Wet Water, Paper Water:
Patterns and Trends in City of Prescott Municipal Water Demand

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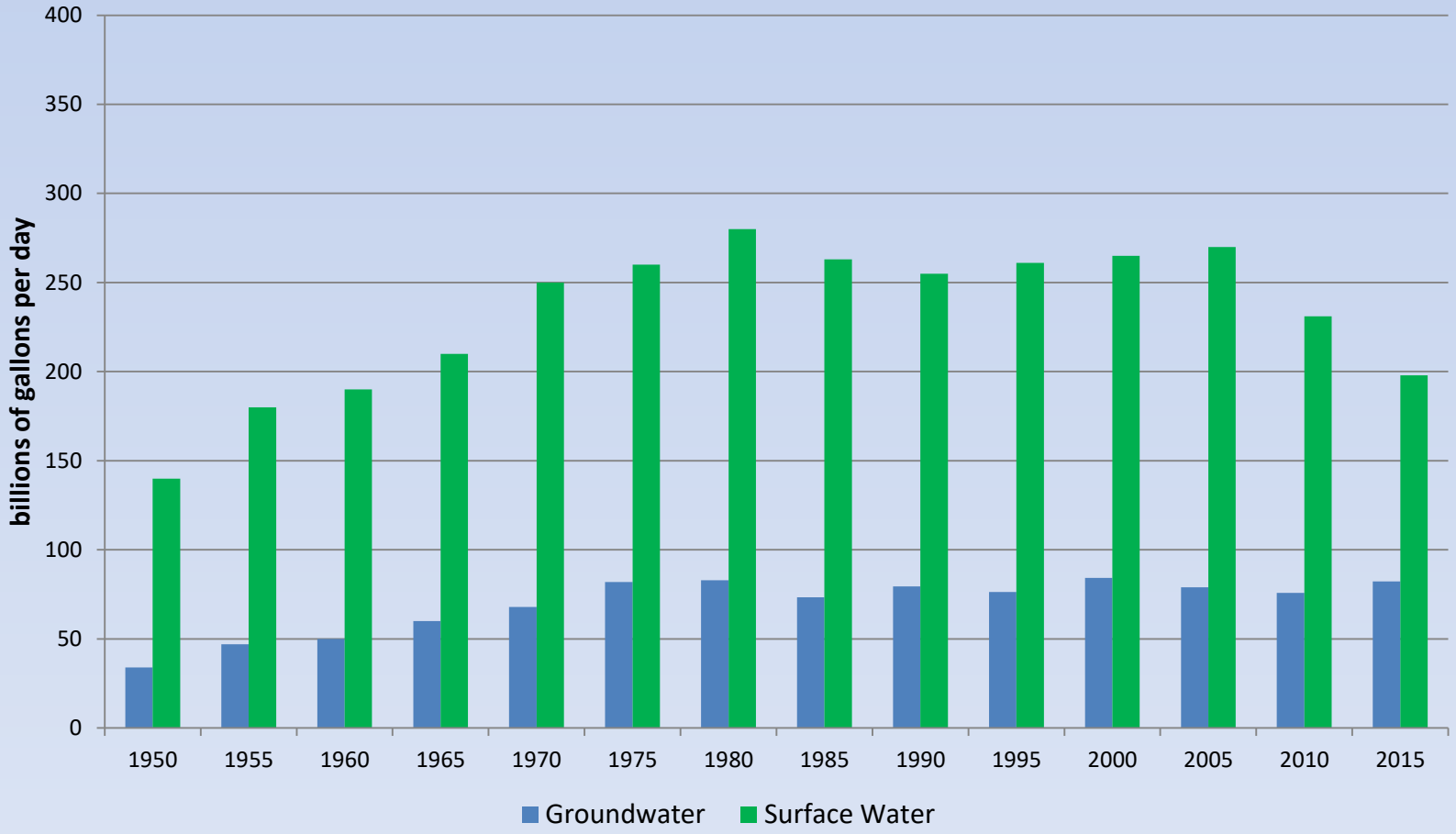
Mayor & Council
City of Prescott

Prescott City Hall
February 26, 2019

Municipal Water Demand Project Goals

1. Develop a detailed understanding of current water demand patterns, including:
   - Examining data at the individual customer level
   - Separating indoor vs. outdoor demand
   - Comparing new construction vs. existing housing stock
   - Considering SFR, MFR, and several CII customer classes
2. Examine recent trends in numbers and types of customers and per-customer usage
3. Model water demand and supplies based on statistical analysis of patterns and trends in order to:
   - Produce forecasts, not simple projections…
   - … that run out to the year 2030…
   - … with a dashboard that supports scenario analysis
4. Incorporate economics into the model to address key issues:
   - Value of deferring major capital projects
   - Impacts of demand trends on revenues & rate implications

USGS reports reduced water diversions



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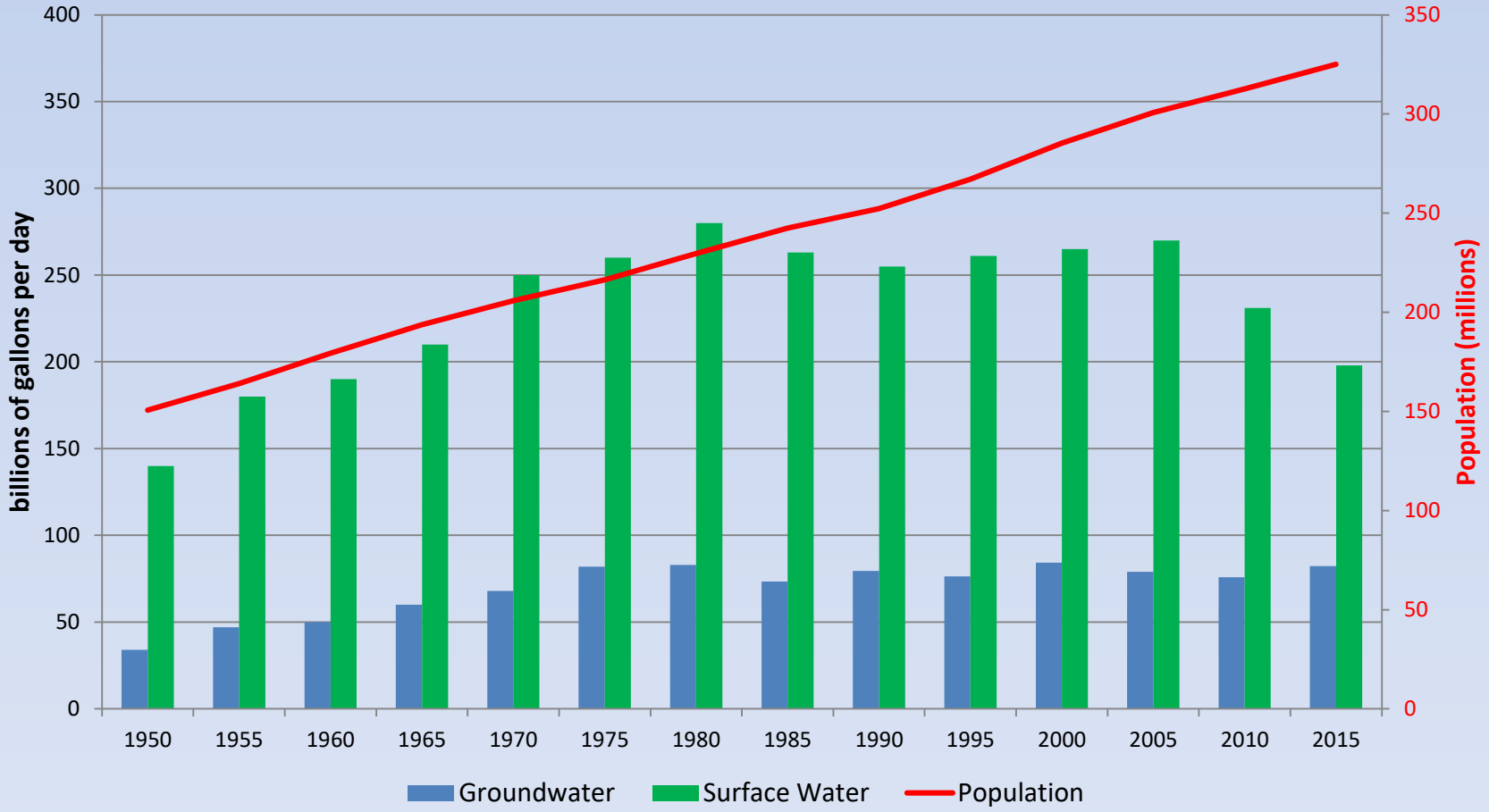
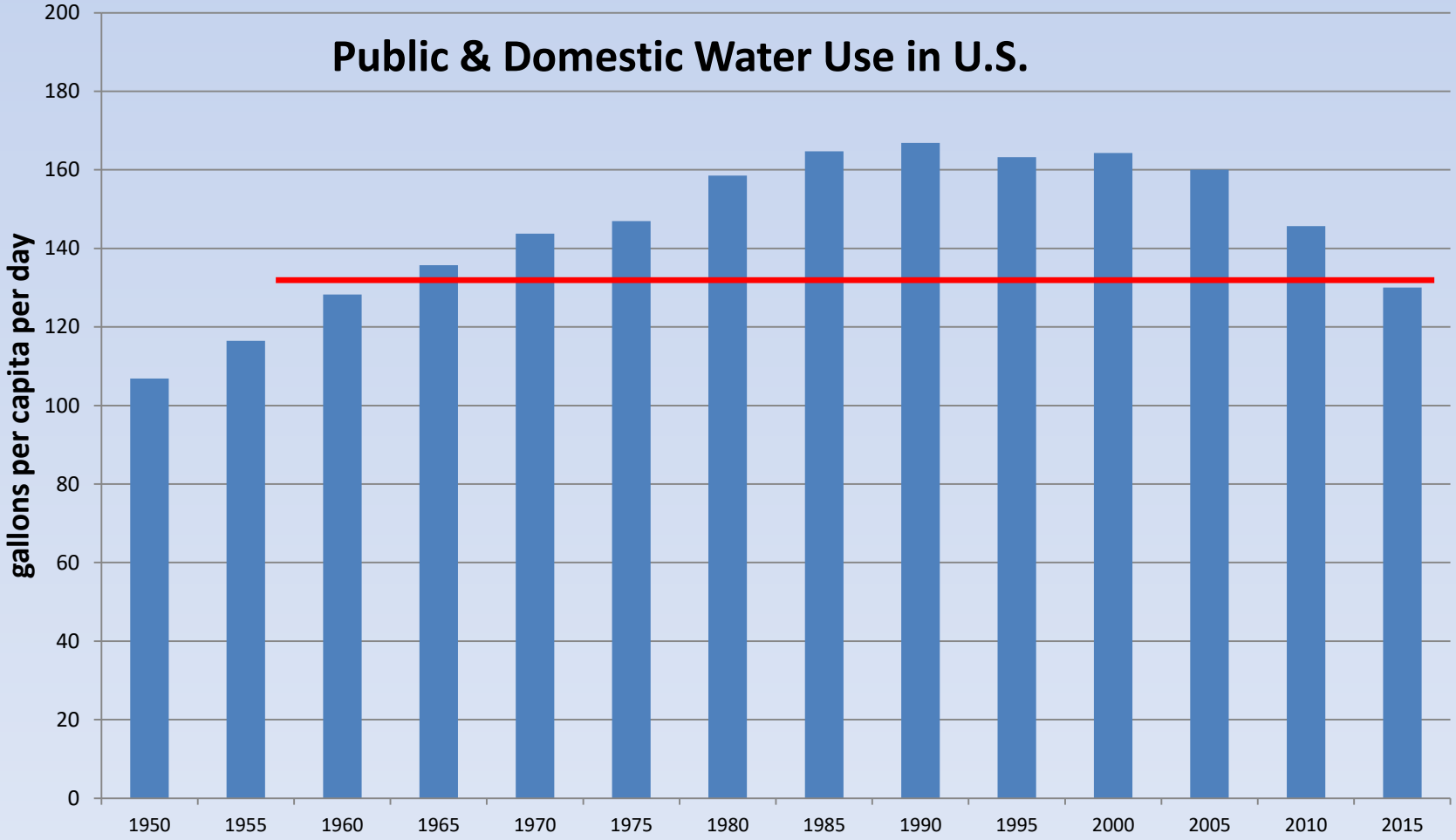


Between 1980 and 2015, we managed to support 95 million more people and a growing economy while reducing water use by 83 billion gallons per day.

