

Urban Stormwater BMP Performance Assessment and Cost-Benefit Analysis

A scenic view of a golf course with a pond and a field of yellow flowers in the foreground. The pond is in the middle ground, reflecting the sky and the surrounding greenery. The foreground is filled with a dense field of yellow flowers, likely Black-eyed Susans, with dark brown centers. The background shows a well-maintained golf course with rolling green hills and scattered trees under a clear sky.

Melissa Baker, Water Resource Technician
Capitol Region Watershed District, St. Paul, MN

Watershed Districts

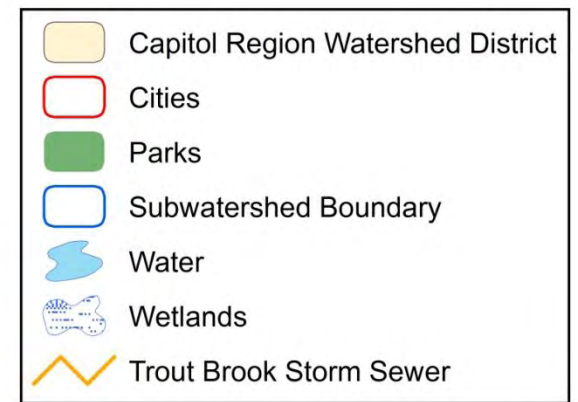
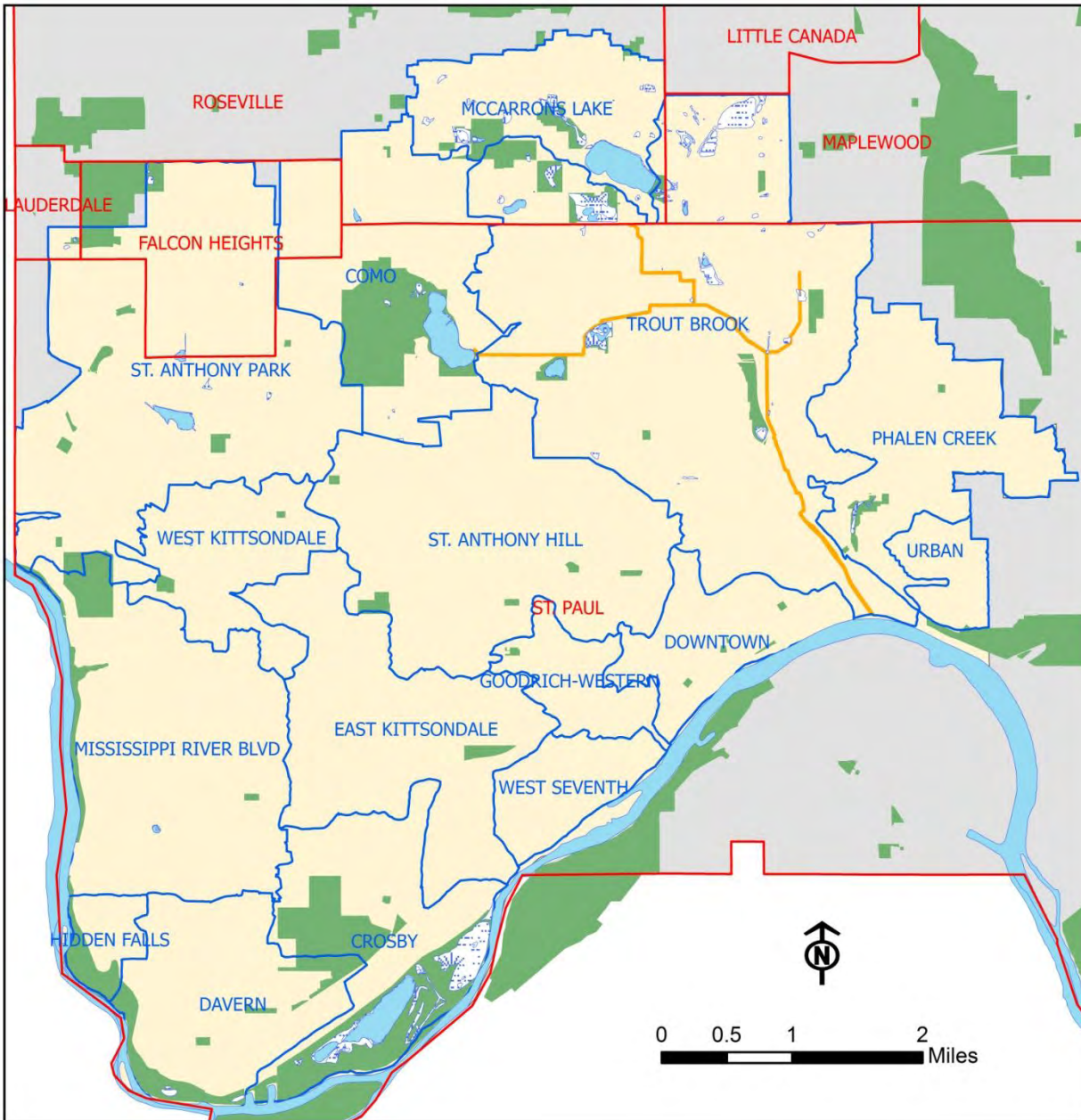
A special purpose unit of local government

