Forest Lake South Direct Stormwater Retrofit Analysis

Prepared by:

WASHINGTON CONSERVATION DISTRICT

for the

COMFORT LAKE FOREST LAKE WATERSHED DISTRICT

MARCH, 2014

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Cover image:
Bing Images – Birds Eye View

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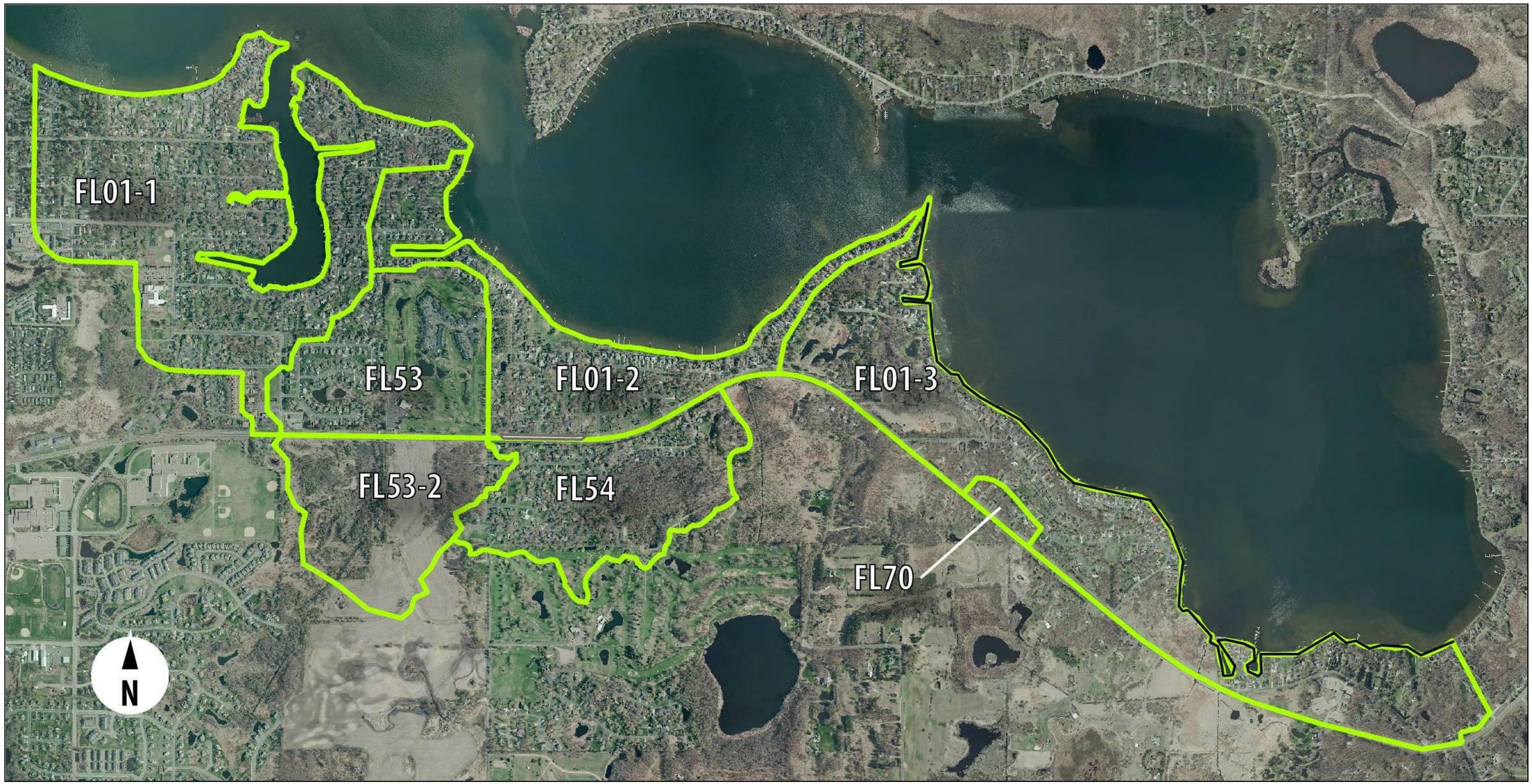
Map of stormwater catchments referred to in this report. Catchment profiles on the following pages provide additional detail.



Executive Summary

This analysis provides recommendations for cost effectively improving treatment of stormwater from areas directly draining to Forest Lake along its southern boundary (herein described as Forest Lake South Direct Subwatershed Retrofit Analysis). This area is entirely located within the Comfort Lake Forest Lake Watershed District (CLFLWD) boundary as well as within the City of Forest Lake.

Although Forest Lake is not considered impaired, annual water monitoring reports reveal pollutant levels (namely phosphorus) are near thresholds for impairment in deep water lakes. The stormwater retrofits in this report will aid with alleviating existing water quality problems in Forest Lake.

Seven catchments (totaling over 930 acres) and their existing stormwater management practices were analyzed for annual pollutant loading - total phosphorus, total suspended solids and runoff volume specifically. Existing treatment measured, where observed, were accounted for in the modeling process. The entire subwatershed was investigated via field reconnaissance. WinSLAMM was used for the water quality modeling. As modeled, base condition loading for total phosphorus is 662 lbs. Observed existing treatment (wetlands, street sweeping, bioretention areas) reduced the total phosphorus amount to 509.8 lbs (23%). Stormwater practice options were compared, for each catchment, given their specific site constraints and characteristics. Six of the seven catchments were selected and modeled at various levels of treatment efficiencies. A stormwater practice was selected by weighing cost, ease of installation and maintenance and ability to serve multiple functions. Concept designs were drafted for individual projects identified through the cost/benefit analysis and ranking.

A variety of stormwater retrofit approaches were identified totaling 181 lbs of total phosphorus reduction (27% reduction vs. base conditions, 35% reduction of existing conditions). Identified bmps included:

Maintenance of, or alterations to, existing stormwater treatment practices
Residential curb-cut raingardens
Stormwater pond retrofits
Stormwater wetland retrofits
Stormwater reuse
Iron-enhanced sand filters (IESFs)
Bioswales and filterstrips

The following table summarizes the assessment results. Treatment levels (percent removal rates) for retrofit projects that resulted in a prohibitive BMP size, or number, or were too expensive to justify installation are not included. Reported treatment levels are dependent upon optimal siting and sizing. The recommended treatment levels/amounts summarized here are based on a subjective assessment of what can realistically be expected to be installed considering expected public participation and site constraints.

Catchments FL1-01 through FL54: Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total phosporus (TP) reduction. Volume and total suspended solids (TSS) reductions are also shown. For more information on each project refer to the catchment profile pages in this report.

Project Rank	Catchment ID	Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Materials / Labor / Design	Promotion & Admin Costs	Total Project Cost	Estimated Annual Operations & Maintenance (2012 Dollars)	Estimated cost/ lb-TP/year (10-year)	Estimated cost/ ton -TSS/year (10-year)
1	FL53+FL53-2	Stormwater Wetland Outlet Modification	1	4.1	1,678	0.3	$240	$0	$240	$0	$6	$29
2	FL53+FL53-2	Ditched Wetland Outlet Modification	1	5.0	1,590	0.1	$750	$0	$750	$0	$15	$94
3	FL54	Ditch Diversion with Pretreatment/Forebay	2	6.6	1900	0.4	$23,420	$500	$23,920	$1,500	$590	$4,097
4	FL1-01	6th Street Dead End - IESF, Diversion + Pretreatment	1	9.1	1,867	N/A	$53,750	$3,000	$56,750	$2,063	$850	$8,290
5	FL1-01	Residential Raingardens	15	12.6	5,620	8.7	$67,554	$6,000	$73,554	$3,375	$852	$3,819
6	FL1-02	217th St. North & Scandia Trl North Raingardens	2	2.9	840	1.8	$15,000	$1,200	$16,200	$1,000	$903	$6,238
7	FL1-01	Residential Raingardens	10	7.9	3,686	5.5	$45,036	$4,000	$49,036	$2,250	$906	$3,881
8	FL1-01	Residential Raingardens	5	3.3	1,455	2.1	$22,518	$2,000	$24,518	$1,125	$1,084	$4,917
9	FL1-01	Woodland Drive - IESF with Pretreatment	1	4.4	1000	N/A	$34,250	$3,000	$37,250	$1,125	$1,102	$9,700
10	FL1-02	Heath Avenue Weland - Restoration & Expansion	1	3	1,106.0	N/A	$18,000	$2,000	$20,000	$1,500	$1,129	$6,329
11	FL53+FL53-2	Stormwater Reuse - Golf Course Irrigation	1	19.3	8,340	17.3	$220,000	$2,000	$222,000	$3,000	$1,306	$6,043
12	FL1-02	Hilo Lane North Raingardens with Pretreatment	3	2.7	1,664	0.8	$22,518	$3,000	$25,518	$1,125	$1,362	$4,419
13	FL1-01	Lakeside Woods - WQ swale meander	1	1.2	98	0.0	$10,000	$2,000	$12,000	$500	$1,417	$34,694
14	FL53+FL53-2	IESF & Pretreatment/Outlet Collector	2	2.8	828	0.0	$41,445	$250	$41,695	$1,000	$1,846	$12,487
15	FL1-02	Hilo Lane North Raingardens with Pretreatment	5	3.1	1,802	1.0	$37,530	$3,000	$40,530	$1,875	$1,912	$6,579

	indicates projects with overlapping drainage areas within a catchment; pollution reduction is not accurate if both projects are installed.
	indicates aggregating projects with benefit calculations estimated by available project locations and landowner participation rates.

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16	FL1-03	Stormwater Wetland Pretreatment Basins	13	3.5	1200	0.0	$33,500	$1,000	$34,500	$3,600	$2,014	$11,750
17	FL1-01	10th Ave SE - Depavement, split flow, raingarden	1	1.8	516	1.2	$29,150	$2,000	$31,150	$1,088	$2,335	$16,298
18	FL1-01	7th Street Dead End - Water Quality Swale (Bioswale) with Pretreatment	1	1.1	308	0.6	$16,000	$2,000	$18,000	$2,025	$3,629	$24,838
19	FL1-01	Lakeside Woods - 3 raingardens	3	1.8	885	2.5	$45,036	$2,000	$47,036	$2,500	$4,002	$16,279
20	FL1-01	Swale (Bioswale) with Pretreatment & stormsewer routing	1	0.7	231	0.3	$21,000	$700	$21,700	$1,800	$5,365	$34,447
21	FL1-01	5th Street Dead End - Filter Strip with Pretreatment/Level Spreader	1	0.4	115	0.1	$8,150	$500	$8,650	$1,250	$6,043	$36,783
22	FL1-02	Shoreline Buffers	25	3.3	720	0.8	$210,000	$1,000	$211,000	$10,000	$9,424	$86,389
23	FL1-02	Shoreline Buffers	75	9.8	2,160	2.3	$630,000	$3,000	$633,000	$30,000	$9,520	$86,389
24	FL1-02	Shoreline Buffers	50	6.5	1,440	1.6	$420,000	$2,000	$422,000	$20,000	$9,569	$86,389
25	FL1-01	Shoreline Buffers	180	19.8	4,446	5.0	$1,512,000	$4,500	$1,516,500	$72,000	$11,295	$100,607
26	FL1-01	Shoreline Buffers	120	13.2	2,964	3.4	$1,008,000	$3,500	$1,011,500	$48,000	$11,299	$100,641
27	FL1-01	Shoreline Buffers	60	6.6	1,482	1.7	$504,000	$2,500	$506,500	$24,000	$11,311	$100,742
28	FL1-03	Shoreline Buffers	90	4.1	614	1.2	$378,000	$2,000	$380,000	$22,500	$14,756	$197,068
29	FL1-03	Shoreline Buffers	270	12.2	1843	3.7	$1,134,000	$6,000	$1,140,000	$67,500	$14,877	$196,961
30	FL1-03	Shoreline Buffers	180	8.1	1229	2.5	$756,000	$4,000	$760,000	$45,000	$14,938	$196,908

	indicates projects with overlapping drainage areas within a catchment; pollution reduction is not accurate if both projects are installed.
	indicates aggregating projects with benefit calculations estimated by available project locations and landowner participation rates.

