

Urban Water Quality BMP Retrofit Analysis

Where, What, How and at What Cost

Melissa Barrick
Shawn Tracy

Outline



Why are we doing what we're doing

What are we doing

Benefits of approach

Who has been involved

What we've done so far

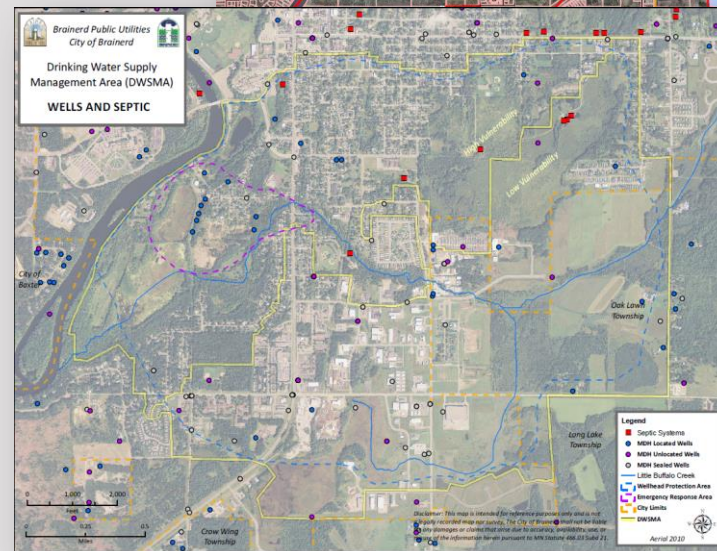
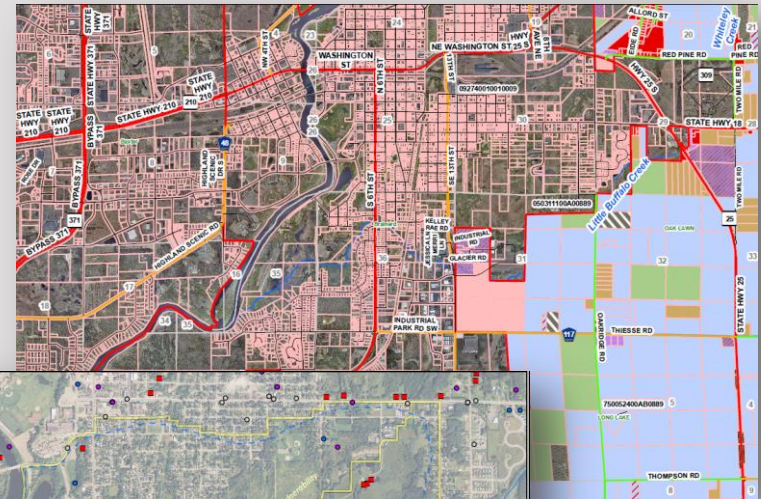
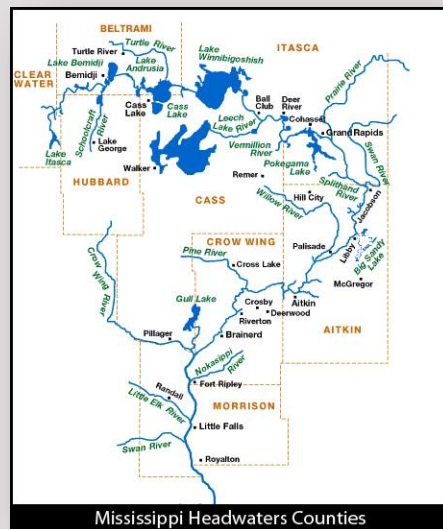
What has this told us

How does this fit into regional planning

Summary of What, Why and Benefits

Why are we doing this?

SWCD Mission
City MS4 requirements
Strategic, value-based planning



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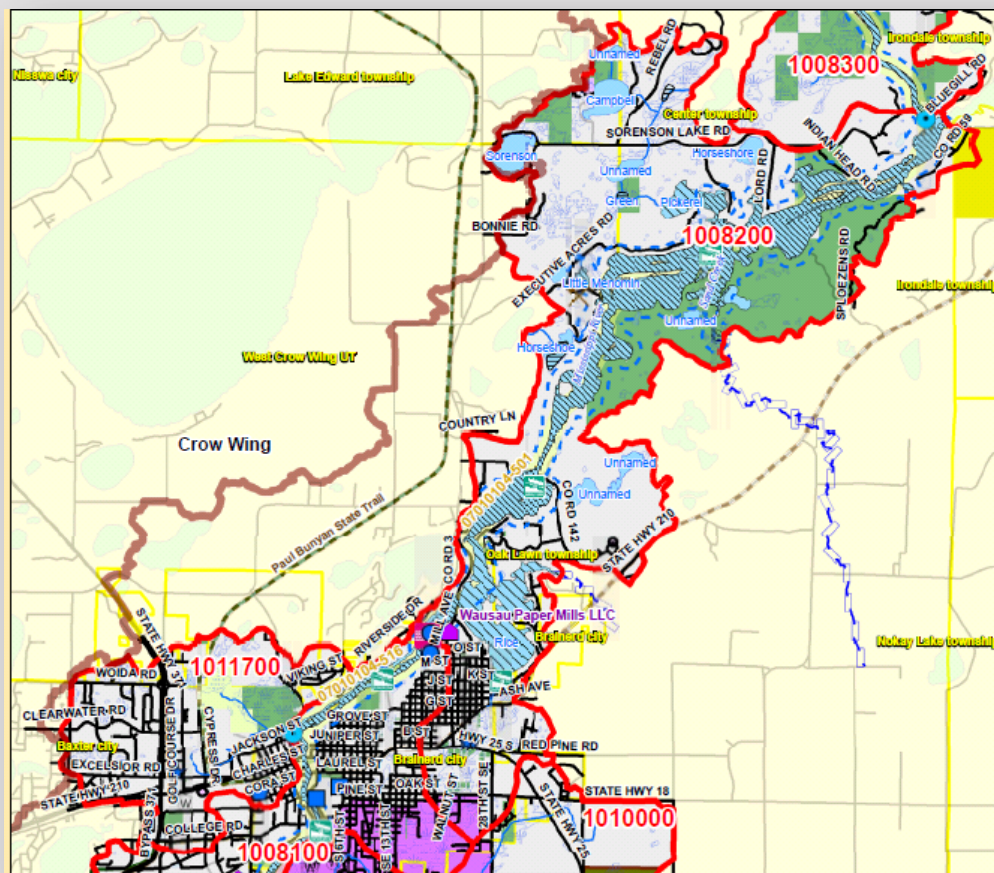
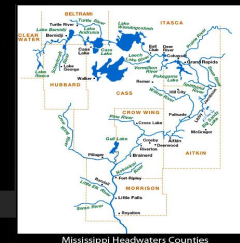
Why are we doing this?



Why are we doing this?



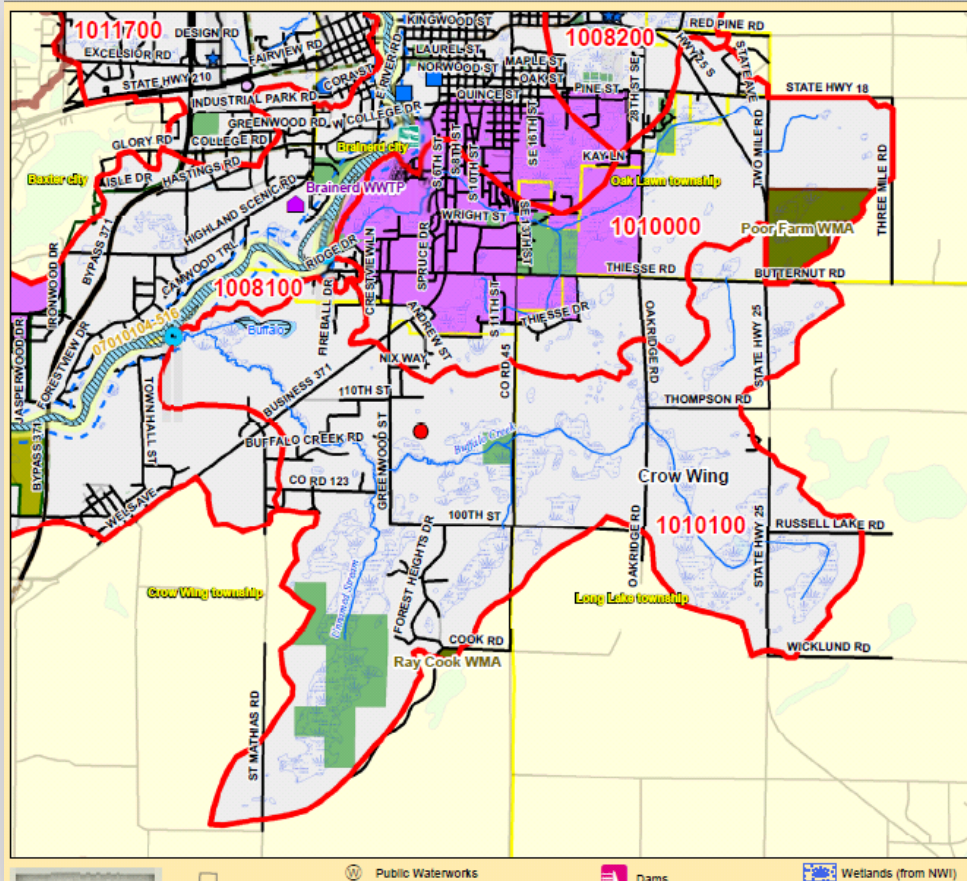
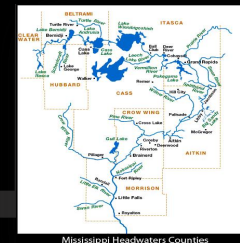
Why are we doing this?



Mississippi R. Catchment Map: Rice Lake / Whiskey Creek

Catchment #	1008200	Catchment #	1011700
River Stretch(es) (AUIDs)	07010104-501	River Stretch(es) (AUIDs)	N/A
Area (sq. miles)	19	Area (sq. miles)	5
Population 2010 (persons per sq. mile)	177	Population 2010 (persons per sq. mile)	512
Population Change 2000 to 2010 (persons per sq. mile)	-12	Population Change 2000 to 2010 (persons per sq. mile)	208
Surficial Geology	Supraglacial Drift Complex	Surficial Geology	Lacustrine
Topography	Steep	Topography	Level
% Slope (avg.)	13	% Slope (avg.)	6
% Forested (private)	29	% Forested (private)	14
% Disturbed Land Cover	19	% Disturbed Land Cover	62
% Developed	11	% Developed	50
# of Animal Units	0	# of Animal Units	0
% Public Land	23	% Public Land	8
% Easements	0	% Easements	5
% Lakes	8	% Lakes	0
% Mississippi River	14	% Mississippi River	0
% Wetlands (private)	9	% Wetlands (private)	6
% Protected	54	% Protected	18
Risk Classification	Protection	Risk Classification	Enhance
Implementation Priorities		Implementation Priorities	
Surface Water		Surface Water	
Aquatic Invasive Species	x	Aquatic Invasive Species	
Development (existing and potential)	x	Development (existing and potential)	x
Agricultural BMPs		Agricultural BMPs	
Lake Focus:	x	Lake Focus:	
Lake Focus: Wild Rice	x	Lake Focus: Wild Rice	
Lake Focus: Shallow /Wildlife	x	Lake Focus: Shallow /Wildlife	
Private Forest Stewardship	x	Private Forest Stewardship	
Bluffs & Steep Slopes	x	Bluffs & Steep Slopes	
Bald Eagle Territory	x	Bald Eagle Territory	x
Critical Bird Habitat	x	Critical Bird Habitat	
Rare Native Plants / Communities	x	Rare Native Plants / Communities	x
Native Mussel Habitat	x	Native Mussel Habitat	
Ground Water		Ground Water	
Wellhead Protection	x	Wellhead Protection	x

Why are we doing this?