Per capita municipal use peaked 30 years ago



Brief background

- Degrees in Chemistry, Law, & Public Policy Studies (Resource Economics), University of Michigan
- Research faculty and administrator at University of Arizona, 1982-2012, including management teams for the Water Resources Research Center and NSF-SAHRA Water Center
- International work with UNESCO on water issues in arid lands
- Co-author, National Water Act, Kingdom of Saudi Arabia
- President of Universities Council on Water Resources
- Consultant, 2012-date, for municipal water departments, private water companies, tribes, developments, water wholesalers, water regulatory bodies, irrigation districts
- Research and consulting on municipal water demand, designing water rates, demand management, water quality issues, impacts of climate and weather on demand

Better understanding through disaggregating

During 37 years of research on municipal water issues, my principal focus has been to improve understanding of municipal water demand and conservation opportunities.

A recurring theme has been to continuously break components of demand into smaller pieces for analysis:

- from annual and quarterly data to monthly, daily, and even 5-second data
- from all customers to residential vs. non-residential
- from all residential customers to SFRs and MFRs, renters and owners
- from total demand to indoor vs. outdoor demand
- from indoor demand to individual water uses, including showers, toilet flushes, loads of laundry and dishes
- from outdoor demand to individual water uses, including summer/winter turf, other landscaping, swimming pools, evaporative coolers

Examples of projects

- Water savings from ULF toilets; performance of aging ULF toilets
- Consumer response to increasing block rates
- Water savings from HE clothes washer rebates
- Impact of demographics and dog ownership on backyard turf
- Rates and impacts of swimming pool removal and abandonment
- Impact of demographics on frequency and length of showers
- Incorporating demand forecasts in rate of return calculations
- Artificial turf penetration rates and impacts on outdoor demand
- Impacts of demographics on clothes washer and dishwasher use
- Evaporative coolers, refrigerative AC, and seasonal demand
- Impacts of urban warming on landscape irrigation
- Rainwater harvesting's effect on landscapes and irrigation

Better forecasting through re-aggregating

Disaggregating demand is useful for evaluating a conservation program, but explaining long-term declines in municipal demand requires that dozens of factors be considered

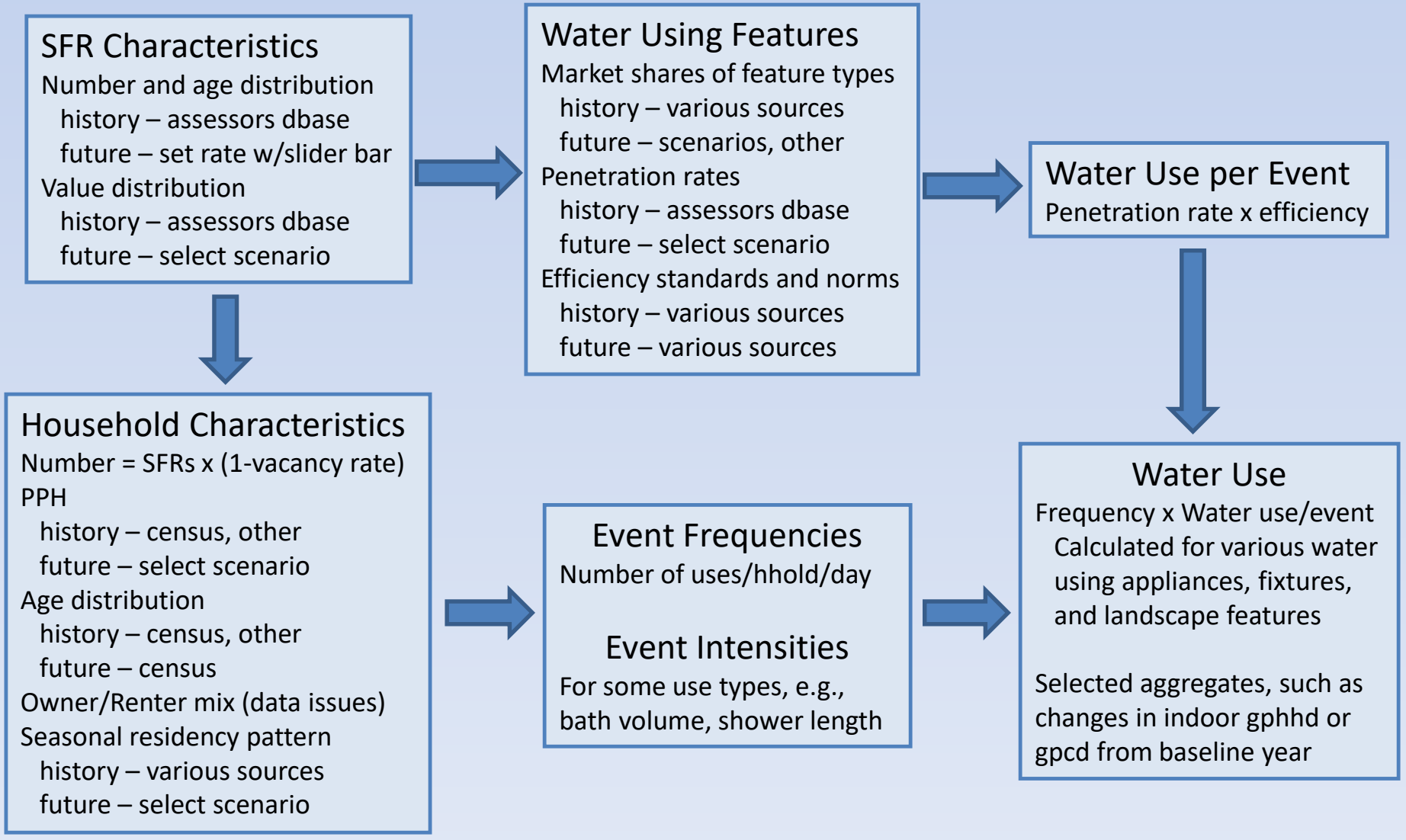
Tools now exist to combine large amounts of data and regression analyses from many diverse sources to create highly detailed models of municipal water demand.

One Phoenix-area model incorporated over 400 million data items.

Features of the new demand modeling approach

- Forecasts rather than projections
- Scenario analysis for experimenting with various policies
- Dynamic simulation including Bayesian analysis for incorporating uncertainty in external factors (e.g., climate change, economic cycles, demographic shifts)
- All major customer classes and all significant end uses of water
- Indoor and outdoor uses
- Focus on rates of change in stocks of appliances, fixtures, and landscape characteristics
- Incorporate impacts of shifting demographics
- Model dashboards with interactive graphics that show key outputs and how they are affected by modifying inputs or altering scenarios
- Model changes in both frequency of use and efficiency of use

Model Structure for Residential Demand Trends



Municipal demand models developed for:

Municipal Water Depts.

- Chandler
- Gilbert
- Glendale
- Mesa
- Peoria
- Scottsdale
- Tempe
- Tucson (twice)

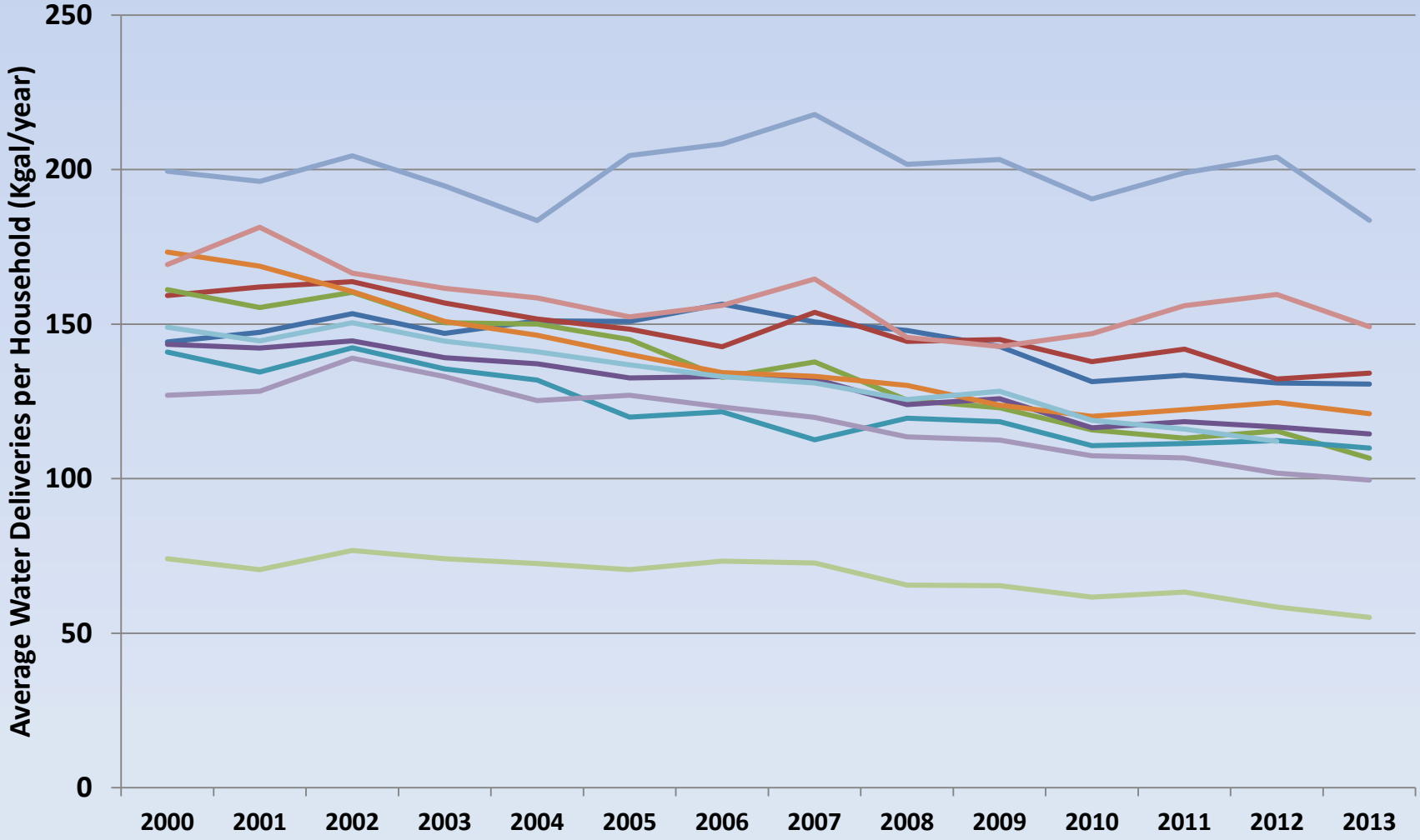
Water Companies:

- Metro Water
- Community Water of Green Valley (twice)

Planned Communities in:

- Clark County, NV
- Northern Arizona

Observed Declines in Demand among 11 municipal providers in Arizona



Similar rates of declining demand, but important differences in the details

- Differences in which declines faster, indoor demand or outdoor demand
- Some have large numbers of new homes that are much more water efficient than the existing housing stock
- Wealthier municipalities have higher rates of renovation and remodeling, and therefore newer, more efficient appliances and fixtures
- Some have well-funded long-term conservation programs that have affected customers preferences for outdoor landscaping

Each municipal water provider is different, in key aspects.

