Irrigation Efficiency Research Update

Tampa Bay Water
Conservation Coordination Committee
May 14, 2014
Clearwater, FL

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Presentation Highlights

• Background
• Existing research and results
• Where to get existing information
• Future research/application issues
UF/IFAS Center for Landscape Conservation and Ecology

• Mission
  – To protect and conserve Florida's natural resources through research-based sustainable urban landscape practices.

• Vision
  – To be the leading source of science-based information on horticulture and the urban environment in Florida.
Irrigation Efficiency:
Design/maint. + Management

Soil Below Root Zone

- Adequate irrigation
  - Non-uniformity (100% uniformity not practical)
- Over irrigation
- Under irrigated
Irrigation Requirements

- Irrig Water Req - Turf 8 inch RZ
- Precip
- ETc

1” = 623 gal/1,000 sq ft

Turfgrass Annual Water Req.

N FL, 33 inches/yr
S FL, 43 inches/yr

=3,700 gal/1,000 sq ft
Irrigation Publications

Some of these publications are PDFs, and requires the free Adobe Acrobat Reader view/print.

- Dr. Dukes' publications in EDIS
- All EDIS publications on irrigation

Dr. Dukes' group peer-reviewed journal articles

<table>
<thead>
<tr>
<th>Year</th>
<th>Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
</tr>
</tbody>
</table>

2012


Soil Moisture Sensor (SMS) controllers

- B187, original SMS project
- B252, SMS reclaimed water project
- Industry
- EPA WaterSense
Soil Moisture Sensor Controller
B187 Phase I, SMS evaluation

- Plot testing, Gainesville, bermudagrass
- 4 SMS brands
- 1, 2, 7 d/wk frequency
Gainesville Plots
Gainesville Plots Dry Period
Overall Results

- **SMS**
  - ~70% savings during normal-wet rainfall
  - ~50% savings during dry conditions
- **Savings while maintaining turf quality**
B187 Phase II, SMS evaluation on homes

- Palm Harbor area homes targeted
- Irrigation audits performed
- 58 homes
  - SMS (soil moisture sensor)
  - EDU (education)
  - RS (rain sensor)
  - MO (monitoring only)
Experimental Treatments

1. Monitoring only

2. Current irrigation system plus rain sensor (1/4” setting)

3. Current irrigation system plus rain sensor and educational materials

4. Current irrigation system plus a soil moisture sensor
Precipitation, Nov 06 – Nov 08
Monthly Effective Precipitation (inches)

Irrigation Application (inches)

- Effective Rainfall
- SMS
- EDU+RS
- RS
- WOS

Rain sensor: (54 in)
Meter only: (62 in)
Rain sensor + edu.: (34 in)
Soil moisture sensor: (22 in)

65%
<table>
<thead>
<tr>
<th>Treatment&lt;sup&gt;R&lt;/sup&gt;</th>
<th>I&lt;sub&gt;actual&lt;/sub&gt;&lt;sup&gt;Z&lt;/sup&gt;</th>
<th>N&lt;sup&gt;Y&lt;/sup&gt;</th>
<th>Max</th>
<th>Min</th>
<th>Median</th>
<th>Std Dev</th>
<th>I&lt;sub&gt;gross&lt;/sub&gt;&lt;sup&gt;T&lt;/sup&gt;</th>
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<tbody>
<tr>
<td>SMS</td>
<td>2.3b&lt;sup&gt;Q&lt;/sup&gt;</td>
<td>191</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>3.4</td>
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<td>RS</td>
<td>5.7a</td>
<td>203</td>
<td>22</td>
<td>0</td>
<td>4</td>
<td>7.1</td>
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<td>MO</td>
<td>6.0a</td>
<td>182</td>
<td>29</td>
<td>0</td>
<td>4</td>
<td>7.8</td>
<td>4</td>
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<td>EDU</td>
<td>4.5ab</td>
<td>196</td>
<td>20</td>
<td>0</td>
<td>3</td>
<td>6.3</td>
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<tr>
<td>Treatment&lt;sup&gt;R&lt;/sup&gt;</td>
<td>I&lt;sub&gt;actual&lt;/sub&gt;&lt;sup&gt;Z&lt;/sup&gt;</td>
<td>N&lt;sup&gt;Y&lt;/sup&gt;</td>
<td>Max</td>
<td>Min</td>
<td>Median</td>
<td>Std Dev</td>
<td>I&lt;sub&gt;gross&lt;/sub&gt;&lt;sup&gt;T&lt;/sup&gt;</td>
</tr>
<tr>
<td>Spring</td>
<td>6.6a</td>
<td>160</td>
<td>29</td>
<td>0</td>
<td>5</td>
<td>5.6</td>
<td>7</td>
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<tr>
<td>Summer</td>
<td>4.3b</td>
<td>177</td>
<td>26</td>
<td>0</td>
<td>2</td>
<td>5.0</td>
<td>4</td>
</tr>
<tr>
<td>Fall</td>
<td>3.8b</td>
<td>202</td>
<td>29</td>
<td>0</td>
<td>2</td>
<td>3.6</td>
<td>5</td>
</tr>
<tr>
<td>Winter</td>
<td>4.2b</td>
<td>233</td>
<td>29</td>
<td>0</td>
<td>3</td>
<td>4.7&lt;sup&gt;O&lt;/sup&gt;</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Uppercase superscript letters indicate footnotes.

