distinct thermal characteristics via a significant contribution of groundwater (Wesley, 2005). According to the KRWMP, the cold streams in the basin represent some of the southernmost trout streams in the Midwest (KRWC, 2011). Cold streams provided habitat to a unique assemblage of fish including the brook trout, a sought-after game fish and the state fish of Michigan (MDNR, n.d.). Further, recreational activities related to the brook trout fishery provide significant revenue to the state of Michigan (Hamilton & Seelbach, 2011). Current cold stream distribution in the Kalamazoo River Watershed is illustrated in Figure-5.

Sensitivity

Unfortunately, land cover changes threaten to warm temperatures in cold streams, which can have deleterious effects on their biological communities. In particular, two land cover mechanisms that threaten cold streams in the Kalamazoo River Watershed have been identified in the KRWMP: **increased stormwater** as a result of impervious surfaces or the loss of riparian vegetation and **reduced canopy** cover as a result of riparian vegetation removal (KRWC, 2011). Fortunately, maintaining natural vegetation in riparian areas adjacent to cold streams can mitigate these impacts. For example, vegetation can interrupt and filter stormwater runoff and also provide shade from the sun to small streams (MDNR; MDEQ, 2009).

It is also important to consider the impact that land cover change can have on groundwater recharge. Because cold streams often maintain cold temperatures as a result of high contributions of groundwater flow, they can be significantly influenced by recharge rates. A study conducted in coldwater tributaries of the Muskegon River (MI) found that land cover alterations that affect recharge have the potential to influence the ability of streams to support brook trout (Waco & Taylor, 2010). For example, the conversion of grassland to urban land was predicted to increase stream temperatures as a result of reduced groundwater recharge (Waco & Taylor, 2010). For this reason, natural land covers near cold streams are given priority in the KRWLMP in an attempt to prevent alterations to groundwater recharge rates near these sensitive features.

GIS Layer

Cold streams are identified in the GIS conservation model using the "Streams and Rivers" layer utilized in Michigan's Water Withdrawal Assessment Tool (WWAT). This data layer uses a fish assemblage classification system that categorizes river segments by size and temperature using the variables drainage area and July mean water temperature, respectively (Hamilton & Seelbach, 2011).

2.2.6 Threatened and Endangered Species

The rare species of southwest Michigan are of environmental and cultural importance, adding value to the landscape via biodiversity, ecosystem services, recreational opportunities, and intrinsic value. While biodiversity is valued in and of itself, the habitats that support threatened and endangered species are also recognized as containing desirable qualities, representative of overall ecosystem health and resiliency (FWS, n.d.). Unfortunately, the rare species of the Kalamazoo River Watershed are threatened by anthropogenic and natural stressors, including climate change, land use changes, habitat fragmentation, and invasive species (KRWC, 2011). Through the identification and conservation of the habitats that support threatened and endangered species, it is anticipated that these recognized threats can be alleviated.

Rare Species in the Watershed

The Kalamazoo River Watershed includes portions of 10 southwest Michigan counties. In total, these counties contain nine **(9)** federally endangered and three **(3)** federally threatened species of flora and/or fauna. Table-3 summarizes the number of federally and state listed endangered and threatened species by county. Threatened and endangered species data were obtained through the Michigan Natural Features Inventory (MNFI) website.

Table-3: Number of Federally and State Listed Threatened and Endangered Species by County

County	State Endangered	State Threatened	Federal Endangered	Federal Threatened
Allegan	15	50	1	1
Barry	10	29	2	1
Calhoun	12	22	1	2
Eaton	6	10	1	2
Hillsdale	15	18	3	1
Jackson	10	27	2	0
Kalamazoo	18	62	2	0
Kent	13	45	3	0
Ottawa	9	27	0	1
Van Buren	17	43	2	1

GIS Layer and Model

Threatened and endangered species are represented in the GIS conservation model through the *Biological rarity index and probability value* GIS layer developed by the Michigan State University Extension as part of the Michigan Natural Features Inventory. For the purposes of the KRWLCP, the **Probability Model** was utilized to determine the likelihood that a threatened or endangered species exist in a given area. The probability model takes into consideration the spatial extent of an occurrence (sighting of a rare species), the presence of suitable habitat for the observed species, and the date of the most recent occurrence (Schools, Enander, & Paskus, n.d.). Based on combinations of the above criteria, an area within the model receives a probability score of high, medium, or low. Given the inclusion of suitable habitat conditions, the probability model allows the user to focus conservation efforts in areas where both species and habitat type are desirable.

3.0-Weighting and Ranking of Conservation Criteria

The conservation criteria used in the KRWLCP each received a weighting based on their relative importance to water quality or the general health of the watershed. These weights acted as a multiplier and were used to add emphasis to the most important criteria in the GIS conservation model. In addition to a weight, each criterion featured an internal ranking that assigned a value to the categories found in the data layer's attribute of interest. These ranking scores were based on each category's impact to water quality and the health of the watershed. To illustrate, consider the criterion of land cover. The data layer that represents land cover contains an attribute which describes land cover categories such as urban or forest; each attribute within this category was ranked based on its water quality or ecological impact. The weightings and rankings utilized in the GIS conservation model are shown in Table-4. The following sections will describe the weighting and ranking decisions in detail.

Table-4: Criteria Weighting and Ranking

Data Layer	**Weighting (10 in sum)**	**Reclassified Categories (Within Attribute)**	**<u>Ranking</u> High=3 Medium=2 Low=1, 0**
Land Cover	2.75	Forested (all types), Grasslands Others	3 0
Wetlands	3.0	Presence (all types) Others (open water)	3 0
Hydrology Buffer	2.0	Within 1000ft of hydrology Within 2000ft Within 3000ft > 3000ft from hydrology	3 2 1 0
Proximity to Conserved Land	1.0	Within 1 mile of conserved lands Within 2 miles Within 3 miles > 3 miles from conserved lands	3 2 1 0
Trout Streams	0.75	Cold streams Others	3 0
Threatened and Endangered Species	0.50	High Moderate Low N/A	3 2 1 0

3.1 Weighting

In order to calibrate the conservation model to select for priority lands, numeric weights (multipliers) were assigned to each criterion. An individual criterion's weight, relative to other criteria, was selected based on its natural features and contribution to overall water quality within the watershed. In determining the appropriate weight, the planning team performed an applicable literature review and coordinated with experts in the ecological, biological, and natural resource management fields. Additionally, local stakeholder input was considered when determining the final weighting scheme.

The weighting process was carried out in an iterative manner, allowing for recalibration and course-correction, as necessary. Three parcels within the watershed were used as "dummy parcels" to calibrate the model against. Each parcel had a predetermined conservation value, agreed upon by the planning team. The model was regulated to ensure that the final conservation model "output" scored the dummy parcels appropriately. The GIS analytical methods are further discussed in Section 4. Final results, including scores obtained for the dummy parcels are presented in Section 5.3.

3.2 Ranking

The conservation criteria are included in the GIS conservation model as individual raster layers. With the exception of the land cover and threatened and endangered species, data was obtained in vector format and had to be rasterized. Each criterion was thus incorporated into the model as a data layer that contained a grid of cells populated by discrete attribute values representing some environmental information about that location in the watershed. These attribute values were assigned based on the internal ranking described in Table-4. Rankings reflected the contribution of the attribute to water quality or the general health of the watershed. These values ranged from 0-3 with higher scores representing greater ecological importance; specifically, a score of three represented HIGH water quality or ecological value, a score of two represented MEDIUM value, a score of one represented LOW value, and zero represented NO value. It was not necessary to assign all ranks (0-3) within each data layer and in many cases, ranking simply expressed the presence (a score of three) or absence (a score of zero) of an important natural feature.

Land Cover

In the land cover layer, all natural land covers (forest and grasslands) were given a value of three, indicating highest water quality value. This ranking was based upon previously cited literature which found natural land covers to be correlated with healthy watersheds. All other land covers, including various types of agriculture and developed land were given a value of zero because they have not generally been found to contribute positively to water quality.

Wetlands and Cold Streams

Within both the cold stream and wetland layers, cells which indicate the presence of a cold stream or a wetland respectively were given a rank of three. This was to reflect the ecological value of both of these natural features and their relative uniqueness within the watershed. All other cells were given a value of zero to indicate the absence of the unique natural features.

Hydrology Buffer

For the proximity to water criterion, cells that fell within 1000 feet of a water body were assigned a rank of three and were intended to capture both natural floodplain and riparian areas. This 1000 foot distance was based on the KRWMP, which explicitly states "riparian areas, perhaps as much as 1000 feet in width if specific detail on runoff is not available, define a zone where land use needs to be scrutinized more carefully" (KRWC, 2011). Cells which fell 1000-2000 feet from a water body were assigned an attribute value of two and cells that were within 2000-3000 feet of a water body received a value of one. These rankings were designed to prioritize lands that were closer to water bodies rather than distant, upland areas. This was based on the assumption that parcels closer to water bodies exhibit a greater influence on water quality. It should be noted that one study found a relationship between land cover 2,250 meters away and wetland nitrogen and phosphorous levels (Houlahan & Findlay, 2004).

Proximity to Conserved Lands

Cells that fell in close proximity to existing conserved lands were given priority over those further away; this ranking was achieved by assigning attribute values in one-mile intervals. Cells that fell within one mile of a conserved land received a rank of three, cells that were one to two miles away from a conserved land received a rank of two, and cells that were two to three miles away from a conserved land received a rank of one. Cells that were not within three miles of a conserved land were assigned a rank of zero.

Threatened and Endangered Species

The threatened and endangered species criterion was assigned rankings based on the probability of encountering a rare species in that location. The MNFI probability model utilized by the KRWLCP contains the attribute "probability value", which places cells into the following categories: no status, low probability of encountering a rare species, medium probability of encountering a rare species, and high probability of encountering a rare species. Within the KRWLCP GIS conservation model, a rank of three was assigned to cells in the high category, a rank of two to cells in the medium category, a rank of one to cells in the low category, and a rank of zero to cells in the no status category. This ranking was intended to prioritize ownership parcels that feature rare species and/or high quality habitat.

4.0-GIS Methodology

The GIS analysis for the KRWLCP was conducted in two phases. The first was a raster overlay analysis that "stacked" the six conservation criteria layers upon 30X30 meter pixels to create a priority index map (Figure-6). The second phase used the ArcGIS zonal statistics tool to assign conservation scores to ownership parcels based on the 30X30 meter pixels in the priority index map.

4.1 Preparation of Data Layers

Once the data layers representing the six conservation criteria were obtained, they were used in a raster overlay analysis. Several of the layers had to be modified in order to do this. The wetlands, cold streams, hydrology, and conserved lands layers were acquired as vector layers and were converted into raster format to be used in this analysis. Table-5 shows the data layers used in this analysis and their original format. The conservation criteria "proximity to conserved lands" and "hydrology buffer" gave preference to areas nearer to conserved lands and open water, respectively (see Section 2.2). In order to reflect this, the Euclidean distance tool in the ArcGIS ArcMap tool box was used to create a series of buffers around these features. For the "hydrology buffer" criteria, a new raster layer was created with buffers of 1,000, 2,000, and 3,000 feet around water bodies. For "proximity to conserved lands", a new raster layer with buffers of one, two, and three miles surrounding conserved lands were created.

Table-5: Criteria Layer Formats (Original)

Criteria	Layer Type
Land Cover	Raster
Wetlands	Vector
Hydrology	Vector
Conserved Lands	Vector
Cold Streams	Vector
Threatened and Endangered Species	Raster

Based on the ranking determinations described in Section 3.2, attributes within the six layers were reclassified. This was done to establish the high, medium, and low ecological importance of the respective attribute categories in each layer. Tables 6-11 show how these layer attributes were reclassified.

Table-6: Land Cover Reclassification

Old Value	New Value
Developed, High Intensity	0
Developed, Medium Intensity	0
Developed, Low Intensity	0
Developed, Open Space	0
Cultivated Crops	0
Pasture/Hay	0
Grassland/Herbaceous	3
Deciduous Forest	3
Evergreen Forest	3
Mixed Forest	3
Scrub/Shrub	0
Palustrine Forested Wetland	0
Palustrine Scrub/Shrub Wetland	0
Palustrine Emergent Wetland	0
Estuarine Forested Wetland	0
Estuarine Scrub/Shrub Wetland	0
Estuarine Emergent Wetland	0
Unconsolidated Shore	0
Bare Land	0
Open Water	0
Palustrine Aquatic Bed	0

Table-7: Wetlands Reclassification

Old Value	New Value
Aquatic Bed	3
Aquatic Bed Mix	3
Emergent	3
Emergent Mix	3
Forested	3
Forested Mix	3
Open Water	0
Scrub Shrub	3
Scrub Shrub Mix	3
Shore	0

Table-8: Hydrology Buffer Reclassification

Old Value	New Value
0-1000ft	3
1000-2000ft	2
2000-3000ft	1
>3000ft	0

Table-9: Proximity to Conserved Lands Reclassification

Old Value	New Value
0-1 mile	3
1-2 miles	2
2-3 miles	1
>3 miles	0

Table-10: Cold Streams Reclassification

Old Value	New Value
Cool Small River	0
Cold Stream	3
Cool Stream	0
Warm Stream	0
Cold Transitional Stream	0
Cold Transitional Small River	0
Warm Large River	0
Warm Small River	0

Table-11: Threatened and Endangered Species-Reclassification

Old Value	New Value
No Status	0
Low	1
High	3
Moderate	2

4.2 Raster Overlay Analysis

Figure-7 depicts the model used in the raster overlay analysis. Blue ovals indicate the input raster layers for the six conservation criteria and green ovals show intermediate and final output raster layers. Yellow boxes show where various model tools were utilized. The yellow “reclassify” boxes represent where “proximity to conserved lands”, “cold streams”, and “threatened and endangered species” were reclassified as described above in Tables 9-11. Not shown here is the reclassification of “land cover”, “wetlands”, and “hydrology buffer”; these layers were reclassified separately, to allow for smoother model processing. For the input “cold streams” layer, the processing extent used in the reclassification step was defined by the “land cover” layer extent. This was done in order to ensure that the “cold streams” output layer covered the entire extent of the Kalamazoo River Watershed.

Once the data layers were reclassified, they were "stacked" upon each other using the raster calculator tool along with the Kalamazoo River Watershed boundary layer, which restricted the analysis to the extent of the watershed. To incorporate the weights described in Section 3.1, the raster calculator tool used the following formula:

(2.75 × Land Cover + 3 × Wetlands + 2 × Hydrology Buffer + 1 × Conservation Reclass + 0.75 × Cold Streams + 0.5 × MNFI Reclass) × Watershed Boundary

This raster calculation resulted in raw overall prioritization scores for each of the 30x30 meter grid cell pixels within the watershed.

In the final step of the overlay analysis, raw output index scores were transformed to a more user friendly scale ranging from 0-100 through the use of the stretch formula tool. A mask of conserved and developed lands was applied to the stretch formula in order to remove these pixels from the prioritization analysis and only include scores for natural lands that are not currently conserved. The scores were stretched to a 0-100 scale using the following formula:

((Output 1 - 0) × 100) / (30 - 0) × Conserved and Developed Land Mask

This last step produced a final raster output layer of overall prioritization index scores from 0-100 for the natural land pixel grid cells within the boundaries of the Kalamazoo River Watershed. Conserved lands were excluded from the final priority index map because the planning team wanted to identify new conservation opportunities, not those which are already in a state of conservation. Developed lands were excluded because they were thought to be of low ecological value.

4.3 Zonal Statistics

The raster overlay analysis produced a final map of conservation scores for 30x30 meter raster grid cell pixels. However, pixels do not offer practical conservation targets and thus, conservation scores were assigned to ownership parcels. To do this, it was necessary to incorporate datasets for all parcels within the watershed.

Original parcel datasets were provided by each of the ten counties in the Kalamazoo River Watershed. For the following analysis, these parcels were fit to the extent of the watershed using the ArcGIS ArcMap clip tool. These individual datasets were then combined into a single layer using the ArcGIS ArcMap merge tool**. Only parcels greater than or equal to 20 acres were added** to the parcel layer, given their greater and more practical conservation/land management benefits. In this way, parcel size could be considered as a seventh criterion used by this analysis to identify important lands to conserve.

To assign conservation scores to the vector parcels based on the raster pixel priority index map, the ArcGIS ArcMap zonal statistics tool was used. The final raster output priority index layer was used as the input value layer and the parcel data was used as the zonal layer. The resultant output table contained the statistical results (minimum, maximum, range, mean, standard deviation, summation) of the conservation value of the input pixels within each parcel. This output table was joined with the parcel layer data based on parcel IDs. Figure-8 illustrates this process.

5.0-Results

The KRWLCP GIS analysis assigned conservation scores to all parcels in the watershed with an area greater than or equal to 20 acres, excluding developed lands and lands that are currently in a state of conservation. These scores were derived from the conservation criteria described in Section 2, ranked and weighted as described in Section 3. The initial raster overlay analysis assigned these scores to 30X30 meter pixels (Figure-6). Ownership parcels were then assigned scores based on the pixels that fell within each of their bounds using the ArcGIS zonal statistics tool.

From the output produced by the zonal statistics tool, each ownership parcel received a value representing the maximum, minimum, mean, range, standard deviation, and sum of the pixels within its bounds. The mean value was used as the final conservation score for each parcel, as the planning team did not want parcels to be targeted or ignored based on extreme maximum or minimum values. Of the 15,668 applicable parcels, conservation scores ranged from zero to sixty-nine (0-69.2), with the highest possible score being 100.

From these conservation scores, conservation priorities can be established for the Kalamazoo River Watershed. To do so, the output from the KRWLCP GIS analysis was used to identify the following conservation opportunities:

- **Top 100 parcels** based on conservation score
- **Parcel priority tiers** to guide land acquisition efforts
- **Priority Hydrologic Units (HUCs)** for localized conservation

These opportunities are described in subsequent sections and provide tangible targets for watershed stakeholders involved in land conservation.

5.1 Top 100 Parcels

Based on the results, 100 parcels were identified as having the top 100 conservation scores. Scores were based on the mean pixel value within each parcel. In total, approximately **4,218 acres** are contained within the top 100 parcels. Conservation scores for the top 100 parcels range from 59.2-69.2. A map of the top 100 parcels within the Kalamazoo River Watershed is illustrated in Figure-9. While the top 100 parcel analysis is a useful approach to identifying top priority parcels, more focused conservation efforts will likely incorporate local environmental and socioeconomic conditions to truly assess conservation value(s) of individual parcels.

The top 100 parcels, along with identification information, were compiled into a Microsoft Excel database and are contained in Attachment-2. In some cases, complete identification information (e.g. parcel address) could not be obtained for the top 100 parcels.

5.2 Priority Tiers

To examine the highest scoring parcels in greater detail, parcels were aggregated into three tiers based on their conservation scores. Tier one included the top 10% scoring parcels, tier two included the following 10% scoring parcels (11%-20%), and tier three included those parcels scoring between the top 21%-30%. Parcels outside of the top 30% scoring parcels were categorized as having modest conservation value. Priority acreage and score range, based on tier, is illustrated in Table-12 below. A map of all priority parcels, broken into tiers, is illustrated in Figure-10.

Table-12: Priority Tier Analysis

	Total Acres	Score Range
Tier 1	68,460.07	48.75-69.17
Tier 2	73,673.24	42.17-48.75
Tier 3	81,011.09	36.61-42.17
Total	223,144.40	0-69.17

Parcels falling in the top two tiers, representing the top 20% scoring parcels, are considered to be initial conservation priorities of the KRWLCP. Given that 15,668 parcels were included in the GIS analysis, this top 20% yields **3,134 parcels**. Based on past experiences from local conservation groups, including the SWMLC, this provides a practical number of parcels on which to focus future conservation efforts. In total, these 3,134 conservation priority parcels include nearly **142,133 acres**, representing approximately 11% of the total acreage within the Kalamazoo River Watershed (1,300,164 acres). The grand mean (mean of means) for conservation scores in the top 20% was approximately 49.36.

In order to provide for the pursuit of these conservation priorities, the 3,134 parcels that compose the top 20% were compiled into a Microsoft Excel database. For each parcel, the database includes information regarding its conservation score and also landowner, location, and contact information. With the help of many local partners, it is the hope of the planning team that this database will be used in an effort to engage landowners across the watersheds regarding the conservation of these priority lands.

Using the database, the KRWC and SWMLC narrowed the focus of future implementation by aggregating priority parcels based on their location within the watershed. The HUC-12 subwatersheds in the Kalamazoo River Watershed ranked based on the concentration of priority parcels. From this comparison, KRWC and SWMLC identified eight priority watershed areas that include 13 HUC-12 subwatersheds. The following areas are the primary priorities for land conservation outreach and implementation:

- Pottawatomie Marsh
- Swan Creek and Lake Allegan
- Rice Creek
- Fish Lake Area
- Silver and Spring Brook Creeks
- Augusta Creek
- Kalamazoo River Floodplain
- Battle Creek River (Ackley Creek, Wanadoga Creek, Clear Lake)

5.3 Dummy Parcels and "Ground-Truthing"

In order to calibrate the conservation model, the planning team relied on three parcels with unanimously agreed upon conservation values and a form of "desktop ground-truthing" to compare against different model outputs. The first parcel (Parcel 1) is located in Kalamazoo County. The 35 acre parcel contains a mix of upland forests (primarily oak), prairie fen wetlands, and a natural groundwater spring. It was unanimously agreed upon by the planning team that Parcel 1 is of high conservation value, and should be reflected as such in the conservation model. Parcel 1 received a conservation score of 50.5 which places it in the top tier of priority parcels. Photographs of Parcel 1 are provided in Attachment-3.

The second parcel (Parcel 2) is located in Calhoun County. The 90 acre parcel contains a mix of upland forest (primarily maple, oak, and aspen), minimal agriculture, and a small area of forested wetland. No streams, rivers, or lakes run through or border Parcel 2. It was unanimously agreed upon by the planning team that Parcel 2, while a natural landscape, is of medium to modest conservation value when considering impacts to overall water quality within the watershed. Parcel 2 received a conservation score of 41.9 which places it in the third tier of priority parcels. Photographs of Parcel 2 are provided in Attachment-3.

The third parcel (Parcel 3) is located in Calhoun County, and adjacent to Parcel 2. The 88 acre parcel contains approximately 95% grassland with patches of deciduous and coniferous trees and minimal agriculture. No streams, rivers, lakes, or wetlands run through or border Parcel 3. It was unanimously agreed upon by the planning team that Parcel 3, while a natural landscape, is of modest conservation value when considering impacts to overall water quality within the watershed. Parcel 3 received a conservation score of 19.6 which places it in the "modest value" tier of priority parcels. Photographs of Parcel 3 are provided in Attachment-3.

5.4 HUC Analysis

Within the Kalamazoo River Watershed, there are 75 12-digit HUCs representing the subwatersheds that compose the basin. The results from the KRWLCP were used to determine which of these subwatersheds contain the largest amount of priority conservation parcels; those HUCs which contain a disproportionately large number of priority parcels are considered priority HUCs. Prioritization of HUCs was determined based on the total acreage of tier one and tier two parcels (representing the top 20% scoring parcels) falling within HUC boundaries. The Priority HUCs identified are candidates for future conservation efforts and planning at a subwatershed scale and their preservation will contribute to the overall health of the Kalamazoo River Watershed. In effect, these priority HUCs can also be thought to represent important clusters of priority conservation parcels and can be used to spatially focus conservation efforts.

Based on this analysis, four HUCs were identified as priority based on the 4,000+ acres of tier one and tier two parcels that they contain. The 4,000 acre break was mainly chosen for illustrative purposes, and thus should not devalue those subwatersheds with fewer priority parcels. While the subwatershed analysis is a useful approach to identifying clusters of top priority parcels, more focused conservation efforts will likely incorporate local environmental and socioeconomic conditions to truly assess conservation value(s). Table-13 details these four priority HUCs in the Kalamazoo River Watershed. The 75 subwatersheds (Top 10 identified) are illustrated in Figure-11. The four top scoring subwatersheds are illustrated in Figures 12-15.

Table-13: HUC Analysis Summary Stats

HUC Name	No. of Tier 1 and 2 Parcels	Tier 1 and 2 Acres
Swan Creek	128	5,548.31
Wanadoga Greek	106	4,770.26
Fenner Creek-Gun River	99	4,321.36
Ackley Creek	88	4,257.52

6.0-Kalamazoo River Area of Concern

6.1 Background

Under the GLWQA, originally signed by the US and Canada in 1972, fourteen AOCs were identified within the state of Michigan. As defined by the GLWQA, AOCs are "[…] geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life" (USEPA). Under the agreement, the Kalamazoo AOC is listed as containing eight of a possible 14 beneficial use impairments (BUIs). The original remedial action plan (RAP), drafted in 1987 and redrafted in 1998 was prepared to identify and address the status of the eight Kalamazoo River AOC BUIs. Per the GLWQA, the RAP is updated every three years by the Michigan Department of Environmental Quality (MDEQ) Office of the Great Lakes (OGL), in cooperation with the USEPA Great Lakes National Program Office. At present, two of the eight BUIs identified for the Kalamazoo River AOC have been removed (McCarthy, 2014).

Additionally, in 1990 the Kalamazoo AOC site was added to the USEPA national priorities list (NPL) per the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Under CERCLA, the USEPA divided the Kalamazoo River Superfund site into five operable units (OUs) (MDEQ-OGL, 2012). The OUs are as follows:

- OU #1, Allied Paper Property/Bryant Mill Pond Area;
- OU #2, Willow Boulevard and A-Site Landfill;
- OU #3, King Highway Landfill;
- OU #4, 12th Street Landfill; and
- OU #5, Portage Creek and Kalamazoo River sediments

To date, records of decision (ROD) have been reached for OUs 2, 3, and 4. With each completed ROD, the remedy selected has been a landfill with a cap (MDEQ-OGL, 2012). In addition, a number of time critical removal actions (TCRA) have taken place to remove PCB hot spots where direct contact threats were realized. AOC landfill locations are illustrated in Figure-16.

6.2-Conservation Strategy in AOC

Given the positioning of the OUs in relation to the Kalamazoo River and the different land use patterns in the area, land conservation goals in and around the Kalamazoo River AOC differ from conservation goals for the watershed as a whole. As a result of numerous TCRAs and the current RODs in place, it is understood that many of the sites associated with the AOC will no longer serve as functional landscapes in an ecological or recreational sense (KRWC, 2009). As evidenced by Table-14 below, future projections show approximately 85 acres of land will have restrictive land use controls associated with the landfill/cap remedies chosen for the respective sites. These landfills are located along the stream banks of Portage Creek and the mainstem of the Kalamazoo River. Historically, these lands were mixed hardwoods and wooded wetlands, as illustrated in Table-14.

As such, the conservation strategy in and around the Kalamazoo River AOC focuses on mitigating the impacts from hydrologically and ecologically isolating these OUs, by permanently conserving lands in and around the Kalamazoo River AOC that offer ecological and recreational benefits to the river. Local stakeholders and state and federal agencies proposed a 1:2 habitat lost to replacement ratio (KRWC, 2009). This ratio, which is directly derived from the MDEQ – Water Resources Division (WRD) wetland mitigation strategy, will be utilized as a benchmark in evaluating the success of conservation strategies in and around the AOC. It is understood by the planning team that the conservation acreage goals are subject to change, especially as the extents of all OUs are further delineated.

