ESTIMATING THE POTENTIAL FOR WATER CONSERVATION IN LONG-RANGE WATER SUPPLY PLANNING

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Introduction

The Metropolitan Water District of Southern California (Metropolitan) is a regional water agency created by the California state legislature to bring imported water to the coastal plain of Southern California. Currently, Metropolitan supplies about half of the water used by over 15 million people. The sources of the imported water supplied by Metropolitan are the Colorado River Aqueduct, owned and operated by Metropolitan, and the State Water Project, which is operated by the California Department of Water Resources. The Metropolitan service area is a diverse and rapidly growing region. Annual population growth has been around 300,000 a year. This large growth coupled with a fourth year of drought is translating into increases in water demand. Water supplies, on the other hand, are becoming increasingly scarce. Increased groundwater contamination, legislation aimed at reducing the City of Los Angeles' major source of water from the Mono Lake/Owens Valley, increased pressure to reduce outflows from the San Francisco Bay/San Joaquin Delta (a major source of Metropolitan's supplies), and a reduced entitlement to the Colorado River (due to Arizona's ability to take more of its entitlement) all relate to reduced reliability in supplies for the Southern California region.

Rapid growth and declining firm water supplies make it essential to integrate water supply planning and water management. Metropolitan's water management strategies include water transfers and exchanges, water storage programs, rebate programs encouraging the use of reclaimed water, wholesale water rates which encourage wise use of Metropolitan's water, and aggressive water conservation.

Problem Statement

However, one of the principle uncertainties in long-range supply planning concerns the estimation of water conservation savings. Theory states that water conservation savings should be estimated by use of the following formula:

$$S_{i,j} = Q_j * R_{ij} * C_{ij}$$

Where: $S_{i,j}$ = conservation savings (in acre-feet per year or mgd) for conservation measure., affecting water use sector ; Q_j = base (without conservation) water use in sector ; R_{ij} = percent reduction from conservation measure affecting sector and C_{ij} = coverage associated with the conservation measure in sector j. However, in practice this can be a fairly complicated procedure. To obtain the percent reduction (R) requires extensive study of each conservation measure for each sector of water use. Similarly, estimates of the coverage factor (C) require extensive knowledge of service areas. Often advanced statistical procedures are used to estimate (R) and (C). Metropolitan is financing a number of local water conservation programs under its Water Conservation Credits program, in which Metropolitan pays up to $154 per acre-foot for reliable and verifiable savings. Metropolitan is involved in state-of-the-art statistical analyses to estimate the actual savings from each program. Once these savings parameters are estimated, they are applied to the projected unrestricted (without conservation) water demand to obtain the potential for long-range water conservation. To accurately estimate these long-range savings, the demands must be disaggregated by user-class or sector (such as residential, commercial, and industrial) and by season (such as summer, winter demands and indoor, outdoor demands). The purpose of this paper is to summarize Metropolitan's work in better estimating the disaggregate base water demand; this allows for assessment of the potential for long-range water conservation.

Water Demand Forecasting and Estimating Seasonal Components

To forecast long-range water demands, Metropolitan uses the MWD-MAIN water demand model, a regional version of the IWR-MAIN forecasting model. MWD-MAIN projects water demand by residential, commercial, industrial, and public users and disaggregates these demands into winter and summer use. The model takes into account changes in weather, demographics (population, housing, and employment) and economics (income and price of water) when forecasting water demand. However, all models need to be extensively verified. Metropolitan has conducted a number of studies in order to verify and calibrate its forecasting model.

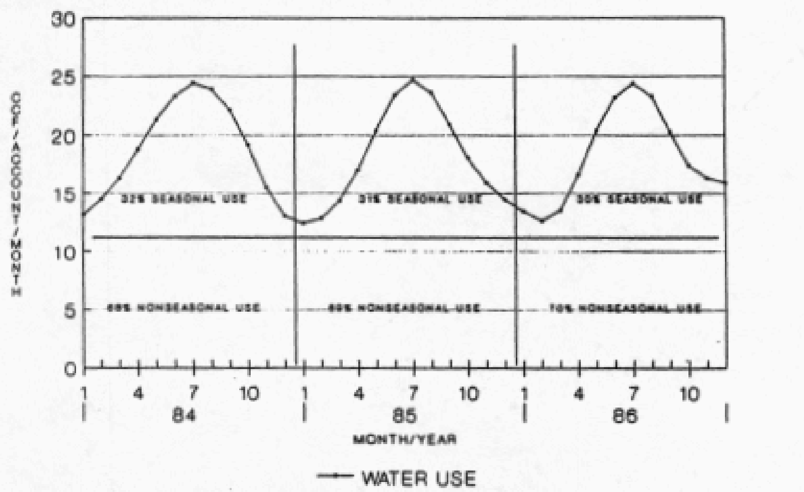
The first study relates to estimating the seasonal components of urban water use in southern California. The results of the study allowed Metropolitan to better estimate how much water was used indoor, outdoor, peak season and nonpeak season. It also allowed Metropolitan to estimate more detailed breakdowns of water use (such as how much residential indoor use is for showers/ baths). This study was critical because assuming incorrect breakdowns of urban water use can lead to significant errors in estimates of conservation potential, even if the estimates of percent reduction are accurate. For example, if you were to estimate future savings from a residential outdoor conservation measure you would need essentially three pieces of information: (1) projected residential water demand; (2) an estimate of percent reduction from implementing the conservation measure; and (3) an estimate of how much residential water is used outdoors. If projected residential water demand is 500 million gallons per day (mgd), and empirical data showed that residential outdoor water use could be reduced by 10 percent, and you assumed that outdoor residential use was 50 percent, then savings would be:

$$S = 500 \text{ mgd} * 0.50 * 0.10 = 25 \text{ mgd}$$

But, if outdoor water use were actually 30 percent, then the correct savings estimate would only be 15 mgd, 40 percent less than the previous estimate. In order to properly estimate seasonal variations in water use, monthly water use records by customer class must be used. The first step is to estimate the seasonal and nonseasonal components of water use for each of the major classes (residential, commercial, etc.) of water use. This was done by examining the monthly water use over a period of time (3 to 8 years). Using the "minimum-month" method where the minimum monthly use for each year is used to establish a base use, the seasonal breakdown could be derived. Figure 1 presents this procedure for single-family residential water use in the City of Los Angeles. In 1984 the seasonal peak period accounted for 32 percent of annual use. In 1986 the seasonal use dropped to 30 percent; In its simplest form the percent seasonal use could approximate the percent of water used outdoors. However, because winter irrigation is practiced in Southern California, this assumption could not be used. Adjustments were made based on looking at the coldest, wettest month on record to establish an indoor water use base. It was assumed that during the coldest, wettest period, no significant outdoor water use occurred. This assumption is consistent with daily flow observations which show sharp declines in use during winter months.

For the commercial and industrial sectors, outdoor water used for cooling was estimated by correlating observed electrical consumption for water-cooled air conditioning. This amount of water use for cooling was then subtracted by the total estimated outdoor use (from seasonal records) to obtain the amount of water used for

FIGURE 1.
SINGLE FAMILY RESIDENTIAL WATER USE FOR LOS ANGELES
(Minimum Month Method)



irrigation and dust control. To estimate more detailed water use components for the residential sector (such as showers, cooking, etc.), data from the literature and from home water and electrical surveys were used in conjunction with the estimates of indoor water use. Table 1 presents the results from the Metropolitan seasonal water use survey.

Commercial and Industrial Water Use Survey

The other major study concerned commercial and industrial water use. Data on water use (for FY 1987/88), employment, standard industrial classification (SIC) codes, and location were obtained for 1,405 commercial and 1,732 manufacturing firms. The purpose of this survey was to obtain data on water-use rates (such as gallons per employee) which could be used by Metropolitan to forecast commercial and industrial waterdemands. Knowledge of water-use rates can increase the precision of forecasting future levels of nonresidential water use as a function of economic growth, and also serve as a basis for assessing potential levels of water conservation.

The survey data was statistically analyzed in order to classify and characterize nonresidential users and estimate water-use rates. Typically, when analyzing nonresidential water use one finds that a small number of commercial and manufacturing establishments contributes a substantial amount to the total water use and displays the greatest amount of variability in water-use rates. This is evident in observing data from Burbank, California. According to this data, only 10 percent of the nonresidential accounts represented about 80 percent of the total nonresidential water use. This is an important finding for forecasting and conservation planning. Identification of the top nonresidential water users will give the most important information on water-use rates which could be used to project future water demands and target water conservation.

The Metropolitan survey, in which establishments were grouped into two- and three-digit standard industrial classification (SIC) codes, revealed that schools, hospitals, hotels and motels, recreational facilities, colleges and universities, nursing homes, and restaurants account for about 65 percent of total commercial water use. The survey also revealed that electronic industries, aircraft, petroleum refining, preserved fruits, beverages, paper mills, and guided missiles account for over 50 percent of total manufacturing water use. Table 2 presents some descriptive statistics for the top commercial and industrial categories.

