SPLASH OR SPRINKLE?
COMPARING THE WATER USE OF
SWIMMING POOLS AND IRRIGATED LANDSCAPES

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Abstract

Residential water use is typically a significant portion of a water agencies' water demand particularly in smaller suburban communities. Summer outdoor water use commonly drives the peak system capacity requirements and therefore a meaningful target for water conservation programs. This paper provides water conservation planners with insight into residential outdoor water use patterns. A comparison of water use of swimming pools and irrigated landscape area is analyzed from information gathered from 1,129 homes in 14 locations in the United States and Canada as part of the Residential End Uses of Water Study by American Water Works Association Research Foundation (Mayer et. al., 1999). It is found that for the 194 homes with swimming pools, the addition of a swimming pool increased demand between 22 to 25 percent. The addition of an automatic sprinkler system increased demand between 54.9 to 60.6 percent. Homes with both a swimming pool and an automatic sprinkler system used the most water over 110 percent more water outdoors than homes without these amenities. Using water use estimates for a typical home in Sacramento, California and Tampa, Florida, it was determined that swimming pools and irrigated lawn area use approximately the same amount of water on a square footage basis. In other words, if a homeowner in these regions were to remove turf grass and install a swimming pool, the water use for each square foot of grass replaced by pool water surface area would be approximately the same.

Introduction

Do swimming pools and irrigated landscape area use the same amount of water on a square footage basis? Does the replacement of turf grass with a swimming pool typically result in an increase in water use? The economic boom of the last decade has fueled increased construction of private in-ground swimming pools. The National Spa and Pool Institute estimates that there are approximately 7 million swimming pools in the United States -- 3.8 million in-ground pools and 3.2 million aboveground pools (Mellezi, 2001). In 1998 alone, the National Spa and Pool Institute determined 172,184 in-ground pools were built. Water planners and conservation

professionals must account for the increased popularity of the recreational use of water within the residential sector in their long range plans and conservation programs.

When installing a swimming pool, most homeowners dig up an existing landscaped area. This raises the question of the new water use characteristics generated by the addition of a swimming pool. How much water is a swimming pool likely to use compared to turf landscape covering the same area? Diving into this issue requires analysis of a variety of factors including pool water losses from the direct evaporation, the evapotranspiration of turf grass, and the actual efficiency of lawn irrigation systems (typically between only 30-50% efficient). Also, if the comparison of swimming pool water use to irrigated landscape were based on landscape design, then would the results vary?

The Residential End Uses of Water study (REUWS), sponsored by AWWARF, involved collection of outdoor water use data from approximately 1,129 homes in 14 study sites including irrigable landscape area and surface area for swimming pools (Mayer et. al, 1999). Using these data, a comparison of outdoor water use normalized for irrigated area and climatic effects is performed and results presented. A theoretical analysis of water use in swimming pools that considers the impact of evaporation, backwashing, splash loss, maintenance and leakage is included and a basic estimation of applied water to irrigated lawn area provided with sample calculations for Sacramento, California and Tampa, Florida.

Purpose

Conventional wisdom suggests that swimming pools are a relatively inefficient use of water, but is this presumption supported by data? How much water does it take to maintain a swimming pool compared with a similarly sized area of turf grass? The purpose of this paper is to answer important questions about swimming pool and irrigated landscape water use and will compare demands in homes with and without swimming pools and with and without automatic sprinkler systems.

Background

The mean annual water use, based on historic billing records analysis, for the 12 combined study sites in the REUWS was 146,000 gallons per household per year with a standard deviation of 103,500 gallons. Across all study sites 42 percent, or 62,000 gallons of the annual use was for indoor purposes and 58 percent, or 84,000 gallons for outdoor purposes. In areas with hot climates such as in study sites Phoenix, Tempe and Scottsdale, the percentage of outdoor use was higher, in the range of 59 to 67 percent, while areas with typically cooler climates had lower outdoor water use percentages in the range of 22 to 38 percent. (Mayer et. al., 1999)

Daily Per Capita Water Use

The mean per capita indoor daily water use in the REUWS was 69.3 gallons and outdoor daily use was 100.3 gallons per capita across all 1,188 homes in 12 study sites as shown in Figure 1.

