Subwatershed BMP Retrofit and Conservation Analysis

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Watershed Ecologist

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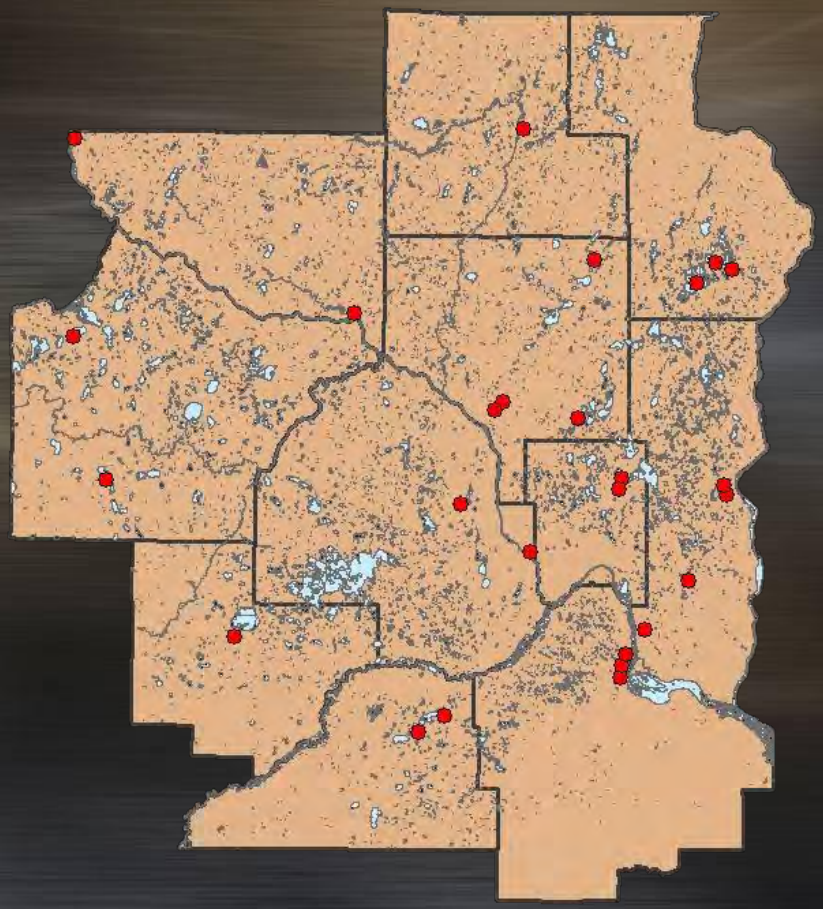
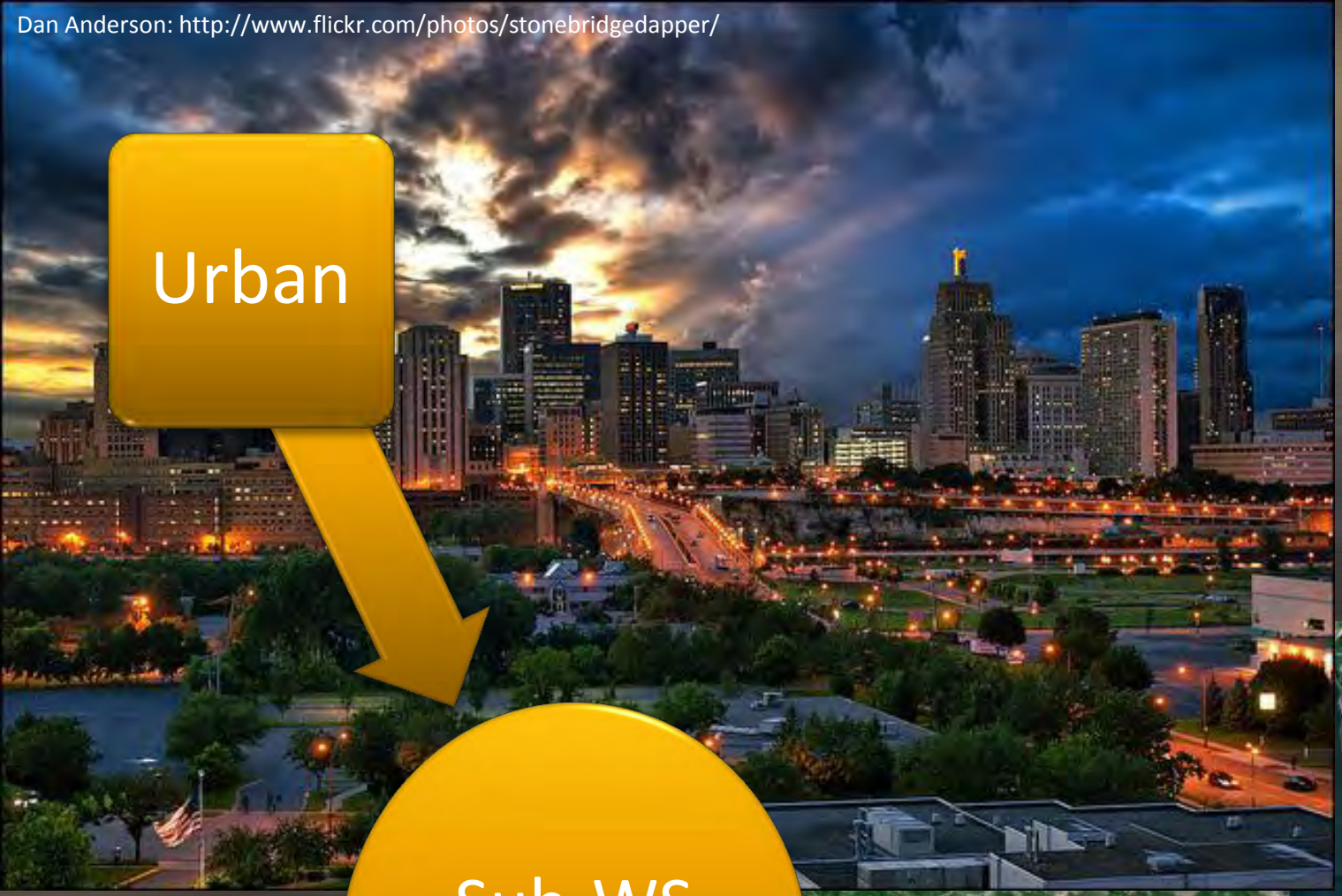
- Why an SRA?
  - Massive effort needed to affect change in WQ
  - Disproportionate (insufficient) funding resources
  - Disproportionate (insufficient) labor resources
  - A need for detailed TMDL implementation guidance
    - Site specific BMP selection and optimized design
    - Assurance of “bang-for-buck”
- Challenges
  - Little-to-no outfall and source-area field data
  - Limited time and budgets



25 SRA’s completed in 2.5 years by SWCD’s with at least 5 more currently being worked on

Dan Anderson: http://www.flickr.com/photos/stonebridgedapper/



Urban

Sub-WS Restoration

Rural & Ag

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Analysis vs. Scale

- Most watershed analyses share a Broad common goal
- The resolution of the questions drives analysis complexity, time and costs
- Each level has value
- Until recently, we had only TMDL's to rely on
- Gap between TMDL, and some implementation plans, and guidance on
  - Precise sites for BMP's (where)
  - Which BMP's (what)
  - Optimal, site-dependent designs (how)
- Where + What + How = Why = VALUE

Subwatershed Selection

Catchment Analysis and Selection

Site + BMP Analysis and Selection

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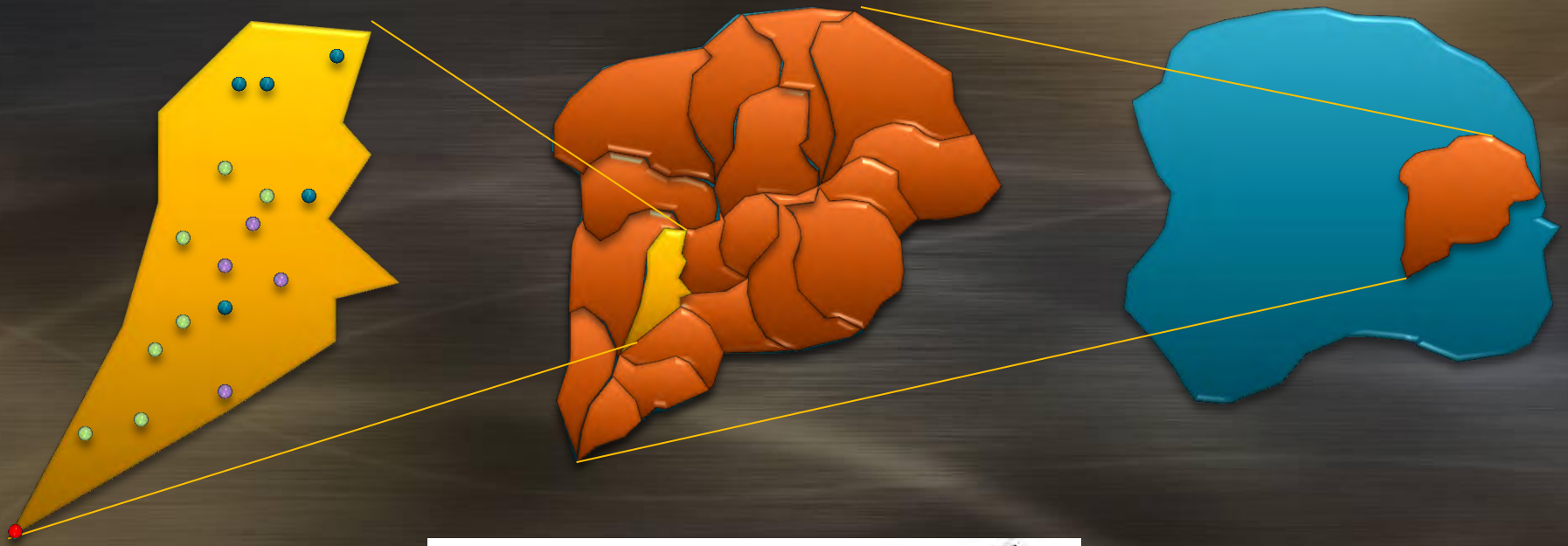

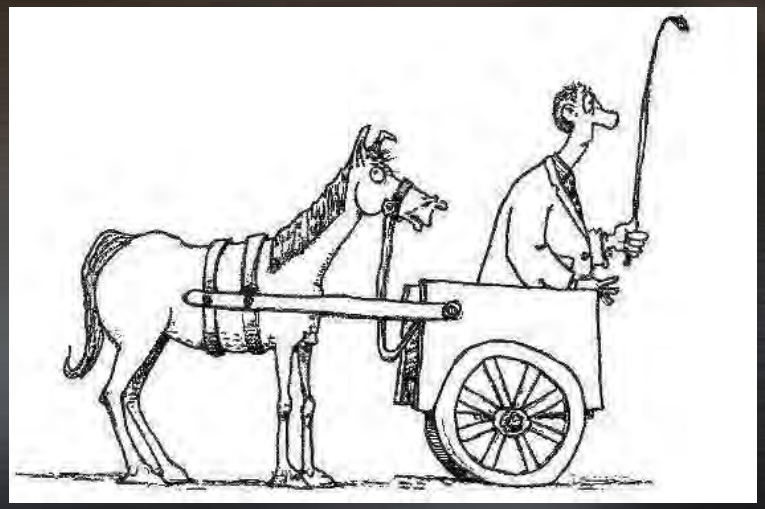

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Scaling – Urban / Rural

1-Selection of Subwatershed

2-Analysis of SW's Catchments

3-Analysis of BMP's by site

Process Overview – Urban / Rural

- Scoping and Remote Data collection
- Desktop Analysis
- Field Reconnaissance
- Treatment modeling and cost analysis
- Report

*Process based largely on the *Center for Watershed Protection* manuals

Process Overview

- Scoping
  - Water body needs
  - LGU needs
  - Existing data review (quality and needs)
  - Budgets and timeframes
  - Stakeholder consensus
- Desktop Analysis
- Field Reconnaissance
- Treatment modeling and cost analysis
- Report

Process Overview

- Scoping and Remote Data collection
- Desktop Analysis
  - Catchment and/or pipeshed delineation
  - Delineate and classify land uses
  - Delineate and classify permeable surface soils
  - Analyze existing WQ treatment / base load model
  - First-tier elimination of catchments for retrofitting
  - First-tier determination of WQ potential treatments
- Field Reconnaissance
- Treatment modeling and cost analysis
- Report

Process Overview

- Scoping and Remote Data collection
- Desktop Analysis
- Field Reconnaissance
  - Visit existing BMPs
  - Confirm/modify land-use and storm sewer data
  - Confirm/modify initial BMP-family selection
  - Selection of 1° and 2° BMP sites (parcels)
  - Site-specific data collection
- Treatment modeling and cost analysis
- Report

Process Overview

- Scoping and Remote Data collection
- Desktop Analysis
- Field Reconnaissance
- Treatment modeling and cost analysis
  - Development and optimization of BMP design
  - Iterations of “train” and/or level of treatment by BMP quantity – load reduction estimates
  - Estimates of installation and life-cycle costs
  - Life-Cycle Cost analysis
- Report

