Assumptions, Extrapolations, & Outliers
Our Dysfunctional Dialogue over
Water Supply and Demand

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What is the value of water demand research?

- Impact of new ULF toilet rebates
- Outdoor misting systems
- Problems with aging ULFs
- Water, gas, elec. rates & optimum landscapes
- Rate structure impacts
- Water reuse incidence
- Quality of harvested water
- Trends in housing stock
- Spatial characteristics of monsoon precipitation
- Time-series cross-sectional econometrics
- Test patio, physical modeling
- Micro-metering
- Models of houses, water and energy fluxes
- Detailed demand forecasts
- Survey
- Sampling, lab tests
- Analysis of appraiser data
- Citizen science program, RainLog.org
When is there value in this type of research?

A piece-meal, “academic” approach can have value if:

- You have a specific question (e.g., how effective is this conservation program; what is likely impact of new rates)
- The bigger picture is clear – you know where things stand overall, and how you got here

Today, most municipal water providers don’t know:

- Underlying causes of changes in GPCD rates
- Which impacts of the “great recession” are temporary
- What future housing construction will look like
Changing perspectives, knowledge base

What we knew in 1982:
- Climate was stationary and weather modification was feasible
- Copper mining was fading away due to foreign competition
- Urban populations were growing exponentially
- New urban development would displace irrigated agriculture
- Urban demand was dictated largely by population levels
- The Colorado River was a highly reliable supply
- Meeting Safe Yield by 2025 would be a major challenge

What we wonder in 2014:
- What is climate change doing to Colorado River flows?
- How many new mines?
- What will a post-recession economy look like?
- How much new Indian agriculture will there be?
- What are the major factors impacting municipal GPCD rates?
- Could energy price spikes and the water-energy nexus cause farmers to switch back to groundwater?
- Is meeting safe yield by 2010 a cause for celebration?
Aggregation of narrowly-focused studies won’t answer these questions

\[ \text{Whole} < \sum \text{parts} \]

Equally true in hydrology, biology, etc.
An emerging issue:

In Arizona, Nevada, and New Mexico, across the Southwest and the West, and throughout North America, household water demand has been dropping for decades.
Tucson, Arizona

Average Single Family Deliveries (Ccf/month)
Phoenix, AZ – per Hholds, SFRs
Buckeye, AZ - hypergrowth
Deliveries in 2013 same as in 1983 – population up 70%, GPCD down 40%
National Water Use Comparison
(Compiled by the Massachusetts Water Resource Authority)

Percent of 1985 Use

Year

* For a few cities where 1985 data was not available the indexing is on the earliest date provided.
Isn’t this a good thing?

Despite growing populations and more customers, many water providers have experienced essentially flat water demand.

Decreasing per-household demand over the last 20-30 years has offset growing populations.

This saved a lot of water and a lot of money.

Then the “Great Recession” came along…
Housing collapse abruptly stopped new hookups

Tucson Water

Single Family Customers, 1985 - 2012

Growth ended abruptly in 2007
The housing bubble burst resulted in:

- plunging hook-up fees
- paying for unused system capacity
- vacant homes not using water
- delinquent water bill payments
- political resistance to rate hikes

Result was steeper declines in demand and substantial reductions in utility revenues.
Other consequences include:

- an aversion to water conservation spending;
- a deeper interest in understanding long-term demand declines; and
- the need to improve ability to forecast future demand trends.
What’s a doghair demand curve?
Building a doghair demand curve:
Seattle – total deliveries
Dog-hair demand curves result from:

- Tying demand to population projections
- Being overly conservative
- Over-reacting to short-term events
- Ignoring or misinterpreting long-term trends
Eugene, OR – water demand & jobs

Estimated daily per capita gallons (vs. unemployment)
Las Vegas Valley Water District gpcd rates

"broken hockey stick"
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.
Who I’ve spoken with...

