This presentation premiered at WaterSmart Innovations

watersmartinnovations.com
Estimating and Integrating Irrigation Efficiency Potential into Implementation Strategies

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Overview

Study area and objectives

Data collection

Analytical methods and findings

Conclusions and next steps
Tampa Bay Water

Regional water supply authority

2.5 million customers

6 member governments, across three counties

Experiencing growth, but susceptible to swings in economy
Tampa Bay Water’s Demand Management Planning

Historical planning and coordination role

- Regional Demand Database
- Demand Management Plan
- Evaluate Existing Programs
- Quantify Potential
Tampa Bay Water’s Demand Management Planning

2018 DMP Update includes evaluation of program implementation strategies

• Potential to reduce capacity development needs
• First linkage between DMP and how it gets implemented
• Includes outdoor programs
Current objectives related to landscape irrigation

- Identify customers using excess amounts of water
  - Estimated irrigation use versus “requirements”
  - Potential numbers of customers and quantities of water
  - Relationship to customer attributes and small geographic areas (parcels, developments, neighborhoods)

Implementation Focus

- How Much Water?
- How Many Customers?
- Where They Reside?
- Descriptive Profile?
# Programmatic options and criteria selected in 2018 DMP

<table>
<thead>
<tr>
<th>Program Option</th>
<th>Targets</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative Water Sources</td>
<td>“Surplus Irrigators” + Upper Quartile of “Deficit Irrigators”</td>
<td>Shallow wells</td>
</tr>
<tr>
<td>Florida Water Star</td>
<td>New Homes</td>
<td>New home certification program</td>
</tr>
<tr>
<td>Soil Moisture Sensors or ET Controllers</td>
<td>Existing Homes (with New Homes Option)</td>
<td>Watering technology</td>
</tr>
</tbody>
</table>
Information Needs

To estimate deficit/surplus irrigation
✓ Potable water consumption
✓ Irrigable area
✓ Theoretical irrigation requirements

To evaluate program targeting (and for analytics)
✓ Geographic locations
✓ Socioeconomic and property attributes
LTDFS Database

Long Term Demand Forecasting System database assembled and maintained for modeling

- Water Use
  - Consumption time series

- Appraiser Data
  - Property attributes

- Census
  - Assignable socioeconomics

- Climatic
  - Weather Obs

Hazen
Water Use Metrics Analyzed

Multi-year averages for each Single-Family location:

- Annual water use
- “Minimum month” use → Annual seasonal use
- High season average (April, May, June)
Theoretical Requirements

The equation for landscape water requirement (LWR) is given by:

\[ LWR = RTM \times \left[ (ET_o \times K_L) - (R_{CT} \times R_{pe}) \right] \times A \times C_u \]

Where:

- \( LWR \) = Landscape water requirement (gpy)
- \( RTM \) = Run-time multiplier (inverse of irrigation efficiency)
- \( ET_o \) = Reference evapotranspiration in inches per year
- \( K_L \) = Landscape coefficient for the dominant plant type
- \( R_{CT} \) = Census Tract precipitation in inches per year
- \( R_{pe} \) = Percent effective precipitation
- \( A \) = Greenspace estimate in square feet
- \( C_u \) = Conversion factor to express \( LWR \) in gpy

- Major assumptions taken from University of Florida research on turf-grass
- Precipitation estimates assigned by parcel according to Census Tract weather contour
Socioeconomic and property attributes for each location

- Total versus pervious area
- Home size (heated area)
- Assessed value (property, land, building)
- Year built and effective age
- Median income (block group assignment)
- Presence of pools
- Presence of devoted irrigation meters
- Access to reclaimed water source
**Mean Consumption Metrics by Group (gallons per unit per day)**

<table>
<thead>
<tr>
<th>“Seasonal” Use</th>
<th>April, May, June</th>
<th>Annual</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation Meter &amp; Pool</td>
<td>621 gpud</td>
<td>537 gpud</td>
<td>292 gpud</td>
</tr>
<tr>
<td>Irrigation Meter Only</td>
<td>397 gpud</td>
<td>348 gpud</td>
<td>184 gpud</td>
</tr>
<tr>
<td>Pool Only</td>
<td>293 gpud</td>
<td>258 gpud</td>
<td>146 gpud</td>
</tr>
<tr>
<td>No Pool and No Irrigation Meter</td>
<td>189 gpud</td>
<td>174 gpud</td>
<td>105 gpud</td>
</tr>
</tbody>
</table>

Progressively lower seasonal peaking and minimum month use.
Effect of Reclaimed Water Access

Mean Consumption Metrics - No Irrigation Meter No Pool Group
(gallons per unit per day)

- No Reclaimed
- Reclaimed Access

Homes with access to reclaimed water use less water through the potable connection.

