

This presentation premiered at WaterSmart Innovations

watersmartinnovations.com



Estimating and Projecting Commercial, Industrial, and Institutional Water Use

M. A. Morales and J. P. Heaney
Presenter: Miguel A. Morales

Conserve Florida Water Clearinghouse
University of Florida
WaterSmart Innovations 2010
October 8, 2010

Conserve Florida Water Clearinghouse

- Organization funded through the Florida Dept. of Environmental Protection and Florida's Water Management Districts
- Developing model to serve as water conservation planning tool (EZ Guide 2)
 - Estimates water use within a water budget
 - Evaluates conservation best management practices

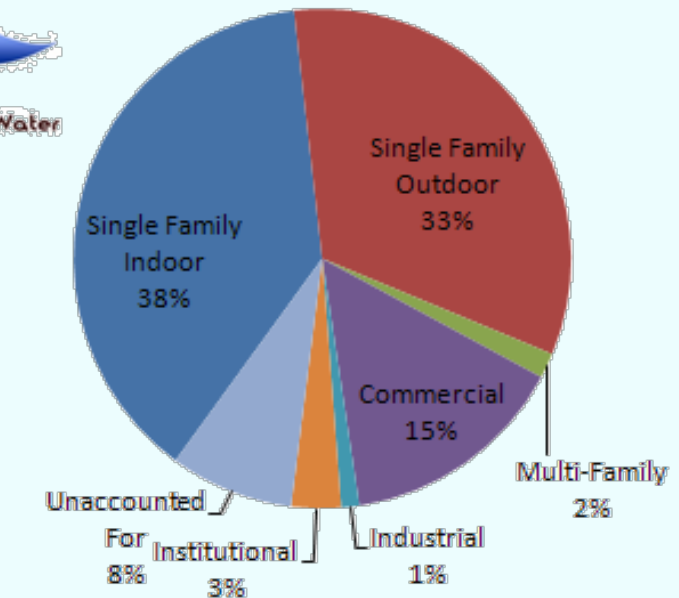
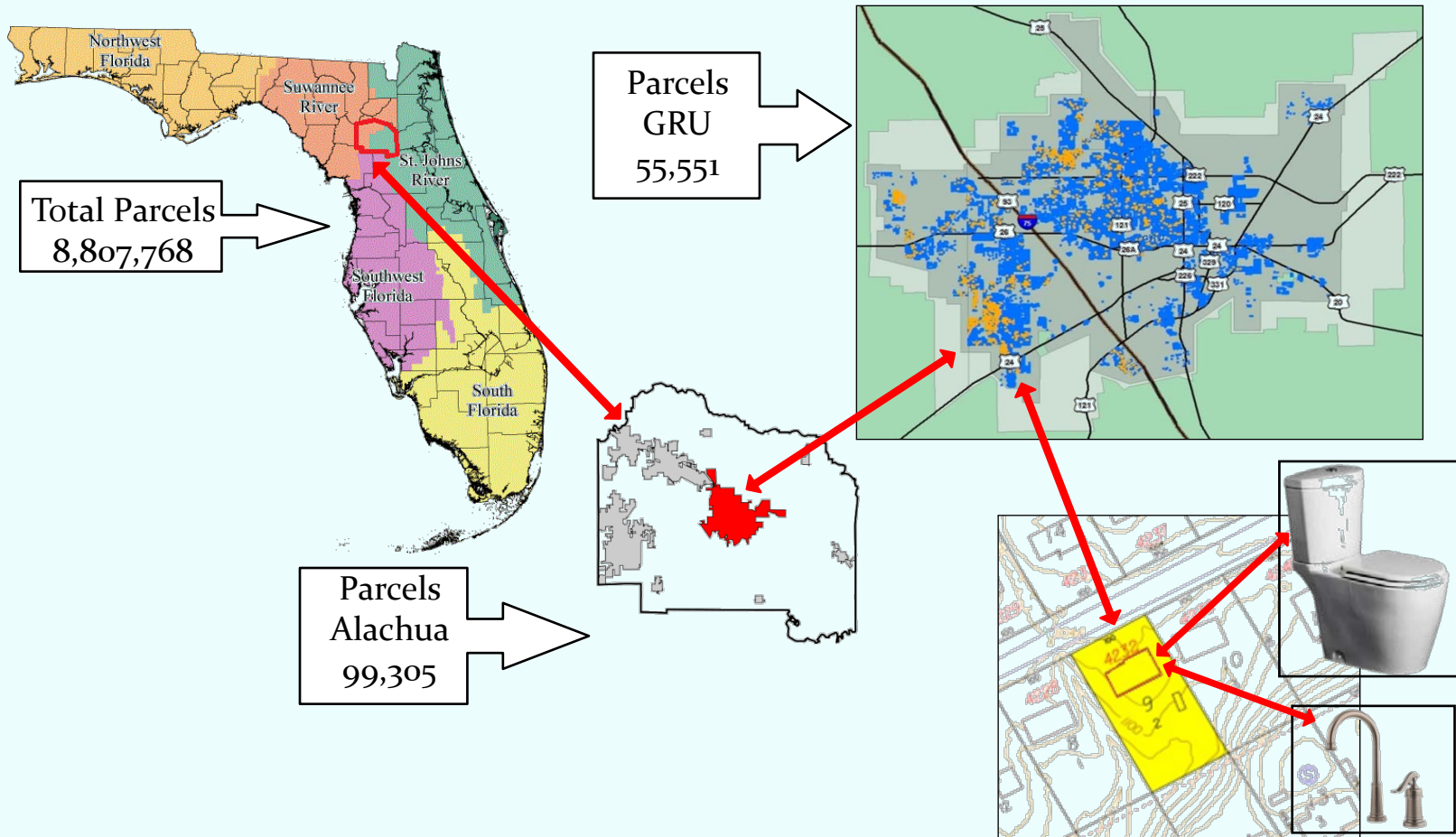