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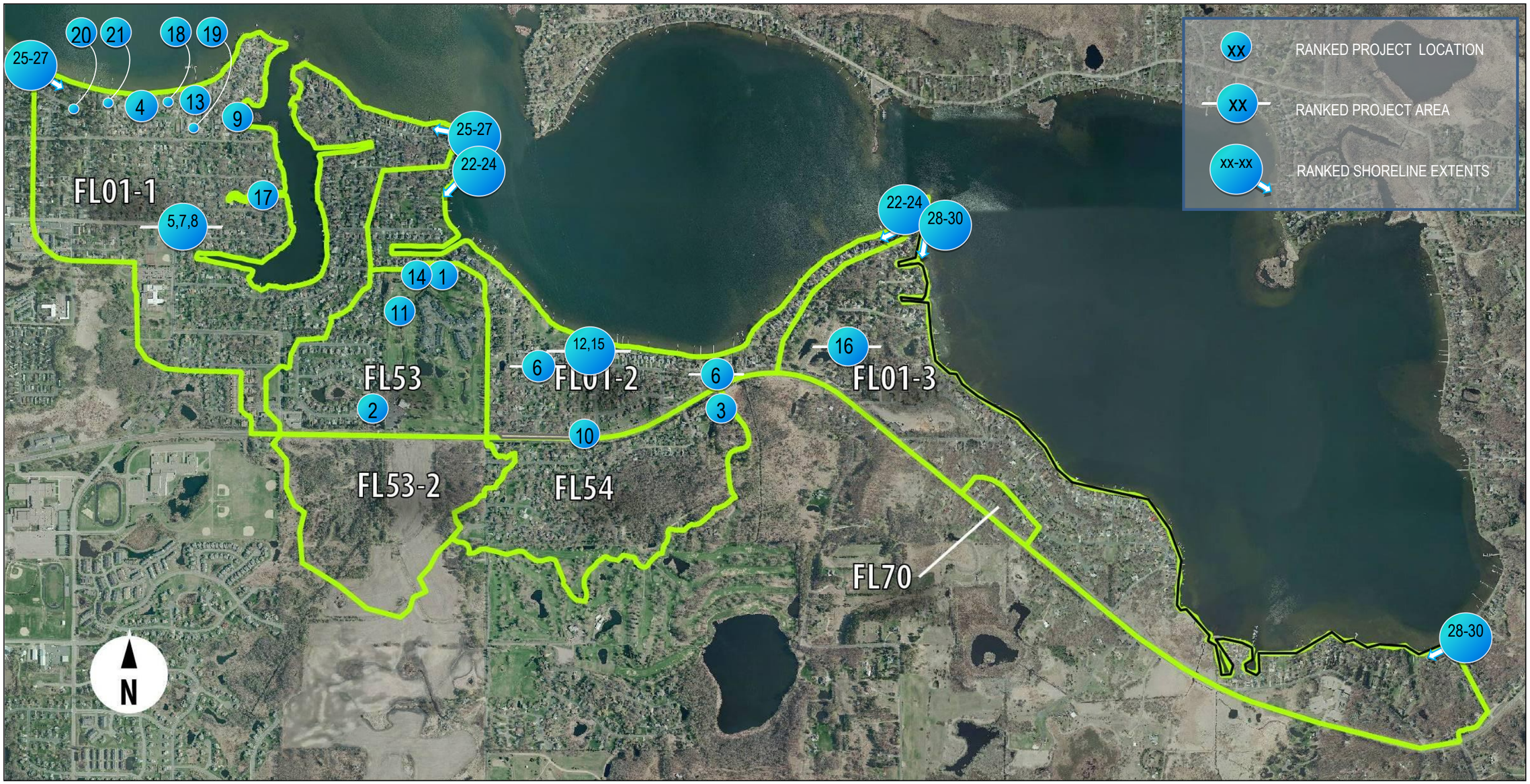
Snapshot: Locations of standalone projects referred to in this report. The 'Catchment Profiles' section provides additional detail on these and other identified catchment-wide projects. See Appendix C for concept designs of all identified standalone projects.



About this Document

This Subwatershed Stormwater Retrofit Analysis is a watershed management tool to help prioritize stormwater retrofit projects by performance and cost effectiveness. This process helps maximize the value of each dollar spent.

Document Organization

This document is organized into three major sections, plus references and appendices. Each section is briefly described below.

Methods

The methods section outlines general procedures used when analyzing the subwatershed. It provides a processes overview of retrofit scoping, desktop analysis, retrofit reconnaissance investigation, cost/treatment analysis and project ranking. See Appendix A for a detailed description of the methods.

Catchment Profiles

The Forest Lake South Direct subwatershed was divided into stormwater catchments using catchment delineations provided by the CLFLWD; however, the east and west boundaries to the subwatershed analysis were defined by streets, not by a catchment boundary (as directed by the CLFLWD). See Appendix B for a guide to reading the catchment profiles. Catchment ID was provided by existing catchment delineation attribute data, with the exception of FL53-2. FL53-2 was added to the analysis after retrofit reconnaissance revealed its hydraulic connectivity, via culvert, to the study area. For each catchment, the following information is detailed:

Catchment Description

Within each catchment profile is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant and volume loads. A brief description of the land cover, stormwater infrastructure, and any other important general information is also described. Existing stormwater practices are noted, and their estimated effectiveness presented.

Retrofit Recommendations

The recommendation section describes the conceptual retrofit(s) that were scrutinized. It includes tables outlining the estimated pollutant removals by each, as well as costs. A map provides the location or several suitable locations for each retrofit.

Retrofit Ranking

This section ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by cost per pound of total phosphorus removed for each project over 10 years – typical contract obligation length for grant funded projects. The final cost per pound treatment value includes design, installation and maintenance costs.

There are many possible ways to prioritize projects, and the list provided is merely a starting point. Other considerations for prioritizing installation may include:

Non-target pollutant reductions
Timing projects to occur with other CIPs
Project visibility
Availability of funding
Total project costs
Educational value

References

This section identifies various sources of information synthesized to produce the assessment protocol used in this analysis.

Appendices

This section provides supplemental information and/or data used at various points along the assessment protocol.

Catchment FL01-1

Catchment Summary - Existing	
Acres	287
Dominant Land Cover	Residential
Parcels	795
Volume (acre-feet/yr)	141.5
TP (lb/yr)	224.6
TSS (lb/yr)	83,673

CATCHMENT DESCRIPTION

Catchment FL01-1 is comprised of primarily medium density, single-family residential land use type as well as a few acres of multi-family residential and school land uses. This catchment is directly connected to lake 1 (west) of forest lake via multiple stormsewer system inlets and direct runoff. A significant portion of the catchment is within a wellhead protection area (see extent in retrofit recommendations graphic) The west boundary of 3rd avenue was set by the CLFLWD Administrator during the scoping portion of the analysis.

EXISTING STORMWATER TREATMENT

Street sweeping of city streets and parking lots occur approximately 10 times annually. WinSLAMM street sweeping inputs factored street sweeping taking place outside of the winter season (11/04 – 03/13) approximately every 4 weeks using a vacuum-assisted sweeper.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**TP (lb/yr)**	239.6	15.0	6%	**224.6**
	TSS (lb/yr)	90,160	6,487.0	7%	**83,673**
	Volume (acre-feet/yr)	141.5	0.0	0%	**141.5**
	Number of BMP's	1			
	BMP Size/Description	Street Sweeping 10 times/yr			

RETROFIT RECOMMENDATIONS

Forest Lake has 31 public lake access points; many of these points are dead-end streets. Several of these dead-end street/lake accesses include local or pipeshed conveyance and, therefore, are good locations for diverting and filtering runoff. Catchment FL1-01 has 6 lake access points.

Catchment-wide TP Reduction Milestones via Ranked Retrofit Recommendations

10%	Existing Treatment 6th Street Dead End-IESF, Diversion + Pretreatment
20%	Residential Raingardens (15 projects) Woodland Drive-IESF with Pretreatment Lakeside Woods-WQ Swale 10th Ave SE – Depavement, Raingarden, Split Flow 7th Street Dead End-WQ Swale with Pretreatment Lakeside Woods-Raingardens
30%	4th Street Dead End – WQ Swale with Pretreatment 5th Street Dead End – Filter Strip with Pretreatment Shoreline Buffers (180)

FL1-01 6th Street Dead-End IESF, Diversion + Pretreatment

Drainage Area – 33.6 acres
Location – 6th Street at lake
Property Ownership – Public
Description – The BMP for this dead-end street location includes adding a flow splitter to the existing stormsewer prior to outletting into the lake. The pipeshed is almost 33 acres; the largest within the catchment. The pretreatment flow-splitter pretreatment level spreader (local runoff) outlets to an IESF totaling approximately 3100 sqft – infiltration cannot be achieved due to depth to water table. As for all dead-end street retrofits, a 4 foot wide access must be maintained.

	Cost/Removal Analysis	***Project ID***	
		6th St Dead-End IESF	
		New trtmt	**Net %**
Treatment	**TP (lb/yr)**	9.1	34.6
	TSS (lb/yr)	1,867	26
	Volume (acre-feet/yr)	0	0
	Number of BMP's	1	
	BMP Size/Description	3,100	Sqft
	BMP Type	IESF, flow-splitter, level spreader/cleanout	
Cofst	**Materials/Labor/Design**	$53,750	
	Promotion & Admin Costs	$3,000	
	Probable Project Cost	**$56,750**	
	Annual O&M	$2,063	
	10-yr Cost/lb-TP/yr	**$850**	
	10-yr Cost/2,000lb-TSS/yr	**$8,290**	

FL1-01 Residential Raingardens

Rank #5,7,8

Drainage Area – 225 acres (intercepting smaller drainage areas within)
Location – upland areas of catchment
Property Ownership – Private/ROW
Description – Very little space is available higher in the catchment. However, there are some opportunities for curb-cut raingardens to treat the residential land use. 15 ideal raingarden locations were identified estimating 300 sqft total area per raingarden. Generally, ideal raingarden locations are immediately up-gradient of a catch basin serving a large drainage area (.5 -2 acres, can be increased with more controlled inlet type). Considering typical landowner participation rates, scenarios of 5, 10, and 15 raingardens were analyzed to treat the residential land use. Catchment-wide volume reduction and removal of TP and TSS could be increased to the levels shown in the following table.

	Cost/Removal Analysis	*Project ID*					
		5 Curb-Cut Rain Gardens		10 Curb-Cut Rain Gardens		15 Curb-cut Rain Gardens	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	3.3	2.3%	7.9	5.4%	12.6	8.7%
	TSS (lb/yr)	1455	2.7%	3686	6.7%	5620	10.3%
	Volume (acre-feet/yr)	2.1	2.5%	5.5	6.5%	8.7	10.0%
	Number of BMP's	5		10		15	
	BMP Size/Description	1,500	Unit	3,000	Unit	4,500	Unit
	BMP Type	Moderately Complex Bioretention		Moderately Complex Bioretention		Moderately Complex Bioretention	
Cost	Materials/Labor/Design	$22,518		$45,036		$67,554	
	Promotion & Admin Costs	$2,000		$4,000		$6,000	
	Probable Project Cost	**$24,518**		**$49,036**		**$73,554**	
	Annual O&M	$1,125		$2,250		$3,375	
	10-yr Cost/lb-TP/yr	**$1,084**		**$906**		**$852**	
	10-yr Cost/2,000lb-TSS/yr	**$4,917**		**$3,881**		**$3,819**	

FL1-01 Woodland Drive – IESF with Pretreatment

Rank #9

Drainage Area – 6.43 acres
Location – Woodland Drive and SE 8th Ave
Property Ownership – Public
Description – This BMP is located within a city-owned parcel that is currently not being used by the city. This practice requires rerouting stormwater runoff from the east side of Woodland Drive via pipe to the public parcel located on the west end of the street. The public parcel does not provide a lot of space and may need retaining walls to incorporate this practice (cost for some retaining is included in the project cost).

	Cost/Removal Analysis	Project ID: Woodland Dr - IESF w/ Pretreatment	
		New treatment	Net %
Treatment	TP (lb/yr)	4.4	87
	TSS (lb/yr)	1000	86
	Volume (acre-feet/yr)	0	0
	Number of BMP's	1	
	BMP Size/Description	3,100	Sqft
	BMP Type	IESF, flow-splitter, level spreader/cleanout	
Cost	Materials/Labor/Design	$34,250	
	Promotion & Admin Costs	$3,000	
	Probable Project Cost	**$37,250**	
	Annual O&M	$1,125	
	10-yr Cost/lb-TP/yr	**$1,102**	
	10-yr Cost/2,000lb-TSS/yr	**$9,700**	

FL1-01 10th Avenue SE Depavement, Split Flow, Biofiltration Raingarden

Rank #17

Drainage Area – 3.51 acres
Location – terminus of 10th Avenue SE at channel
Property Ownership – Public
Description – The scope of work for this BMP includes removing one half of the street width at the street terminus (not necessary for traffic movement in street) and rerouting stormwater runoff via a pipe flow splitter to enter a biofiltration raingarden located in the depavement area. This practice includes an underdrain that connects back into the existing stormsewer. This practice could be easily be enhanced with IESF.

	Cost/Removal Analysis	*Project ID*	
		10 Ave SE Biofiltration Raingarden, Depavement	
		New trtmt	Net %
Treatment	TP (lb/yr)	1.8	87.1
	TSS (lb/yr)	516	86.5
	Volume (acre-feet/yr)	1.2	81.5%
	Number of BMP's	1	
	BMP Size/Description	1,450	Sqft
	BMP Type	Depavement, Biofiltrattion, flow-splitter	
Cost	Materials/Labor/Design	$29,150	
	Promotion & Admin Costs	$2,000	
	Probable Project Cost	**$31,150**	
	Annual O&M	$1,088	
	10-yr Cost/lb-TP/yr	**$2,335**	
	10-yr Cost/2,000lb-TSS/yr	**$16,291**	

FL1-01 Lakeside Woods Townhomes – 3 Raingardens, 1 Water Qual Swale

Rank #13,19

Drainage Area – 6.92 acres
Location – Lakeside Woods Townhomes on 8th Avenue SE
Property Ownership – Private
Description – The Lakeside Woods Townhomes (LWT) site is the only multifamily residential landuse within the catchment containing opportunities stormwater retrofit opportunities. Located on 8th Avenue SE (just east of S Shore Drive), with all of its runoff directly entering Forest Lake without treatment, the LWT site has several areas of greenspace suitable for retrofitting with stormwater BMPs. The southernmost areas of the site are suitable for the use of infiltrating BMPs such as bioinfiltration/raingardens. Depth to water table in the northernmost area (nearest Forest Lake) of the site limits BMPs to biofiltration/raingarden and filtration water quality swale (bioswale). Overall, 4 BMPs were selected: 2 bioinfiltration raingardens, 1 biofiltration raingarden enhanced with an IESF, and a bioswale providing the last opportunity for treatment before outletting to Forest Lake.

