

ESTIMATING WATER END- USE DEVICES IN THE COMMERCIAL AND INSTITUTIONAL SECTORS

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**Miguel A. Morales, Kenneth R. Friedman,
and James P. Heaney**

Department of Environmental Engineering

University of Florida

Gainesville, FL



Introduction

- A true benefit-cost analysis of water conservation best management practices (BMPs) requires:
 - End use inventory of water using devices
 - Their water use efficiency
 - Their frequency of use

Literature Review

- Past studies regarding commercial and institutional (CI) water use have focused on:
 - Aggregate subsector water use
 - General “percentage” end-use break downs
 - Macro “utility-wide” methodologies for estimating conservation potential
 - Pre-selected subsectors

Scope of this Study

- Study presents a methodology to estimate:
 - CI Restroom water use
 - Estimates on number of restroom fixtures,
 - Their water use efficiency, and
 - Frequency of use at the parcel level
 - CI water use attributable to sprinkler systems
 - Subsector-specific water use coefficients
- Allows cost and water saving data to be incorporated into the BMP optimization model that is part of EZ Guide

Data-driven Approach

- Florida Department of Revenue (FDOR) provides:
 - Land use code,
 - Effective year built, and
 - Building and parcel area for all 9 million parcels in Florida
- FDOR serves as the foundation database for EZ Guide
 - Relationships for residential indoor and outdoor, and CI aggregate water use have already been developed

Restroom End Uses – Fixture Count

- Based on Florida plumbing and building code
- FL plumbing code
 - Provides minimum toilet, faucet, and shower fixture requirements for 24 building types
 - Coefficients in terms of building occupancy
- FL building code
 - Provides conversion from occupancy to square footage for 42 building types

Restroom End Uses – Fixture Count

- By linking the FDOR land use codes to FL plumbing and building code categories
 - Fixture count estimates per square foot of heated building area were developed
 - Allows for fixture estimates at the parcel level
 - Minimum of two toilets and faucets per building
 - For urinals: FL plumbing code states that a maximum of 50-67% of male toilets are replaceable by urinals

Restroom End Uses – Frequency of Use

- Restroom frequency of use driven by people
 - By estimating how many, and for how long, people are in a building, one can estimate frequency of use
 - Estimate is complicated since CI facilities have arrival and departure rates that vary widely
- Solution: use functional population
 - Defined as a building's population normalized to 24 hours per day, and 7 days per week
 - Derived from transportation modeling statistics on employment, visitor trips, and length of stay
 - Coefficients from impact fee studies specific to Florida
 - Can be mapped to FDOR

Restroom End Uses – Frequency of Use

- Functional population allows for the application of generic human frequency of restroom use estimates
- Mayer et al. (1999) gathered data indicating that the average person in a single family residence flushes a toilet 5.1 times per day
 - 24-hour equivalent = 7.65 flushes per person per day

	Male	Female
Toilet (flushes/person/day)	2.52	7.56
Urinal (flushes/person/day)	5.04	0
Faucet (minutes/person/day)	12.15	12.15
Shower (minutes/person/day)	5.6	5.6

Restroom End Uses – Fixture Efficiency

- Florida's plumbing code mandates water use efficiencies, provides historical information
- A fixture's efficiency is thus a function of a building's year built and a fixture's replacement rate
- Replacement rate based on 20 year service life for toilets and urinals; 5 year service life for faucets and showerheads (Santa Clara Valley Water District 2008)

Fixture Efficiency Group	Toilets (gal/flush)	Urinals (gal/flush)	Faucets (gal/min)	Showerheads (gal/min)
Pre 1983	5.0	3.0	3.3	4.3
1983-1994	3.5	1.6	1.8	2.0
1995-2008	1.6	1.0	1.0	1.7

