MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

STORMWATER RUNOFF REDUCTION PROGRAM
FINAL REPORT

MMSD CONTRACT W91004E03
FEBRUARY 28, 2007

THE APPLICATION OF STORMWATER RUNOFF REDUCTION BEST MANAGEMENT PRACTICES IN METROPOLITAN MILWAUKEE

Preserving The Environment • Improving Water Quality

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INTRODUCTION

Certain stormwater best management practices (BMPs) can help reduce stormwater runoff through increased infiltration, vegetation uptake, and detention of stormwater. Such practices have the potential to reduce stormwater impacts on the sewer systems, provide environmental benefits, and enhance public participation and education regarding stormwater management.

This report presents an evaluation of stormwater runoff reduction BMPs that may:

- Reduce stormwater runoff volume
- Reduce stormwater peak flow rates
- Improve water quality
- Enhance public education

The results of projects outlined in MMSD's Strategic Plan for Stormwater Runoff Reduction (July 2003) are summarized in this report. The strategic plan elements include:

1. Pilot projects to evaluate the application, costs, and effectiveness of BMPs.

2. A survey of BMP experience in other communities.

3. An audit of local codes and ordinances to identify any barriers to the use of BMPs, and to recommend ordinance revisions that would allow or perhaps promote, the BMPs.

4. A public education and outreach program to support public understanding of stormwater runoff reduction BMPs and to encourage public involvement.

A primary goal of the stormwater runoff reduction program was to provide data and information that assisted the 2020 facilities planning team in developing alternatives that reduce stormwater runoff and pollutant loadings from nonpoint sources. Specifically, the 2020 facilities plan required capital and operational costs, implementation and maintenance information, and an evaluation of the overall effectiveness of BMPs that reduce stormwater runoff and/or reduce nonpoint pollution loads.

Potential stormwater runoff reduction practices were evaluated and described in the Memorandum, *Evaluation of Stormwater Reduction Practices* (MMSD, March, 2003). The following 17 practices were part of this initial evaluation:

1. *Downspout Disconnection*—Disconnection of roof downspouts from sewers and conveyance of roof runoff to pervious land surfaces.

2. *Rain Barrels*— Collection of roof runoff in 50-100 gallon barrels, with subsequent release to landscaped areas.

3. *Cisterns*—Roof runoff collection systems that detain water in aboveground or underground storage tanks. Capacities range from several hundred to 10,000 gallons. Captured water may be reused for toilet, laundry, and lawn watering purposes.

4. *Rain Gardens*—Small (several hundred square feet) vegetated depressions used to capture runoff and promote infiltration and evapotranspiration.

5. *Green Roofs*—Soil and vegetation installed on top of a conventional flat or slightly sloped roof. A complete green roof system may include a watertight membrane, protective layer, insulation, irrigation/drainage system, filter layer, soil, and plants.

6. *Rooftop Storage*—Temporary storage of rainfall on a flat roof and the gradual release of this volume using restricted roof drain inlets.

7. *Green Parking Lots*—Various measures used to reduce the effective impervious area of a parking lot and promote infiltration and/or evapotranspiration.

8. *Stormwater Trees*—Increasing the coverage of tree canopies to provide stormwater interception and evapotranspiration, along with other ecological benefits.

9. *Porous Pavement*—The use of porous asphalt or concrete, modular block systems, grass pavers, or gravel pavers to allow stormwater to percolate through the 'pavement'.

10. *Inlet Restrictors/Pavement Storage*—Flow regulation devices that allow the temporary storage of stormwater on streets and parking lots.

11. *Bioretention*—Landscaped depressions planted with grass, shrubs, and/or trees. These often utilize a sand/gravel underdrain, mulch, and soil amendments.

12. *Onsite Filtering Practices*—Practices such as sand filters, bioretention cells, swales, and filter strips that use a filter media (sand, soil, gravel, peat, or compost) to reduce stormwater runoff and capture pollutants.

13. *Pocket Wetlands*—Small constructed wetlands that can reduce peak flows and runoff volumes, and remove pollutants via settling and bio-uptake.

14. *French Drains and Dry Wells*—Gravel-filled trenches (horizontal are french drains, vertical are dry wells) used to capture roof runoff and allow it to percolate into the soil.

15. *Infiltration Sumps*—Below ground, perforated, cylindrical, concrete structures used to collect stormwater and allow it to percolate into the soil.

16. *Compost Amendments*—Incorporating decomposed organic material into the soil to improve performance for infiltration and vegetation.

17. *Stormwater Rules and Redevelopment Policies*—Land development and stormwater management criteria and requirements, including the Chapter 13 Surface and Stormwater Regulations.

The stormwater runoff reduction practices were evaluated for the following factors:

- Flow impacts
- Environmental impacts
- Implementation issues
- Function
- Operational maintenance
- Potential to promote public involvement and awareness
- Costs

The memorandum provides a summary of these comparisons. Charactieristics of these BMPs are summarized in Tables 1 and 2. Each practice has a range of benefits and has been successfully implemented nationally and internationally; however, certain practices are better suited to the specific conditions found within the MMSD service area. This report focuses on those BMPs that are economically feasible, that can be implemented on a wide-scale basis, that have reasonable maintenance needs, and that are able to provide both water quality and volume/peak discharge reduction benefits.

Table 1
Evaluation of Stormwater Reduction BMPs

Stormwater Reduction Practice	Flow					Environmental		Implementability							Function			Operation and Maintenance Needs	Environmental Awareness
	Delays Runoff	Reduces Runoff Volume	Reduces Peak Flow	Increases Infiltration	Effective In Major Storms	Water Quality Protection	Ecology/ Habitat Improvement	Public Acceptance	Public Education Needed	Financial Incentive Needed	Sensitive to Proper Operation	Opportunity for Partnership	Applicability	Limitations	Plant Uptake	Infiltration	Storage		
1. Downspout Disconnection	Yes	Yes	Yes	Yes	Yes	Yes	No	Good	Yes	Yes	No	Yes	CSSA only.	Interior downspouts. House foundations. Basement flooding. Safety / ice concerns.	●	●		Low. Inspections.	Good. Residential / neighborhood.
2. Rain Barrels	Yes	Yes	Yes	Maybe	No	Maybe	No	Good	Yes	Yes	Yes	Yes	Residential.	Mosquitos. Small lots. House foundations. Winter.	●	●	●	Moderate. Must be emptied. Winter storage. Check fittings and connections.	Very good. Residential.
3. Cisterns	Yes	Yes	Yes	Maybe	Yes	Maybe	No	Fair / Poor	Yes	Yes	Yes	Yes	Residential. Commercial. Industrial.	May reuse water (potential: laundry, toilet, outdoor uses). Winter.			●	Moderate. Check connections and fittings. Disconnect / empty in winter.	Average.
4. Rain Gardens	Yes	Yes	Yes	Yes	No	Yes	Yes	Good	Yes	Maybe	Yes	Yes	Residential and light commercial / industrial.	Land availability. Unsuitable soils.	●	●		Moderate. Plant upkeep. Weed control. Occasional watering.	Very good. Residential/community.
5. Green Roofs	Yes	Yes	Yes	No	Maybe	Yes	Yes	Fair	No	Yes	Yes	Yes	Flat roofs (subject to limitations). Industrial. Commercial.	Load- bearing capacity. Moisture and root penetration resistance.	●	●	●	Moderate. Plant upkeep and maintenance of roof structure. More maintenance than a conventional roof.	Good. Institutions/commercial/industrial.
6. Rooftop Storage	Yes	Maybe	Yes	No	Yes	No	No	Good	No	No	No	Yes	Commercial, industrial, and institutional flat roofs.	Load-bearing capacity. Waterproofing. Mosquitos.			●	Low.	Good.
7. Green Parking Lots	Yes	Yes	Yes	Yes	Maybe	Maybe	Yes	Good	Yes	No	No	Yes	Commercial, industrial, institutional.	Open space: Suitable soil.	●	●		Moderate. Maintain vegetation.	Good public display.
8. Stormwater Trees	Yes	Yes	Yes	Yes	Maybe	Maybe	Yes	Good	Yes	Yes	No	Yes	Most pervious areas, and in planters.	Pervious open space.	●	●		Moderate. Routine tree maintenance and watering.	Good for community group participation.
9. Porous Pavement	Yes	Yes	Yes	Yes	Yes	Yes	No	Fair	Yes	Maybe	Yes	Yes	Low traffic areas and parking lots. Sidewalks.	Winter freeze/thaw.		●		High. High maintenance and cleaning needed to prevent clogging. Monthly vacuuming and power washing 1-2 times/year.	Good.
10. Inlet Restrictors/ Pavement Storage	Yes	No	Yes	No	Yes	No	No	Poor	Yes	No	No	No	Streets with flat grades, low traffic, and curbs and berms to impound water. Residential feeder streets.	Safety. Street access.			●	Low. Minimal.	Average. Maybe good for municipal recognition.

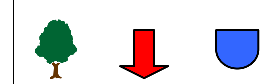
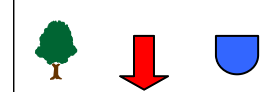
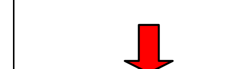
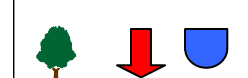
Stormwater Reduction Practice	Flow					Environmental		Implementability							Function			Operation and Maintenance Needs	Environmental Awareness
	Delays Runoff	Reduces Runoff Volume	Reduces Peak Flow	Increases Infiltration	Effective In Major Storms	Water Quality Protection	Ecology/ Habitat Improvement	Public Acceptance	Public Education Needed	Financial Incentive Needed	Sensitive to Proper Operation	Opportunity for Partnership	Applicability	Limitations	Plant Uptake	Infiltration	Storage		
11. Bioretention	Yes	Yes	Yes	Maybe	Maybe	Maybe	Yes	Good	No	No	No	Yes	Open land areas. Well-drained soils (or w/ under drain).	Land availability. Unsuitable soils.				Low. Vegetation upkeep – mowing, removal of invasive species, replanting, removal of debris, and erosion control.	Average.
12. On-site Filtering Practices	Yes	Yes	Yes	Yes	Maybe	Yes	Maybe	Fair	Yes	Yes	Yes	Yes	Small drainage areas.	No steep slopes. Risk of clogging. Standing water.				High. Inspections and cleaning to prevent clogging.	Average.
13. Pocket Wetlands	Yes	Yes	Yes	No	Yes	Yes	Yes	Fair/Poor	No	No	No	Yes	Parking lots. Small sites.	Supplemental irrigation. Site requirements. Mosquitos. Winter & salt.				Low. Sediment removed. Invasive species.	Good.
14. French Drains and Dry Wells	Yes	Yes	Yes	Yes	Maybe	Yes	No	Poor	Yes	No	No	Yes	Small drainage areas. Residential.	Permeable soils. Adequate depth to gw. Clean water.				Low. Annual training. Replace rock and clean out sediment	Average.
15. Infiltration Sumps	Yes	Yes	Yes	Yes	Maybe	Yes	No	Fair	No	No	No	No	Residential areas < 50% impervious. Placed in rights of way of smaller streets.	Permeable soils. Adequate depth to gw.				Low. Clean out sumps every 2-3 years. Every year inspection.	Average.
16. Compost Amendments	Yes	Yes	Yes	Yes	No	Yes	Maybe	Fair	Yes	Yes	No	Yes	Highly compacted soils with low organic matter and nutrients.	Temporarily disturbs vegetative cover.				Low. None.	Average.
17. Stormwater Rules and Redevelopment Policies	Yes	Yes	Yes	Maybe	Yes	Yes	Maybe	Fair	No	No	No	No	New development and redevelopment.	Prescriptive. Rigid criteria.				Low. None.	Average.

Table 2
Cost Effectiveness of Stormwater Reduction BMPs

Stormwater Reduction Practice	Capital Cost	$/Impervious Acre Served (min)	$/Impervious Acre Served (max)	Vol of Runoff/ Imp Ac [gal]	$/gal (min)	$/gal (max)	Assumptions
1. Downspout Disconnection	$50 to $250/downspout.	$4,400	$21,800	12,938	0.34	1.68	Each downspout disconnection drains 500 square feet of roof.
2. Rain Barrels	$150/each rain barrel.	$13,100	--	10,345	1.27	NA	Each rain barrel drains 500 square feet of roof and captures 0.4".
3. Cisterns	$1,000 (500 gallon) to	$43,600	--	19,400	2.25	NA	500-gallon cistern drains 1,000 square feet of roof for 0.75" rain. Two 6,500 gal can capture 1". Water re-use may reduce water supply costs.
	$5,000 (6,500 gallon underground).	$10,000	$20,000	12,938	0.77	1.55	
4. Rain Gardens	$5 to $10/square foot.	$21,800	$43,600	25,875	0.84	1.69	100 square foot rain garden drains 1,000 square feet of roof.
5. Green Roofs	$15/square foot of roof $8/sq ft (net)	$348,480	$653,400	12,938	26.93	50.50	Complete green roof system includes watertight membrane, protective layer, insulation, drainage system, filter layer, soil, and plants.
6. Rooftop Storage	$100/drain restrictor. $5/square foot waterproofing.	$4,356	$222,200	25,875	0.17	8.59	One restrictor per 1,000 square feet of roof. Waterproof entire roof.
7. Green Parking Lots	$200/tree pit. $13,000-$30,000/acre bioretention. $2/square foot turf pavers.	$10,000	$11,700	25,875	0.39	0.45	10% of parking lot area is bioretention, and 10% is turf paved.
8. Stormwater Trees	$200 - $340/tree	$27,800	$47,260	22,869	1.22	2.07	Each acre of trees receives drainage from one impervious acre. $670 per residential acre; $3,300 per commercial/industrial acre. Street trees assume 20' diam. canopy/tree (314 sq ft).
9. Porous Pavement	$2-$4/square foot.	$81,700	$174,000	25,875	3.16	6.72	Lower cost is turf or gravel paver; higher cost is porous asphalt or concrete.
10. Inlet Restrictors / Pavement Storage	$400-$1,200 per restrictor.	$450	$1,350	54,450	0.01	0.02	Each inlet restrictor serves 1.5 acres @ 60% impervious.
11. Bioretention	$13,000-$30,000/acre.	$6,500	$15,000	25,875	0.25	0.58	Each bioretention acre drains two impervious acres.
12. On-site Filtering	Swales: $3,500/5-acre residential site.	$1,200	--	25,875	0.05	NA	Swales: 5-acre 60% impervious residential site.
	Sand filter: $35,000-$75,000/5-ac commercial site.	$8,700	$18,700	25,875	0.34	0.72	Sand Filters: 5-acre 80% impervious commercial site.
	Filter Strips: $13,000-$30,000/acre.	$2,600	--	25,875	0.10	NA	Filter Strips: Each acre of filter strip serves 5 impervious acres.
13. Pocket Wetlands	$60,000/acre/foot.	$16,000	--	25,875	0.62	NA	0.5 acre, 3-foot deep pocket wetland serves 5 acres, ½ of which is impervious.
14. French Drains and Dry Wells	French drain: $15-$17 linear foot.	$26,136	$29,621	12,938	2.02	2.29	Each dry well drains 500 square feet of roof.
	Dry Well: $900 to $1,400/each.	$78,400	$122,000	12,938	6.06	9.43	
15. Infiltration Sumps	$5,000 to $10,000 per sump.	$5,500	$11,000	25,875	0.21	0.43	Each sump serves 1.5 acres @ 60% impervious.
16. Compost Amendments	$1-$2/square foot.	$21,800	$43,600	12,938	1.68	3.37	Each acre of compost amended soil drains two impervious acres.

Notes:
Volume of runoff per impervious acre based on assumption that practices treat between 0.4 and 1.0 inches, depending on practice. WQv = (Rv)(A)(P), where Rv is runoff coefficient and equal to 0.95 assuming 1 ac of imp surface.
1" yields (0.95)(43560 sq ft)(1"/12)(7.5 gal/cu. ft.) = 25,875 gal
0.75" yields (0.95)(43560 sq ft)(0.75"/12)(7.5 gal/cu. ft.) = 19,400 gal
0.5" yields (0.95)(43560 sq ft)(0.5"/12)(7.5 gal/cu. ft.) = 12,938 gal
0.4" yields (0.95)(43560 sq ft)(0.4"/12)(7.5 gal/cu. ft.) = 10,345 gal
Street tree assumptions are based on installed costs of b/w $200-$340 per tree, rainfall interception of 0.525 gal/sq ft (22,869 gal per canopy ac) , and average canopy per tree of 314 sq ft (139 trees per canopy acre).
Inlet restrictor assumes 0.75' depth at gutter, 0% longitudinal street slope, and 7260 cu ft of runoff.

The impact of selected BMPs on average annual stormwater runoff volumes and peak flows during historic storm events that resulted in combined sewer overflows was evaluated by Camp Dresser & McKee (CDM). CDM built baseline models for typical five to six acre residential and commercial city blocks, and then modified those models to reflect the application of various BMPs. Continuous simulation modeling was conducted for the period of 1995 through 2002 using Hydrologic Simulation Program Fortran (HSPF). The model runs were used to estimate percent reductions in flow volumes and peak flows from the baseline condition.

The modeled BMPs are listed in Table 3. A total of 11 BMPs were evaluated—some in combination with other BMPs. Model runs were performed for the combined sewer system and the separate sanitary sewer system.

Table 3
BMPs Modeled with HSPF

Residential	Commercial
Downspout Disconnection	Green Roof
Rain Barrels	Roof Storage
Rain Garden	Bioretention
Compost Amendments	Green Parking Lot
Porous Pavement	Cisterns
Stormwater Trees	

Source: CDM

Within the combined sewer system, BMPs in residential areas were estimated to reduce combined sewer overflow (CSO) volumes by 12 to 38 percent, and peak flows during major events by 5 to 36 percent. Within commercial areas, BMPs may reduce CSO volumes by 22 to 76 percent, and peak flows by 13 to 69 percent. Simulated volume reductions for specific BMPs are listed in Table 4.

Table 4
Simulated CSO Volume Reductions

Stormwater BMP	CSO (MG/yr)	Percent Reduction
Residential Baseline	0.28	--
Downspout Disconnection	0.25	12%
Rain Barrel	0.24	14%
Rain Garden	0.18	36%
Rain Garden & Rain Barrel	0.17	38%
Commercial Baseline	1.17	--
Green Roof	0.91	22%
Bioretention	0.35	70%
Green Parking Lot	0.28	76%

Source: CDM

These performance estimates are based on full (100 percent) implementation of the BMPs. Figures 1 and 2 show the impact of various levels of implementation of rain gardens (along with disconnected downspouts) on CSO volumes and the portion of the combined sewer inflow that would be treated at a wastewater treatment facility.

Figure 1
Effect of Rain Gardens on Combined Sewer Overflow Volume

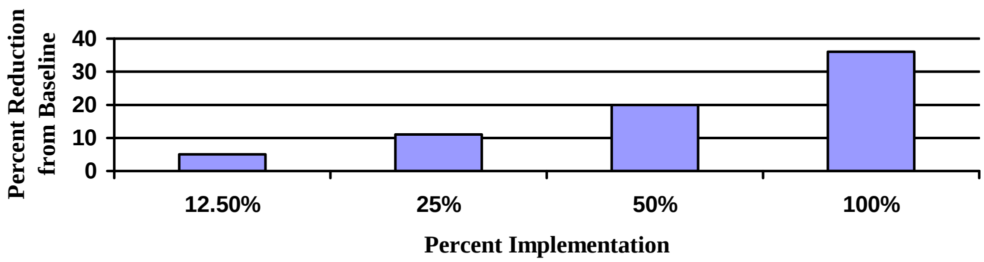
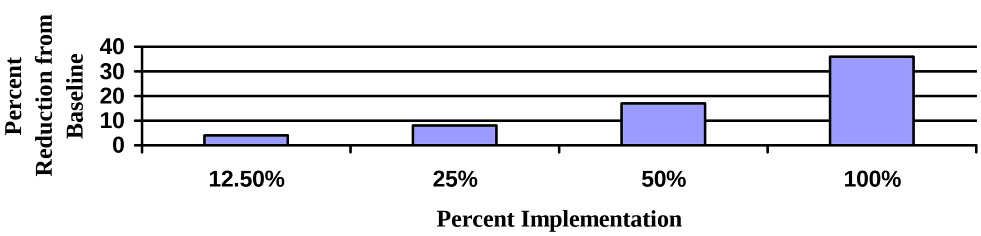


Figure 2
Effect of Rain Gardens on the Treated Portion of Combined Sewer Inflow



The modeling results indicated that within residential areas, rain gardens and rain barrels—combined with downspout disconnection—could effectively reduce CSO volumes. Within commercial areas, green roofs, bioretention, and green parking lots (which include porous pavement) could provide significant benefits. However, widespread implementation of the BMPs would be necessary to provide meaningful benefits.

The pilot project element consists of:

1. BMP Partnership Pilot Projects
2. Menomonee Central Valley Planning
3. Shorewood Wet Weather Flow Volume and Peak Management Project
4. Milwaukee Downtown Downspout Disconnection Project
5. BMP Construction Criteria Projects
6. Urban Open Space Foundation
7. South Shore Beach Stormwater Treatment
8. South Shore Park Watch Neighborhood Demonstration
9. Cambridge Woods Neighborhood Association – Cleaning Rainwater on Site

The pilot projects help demonstrate the application, implementation, effectiveness, and cost of selected BMPs.

Table 5 presents the elements of each of the pilot projects.