Figure 3.2.1 Calibrated Water Budget by Sector

Macro to Nano-Scale Evaluation of Urban Water Use



Estimating Water Use

- Estimates to forecast water use include having a rate of water use for a sector and a measure of its size throughout the planning period

$$Q_{Total} = \sum_{k=1}^n (\alpha_k \times x_k)$$

Where: Q_{Total} = water use for n sectors

α_k = water use coefficient of sector k

x_k = size of sector k

n = number of sectors

- For projecting water use of future customers utilities often rely on:
 - similar customers within their service area
 - water use coefficients developed through studies in other locales

Popular CII Water Use Coefficients

- Number of employees most popular measure of size given its historical availability
 - Measure used by IWR-MAIN and Maddaus' DSS Model
 - Coefficients outdated, IWR-MAIN is no longer supported
- Others coefficients utilize various measures of size depending on the type of facility
 - Databases for these measures of size are lacking

CI category	Unit	Gallons/unit/day
Barber shops	Chairs	54.60
Beauty shops	Station	269.00
Bus/rail depots	Square foot	3.33
Car washes	Inside square foot	4.78
Churches	Member	0.14
Golf/swim clubs	Member	22.20
Bowling alleys	Alley	133.00
Residential colleges	Student	106.00
Hospitals	Bed	346.00
Retail space	Sale square foot	0.11
Elementary schools	Student	3.83
High schools	Student	8.02
YMCA/YWCA	Person	33.30
Service stations	Inside square foot	0.25
Theaters	Seat	3.33

Source: Crews, James E. and Mary Ann Miller. 1983. Forecasting Municipal and Industrial Water Use. IWR Research Report 83R-3. U.S. Army Corps of Engineers, Fort Belvoir, Virginia.

Employment Data

- Available from:
 - U.S. Census
 - Pros: Readily available throughout the United States
 - Cons: Limited by spatial customer classification aggregation require to ensure anonymity (TAZ, 2-digit NAICS employment size classes)
 - Private Surveys
 - Pros: Produce customer-level data
 - Cons: Expensive to conduct and only provide a “snapshot” in time

In Florida there are:

12,747 TAZs, and nearly 9 million parcels!

Why Employment Data?

