Optimal Integration of Outdoor Water Use Management With Other Options

James Heaney and Miguel Morales
U. of Florida

Ken Friedman
Northwest Florida Water Management District

Urban Water Demand Workshop
Arizona State University
February 2015
Urban Water Systems Team (2007-15)

- Engineering School for Sustainable Infrastructure and the Environment, U. of Florida
- Hope to graduate 4 PhDs in this area
Acknowledgement of Support

conservefloridawater.org

NEW: EZ GUIDE 2.0
A WATER CONSERVATION AND PLANNING TOOL

This new tool is pre-populated for the utilities using water production, property appraiser, and census data. Check the new features of EZ Guide 2.0
Relevant papers on outdoor water use and integrated optimization


History of CFWC and EZ Guide


• In March 2006, the University of Florida was selected to house, manage, and expand the operation and functions of the Conserve Florida Water Clearinghouse (CFWC).

• The CFWC developed EZ Guide, a web-based tool to allow any utility in the state to evaluate current water use, project future water use, and prioritize water conservation practices based on cost-effectiveness.
EZ Guide methodology

Results

• Parcel-level estimates of:
  • Fixture inventory (number & efficiency)
  • Fixture water use (frequency of use & efficiency)
  • Cost-effectiveness of implementable water conservation options

• Target customers and BMPs to optimize utility and customer objectives

Land, building, and economic information on each of the 9 million parcels in the state of Florida
Bottom-up approach

Total Parcels
8,807,768

Parcels Alachua
99,305

Total Parcels GRU
55,551

SFR parcels GRU
30,910
Optimal urban water demand management methodology-indoor example

Market segmentation of toilet usage

<table>
<thead>
<tr>
<th>Current Fixture Group</th>
<th>Toilets / house</th>
<th>Existing Fixtures</th>
<th>Existing Gal./toilet/ day</th>
<th>Retrofitted Gal./toilet/ day</th>
<th>Water Savings Gal./toilet/ day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre 1983</td>
<td>1</td>
<td>17</td>
<td>88.44</td>
<td>13.85</td>
<td>74.59</td>
</tr>
<tr>
<td>Pre 1983</td>
<td>2</td>
<td>6,246</td>
<td>44.22</td>
<td>6.93</td>
<td>37.30</td>
</tr>
<tr>
<td>Pre 1983</td>
<td>3</td>
<td>1,302</td>
<td>29.48</td>
<td>4.62</td>
<td>24.86</td>
</tr>
<tr>
<td>Pre 1983</td>
<td>4</td>
<td>4</td>
<td>22.11</td>
<td>3.46</td>
<td>18.65</td>
</tr>
<tr>
<td>1983-1994</td>
<td>1</td>
<td>93</td>
<td>62.54</td>
<td>13.85</td>
<td>48.68</td>
</tr>
<tr>
<td>1983-1994</td>
<td>2</td>
<td>1,944</td>
<td>31.27</td>
<td>6.93</td>
<td>24.34</td>
</tr>
<tr>
<td>1983-1994</td>
<td>4</td>
<td>103</td>
<td>15.63</td>
<td>3.46</td>
<td>12.17</td>
</tr>
<tr>
<td>1995-2008</td>
<td>1</td>
<td>30</td>
<td>29.29</td>
<td>13.85</td>
<td>15.44</td>
</tr>
<tr>
<td>1995-2008</td>
<td>2</td>
<td>3,006</td>
<td>14.65</td>
<td>6.93</td>
<td>7.72</td>
</tr>
<tr>
<td>1995-2008</td>
<td>3</td>
<td>171</td>
<td>9.76</td>
<td>4.62</td>
<td>5.15</td>
</tr>
<tr>
<td>1995-2008</td>
<td>4</td>
<td>36</td>
<td>7.32</td>
<td>3.46</td>
<td>3.86</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15,331</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Savings = current usage - usage if 0.8gpf toilet installed

Calibrated Water Budget By Sector

- Single Family – Indoor
- Single Family – Outdoor
- Multi-Family
- Commercial
- Industrial
- Institutional
- Unaccounted

Optimal urban water demand management methodology-indoor example
EZ Guide results

- Water budget section estimates water use at the parcel level and allows for calibration to known water supply
- Provides segmentation on water demand and population served