... and their major concerns

- Tucson Water
- Mesa Water
- Chandler Water
- Salt River Project
- CAP
- ADWR
- SAWUA
- Reclamation
- ACC

- 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?
- What are CAGRD’s unmet obligations?
- Is turf dead?
- How to adjust rate-making?
New approach to demand forecasting

Most studies of municipal demand:
- Focus on small subset of factors
- Attempt to measure water associated with particular use(s) or change in use

This study of municipal demand:
- Looks at all significant factors
- Relies on existing information on water use rates whenever possible
- Focuses on rates of change in stocks of appliances, fixtures, and landscape characteristics
- Examines triggers of change
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

**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.

**Event Frequencies**
- Number of uses/hhold/day
  - For some use types, average intensity of event (e.g., bath volume or shower length)
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 homes
- replacement of inefficient fixtures, appliances in older homes
- declines in popularity of backyard pools, use of pool covers
- shrinking lot sizes
- swamp coolers replaced by AC
- more seasonal (part-time) residents
One way that PPH can decrease...
...and some alternative mechanisms:

- delayed age at first marriage
- more people never marrying
- declining birth rates
- more single-parent families
- increased longevity
- more affordable housing
- rising incomes
Barring alien abductions, what is the effect of decreasing pph on demand?

birth rates
dead rates
marriage rates
divorce rates
longevity
housing prices
mortgage rates
unemployment

Assume a fixed population and declining PPH

More new residences

Lower per capita indoor demand

Higher per capita outdoor demand

Greater peaking
Growing evidence PPH no longer declining

- Boomerang kids
- Growing percentage of 3-generation households
- More alternate household living arrangements
- Building industry responding with “home within a home” floor plans
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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
A market exists for plastic grass

Many sellers of artificial turf for residences:

- 5 in Pima County
- 12 or more in Maricopa County
- 7 or 8 in Clark County

Three top marketing pitches are:

#3 – Have your own backyard putting green!
#2 – It’s a great place for the kids to play!
#1 – Do it for your dogs!
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
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.
Elvis Best "reads" the Torah at his Bark Mitzvah in 2007

St. Francis of Assisi “Blessing of the Animals”

Attorney Rachel Herschfeld’s mission in life is making certain that companion animals are cared for through pet trusts. Illegal until 1993, it’s now legal in all 50 states! (See PetTrustLawyer.com)

FEMA changed policies after Hurricane Katrina when many people refused to evacuate without their pets. Congress then passed the Pets Evacuation and Transportation Standards Act of 2006 mandating state and local plans.

Bring children at your own risk.
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?
Dog stats from PACC & PetSmart

- 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.

- 35% of all SFRs with backyard turf
- 43% of SFRs with licensed dogs with backyard turf
- 28% of SFRs without dogs with backyard turf
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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

SFRs with swimming pool

SFRs without swimming pool

11.5% → 0.15%
88.5% → 0.55%

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
When it’s a home improvement topic in the paper, it’s passe.

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?

“Stu sure is getting a lot of use out of the new lap pool.”

Close to Home by John McPherson, 12 Aug. ‘13
Typical pools – past, present, future
Trend driven by shrinking pools

![Graph showing annual evaporation per pool and per SFR from 2012 to 2021. The trend line for evaporation per pool is decreasing, indicating a decreasing trend over time.](image-url)
Lot size – turf – swimming pool

3 things that can increase outdoor water demand:
1. Larger lot size
2. Lusher landscaping, especially turf
3. Swimming pools

But these factors cannot be considered in isolation.
In Richland Hts West, pools matter, but not lot size.
In Winterhaven, lot size matters, but not pools.
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
- current water-using fixture or appliance breaks
- 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

Homeowner/Resident #1 ➔ Homeowner/Resident #2

“House Flipper”

Bank/Mortgage Company

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
Other major trigger – it broke

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

• new appliances and fixtures are increasingly efficient
• voluntary standards are becoming de facto standards
• more developers and builders are marketing sustainable homes

* Dishwashers at Best Buy
* Toilets at Home Depot
Clothes washers as prime example
Washing Machine Water Factors
Code and Industry Efficiency Standards

[Graph showing water factors for washing machines from 1995 to 2030, labeled Code - Vertical Axis, Code - Horizontal Axis, Energy Star, CEE]
Impact on demand is substantial and prolonged.
What are the limits to efficiency?