Mean establishment water use in the commercial user category is 16,188 gallons per day and mean establishment employment is 133 employees. For the manufacturing category, mean establishment water use is 34,353 gallons per day and mean establishment employment is 292. The average water-use rate, measured as gallons per employee per day (ged), is estimated to be 122 ged for commercial users and 118 ged for manufacturing users.

In order to better estimate water-use rates for forecasting purposes, regression analysis was performed. The data was analyzed to identify SIC categories with distinctly different relationships between water use and employment. The advantage of regression analysis is that the relationship between water use and employment within SIC category can be statistically evaluated. In addition, a binary variable was introduced to test the geographical and/or climatic variability in the estimated coefficients. Two major geographical zones were created to represent the differences in climate in Southern California. The analysis revealed that there are several commercial categories with significantly higher water use-rates (geds) in the hot, more arid climates of Southern California. This relationship was also tested for the industrial categories, but no significant differences in coefficients were detected. This is probably due to water use in the manufacturing sector being more a function of production, rather than climate induced variability. Figure 2 presents selected commercial and industrial water use-rates and the standard error associated with the regression estimate. The large variance in use-rates among many of the categories is expected. Commercial categories which have large standard errors include power laundries and amusement/recreation establishments. Water use in these categories vary greatly from one establishment to another. Categories in the industrial sector experiencing large variance in use-rates include preserved fruits, dairy, and beverages.

TABLE 1.

	Percent of Total Annual Water Use Components Public *		Residential	Commercial	Industrial
Indoor Use	69.6		71.3	79.5	49.5
toilets			25.1.	–	– –
showers/baths			20.2	–	– –
washing machines			13.2	–	– –
faucets			9.0	–	– –
dishwashers			2.1	–	– –
Outdoor Use	30.4		28.7	20.5	50.5
irrigation			27.2	21.8	12.3
	50.5	cooling (AC)		0.26	.98
	.2		–	other**	3.0 –
	–		–		

Statics: Metropolizan Report, "Seasonal Components *of* Urban Water Use in Southern California," 1990.
• Includes public and other uses such is irrigation of perks.
** Includes uses for swimming pools, car wishing, etc.
– Not estimated.

In order to target commercial and industrial users for certain conservation programs, the results from this study could be used. The introduction of the location variable in the model (see Figure 1) indicated that certain commercial categories exhibited significantly higher water use-rates in the hot and arid climate zone. These categories include: (1) hotels/motels; (2) schools/colleges; (3) day care services; and (4) hospitals. This suggests that these categories have significant outdoor water use components and therefore, would make good targets for commercial landscaping programs. Also, the distribution of water use from the survey could also be used to target water conservation. For example, SIC categories which represented a small proportion of total commercial or manufacturing water use, may not be feasible conservation targets. And finally, the variance of water use-rates could be used as a basis to develop the conservation program. A general conservation program could be set up for those establishments with little variance, but more site-specific programs might be needed if the category exhibited a larger variance.

Conclusion

Knowledge of urban water use characteristics, seasonal breakdowns, and water demand projections axe essential elements of assessing overall water conservation potential. Without this understanding, misapplied savings reductions from water conservation programs can lead to significant errors in conservation policy and facility planning. Metropolitan has, been successful in using these studies in better estimating the base water demand and its components for forecasting and assessing water conservation potential. The results have been incorporated into Metropolitan's facility planning process, support for state-wide water rights hearings, and evaluation of "best management programs" for water conservation.

TABLE 2.

Category	Mean Estab. Employment	Mean Estab. Water Use (gpd)	Average Water Use Per Employee (ged)
COMMERCIAL CATEGORIES			
Schools	111.0	21,732	195.7
Hospitals	920.8	66,054	71.7
Hotels/motels	199.1	37,035	186.0
Amusement/Rec.	440.0	198,812	451.8
Colleges/Univ.	920.3	126,305	137.2
Nursing Homes	102.9	39,140	380.6
Restaurants	32.4	6,621	204.2
INDUSTRIAL CATEGORIES			
Electronics	179.6	34,506	158.9
Aircraft	1428.9	77,098	54.0
Petroleum Ref.	377.6	704,240	1,865.2
Preserved Fruits	238.5	157,435	660.0
Beverages	281.6	205,939	731.3
Paper Mills	383.0	608,832	1,589.6
Guided Missiles	3934.1	289,543	73.6

Source: Metropolitan Report, Commercial and Industrial Water Use in Southern California, 1990.

