

# Predominant Commercial Sectors in Florida & their Water Use Patterns

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Commercial water use comprised 20 percent of public water supply withdrawals for the state of Florida in 2005 (Marella 2009). These estimates of water use were based on county-wide employment figures from the U.S. Census Bureau multiplied by water use per employee coefficients. These coefficients come from a nationwide survey of 3,448 commercial and institutional establishments conducted in the 1980s and surveys of manufacturers by the U.S. Census Bureau and the California Department of Water Resources (Dziegielewski and Boland, 1989).

Employment estimates of commercial activity can be used for a top-down estimate of water use, but in order to evaluate the water use patterns of individual sectors, a bottom-up method is needed. This article presents a bottom-up methodology to estimate commercial water use based on parcel-level land use and water billing databases.

This same methodology is being used to estimate water use for the other major public water supply sectors: single- and multi-family residential, industrial, institutional, and unaccounted-for water use. The end result has been incorporated into the *Conserve Florida Water Clearinghouse EZ Guide 2.0*, a water planning tool to estimate water use and evaluate conservation best management practices ([www.conservefloridawater.org](http://www.conservefloridawater.org)).

## Parcel-Database Methodology

The Florida Department of Revenue (FDOR) maintains a database of legal, physical, and economic property-based information for every parcel of land in the state of Florida. This database is available free of charge from the FDOR FTP Web site (<ftp://sdrftp03.dor.state.fl.us/>) and is audited and updated annually. Parcels are partitioned based on their

land use into 100 sectors using two-digit FDOR codes. FDOR codes are standardized across the state of Florida, providing consistent definitions of terms. The parcel information is provided to the FDOR by the state's 67 county property appraisers. Florida may be the only state to make such data available to the public.

The FDOR database provides a unique opportunity to analyze land use for the entire state of Florida at the parcel level. This analysis provides useful information about development patterns and trends that can be used to better evaluate current and future water use, given that land and water use are intrinsically linked. The attributes of interest are presented in Table 1.

The effective area of a commercial parcel is slightly larger than its heated area. This relationship has been quantified by linking the FDOR database with similar Florida county property appraiser databases that contain information on heated area for each developed parcel (Morales et al. 2009).

Estimates of water use typically include a rate of water use and a measure of its size. The rate of water use, or water use activity coefficient, is the total water use by all customers standardized by the total measure of its size. Total water use over a specific number of sectors is calculated using Equation 1.

$$Q = \sum_{k=1}^n (\alpha_k * X_k) \quad (1)$$

Where:

Q = water use for n sectors

$\alpha_k$  = water use coefficient of sector k

Xk = size of sector k

n = number of sectors

In this study, parcel-level land use characteristics from the FDOR database were linked

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with historic water billing data for 2,214 commercial parcels—1,177 at Hillsborough County Water Resource Services (HCWRS) and 1,037 at Gainesville Regional Utilities (GRU)—to develop water use coefficients normalized by heated building area. HCWRS provided four complete years of water billing from January 2003 through December 2006, while GRU supplied two complete years of water billing from January 2008 to December 2009.

The average water use coefficients were developed by summing the average monthly water use of all parcels within a given sector and dividing by their total heated area, and the average number of days in the months billed. This method of calculating the coefficients provides a weighted average which compensates for the skewness often found in the distribution of commercial water users.

Peak and base water use coefficients were also developed by correspondingly summing the average May and average minimum monthly water use of all parcels in a sector, and dividing by the total heated area of the sector. The average May usage is the peak month use for most water utilities in Florida, so it is appropriate to use May as the peak water use of interest. Unlike the peak

coefficient, where the overall system peak is of concern, the base coefficient provides a measure of the seasonality of a given sector and is dependent on that given sector's own time series. Only parcels reporting monthly water use through the entirety of the study period were included in the analysis.

The measure of size used to

Table 1. Attributes of interest from the Florida Department of Revenue database.

Field	Description
County Number	A unique identifier assigned to each of Florida's 67 counties
Parcel Identification Number	A unique number assigned to each parcel in the state of Florida
FDOR Land Use Code	Provides standardized classification for 100 FDOR land uses
Effective Year Built	Year built of last major improvement on a parcel
Effective Area	Building area that is strongly correlated to the heated area of a structure

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normalize the water use data and develop the activity coefficients is heated area that is available from the Hillsborough County and Alachua County property appraisers. To use these water use coefficients directly with the FDOR state-wide database requires converting effective building area to heated building area.