Mississippi R. Catchment Map: Brainerd SE

Catchment #	1010000	Catchment #	1010100
River Stretch(es) (AUIDs)	N/A	River Stretch(es) (AUIDs)	N/A
Area (sq. miles)	7	Area (sq. miles)	12
Population 2010 (persons per sq. mile)	384	Population 2010 (persons per sq. mile)	72
Population Change 2000 to 2010 (persons per sq. mile)	9	Population Change 2000 to 2010 (persons per sq. mile)	29
Surficial Geology	Till Plain	Surficial Geology	Till Plain
Topography	Gently Rolling	Topography	Gently Rolling
% Slope (avg.)	6	% Slope (avg.)	6
% Forested (private)	26	% Forested (private)	29
% Disturbed Land Cover	53	% Disturbed Land Cover	36
% Developed	24	% Developed	3
# of Animal Units	0	# of Animal Units	40
% Public Land	10	% Public Land	6
% Easements	0	% Easements	0
% Lakes	0	% Lakes	0
% Mississippi River	0	% Mississippi River	0
% Wetlands (private)	10	% Wetlands (private)	18
% Protected	21	% Protected	25
Risk Classification	Enhance	Risk Classification	Enhance
Implementation Priorities		Implementation Priorities	
Surface Water		Surface Water	
Aquatic Invasive Species		Aquatic Invasive Species	x
Development (existing and potential)	x	Development (existing and potential)	x
Agricultural BMPs		Agricultural BMPs	x
Lake Focus:		Lake Focus:	
Lake Focus: Wild Rice		Lake Focus: Wild Rice	x
Lake Focus: Shallow /Wildlife		Lake Focus: Shallow /Wildlife	
Private Forest Stewardship	x	Private Forest Stewardship	x
Bluffs & Steep Slopes		Bluffs & Steep Slopes	
Bald Eagle Territory		Bald Eagle Territory	
Critical Bird Habitat	x	Critical Bird Habitat	
Rare Native Plants / Communities		Rare Native Plants / Communities	
Native Mussel Habitat		Native Mussel Habitat	
Ground Water		Ground Water	
Wellhead Protection	x	Wellhead Protection	

Public Waterworks

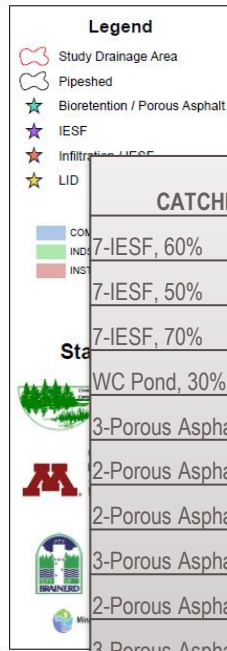
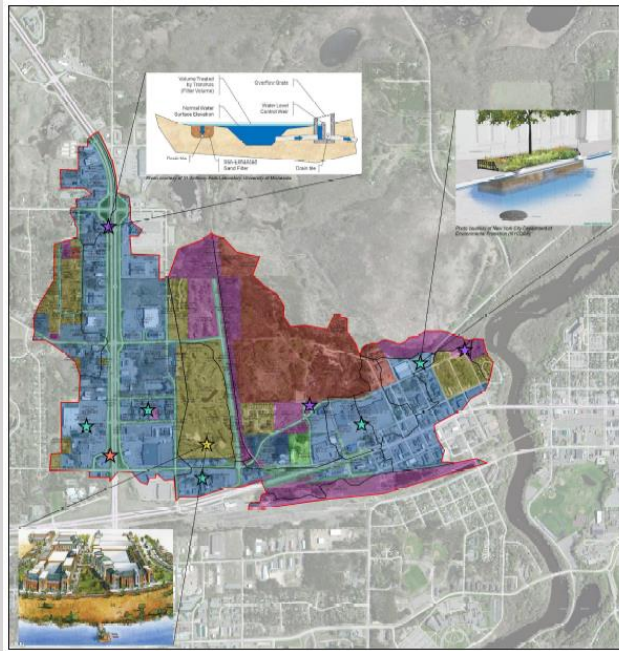
Dams

Wetlands (from NWI)

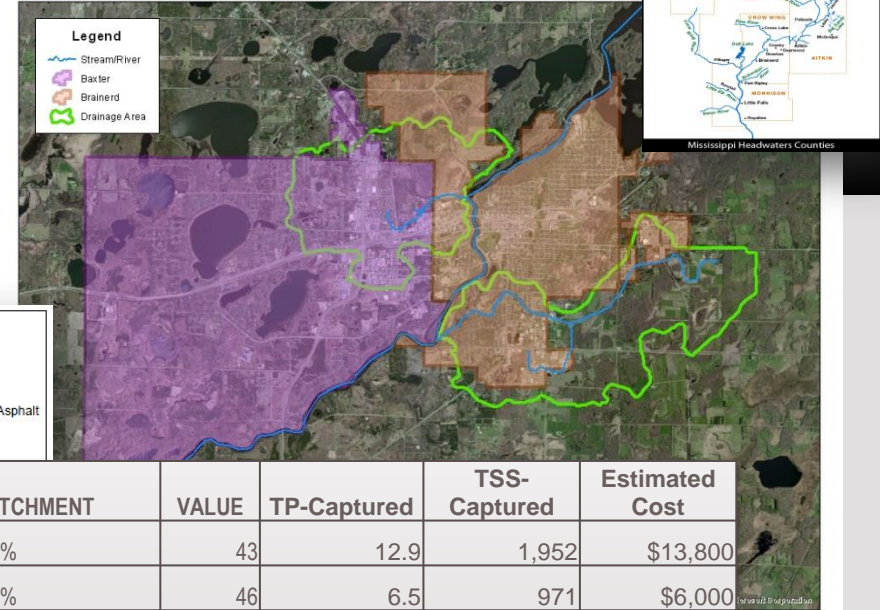
River Stretches (AUIDs) w/ Water Quality Data

Roads

What are we doing



CATCHMENT	VALUE	TP-Captured	TSS-Captured	Estimated Cost
7-IESF, 60%	43	12.9	1,952	\$13,800
7-IESF, 50%	46	6.5	971	\$6,000
7-IESF, 70%	47	20.6	3,175	\$26,160
WC Pond, 30%	58	167.1	87,454	\$280,000
3-Porous Asphalt, 30%	207	11.9	6,767	\$51,000
2-Porous Asphalt, 30%	207	13.0	7,360	\$55,830
2-Porous Asphalt, 50%	217	21.6	9,663	\$96,830
3-Porous Asphalt, 40%	228	15.9	7,887	\$75,140
2-Porous Asphalt, 40%	229	17.3	8,574	\$81,850
3-Porous Asphalt, 50%	251	19.9	8,889	\$103,160
3-Bioretention, 30%	435	11.9	6,743	\$84,200
3-Bioretention, 40%	455	15.9	7,872	\$112,200
3-Bioretention, 50%	520	19.9	8,883	\$160,000



What are the benefits?



Precision targeting of projects

Value-based selection

Multiple values per project

Appropriate scale of analysis

- Data
- Modeling resolution
- Monetary investment

Value:

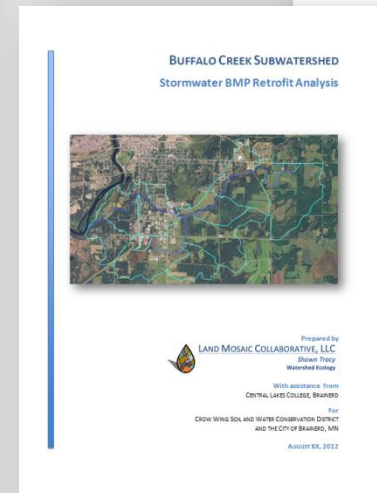
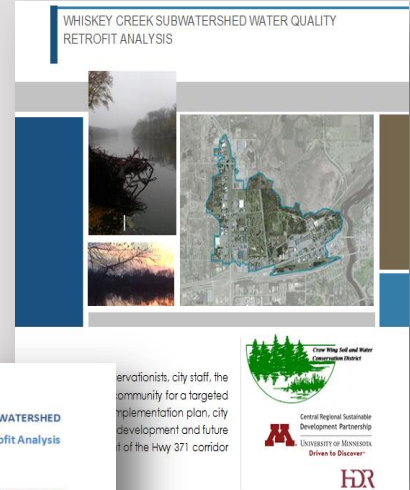
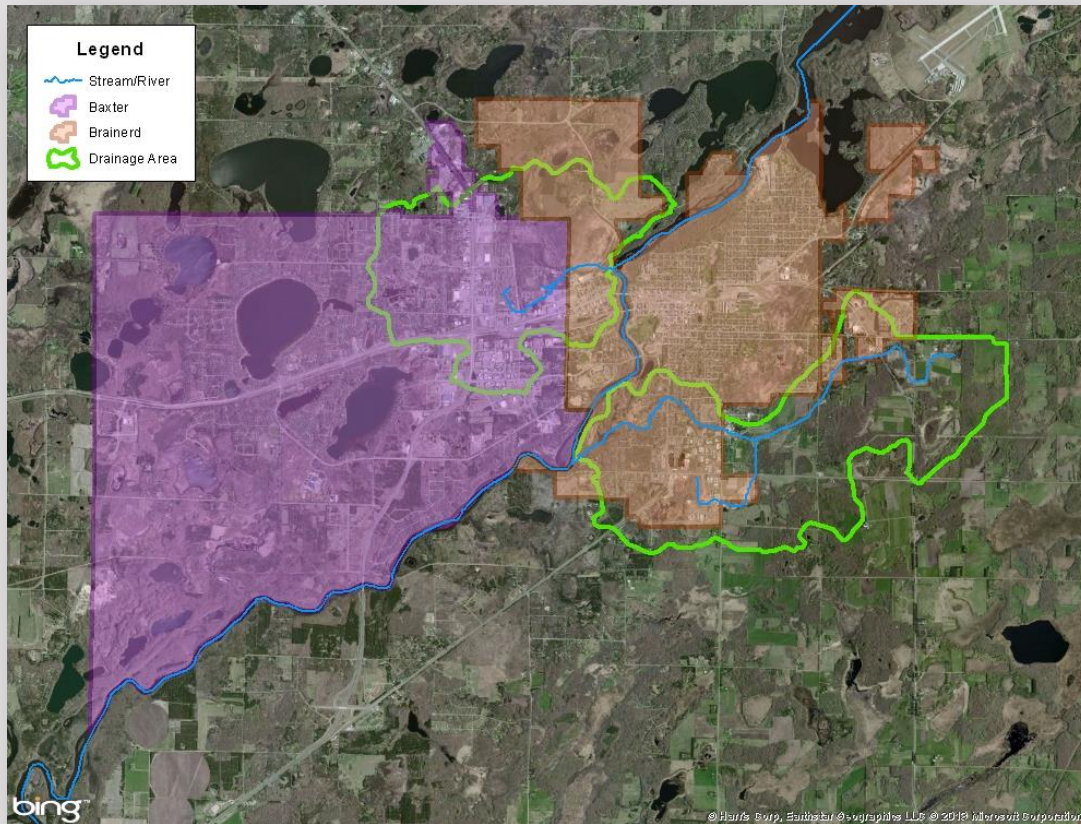
Right Project + Right Location + Right Cost



Who are the current partners?

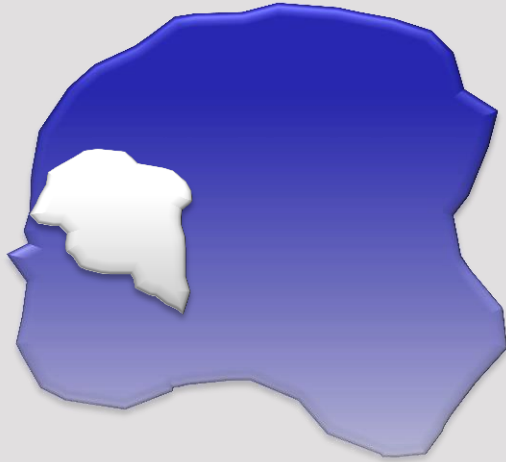


What we've done so far?