<sup>Z</sup> Monthly average number of irrigation events applied.
<sup>Y</sup> N = number of observations in the comparison.
<sup>T</sup> Number of irrigation events per month, calculated from the SWB.
<sup>S</sup> Conversion: 1 inch = 25.4 mm
<sup>R</sup> Treatments are: SMS, time-based controller plus soil moisture sensor system; RS, time-based controller plus rain sensor; MO, time-based controller only; EDU, time-based controller plus rain sensor and educational materials.
<sup>Q</sup> Numbers followed by different letters are statistically different at the 95% confidence level within a year.
<sup>P</sup> Seasons defined as: spring, March, April, May; summer, June, July, August; fall, September, October, November; winter, December, January, February.
<sup>N</sup> AMRs installed during late Spring 2007.
<sup>O</sup> Winter of 2008 consisted of December 2008 and January 2009 only.
B252, SMS Controllers w/Reclaimed

• 64 homes in Palm Harbor
  – SMS (soil moisture sensor)
  – EDU (education)
  – RS (rain sensor)
  – MO (monitoring only)
B252, SMS Controllers w/Reclaimed
Rain Sensors (RS)

- B187, original SMS project
- B284, maximum deficit project
- B252, SMS reclaimed water project
- IA, Smart Water Application Technologies
Plot Based RS Performance, Rainy

- 2 d/wk
- WRS-with rain sensor
- DWRS-WRS & 40% irrigation reduction
- WORS-without sensor

Cumulative irrigation (mm)

Date (2006)

7/22 8/14 9/6 9/29 10/22 11/14 12/7

659 500 428

24%
Plot Based RS Performance, Dry

Cumulative irrigation (mm)

Date (2006)

2-WRS
2-DWRS
2-WORS


0 100 200 300 400 500 600 700

602
525
413

13%
**3-MC** (Mini Clik expanding disk RS)

- **Frequency of occurrences (%)**
- **Cumulative frequency of occurrences (%)**

**Interval of hours for dry-out period**

- 0-6: 8
- 6-12: 8
- 12-18: 32
- 18-24: 84
- 24-30: 93
- 30-36: 99
- 36-42: 100
- 42-48: 100

The graph shows the frequency and cumulative frequency of occurrences for different intervals of dry-out period.
Long Term (3+ yrs) Rain Sensor Testing
IA SWAT Rain Sensor Testing
RS Evaluation at Citra
RS Accuracy & Longevity

• Most are 50% - 70% accurate
• Ex. 0.25” set point triggers at 0.08 to 0.16”
• Accuracy changes -23% to 25% over 3 years
• Annual maint. required for best performance
Evapotranspiration (ET) Controllers

- Hillsborough Co. project
- EPA WaterSense
- Orange County Utilities, ongoing
ET Controllers

• Some can determine runtimes and days

• Programming is key!
  – Soil type
  – Plant type
  – Microclimate
  – Application rates
  – Slope
EPA WaterSense Protocol Evaluation
EPA WaterSense Protocol Evaluation
Assessing Smart Controllers

- **Surplus:** Irrigation exceeding water holding capacity
- **Deficit:** Lack of irrigation to meet plant needs
Turfgrass Water Requirements

- P424, Investigation of methods for permitting
- B284, Maximum turfgrass deficit
- B777, Turfgrass establishment
P424, Investigation of Methods for Permitting

