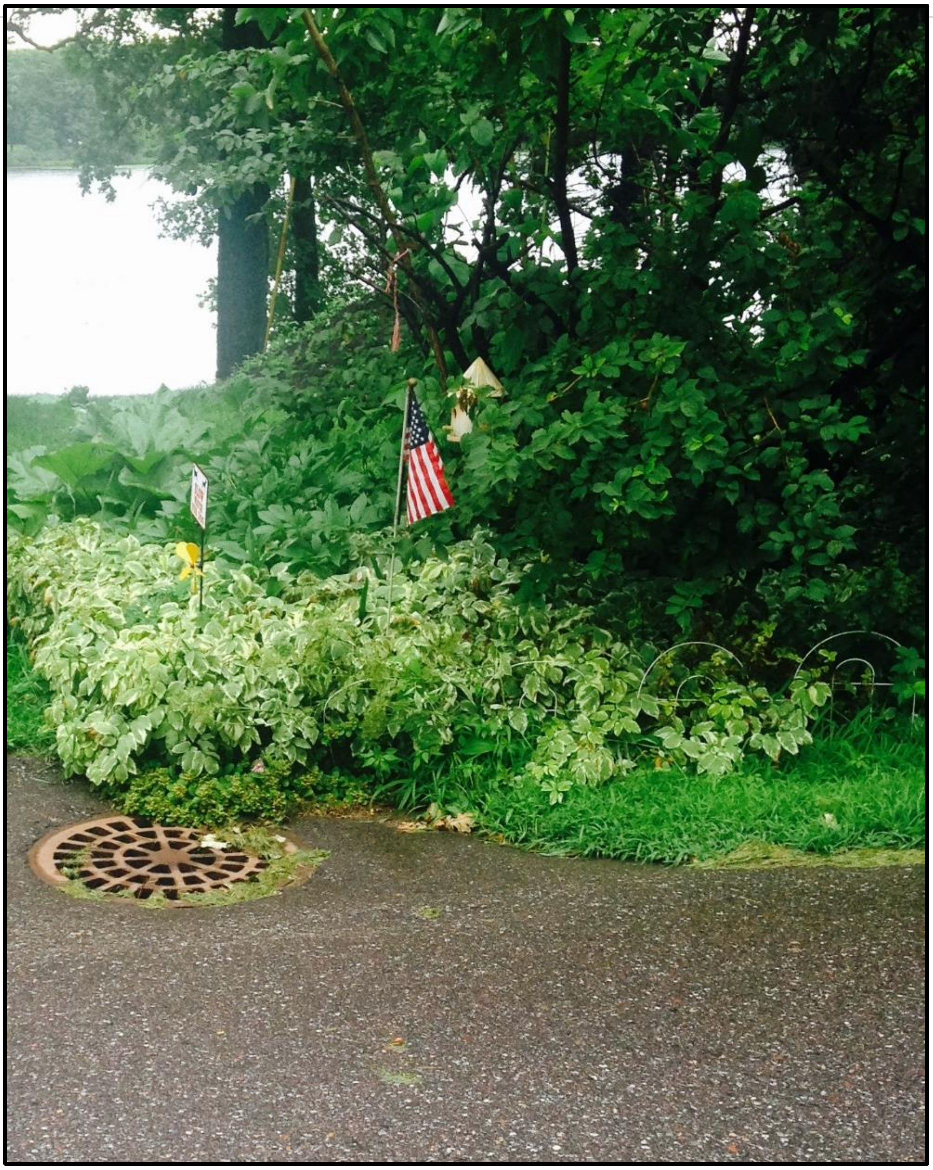

Blue Lake
Stormwater Retrofit Analysis

Prepared by:

Isanti Soil and Water Conservation District

And

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Funding provided in part by the Clean Water Fund of the Clean Water, Land, and Legacy Amendment

Executive Summary

Blue Lake and its surrounding subwatershed are located within both Isanti County and Sherburne County, Minnesota. This study provides recommendations for cost effectively improving treatment of stormwater from areas draining directly to Blue Lake (considered urban) and those outside of the direct drainage area (considered rural). The lake itself and the subwatersheds draining directly to the lake are located in Stanford and Spencer Brook Townships within Isanti County. The Rural subwatershed covers areas in Spencer Brook and Stanford Township in Isanti County and also Baldwin and Livonia Townships in Sherburne County. This report provides sufficient detail to identify projects, rank projects by cost effectiveness at removing phosphorus and begin project planning. It includes project concepts and relative cost estimates for project selection. Site specific planning, designs and refined cost estimates should be done after committed partnerships for project installation are in place.

