



Outline

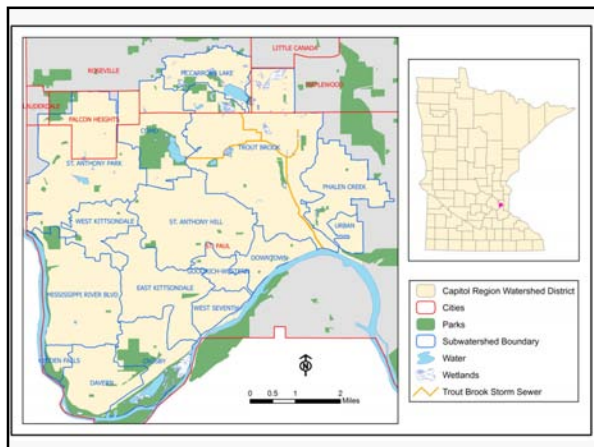
- **Background**
- Model Results
- Operation and Maintenance (O & M) Results
- Cost-Benefit Analysis Results
- Conclusions

Background

- Capitol Region Watershed District (CRWD)
- BMP Project Area
- BMPs
- BMP Stormwater Monitoring
- P8 Model
- BMP Operation and Maintenance

Capitol Region Watershed District

- 41 Square Miles
- 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 in the Como 7 and Adjacent Subwatersheds
 - Address Needed Storm Sewer Improvements
 - Improve Water Quality by Reducing the Amount of Phosphorous Discharging to Como Lake
 - Determine Equitable Distribution of Costs

Map showing the Arlington Pascal Stormwater Improvement Project area. The Como 7 Subwatershed is highlighted in green. The map includes a legend, a scale bar (0, 0.5, 1, 2 miles), and an inset map of Minnesota.

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

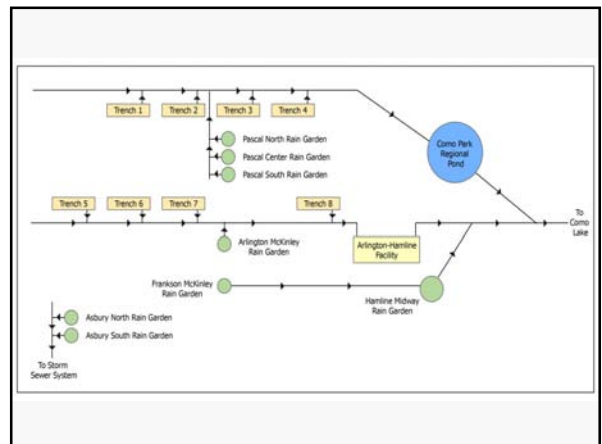
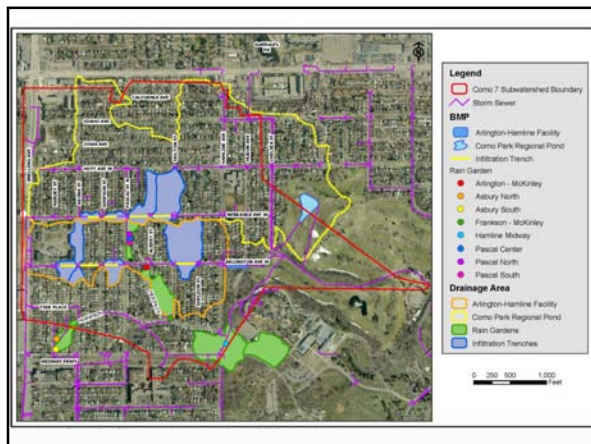
Stormwater BMPs Constructed

- 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: 141,553 ft²
- Combined Storage Volume: 444,390 cf



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

- Total Capital Cost: \$799,000
- Storage Volume: 85,813 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



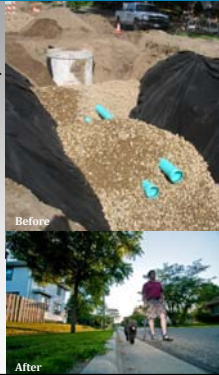
Como Park Regional Pond

- Total Capital Cost: \$1,364,000
- Storage Volume: 301,871 cf
- 128 Acres Direct Drainage Area
- Also Receives Discharges From Gottfried's Pit in Roseville (540 Acres)
- Began Operation: December 2007



Underground Infiltration Trenches

- Total Capital Cost: \$400,000
- Combined Storage Volume: 37,352 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 Serve as Pretreatment Units
- Began Operation: June 2007



Rain Gardens

Total Capital Cost: \$160,000
Combined Storage Volume: 19,354 cf
Combined Drainage Area: 16 Acres
All Rain Gardens Were Operational in 2007



BMP Stormwater Monitoring



- 2007 & 2008
 - Arlington-Hamline Facility
 - 2 Infiltration Trenches (Trenches 4 and 5)
 - 8 Rain Gardens
 - Como Park Regional Pond (2008 Only)