Process Overview

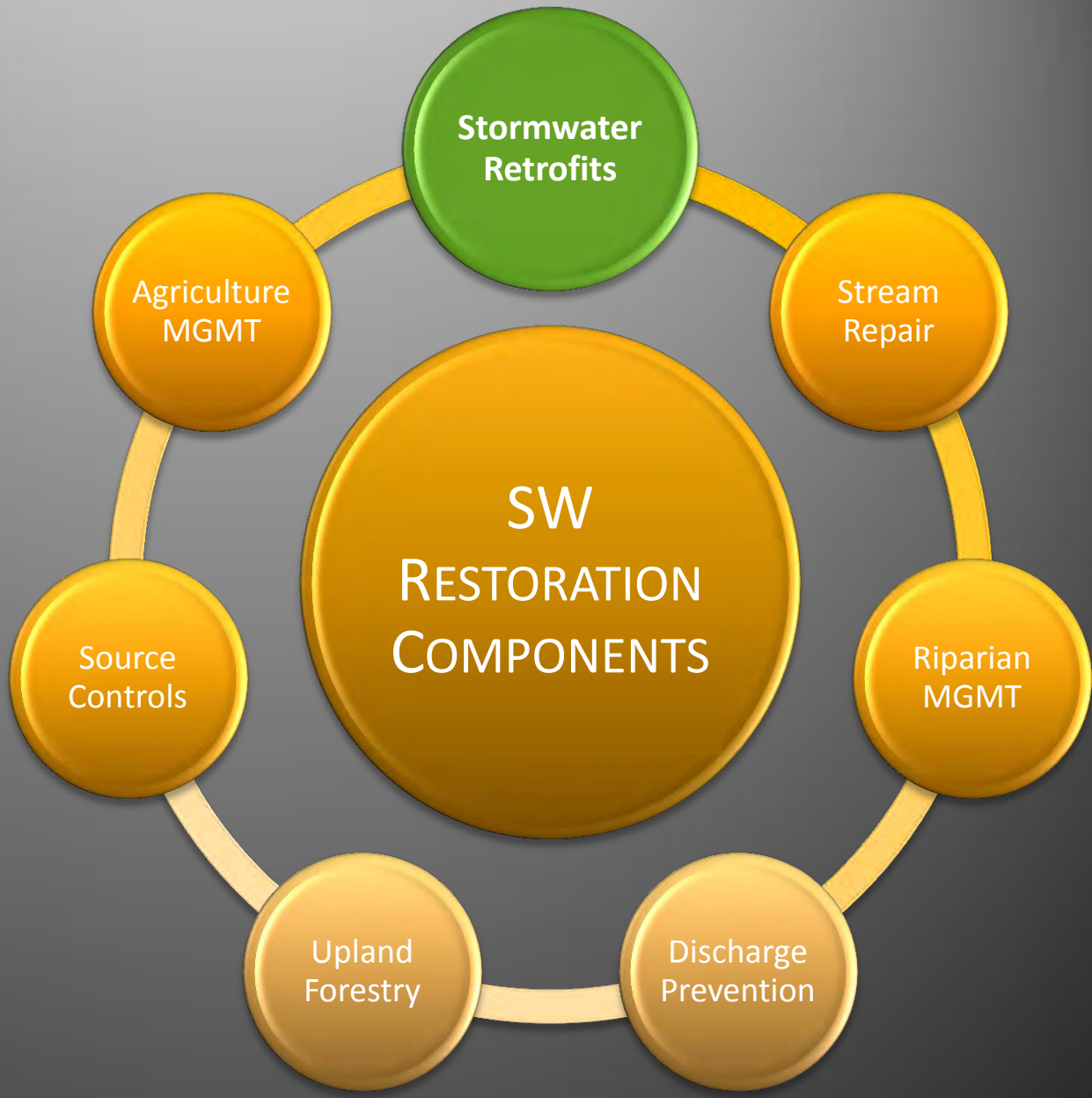
- Scoping and Remote Data collection
- Desktop Analysis
- Field Reconnaissance
- Treatment modeling and cost analysis
- Report
  - Summary table – catchments ranked based on performance ($/lb/LCyr)
  - Catchment profiles
  - Analysis methods and data
  - References

Example of Process

Urban Stormwater

BMP Retrofit

Analysis



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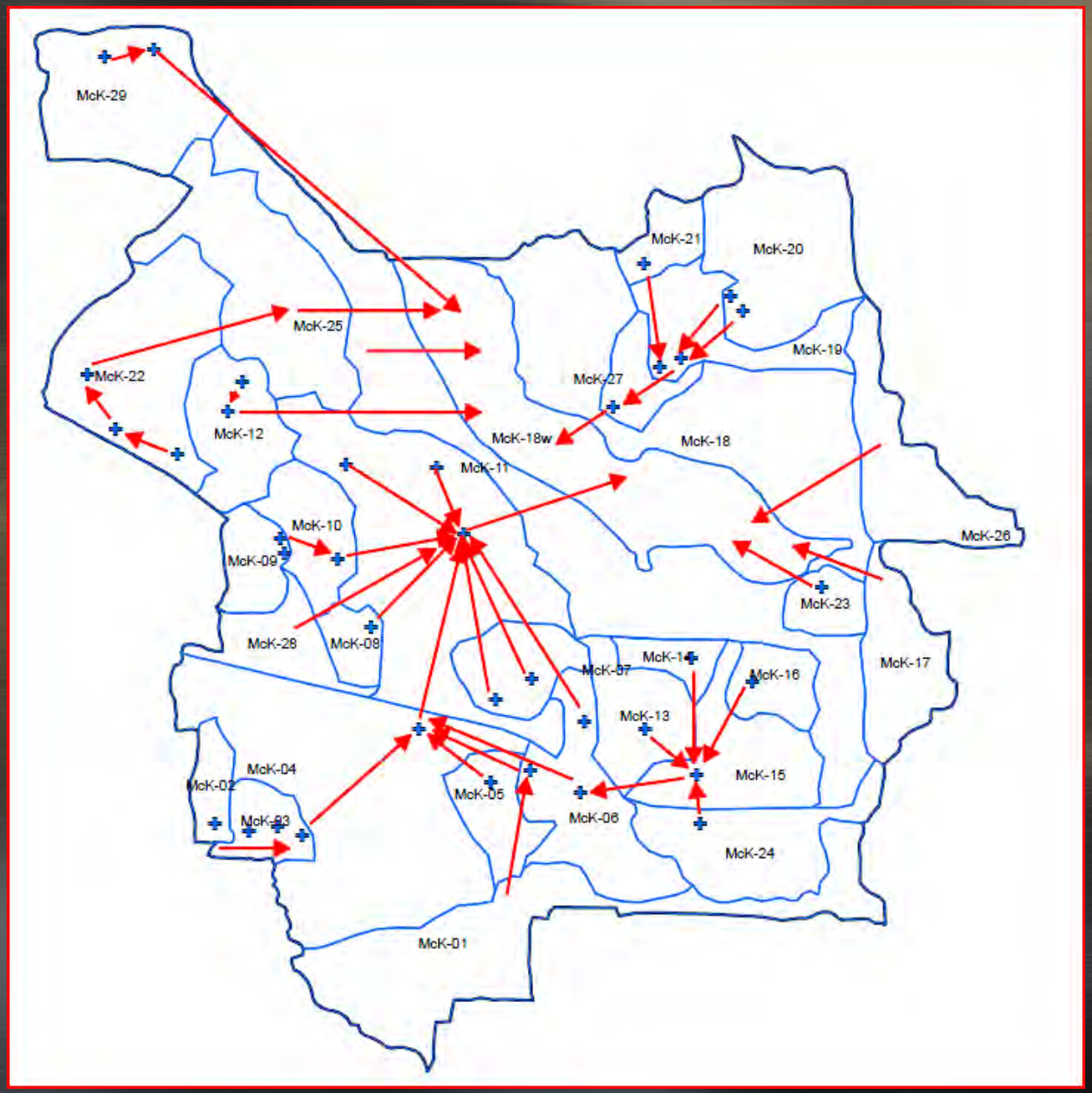
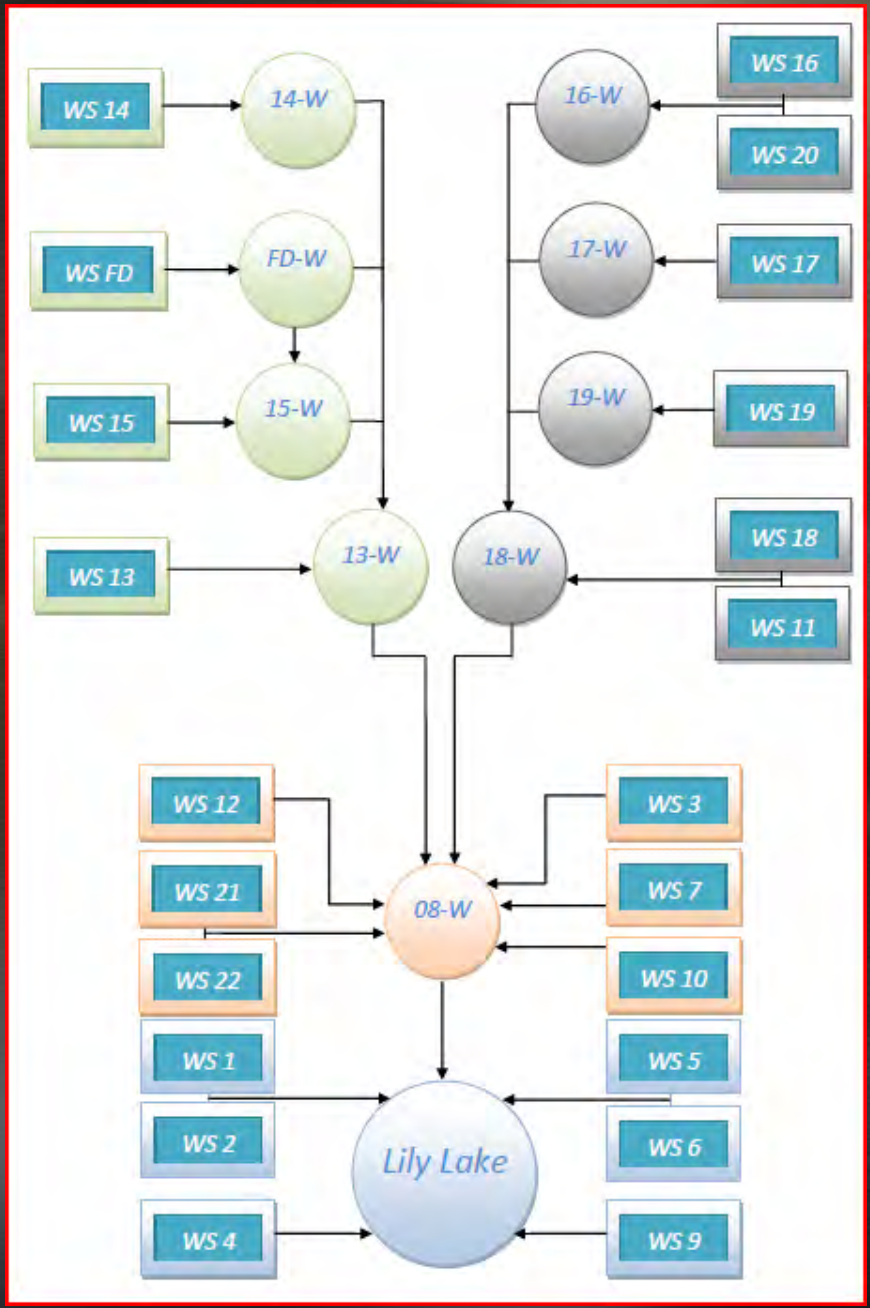
I. Subwatershed Analysis by Catchment



land mosaic collaborative Lake McKusick existing stormwater routing diagram, MSCWMO