Table 5
Pilot Project Elements

	BMP				
Project	**Installation**	**Plan**	**Study**	**Education**	**Monitoring**
ARCCP Rain Gardens	X			X	X
Great Lakes Water Institute Green Roof	X			X	X
Johnson's Park Low Impact Development		X			
Menomonee Valley Stormwater Park		X		X	
Educational Signage for Trinity Creek Constructed Wetlands				X	
Highland Gardens Rain Barrel Installation	X			X	
Urban Ecology Center Green Roof	X			X	X
Pervious Parking Lot and Rain Garden	X			X	X
Menomonee Valley Bioretention Facility	X			X	X
Miller Brewing Co. Rain Garden and Bioretention Swale	X			X	X
Stormwater Management Initiative for Walnut Way	X	X		X	
Milwaukee County Zoo Green Roof	X			X	X

Project	BMP			Education	Monitoring
	Installation	Plan	Study		
Vineyard Terrace Residential Neighborhood Low Impact Development Designs		X		X	
MSOE Pervious Parking Project	X			X	X
City of Greenfield Wetland Detention Basin	X			X	X
UWM Green Parking Lot Design		X	X	X	
Vineyard Terrace Development Bioretention System and Cistern	X			X	X
Residential Action in Neighborhoods (RAIN)	X			X	X
Josey Heights Green Pavement – Phase I	X			X	X
Menomonee Central Valley Planning		X	X	X	
Shorewood Wet Weather Flow Volume and Peak Management Project	X	X	X	X	X
Milwaukee Downtown Downspout Disconnection Project	X	X			
Porous Pavement Construction Criteria			X		X
Design Guidelines to Prevent Increased I/I from Stormwater BMPs			X		X
Wet Detention Basin Infiltration Study			X		X
UWM GLWI Green Roof and Rain Garden Evaluation			X		X
Urban Open Space Foundation			X		
South Shore Beach Stormwater Treatment	X			X	X
South Shore Park Watch Neighborhood Demonstration	X			X	
Cambridge Woods Neighborhood Association – Cleaning Rainwater on Site	X			X	
Porous Pavement—Mitchell International Airport	X			X	
Brown Street Academy Stormwater Park	X	X		X	
Porous Pavement—Urban Ecology Center	X	X		X	
Green Roof—Milwaukee DPW	X	X		X	

BMP Partnerships

Through BMP partnerships in 2003 - 2006, MMSD worked with local public or private parties to demonstrate the planning or implementation of specific BMPs. The partners were responsible for the planning, design, construction, maintenance, and monitoring of the practices. The selected BMP partnership projects generally included monitoring and an educational component. MMSD provided partial funding for the selected projects. The BMPs included in the partnership projects are listed in Table 6. A total of 19 projects were selected during the three-year period. The detailed information on the partnership projects is summarized in Table 7.

Each BMP partner is submitting a report or other deliverables to MMSD. The following is a summary of each project for the period of 2003 through 2005. The 2006 projects are still ongoing:

Table 6
Partnership Project BMPs

2003	2004	2005	2006
1. Rain gardens	1. Bioretention system	1. Pervious parking/bioretention	1. Porous Pavement—public demo
2. Green roof	2. Rain garden and bioretention	2. Wetland detention	2. Porous Parking
3. Low Impact Development	3. Cisterns and bioretention	3. Green parking lot	3. Green roof
4. Stormwater park	4. Green roof	4. Bioretention/swale	4. Playground—stormwater parks
5. Constructed wetland signage	5. Low Impact Development	5. Downspout disconnection/gardens	
6. Rain barrels		6. Porous pavement	
7. Green roof			
8. Porous pavement and rain garden			

Table 7
Summary of Stormwater Reduction BMP Partnership Projects: 2003-2006

Project/ Project #	Cost $ (MMSD)	Cost $ (share)	Schedule	Location	Contact	Description	Other	Deliverables
BMP Partnership 2003								
1. ARCCP Rain Gardens M03015C10	$45,375	$24,500	2003-2005	A & D Truck and Auto Parts 250 S. 11th St. Milwaukee, WI	David Kendziorski (920) 533-5271	Stormtech	Education and landowner involvement.	Installed rain gardens. Infiltration monitoring data. Education materials (PowerPoint presentations to Automotive Recyclers Cooperative Compliance Program (ARCCP) members.
				Al's Auto Salvage 10942 S. 124th St. Franklin, WI				
				Auto Paradise, Inc. 6102 S. 13th St. Milwaukee, WI				
				Auto Paradise Imports 4905 W. Burnham St. Milwaukee, WI				
				Brand Auto Salvage 1144 W. Bruce St. Milwaukee, WI				
				Calumet Auto Parts, Inc. 8501 W. Calumet Rd. Milwaukee, WI				
				Seven Stars Auto Salvage 3626 W. Mill Rd. Milwaukee, WI				
				Urban Ecology Center (2) Riverside Park 2808				
				Alterra Coffee Shop (3) Lincoln Memorial Drive Milwaukee, WI				

Project/ Project #	Cost $ (MMSD)	Cost $ (share)	Schedule	Location	Contact	Description	Other	Deliverables
2. Great Lakes Water Institute Green Roof M03015C03	$110,000	$132,895	2003	Great Lakes Water Institute 600 East Greenfield Avenue, Milwaukee, WI	Dr. Sandra McLellan (414) 382-1747	Great Lakes Water Institute- 7,600 sq. ft. green roof	Energy conservation. Educational demonstration . Web site access.	Installed green roof. Monitoring data. Educational program.
3. Johnson's Park Low Impact Development M03015C04	$44,610	$54,660	2003-2004	Johnsons Park, Milwaukee, WI	Tom Sear (414) 220-4300 Rick Norris (414) 454-8640	Tetra Tech- African American World Cultural Center Preliminary Stormwater Management Plan/LID	Planning multiple BMPs.	Design brochure. Stormwater management plan that incorporates LID.
4. Menomonee Valley Stormwater Park M03015C05	$60,061	$225,011	2003	Menomonee Valley, City of Milwaukee	Brian Reilly (414) 286-5616	Department of City Development- design of a stormwater park.	Public interaction.	Stormwater Park design.
5. Educational Signage for Trinity Creek Constructed Wetlands M03015C06	$27,462	$24,670	2003-2004	Intersection of Baehr Rd and Trinity Creek in Mequon	Charles Boehm (414) 225-5102	Earth Tech- Educational signage along the constructed wetland along Trinity Creek	Public interaction.	Draft designs. Affordable signage.
6. Highland Gardens Public Housing Rain Barrel Installation M03015C07	$31,500	$3,500	2003-2004	Various	Chris Litzau (414) 372-9040	Milwaukee Community Service Corps- Assembly, construction, education and demonstration of rain barrels	Public involvement.	Rain barrels available to the public and educational brochures.
7. Urban Ecology Center Green Roof M03015C07	$40,000	$134,300	2003-2005	Riverside Park 2808 N. Bartlett Ave Milwaukee, WI	Ken Leinbach (414) 964-8505	Urban Ecology Center- Demonstration of green roof on accessible garage	Teaching tool for children.	Constructed green roof. Educational elements. Construction photos.
8. Pervious Parking Lot and Rain Garden M03015C09	$79,900	$29,400	2003-2006	SW Corner of Ryan Rd and 20th St. in Oak Creek	Steven Nikolas (262) 827-4866	Zabest Commercial Group- 0.54 acre of pervious concrete and rain garden installed.	Reduce need for detention. Meets Chapter 13	Constructed pavement and rain garden. Monitoring of flow. Educational PowerPoint.

Project/ Project #	Cost $ (MMSD)	Cost $ (share)	Schedule	Location	Contact	Description	Other	Deliverables
BMP Partnership 2004								
9. Menomonee Valley Bioretention Facility M03015E10	$682,500	$682,500	2005-2006	Central Menomonee Valley, City of Milwaukee	David Windsor (414) 286-0459	City of Milwaukee Department of Public Works- stormwater bioretention facility in Central Menomonee Valley	Centralized bioretention.	Bioretention facility. Bioretention tour. PowerPoint presentation. Brochure/fact sheet. Signage.
10. Miller Brewing Co. Rain Garden and Bioretention Swale M03015E06	$131,080	$136,430	2004-2005	Miller Brewing, Milwaukee, WI	William Gonwa (414) 291-8850	TEI Corporation- Rain garden and bioretention area along West State Street+ educational info and tours	Public interaction.	Education with signage and brewery tour.
11. Stormwater Management Initiative for Walnut Way M03015E07	$44,000	$17,972	2004-2005	12th to 20th, Vine to North in City of Milwaukee	Sharon Adams (414) 264-2326	Walnut Way Conservation Corp.- Installed three 500-gallon cisterns, 0.5 acre bioretention area, and design green roof and green parking lot	Community involvement.	School education. Cisterns, bioretention, designs. Design workshop. Brochure.
12. Milwaukee County Zoo Green Roof M03015E08	$31,500	$31,500	2004-2005	Milwaukee Co. Zoo 10001 West Blue Mound Rd Milwaukee, WI 53226	Chuck Wikenhauser (414) 256-5402	Zoological Society of Milwaukee - construct roof garden	Public interaction.	Webcam, flow and temperature monitoring, educational kiosk.
13. Vineyard Terrace Residential Neighborhood Low Impact Development Designs M03015E09	$24,700	$98,800	2004-2005	Intersection of Vine St. and 5th St.	Tom Sear (414) 220-4300	Tetra Tech- Design stormwater management plan for Vineyard Terrace Residential Neighborhood	Neighborhood Project	Design. Educational brochures. Evidence of public education program. Monitoring Plan. Construction and Site Plans. Status Reports.

Project/ Project #	Cost $ (MMSD)	Cost $ (share)	Schedule	Location	Contact	Description	Other	Deliverables
BMP Partnership 2005								
14. MSOE Pervious Parking Project M03015E21	$331,800	$331,800	2005	Milwaukee St. between State St. and Juneau Ave.	Kenneth A. McAteer (414) 277-7300	MSOE- Converting existing building and impervious parking lot to pervious pavement	Public interaction.	Magazine articles, project signage highlighting the project in MSOE's environmental engineering symposium series, and student education.
15. UWM Green Parking Lot Design M03015E23	$140,317	$140,317	2005-2006	Various parking lot locations	James Wasley (414) 229-4045	University of Wisconsin-Milwaukee- design and engineering plans for three UWM parking lots and develop monitoring protocols	Educational benefits.	Educational signage and a kinetic/ functional sculpture installation in the School of Architecture.
16. Mequon Nature Preserve PieperPower Education Center M03015E24	$26,000	$26,222	2006	County Lind Road and Wauwatosa Road, Mequon	Tom Sear (414) 220-4300	Tetra Tech MPS- Bioretention/Cistern System on the east side of the PieperPower Education Center	Education	Construction of bioretention/cistern system. Educational materials and performance observations.
17. Residential Action in Neighborhood s (RAIN) M03015E25	$31,750	$46,250	2005-2006	12th to 20th, Vine to North in City of Milwaukee	James Sayers (414) 286-5723	City of Milwaukee Department of City Development- provide rebates and technical assistance to encourage rain garden installation and downspout disconnection.	Neighborhood project.	Report provided to MMSD outlining monitoring, evaluation of participation, summary of costs and questionnaires providing maintenance feedback.
18. Josey Heights Green Pavement – Phase I M03015E26	$95,000	$95,000	2005-2006	Josey Heights	James Sayers (414) 286-5723	City of Milwaukee Department of City Development- incorporating porous pavement systems in the Josey Heights Subdivision	Neighborhood project.	Brochures and information for homeowners to educate then on values of methods and maintenance measures.

Project/ Project #	Cost $ (MMSD)	Cost $ (share)	Schedule	Location	Contact	Description	Other	Deliverables
BMP Partnership 2006								
19. Porous Pavement M03030P01	$7,500	$7,500	2006-2007	General Mitchell Airport	David B. Kendziorski	Installation of porous pavement at Mitchell International Airport. Near baggage claim.	Public interaction.	Signage. Educational Brochure explaining project.
20.Stormwater Park M03030P02	$27,300	$36,780	2006-2007	Brown Street Academy, 2029 N. 20, Milwaukee, WI	Heather Mann	Conversion of playground into stormwater park. Its and old school playground that is currently completely paved. The building is used for voting and community activities.	Public interaction.	Signage. Educational brochures about project, classes, report provided to MMSD.
21. Porous Pavement M03030P03	$30,000	$103,716	2006-2007	UEC, Riverside Park, 1500 E. Park Place, Milwaukee, WI 53211	Ken Leinback	Installation of porous lot for parking at their new building.	Public interaction/ involvement.	Signage and Brochures and information educating the values of methods and maintenance measures.
22. Green Roof M03030P04	$35,200	$277,800	2006-2007	DPW, 841 N. Broadway	Jeffery S. Polenske	Installation of green roof on headquarters building.	Public interaction.	Signage and Brochures and information educating the values of methods and maintenance.

1. ARCCP RAIN GARDENS (M03015C10)

The Automotive Recyclers Cooperation Compliance Program (ARCCP) is a stormwater permit compliance group of nearly 120 auto recyclers statewide. Rain gardens were installed at seven ARCCP member sites in the Milwaukee area. Since other ARCCP members decided not to participate in the project, four additional rain gardens were installed at the Urban Ecology Center and at the Alterra Roasters Coffee Shop on Lincoln Memorial Drive. Each garden was designed to receive runoff from the roof of an adjacent building.

Figure 3. Roof runoff was never diverted to this garden at Seven Stars Auto Salvage in Milwaukee, and the lack of water limited the plant growth.

Results: The auto recycler rain gardens were installed in 2003, and the Urban Ecology Center and Alterra gardens were installed in 2004 and 2005. One garden (Al's Auto Salvage) flooded shortly after installation and was subsequently removed. The site had poor drainage that did not allow excess water to overflow from the garden. All other gardens remained in place through 2005, but with varying degrees of health and growth. Some gardens are struggling to survive with stubby growth, while others are flourishing.

Insights from the project include:

1. An adequate supply of water appears to be the most important factor affecting rain garden success. Gardens that have large roofs that drain to the garden fared much better than those with smaller roofs. At least two of the auto recyclers watered their gardens during dry periods. Both of those gardens are thriving.

2. All of the gardens appeared to have adequate sunlight. Since each site was excavated and amended soil was brought in, soil conditions were basically the same at each site.

   Due to site constraints two of the gardens (Brand Auto Salvage and A & D Truck and Auto Parts) were extremely small (less than 50 square feet). Neither garden has grown well, as shown in Figure 4. Regular watering of the gardens may have improved the plant growth.

Figure 4. This very small rain garden at Brand Auto has stunted plant growth.

3. Installing larger plants may increase the success of the rain gardens. Very small seedlings—a couple inches tall—were planted in the auto recycler gardens. Many of the plants did not survive and needed replacement. In contrast, plants in 4 ½ inch pots that were approximately 6-inches tall were planted in the Alterra gardens (and in a subsequent rain garden project in Shorewood). Those taller plants develop sooner and have a higher success rate.

4. The gardens were inspected and maintained quarterly by the contractor for the first year after installation. The maintenance included weeding, replacement of plants, adding mulch, outfall repairs, and repair of erosion and border stones. This type of maintenance is critical during the first year. All of the gardens needed maintenance.

5. Double-ring infiltrometer tests were conducted on the rain gardens at Calumet Auto Parts and Alterra Roasters Coffee Shop in July, 2005. The Calumet garden was constructed in 2003 and had dense healthy plants 3 to 5 feet tall. The Alterra garden had been installed earlier in 2005 and the plants were 12 to 18 inches tall. The infiltration rates for the Calumet garden ranged from 4.6 to 6.0 inches per hour, while the rates for the Alterra garden ranged from 2.9 to 4.3 inches per hour. In comparison, double-ring infiltrometer tests conducted on the turf lawn adjacent to the Calumet garden indicated infiltration rates of less than 1 inch per hour. The amended soils placed in the gardens and the deep root penetration appeared to increase infiltration rates by up to six-fold.

Figure 5. The rain garden at Calumet Auto Parts, Inc., 8501 West Calumet Road in Milwaukee is an excellent example of a successful rain garden. The garden was installed during the summer of 2003. By July, 2005, the plants were diverse, colorful, and healthy. Most were approximately 3 to 5 feet tall. Infiltration rates ranged up to 6-inches per hour. Numerous bees, grasshoppers, butterflies, and birds were observed on the vegetation. The soil was rich with earthworms, centipedes, and insects.

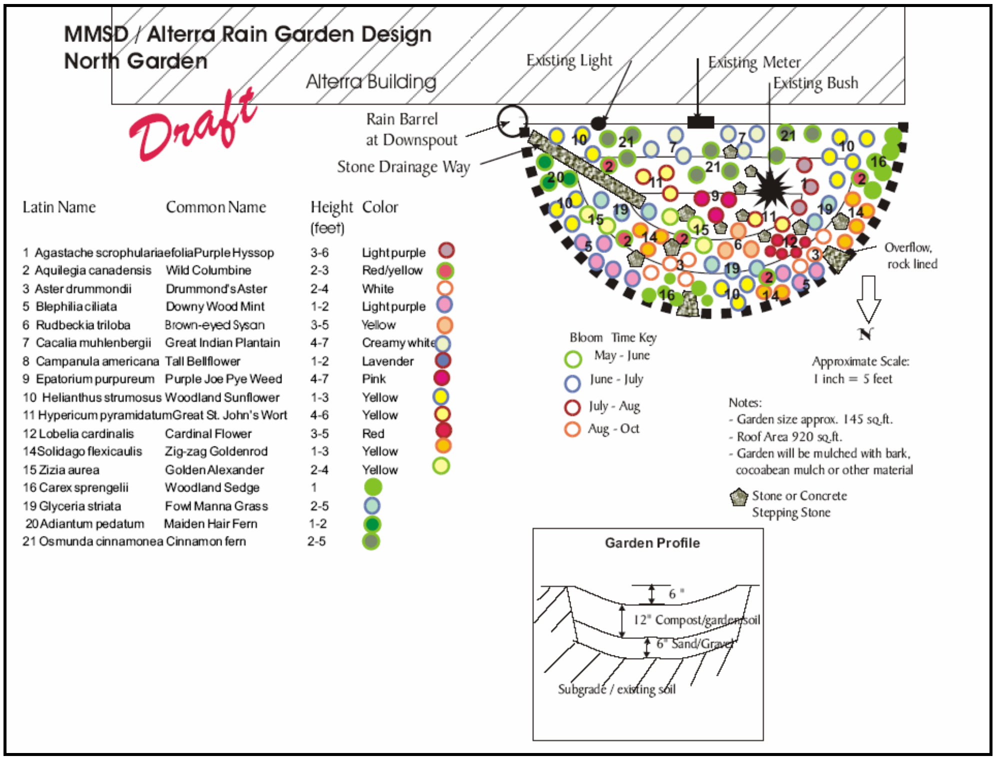


Figure 6. Design of a Alterra Roasters Coffee Shop rain garden prepared by Janine L.Grauvogl-Graham, P.E.

2. GREAT LAKES WATER INSTITUTE GREEN ROOF (M03015C03)

A 7,600 square foot green roof was installed at the Great Lakes Water Institute in fall of 2003. The design included 676 4-inch and 8-inch Green Grid™ interlocking modules. The modules arrived pre-planted and ready for installation. The green roof was successfully installed, and Water Institute staff has maintained it. This project features extensive public outreach and environmental monitoring.

A web cam was installed to allow the public to view the installation and maintenance of the green roof, and a website dedicated solely to the green roof project was created. There were numerous public ceremonies, events, and tours at the location to educate the public on green building technologies.

The green roof is being monitored for temperature impacts, water retention, and water quality. Temperature sensors were installed. Water in the drainpipes from the building was analyzed for temperature, E.coli, and other parameters.

Figure 7. Great Lakes Water Institute green roof in full bloom.

Figure 8. Great Lakes Water Institute green roof.

3. JOHNSON'S PARK LOW IMPACT DEVELOPMENT (M03015C04)

This project included a LID design for the African American World Cultural Center in Johnson's Park. The deliverable was a brochure and design plan set that illustrated a conceptual design including a rain garden, porous pavement, green roof, grassed swale, underground cistern, and wetland system. The LID techniques were intended to reduce the volume and rate of stormwater runoff from the site, while promoting green space. The stormwater management system was designed to maintain runoff rates at pre-development peaks, and to meet applicable City of Milwaukee, MMSD, and WDNR regulatory requirements.

4. MENOMONEE VALLEY STORMWATER PARK (M03015C05)

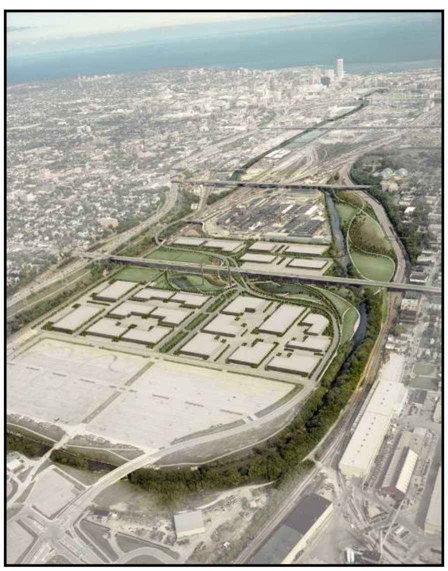


Figure 9. Rendition of Menomonee Valley Stormwater Park.

The City of Milwaukee undertook a $20 million cleanup of the Menomonee Valley located just east of Miller Park. A partnership of the City of Milwaukee, Sixteenth Street Community Health Center, Menomonee Valley Partners, UWM, and MMSD joined together to develop a Stormwater Park at the western edge of the Menomonee Valley. A Stormwater Park is being created to filter stormwater runoff from a 100-acre business park. The Stormwater Park integrates play fields, natural areas, three detention cells, and river access.

The detention cells operate as a treatment train that includes a wet prairie, wetland forest, and an emergent wetland system. The Stormwater Park is a key element of the winning design from the Menomonee River Valley National Design Competition. Primary elements of the Park were completed in 2006. A monitoring and educational program will be developed.

