CONSERVATION DESIGN FORUM

Landscape Architecture · Community Planning · Ecological Restoration · Resource Management

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MEMORANDUM

DATE: September 24, 2001

TO Kimberly Hickson, BNIM Architects

FROM Tom Price

RE Missouri DNR Gray water cistern

CC: David Yocca

MEMO

I have prepared a spreadsheet to aid in sizing a cistern for the Missouri DNR building in Jefferson City. This spreadsheet could also be used to size cisterns for the entire site. The spreadsheet allows for multiple surfaces with different runoff coefficients to contribute to the cistern. The spreadsheet is essentially a daily accounting of rainfall, water supply demand, and cistern volume from January 1977 through July 2001. Shortages and overflow (spill) of the cistern are tracked and summary statistics provided. Although, the demand is assumed to be constant throughout the accounting period (including on weekends), the constant demand number can be changed. It is also assumed that any precipitation that occurs as snowfall is immediately available. Based on our conversations, it sound as though snowfall is relatively small in Jefferson City. Based on the data, only approximately 5% of the annual precipitation occurs as snowfall.

I have provided a copy of the spreadsheet (see excerpt below) so that you can modify the demand and other factors as you get further into design of the building and grounds. The spreadsheet has been annotated to explain the various input and output parameters (mouse over the little red pointers to see notes).

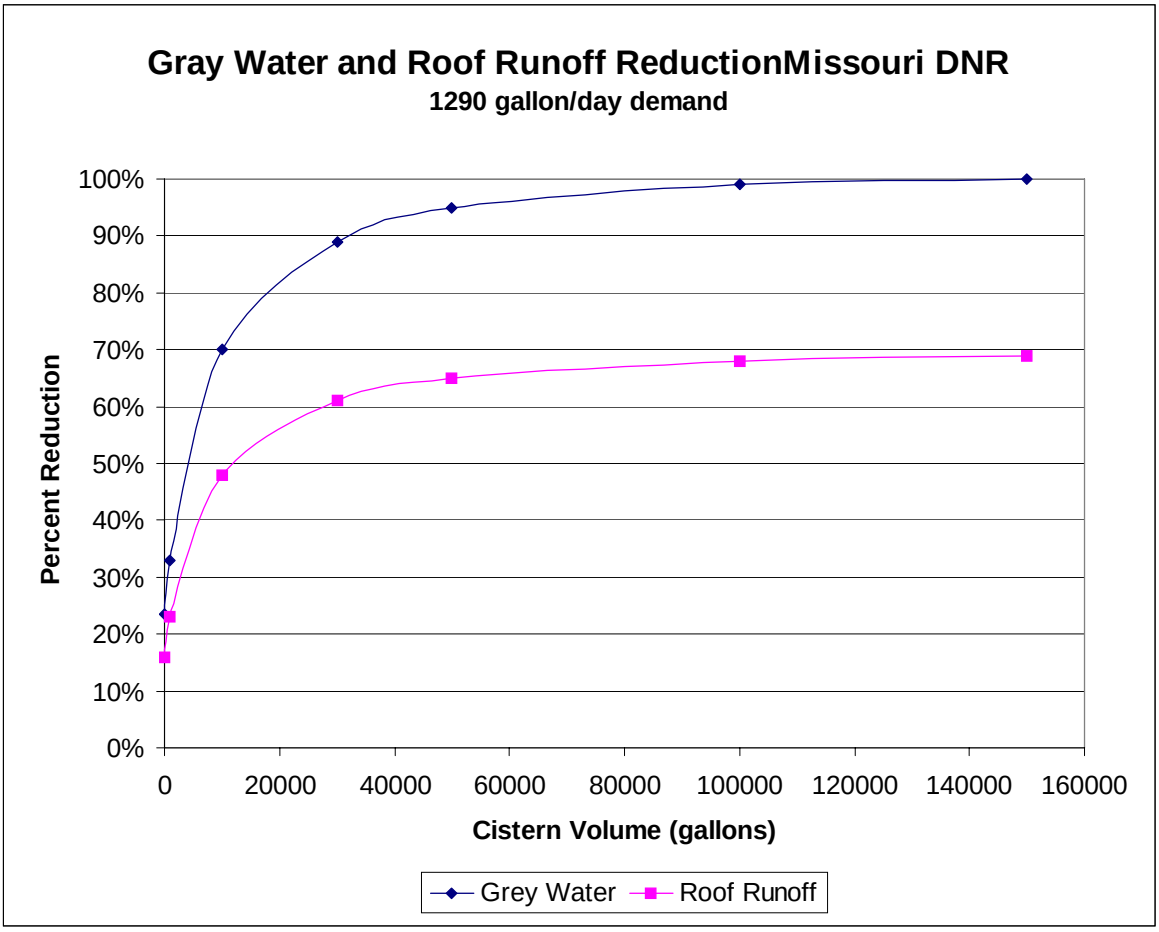
CISTERN VOLUME CALCULATOR											
Jefferson City Missouri											
Input information:					Results:						
Daily Demand (gallons)		2600			#of shortages		288				
Cistern volume (gallons)		1000000	(>0)		# of shortages/year		11.76				
Contributing Area (Sq ft)		Runoff Coefficient			Avg annual shortage:		227635.6	gallons			
Area 1	30000	0.9			Avg annual shortage:		23.97%	of demand			
Area 2	0	0			Avg annual spill:		0	gallons			
Area 3	0	0			Avg annual spill:		0.00%	of supply			
					# of spills/year		0.00				
							Stored	Shortage	Shortage	Spill	Spill
year	month	day	Prcp	Snow	Supply	Demand	Volume	Volume	Count	Volume	Count
1977	1	1	0	0	0	2600	997400	0	0	0	0
1977	1	2	0.04	0.5	673.2	2600	995473	0	0	0	0
1977	1	3	0.01	0.3	168.3	2600	993042	0	0	0	0
1977	1	4	0.04	0.7	673.2	2600	991115	0	0	0	0
1977	1	5	0.18	4	3029.4	2600	991544	0	0	0	0
1977	1	6	0.02	0.9	336.6	2600	989281	0	0	0	0
1977	1	7	0.13	2.1	2187.9	2600	988869	0	0	0	0
1977	1	8	0	0	0	2600	986269	0	0	0	0
1977	1	9	0	0	0	2600	983669	0	0	0	0
1977	1	10	0.23	3	3870.9	2600	984940	0	0	0	0
1977	1	11	0	0	0	2600	982340	0	0	0	0
1977	1	12	0	0	0	2600	979740	0	0	0	0

