URBAN LOW IMPACT DEVELOPMENT BEST MANAGEMENT PRACTICES MATRICES

CRWA developed the following three matrices with the intent to help municipal officials, developers and others with the selection of Stormwater Best Management Practices (BMPs). In the process of choosing an appropriate Low Impact Development (LID) BMP, or set of BMPs, many factors need to be considered, including:

- stormwater managements goals,
- physical and site specific constraints and opportunities, and
- installation, operational, maintenance costs and requirements.

The following three matrices present a comparison of these factors for a set of BMPs particularly suited for urban environments. The information compared here is based on data collected from a variety of sources which are listed following the matrices.

MATRIX A: STORMWATER GOALS

This matrix is designed to provide guidance in selecting BMPs best suited to achieve a project's stormwater management goals. BMPs are rated for stormwater volume reduction, peak flow attenuation and water quality improvement.

MATRIX B: PHYSICAL FACTORS

Site conditions are important when choosing BMPs. Knowledge about minimum or maximum dimensions of stormwater facilities, appropriate site slopes, minimum distance to groundwater, required setbacks to structures, minimum or maximum area to be drained to the BMP, and suitable soils are vital in choosing appropriate BMPs. This matrix is included to provide some of this critical information.

MATRIX C: INSTALLATION AND MAINTENANCE COSTS AND REQUIREMENTS

Installation and maintenance costs are critical aspects when selecting BMPs. This matrix compares cost of installation both as a unit cost and rated for cost per cubic foot of treated runoff. Additionally, maintenance cost and requirements as well as life span and other installation and operational factors which are important to consider are listed.

Shown at right: Bioswale to process stormwater run-off from the road.

Matrix A: Stormwater Goals

	Porous Pavement (Concrete, Asphalt)	Porous Pavers	Urban Forestry[1]	Bioretention				Vegetated Swale	Green Roof		Constructed Wetland[7]	Wet Pond	Rainwater Harvesting	
				Rain Garden	Stormwater Planter		Tree Filter		Extensive	Intensive			Cistern	Rain Barrel
					Infiltration Planter	Flow-Through Planter								
Stormwater Flow Volume Reduction	✓✓✓[2]	✓✓✓[2]	✓✓	✓✓ to ✓✓✓			✓✓	✓✓	✓ to ✓✓[3]	✓ to ✓✓[3]	Varies with size	X	✓ to ✓✓✓[4]	✓ to ✓✓✓[4]
Peak Flow Attenuation	✓✓✓			✓✓✓			✓✓	✓✓	✓✓ to ✓✓✓	✓✓ to ✓✓✓		✓✓✓	✓	✓
Pollutant Removal														
TSS	✓✓✓	✓✓✓	✓	X to ✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓ to ✓✓✓	✓✓ to ✓✓✓	?	?
Total Phosphorus	✓✓ to ✓✓✓	✓✓ to ✓✓✓	?	✓✓	✓✓	✓✓	✓✓✓	✓	X[5]	X[5]	✓✓ to ✓✓✓	✓✓	X	X
Total Nitrogen	✓✓✓	✓✓✓	?	✓ to ✓✓[6]	✓✓	✓✓	✓✓	✓✓	X[5]	X[5]	✓	✓	X	X
Metals	✓✓✓	✓✓✓	✓	✓✓ to ✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓	?	?

LEGEND:

Highly Effective	✓✓✓
Moderately Effectiv	✓✓
Minimally Effective	✓
Not Effective	X
Unknown	?

SOURCES:

AF, 2004
CUFR, 2002
CWP, 2007
Davis, 2003
Geiger, 2002
MA DEP, 2008
Mass Highway, 2004
MAPC, Unknown year
MMSD, 2007
MSSC, 2006
PA DEP, 2005
PBES, Unkown year
SMRC, Unknown year
UNHSC, 2008

NOTES:

[1]Based on model results for 15.3% tree canopy in 3.24", 24 hour storm; stormwater reduction by urban trees will vary significantly with tree species, intensity and duration of rain events, tree spacing and arrangement, and weather.