At 251 acres Blue Lake, the seventh largest lake in the county, is used regularly for recreation such as boating, swimming and fishing. The land directly surrounding Blue Lake is 75% developed, 5% undeveloped and privately owned forested land and 20% lowland marsh or wetland. Blue Lake sits at the threshold for being designated as "impaired" for not meeting state water quality standards for excess nutrients. Recent water quality monitoring data has depicted total phosphorus levels exceeding the Minnesota clean water goals for deep lakes (less than 40 µg/L) by 16% in 2015 and 4% in 2016. The lakeshore homeowners have formed a lake improvement district to organize and fund aquatic invasive species treatment and water quality improvement efforts. Recent efforts to help understand lake trends include surface water monitoring for total phosphorus and total suspended solids in both bays of the lake and four tributary inlets. Other variables being monitored include ortho-phosphorus PH, temperature, dissolved oxygen, conductivity, flow and stage.

This stormwater analysis focuses on "stormwater retrofitting" and ranking projects on cost effectiveness. Stormwater retrofitting refers to adding stormwater treatment to an already developed area or areas being used for production. This process is investigative and creative. Stormwater retrofitting success is sometimes improperly judged by the number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this stormwater analysis we estimated both costs and pollutant reductions and used them to calculate cost effectiveness of each possible project.

The 412 acre urban watershed was delineated using available GIS subwatershed information, on site analysis and maps of stormwater conveyance features. Those areas were then divided into nine smaller stormwater drainage areas, or catchments. Within eight of the nine catchments, smaller sub-catchments were identified to benefit from implementing best management practices. For each sub-catchment, modeling of stormwater volume and pollutants was completed using the software WinSLAMM. Base and existing conditions were modeled, including existing stormwater treatment practices. The catchment not addressed in this document (catchment 8) consists of some low density residential but mostly marshy undeveloped land. Incorporating that information, along with computer analysis and site investigation, areas of concern were not identified in that catchment.

The 6,788 acre rural watershed was delineated through the use of NRCS Engineering Tools. Priority zones were determined using Chisago SWCD protocol (Rural Subwatershed Analysis Protocol Part 1 – Targeting). Once priority zones were established, these were focused upon for Best Management Practice (BMP) implementation through a desktop search using various GIS tools and areal imagery. Field verifications were made when possible, however limited access to private property lots hindered verification in most cases. Zone four identified no beneficial BMPs therefore it is not addressed in this Report. Zone four can be readdressed in the future to track any landscape changes. The Chisago SWCD "Rural Subwatershed Analysis Protocol Part 2 - Prioritizing" was utilized to direct BMP site selection and modeling.

