Kresge Foundation Headquarters – Troy, MI
Methodology for Landscape Performance Benefits

Environmental

- ***Recharges groundwater by infiltrating 64% of average annual rainfall or 1.7 million gallons. The site can infiltrate all water from storms up to 0.86 inches in 24 hours.***

Yearly rainfall on-site was calculated by averaging the total precipitation from 2006-2010 using records from National Climatic Data Center for West Bloomfield, the nearest weather station to Kresge (http://www.ncdc.noaa.gov/oa/climate/stationlocator.html, West Bloomfield COOP ID: 208779; accessed 7-18-2011 by Sarah Alward).

Annual Rainfall in West Bloomfield:
2010: 31.37
2009: 36.32
2008: 39.63
2007: 32.45
2006: 36.17
Average over the last five years 2006-2010: 35.19 in

Annual volume of precipitation on-site at Kresge was calculated using the total site area (2.77 acres) and annual depth of precipitation:

Site area: 2.77 acres * 43,560 ft/ac =120,661.2 sf
Annual rainfall = 35.19 in / 12 in/ft = 2.9325 ft
Total volume of rainwater falling onsite annually: 120661.2 sf x 2.9325 ft = 353,838.969 cf or **2,646,899.300 gals**

A Post-Occupancy Evaluation conducted by University of California Berkeley (Goins, 2011) found that 64% of all precipitation infiltrates on-site at Kresge (Kresge Foundation Complex: Post-Occupancy Evaluation, Center for the Built Environment, 2011). Based on the Berkeley report measurements, the landscape at Kresge infiltrates 64% of 2,646,899.300 gals:

2,646,899.300 gals x 0.64 = **1,694,015.55 gals of rain infiltrated annually**

The Berkeley Post-Occupancy Evaluation also reported that Kresge could infiltrate 100% of storms equal to or smaller than 0.86 inches in 24 hours. This number was determined using the USDA Cover Complex Method; because stormwater at Kresge is managed like a "natural woodland," a comparable natural woodland site would not generate runoff until approximately 0.86 in of rain falls.

- ***Eliminates the use of potable water for irrigation, saving over 1 million gallons of water and $6,400 per year.***

Lawn area before redesign was determined by subtracting the sum of the areas of all buildings, parking lots and trees from the total site area of the Kresge Headquarters property (as measured in AutoCAD file CDF_existing base.dwg, provided by Conservation Design Forum). The total lawn area before construction was 73,609 sf. Lawn area after construction was 9,072 sf (as measured in the AutoCAD file CDF_GENERAL PLANTING.dwg, provided by Conservation Design Forum). Using this information, the change in total lawn area and the percent change in lawn area were determined as follows:

	Area	Percent
Total lawn area before construction:	73,609	100%
Total lawn area after construction:	9,072	12%
Change in total lawn area	**64,537**	**88%**

The significant turf area before the design change required consistent irrigation during the growing season; A typical mid-western office campus requires 1" of irrigation per week (Sustainable Sites Initiative, 2008, http://www.sustainablesites.org/cases/show.php?id=14, accessed 8-2-2011 by Christopher Ellis). Michigan State Extension Service estimates a similar figure, citing cool-season lawn turf requires 0.5 to 1.5 in of water per week (http://www.turf.msu.edu/irrigation-practices-to-preserve-water-quality, accessed 7-19-2011 by Sarah Alward). Assuming the turf was irrigated for six months (May through October, or 26 weeks), the amount of water needed for all turf areas is 26" in depth per year (1" per week x 26 weeks during the growing season).

Total water and cost savings are calculated below:

Decreased lawn area: 64,537 sf
Potable water saved from irrigation per year: 26 in (2.166 ft)
Total water saved per year: 64,537 sf x 2.166 ft = **139,787 cf (1,045,679 gals)**

The charge for metered water in Troy costs $4.59 per 100 cf (http://troymi.gov/PublicWorks/WaterRates2011.pdf, accessed 6-23-2011 by Robin L. Burke); therefore, saving 139,787 cf of water saves Kresge **$6,416.22 per year**.

