

Center for Watershed Protection Research on Runoff Reduction for Stormwater BMPs

Practice	RR (%)	PR- TP (%)	Total Removal
Bioretention	40 to 75		
Infiltration	50 to 75		
Filtering Practice	0		
Dry Swale	40 to 60		
Wet Swale	10 to 20		
Grass Channel	15 to 30		
ED Pond	5 to 15		
Wet Pond	0		
Constructed Wetland	0		
Green Roof	45 to 60		
Pervious Parking	45 to 75		
Raintanks and Cisterns	40		
Disconnection	25 to 50		
Soil Amendments	50 to 75		

KAC Change

A. Raintanks and Cisterns

Limited research has been conducted to evaluate the runoff reduction capability of rain tanks and cisterns. Dual use rain tanks provide indoor potable or grey water and outdoor landscaping irrigation. Modeling research indicates that their runoff reduction capability is limited by tank capacity, and the rate of de-watering between storms, which is strongly influenced by indoor and outdoor water demand, and overflows. The actual rate of runoff reduction for an individual project will require simulation modeling of rainfall and the tank. Based on the prevailing climate for the region, a conservative runoff reduction estimate of 40% is recommended for initial design

LID Practice	Location	Runoff Reduction	Reference
Dual Use Rain Tanks ¹	AUS	60 to 90%	Hardy et al (2004)
Dual Use Rain Tanks	AUS	40 to 45%	Coombes et al (2002)
Dual Use Rain Tanks	NZ	35 to 40%	Kettle et al (2004)
RR Estimate		40%	

B. Green Roofs

Considerable research has been conducted in recent years to define the runoff reduction capability of extensive green roofs. Reported rates for runoff reduction have been shown to be a function of function of media depth, roof slope, annual rainfall and cold season effects. Based on the prevailing climate for the region, a conservative runoff reduction rate for green roofs of 45 to 60% is recommended for initial design

Volumetric Runoff Reduction by Green Roof			
LID Practice	Location	Runoff Reduction	Reference
Green Roof	US	40 to 45%	Jarrett et al (2007)
Green Roof	Germany	54%	Mentens et al (2005)
Green Roof	MI	30 to 85%	Getter et al (2007)
Green Roof	OR	69%	Hutchinson (2003)
Green Roof	NC	55 to 63%	Moran and Hunt (2005)
Green Roof	PA	45%	Denardo et al (2005)
Green Roof	MI	50 to 60%	VanWoert et al (2005)
Green Roof	ONT	54 to 76%	TRCA (2005)
Green Roof	GA	43 to 60	Carter and Jackson (2007)
RR Estimate		45 to 60%	

C. Rooftop Disconnection

Very limited research has been conducted on the runoff reduction rates for rooftop disconnection, so initial estimates are drawn from research on filter strips, which operate in a similar manner. The research indicates that runoff reduction is a function of soil type, slope, vegetative cover and filtering distance. The table below summarizes filter strip runoff reduction rates within the first 15 meters (where a range is given, the first number is for filtering distance of 2 to 5 meters and the second is from 8 to 15 meters). A conservative runoff reduction rate for rooftop disconnection is 25% for HSG C and D soils and 50% for HSG A and B soils. These values apply to disconnection that meet the feasibility criteria, and do not include any further runoff reduction due to the use of compost amendments along the filter path

Volumetric Runoff Reduction Achieved by Rooftop Disconnection			
LID Practice	Location	Runoff Reduction	Reference
Filter Strip	USA	20 to 62	Abu-Zreig et al (2004)
Filter Strip	USA	40%	Strecker at al (1998)
Filter Strip	CA	40 to 70	Barrett (2003)
Runoff Reduction Estimate		25 to 50%	

D. Soakaway Pits (Infiltration)

Relatively little data has been conducted on the runoff reduction capability of soakaway pits, although it is presumed to be high, given that infiltration is the design intent of the practice. Some surface overflows do occur when the infiltration storage capacity is exceeded. Assuming the practice is designed with adequate pretreatment and soil infiltration testing, a conservative runoff reduction rate of 90% is assigned to soakaway pits.

Volumetric Runoff Reduction Achieved by Infiltration			
LID Practice	Location	Runoff Reduction	Reference
Infiltration	NH	90%	UNHSC (2005)
Infiltration	VA	60%	Schueler (1983)
Infiltration	PA	90%	Traver et al (2006)
Infiltration	NC	96-100%	Bright et al (2007)
Runoff Reduction Estimate		90%	

E. Stormwater Planters and Tree Pits

Only one study has measured the hydrologic capacity of stormwater planters or tree pits to reduce runoff, and it found they had relatively low capability (UNHSC, 20007). The actual runoff reduction capability for these practices is related to their contributing drainage area, runoff storage capacity and rate of overflow or underdrain. Consequently, these practices are assigned a conservative runoff reduction capability of 15%

F. Compost Amendments

Several studies have examined the effect of soil compost amendments to reduce the volume of runoff produced by lawn runoff from compacted soils. An additional 50% runoff reduction rate of 50% is given when compost amended soils receive runoff from an appropriately design rooftop disconnection or grass channel. A 90% runoff reduction rate can be used for the runoff from lawn areas that are compost amended, but do not receive any off-site runoff from impervious surfaces.