5. EDUCATIONAL SIGNAGE FOR TRINITY CREEK CONSTRUCTED WETLANDS (M03015C06)

This project included the design, construction, and installation of educational signs along a 35-acre wetland complex being constructed along Trinity Creek in Mequon. The signs promoted the benefits of wetland creation, such as northern pike spawning habitat, wildlife habitat, water quality improvement, stormwater detention, reduced flooding, and educational and recreational opportunities.

The six signs installed were titled:

- Welcome to Trinity Creek
- A Place for Northern Pike
- Calming Storm Water Flow
- Restoring Our Streams
- How Trinity Creek Improves Water Quality
- The Wonders of Wetlands

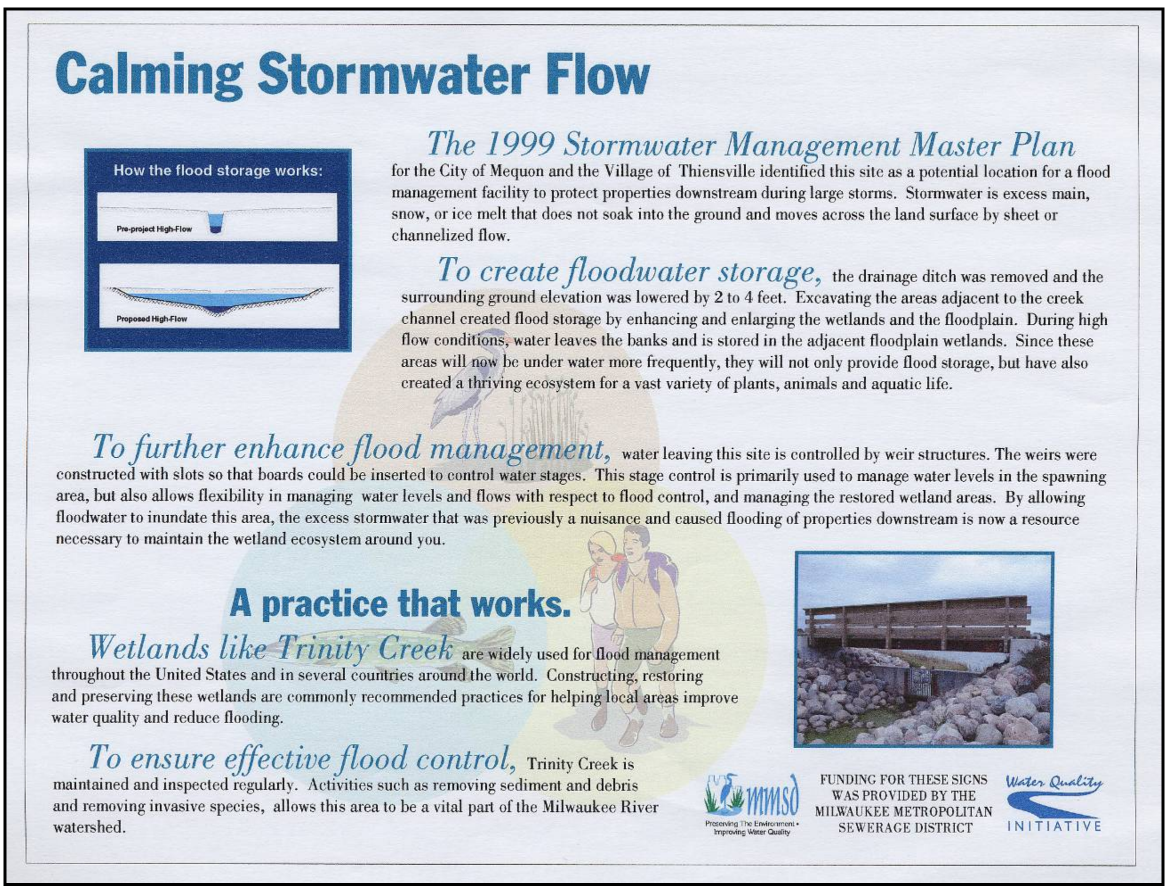


Figure 10. Sign from Trinity Creek Wetland Restoration project.

6. HIGHLAND GARDENS PUBLIC HOUSING RAIN BARREL INSTALLATION (M03015C07)

Figure 11. MCSC participants learn how to install rain barrels.

In May 2004, the City of Milwaukee kicked off a national model initiative to engage public housing residents in managing stormwater. The Milwaukee Community Service Corps (MCSC), a job training and youth development group, constructed rain barrels. The MCSC disconnected 107 roof downspouts and installed 197 rain barrels at public housing residences. The project demonstrated ways for residents to help manage stormwater runoff onsite. The MCSC also prepared and distributed a Rain Barrel Fact Sheet.

7. URBAN ECOLOGY CENTER GREEN ROOF (M03015C08)

In the summer of 2004, the Urban Ecology Center installed a 625 square-foot green roof and sensory garden on the roof of their garage in Riverside Park in Milwaukee. The roof garden is an important children's educational feature at the Center. An impermeable liner was placed on the roof, and filled with 12 to 18 inches of soil. The garden was planted with plant species chosen based on drought tolerance and sensory characteristics.

Figure 12. Urban Ecology Center's green roof located above the garage.

The roof drains to a series of rain barrels and a cistern that are part of a rain harvesting system. The system will divert roof runoff to a storage system where it will be used for non-potable purposes—primarily toilet flushing.

The performance of the Urban Ecology Center green roof will be compared with the performance of a flat roof on a nearby Milwaukee firehouse. The goal of the monitoring effort is to demonstrate the effectiveness of the green roof at both reducing stormwater flow during major rain events and reducing heat flow through the roof. The monitoring apparatus includes:

- Weather station
- Rain gage
- Water level sensors in the rain barrels (to measure roof runoff)
- Soil temperature and moisture probes

The monitoring began in 2006.

8. PERVIOUS PARKING LOT AND RAIN GARDEN (M03015C09)

Zabest Commercial Group, a Brookfield-based developer, installed a 0.54 ace pervious concrete parking lot for a retail development at West 20th Street and Ryan Road in Oak Creek. To meet Chapter 13 and other stormwater regulations, Zabest installed the pervious pavement as an alternative to conventional aboveground or underground detention. The project also includes an approximate 700-square foot rain garden to capture rooftop runoff.

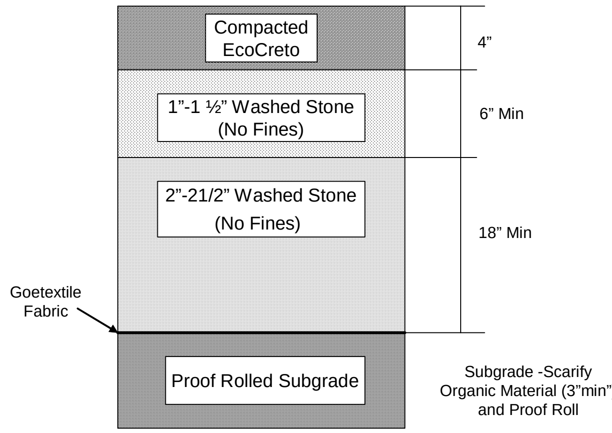


Figure 13. Typical pervious concrete cross section.

Figure 14. Pervious pavement monitoring port.

The developer selected EcoCreto pervious concrete, underlain by an 18-inch crushed stone base. A typical design section of the pavement is shown on Figure 13. The system was sized to store the 100-year 24-hour rain event.

A 6-inch monitoring port was installed in the pavement. The port will allow monitoring of the water level in the stone base, thereby demonstrating that water is penetrating the pavement.

The developer and City of Oak Creek entered into a maintenance agreement. The agreement requires the developer to:

- Keep maintenance records
- Vacuum the pavement on six month intervals
- Power wash the pavement annually
- Maintain the rain garden by annual spring pruning, weeding, and replanting as necessary

The agreement also includes penalties for failure to perform required maintenance.

The building was constructed and the pervious concrete was installed in the fall of 2003. Due to low air temperatures, the pavement needed to be placed in a few lifts which formed some rough areas and seams. The developer concluded that future porous pavements should be laid during warmer weather conditions.

After the pavement hardened, the pavement was tested with a fire hose. Water quickly infiltrated the pavement within a few feet. Observations were made in the monitoring port, but the infiltration rate was so high that no water accumulated in the stone base layer.

The performance of the pervious concrete was observed during four storm events in May 2004. The measured rainfall during these storm events ranged from 0.75 to 1.6 inches. During each event, water quickly passed through the pavement and no ponding or runoff were observed. None of these events produced any standing water in the monitoring port (the water infiltrated into the underlying soil).

In 2006, Zabest installed a similar pervious concrete parking lot at the Rawson Commons Retail Center, 7320 West Rawson Road, Franklin. The performance was monitored during an approximate 1.75-inch storm event that occurred on May 11 and 12, 2006. No runoff or ponding was observed. Measurements at four monitoring ports indicated that 0.25 to 1.5 inches of water temporarily accumulated in the subsurface stone layer. Double ring infiltrometer tests conducted on the underlying clay soils in August 2005 showed infiltration rates ranging from 0.18 to 0.80 inches per hour. The stone layer provides temporary storage of water until it can slowly infiltrate the soil.

Figure 15. Water discharged from a fire hose quickly infiltrates the pervious concrete.

Figure 16. Testing pervious concrete with a fire hose.

Unfortunately, the planned franchise was unable to occupy the Ryan Road premises and the site remained idle from late 2003 until the fall of 2005. During this time there was no water supply to test the pavement or maintain the rain garden. In 2005, a Starbucks franchise purchased the site.

Without supplemental water, the newly-planted rain garden plants did not survive. The rain garden species were replaced with conventional landscaping plants by Starbucks in 2006.

9. MENOMONEE VALLEY BIORETENTION FACILITY (M03015E10)

The Menomonee Valley Bioretention Facility is an approximate two-acre shallow vegetated system that treats stormwater runoff from approximately 70 acres. The facility includes a permeable soil medium over a compacted clay subgrade. An underdrain system discharges treated water to the Menomonee River. The facility was planted with grasses and forbs to maximize evapotranspiration and reduce stormwater runoff peak flows and volumes. The facility also provides improved habitat and aesthetic amenities that enrich the urban setting.

The City of Milwaukee Department of Public Works managed the planning, design, and construction of the bioretention facility. The City will maintain the facility and work with MMSD to establish monitoring and educational programs. The bioretention facility had an estimated capital cost of about $760,000. The facility was completed in 2006.

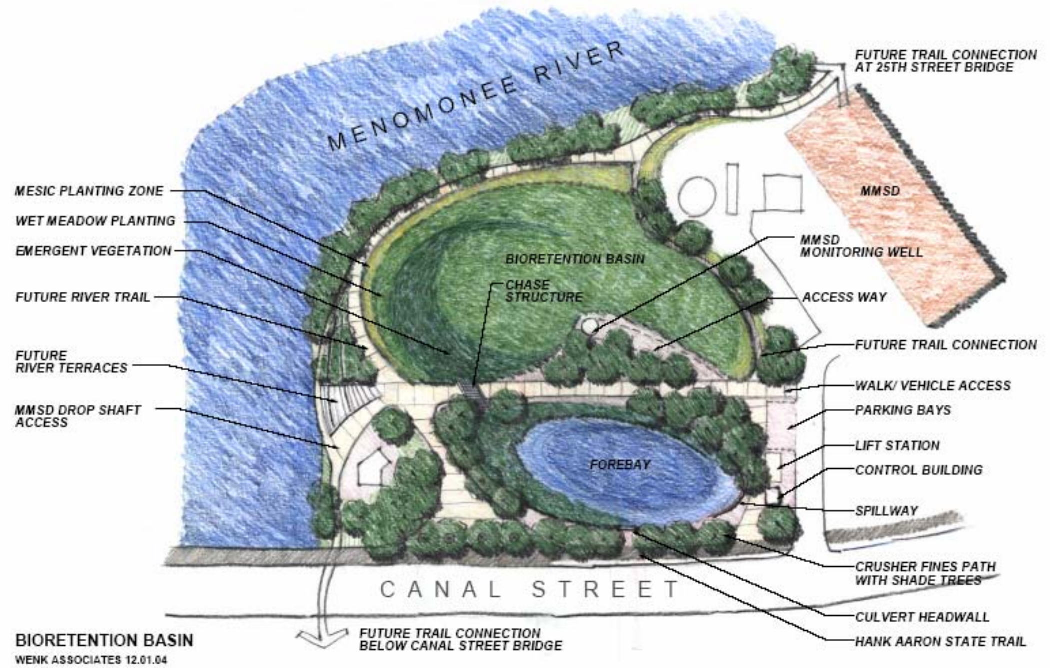


Figure 17. This two-acre bioretention system treats stormwater runoff from about 70 acres in the Menomonee Valley.

10. MILLER BREWING CO. RAIN GARDEN AND BIORETENTION SWALE (M03015E06)

Constructed in 2004, the Miller Brewing Rain Garden and Bioretention Swale captures, slows, and treats overland runoff from a one-acre asphalt-paved parking lot. This water ponds to a depth of up to 18-inches deep above a manufactured soil designed to promote rapid infiltration, filter-out pollutants, and store rainwater. Some of the rainwater that soaks in recharges the groundwater. The rest discharges slowly through a 6-inch underdrain to the City of Milwaukee's combined sewer system. The garden is designed to store approximately 60,000 gallons of stormwater.

Vegetation consists of native grasses and perennial flowers planted in bands to simulate natural prairies. Flowers include the New England Astor, the Prairie Blazing Star, and Ohio Goldenrod. Kentucky Coffeetrees and Professor Spranger Crabapples provide shade and ornamentation. Grasses include Switch Grass, Little Bluestem, India Grass, and Prairie Dropseed.

Figure 18. Rain garden and swale following planting.

Figure 19. Rain garden and swale one year later.

A brochure that describes the rain garden and bioretention swale was prepared. Educational signage was also installed at the site. The rain garden is showcased during public Miller Brewing tours.

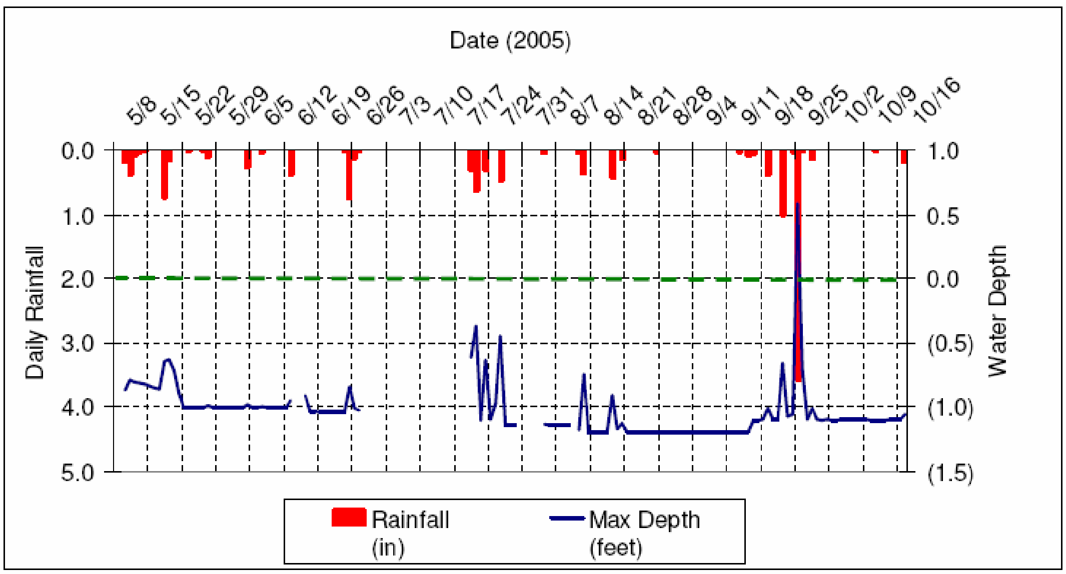


Figure 20. The rain garden had only one discharge from May to October of 2005.

11. STORMWATER MANAGEMENT INITIATIVE FOR WALNUT WAY (M03015E07)

The Walnut Way Conservation Corporation is a 501 (c)(3) not-for-profit entity that is committed to revitalizing the Walnut Way neighborhood in Milwaukee. The project included three elements:

1. Incorporate conceptual designs of a green roof and green parking lot into the proposed Market Place Community Center at 14th Street and North Avenue. Funding for Market Place was awarded in November 2005, and preparation of the conceptual designs by the architect is underway.

2. Create a bioretention system in the Lloyd Street Elementary School playground. The one-half acre bioretention system designed by the Conservation Design Forum was installed and partially planted in September 2005. The remaining plants were installed in the spring of 2006. It includes several interactive educational features, including walkways, a raised gathering spot near the center of the system, and play structures. The bioretention system is a unique hands-on teaching tool that helps students learn about ecosystems and serve as "environmental stewards." The students will assist in the care and maintenance of the plant communities. During large storm events, overflow is discharged into two slightly raised catch basins which discharge to the City of Milwaukee's combined sewer system. The City of Milwaukee obtained a $100,000 grant from USEPA to support this project.

Figure 21 (left). Cisterns will capture residential roof runoff to serve as a water supply for Walnut Way's community gardens.

Figure 22 (right). Lloyd School bioretention system during installation.

A double-ring infiltrometer test was conducted on November 21, 2005 to measure the infiltration rates of the newly placed soil. Unfortunately, the soils in the lower bioretention zones were already nearly saturated due to recent rains. Instead, the tests were conducted in the raised gathering area that was filled with the same soil used in the bioretention areas. The infiltration rates were extremely high—exceeding 12 inches per hour. This rate is at least twice that found for the Calumet Auto Parts and Alterra Roasters Coffee Shop rain gardens. The high infiltration capacity might be attributed to the newly placed loose soil. It was recommended to the Walnut Way Conservation Corporation that additional infiltrometer tests be conducted within a couple years under dry conditions and once plants have matured and established their root zones. Follow up infiltrometer tests will be conducted in 2007.

United Water conducted air temperature readings above the pavement where the bioretention system now lies. The air temperature measured on August 31, 2005 at a point 2-feet above the pavement was 3 to 7 degrees Fahrenheit warmer than the ambient air temperature, thereby illustrating the heating impacts of asphalt pavement. Once the bioretention system is established, the temperature monitoring will be repeated to measure the "cooling" effect of vegetation during the summer.

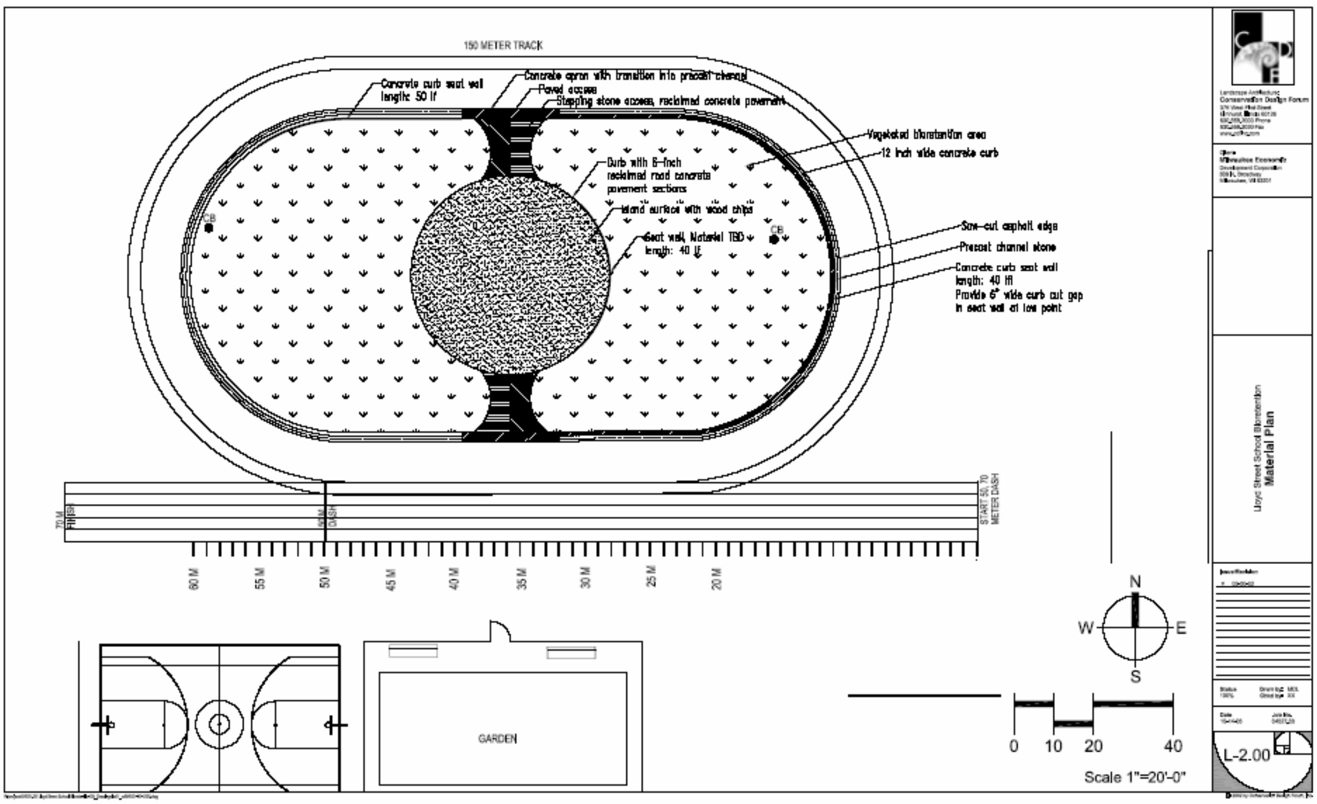


Figure 23. Design for Lloyd School's bioretention system prepared by the Conservation Design Forum.

