Integrating Green Infrastructure into a Combined Sewer Service Area

EPA-funded Demonstration Project in Kansas City, MO

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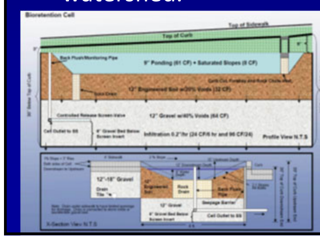
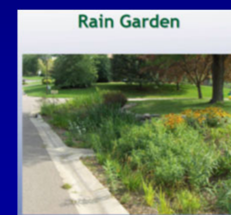
Project Strategy and Modeling

- Conventional CSO evaluations were conducted using XP_SWMM in order to identify the design storm for the demonstration area that will comply with the discharge permits.
- XP_SWMM was also used by KCMO Water Services Department, Overflow Control Program, to examine different biofiltration and porous pavement locations and storage options in the test watershed.





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Project Strategy and Modeling (cont.)

- WinSLAMM, the Source Loading and Management Model, is being used to quantify benefits for different applications of many stormwater controls in the test watershed with continuous simulations. It is also being used to examine capital and maintenance costs, along with quantifying the maintenance schedules needed for the different alternatives. Decision analysis considering many project objectives is also being supported by WinSLAMM and by the EPA's new SUSTAIN model.

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Major Land Use Components in Residential Portion of Study Area (% of area and % of total annual flow contributions)

	Roofs	Drive-ways	Side-walks	Park-ing	Streets	Land-scaped	Total
Directly connected	2 (6)	4 (9)	1 (3)	2 (5)	9 (21)		18 (44)
Disconnected	11 (7)	4 (3)	1 (1)				16 (11)
Landscaped						66 (45)	66 (45)
Total area	13 (13)	8 (12)	2 (4)	2 (5)	9 (21)	66 (45)	100

Based on KCMO GIS mapping and detailed site surveys, along with WinSLAMM calculations.

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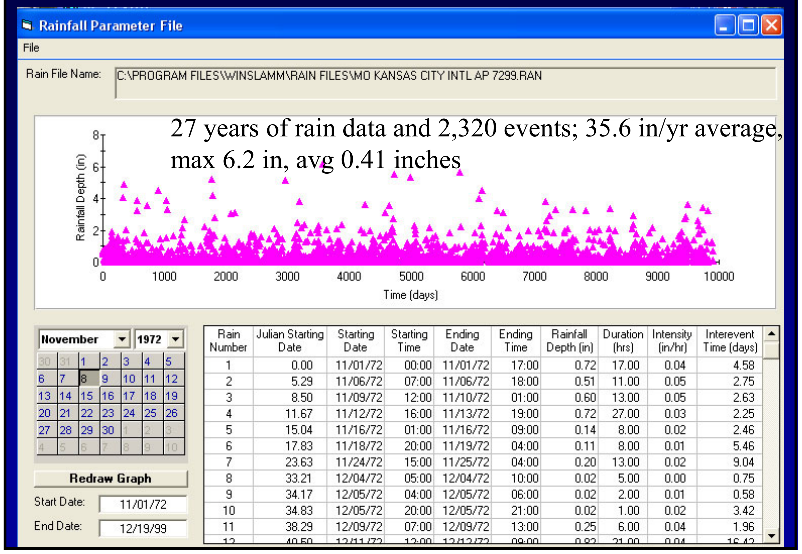
Kansas City 1972 to 1999 Rain Series