- Area based on watershed boundaries
- Purpose is to manage water resources
- MN Watershed law established in 1955
- 48 Watershed Districts throughout Minnesota
- Board of Managers appointed by County
- Funded through tax levy
- Regulatory authority
- Own & operate drainage systems

Capitol Region Watershed District

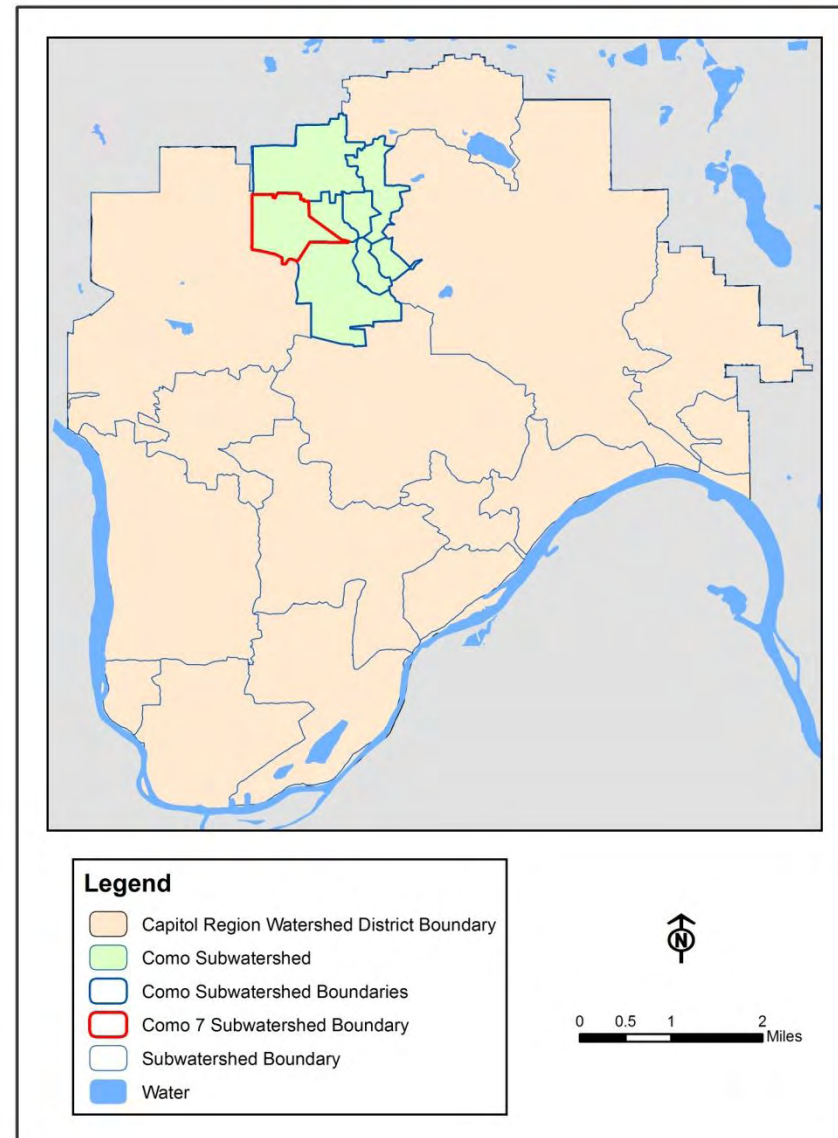
- 41 Square Miles (~26,000 acres)
- Portions of 5 Cities
- Population: 245,000
- 42% Impervious Surfaces
- 4 Lakes (Como, Crosby, Loeb, McCarrons)
- All Runoff Ultimately Flows to the Mississippi River





Arlington Pascal Stormwater Improvement Project

- Multi-Jurisdictional Project in the Como 7 Subwatershed
- Goals:
 - Reduce Flooding
 - Address Storm Sewer Improvements
 - Improve Water Quality of Como Lake
 - Determine Equitable Distribution of Costs



Arlington Pascal Stormwater Improvement Project

- Original Project Cost: \$2.5 Million
 - 60" Storm Sewer Pipe
 - No Water Quality Benefits
 - Final Project Cost: \$2.0 Million
 - 18 Stormwater BMPs
 - Stormwater Volume and Pollutant Reduction Benefits
- *Costs do not include bond interest
- **Final Total Project Capital Cost: \$2.7 Million**
 - *Total Capital Cost = Construction + Design + Bond Interest