Lily Lake Stormwater Retrofit Assessment, 2009, Middle St. Croix WMO

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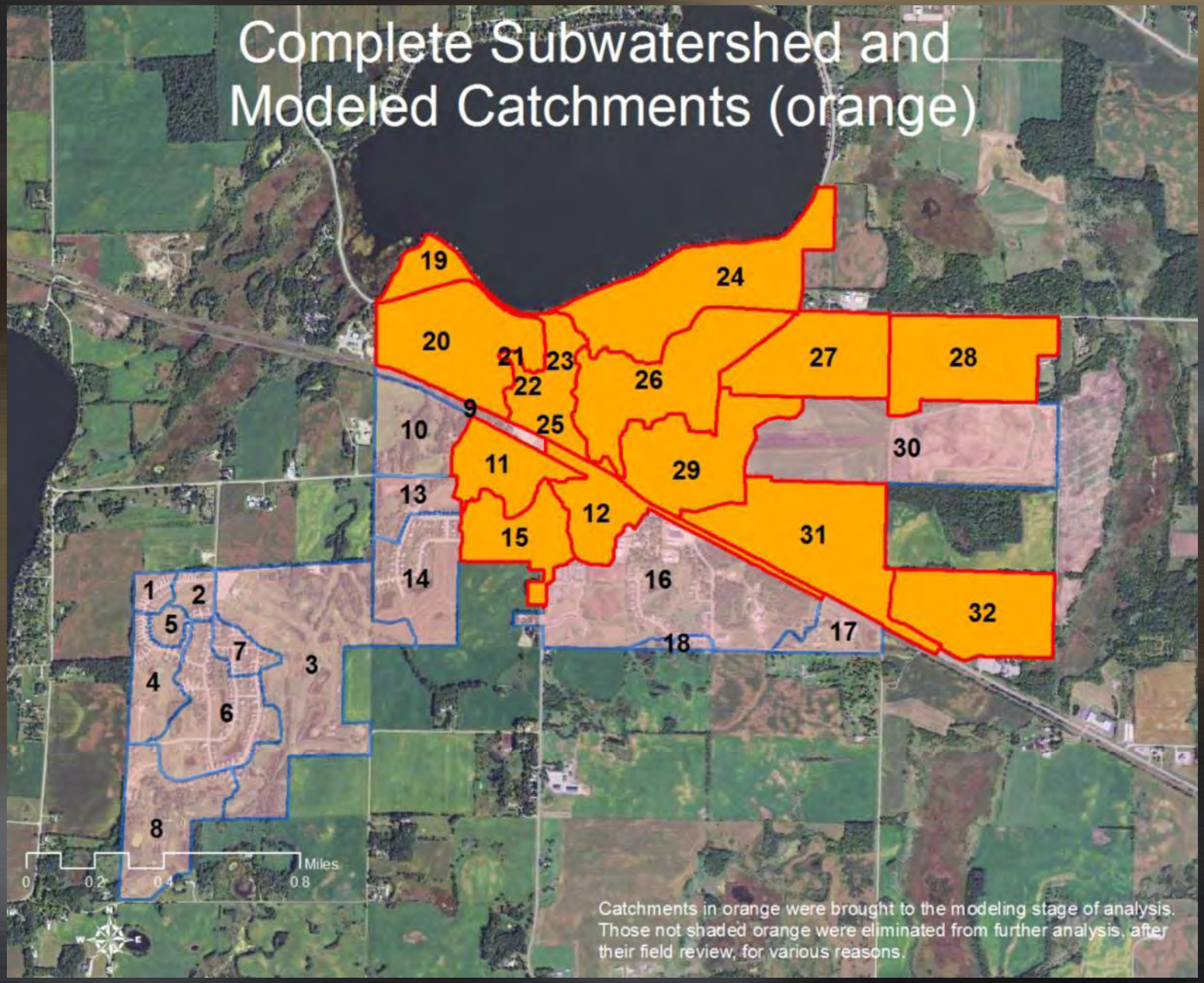
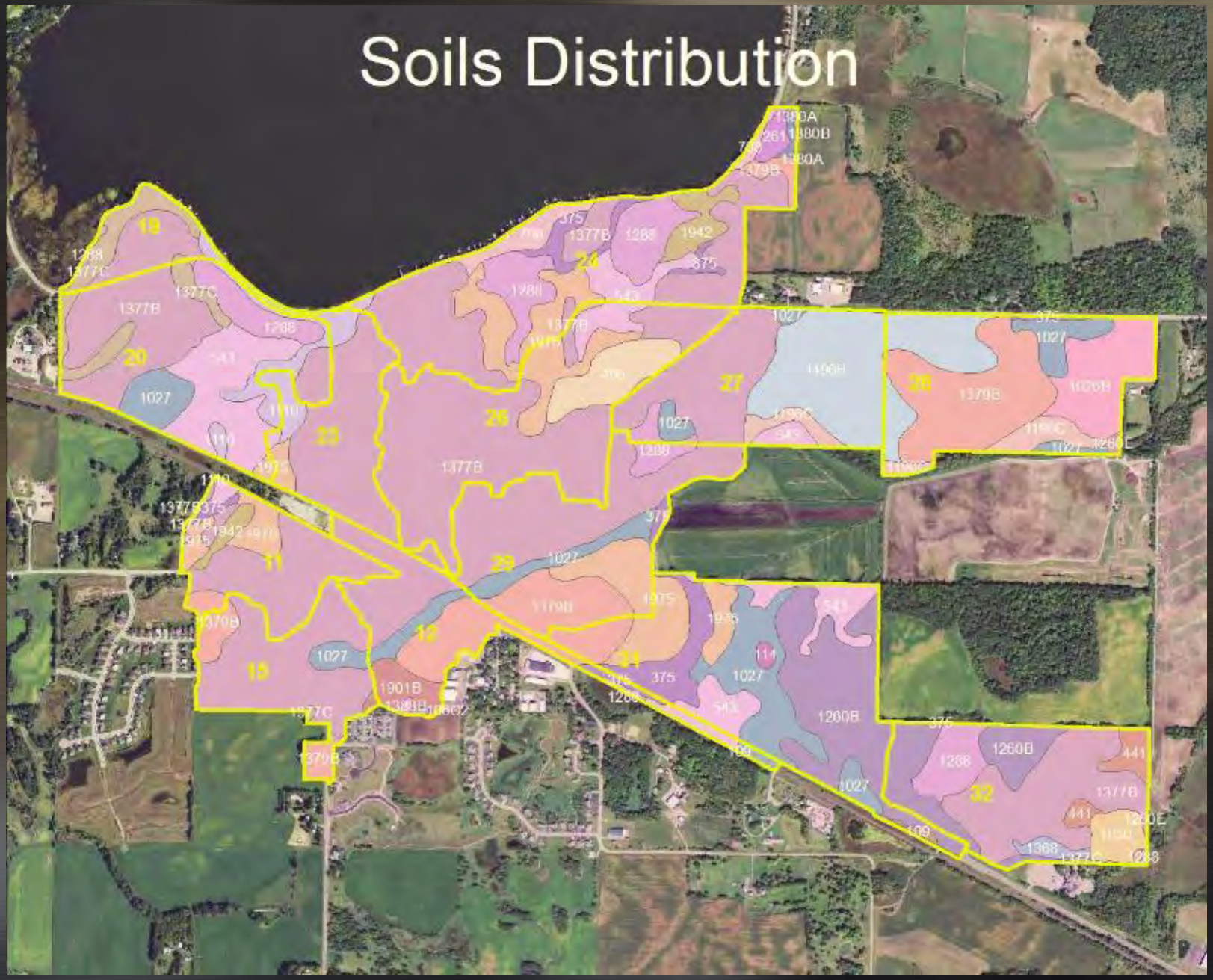
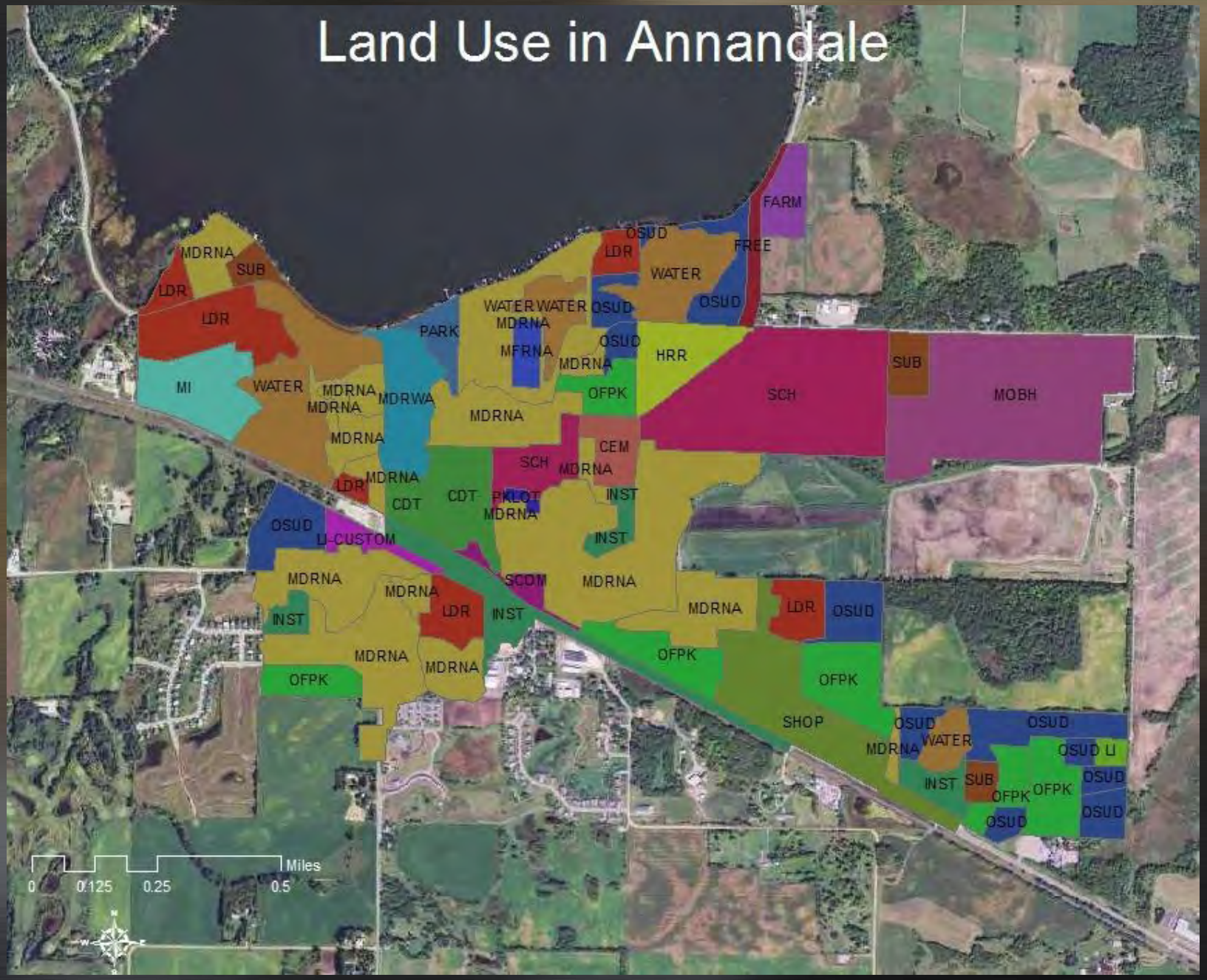
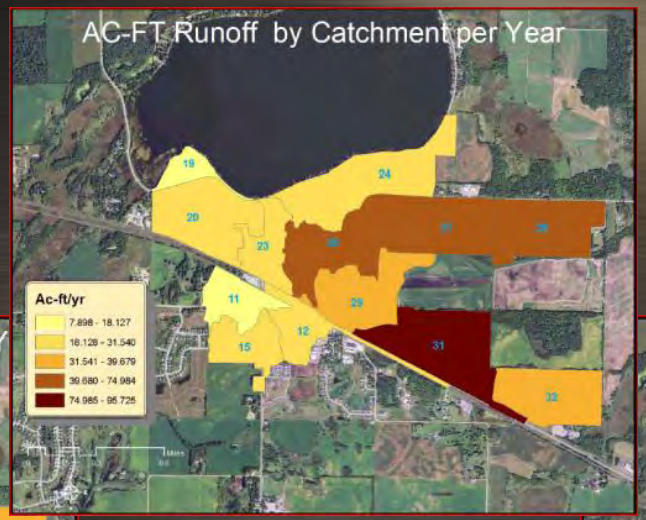

Complete Subwatershed and Modeled Catchments (orange)
19
24
20
21
23
22
26
27
28
9
25
10
30
11
29
13
12
31
15
14
16
32
1
2
5
17
18
7
3
4
6
8
Miles
0
0.2
0.4
0.8
Catchments in orange were brought to the modeling stage of analysis. Those not shaded orange were eliminated from further analysis, after their field review, for various reasons.