Volumetric Reduction in Lawn Runoff Due to Compost Amendments			
LID Practice	Location	Runoff Reduction	Reference
Compost Amendment	WI	74 to 91%	Balousek (2003)
Compost Amendment	AL	84 to 91%	Pitt et al (2002 and 2005)
Compost Amendment	WA	29 to 50%	Kolsti et al (1995)
Compost Amendment	WA	53 to 74%	Hielima (1999)
Runoff Reduction Estimate		50 to 90%	

G. Permeable Pavers Quite a few recent studies are now available to examine the runoff reduction potential for permeable pavers that are designed with the requisite amount of storage to enable infiltration beneath the paver. The research studies have been classified into two categories- permeable paver applications that have underdrains and

those that do not. Assuming the permeable paver is designed with adequate pretreatment and soil infiltration testing, a conservative runoff reduction rate of 90% is assigned to designs that rely upon full infiltration. Permeable paver applications on HSG C and D soils that typically require underdrains should use the lower runoff reduction rate of 45%

Volumetric Runoff Reduction by Permeable Pavement			
LID Practice	Location	Runoff Reduction	Reference
Pervious Pavement *	ONT	99	Van Seters et al (2006)
Pervious Pavement *	PA	94	Traver et al (2006)
Pervious Pavement *	FRA	98	Legret and Colandini (1999)
Pervious Pavement *	NC	100	Bean et al (2007)
Pervious Pavement *	NC	95 to 98%	Collins et al (2007)
Pervious Pavement *	WA	97 to 100	Brattebo and Booth (2003)
Pervious Pavement *	CT	72	Gilbert and Clausen (2006)
Pervious Pavement *	UK	78	Jefferies (2004)
Pervious Pavement #	NC	38 to 66	Collins et al (2007)
Pervious Pavement #	PA	25-45	Pratt et al (1989)
Pervious Pavement #	NC	66	Bean et al (2007)
Pervious Pavement #	UK	53	Jefferies (2004)
Pervious Pavement #	MD	45 to 60	Schueler et al (1987)
Pervious Pavement #	Lab	30 to 55	Andersen et al (1989)
Runoff Reduction Estimate		45# to 90*	
* no underdrain collection # underdrain collection			

H. Tree Clusters

No specific research has been conducted on the runoff reduction rates for tree clusters as set forth in Cappiella et al (2005), although the value of trees in reducing runoff has been established by Portland BES (2003) and PA DEP (2006). These manuals assign a runoff reduction rate of 0.2 cubic meters per qualifying deciduous tree and 0.3 cubic meters per evergreen tree. If planting bed is compost amended, or tree cluster is designed to accept off-site runoff, a higher rate of runoff reduction may be used.

I. Bioretention

Quite a few studies are now available to characterize the runoff reduction rates for bioretention areas. The research can be classified into bioretention applications that possess underdrains and those that do not (and therefore rely on full infiltration into underlying soils). A conservative runoff reduction rate of 80% is assigned to designs that rely upon full infiltration. Bioretention areas located on HSG C and D soils that typically require underdrains should use the lower runoff reduction rate of 45% (see Table blow)

Volumetric Runoff Reduction Achieved by Bioretention			
LID Practice	Location	% Runoff Reduction	Reference
Bioretention *	CT	99%	Dietz and Clausen (2006)

Bioretention *	PA	86%	Ermilio (2005)
Bioretention *	FL	98%	Rushton (2002)
Bioretention *	AUS	73%	Lloyd et al (2002)
Bioretention #	ONT	40%	Van Seters et al (2006)
Bioretention #	Model	30%	Perez-Perdini et al (2005)
Bioretention #	NC	40 to 60%	Smith and Hunt (2006)
Bioretention #	NC	33 to 50%	Hunt and Lord (2006)
Bioretention #	MD	52 to 65%	Davis (2008)
Runoff Reduction Estimate		40# to 80*	
# underdrain design *infiltration design			

J. Grass Channels

Runoff reduction by grass channels is generally low, but is strongly influenced by soil type, slope, vegetative cover, and the length of channel. Recent research indicates that a conservative runoff reduction rate of 10 to 20% can be used depending on whether soils fall in HSG A/B or C/D. The runoff reduction rates can be doubled if the swale is modified to incorporate compost soil amendments

Volumetric Runoff Reduction Achieved by Grass Channels			
LID Practice	Location	% Runoff Reduction	Reference
Grass Channel	VA	0	Schueler (1983)
Grass Channel	USA	40	Strecker at al (2004)
Grass Channel	NH	0	UNHSC (2007)
Grass Channel	check	27 to 41	Liptan and Murase (2000)
Runoff Reduction Estimate		10 to 20	

K. Dry Swales

Limited data is available to define the runoff reduction rate for dry swales, but research indicates that they perform as well or better as bioretention with underdrains. Since an underdrain is an integral design feature for dry swales, the same values are used to define a conservative runoff reduction for the dry swale.

LID Practice	Location	% Runoff Reduction	Reference
Dry Swale	WA	98%	Horner et al (2003)
Dry Swale	MD	46 to 54%	Stagge (2006)
Dry Swale	TX	90%	Barrett et al (1997)
Bioretention		20 to 60%	This memo
Runoff Reduction Estimate		40 to 60	

L. Extended Detention

Limited research has been conducted on the runoff reduction rates extended detention ponds. In lined ED basins, runoff is reduced through evaporation, and in unlined basins, runoff is further reduced by seepage. A study by Rushton et al (2002) found the reductions associated with evaporation and seepage to be 8% and 15%, respectively. Based on the prevailing climate for the region, a conservative runoff reduction estimate of 5% for lined basins, and 15% for unlined basins is recommended for initial design

Practice	Location	% Runoff Reduction	Reference
Dry ED pond	CA	40%	CALTRANS, 2004
Dry ED pond	NC	0%	Hathaway et al, 2007
Dry ED pond	FL	80%	Harper et al, 1999
Wet ED pond		30%	Strecker et al, 2004
Wet ED pond	FL	25%	Rushton et al, 2002
Runoff Reduction Estimate		5 to 15	

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