4.59 x (139,787/100) = $6,416.22

- ***Restored a total of 1.76 acres of native vegetation, which includes 53 native herbaceous plant species identified in a May 2010 site-wide plant survey.***

Area of terrestrial habitat was calculated by adding together the areas of prairie, grasses, ornamental beds, and wetland areas (as measured in AutoCAD file CDF_GENERAL PLANTING.dwg, provided by Conservation Design Forum). The total acreage of restored native vegetation and plant survey data were reported from the Post Occupancy Evaluation conducted by the University of California Berkeley (Goins, 2011). A site-wide plant survey was conducted in May 2010; those plants that were specified in the construction drawings but were not located in the field might not have germinated or erupted at the time of inspection.

In a planting list provided by the landscape contractor from WH Canon on June 30, 2011, a total of 19 wetland and 78 terrestrial species were specified for the site--10 more species than cited in the Berkeley report. This could be attributed to updating the planting list between May 2010 and June 2011. However, in the interest of reporting what species had been established on-site, the Berkeley report may portray the floristic diversity at Kresge most accurately.

- ***Reduced local surface temperatures by using prairie plantings instead of turf grass (average decrease of 12.1°F), light-colored permeable pavers instead of asphalt (average decrease of 5.4°F), and green roof and high reflectance white roof instead of traditional roof surfaces (average decrease of 4.7°F and 10.5°F respectively, as compared to asphalt).***

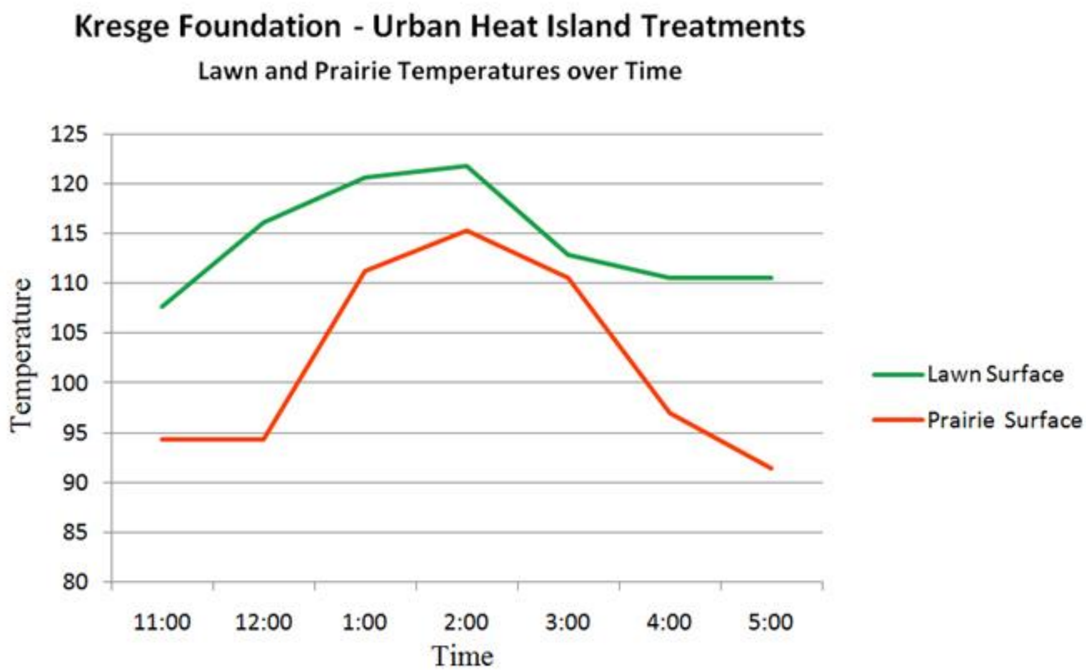
To measure surface and air temperatures at Kresge, Acu-Rite Wireless Thermometer #00782 indoor/outdoor digital thermometer pairs were set up at seven different locations and read once an hour between 11 am and 5 pm on June 30, 2011. Surface temperature was measured by placing the sensor directly on the ground or roof surface; air temperature was measured by placing the sensor 2-feet above the ground on a wooden post, shaded from direct sunlight by a piece of wood.