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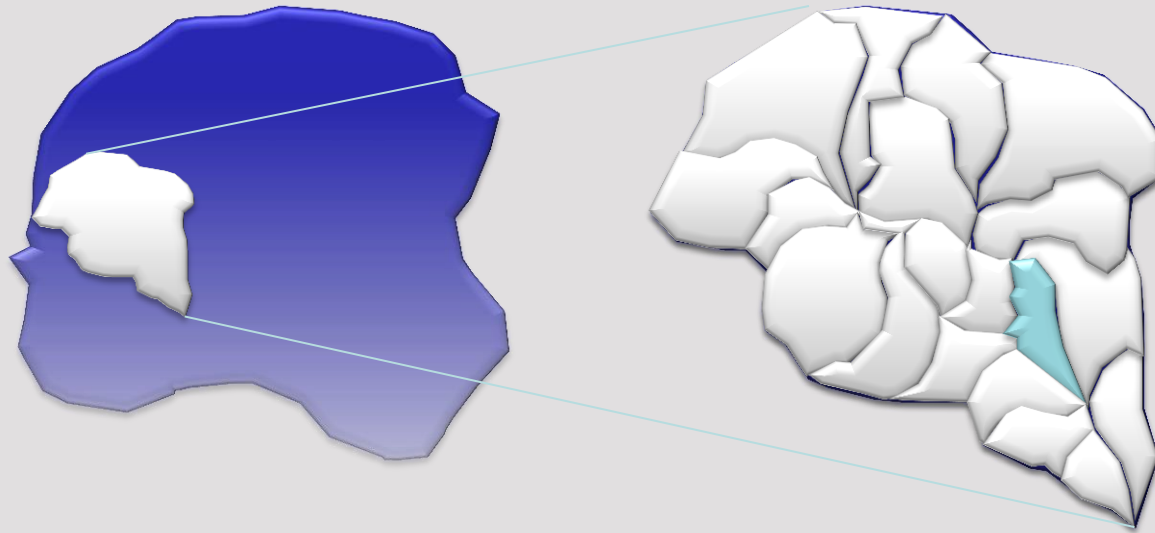
Scaled Analysis



Tier 1

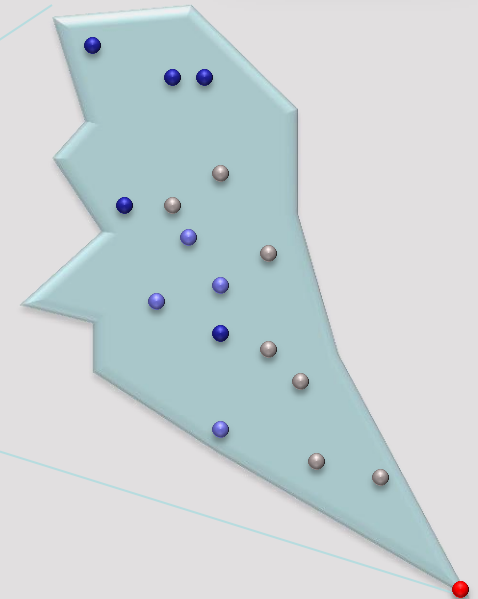
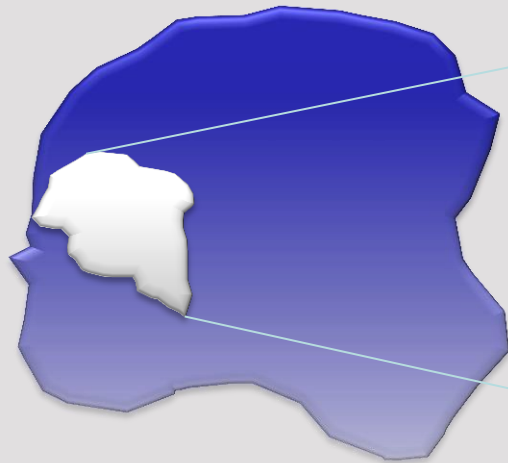
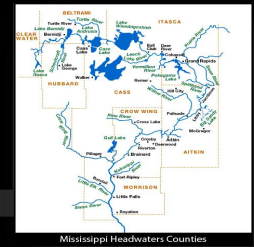
Subwatershed
500 – 5000 acres