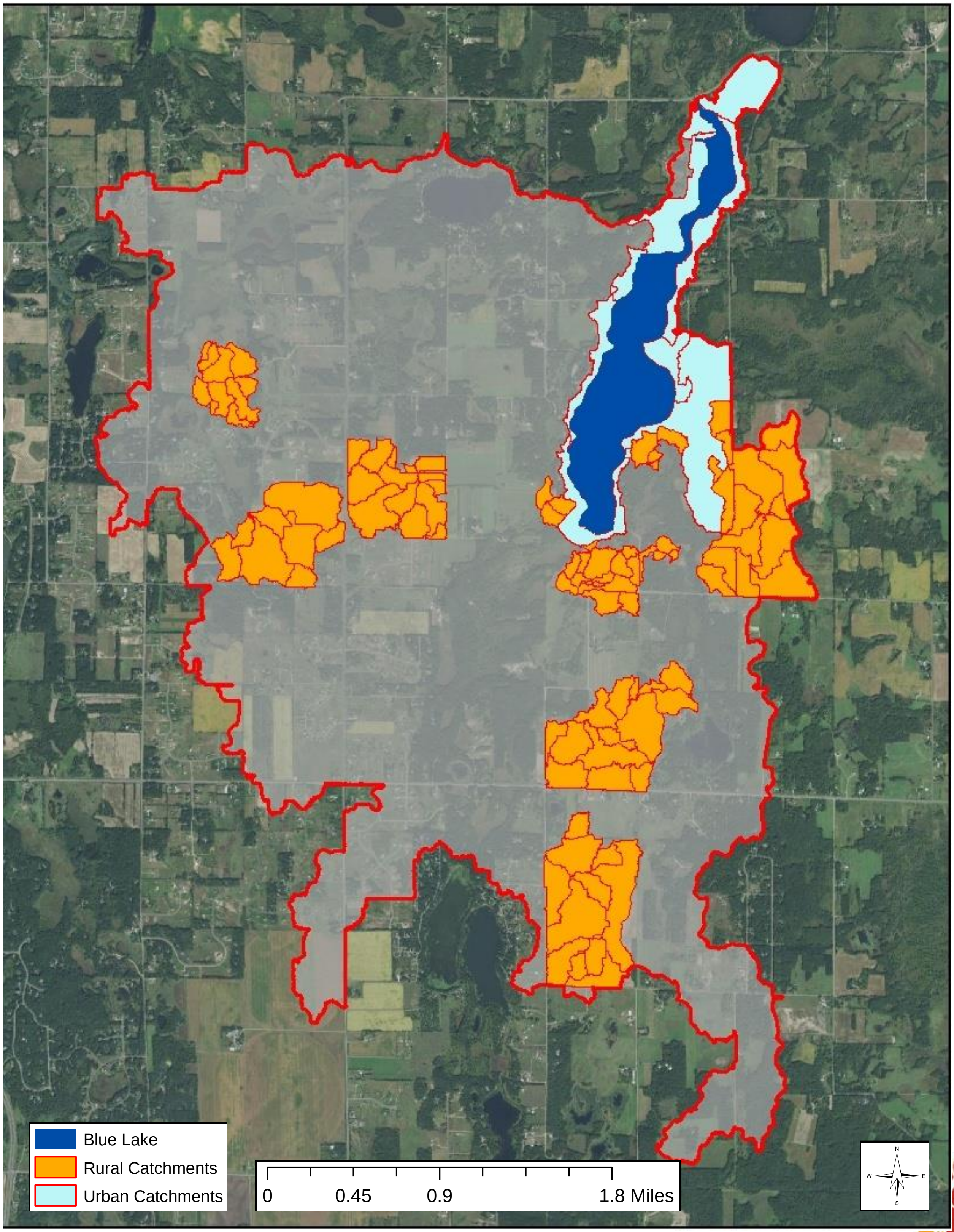
Potential urban and rural stormwater retrofits identified during this analysis were then modeled to estimate reductions in volume, total phosphorus, and total suspended solids. Finally, cost estimates were developed for each retrofit project, including 10-30 years of operations and maintenance. Projects were ranked by cost effectiveness with respect to their reduction of total phosphorus.

A variety of stormwater retrofit approaches were identified. They included:

- Maintenance of, or alterations to, existing stormwater treatment practices,
- Residential curb-cut raingardens,
- Diverting water to catch basins,
- Residential shoreline bioengineering,
- Hillside and gully erosion restoration and stabilization,
- Iron enhanced sand filter (IESF) and sediment pond,
- Stormdrain sediment catch basins,
- Water and sediment control basins,
- Grassed waterways,
- Permanent vegetation,
- Improved infiltration,
- Small farm runoff reduction,
- Wetland restoration.