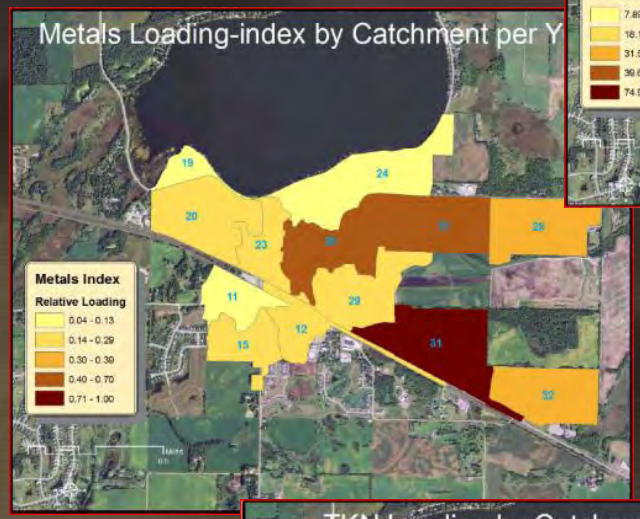
Soils Distribution

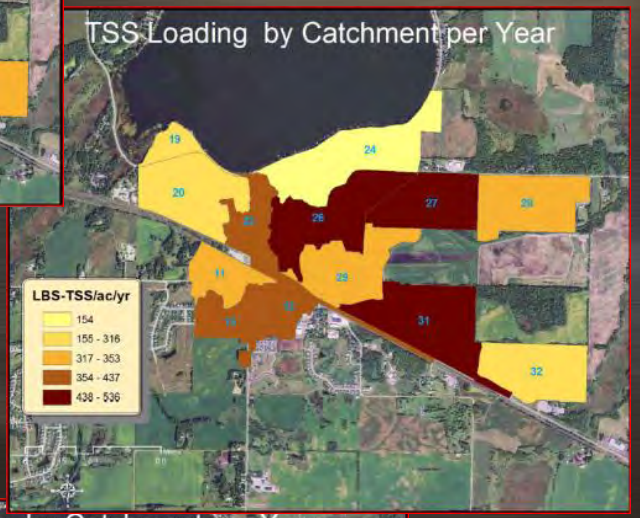


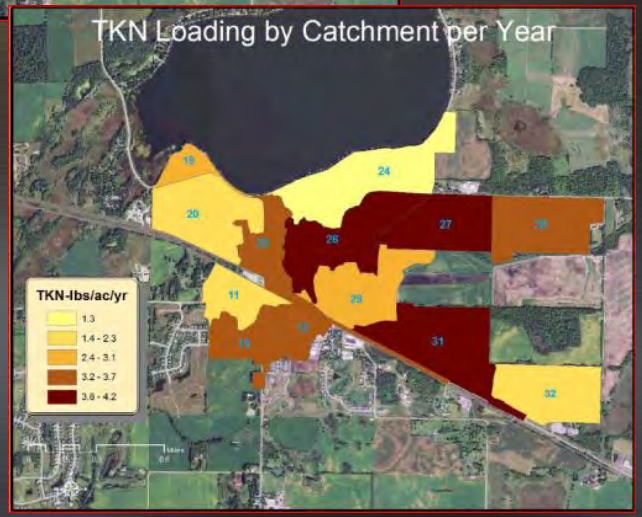
Land Use in Annandale

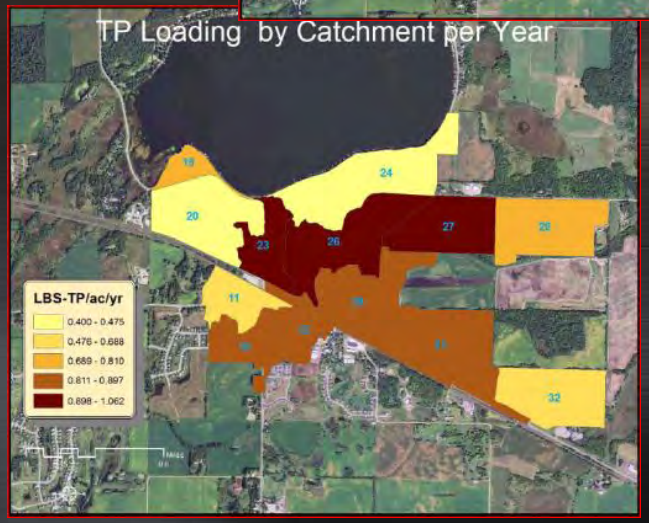



AC-FT Runoff by Catchment per Year
Ac-ft/yr
7.898 - 18.127
18.128 - 31.540
31.541 - 39.679
39.680 - 74.984
74.985 - 95.725

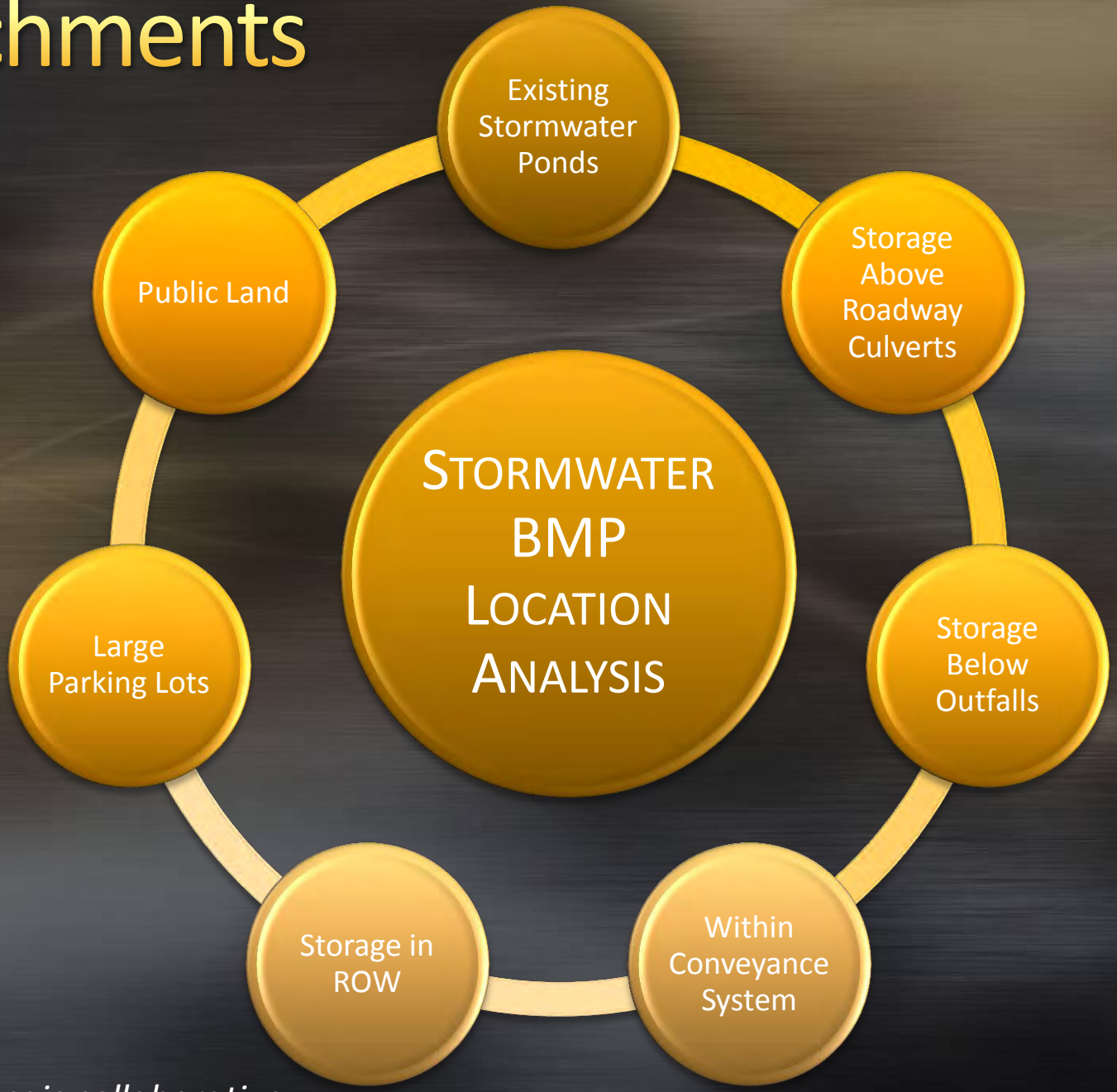

Metals Loading-index by Catchment per Y
Metals Index
Relative Loading
0.04 - 0.13
0.14 - 0.29
0.30 - 0.39
0.40 - 0.70
0.71 - 1.00


TSS Loading by Catchment per Year
LBS-TSS/ac/yr
154
155 - 316
317 - 353
354 - 437
438 - 536


TKN Loading by Catchment per Year
TKN-lbs/ac/yr
1.3
1.4 - 2.3
2.4 - 3.1
3.2 - 3.7
3.8 - 4.2


TP Loading by Catchment per Year
LBS-TP/ac/yr
0.400 - 0.475
0.476 - 0.688
0.689 - 0.810
0.811 - 0.897
0.898 - 1.062

Catchments



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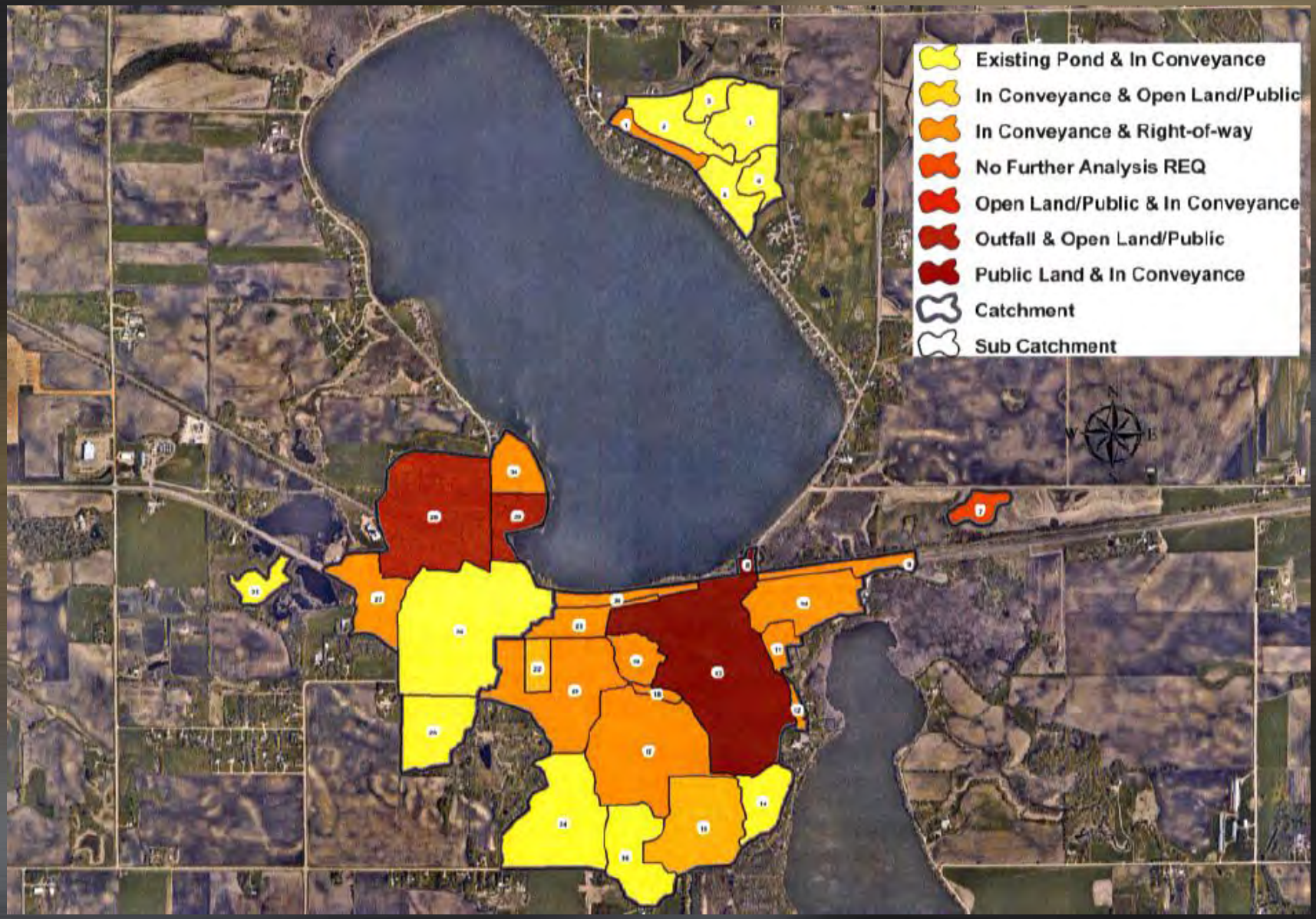
Existing Pond & In Conveyance
In Conveyance & Open Land/Public
In Conveyance & Right-of-way
No Further Analysis REQ
Open Land/Public & In Conveyance
Outfall & Open Land/Public
Public Land & In Conveyance
Catchment
Sub Catchment