Scaled Analysis



Tier 2
Catchment
20 – 500 acres

Scaled BMPs

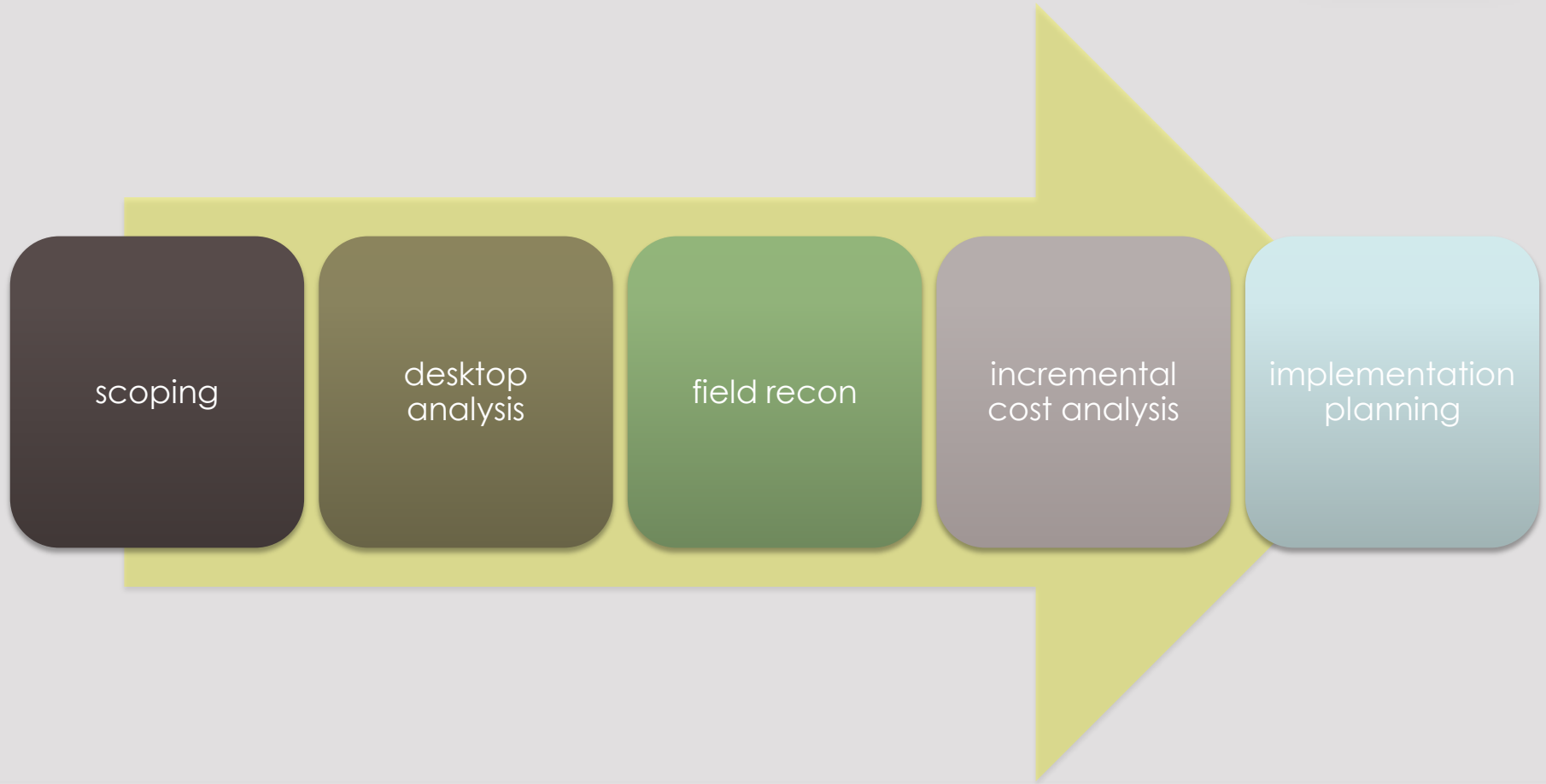


Tier 3

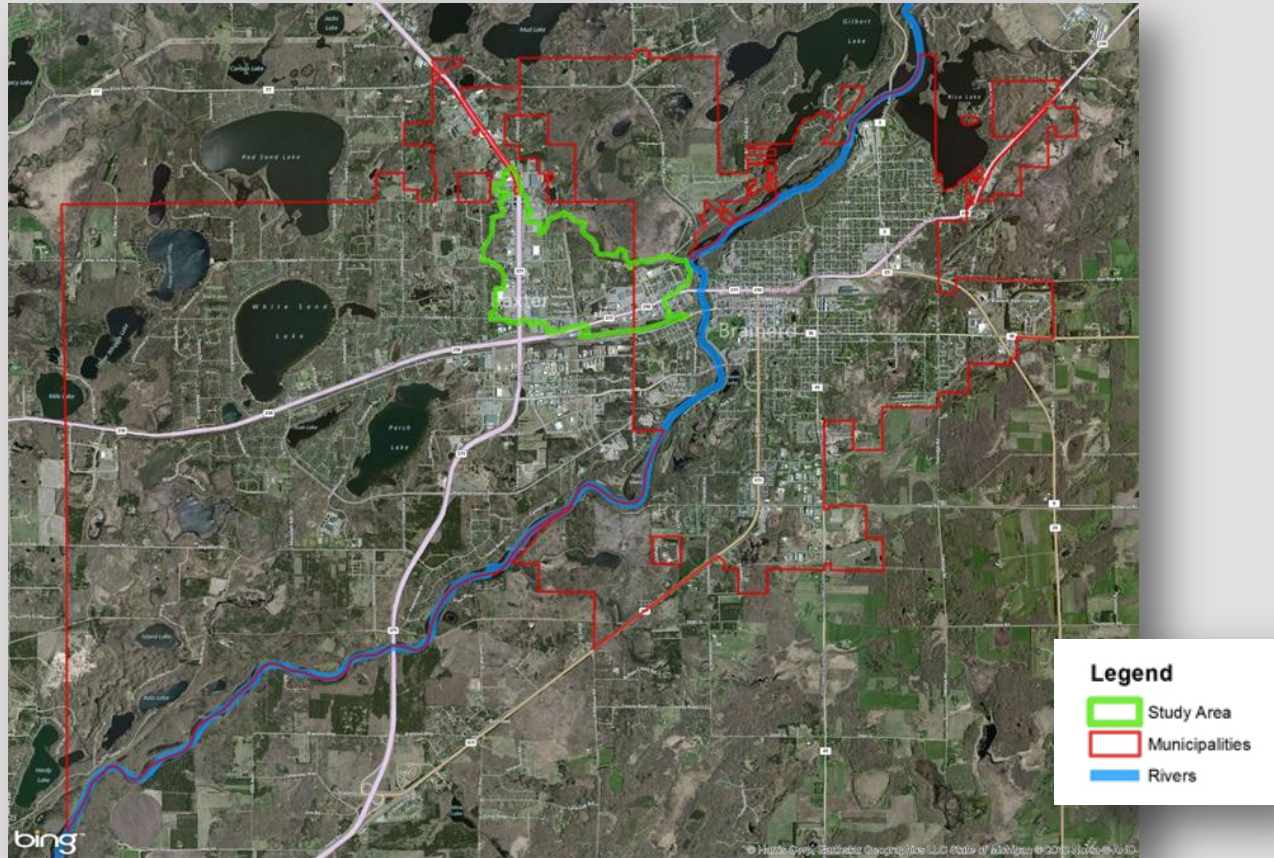
On-Site

$\frac{1}{2}$ – 20 acres

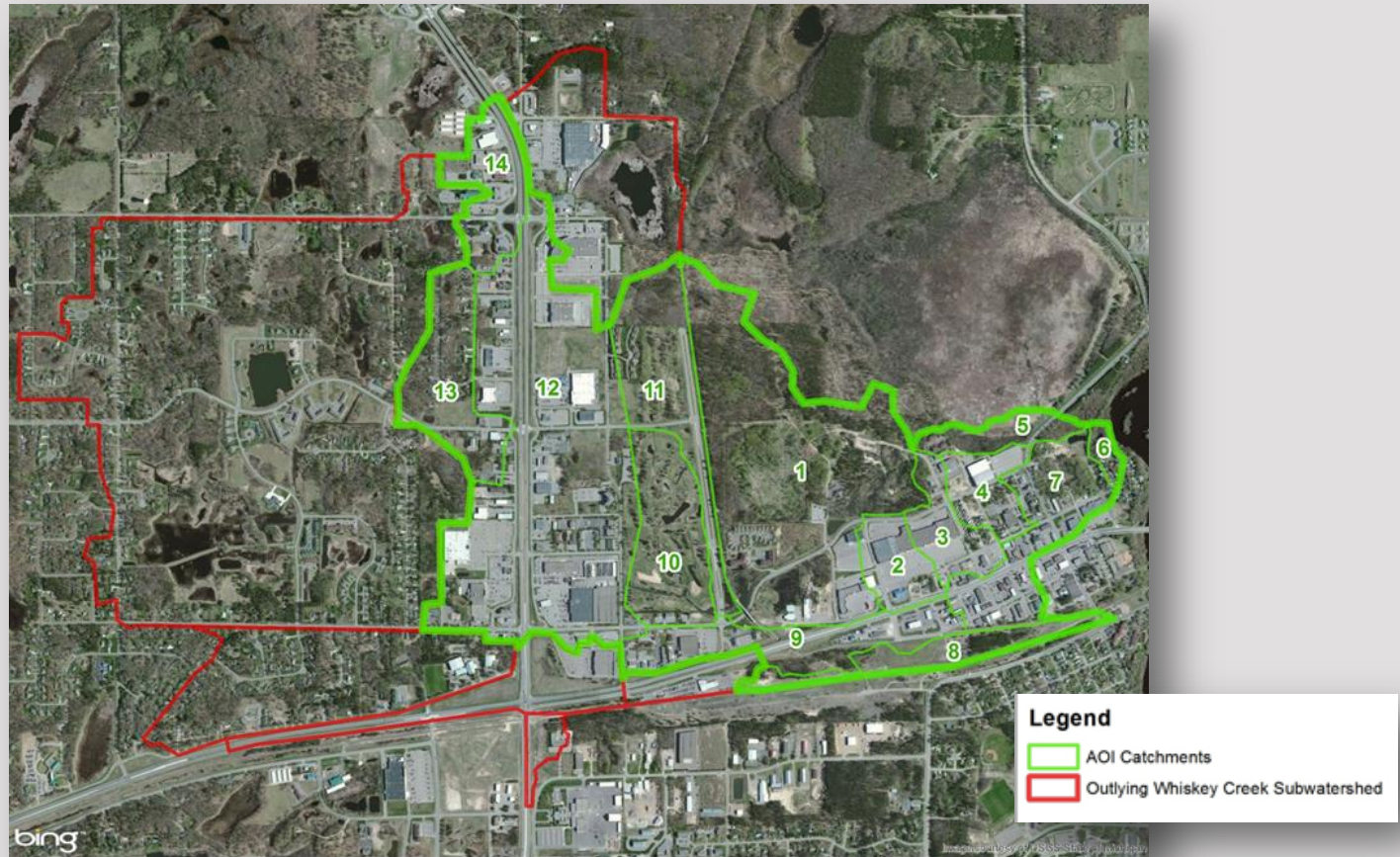
Process



Subwatershed Selection



Catchment Selection



scoping

desktop analysis

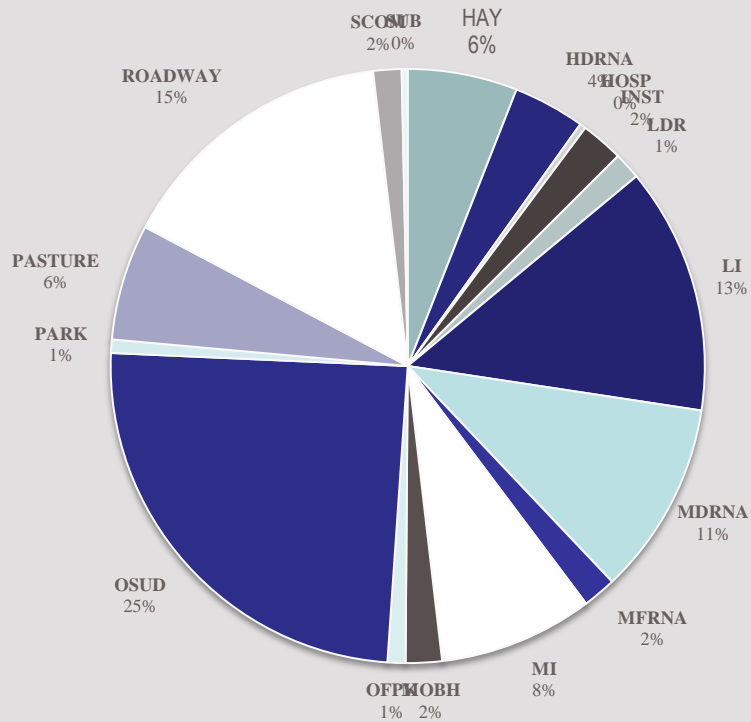
field recon

ICA

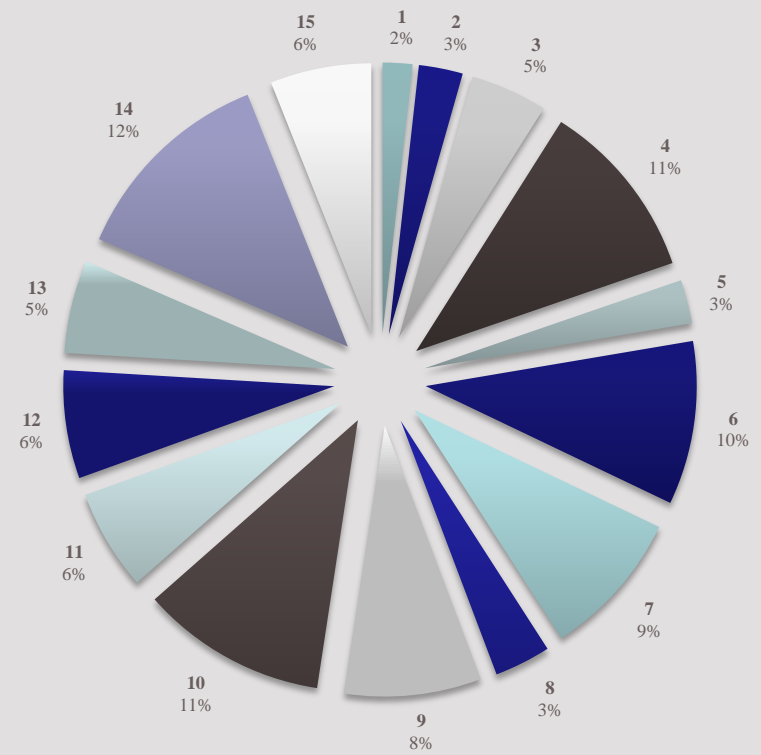
plan



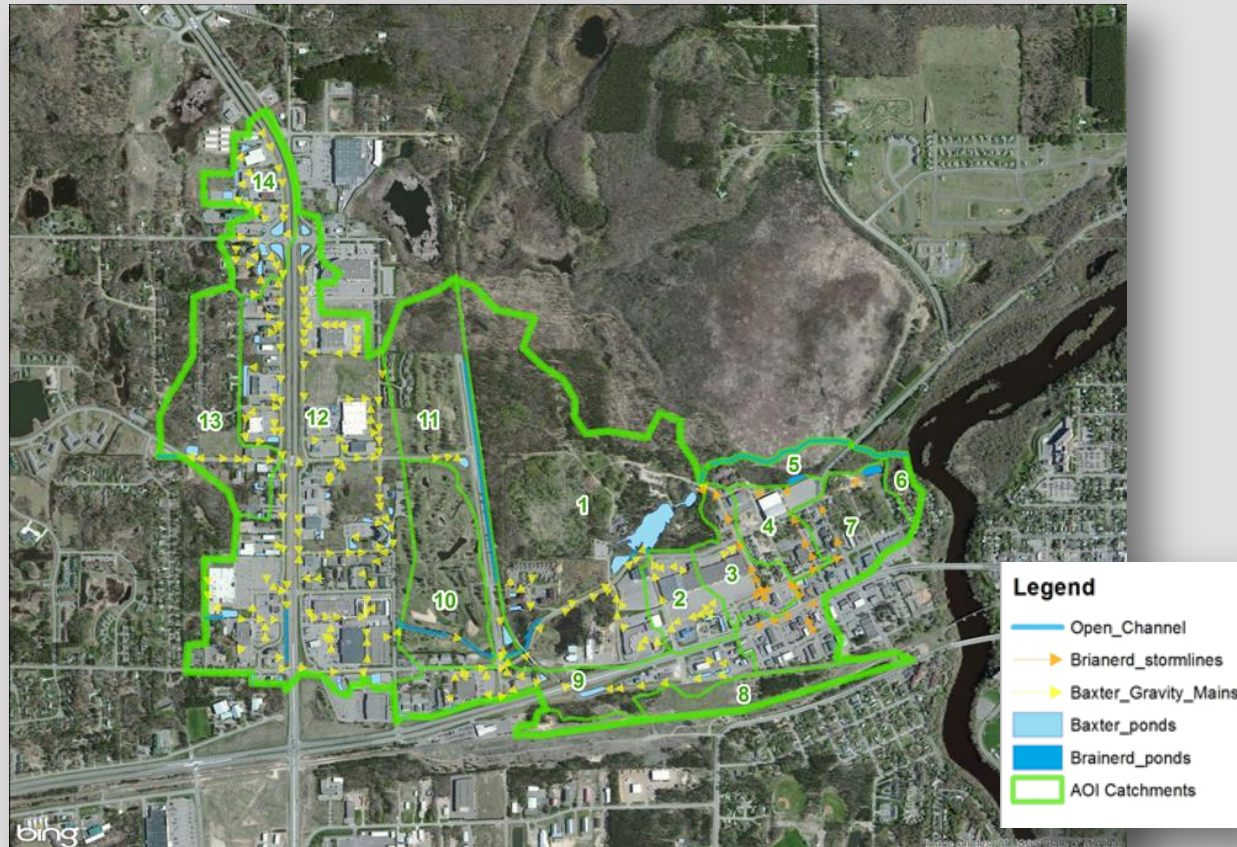
RELATIVE PERCENT ANNUAL LOAD BY LAND USE



RELATIVE PERCENT OF WATERSHED LOAD BY CATCHMENT



Stormwater Routing



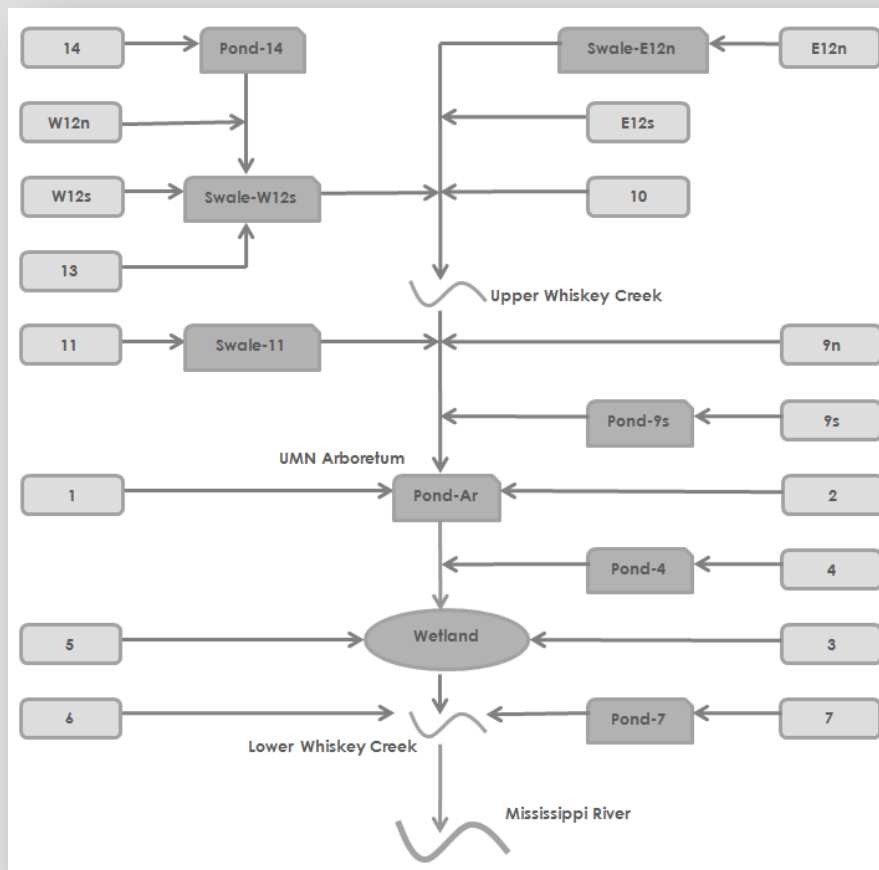
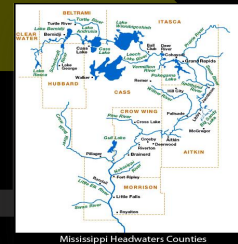
scoping