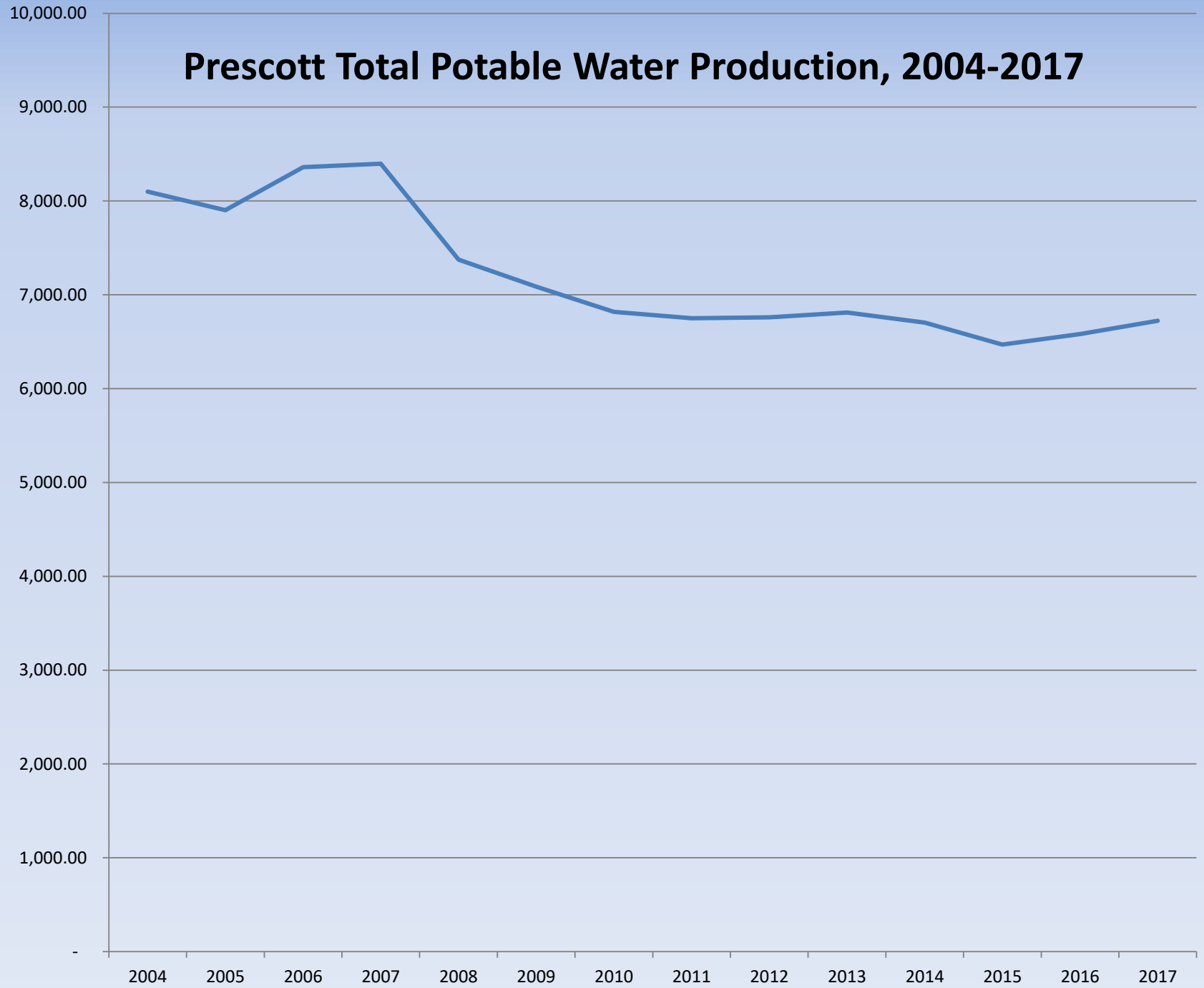
How Prescott is different

Socio-demographics:

- Households are smaller, wealthier, older, more transient
- Households continue to get smaller, bucking state and national trends
- Dog ownership is irrelevant

Environment:

- Prescott is higher, and therefore cooler and wetter
- Swimming pools are rare and an insignificant source of demand
- No winter turf, little artificial turf
- More outdoor demand for non-turf irrigation


Prescott Total Potable Water Production, 2004-2017
10,000.00
9,000.00
8,000.00
7,000.00
6,000.00
5,000.00
4,000.00
3,000.00
2,000.00
1,000.00
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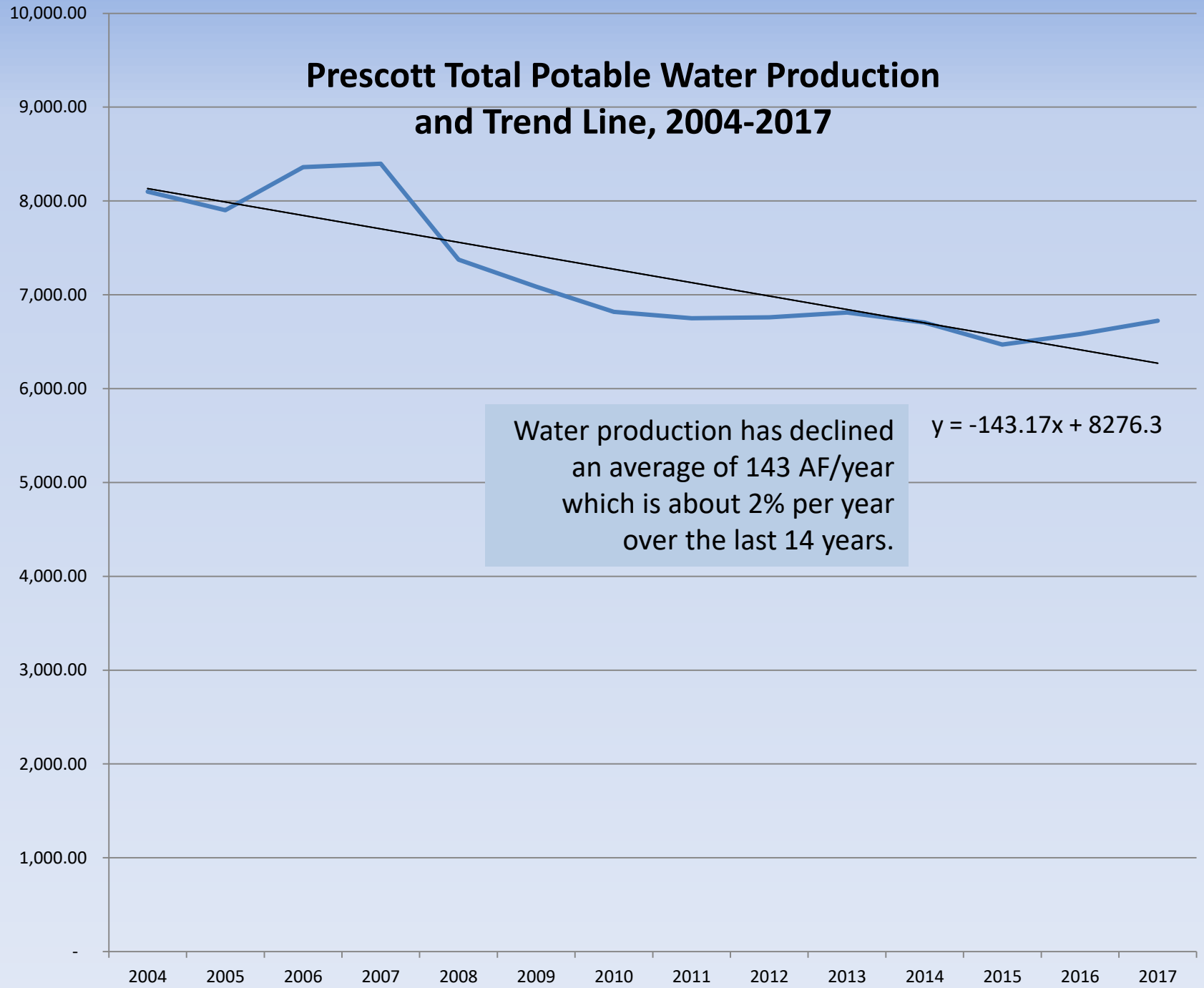
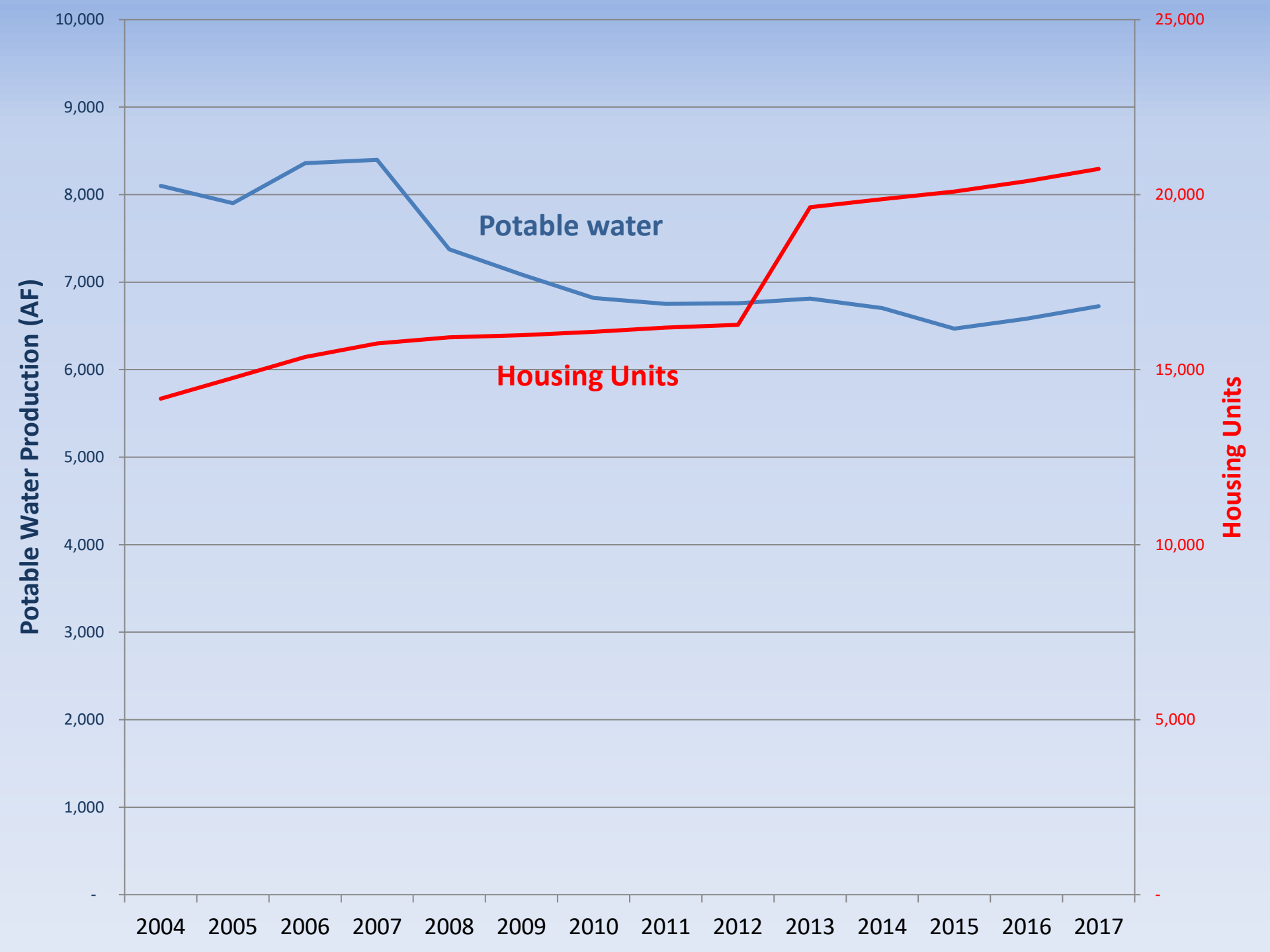
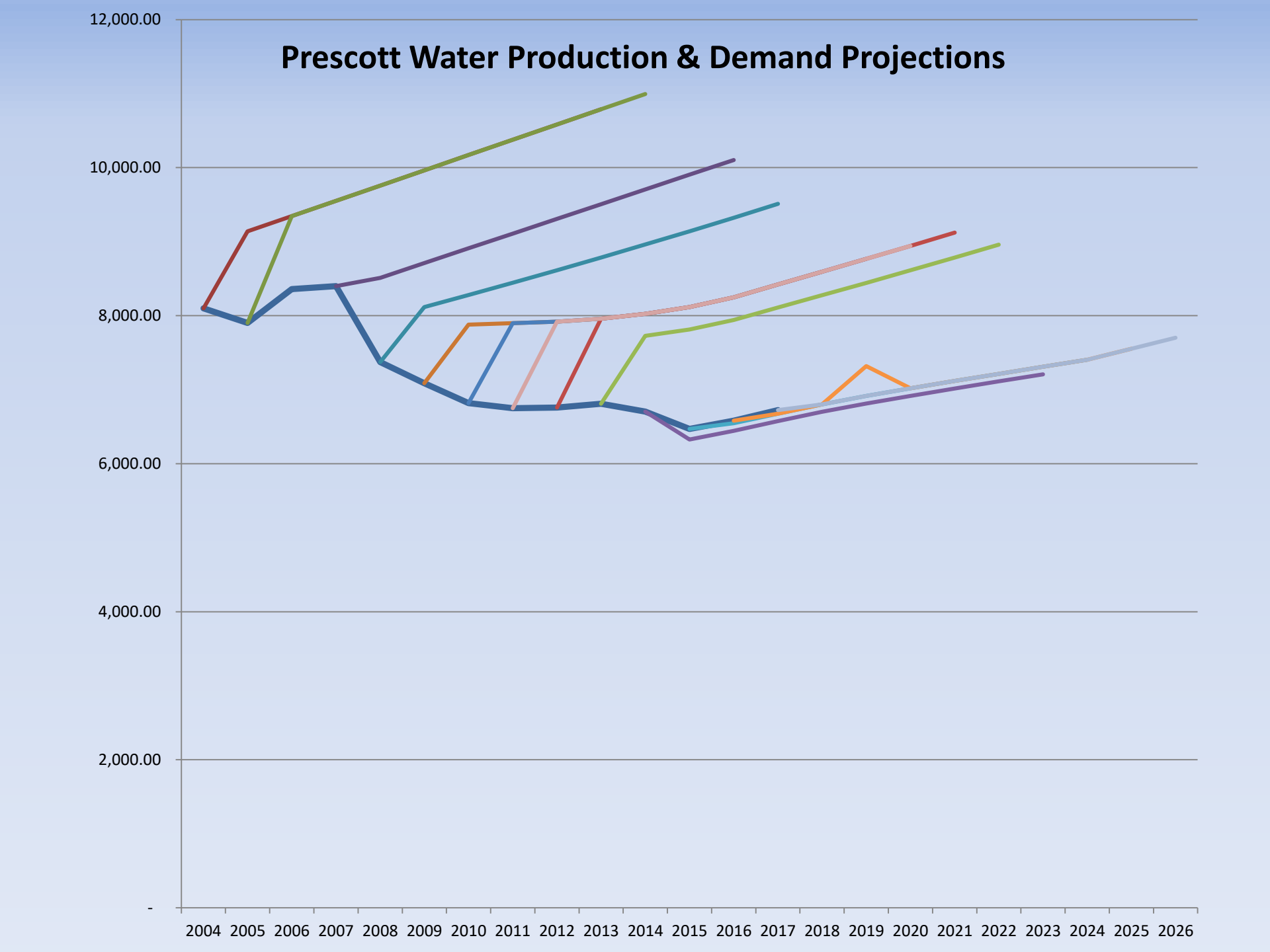
2013
2014
2015
2016
2017