Seasonal signal even with alternative source?

Evidence of year-round irrigation.
Generalized Process for Evaluating Surplus Irrigation

Requirements Ratio = \( RR = \frac{\text{Estimated Seasonal Use}}{\text{Theoretical Requirements}} \)

\( RR > 1 \) defines “Surplus Irrigator”
## Criteria for Identifying Irrigators

<table>
<thead>
<tr>
<th>Effort</th>
<th>Definition of “Irrigators”</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous DMP</td>
<td>Locations using &gt; 177 gpud annually</td>
<td>Covers high water users</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misses substantial number of small households</td>
</tr>
<tr>
<td>2018 DMP</td>
<td>Locations with high season use &gt; 1.1 times annual average use</td>
<td>Captures more households on low use spectrum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misses consistently high year-round users</td>
</tr>
<tr>
<td>Latest option (2018 DMP supplement)</td>
<td>No “irrigator” criteria used to screen</td>
<td>More inclusive by design</td>
</tr>
</tbody>
</table>
Estimated Proportions of Deficit/Surplus Irrigation
(Single-Family Locations without Reclaimed Water)

Requirements Ratio = \( \frac{\text{Estimated Seasonal Use}}{\text{Theoretical Requirements}} \)

Deficit: 86%
Surplus: 14%
Estimated Proportions of Deficit/Surplus Irrigation (Single-Family Locations without Reclaimed Water)

Upper Quartile Deficit + Surplus

\[ \sim 36\% \]
Proportion of Sample Groups Exceeding Estimated Watering Requirements
(Single Family without Reclaimed Access)

Irrigation Meter Only: 41.2% (n = 1,359)
Irrigation Meter & Pool: 39.7% (n = 1,027)
Pool Only: 16.3% (n = 14,630)
No Pool and No Irrigation Meter: 12.8% (n = 33,748)
Proportion of Estimated Total "Surplus" Water Use by Group (No Reclaimed Access)

- Irrigation Meter Only: 3.4%
- Irrigation Meter & Pool: 3.3%
- Pool Only: 34.2%
- No Pool and No Irrigation Meter: 62.5%
20% of Locations → 54% of surplus
or
10,153 locations → 2.5 MGD

5% of Locations → 22% of surplus
or
2,539 locations → 1 MGD

0.1% of Locations → 2% of surplus
Mean surplus = 1,763 gpd
Estimated Surplus by Range of Requirements Ratio

<table>
<thead>
<tr>
<th>Requirements Ratio</th>
<th>Number of Locations</th>
<th>Cumulative Surplus (MGD)</th>
<th>Marginal Surplus (MGD)</th>
<th>Estimated Surplus (gpud)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1.25</td>
<td>12,903</td>
<td>0.2</td>
<td>0.2</td>
<td>19</td>
</tr>
<tr>
<td>1.26 to 1.50</td>
<td>8,651</td>
<td>0.7</td>
<td>0.5</td>
<td>53</td>
</tr>
<tr>
<td>1.51 to 2.00</td>
<td>10,375</td>
<td>1.6</td>
<td>0.9</td>
<td>88</td>
</tr>
<tr>
<td>2.01 to 3.00</td>
<td>9,062</td>
<td>2.8</td>
<td>1.2</td>
<td>132</td>
</tr>
<tr>
<td>3.01 to 4.00</td>
<td>3,585</td>
<td>3.4</td>
<td>0.6</td>
<td>160</td>
</tr>
<tr>
<td>4.01 to 5.00</td>
<td>1,900</td>
<td>3.7</td>
<td>0.3</td>
<td>179</td>
</tr>
<tr>
<td>5.01 to 6.00</td>
<td>1,075</td>
<td>3.9</td>
<td>0.2</td>
<td>192</td>
</tr>
<tr>
<td>6.01 to 7.00</td>
<td>647</td>
<td>4.1</td>
<td>0.1</td>
<td>192</td>
</tr>
<tr>
<td>7.01 to 8.00</td>
<td>438</td>
<td>4.2</td>
<td>0.1</td>
<td>188</td>
</tr>
<tr>
<td>8.01 to 9.00</td>
<td>365</td>
<td>4.2</td>
<td>0.1</td>
<td>205</td>
</tr>
<tr>
<td>9.01 to 10.00</td>
<td>253</td>
<td>4.3</td>
<td>0.1</td>
<td>227</td>
</tr>
<tr>
<td>&gt;10.00</td>
<td>1,510</td>
<td>4.6</td>
<td>0.3</td>
<td>220</td>
</tr>
</tbody>
</table>