	Cost/Removal Analysis	Project ID			
		3 Raingardens		1 Bioswale	
		New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	1.8	30.7%	1.2	21.0%
	TSS (lb/yr)	885	53.3%	98	5.9%
	Volume (acre-feet/yr)	2.5	42.4%	0.03	0.5%
	Number of BMP's	3		1	
	BMP Size/Description	3,000	sf	200	lnft
	BMP Type	Moderately Complex Bioretention		Water Quality Swale	
Cost	Materials/Labor/Design	$45,036		$10,000	
	Promotion & Admin Costs	$2,000		$2,000	
	Probable Project Cost	**$47,036**		**$12,000**	
	Annual O&M	$2,500		$500	
	10-yr Cost/lb-TP/yr	**$4,002**		**$1,417**	
	10-yr Cost/2,000lb-TSS/yr	**$16,279**		**$34,694**	

FL1-01 SE 7th Street Dead End - Water Qual Swale (Bioswale) with Pretreat

Rank #18

Drainage Area – 2.80 acres
Location – SE 7th St terminus at Forest Lake
Property Ownership – Public
Description – The BMP for this dead-end street location includes a simple water quality swale (bioswale) with pretreatment/level spreader. The pretreatment/level spreader captures coarse sediment runoff and can be cleaned out extending the life of the bioswale stormwater BMP. A bioswale is most appropriate for this site due to a relatively small drainage area (2.8 acres) and the likely presence of a shallow water table, limiting stormwater BMP options. As for all dead-end street retrofits, a 4 foot wide access must be maintained.

	Cost/Removal Analysis	*Project ID*	
		Bioswale with Preatreatment	
		New trtmt	Net %
Treatment	TP (lb/yr)	1.1	50.2%
	TSS (lb/yr)	308	58.4%
	Volume (acre-feet/yr)	0.6	43.5%
	Number of BMP's	1	
	BMP Size/Description	300	Lnft
	BMP Type	Water Quality Swale6	
Cost	Materials/Labor/Design	$16,000	
	Promotion & Admin Costs	$2,000	
	Probable Project Cost	**$18,000**	
	Annual O&M	$2,025	
	10-yr Cost/lb-TP/yr	**$3,629**	
	10-yr Cost/2,000lb-TSS/yr	**$24,838**	

FL1-01 SE 4th Street Dead End - Water QualSwale (Bioswale) with Pretreat and Stormsewer Rerouting

Rank #20

Drainage Area – 3.0 acres
Location – SE 4th St terminus at Forest Lake
Property Ownership – Public
Description – The BMP for this dead-end street location includes a simple water quality swale (bioswale) with pretreatment. In order to collect 3.0 at this location 1 catchbasin must be rerouted to the proposed practice.The pretreatment/sump captures coarse sediment runoff and can be cleaned out extending the life of the bioswale stormwater BMP. A bioswale is most appropriate for this site due to a relatively small drainage area (3.0 acres) and the narrowness of the available greenspace on the site, limiting stormwater BMP options. The proposed bioswale would link up to an existing bioswale located closer to the lake. As for all dead-end street retrofits, a 4 foot wide access must be maintained.

	Cost/Removal Analysis	Project ID: Bioswale with Preatreatment	
		New trtmt	Net %
Treatment	TP (lb/yr)	0.7	56.0%
	TSS (lb/yr)	231	76.7%
	Volume (acre-feet/yr)	0.3	38.0%
	Number of BMP's	1	
	BMP Size/Description	205	Lnft
	BMP Type	Water Quality Swale6	
Cost	Materials/Labor/Design	$21,000	
	Promotion & Admin Costs	$700	
	Probable Project Cost	**$21,700**	
	Annual O&M	$1,800	
	10-yr Cost/lb-TP/yr	**$5,365**	
	10-yr Cost/2,000lb-TSS/yr	**$34,447**	

FL1-01 SE 5th Street Dead End – Filter Strip with Pretreat/Level Spreader

Rank #21

Drainage Area – 2.7 acres
Location – SE 5th St terminus at Forest Lake
Property Ownership – Public
Description – The BMP for this dead-end street location includes a filter strip with pretreatment. The pretreatment/level spreader captures coarse sediment runoff and can be cleaned out extending the life of the BMP. A filter strip is most appropriate for this site due the sizable width but limited length of the available greenspace on the site, limiting stormwater BMP options. As for all dead-end street retrofits, a 4 foot wide access must be maintained.

	Cost/Removal Analysis	Project ID: Filter Strip with Pretreatment	
		New trtmt	Net %
Treatment	TP (lb/yr)	0.4	18.8%
	TSS (lb/yr)	115	22.6%
	Volume (acre-feet/yr)	0.1	7.5%
	Number of BMP's	1	
	BMP Size/Description	1,750	Sqft
	BMP Type	Filter Strip	
Cost	Materials/Labor/Design	$8,150	
	Promotion & Admin Costs	$500	
	Probable Project Cost	**$8,650**	
	Annual O&M	$1,250	
	10-yr Cost/lb-TP/yr	**$6,043**	
	10-yr Cost/2,000lb-TSS/yr	**$36,783**	

FL1-01 - Shoreline Buffers

Rank #25,26, 27

Drainage Area – 51 acres (assuming 17,900 lnft of shoreline and average of 125 ft of land (primarily turf and residence roof runoff) per lnft of shoreline
Location – all shoreline within FL1-01 (17,900 lnft)
Property Ownership – Private
Description – Almost a fifth (18%) of the FL1-01 catchment drainage area is the rear yard (lake facing) area of each lakefront residence. A large majority of these lakefront residences backyards and shorelines composed primarily of turfgrass. Shoreline conditions void of native plant vegetation allow for stormwater runoff, fertilizer, pesticides and herbicides to enter the lake without any treatment. Moreover, shoreline erosion occurs much more readily along shorelines without native plant vegetation. The proposed stormwater BMP for these areas is a shoreline buffer to filter stormwater runoff and associated pollutants prior to entering the lake as well as providing structural stability to the shoreline. Shoreline buffers were modeled per 100 lnft of shoreline at an average of 25ft width, 0.03 longitudinal slopes and average 3ft vegetation height.

Considering typical landowner participation rates, scenarios of 60 (33% of total shoreline), 120 (66% of total shoreline), and 180 (100% of total shoreline) individual shoreline buffers at 100 lnft per buffer were analyzed to treat the residential lake frontage. Catchment-wide volume reduction and removal of TP and TSS using shoreline buffers is found in the following table. Note: the pollutant reduction figures shown (TP and TSS) do not represent pollution reduction through reduced soil erosion along the shoreline, only what is filtered from backyards and rooftops.

	Cost/Removal Analysis	***Project ID***					
		60 Shoreline Buffers		**120 Shoreline Buffers**		**180 Shoreline Buffers**	
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	6.6	29.7%	13.2	59.3%	19.8	89.0%
	TSS (lb/yr)	1482.0	29.7%	2964.0	59.5%	4446.0	89.2%
	Volume (acre-feet/yr)	1.7	27.2%	3.4	54.5%	5.0	81.7%
	Number of BMP's	60		120		180	
	BMP Size/Description	150,000	sqft	300,000	sqft	450,000	sqft
	BMP Type	Shoreline Buffer w/o Hard Armoring		Shoreline Buffer w/o Hard Armoring		Shoreline Buffer w/o Hard Armoring	
Cost	**Materials/Labor/Design**	$504,000		$1,008,000		$1,512,000	
	Promotion & Admin Costs	$2,500		$3,500		$4,500	
	Probable Project Cost	**$506,500**		**$1,011,500**		**$1,516,500**	
	Annual O&M	$24,000		$48,000		$72,000	
	10-yr Cost/lb-TP/yr	**$11,311**		**$11,299**		**$11,295**	
	10-yr Cost/2,000lb-TSS/yr	**$100,742**		**$100,641**		**$100,607**	

Catchment FL01-2

Catchment Summary - Existing	
Acres	131.3
Dominant Land Cover	Residential
Parcels	219
Volume (acre-feet/yr)	68.1
TP (lb/yr)	90.1
TSS (lb/yr)	33,528

CATCHMENT DESCRIPTION

Catchment FL01-2 is comprised of primarily medium density, single-family residential land use. This catchment is directly connected to lake 2 (middle) of forest lake via direct runoff, ditch conveyance along Hwy 97 simple single catchbasin to pipe conveyance and one collector stormsewer on Hilo lane. There is a ditched wetland between Heath Ave and Hilo Lane just north of Hwy 97 – pollution reduction benefit was not assumed as research shows ditched wetlands can be both nutrient sources as well as sinks. Additionally, any alterations to the wetland (i.e. adding a weir to the ditch within the wetland or expanding the wetland) were not considered due to the low floor elevations and proximity of adjacent residences.

EXISTING STORMWATER TREATMENT

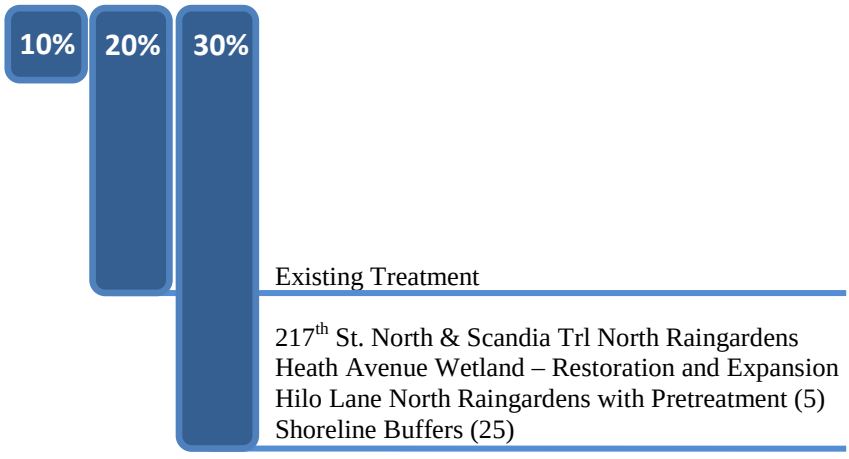
Street sweeping of city streets and parking lots occur approximately 10 times annually. WinSLAMM street sweeping inputs factored street sweeping taking place outside of the winter season (11/04 – 03/13) approximately every 4 weeks using a vacuum-assisted sweeper. A small pond between Healy and Harrow avenues has a drainage area of approximately 3.5 acres and does not overflow according to adjacent landowners. The preliminary pollutant benefits for the Hilo Lane IESF, under design development and planned for installation in 2014, were included in the treatment figures in the table below.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**TP (lb/yr)**	112.1	24.8	22.1%	**87.3**
	TSS (lb/yr)	42,736	10,208	23.9%	**32,528**
	Volume (acre-feet/yr)	68.3	1.9	2.8%	**66.4**
	Number of BMP's	3			
	BMP Size/Description	Street Sweeping 10 times/yr, Hilo Lane IESF (2014), small area pond between Healy and Harrow			

RETROFIT RECOMMENDATIONS

With the planned IESF installation on Hilo Lane and existing street sweeping efforts, Catchment FL1-02 has considerable pollution reduction measures in place (approximately 20% reduction for TSS and TP). However there is still room for improvement in pollutant reduction and volume reduction.

Catchment-wide TP Reduction Milestones via Ranked Retrofit Recommendations



FL1-02 - 217th St. North and Scandia Trl North Raingardens

Rank #6

Drainage Area – 73 acres
Location – Upland areas of catchment – specifically, along 217th St. North and Scandia Trl North
Property Ownership – Private (ROW)
Description – There are a couple opportunities for raingardens in the other parts of FL1-02 not already identified. In particular, there are significant drainage areas along the locations outlined above that could be treated, in part, by bioinfiltration raingardens.

	Cost/Removal Analysis	***Project ID***	
		Raingardens	
		New trtmt	**Net %**
Treatment	**TP (lb/yr)**	2.9	5%
	TSS (lb/yr)	840	5%
	Volume (acre-feet/yr)	1.8	6%
	Number of BMP's	2	
	BMP Size/Description	1,000	sqft
	BMP Type	Simple Bioretention	
Cost	**Materials/Labor/Design**	$15,000	
	Promotion & Admin Costs	$1,200	
	Probable Project Cost	**$16,200**	
	Annual O&M	$1,000	
	10-yr Cost/lb-TP/yr	**$903**	
	10-yr Cost/2,000lb-TSS/yr	**$6,238**	

FL1-02 - Heath Avenue Wetland – Restoration and Expansion

Rank #10

Drainage Area – 9.0 acres
Location – Between Heath Avenue and Hilo Lane North, north of Hwy 97
Property Ownership – Private/Public
Description – This wetland (~.7 acres) is ditched to allow for positive drainage off of the residential developed land to the north. In this analysis, the base conditions for this wetland assumed no pollution reduction benefit as studies show ditched wetlands can be both nutrient sources as well as sinks. The proposed bmp for this wetland is a 0.4 acre wetland expansion and adding a weir structure to maintain the hydrology of the original (altered) wetland. The assumed benefit for this practice is set at an estimate of a 58% reduction in pollutants and no reduction in volume per average benefits shown in studies of restoring ditched wetlands (Fisher and Acreman, 2004).

	Cost/Removal Analysis	***Project ID***	
		ditched wetland restoration and expansion	
		New trtmt	**Net %**
Treatment	**TP (lb/yr)**	3.1	42%
	TSS (lb/yr)	1,106	58%
	Volume (acre-feet/yr)	0.0	0%
	Number of BMP's	1	
	BMP Size/Description	17,400	sqft
	BMP Type	Stormwater Wetland	
Cost	**Materials/Labor/Design**	$18,000	
	Promotion & Admin Costs	$2,000	
	Probable Project Cost	**$20,000**	
	Annual O&M	$1,500	
	10-yr Cost/lb-TP/yr	**$1,129**	
	10-yr Cost/2,000lb-TSS/yr	**$6,329**	

FL1-02 - Hilo Lane North Bioinfiltration Raingardens with Pretreatment

Rank #15

Drainage Area – 3.1 acres
Location – Along west and north sides of Hilo Lane North
Property Ownership – Private (ROW)
Description – There are several opportunities for curb-cut raingardens to treat the residential land use along Hilo Lane (not part of IESF treatment area). Five raingarden locations were identified. With the limited stormsewer infrastructure, these raingardens bioinfiltration only - are not connected via underain to existing stormsewer networks. These raingardens are modeled at 500 sqft total footprint and best perform with drainage areas between 0.3 - 1 acre. Considering typical landowner participation rates, scenarios of 3 and 5 raingardens were analyzed to treat the residential land use. Catchment-wide volume reduction and removal of TP and TSS could be increased to the levels shown in the following table.

