Water Provider Information Needs and Innovative Research

Understanding Residential Water Use: New Approaches to Analyzing, Projecting and Managing Demand
May 11th, 2012
Decision Center for a Desert City and ASU Center for Environmental Economics and Sustainability Policy

Water Provider Information Needs and Innovative Research

- Bruce Flory, Seattle Public Utilities
- Doug Frost, City of Phoenix Water Services
- Tom Arnold, Tucson Water
City of Phoenix Water Use And Wastewater Generation Trends

- Context
- What We Used To Think
- What We’ve Experienced
- What We’ve Learned
- How We’re Applying What We’ve Learned
- How We Can Learn More In The Future

Phoenix – Context (System)

- Service area: 540 square miles
- Population served: 1,502,287
- Water accounts: 404,647
- Miles of water mains: 6,962
- Treatment plants: 5
- Booster stations: 105 (0.03 to 135 MGD)
- Pressure reducing stations: 95 (0.3 to 80 MGD)
- Storage facilities: 47 (0.006 to 90 MG)
- Active wells: 24 (38 MGD Total Capacity)
Phoenix – Context (Water Portfolio)

What We Used To Think

- Demand from existing homes and businesses is relatively stable
- Use is affected primarily by price and personal behavior
- Strong population and economic growth would consistently lead to increased water use
- Water demand & wastewater generation would grow steadily, with some response to rate increases
What We’ve Experienced

- Total water production remains stable even as growth occurs
- Volume to wastewater treatment plants stays about same even as growth occurs
- Lower water demand on a per capita basis for existing and especially new customers
- Very low flows in sewers and lift stations in new areas
- Increasing concerns about water quality and sewer maintenance because of low flows
Total Water Use and Wastewater Generation Has Been Stable

Phoenix Per Capita Water Use: 1996-2010
What We’ve Learned (1)

- Understanding water demand & wastewater generation like solving puzzle
- Solving puzzle requires research at different levels
- New development is much more efficient
- Existing homes and businesses are gradually becoming more efficient
- Long-term structural change is more important than short-term behavior change

City-Wide Analysis of Data
City-Wide Analysis of Data

- Tracking of metered demand by type of user (single family, multifamily, general commercial, landscape, etc.) category over time
- Analysis of SF and MF demand using additional data from assessment or other records
- Review of aggregate WTP production (daily, monthly, annually, etc.)
- Review of aggregate use of WWTP capacity (daily, monthly, annually, etc.)

Neighborhood or Subdivision Analysis of Data
Neighborhood or Subdivision Analysis of Data

- Sewer metering at subdivision or larger level to isolate distinct uses and per unit flows (all single homes, all industrial, etc.)
- Comparison of metered water use data and sewer meter data
- Analysis of landscape type using aerial photography and satellite imagery
- Comparison of metered water use data and landscape coding

Wastewater Metering/Data Collection
Sewer Metering Study Site Selection

- Large sample population
- Homogenous customer base
- One outfall to the collection system
- Post 1994 construction date
Individual Home or Business Analysis of Data

- Site visits to identify number, type and age of fixtures, appliances and irrigation systems
- Creation of inventories of water-using devices and comparison with metered data
- Data-logging to analyze use of appliances, fixtures and irrigation systems in individual homes for limited periods
- In the future, use of advanced water meters that track use over 15 minute increments rather than over 30 day increments
Individual Home Analysis

Data Logging
- Trace Analysis
- Discreet End-Use Information

What We’ve Learned (2)
- Data indicates that change in water use due to long-term technological and cultural factors, not short-term behavioral/price factors
- Water demand and wastewater generation falling since 2000 on per capita and per unit basis
- Steadily declining water use and wastewater generation seen in all sectors, in all areas, and in existing and new customers
- Trends seen across U.S. regardless of rates
- Change most pronounced in new customers
New Homes Use Less Water and Generate Less Wastewater