Estimating Restroom Fixture Water Use

Functional population

Frequency of fixture use

Fixture efficiency

Fixture count

$$\left(\frac{\text{functional population}}{\text{ft}^2} \right) \left(\frac{\text{uses}}{\text{person} * \text{day}} \right) \left(\frac{\text{gallons}}{\text{use}} \right) \left(\frac{\text{ft}^2}{\text{fixtures}} \right) = \frac{\text{gallons}}{\text{fixture} * \text{day}}$$

From FL-specific impact fee studies

From national studies on residential frequency of use

From FL plumbing and building codes

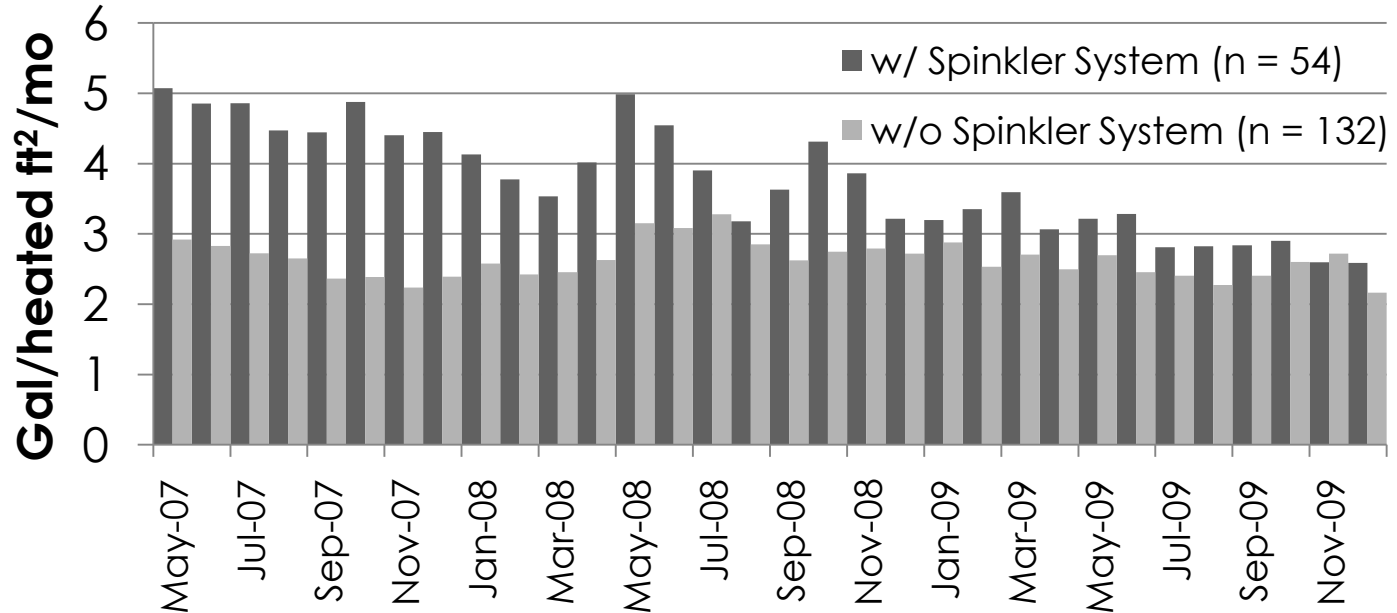


Sprinkler System Water Use

- Gainesville Regional Utilities (GRU) provided water billing data for 738 parcels, representing the ten largest commercial subsectors of water use
- Alachua County Property Appraiser (ACPA) data, which identifies accounts with sprinkler systems
- Water billing time series information for the top ten commercial subsectors can thus be split into parcels with and without sprinkler systems

Sprinkler System Water Use

- Water billing time series information normalized by heated square footage for the 186 one-story office buildings in GRU:



Sprinkler System Water Use - Coefficient Calculation

- Average water use coefficients normalized by heated area are determined for FDOR parcels with sprinkler systems and those without via GRU billing, and associated ACPA data :

$$AWU = \left[\sum_{i=1} Q_i / \sum_{i=1} HA_i \right]$$

Where:

AWU = average weighted water use coefficient (monthly gallons/heated ft²)

Q_i = average monthly water use of parcel i (gallons/month)

HA_i = heated square footage of all buildings on parcel i (ft²)

Sprinkler System Water Use - Coefficient Calculation

- Similar to AWU, the base weighted water use coefficients (BWU) can be calculated using the total sector minimum water use month
- The seasonal water use (SWU) coefficient is then obtained by subtracting the base water use (BWU) coefficient from the average water use (AWU)
- The difference between the sprinkler and non-sprinkler seasonal water use coefficients is taken to be water use attributable to sprinkler systems

$$WU_{sprk} = SWU_{ws} - SWU_{wos}$$

Sprinkler System Water Use

- Methodology is directly dependent on the hydrograph signature of sprinkler and non-sprinkler parcels in each subsector analyzed
- Unlike the residential sector, the CI subsectors are often prone to other seasonal drivers besides irrigation
- By taking into account the seasonality associated with the non-sprinkler parcels, this better ensures that other seasonal components are not included

Sprinkler System Water Use Coefficients

F D O R	Description	Sample size	% of total	Avg. water use (gal/ft²/mo)	Seasonal water use (gal/ft²/mo)	Water use attributable to sprinkler systems (gal/ft²/mo)	% water use attributable to sprinkler systems	% of parcel area irrigated
11	Stores, One-Story	137	18%	6.23	1.20	0.87	14%	10%
16	Community Shopping Centers	71	34%	1.62	0.27	0.00	0%	0%
17	Office, One-Story	186	29%	3.92	0.75	0.39	10%	5%
18	Office, Multi-Story	28	71%	1.82	0.57	0.39	21%	5%
19	Medical Office	115	50%	6.94	1.31	0.86	12%	14%
21	Restaurant	41	39%	23.65	1.70	0.29	1%	3%
22	Fast-Food Restaurants	41	59%	23.16	2.09	0.61	3%	4%
39	Hotels / Motels	37	30%	7.52	1.15	0.12	2%	3%

Prevalence of Sprinkler Systems

- Parcels with sprinkler systems only make up a fraction of the total parcels within a given subsector
- This percentage of parcels with sprinkler systems largely influences the relative subsector importance of this end-use device

FDOR	Sample size			Average heated area (ft ²)			% with sprinkler systems		
	Pre 1983	1983-1994	1995-2008	Pre 1983	1983-1994	1995-2008	Pre 1983	1983-1994	1995-2008
11	68	40	28	4,985	6,812	13,211	7%	18%	46%
16	28	27	15	27,820	46,600	48,637	7%	44%	67%
17	98	47	41	5,414	7,865	9,351	14%	36%	56%
18	9	15	4	32,352	13,742	26,306	67%	67%	100%
19	31	33	51	8,108	10,021	8,631	45%	58%	47%
21	18	12	11	3,645	5,544	6,424	6%	58%	73%
22	10	19	11	2,402	2,682	2,903	30%	68%	64%
39	19	12	5	21,489	27,723	67,026	16%	42%	60%
weighted avg.				9,174	13,277	13,749	17%	44%	58%

BMP Evaluations

- Water use and end-use device estimates, along with economic data on total cost of retrofits and water, allow for evaluation of water conservation BMPs
- Cost-effectiveness of a retrofit will increase the less water efficient an existing end-use device is, and with increased use of the device
- With this methodology, and heated area and effective year built (from FDOR)
 - Water use per end use device can be calculated
 - BMPs evaluated for cost effectiveness.

Conclusions and Future Work

- This methodology allows for the evaluation of water conservation BMPs for cost-effectiveness for CI restroom fixtures and sprinkler systems
- Future work in this area should:
 - Validate the use of minimum fixture requirements by using survey data
 - Increase sample sizes across the CI subsectors
 - Expanded to include other end uses such as cooling towers, hotel/motel clothes washers, and restaurant spray valves

QUESTIONS?
COMMENTS?
SUGGESTIONS?