desktop analysis

field recon

ICA

plan





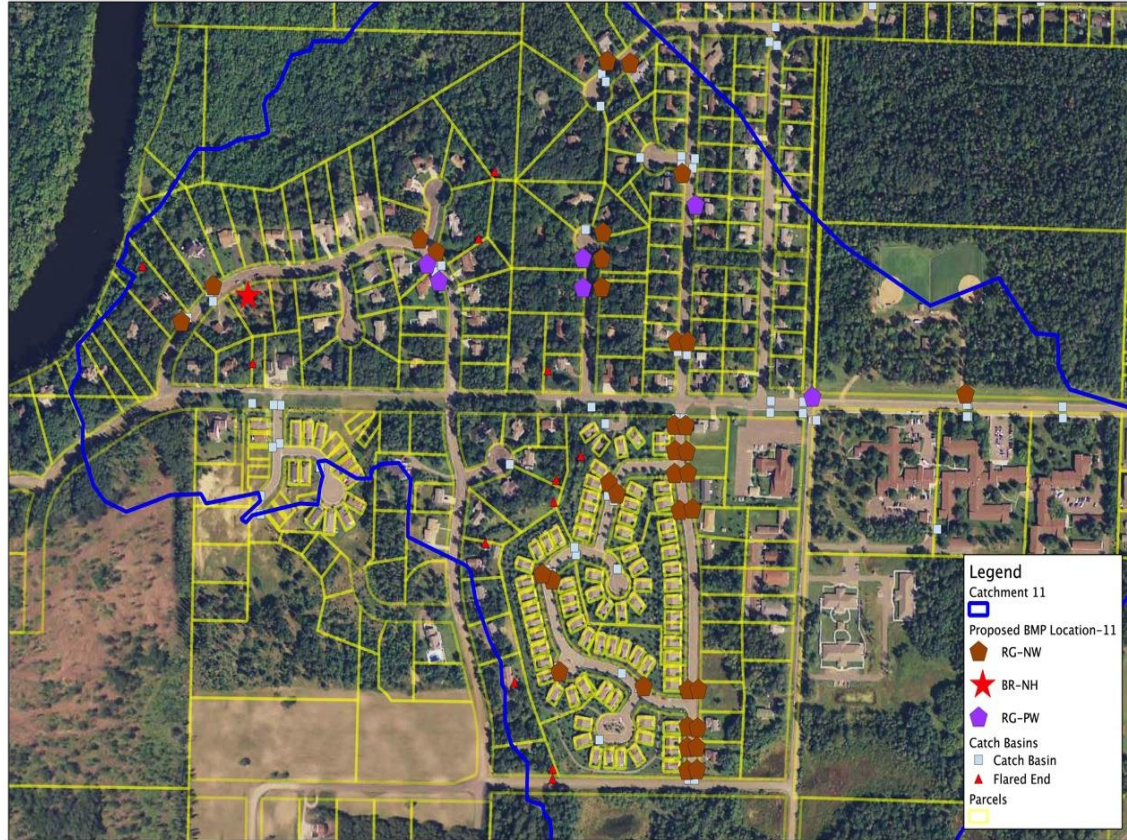
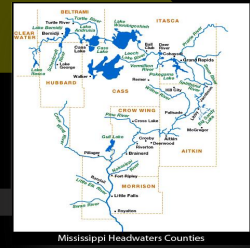
scoping

desktop analysis

field recon

ICA

plan



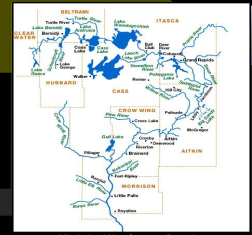
scoping

desktop analysis

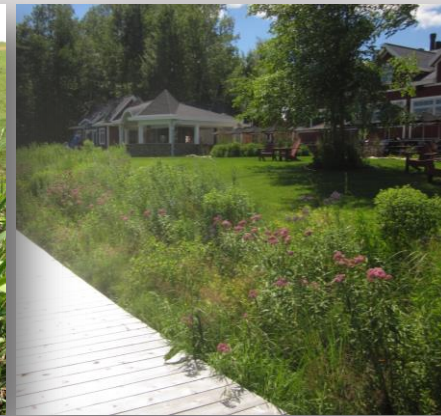
field recon

ICA

plan



Mississippi Headwaters Counties



scoping

desktop analysis

field recon

ICA

plan



Biofiltration Control Device

Land Use: Residential

Biofilter Number 1

Device Properties

Top Area (sf)	250
Bottom Area (sf)	100
Total Depth (ft)	4.00
Typical Width (ft) (Cost est. only)	10.00
Native Soil Infiltration Rate (in/hr)	0.2
Native Soil Infiltration Rate COV	N/A
Infil. Rate Fraction-Bottom (0-1)	1.00
Infil. Rate Fraction-Sides (0-1)	1.00
Rock Filled Depth (ft)	
Rock Fill Porosity (0-1)	
Engineered Soil Type	Compost-Sand
Engineered Soil Infiltration Rate (in/hr)	2.10
Engineered Soil Depth (ft)	2.5
Engineered Soil Porosity (0-1)	0.30
Percent solids reduction due to Engineered Soil (0-100)	N/A
Inflow Hydrograph Peak to Average Flow Ratio	3.80
Number of Devices in Source Area or Land Use	10

Add Outlet/ Discharge

Outlet/Discharge Options

- ☐ 1. Sharp Crested Weir
☐ 2. Broad Crested Weir
☐ 3. Vertical Stand Pipe
☐ 4. Evaporation
☐ 5. Rain Barrel/Cistern
☐ 6. Underdrain Outlet

Edit Existing Outlet

Selected Outlets

- 1 - Broad Crested Weir
 2 - Underdrain Outlet

Change Geometry

Copy Biofilter Data

Paste Biofilter Data

Select Native Soil Infiltration Rate

- ☐ Sand - 8 in/hr
☐ Loamy sand - 2.5 in/hr
☐ Sandy loam - 1.0 in/hr
☐ Loam - 0.5 in/hr
☐ Silt loam - 0.3 in/hr
☒ Sandy silt loam - 0.2 in/hr
☐ Clay loam - 0.1 in/hr
☐ Silty clay loam - 0.05 in/hr
☐ Sandy clay - 0.05 in/hr
☐ Silty clay - 0.04 in/hr
☐ Clay - 0.02 in/hr
☐ Rain Barrel/Cistern - 0.00 in/hr

Route Through Wet Detention Pond First

☐ Use Random Number Generation to Account for Infiltration Rate Uncertainty

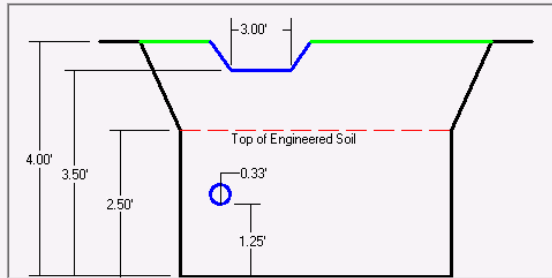
Select Particle Size File

Source Areas from Land Use that Contribute Runoff to Biofiltration Control Device(s)

- ☒ Rooftop 1
☒ Rooftop 2
☐ Rooftop 3
☐ Rooftop 4
☐ Rooftop 5
☒ Paved Parking/Storage 1
☐ Paved Parking/Storage 2
☐ Paved Parking/Storage 3
☐ Unpaved Pkng/Storage 1
☐ Unpaved Pkng/Storage 2
☐ Playground 1
☐ Playground 2
☒ Driveways 1
☒ Driveways 2
☐ Driveways 3
☒ Sidewalks/Walks 1
☒ Sidewalks/Walks 2
☒ Street Area 1
☒ Street Area 2
☒ Street Area 3
☐ Paved Land and Shoulder 1
☐ Paved Land and Shoulder 2
☐ Paved Land and Shoulder 3
☐ Paved Land and Shoulder 4
☐ Paved Land and Shoulder 5
☒ Large Landscaped Area 1
☐ Large Landscaped Area 2
☒ Undeveloped Area
☒ Small Landscaped Area 1
☐ Small Landscaped Area 2
☐ Small Landscaped Area 3
☒ Other Pervious Area
☐ Other Dir Cnctd Imp Area
☐ Other Part Cnctd Imp Area
☐ Large Turf Areas
☐ Undeveloped Areas
☐ Other Pervious Areas
☐ Other Directly Cnctd Imp
☐ Other Partially Cnctd Imp