Prescott Total Potable Water Production and Trend Line, 2004-2017
10,000.00
9,000.00
8,000.00
7,000.00
6,000.00
5,000.00
4,000.00
3,000.00
2,000.00
1,000.00
-
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Water production has declined an average of 143 AF/year which is about 2% per year over the last 14 years.
y = -143.17x + 8276.3


Potable Water Production (AF)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
25,000
20,000
15,000
10,000
5,000
-
Housing Units
Potable water
Housing Units
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


Prescott Water Production & Demand Projections
12,000.00
10,000.00
8,000.00
6,000.00
4,000.00
2,000.00
-
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

Dog-hair demand curves can result from:

- Tying demand to population projections
- Being overly conservative
- Over-reacting to short-term events
- Ignoring or misinterpreting long-term trends

But in this case, the blame mostly lies with ADWR's annual reporting format.

*	*

Explain how the non-residential demand was calculated. Use a separate sheet if necessary.
* Non-residential demand is included as a component of the 0.35 demand per residential lot from 1999 - May 2017. In May 2017 the City updated its allocation policy (Res. No. 4411-1620). From June 2017 - December 2017 the inclusion of a 0.1 AF on the residential allocaiton was removed. In 2018 reporting, data will be available for non-residential parcels.

PART 2 - PROJECTED ANNUAL DEMAND

Project the annual water demand in acre-feet for each year indicated. Calculate the increase in demand each year from the previous year. The projected demand in most cases will be greater than the total water use for the current calendar year. Current year demand should equal the total water deliveries in the service area for 2017 as reported on the Schedule F forms, plus system losses and unaccounted for water. Include all water sources used.

Year	Projected Population	GPCD	Total Production (af/yr)	Increase from Previous Year (af/yr)
2017	49,669	121	6723.41	141.80
2018	50,608	120	6802	79
2019	51,449	120	6916	114
2020	52,213	120	7018	102
2021	52,949	120	7117	99
2022	53,671	120	7214	97
2023	54,379	120	7309	95
2024	55,080	120	7404	95
2025	56,182	120	7552	148
2026	57,306	120	7703	151

PART 3 - WATER QUALITY

A. Is the provider currently in compliance with the Arizona Department of Environmental Quality's state water quality standards and reporting requirements? [X] Yes [ ] No

B. Have any new Superfund or WQARF sites been identified within the provider's service area or have existing contaminant plumes migrated to be within one mile of any service area wells? [ ] Yes [N] No

Please contact the Office of Assured and Adequate Water Supply if you need assistance completing this form.
(602) 771-8622

Not understanding or not accepting the trend creates planning challenges…

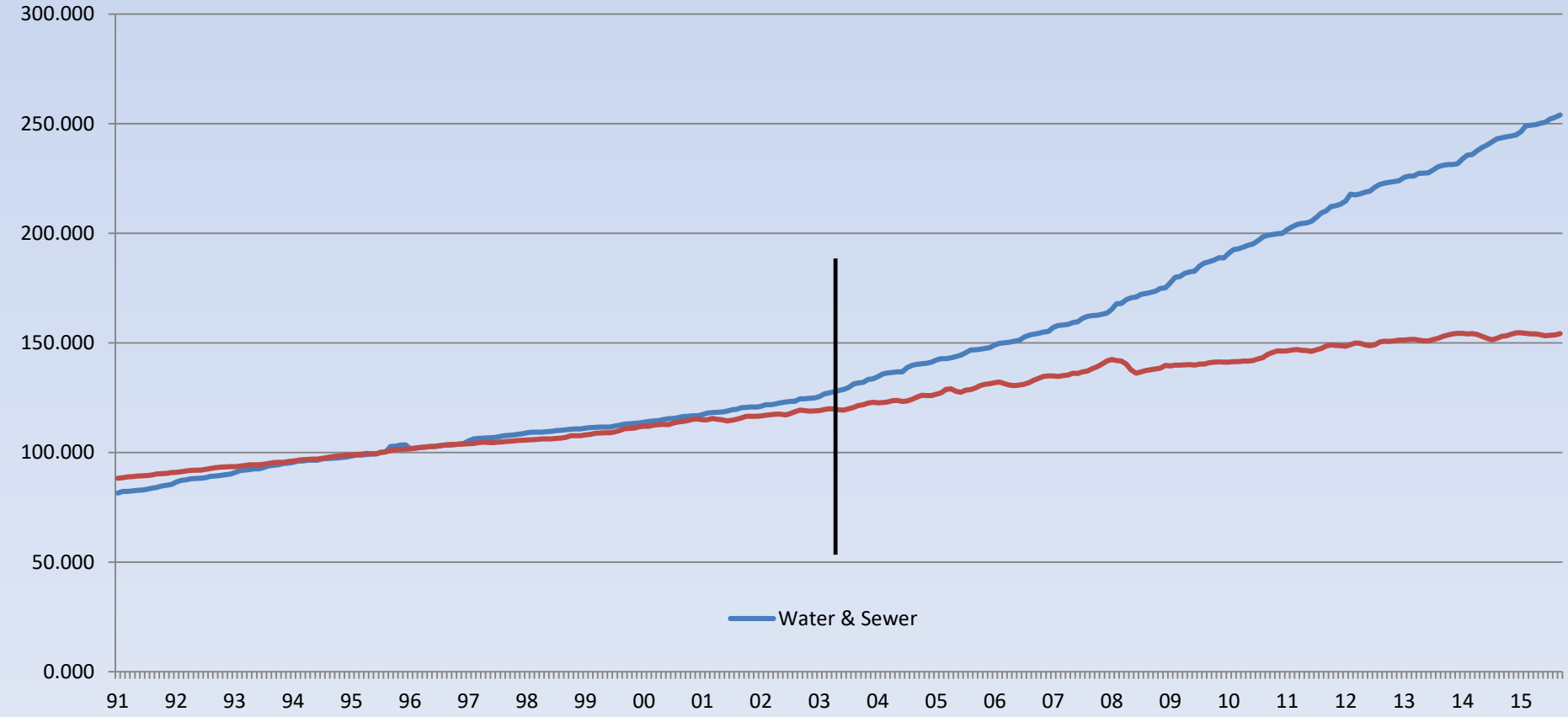
Water providers and wastewater plant operators must adjust:

- acquisition & development plans for new supplies
- timing of capital improvements
- design of water conservation programs
- revenue projections and budgets
- rate setting
- public education and outreach – *"No, we're not running out of water."*

How decreasing demand forces rate increases

- Water utilities have large fixed costs, typically over 85%
- Energy and chemicals account for most of the variable costs
- When demand falls, revenues fall far more than costs
- This problem is exacerbated by increasing block rates
- The response is continually rising water (and sewer) rates
- Decreasing demand is driving the price of water up, rather than the other way around
- This is reflected in inflation rates since 2000

Cost of water, sewer began deviating from all other goods and services post-2000, when municipal demand began to fall



Impact of declining demand on revenues & rates

To determine impact of declining demand on revenues and rates, we need to know the following:

- Change in number of customers - increasing 1%/year
- Change in potable water deliveries - declining 2%/year
- Fixed vs. variable costs for water dept.
  - Capital is $10M, Fixed Operations is $8.9M, Variable is $1.7M
  - Chemicals & power are 17% of operations, 8.5% of total budget
- Revenues from fixed fees vs. commodity charges
  - 37% from fixed fees, 63% from variable or commodity charges
- Rate structure – increasing block rates

Net impact on water department budget

Revenue impacts (ignoring block rates):

- 1%/year increase in customers = +0.37%
- 2%/year decrease in deliveries = -1.26%
- Net change in annual revenues = -0.89%

Cost impacts:

- 2%/year decrease in deliveries = -0.17%

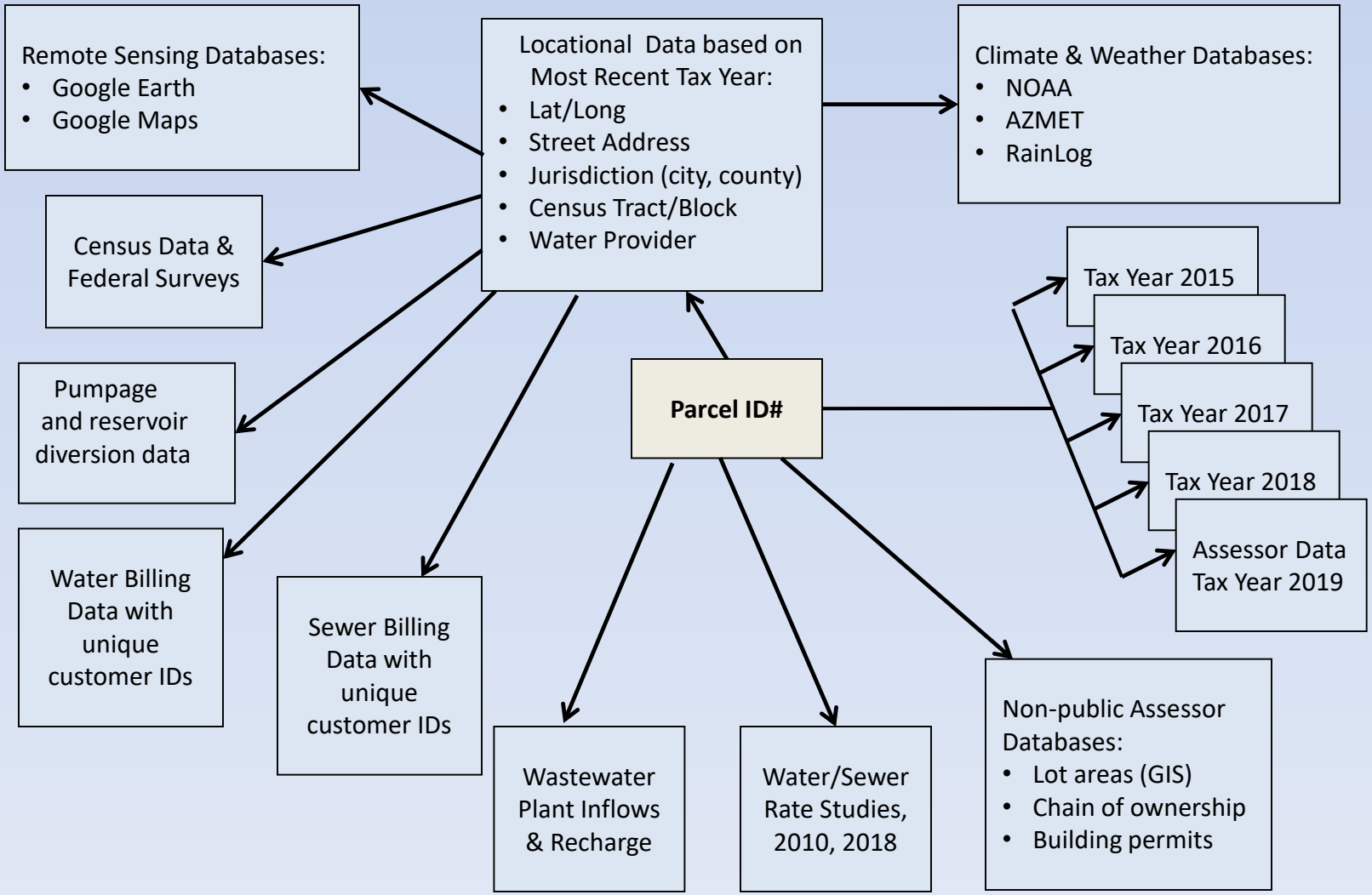
Net Impact on annual budget = -0.72%

Increasing block rates make the actual impact greater, as revenues will fall more than 1.26%.

Also, with more customers, fixed costs may increase.

Similar story for wastewater rates

Databases for Modeling Prescott Demand



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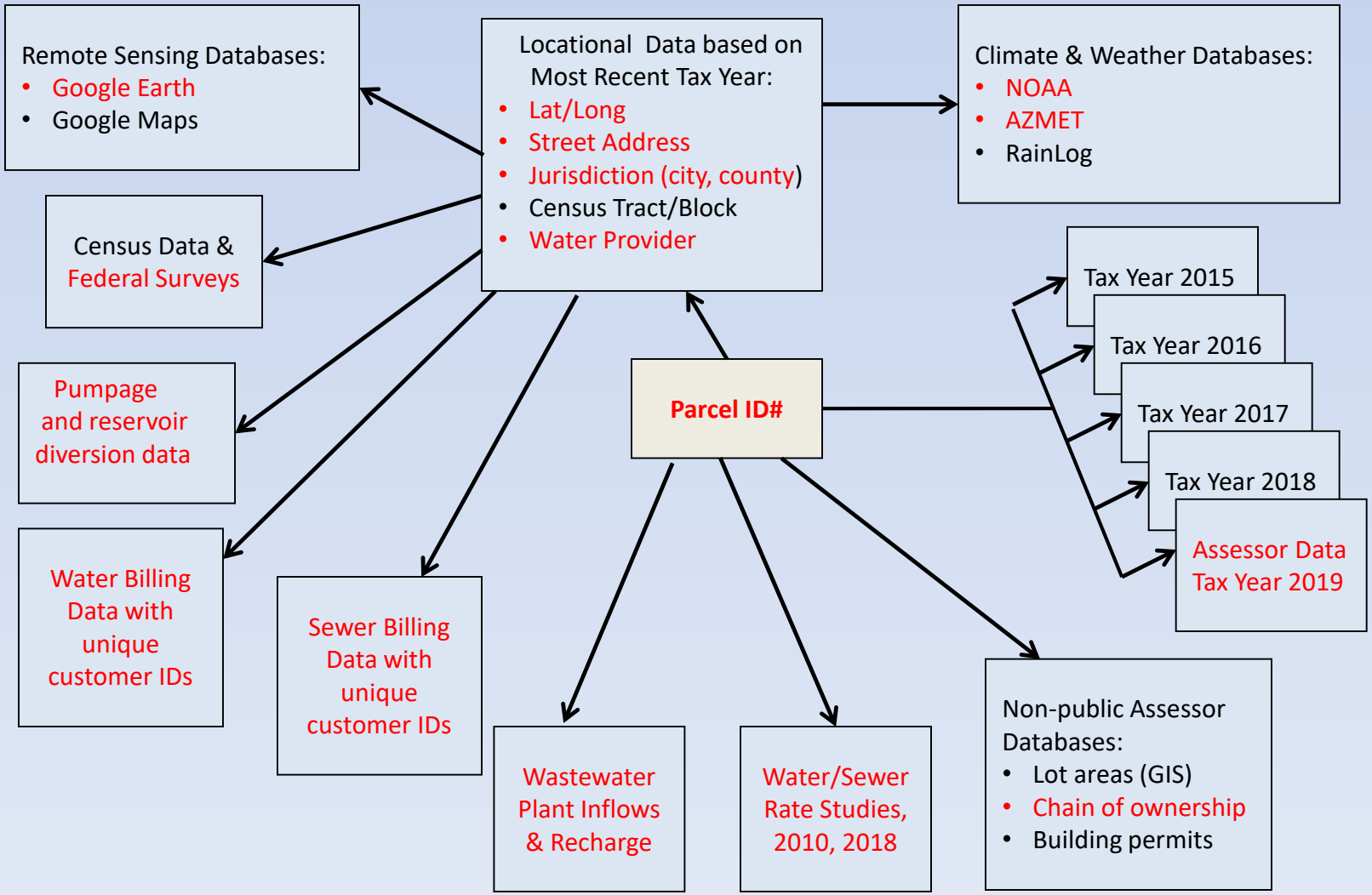


