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Predominant Commercial Sectors in Florida and their Water Use Patterns

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Introduction

Commercial water use comprised 20% 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 1980's, as well as from 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 paper 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).

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 publicly available free of charge from the FDOR FTP website (<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 FDOR by the state's 67 Florida County Property Appraisers (FCPAs). 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 at the parcel level for the entire state of Florida. 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 FCPA databases that contain information on heated area for each developed parcel (Morales et al. 2009).

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

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 n sectors is calculated using Equation 1.

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

Where: Q = water use for n sectors
 α_k = water use coefficient of sector k
 x_k = size of sector k
n = number of sectors

In this study, parcel-level land use characteristics from the FDOR database were linked with historic water billing data for 2,214 commercial parcels, 1,177 in Hillsborough County Water Resources Services (HCWRS) and 1,037 in 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. Thus, 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 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. In order 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 subheading 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 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. South Florida Water Management District (WMD), St. Johns River WMD, and Southwest Florida WMD provide the water service area boundaries of utilities in their districts as polygon shapefiles available in their respective websites 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.

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.

F D O R	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	7,644	0.93	0.098	0.093	0.004	0.104	4.2%	7.1%	5.2%
12	Mixed Use	143	1976	11,483	0.92	0.092	0.089	0.003	0.095	3.4%	5.3%	3.6%
13	Department Stores	19	1994	128,183	0.89	0.062	0.054	0.008	0.063	12.2%	7.8%	3.6%
14	Supermarkets / Convenience Stores	123	1991	5,795	0.93	0.270	0.238	0.032	0.291	11.8%	2.3%	4.6%
15	Regional Malls	3	1996	856,391	0.93	0.073	0.065	0.008	0.073	10.6%	8.2%	4.5%
16	Community Shopping Centers	239	1988	39,269	0.95	0.099	0.098	0.001	0.101	0.9%	30.0%	22.3%
17	Office, One-Story	384	1984	5,983	0.96	0.129	0.117	0.012	0.138	9.0%	7.4%	7.1%
18	Office, Multi-Story	73	1987	30,576	0.97	0.069	0.065	0.005	0.077	6.7%	7.1%	3.7%
19	Medical Offices	264	1990	7,543	0.97	0.158	0.144	0.014	0.168	8.7%	6.4%	7.6%
20	Transit Terminals	6	1982	9,257	0.97	0.339	0.254	0.085	0.349	25.0%	0.2%	0.5%
21	Restaurants	120	1988	4,902	0.96	0.741	0.711	0.030	0.757	4.0%	1.9%	10.5%
22	Fast-Food Restaurants	105	1994	2,910	0.96	0.657	0.636	0.021	0.680	3.3%	1.0%	4.8%
23	Financial Institutions	98	1992	5,108	0.91	0.373	0.349	0.024	0.397	6.6%	1.6%	4.5%
24	Insurance Offices	11	1988	10,736	0.94	0.073	0.060	0.012	0.086	17.0%	0.4%	0.2%
25	Service Shops	49	1981	5,393	0.80	0.176	0.159	0.017	0.187	9.9%	0.8%	1.1%
26	Service Stations	5	1986	1,829	0.71	0.170	0.145	0.025	0.213	14.7%	0.0%	0.0%
27	Auto Sales / Repair	174	1984	8,009	0.86	0.124	0.110	0.014	0.126	11.3%	4.5%	4.1%
29	Wholesale Outlets	5	1972	23,700	0.76	0.025	0.021	0.004	0.030	17.7%	0.4%	0.1%
30	Florists / Greenhouses	2	1966	3,376	0.92	0.216	0.144	0.072	0.250	33.5%	0.0%	0.0%
32	Enclosed Theaters / Auditoriums	3	2000	51,203	0.94	0.120	0.095	0.025	0.125	20.9%	0.5%	0.4%
33	Nightclubs / Bars	20	1972	4,676	0.95	0.198	0.164	0.034	0.247	17.3%	0.3%	0.4%
34	Bowling Alleys / Skating Rinks	3	1986	33,201	0.96	0.038	0.033	0.004	0.034	11.3%	0.3%	0.1%
39	Hotels / Motels	50	1982	32,676	0.95	0.231	0.206	0.025	0.245	10.9%	5.2%	9.1%
	Total Commercial	2,214	1986	14,108	0.93	0.133	0.129	0.004	0.139	2.8%	100.0%	100.0%

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).