BMP Monitoring Methods

- Inlet and Outlet Monitored (except Rain Gardens)
 - Continuous Water Level and Flow Recorded Every 10 Minutes
 - 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

Total Solids Load

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



P8 Model

- Simulated the Performance of Each BMP over an Entire Year
 - Total Discharge and TP and TSS Loads
- Calibrated Using Actual Precipitation Data and 2008 BMP Monitoring Data
- Annual Results for 2007, 2008, and an Average Precipitation Year (Projected Annual)

BMP Operation and Maintenance

- Developed a Manual of 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
 - 2007, 2008, Projected Annual Year



BMPs Maintained

2007 & 2008

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

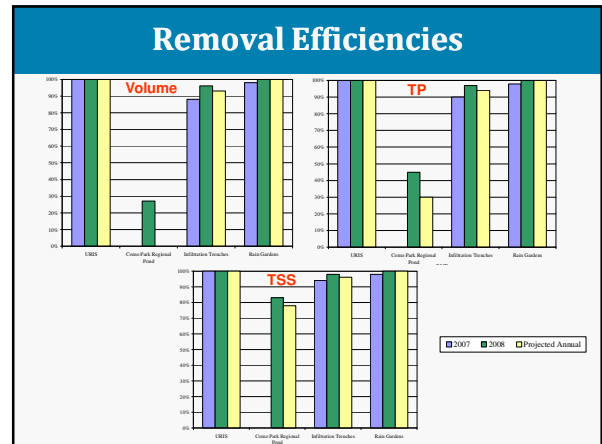
Model Results

- Volume Reduction and Pollutant (TP & TSS) Removal Efficiencies
- Total Solids Removal Results

Removal Efficiencies

		Arlington-Hamline Facility	Como Park Regional Pond	Infiltration Trenches	Rain Gardens
2007	Volume	100%	NA	88%	98%
	TP	100%	NA	90%	98%
	TSS	100%	NA	94%	98%
2008	Volume	100%	27%	96%	100%
	TP	100%	45%	97%	100%
	TSS	100%	83%	98%	100%
Projected Annual	Volume	100%	0%	93%	100%
	TP	100%	30%	94%	100%
	TSS	100%	78%	96%	100%

NA: Not Applicable



Total Solids Removal Results

		Arlington-Hamline Facility	Como Park Regional Pond	Infiltration Trenches	Rain Gardens
Subwatershed Area (acres)					
		50	128	23	16
Rainfall (in)		29.72	29.72	29.72	29.72
2007	Total Solids Load Removed (lbs)	70,142	NA	76,991	53,014
	Total TSS Load Removed: BMP	16,420	NA	6,605	3,089
	Settleable Solids Removed: BMP	28,130	NA	NA	49,925
	Settleable Solids Removed: Pretreatment Units	25,592	NA	70,386	NA
	Rainfall (in)	21.67	21.67	21.67	21.67
2008	Total Solids Load Removed (lbs)	48,159	197,932	39,144	26,122
	Total TSS Load Removed: BMP	5,869	30,175	4,158	1,309
	Settleable Solids Removed: BMP	28,130	167,757	NA	24,817
	Settleable Solids Removed: Pretreatment Units	14,160	NA	34,986	NA
	Rainfall (in)	26.02	26.02	26.02	26.02
Projected Annual	Total Solids Load Removed (lbs)	51,110	210,434	39,767	26,597
	Total TSS Load Removed: BMP	8,820	42,674	4,781	1,780
	Settleable Solids Removed: BMP	28,130	167,757	NA	24,817
	Settleable Solids Removed: Pretreatment Units	14,160	NA	34,986	NA
	Rainfall (in)	26.02	26.02	26.02	26.02

- ### Operation and Maintenance Results
- Inspection and Maintenance Activities
 - O & M Costs
 - 2007, 2008, Projected Annual
 - O & M Hours

Arlington-Hamline Facility

2007, 2008, and Projected Activities:

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

Projected Activities:

- Debris Removal From Pipe Gallery

Como Park Regional Pond

2008 and Projected Activities:

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

Projected Activities:

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

Infiltration Trenches

2007, 2008, and Projected Activities:

- 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

Projected Activities:

- Jet Out and Remove Debris Accumulated in Perforated Pipes



Rain Gardens



2007, 2008, and Projected Activities:

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

Annual O & M: Costs & Hours

- Annual O & M Cost = 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

- Annual Capital Costs
- Annual Operating Costs
- Volume Reduction Costs
- TP Removal Costs
- Total Solids Removal Costs

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* (\$/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

- BMP monitoring is important
- BMPs are performing as or better than expected
- Properly **designed, constructed, and maintained** BMPs are exhibiting high removal efficiencies
- Volume reduction and pollutant removal costs are largely affected by volume and pollutant load reductions
- Pond had the lowest removal costs
- Few studies which have this type of comprehensive analysis
- Continue research
- Pretreatment units are very beneficial

Questions

Stormwater BMP Performance Assessment and Cost-Benefit Analysis

Report is available online at:

www.capitolregionwd.org