Average Water Use (2008) by Year of Home Construction

All Homes are Using Less Water and Generating Less Wastewater

- Water use by single family homes decreased 12 - 15% during the first decade of the 21st Century

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>pre - 1960</td>
<td></td>
<td>437</td>
<td>367</td>
</tr>
<tr>
<td>1960 - 1975</td>
<td></td>
<td>478</td>
<td>409</td>
</tr>
<tr>
<td>1975 - 1990</td>
<td></td>
<td>473</td>
<td>412</td>
</tr>
<tr>
<td>1990 - pre</td>
<td></td>
<td>436</td>
<td>368</td>
</tr>
</tbody>
</table>

Results displayed in average gallons per account per day (GAPD)
What We’ve Learned (3)

- Indoor residential reductions due mostly to gradual transition to more efficient devices
- Majority of residential reductions due to more efficient toilets and washing machines
- Indoor business reductions more complex
- Outdoor residential reductions due to conscious shift to desert landscaping
- Individual homes use same amount of water while green, then use falls dramatically with transition to drier landscape

<table>
<thead>
<tr>
<th>SUBDIVISION NAME</th>
<th>UNITS</th>
<th>TOT FLOW WW / UNIT</th>
<th>% WW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthem West</td>
<td>631</td>
<td>88,854</td>
<td>61%</td>
</tr>
<tr>
<td>Carefree Crossing</td>
<td>370</td>
<td>61,693</td>
<td>66%</td>
</tr>
<tr>
<td>Colina Del Norte #2</td>
<td>294</td>
<td>65,625</td>
<td>78%</td>
</tr>
<tr>
<td>Country Place</td>
<td>1143</td>
<td>180,120</td>
<td>55%</td>
</tr>
<tr>
<td>Desert Ridge Lot #24</td>
<td>475</td>
<td>38,744</td>
<td>32%</td>
</tr>
<tr>
<td>Foothills Clubwest MH #407</td>
<td>320</td>
<td>39,533</td>
<td>42%</td>
</tr>
<tr>
<td>Foothills Clubwest MH #105</td>
<td>536</td>
<td>84,081</td>
<td>58%</td>
</tr>
<tr>
<td>Larissa</td>
<td>324</td>
<td>33,028</td>
<td>43%</td>
</tr>
<tr>
<td>Moon Valley</td>
<td>1000</td>
<td>120,602</td>
<td>37%</td>
</tr>
<tr>
<td>North Canyon</td>
<td>588</td>
<td>64,919</td>
<td>43%</td>
</tr>
<tr>
<td>Ocotillo</td>
<td>312</td>
<td>33,874</td>
<td>48%</td>
</tr>
<tr>
<td>Silver Creek</td>
<td>226</td>
<td>30,768</td>
<td>56%</td>
</tr>
<tr>
<td>Sonoran Foothills</td>
<td>701</td>
<td>68,178</td>
<td>34%</td>
</tr>
<tr>
<td>Tarcata</td>
<td>534</td>
<td>86,132</td>
<td>69%</td>
</tr>
<tr>
<td>Tatum Highlands</td>
<td>1248</td>
<td>240,248</td>
<td>76%</td>
</tr>
<tr>
<td>Trailwood East</td>
<td>470</td>
<td>73,291</td>
<td>69%</td>
</tr>
<tr>
<td>Trailwood West</td>
<td>707</td>
<td>62,965</td>
<td>42%</td>
</tr>
<tr>
<td>Tramonto Parcel #4</td>
<td>268</td>
<td>58,578</td>
<td>66%</td>
</tr>
<tr>
<td>Volterra</td>
<td>490</td>
<td>55,124</td>
<td>49%</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>560</td>
<td>78,345</td>
<td>64%</td>
</tr>
</tbody>
</table>
More Efficient Devices Have Driven Falling Indoor Use

- Major efficiency improvements have been achieved for toilets and clothes washers

