Dynamic Simulation Modeling of Outdoor Demand:
Key factors, trends, and triggers

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Water providers & regulators supporting this work:

- Tucson Water
- Central Arizona Project
- Bureau of Reclamation
- AZ Dept. of Water Resources
- SAWUA
- Metro Water
- Comm. Water - Green Valley
- Pima County Wastewater

Additional work for litigation support on new construction in Clark County

- Salt River Project
- Central Arizona Project
- Bureau of Reclamation
- AZ Dept. of Water Resources
- Chandler
- Gilbert
- Glendale
- Mesa
- Peoria
- Scottsdale
- Tempe
Some major questions & concerns

- How low could it go?
- Are some recession-caused drops in demand permanent?
- What will new housing look like in 3-5 years?
- Why the sharp drop in pools?
- Is turf dead?
- Is demand becoming more seasonal?
- How to adjust rate-making?
- How to distinguish active & passive conservation?
Preliminary numbers for 2014 suggest another 3% drop in overall municipal demand.
### Table 1. Annual Percent Change in SFR Water Demand, 2000-2013

<table>
<thead>
<tr>
<th>Component of Per-Household Demand</th>
<th>Total</th>
<th>Indoor</th>
<th>Outdoor</th>
<th>Peak Outdoor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MARICOPA COUNTY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2.12</td>
<td>-2.02</td>
<td>-2.33</td>
<td>-2.90</td>
<td></td>
</tr>
<tr>
<td><strong>PIMA COUNTY PROVIDERS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMUNITY WATER (Green Valley)</td>
<td>-2.0</td>
<td>-1.5</td>
<td>-3.2</td>
<td>-3.6</td>
</tr>
<tr>
<td>METRO WATER</td>
<td>-2.2</td>
<td>-2.0</td>
<td>-2.8</td>
<td>-2.5</td>
</tr>
<tr>
<td>TUCSON WATER</td>
<td>-2.3</td>
<td>-1.5</td>
<td>-5.0</td>
<td>-5.1</td>
</tr>
<tr>
<td>PIMA COUNTY (weighted average)</td>
<td>-2.29</td>
<td>-1.53</td>
<td>-4.80</td>
<td>-4.88</td>
</tr>
</tbody>
</table>
Factors affecting municipal water demand:

**Economics**
- Water & sewer rates
- Income levels

**Conservation**
- Education & preachments
- Rebates & give-aways
- Demonstration sites

**Changing Tastes**
- Pools
- Landscapes
- New homes

**Environment**
- Persistent drought
- Climate change
- Urban heat island

**Changing Socio-demographics**
- Composition of households
- Seasonal residents

**Efficiency Standards**
- Federal mandatory
- Federal voluntary
- Neighboring state effects

**New Technology**
- Smart meters
- Next generation washers
- Smart irrigation controllers
Model Structure for Residential Demand Trends

**SFR Characteristics**
- Number and age distribution
  - history – assessors dbase
  - future – set rate w/slider bar
- Value distribution
  - history – assessors dbase
  - future – select scenario

**Household Characteristics**
- Number = SFRs x (1-vacancy rate)
  - PPH
  - history – census, other
  - future – select scenario
- Age distribution
  - history – census, other
  - future – census
- Owner/Renter mix (data issues)
- Seasonal residency pattern
  - history – various sources
  - future – select scenario

**Water Using Features**
- Market shares of feature types
  - history – various sources
  - future – scenarios, other
- Penetration rates
  - history – assessors dbase
  - future – select scenario
- Efficiency standards and norms
  - history – various sources
  - future – various sources

**Event Frequencies**
- Number of uses/hhold/day
  - For some use types, average intensity of event (e.g., bath volume or shower length)

**Water Use per Event**
- Penetration rate x efficiency

**Water Use**
- Frequency x Water use/event
  - Calculated for various water using features, appliances, and fixtures.
  - Selected aggregates, such as changes in indoor gphhd or gpcd from baseline year.
Why a dynamic simulation model?

• Integrates significant SFR water demand
• Addresses uncertainty
• Compares scenarios
• User interface
• Transparent
• Graphical outputs
Users can ask “What if?” questions and define a scenario

Adjustable factors include:

- Housing markets
- Socio-demographics
- Device water use efficiency
- Mandates and rebates
- Increase in water-conscious consumers

Users can also select a pre-defined scenario
Before you can edit inputs, the model must be in edit mode, with Live Model selected in the Scenarios dropdown in the box to the right.

- To activate edit mode, press F4. To activate results mode, click [Run].
- To save a scenario for future use, click [ ].
- To run the model using a preset or saved scenario, select an option from the Scenarios dropdown and click [Run].