Table - 14: AOC Land Conservation Goals

Operable Unit	Acreage Lost	Conservation Acreage Goal	Pre-settlement land cover	Acreage Replaced to Date
OU#1	22	44	Mixed Oak Savanah	none
OU#2	33	66	Mixed Hardwood Swamp	none
OU#3	23.2	46.4	Mixed Hardwood Swamp	none
OU#4	6.5	13	Mixed Hardwood Swamp	none
Total	84.7	169.4		0

6.3 AOC Conservation Methods and Results

Conservation criteria and model outputs, as described in Sections 2.0 and 4.0 respectively were used in evaluating the conservation potential for parcels in and around the AOC. For the purposes of the KRWLCP, special attention was given to the spans of river stretching from the southernmost landfill (OU#1) to the northernmost landfill (OU#4), as depicted in Figure-16. This includes segments of Portage Creek and the mainstem of the Kalamazoo River. In order to evaluate the conservation suitability of parcels in this region, a 3,000 foot buffer was created using ArcGIS, around the subject stretch of river. Within the 3,000 foot buffer, an examination identical to the HUC analysis was conducted; the analysis identified the total of parcels and acreage scoring in the top 20% (Tier 1 and Tier 2).

Within the AOC buffer, approximately **130 parcels** scored in the top 20% of scoring parcels, containing approximately **5,900 acres**. The grand mean for the top 20% of scoring parcels in the AOC buffer was approximately 50.45, which is slightly higher than the grand mean for the watershed as a whole. The highest scoring parcel in the AOC buffer was 65.72. The top 20% of scoring parcels within the AOC are illustrated in Figure-17. Of the 130 parcels identified in the top 20%, **seven parcels** were identified in the top 100 scoring parcels, identified in Section 5.1. These seven parcels are highlighted in Attachment-2.

7.0-Discussion and Outreach

The results described in Section 5 provide a snapshot of conservation targets developed from the KRWLCP. The primary unit of focus of this plan was ownership parcels but these are not easy to succinctly include in a report. As a result (and with the exception of the top 100 of these parcels) specific priority conservation parcels are not individually identified in this report. To compensate for this, a database of these priority parcels, described in Section 5.2, was created to house this information. Organizations and individuals interested in pursuing these conservation targets should contact either the KRWC or the SWMLC to acquire a copy of this database. In addition to providing these concrete conservation targets, this plan can be thought of as a “jumping off” point for future conservation efforts. In particular, the subwatersheds identified as priorities can be thought of in this way and represent excellent candidates for future study and planning.

In the short term, to provide for the immediate implementation of the KRWLCP, the SWMLC and other project partners plan to conduct targeted mailings to high priority land owners. Initial contact will be made using a suite of postcards developed by the planning team, addressing specific natural features found on a targeted parcel (Attachment-4 for postcard examples). In addition, the SWMLC plans to hold several outreach meetings annually for owners of high priority parcels. These meetings will serve to provide information to landowners regarding conservation options available to them.

While it is believed by the planning team that those parcels and subwatersheds identified by the conservation model represent quality targets for future land conservation efforts, it is also understood that local conservation efforts should take into consideration local environmental and socioeconomic conditions when identifying priority lands. Additionally, the conservation model utilizes the appropriate GIS data layers available at the time it was constructed. As data layers are updated and new criteria relevant to water quality are made available as spatial data, the conservation model should be re-evaluated and the addition of new/relevant GIS data should be considered. It is recommended that the KRWLCP be reviewed and potentially updated on schedule with revisions to the KRWMP. In this sense, the KRWLCP should serve as a working or "living" plan that continually evolves based on shifting conservation values and realities.

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Software:

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Data Layers:

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Conservation and Recreation Lands (CARL), Ducks Unlimited, http://www.ducks.org/conservation/glaro/carl-gis-layer

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2006 Coastal Change Analysis Program, provided by MDEQ, Water Resources Division – Wetlands, Lanes, and Streams Unit

The following layers provided by Michigan Geographic Data Catalog (MiGDL), http://www.mcgi.state.mi.us/mgdl/:

Inland Lakes Assessment Units
Stream Rivers Assessment Units
MI Geographic Framework All Roads (v13a)
MI Geographic Framework Cities (v13a)
MI Geographic Framework State Roads (v13a)
MI Geographic Framework Counties (v13a)
Watershed Boundary – 12 Digit
Watershed Boundary – 8 Digit

Additional Conserved Lands provided by:

Southwest Michigan Land Conservancy
Mid-Michigan Land Conservancy
Michigan Nature Association
Land Conservancy of West Michigan

Parcel Data

Ottawa County Ownership Parcels, Ottawa County GIS Department, gisdept@miottawa.org. West Olive, MI

Kent County Ownership Parcels, accessKent GIS Data Library, https://www.accesskent.com/GISLibrary/#Parcels&Streets. Grand Rapids, MI

Hillsdale County Ownership Parcels, Hillsdale County Equalization & Land Information, http://www.hillsdalecounty.info/equalization.asp. Hillsdale County, MI

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Barry County Ownership Parcels, Land Information / IT Services, http://www.barrycounty.org/directory/. Hastings, MI

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Figure-1

Site Map

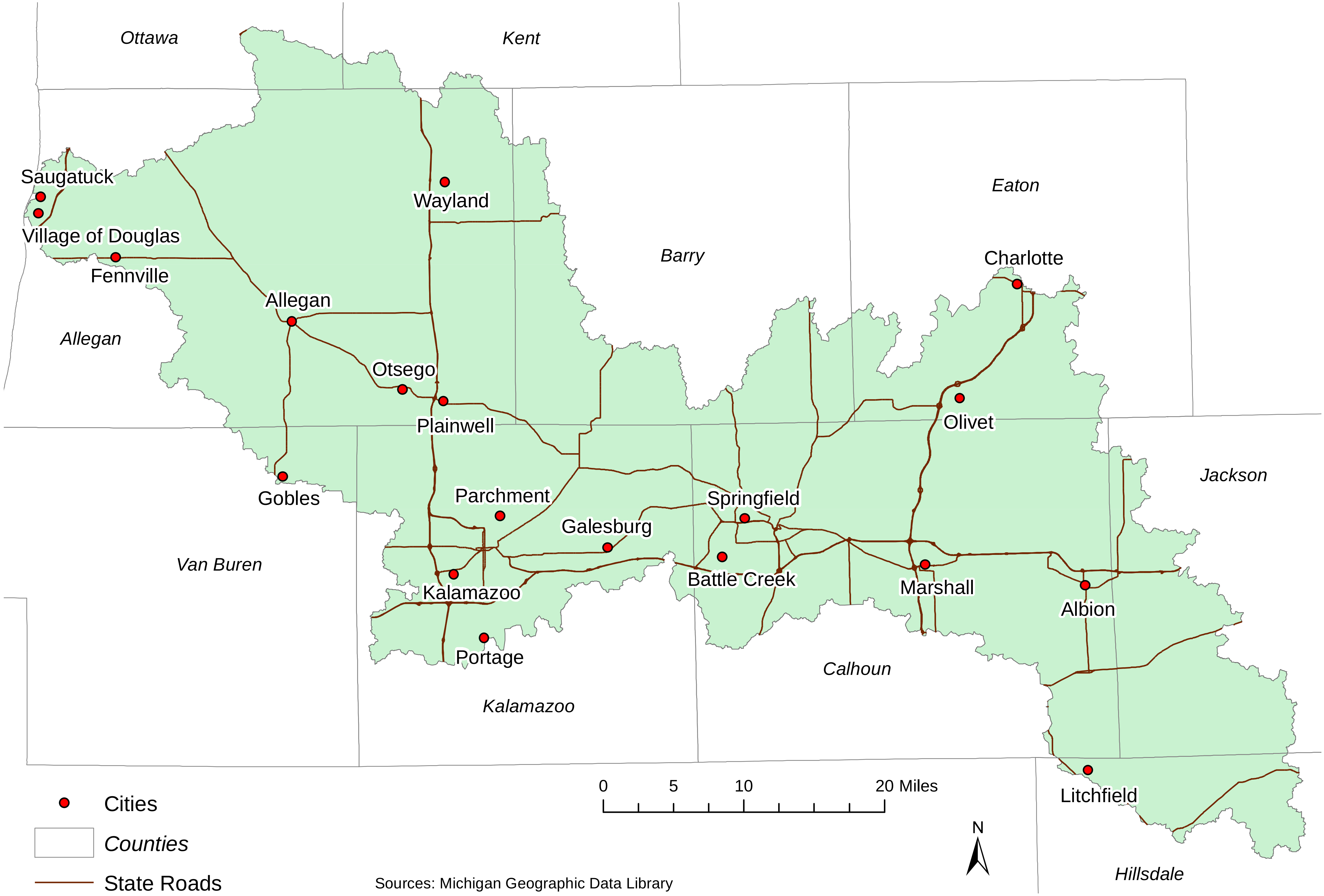
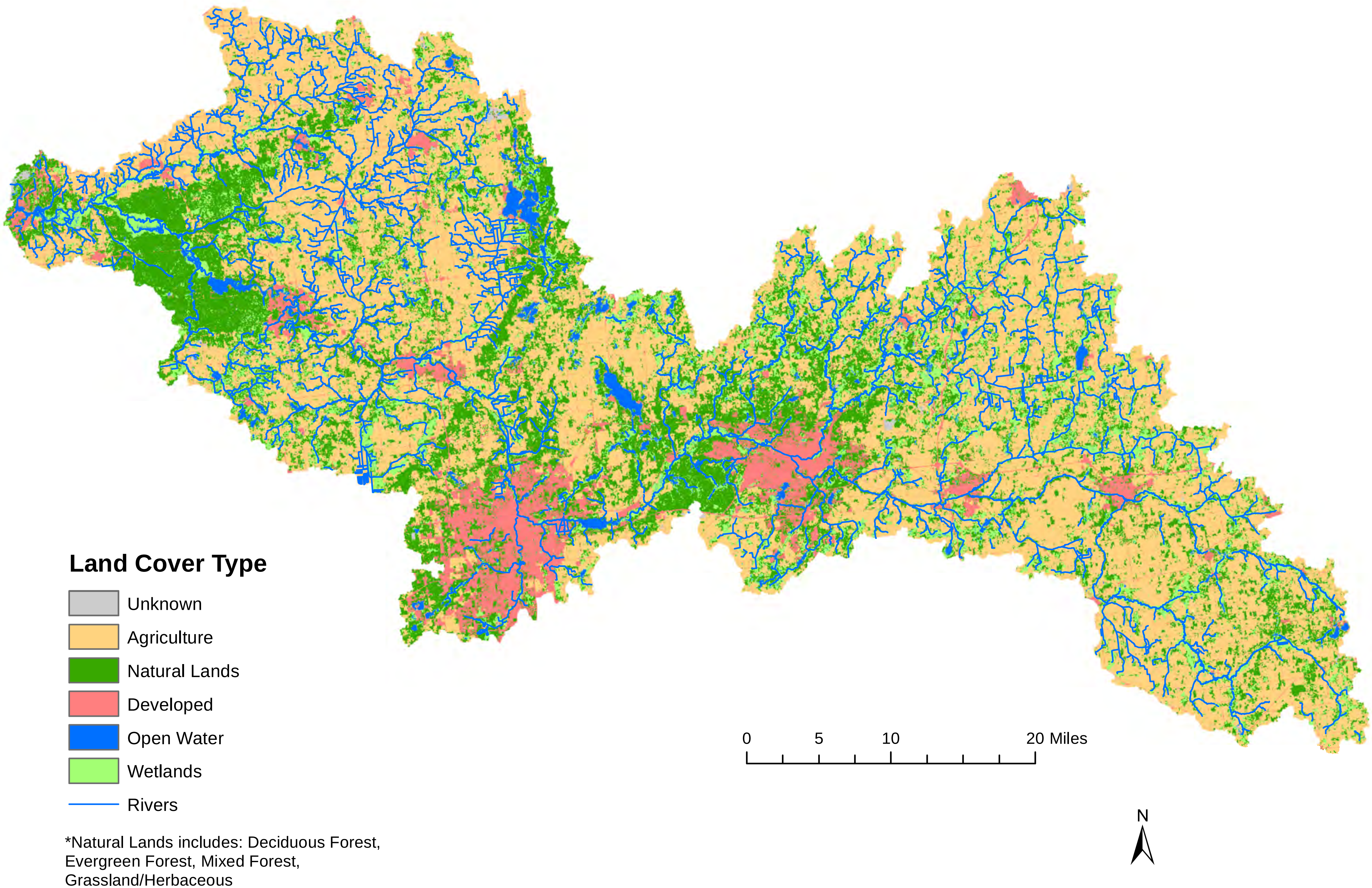


Figure-2

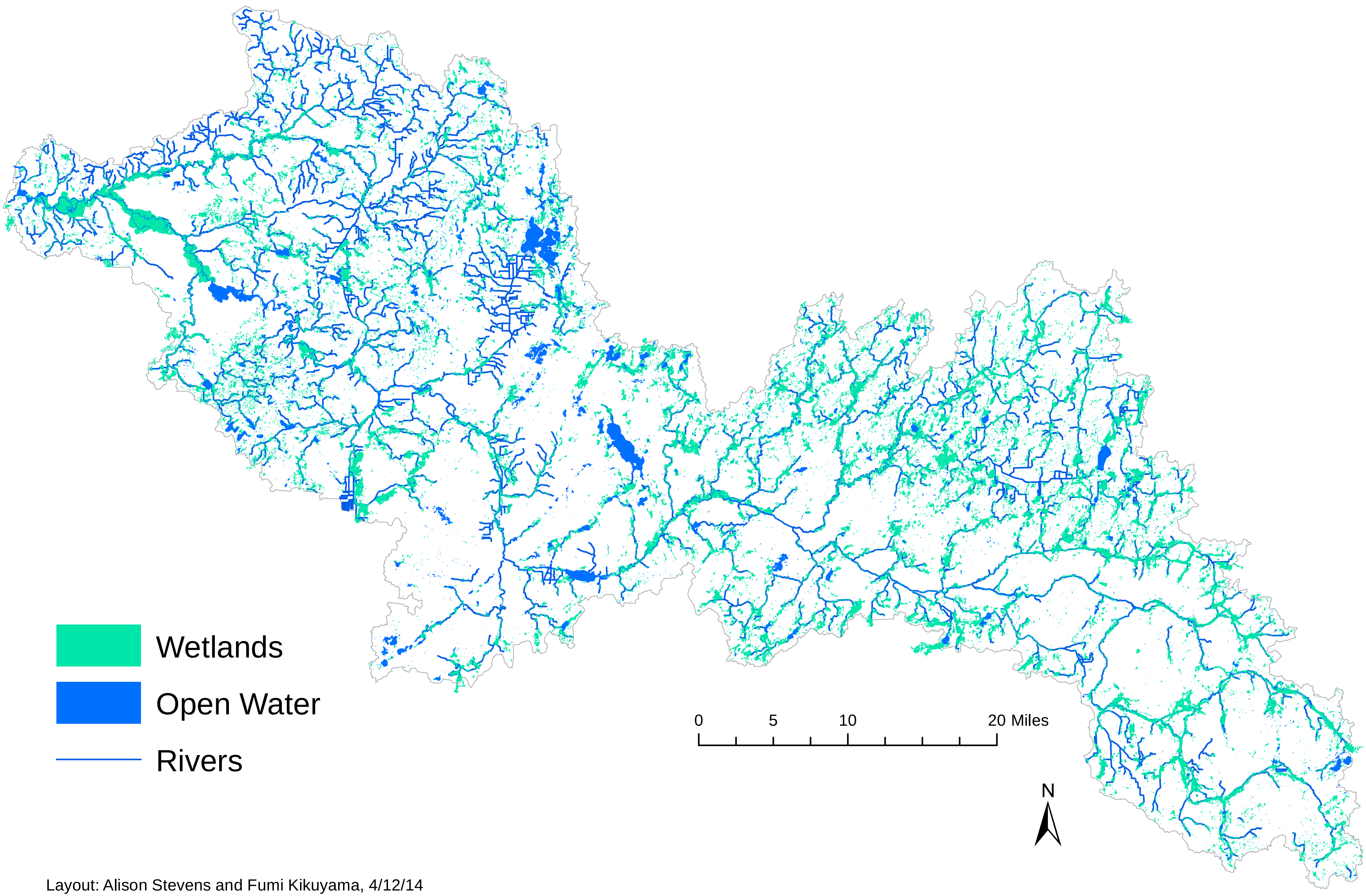
Kalamazoo River Watershed Land Cover Types



Alison Stevens and Fumi Kikuyama, 4/9/14
Source: MiDEQ, MiGDL

Figure-3

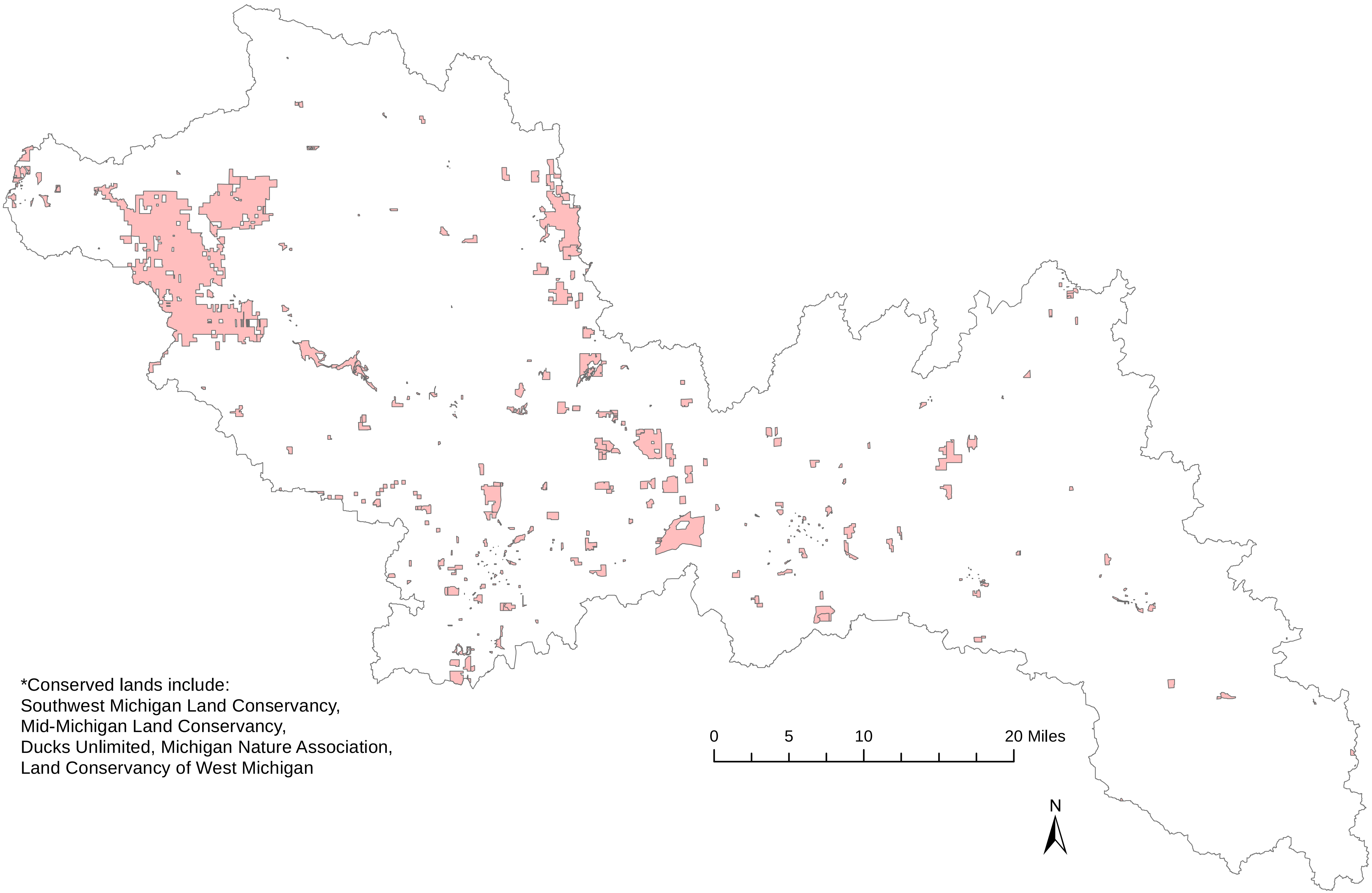
Kalamazoo River Watershed Wetlands



Layout: Alison Stevens and Fumi Kikuyama, 4/12/14
Sources: MDEQ, MiGDL

Figure-4

Kalamazoo River Watershed Conserved Lands

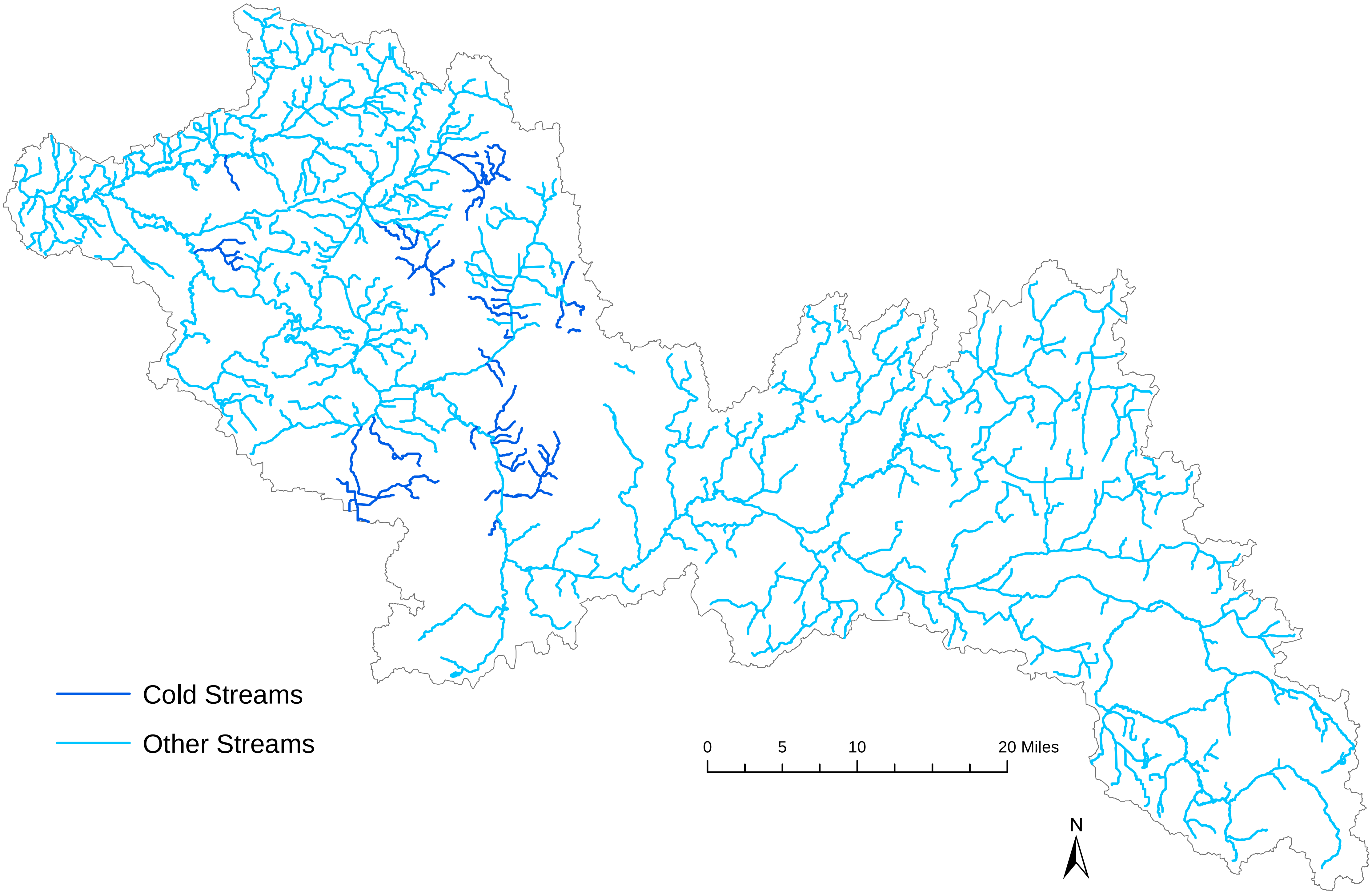


*Conserved lands include:
Southwest Michigan Land Conservancy,
Mid-Michigan Land Conservancy,
Ducks Unlimited, Michigan Nature Association,
Land Conservancy of West Michigan

Layout: Alison Stevens and Fumi Kikuyama, 4/12/14
Sources: SWMLC, MMLC, DU, MNA, LCWM

Figure-5

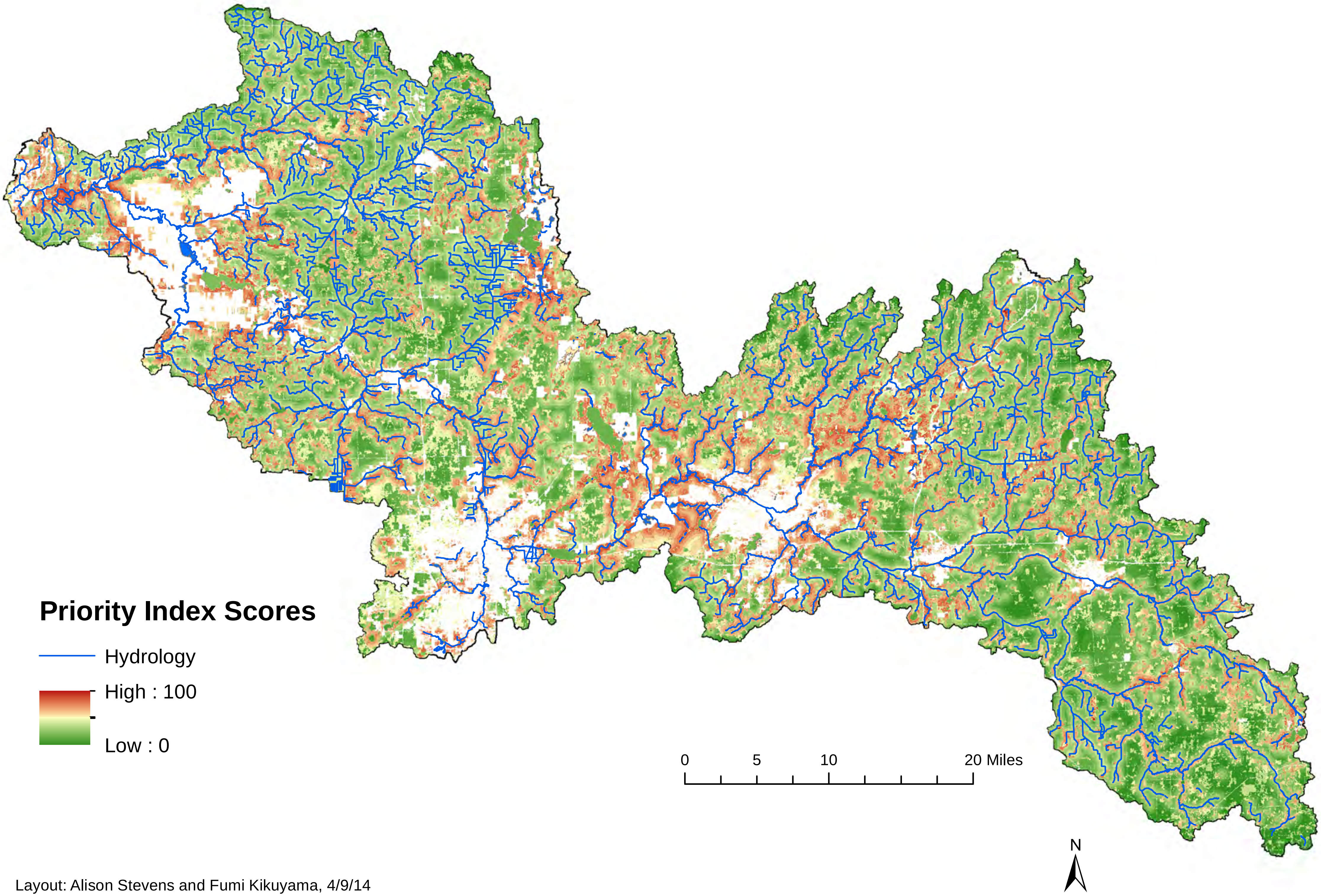
Kalamazoo River Watershed Cold Streams



Layout: Alison Stevens and Fumi Kikuyama, 4/12/14
Sources: MiGDL

Figure-6

Kalamazoo River Watershed Priority Index Map



Layout: Alison Stevens and Fumi Kikuyama, 4/9/14
Sources: MiGDL, MiDEQ, Ducks Unlimited, SWMLC, Michigan Nature Association, MSU Extension