1 Fraction of Runoff From Selected Source Areas Routed to Land Use Biofilters (0 - 1)

Biofilter Geometry Schematic

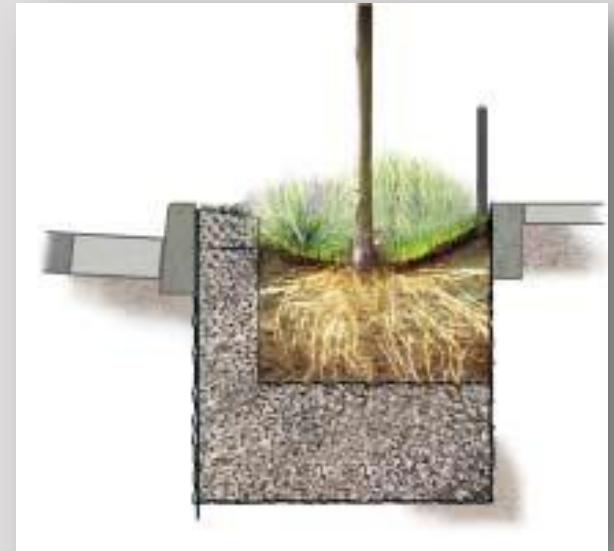


Refresh Schematic

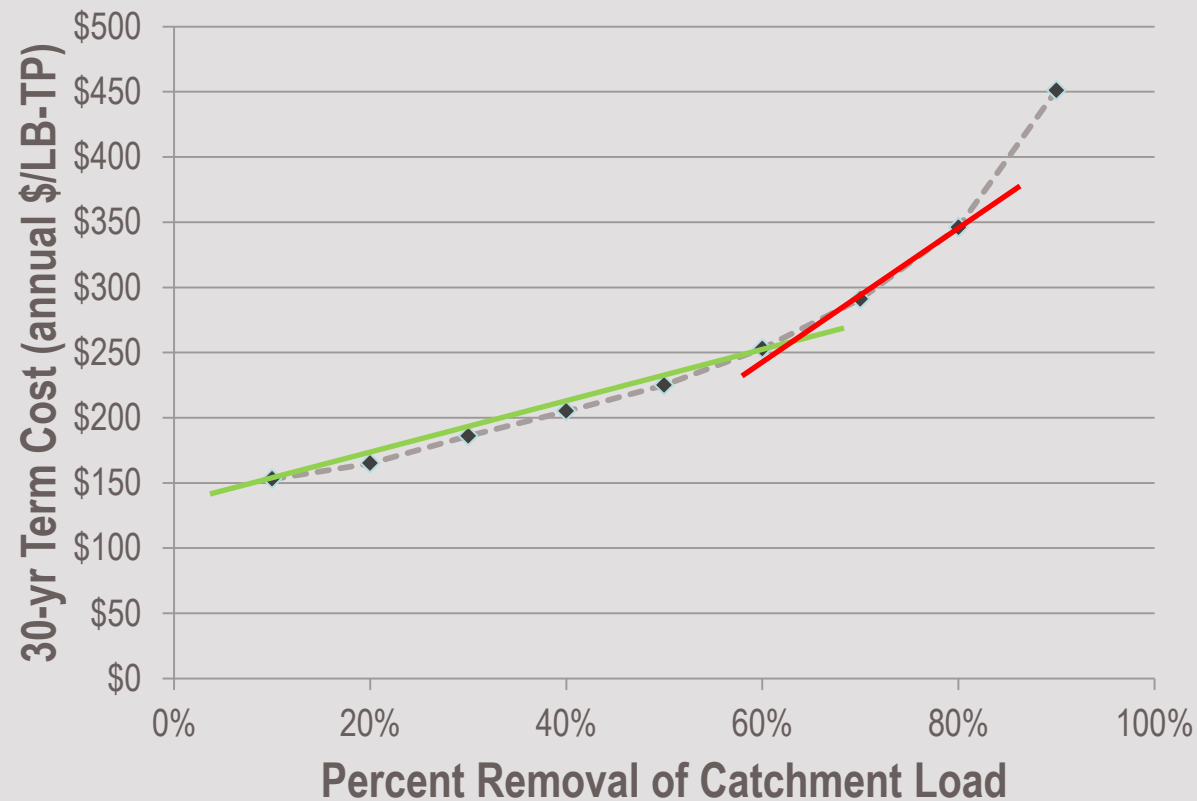
Delete

Cancel

Continue



Scaled Treatment Value

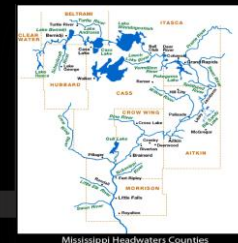


Scaled Treatment Value



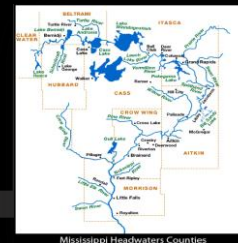
		Base Loading	Exist. Treat.	Net Treat. %	Existing Load	NEW TREATMENT					
						OPT-A		OPT-B		OPT-C	
						New treat.	Net %	New treat.	Net %	New treat.	Net %
TREATMENT	TP (lb/yr)	565.8	0	0	565,8	146.9	26%	160.0	28%	167.1	30%
	TSS (lb/yr)	151,435	0	0	151,435	84,206	56%	86,329	57%	87,454	58%
	Number of BMP's					1		1		1	
	BMP Size					670,000	Cu ft	670,000	Cu ft	670,000	Cu ft
	BMP Type					Stormwater Wetland		Stormwater Wetland w/ IESF (1000 ft ²)		Stormwater Wetland w/ IESF (2000 ft ²)	
COST		Materials/Labor/Design				\$250,000		\$265,000		\$280,000	
		Promotion & Admin Costs				0		0		0	
		Probable Project Cost				\$250,000		\$265,000		\$280,000	
		Annual O&M				\$250		\$350		\$450	
		30-yr Cost/lb-TP				\$58		\$57		\$58	
		30-yr Cost/1,000lb-TSS				\$102		\$106		\$112	

Value-ranked Strategies



CATCHMENT	30-yr, Annual Value	Annual TP- Captured (lbs)	Estimated Cost
7-IESF, 60%	\$43	12.9	\$13,800
7-IESF, 50%	\$46	6.5	\$6,000
7-IESF, 70%	\$47	20.6	\$26,160
WC Pond, 30%	\$58	167.1	\$280,000
3-Porous Asphalt, 30%	\$207	11.9	\$51,000
2-Porous Asphalt, 30%	\$207	13.0	\$55,830
2-Porous Asphalt, 50%	\$217	21.6	\$96,830
3-Porous Asphalt, 40%	\$228	15.9	\$75,140
2-Porous Asphalt, 40%	\$229	17.3	\$81,850
3-Porous Asphalt, 50%	\$251	19.9	\$103,160
3-Bioretenction, 30%	\$435	11.9	\$84,200
3-Bioretenction, 40%	\$455	15.9	\$112,200
3-Bioretenction, 50%	\$520	19.9	\$160,000

Value-ranked Strategies



CATCHMENT:BMP Option	30-yr, Annual Value	Annual TP-Captured (lbs)	Estimated Cost
1-10: FeCl ₃ /Desilt System	\$72 - \$98	255	\$150,000 -\$200,000
14: S-Extended Detention plus Iron-enhanced Sand Filter(south)	\$204	17.1	\$96,000
14: N-Extended Detention plus Iron-enhanced Sand Filter	\$317	41.9	\$191,000
14: S+N-Extended Detention plus Iron-enhanced Sand Filter	\$342	58.3	\$286,000
14: Bioretention	\$396	12.3	\$68,000
11: Bioretention	\$406	8.6	\$40,000
12: Bioretention	\$413	8.3	\$39,000
14: Water Quality Swale	\$442	1.4	\$8,900
13: Bioretention	\$494	7.8	\$51,000
15: Bioretention	\$528	9.9	\$73,000
14: Dry Swale	\$636	2.5	\$14,000