<table>
<thead>
<tr>
<th>DEMOGRAPHICS</th>
<th>INDOOR USES</th>
<th>OUTDOOR USES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual birth rate, %</td>
<td>Clothes washer efficiency, gals/load</td>
<td>Annual backyard turf removal rate, %</td>
</tr>
<tr>
<td></td>
<td>[1] - [1.4]</td>
<td>[0] - [8]</td>
</tr>
<tr>
<td>Annual growth rate of new SFRs, %</td>
<td>Start date, 2-gpm shower head mandate</td>
<td>Annual pool removal rate per year, %</td>
</tr>
<tr>
<td>[0] - [1.2]</td>
<td>[2016]</td>
<td>[0] - [0.2]</td>
</tr>
<tr>
<td>Annual sales rate of existing SFRs, %</td>
<td>Year dual-flush toilet rebate began</td>
<td>Evaporative cooler consumption, gpd</td>
</tr>
<tr>
<td>[0] - [12]</td>
<td>[Never]</td>
<td>[20] - [40]</td>
</tr>
<tr>
<td>Houses flipped, % existing homes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dynamic simulation allows models to incorporate deep and complex linkages

Selecting an economic scenario changes
the rate of housing construction
and the distribution of new homes by value
which affect percent of new homes with pools
and the average size of pools
both of which affect outdoor water demand

New SFRs also have larger households with more pre-adults
which changes overall household socio-demographics, and
frequency of use of appliances & fixtures
which affects all facets of indoor demand
And more linkages...

Selecting an economic scenario also changes
the rate of sales of existing houses
and the distribution of existing home sales by value
which affect home remodeling
which affects indoor water demand

Sales of existing SFRs also trigger conversion of swamp to AC
which affects outdoor demand

*Everything affects everything, and this model captures that.*
Possible factors of long-term decline:

- water (and sewer) rate increases
- more effective water conservation programs
- declining household sizes (PPH)
- changing tastes in landscaping
- more water-efficient fixtures and appliances in new housing
- replacement of inefficient fixtures, appliances in older homes
- more seasonal residents
- shrinking lot sizes
- declines in popularity of backyard pools, use of pool covers
- evaporative coolers replaced by air conditioning
20% of SFRs have a pool, but the popularity appears to have been in decline for decades.
Home swimming pools and transition rates

Transition rates are affected by:
- PPH, demographics
- neighborhood pools
- new home owner
- home value, wealth

New SFR construction

11.5% → SFRs with swimming pool

88.5% → SFRs without swimming pool

0.55% ← SFRs without swimming pool

0.15% ← SFRs with swimming pool
When do anecdotes become a trend?

Maybe when humorists start to notice…

...or maybe when someone discovers a profit motive.

F Minus, Arizona Daily Star, Jan. 5, 2013
Swimming pools are fun, but are they worth the time and effort?

See how you can save time and money by converting a swimming pool to a rainwater harvesting tank.

$20 for Members
$40 for Nonmembers

Feb. 26, 2013
New uses for old swimming pools
Convert space into useful, attractive landscape features

Mark "Eb" Eberlein, near a pond on his property, put a deck over the swimming pool and created a cistern that stores rainwater for a Painted Hills home's garden and desert landscaping.  "Arizona Daily Star, March 7, 2013."
Pools are not only scarcer, they’re shrinking

Swimming pools built today are only a bit more than half the size of pools installed in the 1970s and early 1980s.

*What’s a spool?*
Typical pools – past, present, future
Pool cover frequency and patterns of use

Roughly 3 out of 5 pool owners report they have pool covers, but most describe them as hard to use. Annual usage patterns show covers are used half the time, mostly to prolong the swim season, in spring and fall.

Examination of remote sensing data show the problem is even worse, with less than 5% of pools showing deployed pool covers.
Trend driven by shrinking pools

Evaporation per Pool and Per SFR

- **Evaporation per Pool**
- **Evaporation per SFR**
Backyard pools are becoming:

- less popular
- smaller in size
- used by adults, not families with children
- more likely to be removed
Pools and turf in Pima County:

- 35% of SFRs have some backyard turf
- 22% of SFRs have a backyard pool
- Correlation between turf and pools is ZERO!

What factors are driving backyard turf?
PPH is no longer falling, but households are still changing

- Fewer infants, children and teens
- More 1-adult households, including with children
- More retirees and snowbirds
- In general, a graying population
Changes in households are affecting frequencies of indoor water uses

Regressions run on AquaCraft WRF data reveal:

- Shower, clothes washer, and dish washer usage is affected by temperature
- Infants don’t flush toilets or take showers
- Children account for most baths
- Teenagers really do take more frequent and longer showers than adults
- Most usage rates hold across 9 urban areas
Clothes Washer Loads per Day by Age Cohort in 2020
Reduced turf irrigation due to:

- Abandonment
- Reductions in area
- Replacement with xeriscapes, drought-tolerant plant species
- Restrictions in new construction
- Less winter over-seeding with rye grass
- Replacement with artificial turf
Changing face of the American family

Only 33% of households have children, and the figure is declining.