Figure-7: Model Builder/Raster Analysis

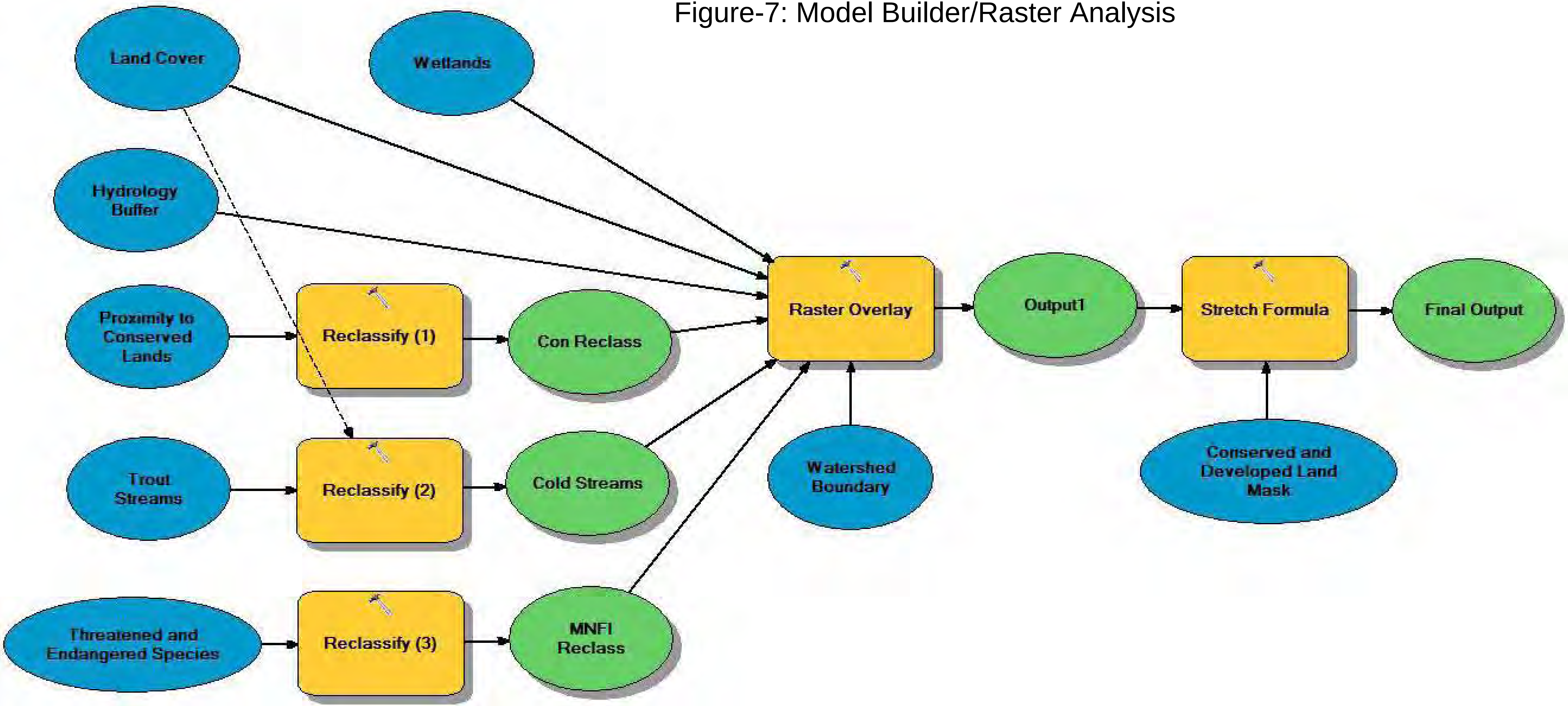
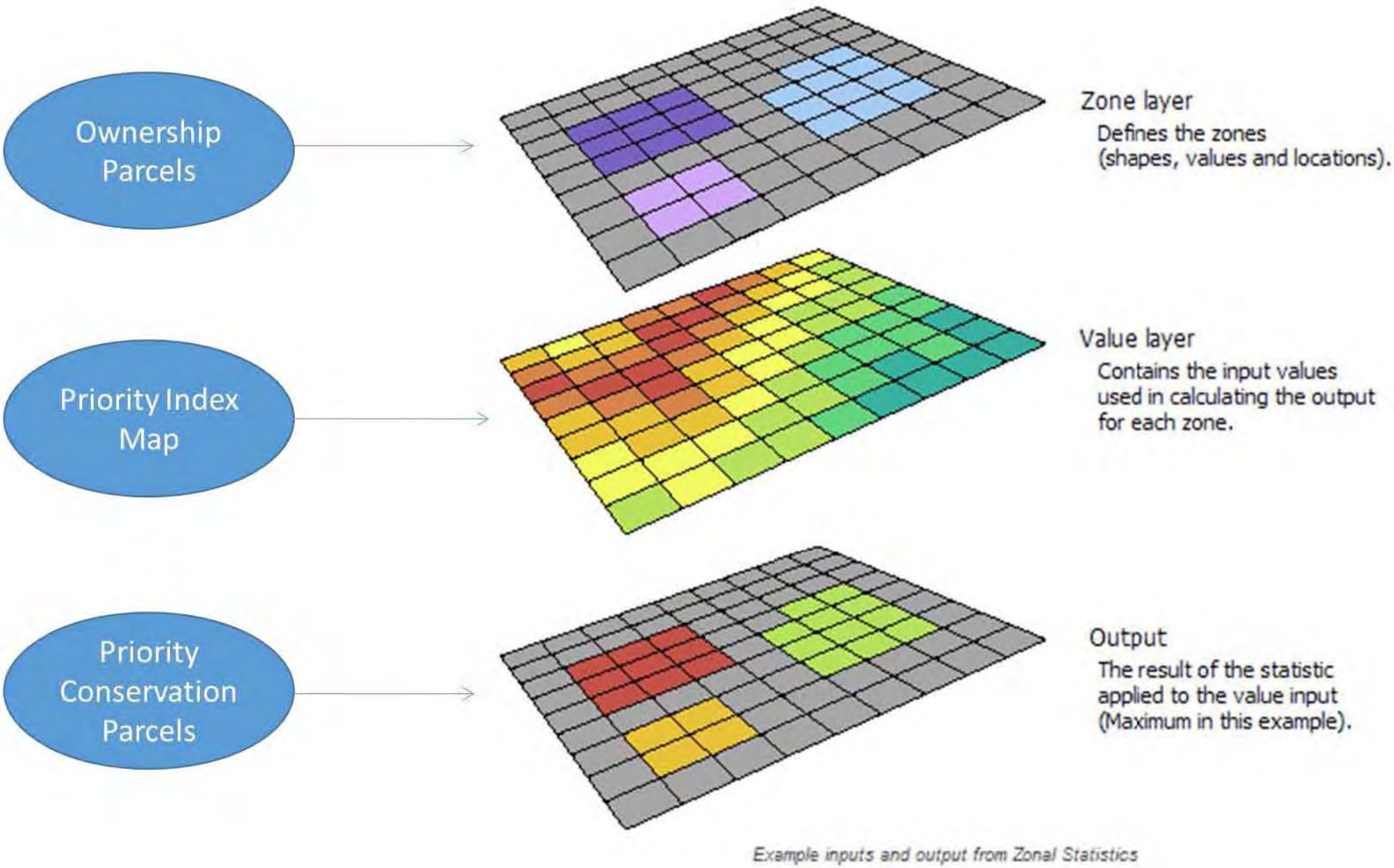


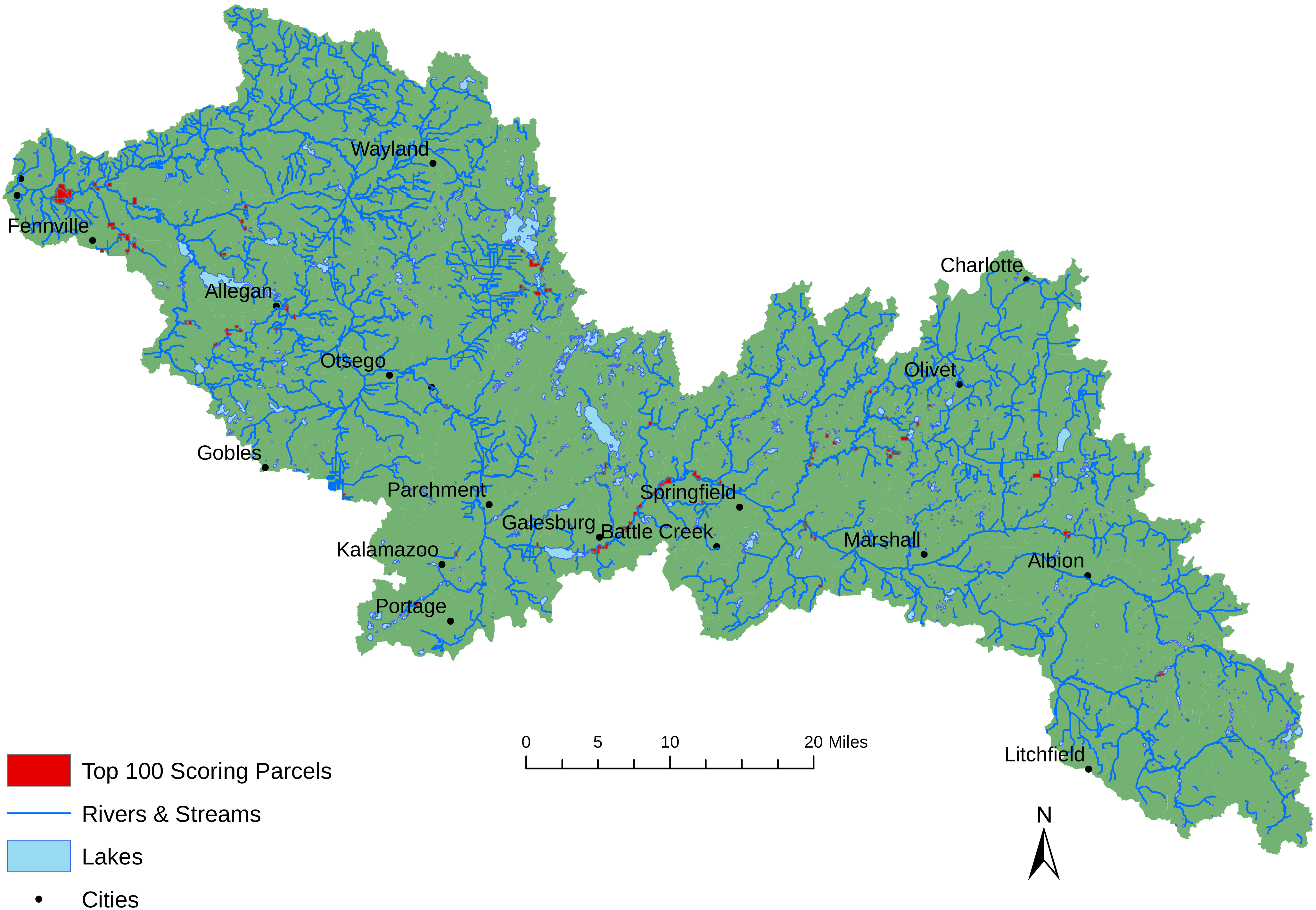
Figure-8: Zonal Statistics Diagram



Source:ArcGIS Help
Library 10.0

Figure-9

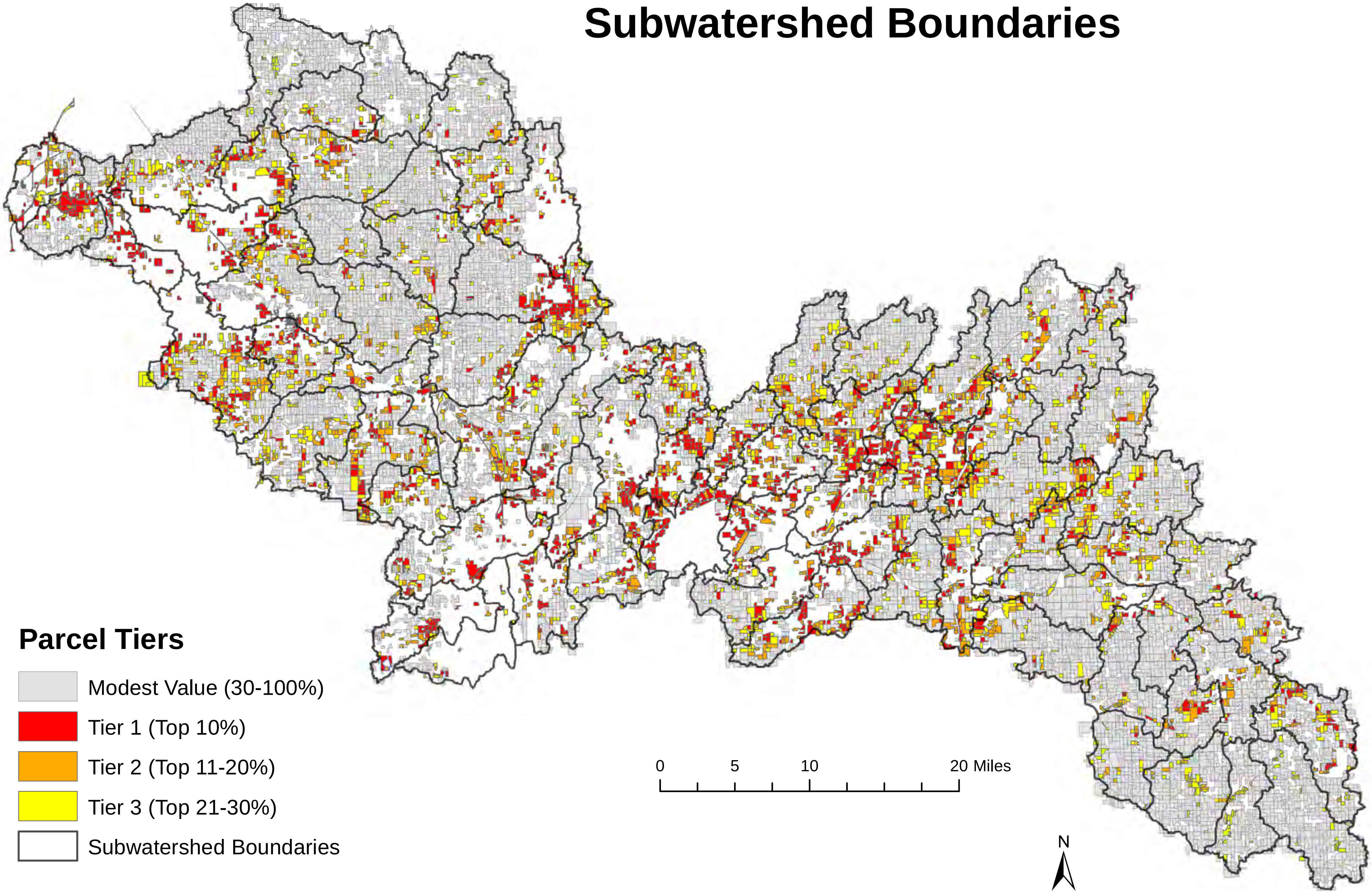
Top 100 Scoring Parcels



Layout: Ben Sasamoto, 4/16/2014
Source: Kalamazoo River Watershed County Contacts and Websites, MiGDL

Figure-10

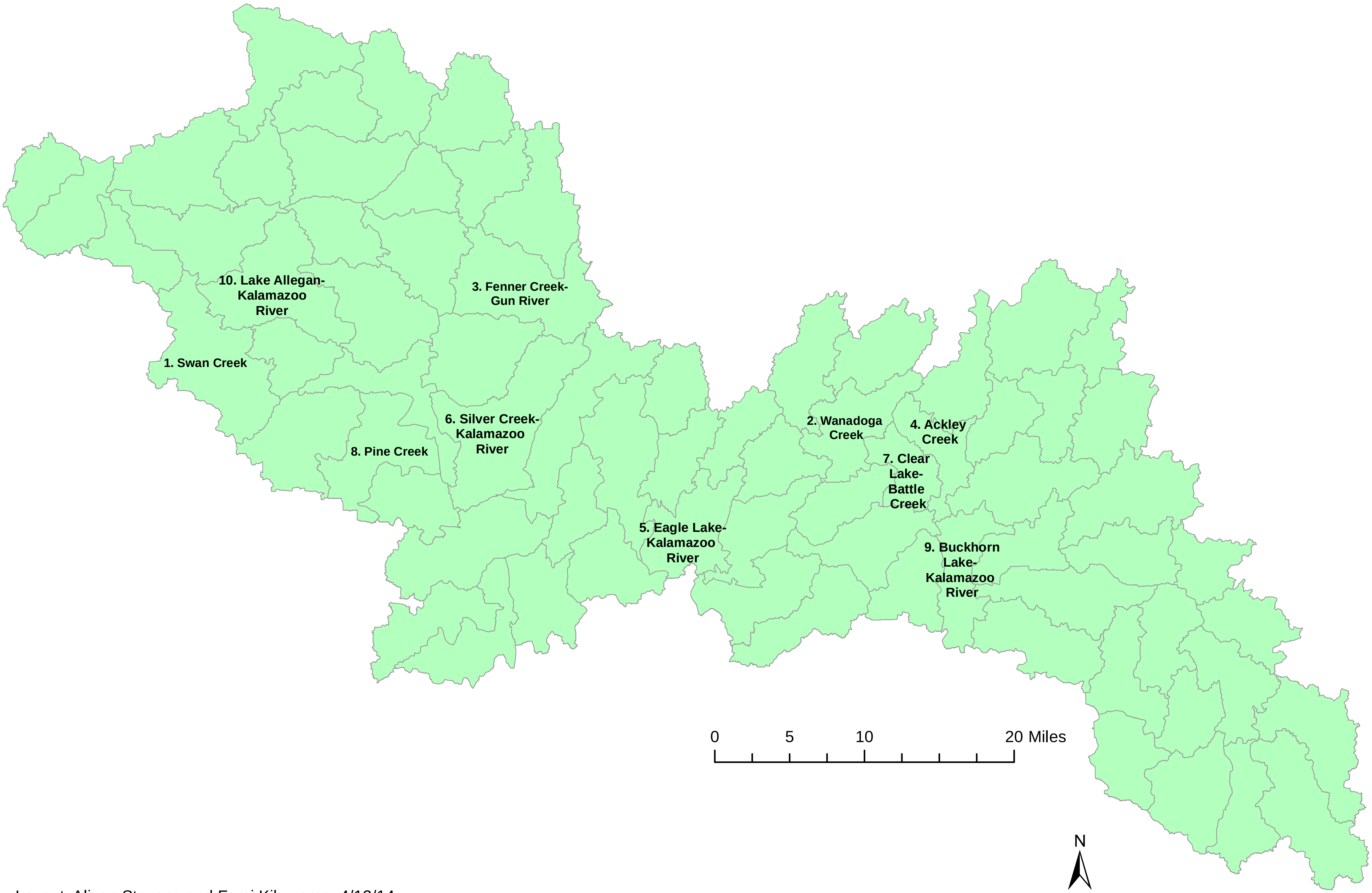
Kalamazoo River Watershed Parcel Tiers and Subwatershed Boundaries



Layout: Alison Stevens and Fumi Kikuyama, 4/9/14
Sources: Kalamazoo River Watershed County Contacts and Websites, MiGDL

Figure-11

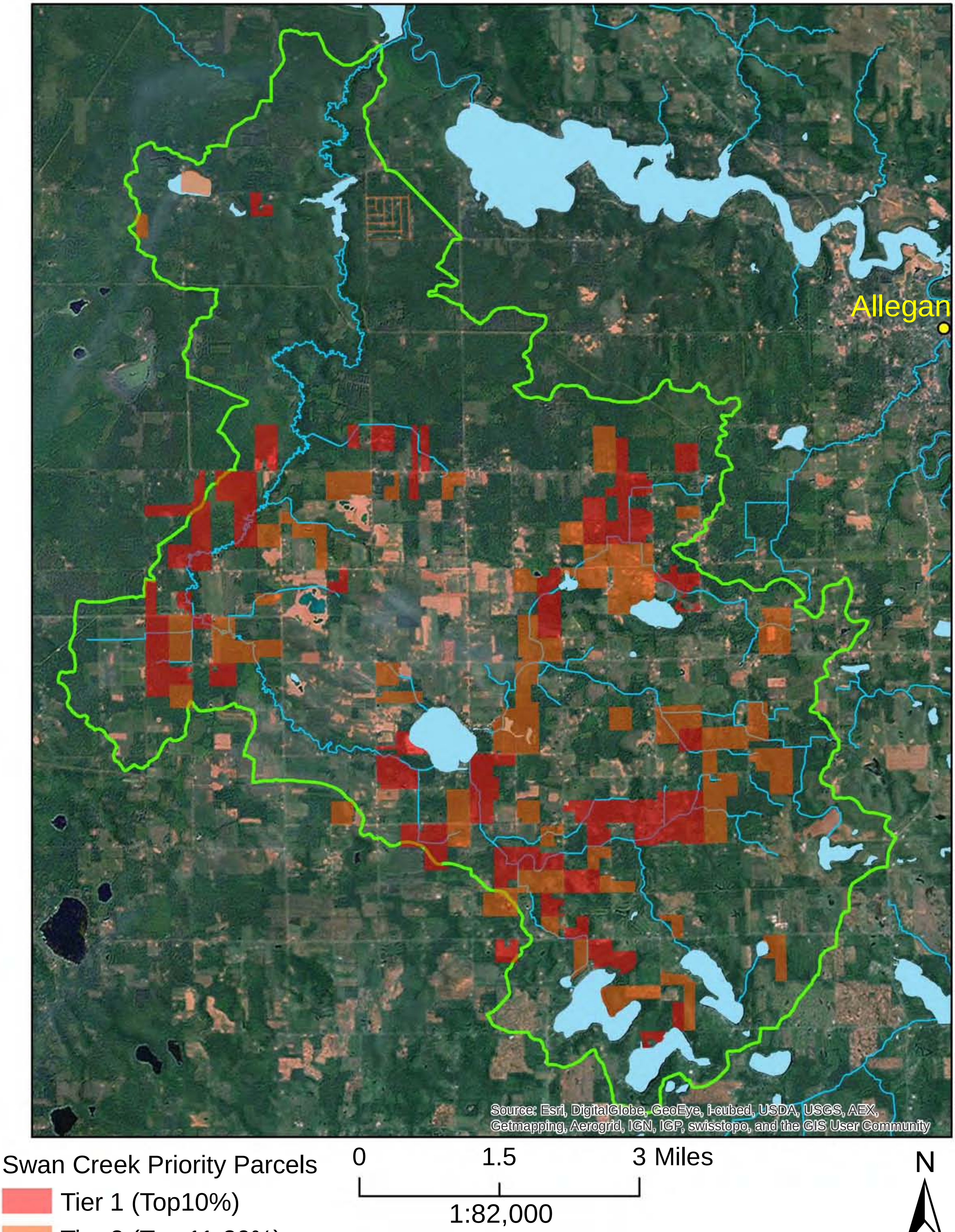
Kalamazoo River Watershed - Top 10 Scoring Subwatersheds



Layout: Alison Stevens and Fumi Kikuyama, 4/12/14
Sources: MiGDL

Swan Creek Subwatershed

Figure-12

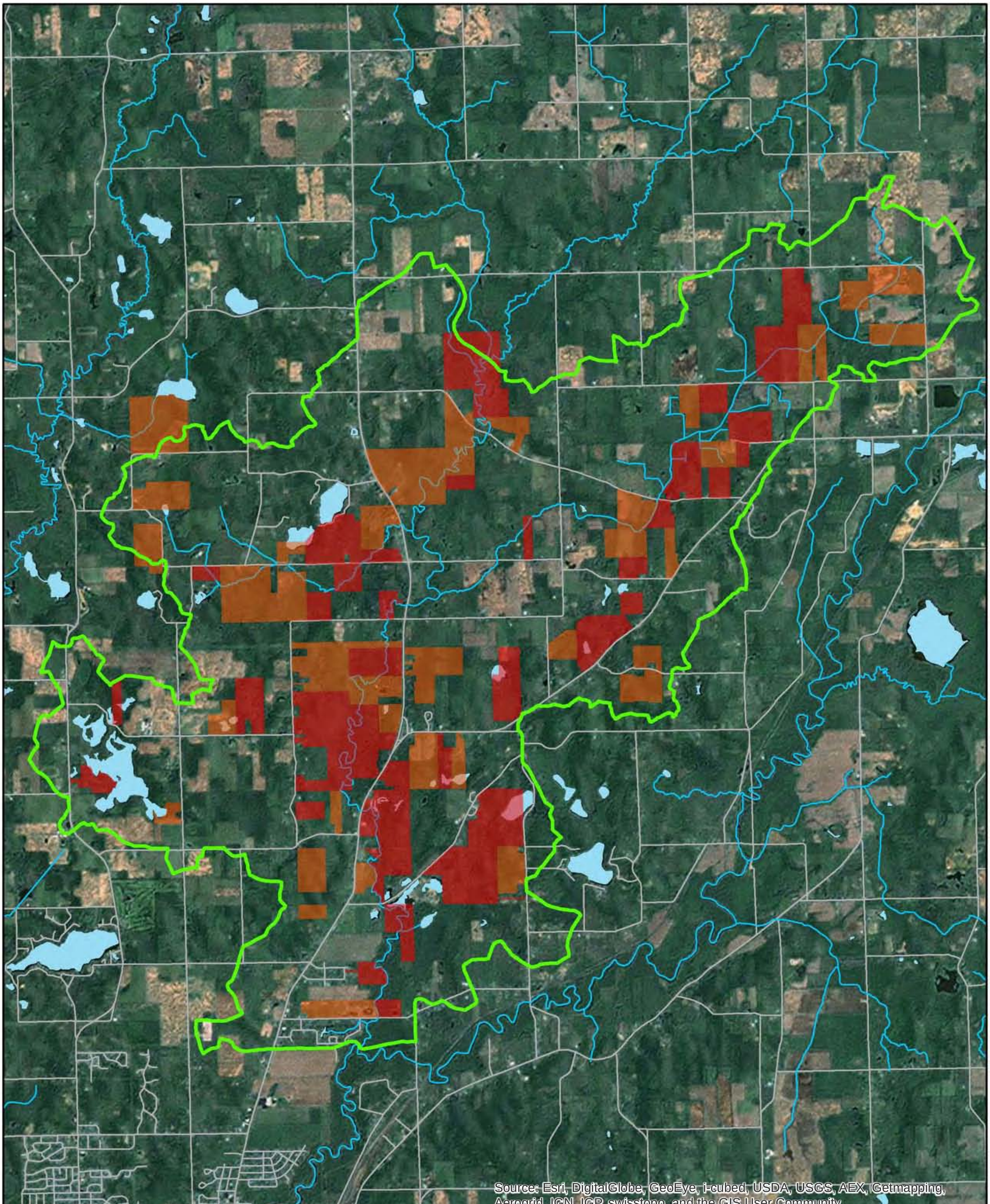


Layout: Kyle Alexander 4/20/14

Source: Framework - MiGDL, Google Maps

Figure-13

Wanadoga Creek Subwatershed



Wanadoga Creek Priority Parcels

Tier 1 (Top 10%)

Tier 2 (Top 11-20%)