As we discussed during the workshop, a cistern volume of 151,000 is required to eliminate any shortages during the approximately 24½-year period for which I have data. While smaller cistern volumes result in shortages from time to time, the actual percentage of the demand that must be supplied by City water can be limited to a relatively small amount with significantly smaller cistern volumes.

Although the primary focus of the cistern has been to reduce reliance on City water, there is also a significant stormwater benefit to using roof runoff for graywater use. The stormwater runoff from the roof can be reduced by as much as 69% with the 1290 gallon/day demand rate supplied by your office. The runoff volume reduction could be increased if the demand were increased.

The following table and graph summarize the City water supply and runoff volume reduction achieved for varying cistern sizes. The table assumes that only roof water contributes to the cistern.

Cistern volume (gallons)	Roof Area (Sq. ft.)	Grey water demand (gallons)	Grey Water Reduction	Roof Runoff volume reduction
151000	30000	1290	100%	69%
100000	30000	1290	99%	68%
50000	30000	1290	95%	65%
30000	30000	1290	89%	61%
10000	30000	1290	70%	48%
1000	30000	1290	33%	23%



The table and chart show that with a cistern volume as low as 50,000 gallons and the given demand of 1290 gallons/day, the city water requirement for gray water use could be limited to 5% of the demand. With a 50,000 gallon cistern, the runoff volume reduction will still be as low as 65% (compared to 69% with a 150,000 gallon cistern). Also, the excess water can be incorporated into bioswales or level spreaders to provide more significant reduction of stormwater runoff.

To provide you with a feel for the numbers, the table below summarizes results for doubling the demand rate for the given contributing runoff area and doubling the runoff area for the given demand rate.

With a demand as high as 2600 gallons/day (~ double the specified demand rate), there is insufficient supply to eliminate the need for city water and even with an enormous cistern, the percentage of the demand that must be supplied by city water can only be reduced to 36%. Conversely, if the area contributing water to the cistern is doubled for the given demand rate, the required cistern volume is decreased significantly. For example, the need for city water could be eliminated with only a 60,000 gallon cistern (as opposed to 151,000 gallons). To reduce the need for city water to 5% of the total demand, the cistern volume would need to be 30,000 gallons.

Cistern volume (gallons)	Runoff Area (Sq. ft.)	Grey water demand (gallons)	Grey Water Reduction	Roof Runoff volume reduction
450000	30000	2600	74%	100%
300000	30000	2600	72%	99%
151000	30000	2600	70%	97%
100000	30000	2600	68%	94%
50000	30000	2600	64%	88%
10000	30000	2600	45%	62%
1000	30000	2600	33%	23%
80000	60000	1290	100%	34%
50000	60000	1290	99%	34%
30000	60000	1290	95%	33%
10000	60000	1290	78%	27%
1000	60000	1290	36%	12%

As can be seen, the appropriate size of the cistern depends on the graywater demand, the area contributing water to the cistern, and the goals for reducing reliance on City water.

Although I do not have any information on the size of the existing water tower, it appears that the tower may have capacity to store more than 250,000 gallons (assuming a diameter of 55 feet and a height of 15 feet). While all this volume could be used to serve the DNR building, a greater total reduction in City water demand could be achieved by using the tower to serve all buildings on the site. This is particularly true if access to the tower for graywater could be used as an incentive for building owners to provide additional storage within their own buildings. In any case, a modest amount of storage below the elevation of the roof will be necessary so that runoff does not need to be pumped up to the tower at the rate of runoff and instead can be pumped at a slower rate (and therefore smaller pump size) and during night time, off-peak electrical rates. Further, if the cistern can be incorporated into the roof structure, the need for pumping could be significantly reduced.

Should you have any questions regarding this memorandum, sizing of the cistern, or other related issues, please do not hesitate to call.