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

FSAWWA Fall Conference, November 29, 2010

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

Department of Environmental Engineering

University of Florida

Gainesville, FL

UF | Environmental Engineering Sciences

Conserve Florida Water Clearinghouse

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

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

From FL-specific impact fee studies

From national studies on residential frequency of use

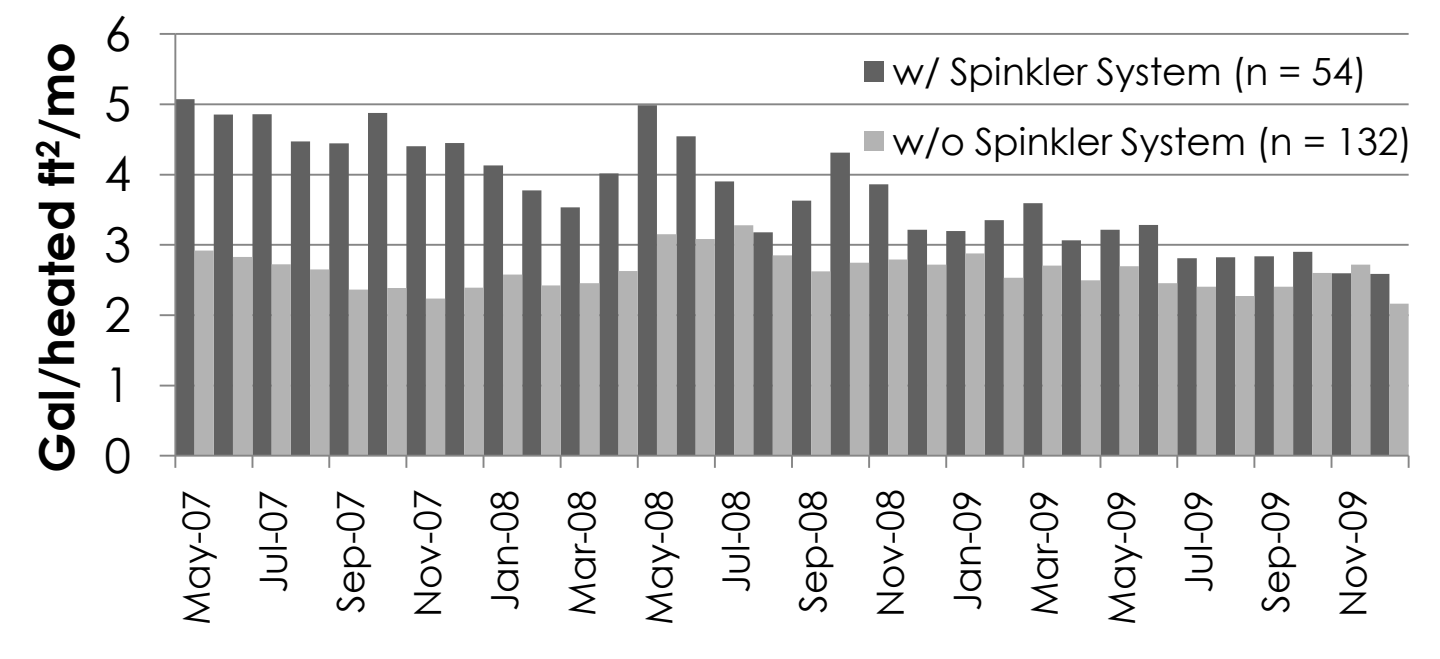
From FL plumbing and building codes

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 :

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

Where:

AWU = average weighted water use coefficient (monthly gallons/heated ft^2)

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

HAi = heated square footage of all buildings on parcel i (ft^2)

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

FDOR	Description	Sample size	% of total	Avg. water use (gal/ft^2/mo)	Seasonal water use (gal/ft^2/mo)	Water use attributable to sprinkler systems (gal/ft^2/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

	Sample size			Average heated area (ft^2)			% with sprinkler systems		
FDOR	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?