- Determine turfgrasses well-watered ET
- Determine ET on representative ornamental species
- Determine mixed landscapes irrigation requirements/balancing quality
Mixed Landscapes ET

![Graph showing ET values for 2010 and 2011 with bars for different ETo values and line for rain.](image-url)
P424 Key Outcomes

• Irrigation with 75% ETo balanced quality with the least irrigation
• 75% ETo used 14% less irrigation than 90% ETo
• Can be used to update permitting methodology, likely reducing permitted irrigation
B284, Maximum Turfgrass Deficit

• Three cultivars
  – Floratam St. Augustine
  – Empire Zoysia
  – Captiva St. Augustine

• 10 irrigation levels
  – 2 d/wk w/o RS
  – ET
  – Reduced time
  – % wilt
  – No irrigation
Laying Sod
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
<th>Days wk$^{-1}$</th>
<th>Application (inches wk$^{-1}$)$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>IFAS recommended amount, WOS$^b$</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>T2</td>
<td>One half of IFAS recommended amount, WRS$^c$</td>
<td>1</td>
<td>up to 0.7</td>
</tr>
<tr>
<td>T3</td>
<td>IFAS recommend amount, WRS</td>
<td>2</td>
<td>up to 1.4</td>
</tr>
<tr>
<td>T4</td>
<td>Calculated amount relative to maximum daily average ET in June</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>T5</td>
<td>Turf canopy more 60 to 80% of plot wilted (NTR = 0.1)$^d$</td>
<td>any</td>
<td>as needed</td>
</tr>
<tr>
<td>T6</td>
<td>Turf canopy 30 to 50% wilted (NTR = 0.5)</td>
<td>any</td>
<td>as needed</td>
</tr>
<tr>
<td>T7</td>
<td>Turf canopy up to 30% wilted; first sign of wilt (NTR = 0.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T8</td>
<td>Turf canopy fully-wilted (1 to 3 days after NTR = 0.1)</td>
<td>any</td>
<td>as needed</td>
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<tr>
<td>T9</td>
<td>Non-irrigated after establishment</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>T10</td>
<td>Re-establishment irrigation applied only when stand death was deemed imminent</td>
<td>none</td>
<td>as needed</td>
</tr>
</tbody>
</table>
Turf Quality

- Bahiagrass
- St. Augustinegrass
- Zoysiagrass

Visual turf quality (Scale 1 to 9)

Date: 6/1/2011 to 12/1/2012
B777, Turfgrass Establishment

- Four cultivars
  - Floratam St. Augustine
  - Empire Zoysia
  - Captiva St. Augustine
  - Argentine Bahia

- Three establishment irrigation schedules
  - Immediate 2 or 1 d/wk
  - 15-15
  - 30-30

- Three plantings
  - Jan
  - Jul
  - Sept
Visual Quality Assessment

Empire Zoysiagrass

Quality Rating 3

Floratam St. Augustinegrass

Quality Rating 3

Captiva St. Augustinegrass

Quality Rating 3

Quality Rating 5

Quality Rating 7

Quality Rating 3

Quality Rating 5

Quality Rating 6.5

Quality Rating 3

Quality Rating 5

Quality Rating 6.5

Quality Rating 3

Quality Rating 5

Quality Rating 6.5
Sod Establishment Conclusions

- Bahiagrass – Increasing establishment irrigation did not increase long-term quality
- Captiva St. Augustinegrass – Higher quality on 30-30 or 15-15 in summer
- Floratam St. Augustinegrass – Higher quality on 30-30 or 15-15 in summer
- Empire Zoysiagrass – Highest quality 30-30 first summer
- 15-15 reduced irrigation vs. 30-30 → 26%Summer, 15%Fall, 36%Winter
Orange County Utilities SMS/ET demo

- Will smart controllers reduce irrigation on moderate to high use single family homes?
- What is effectiveness of ET vs. SMS controllers?
- Impact on landscape quality?
- Customers feelings about technology?
Selection of Excess Irrigators

Theoretical limit = 3 in month\(^{-1}\)

4 times theoretical limit = 12 in month\(^{-1}\)

1.5 times theoretical limit = 4.6 in month\(^{-1}\)