Sites

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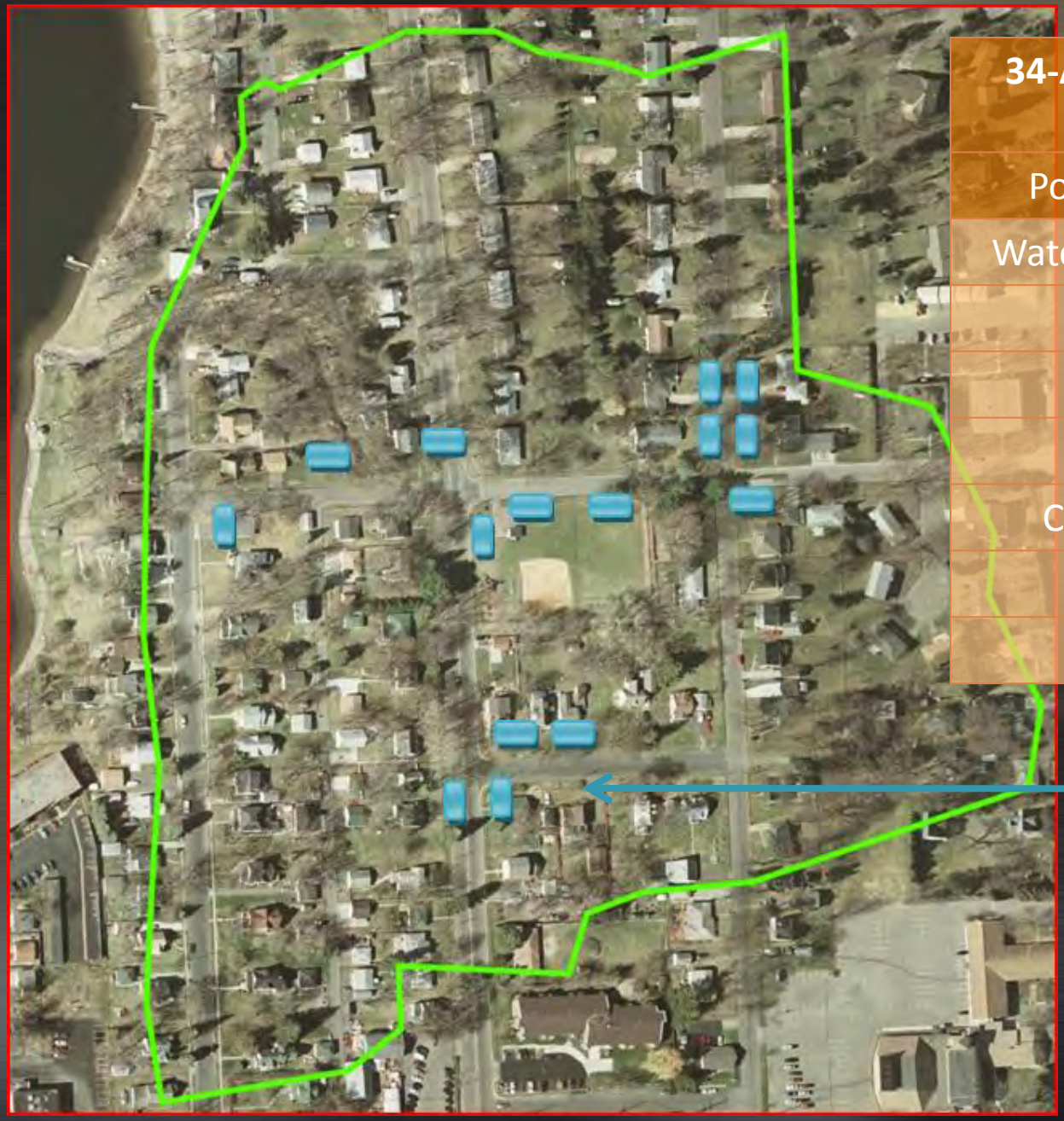
RRI SITE / PARCEL CODE SHEET

CODE	BMP
PND	Pond Retrofits
EXD	Extended Detention
WTP	Wet Pond
WET	Stormwater Wetland
INB	Infiltration Basin (regional treatment - e.g., recreational field with stormwater drained to it for infiltration)
SDC	Stormwater disconnect to pervious area
ICC	Impervious Cover Conversion
RBR	Rain Barrels
CIS	Cisterns
DWL	French Drain/Dry Well
WTS	Wet Swale (vegetated swale with no underdrain)
WQS	Water Quality Swale (Dry Swale (swale with filtration media and drain tile)
USF	Underground Sand Filter
SSF	Structural Sand Filter (a surface filter including peat, compost, iron amendments, or similar)
RDG	Rain Leader Disconnect Raingardens
BRA	Simple Bioretention (no engineered soils or under-drains, but w/curb cuts and forebays)
BRB	Moderate Bioretention (engineered soils, under-drains, curb cuts, forebays but no retaining walls)
BRC	Complex Bioretention (as BRB but with partial, or 1-3 ft retaining walls)
BRD	Highly Complex Bioretention (as BRB but with perimeter or 3-5 ft retaining walls)
STP	Stormwater Tree Pits
STP	Stormwater Planter
PPG	Grass/Gravel Permeable Pavement (sand base)
PPA	Permeable Asphalt (granite base)
PPC	Permeable Concrete (granite base)
PPP	Permeable Pavers (granite base)
EGR	Extensive Green Roof
IGR	Intensive Green Roof

CODE	SITE APROPRIATENESS BY FIELD INDICATOR
1	Prime: ideally situated within catchment, few physical constraints, little to no grading required, easy maint.
2	Alternate: a possible substitute for Prime location with oderate indicators
3	Poor: not suitable; porrly situated in catchment, too many constraints, extensive grading, difficult maint.

Example Site Code for RRI	
CODE	DESCRIPTION
1WQS	A perfect site/parcel for a Water Quality Swale
2BRB	An alternate site/parcel, after all Prime sitess have been pursued, for Moderate Bioretention
3	Do not pursue BMP placement of any type on this site/parcel



34-Acre Medium Density Residential Area	
Pollutant	Amt/year
Water Runoff	963,715 ft^3
TSS	12,900 lbs
TP	35 lbs
TKN	128 lbs
Copper	0.73 lbs
Lead	1.34 lbs
Zinc	5.80 lbs

First Tier possible BMP locations

Lindstrom Retrofit Assessment, 2009, Chisago SWCD

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8 Methods

The following stormwater BMPs were considered for each catchment/site:

Stormwater Treated Options for Retrofitting

Area Best Management

WinSLAMM Model Output

File View

Runoff Volume | Particulate Solids | **Pollutants** | Output Summary

Concentration | **Yield (lbs)** | Percent SA Contribution

Data File: SLU Med Density Res no alleys Silt_17_B.DAT

Rain File: MN Minneapolis 59.RAN

Date: 12-21-10 Time: 3:09:49 PM

Site Description: Standard Land Use File-Medium Density Residential, No Alleys, fair Curb & Gutter. Area Ratio adjustment: 0.5070

Total Area, with Drainage and Outfall Controls - Yield of Total Solids (lbs)

Summary of Runoff Producing Events

	Rain Total (inches)	Total Before Drainage System	Total After Drainage System	Total After Outfall Controls
Minimum:	0.01	0.8638	0.8638	0.8638
Maximum:	2.40	2188	2188	2188
Fl Wt Ave:		895.3	895.3	895.3
Total:	26.88	14288	14288	14288

Total Area, with Drainage and Outfall Controls - Yield of Total Phosphorus (lbs)

Summary of Runoff Producing Events

	Rain Total (inches)	Total Before Drainage System	Total After Drainage System	Total After Outfall Controls
Minimum:	0.01	0.001606	0.001606	0.001606
Maximum:	2.40	6.941	6.941	6.941
Fl Wt Ave:		2.635	2.635	2.635
Total:	26.88	37.87	37.87	37.87

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Cost/Benefit Analysis

		EXISTING CONDITIONS		RETROFIT OPTIONS			
				Marginal Network Treatment By BMP			
		Base Loading	Treatment	Level 1 (8 RG+VS)		Level 2 (18 RG+VS)	
Treatment	Existing BMP performance		0.0%-TP	New	New %	New	New %
	TP (lb/yr)	61.9	0.0	6.6	10.6	8.9	14.4
	TSS (lb/yr)	27010	0	3137	11.6	4330	16.0
	Volume (acre-feet/yr)	58.81	0.00	52.00	88.4	9.57	16.3
	Square feet of practice			11700		13200	
Costs	BMP Type	No Treatment		Moderately Complex Bioretention + Vegetated Swale		Moderately Complex Bioretention + Vegetated Swale	
	Materials/Labor/Design			$40,950		$46,200	
	Unit Promotion & Admin			$57		$52	
	Total Project Cost			$47,586		$53,057	
	Annual O&M			$900		$2,025	
	Term Cost/lb/yr (30 yr)			**$380**		**$424**	

Catchment or Pond ID	Retro Type	Qty of 100 ft^3 BMPs	TP Reduction (%)	TP Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Overall Est. Cost[1]	O&M Term (years)	Total Est. Term Cost/lb-TP/yr
LILY-03	B	12	10	5	4	$19,900	30	**$313**
LILY-04	B, PS, VS	8	10	3.3	2.9	$14,150	30	**$313**
LILY-01	B	11	10	4.4	3.6	$17,650	30	**$315**
LILY-02	B	11	10	4.5	3.7	$18,000	30	**$315**
LILY-12	B	18	10	3.2	2.5	$12,000	30	**$316**
LILY-07	B, VS	20	20	7	5.8	$24,000	30	**$318**
LILY-09	B	11	20	4.3	3.6	$18,450	30	**$337**
LILY-22	B	14	20	2.5	4.2	$22,320	30	**$352**
LILY-10	B, PS, F	7	10	2.9	2.4	$15,225	30	**$353**
LILY-21	B	12	20	2.2	3.6	$19,325	30	**$353**
[2]P13-W	PM	n/a	50	20	0	$130,000	15	**$433**
[2]P18-W	PM	n/a	50	30	0	$265,000	15	**$589**

Plan

Lambert Creek Retrofit ID and Design Project

Prepared by:

RCD

Ramsey Conservation District

With assistance from:

THE METRO CONSERVATION DISTRICTS

for the

VADNAIS LAKE AREA WATERSHED MANAGEMENT ORGANIZATION

Lambert Creek Retrofit ID and Design Project

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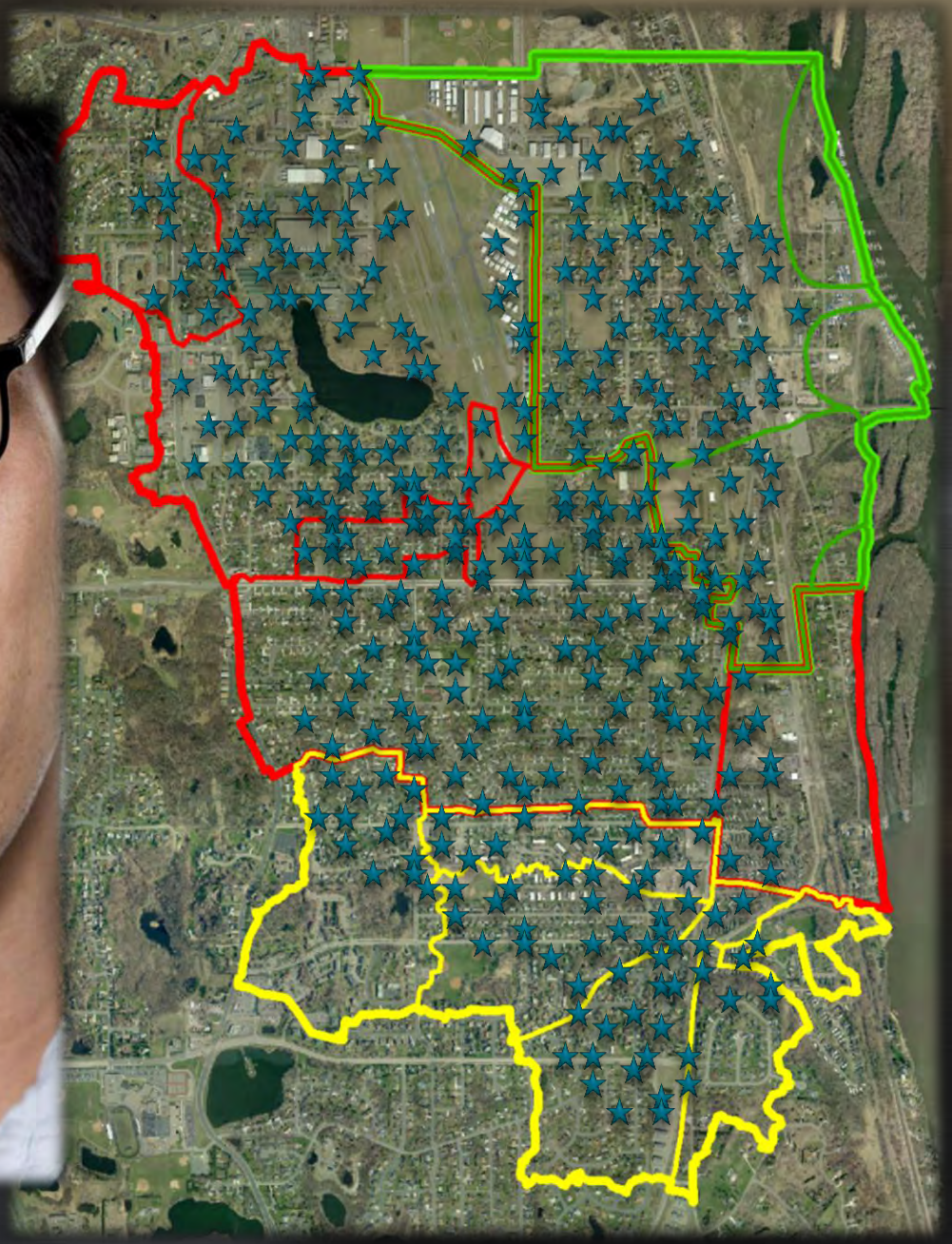

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II. Site Specific BMP Performance Analysis

Scaling – Urban / Rural

1-Selection of Subwatershed

2-Analysis of SW's Catchments

3-Analysis of BMP's by site

Why?