Rain Number	Julian Starting Date	Starting Date	Starting Time	Ending Date	Ending Time	Rainfall Depth (in)	Duration (hrs)	Intensity (in/hr)	Interevent Time (days)
1	0.00	11/01/72	00:00	11/01/72	17:00	0.72	17.00	0.04	4.58
2	5.29	11/06/72	07:00	11/06/72	18:00	0.51	11.00	0.05	2.75
3	8.50	11/09/72	12:00	11/10/72	01:00	0.60	13.00	0.05	2.63
4	11.67	11/12/72	16:00	11/13/72	19:00	0.72	27.00	0.03	2.25
5	15.04	11/16/72	01:00	11/16/72	09:00	0.14	8.00	0.02	2.46
6	17.83	11/18/72	20:00	11/19/72	04:00	0.11	8.00	0.01	5.46
7	23.63	11/24/72	15:00	11/25/72	04:00	0.20	13.00	0.02	9.04
8	33.21	12/04/72	05:00	12/04/72	10:00	0.02	5.00	0.00	0.75
9	34.17	12/05/72	04:00	12/05/72	06:00	0.02	2.00	0.01	0.58
10	34.83	12/05/72	20:00	12/05/72	21:00	0.02	1.00	0.02	3.42
11	38.29	12/09/72	07:00	12/09/72	13:00	0.25	6.00	0.04	1.96

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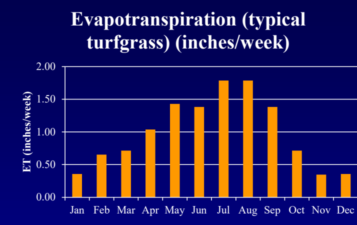
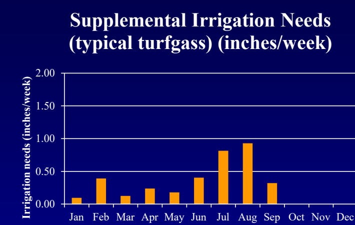
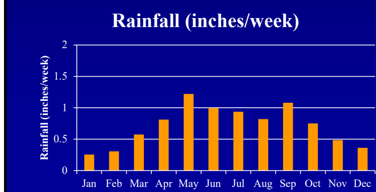
Water Harvesting Potential of Roof Runoff







Irrigation needs for the landscaped areas surrounding the homes were calculated by subtracting long-term rainfall from the regional evapotranspiration demands for turf grass.

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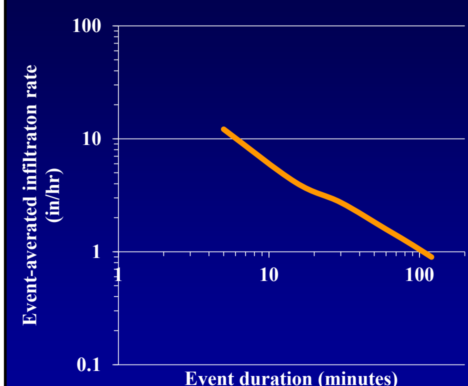
Long-duration Site Infiltration Rates



Clusters of three small Turf-Tec infiltrometers were used at each monitored location to obtain site infiltration rates in the disturbed urban soils.

The surface infiltration rates are less than 1 in/hr for rains about 2 hrs in duration and longer, but can be quite large for short duration (small) events.

Additional site measurements and deep soil profiles have indicated that infiltration rates are quite low for most of the area. Therefore, 0.2 in/hr was used during these evaluations for critical long-duration rains.

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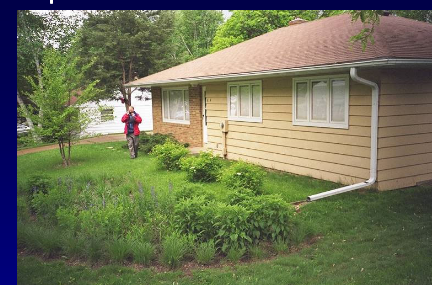
Rain Garden Designed for Complete Infiltration of Roof Runoff

This presentation only presents the results of recent modeling efforts examining rain gardens and rain barrels/water tanks to control the annual runoff quantity from directly connected roofs. The modeling will be expanded when the curb-cut biofilter designs are finalized.