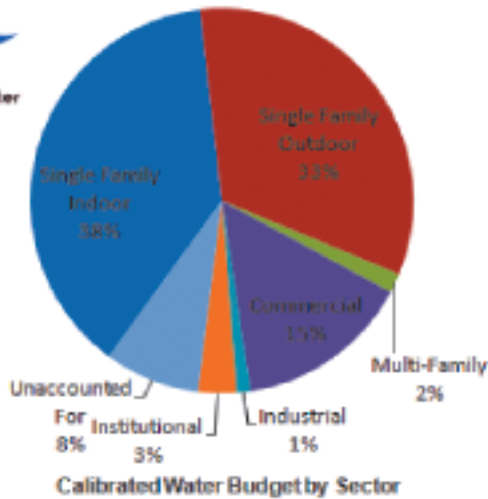
The correlation coefficient between heated and effective area for all commercial parcels in HCWRS and GRU exceeded 0.99. The coefficients to convert from effective area (EA) to heated area (HA) are presented under the sub-heading of HA/EA.

The developed water use coefficients for the available 24 of the 28 commercial FDOR

sector categories are shown in Table 2. This table includes the sample sizes from which the coefficients were derived; the average effective year built and heated building areas; and percent seasonal, a measure of the significance of seasonal water use. This measure is obtained by subtracting the average water use coefficient from the base coefficient to arrive at the

Table 2. Water use coefficients and sector statistics based on a sample of 2,214 commercial parcels from Hillsborough County Water Resources Services and Gainesville Regional Utilities.

FDOR	Description	Sample Size	Average Effective Year Built	Average Heated Building Area (sf)	HA/EA	Weighted Water Use Coef. (gallons/heated square foot/day)				% Seasonal	% Heated Area in Sector	% Avg. Water Use in Sector
						Avg.	Base	Seasonal	May Peak			
11	Stores, One-Story	289	1985	7644	0.93	0.098	0.093	0.004	0.104	4.2%	7.1%	5.2%
12	Mixed Use	143	1976	11483	0.92	0.092	0.089	0.003	0.095	3.4%	5.3%	3.6%
13	Department Stores	19	1994	128183	0.89	0.062	0.054	0.008	0.063	12.2%	7.8%	3.6%
14	Supermarkets / Convenience Stores	123	1991	5795	0.93	0.270	0.238	0.032	0.291	11.8%	2.3%	4.6%
15	Regional Malls	3	1996	856391	0.93	0.073	0.065	0.008	0.073	10.6%	8.2%	4.5%
16	Community Shopping Centers	239	1988	39269	0.95	0.099	0.098	0.001	0.101	0.9%	30.0%	22.3%
17	Office, One-Story	384	1984	5983	0.96	0.129	0.117	0.012	0.138	9.0%	7.4%	7.1%
18	Office, Multi-Story	73	1987	30576	0.97	0.069	0.065	0.005	0.077	6.7%	7.1%	3.7%
19	Medical Offices	264	1990	7543	0.97	0.158	0.144	0.014	0.168	8.7%	6.4%	7.6%
20	Transit Terminals	6	1982	9257	0.97	0.339	0.254	0.085	0.349	25.0%	0.2%	0.5%
21	Restaurants	120	1988	4902	0.96	0.741	0.711	0.030	0.757	4.0%	1.9%	10.5%
22	Fast-Food Restaurants	105	1994	2910	0.96	0.657	0.636	0.021	0.680	3.3%	1.0%	4.8%
23	Financial Institutions	98	1992	5108	0.91	0.373	0.349	0.024	0.397	6.6%	1.6%	4.5%
24	Insurance Offices	11	1988	10736	0.94	0.073	0.060	0.012	0.086	17.0%	0.4%	0.2%
25	Service Shops	49	1981	5393	0.80	0.176	0.159	0.017	0.187	9.9%	0.8%	1.1%
26	Service Stations	5	1986	1829	0.71	0.170	0.145	0.025	0.213	14.7%	0.0%	0.0%
27	Auto Sales / Repair	174	1984	8009	0.86	0.124	0.110	0.014	0.126	11.3%	4.5%	4.1%
29	Wholesale Outlets	5	1972	23700	0.76	0.025	0.021	0.004	0.030	17.7%	0.4%	0.1%
30	Florists / Greenhouses	2	1966	3376	0.92	0.216	0.144	0.072	0.250	33.5%	0.0%	0.0%
32	Enclosed Theaters / Auditoriums	3	2000	51203	0.94	0.120	0.095	0.025	0.125	20.9%	0.5%	0.4%
33	Nightclubs / Bars	20	1972	4676	0.95	0.198	0.164	0.034	0.247	17.3%	0.3%	0.4%
34	Bowling Alleys / Skating Rinks	3	1986	33201	0.96	0.038	0.033	0.004	0.034	11.3%	0.3%	0.1%
39	Hotels / Motels	50	1982	32676	0.95	0.231	0.206	0.025	0.245	10.9%	5.2%	9.1%
	<b>Total Commercial</b>	<b>2214</b>	<b>1986</b>	<b>14108</b>	<b>0.93</b>	<b>0.133</b>	<b>0.129</b>	<b>0.004</b>	<b>0.139</b>	<b>2.8%</b>	<b>100.0%</b>	<b>100.0%</b>