Regular inspections and maintenance of the bioretention plants are performed by the school building and grounds maintenance staff. When school is not in session, the plants are maintained by the Walnut Way Conservation Corporation.

3. Provide cisterns to capture roof runoff from residential homes. The stored runoff is used as a water supply for the popular Community Market Gardens, and for Walnut Way's Urban Orchard. Three 500-gallon Top Tank cisterns were purchased and delivered in November 2005. Each

cistern has a diameter of 45 inches and is 83 inches high. The cisterns were installed in the fall of 2006 to store roof runoff from the Walnut Way Neighborhood Center at 2240 North 17th Street, Milwaukee. The total roof area that discharges to the three cisterns is 1,960 square feet. The cisterns have the capacity to store the runoff from an approximate one inch storm event.

This project generated community-wide environmental awareness. It involved the collective partnership of homeowners, the Walnut Way Conservation Corporation, MMSD, the City of Milwaukee, Milwaukee Public Schools, U.S. EPA, and United Water. Educational activities included extensive community outreach and participation, brochures, and the Walnut Way Newsletter. Special events included a bioretention design workshop, a community garden tour, a rain garden demonstration, and Walnut Way's Harvest Day—an annual celebration of the community gardens.

12. MILWAUKEE COUNTY ZOO GREEN ROOF (M03015E08)

This joint effort of the Milwaukee County Zoo, We Energies, and MMSD included construction of a 2,356 square foot modular green roof on the Karen Peck Katz Conservation Education Center at the Milwaukee County Zoo. The project utilized 4-inch deep GreenGrid Roof modules. The project also includes runoff monitoring, a public open house, temperature monitoring, a web cam, and educational Kiosk.

Figure 24. Installation of the zoo's green roof.

Figure 25. Milwaukee County Zoo's green roof.

The Zoological Society had monitoring equipment installed but was not able to obtain any runoff measurements in 2005. However, the Zoological Society obtained simulated runoff data from the GreenGrid manufacturers and installers. The data showed that the 4-inch GreenGrid system should retain 72.2% of a one-inch rainfall and 33.7% of a four-inch rainfall. The Zoological Society was able to successfully monitor the temperature of the green roof. The temperature results are available to the public through the Zoological Societies interactive website (http://www.zoosociety.org/Education/GreenRoof.php).

Figure 26. Milwaukee County Zoo's green roof educational kiosk.

13. VINEYARD TERRACE RESIDENTIAL NEIGHBORHOOD LOW IMPACT DEVELOPMENT DESIGNS (M03015E09)

The Vineyard Terrace Residential Development Project will construct ten single-family residential homes on approximately 1.93 acres of land in the central portion of the City of Milwaukee. Under this project, Tetra Tech evaluated several Low Impact Development (LID) techniques, including paving blocks, bioretention systems, and underground cisterns. Tetra Tech applied various hydrologic analysis techniques to quantify the expected reduction in peak discharge and runoff volumes over a range of storm events. Following the evaluation, Tetra Tech recommended that a bioretention cell/cistern system along with paver blocks be designed to capture the runoff volume during a 100-year 24-hour storm event. Tetra Tech developed several design criteria for the cisterns and bioretention systems.

In July, 2004, Tetra Tech discussed possible implementations of the recommended practices with City of Milwaukee staff. City staff raised concerns about the plumbing and discharge from the underground cisterns, and about the operation and maintenance of the cisterns and bioretention systems. In response to the City's concerns, the developer decided to avoid construction delays and proceed with a previously approved conventional stormwater management approach. The developer expressed an interest in considering bioretention and cisterns in future development projects.

14. MSOE PERVIOUS PARKING PROJECT (M03015E21)

This partnership project between the Milwaukee School of Engineering (MSOE), MMSD, and TEI Corporation includes:

- Design and construction of a 0.8 – acre porous pavement parking lot at MSOE
- An educational program offering teaching and research opportunities, signage, and brochures
- A limited monitoring program to evaluate the performance of the pavement to reduce stormwater runoff

Pervious asphalt was placed on the southern three-quarters of the parking lot and the northern quarter was covered with pervious concrete. The access drives were finished with standard asphalt. The pavements were placed over a stone layer that measured 16 inches for the concrete section and 18 inches for the asphalt section. Underlying soils were sand and gravel, or sand with silt. Borings showed no evidence of high water table or groundwater to a depth of 10 feet. The parking lot's stormwater storage capacity equals or exceeds the 100-year storm event.

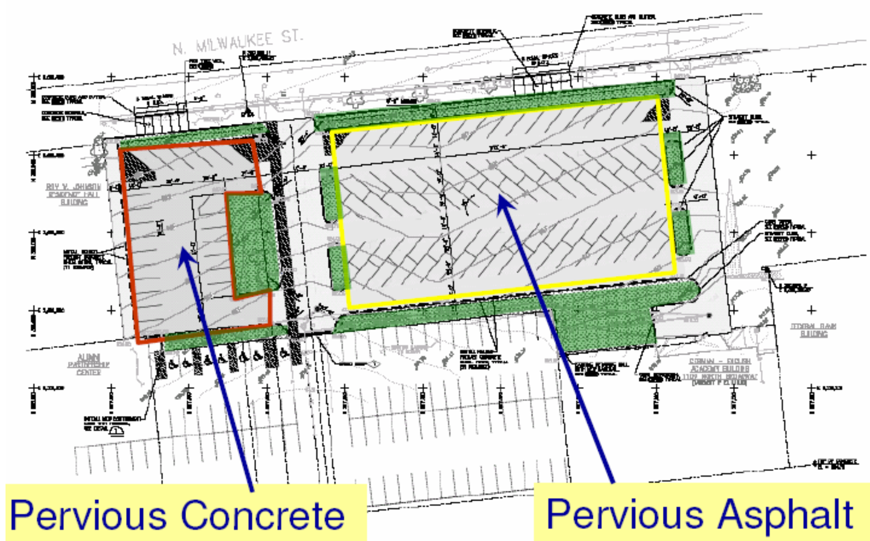


Figure 27. Site plan for MSOE pervious pavement project.

During design and construction the following problems were encountered:

1. The existing drainage infrastructure was found to be inadequate. A new catch basin and storm sewer were installed to correct the problem.

2. Placing the pervious concrete mix was difficult because the mix was too stiff and sticky. Pounding needed to level the surface caused separation along the cold joints between strips of concrete.

3. The asphalt mix was also very sticky and too soft, which caused problems with the equipment.

Figure 28. MSOE's porous pavement during a rain event.

After more than eight years of intensive porous pavement research and over 280 applications, porous pavement experts recommend that applications be supervised by qualified and experienced contractors (especially for pervious concrete). For porous asphalt, important design and technology advancements have been made over the past three years (B.K. Ferguson, <u>Porous Pavements</u>. 2005). Much is now known about proper design in cold climates (i.e., extending the bed bottom below frost depth), proper construction techniques (to avoid compaction and sediment clogging), and careful maintenance.

The porous pavement unit costs for this project were $3.32/square foot of porous asphalt and $5.97/square foot of pervious concrete. This compares to a conventional asphalt pavement cost of $3.55/square foot.

The project included extensive educational activities such as MSOE class visits, the Milwaukee Cleaner River Conference, tours, radio interviews, signage, and numerous presentations. Local municipal engineers and consultants also observed the construction.

The project team recommended the following maintenance activities:

1. *Erosion Control*
   MSOE will maintain adjacent landscaped areas to avoid tracking of eroded soil onto the pavement. Contractors will not be allowed to store soil or debris on the pavement. No dumpsters will be placed on the pavement.

2. *Vacuum Sweeping*
   MSOE will vacuum sweep the pavement at least three times each year. The first sweeping occurred at the end of November, 2005. TEI identified at least five service contractors in the Milwaukee area that provide vacuum sweeping.

3. *Snow Removal*
   MSOE will apply a chemical deicer to the pavement and plow as needed. A rubber cutting edge was installed on one of MSOE's snowplows to reduce wear and tear on the pavement. Other studies have found that porous pavement may require less deicing salt usage because the water does not remain on top of the pavement (MMSD Memo, 2003).

On March 25, 2006, members of the MSOE Ecology Club and Professors Gonwa and Diggleman conducted system monitoring of the pervious parking lots. During the system monitoring, students applied simulated rainfall to the parking lot from a non-oscillating lawn sprinkler at various locations in the parking lots while observing both surface runoff and monitoring for discharge through the drain tile.

In the pervious concrete area, 317 gallons of water were applied over a 21 foot diameter area over a period of 45 minutes (an application rate of 2 inches per hour). The application area was located immediately above the drain tile that drains the parking lot base course should infiltration fail to occur. No runoff occurred nor was there any discharge through the drain tile during the course of the testing.

To estimate the maximum infiltration capacity of pervious concrete, the water supply was applied directly to the pervious concrete from the end of a garden hose and the area of the wetland surface measured. Water, applied at a rate of 7gpm, spread over a 4.6 square foot area upon reaching steady-state conditions. This flow rate and spread converts to an infiltration rate of 147 inches per hour. The same test was performed on the pervious asphalt. At the 7gpm flow rate, a rivulet formed and the runoff flowed downslope to the limit of the pervious asphalt so no maximum infiltration rate could be computed. It is clear that the pervious concrete has a much greater infiltration capacity than the asphalt.

In the pervious asphalt area, 109 gallons of water were applied over a 21 foot diameter area over a period of 15 minutes (an application rate of 2 inches per hour). Upon initiating the simulated rainfall, a small rivulet of runoff flowed downslope for a distance of approximately 20 feet until finally infiltrating. The runoff stopped once the pervious asphalt surface became thoroughly moist.

Because of the large water storage capacity in the 16 to 18 inches thick stone layer beneath the porous pavement base course, it is not anticipated that antecedent moisture conditions affects infiltration through the pavement surface. The stone drains fast enough to prevent rainwater from saturating the pavement surface or affecting infiltration rates on days following a rainfall. At no time during actual or simulated rainfalls, or direct application of large volumes of water to small areas, was there any evidence of decreased infiltration rates caused by soil wetting.

Water quality sampling and testing was not possible because the pervious pavements do not discharge runoff even during the simulated rainfalls. The pervious parking lot is 100% effective at eliminating discharge of contaminants through surface runoff during rainfall events.

Since its placement, the porous concrete surface has suffered from loose stones, uneven joints, and two squares that apparently had an inferior concrete mix. It was hoped that the loss of stone would cease after an initial loss of poorly cemented stones. At the end of the first year of service, it became apparent that the loss of stone had not ceased and the uneven joints had become a safety hazard for pedestrian traffic.

MSOE explored various methods to rehabilitate the pavement. These included:

- Replacing defective squares with porous concrete and repairing joints with concrete grout
- Repairing defective squares and overlaying the entire porous concrete surface with Eco-Creto pervious concrete
- Repairing defective squares and overlaying the entire porous concrete surface with porous asphalt

MSOE selected the porous asphalt overlay because it would provide a uniform wearing course and the porous asphalt surfaced placed at the same time has performed well. The overlay was placed in 2006.

15. UWM GREEN PARKING LOT DESIGN (M03015E23)

This project is part of the "UWM as a Zero-Discharge Zone" project undertaken by the University of Wisconsin—Milwaukee in partnership with MMSD. Under this contract, UWM developed architectural and engineering plans to implement three BMP demonstration projects for two parking lots on campus and one remote parking lot. Implementing stormwater runoff reduction BMPs on UWM's parking lots would reduce the amount of stormwater entering the sewer systems, alleviate local drainage problems, and create a richer natural campus environment.

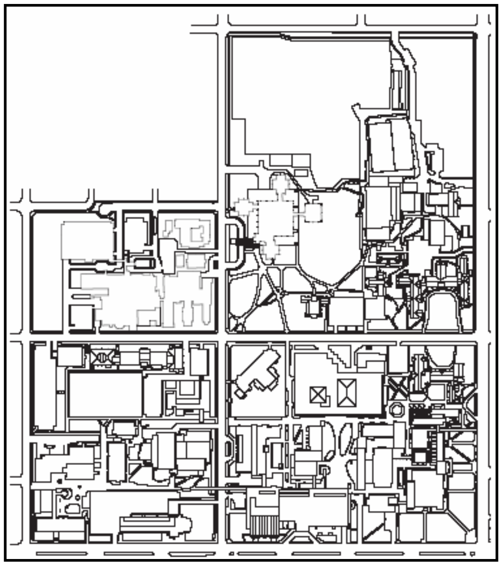


Figure 29. UWM Campus.

This project was supported by a public stormwater design symposium, an intensive parking lot design charrette, and input from visiting stormwater design experts. A SWMM model was created to simulate the hydrology of the storm sewer systems on and around the UWM campus. The model is the primary analytical tool used to evaluate alternative stormwater strategies on campus.

The project included:

- The inventory and mapping of impervious surfaces on campus. About 53% of the campus is impervious.
- Establishing a goal of reducing 100-year peak flow by at least 75%
- An analysis of the benefits of retrofitting existing roofs with green roofs. Full implementation of green roof retrofits and downspout disconnections to rain gardens was estimated to achieve a 15% reduction in both peak flow and total volume.

Figure 30. Parking lot design charrette.

- Conceptual stormwater zero discharge designs for two campus parking lots: Lot 18 and Lot 16. The designs include downspout disconnections, rain gardens, experimental research gardens, an interpretive pathway, sculptural cisterns, reduced paved area with a corresponding slight reduction in parking spaces, porous pavement, and enhanced landscaping and water features. A "treatment train" approach guided the overall plan.

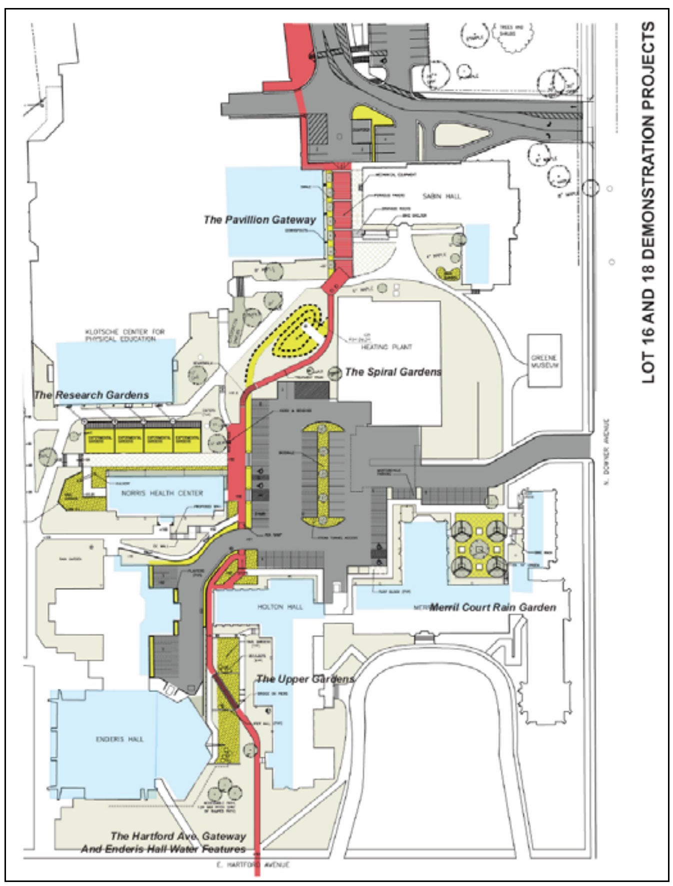


Figure 31. Design plan for parking lots 16 and 18 at UWM.

16. MEQUON NATURE PRESERVE (M03015E24)

The project site is the PieperPower Education Center site, scheduled to be opened in 2006, located on the north side of County Line Road, west of Wauwatosa Road, on the south side of the Mequon Nature Preserve. The Education Center will serve visitors to the Nature Preserve and the adjoining Milwaukee County Kohl Park. The Center will welcome students of all ages and environmental education organizations from throughout the metropolitan area. In line with its environmental mission, the Education Center will demonstrate innovative strategies relating to application of on-site stormwater best management practices.

The project includes:

- The design and construction of a bioretention / cistern system to be located on the east side of the PieperPower Education Center building. The proposed bio-retention / cistern system will receive stormwater runoff from the building rooftop and potentially a portion of the adjacent parking area. The system was constructed in 2006.
- Performance of the bioretention / cistern system will be monitored by on-site volunteers; and reductions in site runoff volumes will be calculated by Tetra Tech. The monitoring will begin in 2007.
- Education opportunities and activities will be offered by the Education Center.

17. RESIDENTIAL ACTION IN NEIGHBORHOODS (RAIN) (M03015E25)

This City of Milwaukee Department of City Development initiative will provide technical and financial assistance to residents who agree to disconnect downspouts and install rain gardens. The neighborhood is bordered by 12th Street, 20th Street, Vine Street, and North Avenue.

The assistance was provided by the City of Milwaukee and MMSD. The Walnut Way Conservation Corporation conducted outreach to neighborhood residents, and coordinated educational activities. The purpose of the project was to assist residents in disconnecting downspouts and installing rain gardens within a 37-block central city area served by combined sewers. The project increased environmental awareness and helped identify resident concerns and needed resources to implement these practices.

Walnut Way appointed a team of volunteers to organize and manage the RAIN project. Printed materials were distributed to residents, volunteers made presentations at neighborhood meetings, and telephone calls and personal visits were made to encourage residents to participate in the program. Residents were encouraged to disconnect downspouts and install a rain garden on their property. Residents were allowed to select a garden design from among six standardized designs produced by two landscape architects. Residents expressed two primary concerns about the rain gardens:

1. Visual Appearance: Prevailing guidelines generally focus on native plant species which tend to have an undisciplined, wild flower appearance. Some residents believed that such a garden was not suitable for the small front yards in a highly urbanized area.
2. Potential Water Overflow: Residents feared that overflow from the gardens during heavy rains could endanger house foundations, cause erosion, and form ice conditions on sidewalks.

To address these concerns, Walnut Way worked with the landscape architects to identify and offer a variety of perennial plant species that would thrive in the urban settings yet be more visually acceptable. Walnut Way also provided explicit construction guidelines to residents and contractors to try to minimize drainage problems caused by overflows.

The project was well received by the community, with 38 residents agreeing to disconnect downspouts and install a rain garden. Contractors removed compacted soil from each garden site and replaced it with pea gravel, composted soil, and mulch. The contractors also disconnected the downspouts and directed the water flow to the gardens. The plants were ordered from a nearby nursery. The gardens were planted by residents and volunteers.

Walnut Way estimated that the gardens would divert approximately 4,400 gallons of runoff from the combined sewers during a ¼-inch storm event. The landscape architects estimated that the 38 rain gardens would divert approximately 552,000 gallons of water per year.

In addition to the environmental benefits, the RAIN initiative drew wide-spread public attention. Multiple Walnut Way rain gardens were included in Milwaukee County's Rain Garden Tours in 2005 and 2006. Walnut Way's first demonstration garden was featured in an environmental exhibit at State Fair in 2006. Neighborhood rain gardens were also featured in the "Raining Champions" article in the April/May 2006 issue of Living on the Lake magazine.

Within the Walnut Way neighborhood, the RAIN initiative generated enthusiasm to engage in expanded gardening efforts and increased community interaction. Walnut Way expects to continue to grow its gardening programs and demonstrate environmental stewardship within the neighborhood, the City of Milwaukee, and beyond.

18. JOSEY HEIGHTS GREEN PAVEMENT—PHASE I (M03015E26)

The initial proposal called for installing porous pavement within the Josey Heights subdivision and the 20th & Walnut Way subdivision. Due to limited funds, the porous pavement will only be installed within Josey Heights.

Josie Heights is bordered by West Lloyd Street, North 14th Street, West Brown Street, and North 12th Street within the Milwaukee central city. It lies within the Walnut Way neighborhood. The site, cleared for the never-built Park West freeway, will be developed for 53 new homes. The developer is Coach House Development.

A stormwater management plan for Josey Heights was prepared by Conservation Design Forum (CDF). The plan includes the following "green" features:

- The streets and alley are constructed of interlocking permeable concrete pavers underlain by a 12-inch aggregate base.
- Bioswales, or rain gardens, are located between the street curb and the public sidewalk, adjacent to the alley, within a traffic circle at 13th and Harmon Street, and within some residential yards.

The plan is designed to meet the City's and MMSD's runoff standards for the 2-year and 100-year events.

The roads, alley, and most of the bioswales were completed by October 31, 2006. However, only two of the new home have been built. Over the next several years, the City of Milwaukee will evaluate how well the stormwater system performs, and assess functionality, maintenance costs, durability, and cost-effectiveness. The results will help the City of Milwaukee, MMSD, and other municipalities and developers better understand the benefits and concerns associated with innovative green development.

Coach House has prepared informational packets for homeowners to introduce them to the unique stormwater features. The packets discusses the advantages and responsibilities for maintaining the bioswales. It is anticipated that the development will attract environmentally-conscious buyers. Together with existing ongoing outreach efforts, the use of the permeable pavers will be a hands-on educational tool within the Milwaukee area.

Menomonee Central Valley Planning

MMSD joined with numerous stakeholders—the City of Milwaukee, Menomonee Valley Partners, Milwaukee Transportation Partners, Sixteenth Street Community Health Center, and local property owners—to promote a comprehensive integrated approach to stormwater management in the Menomonee Central Valley. The objectives were to address regional and on-lot practices, permitting requirements and compliance activities, monitoring, and implementation.

MMSD attended meetings with the other stakeholders to address stormwater management for the reconstructed Canal Street, a regional stormwater plan developed by Wenk & Associates, on-lot practices for existing development and redevelopment, and permit requirements for Chapter 30, NR216, NR151, MMSD Chapter 13, the City of Milwaukee Chapter 120 Stormwater Code, and U.S. Army Corps of Engineers regulations.