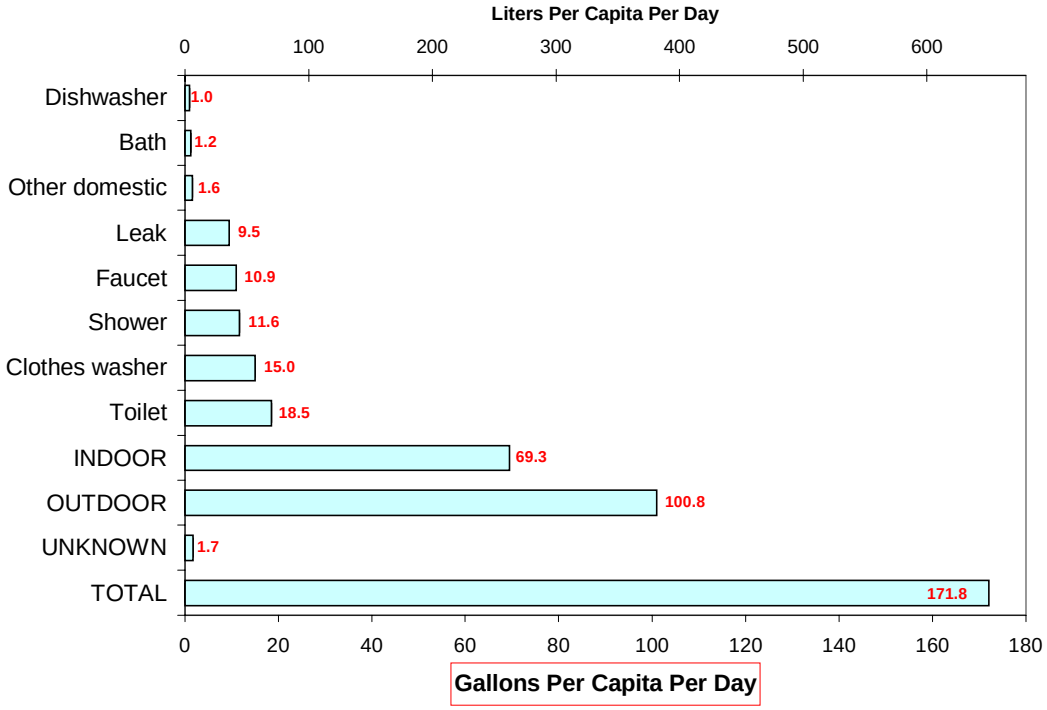

Figure 1: Mean daily per capita water use, from 12 REUWS sites[1]

Factors Affecting Outdoor Water Use

Some of the most important variables that affect landscape water use are:

- The amount and frequency of rainfall during the growing season
- Length of growing season
- Area of landscape/garden
- Type and amount of plant material
- Extent and root depth of turf grass
- Consumptive use requirements of the plant material (which is a function of evapotranspiration)
- Soil type
- Slope
- Amount of shade
- Wind
- Method of irrigation (hose and sprinkler, in-ground sprinkler system, drip, bubbler, etc.)
- Efficiency of application method(s) (frequent adjustment of time clocks to "track" evapotranspiration, rain shut-off devices, etc.)
- General horticulture (particularly turfgrass horticulture) and maintenance practices

[1] Source: Residential End Uses of Water Study, AWWA Research Foundation, 1999.

Some of the most important variables that affect swimming pool water use are:

- Surface area of pool for evaporation
- Daily and seasonal climate variations (temperature, wind, etc.)
- Covering of the pool and type of cover (bubble wrap, insulated, etc.)
- Amount of use (splashing)
- Maintenance (backwashing, flushing of solar heating system)
- Frequency of refilling

Factors vary widely from individual home site to home site, and it is not practical to accurately quantify each single family detached home use for different regions of the country. However, some general trends can be seen as illustrated in the following discussion.

REUWS Data Analysis

To evaluate the impact of swimming pools and automatic sprinkler systems on residential water use, the extensive database from the REUWS was accessed. This database includes information on annual water use, outdoor water use, irrigable area, and detailed survey responses from a sample of 1,188 homes in 14 cities in the U.S. and Canada. A summary of the data extracted from this data set is shown in Table 1. There were a total of 194 homes with swimming pools and 1,129 homes for which irrigable area data were available.