- Other measures of size, such as building area, have been shown to be better predictors of water use across the CII subsectors (Dziegielewski et al. 2000)
- **Reasoning:** Employee data has historically been readily available compared to other parameters such as acreage (Mercer and Morgan 1974)

Source	Available	Smallest geographical unit
U.S. Economic Census	Every 5 years	City
County Business Patterns	Annually	Zip code
Longitudinal Employer-Household Dynamics	Quarterly	TAZ
Commercial surveys	Varies	Customer

EPA WaterSense

- Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program (2009)
- Provides literature review of research on CII
- Documents national and international CII water efficiency programs
- Outlines information gaps
 - Subsector specific data, such as:
 - Water usage by facility and end use, and
 - Existing benchmarks with which to set targets
- Other studies such as *CI End Uses of Water* (Dziegielewski et al. 2000) and Colorado WaterWise's *ICI Benchmarking Taskforce* (2007), have presented such data, but only for a limited number of CII subsectors

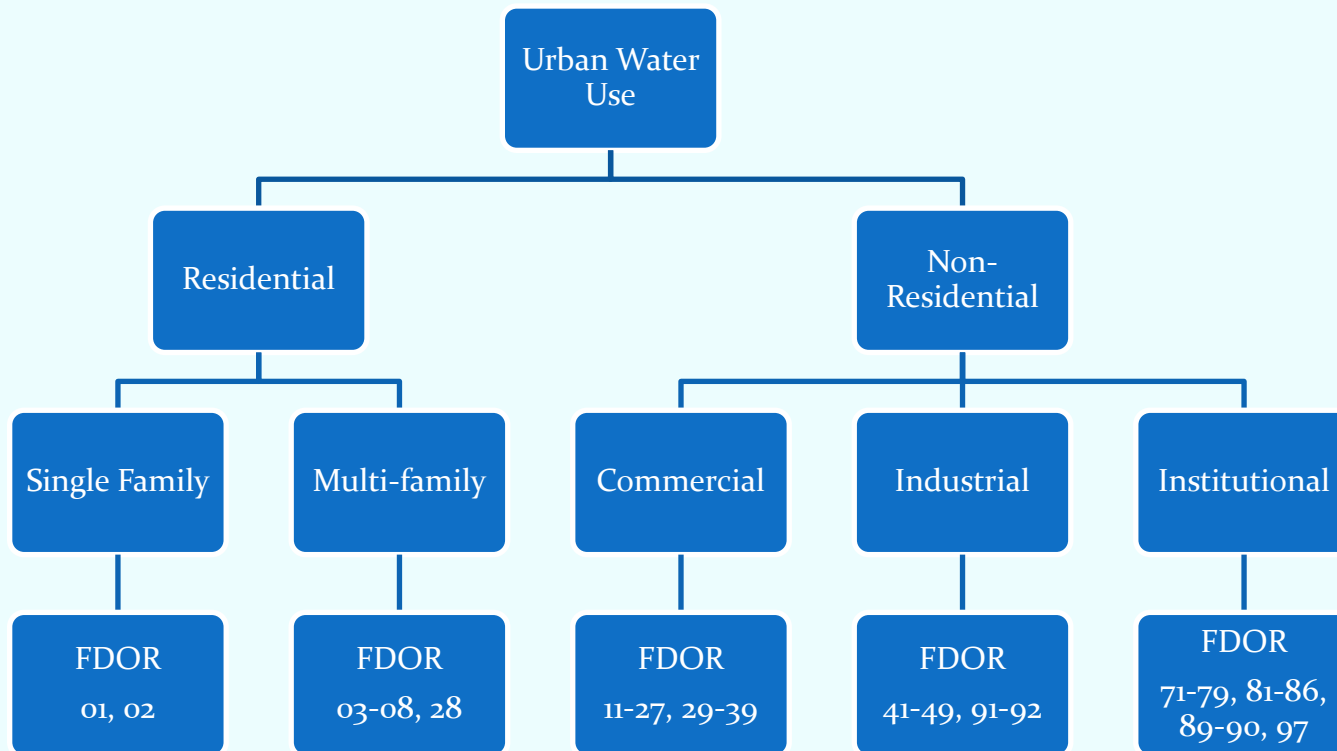
Improved Water Use Coefficients

- Measures of size need to be:
 - Good predictor of water use
 - Consistent and available at a finer spatial resolution
- Same measure of size for all CII subsectors allows for:
 - Comparisons of water use across subsectors
 - More readily available databases
- Physical and economic property data available from every parcel in the state of Florida through:
 - Florida Department of Revenue (FDOR) and
 - Florida County Property Appraisers (FCPA)