Madison, WI

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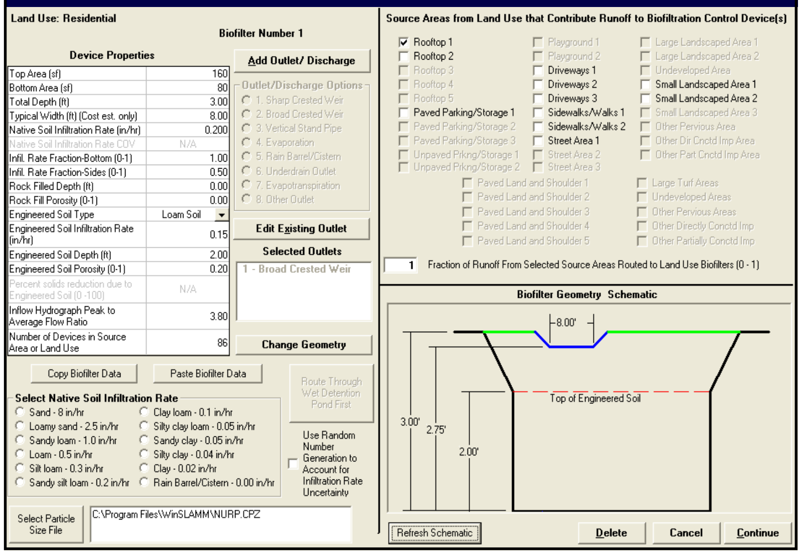
Basic Rain Garden Input Screen in WinSLAMM



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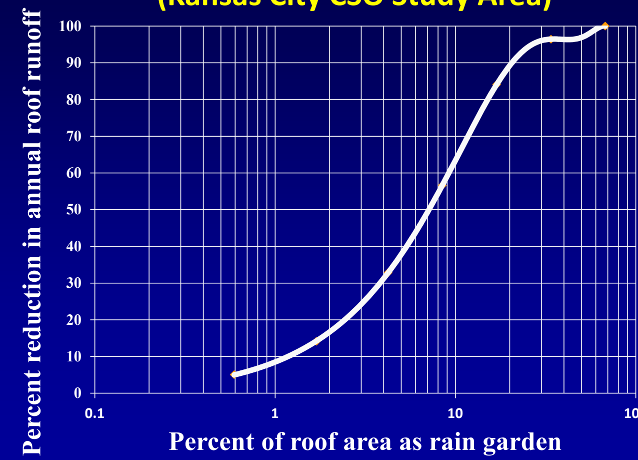
Reductions in Annual Flow Quantity from Directly Connected Roofs with the use of Rain Gardens (Kansas City CSO Study Area)



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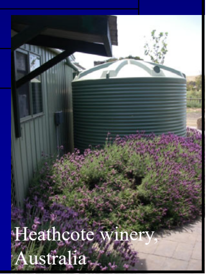
Household water use (gallons/day/house) from rain barrels or water tanks for outside irrigation to meet ET requirements:

January	42	July	357
February	172	August	408
March	55	September	140
April	104	October	0
May	78	November	0
June	177	December	0


Warrabungles National Park, Australia


Siding Springs Observatory, Australia


Heathcote winery, Australia

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Water Use Calculations in WinSLAMM

WinSLAMM conducts a continuous water mass balance for every storm in the study period.

For rain barrels/tanks, the model fills the tanks during rains (up to the maximum amount of runoff from the roofs, or to the maximum available volume of the tank).

Between rains, the tank is drained according to the water demand rate. If the tank is almost full from a recent rain (and not enough time was available to use all of the water in the tank), excess water from the event would be discharged to the ground or rain gardens after the tank fills.