Table 1: Outdoor use, application rate, and swimming pools – REUWS sites

Study City	**# of Homes in Sample**	**Avg. Irrigable Area** (sf)	**Avg. Annual Outdoor Use** (kgal)	**Avg. Application Rate** (inches)	**Net ET for Turf Grass** (inches)	**# of Swimming Pools**
Cambridge, Ontario	54	6998	7.8	3.1	15.7	6
Waterloo, Ontario	35	5951	7.8	2.9	15.7	4
Seattle, WA	74	6058	21.7	7.7	26.4	1
Tampa, FL	99	12361	30.5	6.3	26.0	21
Lompoc, CA	100	4696	39.9	14.9	35.5	0
Eugene, OR	93	6863	46.7	16.9	23.7	2
Boulder, CO	100	6512	72.9	16.7	30.2	1
San Diego, CA	94	5904	99.3	33.1	44.0	9
Tempe, AZ	39	7341	100.3	47.5	72.5	18
Denver, CO	99	7726	104.7	28.3	33.4	1
Walnut Valley WD	98	10282	114.8	27.4	67.1	23
Scottsdale, AZ	60	4968	156.5	34.9	72.5	28
Phoenix, AZ	93	9075	161.9	38.6	73.4	32
Las Virgenes MWD	91	16306	213.2	36.0	48.1	48

Water Use With and Without a Swimming Pool

The best way to compare outdoor water use in homes with and without swimming pools and automatic sprinkler systems is to examine the average annual application rate of water in these groups. The application rate is simply the total outdoor water use (from annual billing data) divided by the irrigable area. By comparing application rate rather than annual outdoor use, the impact of varying landscape sizes is controlled.

Table 2 shows a comparison of the application rate at homes from the REUWS with and without swimming pools. There were also 83 homes that did not respond to the question. It is suspected that most of these non-respondent households do not have swimming pools. Households with swimming pools used substantially more water outdoor that houses without swimming pools. Households with pools applied 35.3 inches of water compared to 20.5 inches for households without pools – a 72.2% difference.

Table 2: Application rate of homes with and without swimming pools

House Category	Count	Mean Application Rate (inches)	Std. Deviation	Std. Error
No Swimming Pool	852	20.5	24.6	0.84
Swimming Pool	194	35.3	28.9	2.07
Non-Response	83	19.9	26.1	2.87

Swimming Pools vs. Automatic Sprinkler Systems

An important consideration for this research is the impact of automatic sprinkler systems on water use. This information is also available from the REUWS database.[2] How do automatic sprinkler systems impact water use compared to or along with swimming pools. Results of this analysis are shown in Table 3.

Table 3: Application rate in homes with and without pools and auto sprinklers

Swimming Pool?	Auto Sprinkler System?	Count	Mean Application Rate (inches)	Std. Deviation	Std. Error
No	No	503	14.0	17.3	0.77
Yes	No	63	19.6	19.1	2.40
NR	No	52	15.8	19.6	2.72
No	Yes	349	29.9	30.1	1.61
Yes	Yes	131	42.8	29.8	2.60
NR	Yes	31	26.8	33.6	6.04

[2] Homes with an automatic irrigation system in either their front or backyard (or both) were included in this category.

In this analysis it can be seen that automatic sprinkler systems increase outdoor water use more substantially than swimming pools. The 503 homes without a swimming pool or an automatic sprinkler applied an average of 14.0 inches of water per year. The 63 homes with a swimming pool, but not an automatic sprinkler applied 19.6 inches of water per year. The 349 homes without a swimming pool, but with an automatic sprinkler applied 29.9 inches of water per year. From this analysis, adding a swimming pool increases outdoor use by 40%, but adding an automatic sprinkler system increases outdoor use by 114%.

Climate Zones and Water Use

To account for seasonal variations, this analysis was repeated after first separating houses in high irrigation climates and low irrigation climates. A total of 774 homes from Boulder, Denver, San Diego, Phoenix, Tempe, Scottsdale, Walnut Valley, Las Virgenes, and Lompoc were included in the high irrigation group. A total of 355 homes from Eugene, Seattle, Tampa, Cambridge, and Waterloo were included in the low irrigation group. There were 160 homes (20.7%) with swimming pools in the high irrigation group and 34 homes (9.6%) in the low irrigation group.

The analysis that compares the impact of swimming pools and automatic sprinkler systems was repeated for both of these groups of homes. Results from the high irrigation group are shown in Table 4 and from the low irrigation group are shown in Table 5.