7,407 possible participants

Number of customers

Estimated irrigation (mm month\(^{-1}\))
### Site Evaluation

**IRRIGATION SYSTEM EVALUATION**

- **Address:**
- **Timer location:** Garage, Outside wall, Other: _____________
- **Original schedule:**
  - A) Start time(s):
  - Mon ___________ Tue ___________ Wed ___________ Thu ___________ Fri ___________ Sat ___________ Sun ___________
  - B) Start time(s):
  - Mon ___________ Tue ___________ Wed ___________ Thu ___________ Fri ___________ Sat ___________ Sun ___________
- **Rain sensor:** Location: Roofline, Not connected, Obstructed, Misplaced, Absent:

### Irrigation Zones (stations)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Location from the house</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td>1.</td>
<td>a. Front</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>b. Left</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>c. Center</td>
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<td>d. Right</td>
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<td>e. Back</td>
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<td>2.</td>
<td>Sun reaching the zone</td>
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<tr>
<td></td>
<td>b. Mostly sunny</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>c. Mostly shady</td>
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<td>d. Full shade</td>
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<tr>
<td></td>
<td>a. Turf</td>
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<td></td>
<td>b. Ornamentals</td>
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<td></td>
<td>c. Mixed (%) Turf</td>
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<tr>
<td></td>
<td>c. Mixed (%) Orn.</td>
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<td>4.</td>
<td>Turf Quality (1=Dead, 9=Top Qual.)</td>
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<td>5.</td>
<td>Num. of Irrigation heads</td>
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<td></td>
<td>b. Rotors</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td>c. Microirrigation</td>
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</tr>
</tbody>
</table>

Irrigated Area: Calculated (Aerial photo) _________ ft²  Corrected (in situ) _________ ft²

Flow Test: Run time per zone _________ minutes  Meter reading before ___________ Meter reading after ___________

Comments: ____________________________________________________________________________________________
Summary of Participants
## OCU Technologies & Expt. Design

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ET Technology</th>
<th>ET+Edu Technology</th>
<th>SMS Technology</th>
<th>SMS+Edu Technology</th>
<th>Comparison</th>
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<tbody>
<tr>
<td>Rain Bird ESP-SMT</td>
<td>Rain Bird ESP-SMT</td>
<td>Baseline WaterTec S100</td>
<td>Baseline WaterTec S100</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

| Locations Installed | 7 | 9 | 7 | 9 | 9 |
| Number Installed    | 28 | 38 | 28 | 38 | 35 |

Monitored: 1 Dec 2011 through 30 Nov 2012 (12 months)
Contractor Group

- **ET**
  - Contractor programmed with default landscape settings
  - Daily water windows
  - Limited interaction with homeowner

- **SMS**
  - Buried at 6 inches in minimally compacted soil
  - Re-programmed time clock schedules for daily irrigation:
    - 20 minutes spray
    - 45 minutes rotor
  - Limited interaction with the homeowner
Controllers with IFAS Recommendations

- **ET+Edu treatment**
  - Reprogrammed for site specifics
  - 5 minute tutorial
  - Total Count = 38
  - Total Locations = 9

- **SMS+Edu treatment**
  - Inserted into soil column at 3 inch depth
  - Reprogrammed for 0.25” per event, 2 events per day, 3 d/wk
  - 5 minute tutorial
  - Total count = 38
  - Total locations = 9
Residential Avg. Irrigation

### Flatwoods

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average Weekly Irrigation Application (in)</th>
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<tbody>
<tr>
<td>Comparison</td>
<td>0.99ab</td>
</tr>
<tr>
<td>ET</td>
<td>0.78b</td>
</tr>
<tr>
<td>ET+Edu</td>
<td>0.69b</td>
</tr>
<tr>
<td>SMS</td>
<td>0.77b</td>
</tr>
<tr>
<td>SMS+Edu</td>
<td>0.53c</td>
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### Sand

<table>
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<tbody>
<tr>
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<td>1.22a</td>
</tr>
<tr>
<td>ET</td>
<td>1.1a</td>
</tr>
<tr>
<td>ET+Edu</td>
<td>0.77b</td>
</tr>
<tr>
<td>SMS</td>
<td>0.82b</td>
</tr>
<tr>
<td>SMS+Edu</td>
<td>0.77b</td>
</tr>
</tbody>
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Turfgrass Quality

Average Turfgrass Quality

Before treatments  Fall 2011  Winter 2011-2012  Spring 2012  Summer 2012  Fall 2012