0 0.75 1.5 3 Miles

1:65,000

N

Figure-14

Fenner Creek-Gun River Subwatershed

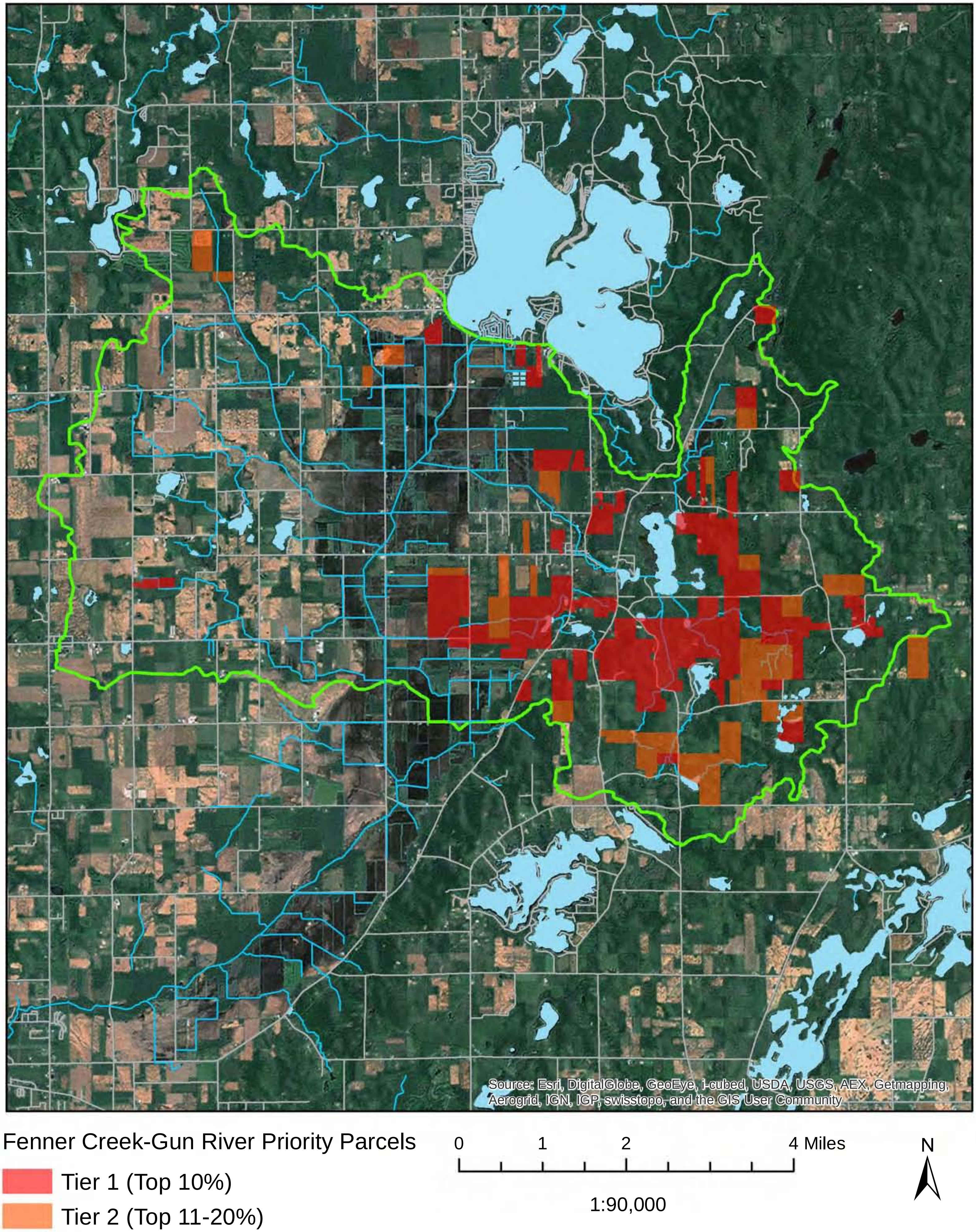
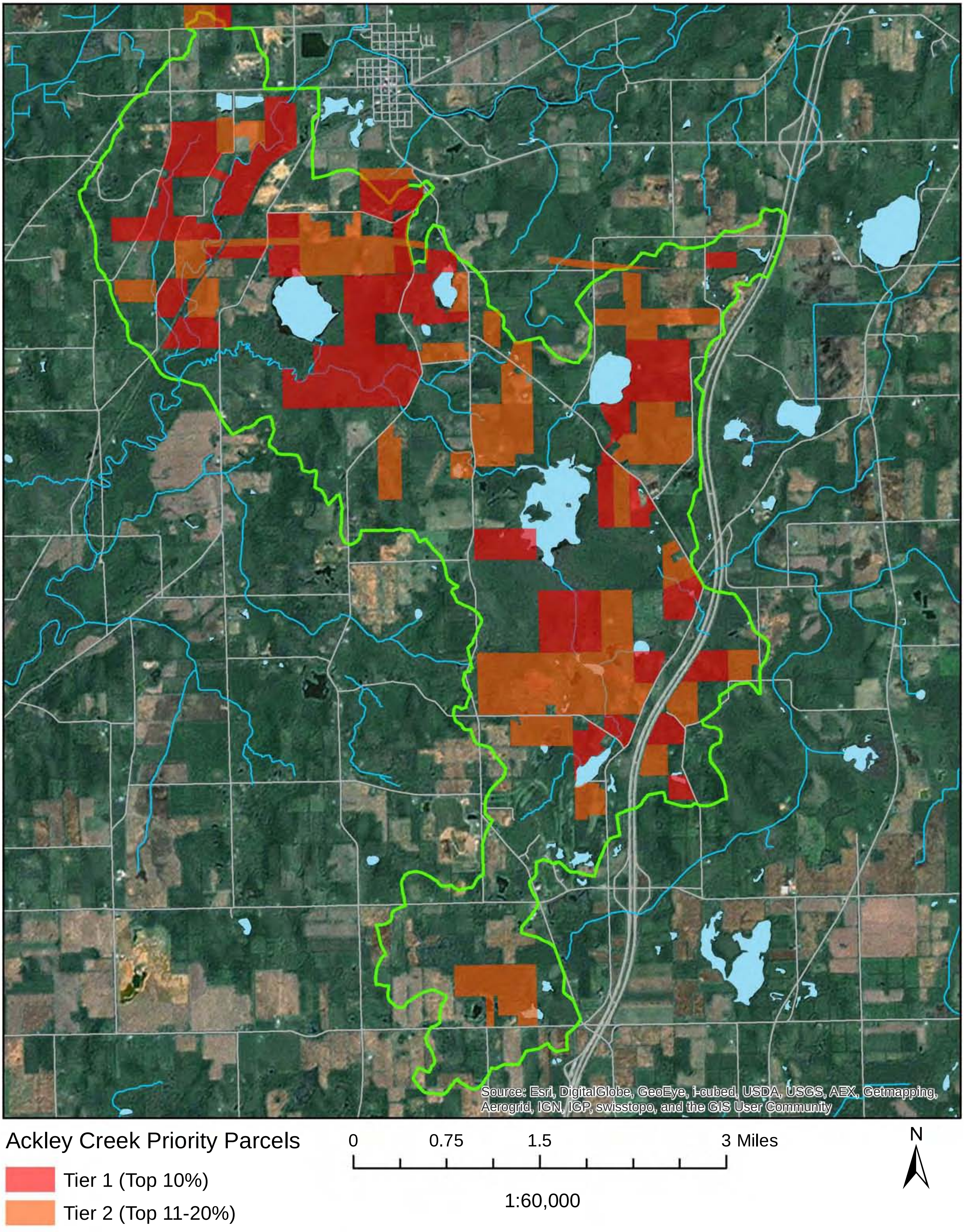
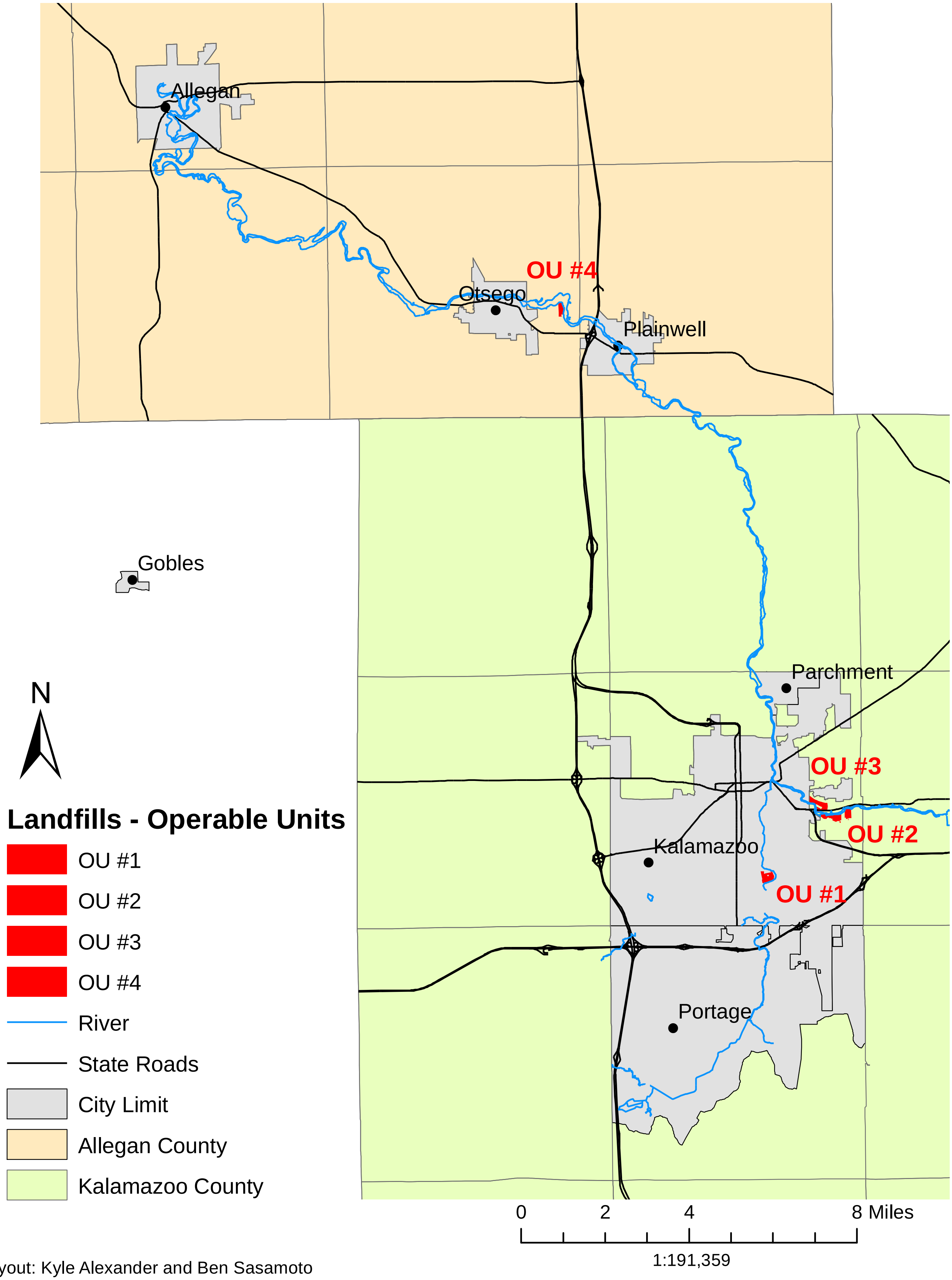


Figure-15

Ackley Creek Subwatershed



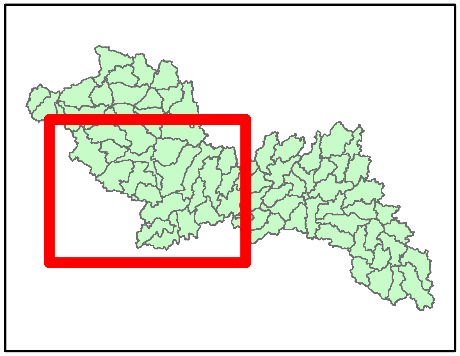
Kalamazoo River - AOC Operable Units



Layout: Kyle Alexander and Ben Sasamoto
Source: Kalamazoo and Allegan County Framework -MIGDL,
Landfill Locations - Google Maps

Figure-17

AOC Priority Conservation Parcels

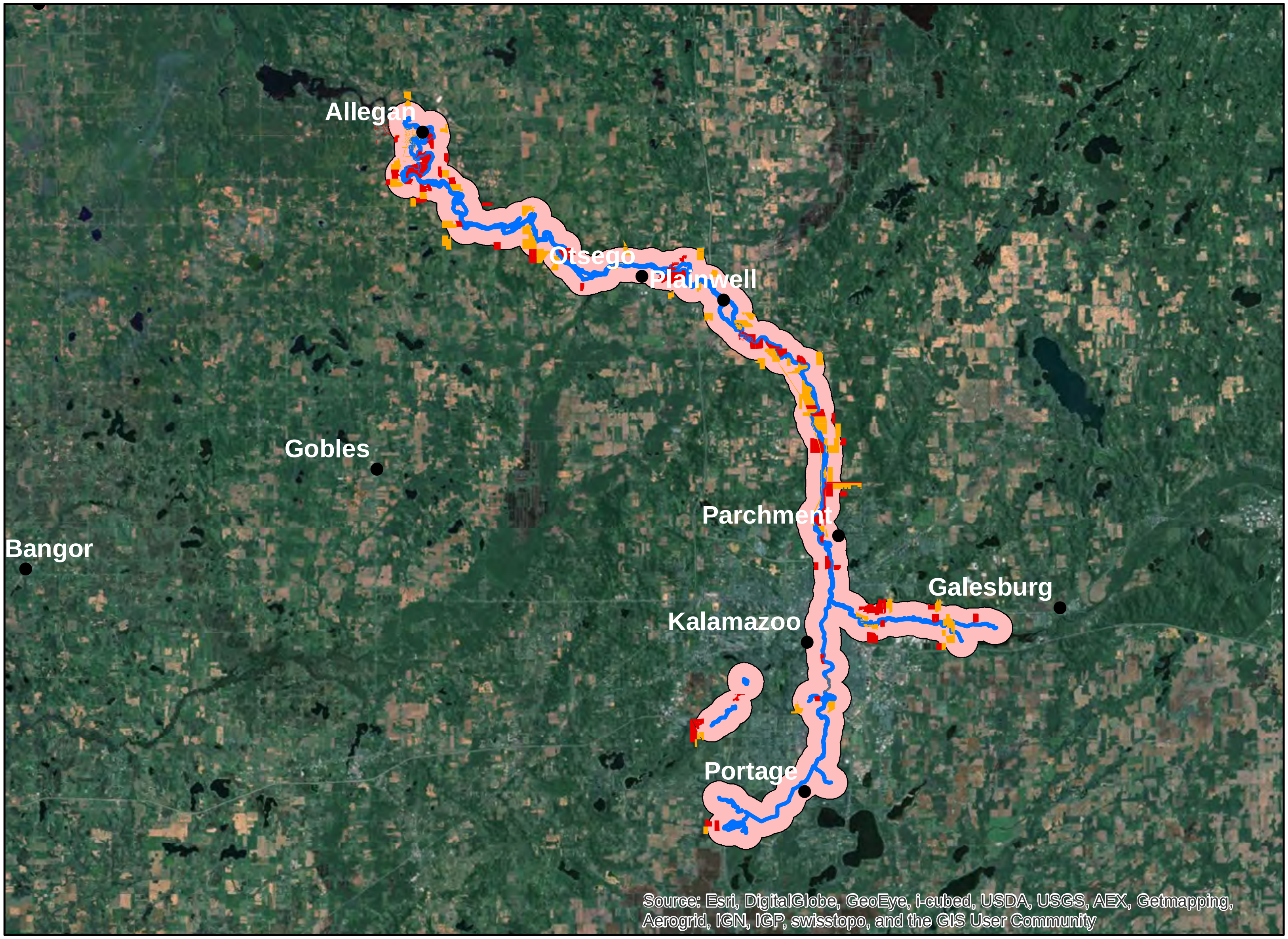


- Cities
- Kalamazoo River
- 3000 AOC Foot Buffer

Parcels

- Tier 1 (Top 10% of Scores)
- Tier 2 (Top 11-20% of Scores)

N



0 4 8 16 Miles

Layout: Ben Sasamoto 4/16/2014
Source: Kalamazoo River Watershed County Contacts and Websites, MiGDL

Attachment 1: June 2013 Stakeholder Attendees

Last	First	Organization	Email
Adams	Lee	Kalamazoo Co Dept of Planning & Community Development	laadam@kalcounty.com
Alexander	Kyle	SNRE	kydoran@umich.edu
Buckham	Kathy	Kalamazoo Conservation District	kathy.buckham@mi.nacdnet.net
Binoniemi-Smith	Liz	Gun Lake Tribe	eabinoniemi@mbpi.org
Bronson	Tracy	Calhoun Conservation District	tracy.bronson@macd.org
Coury	Jim	Kalamazoo River Watershed Council	Coury.James@yahoo.com
Cramer	Dane	Ducks Unlimited	dcramer@ducks.org
Crowley	Patricia	Kalamazoo County Drain Commissioner	pacrow@kalcounty.com
Eichorst	Tiffany	City of Battle Creek	taeichorst@ci.battle-creek.mi.us
Hamilton	Stephen	MSU Kellogg Biological Station	hamilton@kbs.msu.edu
Hammond	Charlotte	Trout Unlimited-Kalamazoo Chapter	Charlotte.hammond23@gmail.com
Hohm	Janelle	DEQ	HohmJ@michigan.gov
Kieser	Mark	Kieser & Associates	mkieser@kieser-associates.com
Kirkwood	Julia	DEQ	KIRKWOODJ@michigan.gov
Krauss	Bri	Audubon Society	bri@michiganaudubon.org
Mackay	Mark	DNR	mackaym@michigan.gov
McCarthy	Jamie	Kalamazoo River Watershed Council	krwc@kalamazooriver.org
Micklin	Philip	SWMLC board	philip.micklin@wmich.edu
Reding	Sarah	Kalamazoo Nature Center	sreding@naturecenter.org
Reed	Bill	The FORUM of Greater Kalamazoo	ForumofKal@gmail.com
Richards	Michele	Fort Custer	michele.richards@us.army.mil
Riley	John	DEQ	RILEYJ2@michigan.gov
Sanders	Jerrod	DEQ - Kalamazoo District Assistant Supervisor	sandersj3@michigan.gov
Sasamoto	Ben	SNRE	btsa@umich.edu
Schieber	Mark	Allegan Conservation District	mark.schieber@macd.org
Scholtz	April	Land Conservancy of West Michigan	april@nearbynature.org
Schultz	Matt	Michigan Nature Association, Regional Stewardship Organizer	MSchultz@michigannature.org
Simons	Jessica	Potawatomi RC&D Council	j.m.simons@hotmail.com
Smith	Sigrid	University of Michigan - SNRE	sdpsmith@umich.edu
Stevens	Ali	SNRE	aliwstev@umich.edu
Ter Louw	Peter	Southwest Michigan Land Conservancy	terlouw@SWMLC.org
Wager	Gary	Kalamazoo River Cleanup Coalition	glwager@gmail.com
Wilke	Emily	Southwest Michigan Land Conservancy	ewilke@swmlc.org
Zbiciak	Rob	DEQ - Wetlands	zbiciakr@michigan.gov

Attachment 2: Top 100 Parcels

Rank	Parcel Owner(s)	Mean Score	Parcel Address	Owner Address	Subwatershed Name	Area (Acres)
1	FLAMM PROPERTIES BATTLE CREEK LLC.	69.17	97 Kenosha Battle Creek, MI 49014	8282 North 27th Street Richland, MI 49083	Willow Creek-Kalamazoo River	61.0
2	POTTAWATOMIE CLUB	65.96	Kalamazoo River Marsh	638 Cascade Hills Hollow SE Grand Rapids, MI 49546	Peach Orchid Creek-Kalamazoo River	33.1
3	JR INVESTMENT GROUP LLC	65.72	113th Ave	1848 M-40 Allegan, MI 49010	Lake Allegan-Kalamazoo River	30.0
4	STS HYDROPOWER LTD	65.00	Miller Drive	14550 N Frank Lloyd Wright Blvd 210 Scottsdale, AZ 85260	City of Galesburg-Kalamazoo River	20.9
5	WINKLE TERRY & LOUANNE	64.12	2830 Baseline RD	916 Brownell SE Grand Rapids, MI 49508	Silver Creek-Kalamazoo River	20.1
6	HEWITT WILLIAM & CARRIE	64.11	14 Mile Road Battle Creek, MI 49014	21114 14 Mile RD Battle Creek MI 49014	Clear Lake-Battle Creek	20.2
7	MERVENNE ARTHUR J JR	64.03		5663 N Lakeshore Drive Holland, MI 49424	Peach Orchid Creek-Kalamazoo River	33.9
8	SYLVESTER PATRICIA A	63.97		S Helmer Rd Battle Creek, MI 49015	Minges Brook	22.7
9	HOWARD CHRISTOPHER & DEBRA	63.88		12929 Fort Custer Drive Galesburg, MI 49053	Eagle Lake-Kalamazoo River	24.6
10		63.70			Tannery Creek-Kalamazoo River	22.5
11	BLACKMORE WILLIAM	63.67	Guernsey Lake RD	9615 W Keller Rd Delton, MI 49048	Fenner Creek-Gun River	30.1
12	EMMONS ROBERT & ROSALIE	63.62	Miller Drive	10461 Miller Dr Galesburg, MI 49053	Eagle Lake-Kalamazoo River	35.0
13	PLOTTS WAYNE JR & SIBYL	63.55	13234 Augusta Drive Augusta, MI 49012	13234 Augusta Drive Augusta, MI 49012	Eagle Lake-Kalamazoo River	42.5

14	VILLAGE OF AUGUSTA	63.48			Eagle Lake-Kalamazoo River	42.7
15	WRIGHT LEO J & DOROTHY A /TRUST	63.45		2335 B Drive South Climax, MI 49034	Minges Brook	21.3
16	EASON RICHARD JR & MARTHA	63.19		10221 Guernsey Lake RD Box 472 Shelbybille, MI 49344	Fenner Creek-Gun River	39.8
17	BLAKESLEE RICHARD & JILLYNE	63.18	576 Streamside Dr Galesburg, MI 49053	576 Streamside Dr Galesburg, MI 49053	City of Galesburg-Kalamazoo River	51.0
18	GARDNER MARK V & WILLIAM A	63.05	Ceresco, MI 49033	464 Grace St Northville, MI 48167	Harper Creek	26.7
19	POTTAWATOMIE CLUB	63.02	Kalamazoo River Marsh	638 Cascade Hills Hollow SE Grand Rapids, MI 49546	Peach Orchid Creek-Kalamazoo River	54.8
20	TERBURG MARILYN M	63.01	Enzian Rd	5870 E Richplain DR Richland, MI 49083	Fenner Creek-Gun River	60.6
21	FRENCH W & THUNDER J & P HUNTINGTON	62.81		19381 East Ave North Battle Creek, MI 49017	Eagle Lake-Kalamazoo River	38.6
22	MAINSTONE LYLE D & CECELIA A	62.55	Q Drive North	22600 Clear Lake Road Battle Creek, MI 49014	Clear Lake-Battle Creek	40.2
23	BELDEN LAWRENCE C	62.51	122nd Ave	2316 Lincoln Road Allegan, MI 49010	Bear Creek-Kalamazoo River	39.0
24	FARNHAM LARRY TRUST	62.41	14 1/2 Mile Road Battle Creek, MI 49014	3011 Thorpe Road Delton, MI 49046	Ackley Creek-Battle Creek	20.1
25	WILSON FAMILY TRUST	62.37	Keller Road	38666 Covington Drive Wayne, MI 48184	Gun Lake-Gun River	29.3
26	CONCORD ASSOCIATES GROUP LLC	62.31	5289 124th Ave	810 Leonard Street NE Grand Rapids, MI 49503	Mann Creek	29.7
27	SUMMERS GLEN M TRUSTEE	62.22	E Fort Custer Drive	PO Box 123 Kalamazoo, MI 49007	Eagle Lake-Kalamazoo River	29.2

28	YOUNG HAZEL CALHOUN CO. LIMITED PA	62.20	8632 G Drive North Battle Creek, MI 49014	8632 G Drive North Battle Creek, MI 49014	Willow Creek-Kalamazoo River	29.3
29	POTTAWATOMIE CLUB	62.16	6022 Old Allegan Road	638 Cascade Hills Hollow SE Grand Rapids, MI 49546	Peach Orchid Creek-Kalamazoo River	363.7
30	PERRA ROBERT G & ANN C	62.16		11081 Greer Drive Richland, MI 49083	Gull Creek	30.3
31	WEST JANICE	62.08		2855 36th Street Allegan, MI 49010	Bear Creek-Kalamazoo River	40.2
32	CITY OF ALLEGAN	61.86	Mill District	112 Locust Street Allegan, MI 49010	Lake Allegan-Kalamazoo River	23.2
33	BIRDS EYE FOODS LLC	61.84	124th Ave	399 Jefferson Road Parsippany, NJ 07054	Mann Creek	39.8
34	POTTAWATOMIE CLUB	61.83	62ND/River Vacant NW QTR	638 Cascade Hills Hollow SE Grand Rapids, MI 49546	Peach Orchid Creek-Kalamazoo River	122.6
35	CALDERONE, ANTHONY & SANDRA	61.83	Reynolds RD bellevue, MI	75 Garrison Ave Battle Creek, MI 49017	Ackley Creek-Battle Creek	29.2
36	EMMONS ROBERT & ROSALIE	61.82	Augusta Drive	10461 Miller Dr Galesburg, MI 49053	Eagle Lake-Kalamazoo River	32.6
37	HENDRICK WILLIAM E & E RUTH	61.79	Miller Drive	10899 Miller Drive Galesburg, MI 49053	City of Galesburg-Kalamazoo River	38.5
38	WILLISTON GEORGE H & ROBBINS KELLY	61.76	Keller Road	10334 Keller Road Delton, MI 49046	Fenner Creek-Gun River	20.3
39	ON TARGET ENTERPRISES, LLC	61.69	Land Locked Battle Creek, MI 48014	6422 Enclave Drive Clarkston, MI 48348	Wanadoga Creek	21.6
40	ALEXANDER MARION & MANTARRO BARB	61.65	22684 Junction Road Bellevue, MI 49021	22684 Junction Road Bellevue, MI 49021	Ackley Creek-Battle Creek	35.5
41	MICHIGAN DEPT OF NATURAL RESOURCES	61.60	Bond Street	PO BOX 30028 Lansing, MI 48909	Lake Allegan-Kalamazoo River	35.6