Percentage and gpcd Summary by Sector

Sector	% of Total Water Use	Breakdown of Gross gpcd	Breakdown of Gal/Hd. Sq. Ft./Month
Single Family	71.3%	95	5.01
Single Family Indoor	38.2%	51	2.68
Single Family Outdoor	33.1%	44	2.32
Multi-Family	1.6%	2	0.96
Commercial	14.7%	20	4.72
Industrial	1.2%	2	0.78
Institutional	3.2%	4	3.38
Unaccounted For	8.0%	11	0.37
<b>TOTAL</b>	<b>100.0%</b>	<b>134</b>	<b>4.65</b>

Figure 1. EZ Guide 2.0 water budget summary for a utility in South Florida.

seasonal water use coefficient. This coefficient is then divided by the average water use coefficient to arrive at an estimate of the percentage of total water use that is seasonal.

Aggregated commercial water use coefficients can be calculated by carrying out a weighted average of the commercial coefficients in Table 2 based on the total heated areas of commercial FDOR sectors in a given utility. These aggregated coefficients are directly dependent on the land use mix within a given service area boundary. Data for the following commercial categories was unavailable from HCWRS or GRU: open stadiums (FDOR 31), tourist attractions (FDOR 35), camps (FDOR 36), and race tracks (FDOR 37).

### Application of Water Use Coefficients

By employing a measure of size that is standard and reliable across the commercial sectors, along with default water use coefficients, any utility within the state can estimate the sectoral breakdown of commercial water use within their service boundary. The FDOR database is accompanied by polygon shapefiles delineating every parcel in the state. This database can be queried to determine which parcels are within the service boundaries of a given utility.

The South Florida Water Management District, the St. Johns River Water Management District, and the Southwest Florida Water Management District provide the water service area boundaries of utilities in their districts as polygon shapefiles available in their respective Web sites to be viewed in GIS. The parcels are identified by a unique parcel identification number which can be related to the FDOR database to find the attributes for the parcels in the utility being analyzed.

EZ Guide 2.0 utilizes the coefficients shown in Table 2 to estimate commercial water

use for any utility in the state. Similar coefficients were developed for the industrial and institutional sectors of water, and are also applied within the water budget section of EZ Guide 2.0 (Figure 1).

By estimating the individual water use for each customer sector, a utility or planning agency can plan a conservation strategy according to the relative importance and water use intensity of its sectors. To estimate the amount of water use for the single- and multi-family residential sectors, a similar data-driven measure of size approach is also taken. EZ Guide 2.0 is available free online, and the Conserve Florida Water Clearinghouse can assist water utilities and water management districts in generating the necessary information ([www.conservefloridawater.org](http://www.conservefloridawater.org)).

### Priority Water Using Commercial Sectors in Florida

The balance of this article will examine the individual facility types that make up the commercial sector to identify the larger water users and how they vary across the state. Since the FDOR database provides standardized land use information for all parcels in the state, the coefficients presented in Table 2 can be applied to estimate the total statewide contribution of each commercial sector to public water use. The top commercial water use sector for each county is shown in Figure 2.

The two largest commercial public water users in the state, as shown in Table 3, are: hotels/motels and community shopping centers. These commercial water users account for approximately 30 percent of total commercial water use, or 88 million gallons per day (MGD) of public water use in the state of Florida.