[2] Assumes infiltration is possible

[3] Storage volume = (green roof area) * (soil depth) * (soil porosity)

[4] Varies with storage capacity and water reuse practices

[5] Some studies indicate that green roofs may actually leach nutrients into stormwater runoff

[6] If soil media is > 30 inches

[7] To achieve high end Pollutant Removal rates refer to "The Next Generation of Stormwater Wetlands" (CWP, 2008)

Matrix B: Physical Factors

	Porous Pavement (Concrete, Asphalt)	Porous Pavers	Urban Forestry	Bioretention				Vegetated Swale	Green Roof		Constructed Wetland	Wet Pond	Rainwater Harvesting	
				Rain Garden	Stormwater Planter		Tree Filter		Extensive	Intensive			Cistern	Rain Barrel
					Infiltration Planter	Flow-Through Planter								
Dimension (Width, Length, Depth)	Varies	Varies	Varies by tree species, must accommodate the critical root zone	100-300 sq. ft., maximum depth of 12 in.	Varies: minimum width of 30 in., depth and length will vary	Varies: minimum width of 18 in., depth and length will vary	Varies: precast systems available in surface area sizes ranging from 3' x 3' to 9' x 16'[1]	Varies: minimum depth of 6", minimum width of 5', maximum width of 12' and side slopes < 3:1	Varies	Varies	Surface area should be 3-5% of the contributing drainage area, length:width ratio should be >2:1	Surface area should be > 0.25 acres with length:width ratio >3:1, recommended depth is 3-10 ft. (permanent pool depth should be 3-8 ft.)	Up to 10,000 gallons	Typically 50-100 gallons
Site Slope	< 10%	< 2%	< 30 %	< 5%	< 10%	< 10%	Varies with width of filter box, always <12%[1]	Site topography must allow for swales with side slopes >0.5% and <4% and slope in flow direction <5%	Roof slope <40%, slopes >15% require structures to hold substrate and vegetation in place		No minimum, however 3-5 ft. elevation drop from inlet to outlet is recommended to ensure that hydraulic conveyance by gravity is feasible	< 25%		Should be placed on flat surface
Distance to Groundwater	2-5 ft. from bottom of infiltration trench	2-5 ft. from bottom of infiltration trench		3 ft.	3 ft.	3 ft.		3 ft.	N/A	N/A	No minimum, although high groundwater levels may reduce effectiveness of pollutant removal	No minimum	N/A	N/A
Setbacks	10 ft. downgradient of buildings, 100 ft. away from drinking water wells	10 ft. downgradient of buildings, 100 ft. away from drinking water wells	Setback requirements vary by municipality	10 ft. from buildings	10 ft. from buildings	None	None[1]	10 ft. from buildings	N/A	Depends on type of vegetation, overhead setbacks may be required	25 ft. from building foundations, 50 ft. from septic systems, 100 ft. from wells	25 ft. from building foundations, 50 ft. from septic systems, 100 ft. from wells	None	None
Drainage Area	Surface area of porous pavement should be at least 25% of impervious drainage area treated	Surface area of porous pavement should be at least 25% of impervious drainage area treated		Surface area of rain garden should be approximately 10% of impervious drainage area treated	Surface area should be approximately 40% of impervious drainage area treated	Varies	Surface area of tree box filter(s) should be approximately 0.33% of drainage area to treat 90% of runoff	< 10 acres	1 to 1 ratio with rooftop area	1 to 1 ratio with rooftop area	> 10 acres, drainage area must be large enough to maintain wetland characteristics[2]	> 10 acres, drainage area must be large enough to maintain minimum, permanent water volume	Varies	Varies
Underlying soil requirements	Permeability rates > 0.25 in/hr	Permeability rates > 0.25 in/hr	Varies by tree species, poor soil quality can reduce a tree's lifespan	Uncompacted with infiltration rates > 2 in/hr (not all rain gardens infiltrate)	Suitable for infiltration	None	None	Permeability rates > 0.3 in/hr, type A and B soils are ideal, soils need to support vegetation	Less than 6" of soil medium required above roofing material	More than 6" of soil medium required above roofing material	Constructed wetlands can be designed to function on almost any soil types	Non-infiltrating, type C and D soils are ideal, type A and B soils will require liners	None	None