<table>
<thead>
<tr>
<th>Fixture / Appliance</th>
<th>1999 Use Rate (gal/day)</th>
<th>2009 Use Rate (gal/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet</td>
<td>48.3</td>
<td>35.2</td>
</tr>
<tr>
<td>Clothes Washer</td>
<td>43.5</td>
<td>27.9</td>
</tr>
<tr>
<td>Shower</td>
<td>33.3</td>
<td>31.3</td>
</tr>
<tr>
<td>Faucet</td>
<td>24.7</td>
<td>28.0</td>
</tr>
<tr>
<td>Leak</td>
<td>14.1</td>
<td>15.1</td>
</tr>
<tr>
<td>Other</td>
<td>10.1</td>
<td>11.7</td>
</tr>
<tr>
<td>Dish Washer</td>
<td>2.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Bathtub</td>
<td>3.0</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>179.2</strong></td>
<td><strong>152.0</strong></td>
</tr>
</tbody>
</table>

Data from the 1999 EUPRS and the 2009 city of Phoenix Efficiency Study.

Still Plenty of Capacity For Increased Efficiency Indoors

- More than 74% of single family households have installed low-flow toilets, but 77% have yet to install high efficiency clothes washers.

<table>
<thead>
<tr>
<th>Penetration Rates for Efficient Residential Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Flow Toilets (ULFT)</td>
</tr>
<tr>
<td>Shower Heads (ULFS)</td>
</tr>
<tr>
<td>Bathroom Faucets (ULFF)</td>
</tr>
<tr>
<td>High Efficiency Clothes Washers</td>
</tr>
<tr>
<td>High Efficiency Dish Washers</td>
</tr>
</tbody>
</table>
Major Transition Underway From Green to Drier Landscapes

- Most residential and business landscapes 30 years ago were ‘green’ (turf, non-native, etc.)
- Transition to alternative landscapes appears to have begun in large way in 1990s
- Some switch to totally desert landscapes
- Most switch to mixed with native species
- Switching to mixed with native species dramatically reduces use, even with pool
- Culture plays big role – whole neighborhoods seem to convert quickly
Estimated Use by Ahwatukee SF Units Built in Late 70s & Early 80s (Average Annual Gallons Per Day)

Estimates of Water Use by Sample of Ahwatukee Single Family Units Built During Late 70s and Early 80s

<table>
<thead>
<tr>
<th></th>
<th>1986</th>
<th>2000 Green</th>
<th>2000 Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilets/Washers</td>
<td>110</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Shower/Faucets/Bath</td>
<td>80</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Other Indoor/Leaks</td>
<td>50</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>TOTAL INDOOR</td>
<td>240</td>
<td>175</td>
<td>175</td>
</tr>
<tr>
<td>Outdoor Irrigation</td>
<td>250</td>
<td>250</td>
<td>120</td>
</tr>
<tr>
<td>Net Pool</td>
<td>40</td>
<td>40</td>
<td>55</td>
</tr>
<tr>
<td>TOTAL OUTDOOR</td>
<td>290</td>
<td>290</td>
<td>175</td>
</tr>
<tr>
<td>TOTAL</td>
<td>530</td>
<td>465</td>
<td>350</td>
</tr>
</tbody>
</table>

Assumes Lot Size of Approximately 9,000 Sq.Ft.
Toilets/Washers = Toilets, Clothes Washers and Dish Washers
Other Indoor/Leaks = Evaporative Coolers, Water Softeners, Leaks and Unknown
Net Pool = Difference Between Pool and No Pool (Less Grass for Green Lots)
What We’ve Learned (4)

- Even with new population and economic growth, new customers may not be enough to offset demand reductions due to efficiency
- Strong population and economic growth experienced during 1960-2000 not inevitable
- Unclear what drivers of new economic expansion will be
- Unlikely that new industries or businesses would be major water users or wastewater generators

Greater Phoenix Y/Y Job Losses - Recent Recessions
Duration in Months – BLS - January
Single-Family Permits
Greater Phoenix 1975–2016