- The subwatershed analysis (SRA) identifies which subwatersheds to analyze, which of their catchments to work within, and optimal site locations for specific BMPs in each of these catchments
- Next step: determine which of these low-hanging fruit projects returns the highest value on investment (lowest $/lb-pollutant)
- If SRA identifies fewer projects, or if no general treatment model can be made for catchments, each site should be modeled given the specific drainage area make-up and BMP design
- However, the SRA may identify hundreds of such “first-tier” projects in each catchment and modeling each one would be unrealistic and inappropriate in many cases (i.e., if you have hundreds of potential first-tier projects identified, why build highly-detailed models for sites that may not yet get approved? Nearly all will be on private land and agreements need to be solidified first)

A Proposed Method

Subwatershed Analysis
(SW→Catchments→1° Sites)

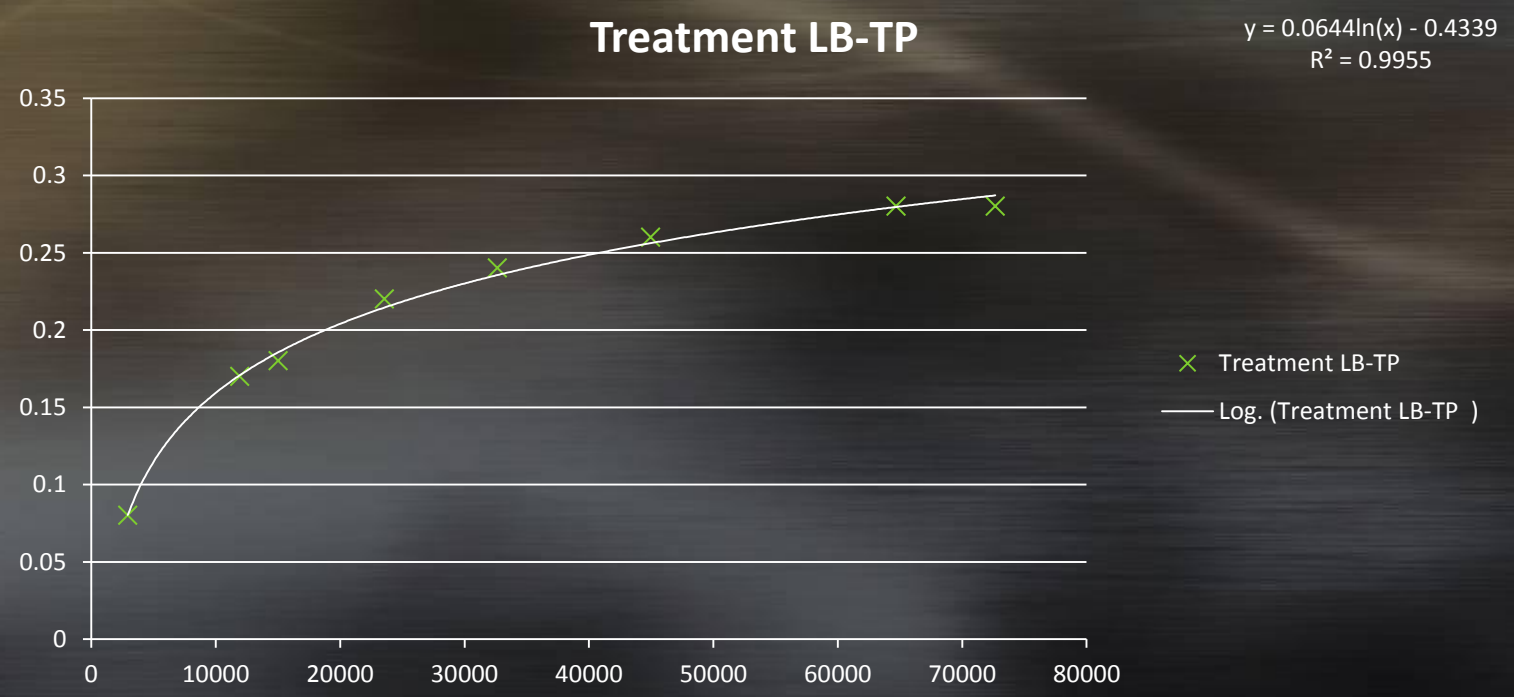
Land Use Analysis (model a representative "run" within catchments for each Land Use-Soil-BMP combination (LU-SC-BMP)

Project Ranking (apply results across study area to each parcel – rank by Value)

Cost Share Level Determination
(multiply each BMP's treatment amount by the capacity cost of most efficient BMP)

Process

- For Primary Catchments identified in SRA:
  1. For each LU-SC-BMP, model performance for an incrementally increasing, drainage area
  2. Generate an area-based equation from results – identify peak performance (asymptote)



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Process

curb-cut bioretention family (for directly-connected areas only)

- For Primary Catchments identified in SRA:
  3. Rank the top performing identified BMPs from each LU-SC-BMP in the study area
  4. Determine the Capacity Cost of #1
  5. For all identified potential projects identified in the SRA, measure drainage are served by each
  6. Identify the LU-SC-BMP family the site fits within
  7. Apply the appropriate LU-SC-BMP performance model to estimate load reduction
  8. Determine Life Cycle (LC) value

Process

curb-cut bioretention family (for directly-connected areas only)

- For Primary Catchments identified in SRA:
  9. Rank all Watershed projects by LC value
  10. Multiply each project's load reduction by the Capacity Cost of the Watershed's highest performing BMP –> performance-based cost share amount

After projects are contracted, designed and built, survey the as built and do a site-BMP specific performance model for reporting purposes and/or monitor performance.

EXAMPLE: MEDIUM-DENSITY RESIDENTIAL SAMPLE AREA: Boudin Neighborhood, Prior Lake-Spring Lake Watershed District

(For other land-uses, representative samples are similarly analyzed)

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HOUSE	STREET	Street (sq ft)	Direct Roof (sq ft)	Indirect Roof (sq ft)	Driveway (sq ft)	Green Space (sq ft)	TOTAL CATCHMENT (sq ft)
14024	Rutgers	1345	0	0	225	1360	2930
14038	Rutgers	3045	1370	475	2380	4680	11950
14054	Rutgers	3675	1370	925	2380	6690	15040
14070	Rutgers	5445	2935	1335	4425	9440	23580
14086	Rutgers	7557	3507	1857	5799	13928	32648
14124	Rutgers	9808	3507	2629	6762	22268	44974
14144	Rutgers	12675	4895	4350	10055	32725	64700
14164	Rutgers	13980	5435	4890	11965	36395	72665

		Catchment Loading		BMP Treatment (load removed)					
HOUSE	STREET	Volume (cu ft)	TP (lb)	Volume (cu ft)	TP (lb)	$/ft2	ft2	Install $	Capacity $
14024	Rutgers	2752	0.11	2211	0.08	14	250	3500	41672
14038	Rutgers	12111	0.38	4810	0.17	16	250	4000	23529
14054	Rutgers	13438	0.45	4929	0.18	16	250	4000	22222
14070	Rutgers	23010	0.72	5734	0.22	18	250	4500	20455
14086	Rutgers	30419	0.97	6047	0.24	14	250	3500	14583
14124	Rutgers	36821	1.26	6161	0.26	14	250	3500	13462
14144	Rutgers	54227	1.85	6295	0.28	14	250	3500	12500
14164	Rutgers	57822	1.98	6303	0.28	14	250	3500	12500

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14124	Rutgers	36821	1.26	6161	0.26	14	250	3500	13462
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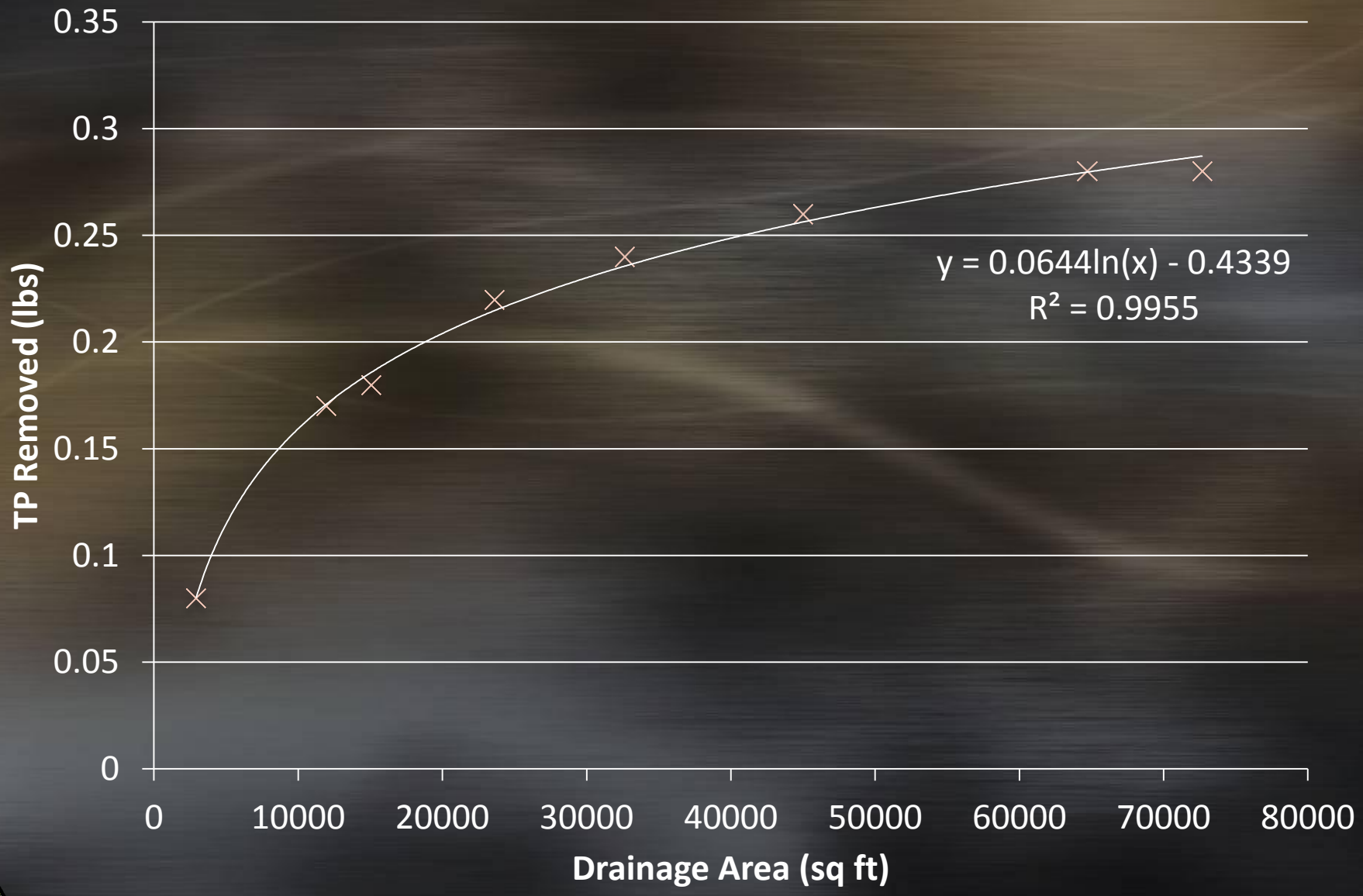
Estimated Treatment for Filtering Bioretention Systems in MDRNA, Clay Soils (LUSCBMP 51)