Stormwater BMPs

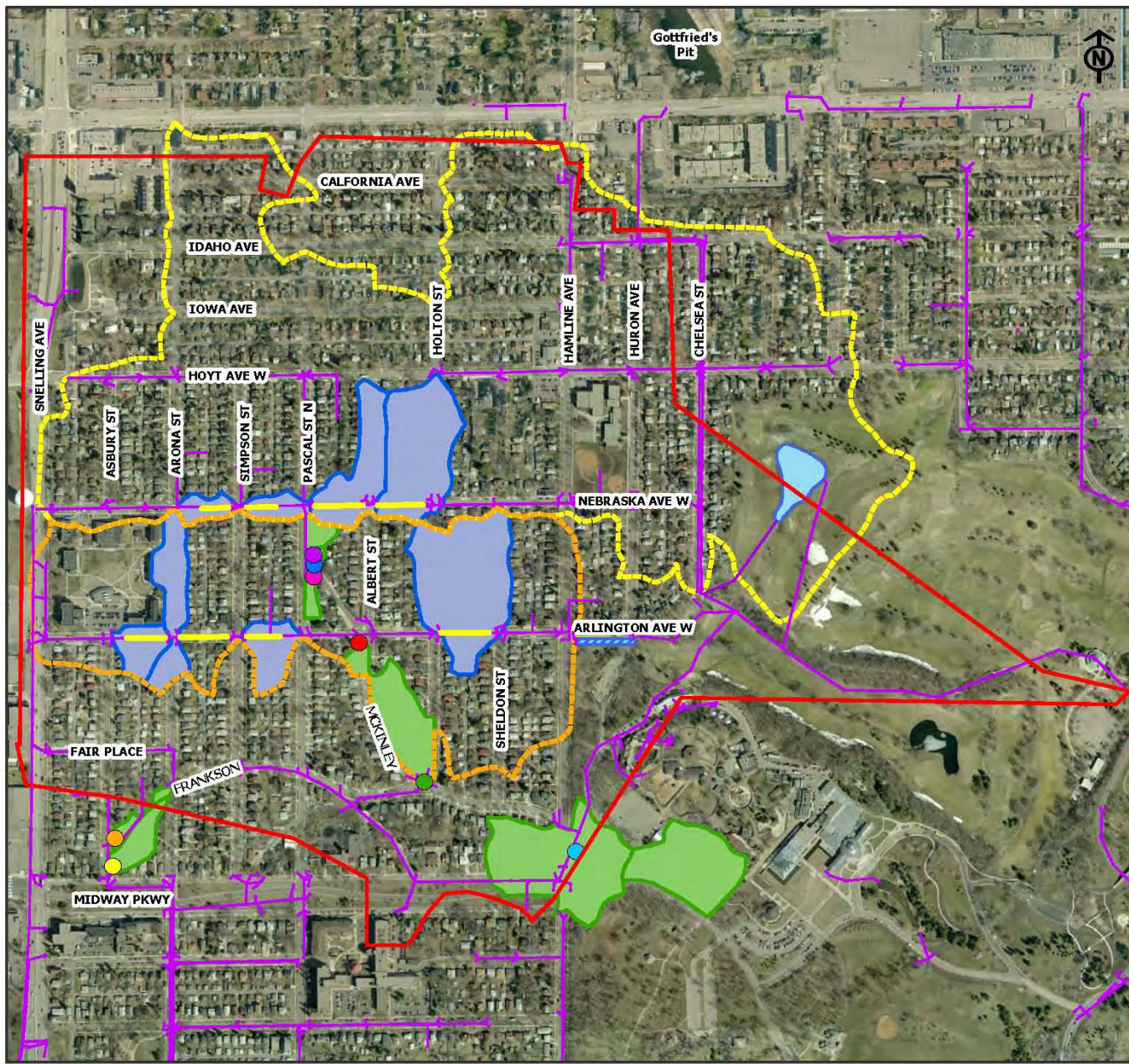
- Underground Stormwater Storage and Infiltration System (Arlington-Hamline Facility)
- Regional Stormwater Pond (Como Park Regional Pond)
- 8 Underground Infiltration Trenches
- 8 Rain Gardens



Stormwater BMPs

- Treatment Train of BMPs
- Total Drainage Area: 190 Acres
- Combined Storage Area: 142,000 ft²
- Combined Storage Volume: 444,000 cf





Legend

- Como 7 Subwatershed Boundary
- Storm Sewer

BMP

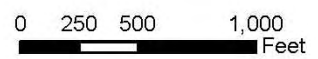
- Arlington-Hamline Facility
- Como Park Regional Pond
- Infiltration Trench