About 45% of households have at least one dog.
We recently had a Tucson Turf Lawn installed, and with 4 dogs it has made all the difference. The interior of our home is much cleaner without the dogs tracking in dirt from the yard. Thank you!  - Karen F., Tucson, AZ

I wanted to let you know how much we love and enjoy our new backyard patio with your turf. Even our dog loves it. She rolls and sleeps on it (and doesn't dig or rip at it!).

Source of the quotes and pictures is: www.tucsonturf.com/testimonials.html
NOTE – not one photo or mention of kids.

Our new puppy loves her new lawn, as do all of us.

My two small puppies love their new playground. They used to tip-toe around on the rocks - now they run and play like crazy! After playing and chasing each other on the grass for awhile, they love to lay on the grass to catch their breath (and pose for a quick pic). Thanks again.  - Sam
20% of Pima County households have a licensed dog
Fewer than half of dogs in Pima County are licensed
About 45% of households have one or more dogs.

PACC provided a random sample of 500 addresses of licensed dog owners.
Dog ownership and backyard turf are definitely correlated.
Outdoor water uses – evaporative coolers

35% of SFRs have an evaporative cooler.

Only 5% of SFRs built since 2002 have one.
Other outdoor water uses – swamp coolers
Home cooling options and transition rates

- SFRs cooled by Swamp only
- New SFR construction
- SFRs cooled by Dual AC/Swamp
- SFRs cooled by AC only

2% of existing evaporative coolers are replaced by refrigeration or dual systems annually.

Virtually all new homes have cooling by refrigeration.
The concept of a trigger

Why does someone decide today to put in a pool, or to replace their evaporative cooler with AC, or to buy a horizontal-axis clothes washer?

Why today and not yesterday, or a month ago?

*What triggers these types of decisions?*
Transitions can be triggered by:

- new home owners
- switch between owner-occupied and rented
- major home renovation
- water-using fixture or appliance or landscape dies
- targeted conservation program, e.g., rebate
- having kids / empty nest syndrome
- contagion effect – the neighbors do something
- drought, price shock, recession, etc.
Home ownership transfers

How many foreclosed homes have landscapes die due to irrigation turned off or system failure?

How many homes that are “flipped” have bathroom remodels and/or new washer/dryers installed?
Is house flipping a water conservation trigger?
What is effect of house flipping on demand?

A house with 3 owners within 1 year is likely to:

• be over 10 years old and not well-maintained
• get new water-efficient fixtures in bathrooms and kitchen
• have one or more new water-using appliances
• have its landscaping reduced
• be sold to an investor and then rented
One major trigger – it died

End of useful life for appliance or fixture can trigger water savings because:

• new appliances and fixtures are increasingly efficient
• voluntary standards have become de facto standards

Landscape vegetation also has a finite lifespan, and landscapers are planting more drought-resistant species

Swimming pools never die of natural causes, but old ones may be removed.
Not understanding or denying the trend creates planning challenges...

Water providers, wholesalers, wastewater plant operators, water regulatory agencies must adjust:

- optimal timing of capital improvements
- acquisition of new supplies
- rate setting
- budgeting uncertainties
- design of water conservation programs
- reuse of reclaimed water
...and some unintended consequences

Lower demand in new developments means:

- fire flows increasingly determine pipe sizes
- water stays in distribution system longer – “water age”
- more chlorine must be added, at new points
- water becomes warmer

All this results in more disinfection byproducts, such as THMs, and can lead to more hydrant flushing or DBP treatment.
Recap and Conclusions - 1

Three factors are driving declines in domestic demand:

- Adding new, water-efficient houses to existing housing stock
- Active conservation efforts – program-related
- “Passive conservation” driven by changes in tastes and preferences and more efficient devices

In most cases, active conservation is the third most important factor, but it often gets all the credit/blame.
Recap and Conclusions - 2

- We are far past peak cooler
- We are well past peak lawn
- We appear to be near peak pool

Average consumption forecast for Pima County:

_Outdoor_

- Pools: gradual decline
- Evap Coolers: gradual exponential decline
- Turf: front yards all but gone, backyard gradual decline
Recap and Conclusions - 3

- Municipal demand is de-coupled from population; GPCD declines exceeding growth
- Attributing all or most of declines to active conservation is iffy
- Even without active conservation, indoor GPCD will continue to decline for many years
- We now have improved ability to model and forecast indoor demand – time to use it!