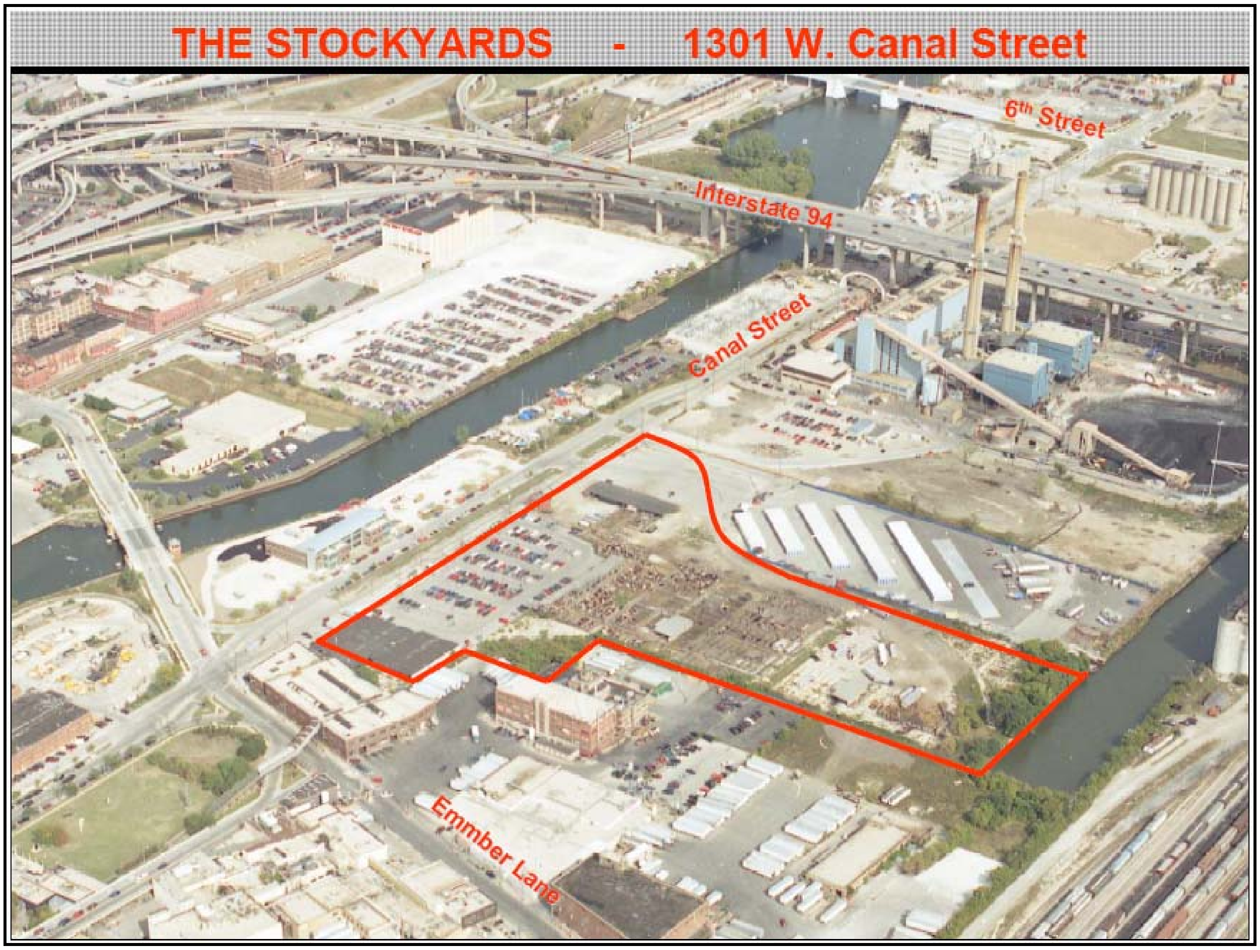


Figure 32. Menomonee Valley Stockyards.

Rather than develop a comprehensive master stormwater plan for the entire Central Valley, the stakeholders developed projects that demonstrate a coordinated approach to stormwater management in the Menomonee Valley. One such project is the Menomonee Valley Bioretention Facility (M03010) discussed previously. The City of Milwaukee constructed a two-acre bioretention system that will treat stormwater runoff from a total of 70 acres of public and private property.

A second project is the redevelopment of the stockyards property, which is a 13-acre parcel located at 104 South Emmber Lane in Milwaukee. This project is led by the Menomonee Valley Partners. The Conservation Design Forum (CDF) developed a LID alternative for the stockyard site and Stormtech, Inc. prepared a "conventional" stormwater management alternative and estimated the costs of each alternative. With those alternative plans as a guide, Menomonee Valley Partners purchased the stockyards property, and is preparing to sell it to a developer or end user.

Menomonee Valley Partners entered into a Cooperative Agreement with the City of Milwaukee to develop a comprehensive stormwater plan for the site that includes a regional treatment system. The first phase of the project will be to install a two-acre system that would treat stormwater runoff from a five-acre portion of the Canal Street right-of-way, and up to 10-acres of private development on the stockyards site. The second phase of the project will be to expand the treatment system to about four acres to accommodate runoff from an additional 20-acres of private property.

This regional treatment system will help property owners comply with applicable state and local stormwater regulations. However, new property owners will still be required to prepare and comply with a site-specific stormwater management plan, as required by the City.

Under the agreement, the City of Milwaukee will construct and help fund the treatment system (up to $1 million). The City also agreed to provide other technical and financial support. The City staff will seek to amend the City's stormwater ordinance to require future developments within the treatment area to use the treatment system. As an alternative, the City may seek to establish a renewal plan, zoning, or stormwater overlay district. Private property owners beyond the stockyards site may be required to provide cost sharing for the construction, operation, and maintenance of the regional treatment system.

Shorewood Wet Weather Flow Volume and Peak Management Project

This joint project by the Village of Shorewood and MMSD will provide basement backup protection for the combined sewer service area of the Village of Shorewood. While structural solutions that provide adequate pipe capacity to achieve this purpose have already been identified, the project seeks an alternative approach that is aimed at managing wet weather capacities, runoff volumes, and flow peaks in order to arrive at a more cost effective and comprehensive solution package that coincides with interest in volume and peak management improvements.

The three main purposes of the project are to:

1. Provide demonstration, evaluation, and education opportunities for management practices.
2. Evaluate the effect of management techniques on reducing basement backup risks in the combined service area of Shorewood.
3. Evaluate the effect of management techniques on volume and peak flows discharging to the MMSD systems.

The project engineer, Bonestroo, Rosene, Anderlik & Associates, Inc., recommended:

1. Catch basin rerouting
2. Storm sewer construction
3. Downspout disconnections
4. On-Lot flow management by installing rain barrels and rain gardens
5. Inlet flow regulators in the Shorewood combined sewer area

6. Runoff reduction at UWM.

DOWNSPOUT DISCONNECTION

At least three separate mailings and a door-to-door campaign resulted in a robust response from the area residents. As of December 2, 2005, the resident outreach efforts had attracted responses from about 55 percent of the households in the project area; these households had about half of all connected downspouts in the area.

After field visits to the responding residences, the project team was able to identify one or more disconnections at about 59 percent of the residences.

The total number of downspouts identified for disconnection in 2005 was 505, which is about 35 percent of all connected downspouts. The disconnections represent the equivalent removal of 126 roofs from the combined sewers.

The Gutter Company, Inc. disconnected the downspouts, sealed the openings, and provided a minimum five-foot extension for a base price of $35 per downspout. There were additional allowances for extra costs where needed.

Table 8
Summary of Disconnections in Shorewood Project Area

Number of residences that responded to outreach	458 (55% of homes)
Number of residences where one or more downspouts were identified for disconnection	269 (59% of responses)
Number of connected downspouts at these 458 residences	1,443 (51% of all downspouts)
Number of confirmed disconnections	505 (35% of connected)
Equivalent roofs slated for disconnection	126

ON-LOT RUNOFF MANAGEMENT

A total of 50 rain gardens were constructed in 2005. Forty-eight of these were residential gardens, and two larger rain gardens were built as demonstration sites at the Shorewood Library Village Center and at Atwater School. No more rain gardens will be constructed as part of this project.

As of December 2, 2005, 80 rain barrels were installed at 54 households. Another 11 rain barrels have been scheduled for installation as weather permits in 2005 or more likely, in early spring of 2006. More rain barrels may be ordered as the project returns to action in 2006 and beyond. The rain barrels cost $59 each, and the installation cost was $50 per rain barrel. A $30 diverter was placed on each rain barrel to allow the discharge to bypass the rain barrels during the winter and extreme rain events.

Shorewood

OFFICIAL NOTICE

2005 RAIN GARDEN DESIGN AND INSTALLATION

VILLAGE OF SHOREWOOD

PLEASE TAKE NOTICE that sealed bids will be received by the Village of Shorewood in the office of the Director of Public Works, 3801 North Morris Blvd., Shorewood, Wisconsin, 53211, up to but no later than 11:00 A.M., C.D.S.T., on Thursday, May 12, 2005 at which time bids will be opened for the provision of all labor, equipment and material necessary for the following work:

1. **Site Assessment/Soil Testing:** Determine optimal placement of the Rain Garden and current soil conditions.
2. **Rain Garden Design:** Prepare and present proposed layout and design for homeowner and Village approval.
3. **Digger's Hotline Location:** Submit request for location of utilities prior to commencement of work.
4. **Rain Garden Installation – ASSUME 100 SQUARE FEET:**
   a. Define Rain Garden location.
   b. Plywood lawn areas, as needed, to minimize compaction and lawn disturbance from equipment.
   c. Excavate soil 2 to 3 feet, based on site assessment.
   d. Use portion of excavated soil to create berm, as dictated by site topography; remove remaining excavated soil from site and deposit at Shorewood DPW.
   e. Furnish and install approximately 6.5 CY of custom soil mix (50% sand/25% topsoil/25% compost). Final grade to be 3" below existing lawn grade to allow for future settling.
   f. Furnish and install 75 plants – (25) plugs and (50) 4½" pots.
   g. Furnish and install approximately 1" of shredded hardwood bark mulch.
   h. Water in plant material (one time).
   i. Remove debris and dispose of off site.
5. **Drainage:** Furnish and install flagstone steppers (or approved equivalent) to direct water from downspout extension to Rain Garden. Flagstone to extend 5feet from extension, and installed at grade to allow for ease of mowing. If distance of Rain Garden is greater than 10feet from house, additional grading/swales shall be provided.
6. **Post-Construction Lawn Repair:** Top-dress disturbed lawn with topsoil, seed and mulch, and water (once).
7. **Maintenance:** Allow for 10 hours of maintenance (weeding, watering, cutbacks) or 8 visits to the Rain Garden (4 visits in the first 2 months after installation, 3 monthly visits during the following three months, and one visit in the Spring following installation).

Your bid must contain a unit price per rain garden (as described above) and be received in a sealed envelope with "2005 RAIN GARDEN DESIGN AND INSTALLATION" clearly typed on it.

The letting of work is subject to the provisions of Section 66.0901 of the Wisconsin Statutes. Recommendations will be made to the Village Board at their meeting in May 2005. Award will be made to the lowest, best, most responsible bidder. The Village of Shorewood reserves the right to reject any or all bids.

Dated at Shorewood, Wisconsin, this 26th day of April, 2005.

VILLAGE OF SHOREWOOD
James F. Bartnicki
Director of Public Works

Figure 33. Rain garden specifications for the Village of Shorewood.

The rain gardens were installed by Landworks Horticultural Services for the base fee of $23.30 per square foot, or $2,300 for a typical 100-square foot rain garden. Each rain garden will be inspected and maintained for one year by Landworks.

STORM SEWER CONSTRUCTION

The purpose of storm sewer construction is to redirect 18 catch basins currently connected to combined sewers into the storm sewer pipes. This component of the project is coordinated with the Village's street reconstruction program.

The goal of the storm sewer construction component is the redirection of runoff from about 15 acres of land from combined sewers to storm sewers, thereby reducing total runoff rates and volumes in the combined sewers.

Table 9
Shorewood Storm Sewer Construction – Redirecting Runoff from Combined Sewers to Storm Sewers

Improvement	Location	Status
400 ft. of 12 inch diameter pipe	Cramer Street between Lake Bluff and Kensington	Construction in Spring 2006
375 ft of 12 inch pipe	Lake Bluff from Cramer to Oakland Avenue	Construction in Spring 2006
600 ft. of 12 inch diameter pipe	Prospect Avenue between Lake Bluff and Kensington	Constructed in 2005
450 ft of 12 inch pipe	Lake Drive, north of Lake Bluff	Design complete
750 ft of 12 inch pipe	Lake Drive between Marion Street and Wood Place	Design complete
350 ft. of 12 inch pipe	Wood Place between Stowell Avenue and Downer Avenue.	Design complete
350 feet of 12 inch diameter pipe	North Downer Avenue, south of Jarvis Street	Design complete
375 feet of 12 inch diameter pipe	North Stowell Avenue, south of Jarvis Street	Constructed in 2005
380 feet of 12 inch diameter pipe, 400 feet of 15 inch pipe, and 6 catch basins	North Lake Drive at Capitol Drive	Design complete

CATCH BASIN FLOW REGULATORS AND STREET STORAGE

Catch basin flow regulators or restrictors have been in use in Shorewood for the last four years. The relatively benign short term street flooding caused by these devices appears to have been accepted as a small price to pay for their considerable hydraulic benefits.

Shorewood is also creating designated street storage areas that work hand in hand with inlet flow restrictors. The first one of these street storage areas is on the newly reconstructed Prospect Avenue.

The catch basin restrictor at this location will be installed in the catch basin in 2006, but the street is currently graded such that it will allow a maximum of 6 inches of runoff storage during a brief period.

In the following picture (Figure 34) taken after street reconstruction, the dots indicate the location of the inlets. The storage area is imperceptible to the naked eye during dry periods.

Figure 34. Inlet restrictor locations, Prospect Avenue.

RUNOFF REDUCTION ESTIMATES

Downspout Disconnection

With an average surface area of 1,950 square feet per roof in the project area, a total of 5.64 acres of impervious surface have been removed from the combined sewers in Shorewood. This corresponds to an 8 percent reduction in imperviousness in the combined sewer watershed, or the removal of 20,500 cubic feet of runoff from the combined sewers per inch of rainfall.

The ultimate objective of the project is to remove another 5 acres from draining into the combined sewers, thereby reducing total imperviousness by 15 percent. The expected total reduction of runoff volume per inch of rainfall is therefore 40,000 cubic feet.

Because the project area is partially separated, the installation of rain gardens and rain barrels provided water quality benefits, but no additional runoff reduction.

Storm Sewer Construction

Each new storm sewer segment removes catch basins and inlets currently connected to the combined sewers. Each storm sewer segment removes between 1.5 and 3 acres of watershed area (front yards, sidewalks, side yards, streets, etc.) from the combined sewer watershed. A land cover review indicates that the average imperviousness in this watershed is 40 percent, and each new storm sewer segment is expected to remove about 3,000 cubic feet of runoff from the combined sewers per inch of rainfall.

The ultimate objective of the project is to remove 15 acres from the combined sewer watershed through storm sewer construction and thereby achieve a net removal of 22,000 cubic feet of runoff per inch of rainfall.

Table 10
Summary of Runoff Volume Reduction Estimates in Shorewood

Project Element	**Current**	**Ultimate**
	ft^3 of runoff per 1 inch of rain	
Volume Reduction Due to Downspout Disconnection	20,500	40,000
Volume Reduction Due to Storm Sewer Construction	6,000	22,000
TOTAL RUNOFF VOLUME REDUCTION	26,500	62,000

Milwaukee Downtown Downspout Disconnection Project

This project evaluated the feasibility of disconnecting roof downspouts from public and institutional buildings in the Milwaukee downtown area and directing that stormwater to a suitable pervious area. Downspout disconnection is one way to reduce the volume of stormwater entering the City of Milwaukee's combined sewer system. This project also helped promote public awareness and knowledge of disconnecting downspouts.

A total of 137 public and institutional buildings were surveyed within a 1.4 square mile downtown area. The majority of the buildings were owned by schools or universities, government agencies, or churches. General guidelines were developed to identify buildings that were suitable for downspout disconnection. The guidelines are listed in Table 11.

Table 11
General Guidelines to Identify Buildings That May Be Suitable for Downspout Disconnection

1. *Lot size 6,000 square feet or larger.*
2. *Maximum 700 square feet of roof surface may drain to each disconnected downspout.*
3. *Downspout must be external, and not internally routed through the building.*
4. *Ground must slope away from the foundation.*
5. *Discharge must flow away from the building over a pervious surface, and not over sidewalks or driveways, nor onto an adjacent property.*
6. *Discharge point must extend at least 5 feet from the foundation.*
7. *Any rain gardens installed must be located at least 10 feet from the foundation.*

The study indicated that it is reasonable to disconnect the downspouts from 16 buildings and several additional buildings could be partially disconnected. The potential downspout disconnection buildings were prioritized based on the availability of pervious green space, building ownership, and the presence of external accessible downspouts.

The most feasible sites for downspout disconnection are:

- Haggerty House, Marquette University
- Helfaer Theather, Marquette University
- Triangle Fraternity House
- Ardupe House, Wisconsin Province of the Society of Jesus
- Sarah Scott Middle School, Milwaukee Public Schools

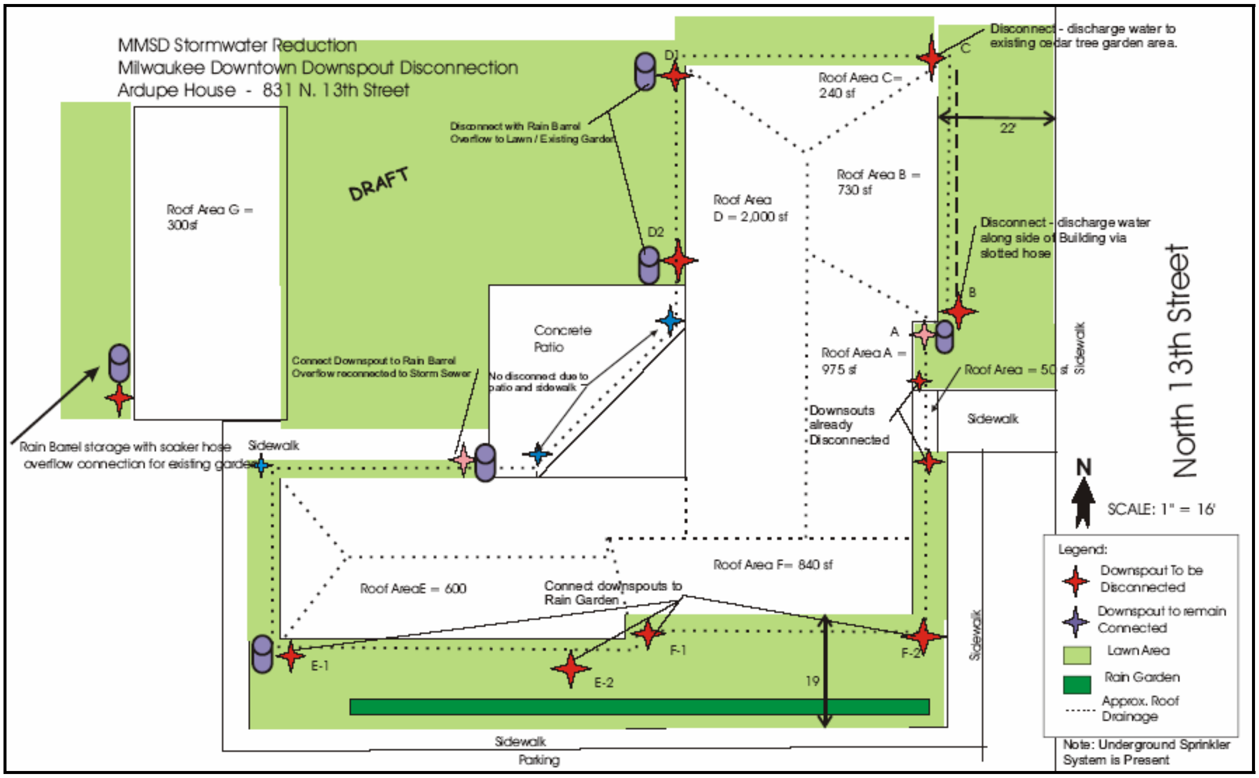


Figure 35. Draft disconnection plan for the Ardupe House.

The findings of this project are:

- External downspouts were observed on 26 percent of the surveyed buildings. Most large public and institutional buildings have internal downspouts.
- About 12 percent of the buildings could be at least partially disconnected, with the runoff being discharged onto a suitable pervious surface. If additional storage vessels, rain gardens, or conveyance systems were constructed, up to 20 percent of the buildings could be at least partially disconnected.
- Some local ordinances may prohibit the disconnection of downspouts from non-residential structures. Milwaukee Code of Ordinances 225-4, *Plumbing and Drainage*, was revised to allow the disconnections.

BMP Construction Criteria Projects

In 2005, MMSD awarded funding for four BMP construction criteria projects. The primary objective of these projects is to determine whether increased infiltration of stormwater by BMPs such as porous pavement, rain gardens, downspout disconnection, green roof discharges, and wet detention basins may increase soil saturation levels and increase infiltration and inflow into sanitary sewers and laterals. These projects will assess the impacts on sewer infiltration and inflow, and define criteria that could be used to minimize that risk.