Matrix B: Physical Factors - Continued

	Porous Pavement (Concrete, Asphalt)	Porous Pavers	Urban Forestry	Bioretention				Vegetated Swale	Green Roof		Constructed Wetland	Wet Pond	Rainwater Harvesting	
					Stormwater Planter									
				Rain Garden	Infiltration Planter	Flow-Through Planter	Tree Filter		Extensive	Intensive			Cistern	Rain Barrel
Other Restrictions	Not appropriate for use in areas where pollutant spills are likely or areas with high sediment loading	Not appropriate for use in areas where pollutant spills are likely or areas with high sediment loading			Can be flush with ground or above ground level; not appropriate for use in areas where pollutant spills are likely	Can be flush with ground or above ground level	Should not be placed at a low point	Should not be used in areas where pollutant spills are likely. Require more land area surrounding right-of-way than typical curb and gutter system.	Roof must be structurally capable of supporting load of saturated soils	Roof must be structurally capable of supporting load of saturated soils	Constructed wetlands can raise water temperatures and may not be appropriate for use upgradient of cold water fisheries. May require pretreatment by a sediment forebay.	Shallow wet ponds can raise water temperatures and may not be appropriate for use upgradient of cold water fisheries. Wet ponds do not infiltrate and therefore may be appropriate for use on land uses with higher potential pollutant loads. May require pretreatment by a sediment forebay.		

NOTES:

[1] Based on Filterra Bioretention Systems proprietary products

[2] Using new stormwater wetland designs might reduce the required drainage area to < 5 acres (CWP, 2008)

SOURCES:

Banneran, 2003
CWP, 2007
GSMM, 2001
LIDC, 2005
LIDC, 2007
MA DEP, 2008
MassHighway, 2004
MAPC(a), Unknown Year
MAPC(b), Unknown Year
MSSC, 2006
PBES, Unknown Year
PBES, 2008
SMRC, Unknown Year

Matrix C: Installation and Maintenance Costs and Requirements

	Porous Pavement (Concrete, Asphalt)	Porous Pavers	Urban Forestry	Bioretention				Vegetated Swale	Green Roof		Constructed Wetland	Wet Pond	Rainwater Harvesting	
				Rain Garden	Stormwater Planter		Tree Filter		Extensive	Intensive			Cistern	Rain Barrel
					Infiltration Planter	Flow-Through Planter								
Installation														
Cost/Cubic Ft of Treated Runoff		High		Very Low	Low	Low	Moderate	Low	High	High			Very Low	Low
Cost	$7-15 sq. ft.	$8-12 sq. ft	$20-100/tree; installation cost is approximately $1000 - 1200	$10-12 sq. ft.	$8/ sq. ft.	$8/sq. ft.	$8,000 - 10,000 to purchase a prefabricated system; $1,500 - 6,000 to install	Approximately $7/sq. ft., will vary depending on extent of grading and infrastructure required	$5-25/sq. ft.	$5-25/sq. ft.	$0.90-2/ sq. ft.		$600-13,000, cost will vary significantly depending on the extent of accompanying plumbing system	$85-250
Maintenance														
Needs	Vacuum sweeping and inspection to ensure infiltration is occurring	Vacuum sweeping, inspection to ensure infiltration is occurring, removal of surrounding grass clippings and replacement of paver blocks	Debris removal, pruning and general landscaping, more frequent watering in early years, and wind and animal protection in the first few years	General landscaping; check inlet and outlet structures	Regular landscaping, inspect integrity of the planter structure, check inlet and outlet structures, ensure infiltration is occurring at desired rates, and repair planter structure as needed	Regular landscaping, inspect integrity of the planter structure, check inlet and outlet structures, and repair planter structure as needed	Inspect plants and structural components, clean inlet and outlet structures, test mulch and soil for pollutant build-up, and replace mulch	Regular inspection for erosion, regular mowing and landscaping, and periodic removal of accumulated sediment and trash; check inlet and outlet structures	Regular landscaping and repairs as needed	Regular landscaping and repairs as needed	Planting communities require active maintenance through the lifespan of the wetland and especially during the first few years when the vegetation gets established. Mow embankments; re-plant vegetation as necessary; inspect and remove debris/trash from inlet and outlet structures; monitor and control invasive species dispersal; and dredge sediment.	Mow embankments, inspect and remove debris/trash from inlet and outlet structures, and dredge sediment	Inspect after rain events for clogging, remove sediment and test water quality as needed, and inspect and repair plumbing system	Inspect after rain events for clogging, and \remove sediment and test water quality as needed for reuse purposes
Frequency	3 to 4 times/year	2 to 4 times/year	2 to 3 times/year	Similar to traditional landscaping, heavier in first two years			1 to 2 times/year	2 to 4 times/year	More frequently in first two years, annual/biannual once established	More frequently in first two years, annual/biannual once established	Sediment dredging approximately every 15-25 years	Sediment dredging approximately every 15-25 years		
Annual Maintenance Cost	$400-500 (vacuum sweeping of a half acre parking lot)	$400-500 (vacuum sweeping of a half acre parking lot)		Similar to traditional landscaping	$400-500/500 sq. ft. planter, although cost will vary with size and material of planter structure and type of vegetation	$400-500/500 sq. ft. planter although cost will vary with size and material of planter structure and type of vegetation	$100-500/tree filter, purchase of some prefabricated systems may include up to two years of maintenance	Approximately $200	Similar to traditional landscaping, $0.25-1.25/sq. ft., estimated repair costs $1200/ year over lifetime of roof	Similar to traditional landscaping, estimated repair costs $1200/year over lifetime of roof	<$1/sq. ft.		Approximately $550	Minimal
Lifespan	15-25 years	Approximately 25 years	Varies				25 years	Indefinitely with proper maintenance	Up to 20 years longer than traditional roof	Up to 20 years longer than traditional roof	20+ years		25 years	25 years