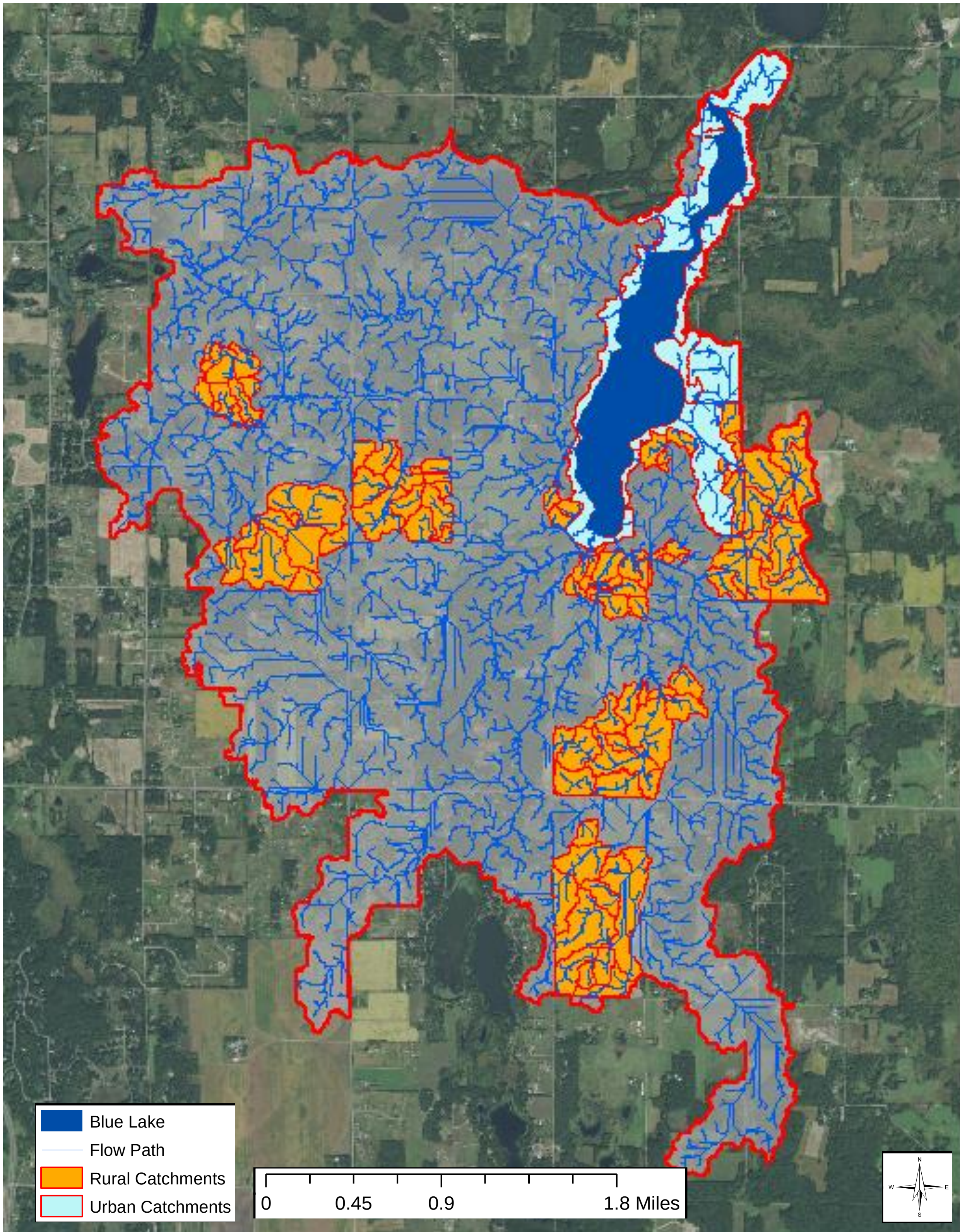
If a project is selected, site-specific designs must be prepared. In addition, many of the proposed retrofits (e.g. IESF and Sediment Pond) will require engineered plan sets if selected. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners when installed on private property. Other factors, including a project's educational value/visibility, construction timing, total cost, or non-target pollutant reduction also affect project installation decisions and will need to be weighed by resource managers when selecting projects to pursue.

This document will be modified to include updates as needed.



Blue Lake Rural Priority Zones and Urban Catchments.

Funding provided in part by the Clean Water Fund of the Clean Water, Land, and Legacy Amendment



Blue Lake Watershed's Concentrated Flow Paths.

Funding provided in part by the Clean Water Fund of the Clean Water, Land, and Legacy Amendment

Retrofit Ranking

The tables on the next pages summarize potential projects organized from most cost effective to least, based on cost per pound of total phosphorus removed. Reported treatment levels are dependent upon optimal siting and sizing. More detail about each project can be found in the catchment profile pages of this report. Projects that were deemed unfeasible due to prohibitive size, number, or were too expensive to justify installation are not included in the tables on the next pages.

Installing all of these projects is unlikely due to funding limitation and landowner interest. Instead, it is recommended that projects be installed in order of cost-effectiveness (points of pollution reduced per dollar spent). Other factors, including a projects educational value, visibility, construction timing, total cost, focusing on upstream projects that benefit all lakes, or non-target pollutant reduction also affect project installation decisions and will need to be weighted by resource managers when selecting projects.

Urban retrofit projects are ranked against projects in the direct watershed (urban) projects only and the rural retrofit projects are ranked against the rural watershed projects only.

Funding provided in part by the Clean Water Fund of the Clean Water, Land, and Legacy Amendment

Table 1: Urban Project Ranking

Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total Phosphorus (TP) Reduction.