42	SWAINS LAKE FARMS INC	61.30	Swains Lake Drive Concord, MI 49237	8651 Mohawk CT Stanwood, MI 49346	Swains Lake Drain-South Branch Kalamazoo River	58.1
43	COTTON DUANE M & COTTON JULIE A	61.19	1118 38th Street Allegan, MI 49010	1118 38th Street Allegan, MI 49010	Swan Creek	38.6
44	SCHOON ROBERT JR & BARBARA	61.14	2491 54th Street	PO BOX 378 Fennville, MI 49408	Mann Creek	39.4
45	OLIVER HARRY M JR TRUSTEE	61.10	Old Allegan RD	1948 North Lincoln Ave Chicago, IL 60614	Mann Creek	20.1
46	TURNER ELLA	61.09	Q Drive North Battle Creek, MI 49014	13175 6 1/2 Mile Road Battle Creek, MI 49014	Clear Lake-Battle Creek	21.5
47	JUNCTION (THE) LLC	61.07		1200 Central Ave Holland, MI 49423	Bear Creek-Kalamazoo River	40.4
48	WAITE PHILLIP L. & DEBORAH A.	61.05	8052 E River Road Battle Creek, MI 49104	8052 E River Road Battle Creek, MI 49104	Willow Creek-Kalamazoo River	26.1
49	BATTLE CREEK TIFA	61.02	Hill-Brady Road Battle Creek, MI 49037		Harts Lake-Kalamazoo River	22.5
50	4-D INVESTMENTS, LLC	60.97	Bellevue Road Battle Creek, MI 49014	7235 Tower Road Battle Creek, MI 49014	Clear Lake-Battle Creek	22.3
51	TRIPLE J HOLDINGS LLC	60.95	N 44th Street	PO BOX 50190 Kalamazoo, MI 49005	Augusta Creek	33.7
52	RABBERS JOYCE L NON-EX MAR TRUST	60.91	Lindsey Road	19459 Thompson Lane Three Rivers, MI 49093	Gun Lake-Gun River	65.3
53	CUTLER GREGORY J	60.90	4006 110th Ave	PO BOX 295 Allegan, MI 49010	Swan Creek	30.0
54	4-D INVESTMENTS, LLC	60.89	Feld Ave Battle Creek, MI 49017	620 South Main Street bellevue, MI 49021	Harts Lake-Kalamazoo River	31.9
55	LAURENS ANDREIS V & TEGAN A	60.89	11512 E DE Ave Richland, MI 49083	11512 E DE Ave Richland, MI 49083	Gull Creek	36.5
56	FLACH PAUL & ALICE TRUST	60.81	NRF	2714 North 38th Street Augusta, MI 49102	Eagle Lake-Kalamazoo River	35.3

57	TRUAX TODD E	60.80	1651 36th Street Allegan, MI 49010	1651 36th Street Allegan, MI 49010	Lake Allegan-Kalamazoo River	24.3
58	CITY OF KALAMAZOO	60.77		241 W. South Street Kalamazoo, MI 49006	West Fork Portage Creek	45.0
59	MESHKIN JOHN L	60.73	124th Ave	559 Elmdale CT Holland, MI 49423	Mann Creek	63.4
60	KENNEDY JOHN & BETH	60.71	N 2nd Street	8910 North 6th Street Kalamazoo, MI 49009	Pine Creek	24.9
61	STS HYDROPOWER LTD	60.69		14550 N Frank Lloyd Wright Blvd 210 Scottsdale, AZ 85260	City of Galesburg-Kalamazoo River	43.1
62	BATTLE CREEK CITY	60.67	Teal Street	00000 Teal Street Battle Creek, MI 49037	Eagle Lake-Kalamazoo River	97.2
63	HALL WILLIAM C	60.65		1169 37th Street Allegan, MI 49010	Tannery Creek-Kalamazoo River	30.1
64	MCENTYRE KENNETH W	60.57	1267 44th Street Pullman, MI 49450	1267 44th Street Pullman, MI 49450	Swan Creek	44.5
65	FRENCH W & THUNDER J & P HUNTINGTON	60.53		19381 East Ave North Battle Creek, MI 49017	Eagle Lake-Kalamazoo River	99.4
66	COMSTOCK CHARTER TOWNSHIP	60.53	River Villa Preserve	PO Box 449 Comstock, MI 49041	Davis Creek-Kalamazoo River	21.2
67	WMU STATE OF MICHIGAN	60.44	1940 Howard	1903 W. Michigan Ave Kalamazoo, MI 49008	Averill Lake-Kalamazoo River	21.9
68	STOREY REBECCA A TRUST	60.35	Pony Ave	124 Candlewood Lane Battle Creek, MI 49014	Spring Lakes-Battle Creek	25.0
69	BOURDO EARL, JUNE, TERRI, MARK	60.33	7615 Marsh Road Plainwell, MI 49080	7615 Marsh Road Plainwell, MI 49080	Fenner Creek-Gun River	23.0
70	HOBBS LARRY C & LINDA K	60.33	5224 123RD Ave Fennville, MI 49408	5224 123RD Ave Fennville, MI 49408	Mann Creek	30.1
71	SWEET LINDA TRUSTEE	60.33	36th Street	138 Grand Street Allegan, MI 49010	Bear Creek-Kalamazoo River	40.6

72	HAHN MARK & SUSAN	60.28	3741 112th Ave Allegan, MI 49010	3741 112th Ave Allegan, MI 49010	Swan Creek	29.1
73	BUFORD RAYMOND H./TRUST	60.19	G Drive North/Vacant	4162 H Drive South East Leroy, MI 49051	Willow Creek-Kalamazoo River	23.1
74	TRI-STATE HOLDINGS LLC.	60.15	E River Road/Vacant	PO Box 261047 Plano, TX 75026	Willow Creek-Kalamazoo River	21.5
75	GALLIHUGH RICHARD & SUSANNE	60.14	20981 15 Mile Road Bellevue, MI 49021	20981 15 Mile Road Bellevue, MI 49021	Clear Lake-Battle Creek	37.4
76	EAZY ACRES LLC	59.96	124th Ave	416 Hubbard Allegan, MI 49010	Mann Creek	67.2
77	SPARROW DANNY K & TRICIA	59.91	7329 Marsh Rd Plainwell, MI 49080	7329 Marsh Rd Plainwell, MI 49080	Fenner Creek-Gun River	39.7
78	ROBINSON MARILYN	59.91	21990 15 Mile Road Bellevue, MI 49021	1138 Henlon Circle Saline, MI 48176	Ackley Creek-Battle Creek	80.5
79	BROWN DENNIS H & SOILA	59.87	8719 Pennfield Road Battle Creek, MI 49017	8719 Pennfield Road Battle Creek, MI 49017	Wanadoga Creek	21.8
80	VOLKER DAVID W & VOLKER NATHAN	59.86	112th Ave	3638 115th Ave Allegan, MI 49010	Swan Creek	29.9
81	HARRY DOUGLAS A TRUST	59.83	2587 36th Street Allegan, MI 49010	2587 36th Street Allegan, MI 49010	Bear Creek-Kalamazoo River	33.2
82	WILLIAMS JONATHAN S	59.79	5010 123rd Ave	974 Bluebell Dr Holland, MI 49423	Mann Creek	20.0
83	CENSKE THOMAS W. & JUDY L.	59.78	S Dexter St/Vacant	337 Dexter St Battle Creek, MI 49014	Willow Creek-Kalamazoo River	27.8
84	ORTIZ CONRADO & REBECCA	59.78	27 Mile Rd Albion, MI 49224	14745 27 Mile Rd Albion, MI 49224	South Branch Rice Creek	32.5
85	NEWMAN JULIA SWEET	59.76	Clear Lake Ave	1349 Clear Lake Ave Battle Creek, MI 49014	Clear Lake-Battle Creek	38.6
86	REAGLE AMOS & CAROLYN	59.74	13031 15 Mile Road Marshall, MI 49068	13031 15 Mile Road Marshall, MI 49068	North Branch Rice Creek	80.4
87	BELDEN LAWRENCE C	59.66	122nd Ave	2316 Lincoln Road Allegan, MI 49010	Bear Creek-Kalamazoo River	31.5

88	RABBERS JOYCE L NON-EX MAR TRUST	59.66	Marsh Road	19459 Thompson Lane Three Rivers, MI 49093	Gun Lake-Gun River	80.7
89	RASMUSSEN JOHN	59.66	22111 Pine Lake Road Battle Creek, MI 49017	319 Eaton Battle Creek, MI 49017	Wanadoga Creek	38.4
90	NORTHBROOK ENERGY	59.60	Powerline	14550 N Frank Lloyd Wright Blvd 210 Scottsdale, AZ 85260	City of Galesburg-Kalamazoo River	52.0
91	WHEELER, HERBERT A & VICKIE L TRUST	59.57	9977 Ackley Road Bellevue, MI 49021	9977 Ackley Road Bellevue, MI 49021	Ackley Creek-Battle Creek	20.0
92	CITY OF KALAMAZOO	59.51		241 W. South Street Kalamazoo, MI 49006	West Fork Portage Creek	25.1
93	ALEXANDER ROSS C & EDNA M	59.35		2425 58th St PO BOX 28 Fennville, MI 49408	Mann Creek	77.6
94	WARREN ALVIN & JOAN	59.32	Marsh Road	10966 West Keller Road Delton, MI 49046	Fenner Creek-Gun River	39.3
95	GEYER JOHN & LUCINDA	59.31		1010 S Eaton Street Albion, MI 49224	South Branch Rice Creek	60.0
96	COOK STEVEN J	59.26	5426 126th Ave	PO Box 440 Fennville, MI 49408	Mann Creek	34.4
97	POTTAWATOMIE CLUB	59.26	Vacant Land	638 Cascade Hills Hollow SE Grand Rapids, MI 49546	Peach Orchid Creek-Kalamazoo River	116.3
98	HEINTZELMAN ROBERT II	59.26	1254 44th Street Pullman, MI 49450	1254 44th Street Pullman, MI 49450	Swan Creek	20.6
99	STEVENS GARY	59.21	4831 Torsten Drive	803 129th Ave Shelbyville, MI 49344	Gun Lake-Gun River	22.5
100	EMERICK STANLEY & CANDACE	59.19	5140 130th Ave Hamilton, MI 49419	5140 130th Ave Hamilton, MI 49419	Bear Creek-Kalamazoo River	79.6

Parcels highlighted in green fall within the AOC-buffer, described in Section 6.

Attachment-3: Ground Truthing Parcel Photos

Attachment-1: Ground Truthing Photos

Parcel 1: Groundwater-fed stream (Source: SWMLC)

Parcel 1: Prairie Fen (Source: SWMLC)

Attachment-1: Ground Truthing Photos

Parcel 2: Hardwood forest (Source: Kyle Alexander)

Parcel 2: Forested wetland (Source: Kyle Alexander)

Attachment-1: Ground Truthing Photos

Parcel 3: Grassland (Source: Kyle Alexander)

Parcel 3: Grassland and young coniferous trees (Source: Kyle Alexander)

Attachment 4: Outreach Postcards

Preserve your forest!

What makes a forest a forest?
A forest is a large, non-agricultural area that is predominantly covered by trees.

Why do they matter?
Forests are helpful to both us and the environment. They do things like provide lumber, prevent floods, provide a home for many animals, and are a great place to relax and enjoy the outdoors.

Protecting your land!

Take action now and preserve the land for future generations to enjoy!

There are many reasons to protect your land in addition to helping the environment:

- Defending your land against development
- federal income, estate, and property tax deductions
- helping to preserve the water quality of the Kalamazoo River

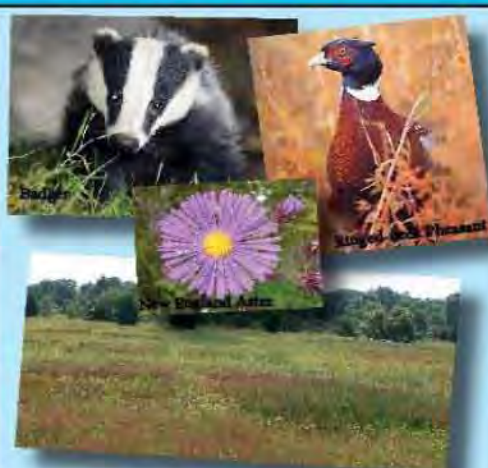
Kalamazoo River Watershed Council

SWMLC Southwest Michigan Land Conservancy

Preserve your grassland!

What is a grassland? A grassland is an area of land in which the most common form of plant life is grass.

Why do they matter?
Grasslands are helpful to both us and the environment. They do things such as keep soil healthy, prevent erosion, provide a home for many animals including several game species, help keep water clean, and serve as a habitat for many species of wildflowers.



Protecting your land!

Take action now and preserve the land for future generations to enjoy!

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- federal income, estate, and property tax deductions
- helping to preserve the water quality of the Kalamazoo River

Kalamazoo River Watershed Council

SWMLC Southwest Michigan Land Conservancy

Preserve your waterfront land!

Did you know? The land around your stream, river, or lake is called a **riparian area.** Riparian areas include the bank, bed, and land around the water.

Why do they matter?
Forests are helpful to both us and the environment. They do things such as keeping the water clean, controlling floods, providing a home for many plants and animals, and offering recreational opportunities.

Protecting your land!

Take action now and preserve the land for future generations to enjoy!

There are many reasons to protect your land in addition to helping the environment:

- Defending your land against development
- federal income, estate, and property tax deductions
- helping to preserve the water quality of the Kalamazoo River

Kalamazoo River Watershed Council

SWMLC Southwest Michigan Land Conservancy

Preserve your wetland!

What is a wetland? A wetland is an area where standing water covers the soil or an area where the ground is very wet. They may stay wet all year long, or the water may evaporate during the dry season.

Why do they matter?
Wetlands are helpful to both us and the environment. They do things such as cleaning up water, providing a home for many plants and animals (including certain game animals), and preventing floods.

Protecting your land!

Take action now and preserve the land for future generations to enjoy!

There are many reasons to protect your land in addition to helping the environment:

- Defending your land against development
- federal income, estate, and property tax deductions
- helping to preserve the water quality of the Kalamazoo River

Kalamazoo River Watershed Council

SWMLC Southwest Michigan Land Conservancy

Interested in conserving **your** land?

Contact information goes here!!!

Southwest Michigan Land Conservancy
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Attachment 14. Landscape Level Wetlands Functional Assessment: Results from the Kalamazoo River Watershed Analysis

KALAMAZOO RIVER WATERSHED

Landscape Level Wetland Functional Assessment

(Enhanced NWI)

May 2015

KALAMAZOO RIVER WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 253,508 Acres of Wetlands
- 11,490 Polygons
- Average Size – 22 Acres

2005 Wetland Condition

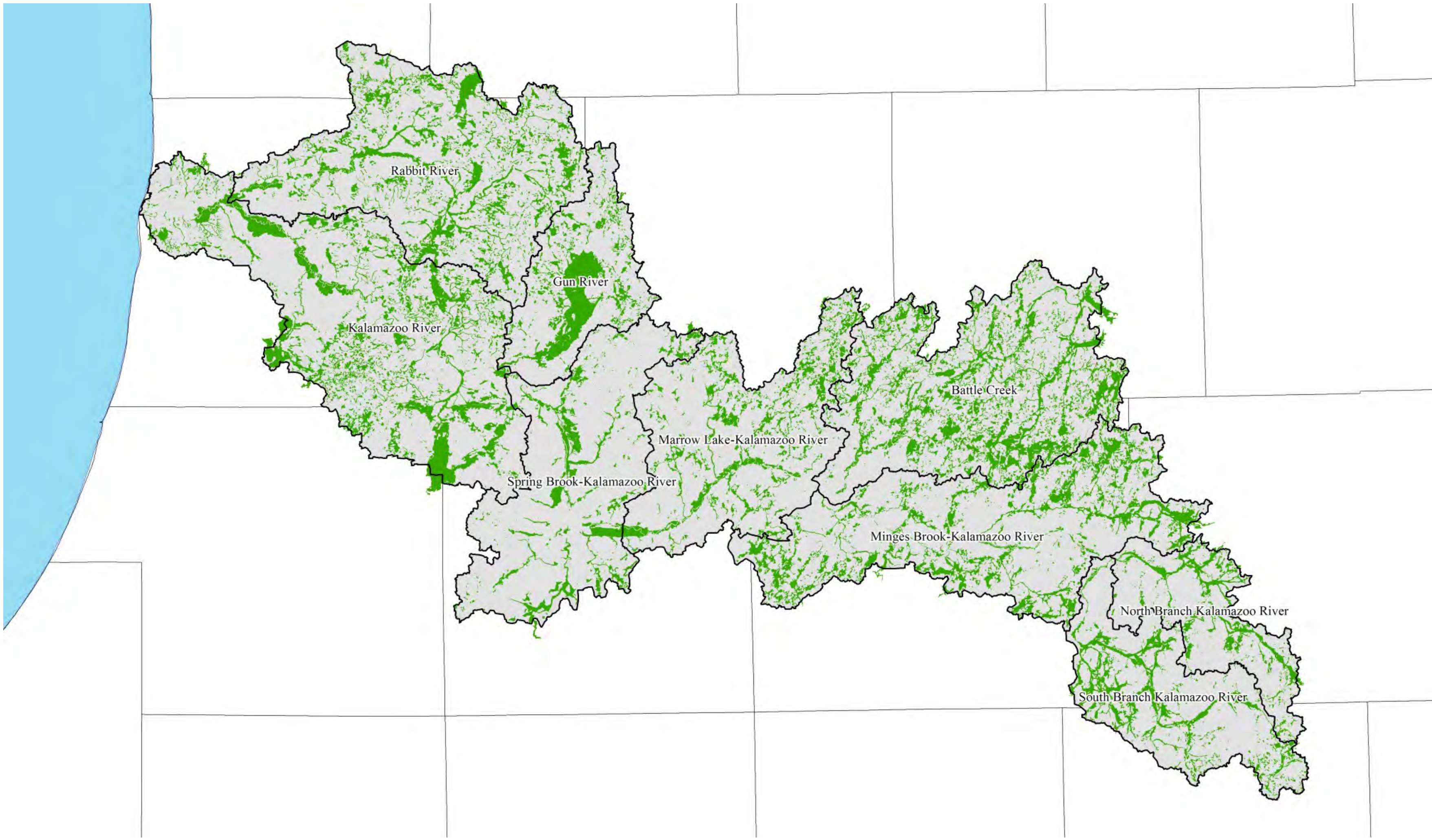
- 159,355 Acres of Wetlands
- 28,035 Polygons
- Average Size – 6 Acres

63% OF ORIGINAL WETLAND ACREAGE REMAINS
37% LOSS OF TOTAL WETLAND RESOURCE

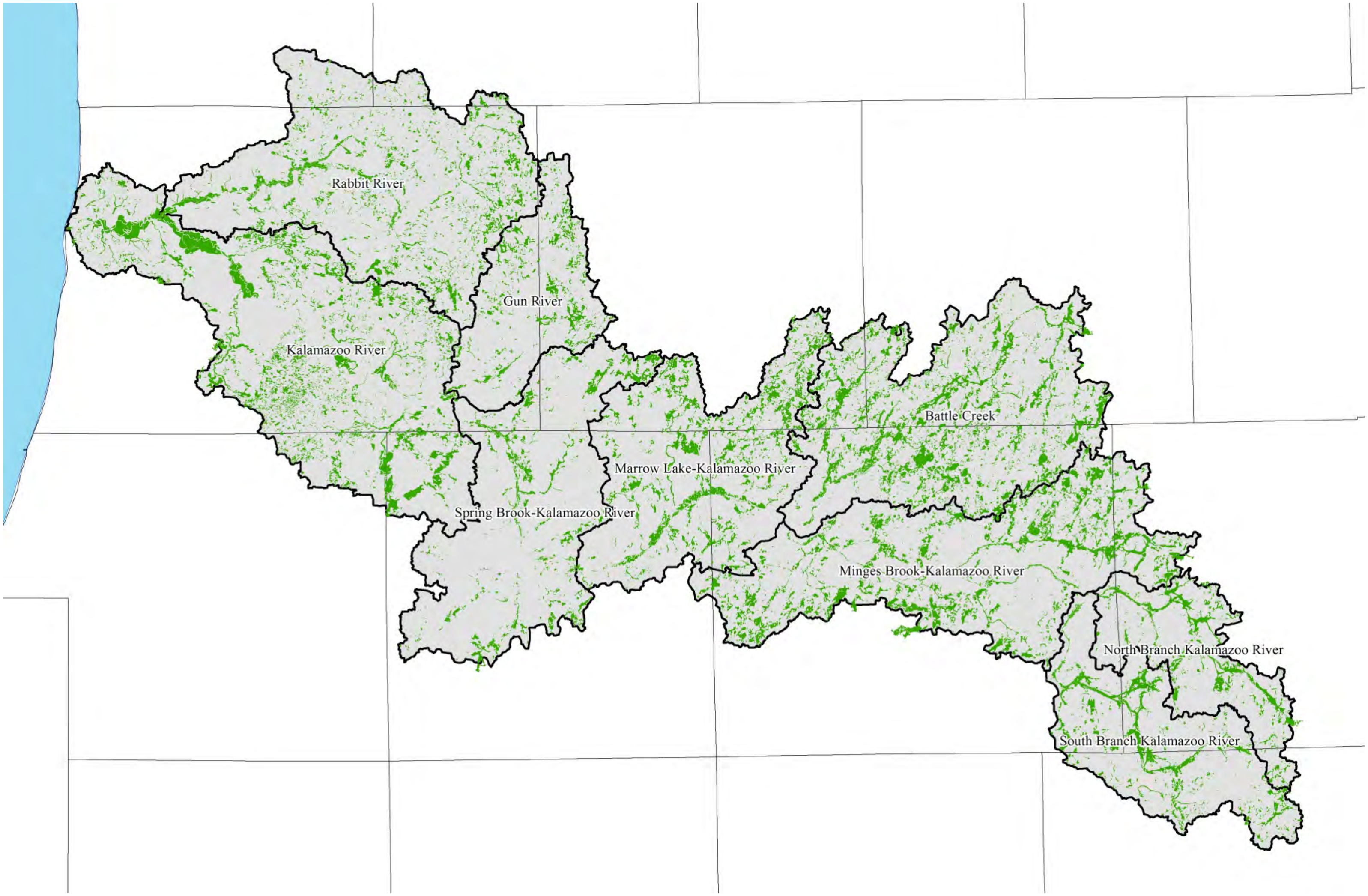
TOTAL ACREAGE LOSS OF:
94,153 ACRES

* These figures exclude open water type wetlands

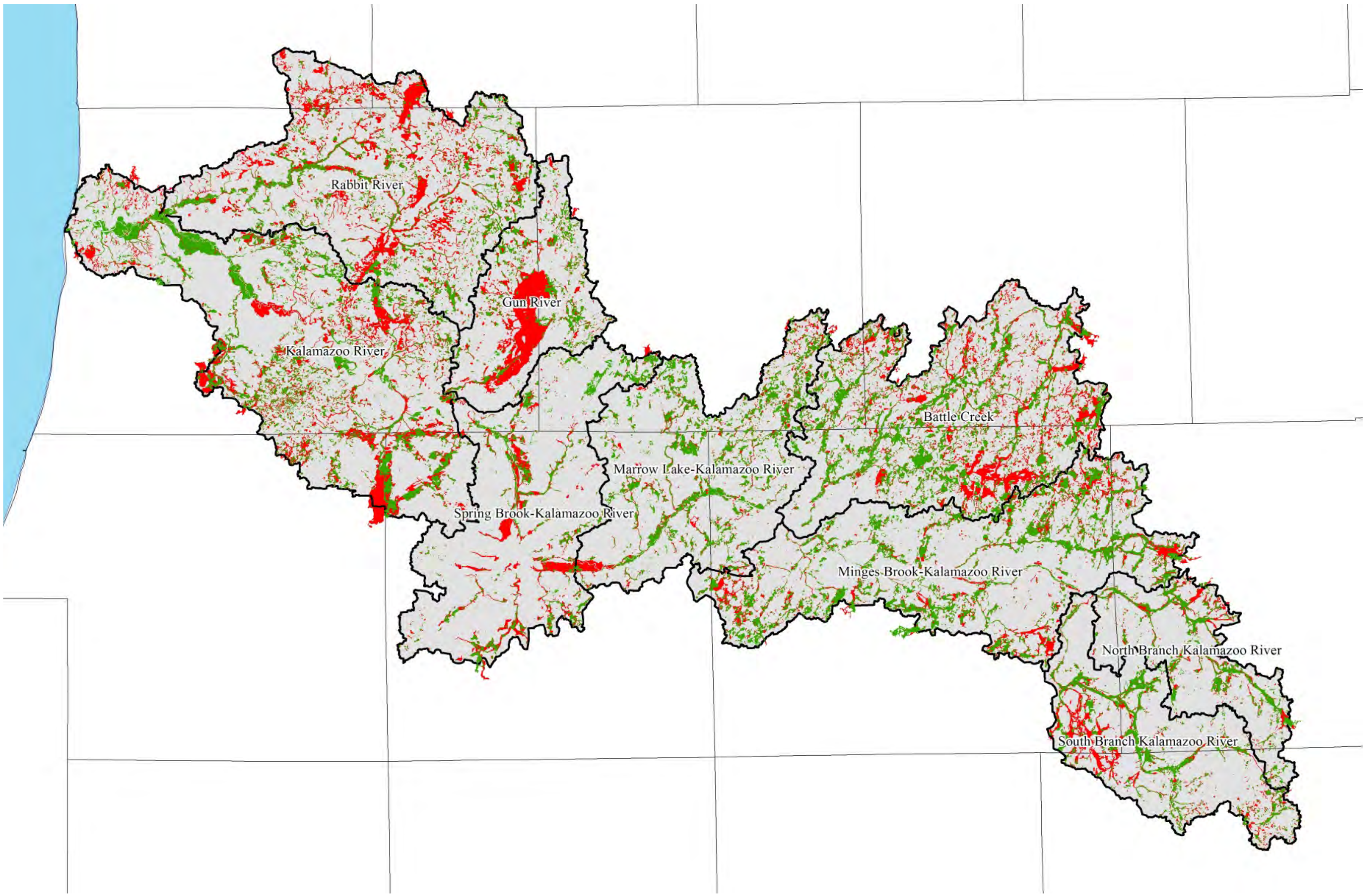
PRE-EUROPEAN SETTLEMET WETLAND COVERAGE



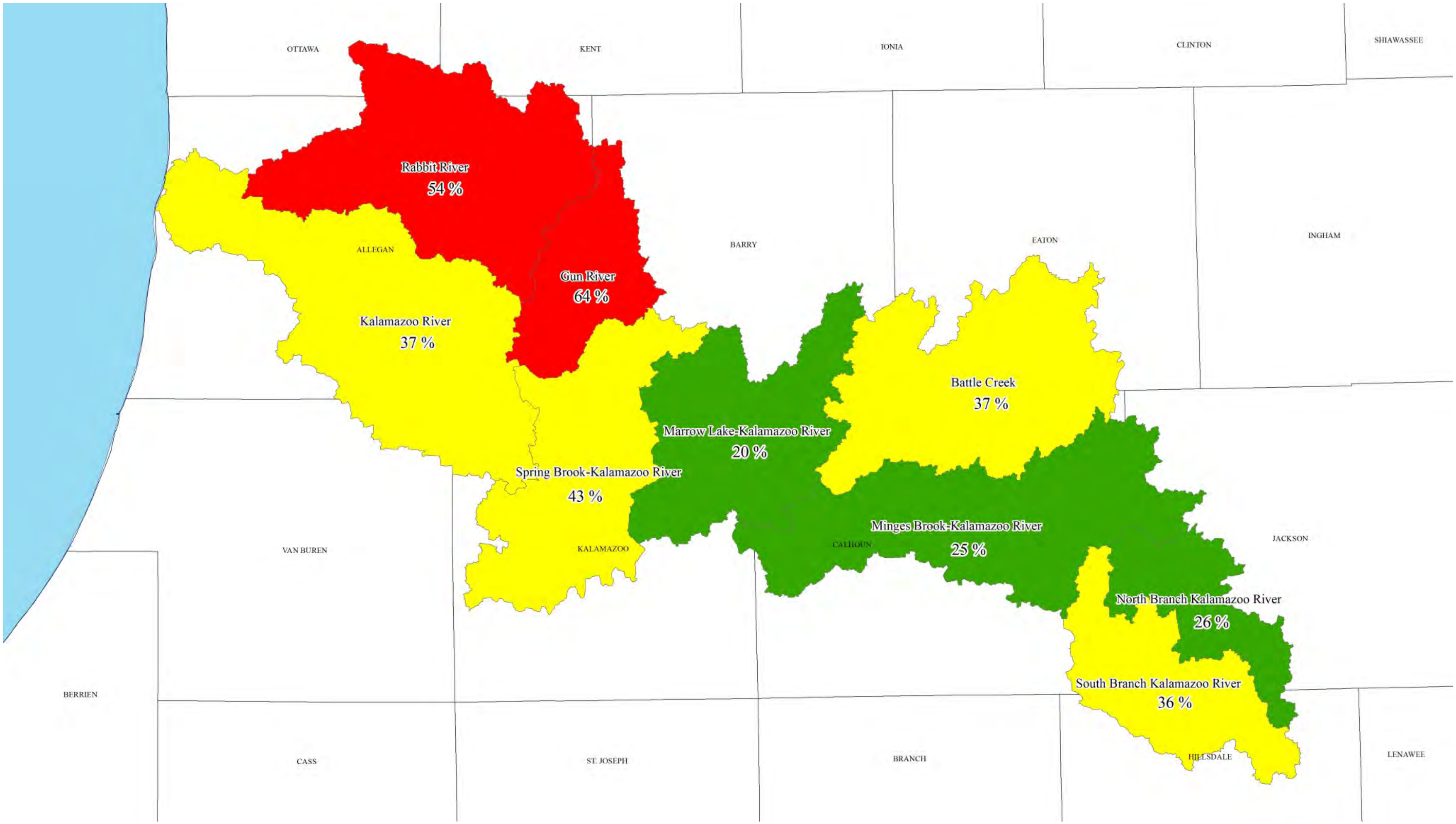
2005 WETLAND COVERAGE



APPROXIMATE WETLAND LOSS PRE-EUROPEAN SETTLEMENT TO 2005



Percent Wetland Loss By Sub-Basin



RABBIT RIVER WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 37,401 Acres of Wetlands
- 1,807 Polygons
- Average Size – 21 Acres