FDOR and FCPA Databases

- Both databases have data fields with parcel and building characteristics
- Florida Department of Revenue
 - Standard data fields
 - Free and easily accessible
 - Partitions all parcels into 100 land use categories
 - Square footage of building is ‘effective area’- not a true measure of area
 - Spatial location and dimensions of every parcel in the state of Florida
- Florida County Property Appraisers
 - Additional data fields vary between counties
 - Needs to be obtained from the FCPA
 - Square footage of building area is ‘heated area’
 - Uses FDOR’s 100 categories plus sub-categories
 - Available for this study:
 - Hillsborough County Property Appraiser, Alachua County Property Appraiser

Categories of Customers



- FDOR classifications allow for simple aggregation and disaggregation of customer types

Levels of Spatial Aggregation in Florida

Item	Value	Population/no.
Population	18,800,000	1
Parcels	8,800,000	2.14
Census Blocks	362,499	51.9
Traffic Analysis Zones	12,747	1,475
Utilities	2,623	7,167
Counties	67	280,597

Utility (Sample) CII Data

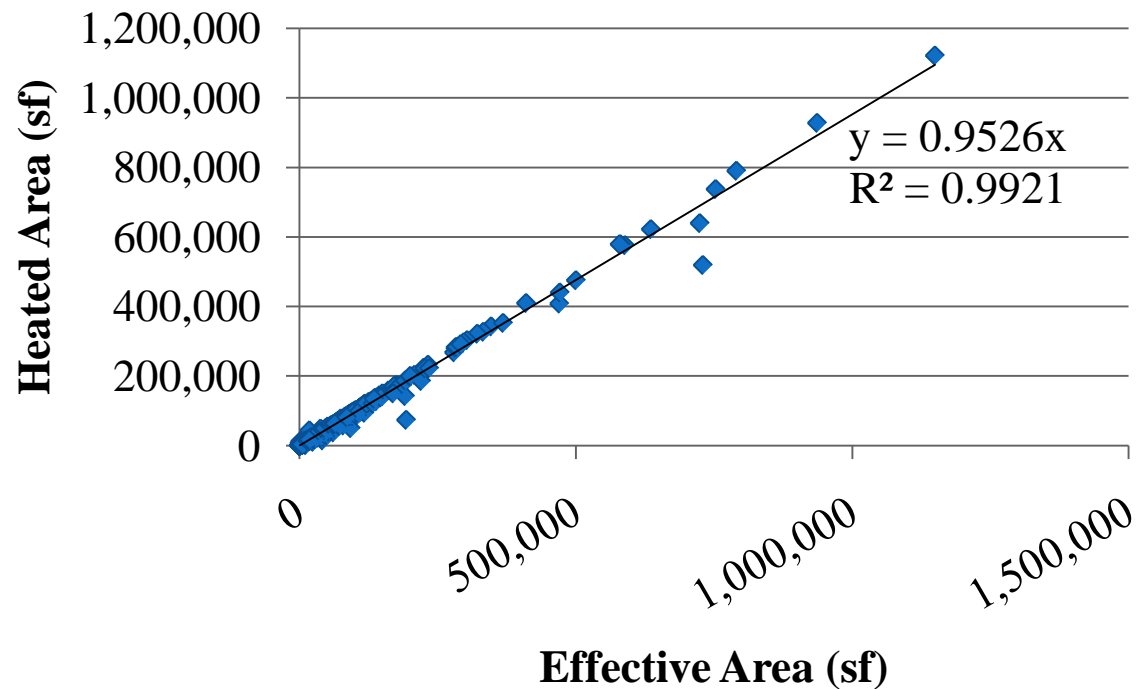
- Utility data for this study supplied by Hillsborough County Water Resources Services (HCWRS), and Gainesville Regional Utilities (GRU)
- Corresponding FCPA CII data obtained

	HCWRS	GRU
Commercial	67%	72%
Industrial	9%	10%
Institutional	24%	18%
CII parcels	1,768	1,437
Years of billing	4 years	2 years

- Total sample of 3,205 CII parcels, 1% sample of all CII parcels in state of Florida

Relationship of Effective Area to Heated Area

- FDOR database more readily available than FCPA, but only presents effective area (EA)



- Strong relationship between EA and heated area (HA) for all 3,205 CII parcels sampled allows for reliable conversion between these two measures of size

Relationship of Heated Area to Water Use

- Strong correlation between heated area and water use for all 3,205 CII parcels in HCWRS and GRU:

Correlation Coefficient, R	Heated area (sf)	Effective area (sf)	Parcel area (acres)	Effective year built	Average monthly water use
Heated area (sf)	1.000				
Effective area (sf)	0.996	1.000			
Parcel area (acres)	0.347	0.356	1.000		
Effective year built	0.028	0.030	0.003	1.000	
Average monthly water use (gal)	0.631	0.639	0.096	0.021	1.000

- Step information of stepwise regression:

	Multiple R	R ²	Adjusted R ²	StErr of estimate	Enter or exit
Heated area (sf)	0.6275	0.3938	0.3938	3802	Enter
Effective year built	0.6297	0.3966	0.3964	3794	Enter
Parcel area (acres)	0.6439	0.4146	0.4142	3738	Enter

- Indicates little predictive power is gained by addition of other variables

Developing Water Use Coefficients Based on Heated Area

- The FDOR and FCPA databases have been linked with customer billing data for 3,205 CII establishments to develop water use coefficients
 - An opportunity to develop coefficients that are Florida-specific
- Utility sample database
 - Monthly water use data
 - Customer classification via FDOR land use code
 - Heated area from FCPA
- Coefficient: water use/heated sq. feet
 - Water use coefficients can have different levels of aggregation

Top CII Subsectors in Florida

FDOR Code	Description	Sample Size	HA EA	q _j	q _p	Peak Avg. Ratio	State Parcel Count	State Total		% CII Heated Area in State	% of CII Water Use in State
				(gallons/heated ft ² /day)	(gallons/heated ft ² /day)			Heated Area (acres)	State Total Water Use (MGD)		
11	Stores, One-Story	289	0.926	0.0976	0.1038	1.06	41,049	6,398	27.21	6.23%	5.85%
16	Community Shopping Centers	239	0.952	0.0987	0.1007	1.02	8,164	6,818	29.33	6.64%	6.30%
17	Office, One-Story	384	0.963	0.1290	0.1378	1.07	39,400	4,145	23.29	4.04%	5.01%
18	Office, Multi-Story	73	0.969	0.0692	0.0767	1.11	16,311	7,503	22.63	7.31%	4.86%
19	Medical Office	264	0.971	0.1580	0.1682	1.07	21,976	2,773	19.08	2.70%	4.10%
21	Restaurant	120	0.962	0.7411	0.7574	1.02	8,091	803	25.93	0.78%	5.57%
22	Fast-Food Restaurants	105	0.965	0.6574	0.6803	1.03	4,521	323	9.26	0.31%	1.99%
23	Financial Institutions	98	0.897	0.3732	0.3970	1.06	4,994	781	12.70	0.76%	2.73%
27	Auto Sales / Repair	174	0.866	0.1238	0.1265	1.02	15,807	2,412	13.01	2.35%	2.80%
39	Hotels / Motels	50	0.944	0.2313	0.2451	1.06	22,633	5,803	58.46	5.65%	12.56%
	Other Commercial	418	0.927	0.1012	0.1035	1.02	47,935	10,251	55	9.98%	11.90%
	Total Commercial	2,214	0.941	0.1332	0.1385	1.04	230,881	48,009	296.26	46.75%	63.67%
41	Light Manufacturing	33	0.900	0.0550	0.0567	1.03	19,109	6,227	14.91	6.06%	3.21%
48	Warehousing / Distribution	228	0.947	0.0345	0.0372	1.08	44,419	18,464	27.75	17.98%	5.96%
49	Open Storage	19	0.971	0.1520	0.1693	1.11	12,589	2,852	18.88	2.78%	4.06%
	Other Industrial	27	0.946	0.1196	0.1150	0.96	17,147	3,309	17.24	3.22%	3.71%
	Total Industrial	307	0.942	0.0502	0.0518	1.03	93,264	30,851	78.79	30.04%	16.93%
71	Churches	337	0.946	0.0492	0.0549	1.12	23,275	4,538	9.73	4.42%	2.09%
74	Homes for the Aged	12	0.922	0.1007	0.1082	1.07	4,898	3,251	14.26	3.17%	3.06%
83	Public County Schools	52	0.980	0.0684	0.0743	1.09	5,685	7,962	23.71	7.75%	5.10%
	Other Institutional	283	0.966	0.1054	0.1069	1.01	73,995	8,075	42.54	7.86%	9.14%
	Total Institutional	684	0.963	0.0782	0.0828	1.06	107,853	23,826	90.24	23.20%	19.39%