Source: PMHS / RL Brown

How We Are Applying What We Learned

• Improved planning – specific development level
• Improved planning – drainage basin level
• Improved planning – City-wide infrastructure and water resource plans
  • Use of scenarios
Improved Planning – Specific Development Level: Revised (Proposed) Wastewater Design Standards

<table>
<thead>
<tr>
<th>Land Use</th>
<th>2004 Design Standards</th>
<th>Wastewater Proposed Design Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit</td>
<td>Daily Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(liters)</td>
</tr>
<tr>
<td>Single Family</td>
<td>Dwelling</td>
<td>320</td>
</tr>
<tr>
<td>Multi Family</td>
<td>Dwelling</td>
<td>250</td>
</tr>
<tr>
<td>Commercial (retail/mall)</td>
<td>Sq ft</td>
<td>.5</td>
</tr>
<tr>
<td>Commercial (office)</td>
<td>1000 sq ft</td>
<td>100</td>
</tr>
<tr>
<td>Warehousing/Big Box Retail</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Industrial</td>
<td>Person</td>
<td>50</td>
</tr>
<tr>
<td>Schools</td>
<td>Student</td>
<td>75</td>
</tr>
<tr>
<td>Hotel/Hotel (w/restaurant)</td>
<td>Room</td>
<td>130</td>
</tr>
<tr>
<td>Hotel (w/restaurant)</td>
<td>Room</td>
<td>130</td>
</tr>
<tr>
<td>Hospital</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Improved Planning – Drainage Basin Level

- Opportunities for reducing scale and cost of new facilities
  - Estrella lift station example:
    - 15 MGD expansion of existing station vs construction of proposed 40 MGD regional station and deep sewers
  - Laveen sewer main example:
    - One 12” and one 15” increased to a 24” will replace a 36”
Improved Planning – Use of Scenarios in City-Wide Infrastructure & Resource Plans

- Difficult to predict long-term technological, demographic and economic trends
- Possible to provide range of realistic possibilities for 5-20 year period to assist with planning
- Scenario planning is good way to provide realistic range of possibilities to manage risk
- Phoenix is using three scenarios to estimate likely range of possible outcomes
- Scenarios combine assumptions about water use and future development
Planning 40 Years Out Is Difficult
1951 Phoenix Population Projections and Actual Growth

Actual and Assumed Annual Single Family Unit Production

*what was actually needed to accommodate population growth*
Existing SF Residential Customers
Efficiency Assumptions - Toilets

- **LOW SCENARIO**: All inefficient units replaced within 20 years
- **MEDIUM SCENARIO**: All inefficient units replaced within 30 years
- **HIGH SCENARIO**: All inefficient units replaced within 40 years

Existing SF Residential Customers
Efficiency Assumptions - Washing Machines

- **LOW SCENARIO**: All inefficient units replaced within 15 years
- **MEDIUM SCENARIO**: All inefficient units replaced within 20 years
- **HIGH SCENARIO**: All inefficient units replaced within 25 years
Existing SF Residential Customers
Efficiency Assumptions – Landscapes

- **LOW SCENARIO**
  - All landscapes are mixed or desert within 20 years

- **MEDIUM SCENARIO**
  - All landscapes are mixed or desert within 30 years

- **HIGH SCENARIO**
  - All landscapes are mixed or desert within 75 years

Existing Single Family Customers
Comparing Rates of Change in Demand

![Bar chart showing rates of change in demand for single family homes built 1965-1974 for different scenarios.](chart)
Projected Change in Water Demand by City of Phoenix Area
Medium Scenario - 2030

How We Can Learn More In The Future
Better Information On:

- How people actually use appliances, fixtures & irrigation systems
- Adoption of more efficient appliances, fixtures & irrigation systems
- Actual (not theoretical) water use for various vegetation types
- Economic & cultural trigger points for major changes
- Trigger points and trends for commercial, industrial and MF