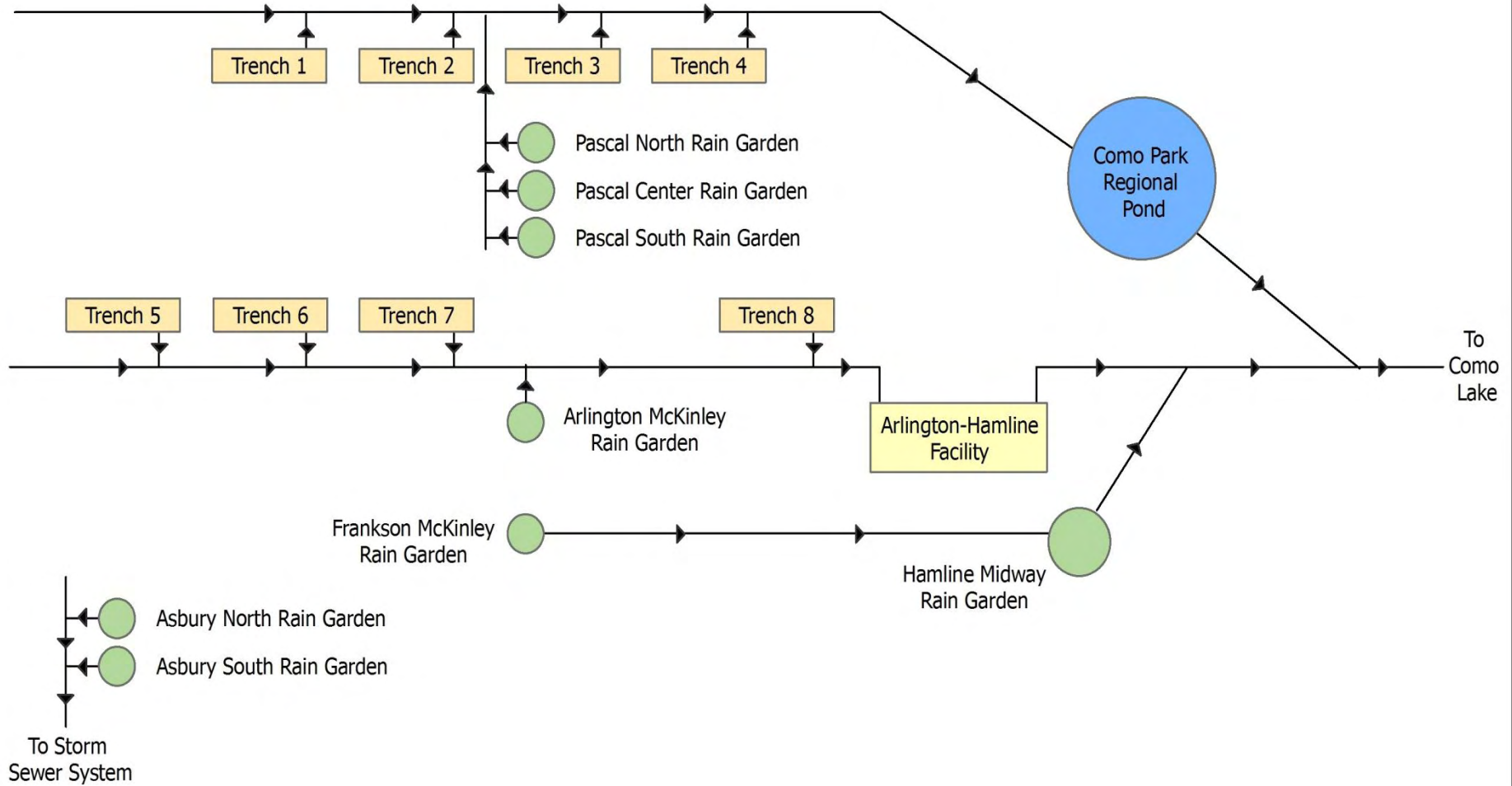
Rain Garden

- Arlington - McKinley
- Asbury North
- Asbury South
- Frankson - McKinley
- Hamline Midway
- Pascal Center
- Pascal North
- Pascal South

Drainage Area

- Arlington-Hamline Facility
- Como Park Regional Pond
- Rain Gardens
- Infiltration Trenches





Underground Stormwater Storage and Infiltration System (Arlington-Hamline Facility)

- Total Capital Cost: \$799,000
- Storage Volume: 86,000 cf
- Drainage Area: 50 Acres
- 849 Feet of 10-Foot Diameter, Corrugated, Perforated Metal Pipes
- Vortech[®] Serves as a Pretreatment Unit
- Began Operation: Fall 2006



Como Park Regional Pond

- Total Capital Cost: \$1,364,000
- Storage Volume: 302,000 cf
- 128 Acres Direct Drainage Area
- **Also Receives Discharges From Gottfried's Pit in Roseville (540 Acres)**
- Began Operation: December 2007



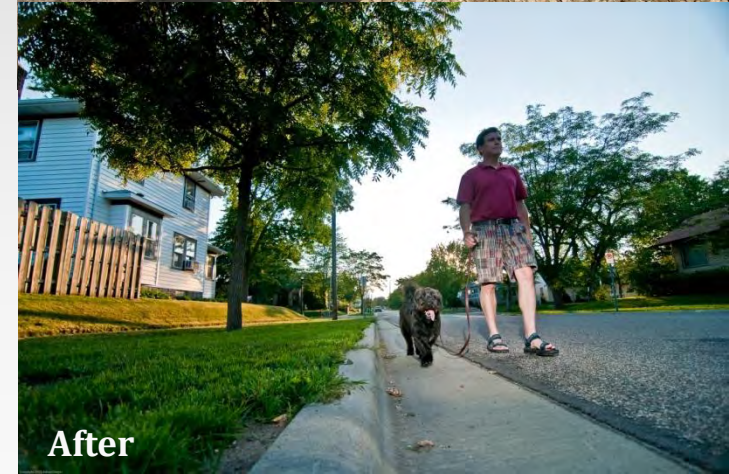
Normal Water Level



High Water Level

Underground Infiltration Trenches

- Total Capital Cost: \$400,000
- Combined Storage Volume: 37,000 cf
- Combined Drainage Area: 23 Acres
- Comprised of an Aggregate Backfill with 2, 10-Inch Perforated Pipes
- 30 Sumped Catch Basins and 16 Sumped Manholes
- Began Operation: June 2007