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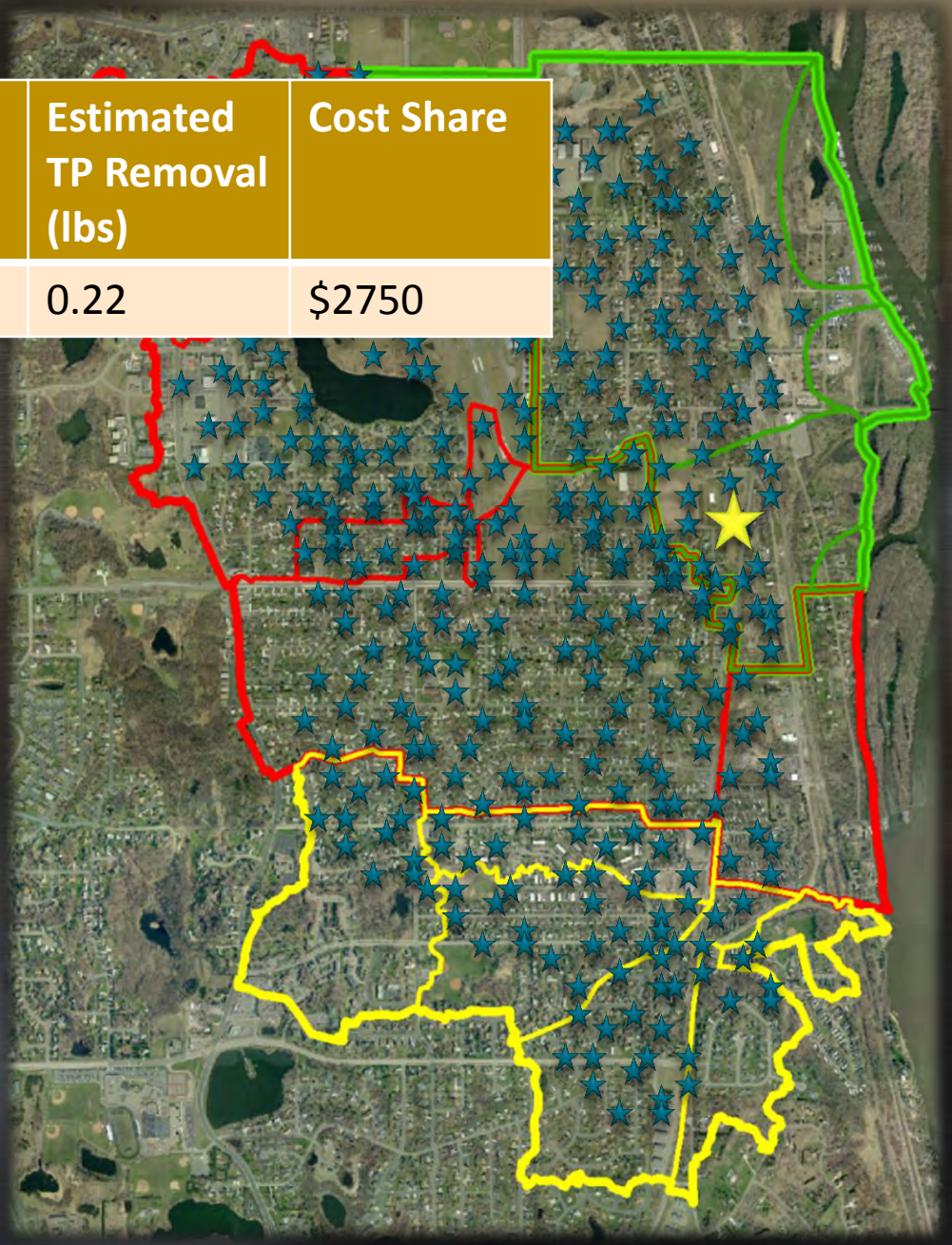
Site Code	LUSBMP Code	D.A. (acres)	Estimated TP Removal (lbs)
126	51	0.90	0.22
127	51	1.20	0.25
128	42	35.25	21.35
129	40	1.55	0.50
130	17	3.50	1.75
131	51	0.50	0.17
132	40	1.25	0.45
133	40	0.25	0.15
134	40	0.85	0.35
135	17	5.75	2.10
136	42	17.52	13.25
137	42	60.00	35.00
138	51	0.75	0.19

Site	LUSBMP	D.A. (acres)	Estimated TP Removal (lbs)	Cost Share
126	51	0.9	0.22	$2750



Highest performing cell in study area's
Capacity Cost = $12,500

Performance-based cost share amount:
0.22 X $12,500 = $2750

Highest performing cells in study area
Cost share amount is 100%

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BMP Equivalents

The quantity of each 4 stormwater BMP types needed to provide the same annual TP-removal at this example site

Curb Cut Raingarden

Example Site-Specific Costs

- $3,500 installation
- $505/LB-TP/YR
- 0.28 LB-TP/YR removed, total

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Permeable Driveways (6)

Example Site-Specific Costs

- $150,00 installation
- $16,575/LB-TP/YR
- 0.28 LB-TP/YR removed, total

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Rain-leader Raingardens (40)

Example Site-Specific Costs

- $8,000 installation
- $4,520/LB-TP/YR
- 0.28 LB-TP/YR removed, total

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Rain Barrels (100)

Example Site-Specific Costs

- $10,000 installation
- $1,190/LB-TP/YR
- 0.28 LB-TP/YR removed, total

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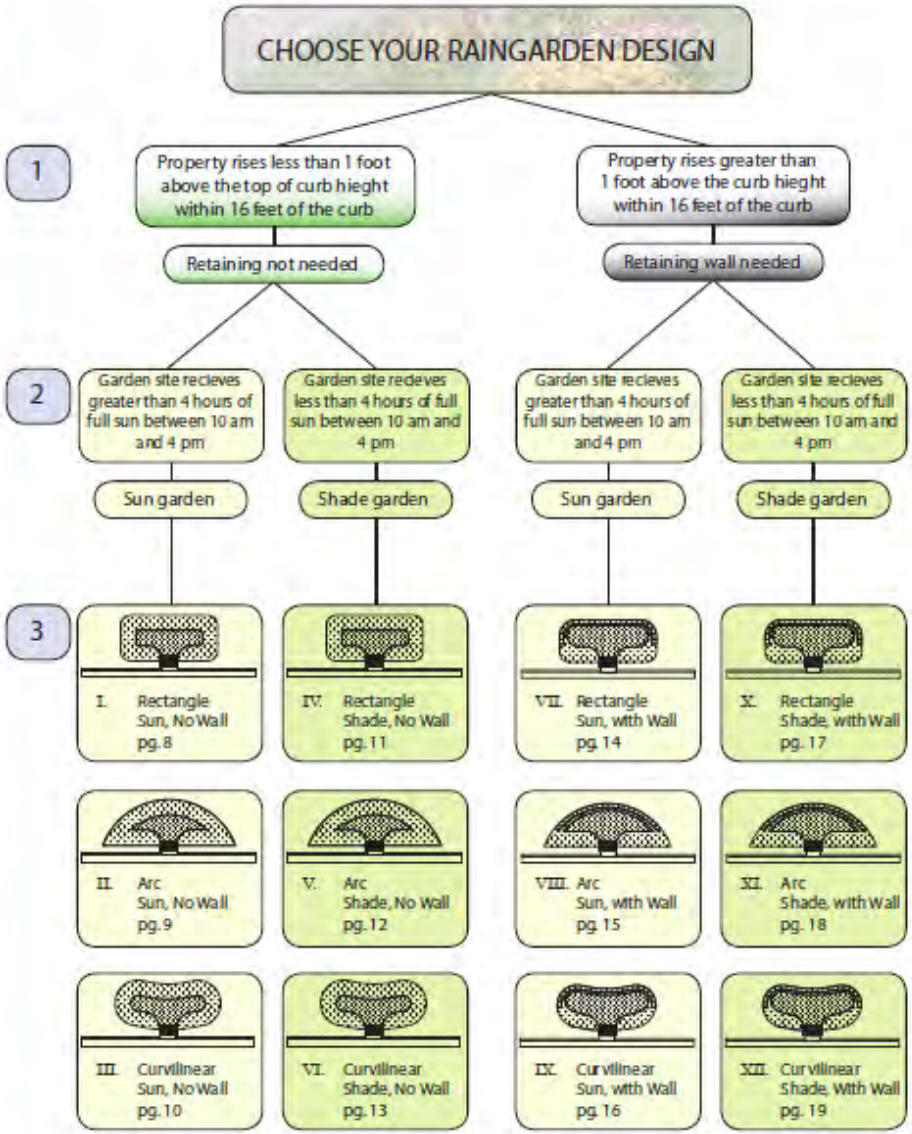
III. Design and Implementation

ANOKA COUNTY CURB-CUT RAINGARDENS

Drawing rainwater from the street gutter reduces runoff and pollutants to local water bodies

ANOKA CONSERVATION DISTRICT

Prepared by the Anoka Conservation District in association with the Metropolitan Conservation Districts



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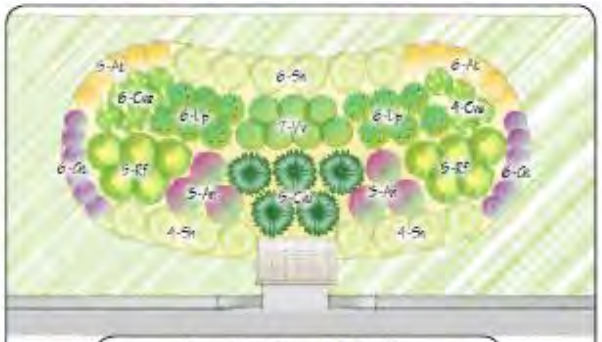
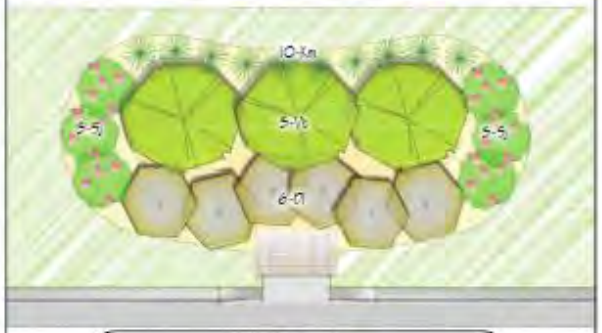
III. Curvilinear Garden - Sunny Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY *Aronia melanocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS *Calamagrostis acutifolia*
Cvu	FOX SEDGE *Carex vulpinoidea*
Cvu	COREOPSIS 'MOONBEAM' *Coreopsis verticillata 'Moonbeam'*
Dp	PURPLE PRARIE CLOVER *Dalea purpurea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gt	PRAIRIE SMOKE *Geum triflorum*
Km	JUNE GRASS *Koeleria macrantha*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sj	DART'S RED SPIRAEA *Spiraea japonica*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Veronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

FLOWERING PERENNIAL
Plant pallette

CANADA ANEMONE
Anemone canadensis

GOAT'S BEARD
Aruncus dioicus

BUTTERFLY MILKWEED
Asclepias tuberosa

ASTER 'PURPLE DOME'
Aster novae-angliae 'Purple Dome'

COREOPSIS 'MOONBEAM'
Coreopsis verticillata 'Moonbeam'

PURPLE PRARIE CLOVER
Dalea purpurea

PURPLE CONEFLOWER
Echinacea purpurea

GERANIUM JOHNSON BLUE'
Geranium himalayense x pratense

PRAIRIE SMOKE
Geum triflorum

SNEEZEWEED
Helenium autumnale

ALUMROOT
Heuchera richardsonii

PRAIRIE BLAZING STAR
Liatris pycnostachya

CARDINAL FLOWER
Lobelia cardinalis

SENSITIVE FERN
Onoclea sensibilis

GOLDSTRUM BLACK-EYED SUSAN
Rudbeckia fulgida

CULVERS ROOT
Veronicastrum virginicum

SHRUB
Plant pallette

BLACK CHOKEBERRY
Aronia melonocarpa

DWARF BUSH HONEYSUCKLE
Diervilla lonicera

DART'S RED SPIRAEA
Spiraea japonica

CRANBERRYBUSH VIBURNUM
Viburnum trilobum 'compactum'

GRASSES
Plant pallette

KARL FORESTER GRASS
Calamagrostis acutifolia

PENNSYLVANIA SEDGE
Carex pennsylvanica

FOX SEDGE
Carex vulpinoidea

JUNE GRASS
Koeleria macrantha

LITTLE BLUESTEM
Schizachyrium scoparium

PRAIRIE DROPSEED
Sporobolis heterolepsis

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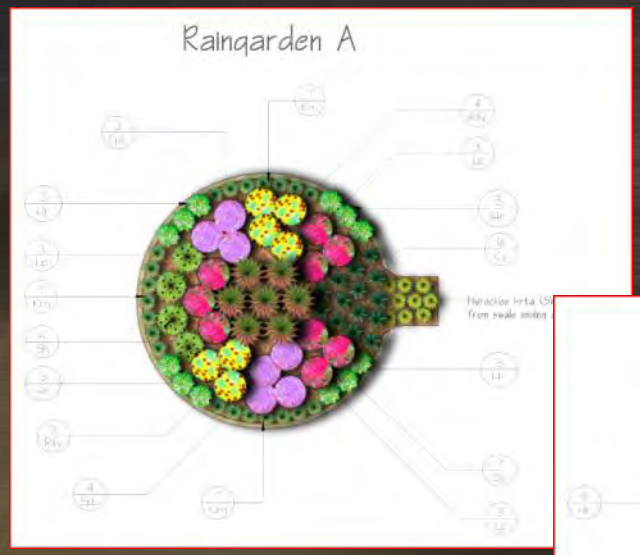