Given the heterogeneous nature of commercial customers, in order to carry out a meaningful analysis of water use, it is best to

focus on a small number of sectors and thoroughly analyze their water use patterns and drivers of demand. An expanded analysis of water use follows in which the top two commercial sectors, along with restaurants, are further investigated. Restaurants were included given their frequency as a top county commercial user, as shown in Figure 2, and for their higher water use rate (Table 2).

### Analysis of Larger Commercial Sectors

Further analysis of water use patterns begins with the time series signature of a sector's water use. The billing records from HCWRS and GRU were linked to FDOR parcel attributes in order to disaggregate water users based on FDOR land use codes, as well as find relationships between parcel attributes and water use. Prior to this more detailed analysis, outliers were identified and removed.

Outliers were determined via both regression and time series analysis. If a parcel had a recognizably small or large water use given its heated building area, or a discrepancy in its water billing, then that parcel was removed from the analysis. The cumulative water use time series of hotels/motels (FDOR 039), community shopping centers (FDOR 016), and restaurants/cafeterias (FDOR 021) for HCWRS (Jan. 2003 – Dec. 2006), and GRU (Jan. 2008 – Dec. 2009) are presented in Figure 3.

From inspection of these time series, it is clear that neither significant seasonal nor longer term trends occur. The small seasonal components also show that indoor water use is predominant for the sector.

Outdoor water use for the commercial sector would be expected to be less important than for residences because of the limited amount of irrigable area, since most of the

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non-structural land use is for parking. Cooling water use could be important but only larger commercial establishments have cooling towers. The effects of other seasonal factors such as tourism and transient populations

do not appear to be significant.

The next step in evaluating sectors for water use patterns is to disaggregate sector classifications further. Whereas overall water use may remain stable, this could be the result of offsetting impacts of changing heated area

per parcel and the water use coefficient.

Commercial water use should be impacted strongly by the plumbing codes that have had a significant impact on residential water use (Mayer et al., 1999, 2005). Year built of a facility might affect water use, given the requirement or availability of certain end-use devices at the time of construction. For example, the residential sector can be partitioned into three age groups (pre-1983, 1983-1994, post-1994), corresponding with state and federal regulations requiring minimum plumbing fixture water efficiencies (Friedman, 2009).

The results of a similar breakdown for FDOR's 16, 21, and 39 are shown in Table 4. The average heated area for hotels/motels has increased significantly from about 24,000 square feet prior to 1983 to over 52,000 square feet after 1994. On the other hand, the water use coefficient has declined for the hotel/motel category during this same period. Similarly, the average sizes of community shopping centers and restaurants have increased, but the water use coefficients for shopping centers and restaurants are also increasing.