Table 4: High irrigation group - application rate in homes with and without pools and auto sprinklers

Swimming Pool?	**Auto Sprinkler System?**	**Count**	**Mean Application Rate** (inches)	**Std. Deviation**	**Std. Error**
No	No	259	20.8	19.4	1.21
Yes	No	44	26.0	19.2	2.89
NR	No	30	22.7	23.1	4.21
No	Yes	298	33.4	30.8	1.78
Yes	Yes	116	45.4	29.4	2.73
NR	Yes	27	29.6	35.2	6.77

In the high irrigation group (Table 4), homes without a swimming pool or automatic irrigation system used an average of 20.8 inches of water per year. The addition of a swimming pool increased demand by 25% to 26.0 inches of water per year. The addition of an automatic sprinkler system increased demand 60.6% to 33.4 inches of water per year. Homes with both a swimming pool and an automatic sprinkler system used by far the most water – 45.4 inches per year.

In the low irrigation group (Table 5), homes without a swimming pool or automatic irrigation system used an average of 6.7 inches of water per year. In the 19 homes with a swimming pool but no auto sprinkler system, the average annual demand was 25% lower at 5.0 inches per year. The 51 homes that had an auto sprinkler system but no swimming pool used an average of 9.2 inches per year. The 15 homes with both a swimming pool and auto sprinkler used the most

water by far – an average of 22.5 inches – 236% more than homes without a pool or auto sprinkler system.

Table 5: Low irrigation group - application rate in homes with and without pools and auto sprinklers

Swimming Pool?	Auto Sprinkler System?	Count	Mean Application Rate (inches)	Std. Deviation	Std. Error
No	No	244	6.7	10.6	0.68
Yes	No	19	5.0	7.0	1.60
NR	No	22	6.4	6.1	1.30
No	Yes	51	9.2	12.4	1.73
Yes	Yes	15	22.5	25.6	6.62
NR	Yes	4	8.3	7.7	3.86

Theoretical Discussion & Estimates of Outdoor Water Use

To dive a little deeper into the general trends discussed above, one can explore possible means for estimating outdoor water end uses for both swimming pools and irrigated landscapes. The approximations presented below are for example and comparative purposes to gain additional insights into outdoor water use patterns for the water conservation planner.

Estimation of Water Use for Swimming Pools

A common sense approach to approximating water use from swimming pools considers the following:

- Summer peak evaporation
- Annual evaporation
- Splashing
- Maintenance
- Leaks
- Refilling

Sample Calculations for Pool Water Use in Higher Irrigation Group(Sacramento, California)

Estimating swimming pool water use in Sacramento, California was performed using the peak summer evaporation rate of 13 inches of water per month and annual evaporation rate of 50 inches per year. (University of California, Davis (IPM Weather Database) http://www.ipm.ucdavis.edu/WEATHER/AVERAGES/davis.html, 2000) Annual evaporation from a swimming pool with total evaporative surface area of 800 ft^2 (dimension of 20 feet by 40 feet) was estimated as 25,000 gallons per year and 6,500 gallons per peak summer month in July. Splashing is assumed to account for 12-18 inches per year, approximately 5 inches per 3-summer month usage period, or 7,500 gallons per year (Nelson, 2000). Maintenance is estimated at 20 to

40 gallons per month or 360 gallons average per year. Leakage is negligible and refilling assumed to occur once every 7-10 years was also neglected (Sudduth, February 2000).[3] Total annual swimming pool water use was estimated at 33,000 gallons per year or approximately 10,000 gallons per summer month in Sacramento, California.

Sample Calculations for Pool Water Use in Lower Irrigation Group (Tampa, Florida)

Identical methodology as used above was applied to estimate total annual swimming pool water use in Tampa, Florida, at 44,600 gallons per year or approximately 6,800 gallons per peak month. This estimate was determined given the peak evaporation rate in May of 8.5 inches of water per month and annual evaporation rate of 73.68 inches per 30-year annual average for the South Central Florida area. (Florida Climate Center, Tallahassee, Florida, 2001) Annual evaporation from a swimming pool with total evaporative surface area of 800 ft^2 was estimated as 36,740 gallons per year and 4,240 gallons per peak summer month.