	Cost/Removal Analysis	***Project ID***			
		3 Curb-Cut Rain Gardens		**5 Curb-Cut Rain Gardens**	
		New trtmt	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	2.7	67.0%	3.1	76.7%
	TSS (lb/yr)	1,664	79.4%	1,802	86.0%
	Volume (acre-feet/yr)	0.8	51.0%	1.0	67.1%
	Number of BMP's	3		5	
	BMP Size/Description	1,500	Unit	2,500	Unit
	BMP Type	Moderately Complex Bioretention		Moderately Complex Bioretention	
Cost	**Materials/Labor/Design**	$22,518		$37,530	
	Promotion & Admin Costs	$3,000		$3,000	
	Probable Project Cost	**$25,518**		**$40,530**	
	Annual O&M	$1,125		$1,875	
	10-yr Cost/lb-TP/yr	**$1,362**		**$1,912**	
	10-yr Cost/2,000lb-TSS/yr	**$4,419**		**$6,579**	

FL1-02 - Shoreline Buffers

Rank #22,23, 24

Drainage Area – 30 acres (assuming 7540 lnft of shoreline and average of 175 ft of land (primarily turf and residence roof runoff) per lnft of shoreline
Location – all shoreline within FL1-02 (7540 lnft)
Property Ownership – Private
Description – Almost a quarter (23%) of the FL1-02 catchment drainage area is the rear yard (lake facing) area of each lakefront residence. A large majority of these lakefront residences backyards and shorelines composed primarily of turfgrass. Shoreline conditions void of native plant vegetation allow for stormwater runoff, fertilizer, pesticides and herbicides to enter the lake without any treatment. Moreover, shoreline erosion occurs much more readily along shorelines without native plant vegetation. The proposed stormwater BMP for these areas is a shoreline buffer to filter stormwater runoff and associated pollutants prior to entering the lake as well as providing structural stability to the shoreline. Shoreline buffers were modeled per 100 lnft of shoreline at an average of 25ft width, 0.03 longitudinal slopes and average 3ft vegetation height.

Considering typical landowner participation rates, scenarios of 25 (33% of total shoreline), 50 (66% of total shoreline), and 75 (100% of total shoreline) individual shoreline buffers at 100 lnft per buffer were analyzed to treat the residential lake frontage. Catchment-wide volume reduction and removal of TP and TSS using shoreline buffers is found in the following table. Note: the pollutant reduction figures shown (TP and TSS) do not represent pollution reduction through reduced soil erosion along the shoreline, only what is filtered from backyards and rooftops.

	Cost/Removal Analysis	Project ID					
		25 Shoreline Buffers		50 Shoreline Buffers		75 Shoreline Buffers	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	3.3	25.4%	6.5	50.8%	9.8	76.2%
	TSS (lb/yr)	720.0	25.5%	1440.0	51.0%	2160.0	76.5%
	Volume (acre-feet/yr)	0.8	22.8%	1.6	45.6%	2.3	68.4%
	Number of BMP's	25		50		75	
	BMP Size/Description	62,500	sqft	125,000	sqft	187,500	sqft
	BMP Type	Shoreline Buffer w/o Hard Armoring		Shoreline Buffer w/o Hard Armoring		Shoreline Buffer w/o Hard Armoring	
Cost	Materials/Labor/Design	$210,000		$420,000		$630,000	
	Promotion & Admin Costs	$1,000		$2,000		$3,000	
	Probable Project Cost	**$211,000**		**$422,000**		**$633,000**	
	Annual O&M	$10,000		$20,000		$30,000	
	10-yr Cost/lb-TP/yr	**$9,424**		**$9,569**		**$9,520**	
	10-yr Cost/2,000lb-TSS/yr	**$86,389**		**$86,389**		**$86,389**	

Catchment FL01-3

Catchment Summary - Existing	
Acres	252
Dominant Land Cover	Residential/Open Space
Parcels	342
Volume (acre-feet/yr)	68.1
TP (lb/yr)	90.1
TSS (lb/yr)	33,528

CATCHMENT DESCRIPTION

FL1-03 directly drains to Forest Lake however There are 12.75 acres of wetland (not directly connected to Forest Lake within the catchment. The land use is medium density residential matrix with lowland open space. Most of the roads in this area are paved, with few gravel sections and drainage tends to be through rural ditches (to wetlands) or simple catch basin with pipes to Forest Lake. There is one industrial lot along Hwy 97 (12.5 acres); no outlet was observed and therefore was removed from the existing catchment profile. A large wetland (12.9 acres) connected to Forest Lake was considered part of the lake in this analysis and, therefore, removed from catchment drainage calculations. Lots with lake frontage average 50' widths.

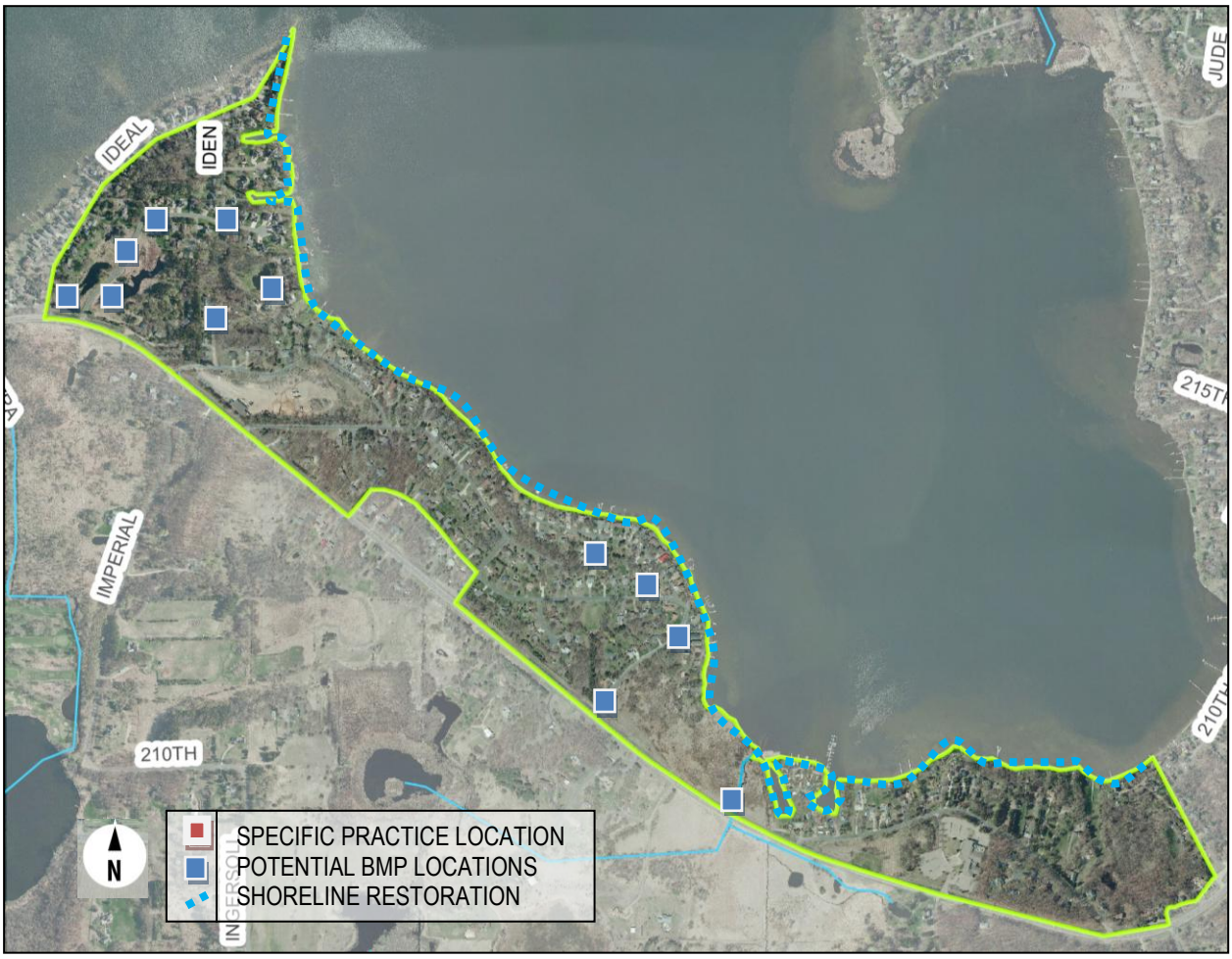
EXISTING STORMWATER TREATMENT

There are 5 wetlands, 12.75 acres total, receiving runoff from 71 acres (28 %) of the catchment. The functionality of this wetland is unknown; a conservative estimate of a 58% reduction in pollutants and no reduction in volume was used in this analysis. There is a bioinfiltration bmp and infiltration trench, installed in 2012, at Hosanna Lutheran Church. There is also an extended detention basin pretreated church parking lot runoff prior to entering a large wetland. Street sweeping of city streets and parking lots occur approximately 10 times annually. WinSLAMM street sweeping inputs factored street sweeping taking place outside of the winter season (11/04 – 03/13) approximately every 4 weeks using a vacuum-assisted sweeper.

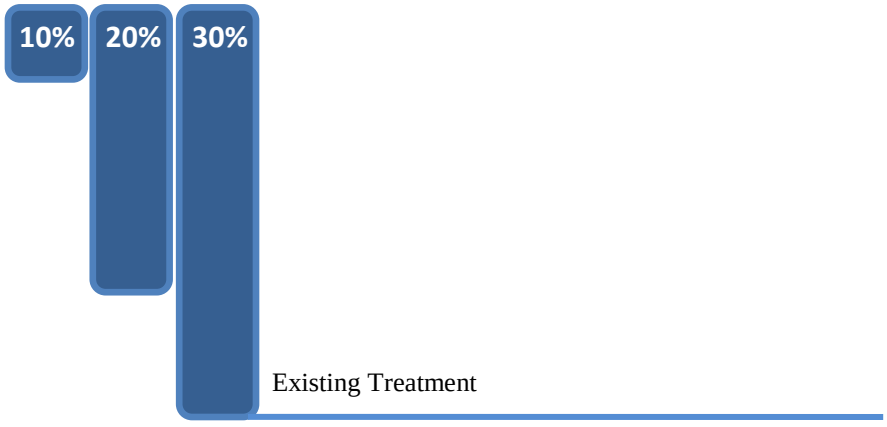
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	173.0	53.0	30.6%	**120.0**
	TSS (lb/yr)	63,631	26,085.0	41.0%	**37,546**
	Volume (acre-feet/yr)	99.6	7.0	7.0%	**92.6**
	Number of BMP's	7			
	BMP Size/Description	5 stormwater wetlands, 1 bioinfiltration raingarden, Street Sweeping 10 times/yr			

RETROFIT RECOMMENDATIONS

With the high percentage of stormwater wetlands present, catchment FL1-03 already meets the 30% reduction goal in TP and TSS reduction. However, the wetlands are negatively impacted by catchment runoff – pretreatment and enhanced good housekeeping practices will allow these wetlands to function in the long term. The bmp recommendations for catchment FL1-03 outline the potential pollutant reduction benefits of additional street sweeping and highlight best locations for runoff pretreatment before entering stormwater wetlands.



Catchment-wide TP Reduction Milestones via Ranked Retrofit Recommendations



FL1-03 – Stormwater Wetland Pretreatment Basins

Rank #16

Drainage Area – 53 acres (75% of wetland drainage area)
Location – multiple sites near existing stormwater wetlands
Property Ownership – Private (easement)
Description – These pretreatment basin practices are an attempt to extend the life of the stormwater wetlands by capturing sediment prior to entering into the wetland. Conceptually these basins can be installed as rock swirl chambers offline of the flow path. For this analysis, it was assumed that these basins could be placed around the stormwater wetlands and intercept approximately 75% of the stormwater entering the wetlands.

	Cost/Removal Analysis	***Project ID***	
		Stormwater Wetland Pretreatment Basins	
		New trtmt	**Net %**
Treatment	**TP (lb/yr)**	3.5	7%
	TSS (lb/yr)	1,200	9%
	Volume (acre-feet/yr)	0.0	0%
	Number of BMP's	13	
	BMP Size/Description	400	sqft
	BMP Type	Sediment Forebays (for existing stormwater wetlands)	
Cost	**Materials/Labor/Design**	$33,500	
	Promotion & Admin Costs	$1,000	
	Probable Project Cost	**$34,500**	
	Annual O&M	$3,600	
	10-yr Cost/lb-TP/yr	**$2,014**	
	10-yr Cost/2,000lb-TSS/yr	**$11,750**	

FL1-03 - Shoreline Buffers

Rank #28,29, 30

Drainage Area – 46.75 acres (assuming 13,600 lnft of shoreline and average of 150 ft of land (primarily turf and residence roof runoff) per lnft of shoreline
Location – all shoreline within FL1-03
Property Ownership – Private
Description – Almost a fifth (18.5%) of the FL1-03 catchment drainage area is the rear yard (lake facing) area of each lakefront residence. A large majority of these lakefront residences backyards and shorelines composed primarily of turfgrass. Shoreline conditions void of native plant vegetation allow for stormwater runoff, fertilizer, pesticides and herbicides to enter the lake without any treatment. Moreover, shoreline erosion occurs much more readily along shorelines without native plant vegetation. The proposed stormwater BMP for these areas is a shoreline buffer to filter stormwater runoff and associated pollutants prior to entering the lake as well as providing structural stability to the shoreline. Shoreline buffers were modeled per 50 lnft of shoreline at an average of 25ft width, 0.03 longitudinal slopes and average 3ft vegetation height.

Considering typical landowner participation rates, scenarios of 90 (33% of total shoreline), 180 (66% of total shoreline), and 270 (100% of total shoreline) individual shoreline buffers at 100 lnft per buffer were analyzed to treat the residential lake frontage. Catchment-wide volume reduction and removal of TP and TSS using shoreline buffers is found in the following table. Note: the pollutant reduction figures shown (TP and TSS) do not represent pollution reduction through reduced soil erosion along the shoreline, only what is filtered from backyards and rooftops.