Such criteria may include:

- Soil type limitations
- Setback distances for BMPs from sewers
- Limit selection of BMPs
- BMP construction or design specifications (size, liners, material)
- Monitoring recommendations

Table 12
Summary of BMP Construction Criteria Projects

Project	Cost $ (MMSD)	Cost $ (share)	Schedule	Location	Contact	Description
Porous Pavement Construction Criteria M03015E18	$35,000	$35,000	Jan. 2005 – July 2007	Mitchell International Airport	Stormtech David Kendziorski (920) 533-5271	A porous concrete pad was installed at Mitchell International Airport. Monitoring equipment will be installed to measure lateral water movement. Results and performance information to be used to develop pervious concrete design and construction criteria.
Design Guidelines to Prevent Increased I/I from Stormwater BMPs M03015E18	$49,750	$49,750	Jan. 2005 - Nov. 2005	Various in District Service Area	Triad Engineering William Gonwa (414) 291-8850	Field experiments were performed on rain gardens, downspout extenders, and rain barrels to determine their effects on I/I. From these experiments, design and construction guidelines were developed on stormwater BMPs.
Wet Detention Basin Infiltration Study M03015E17	$39,580	$39,580	Jan. 2005 - Dec. 2005	Wet Detention- N. Granville Woods Rd. & W. Dean Rd. Dry Detention- W. Brown Deer Rd. & N. Lauer St.	City of Milwaukee Pat Obenauf (414) 286-0516	Flow was monitored upstream and downstream of two detention basins. Data were used in conjunction with modeling software and a model of the sanitary systems. Various storms were run through the model to determine infiltration into the sanitary sewers.
UWM GLWI Green Roof and Rain Garden Evaluation M03015E15	$55,458	$64,879	Oct. 2004 – July 2007	GLWI Green Roof, UWM campus-rain garden, Edgewood Ave. and Downer Ave.	UW-Milwaukee Hector Bravo (414) 229-6756 Sandra McLellan (414) 382-1700	Comprehensive monitoring program for the evaluation of the Great Lakes Water Institute's green roof. Quantitative data on the effect of rain gardens on groundwater and underground infrastructure will be provided.

POROUS PAVEMENT CONSTRUCTION CRITERIA

Mitchell International Airport is evaluating the potential performance of porous pavement. The Zabest Commercial Group installed a 4-inch thick, 8 foot x 10 foot Eco Creto pervious concrete pad over a stone detention layer consisting of six inches of 1-inch stone, and 18 inches of 2-inch stone, over a geotextile fabric. A four-inch diameter PVC monitoring port was installed in the center of the test pad. Monitoring points will be installed at various distances and depths from the pad. A data logger will be installed in the monitoring port within the pad, and in the monitoring points. The monitoring is to be completed by July 2007.

DESIGN GUIDELINES TO PREVENT INCREASED I/I

The Triad project consisted of three field experiments at five private property sites. The project evaluated downspout extensions, rain gardens, and rain barrels. The project results were as follows:

> Rain Gardens: The closer the rain garden to the sewer lateral, the more it had an effect on soil moisture (which may be indicative of infiltration into a sewer). The project showed that it is not advisable to place a rain garden directly on top of a sewer lateral. However, at 10 feet away, the rain gardens had no significant effect on soil moisture. Water that falls on a rain garden percolates straight down and there is little horizontal movement in the unsaturated zone.
>
> Downspout Extension: Downspout experiments performed with 5-foot extenders resulted in no discharge into the foundation drains.
>
> Rain Barrels: Discharge from a rain barrel through a 25 foot long weeping hose placed 2.5 feet from the foundation showed no discharge into the foundation drains. The discharge was completely absorbed by the soil.

Triad recommended that:

1. Rain gardens should be placed at least 10 feet away from a sewer lateral or house foundation.

2. Downspout extenders have a minimum length of five feet, although 10 foot long extenders are preferred to prevent possible damage to a building foundation.

3. Rain barrel weeping hoses may be placed anywhere along a house, as long as they discharge at least 10 feet away from the foundation onto relatively dry soil consisting of sandy loam or finer material.

WET DETENTION BASIN INFILTRATION STUDY

The City of Milwaukee's Wet Detention Infiltration Study evaluated the amount of infiltration entering sanitary sewers near stormwater detention facilities. The City would use this information as guidance when determining the location of detention ponds or other stormwater BMPs near sanitary sewers to prevent or reduce infiltration. A wet detention basin with a liner designed to prevent infiltration, located near N. Granville Woods Road and W. Dean Road, was evaluated. A dry detention basin at W. Brown Deer Road and N. Lauer Street, without a liner, was also evaluated. The City installed Sigma 910 monitors in manholes both upstream and downstream of the two pond locations.

The study found there was no infiltration into the system from either location. This study indicates that the City's guidelines were appropriate for the wet basin and dry basin that were studied. The detention ponds used in this study were not directly over the sanitary sewer and no sanitary sewer laterals were near the detention facilities. Additional investigation is needed to determine if the City's guidelines are adequate to protect against infiltration into sanitary sewer if the detention basins are located over the sanitary sewer or near a sanitary sewer lateral.

UWM GREEN ROOF AND RAIN GARDEN EVALUATION

The UWM project evaluated rain gardens (and similar infiltration practices) and the Great Lakes Water Institute green roof. The project results were as follows:

Rain Garden: A 10 foot artificial rain garden was constructed on the UWM Campus near the corner of Downer and Edgewood Avenues. Time Domain Reflectometry (TDR) probes were installed in a 10-foot deep trench along one side of the rain garden. During the tests, the rain garden was flooded and the TDR probes measured soil moisture at various depths. The rain garden was moved to a different distance from the trench and retested. The excavated soils were clay.

Despite the clay soils, about 6.4 inches of water infiltrated into the soil during the first 45 minutes (equivalent to a two-year one hour storm). After the initial hour, infiltration continued at 2 to 3 inches per hour. The results indicated that water infiltration from the artificial rain garden caused the soil moisture content in the trench located two feet from the garden to increase by approximately 0.5% at 9.5 feet below the surface (near sewer lateral depth) after 10 hours. The project concluded that a rain garden built at a horizontal distance of 2 feet or greater from a sewer lateral would probably not lead to a significant increase in infiltration into the sewer lateral.

Figure 36. Artificial rain garden used in the UWM project.

Green Roof: Flow monitoring equipment was installed on the Great Lake Water Institute green roof in October 2005. Flow measurements will be taken during the spring and summer of 2007. The reduction in runoff volume and peak discharge produced by the green roof will be calculated. Water quality will also be monitored.

Urban Open Space Foundation

The Urban Open Space Foundation (UOSF), a private not-for-profit conservation organization, is leading a public space planning process for one of Milwaukee's inner city neighborhoods. The *Fond du Lac and North Avenue Green Infrastructure Initiative* aims to revitalize the civic realm by transforming unused, underused and blighted outdoor spaces into vibrant public places. Through these efforts, the Foundation is helping to address stormwater issues and cultivate a more sustainable urban environment UOSF published "Green Infrastructure Planning for Milwaukee's Inner City: Fond du Lac & North Avenue Neighborhood, Milwaukee" in February 2005. The report mapped existing vegetated areas, impervious surfaces, ground cover at public and private school grounds, vegetative cover within street rights-of-way, tree canopy cover, and streetscaping. The green infrastructure plan focuses on reducing the pressures of the regional stormwater system by increasing the quantity of natural vegetation and reducing impervious surfaces. MMSD provided funding to support the formative stage of this green infrastructure project by mapping features relevant to stormwater management.

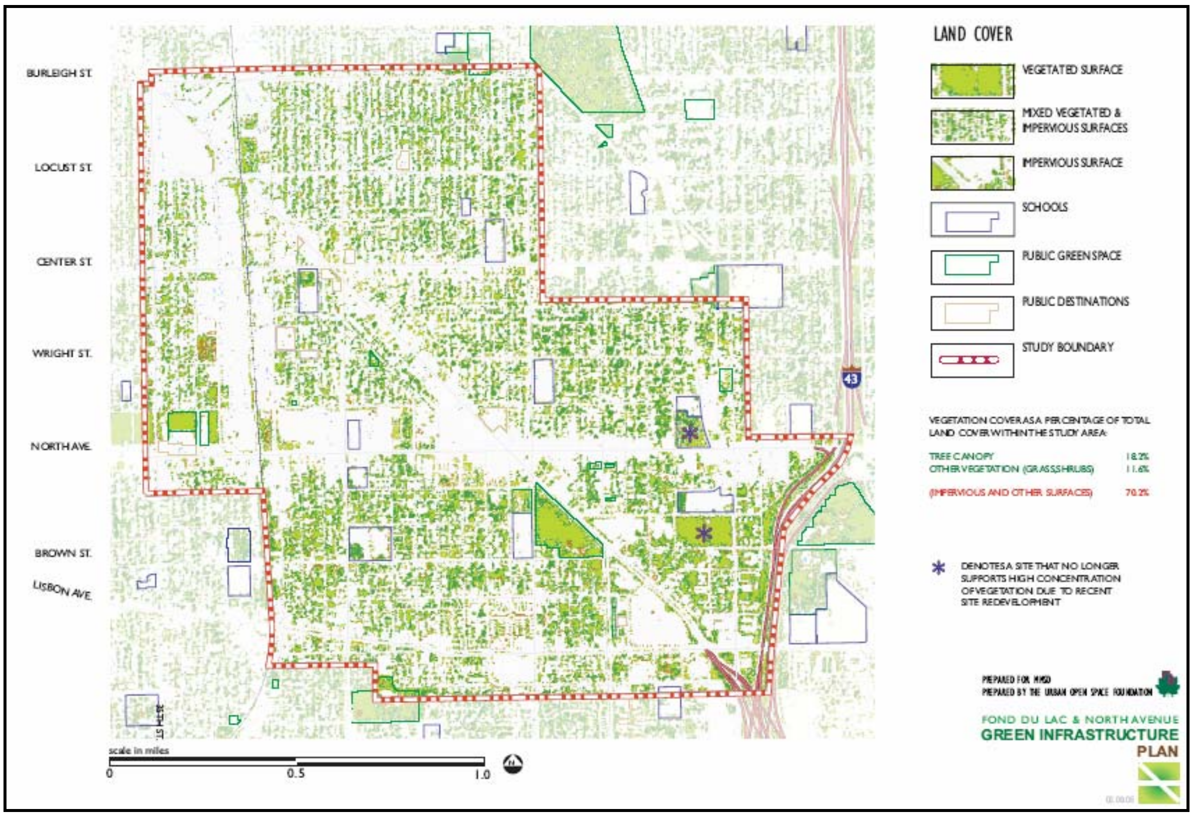


Figure 37. Land cover in the Fond du Lac & North Avenue Neighborhood.

South Shore Beach Stormwater Treatment

The high number of beach closings at South Shore Beach in Milwaukee has attracted the attention of citizens, public health officials, the Wisconsin Department of Natural Resources, and state legislators. This trend seems contrary in light of the recent progress in reduction of fecal pollution entering Lake Michigan each year, yet is a typical problem in other recreational areas throughout the state. Data from intensive water sampling and subsequent E.coli quantification demonstrate persistent, localized contamination at South Shore Beach. Roosting birds and stormwater runoff were two major sources of E.coli bacteria levels at South Shore Beach. The loading of indicator bacteria from urban nonpoint source runoff is well documented by WDNR. Bacterial levels, at times reaching 100,000 to 250,000 CFU/100 ml, have been detected in urban stormwater by MMSD and WDNR monitoring programs.

Figure 38. StormTreat device at South Shore Beach.

At South Shore Beach, management practices could provide effective tools in addressing localized problems. Under a joint project between Milwaukee County, Coastal Zone Management, the Great Lakes Water Institute, and MMSD, a trench interceptor and StormTreat cell were installed at the South Shore boat ramp to collect and treat stormwater runoff from the parking lot. A monitoring program was intended to test runoff water quality from the parking lot after installation to assess the effectiveness of the BMP at this site. However, due to equipment malfunction, the monitoring was not successful. An interpretive sign will identify the project as a stormwater BMP and direct interested parties to a web line; detailed information on the rationale, installation, and technology will be provided on the Water Institute web site, along with general information about the negative impact of urban stormwater runoff on water quality.

South Shore Park Watch Neighborhood Demonstration

South Shore Park Watch is a non-profit organization in Milwaukee's Bay View neighborhood. The South Shore Park Watch initiated a downspout disconnection and rain barrel program along a 12-block stretch of Delaware Avenue between Oklahoma Avenue and St. Clair Street. The project area includes approximately 200 single family and two-family homes and 30 small businesses.

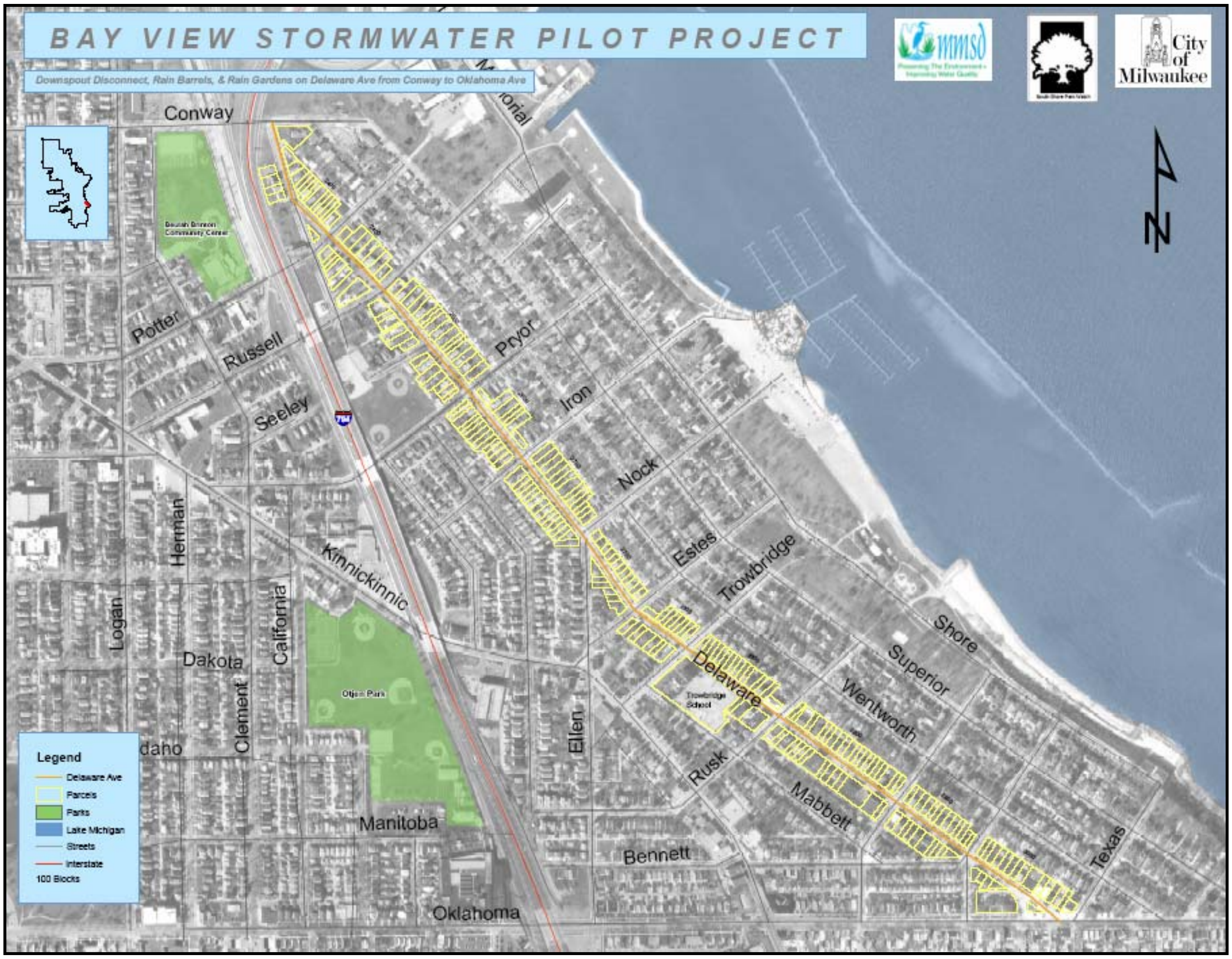


Figure 39. South Shore Park Watch Project area is shown in yellow.

The project is intended to reduce the amount of water that enters the sewer system and to demonstrate the feasibility of disconnecting downspouts and installing rain barrels in a neighborhood with small narrow lots. The goal of the project is to implement downspout disconnection and rain barrels for two properties on each block. The homeowners will be responsible for disconnecting their own downspouts and installing their rain barrels, but will be required to attend a training session if using supplies provided by the South Shore Park Watch pilot project. Homeowners who are not using supplies provided by the demonstration project will also be invited and encouraged to attend the training sessions. Limited funds will be set aside to assist homeowners who are not able to perform the disconnections or installations themselves.

The project will also include a community rain garden. Residents of the community will be invited to participate in a rain garden training/informational session and will work together to construct the rain garden. Residents with enough space on their properties will be encouraged to install rain gardens on their own.

An open house was held in October of 2005 to inform residents of the demonstration project. Training sessions and construction were scheduled to begin in 2006.

Cambridge Woods Neighborhood Association – Cleaning Rainwater on Site

The Cambridge Woods Neighborhood Association implemented a pilot project in their neighborhood to reduce the amount of water entering the combined sewer system and to provide a model for other neighborhoods to mimic. This project will include disconnecting downspouts, installing rain barrels, and establishing rain gardens and green roofs. The Cambridge Woods neighborhood has a population of about 12,000 people and is located near the University of Wisconsin - Milwaukee and Columbia Hospital.

The Cambridge Woods Neighborhood Association distributed one rain barrel for each of the 27 blocks in the project area plus 27 more to others throughout the same neighborhood, for a total of 54 rain barrels. They also installed one rain garden and one green roof on residential property. The property owners have agreed to allow visitors to their property to learn more about their rain garden and green roof. Three other neighborhoods (Murray Hill, Water Tower Trust, Mariners) are planning to implement similar programs during the next three years, one neighborhood per year. Each year a report will summarize the successes and challenges of the program so improvements can be made. This project includes education, publicity, installation, and evaluation components.

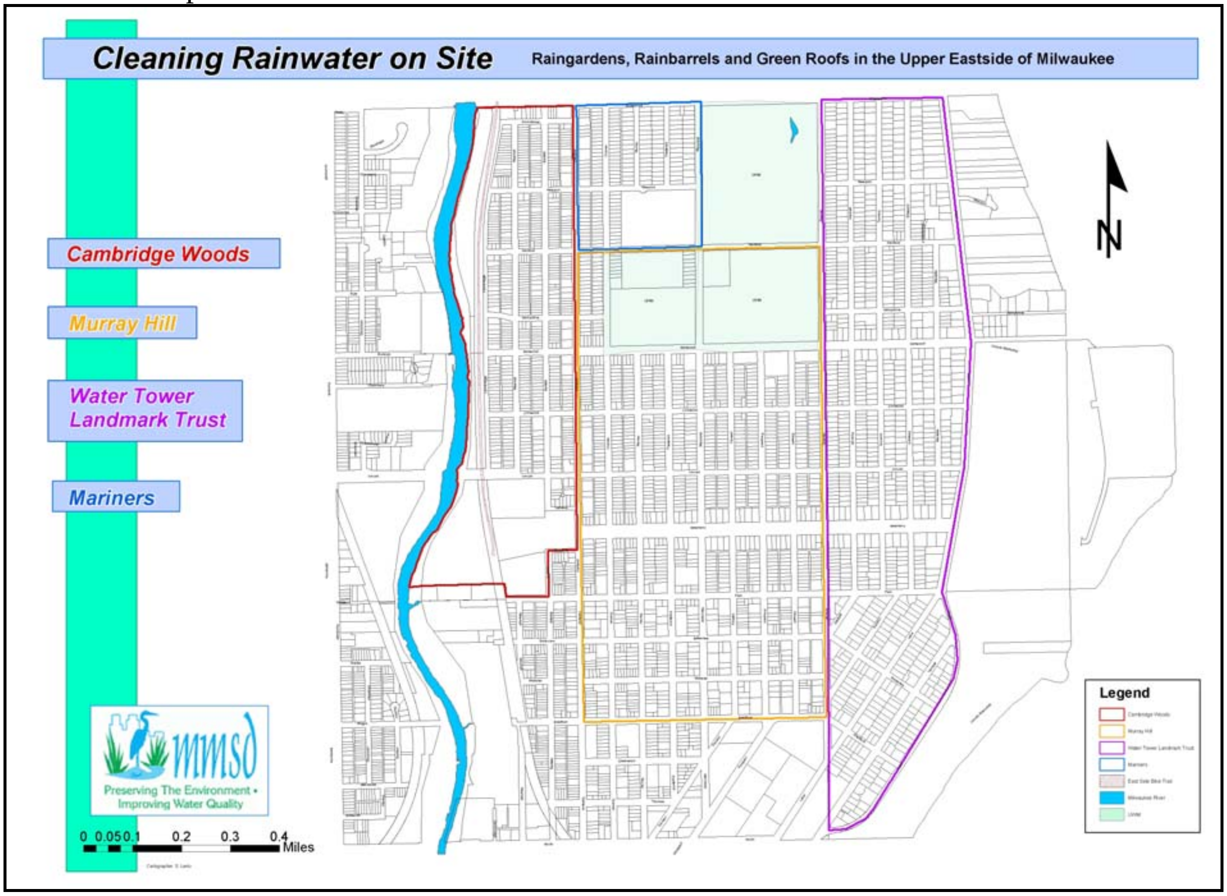


Figure 40. Neighborhoods involved with the Cambridge Woods project.

Certain communities in the United States have documented the effectiveness of stormwater runoff volume reduction programs in association with strategies directed towards mitigating the frequency and magnitude of combined sewer and sanitary sewer overflows (CSO and SSO, respectively). This survey of communities with successful programs was conducted by the Center for Watershed Protection. Specific communities highlighted include:

- Portland, OR
- Bremerton, WA
- Philadelphia, PA
- Johnson County, KS
- South Portland, ME

The communities summarized do not rely exclusively on volume reduction approaches to address their CSO and SSO issues, but rather use them as one of several tools they apply. An added benefit that communities realize from volume reduction approaches is that they typically require interaction with and education of the general public, which is valuable in terms of increasing public awareness and understanding. These added benefits also help meet various NPDES permit requirements facing communities.