Comparison ET+edu SMS+edu ET SMS

Values: 6.4 abcd 6.7 c 6.2 d 6.6 c 7.6 a 7.1 b

Season
# Customer Driven Issues

<table>
<thead>
<tr>
<th>Complaint Description</th>
<th>Count of Complaints from Cooperators</th>
</tr>
</thead>
<tbody>
<tr>
<td>High water bill</td>
<td>14</td>
</tr>
<tr>
<td>Too much water</td>
<td>10</td>
</tr>
<tr>
<td>Too little water</td>
<td>15</td>
</tr>
<tr>
<td>Sensor not working</td>
<td>5</td>
</tr>
<tr>
<td>Sensor not allowing irrigation</td>
<td>1</td>
</tr>
<tr>
<td>Sensor not preventing irrigation</td>
<td>3</td>
</tr>
<tr>
<td>Watering too soon after rain</td>
<td>12</td>
</tr>
<tr>
<td>ET controller not working</td>
<td>2</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>62</strong></td>
</tr>
</tbody>
</table>
B283, Landscape Irrigation Use SW FL

- Characterize irrigation use throughout SWFWMD
- Assess 300 gpad benchmark
- Utility data from TBW
  - Pasco Co.
  - New Port Richey
  - Pinellas Co.
  - St. Petersburg
  - NW Hillsborough
  - SC Hillsborough
  - Tampa
Estimating SFH Irrigation

- Tampa Bay Water (TBW)
- Potable monthly water billing records for single-family residential for ~12 years
- Parcel records including greenspace
- Soil data (sandy, urban)
- Daily rainfall and ET data

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Observations</th>
<th>Variables</th>
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<tbody>
<tr>
<td>Customers</td>
<td>~650,000</td>
<td>-</td>
</tr>
<tr>
<td>Monthly water billing</td>
<td>~44,000,000</td>
<td>25</td>
</tr>
<tr>
<td>Parcels</td>
<td>~432,000</td>
<td>24</td>
</tr>
<tr>
<td>Soils</td>
<td>~40,000</td>
<td>40</td>
</tr>
<tr>
<td>Daily weather</td>
<td>~5,782,000</td>
<td>12</td>
</tr>
</tbody>
</table>
Individual SFH Irrigation Estimate

- Irrigation required based on daily soil-water balance
- 1,440 separate calculations for 4,380 days, summed monthly

![Annual ET₀ (2000)](image1)
![Annual Precipitation (2000)](image2)
![Soil types](image3)
Tampa Bay Region Irrigation

- **Irrigation required**
- **Non-irrigator demand**
- **Irrigator demand**

**Depth (inches)**

- January (Jan)
- February (Feb)
- March (Mar)
- April (Apr)
- May
- June (Jun)
- July (Jul)
- August (Aug)
- September (Sep)
- October (Oct)
- November (Nov)
- December (Dec)
## Per capita Across District

<table>
<thead>
<tr>
<th>Service area</th>
<th>Average daily irrigation volume for all customers (gpad)</th>
<th>Average daily irrigation volume for “irrigating” customers (gpad)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasco</td>
<td>109</td>
<td>208</td>
</tr>
<tr>
<td>NPR</td>
<td>77</td>
<td>159</td>
</tr>
<tr>
<td>Pinellas</td>
<td>138</td>
<td>345</td>
</tr>
<tr>
<td>St. Pete</td>
<td>114</td>
<td>226</td>
</tr>
<tr>
<td>NWH</td>
<td>120</td>
<td>253</td>
</tr>
<tr>
<td>Tampa</td>
<td>114</td>
<td>226</td>
</tr>
<tr>
<td>SCH</td>
<td>113</td>
<td>231</td>
</tr>
<tr>
<td>All TBW</td>
<td>111</td>
<td>256</td>
</tr>
</tbody>
</table>

- Planning estimate is 300 gpad
Scope Revision

• Assess FFL irrigation savings
• Determine source of savings
Summary

• Rain sensors not effective at saving water “in the wild”
• SMS & ET controllers effective (>25% savings) in OCU when set up properly
• Higher savings possible (up to 70%) given plot research results
Future Needs

• Long term monitoring of SMS and ET performance
  – B252 reclaimed project monitoring can be extended
  – Continue OCU monitoring

• Pilot scale project implementation
  – Education of contractors (via Extension)
  – Ongoing monitoring/verification of impact
Questions?

PLEASE DO NOT WALK ON GRASS

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