Rain Gardens

- 
- **Total Capital Cost: \$160,000**
 - **Combined Storage Volume: 19,000 cf**
 - **Combined Drainage Area: 16 Acres**
 - **All Rain Gardens Were Operational in 2007**

BMP Stormwater Monitoring



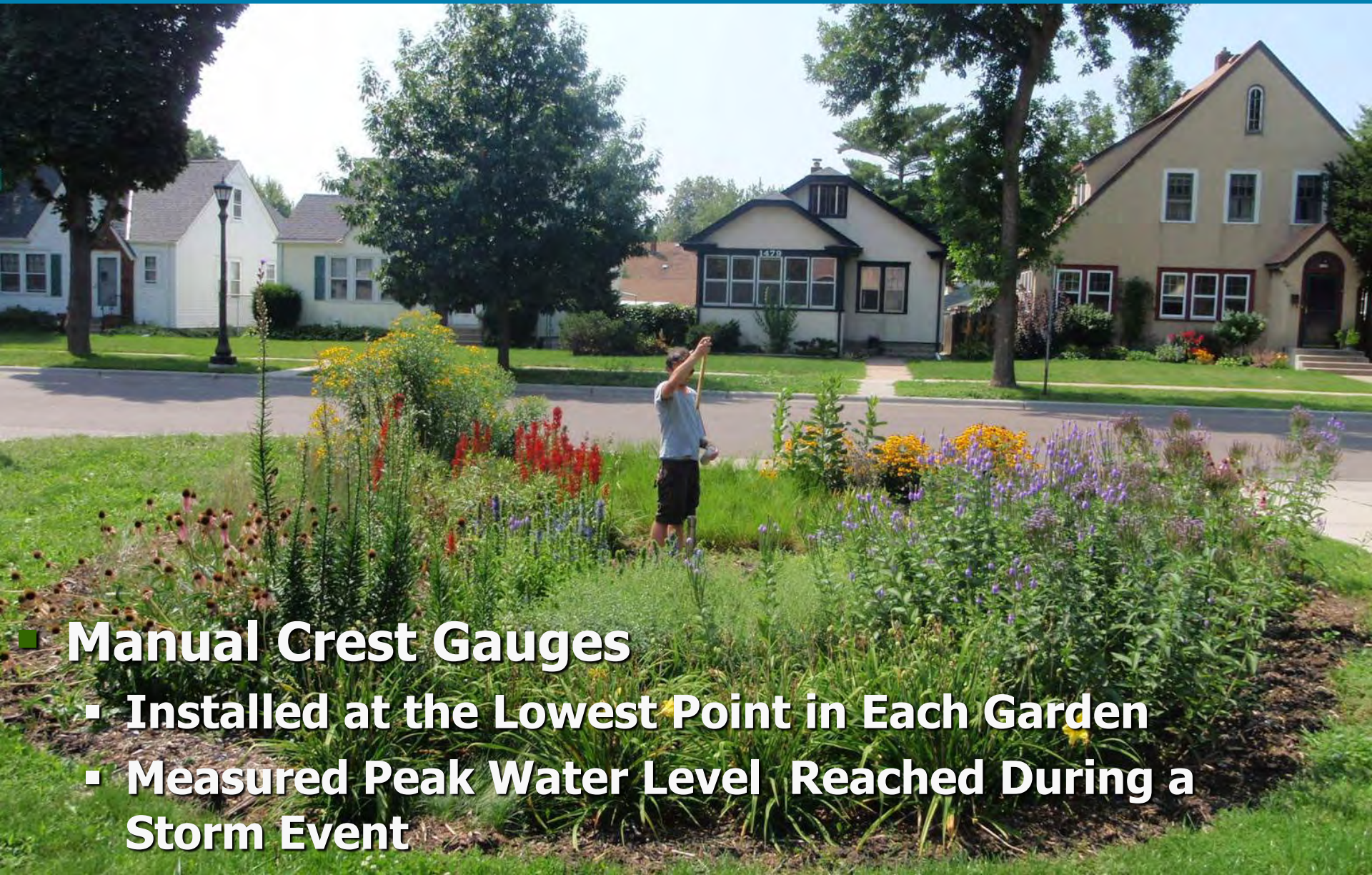
- Since 2007:
 - Arlington-Hamline Facility
 - 2 Infiltration Trenches (Trenches 4 and 5)
 - 8 Rain Gardens
 - Como Park Regional Pond (Monitoring Began in 2008)

BMP Monitoring Methods

- Inlet and Outlet (except Rain Gardens)
 - Continuous Water Level and Flow Recorded
 - Water Quality Samples Collected During Storm Events
- For Each Storm Event and Monitoring Season:
 - Determined Total Flow and Calculated Total Phosphorous (TP) and Total Suspended Solids (TSS) Loads
- Also Determined Total Solids Loads Removed