2005 Wetland Condition

- 17,446 Acres of Wetlands
- 3,945 Polygons
- Average Size – 4.4 Acres

46% OF ORIGINAL WETLAND ACREAGE REMAINS
54% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
19,955 ACRES

* These figures exclude open water type wetlands

Gun River Watershed
Wetland Resources Status and Trends

<u>Pre-settlement Wetland conditions</u>

- 18,043 Acres of Wetlands
- 686 Polygons
- Average Size – 26 Acres

<u>2005 Wetland Condition</u>

- 6,498 Acres of Wetlands
- 1,199 Polygons
- Average Size – 5.4 Acres

36% OF ORIGINAL WETLAND ACREAGE REMAINS
64% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
11,545 ACRES

BATTLE CREEK RIVER WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions
- 47,308 Acres of Wetlands
- 2,187 Polygons
- Average Size – 22 Acres

2005 Wetland Condition
- 30,115 Acres of Wetlands
- 5,358 Polygons
- Average Size – 5.6 Acres

63% OF ORIGINAL WETLAND ACREAGE REMAINS
37% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
17,193 ACRES

* These figures exclude open water type wetlands

MARROW LAKE-KALAMAZOO RIVER WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 22,238 Acres of Wetlands
- 998 Polygons
- Average Size – 22 Acres

2005 Wetland Condition

- 17,836 Acres of Wetlands
- 3,280 Polygons
- Average Size – 5.4 Acres

80% OF ORIGINAL WETLAND ACREAGE REMAINS
20% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
4,402 ACRES

* These figures exclude open water type wetlands

MINGES BROOK-KALAMAZOO RIVER WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 36,842 Acres of Wetlands
- 1,727 Polygons
- Average Size – 21 Acres

2005 Wetland Condition

- 27,811 Acres of Wetlands
- 3,789 Polygons
- Average Size – 7.3 Acres

75% OF ORIGINAL WETLAND ACREAGE REMAINS
25% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
9,031 ACRES

* These figures exclude open water type wetlands

SOUTH BRANCH-KALAMAZOO RIVER WATERSHED

Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 17,226 Acres of Wetlands
- 847 Polygons
- Average Size – 20 Acres

2005 Wetland Condition

- 10,970 Acres of Wetlands
- 1,576 Polygons
- Average Size – 7 Acres

64% OF ORIGINAL WETLAND ACREAGE REMAINS
36% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
6,256 ACRES

* These figures exclude open water type wetlands

SPRING BROOK-KALAMAZOO RIVER WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 16,880 Acres of Wetlands
- 543 Polygons
- Average Size – 31 Acres

2005 Wetland Condition

- 9,730 Acres of Wetlands
- 1,844 Polygons
- Average Size – 5 Acres

57% OF ORIGINAL WETLAND ACREAGE REMAINS
43% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
7,150 ACRES

* These figures exclude open water type wetlands

MOUTH-KALAMAZOO RIVER WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 51,115 Acres of Wetlands
- 2,166 Polygons
- Average Size – 23.5 Acres

2005 Wetland Condition

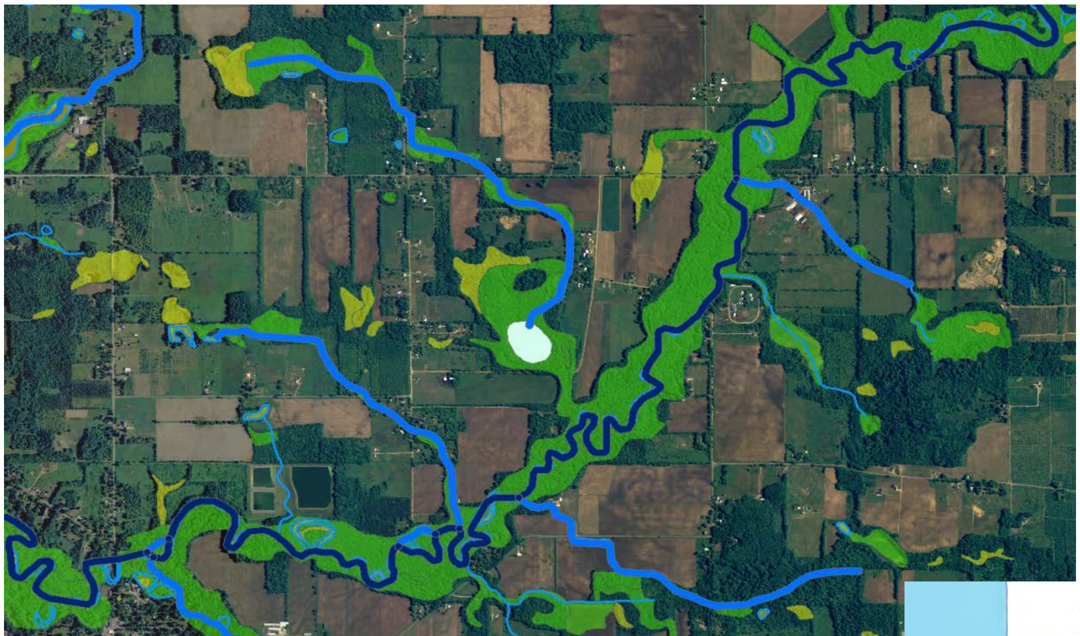
- 32,227 Acres of Wetlands
- 5,930 Polygons
- Average Size – 5.4 Acres

63% OF ORIGINAL WETLAND ACREAGE REMAINS
37% LOSS OF TOTAL WETLAND RESOURCE

TOTAL ACREAGE LOSS OF:
18,888 ACRES

* These figures exclude open water type wetlands

ENHANCING NWI FOR LANDSCAPE-LEVEL WETLAND FUNCTIONAL ASSESSMENT IN THE KALAMAZOO RIVER WATERSHED



Using NWI for Functional Assessment

- Lack of hydro-geomorphic (HGM) information
  - No landscape position
  - No landform
  - No water flow direction
  - General pond classification
  - Features important for assessing many functions are lacking
- *Most of these features can be interpreted from the maps*

What information can we extract from NWI?

How many wetlands are there?

What is the size range of wetlands?

What is the average size of a given wetland type?

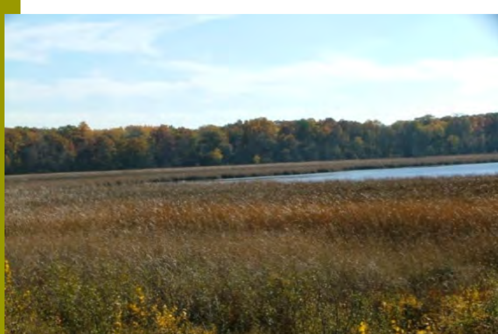
How many wetlands are in various size classes?

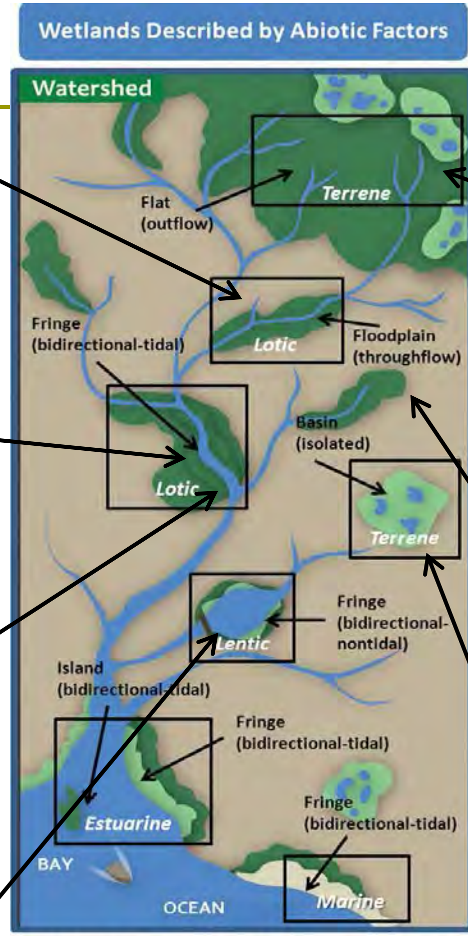
…With HGM information added?

How much and how many

- occur along rivers?
- along streams?
- in lake basins?
- are isolated?
- are sources of streams?
- have inflow but no outflow?
- are connected to other wetlands?
- What types of ponds are there and what is their extent?

WETLAND LANDSCAPE POSITIONS





Key: Landscape position – white italicized, Landform – text from arrow, Water flow path – in parenthesis

Terrene - isolated wetlands, headwater outflow wetlands, and wetlands along streams but not subject to overflow due to their elevation

Lotic - wetlands along rivers and streams and subject to periodic overflows (e.g., floodplains), including freshwater tidal wetlands

Lentic - wetlands within the basins of lakes and reservoirs where their hydrology is greatly affected by fluctuating lake or reservoir water levels

Estuarine - salt and brackish tidal wetlands associated with estuaries

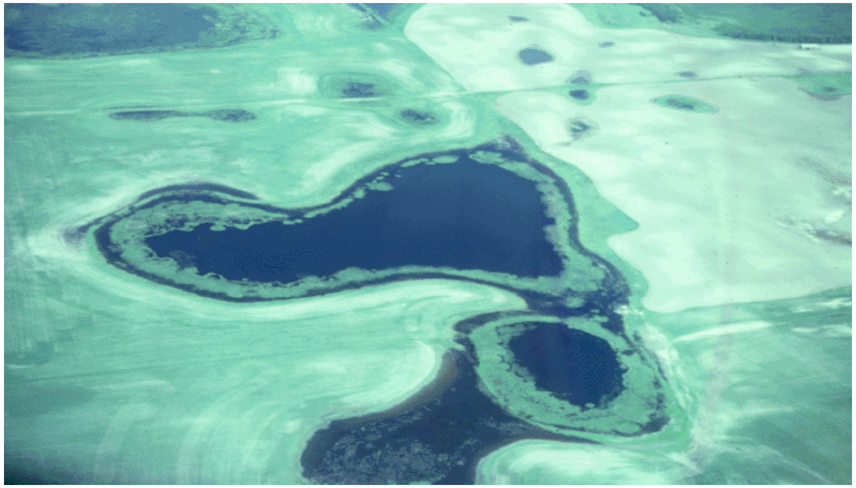
Marine - saltwater tidal wetlands along the shores of the ocean and its open embayments

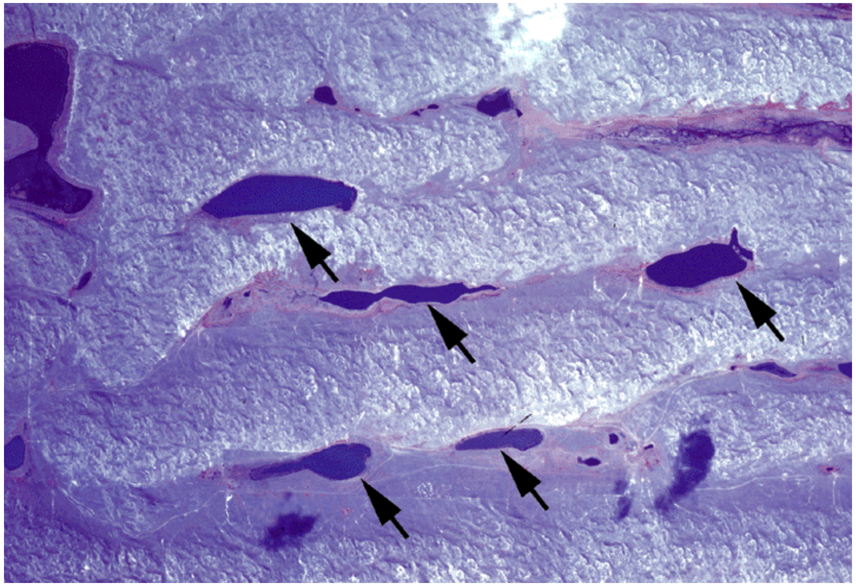
Wetland Landform Types

- Fringe
- Basin
- Flat
- Floodplain
- Slope

FRINGE

BASIN





FLAT

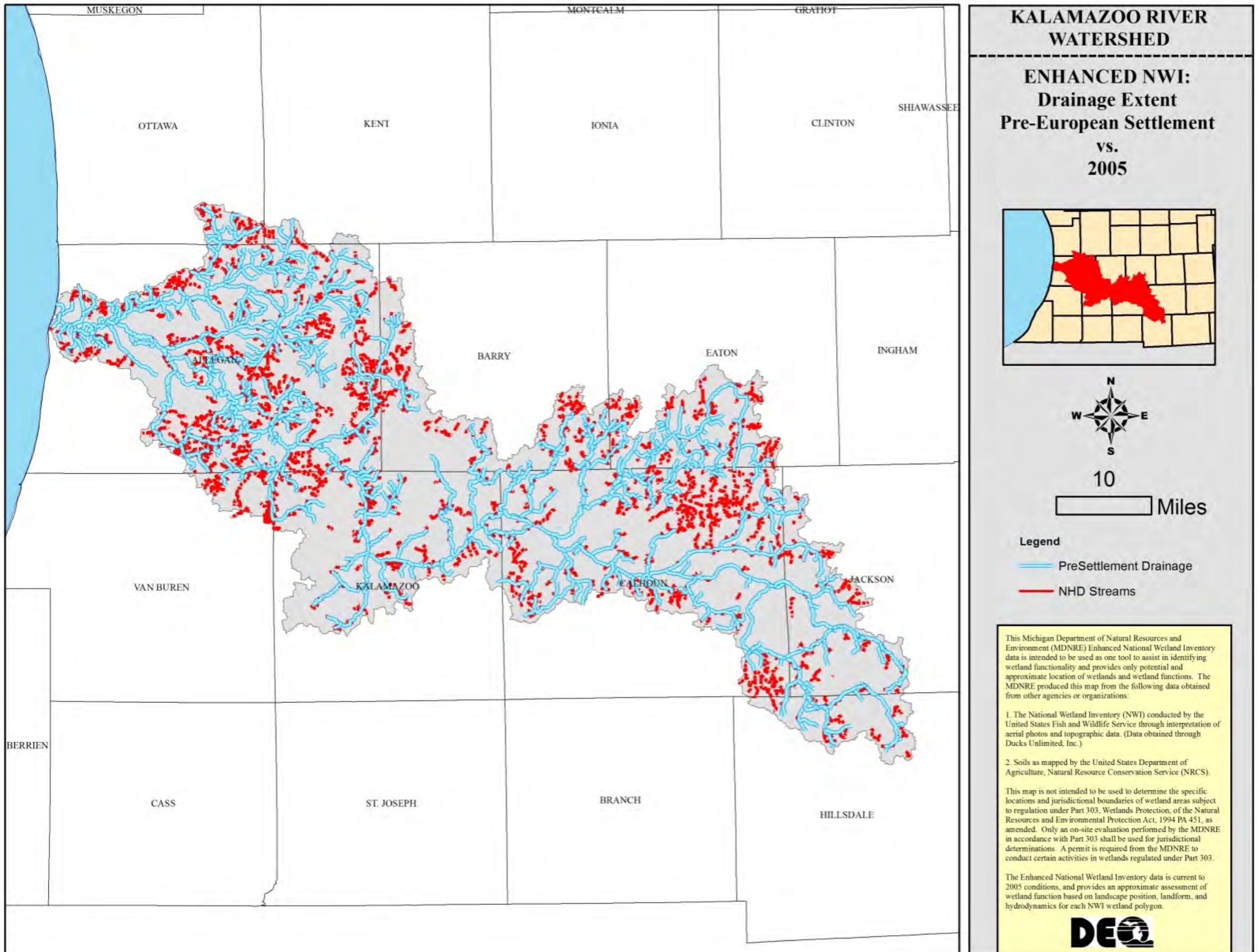
FLOODPLAIN

SLOPE

Evaluated Wetland Functions

- Flood Water Storage
- Streamflow Maintenance
- Nutrient Transformation
- Sediment and Other Particulate Retention
- Shoreline Stabilization
- Stream Shading
- Conservation of Rare and Imperiled Wetlands
- Ground Water Influence
- Fish Habitat
- Waterfowl/Waterbird Habitat
- Shorebird Habitat
- Interior Forest Bird Habitat
- Amphibian Habitat
- Carbon Sequestration
- Pathogen Retention

DRAINAGE EXTENT



DETAILED FUNCTIONAL COMPARISONS

Table 2: Detailed Functional Comparisons				
Function	Potential Significance	Pre-European Settlement Acreage	2005 Acreage	% Change in Acreage
Flood Water Storage	High	120,944.44	92,122.41	-24
	Moderate	114,346.46	21,935.92	-81
	Total	235,290.90	114,058.33	-52
Streamflow Maintenance	High	167,282.68	108,097.00	-35
	Moderate	59,877.37	45,967.34	-23
	Total	227,160.05	154,064.34	-32
Nutrient Transformation	High	163,773.13	125,598.07	-23
	Moderate	89,735.14	32,427.72	-64
	Total	253,508.26	158,025.79	-38
Sediment and Retention of Other Particulates	High	126,936.35	66,555.34	-48
	Moderate	60,731.24	46,021.82	-24
	Total	187,667.60	112,577.17	-40
Shoreline Stabilization	High	105,871.26	80,076.54	-24
	Moderate	97,145.53	51,111.14	-47
	Total	203,016.79	131,187.68	-35
Fish Habitat	High	226,081.09	91,291.31	-60
	Moderate	9,807.37	46,830.56	378 *
	Total	235,888.47	138,121.87	-41
Stream Shading	High	38,182.76	25,649.55	-33
	Moderate	10,458.96	8,727.48	-17
	Total	48,641.72	34,377.03	-29

* Increases in the moderate & high category in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

DETAILED FUNCTIONAL COMPARISONS CONT…

Function	Potential Significance	Pre-European Settlement Acreage	2005 Acreage	% Change in Acreage
Waterfowl/Waterbird Habitat	High	38,494.63	65,039.85	69 *
	Moderate	72,768.85	59,746.52	-18
	Total	111,263.48	124,786.37	12 *
Shorebird Habitat	High	0.00	1,778.45	Null
	Moderate	247,089.27	153,935.10	-38
	Total	247,089.27	155,713.55	-37
Interior Forest Bird Habitat	High	59,087.49	43,686.75	-26
	Moderate	179,086.83	63,910.00	-64
	Total	238,174.33	107,596.76	-55
Amphibian Habitat	High	118,071.67	49,254.05	-58
	Moderate	23,202.06	20,679.05	-11
	Total	141,273.74	69,933.10	-50
Carbon Sequestration	High	21,297.18	15,641.39	-27
	Moderate	140,505.31	47,917.40	-66
	Total	161,802.49	63,558.80	-61
Ground Water Influence	High	26,864.72	3,674.53	-86
	Moderate	200,788.19	152,833.60	-24
	Total	227,652.92	156,508.12	-31
Conservation of Rare & Imperiled Wetlands & Species	High	Null	57,424.82	Null
	Moderate	Null	78,130.31	Null
	Total	Null	135,555.13	Null

* Increases in the moderate & high categories in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

FUNCTIONAL ACRES COMPARISON

Table 3: Functional Acres comparison

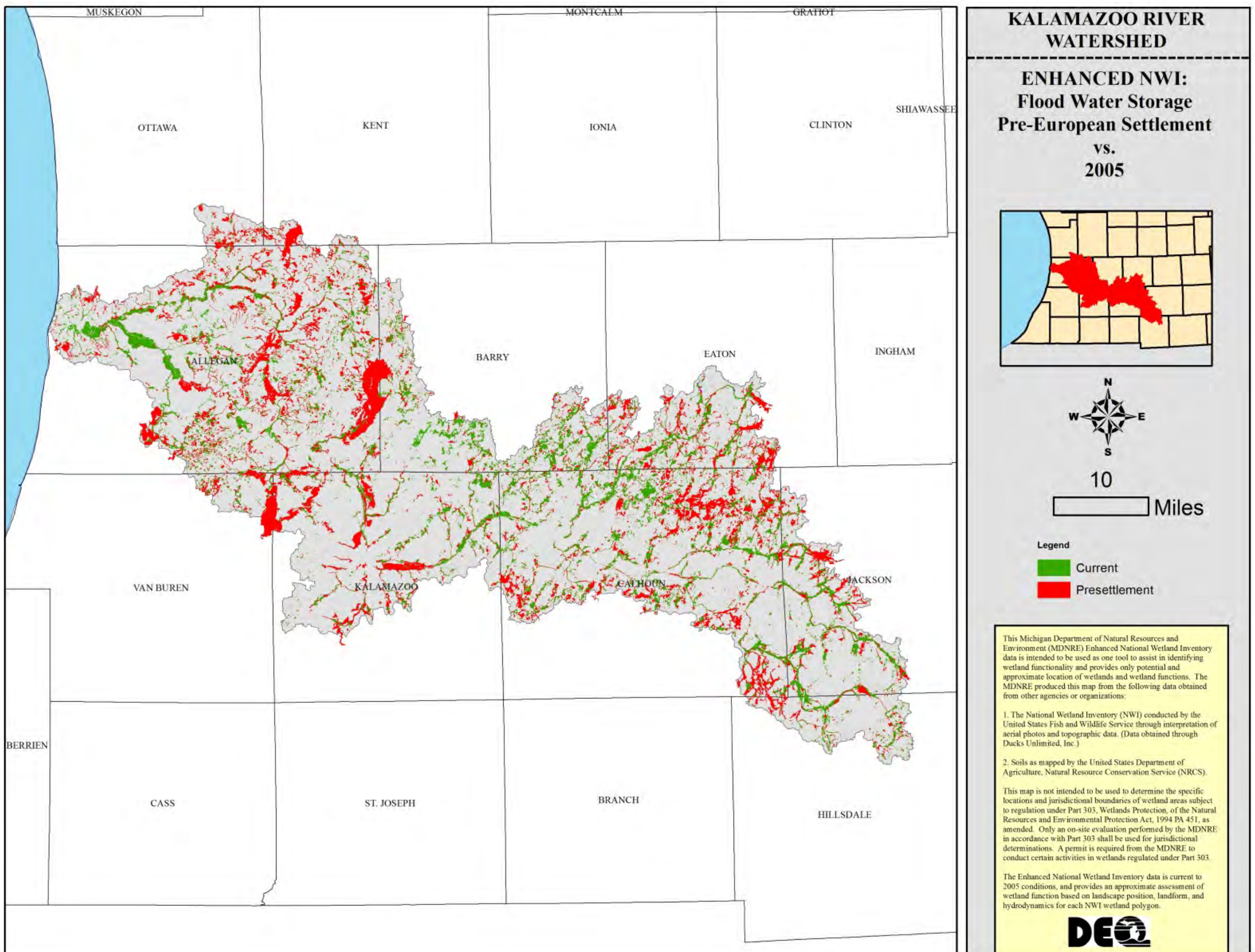
Function	Pre-European Settlement Functional Acres	2005 Functional Acres	Predicted % of Original Capacity Left	Predicted % Change in Functional Capacity
Flood Water Storage	356,235.35	206,180.73	58	-42
Streamflow Maintenance	394,442.73	262,161.35	66	-34
Nutrient Transformation	417,281.39	283,623.87	68	-32
Sediment and Other Particulate Retention	314,603.95	179,132.51	57	-43
Shoreline Stabilization	308,888.05	211,264.22	68	-32
Fish Habitat	461,969.56	229,413.18	50	-50
Stream Shading	86,824.49	60,026.58	69	-31
Waterfowl and Waterbird Habitat	149,758.11	189,826.21	127	27 *
Shorebird Habitat	247,089.27	157,492.00	64	-36
Interior Forest Bird Habitat	297,261.82	151,283.51	51	-49
Amphibian Habitat	259,345.41	119,187.15	46	-54
Carbon Sequestration	183,099.66	79,200.19	43	-57
Ground Water Influence	254,517.64	160,182.65	63	-37
Conservation of Rare & Imperiled Wetlands & Species	0	192,979.95	100	100

• Increases in the predicted percent change functional capacity in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

FLOOD WATER STORAGE

- This function is important for reducing the downstream flooding and lowering flood heights, both of which aid in minimizing property damage and personal injury from such events.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

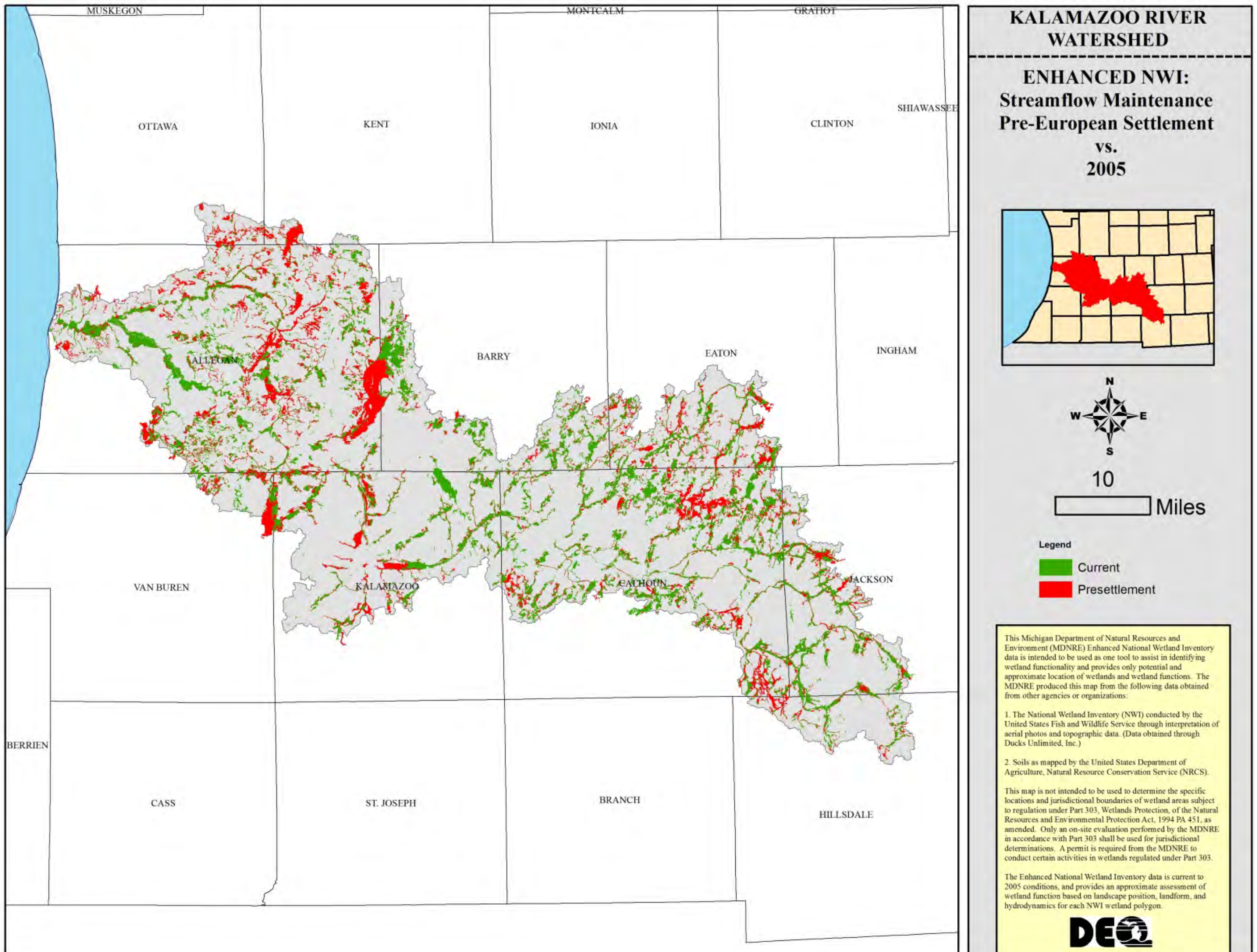
FLOOD WATER STORAGE



STREAMFLOW MAINTENANCE

- Wetlands that are sources of groundwater discharge that sustain streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams. All wetlands classified as headwater wetlands are important for streamflow.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