It appears that MMSD is keeping pace with and in many cases surpassing the initiatives being undertaken in other communities that are incorporating innovative approaches to volume reduction into their combined sewer overflow strategies.

For the purpose of this survey, volume reduction refers to practices that reduce the amount of stormwater runoff that enters into the combined sewer or sanitary sewer system. Examples include downspout, foundation, driveway and yard drain disconnections, infiltration practices, and impervious area separation (e.g., collecting and conveying runoff from large impervious areas such as parking lots to stormwater best management practices, which in turn discharge to receiving waters).

Portland, OR

Portland, Oregon has one of the more advanced CSO programs in the country and perhaps the most significant examples of widespread implementation of volume reduction practices. Specifically, Portland's volume reduction strategy has focused on downspout disconnection and deep infiltration sumps. More recent attention has been given to emerging technologies such as green roofs; however, widespread implementation of these newer practices has not yet occurred.

Figure 41. Siskiyou Street Curb Extension (Portland BES).

As of 2005, Portland has completed more than 47,000 downspout disconnections. The estimated annual volume reduction associated with these disconnections is over one billion gallons (Rosen, 2005). Since 1993, Portland has installed about 3,000 deep infiltration sumps. The estimated volume reduction to the combined system realized due to the sumps is approximately three billion gallons per year. It has become increasingly difficult for the City to find suitable sites for locating deep sumps primarily due to poor geological conditions.

Portland has a robust demonstration project program underway as well that is closely tied to combined sewer strategies and reducing flows and volumes to the system. Successful examples of multiple installations include green streets/parking lots (Figure 41), green roofs (Figure 42), and stormwater planters (Figure 43). For example, flow testing of green street application demonstrated an 85% volume reduction for the 25-year design event (1.89 inches in 6 hours) and peak flow reduction of 88% (Portland BES, 2004). Green roof monitoring over a two-year period showed annual volume reductions of about 70% (Hutchinson et al., 2003). Now that the City has seen positive results and collected reliable data using these newer practices, they are moving into a more targeted strategy of modeling the effectiveness of these practices on a sewershed basis (Rosen, 2005).

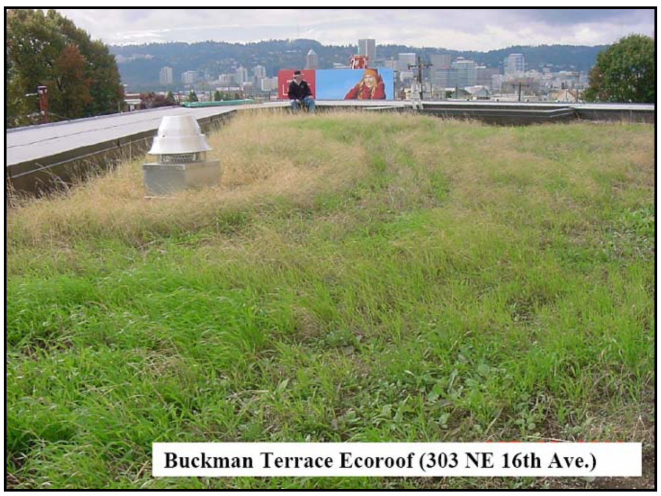


Figure 42. Buckman Terrace green roof (Portland BES).

Figure 43. Stormwater Planter (Portland BES).

Bremerton, WA

The City of Bremerton, Washington is located in the Puget Sound region west of Seattle. It has a population of about 39,000 and spans about 23 square miles (http://www.ci.bremerton.wa.us/). In 1992, Bremerton developed a CSO reduction plan that included engineered solutions such as online/inline storage, increased treatment plant capacity, and new and expanded pump stations. 1994 flow monitoring indicated that initial planning estimates of CSO volumes were low and that planned engineered solutions would not be sufficient. As a result, the City decided to target private property stormwater connections to the combined system. This included disconnecting downspouts, foundation drains, and yard inlets for the combined system.

Under a two-year grant, from 2001 to 2002, the City provided free site inspections and technical assistance to private property owners. In addition, the City provided financial assistance to property owners to have work completed. By the end of the grant period, the program completed 2,900 site inspections, of which 467 properties (16%) had direct stormwater connections to the combined sewer system. Of these, 358 separations (77% of the targeted properties) were made. The City estimates that for every one-inch rain, roughly 260,000 gallons of runoff is removed from their combined system. The program cost was $270,000 or approximately $1.04 per gallon of runoff removed per one-inch rain. This cost compares quite favorably to the City's estimated cost of $5-$10 per gallon removed or treated using engineered solutions.

City of Bremerton staff indicates that as of 2005, the City has achieved a 99% reduction in overflows and that the disconnection program provided significant benefits to their overall strategy to reduce overflows. Staff also indicated that an important objective of disconnection is to try to provide some type of treatment, if only vegetative filtering of the stormwater, prior to discharge to receiving waters (Berthiaume, 2005).

Philadelphia, PA

The Philadelphia Water Department (PWD) has investigated a variety of mechanisms to reduce stormwater flows to both its combined and separate storm systems. The recently completed *Cobbs Creek Integrated Watershed Management Plan* (PWD, 2004) analyzes a variety of structural and nonstructural measures to reduce both quantity and pollutant loads of stormwater discharges. The measures investigated include zoning and land use control, municipal measures (e.g., sanitary overflow elimination, reduction of I/I, etc.), and source control measures (e.g., better site design, porous pavement, green rooftops, etc.). The City has developed a long-term (20-year) goal of capturing 85% of all sanitary overflows into the storm system.

In addition, PWD's "Stormwater Management Guidance Manual" provides a system of incentives and credits for impervious disconnection, use of rain barrels, porous pavement, and other volume reduction measures. The intent of these measures is to reduce "Directly Connected Impervious Area (DCIA)." The manual will become effective January, 2006.

PWD has conducted detailed modeling studies to assess the effectiveness of a suite of stormwater best management practices at reducing runoff volumes to both separate and combined sewer systems at the watershed scale. Myers et al. (2004) reported that SWMM simulations of the Cobb Creek watershed showed a theoretical volume reduction at the watershed scale for dry wells, porous pavement, and green roofs of 35%, 13%, and 55%, respectively.

The program is in Year 1 of implementation. Several small projects have been installed, but the "on-the-ground" phase is just beginning.

Johnson County, KS

An older case study worth noting is that of Johnson County, Kansas and Johnson County Wastewater (JCW). This case study is frequently highlighted by EPA and specifically deals with SSOs as opposed to CSOs. Nevertheless, the effectiveness of the approach JCW employed has relevance to combined sewer system volume reduction strategies.

JCW's service area is a 20-square mile section of eastern Kansas that shares a border with Kansas City, Missouri. Land use in the region is dominated by single-family residential, commercial business, and some light industry. The service area encompasses 22 communities with a population of about 500,000 (http://www.epa.gov/npdes/sso/kansas/index.htm).

In the mid 1980s, JCW set out to study and develop a mitigation plan to reduce the number and volume of SSOs that were plaguing the sanitary system. It was believed that unpermitted inflow from private property sources (e.g., outdoor drains, downspouts, sump pumps, basement drains, and foundation drains) were a major source of wet weather flow that was causing SSOs. Beginning in 1985, JCW surveyed more than 55,000 residences and businesses, identifying 15,600 private sources of inflow. These properties were the focus of JCW's disconnection program, which was phased in through 1994.

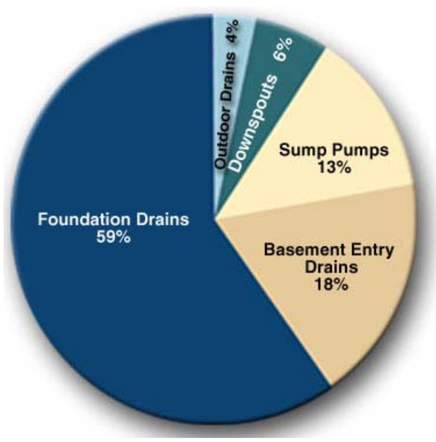


Figure 44. Distribution of Private Inflow Sources to JCW System

Funds were set aside to reimburse owners for direct costs associated with removal of the unpermitted connections. JCW established informal fixed-price contracts with local contractors, and provided property owners with a list of pre-approved contractors. The inflow reduction program resulted in wet weather flow reductions estimated at 280 million gallons per day during the 10-year, 6-hour storm. Total cost of the private property inflow reduction program was approximately $11.2 million (USEPA, 2004).

South Portland, ME

South Portland, Maine is a small city of 23,000 people with a combined sewer service area of approximately 12 square miles. From 1986 to 1995 the City spent over $2 million to reduce wet weather inflows into their system by instituting a disconnection program that focused on downspouts and sump pumps. The program redirected 65% of known sources, which resulted in a 58 million gallon per year reduction in CSOs and a three percent reduction in annual flow to the local wastewater treatment plant (USEPA, 2004).

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IMPACT OF LOCAL ORDINANCES ON STORMWATER RUNOFF REDUCTION BMPS

Local ordinances and codes can affect the implementation of BMPs. Some ordinances can prohibit or restrict the use of certain BMPs. Ordinances can also promote implementation by requiring or encouraging BMPs, and by setting standards and criteria for design, construction, and maintenance. MMSD retained Stormtech, Inc. and the Center for Watershed Protection (CWP) to conduct an audit of local codes and ordinances governing site development to determine whether better site development guidelines can be met under current regulations. The audit identified obstacles to using stormwater runoff reduction BMPs and offered recommendations to improve BMP implementation.

MMSD established a Stormwater Ordinance Review Committee in June of 2005 to review the audit findings and recommendations. The MMSD Technical Advisory Team was asked to designate local staff to serve on the Committee. Representatives of the City of Milwaukee, City of Mequon, City of Brookfield, Village of Brown Deer, and Village of Menomonee Falls participated on the Committee.

Stormwater Ordinance Review Committee

The members of the Stormwater Ordinance Review Committee are:

Chris Rute, Department of City Development, City of Milwaukee
Mark Lloyd, P.E., Assistant City Engineer, City of Mequon
Jeff Nettesheim, P.E., Senior Utility Engineer, Village of Menomonee Falls
Bill Freisleben, Director of Community Development, Village of Menomonee Falls
Mike Theis, Planning Administrator, City of Brookfield
Larry Neitzel, Director of Public Works, Village of Brown Deer

The CWP staff conducted the audit of local codes and ordinances. The audit consisted of the following tasks:

1. Develop a set of benchmarks or principles.
2. Identify ordinances that affect development and redevelopment.
3. Create a checklist to be used to evaluate the ordinances.
4. Conduct the audit for all communities within the MMSD service area.
5. Summarize the audit results and findings.
6. Provide recommendations to modify ordinances where needed to support stormwater BMPs.

Benchmarks

The stormwater runoff reduction benchmarks are principles that were used as the basis for evaluating the ordinances. The benchmarks were derived from the Model Development Principles that were presented in Better Site Design: A Handbook for Changing Development Rules in Your Community, (CWP, 2001). The local ordinances were evaluated against the following benchmarks:

1. Have an effective stormwater management program
2. Establish a plan review process
3. Minimize impervious cover
4. Store or redirect rooftop runoff
5. Reduce stormwater runoff from parking lots
6. Design streetscaping to store or reduce stormwater runoff
7. Use pervious paving materials
8. Preserve native soils and vegetation
9. Inspect and maintain stormwater BMPs

Audited Codes and Ordinances

Development and redevelopment standards and requirements are typically included within several different ordinances. The following ordinances were reviewed by the CWP: zoning ordinances, subdivision codes, building codes, erosion control ordinances, stormwater and drainage regulations, and shoreland/floodplain ordinances. In addition to the community ordinances, the CWP reviewed county and state regulations that were relevant to local development.

Audit Checklist

A checklist was developed to help evaluate the codes and ordinances. The checklist consisted of 53 questions that supported the nine benchmarks. The audit was conducted over a six-month period in 2004. Copies of relevant ordinances were obtained and forwarded to the CWP for review. CWP staff evaluated each ordinance and completed the checklist for each community. As needed, local community staffs were contacted to verify interpretations and clarify language. To ensure consistency in the audit process, detailed guidance on answering the questions was developed and circulated to those evaluating the ordinances.

Audit Results

Table 13 presents the audit results for each community. The scoring system was as follows:

- Yes (Y) answers indicate that a particular stormwater BMP is allowed or supported
- No (N) answers indicate that a particular stormwater BMP is restricted or prohibited
- Don't Know (?) answers indicate that a particular stormwater BMP is either not addressed or the code language is unclear

Overall, 30% of the questions were answered Yes; 29% of the questions were answered No; and 41% of the questions were answered Don't Know.

The audit revealed that most communities already require that new development plans address stormwater management and follow a specified plan review process. In contrast, relatively few communities require or encourage BMPs that would reduce impervious cover or stormwater runoff from parking lots. Most ordinances did not address BMPs that would promote porous paving materials, reduced rooftop runoff, native soils and vegetation, streetscaping, and BMP inspection and maintenance.

Table 13
Community Audit Results

Community	Number			Percent		
	Y	N	?	Y	N	?
Bayside	18	19	12	37	39	24
Brookfield	24	23	4	47	45	8
Brown Deer	13	14	22	27	29	45
Butler	15	16	18	31	33	37
Cudahy	18	9	23	36	18	46
Elm Grove	12	15	23	24	30	46
Fox Point	13	13	24	26	26	48
Franklin	21	15	16	40	29	31
Germantown	16	18	16	32	36	32
Glendale	20	12	21	38	23	40
Greendale	10	15	25	20	30	50
Greenfield	12	16	24	23	31	46
Hales Corner	16	13	24	30	25	45
Menomonee Falls	17	14	21	33	27	40
Mequon	20	18	11	41	37	22
Milwaukee	10	20	18	21	42	38
Muskego	21	12	19	40	23	37
New Berlin	20	15	18	38	28	34
Oak Creek	22	11	17	44	22	34
River Hills	13	4	20	34	11	53
St. Francis	11	19	20	22	38	40
Shorewood	12	12	24	25	25	50
Thiensville	13	17	21	25	33	41
Wauwatosa	13	17	19	27	35	39
West Allis	13	13	22	27	27	46
West Milwaukee	11	15	25	22	29	49
Whitefish Bay	10	12	30	19	23	58

Recommendations

Based upon the audit results, the CWP proposed 38 recommendations to support the benchmarks. Most of the recommendations are already being implemented by some of the communities, and there are several good local examples available. The recommendations reflect better site design practices that are well developed and used elsewhere in the United States.

The Stormwater Ordinance Review Committee reviewed each of the recommendations with CWP staff. The Committee considered the rationale for the recommendation, its applicability to the region, and its acceptability within their community and throughout the region. The Committee suggested revised language for some of the recommendations.

The 29 recommendations approved by the Committee are presented in Table 14.

Table 14
MMSD Audit of Ordinances for Stormwater Reduction Capacity
Summary of Recommendations

Heading	#	Recommendation	Rationale*
Overall	1	Add code language that identifies impervious cover reduction and stormwater runoff reduction as a goal and promotes use of on-site stormwater reduction practices such as rain barrels, rain gardens and green rooftops by providing incentives. Encourage efficient layouts to reduce impervious cover and provide incentives to reduce impervious cover such as stormwater credits	Use of on-site stormwater treatment practices such as bioretention, rain gardens, swales, and filters promote infiltration of stormwater, thereby reducing runoff to the system (and recharging groundwater). Encouraging use of these practices by providing incentives can cumulatively have a significant impact on runoff reduction.
Plan Review	2	Require submittal and approval of preliminary site plan that includes stormwater plan concepts. The preliminary plans would be reviewed and approved by the local municipality	Requiring submittal of a preliminary site plan prior to submittal and approval of the final site plan allows any potential site design issues to be addressed early on. In particular, if stormwater concept plans must be reviewed during the preliminary plan stage, input from multiple agencies can be used to avoid poor designs or locations. When preliminary plans are not required and stormwater plans are only reviewed for the final approval, officials may be reluctant to make significant changes, even if these changes would improve the efficiency of the practice. The preliminary site plan review process should be used to encourage the comprehensive application of techniques to reduce stormwater runoff and to improve developer confidence that these practices will be approved. Another important component of the preliminary plan approval is that multiple agencies must approve it rather than only one department.
Imp. Cover Reduction	3	Encourage the maximum practicable reduction of stormwater at redevelopment sites through implementing best management practices.	In areas that have already been developed, a policy approach can be applied with redevelopment criteria that require sites to reduce the amount of impervious surface. This can also have significant effects over time at reducing runoff volumes and peak discharges. Under WI state regulations, redevelopment sites with no increase in impervious cover are exempt from stormwater regulations. The purpose of this recommendation was to go above and beyond the state regulation.
	4	Adopt an open space design ordinance that provides flexible design criteria	See BSD #11

* The BSD # refers to the Better Site Design Principle presented in Better Site Design: A Handbook for Changing Development Rules in Your Community, Center for Watershed Protection, August, 1998

Heading	#	Recommendation	Rationale*
Rooftop and plumbing	5	Allow clean water sources to discharge to suitable pervious areas	Temporary storage of rainwater on rooftops or direction of rooftop runoff to pervious areas for infiltration can significantly reduce runoff volumes and peak discharges if implemented over a widespread area. Methods include use of rooftop storage, cisterns, green rooftops, rain barrels, rain gardens, and downspout disconnection. Code language should at a minimum not restrict the use of these practices and ideally promote them by providing incentives.
	6	Allow temporary storage of water on rooftops	
Parking Lots	7	Enforce parking ratios as minimum, maximum, or average	See BSD #6
	8	Encourage use of shared parking and allow reduction in required parking spaces where shared parking, mass transit or public parking is available	See BSD #7
	9	Reduce minimum parking stall width to 9 feet or less, where appropriate	See BSD #8
	10	Reduce minimum parking stall length to 18 feet or less, where appropriate	See BSD #8
Street-scaping	11	Within a combined sewer service area, remove restrictions to street storage of stormwater in code language and consider adding language that specifically allows street storage	Temporary storage of runoff during storms allows for gradual release to combined sewer system.
	12	Reduce residential street (low traffic feeder street) widths as much at practicable, but no more than 24 feet	See BSD #1
	13	Encourage use of landscaped islands designed to receive stormwater in cul-de-sacs	See BSD #4
	14	Encourage use of alternative turnarounds such as hammerheads	See BSD #4
	15	Reduce sidewalk width to 4 feet minimum	See BSD #13
	16	Make sidewalks optional and allow flexibility to provide them on only one side of the street	See BSD #13
	17	Encourage use of vegetated open channels where density and topography permit	See BSD #5
	18	Require large street trees and urban forestry management practices that promote stormwater runoff reduction, unless inappropriate. Specify a minimum width of 6 feet for tree lawn (planting area) to ensure adequate soil volume and setback between trees and infrastructure. Utilize proper maintenance practices to protect the health of the trees and assure continued stormwater runoff reduction benefits	Large shade trees capture and use rainwater through rainfall interception, evapotranspiration, and infiltration, resulting in less runoff. However, many street trees cannot provide this benefit because the landscape strips they are planted in are too small to provide enough soil for a large tree. Linear street tree planting strips should be a minimum of 6 feet wide for large trees to promote tree health. Street trees have been found to cause cracking and lifting of sidewalks when large trees are planted in small spaces. This typically results in removal of the tree. Providing adequate sized planting strips reduced this tree/pavement conflict.
Paving Materials	19	Encourage the use of structured pervious surfaces on overflow parking areas, driveways, sidewalks and private low-use street sections and remove any language that prohibits use	See BSD #8
Stormwater	20	Provide reduced stormwater requirements for redevelopment and infill sites	The purpose of this recommendation is to encourage redevelopment and infill over greenfield development, because new development can greatly increase runoff volume, while with redevelopment and infill, IC may stay the same or even decrease. Redevelopment and infill is also less burdensome on existing infrastructure.
	21	Refer to the Wisconsin Stormwater Manual and Technical Standards for Erosion Control (WDNR)	See BSD #5, 10, and 22

Heading	#	Recommendation	Rationale*
	22	Consider establishing a stormwater utility to help fund stormwater projects	Stormwater utilities are a good tool for funding construction and maintenance of stormwater reduction practices recommended through this audit. The utility rate structure should be based on the site impervious cover, which provides an incentive for developers to reduce the amount of impervious surface at the development site.
Native Vegetation	23	Encourage or require limiting clearing and grading at development sites and incorporate language that promotes construction site phasing and site fingerprinting	See BSD #19
	24	Adopt regulations that require preservation of some minimum amount of native vegetation at development sites	See BSD #19 and 20
	25	Require open space to be managed in an undisturbed condition with native vegetation	See BSD #15
	26	Promote use of landscaped areas to treat stormwater runoff and remove any language restricting this (e.g., restrictions on use of curb cuts)	See BSD #17
Maintenance	27	Require limits of disturbance to be physically marked at construction sites and inspect for compliance with site plan as part of regular inspection process	See BSD #19
	28	Regularly inspect all sites subject to erosion control or stormwater regulations during the construction phase and post-construction phase. Modify code language to identify responsible party, inspection schedule and tracking and enforcement measures.	While the recommendations made for all previous sections of the MMSD audit provide the potential to reduce stormwater runoff, the important missing element is to include mechanisms to ensure that stormwater reduction practices are properly maintained, inspected and enforced. Without measures in place to maintain, inspect and enforce the practices, the code requirements have no regulatory 'teeth,' which can result in stormwater treatment practices that are functioning poorly, and regulations aimed at reducing stormwater that are not being implemented or enforced. For many communities, only a final inspection is required; interim inspections are not conducted during construction. The language is often vague about whether inspections are always required and when/how often they are conducted. In some cases the owner is responsible for setting it up.
	29	Require maintenance agreements for all BMPs	See BSD #22

Additional potential recommendations that were considered by the Committee, but not approved, are listed in Table 15.