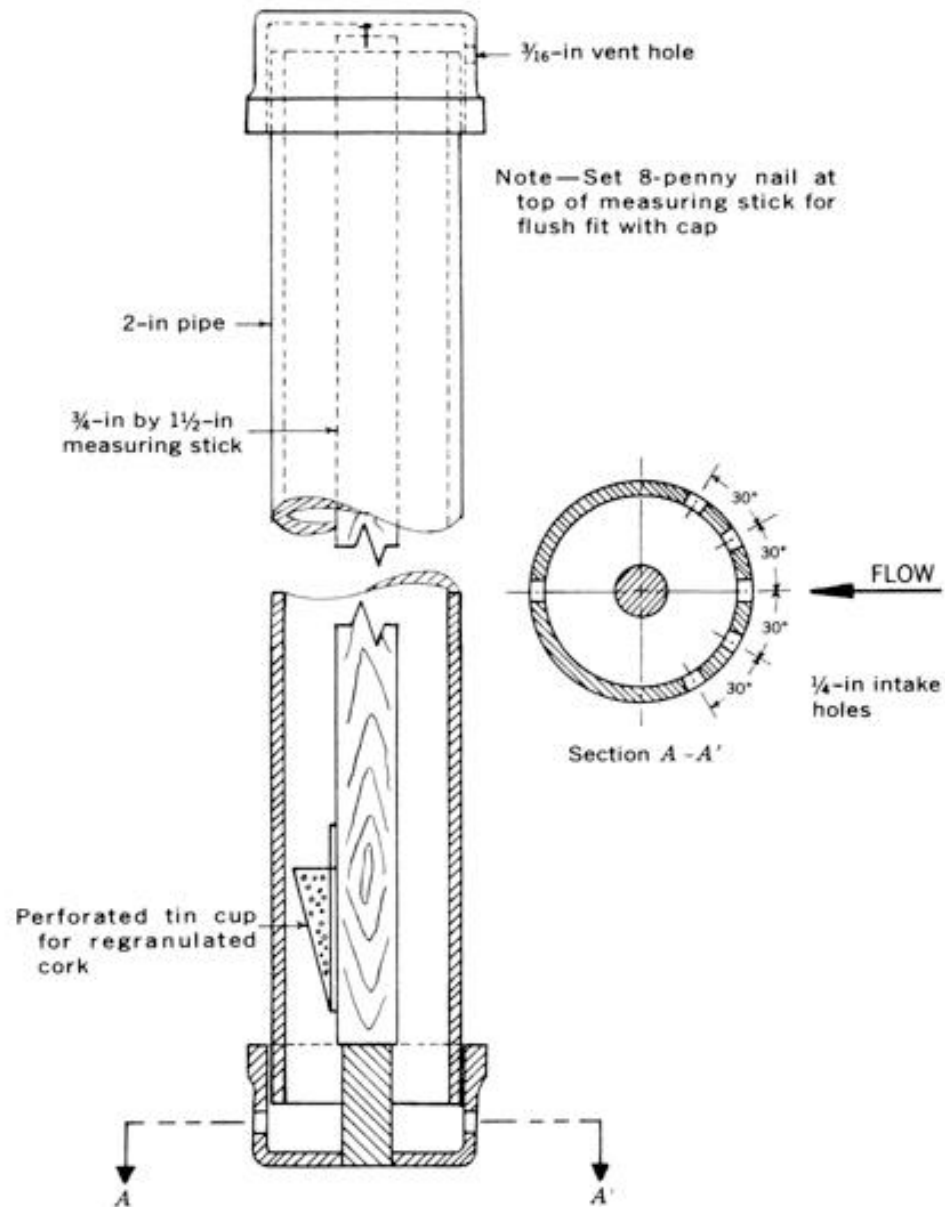
Rain Garden Monitoring



- **Manual Crest Gauges**

- **Installed at the Lowest Point in Each Garden**
- **Measured Peak Water Level Reached During a Storm Event**