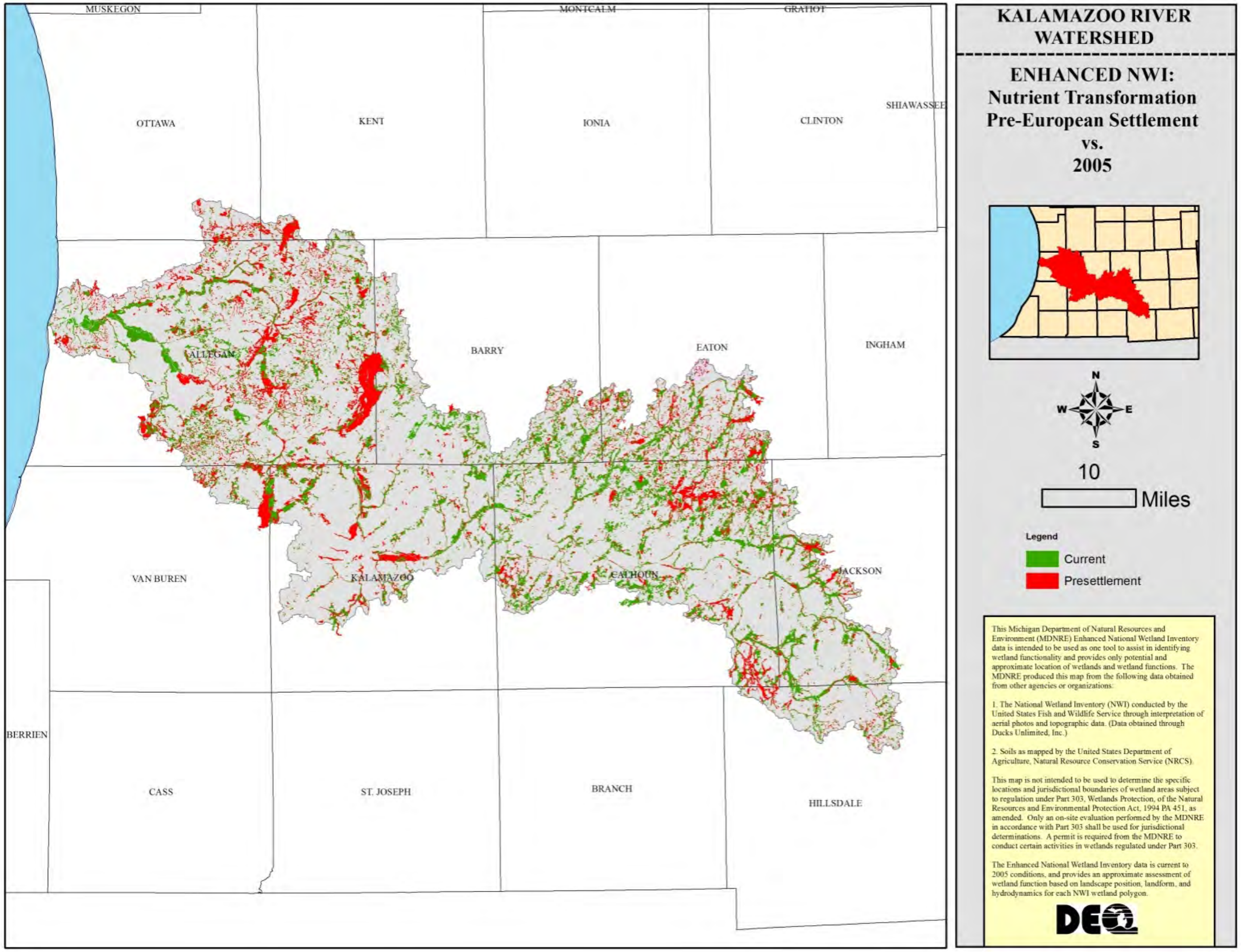
STREAMFLOW MAINTENANCE



NUTRIENT TRANSFORMATION

- Wetlands that have a fluctuating water table are best able to recycle nutrients. Natural wetlands performing this function help improve local water quality of streams and other watercourses.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

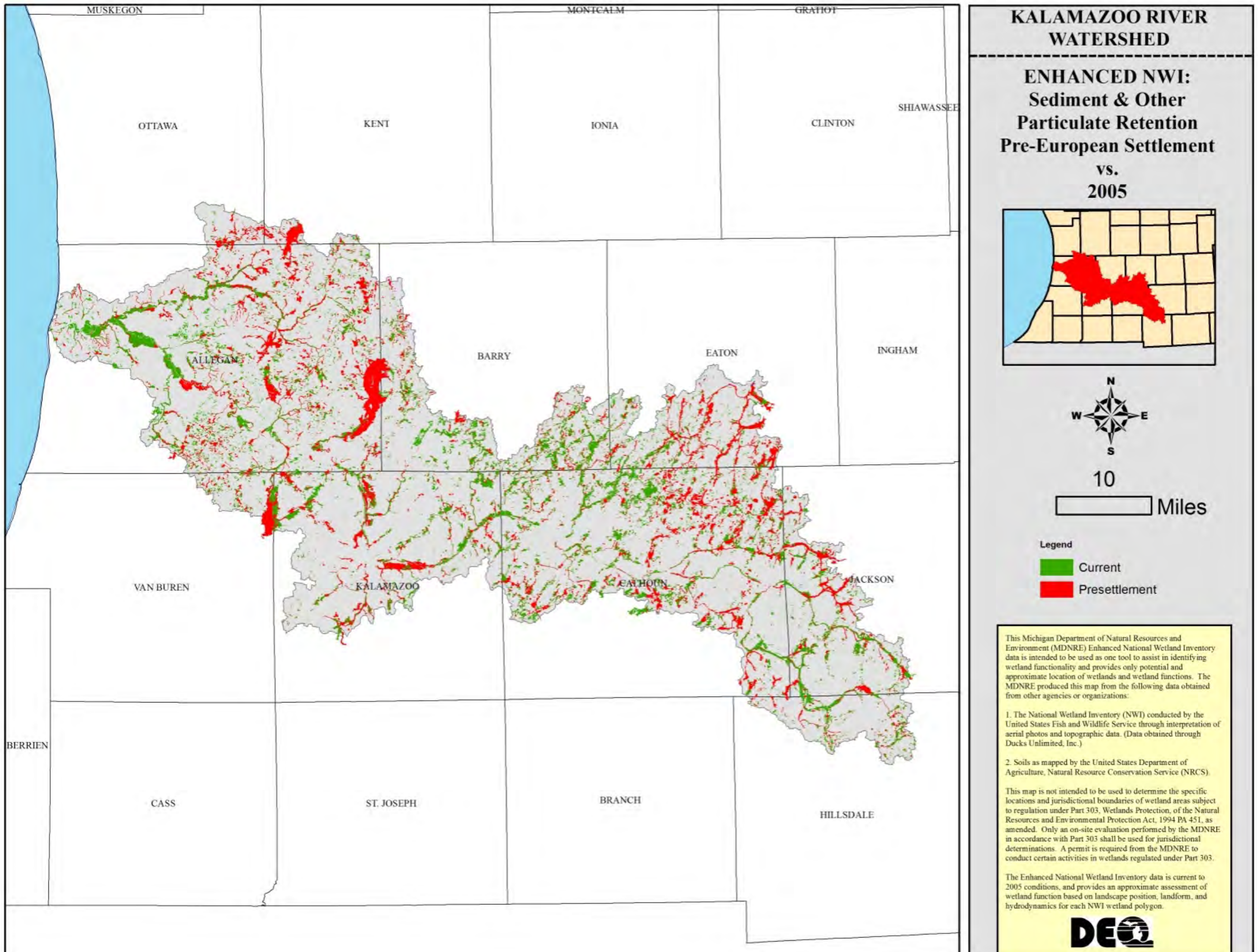
NUTRIENT TRANSFORMATION



SEDIMENT AND OTHER PARTICULATE RETENTION

- This function supports water quality maintenance by capturing sediments with bonded nutrients or heavy metals. Vegetated wetlands will perform this function at higher levels than those of non-vegetated wetlands.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

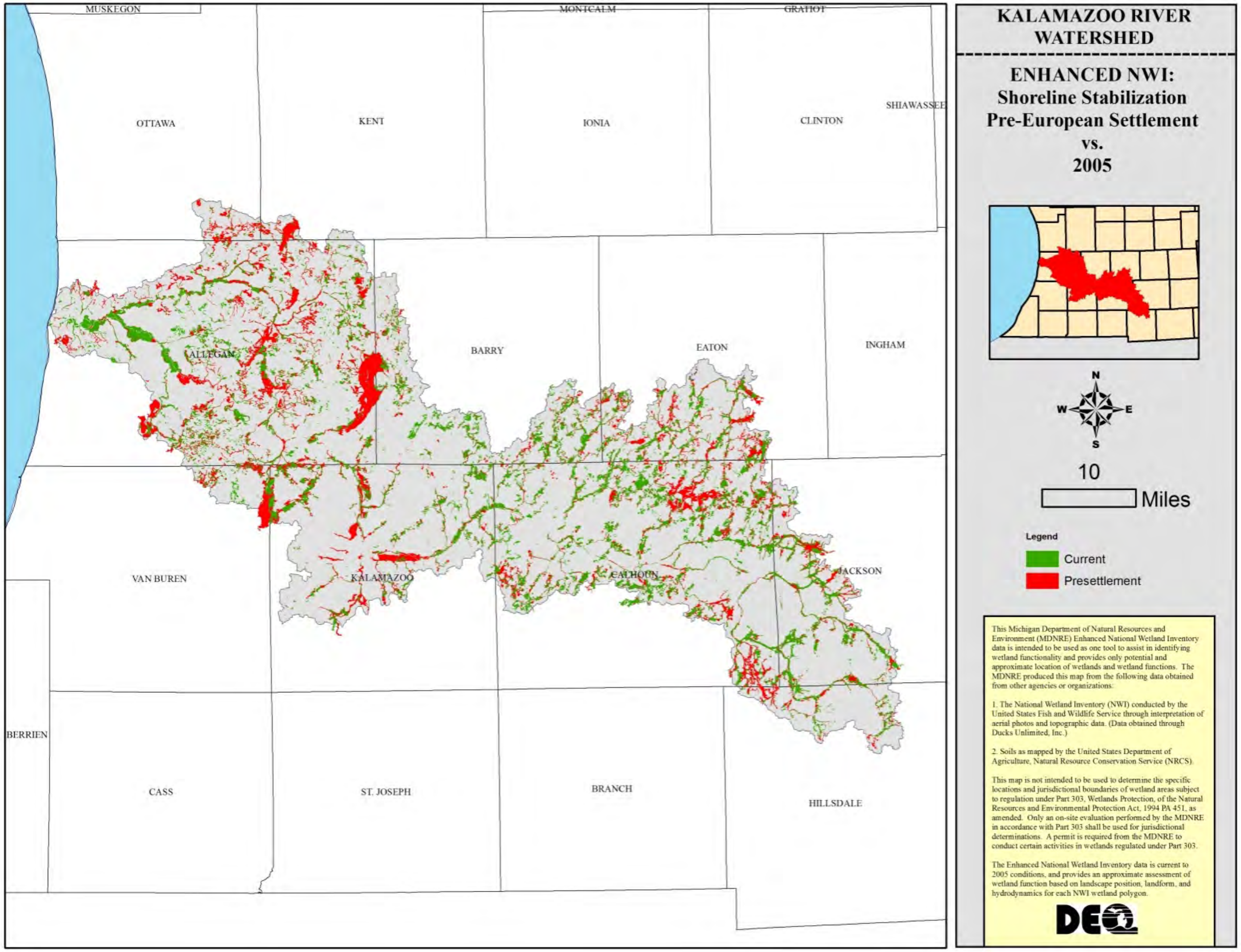
SEDIMENT AND OTHER PARTICULATE RETENTION



SHORELINE STABILIZATION

- Vegetated wetland along all waterbodies (e.g. estuaries, lakes, rivers, and streams) provide this function. Vegetation stabilizes the soil or substrate and diminished wave action, thereby reducing shoreline erosion potential.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

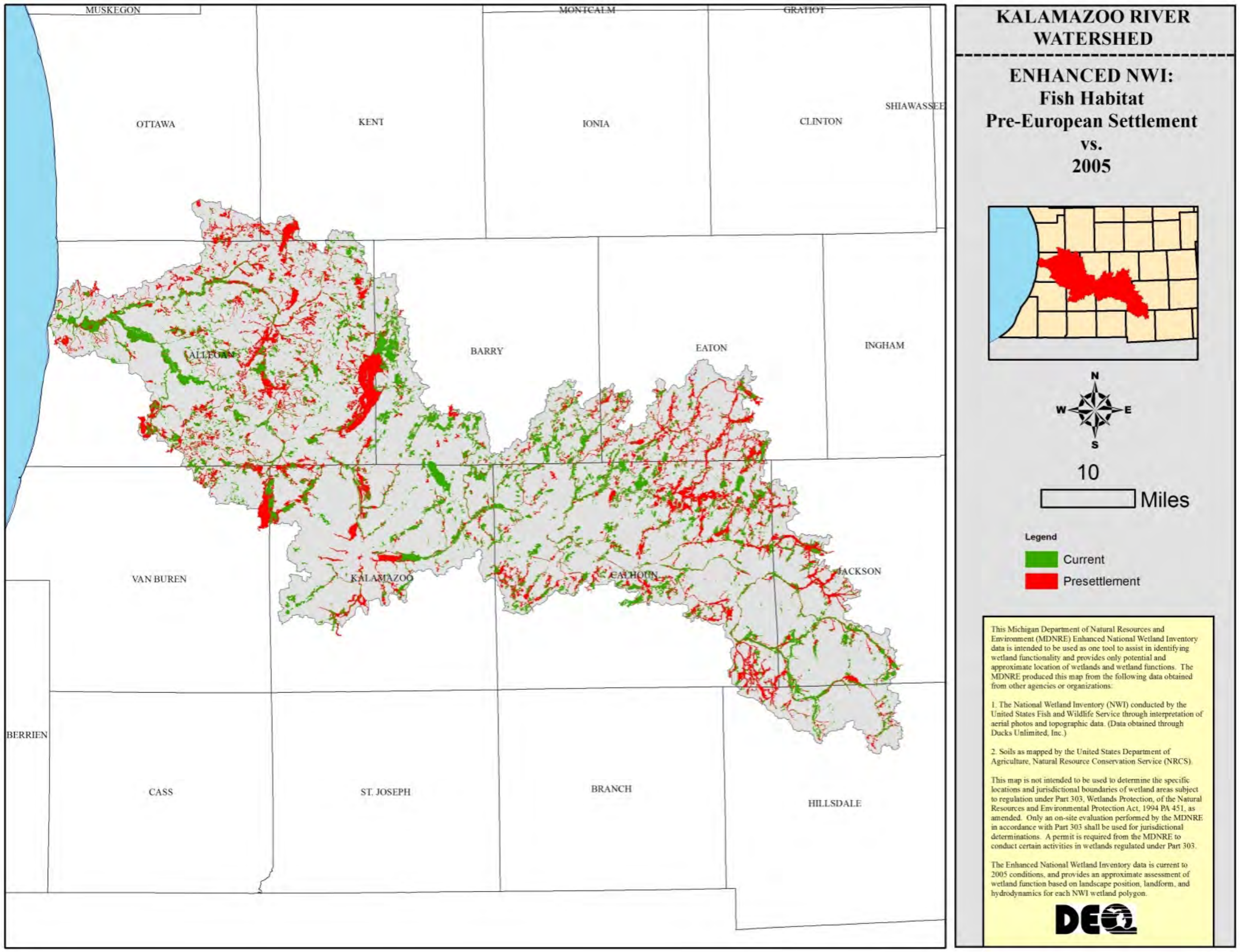
SHORELINE STABILIZATION



FISH HABITAT

- Wetlands that are considered essential to one or more parts of fish life cycles. Wetlands designated as important for fish are generally those used for reproduction, or feeding.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

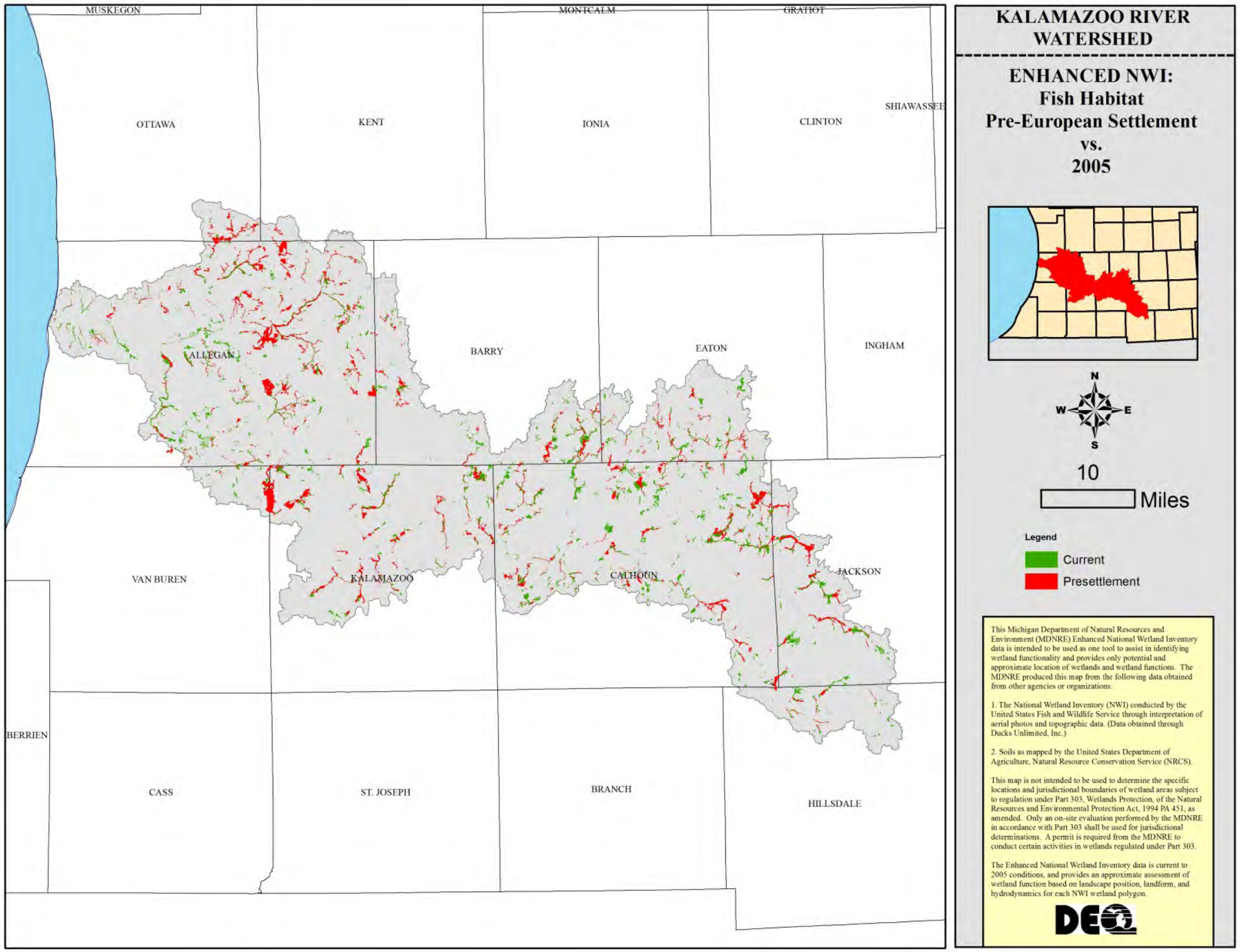
FISH HABITAT



STREAM SHADING

- Wetlands that perform water temperature control due to the proximity to streams and waterways. These wetlands generally are Palustrine Forested or Scrub-Shrub.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

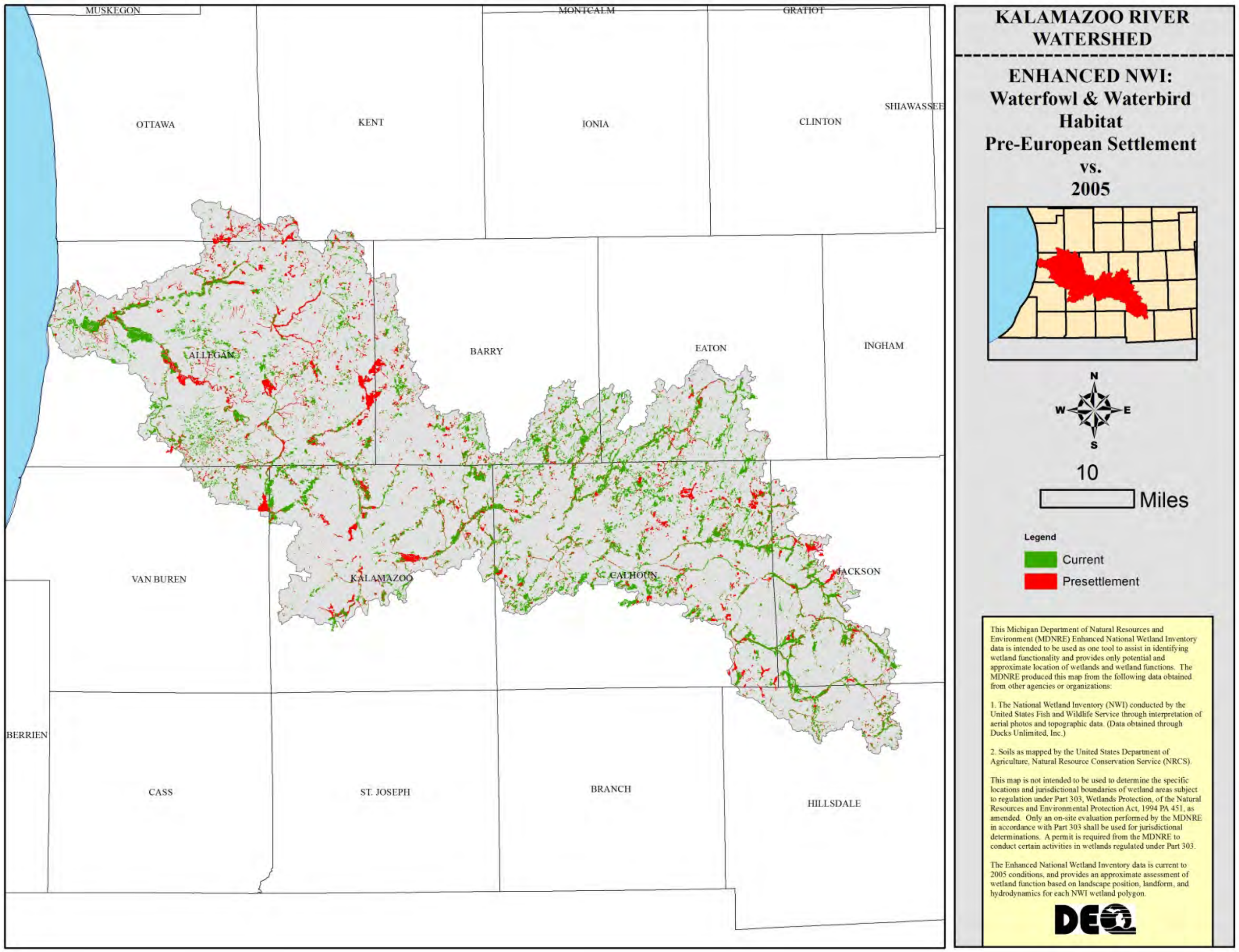
STREAM SHADING



WATERFOWL AND WATERBIRD HABITAT

- Wetlands designated as important for waterfowl and waterbirds are generally those used for nesting, reproduction, or feeding. The emphasis is on the wetter wetlands and ones that are frequently flooded for long periods.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

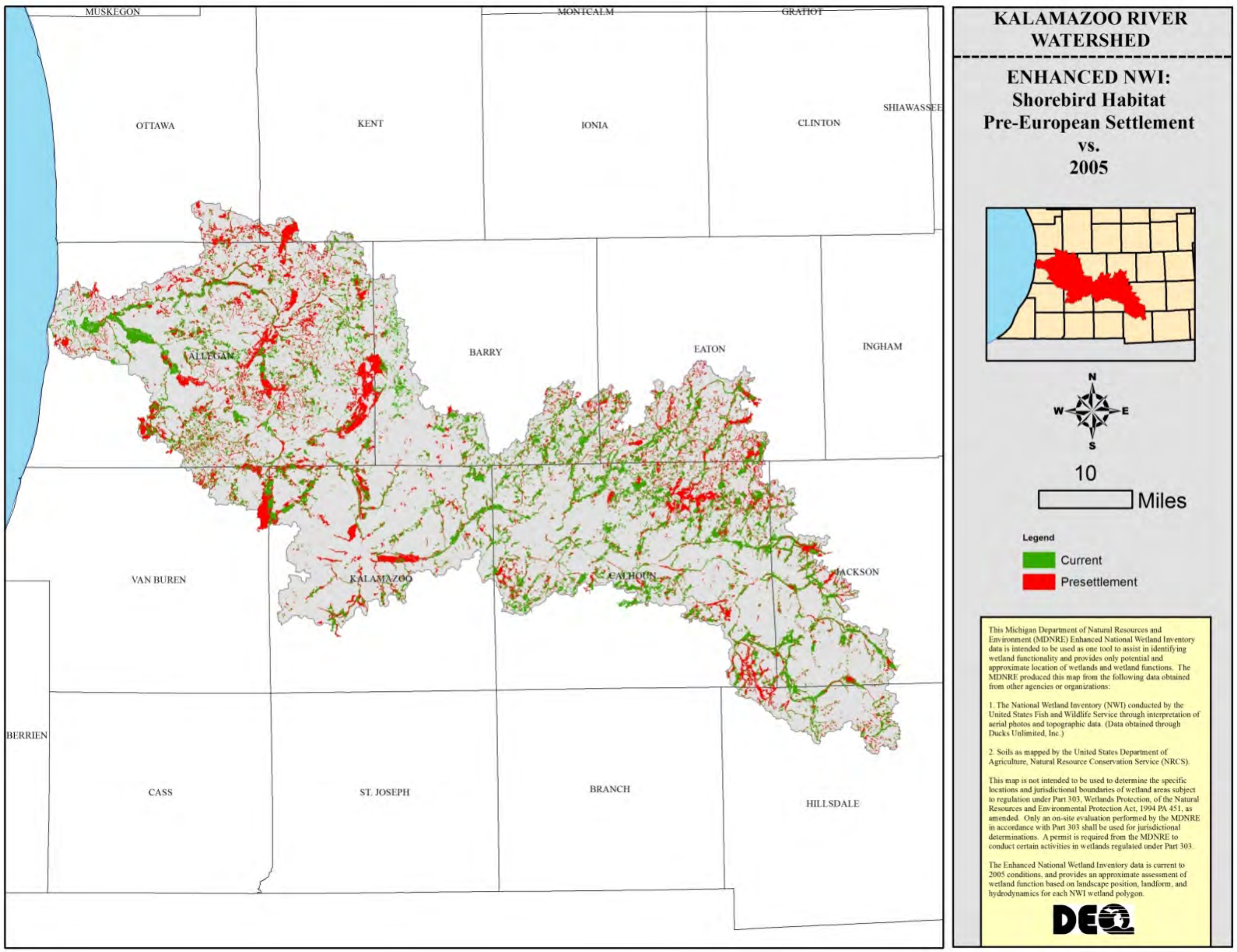
WATERFOWL & WATERBIRD HABITAT



SHOREBIRD HABITAT

- Shorebirds generally inhabit open areas of beaches, grasslands, wetlands, and tundra and undertake some of the longest migrations known. Along their migration pathway, many shorebirds feed in coastal and inland wetlands where they accumulate fat reserves needed to continue their flight. Common species include; plovers, oystercatchers, avocets, stilts, and sandpipers. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