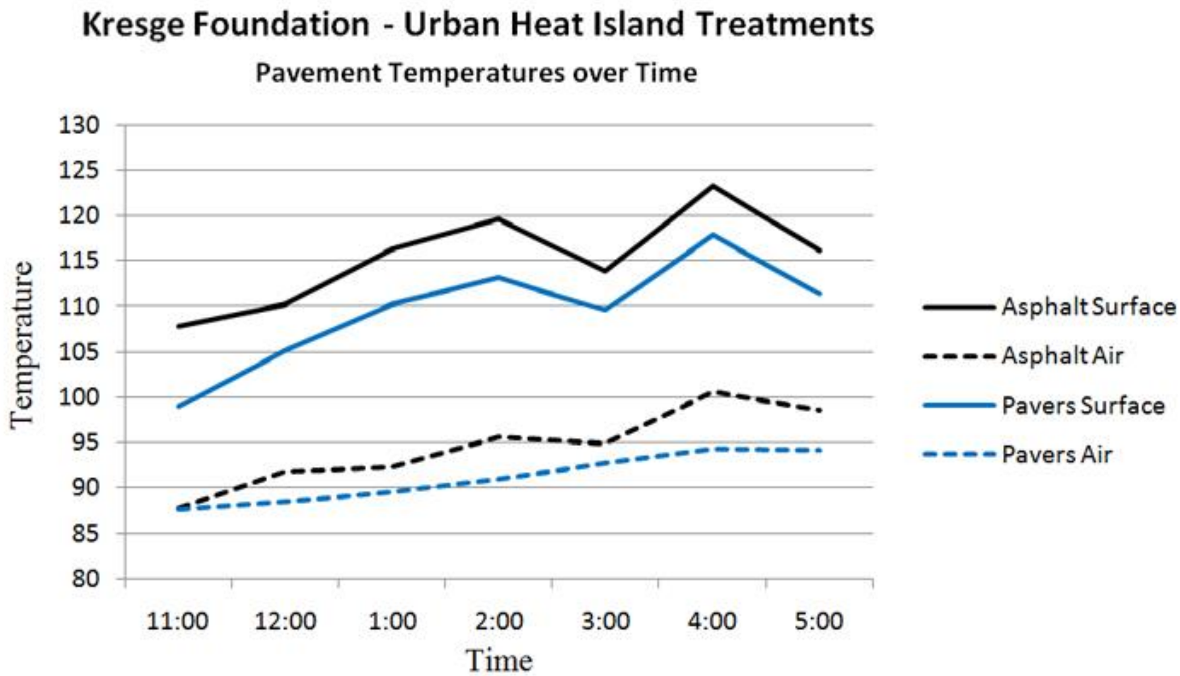
The following locations were sampled:

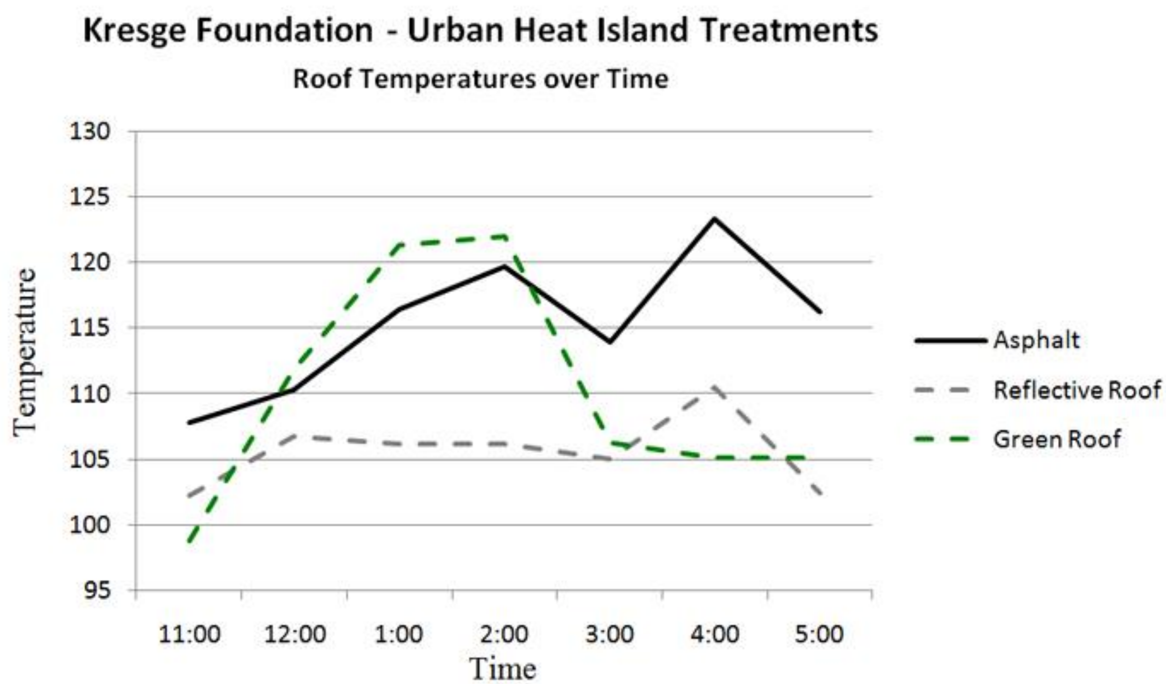
1. Surface and air temperature in an asphalt parking lot just northeast of the Kresge site
2. Surface and air temperature in the permeable parking lot at the far south end of the lot
3. Surface and air temperature in the prairie, south of the walking path and at the same elevation as the parking lot
4. Surface temperature of the prairie garden west of the farmhouse
5. Surface temperature of the lawn in the easement, just north of the front sidewalk.
6. Surface temperature on the green roof north of the courtyard.
7. Surface temperature on the high-reflectance roof, directly east of the courtyard.

Weather in Troy, MI on June 30, 2011 was mostly sunny with a mean temperature of 72 degrees and a maximum temperature of 84 degrees (http://www.wunderground.com/history /, accessed 7/26/2011 by Sarah Alward).

Temperature data were recorded throughout the day and can be seen in the graph and table below. Temperature differences between surfaces were calculated by finding the difference in temperature each hour and averaging over the six time points.







- ***Reduces annual hydrocarbon and carbon monoxide emissions by 15.1 pounds and 488.2 pounds, respectively, by replacing motorized landscaping equipment with weekly hand weeding and annual prescribed burns.***

The maximum allowable emissions from lawn mowers are regulated by the United States Environmental Protection Agency and are listed in the table below:

	Effective model year	Hydrocarbons & nitrogen oxides (g/kW-hr)	Nonmethane hydrocarbons & nitrogen oxides (g/kW-hr) [1]	Carbon monoxide (g/kW-hr)
Mowers	1997	16.1	--	519

(http://news.consumerreports.org/home/2008/10/epa-sets-lower.html, Oct 2, 2008 12:01 AM, Ed Perratore. Retrieved 7-21-2011 by Robin L. Burke)

The exact model of lawnmower used at Kresge is unknown; therefore, emissions calculations are based on a Cub Cadet Commercial Z-Force S with a 48” deck and 22 horsepower, a mid-size commercial mower. If this model runs at 3.5 mph, it will cut 1.7 acres per hour (http://www.cubcadet.com/webapp/wcs/stores/servlet/CubCadetFullPageArticleDisplayView?langId=-1&storeId=10051&catalogId=14101&pageView=Cubcadet_Commercial/AcresPerHour.html). Because there were approximately 1.69 acres of lawn before construction, it is estimated that lawn mowing would take one hour each time.