	Cost/Removal Analysis	***Project ID***					
		90 Shoreline Buffers		**180 Shoreline Buffers**		**270 Shoreline Buffers**	
		New trtmt	**Net %**	**New trtmt**	**Net %**	**New trtmt**	**Net %**
Treatment	**TP (lb/yr)**	4.1	90.0%	8.1	90.0%	12.2	90.0%
	TSS (lb/yr)	614	93.7%	1228	93.7%	1843	93.7%
	Volume (acre-feet/yr)	1.2	82.0%	2.5	82.0%	3.7	82.0%
	Number of BMP's	90		180		270	
	BMP Size/Description	112,500	sqft	225,000	sqft	337,500	sqft
	BMP Type	Shoreline Buffer w/o Hard Armoring		Shoreline Buffer w/o Hard Armoring		Shoreline Buffer w/o Hard Armoring	
Cost	**Materials/Labor/Design**	$378,000		$756,000		$1,134,000	
	Promotion & Admin Costs	$2,000		$4,000		$6,000	
	Probable Project Cost	**$380,000**		**$760,000**		**$1,140,000**	
	Annual O&M	$22,500		$45,000		$67,500	
	10-yr Cost/lb-TP/yr	**$14,756**		**$14,938**		**$14,877**	
	10-yr Cost/2,000lb-TSS/yr	**$197,068**		**$196,908**		**$196,961**	

Catchment FL53 + FL53-2

Catchment Summary - Existing	
Acres (FL53/FL53-2)	106.3/95.5
Dominant Land Cover	Residential
Parcels	168/12
Volume (acre-feet/yr)	51.5
TP (lb/yr)	65.32
TSS (lb/yr)	23,450

CATCHMENT DESCRIPTION

Catchment FL53 and FL53-2 are comprised of primarily golf course and undeveloped lowlands respectively. Also within catchment FL53 is a small commercial area (Stellas) and medium density single family residential land uses. Separating catchments FL53 and FL53-2 is a Hwy 97. These two catchments are combined in this analysis as FL53-2 is entirely routed through FL53 and no stormwater BMPs or options for BMPs are present within FL53-2. These catchments are connected to lake 2 (middle) of forest lake via pond, pipe and channel conveyance through the golf course and through a ditched wetland.

EXISTING STORMWATER TREATMENT

There are 7 storm ponds in the FL53 including 6 within the municipal golf course. There is 1 stormwater wetland (1 treatment FL53-2 runoff) and 1 ditched wetland taking runoff from the NE quadrant of the golf course and townhomes. The commercial area (Stellas) installed 2 biofiltration practices in 2013 during a parking lot reconstruction.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	99.6	48.1	48.3%	**51.5**
	TSS (lb/yr)	36,108	12,658.0	35.1%	**23,450**
	Volume (acre-feet/yr)	55.0	3.5	6.4%	**51.5**
	Number of BMP's	11			
	BMP Size/Description	7 stormwater ponds (6 in golf course), 1 stormwater wetland, 1 ditched wetland, 2 biofiltration practices (Stellas)			

RETROFIT RECOMMENDATIONS

As modeled, the existing treatment for FL53 and FL53-2 is considerably more than any other catchment in the analysis and already meets the 30% reduction goal in TP and TSS reduction. However, the proposed retrofit recommendations aim to enhance the performance of existing practices.

Catchment-wide TP Reduction Milestones via Ranked Retrofit Recommendations

FL53 + FL53-2 – Stormwater Wetland Outlet Modification

Rank #1

Drainage Area – 132.5 acres
Location – North of Hwy 97, West of Stellas
Property Ownership – Private (easement)
Description – This a simple and quick change to the existing outlet structure of the stormwater wetland. There is room in the structure to add a 1 foot tall stop log.

	Cost/Removal Analysis	***Project ID***	
		Outlet Modification	
		New trtmt	**Net %**
Treatment	**TP (lb/yr)**	4.1	11%
	TSS (lb/yr)	1,678	13%
	Volume (acre-feet/yr)	0.3	1%
	Number of BMP's	1	
	BMP Size/Description	1	ft (height)
	BMP Type	Outlet Modification (wood stop log)	
Cost	**Materials/Labor/Design**	$240	
	Promotion & Admin Costs	$0	
	Probable Project Cost	**$240**	
	Annual O&M	$0	
	10-yr Cost/lb-TP/yr	**$6**	
	10-yr Cost/2,000lb-TSS/yr	**$29**	

FL53 + FL53-2 – Ditched Wetland Outlet Modification

Rank #2

Drainage Area – 14.0 acres
Location – Northeast corner of golf course at end of cul-de-sac
Property Ownership – Private (easement)
Description – This a simple and quick change to the existing outlet structure of the stormwater wetland. The existing outlet is a pipe set lower than most of wetland. The wetland is ditched and conveyed to the pipe. A simple riser and trash guard would restore hydrology to the wetland and reduce stormwater runoff.

	Cost/Removal Analysis	*Project ID*	
		Outlet Modification	
		New trtmt	Net %
Treatment	TP (lb/yr)	5.0	42%
	TSS (lb/yr)	1,590	41%
	Volume (acre-feet/yr)	0.1	1%
	Number of BMP's	1	
	BMP Size/Description	1	ft (height)
	BMP Type	Outlet Modification (riser ~ 1 ft height	
Cost	Materials/Labor/Design	$750	
	Promotion & Admin Costs	$0	
	Probable Project Cost	**$750**	
	Annual O&M	$0	
	10-yr Cost/lb-TP/yr	**$15**	
	10-yr Cost/2,000lb-TSS/yr	**$94**	

FL53 + FL53-2 – Stormwater Reuse – Golf Course Irrigation

Rank #11

Drainage Area – 187 acres
Location – Second to last pond in pond chain within golf couse
Property Ownership – Public
Description – This bmp consists of installing an irrigation pump and weir to reuse stormwater runoff to meet a portion of Castlewood Country Club's, a municipal golf course, irrigation needs. The model inputs for daily water withdrawal rates, needed for WinSLAMM reuse modeling, came from Minnesota's 2012 Stormwater Reuse Guide 'Irrigation - Variable Demand' spreadsheet. Drawdown depth in the pond was considered to be no more than 2 feet over 0.4 acre pond area resulting in approximately 260,663 gal available storage. It was assumed the pond would have enough depth to allow for the drawdown depth and an additional 3 feet for permanent pool. The Stormwater Reuse's model estimated the proposed stormwater reuse bmp would meet 36% of the golf course's irrigation needs, while 64% will still need to be augmented through existing means.

	Cost/Removal Analysis	***Project ID***	
		Stormwater Reuse (2nd to last pond in golf course pond sequence)	
		New trtmt	**Net %**
Treatment	**TP (lb/yr)**	19.3	36%
	TSS (lb/yr)	8,340	42%
	Volume (acre-feet/yr)	17.3	37%
	Number of BMP's	1	
	BMP Size/Description	17,424	sqft
	BMP Type	Stormwater Reuse (use existing pond)	
Cost	**Materials/Labor/Design**	$220,000	
	Promotion & Admin Costs	$2,000	
	Probable Project Cost	**$222,000**	
	Annual O&M	$3,000	
	10-yr Cost/lb-TP/yr	**$1,306**	
	10-yr Cost/2,000lb-TSS/yr	**$6,043**	

FL53 + FL53-2 – IESF and Pretreatment/Outlet Collector

Rank #14

Drainage Area – 201.8 acres
Location – at dead-end of 12th Ave SE
Property Ownership – Public (easement)
Description – This BMP addresses the actively eroding banks of a channel conveying runoff from the ditched wetland and golf course drainages as well as drainage from 12th Ave SE into Forest Lake. The proposed BMPs connects these outlets into a large concrete sump structure providing additional treatment and redirects outlet flows away from the channel banks. An IESF is also proposed to receive low flow events from the new sump structure. Note: the pollutant reduction figures shown (TP and TSS) do not represent pollution reduction from stopping erosion of channel banks by directing stormwater flows into the permanent water pool vs. at the channel bank face.

	Cost/Removal Analysis	Project ID: Outlet Control and IESF	
		New trtmt	Net %
Treatment	TP (lb/yr)	2.8	5%
	TSS (lb/yr)	828	4%
	Volume (acre-feet/yr)	0.0	0%
	Number of BMP's	2	
	BMP Size/Description	1,000	sqft
	BMP Type	Outlet Modification (riser ~ 1 ft high)	
Cost	Materials/Labor/Design	$41,445	
	Promotion & Admin Costs	$250	
	Probable Project Cost	**$41,695**	
	Annual O&M	$1,000	
	10-yr Cost/lb-TP/yr	**$1,846**	
	10-yr Cost/2,000lb-TSS/yr	**$12,487**	

Catchment FL54

Catchment Summary – Existing	
Acres	62
Dominant Land Cover	Suburban
Parcels	112
Volume (acre-feet/yr)	12.6
TP (lb/yr)	36.4
TSS (lb/yr)	10067

CATCHMENT DESCRIPTION

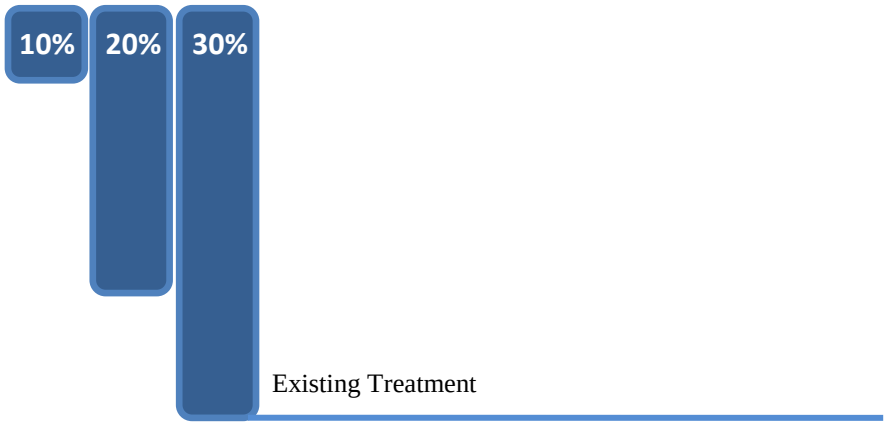
FL54 drains to Forest Lake through a rural ditch network as well as via a large wetland complex. Approximately 45 acres or 73% of the catchment drains to the wetland complex. The specific pollution reduction benefit of this wetland was not included in the analysis.

EXISTING STORMWATER TREATMENT

There is a large wetland network receiving runoff from the majority of the catchment area (45 acres). The functionality of this wetland is unknown; a conservative estimate of a 58% reduction in pollutants and no reduction in volume was used in this analysis. Street sweeping of city streets and parking lots occur approximately 10 times annually. WinSLAMM street sweeping inputs factored street sweeping taking place outside of the winter season (11/04 – 03/13) approximately every 4 weeks using a vacuum-assisted sweeper.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**TP (lb/yr)**	37.6	11.24	46.7%	**26.4**
	TSS (lb/yr)	10563	3314	31.4%	**7249**
	Volume (acre-feet/yr)	12.6	0	0	**12.6**
	Number of BMP's	2			
	BMP Size/Description	Street Sweeping 10 times/yr, large wetland			

Catchment-wide TP Reduction Milestones via Ranked Retrofit Recommendations



FL54 – Ditch Diversion with Pretreatment and Forebay

Rank #3

Drainage Area – 16.4 acres
Location – SW quadrant of Hoekstra and Hwy 97
Property Ownership – Private
Description – This stormwater BMP addresses the rural ditch runoff routed past the large wetland complex directly into Forest Lake. The proposed BMP consisted of a vegetated ditch swale and forebay for pretreatment and a split flow structure to divert runoff

	Cost/Removal Analysis	***Project ID***	
		Ditch Diversion with Pretreatment (grass swale and forebay)	
		New trtmt	**Net %**
Treatment	**TP (lb/yr)**	6.6	67%
	TSS (lb/yr)	1,900	69%
	Volume (acre-feet/yr)	0.4	13%
	Number of BMP's	2	
	BMP Size/Description	2,000	Sqft
	BMP Type	grass swale, diversion structure and forebay	
Cost	**Materials/Labor/Design**	$23,420	
	Promotion & Admin Costs	$500	
	Probable Project Cost	**$23,920**	
	Annual O&M	$1,500	
	10-yr Cost/lb-TP/yr	**$590**	
	10-yr Cost/2,000lb-TSS/yr	**$4,097**	

Retrofit Ranking

The table on the next page summarizes potential projects. Potential projects are organized from the most cost effective to the least, based on cost per pound of total phosphorus removed. Installation of projects with overlapping drainage areas will result in lower total treatment than the simple sum of treatment across the individual projects due to treatment train effects. Reported treatment levels of identified projects 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 table.

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Catchments FL1-01 through FL54: Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total phosporus (TP) reduction. Volume and total suspended solids (TSS) reductions are also shown. For more information on each project refer to the catchment profile pages in this report.