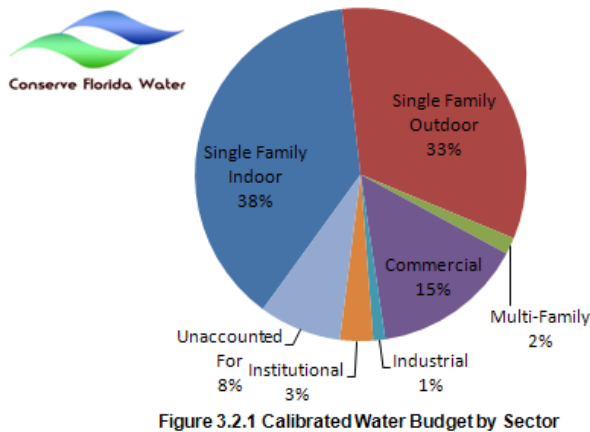


Table 3.2.1 Percentage and gpcd Summary by Sector

Sector	% of Total Water Use	Breakdown of Gross gpcd	Breakdown of Gal/Htd. 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
TOTAL	100.0%	134	4.65

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

Priority Water Using Commercial Sectors in Florida

The balance of this paper 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 state-wide 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% of total commercial water use, or 88 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).

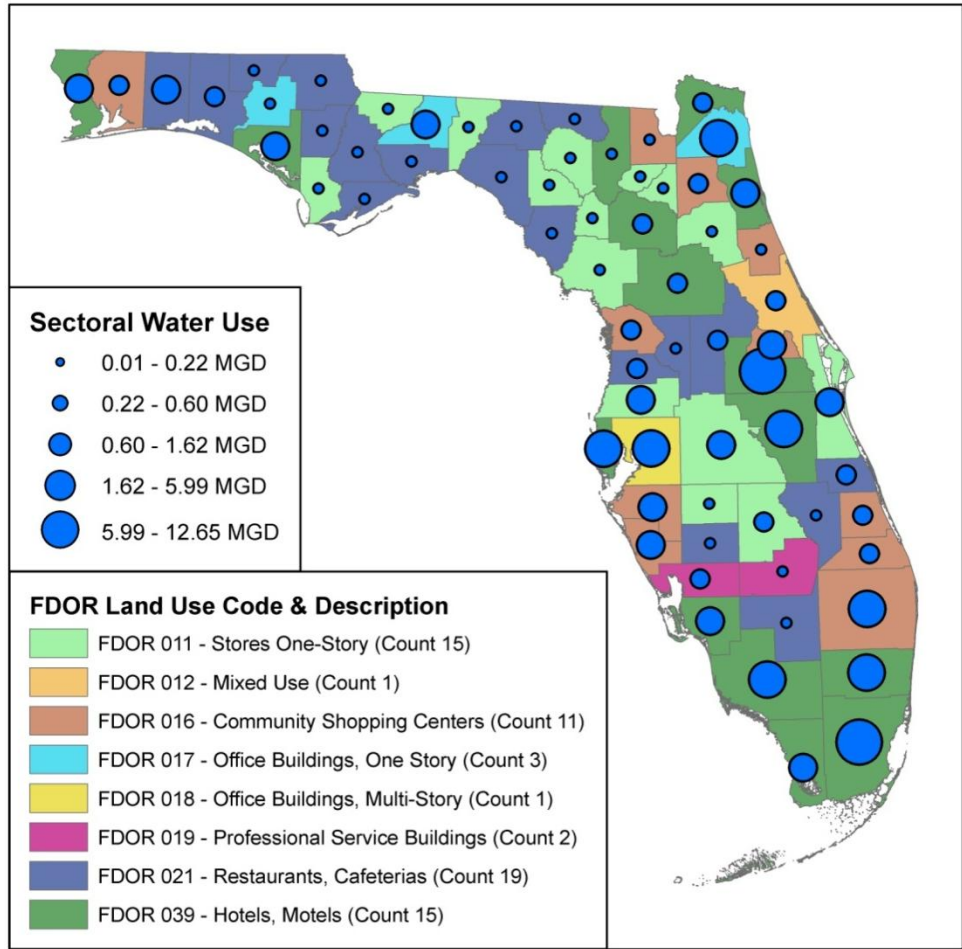


Figure 2. Top commercial water use sector for each county in the state of Florida.

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	22,633	253,540,438	0.231	58.64	12.16%	19.83%
16	Community Shopping Centers	8,164	296,825,013	0.099	29.31	14.24%	9.91%
11	Stores, One-Story	41,049	280,527,752	0.098	27.39	13.46%	9.26%
21	Restaurants	8,091	35,013,229	0.741	25.95	1.68%	8.77%
17	Office, One-Story	39,400	180,458,947	0.129	23.28	8.66%	7.87%
18	Office, Multi-Story	16,311	326,394,693	0.069	22.60	15.66%	7.64%
19	Medical Office	21,976	120,623,253	0.158	19.06	5.79%	6.44%
27	Auto Sales / Repair	15,807	104,135,532	0.124	12.89	5.00%	4.36%
23	Financial Institutions	4,994	34,378,307	0.373	12.83	1.65%	4.34%
22	Fast-Food Restaurants	4,521	14,083,978	0.657	9.26	0.68%	3.13%
	All Others	47,935	438,793,381	0.124	54.57	21.05%	18.45%
	Total Commercial	230,881	2,084,774,521	0.142	295.77	100.00%	100.00%

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.