Reducing Evaporation with Swimming Pool Covers

Modeled results for the Sacramento, California and Tampa, Florida locations indicate that evaporation can be reduces substantially if a swimming pool cover is use (US DOE, 2001). To analyze the benefits of swimming pool covers the United States Department of Energy developed a software package called "Energy Smart Pools". The DOE Institutional Conservation Program (ICP), RSPEC (Reduce Swimming Pool Energy Costs) is no longer funded, but the materials produced under the program are still available on their web site: http://www.eren.doe.gov/rspec/

Pool water consumption in Sacramento, California was estimated at 60,474 gallons per year assuming 15% wind speed and 30% shading during daylight hours. When using a manually operated pool cover, water evaporation savings of 17,089 gallons – a 28.2 percent reduction – were estimated. Holding all parameters in the model constant other than geographic location, water consumption in Tampa, Florida was estimated at 41,286 gallons per year. Savings due to reduced evaporation from a pool cover were approximated at 12,252 gallons per year, or 29.6 percent. The water consumption estimates are higher than previously calculated due to the addition of weather factors such as wind and shading.

Estimated Lawn Water Requirements in Warm Climate Group (Sacramento, California)

Both a "rule of thumb" basic method and a more involved method to estimate the annual water requirement for an irrigated landscape area are available on WaterWiser under Residential Water Use, Outdoor Use (Nelson, 1998).

The basic methodology was used to estimate the applied water requirement (AWR) for an irrigated lawn area of 800 square feet to be 27,200 gallons/year for warm season grasses and 39,000 gallons per year for cool season grasses under climatic conditions for Sacramento, California. This assumes a relatively high 50% irrigation system efficiency and 39.0 inches of

[3] These assumptions are valid for Sacramento, but it should be noted that outdoor pools in regions that freeze in the winter generally must be drained.

water per year climatic factor. Peak summer water requirements were estimated at 6,000 gallons per month for warm season grasses and 8,500 gallons per month for cool season grasses with an 8.5 inches per month for climatic factor.

Estimated Lawn Water Requirements in Cool Climate Group (Tampa, Florida)

To compare with a geographic area of higher humidity and less irrigation requirements, the basic methodology was again used to estimate the AWR for an irrigated landscape in the vicinity of Tampa, Florida. Using a lawn area of 800 square feet to be 25,400 gallons/year for warm season grasses and 36,300 gallons per year for cool season grasses under relative cooler climatic conditions. This assumes a relatively high 50% irrigation system efficiency and 36.4 inches of water per year climatic factor.

Comparison of Water Use Estimates

Using calculations for evaporative losses under Sacramento area climatic conditions, it appears that swimming pools and irrigated lawn area use approximately the same amount of water on a square footage basis. If a homeowner were to remove turf grass and install a swimming pool, the water use for each square foot of grass replaced by pool water surface area would be approximately the same. This is primarily due to the direct evaporation from the pool's surface compared to the evapotranspiration of the grass and lack of efficiency in the lawn irrigation system (typically between only 30-50% efficient). A comparison of the annual water requirements on a square footage basis is presented in Table 6.

Table 6: Comparison of Estimated Lawn & Swimming Pool Annual Water Requirements

Type of Use	**Estimated Annual Water Use**			
	Sacramento, California		Tampa, Florida	
	gal/ft^2	inches applied	gal/ft^2	inches applied
Swimming Pool	41.3	66.3	55.8	89.5
Irrigated Lawn Area – Cool Season Grasses	48.8	78.3	45.4	72.8
Irrigated Lawn Area – Warm Season Grasses	34.0	54.5	31.8	51.0

However, if comparison of swimming pool water use to irrigated lawn is based on landscape design of 1,500 square feet of irrigated lawn compared to 800 square feet of pool surface area and 600 square feet of decking, then irrigated lawn would have higher water use. Under this scenario, a homeowner's backyard with irrigated lawn can use 1.0 to more than 1.5 times as much water particularly if using an automatic timed irrigation system. When a pool cover is used, evaporation can be reduced by approximately 30%. Then the comparative difference in irrigated lawn water use is closer to 2.0 to 3.0 times more when combined with landscape design considerations.

Conclusions

The water conscious behavior of the homeowner is the principal factor in determining if the swimming pool or the irrigated lawn uses more water. A comparison of water use of swimming pools and irrigated landscape area was analyzed from information gathered from 1,129 homes in 14 locations in the United States and Canada as part of the REUWS. It was found that for the 194 homes with swimming pools, the addition of a swimming pool increased demand between 22 to 25 percent. The addition of an automatic sprinkler system increased demand between 54.9 to 60.6 percent. Homes with both a swimming pool and an automatic sprinkler system used the most water. Water use estimates for a typical home in Sacramento, California, show that swimming pools and irrigated lawn area use approximately the same amount of water on a square footage basis. In other words, if a homeowner in this region were to remove turf grass and install a swimming pool, the water use for each square foot of grass replaced by pool water surface area would be approximately the same.