Aggregation of Water Use Coefficients in EZ Guide 2.0

	HA/EA	Weighted Average Water Use Coef. (gal/hsf /mo)	Number of Parcels	Total Effective Area (sf)	Avg. Heated Area (sf)	Total Heated Area (sf)	% of Total Heated Area in Sector	Avg. Monthly Water Use (gal)	Total Monthly Water Use (MG)	% of Total Water Use in Sector
Commercial	0.95	4.39	884	8,552,417	9,210	8,141,215	43.1%	40,441	35.75	54.7%
Industrial	0.86	0.93	398	7,867,627	16,909	6,729,889	35.7%	15,801	6.29	9.6%
Institutional	0.93	5.83	268	4,288,555	14,940	4,003,940	21.2%	87,048	23.33	35.7%
TOTAL CII	0.91	3.46	1,550	20,708,599	12,177	18,875,044	100.0%	42,173	65.37	100.0%

Description	HA/EA	Weighted Average Water Use Coef. (gal/hsf /mo)	Number of Parcels	Total Effective Area (sf)	Avg. Heated Area (sf)	Total Heated Area (sf)
Stores, One-Story	0.95	2.18	235	1,047,601	4,251	998,933
Mixed Use	0.92	2.78	46	72,378	1,447	66,559
Department Stores	0.97	1.78	14	1,808,360	124,791	1,747,080
Supermarkets / Convenience Stores	0.95	7.92	2	45,650	21,655	43,311
Fast-Food Restaurants	0.96	20.95	23	59,711	2,496	57,405
Financial Institutions	0.87	7.64	18	77,445	3,759	67,664
Auto Sales / Repair	0.88	3.84	95	863,638	8,007	760,670
TOTAL COMMERCIAL	0.95	4.39	884	8,552,417	9,210	8,141,215

- A weighted average of the coefficients is carried out based on the total area of the two-digit FDOR sectors
- Coefficients are directly dependent on the land use mix within a given service area boundary

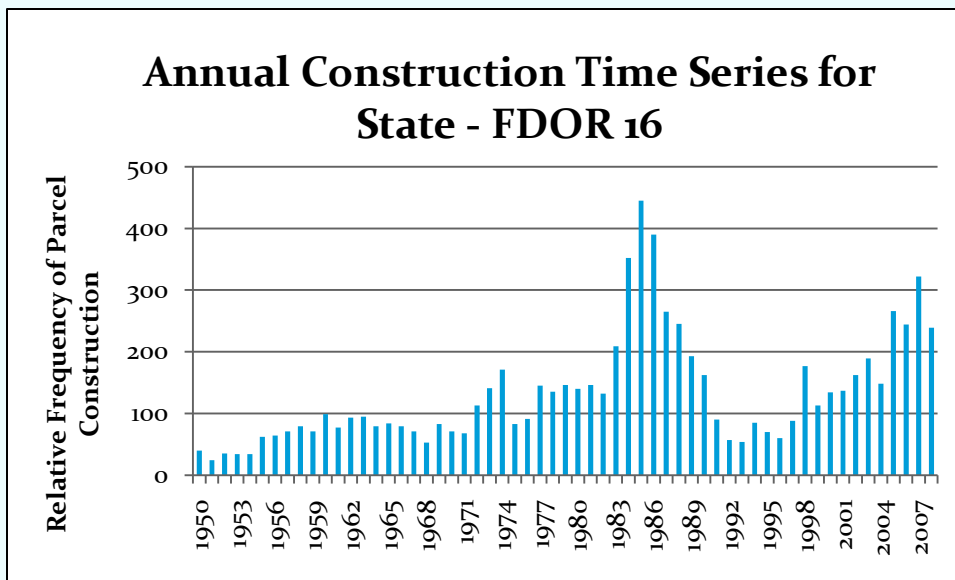
Projecting Water Use

- FDOR includes year built for each parcel in the State
- Allows for time series projections based on:
 - Number of accounts,
 - Measures of size (average building heated area), and
 - Water use
- Great improvement on projecting methods of the past
 - Offers subsector projections
 - Based on all constructed parcels
 - Able to link with population projections

Projection Example (FDOR 16)