Table 15
Additional Recommendations Considered by the Committee That Were Not Included in the Final Set of Recommendations

Heading	#	Recommendation	Rationale
Rooftop and plumbing	1	Implement inspection process to verify that clean water sources (downspouts) do not enter the sanitary sewer	An inspection process that verifies that downspouts are not connected to the sanitary sewer and evaluates the conditions of lateral sewer pipes routinely (e.g., during change of ownership) is also beneficial in terms of reducing the volume of runoff to the combined sewer system by minimizing direct entry of stormwater into the sanitary sewer and by minimizing indirect entry of groundwater through cracked pipes in poor condition.
	2	Inspect condition of lateral pipes during routine point-of-sale transactions	
Parking Lots	3	Conduct local study of parking demand and update parking codes accordingly	See BSD[1] #6
	4	Require at least 30% of parking spaces to have compact car dimensions and designate hybrid vehicle parking near buildings to encourage use	See BSD #9
Street-scaping	5	Encourage use of queuing streets	See BSD #1
	6	Specify placement of utilities under the paved portion of right-of-way	See BSD #3
	7	Reduce cul-de-sac radius to 35 feet or less	See BSD #4
Storm water	8	Adopt a requirement that is as least as stringent as: developments that increase impervious cover by 1/2 acre or disturb 1 acre of land are subject to stormwater regulations	These numbers are based on MMSD Chapter 13 requirements, which the majority of the communities have adopted. Others who have not adopted Chapter 13 have higher thresholds for stormwater regulations. Additional volume and pollutant reduction can be achieved by lowering the threshold that determines which development sites are subject to stormwater regulations, assuming the appropriate elements are in place to design, install, inspect, enforce, fund and maintain the stormwater practices (e.g., staff, resources and capacity.).
	9	Revise current stormwater manual to provide design criteria for BMPs	This recommendation applies only to the City of Milwaukee as the City was the only community that had its own Stormwater Design manual (all others referenced the WI BMP Manual).

[1] The BSD # refers to the Better Site Design Principle presented in Better Site Design: A Handbook for Changing Development Rules in Your Community, Center for Watershed Protection, August, 1998

Implementation

The Stormwater Ordinance Review Committee considered several alternative ways to help communities adopt the recommendations and incorporate them into their ordinances.
The alternatives included:

- Developing a single model ordinance.
- Developing separate model ordinances for zoning, subdivision, erosion control, open space, and stormwater codes.
- Assisting one or two communities in implementing the recommendations, which would serve as an example for other communities.
- Establishing a regional roundtable process to assist all communities in implementing the recommendations.

It was recognized that the 2020 facilities plan might recommend an implementation program that could differ from the strategy approved by the Committee. In addition, communities may involve other stakeholders – such as environmentalists, neighborhood groups, and builders-- who prefer a different approach.

Nevertheless, the Committee agreed that an implementation strategy should be selected at this time, and that communities should proceed with the recommended changes. The Committee preferred a voluntary implementation strategy that includes:

1. A model ordinance containing code language and provisions that can be used by the communities as a guide to revise their ordinances. The model ordinance will suggest which ordinance sections would typically include each provision.

2. A voluntary review schedule that sets a deadline goal for communities to review their ordinances for proposed changes.

3. Assistance from MMSD to help promote the benefits and value of stormwater runoff reduction BMPs, and to encourage communities to use local ordinances as an implementation tool.

4. Compliance monitoring by MMSD to determine whether additional assistance or incentives are needed.

Public education and participation was part of many—if not most—of the projects summarized in this report. Numerous presentations, brochures, signs, outreach efforts, PowerPoints, media distributions, and public meetings have helped:

- Inform the public about stormwater pollution problems and potential solutions
- Create environmental awareness and knowledge
- Increase participation and support
- Assist with implementation of BMPs
- Seek input on public concerns and priorities

The MMSD stormwater runoff reduction program was based on the concept of "community partnerships". The active participation and contribution of community resources generated local support for BMP initiatives. The BMP Partnership projects alone involved over 30 public and private entities. Many other groups proposed projects that were not selected for funding. The interest in working with MMSD to demonstrate innovative BMPs was overwhelming.

Public participation is particularly critical for BMP implementation. Since the projects showed that widespread implementation of BMPs is needed to achieve significant benefits to the MMSD system, what incentives are needed to convince property owners to implement BMPs? Options include financial incentives, education, regulations, community-led initiatives, and providing construction and maintenance services.

To provide overall support for the projects and to generate District-wide interest, a *Roadmap to Stormwater Management* was produced and distributed. The Roadmap materials included:

- 13 Fact Sheets on specific BMPs
- A poster that summarized BMP practices that can be implemented in residential areas
- PowerPoint presentations

Mailings were sent to the 28 municipalities in MMSD's jurisdictions and the fact sheets have been distributed at numerous conferences.

Figure 45. Example of the Rain Barrel Fact Sheet.

Stormwater management issues and BMP solutions have become exceedingly complex. Once limited to public works operations (street sweeping), ponds, and a few treatment devices, urban BMPs now include a growing array of practices that integrate engineering, landscaping, education, better site development principles, regulations, soil management, and hydrology. Of particular interest to MMSD are the new and innovative BMPs that reduce stormwater runoff and improve water quality.

Over the past three years, MMSD – working hand-in-hand with local communities, interest groups, and residents – has undertaken a large and diverse number of BMP projects, plans, and studies, as shown in Figure 46. While the scope and deliverables of these projects have varied widely, the overall goal of the stormwater runoff reduction program is to define, to the extent possible:

1. BMP performance
2. BMP maintenance requirements
3. BMP capital and O&M costs
4. Public awareness, interest and acceptance of new and innovative approaches
5. BMP implementation strategies

BMP Performance

For the purposes of this program, BMP performance is basically defined as the ability of the BMP to reduce stormwater runoff peak flows and volumes. These reduced flows may be discharged to either a sewer system, or directly into a receiving water. It is also recognized that these BMPs offer many other benefits besides runoff control.

BMP performance was evaluated by:

- Reviewing literature and research studies
- Surveying the experiences of other communities with these BMPs
- Conducting limited monitoring as part of some of the BMP Pilot Projects
- Performing visual observations (which are appropriate for evaluating certain aspects of performance)
- Conducting BMP-specific HSPF model simulation analyses

The most useful quantitative performance data came from the review of research studies (most of which were summarized in the Evaluation of Stormwater Reduction Practices memorandum), and from the HSPF modeling analyses conducted by CDM. The monitoring performed as part of the Pilot Projects was not designed to include the rigorous, instrumented, long-term data collection that would be needed to measure BMP performance.

Due to the variability in BMP design and construction, and unique site conditions, it is appropriate to discuss BMP performance in general terms. Overall, it appears that several of the best BMPs (downspout disconnections, rain gardens, porous pavement, bioretention, green parking, and green roofs) can achieve an approximate 30% reduction in peak flows and volumes under total and widespread implementation. For a particular site, BMPs such as porous pavement, green roofs, and bioretention can be designed to reduce runoff by 70% or more.

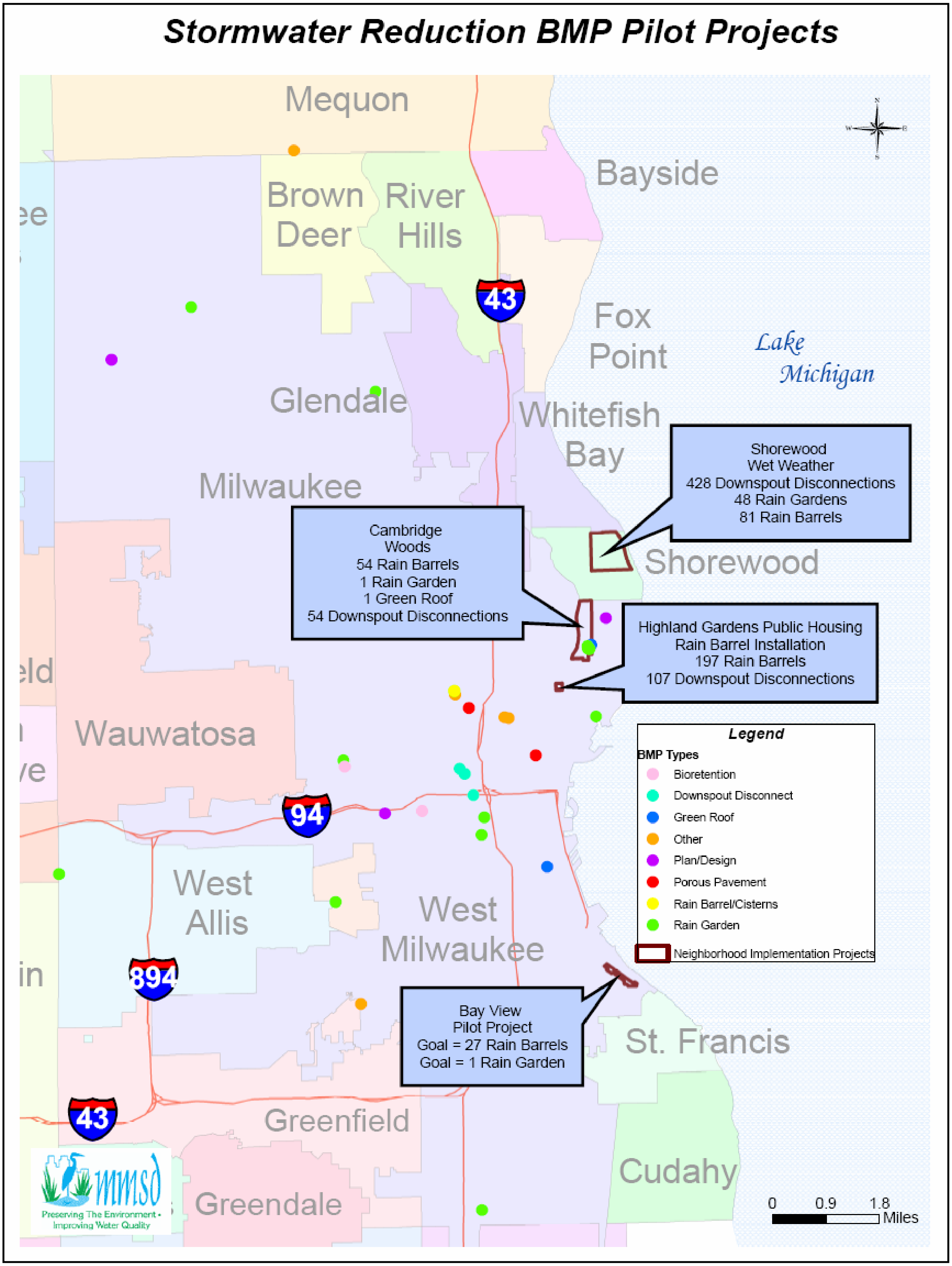

Figure 46. Pilot projects included in the Stormwater Runoff Reduction Program.

Detailed performance data on individual BMPs is presented in Tables 16, 17, and 18.

Table 16
Simulated Performance of Stormwater Runoff Reduction BMPs

Stormwater Reduction BMP	Volume Reduction
1. Downspout Disconnection (dd)	12%
2. Rain Barrel (w/ dd)	14%
3. Rain Garden (w/ dd)	36%
4. Rain barrel and Rain Garden (w/ dd)	38%
5. Green Roof	22%
6. Bioretention	70%
7. Green Parking Lot	76%
8. Stormwater Trees	10%

Source: CDM

Table 17
Reported Performance of Stormwater Runoff Reduction BMPs

Stormwater Reduction BMP	Performance
1. Downspout Disconnection	▪ Annual volume reduction 26,000 gallons/house (Toronto) ▪ 40-44% reduction in directly connected impervious area, reducing wet weather runoff by 5.05 billion gallons/yr (Detroit)
2. Rain Barrels	▪ City of Dearborn flow monitoring study of rain barrels is underway
3. Green Roofs	▪ Green roofs retain 15-90% of rainfall ▪ Summer retention: 65-100% ▪ Winter retention: 10-40% ▪ 50-60% overall runoff volume reduction ▪ Testing of Portland roof garden: wet season—10% reduction dry season—100% reduction
4. Stormwater Trees	▪ Portland: 1,021 acres of tree canopy will reduce stormwater runoff by 290 MG/yr. ▪ Milwaukee CSSA: if existing 10% canopy coverage were increased to 40%, 484 MG/yr would be intercepted
5. Porous Pavement	▪ Concrete paver blocks reduce runoff by 80% (Olympia, WA) ▪ 80-90% reduction in runoff (Florida) ▪ 16 year old porous pavement in Philadelphia reported zero discharge during Hurricane Floyd in 1999 (10" rain/24 hours)
6. Inlet Restrictors	▪ Chicago installed 200,000 flow restrictors and reduced basement flooding complaints by half ▪ Portland installed 30 flow restrictors and reduced CSS flow by 12 MG/yr
7. Onsite Practices	▪ Redirecting parking lot runoff to swales can reduce runoff volume by 30% (Florida)

Source: MMSD, Evaluation of Stormwater Reduction Practices, Memorandum, March 2003

Table 18
Pollutant Removal Estimates for Stormwater Runoff Reduction BMPs

Pollutant	Infiltration Practices	Bioretention	Porous Pavement	Constructed Wetland
Total phosphorus	70	34	85	49
Soluble phosphorous	85	38	--	35
Total nitrogen	51	84	--	30
Nitrate	82	31	30	67
Copper	--	51	--	40
Zinc	99	71	--	44
TSS	95	81	85	76

Sources:
National Pollutant Removal Performance Database for Stormwater Treatment Practices, Center for Watershed Protection, June 2000
Pennsylvania Stormwater Manual (draft, 2004)

While the general performance data cited above provide useful guidance, it is recommended that more detailed monitoring studies be performed. This long-term monitoring should be conducted by qualified researchers using appropriate controls and instrumentation. Additional monitoring should be considered for bioretention systems, green parking, green roofs, porous pavement, and rain gardens. The monitoring should address seasonal differences in performance, and various BMP designs and site conditions. Monitoring of practices will take time to develop adequate data sets to make reasonable conclusions. Additional insight can be gained through qualitative or semi-quantitative observations of BMP performance. While not as rigorous as instrumented monitoring, photo documentation during and after storm events, and visual assessments of vegetation and other practice features can be useful in improving future installations and long term maintenance.

BMP Maintenance Requirements

It is important that landowners commit to the long-term maintenance of new BMPs. Education, awareness and public participation have an important role in providing the needed maintenance. In many cases, BMP maintenance can be integrated with other common maintenance activities that occur on sites such as landscaping, street sweeping, and trash and debris clean up. BMP maintenance may involve regular inspections, cleaning, sweeping, repairs, and landscape care. Landscape care includes pruning, weeding, replanting and reseeding, erosion control, and occasional watering.

Table 19 presents maintenance guidelines for individual BMPs.

Table 19
Recommended Maintenance Activities for Stormwater Runoff Reduction BMPs

Stormwater Reduction BMP	Maintenance Activity
1. Downspout Disconnection	▪ Cleaning of gutters to prevent clogging with leaves and twigs ▪ Discharge at least 5 feet from structure ▪ Do not discharge onto walkways or driveways (ice)
2. Rain Barrels and Cisterns	▪ Discharge runoff at least 5 feet away from structure ▪ Drain barrel between storm events (always within 4 days) ▪ <u>Winter:</u> Disconnect, turn upside down or remove ▪ Keep screen in place to control mosquitoes ▪ Clean occasionally to avoid clogging ▪ Do not discharge onto walkways or driveways (ice) ▪ Cisterns: inspect plumbing component twice/year.
3. Rain Gardens and Bioretention	▪ Inspect twice/year. ▪ Weed as needed ▪ Annual pruning ▪ Remove debris as needed ▪ Water during extreme drought ▪ Do not mow ▪ Control erosion and sediment tracking
4. Green Roofs	▪ Regularly inspect vegetation ▪ Regular watering for first 6 months ▪ Long term water as needed, especially during drought ▪ Fertilize and weed, mostly in first two years ▪ Weed occasionally after first two years ▪ Do not cut or mow ▪ Regularly inspect for leaks, drainage backups, root punctures, and integrity of the membrane
5. Rooftop Storage	▪ Inspect liner annually ▪ Periodically inspect outlets and downdrains for clogging and debris.
6. Green Parking Lots	▪ Same as porous pavement and bioretention/rain gardens.
7. Stormwater Trees	▪ Utilize urban forestry practices that promote sustainable ecosystem development and stormwater retention.
8. Porous Pavement	▪ Vacuum sweep 2-3 times/year ▪ Clean inlets twice/year ▪ Do not seal coat ▪ Patch with porous pavement ▪ Prevent sediment storage & tracking ▪ <u>Snow Management:</u> o Do not use sand o Deicing salt ok (reduced need) o Plowing ok—raise blade slightly, use rubber blade edge
9. Inlet Restrictors/Pavement Storage	▪ Routine street maintenance ▪ Street sweeping ▪ Catch basin cleaning at least twice/year

BMP Costs

The capital costs of most BMPs can be reasonably estimated. O&M costs are more difficult to determine. Engineers and planners often designate an annual O&M cost as a percentage of the capital cost. Since most of these BMPs are fairly new, especially to Wisconsin, costs may decline in the future as more contractors enter the market and efficiencies increase.

Costs for individual BMPs are summarized in Table 20.

Table 20
Costs for Stormwater Runoff Reduction BMPs

Stormwater Reduction BMP	Capital Cost—Evaluation Memo	BMP Pilot Projects
1. Downspout Disconnection	$50 to $250/downspout	$35.00 to $156.12/downspout (Shorewood bids)
2. Rain Barrels	$150/each rain barrel	Diverter--$30 each (Shorewood) $59.00 each rain barrel (Shorewood) $16.80-$50 each installation (Shorewood bids)
3. Cisterns	$1,000 (500 gallon) to $5,000 (6,500 gallon underground)	$500 (500 gallon)/Walnut Way
4. Rain Gardens	$5 to $10/square foot	$23.30-$47.62/square foot (Shorewood bids) $10/square foot (ARCCP)
5. Green Roofs	$15/square foot of roof for complete system	$15.82/square foot (GLWI) $19.10/square foot (Milw. Zoo)
6. Rooftop Storage	$100/drain restrictor $5/square foot waterproofing	--
7. Green Parking Lots	$200/tree pit $13,000-$30,000/acre bioretention $2/square foot turf pavers	--
8. Stormwater Trees	$40/tree	--
9. Porous Pavement	$2/square foot paver blocks $2.50/square foot conventional asphalt $4/square foot porous pavement	$4.25/sq ft pervious concrete (Zabest) $3.32/sq ft porous asphalt (MSOE) $5.97/sq ft pervious concrete (MSOE) $3.55/sq ft conventional asphalt (MSOE)
10. Inlet Restrictors/Pavement Storage	$400 to $1,200/per restrictor	--
11. Bioretention	$13,000 to $30,000/acre	$6.50/square foot (Miller Brewing) $8.74/square foot (Men. Valley Bioret.)

Public Awareness, Interest, and Acceptance

In 2003, a Water Quality Initiative telephone survey found that less than 40% of the residents surveyed had ever heard about any of the stormwater runoff reduction BMPs. Furthermore, except for disconnecting downspouts, less than half of the residents surveyed were willing to implement any of these BMPs. Whether due to a lack of familiarity or knowledge, or to concerns about BMP cost, public safety, performance, or maintenance, until a few years ago there was little public interest in the BMPs presented in this report.

The MMSD stormwater runoff reduction program helped introduce stormwater BMPs to the residents of Metropolitan Milwaukee. The program educated residents, inspired community groups and local governments to pursue partnerships and demonstration projects, and built a database that begins to answer many of the questions and concerns about these new and innovative BMPs.

Milwaukee, like Portland, Philadelphia, and many other communities, is seeing a growing public awareness of how urban development affects water quality and watershed health. There is a corresponding willingness – on the part of municipalities such as Shorewood, community groups such as the Walnut Way Conservation Corps, environmental organizations such as the Urban Ecology Center and Menomonee Valley Partners, and businesses such as Miller Brewing and Alterra Roasters Coffee Shop – to learn about and invest in BMPs that reduce stormwater flows, improve water quality, and provide numerous other environmental and educational benefits.

BMP Implementation Strategies

The stormwater runoff reduction project results indicate that widespread implementation of BMPs would be needed to provide significant benefits for the District system. That conclusion, of course, is not surprising given the dispersed nature of urban runoff and nonpoint source pollution.

The following insights on implementation are noteworthy:

1. There appears to be a growing public interest in at least some of these innovative BMPs, particularly in BMPs that incorporate sustainable landscaping (rain gardens, green roofs, and bioretention).

2. Regulations – either existing ordinances or new regulations – are powerful tools for BMP implementation, especially for new development and redevelopment.

3. Education and outreach efforts can raise public awareness and share important information, and education is an important component of any implementation strategy. But, by itself, education has limited effect on implementation.

4. Financial incentives had mixed results. Smaller payments or rebates (say, $50 - $100) seem to have little impact on landowner motivation. On the other hand, significant cost-share arrangements may motivate landowners and public entities to invest in more costly BMPs like green roofs and porous pavement.

5. Community-led grass-roots implementation programs can be successful. Neighborhood groups were able to achieve a high level of BMP interest and acceptance.

6. It is helpful to focus on the variety of benefits that BMPs offer (besides stormwater runoff reduction):

   - Water quality
   - Habitat
   - Aesthetics
   - Education
   - Environmental health
   - Energy savings
   - Community participation

7. A successful implementation strategy will likely include some or all of the tools listed above.