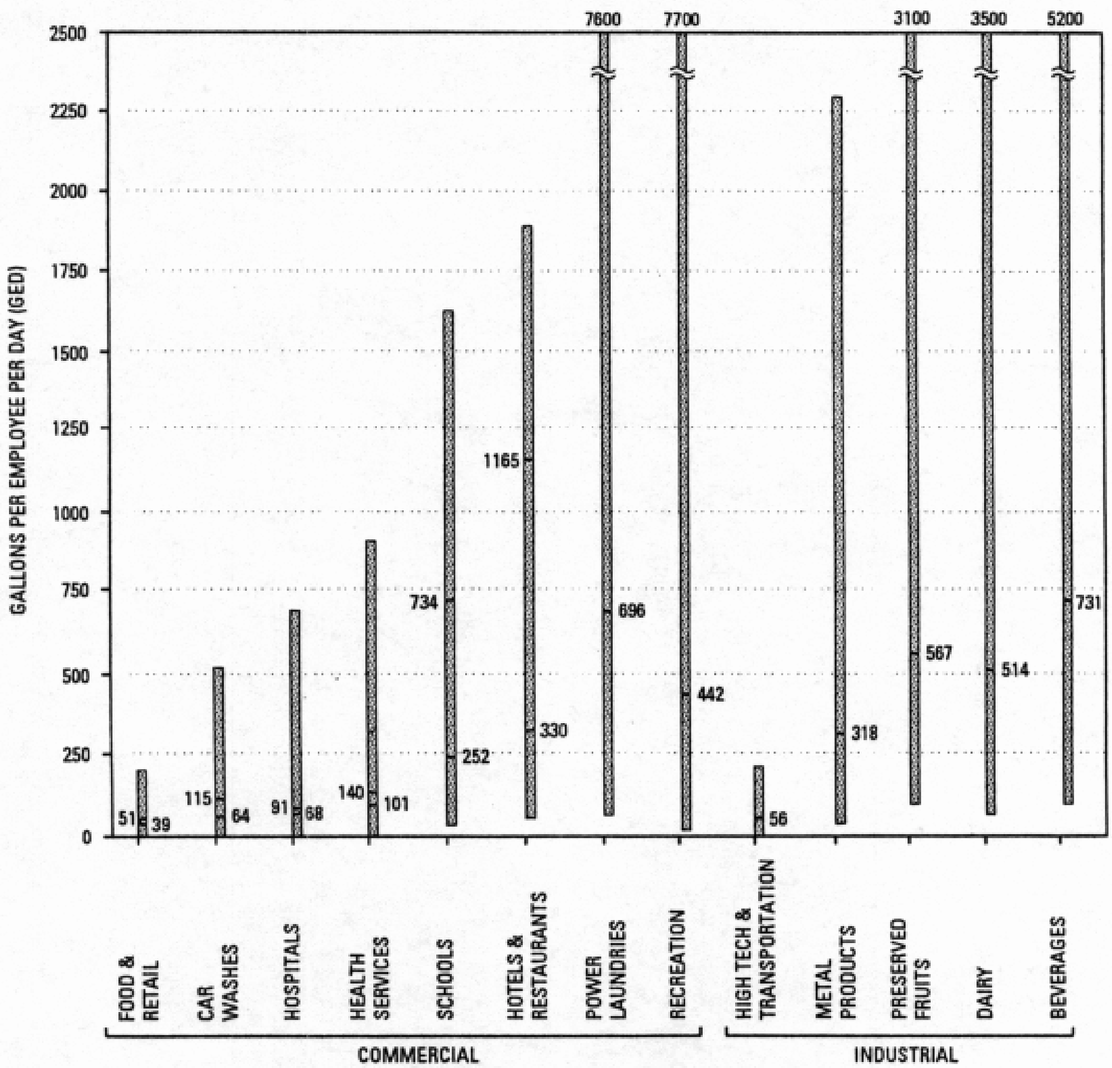
References

Rodrigo, D., Home, F. W., and Dziegielewski, B. 1990. Commercial and Industrial Water Use in Southern California and the Potential for Water Conservation. Paper presented at CONSERV'90 water supply conference, August, 1990.

Metropolitan Water District. 1990. Seasonal Components of Urban Water Use in Southern California.

Metropolitan Water District. 1990. Commercial and Industrial Water Use in Southern California.

FIGURE 2.
STANDARD ERROR OF THE COEFFICIENT FOR SELECTED COMMERCIAL AND INDUSTRIAL WATER USE RATES



• THE LENGTH OF THE BARS INDICATE THE STANDARD ERROR OF THE COEFFICIENT (OR GED).
• RIGHT HAND LOWER NUMBERS REPRESENT THE ESTIMATED AVERAGE GED.
• LEFT HAND UPPER NUMBERS REPRESENT THE ESTIMATED GED FOR HOT, ARID CLIMATE.