Crest Gauge



Total Solids Load

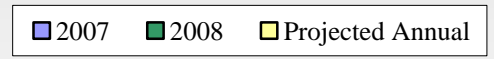
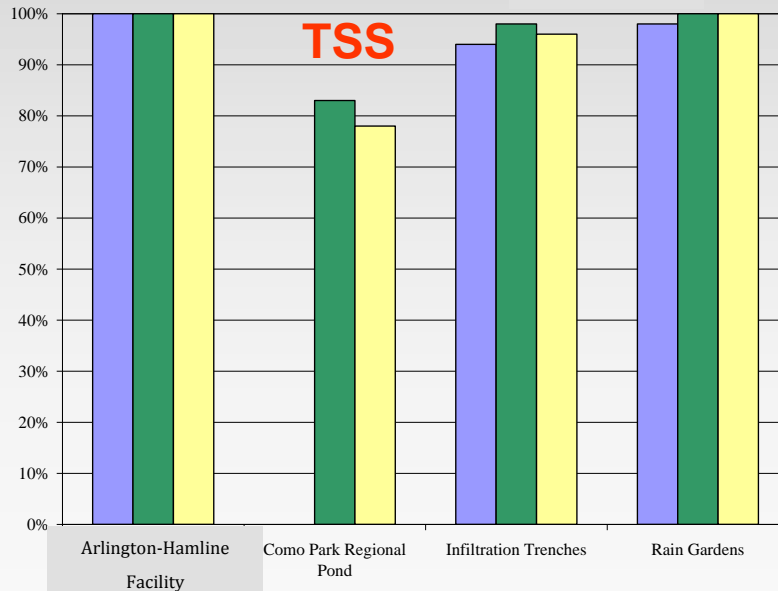
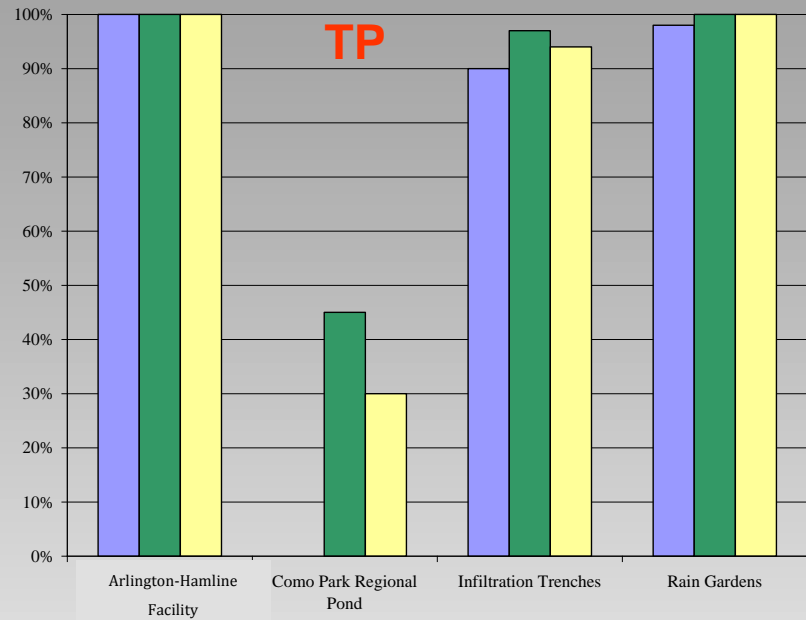
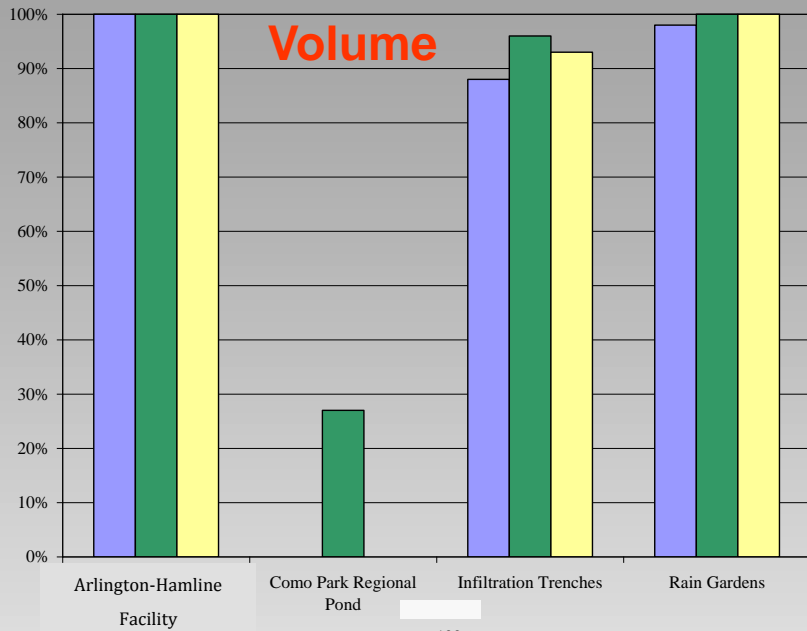
- Sum of:
 - Total TSS Load Removed by BMP
 - **Gross Solids** Captured by BMP
 - **Gross Solids** Captured by Pretreatment Units
- * **Gross Solids** are Particles Larger than Suspended Size (Debris Such as Floatables, Organic Matter, and Sediment).
- Gross Solids were **Measured** in Pretreatment Units for Arlington-Hamline Facility and Trenches
- Gross Solids Captured by Rain Gardens and Como Park Regional Pond Were **Estimated**



P8 Model

- P8 Urban Catchment Model
 - Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds (William W. Walker, Jr. PhD)
- Simulated the Performance of Each BMP over an Entire Year
 - Total Discharge and TP and TSS Loads
- Calibrated Using Actual Precipitation Data and BMP Monitoring Data
- Annual Results for 2007, 2008, and an Average Precipitation Year (Projected Annual)

Removal Efficiencies



BMP Operation and Maintenance

- Developed Inspection and Maintenance Protocols
- Documented Activities Using Electronic Field Forms
 - BMP, Activity, Staff, Time
- Staff Labor Rates Determined and Used to Calculate Labor Costs of Each Activity
- Determined Annual Operation and Maintenance Costs



BMPs Maintained

Since 2007:

- Arlington-Hamline Facility
 - Vortech[®] Unit
- 8 Infiltration Trenches
 - 30 Sumped Catch Basins
 - 16 Sumped Manholes
- 8 Rain Gardens
- Como Park Regional Pond (Became Operational in 2008)

Arlington-Hamline Facility O&M

Routine O&M:

- Pipe Gallery Inspections
- Vortech[®] Sediment Inspections
- Manhole Sediment Inspections
- Debris Removal From Vortech[®] Unit

Future O&M:

- Debris Removal From Pipe Gallery



Como Park Regional Pond O&M

Routine O&M:

- Sluice Gate and Gate Valve Maintenance
- Debris Removal From Pond Perimeter and Outlet Structure
 - Completed by City of St. Paul Parks & Rec

Future O&M:

- Bathymetric Survey of Pond
- Debris Removal From Pond (Dredging)



Infiltration Trenches

Routine O&M:

- Manhole and Catch Basin Sediment Inspections
- Post-Rain Trench Infiltration Inspections
- Debris Removal From Sumped Catch Basins and Manholes
- Catch Basin Hood Inspections and Gasket Replacement

Future O&M:

- Jet Out and Remove Debris Accumulated in Perforated Pipes



Rain Gardens



Routine O&M:

- Monthly Inspections
- Post-Rain Inspections
- Maintenance
 - Mulching, Weeding, Mowing, Leaf Removal

Annual O & M: Costs & Hours

- Total Cost of Labor + Equipment and Materials + Contract Services

	2007		2008		Projected Annual O & M Cost
	O & M Cost	Hours	O & M Cost	Hours	
Arlington-Hamline Facility	\$531	13	\$2,025	14	\$2,867
Como Park Regional Pond	NA	NA	\$6,558	78	\$4,550
Infiltration Trenches	\$5,509	138	\$12,405	88	\$12,339
Rain Gardens	\$14,851	640	\$7,544	406	\$5,803
APSIP Total:	\$20,891	791	\$28,532	585	\$25,559

Cost-Benefit Analysis

- **Volume Reduction and Pollutant Removal Costs (\$/cf, \$/lb)**
 - **Annual Operating Cost / Volume or Pollutant Reduction**

Reference Document:

A Public Works Perspective Regarding Cost vs. Benefit for Various Stormwater Best Management Practices (BMPs) Utilized to Manage Stormwater

(Minnesota Public Works Association, 2007)

Annual Capital Costs

- Total Capital Cost Amortized Over 35 Years

	2007	2008	Projected Annual
Arlington-Hamline Facility	\$24,605	\$24,605	\$24,605
Como Park Regional Pond	NA	\$38,981	\$38,981
Infiltration Trenches	\$11,430	\$11,430	\$11,430
Rain Gardens	\$4,578	\$4,578	\$4,578
APSIP Total:	\$40,614	\$79,595	\$79,595

*Total Capital Cost = Construction + Design + Bond Interest

Annual Operating Costs

- Sum of Annual O & M Cost and Annual Capital Cost

	2007	2008	Projected Annual
Arlington-Hamline Facility	\$25,136	\$26,630	\$27,473
Como Park Regional Pond	NA	\$45,539	\$43,531
Infiltration Trenches	\$16,939	\$23,835	\$23,769
Rain Gardens	\$19,429	\$12,122	\$10,381
APSIP Costs:	\$61,505	\$108,127	\$105,154

Volume Reduction and Pollutant Removal Costs

- **Volume Reduction Costs** = Annual Operating Cost (\$) / Volume Reduction (cf)
- **Pollutant Removal Costs** = Annual Operating Cost (\$) / TP or Total Solids Load Removed (lbs)

		Arlington-Hamline Facility	Como Park Regional Pond	Infiltration Trenches	Rain Gardens
Annual Operating Cost	2007	\$25,136	NA	\$16,939	\$19,429
	2008	\$26,630	\$45,539	\$23,835	\$12,122
	Projected	\$27,473	\$43,531	\$23,769	\$10,381
TP Removal Cost (\$/lb)	2007	\$1,007	NA	\$1,126	\$3,494
	2008	\$2,517	\$888	\$2,221	\$4,329
	Projected	\$1,828	\$714	\$1,909	\$2,791
Total Solids Removal Cost ^a (\$/lb)	2007	\$0.36	NA	\$0.22	\$0.37
	2008	\$0.55	\$0.23	\$0.61	\$0.46
	Projected	\$0.54	\$0.21	\$0.60	\$0.39
Volume Reduction Cost (\$/cf)	2007	\$0.03	NA	\$0.02	\$0.06
	2008	\$0.07	\$0.02	\$0.03	\$0.07
	Projected	\$0.05	NA	\$0.03	\$0.04

Conclusions

- Monitoring is important
- Properly **designed**, **constructed**, and **maintained** BMPs are exhibiting high removal efficiencies
- BMPs are performing as or better than expected
- Volume reduction and pollutant removal costs are largely affected by volume and pollutant load reductions
- Pond had the lowest removal costs
- Continue research
- Pretreatment units are very beneficial

Questions

Stormwater BMP Performance Assessment and Cost-Benefit Analysis

Report is available online at:

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