Assuming the lawn is cut once per week for 26 weeks over the growing season (May-October), the total horsepower hours equals 572 hp-hr:

> 1 hour per week for 26 weeks = 26 hours
> 22 horsepower x 26 hours = 572 hp-hr

Emissions of hydrocarbons and carbon monoxide are listed in grams per kilowatt-hour (1 hp = .746 kW), and are calculated below:

> 572 hp-hr x 0.746 = 426.7 kW-hr
> Hydrocarbons + nitrogen oxides: 426.7 kW-hr x 16.1 g/kW-hr = 6869.9 g = **15.1 lbs**
> Carbon monoxide: 426.7 kW-hr x 519 g/kW-hr = 221,457.3 g = **488.2 lbs**

Social

- ***Increases satisfaction and restorative benefits with 87% of Kresge employees reporting that they are satisfied with the design of the exterior grounds, including plazas, landscape, and outdoor seating areas.***

As part of the Post-Occupancy Evaluation of the Kresge Foundation Headquarters by the University of California Berkeley (Goins, 2011), researchers conducted an occupant survey that asked employees about their satisfaction with the building layout and furnishings, acoustic quality, thermal comfort, air quality, cleanliness and maintenance, and lighting. While primarily reporting about the building itself, section 2.9 of the report asked the following question: *How satisfied are you with the design of the buildings exterior grounds, including its plazas, landscaping, and outside seating areas?* (Goins, 2011). Of the 61 responses, 87% were satisfied, 10% were neutral, and 3% were dissatisfied.

According to a 2010 study by Ke-Tsung Han, scenic beauty, landscape preference, and restoration are all closely related concepts. However, study participants who had a preference for a given landscape were also significantly more likely to perceive scenic beauty and the potential for restoration from the same landscape. This study suggests that because 87% of Kresge employees are satisfied with the landscape, they might also find it to be beautiful and a source of mental and physical restoration.

References

Goins, J. 2011. Case Study of Kresge Foundation Office Complex. Summary report to Kresge Foundation. http://escholarship.org/uc/item/6db458q9#page-1.
Han, K. 2010. An Exploration of Relationships Among the Responses to Natural Scenes Scenic Beauty, Preference, and Restoration. Environment and Behavior, Volume 42, Number 2, p. 243-270.

- ***Promotes environmental awareness and stewardship by introducing Kresge's 200 annual visitors to the site's native plantings and stormwater management practices. (Kresge is a research funding organization and is not normally open to the public).***

The public welfare benefits of exposing visitors to sustainable practices in landscape architecture have been summarized in a lecture given at the 2011 Council of Educators in Landscape Architecture annual meeting (Deming et al, 2011). According to Deming et al (2011), a review of existing literature supports that landscape architecture intrinsically promotes public welfare by enhancing human communities through awareness and stewardship of natural environments. David Yocca and Patrick Judd of Conservation Design Forum, and Cynthia Powors of the Kresge Foundation indicated that the landscape at the site was designed with the intention of promoting ecological health, environmental awareness and sustainable stewardship practices (personal communications, 6-2011 through 7-2011). The implementation of this intended educational agenda is measurable because the Kresge Foundation Headquarters conducts educational tours of its building and landscape aimed at architects, representatives of municipalities, and college students. About 200 people who are interested in learning about the sustainable practices implemented on-site attend these tours each year (personal communication, Cynthia Powors, 6-30-2011). Tour attendees can be said to benefit from the promotion of public welfare through increased awareness of stewardship of natural environments, through an educational opportunity made possible by the presence of the sustainably-designed landscape.

References
Deming, M.E., J. Albizo, C. Phillips and C.D. Ellis. 2011. “Landscape Architecture and Public Welfare: A Content Analysis” Council of Educators in Landscape Architecture, March 30-April 2, 2011. Los Angeles, CA.