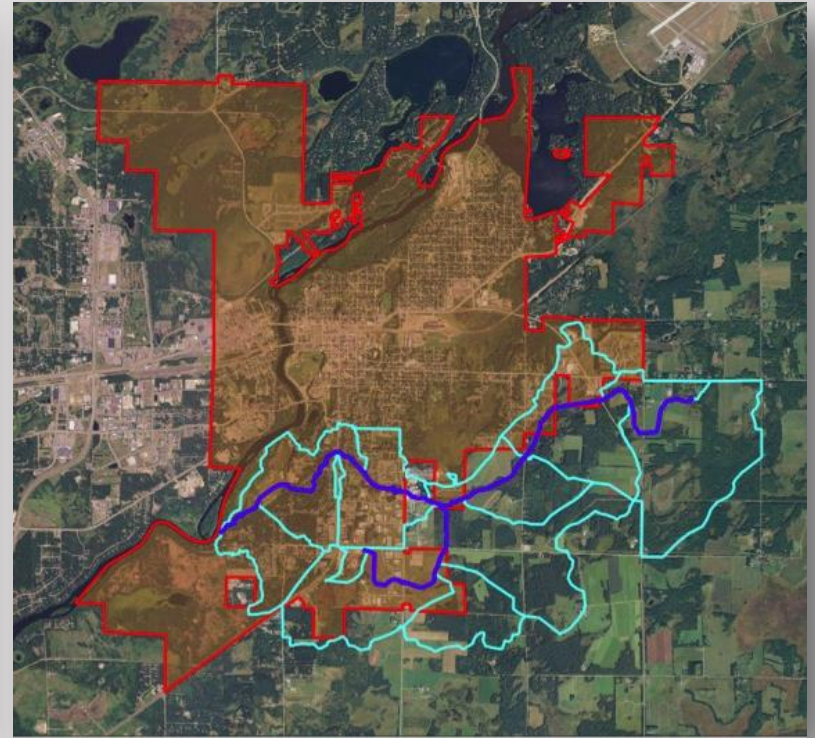
Results To-Date



Whiskey Creek



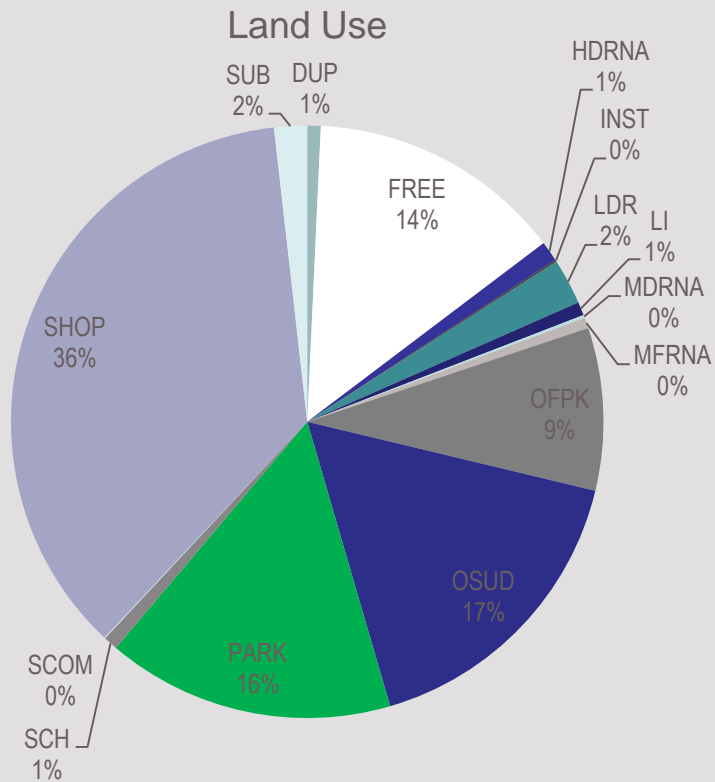
Little Buffalo Creek



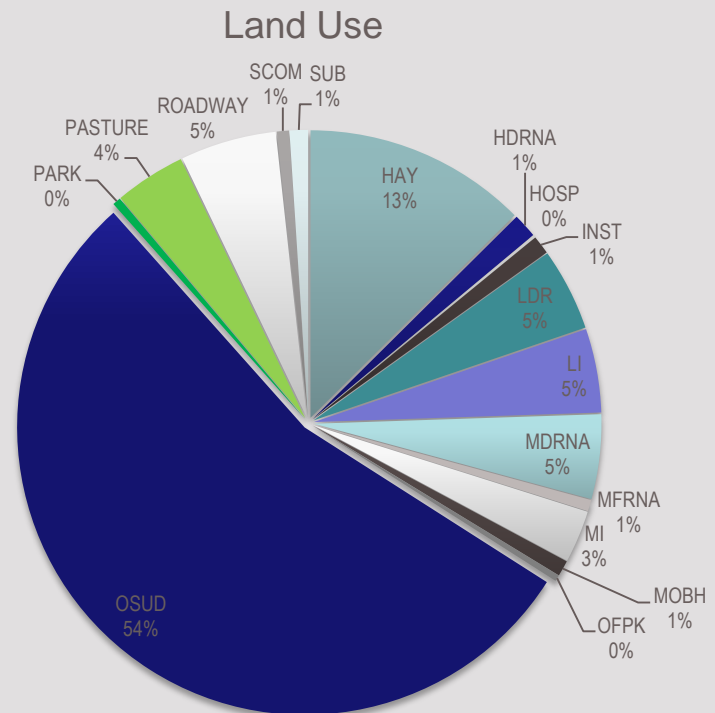
Results To-Date



Whiskey Creek



Little Buffalo Creek

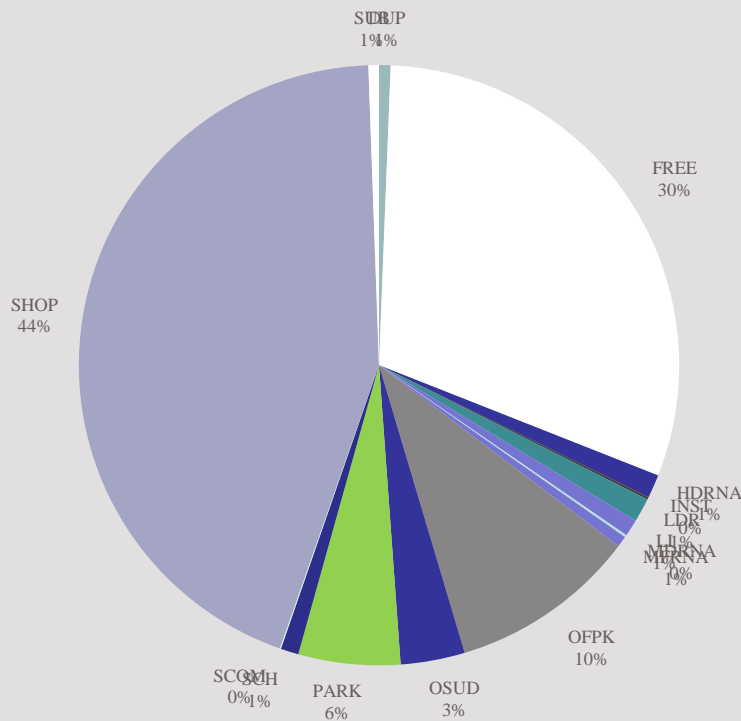


Results To-Date



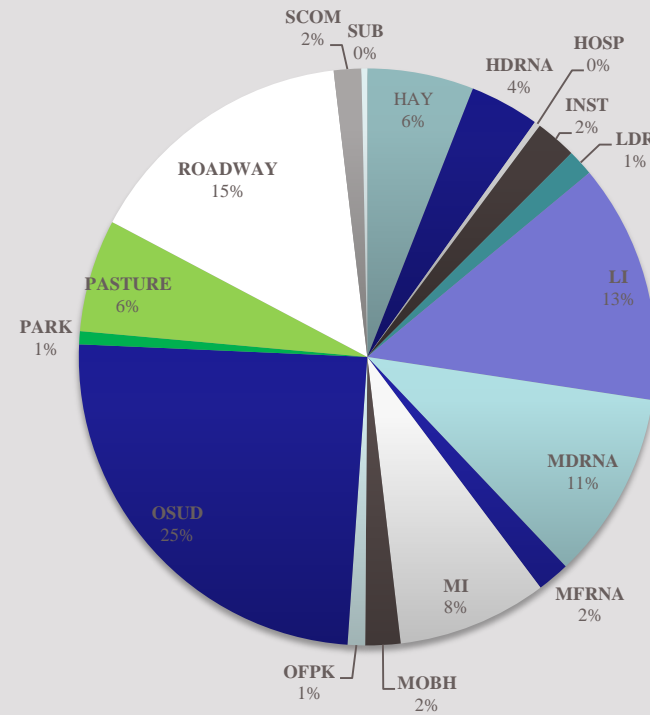
Whiskey Creek

RELATIVE PERCENT ANNUAL LOAD BY LAND USE



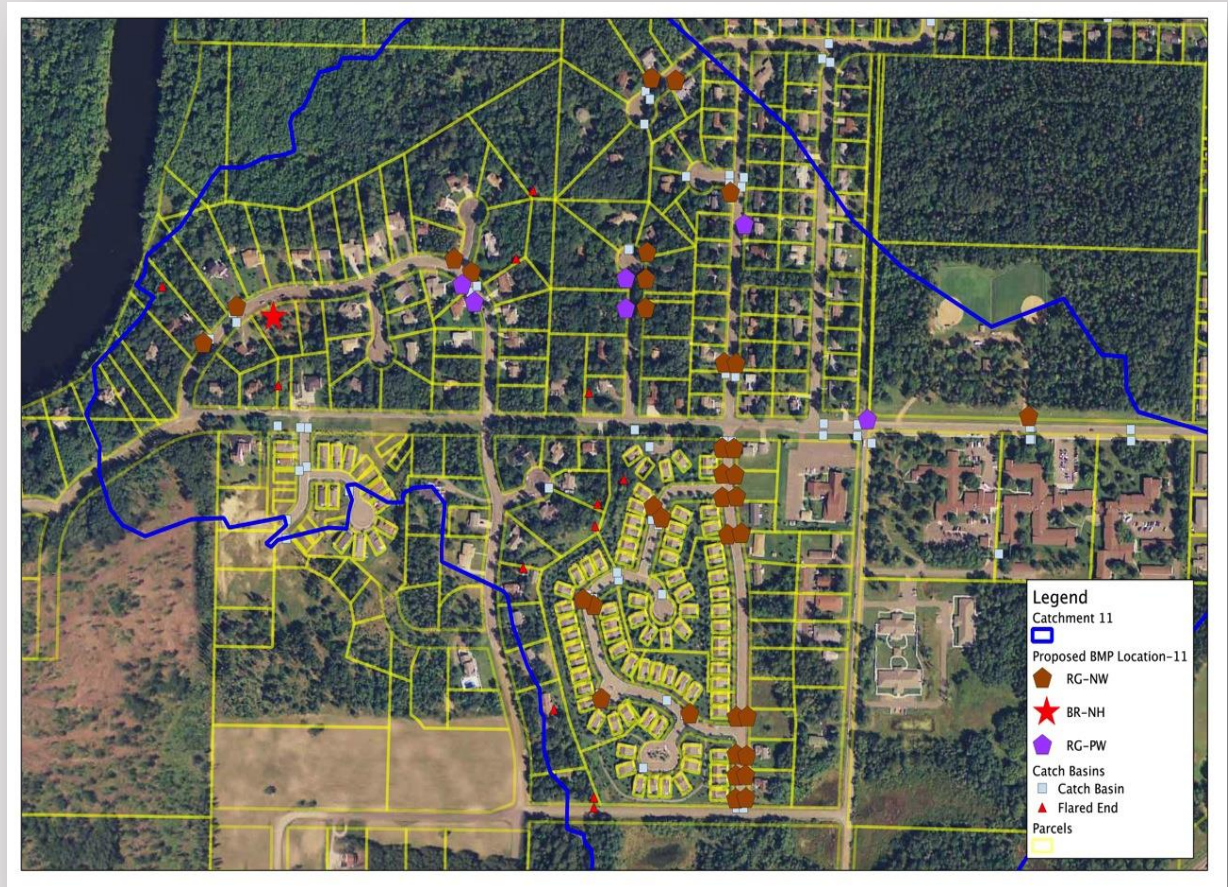
Little Buffalo Creek

RELATIVE PERCENT ANNUAL LOAD BY LAND USE

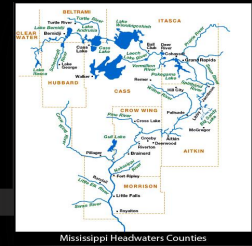


Results To-Date

Little Buffalo Creek



Results To-Date



Little Buffalo Creek



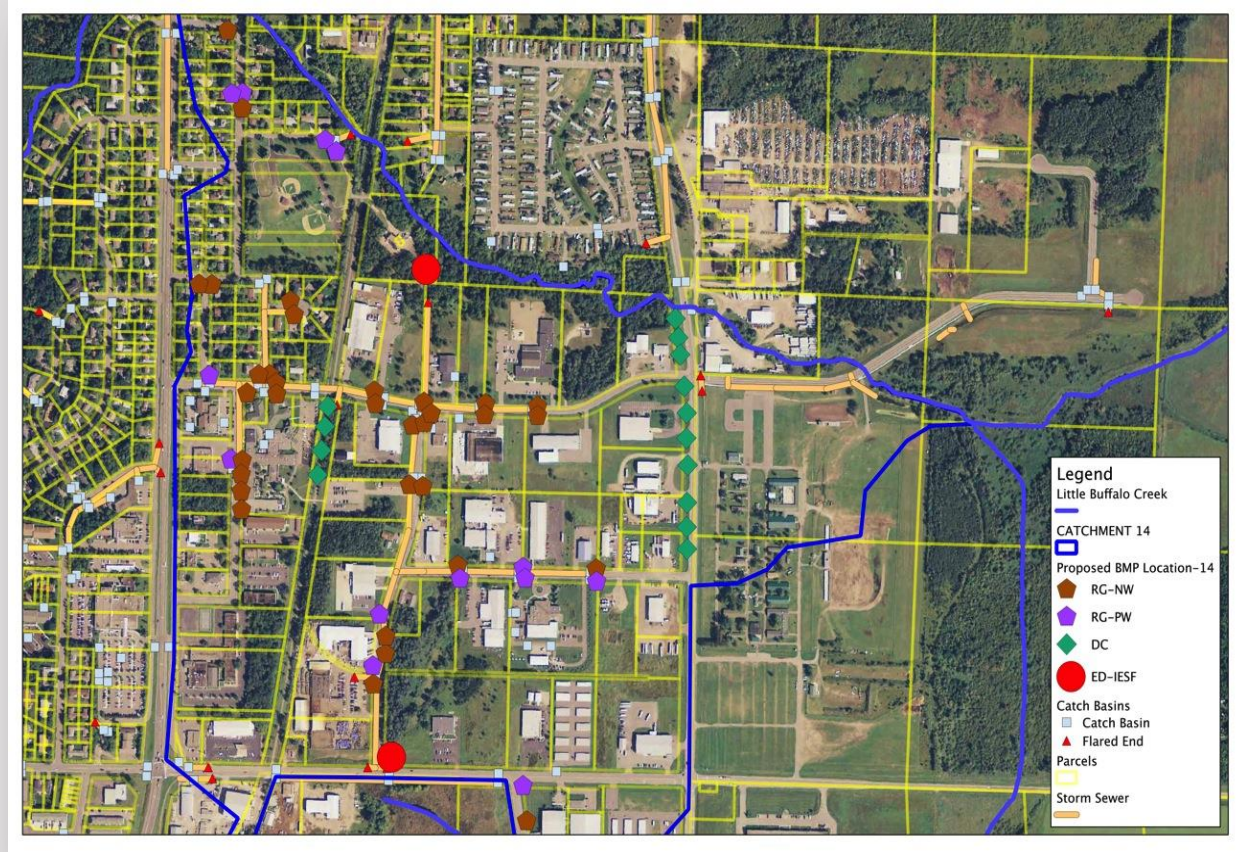
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Legend
CATCHMENT 13
 Little Buffalo Creek
 Proposed BMP Location-13
 RC-NW
 RC-PW
 Catch Basins
 Catch Basin
 Flared End
 Parcels