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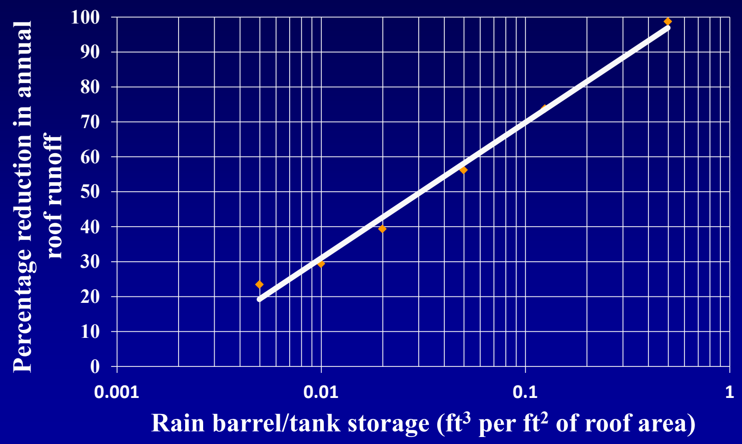
Reductions in Annual Flow Quantity from Directly Connected Roofs with the use of Rain Barrels and Water Tanks (Kansas City CSO Study Area)



0.125 ft of storage is needed for use of 75% of the total annual runoff from these roofs for irrigation. With 945 ft^2 roofs, the total storage is therefore 118 ft^3, which would require 25 typical rain barrels, way too many! However, a relatively small water tank (5 ft D and 6 ft H) can be used instead.

rain barrel/tank storage per house (ft^3)	percentage reduction in annual roof runoff	# of 35 gallon rain barrels per house	tank height size required if 5 ft D (ft)	tank height size required if 10 ft D (ft)
0	0	0	0	0
4.7	20	1	0.24	0.060
9.4	31	2	0.45	0.12
19	43	4	0.96	0.24
47	58	10	2.4	0.60
118	75	25	6.0	1.5
470	98	100	24	6.0

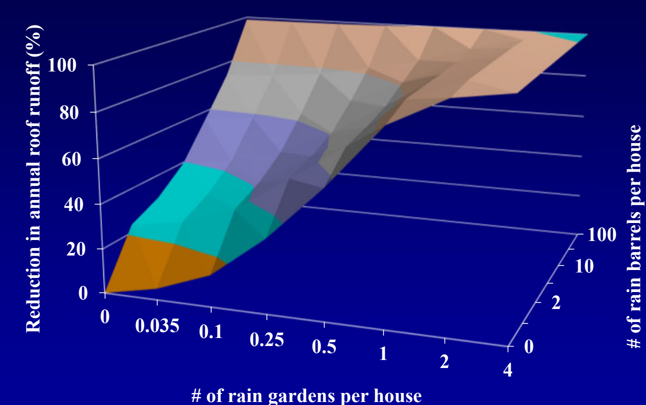
Interactions of "Green Infrastructure" Controls being Evaluated in the Kansas City CSO Study Area

- When evaluated together, rain barrels/tanks collect the roof runoff first (for later irrigation use); the excess water can be discharged to the rain gardens. Overflow from the rain gardens is directed to the curb-side drainage system and biofilters.

- All of the site water (from the excess from the roof treatment systems or other upland controls and all other areas) is collected in the curb-side drainage system. The curb-cut biofilters are modeled as a cascading swale system where the site runoff is filtered and allowed to infiltrate. If the runoff volume is greater than the capacity of the biofilters, the excessive water is discharged into the combined sewer.

- As noted, the continuous simulations drain the devices between the runoff events, depending on the interevent conditions and water demand.

Interaction Benefits of Rain Barrels and Rain Gardens in the Kansas City CSO Study Area



Two 35 gal. rain barrels, plus one 160 ft^2 rain garden, per house can reduce the total annual runoff quantity from directly connected roofs by about 90%

Conclusions

- Extensive use of biofilters and other practices is needed in order to provide significant benefits to the combined sewer system.
- It is likely that these "green infrastructure" components will be cost effective and provide additional neighborhood benefits.
- Different models should be used to evaluate different aspects of complex problems.
- The weight-of-evidence provided by independent evaluations decreases the uncertainty of complex decisions.