Economic

- ***Saved over $25,000 in material costs and avoided 11,000 vehicle miles and 73.6 tons of carbon emissions by recycling approximately 318 tons of locally-sourced crushed concrete in gabion walls.***

Karl Koto of W.H. Canon, the landscape contractor, provided a spreadsheet that estimated the cost and total amount of recycled concrete and trap rock used in the gabion walls.

If no concrete was used in the gabion walls, an additional 535 tons of trap rock would be needed at $56 per ton, costing $29,965. Subtracting out the cost of 318 tons of recycled concrete (318 tons x $15 per ton = $4,772) yields the value of recycling concrete instead of buying more trap rock:

$29,965 - $4,772 = **$25,193 saved in material cost**

In addition to material costs, recycling local concrete also resulted in significantly fewer vehicle miles and emissions. Transporting 535 tons of trap rock requires 15 truck loads carrying 35 tons each (according to Karl Koto). The trap rock supplier is in Ontario, Canada, and is approximately 368 miles (736 miles roundtrip) from Troy.

Total vehicle miles avoided is calculated below:

15 trips x 736 miles each trip = **11,040 miles**

Formulas for estimating emissions from trucks and product transport were used to estimate carbon reductions (See Table 6 in EPA, 2008). Ton-miles were used to estimate carbon emissions driving from the supplier to the site with 35 tons of trap rock:

<u>Emission Factors for On-Road Truck Product Transport (ton-mile)</u>

Ton-miles:	368 miles x 15 trips x 35 tons per trip = 193200 ton-miles
Carbon per ton-mile:	0.297 kg CO_2/ton-mile
Pounds:	2.2 x 0.297 = 0.653 lbs CO_2 per ton-mile
Total carbon:	0.653 lbs per ton-mile x 193200 ton-miles = 126159.6 lbs
Convert to tons:	126159.6 lbs/2000 lbs = **63.1 tons**

Vehicle-mile emissions from driving back to the supplier with an empty truck, were calculated (See Table 5 in EPA, 2008):

Carbon released on return trips (empty truck from site to supplier)
<u>Emission Factors for On-Road Vehicle Product Transport (vehicle-mile)</u>

Medium- and Heavy-duty Truck:	1.726kg CO_2/vehicle-mile
Pounds:	1.726 x 2.2 = 3.797 lbs
Vehicle mile:	15 trips x 368 miles = 5520
Total carbon:	5520 vehicle miles x 3.797 lbs = 20,959 lbs of carbon for return trips to a trap rock quarry in Canada
Convert to tons:	20,959 lbs / 2000 lbs = **10.5 tons**