Project Rank	Catchment ID	Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Materials / Labor / Design	Promotion & Admin Costs	Total Project Cost	Estimated Annual Operations & Maintenance (2012 Dollars)	Estimated cost/ lb-TP/year (10-year)	Estimated cost/ ton -TSS/year (10-year)
1	FL53+FL53-2	Stormwater Wetland Outlet Modification	1	4.1	1,678	0.3	$240	$0	$240	$0	$6	$29
2	FL53+FL53-2	Ditched Wetland Outlet Modification	1	5.0	1,590	0.1	$750	$0	$750	$0	$15	$94
3	FL54	Ditch Diversion with Pretreatment/Forebay	2	6.6	1900	0.4	$23,420	$500	$23,920	$1,500	$590	$4,097
4	FL1-01	6th Street Dead End - IESF, Diversion + Pretreatment	1	9.1	1,867	N/A	$53,750	$3,000	$56,750	$2,063	$850	$8,290
5	FL1-01	Residential Raingardens	15	12.6	5,620	8.7	$67,554	$6,000	$73,554	$3,375	$852	$3,819
6	FL1-02	217th St. North & Scandia Trl North Raingardens	2	2.9	840	1.8	$15,000	$1,200	$16,200	$1,000	$903	$6,238
7	FL1-01	Residential Raingardens	10	7.9	3,686	5.5	$45,036	$4,000	$49,036	$2,250	$906	$3,881
8	FL1-01	Residential Raingardens	5	3.3	1,455	2.1	$22,518	$2,000	$24,518	$1,125	$1,084	$4,917
9	FL1-01	Woodland Drive - IESF with Pretreatment	1	4.4	1000	N/A	$34,250	$3,000	$37,250	$1,125	$1,102	$9,700
10	FL1-02	Heath Avenue Weland - Restoration & Expansion	1	3	1,106.0	N/A	$18,000	$2,000	$20,000	$1,500	$1,129	$6,329
11	FL53+FL53-2	Stormwater Reuse - Golf Course Irrigation	1	19.3	8,340	17.3	$220,000	$2,000	$222,000	$3,000	$1,306	$6,043
12	FL1-02	Hilo Lane North Raingardens with Pretreatment	3	2.7	1,664	0.8	$22,518	$3,000	$25,518	$1,125	$1,362	$4,419
13	FL1-01	Lakeside Woods - WQ swale meander	1	1.2	98	0.0	$10,000	$2,000	$12,000	$500	$1,417	$34,694
14	FL53+FL53-2	IESF & Pretreatment/Outlet Collector	2	2.8	828	0.0	$41,445	$250	$41,695	$1,000	$1,846	$12,487
15	FL1-02	Hilo Lane North Raingardens with Pretreatment	5	3.1	1,802	1.0	$37,530	$3,000	$40,530	$1,875	$1,912	$6,579
16	FL1-03	Stormwater Wetland Pretreatment Basins	13	3.5	1200	0.0	$33,500	$1,000	$34,500	$3,600	$2,014	$11,750
17	FL1-01	10th Ave SE - Depavement, split flow, raingarden	1	1.8	516	1.2	$29,150	$2,000	$31,150	$1,088	$2,335	$16,298
18	FL1-01	7th Street Dead End - Water Quality Swale (Bioswale) with Pretreatment	1	1.1	308	0.6	$16,000	$2,000	$18,000	$2,025	$3,629	$24,838
19	FL1-01	Lakeside Woods - 3 raingardens	3	1.8	885	2.5	$45,036	$2,000	$47,036	$2,500	$4,002	$16,279
20	FL1-01	4th Street Dead End - Water Quality Swale (Bioswale) with Pretreatment & stormsewer routing	1	0.7	231	0.3	$21,000	$700	$21,700	$1,800	$5,365	$34,447
21	FL1-01	5th Street Dead End - Filter Strip with Pretreatment/Level Spreader	1	0.4	115	0.1	$8,150	$500	$8,650	$1,250	$6,043	$36,783
22	FL1-02	Shoreline Buffers	25	3.3	720	0.8	$210,000	$1,000	$211,000	$10,000	$9,424	$86,389
23	FL1-02	Shoreline Buffers	75	9.8	2,160	2.3	$630,000	$3,000	$633,000	$30,000	$9,520	$86,389
24	FL1-02	Shoreline Buffers	50	6.5	1,440	1.6	$420,000	$2,000	$422,000	$20,000	$9,569	$86,389
25	FL1-01	Shoreline Buffers	180	19.8	4,446	5.0	$1,512,000	$4,500	$1,516,500	$72,000	$11,295	$100,607
26	FL1-01	Shoreline Buffers	120	13.2	2,964	3.4	$1,008,000	$3,500	$1,011,500	$48,000	$11,299	$100,641
27	FL1-01	Shoreline Buffers	60	6.6	1,482	1.7	$504,000	$2,500	$506,500	$24,000	$11,311	$100,742
28	FL1-03	Shoreline Buffers	90	4.1	614	1.2	$378,000	$2,000	$380,000	$22,500	$14,756	$197,068
29	FL1-03	Shoreline Buffers	270	12.2	1843	3.7	$1,134,000	$6,000	$1,140,000	$67,500	$14,877	$196,961
30	FL1-03	Shoreline Buffers	180	8.1	1229	2.5	$756,000	$4,000	$760,000	$45,000	$14,938	$196,908

	indicates projects with overlapping drainage areas within a catchment; pollution reduction is not accurate if both projects are installed.
	indicates aggregating projects with benefit calculations estimated by available project locations and landowner participation rates.

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Appendix A: Methods

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Methods

Selection of Subwatershed

Many factors are considered when choosing which subwatershed to analyze for stormwater retrofits. Water quality monitoring data, non-degradation report modeling, and TMDL studies are just a few of the resources available to help determine which water bodies are a priority. Stormwater retrofit analyses supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the process also rank highly. For some communities a stormwater retrofit analysis complements their MS4 stormwater permit. The focus is always on a high priority waterbody.

For this analysis, areas draining to Moore Lake were chosen for study. Moore Lake is a high priority because it is classified as a Tier II water body by the Rice Creek Watershed District and is used regularly for recreation. Moore Lake was added to the EPA's 303(d) list of impaired waters for excess nutrients in 2002. Years of water quality monitoring identified increased levels total phosphorus and chlorophyll a that exceeded state standards.

Stormwater runoff from impervious surfaces like pavement and roofs can carry a variety of pollutants. While stormwater treatment to remove these pollutants is adequate in some areas, other areas were built before modern-day stormwater treatment technologies and requirements or have undersized treatment devices.

Stormwater Retrofit Analysis Methods

The process used for this analysis is outlined in the following pages and was modified from the Center for Watershed Protection's *Urban Stormwater Retrofit Practices,* Manuals 2 and 3 (Schueler, 2005, 2007). Locally relevant design considerations were also incorporated into the process (*Minnesota Stormwater Manual*).

Step 1: Retrofit Scoping

Retrofit scoping includes determining the objectives of the retrofits (volume reduction, target pollutant, etc.) and the level of treatment desired. It involves meeting with local stormwater managers, city staff and watershed management organization members to determine the issues in the subwatershed. This step also helps to define preferred retrofit treatment options and retrofit performance criteria. In order to create a manageable area to analyze in large subwatersheds, a focus area may be determined.

In this analysis, the focus area was all areas that drain to East and West Moore Lakes. Included are areas of residential, commercial, industrial, and institutional land uses. The subwatershed was divided into 10 catchments using a combination of existing subwatershed mapping data, stormwater infrastructure maps, and observed topography.

The targeted pollutant for this study was total phosphorus, though total suspended solids and volume were also modeled and reported. Total phosphorus (TP) was chosen as the primary target pollutant because long term water quality monitoring has identified elevated levels in East Moore Lake. Total suspended solids (TSS) was also reported because many other pollutants, such as heavy metals, are transported by these particles. Volume of stormwater was tracked throughout this study because it is necessary for pollutant loading calculations and potential retrofit project considerations.

Step 2: Desktop Retrofit Analysis

The desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that don't need to be analyzed because of existing stormwater infrastructure or disconnection from the target water body. Accurate GIS data are extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS layers include: 2-foot or finer topography, hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography and the stormwater drainage infrastructure (with invert elevations).

Desktop retrofit analysis features to look for and potential stormwater retrofit projects.

Feature	*Potential Retrofit Project*
Existing Ponds	**Add storage and/or improve water Add storage and/or improve water quality by excavating pond bottom, modifying riser, raising embankment, and/or modifying flow routing.**
Open Space	**New regional treatment (pond, bioretention).**
Roadway Culverts	**Add wetland or extended detention water quality treatment upstream.**
Outfalls	**Split flows or add storage below outfalls if open space is available.**
Conveyance system	**Add or improve performance of existing swales, ditches and non-perennial streams.**
Large Impervious Areas (campuses, commercial, parking)	**Stormwater treatment on site or in nearby open spaces.**
Neighborhoods	**Utilize right of way, roadside ditches, curb-cut rain gardens, or filter systems before water enters storm drain network.**

Step 3: Retrofit Reconnaissance Investigation

After identifying potential retrofit sites through this desktop search, a field investigation was conducted to evaluate each site and identify additional opportunities. During the investigation, the drainage area and stormwater infrastructure mapping data were verified. Site constraints were assessed to determine the most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have also revealed additional retrofit opportunities that could have gone unnoticed during the desktop search.

General list of stormwater BMPs considered for each catchment/site.

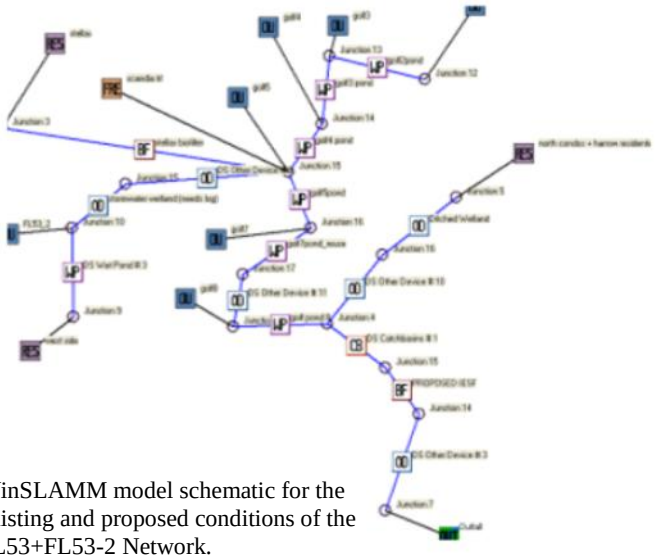
Stormwater Treatment Options for Retrofitting		
Area Treated	**Best Management Practice**	**Potential Retrofit Project**
5-500 acres	Extended Detention	**12-24 hr detention of stormwater with portions drying out between events (preferred over wet ponds). May include multiple cell design, infiltration benches, sand/peat/iron filter outlets and modified choker outlet features.**
	Wet Ponds	**Permanent pool of standing water with new water displacing pooled water from previous event.**
	Wetlands	**Depression less than 1-meter deep and designed to emulate wetland ecological functions. Residence times of several days to weeks. Best constructed off-line with low-flow bypass.**
0.1-5 acres	Bioretention	**Use of native soil, soil microbe and plant processes to treat, evapotranspirate, and/or infiltrate stormwater runoff. Facilities can either be fully infiltrating, fully filtering or a combination thereof.**
	Filtering	**Filter runoff through engineered media and pass it through an under-drain. May consist of a combination of sand, soil, compost, peat, and iron.**
	Infiltration	**A trench or sump that is rock-filled with no outlet that receives runoff. Stormwater is passed through a conveyance and pretreatment system before entering infiltration area.**
	Swales	**A series of vegetated, open channel practices that can be designed to filter and/or infiltrate runoff.**
	Other	**On-site, source-disconnect practices such as rain-leader Disconnect rain gardens, rain barrels, green roofs, cisterns, stormwater planters, dry wells, or permeable pavements.**

Step 4: Treatment Analysis/Cost Estimates

Sites most likely to be conducive to addressing the cities' and watershed district's goals and appear to have simple-to-moderate design, installation, and maintenance were chosen for a cost/benefit analysis. Estimated costs included design, installation, and maintenance annualized across a 30-year period. Estimated benefits included are pounds of phosphorus and total suspended solids removed, though projects were ranked only by cost per pound of phosphorus removed annually.

Treatment analysis

Each proposed project's pollutant removals were estimated using the stormwater model WinSLAMM. WinSLAMM uses an abundance of stormwater data from the upper Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It is useful for determining the effectiveness of proposed stormwater control practices. It has detailed accounting of pollutant loading from various land uses, and allows the user to build a model "landscape" that reflects the actual landscape being considered. The user is allowed to place a variety of stormwater treatment practices that treat water from various parts of this landscape. It uses rainfall and temperature data from a typical year, routing stormwater through the user's model for each storm.



WinSLAMM model schematic for the existing and proposed conditions of the FL53+FL53-2 Network.

The newest version of WinSLAMM (version 10), which allows routing of multiple catchments and stormwater treatment practices, was used for this analysis because of the unique connectivity amongst the catchments identified in the focus area under investigation.

The initial step was to create a "base" model which estimated pollutant loading from each catchment in its present-day state without taking into consideration any existing stormwater treatment. To accurately model the land uses in each catchment, we delineated each land use in each catchment using geographic information systems (specifically, ArcMap), and assigned each a WinSLAMM standard land use file. A site specific land use file was created by adjusting total acreage and accounting for local soil types (all soils were modeled as silt in this analysis). This process resulted in a model that included estimates of the acreage of each type of source area (roof, road, lawn, etc.) in each catchment. For certain source areas critical to our models we verified that model estimates were accurate by calculating actual acreages in ArcMap, and adjusting the model acreages if needed.

Once the "base" model was established, an "existing conditions" model was created by incorporating any existing stormwater treatment practices in the catchment. For example, street cleaning with mechanical or vacuum street sweepers, rain gardens, stormwater treatment ponds, and others were included in the "existing conditions" model if they were present in the catchment.

Finally, each proposed stormwater treatment practice was added to the "existing conditions" model and pollutant reductions were generated. Because neither a detailed design of each practice nor in-depth site investigation was completed, a generalized design for each practice was used. Whenever possible, site-specific parameters were included. Design parameters were modified to obtain various levels of treatment. It is worth noting that we modeled each practice individually, and the benefits of projects may not be additive, especially if serving the same area. Reported treatment levels are dependent upon optimal site selection and sizing.