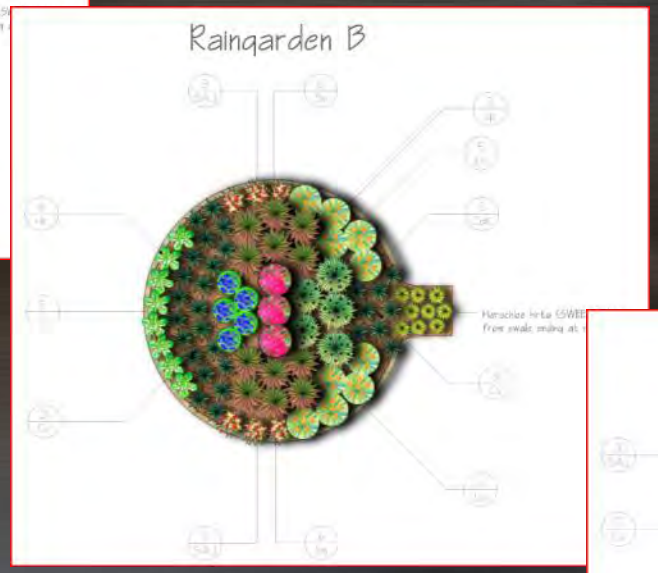

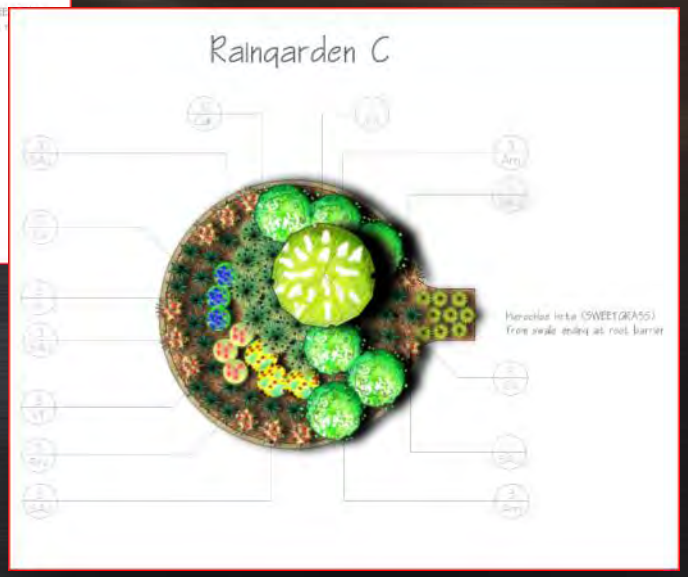

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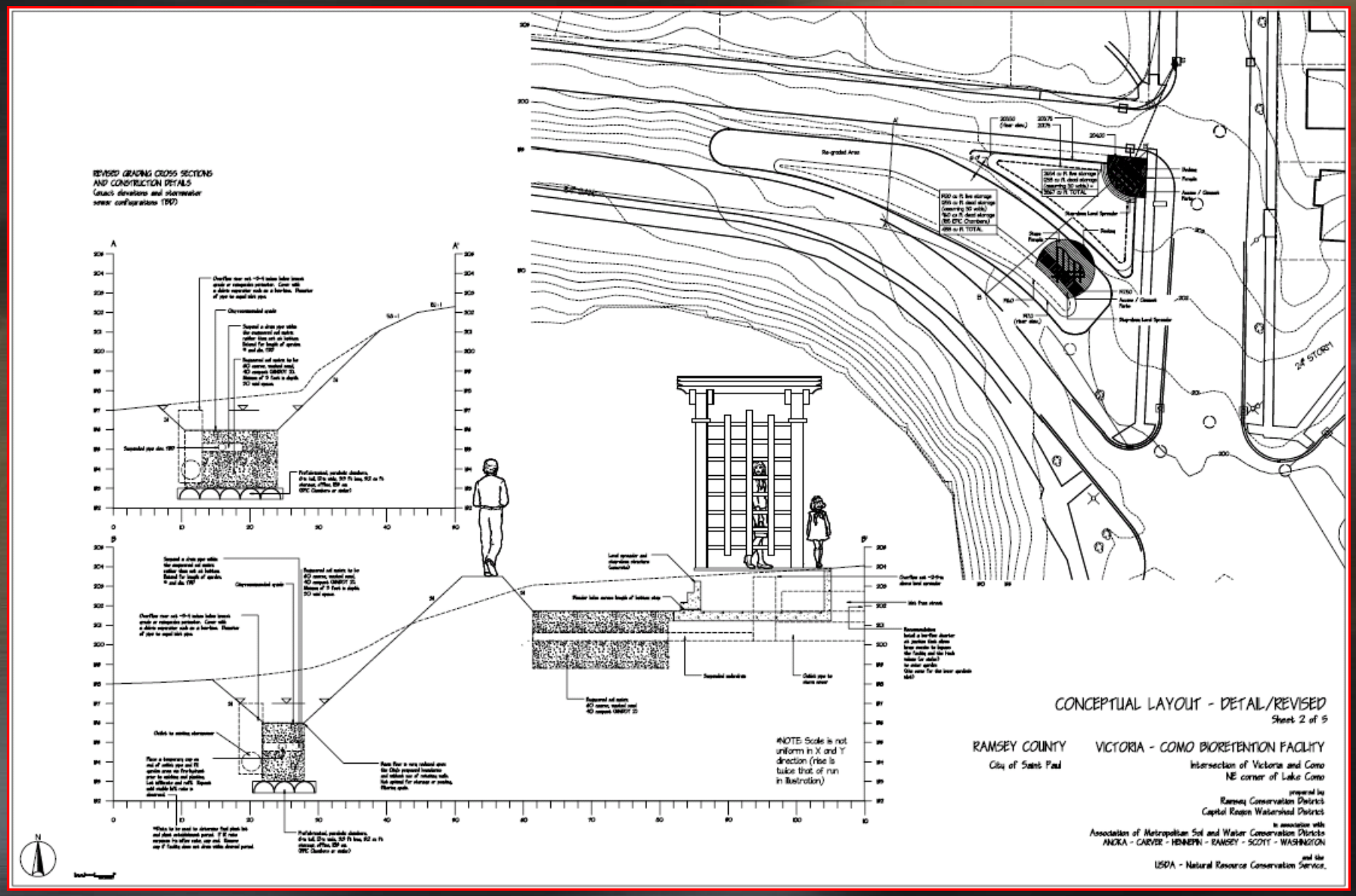

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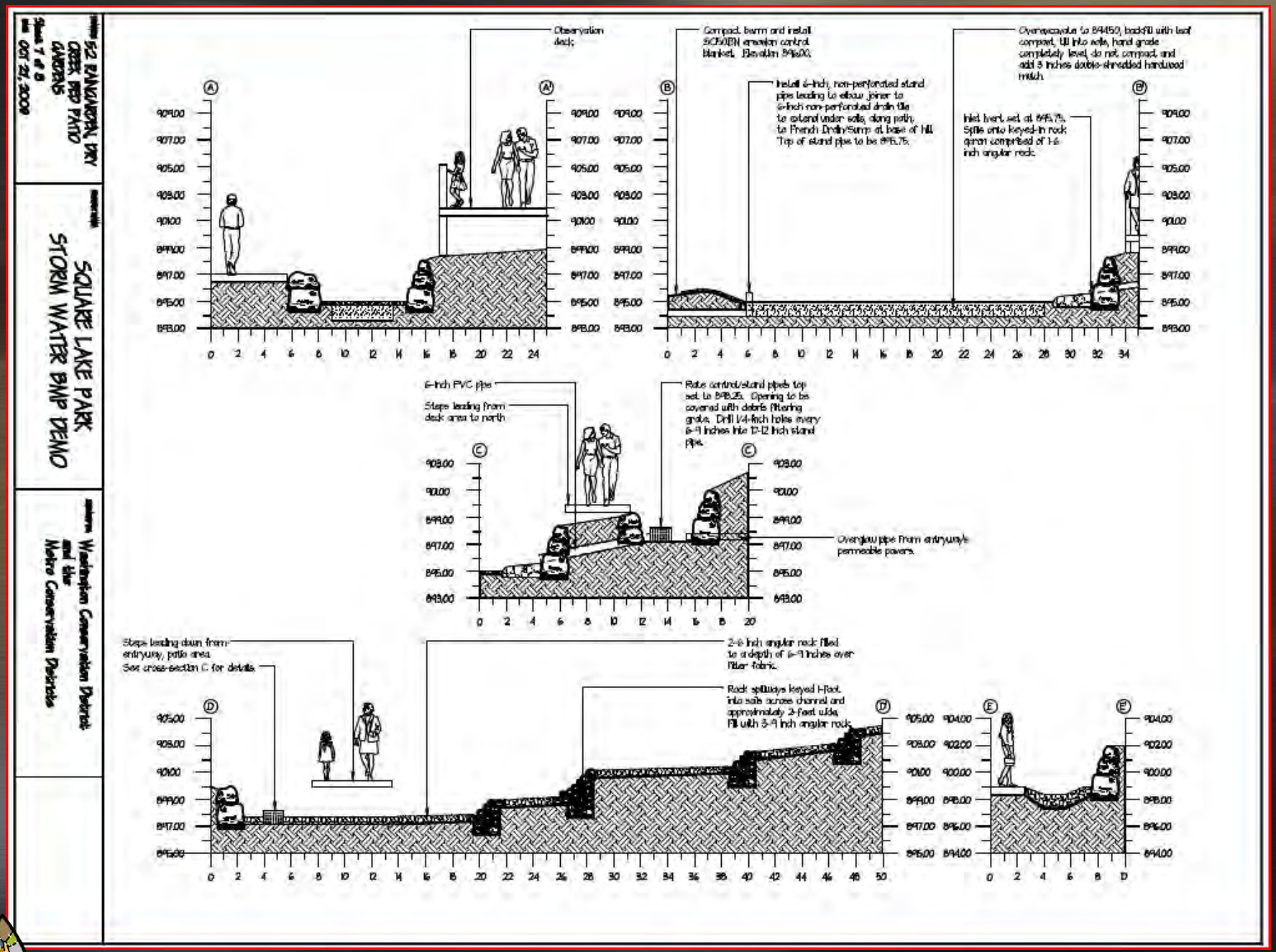

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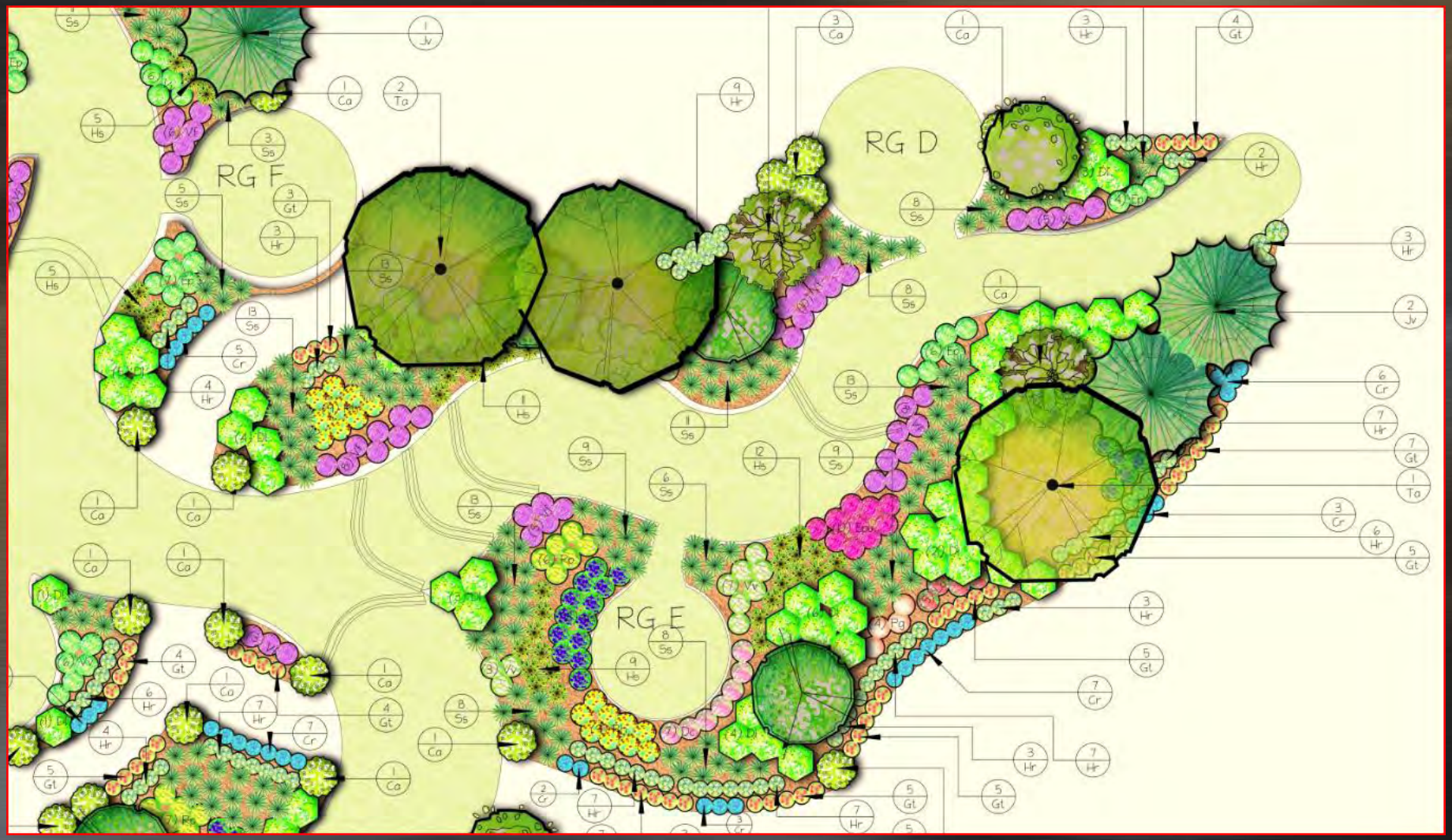

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STAINLESS

Resources

Goals addressed

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QUESTIONS

Shawn Tracy
Watershed Ecologist

651.278.4047
shawn.tracy@land-mosaic-collaborative.com

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