Total carbon emissions avoided: 63.1 tons + 10.5 tons = **73.6 tons**

					Concrete				Actual Trap Rock Used			Additional Trap Rock needed if not using Concrete		
Wall	**Total Length (ft)**	**Section Height (ft)**	**Section Width (ft)**	**Total volume (CF)**	**Estimated % concrete**	**Volume concrete (CF)**	**total lbs (110 lbs/cf)**	**total tons (2,000 lbs)**	**Volume trap rock (CF)**	**total lbs (185 lbs/cf)**	**total tons (2,000 lbs)**	**Volume of trap rock (CF)**	**total lbs (185 lbs/cf)**	**total tons (2,000 lbs)**
1	166	3	2	747	0%	0	0	0	747	138,195	69	0	0	0
2	170	3	2	765	0%	0	0	0	765	141,525	71	0	0	0
4	200	3	3	1,800	50%	900	99,000	50	900	166,500	83	900	166,500	83
7	309	3	3	2,781	50%	1,391	152,955	76	1,391	257,243	129	1,391	257,243	129
8	258	3	3	2,322	50%	1,161	127,710	64	1,161	214,785	107	1,161	214,785	107
10	45	3	3	405	50%	203	22,275	11	203	37,463	19	203	37,463	19
11	45	3	3	405	50%	203	22,275	11	203	37,463	19	203	37,463	19
12	95	3	3	855	50%	428	47,025	24	428	79,088	40	428	79,088	40
13	10	3	3	90	50%	45	4,950	2	45	8,325	4	45	8,325	4
A	5	3	3	45	25%	11	1,238	1	34	6,244	3	11	2,081	1
B	30	3	3	270	25%	68	7,425	4	203	37,463	19	68	12,488	6
C	27	3	3	243	25%	61	6,683	3	182	33,716	17	61	11,239	6
D	27	3	3	243	25%	61	6,683	3	182	33,716	17	61	11,239	6
E	15	3	3	135	25%	34	3,713	2	101	18,731	9	34	6,244	3
F	43	3	3	387	25%	97	10,643	5	290	53,696	27	97	17,899	9
G	50	3	3	450	25%	113	12,375	6	338	62,438	31	113	20,813	10
H	250	3	3	2,250	45%	1,013	111,375	56	1,238	228,938	114	1,013	187,313	94
							Total Ton of Concrete	318	Total Ton of Trap Rock		778		Ton of Trap Rock	535
							cost per ton	15	cost per ton		56.00		cost per ton	56.00
							Total cost of Concrete	4,772	Total cost of Trap Rock		43,555		Cost of Trap Rock	29,965

Total concrete used (ton)	318
Total cost of concrete used	4,772
Additional cost of trap rock if no concrete was used	29,965
Total savings by using concrete	**25,193**

<u>truck trips avoided</u>	
Additional trap rock needed if no concrete:	535 tons
Tons per truck load:	35
Trips avoided:	15
Miles per round-trip between supplier in Canada to Troy:	736
Total miles avoided:	**11,250**

References

EPA Climate Leaders: Greenhouse Gas Inventory Protocol Core Module Guidance, May 2008.

http://www.epa.gov/climateleaders/documents/resources/commute_travel_product.pdf, accessed 7/22/11 by Sarah Alward

Cost Comparison Methodology

- ***Native landscapes save $30,500 in irrigation and maintenance costs each year, when compared to maintaining the same area as a traditional perennial garden.***

W.H. Canon, the landscape contractor, provided the 2011 maintenance budget for the grounds at the Kresge Headquarters. The total cost of landscape maintenance is $27,340, plus an additional charge of $6,000 for the annual burn. In total, Kresge spends approximately $33,340 per year on landscape maintenance.

The rich plant diversity at Kresge is much greater than a traditional office park with turf and canopy trees; therefore, the cost of maintaining this landscape was compared to an ornamental perennial garden of the same size, 0.96 acres. To estimate these costs, the RSMeans Costworks online estimator was used (http://meanscostworks.com/, requires registration). In addition to the maintenance estimate, weekly irrigation needs were also estimated below.

Maintenance:
A traditional perennial garden of 0.96 acres, approximately half shrubs and half flowers, was entered into the RS Means cost estimator. Maintenance tasks required in a typical perennial garden were included in this estimate: hand edging, mulching flower beds, cleaning the beds in the fall and spring, weeding, pruning, and fertilizing. The yearly maintenance cost for this garden was estimated to be **$59,975.**

Irrigation:
Assuming 1” of irrigation needed each week for 26 weeks (May-October) over the entire 0.96 acres (41817.6 sf).

41817.6 sf x 2.166 ft of water per year = 90,604.8 cf = **677,769.21 gals**

The charge for metered water in Troy costs $4.59 per 100 cf

906.048 x 4.59 = **$4158.76 per year for water**

Adding the maintenance costs with irrigation costs gives the total expected costs of a 0.96 acre ornamental perennial garden:

$59,975 + $4,159 = **$64,134 total expected maintenance cost**

Subtracting the actual cost of maintenance at Kresge ($33,340) yields the cost savings of maintaining the native landscape:

$64,134 - $33,340 = **$30,794 saved**