Results To-Date



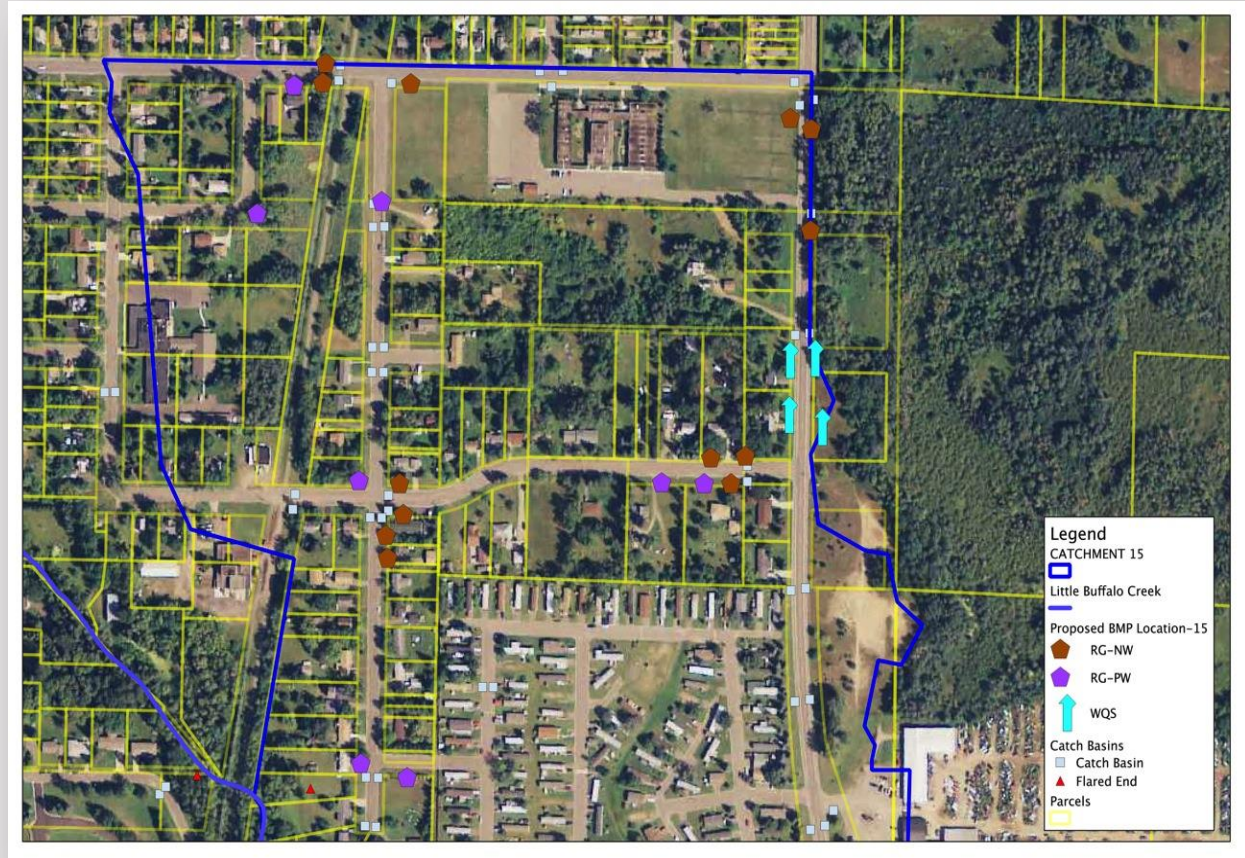
Little Buffalo Creek



Results To-Date



Little Buffalo Creek



Results To-Date



Whiskey Creek



Results To-Date



TABLE 5. EXISTING CONDITIONS CATCHMENT LOADING AND TREATMENT OF TP

Contributing Catchment	Total TP-Load (lbs/yr)	Sample Point/BMP	1st Receiving Water Body	Treatment of Upstream Load ^a	
				Total TP-Trapped (lbs/yr)	Load Reduction (%)
Entire AOI	823.5	Lower Whiskey Creek	Mississippi River	207.1	22
1, 2, 3, 4, 5, 9n, 9s, 10, 11 E12n, E12s, W12n, W12s, 13, 14	778.6	Wetland	Lower Whiskey Creek	0.0	0
1, 2, 9n, 9s, 10, 11 E12n, E12s, W12n, W12s, 13, 14	787.4	Arboretum Ponds	Wetland	79.3	10
E12n, E12s, W12n, W12s, 13, 14	565.8	Upper Whiskey Creek	Arboretum Ponds	0.0	0
1	89.9	Arboretum Ponds	Wetland	0.0	0
2	43.2	Arboretum Ponds	Wetland	0.0	0
3	39.8	No BMP	Wetland	0.0	0
4	41.7	Pond-4	Wetland	15.2	37
5	4.3	No BMP	Wetland	0.0	0
6	2.6	No BMP	Lower Whiskey Creek	0.0	0
7	73.8	Pond-7	Lower Whiskey Creek	31.5	43
10	64.6	No BMP	Upper Whiskey Creek	0.0	0
11	40.3	Swale-11	Arboretum Ponds	15.7	39
9n	31.9	Arboretum Ponds	Wetland	0.0	0
9s	51.8	Pond-9s	Arboretum Ponds	19.7	38
E12n	67.5	Swale-E12n	Upper Whiskey Creek	20.3	30
E12s	229.5	No BMP	Upper Whiskey Creek	0.0	0
W12n	54.0	Swale-W12s	Upper Whiskey Creek		
W12s	99.0	Swale-W12s	Upper Whiskey Creek	12.9	5
13	52.6	Swale-W12s	Upper Whiskey Creek		
14	64.6	Pond-14	Upper Whiskey Creek	32.8	51

Results To-Date



Whiskey Creek

CATCHMENT	30-yr, Annual Value	Annual TP-Captured (lbs)	Annual TSS-Captured (lbs)	Estimated Cost
7-IESF, 60%	\$43	12.9	1,952	\$13,800
7-IESF, 50%	\$46	6.5	971	\$6,000
7-IESF, 70%	\$47	20.6	3,175	\$26,160
WC Pond, 30%	\$58	167.1	87,454	\$280,000
3-Porous Asphalt, 30%	\$207	11.9	6,767	\$51,000
2-Porous Asphalt, 30%	\$207	13.0	7,360	\$55,830
2-Porous Asphalt, 50%	\$217	21.6	9,663	\$96,830
3-Porous Asphalt, 40%	\$228	15.9	7,887	\$75,140
2-Porous Asphalt, 40%	\$229	17.3	8,574	\$81,850
3-Porous Asphalt, 50%	\$251	19.9	8,889	\$103,160
3-Bioretention, 30%	\$435	11.9	6,743	\$84,200
3-Bioretention, 40%	\$455	15.9	7,872	\$112,200
3-Bioretention, 50%	\$520	19.9	8,883	\$160,000

Little Buffalo Creek

CATCHMENT:BMP Option	30-yr, Annual Value	Annual TP-Captured (lbs)	Estimated Cost
1-10: FeCl ₃ /Desilt System	\$72 - \$98	255	\$150,000 - \$200,000
14: S-Extended Detention plus Iron-enhanced Sand Filter(south)	\$204	17.1	\$96,000
14: N-Extended Detention plus Iron-enhanced Sand Filter	\$317	41.9	\$191,000
14: S+N-Extended Detention plus Iron-enhanced Sand Filter	\$342	58.3	\$286,000
14: Bioretention	\$396	12.3	\$68,000
11: Bioretention	\$406	8.6	\$40,000
12: Bioretention	\$413	8.3	\$39,000
14: Water Quality Swale	\$442	1.4	\$8,900
13: Bioretention	\$494	7.8	\$51,000
15: Bioretention	\$528	9.9	\$73,000
14: Dry Swale	\$636	2.5	\$14,000

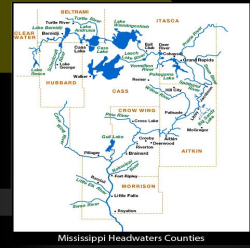
scoping

desktop analysis

field recon

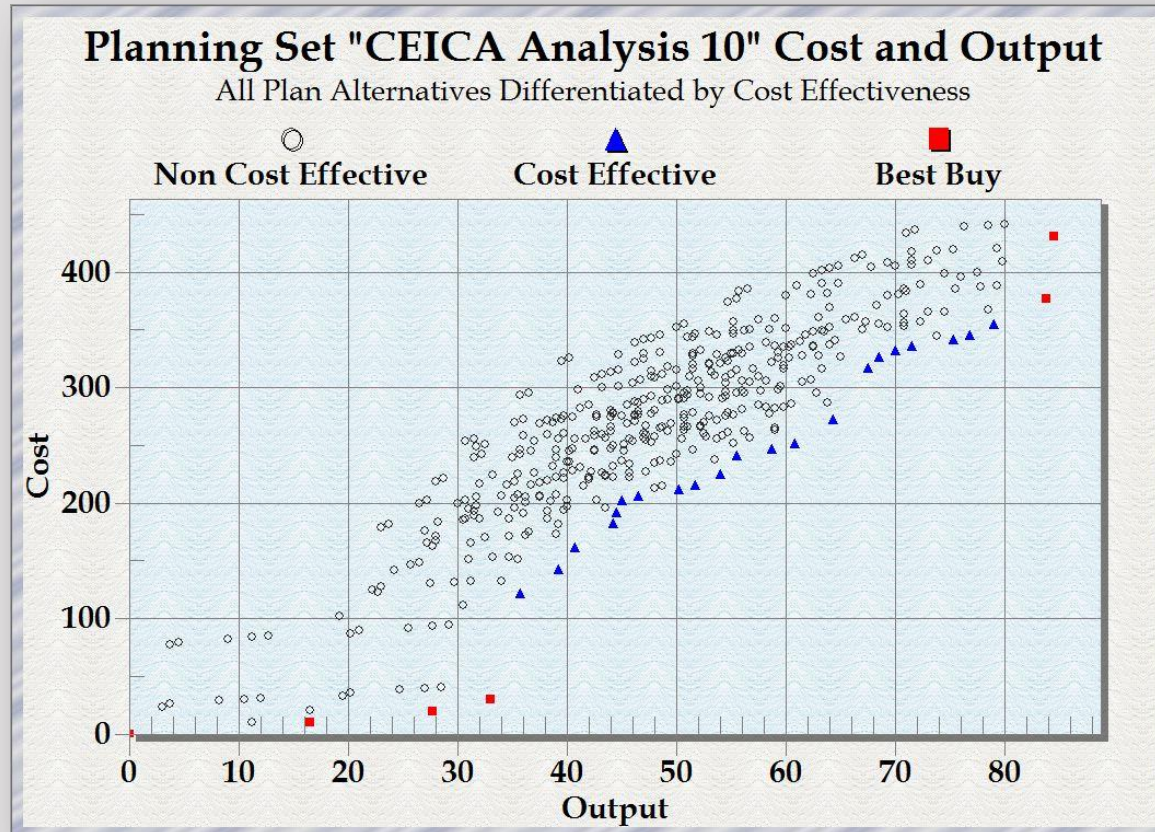
ICA

plan

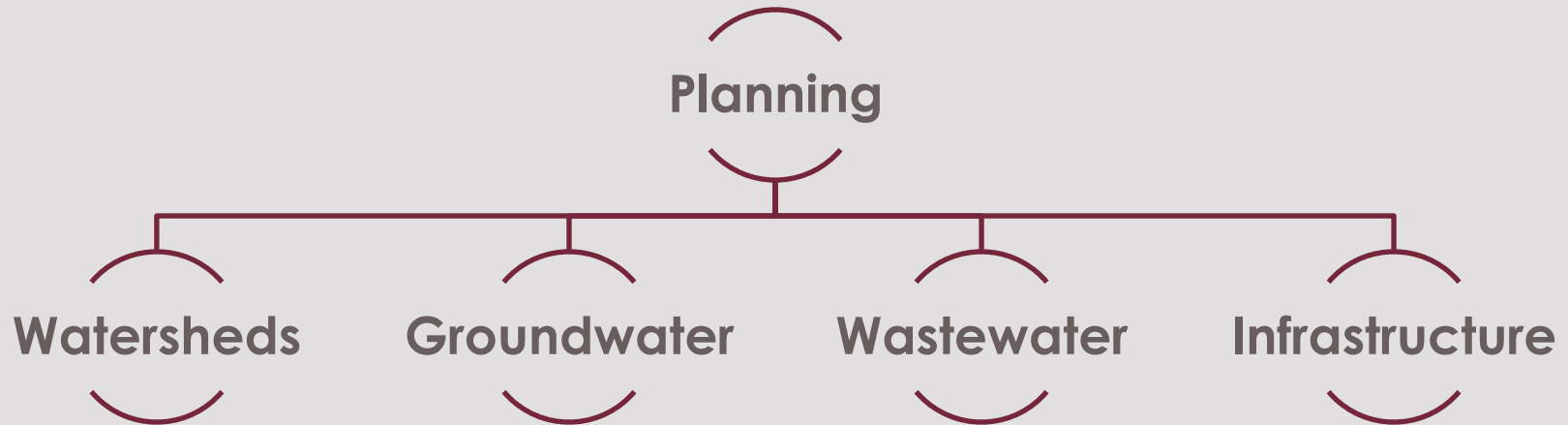


Solution	Scale
Extended Wet Detention	Single Cell
	Double Cell
	Double Cell with IESF
Bioretention	Neighborhood Treatment – 30%
	Neighborhood Treatment – 50%
	Neighborhood Treatment – 70%
	Street CC – 20% TP
	Street CC – 30% TP
	Street CC – 40% TP
WQ Swales	Street – 30% TP
	Street – 50% TP

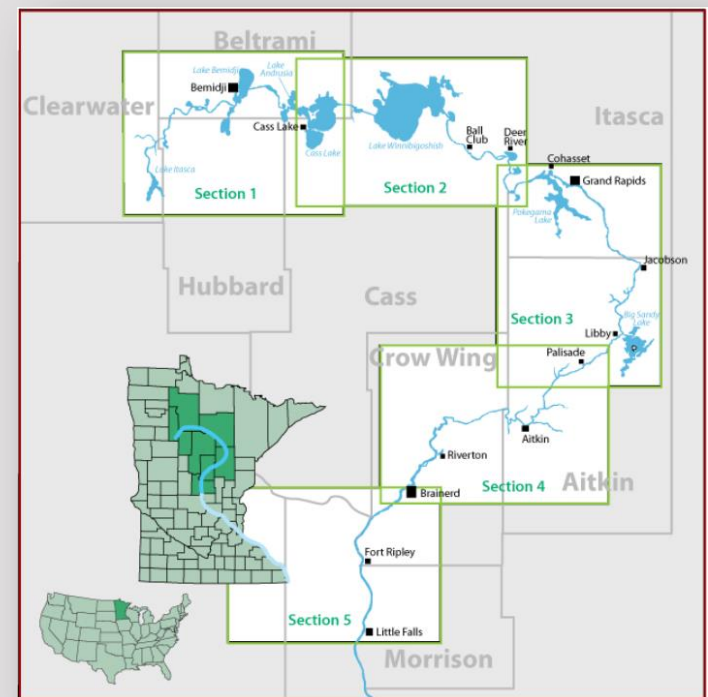
Variables	Units
TP	lbs/yr
TN	lbs/yr
TSS	tons/yr
Volume	ac-ft/yr



Typical Planning Process



Integrated Planning



Sustainable Return on Investment



- Measures “triple bottom line” of projects – Environmental, Economic & Social impacts
- Helps communicate full value of an investment
- Helps avoid unintended consequences
- Helps stakeholders understand and endorse project



[illegible]

A collage of four photographs. The top-left photo shows a pond with many green lily pads and tall grass in the foreground. The top-right photo shows a wooden bridge with a metal railing over a stream, with two people standing on it. The bottom-left photo shows a metal structure with a tall pole, possibly a water pump or well, in a grassy field. The bottom-right photo shows a large, leafy tree in a park setting.