### Other Florida-specific Commercial Water Use Studies & Programs

Previous methods to estimate commer-

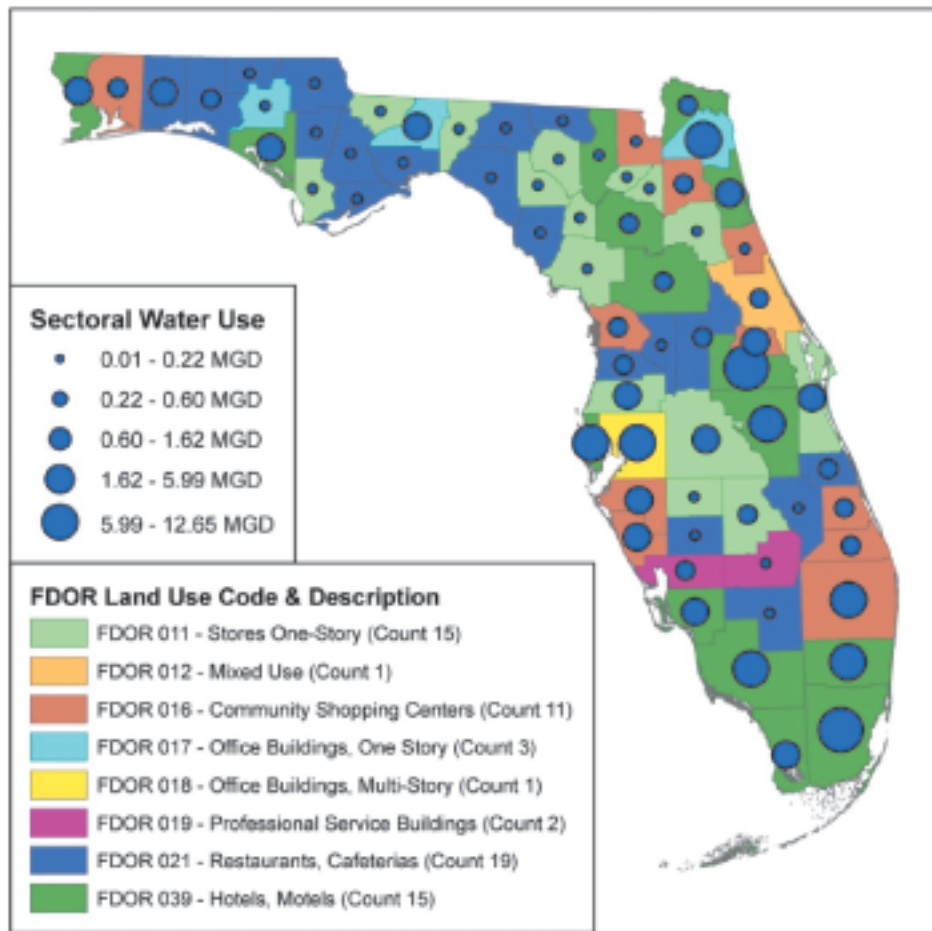


Figure 2. Top commercial water use sector for each county in the state of Florida.

Table 3. State of Florida sectoral breakdown of commercial water use.

FDOR	FDOR Description	Parcel Count	Total Heated Area (sq. ft.)	Average Water Use Coef. (gal/hsf/d)	Estimated Water Use (MGD)	% of Total Heated Area	% of Total Water Use
39	Hotels / Motels	22633	253540438	0.231	58.64	12.16%	19.83%
16	Community Shopping Centers	8164	296825013	0.099	29.31	14.24%	9.91%
11	Stores, One-Story	41049	280527752	0.098	27.39	13.46%	9.26%
21	Restaurants	8091	35013229	0.741	25.95	1.68%	8.77%
17	Office, One-Story	39400	180458947	0.129	23.28	8.66%	7.87%
18	Office, Multi-Story	16311	326394693	0.069	22.60	15.66%	7.64%
19	Medical Office	21976	120623253	0.158	19.06	5.79%	6.44%
27	Auto Sales / Repair	15807	104135532	0.124	12.89	5.00%	4.36%
23	Financial Institutions	4994	34378307	0.373	12.83	1.65%	4.34%
22	Fast-Food Restaurants	4521	14083978	0.657	9.26	0.68%	3.13%
	All Others	47935	438793381	0.124	54.57	21.05%	18.45%
	<b>Total Commercial</b>	<b>230881</b>	<b>2084774521</b>	<b>0.142</b>	<b>295.77</b>	<b>100.00%</b>	<b>100.00%</b>