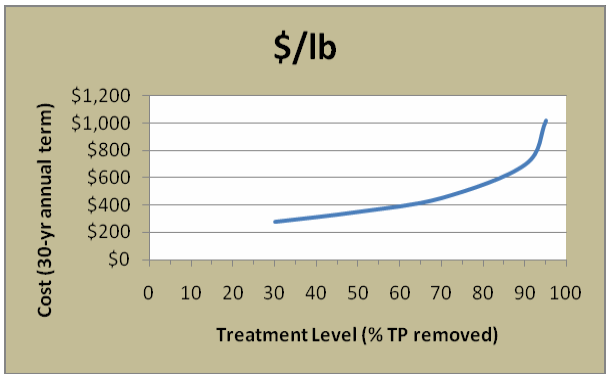
WinSLAMM stormwater computer model inputs

General WinSLAMM Model Inputs	
Parameter	**File/Method**
Land use acreage	ArcMap
Flow/Routing	Municipal Stormsewer data (available only for FL01-1) -Incomplete
Precipitation/Temperature Data	Minneapolis 1959 – the rainfall year that best approximates a typical year.
Winter season	Included in model. Winter dates are 11-4 to 3-13.
Pollutant probability distribution	WI_GEO01.ppd
Runoff coefficient file	WI_SL06 Dec06.rsv
Particulate solids concentration file	WI_AVG01.psc
Particle residue delivery file	WI_DLV01.prr
Street delivery files	WI files for each land use.

Cost Estimates

All estimates were developed using 2013 dollars. Cost estimates were annualized costs that incorporated design, installation, installation oversight, and maintenance over a 10-year period. In cases where promotion to landowners is important, such as rain gardens, those costs were included as well. In cases where multiple, similar projects are proposed in the same locality, promotion and administration costs were estimated using a non-linear relationship that accounted for savings with scale. Design assistance from an engineer is assumed for practices in-line with the stormwater conveyance system, involving complex stormwater treatment interactions, or posing a risk for upstream flooding. It should be understood that no site-specific construction investigations were done as part of this stormwater retrofit analysis, and therefore cost estimates account for only general site considerations.

The costs associated with several different pollution reduction levels were calculated. Generally, more or larger practices result in greater pollution removal. However the costs of obtaining the highest levels of treatment are often prohibitively expensive (see figure). By comparing costs of different treatment levels, the cities and watershed district can best choose the project sizing that meets their goals.



Step 5: Evaluation and Ranking

The cost per pound of phosphorus treated was calculated for each potential retrofit project. Only projects that seemed realistic and feasible were considered. The recommended level was the level of treatment that would yield the greatest benefit per dollar spent while being considered feasible and not falling below a minimal amount needed to justify crew mobilization and outreach efforts. Local officials may wish to revise the recommended level based on water quality goals, finances, or public opinion.

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Appendix B:
How to Read Catchment Profiles

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Catchment Profiles and How to Read Them

The analysis contains pages referred to as "Catchment Profiles." These profiles provide the most important details of this report, including:

- Summary of existing conditions, including existing stormwater infrastructure, and estimated pollutant export to Moore Lake
- Map of the catchment
- Recommended stormwater retrofits, pollutant reductions, and costs.

Following all of the catchment profiles (also in the executive summary) is a summary table that ranks all projects in all catchments by cost effectiveness.

To save space and avoid being repetitive, explanations of the catchment profiles are provided below. We strongly recommend reviewing this section before moving forward in the report.

The analyses of each catchment are broken into "base, existing, and proposed" conditions. They are defined as follows:

Base conditions - Volume and pollutant loadings from the catchment landscape without any stormwater practices.
Existing conditions -Volume and pollutant loadings after already-existing stormwater practices are taken into account.
Proposed conditions - Volume and pollutant loadings after proposed stormwater retrofits.

Analyses were performed at one of two geographic scales, "catchment or network." They are defined as follows:

Catchment level analyses - Volume and pollutant loads exiting the catchment at the catchment boundary. There may be other stormwater practices existing or proposed farther downstream, but this analysis ignores them.

The example catchment profile on the following pages explains important features of each profile.

HOW TO READ THE CATCHMENT PROFILES

EXAMPLE Catchment A

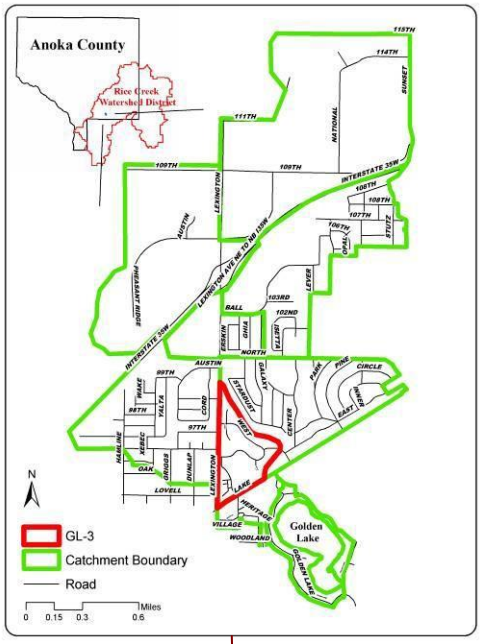
Existing Catchment Summary	
Acres	58.90
Dominant Land Cover	Residential
Parcels	237
Volume (acre-feet/yr)	18.37
TP (lb/yr)	25.00
TSS (lb/yr)	6461.00

DESCRIPTION

Example Catchment is primarily comprised of medium- density, single-family residential development…

EXISTING STORMWATER TREATMENT

Existing stormwater treatment practices within Example Catchment consist of street cleaning with a mechanical sweeper in the spring and fall and a network of stormwater treatment ponds…



Catchment ID banner.

Volume and pollutants generated from this catchment under existing conditions, and excludes existing network-wide treatment practices

Catchment locator map.

HOW TO READ THE CATCHMENT PROFILES

Catchment-level analysis of existing conditions.

Catchment Specific Existing Conditions

Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
TP (lb/yr)	25.2	0.2	1%	**25.0**
TSS (lb/yr)	7,186	725.0	10%	**6,461**
Volume (acre-feet/yr)	18.4	0.0	0%	**18.4**
Number of BMP's	1			
BMP Size/Description	Street cleaning, stormwater pond			

Volume of water and pounds of pollutants generated from the catchment without any stormwater management practices (base conditions).

Pollutants and volume removed by existing stormwater management practices (existing conditions).

Pollutants and volume exiting the catchment after existing practices.

Percent reductions by existing practices.

HOW TO READ THE CATCHMENT PROFILES

Map shows catchment boundaries, stormwater infrastructure, and the locations of proposed stormwater retrofits.

Proposed stormwater retrofits. The project ID number corresponds to this project's catchment and project type.

RETROFIT RECOMMENDATIONS

Project ID LCC-1 Residentia l RG's – Curb-Cut Rain Garden Network

Drainage Area – 33.7 acres
Location – 5 locations throughout residential area
Property Ownership – Private
Description – The residential land cover within this catchment is best suited to residential, curb-cut rain gardens (see Appendix B for design options). Seven optimal rain garden locations were identified (see map below). Generally, ideal curb-cut rain garden locations are immediately up-gradient of a catch basin serving a large drainage area. Considering typical land owner participation rates we analyzed multiple quantity sets of raingardens (and shoreline restorations) within our study. Volume and pollutant reductions resulting from the rain garden installations are highlighted in the tables below.

HOW TO READ THE CATCHMENT PROFILES

EXAMPLE Catchment Specific Cost/Benefit Analysis

Volume or pollutant removal this project will achieve.

Three "levels" of this project are compared: 6, 9, or 12 rain gardens, for example.

Pollutant removal achieved by this project.

Cost/Benefit Analysis	*Project ID*					
	6 Rain Gardens		9 Rain Gardens		12 Rain Gardens	
	New trtmt	Net trtmt %	New trtmt	Net trtmt %	New trtmt	Net trtmt %
TP (lb/yr)	5.4	39%	6.8	43%	7.7	46%
TSS (lb/yr)	1,684	41%	2,127	45%	2,408	48%
Volume (acre-feet/yr)	4.2	33%	5.4	38%	6.1	41%
Number of BMP's	6		9		12	
BMP Size/Description	1,500 sq ft		2,250 sq ft		3,000 sq ft	
BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Materials/Labor/Design	$27,210		$40,710		$54,210	
Promotion & Admin Costs	$2,450		$2,870		$3,290	
Total Project Cost	$29,660		$43,580		$57,500	
Annual O&M	$450		$675		$900	
Term Cost/lb-TP	$855		$1,000		$1,170	
Term Cost/2,000lb-TSS	**$266**		**$313**		**$364**	

Project installation cost estimation.

Cost effectiveness at suspended solids removal. The project cost is divided by suspended solids removal in tons (10 yrs). Includes operations and maintenance over the project contract life (10 years).

Cost effectiveness at phosphorus removal. The project cost is divided by phosphorus removal in pounds (10 yrs). Includes operations and maintenance over the project life (10 years unless otherwise noted).

Compare cost effectiveness of various project "levels" in these rows for TP (2ND row from bottom) or TSS (bottom row) removal. Compare cost effectiveness numbers between projects to determine the best value.

HOW TO READ THE CATCHMENT PROFILES

EXAMPLE Network-Wide Cost/Benefit Analysis

Cost/Benefit Analysis	*Project ID*					
	6 Rain Gardens		9 Rain Gardens		12 Rain Gardens	
	New trtmt	Net trtmt %	New trtmt	Net trtmt %	New trtmt	Net trtmt %
TP (lb/yr)	5.4	39%	6.8	43%	7.7	46%
TSS (lb/yr)	1,684	41%	2,127	45%	2,408	48%
Volume (acre-feet/yr)	4.2	33%	5.4	38%	6.1	41%
Number of BMP's	6		9		12	
BMP Size/Description	1,500 sq ft		2,250 sq ft		3,000 sq ft	
BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Materials/Labor/Design	$27,210		$40,710		$54,210	
Promotion & Admin Costs	$2,450		$2,870		$3,290	
Total Project Cost	$29,660		$43,580		$57,500	
Annual O&M	$450		$675		$900	
Term Cost/2,000lb-TSS/yr	$855		$1,000		$1,170	
Term Cost/lb-TP/yr	**$266**		**$363**		**$414**	

This table is the same as the previous catchment-level table, except it examines the costs and benefits of proposed stormwater retrofits at the network level.

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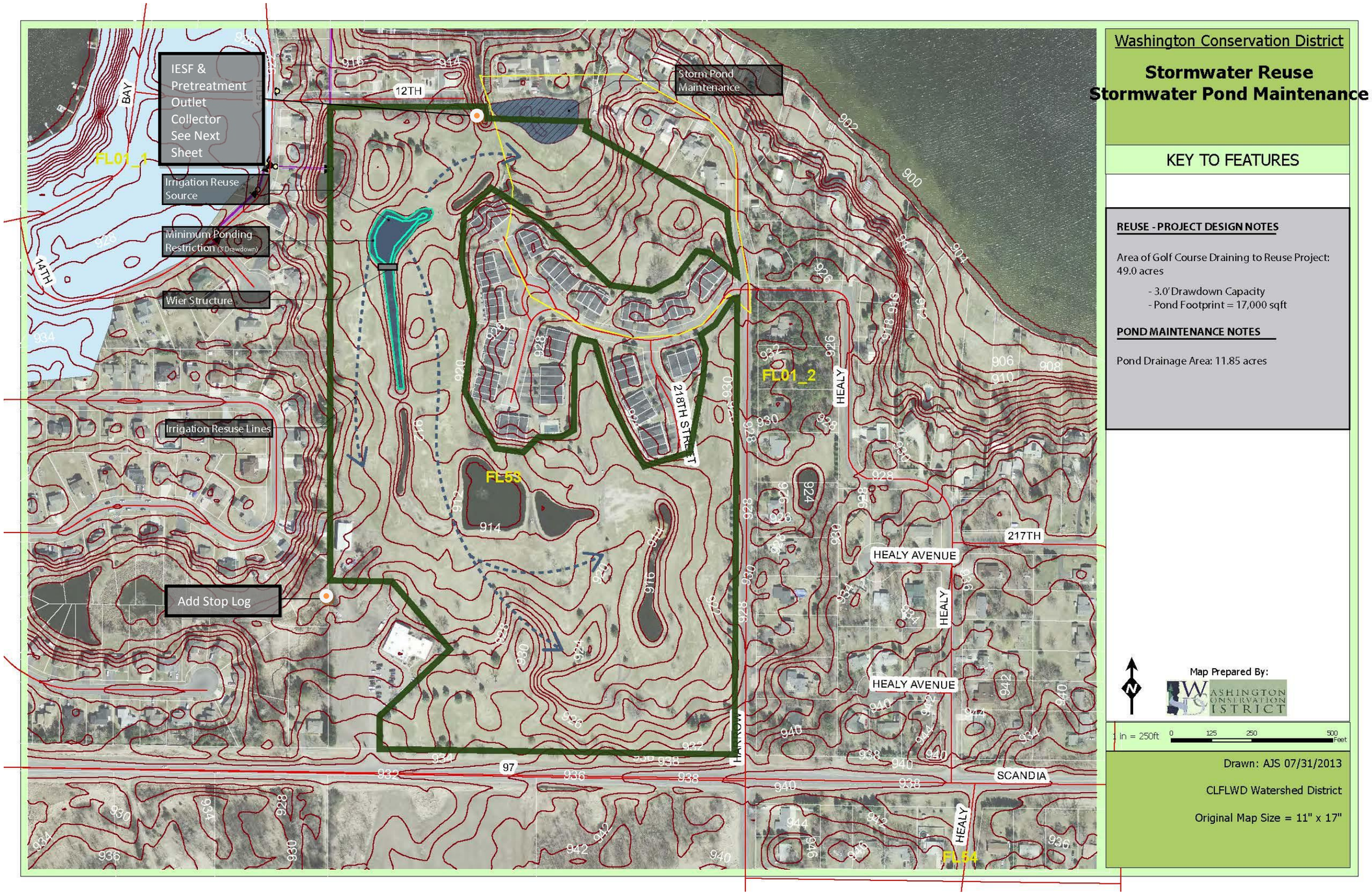
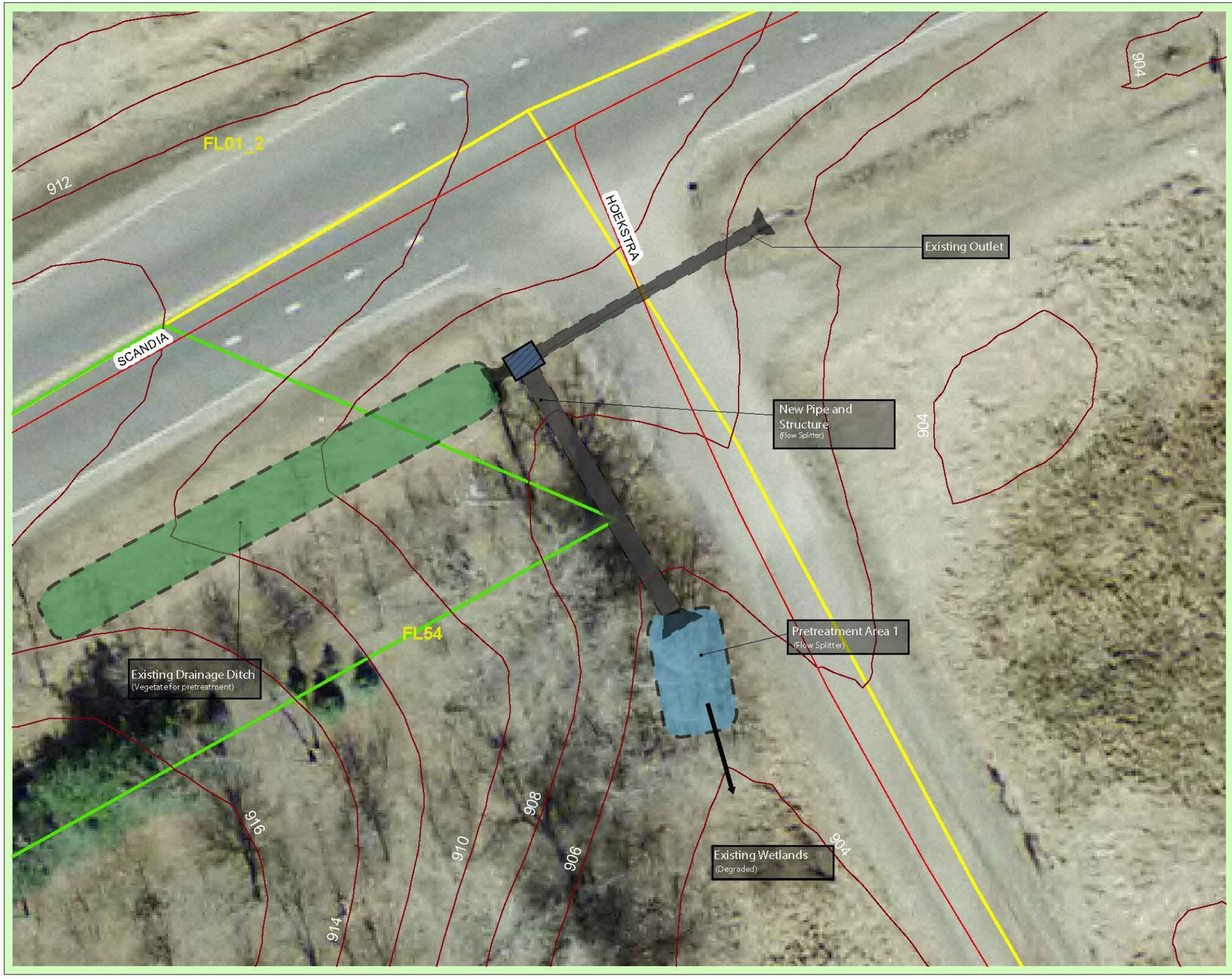
Appendix C: Retrofit Concept Designs for Top Projects