Matrix C: Installation and Maintenance Costs and Requirements - Continued

	Porous Pavement (Concrete, Asphalt)	Porous Pavers	Urban Forestry	Bioretention				Vegetated Swale	Green Roof		Constructed Wetland	Wet Pond	Rainwater Harvesting	
				Rain Garden	Stormwater Planter		Tree Filter		Extensive	Intensive			Cistern	Rain Barrel
					Infiltration Planter	Flow-Through Planter								
Other Considerations		Site in areas where pavers can be replaced safely with minimal traffic impacts. Additionally, surface may be uneven and not appropriate for areas where women frequently walk in high heels.		For infiltrating rain gardens precautions must be taken to prevent soil compaction during construction. Additionally, during construction runoff must be directed away from garden site. Rain gardens must be designed and maintained properly to ensure infiltration is occurring at desired rate to prevent mosquito breading.	Precautions must be taken to prevent soil compaction during construction. Planter may require fencing or curbing if placed at ground level.	Planter may require fencing or curbing if placed at ground level.			Roof must be waterproof and underdrain system must be constructed adequately so as not to be penetrated by root systems. Roof must be accessible for maintenance, this may require extra precautions on roofs with steep slopes.	Roof must be waterproof and underdrain system must be constructed adequately so as not to be penetrated by root systems. Roof must be accessible for maintenance.	Creation of a wetland bed requires extensive planning and preparation prior to planting. Certain design features can be incorporated to make sediment cleanouts of any forebays and shallow pools easier. The main wetland area should be equipped with a drain to draw down the water level during dredging.	May require fencing around pond and mosquito control within the pond.	Must be secured to prevent accidental drownings; mosquito control may be required	Must be secured to prevent accidental drownings; mosquito control may be required

LEGEND:

High	$96+/cubic ft. of treated runoff
Moderate	$56-96/cubic ft. of treated runoff
Low	$21-55/cubic ft. of treated runoff
Very Low	$0-20/cubic ft. of treated runoff

SOURCES:

Banneran, 2007
CWP, 2007
GSMM, 2001
LIDC, 2005
LIDC, 2007
MA DEP, 2008
MassHighway, 2004
Roy, 2007
PBES, Unknown Year

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