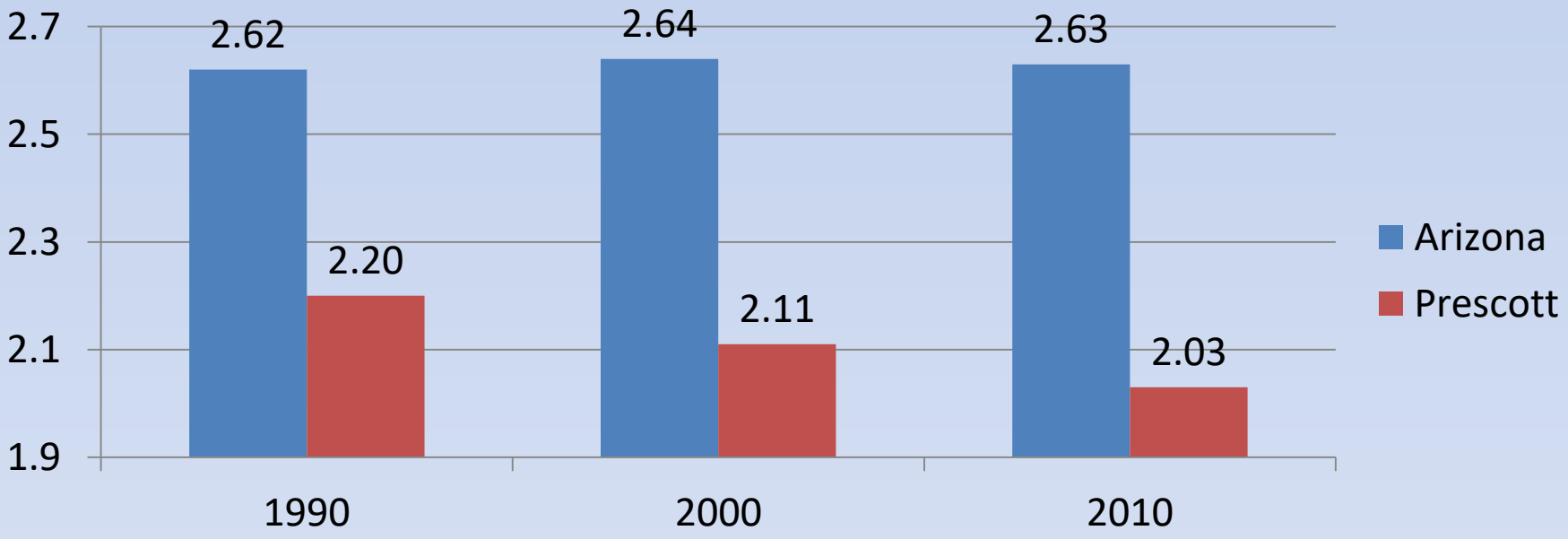
Data issues and challenges:

- Yavapai County assessor lost track of evaporative coolers
- Parcel sales data are unusable
- 14 categories of non-residential customers complicate the model
- No way to disaggregate non-residential customers that are on septic systems
- Lack of data on seasonal residents – how many and when?
- Estimating indoor demand is made difficult by I&I water impacting WWTPs, seasonal residents, and large numbers of non-sewered customers, including non-residential

Possible factors of long-term decline:

- water (and sewer) rate increases
- more effective water conservation programs
- declining household sizes (PPH) & shifting demographics
- more water-efficient fixtures and appliances in new homes
- replacement of inefficient fixtures, appliances in older homes
- changing tastes and preferences in landscaping
- declines in popularity of backyard pools
- shrinking lot sizes and landscapable areas
- evaporative coolers replaced by AC
- more renters, more AirB&B, VRBO rentals
- more seasonal (part-time) residents

In Prescott, PPH is still dropping:



This impacts indoor demand:

- PPH declined from 2.20 to 2.03 between 1990 and 2010.
- That is an 8% decrease over 20 years.
- Average annual decrease is 0.4%.
- This would decrease indoor demand by about 0.4%/year.

Household demographics are changing in other ways that impact demand

- Fewer infants, children and teens
- More 1-adult households, including with children
- More retirees and snowbirds
- In general, a graying population

These changes are happening faster in Prescott.
In addition, income per household has increased.

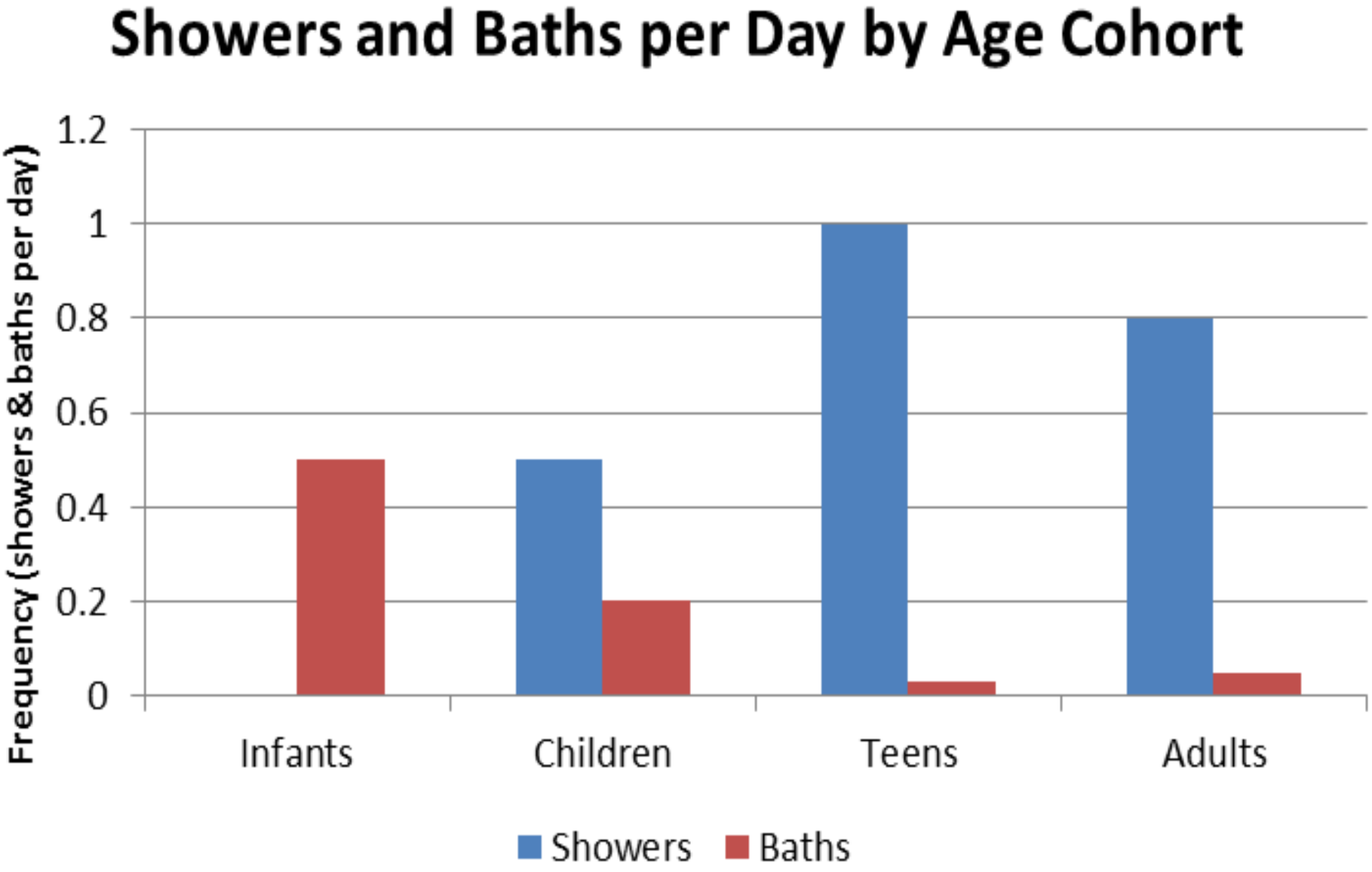
What are the impacts on indoor demand?

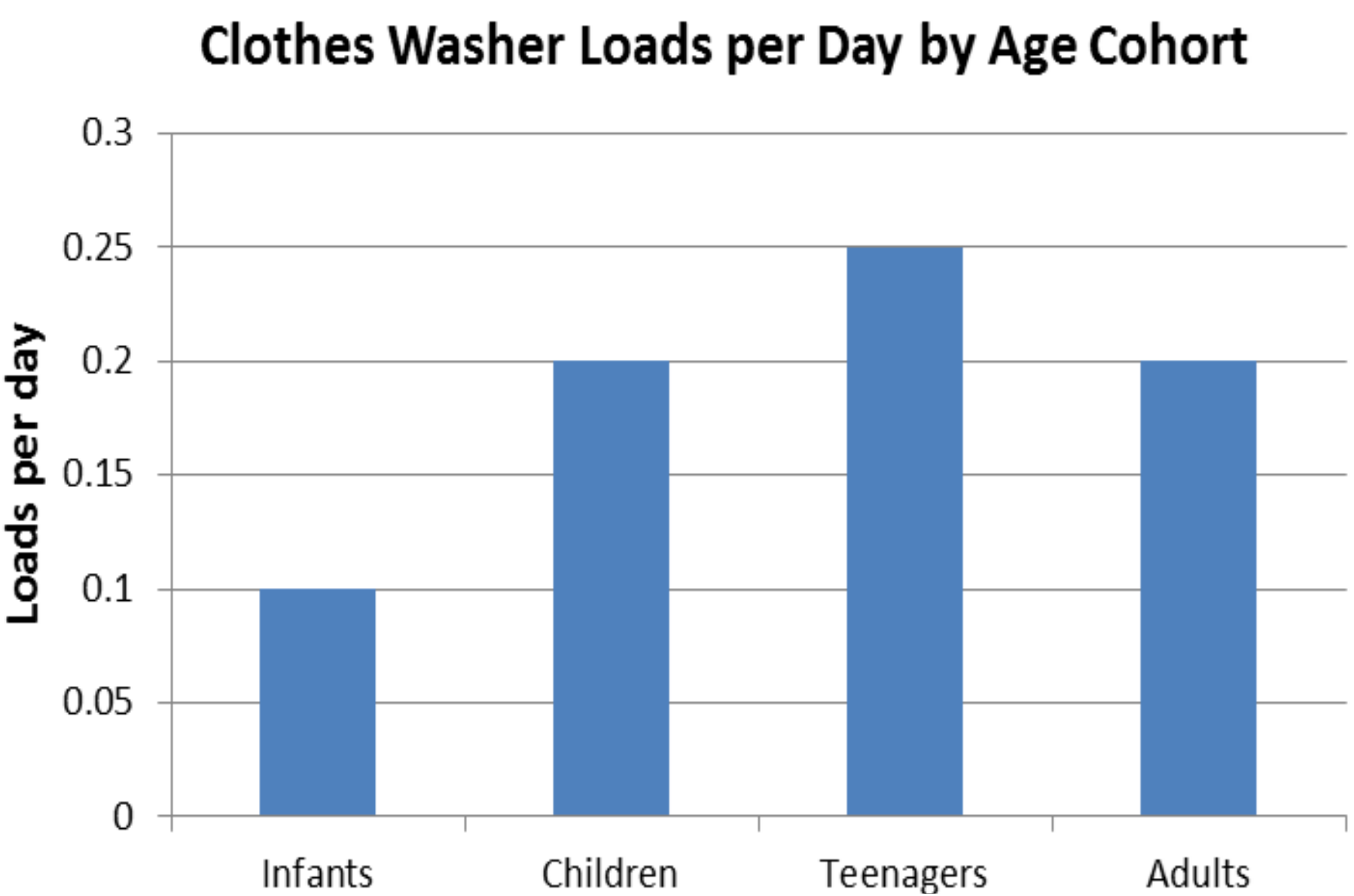
Changes in households affect frequencies and intensities of indoor water uses

Regressions run on AquaCraft WRF data reveal:

- 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 indoor usage trends hold across all 9 urban areas studied, but levels and rates depend on each locality's specific demographics and housing stock.