References

American Water Works Association, WaterWiser http://www.waterwiser.org, February 2000

Mayer, P.W., W.B. DeOreo, E.M. Opitz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. 1999. *Residential End Uses of Water*. Denver, Colo.: AWWA and AWWARF.

Mellezi, Margi, Pool & Spa News, Personal Communication, March 7, 2001.

Nelson, J.O. 1998. Residential water use, outdoor. AWWA WaterWiser.org http://www.waterwiser.org. Accessed April 2001.

Nelson, John, Water Resources Management, Personal Communication, February 9, 2000.

Sudduth, Daniel, Swimming Pool Pump Manufacturer Representative & Repairman, Personal Communication, February 9, 2000.

United States Department of Energy. 2001. Institutional Conservation Program Reduce Swimming Pool Energy Costs. http://www.eren.doe.gov/rspec/

University of California, Davis (IPM Weather Database)
http://www.ipm.ucdavis.edu/WEATHER/AVERAGES/davis.html, February 2000

APPENDIX A

Recommendations for Swimming Pool and Irrigated Landscape Water Use

Some general guidelines for water savings associated with swimming pools include:

- Channel splashed-out pool water into landscaping.

- Lower pool water if necessary to reduce excessive splashing.
- Use a pool cover to reduce evaporation when pool is not being used. Also helps keep pool clean, which reduces frequency of cleaning pool filters, and need to add chemicals.
- If purchasing a diatomaceous earth (DE) or sand pool filter, include a water recovery system that saves 20-50 gallons of water by cleaning and recycling backwash water to the pool.
- If cleaning a cartridge-type pool filter, use a hose sprayer to clean cartridges and do not leave the hose running continuously.

Some general guidelines taken from the WaterWiser web page related to lawn irrigation includes:

- As much as 30% of water can be lost to evaporation by watering the lawn during midday.
- Homes with in-ground sprinkler systems use 35% more water outdoors than those who do not have an in-ground system. One reason may be that system controllers are not adjusted according to seasonal irrigation needs.
- Water before 8 A.M. or after 6 P.M. and avoid watering on windy days.
- Water in several short sessions rather than one long one. For example, three ten minute sessions spaced 30 minutes to an hour apart will allow your lawn to better absorb moisture than one straight 30 minute session.
- Only water when your lawn is thirsty. Over watering promotes shallow root growth making your lawn less hardy. (To determine if your lawn needs be watered, simply walk across the grass. If you leave footprints, it's time to water.)
- Install moisture sensors in each irrigation zone (sunny, shady, etc.) to better determine irrigation needs.
- Check sprinkler system valves periodically for leaks and keep the heads in good repair.
- Adjust the timer on automatic sprinklers according to seasonal water demands and weather conditions.
- Install a rain shut-off device on automatic sprinklers to eliminate unneeded applications.
- Make sure your sprinkler is placed so it only waters the lawn, not the pavement.
- Avoid sprinklers that spray a fine mist, which increases evaporation.

Drip irrigation

- Install a drip irrigation system for watering gardens, trees and shrubs. Drip irrigation provides a slow, steady trickle of water to plants at their roots through a network of hidden pipes and hoses. The systems are regulated by a controller that can be adjusted for different levels of watering according to the needs of the plants. Drip irrigation systems reduce overwatering, inefficient watering, weed growth, and the time and labor involved in hand watering.

Web site Resources

Although homeowners should contact their water agency to check on water retrofit kits and water audit programs being offered at no or minimal cost, a web site for water efficiency products is: http://store.yahoo.com/cottonswow/watefprod.html

For direct web links to water conservation tips for homeowners, please review the following web sites.

http://www.monolake.org/socalwater/wctips.htm

http://www.getwise.org/wwise/index.html

http://www.americanwater.com/49ways.htm

http://www.r5.pswfs.gov/inyo/vvc/mono/wtrislif.htm

http://www.waterwiser.org/

Some additional water conservation related web sites that may be useful links include:

Water Education Foundation
http://www.water-ed.org/

US Water News
http://www.uswaternews.com/homepage.html

US Department of Energy
http://www.eren.doe.gov/

Center of Excellence for Sustainable Development
http://www.sustainable.doe.gov/efficiency/weinfo.htm

California Urban Water Conservation Council
http://www.cuwcc.org

Aquacraft, Inc. Water Engineering and Management
www.aquacraft.com