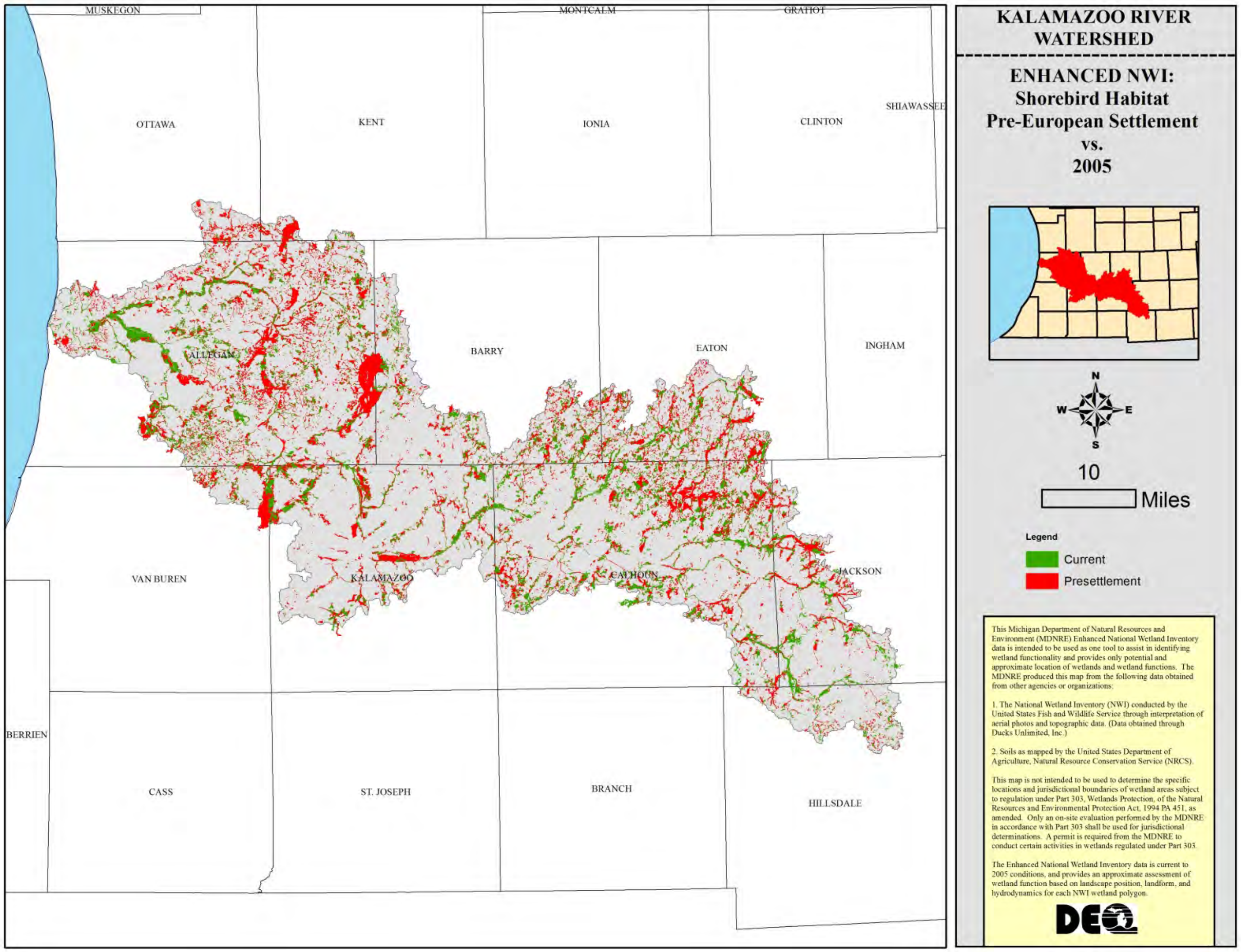
SHORE BIRD HABAITAT



INTERIOR FOREST BIRDS

- Interior Forest Birds require large forested areas to breed successfully and maintain viable populations. This diverse group includes colorful songbirds such as; tanagers, warblers, vireos that breed in North America and winter in the Caribbean, Central and South America, as well as residents and short-distance migrants such as; woodpeckers, hawks, and owls. They depend on large forested tracts, including streamside and floodplain forests. It is important to note that adjacent upland forest to these riparian areas are critical habitat for these species as well. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

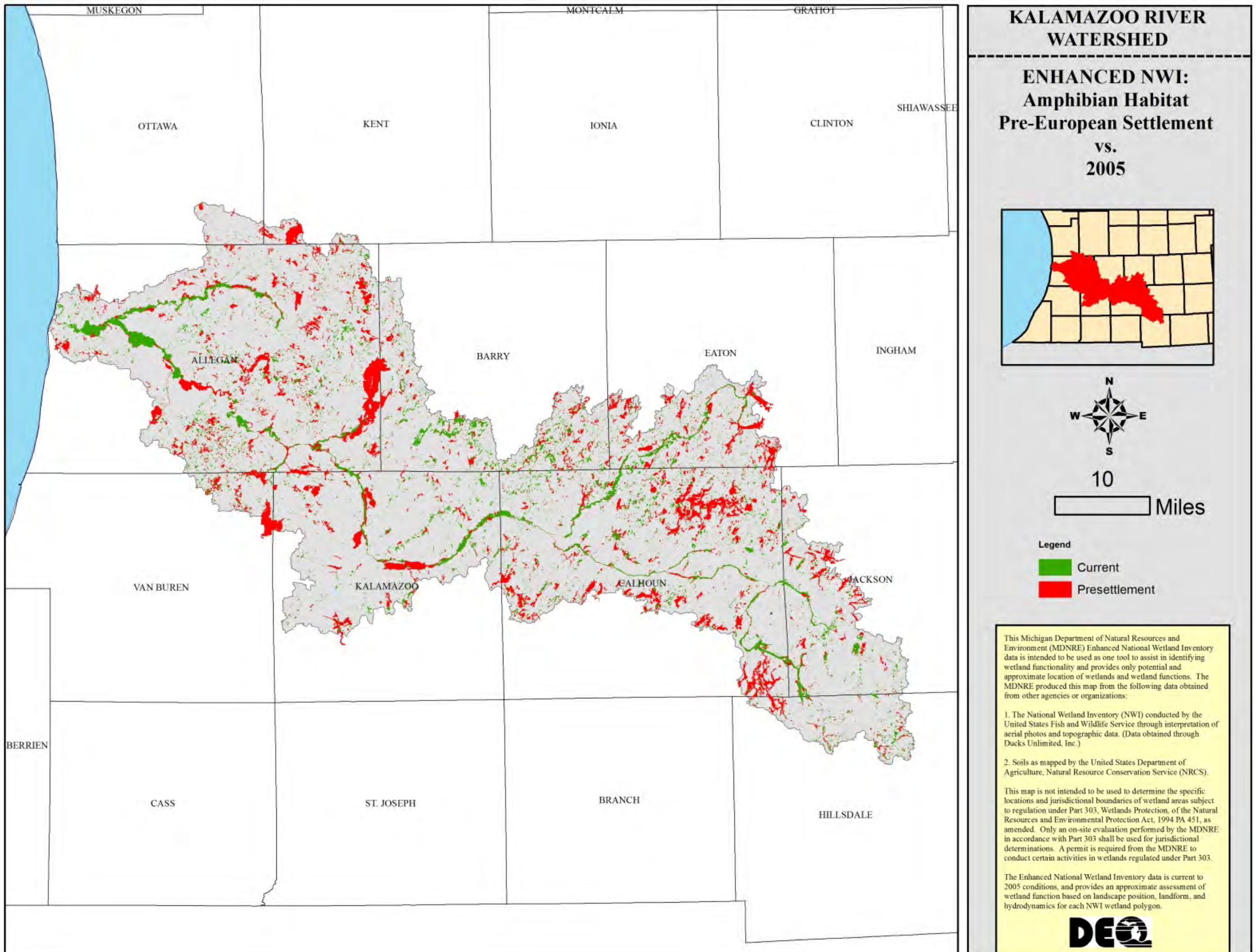
INTERIOR FOREST BIRD HABITAT



AMPHIBIAN HABITAT

- Amphibians share several characteristics in common including wet skin that functions in respiration and gelatinous eggs that require water or moist soil for development. Most amphibians have an aquatic stage and a terrestrial stage and thus live in both aquatic and terrestrial habitats. Aquatic stages of these organisms are often eaten by fish and so for certain species, successful reproduction may occur only in fish-free ponds. Common sub-groups of amphibians are salamanders, frogs, and toads. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

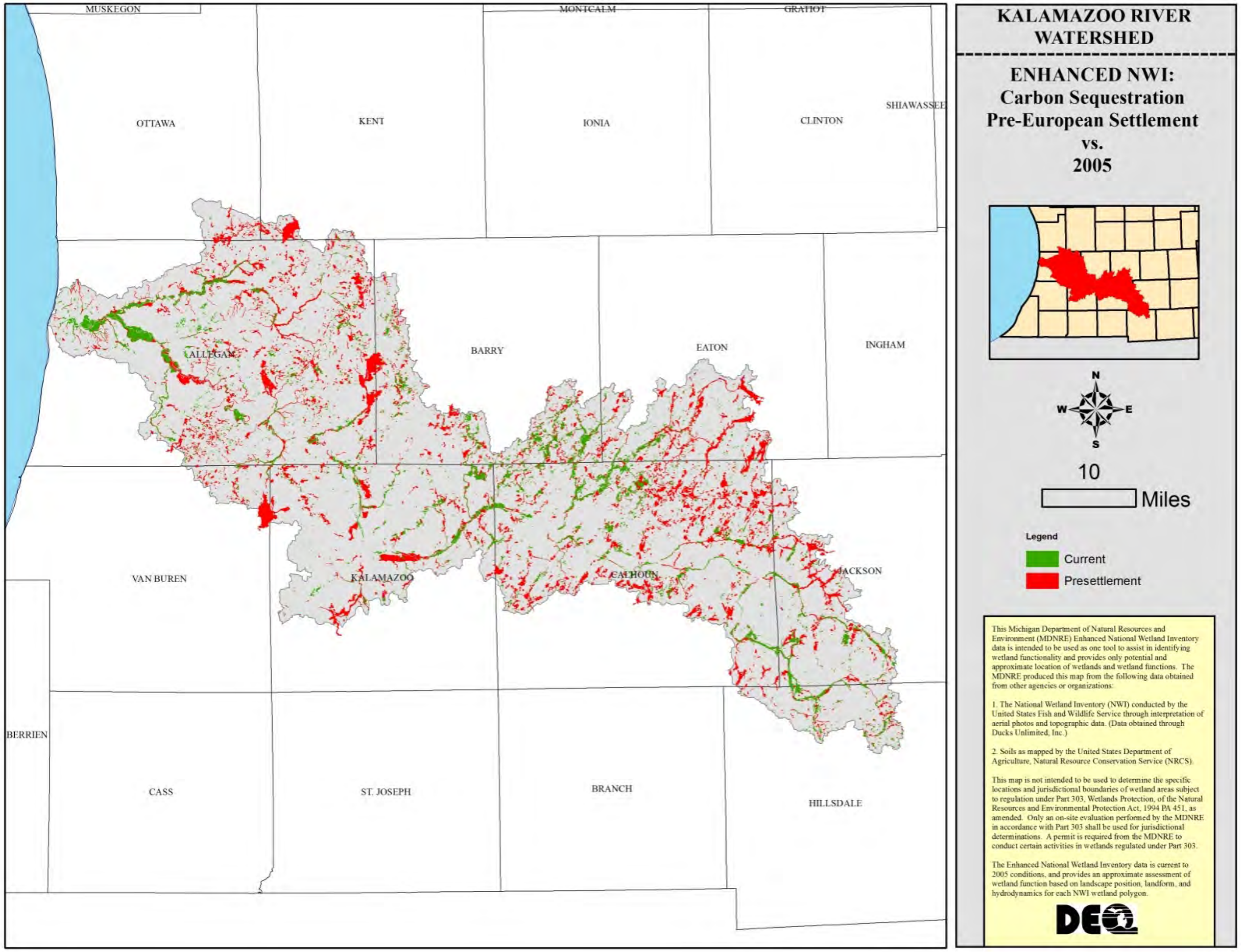
AMPHIBIAN HABITAT



CARBON SEQUESTRATION

- Wetlands are different from other biomes in their ability to sequester large amounts of carbon, as a consequence of high primary production and then deposition of decaying matter in the anaerobic areas of their inundated soils.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

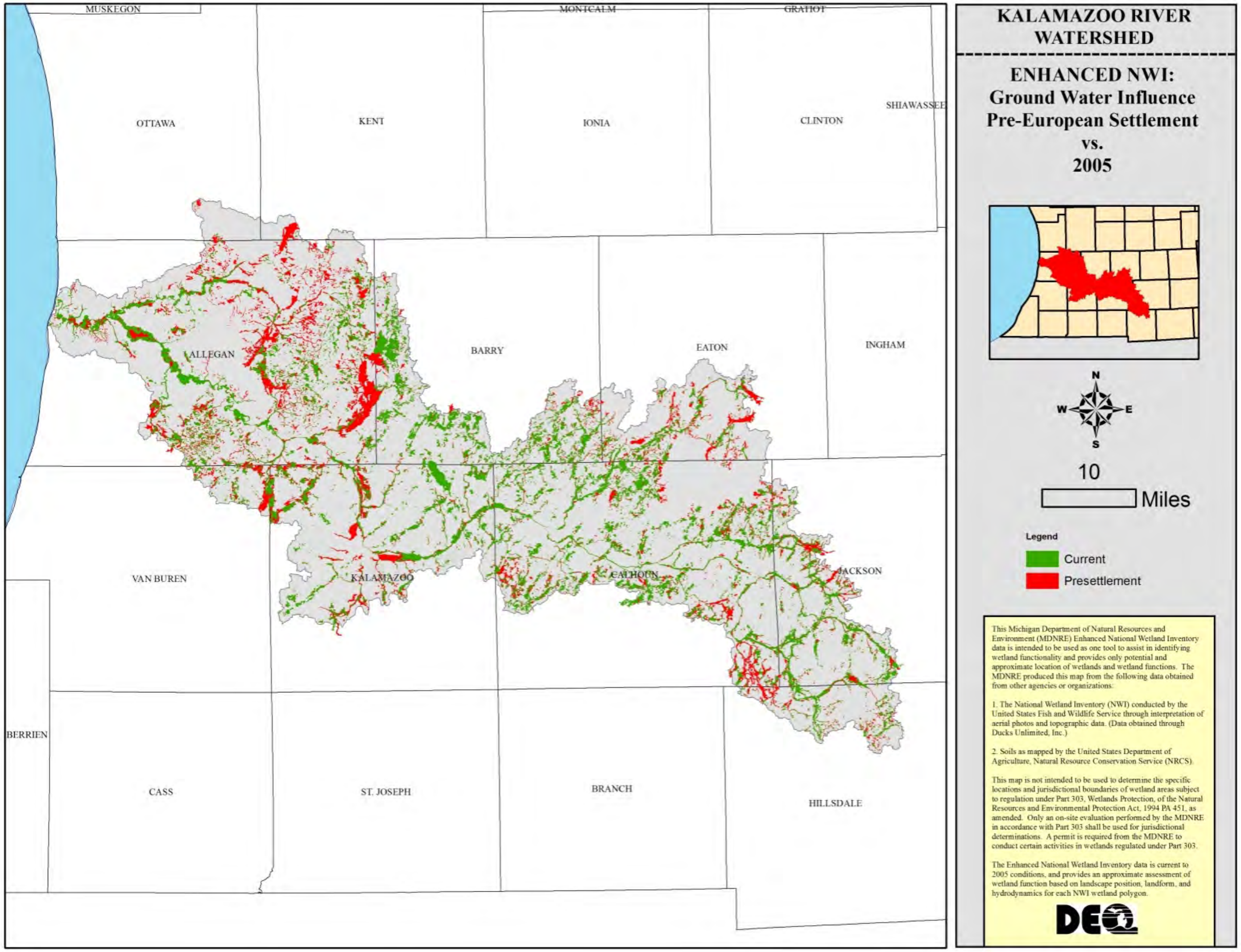
CARBON SEQUESTRATION



GROUND WATER INFLUENCE

- Wetlands categorized as High or Moderate for Groundwater Influence are areas that receive some or all of their hydrologic input from groundwater reflected at the surface. The DARCY (definition of acronym) model was the data source utilized to determine this wetland/groundwater connection, which is based upon soil transmissivity and topography. Wetlands rated for this function are important for maintaining streamflows and temperature control in waterbodies.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

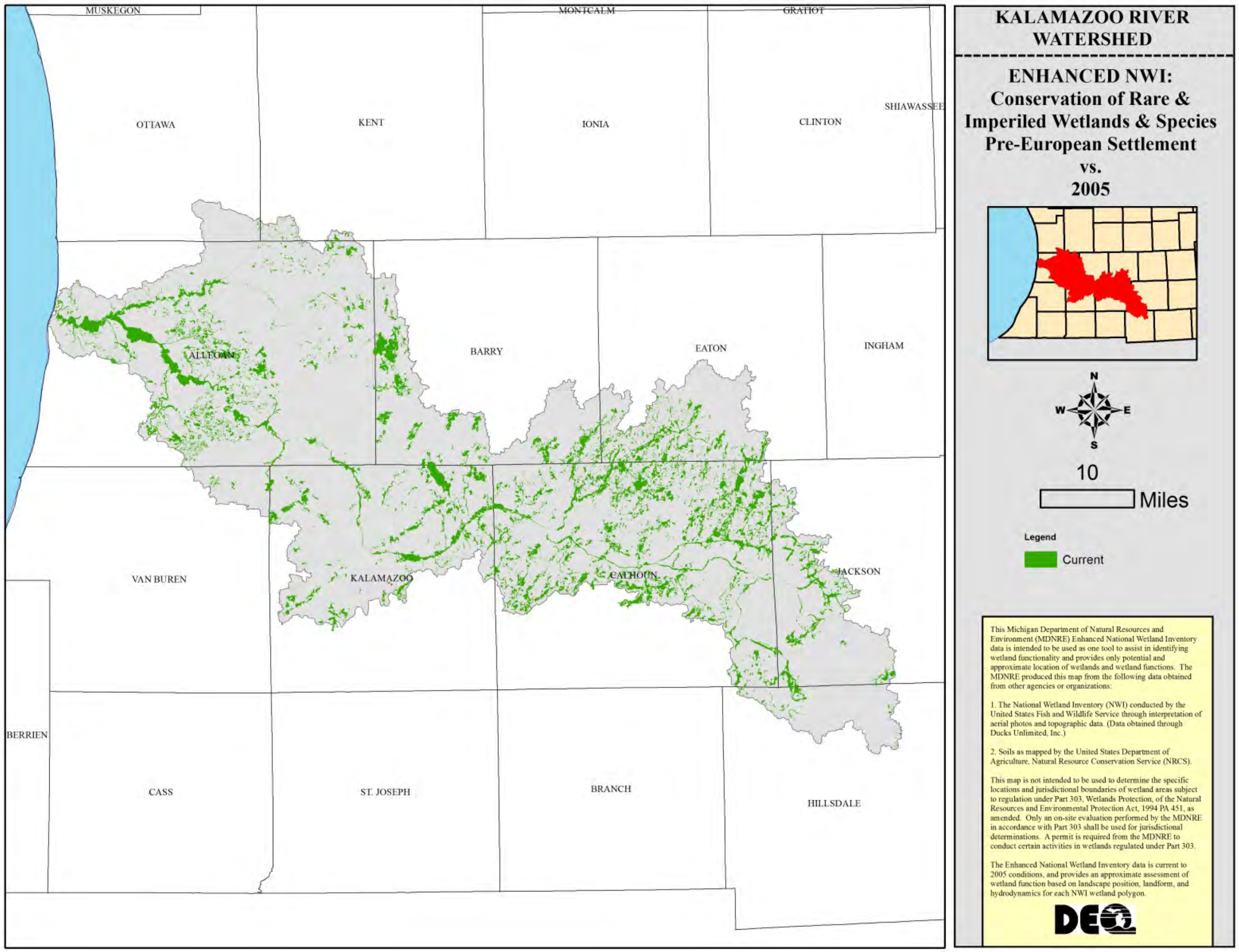
GROUND WATER INFLUENCE



CONSERVATION OF RARE AND IMPERILED WETLANDS & SPECIES

- Wetlands that are considered rare either globally or at the state level. They are likely to contain a wide variety of flora and fauna, or contain threatened or endangered species.
- This function is derived from the Michigan Natural Features Dataset (MNFI) of known sightings of threatened, endangered, or special concern species and high quality natural communities. The model values are reported on a 40 acre polygon grid for the state of Michigan, or a subset of MI. Due to this the dataset should not be used as a comprehensive inventory of Rare and Imperiled wetlands.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in (green) circa 2005.

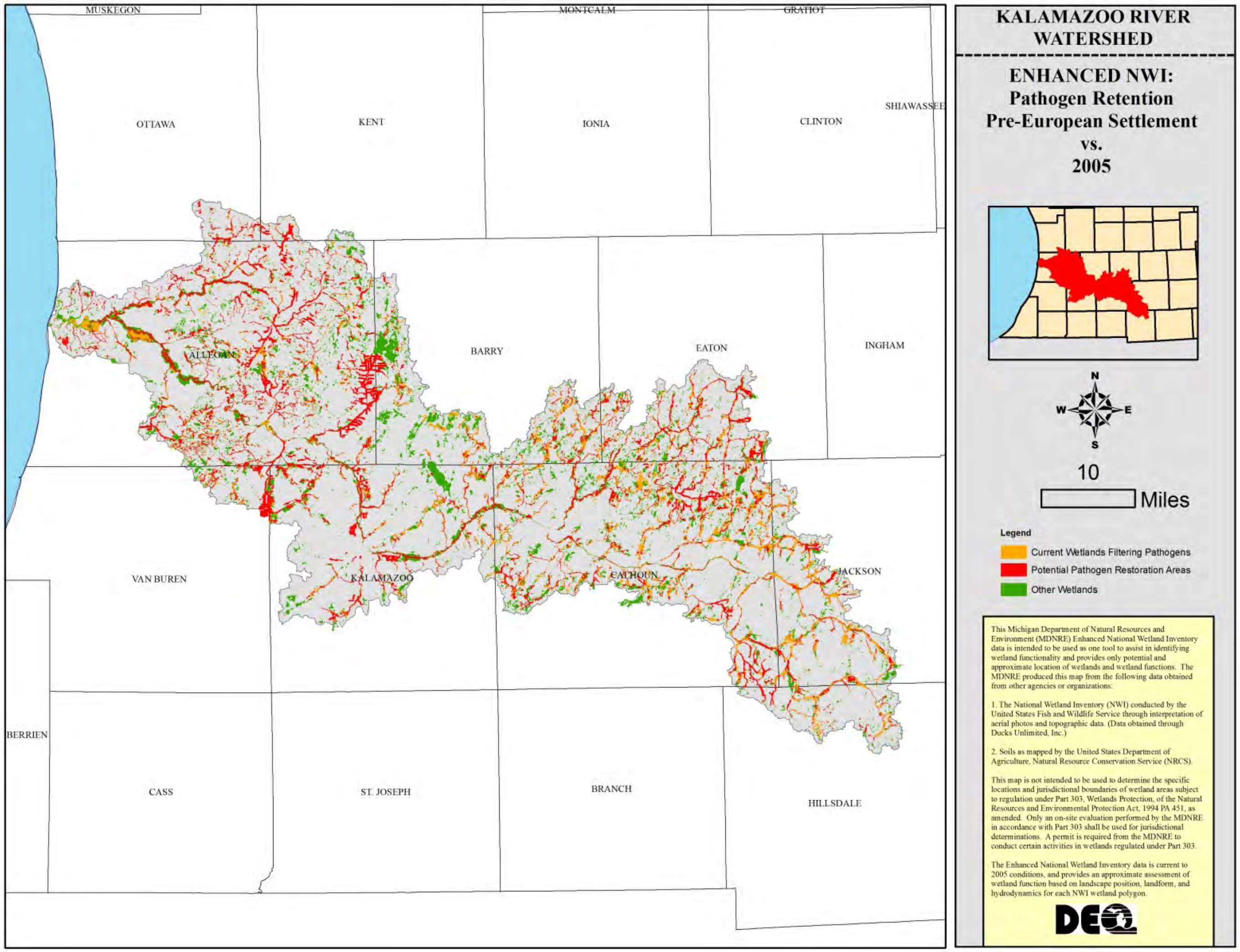
CONSERVATION OF RARE IMPERILED WETLANDS, & SPECIES



PATHOGEN RETENTION

- Wetlands can improve water quality through natural processes of filtration for sedimentation, nutrients and Escherichia coli (E. coli). E. coli is a sub-set of fecal coli forms whose presence in water indicates fecal contamination from warm blooded animals. The presence of E. coli indicates that contamination has occurred, and other harmful pathogens may also be present.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function at a high level are mapped in (orange) circa 2005. Wetlands deemed valuable for restoration for this function are mapped in (red). All other wetland areas are mapped in (green).

PATHOGEN RETENTION



Data Limitations and Disclaimer

National Wetlands Inventory Plus (NWI)

- Wetland boundaries determined from Aerial Imagery
- Last updated in 2005
- Obvious limitations to Aerial Photo Interpretation:
  - Errors of Omission (forested and drier-end wetlands)
  - Errors of Comission (misinterpretation of aerials)

The 2005 NWI data was used in this analysis to report status and trends, as this is currently the best data source available. However, this data may not accurately reflect current conditions on the ground.

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

Landscape Level Wetland Functional Assessment (LLWFA)

- Source data are a primary limiting factor.
- Wetland mapping limitations due to scale, photo quality, and date and time of year of the photos.

- Functional assessment is a preliminary one based on:
  - Wetland Characteristics interpreted through remote sensing
  - Professional Judgment of various specialists to develop correlations between those wetlands and their functions.
- Watershed-based Preliminary Assessment of wetland functions:
  - Applies general knowledge about wetlands and their functions
  - Develops a watershed overview that highlights possible wetlands of significance
  - Does not consider the condition of the adjacent upland
  - Does not obviate the need for more detailed assessment of various functions
- This analysis is a “Landscape Level” assessment and used to identify wetlands that are likely to perform a given function at a level above that of other wetlands not designated