IESF & Pretreatment Outlet Collector See Next Sheet
Irrigation Reuse Source
Minimum Ponding Restriction (3' Drawdown)
Wier Structure
Irrigation Resuse Lines
Add Stop Log
Storm Pond Maintenance
FL01_1
FL01_2
FL53
FL64
12TH
14TH
BAY
218TH STREET
HEALY
HEALY AVENUE
217TH
SCANDIA
HARROW
97
Washington Conservation District
Stormwater Reuse
Stormwater Pond Maintenance
KEY TO FEATURES
REUSE - PROJECT DESIGN NOTES
Area of Golf Course Draining to Reuse Project: 49.0 acres
- 3.0' Drawdown Capacity
- Pond Footprint = 17,000 sqft
POND MAINTENANCE NOTES
Pond Drainage Area: 11.85 acres
Map Prepared By:
WASHINGTON CONSERVATION DISTRICT
1 in = 250ft
0 125 250 500 Feet
Drawn: AJS 07/31/2013
CLFLWD Watershed District
Original Map Size = 11" x 17"



Washington Conservation District

FL 54_Ditch Diversion

KEY TO FEATURES

Map Prepared By:

1 in = 20ft 0 10 20 40 Feet

Drawn: AJS 07/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"


FL01_1
Maintain Lake Access
Pretreatment Area 1
(Flow Splitter)
Existing Storm Pipe
(15"-18")
IESF Filtration
(3100 sqft)
Pretreatment Area 2
(4"wide Clean-out Structure)
Level Spreader
6TH
Washington Conservation District
6th Street Deadend
KEY TO FEATURES
PROJECT DESIGN NOTES
Contributing Drainage Area: 33.6 acres
BMP Types: IESF Filtration + Pretreatment flow splitter
Total Available Area for BMP: 3600 sqft
Pretreatment: 500 sqft
IESF Filtration: 3100 sqft
ALL DEADEND STREETS ARE REQUIRED TO MAINTAIN A 4' MIN. ACCESS TO FOREST LAKE
Flow Direction
N
Map Prepared By:
WASHINGTON CONSERVATION DISTRICT
1 in = 20ft
0 10 20 40 Feet
Drawn: AJS 07/31/2013
CLFLWD Watershed District
Original Map Size = 11" x 17"

Washington Conservation District

10th Ave SE Diversion

KEY TO FEATURES

PROJECT DESIGN NOTES

Contributing Drainage Area: 3.51 acres

BMP Types: Infiltration + Pretreatment Flow Splitter

Total Available Area for BMP: 700 sqft

Flow Direction

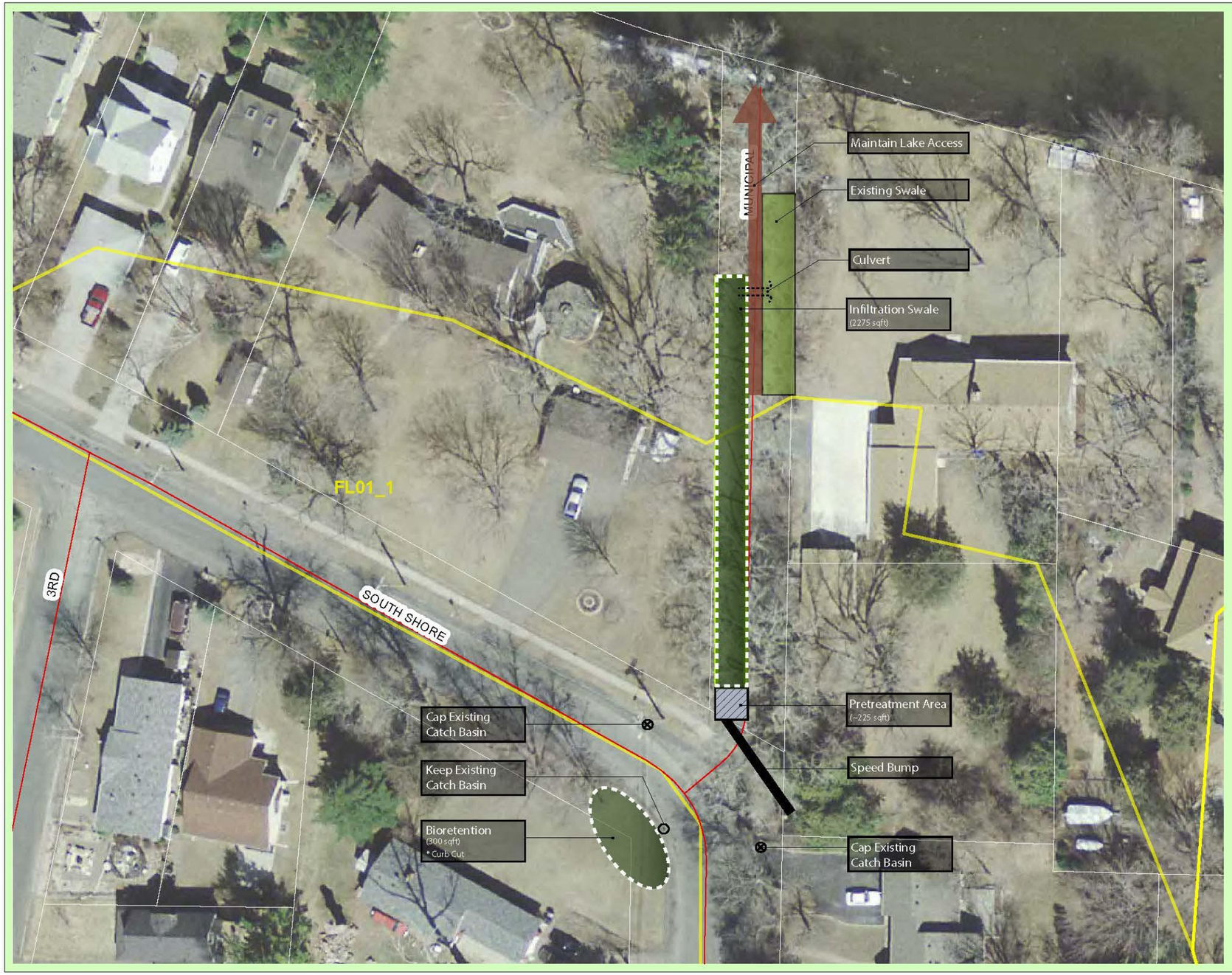
Map Prepared By:

1 in = 20ft 0 10 20 40 Feet

Drawn: AJS 07/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"



Washington Conservation District

4th Street Deadend

KEY TO FEATURES

PROJECT DESIGN NOTES

Contributing Drainage Area:
Infiltration Swale: 3.0 acres
Bioretention: 1.6 acres

BMP Types: Infiltration Swale + Bioretention

Total Available Area for BMP: 3000 sqft

ALL DEADEND STREETS ARE REQUIRED TO MAINTAIN A 4' MIN. ACCESS TO FOREST LAKE

Map Prepared By:

1 in = 40ft 0 20 40 80 Feet

Drawn: AJS 07/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"

Washington Conservation District

5th Street Deadend

KEY TO FEATURES

PROJECT DESIGN NOTES

Contributing Drainage Area: 2.7 acres

BMP Types: Filter Strip

Total Available Area for BMP: 1530 sqft

ALL DEADEND STREETS ARE REQUIRED TO MAINTAIN A 4' MIN. ACCESS TO FOREST LAKE

Map Prepared By:

Washington Conservation District

1 in = 20ft 0 10 20 40 Feet

Drawn: AJS 07/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"

Washington Conservation District

6th Street Deadend

KEY TO FEATURES

PROJECT DESIGN NOTES

Contributing Drainage Area: 33.6 acres

BMP Types: IESF Filtration + Pretreatment flow splitter

Total Available Area for BMP: 3600 sqft
Pretreatment: 500 sqft
IESF Filtration: 3100 sqft

ALL DEADEND STREETS ARE REQUIRED TO MAINTAIN A 4' MIN. ACCESS TO FOREST LAKE

Flow Direction

Map Prepared By:

1 in = 20ft 0 10 20 40 Feet

Drawn: AJS 07/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"

Washington Conservation District

7th Street

KEY TO FEATURES

PROJECT DESIGN NOTES

Contributing Drainage Area: 2.8 acres

BMP Types: Filtration Swale

Total Available Area for BMP: 2700 sqft

ALL DEADEND STREETS ARE REQUIRED TO MAINTAIN A 4' MIN. ACCESS TO FOREST LAKE

Map Prepared By:

Washington Conservation District

1 in = 20ft 0 10 20 40 Feet

Drawn: AJS 07/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"

Washington Conservation District

Woodland Dr. Diversion

KEY TO FEATURES

PROJECT DESIGN NOTES

Contributing Drainage Area: 6.43 acres

BMP Types: IESF Filtration + Flow Splitter

Total Available Area for BMP: 1450 sqft

Flow Direction

Map Prepared By:

Washington Conservation District

1 in = 20ft 0 10 20 40 Feet

Drawn: AJS 07/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"

Washington Conservation District

FL53+FL53_2
Outlet Stabilization and IESF

KEY TO FEATURES

PROJECT DESIGN NOTES

Contributing Drainage Area: 203 acres

BMP Types: IESF Filtration + scour reduction through outlet modification

Total available area for BMP: 1500 sqft
IESF Filtration: 1000 sqft
Outlet Modification: 500 sqft

Flow Direction

Map Prepared By:

1 in = 40ft 0 20 40 80 Feet

Drawn: AJS 12/31/2013

CLFLWD Watershed District

Original Map Size = 11" x 17"


1 inch = 60 feet
0 15 30 60 90 120 150
Feet
RAINGARDEN 1
RAINGARDEN 2
RAINGARDEN 3
BIOSWALE
FOREST LAKE
NAME
ADDRESS
CITY
PIN:
2013 Aerial Photo
ASHINGTON CONSERVATION DISTRICT
COMFORT LAKE FOREST LAKE WATERSHED DISTRICT
LAKESIDE WOODS CONDOMINIUMS
8th Avenue and South Shore Drive
Forest Lake
RAINGARDENS - WATER QUALITY SWALE CONCEPT
KEY TO FEATURES
Parcels