Possibility to target majority of surplus, while reducing risk of imprecision in estimates
Proportion Exceeding Estimated Watering Requirements by Water Demand Planning Area (No Reclaimed Access)

- South Central Hillsborough Co.: 26.7%
- Northwest Hillsborough Co.: 24.5%
- City of Tampa: 14.8%
- Pasco Co.: 12.2%
- New Port Richey: 1.5%
- Pinellas Co.: 1.4%
- St. Petersburg: 0.4%
All Identified as Surplus

Ability to define neighborhoods and HOAs

>10x Theoretical Requirements
Explanatory Factors: Median Income

Surplus Irrigators tend to live in higher income areas

<table>
<thead>
<tr>
<th>Surplus_ID</th>
<th>N Obs</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>308,039</td>
<td>55,559</td>
<td>51,524</td>
</tr>
<tr>
<td>1</td>
<td>50,764</td>
<td>70,778</td>
<td>68,083</td>
</tr>
</tbody>
</table>
Explanatory Factors: Heated Area

Surplus Irrigators tend to live in larger homes

<table>
<thead>
<tr>
<th>Surplus_ID</th>
<th>N Obs</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>308,039</td>
<td>2,257</td>
<td>2,045</td>
</tr>
<tr>
<td>1</td>
<td>50,764</td>
<td>3,679</td>
<td>3,724</td>
</tr>
</tbody>
</table>
### Explanatory Factors: Effective Age of SF Home

**Surplus Irrigators tend to live in newer homes**

<table>
<thead>
<tr>
<th>Surplus_ID</th>
<th>N Obs</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>308,039</td>
<td>27.26</td>
<td>27.00</td>
</tr>
<tr>
<td>1</td>
<td>50,764</td>
<td>13.54</td>
<td>11.00</td>
</tr>
</tbody>
</table>
Proportion Exceeding Estimated Watering Requirements by Effective Age Cohort
(Single Family without Reclaimed Access)

Effective Age in Years

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6</td>
<td>56.4%</td>
</tr>
<tr>
<td>6 to 10</td>
<td>43.4%</td>
</tr>
<tr>
<td>11 to 15</td>
<td>26.7%</td>
</tr>
<tr>
<td>16 to 20</td>
<td>12.5%</td>
</tr>
<tr>
<td>21 to 30</td>
<td>5.5%</td>
</tr>
<tr>
<td>31 to 40</td>
<td>2.5%</td>
</tr>
<tr>
<td>41 to 50</td>
<td>2.7%</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

Proportion “Surplus” Decreases with Home Age
Predictive Analytics Framework

Statistical model that predicts likelihood of being a surplus irrigator

Statistical controls:
✓ Pervious area (-)
✓ Median income (+)
✓ Heated area (+)
✓ Effective age (-)
✓ Presence of pool (+)
✓ Presence of irrigation meter (+)
Example of predicted probabilities of being a Surplus Irrigator

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Hypothetical Property</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Effective age</td>
<td>2</td>
</tr>
<tr>
<td>Median income</td>
<td>200,000</td>
</tr>
<tr>
<td>Heated area</td>
<td>3000</td>
</tr>
<tr>
<td>Pervious area</td>
<td>1000</td>
</tr>
<tr>
<td>Pool (0/1)</td>
<td>1</td>
</tr>
<tr>
<td>Irrigation meter (0/1)</td>
<td>1</td>
</tr>
<tr>
<td>Prob(Surplus)</td>
<td>0.96</td>
</tr>
</tbody>
</table>
Conclusions

• About half of Agency’s demand management goal could be met by eliminating surplus irrigation
  • Program participation rates likely to reduce savings below estimated potential

• Savings potential identifiable geographically and by quantity thresholds
  • Objective is to refine targets to maximize B/C ratio
  • Focus on more extreme cases to address uncertainties in calculations
Conclusions

• Generalized attributes of program targets provides program focus
  
  • Relatively new, larger homes, on relatively smaller lots in higher income areas
  
  • Accounting for influence of other factors, surplus use may decrease with time without changing sources or technologies
Next Steps - Implementation

Design implementation plan(s) focused on:

1. New Homes - offer Florida Water Star funds to facilitate paradigm shift in the new home market
2. Existing homes - provide Alternative Source incentives to surplus irrigators and the upper quartile of deficit irrigators
3. Existing homes – promote Soil Moisture Sensors and ET Controller installation where Alternative Sources (shallow wells) are precluded
Next Steps - Analytics

• Continue data updates and model refinements
  • Extend data to capture more historical time periods up to current data
  • Update and integrate predictive model within GIS
  • Once programs are implemented, incorporate and model attributes of program participants
  • Perform a pilot application of the model to assess tangible benefits for optimizing costs/value of implementation
Thank you!

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