Project Rank	Project ID	Retrofit Type	Projects Identified	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2016 Dollars)	Estimated Annual Operations & Maintenance (2016 Dollars)	Estimated cost/ 1,000lb-TP/year (30-year)[1]	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
1	5a	Gully/Hill Slump/Shoreline Repair and Restoration	3	5	6.24	13297.00	119.00	$23,298	$700	$237	$111
2	4a	Gully/Washout Repair	1	4	0.91	2140.00	0.00	$7,784	$75	$386	$156
3	Lakeshore	Lakeshore Restoration - 20 High Priority Sites	20	Lakeshore (1-9) Exclude 8	8.40	10498.34	0.00	$80,194	$195	$341	$273
4	Lakeshore	Lakeshore Restoration - 15 High Priority Sites	15	Lakeshore (1-9) Exclude 8	6.63	8288.16	0.00	$63,180	$195	$347	$278
5	Lakeshore	Lakeshore Restoration - 10 High Priority Sites	10	Lakeshore (1-9) Exclude 8	4.42	5525.44	0.00	$42,950	$195	$368	$294
6	Lakeshore	Lakeshore Restoration - 5 High Priority Sites	5	Lakeshore (1-9) Exclude 8	2.21	2762.72	0.00	$22,720	$195	$431	$345
7	5b	IESF with Settling Pond	1	5	24.1	9,885	2.7	$826,071	$2,090	$1,229	$2,997
8	2b	Rain Garden 300sq/ft	1	2	0.70	183.00	0.90	$12,284	$225	$906	$3,467
9	2a	Rain Garden 400sq/ft	1	2	0.50	140.00	0.56	$15,581	$225	$1,489	$5,317
10	4b	Stormwater Pond	1	4	0.72	254.00	3060.0	$113,163	$1,000	$6,656	$18,788
11	4c	Sump	2	4	0.10	36.00	0.00	$12,784	$1,750	$21,761	$60,448
12	2c	Sump	1	2	0.30	14.00	0.00	$13,784	$1,750	$7,365	$157,818

Table 2: Rural Project Ranking (continues through page 14)

Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total Phosphorus (TP) reduction.								
BMP Characteristics						**Cost-Benefit**		
Project Rank	**Priority Zone**	**Sub-Basin**	**Retrofit Type**	**Sediment reduction (t/yr)**	**Phosphorus reduction (lb/yr)**	**Practice Cost**	**P reduction (lb/yr)**	**$ per lb TP Removed**
1	5	7	Filter Strip	1.42	1.79	$74.58	1.79	$41.66
2	2	6	Filter Strip	2.73	3.83	$257.64	3.83	$67.27
3	5	5	Filter Strip	1.19	1.51	$108.48	1.51	$71.84
4	6	15	Filter Strip	1.60	2.3	$196.62	2.33	$84.39
5	2	11	Filter Strip	1.31	1.92	$189.84	1.92	$98.88
6	7a	5	Filter Strip	1.85	2.47	$250.86	2.47	$101.56
7	3	5	Filter Strip	2.85	3.41	$413.58	3.41	$121.28
8	2	10	Filter strip	0.72	1.06	$128.82	1.06	$121.53
9	7a	1	Filter Strip	1.65	2.25	$277.98	2.25	$123.55
10	6	2	Filter Strip	1.17	1.49	$196.62	1.49	$131.96
11	5	14	Filter Strip	1.01	1.11	$162.72	1.11	$146.59
12	5	6	Filter Strip	0.33	0.48	$74.58	0.48	$155.38
13	6	7	Filter Strip	0.82	1.11	$176.28	1.11	$158.81
14	7a	6	Filter Strip	2.97	4.01	$664.44	4.01	$165.70
15	6	13	Filter Strip	3.48	4.56	$759.36	4.56	$166.53
16	2	13	Filter Strip	1.33	1.77	$298.32	1.77	$168.54
17	5	16	Filter Strip	1.71	2.00	$359.34	2.00	$179.67
18	2	13	Filter Strip	1.26	1.68	$305.10	1.68	$181.61
19	6	10	Filter Strip	1.34	1.41	$277.98	1.41	$197.15
20	6	8	Filter Strip	2.88	3.00	$596.64	3.00	$198.88
21	2	9	Filter Strip	0.76	1.12	$223.74	1.12	$199.77
22	7a	11	Filter Strip	3.8	5.1	$1,064.46	5.13	$207.50
23	7a	13	Filter Strip	0.49	0.65	$142.38	0.65	$219.05
24	6	1	Filter Strip	0.69	0.85	$196.62	0.85	$231.32
25	7b	3	Filter Strip	1.10	1.49	$359.34	1.49	$241.17

Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total Phosphorus (TP) reduction.								
BMP Characteristics						Cost-Benefit		
Project Rank	Priority Zone	Sub-Basin	Retrofit Type	Sediment reduction (t/yr)	Phosphorus reduction (lb/yr)	Practice Cost	P reduction (lb/yr)	$ per lb TP Removed
26	6	12	Filter Strip	3.10	4.24	$1,050.90	4.24	$247.85
27	9	3	Filter Strip	0.66	0.84	$210.18	0.84	$250.21
28	5	11	Filter Strip	1.33	1.70	$427.14	1.70	$251.26
29	3	6	Filter Strip	2.43	2.93	$745.80	2.93	$254.54
30	7a	8	Filter Strip	0.61	0.83	$216.96	0.83	$261.40
31	7a	5	Filter Strip	0.67	0.89	$244.08	0.89	$274.25
32	5	9	Filter Strip	0.80	0.96	$264.42	0.96	$275.44
33	1	8	Filter strip	0.23	0.36	$101.70	0.36	$282.50
34	5	10	Filter Strip	2.47	3.11	$915.30	3.11	$294.31
35	1	7	Filter strip	0.47	0.76	$223.74	0.76	$294.39
36	6	4	Filter Strip	0.62	0.91	$291.54	0.91	$320.37
37	9	1	Filter Strip	0.95	1.30	$454.26	1.30	$349.43
38	1	10	Filter strip	0.64	0.95	$332.22	0.95	$349.71
39	2	7	Filter Strip	0.57	0.88	$325.44	0.88	$369.82
40	1	1	Filter Strip	0.2	0.32	$122.04	0.32	$381.38
41	6	3	Filter Strip	0.40	0.53	$203.40	0.53	$383.77
42	8	4	Filter Strip	0.73	0.95	$366.12	0.95	$385.39
43	5	17	Filter Strip	0.35	0.47	$196.62	0.47	$418.34
44	3	2	Grassed waterway	7.81	6.63	$2,152.59	6.63	$324.67
45	1	9	Grassed waterway	4.03	3.43	$1,126.70	3.43	$328.48
46	2	12	Grassed waterway	4.04	3.44	$1,304.60	3.44	$379.24
47	7a	7	Grassed waterway	5.51	4.69	$1,779.00	4.69	$379.32
48	7a	14	Grassed waterway	4.41	3.75	$1,423.20	3.75	$379.52
49	7b	5	Grassed waterway	5.88	5.00	$1,897.60	5.00	$379.52
50	7b	5	Grassed waterway	8.64	7.34	$2,787.10	7.34	$379.71

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Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total Phosphorus (TP) reduction.

BMP Characteristics						Cost-Benefit		
Project Rank	Priority Zone	Sub-Basin	Retrofit Type	Sediment reduction (t/yr)	Phosphorus reduction (lb/yr)	Practice Cost	P reduction (lb/yr)	$ per lb TP Removed
51	5	8	Grassed waterway	2.25	1.91	$741.25	1.91	$388.09
52	7a	14	Grassed waterway	4.83	4.1	$1,630.75	4.1	$397.74
53	7a	2	Grassed waterway	7.28	6.19	$2,490.60	6.19	$402.36
54	3	4	Grassed waterway	3.61	3.07	$1,245.30	3.07	$405.64
55	6	4	Grassed waterway	4.14	3.52	$1,452.85	3.52	$412.74
56	5	4	Grassed waterway	6.85	5.82	$2,549.90	5.82	$438.13
57	5	15	Grassed waterway	2.71	2.30	$1,008.10	2.30	$438.30
58	7b	1	Grassed waterway	3.16	2.69	$1,186.00	2.69	$440.89
59	7b	4	Grassed waterway	3.16	2.69	$1,186.00	2.69	$440.89
60	6	1	Grassed waterway	4.26	3.62	$1,601.10	3.62	$442.29
61	7a	9	Grassed waterway	6.29	5.35	$2,401.65	5.35	$448.91
62	6	14	Grassed waterway	6.5	5.5	$2,905.70	5.51	$527.35
63	1	6	Grassed waterway	5.82	4.95	$2,621.06	4.95	$529.51
64	6	11	Grassed waterway	2.18	1.85	$1,008.10	1.85	$544.92
65	6	6	Grassed waterway	4.18	3.55	$2,016.20	3.55	$567.94
66	2	2	Grassed waterway	5.44	4.62	$2,763.38	4.62	$598.13
67	7a	4	Grassed waterway	6.93	5.89	$3,528.35	5.89	$599.04
68	2	1	Grassed waterway	4.03	3.42	$2,134.80	3.42	$624.21
69	7b	10	Grassed waterway	3.27	2.78	$1,779.00	2.78	$639.93
70	1	3	Grassed waterway	2.66	2.26	$1,482.50	2.26	$655.97
71	7b	6	Grassed waterway	1.98	1.68	$1,186.00	1.68	$705.95
72	5	13	Gully stabilization	2.57	2.19	$622.65	2.19	$284.32
73	2	14	Gully stabilization	4.88	4.15	$1,363.90	4.15	$328.65
74	8	1	Gully stabilization	7.08	6.01	$2,283.05	6.01	$379.88
75	5	3	Gully stabilization	4.84	4.11	$1,779.00	4.11	$432.85

Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total Phosphorus (TP) reduction.

BMP Characteristics						Cost-Benefit		
Project Rank	Priority Zone	Sub-Basin	Retrofit Type	Sediment reduction (t/yr)	Phosphorus reduction (lb/yr)	Practice Cost	P reduction (lb/yr)	$ per lb TP Removed
70	1	3	Grassed waterway	2.66	2.26	$1,482.50	2.26	$655.97
71	7b	6	Grassed waterway	1.98	1.68	$1,186.00	1.68	$705.95
72	5	13	Gully stabilization	2.57	2.19	$622.65	2.19	$284.32
73	2	14	Gully stabilization	4.88	4.15	$1,363.90	4.15	$328.65
74	8	1	Gully stabilization	7.08	6.01	$2,283.05	6.01	$379.88
75	5	3	Gully stabilization	4.84	4.11	$1,779.00	4.11	$432.85
76	7a	10	Gully stabilization	2.49	2.12	$978.45	2.12	$461.53
77	3	7	Permanent Vegetation	15.37	23.96	$1,430.00	23.96	$59.68
78	1	9	Permanent Vegetation	0.40	0.81	$286.00	0.81	$353.09
79	8	3	Permanent vegetation	0.56	0.72	$407.00	0.72	$565.28
80	6	9	Permanent Vegetation	1.55	2.42	$1,408.00	2.42	$581.82
81	7b	11	Permanent vegetation	6.75	12.43	$14,300.00	12.43	$1,150.44
82	2	8	WASCOB	13.32	11.33	$9,803.70	11.33	$865.29
83	2	5	WASCOB	9.96	8.46	$9,803.70	8.46	$1,158.83
84	1	2	WASCOB	8.44	7.17	$9,803.70	7.17	$1,367.32
85	2	3	WASCOB	10.54	8.96	$13,087.50	8.96	$1,460.66
86	3	1	WASCOB	7.10	6.04	$9,803.70	6.04	$1,623.13
87	5	1	WASCOB	7.10	6.04	$13,087.50	6.04	$2,166.80
88	6	5	WASCOB	4.94	4.20	$9,803.70	4.20	$2,334.21
89	7a	12	WASCOB	6.37	5.41	$13,087.50	5.41	$2,419.13
90	8	2	WASCOB	4.48	3.80	$9,803.70	3.80	$2,579.92
91	7a	3	WASCOB	5.93	5.04	$13,087.50	5.04	$2,596.73
92	6	5	WASCOB	3.69	3.13	$9,803.70	3.13	$3,132.17
93	9	2	WASCOB	3.36	2.86	$9,803.70	2.86	$3,427.87
94	7b	2	WASCOB	4.48	3.80	$13,087.50	3.80	$3,444.08
95	7b	9	WASCOB	3.30	2.81	$13,087.50	2.81	$4,657.47
96	7b	7	WASCOB	1.89	1.61	$9,803.70	1.61	$6,089.25
97	7b	8	WASCOB	0.94	0.80	$9,803.70	0.80	$12,254.63
N.A.	3	3	Wetland Restoration	-	-			
N.A.	3	8	Wetland Restoration	-	-			
N.A.	8	4	Wetland Restoration	5.88	5.00			
N.A.	5	2	Manure mgmt	-	-			

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