Showers and Baths per Day by Age Cohort
Frequency (showers & baths per day)
1.2
1
0.8
0.6
0.4
0.2
0
Infants
Children
Teens
Adults
Showers
Baths


Clothes Washer Loads per Day by Age Cohort
Loads per day
0.3
0.25
0.2
0.15
0.1
0.05
0
Infants
Children
Teenagers
Adults

New home construction situation

- Post-bubble shakeout left only 7 national builders
- Four of them claim their homes are “sustainable”, “green”, and/or efficient
- Two of them appear to be serious
- New homes will continue to be more water-efficient, both indoors and outdoors
- Market forces will decide how hard builders push the trend; government not currently having any real effect

Changes in water demand 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

Types of ownership:

- Owner-occupied, year-round
- Owner-occupied, seasonal
- Rented
- Leased out via AirB&B, VRBO

Both ownership status and changes in status affect demand

Another 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
- Useful lifespans of some appliances may be decreasing

Landscape vegetation also has a finite lifespan, and landscapers are planting more native and drought-resistant species. While drought increases irrigation in the short run, it may decrease it in the long run.

Impacts of national voluntary standards and state mandatory standards

April 8, 2015 California headline:

Energy Commission Approves Water Appliance Standards

To Save More Than 100 Billion Gallons Per Year

Governor Brown's recent executive order helps to speed up approval

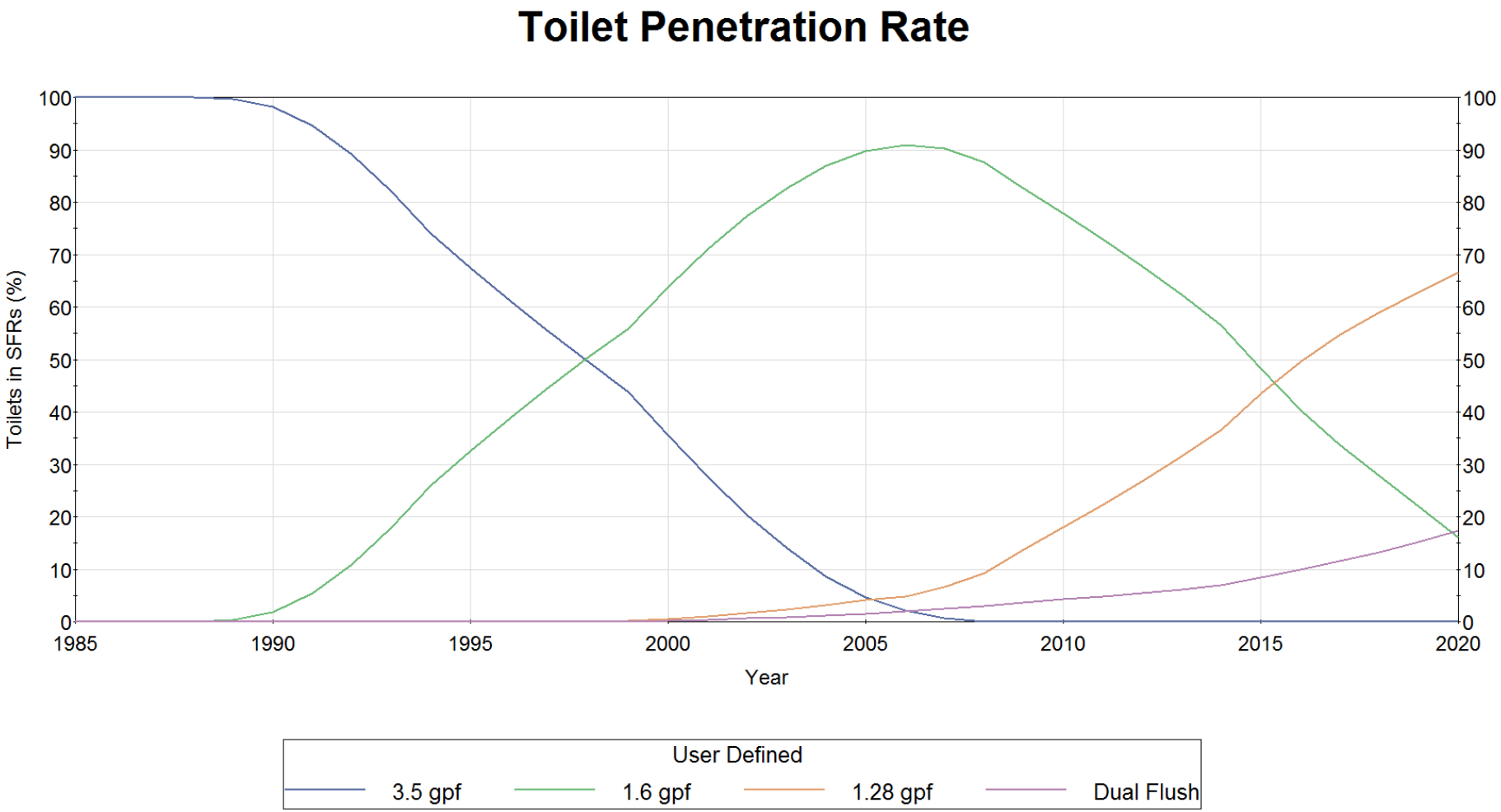
California, and then Texas and Colorado, made federal voluntary standards mandatory, reducing the water used by key fixtures by 20%, for example:

- toilets from 1.6 gpf to 1.28 gpf
- shower heads from 2.5 gpm to 2.0 gpm

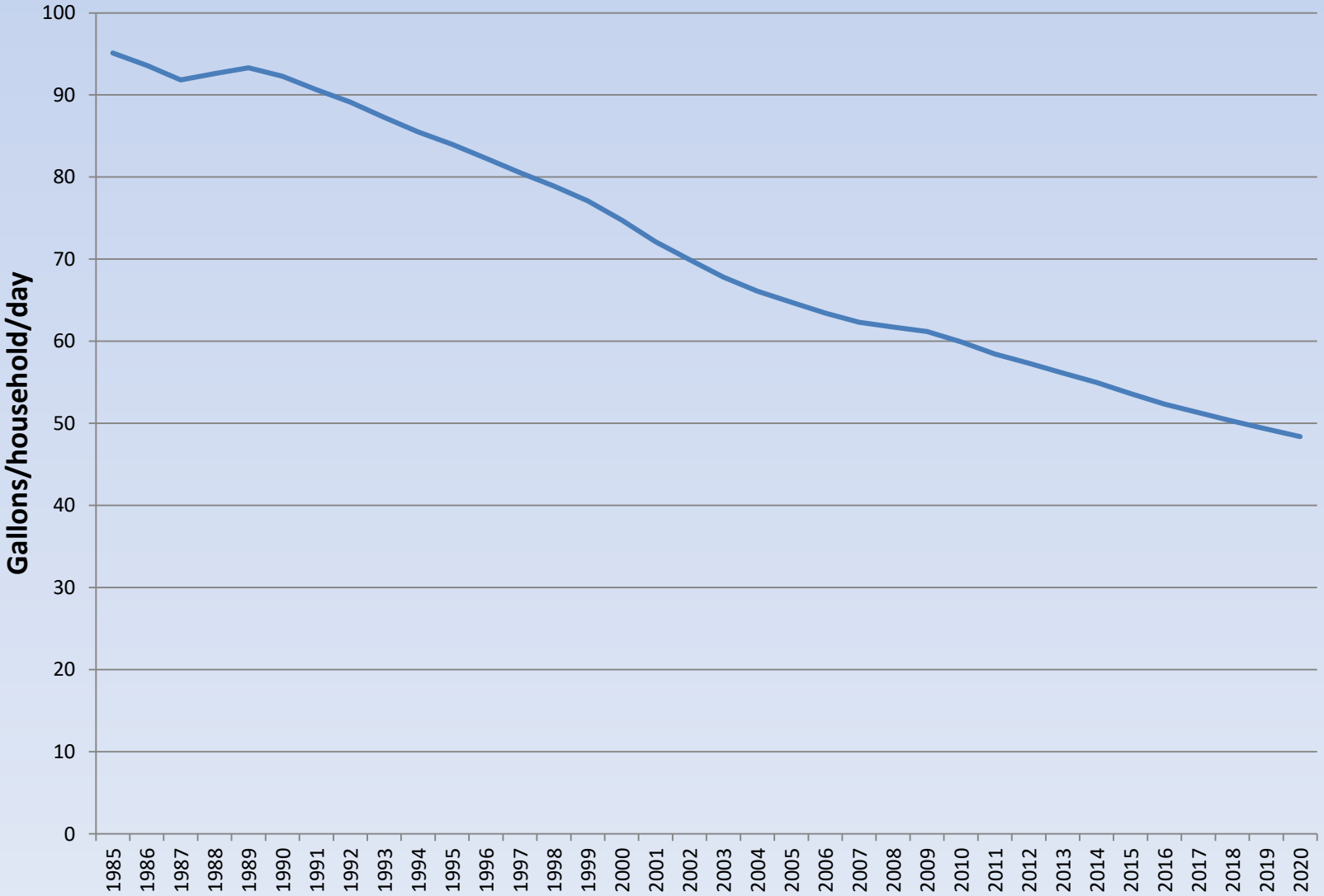
Appliance & fixture markets in Arizona, New Mexico, and Nevada were affected

- Dishwashers – 76 of 80 models sold by Best Buy meet the voluntary Energy Star standard
- Toilets – 18 of 19 models sold in Home Depot and all models sold in Lowe's meet or exceed the CalGreen and Texas 1.28 gpf standard
- Shower heads – market share of 2.0 gpm models in Home Depot soar from 5% to 75%

Efficient toilets initially drove indoor declines



Pima County Indoor Demand Trends



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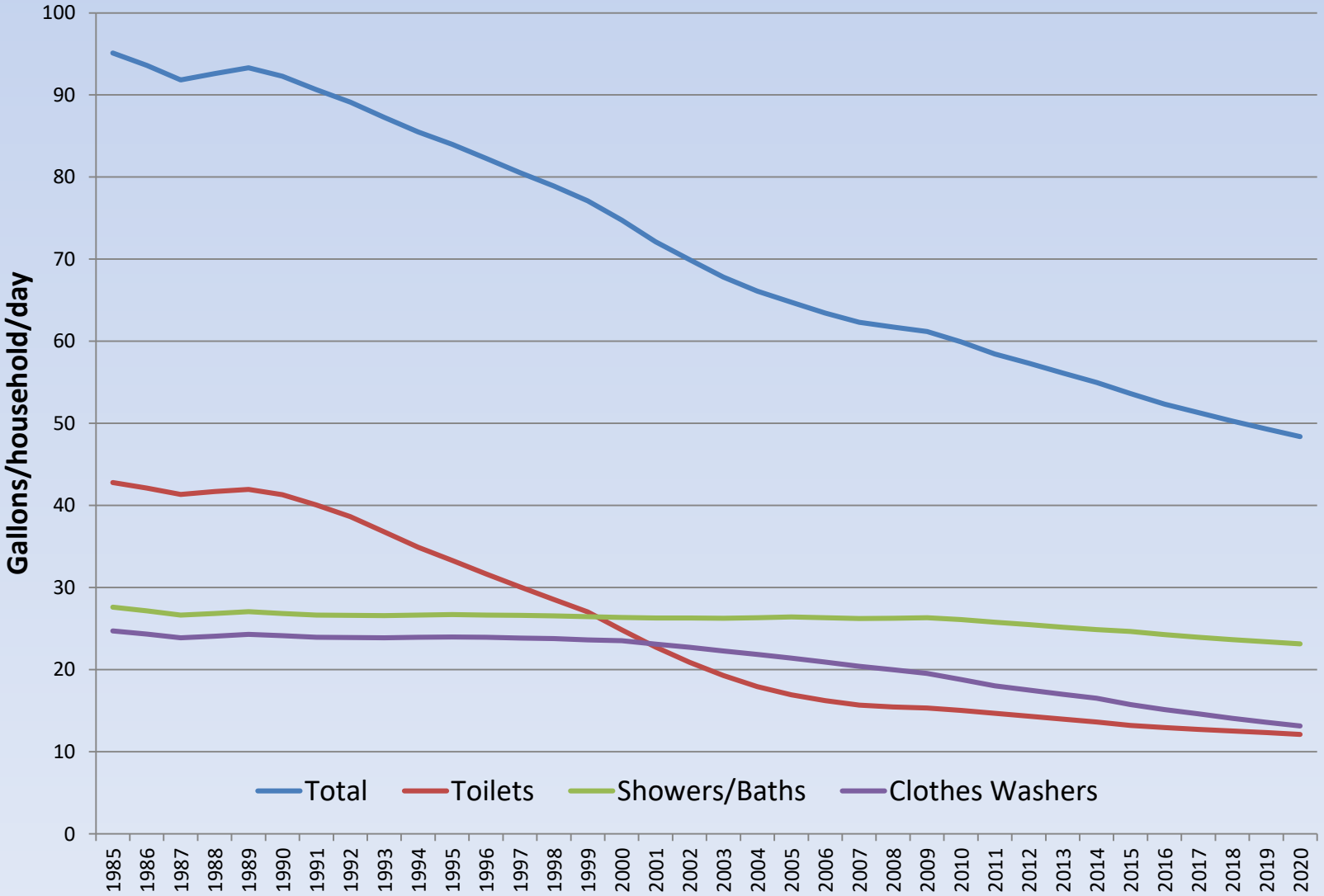