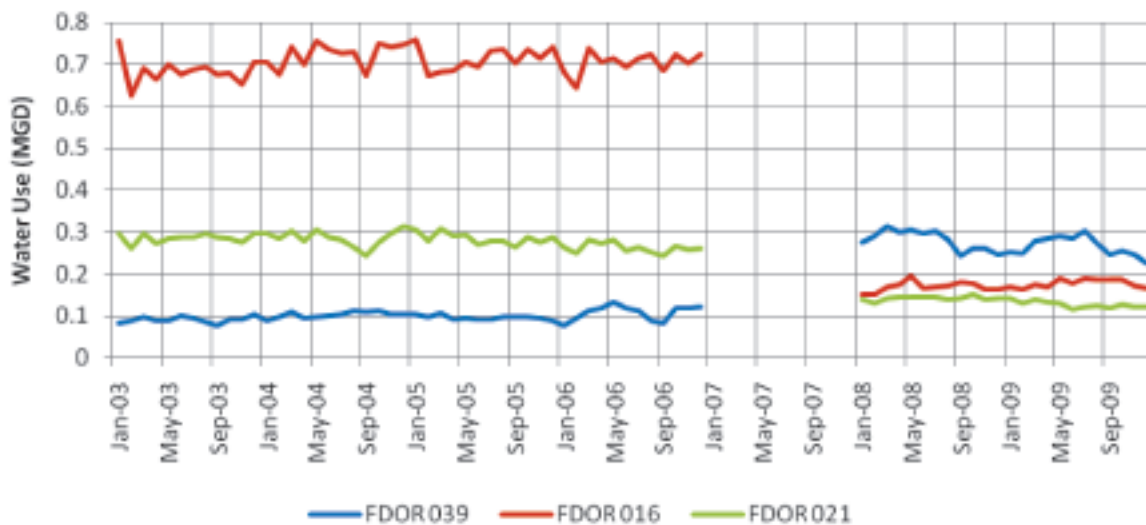


Figure 3. Monthly water use for hotels/motels (FDOR 039), community shopping centers (FDOR 016), and restaurants/cafeterias (FDOR 021) in HCWRs (Jan. 2003 – Dec. 2006) and GRU (Jan. 2008 – Dec. 2009).

cial water use in Florida include the Hazen and Sawyer, and PMCL (2004) utility-wide model for Tampa Bay Water, a wholesale distributor. This model was used to estimate single- and multi-family residential and non-residential water use for seven different member government planning areas. The model utilized an equation to estimate the non-residential water use coefficient based on historical usage, composition of the non-residential sector, local affluence, and climate.

A commercial vendor provided the historical employment and income data for the years 1999 to 2002 by survey. The study included 39,727 NR parcels and linked the parcel data to their billing records. The values were averaged per Traffic Analysis Zone and combined with rainfall data to run a regression and develop the monthly water use coefficients. Total employment is the size of the non-residential sector used to estimate water use.

This non-residential model explained only 2 percent of the variation in water use (Hazen and Sawyer, PMCL 2004). The modelers attribute this low explanatory power to the typically heterogeneous nature of non-residential water use. The methodology presented in this article provides more specific customer classifications for the non-residential sector, allowing each group of customers to be more homogeneous in their application of water.

The Southwest Florida Water Management District (1997) conducted a study which included end use breakdowns of water use and potential savings through conservation for hotels/motels, restaurants, and office buildings. The district also provides a free educational program (Water PRO) to help restaurants conserve water, as well as an equivalent hotel/motel program (Water CHAMP) that currently is being piloted by South Florida Water Management District in the Florida Keys. The Florida Department of Environmental Protection's Green Lodging Program

Age Group	Sample Size	Average Effective Year Built	Average Heated Area (sf)	Weighted Average Water Use Coef. (gal/hsf/d)
<b>FDOR 039 - Hotels, Motels</b>				
Pre-1983	23	1969	23506	0.260
1983-1994	15	1987	27354	0.298
Post-1994	11	2000	52302	0.191
<b>Total</b>	<b>49</b>	<b>1981</b>	<b>31148</b>	<b>0.244</b>
<b>FDOR 016 – Community Shopping Centers</b>				
Pre-1983	56	1975	27289	0.068
1983-1994	115	1988	39183	0.101
Post-1994	63	1999	47372	0.108
<b>Total</b>	<b>234</b>	<b>1988</b>	<b>38541</b>	<b>0.097</b>
<b>FDOR 021 - Restaurants, Cafeterias</b>				
Pre-1983	33	1968	3169	0.435
1983-1994	27	1989	4678	0.819
Post-1994	52	1999	5932	0.824
<b>Total</b>	<b>112</b>	<b>1987</b>	<b>4816</b>	<b>0.747</b>

Table 4. Trends in the average heated area and water use coefficients for three priority commercial water use sectors.

also encourages water conservation by designing and recognizing lodging facilities which make environmental efforts.

### Summary & Conclusions

This article presents a new methodology by which to estimate commercial water use based on parcel-level, publicly available databases and Florida-specific water use coefficients. These coefficients were applied in a statewide analysis of commercial water use to

arrive at the top commercial water users in the state. From this analysis, it was determined that a short list of sectors is responsible for the bulk of commercial water use in the state.

More extensive analysis was carried out on the top three commercial sectors of concern: hotels/motels, community shopping centers, and restaurants. From this analysis it was determined that these sectors are not affected by significant trends and their outdoor water use is minimal. This bottom-up methodology has

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been incorporated into *EZ Guide 2.0*, which is available free online from the Conserve Florida Water Clearinghouse at the University of Florida ([www.conservefloridawater.org](http://www.conservefloridawater.org)).

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