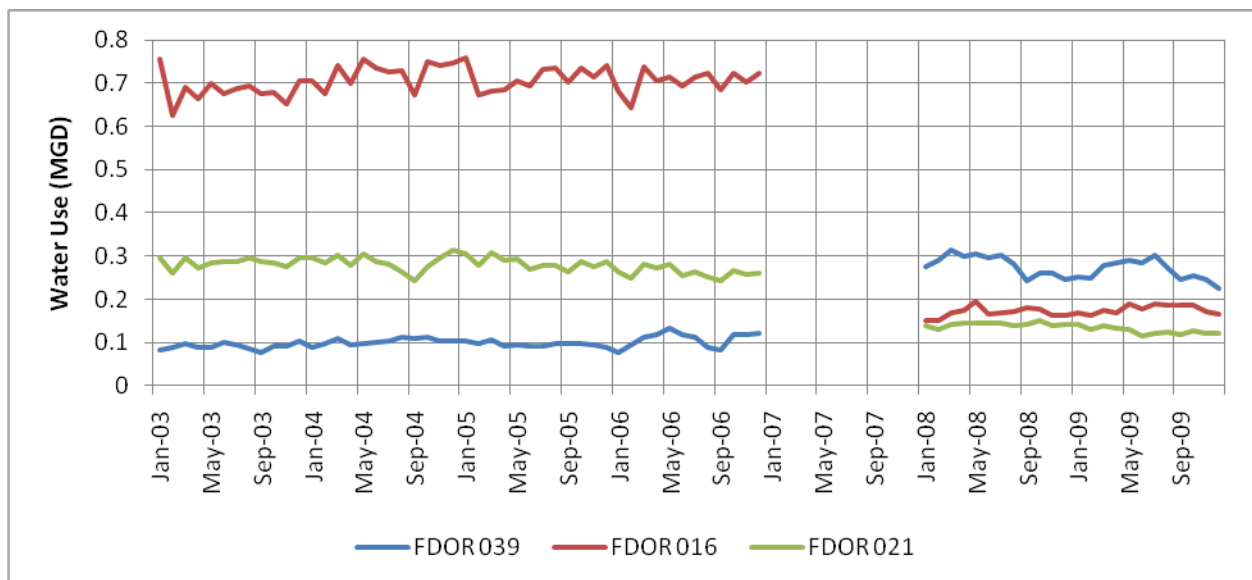


Figure 3. Monthly water use for hotels/motels (FDOR 039), community shopping centers (FDOR 016), and restaurants/cafeterias (FDOR 021) in HCWRS (Jan. 2003 – Dec. 2006) and GRU (Jan. 2008 – Dec. 2009).

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 water use for the sector is predominantly indoor. Outdoor water use for the commercial sector would be expected to be less important than for residences due to the limited amount of irrigable area since most of the 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 strongly impacted 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. However, the water use coefficients for shopping centers and restaurants are also increasing.

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

Age Group	Sample Size	Average Effective Year Built	Average Heated Area (sf)	Weighted Average Water Use Coef. (gal/hsf/d)
FDOR 039 - Hotels, Motels				
Pre-1983	23	1969	23,506	0.260
1983-1994	15	1987	27,354	0.298
Post-1994	11	2000	52,302	0.191
Total	49	1981	31,148	0.244
FDOR 016 - Community Shopping Centers				
Pre-1983	56	1975	27,289	0.068
1983-1994	115	1988	39,183	0.101
Post-1994	63	1999	47,372	0.108
Total	234	1988	38,541	0.097
FDOR 021 - Restaurants, Cafeterias				
Pre-1983	33	1968	3,169	0.435
1983-1994	27	1989	4,678	0.819
Post-1994	52	1999	5,932	0.824
Total	112	1987	4,816	0.747

Other Florida-specific Commercial Water Use Studies and Programs

Previous methods to estimate commercial 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 (NR) water use for seven different member government planning areas. The model utilized an equation to estimate the NR water use coefficient based on historical usage, composition of the NR 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 NR sector used to estimate water use. This NR model explained only two percent of the variation in water use (Hazan and Sawyer, PMCL 2004). The modelers attribute this low explanatory power to the typically heterogeneous nature of NR water use. The methodology presented in this paper provides more specific customer classifications for the NR sector, allowing each group of customers to be more homogeneous in their application of water.

Southwest Florida WMD (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) which is currently also being piloted by South Florida WMD in the Florida Keys. The Florida Department of Environmental Protection's Green Lodging Program also encourages water conservation by designating and recognizing lodging facilities which make environmental efforts.

Summary and Conclusions

This paper 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 State-wide 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 been incorporated into EZ Guide 2.0 which is available from the Conserve Florida Water Clearinghouse at the University of Florida (www.conservefloridawater.org).

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