- Toilets – from 5 gallons to 3.5 to 1.6 to 1.28 to 1 (dual)
- Shower heads – from 4 gallons/min to 2.5 to 2.0 to 1.5
- Clothes washers – from 40 gallons/load to 27 to 23...

New clothes washing technology may reduce water usage to under 8 gallons/load.
Residential water demand conclusions:

Considerable evidence suggests we are:

- Way past peak lawn
- Near peak pool and past peak pool size
- Way past peak evaporative cooler
- Just beginning to see impacts of highly efficient clothes washers and toilets
- Builders using “sustainable”, “green” and “efficient” to market new homes

Further substantial declines in GPCD rates appear very likely for at least another decade.
We are also past peak golf because:

- Younger generations are more interested in other outdoor activities
- The work/leisure balance has gotten worse
- Developers harmed the sport by making new courses:
  - longer and thus it takes longer to play
  - harder and thus it’s frustrating for casual golfers
  - expensive and thus the greens fees are higher
- Developers no longer see major profits from selling lots on fairways
Fewer golfers are playing fewer rounds...
...and more courses are closing than opening
BLACK SWANS

Dealing with the unanticipated
Climate change as a black swan

...and its unknown impacts on water demand:

- Short-term impacts on demand (greater ET, evaporation rates, longer growing seasons) may be opposite of long-term impacts (modify or abandon the landscape)

- Where are Southwestern cities on the S-shaped growth curves? Will urban heat islands, drought, and climate change hasten the transition to lower population growth rates?

New state water plan omits all mention of climate change impacts, but contains 33 references to weather modification.
Paul Revere, Cassandra, or Chicken Little?

Knows the truth and is believed; people act and disaster is averted.

Knows the truth but is not believed; disaster ensues, she goes mad.

Is mistaken about the truth; is believed by some, for whom disaster ensues.
Where is the next black swan of water demand?

Potential major surprises, disruptions include:

- Large change in energy prices and the water/energy nexus
- Shrinking middle class
- Others too surprising to even comprehend
A potential black swan: large change in energy costs

Why energy costs could skyrocket:
- Major weather disasters, other mounting evidence of climate change spur rapid curbs on CO₂ emissions
- Spreading unrest, radical governments in Middle East reduce supplies
- Over a billion Chinese, Indians, and sub-Saharan Africans become middle class and start driving cars and building homes with air conditioning

Why energy costs could plummet:
- Huge new supplies from fracking, tar sands, methane hydrates
- Vehicles and appliances become significantly more energy-efficient
- Solar, geothermal, wind continue to get more cost-competitive
- Breakthroughs in energy storage allow greater use of renewable energy
- Possible breakthrough in PV, nuclear fusion, and/or algae farming
What if the middle class is disappearing?

Long predicted, especially in popular culture:
• H.G. Welles, Eloi and Morlocks
• Hunger Games – Districts vs. the Capital
• Elysium – the ultimate gated community
Entire classes of jobs are disappearing

- More robots, fewer humans making cars
- Cars starting to drive themselves
- Siri answers simple questions
- Robots vacuum our home
- Drones deliver packages
Another disappearing job – meter reader
High-tech jobs susceptible as well

- Computers read X-rays, mammograms
- Watson answers hard questions
- Drones replacing pilots
- Computers forecast weather
If the middle class is shrinking...

...potential impacts will be felt through:

- price elasticity
- income elasticity
- conservation programs, rebates
Are there multiple markets for water-using fixtures, appliances, and landscape features?

- Most new AC systems are being installed in homes with older AC systems, not in homes with evaporative coolers.
- What percent of high-end horizontal-axis clothes washers with steam cleaning and internet connectivity will be purchased by people with 11-year-old horizontal-axis clothes washers?