### Water Use Summary By Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>% Water Use</th>
<th>Residential GPCD</th>
<th>Gross GPCD</th>
<th>Population</th>
<th>% Total Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family</td>
<td>61.8%</td>
<td>97</td>
<td>81</td>
<td>91,147</td>
<td>83%</td>
</tr>
<tr>
<td>Single Family - Indoor</td>
<td>42.7%</td>
<td>67</td>
<td>56</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Single Family - Outdoor</td>
<td>19.1%</td>
<td>30</td>
<td>25</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>9.6%</td>
<td>73</td>
<td>13</td>
<td>18,841</td>
<td>17%</td>
</tr>
<tr>
<td>CII</td>
<td>13.6%</td>
<td>--</td>
<td>18</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Commercial</td>
<td>9.9%</td>
<td>--</td>
<td>13</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Industrial</td>
<td>1.5%</td>
<td>--</td>
<td>2</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Institutional</td>
<td>2.2%</td>
<td>--</td>
<td>3</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Unaccounted</td>
<td>15.0%</td>
<td>--</td>
<td>20</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
<td>--</td>
<td>131</td>
<td>109,988</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Conservation BMP Cost Effectiveness

#### Graph: Conservation BMP Cost Effectiveness

- **BMP Cost**
- **Water Savings**

- **Parcel-level estimates of current water use by fixtures**
- **Refined estimates of water savings associated with BMPs + Cost data**
- **Cost-effectiveness evaluations of BMPs at fine spatial scale**
Optimal blend of demand management across all 64 sectors

- Dual variable to minimum cost solution is marginal cost of water savings
- Methodology has been extended to include demand management across all 64 sectors
  - Most studies just focus on residential indoor uses
- Identity of parcel level water savings maintained throughout analysis
  - Allows for spatial clustering
Optimal solution for the residential irrigation sector
Single family residential housing trends in Gainesville Florida for about 31,000 parcels
Friedman et al. 2013

- Significant increase in homes with automatic sprinklers from 10% of new homes in 1982 to about 90% of new homes at present
- Increase in irrigable area from 10,000 sf in 1960 to 15,000 sf in 1980
- Decline in irrigable area after 1980 to about 8,000 sf at present
- Overall, about 27% of homes have irrigation systems at present
1,402 irrigation systems have significant outdoor water use as compared with 29,501 single meter accounts
Friedman et al. 2013

- 1,402 dual metered homes with irrigation systems average about 400 gpad outdoor and 200 gpad indoor
- Peak outdoor usage of about 750 gpad in April and May
Irrigable areas and annual application rates for 16,303 irrigators in Gainesville
Friedman et al. 2013

- Horizontal red line denotes a benchmark application rate of 25 inches/yr.
- Want to target “overirrigators”
- Isoquants of outdoor water use are shown
Water savings potential for benchmarks of 1, 25, and 40 in./yr.
Friedman et al. 2013

FIGURE 7  Comparison of savings potential for varying maximum application rates for Gainesville Regional (Fla.) Utilities irrigators

Exponential fit:
- $y = 3,607,911 (1 - e^{-0.000231x})$, $R^2 = 0.9828$
- $y = 440,119 (1 - e^{-0.000187x})$, $R^2 = 0.9980$
- $y = 144,119 (1 - e^{-0.000302x})$, $R^2 = 0.9983$
Normalized irrigation water savings distributions
Friedman et al. 2014a

• Fitted irrigation water usage distributions can be transformed into normalized water savings production functions

• Results: both exponential and lognormal distributions work well, with the bivariate lognormal performing slightly better than bivariate exponential

• This approach provides a generalized theory which can be utilized in absence of direct data
Finding optimal % of irrigators to target
Friedman et al. 2014b

Figure 2. Normalized cumulative savings from soil moisture sensor retrofits and associated benefit-cost objective function for 2,746 eligible irrigators currently above 63.5 cm/yr.
Summary and conclusions

• Bottom-up, process-oriented, approach evaluates conservation options at the parcel scale.

• In Florida, the basic parcel level information is available from public sources for 9 residential and 55 CII sectors.

• Outdoor water use is a major concern because of the growing popularity of in-ground sprinkling systems. The impact of this growth is partially offset by the trend towards smaller irrigable areas.

• EZ Guide can provide a high quality estimate of the end use of water for any utility in Florida. The same methods can be applied elsewhere if property appraiser and related data are available.

• Best mix of BMPs for a given incremental cost can be found using this extensive data and associated analytical techniques.

• Our current research is focused on the impact of pricing on outdoor water use.
More Information?

www.conservefloridawater.org