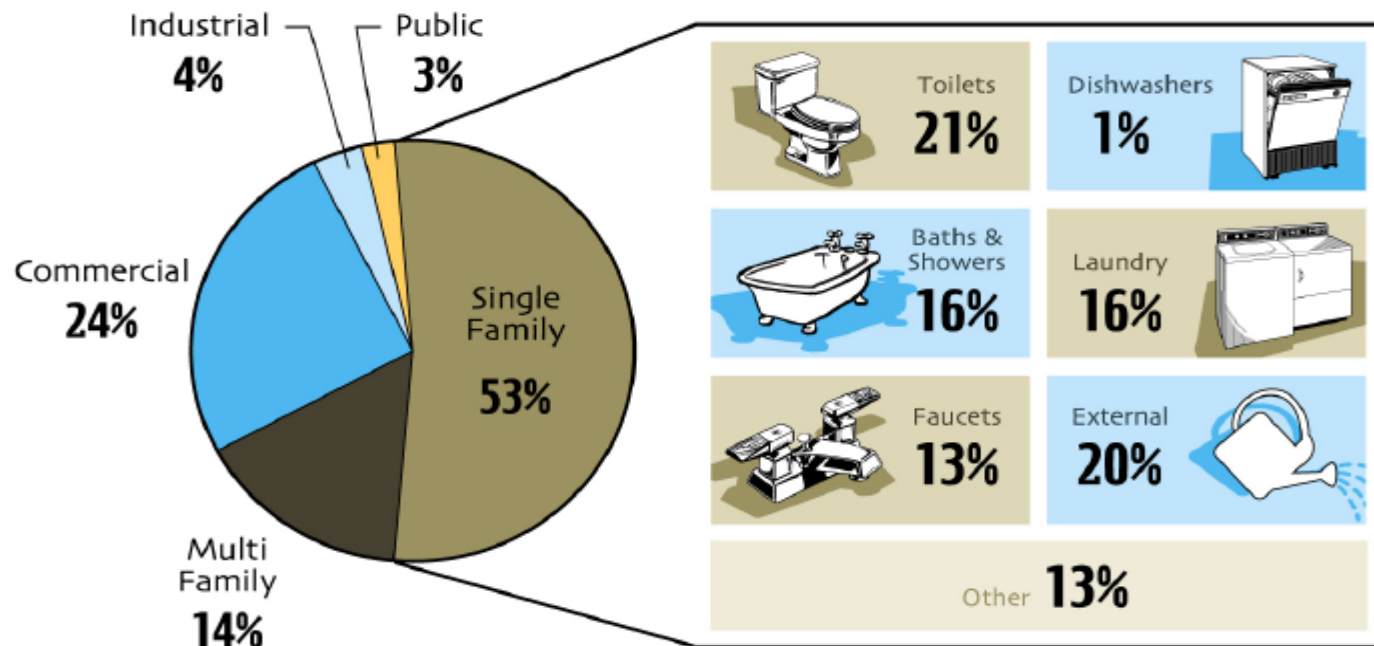
FDOR 016 - Community Shopping Centers				
Age Group	Sample Size	Average Effective Year Built	Average Heated Area (ft ²)	Weighted Average Water Use Coef. (gal/heated ft ² /d)
Pre-1983	56	1975	27,289	0.068
1983-1994	115	1988	39,183	0.101
Post-1994	63	1999	47,372	0.108
Total	234	1988	38,541	0.097

- Time series trends for community shopping centers (FDOR 16):
 - Average heated area is increasing
 - Water use per ft² of heated area is increasing
 - At the State level, approximately 250 parcels are built each year



Future Work

- Expand the analysis to include end uses of the more important FDOR categories



Maddaus. (2004). "Evaluating Water Conservation Cost-Effectiveness with an End Use Model"

Conclusions

- The availability of the FDOR database provides a major improvement in our ability to estimate and project CII water use
- The Conserve Florida Water Clearinghouse (www.conservefloridawater.org) is developing these water use coefficients and heated area statistics and will make them available to interested utilities
- These coefficients should provide good estimates for CII users outside of Florida except where landscape irrigation is a significant component of water use
- FDOR land use codes can be mapped to SIC or NAICS
- Heated area as measure of size allows for application to other property appraiser databases outside the State of Florida

Questions?
Comments?
Suggestions?