Rates of increased efficiency vary

The stock of appliances and fixtures are affected by rates of:

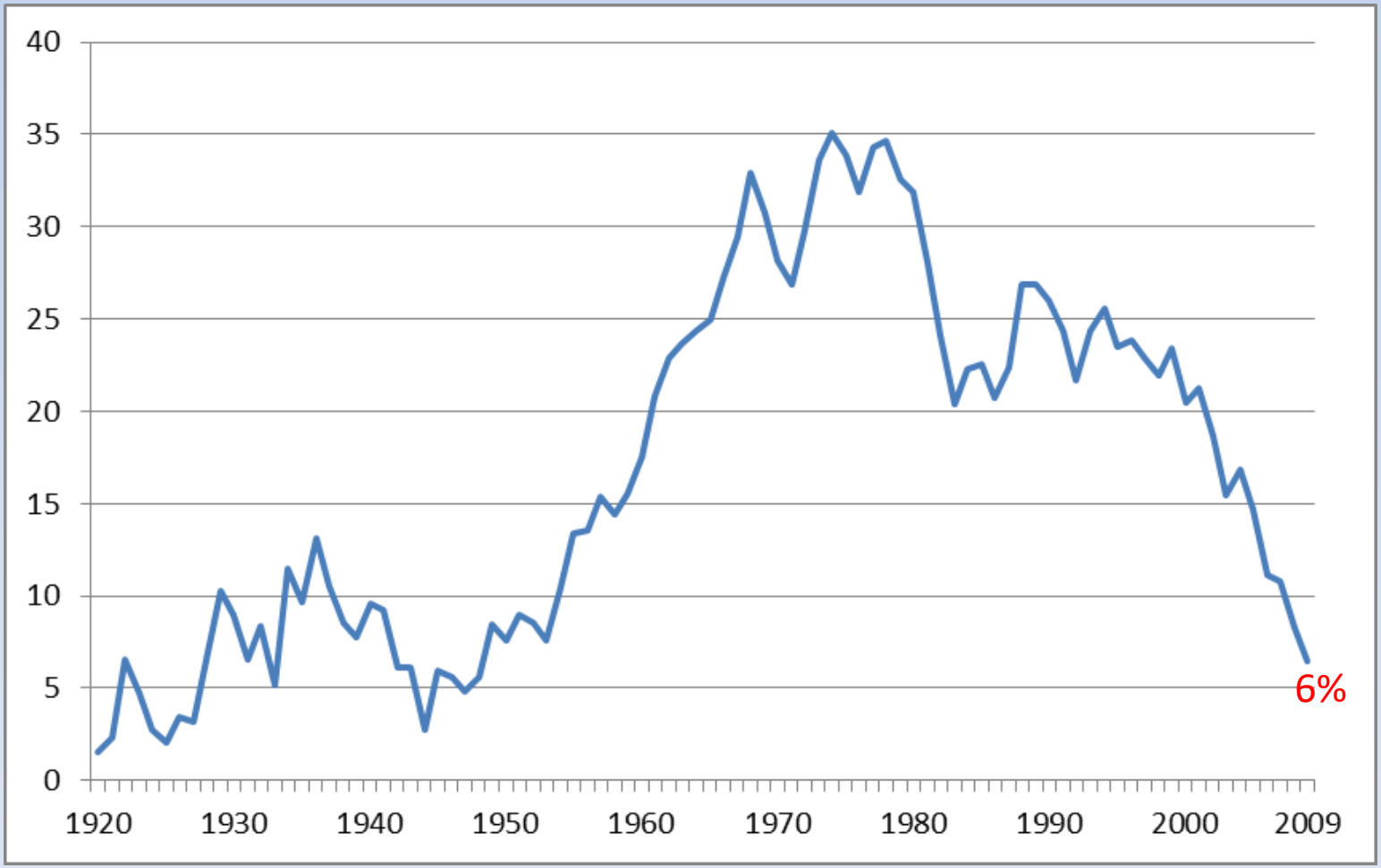
- new construction
- resales of existing homes
- remodeling of kitchens, bathrooms
- conversions from owner-occupied to rental

Therefore, the level of water use efficiency and rate of improvement vary across cities.

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

Other outdoor water uses - pools



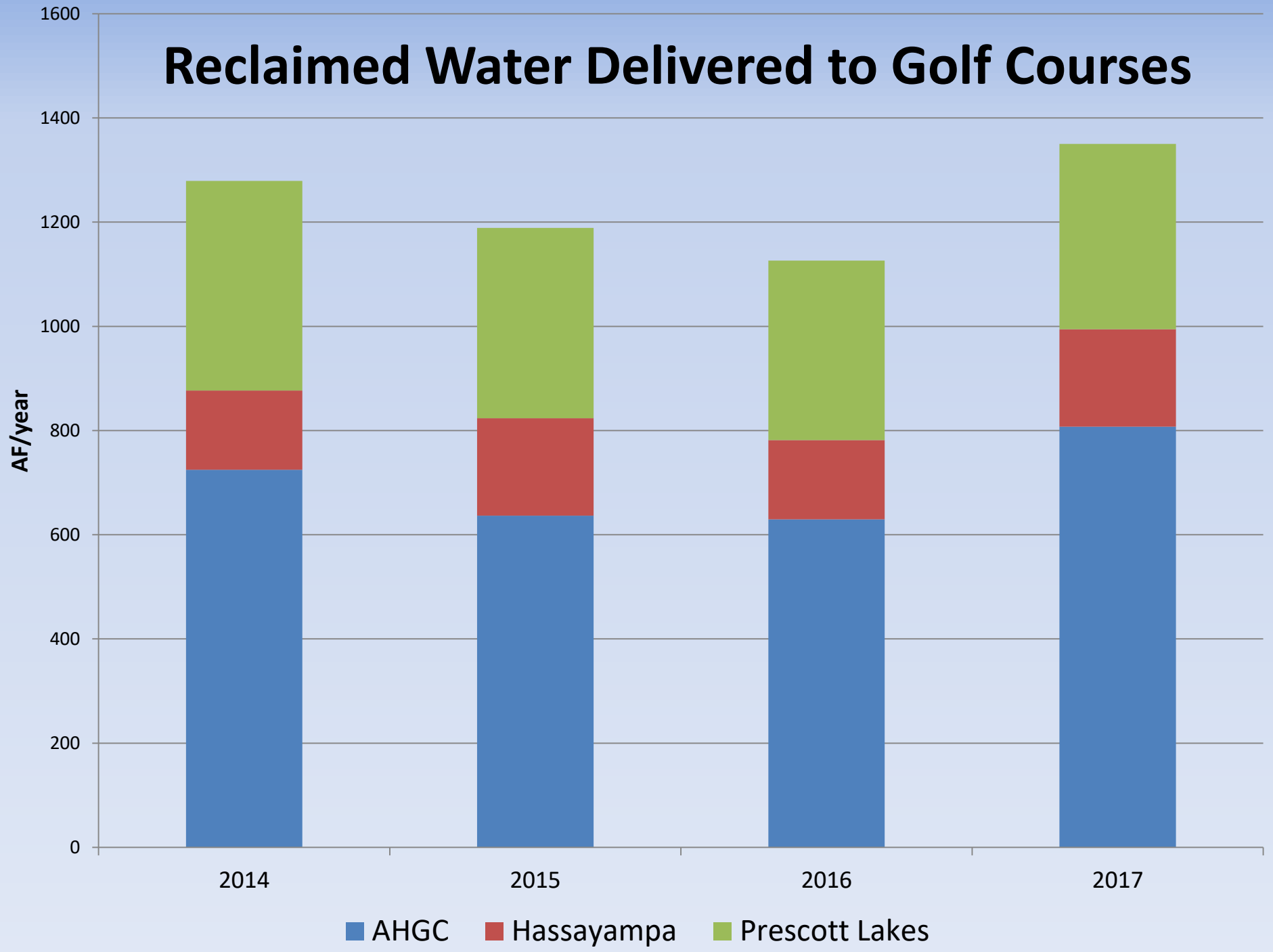
20% of Tucson SFRs have a pool, but the popularity appears to have been in decline for decades.

Outdoor demand is relatively simple in Prescott

Unlike cities in Maricopa and Pima Counties,
Prescott has:

- very few pools (about 140)
- much less turf
- essentially no winter overseeding
- apparently little if any artificial turf
- an unknown but significant number of evaporative coolers

Reclaimed Water Delivered to Golf Courses



Conservation has evolved from slogans and give-aways to data-driven planning

This is reflected in answers to “Why conserve?” over time

- Because we live in a desert
- It’s just the right thing to do
- To keep water rates from going up
- To support growth and the local economy
- For future generations
- To protect the environment
- Because conserved water is the cheapest new supply
- We can use conserved water to enhance our quality of life

One constant – the conservation office is still largely the public face of the utility.

Moving toward One Water

- Growth of rainwater harvesting programs
- Exploration of stormwater opportunities
- Rethinking the role of recycled water
- Persistence with traditional demand management programs
- Drought planning, developing local partnerships, including with other utilities

Rainwater harvesting observations

Tucson Water has spent millions on RWH rebates. Some lessons are starting to emerge:

- RWH rebates are potentially very popular with elected officials and some customers
- Can function like “reverse Robin Hood”, subsidizing the most financially well-off customers
- Reduces outdoor demand, consumptive demand, peak demand, but in part because of other landscape changes
- Not terribly cost-effective compared to other measures
- Not clear what useful life of systems is - will RWH systems continue to be used by subsequent owners?
- Has ancillary environmental benefits

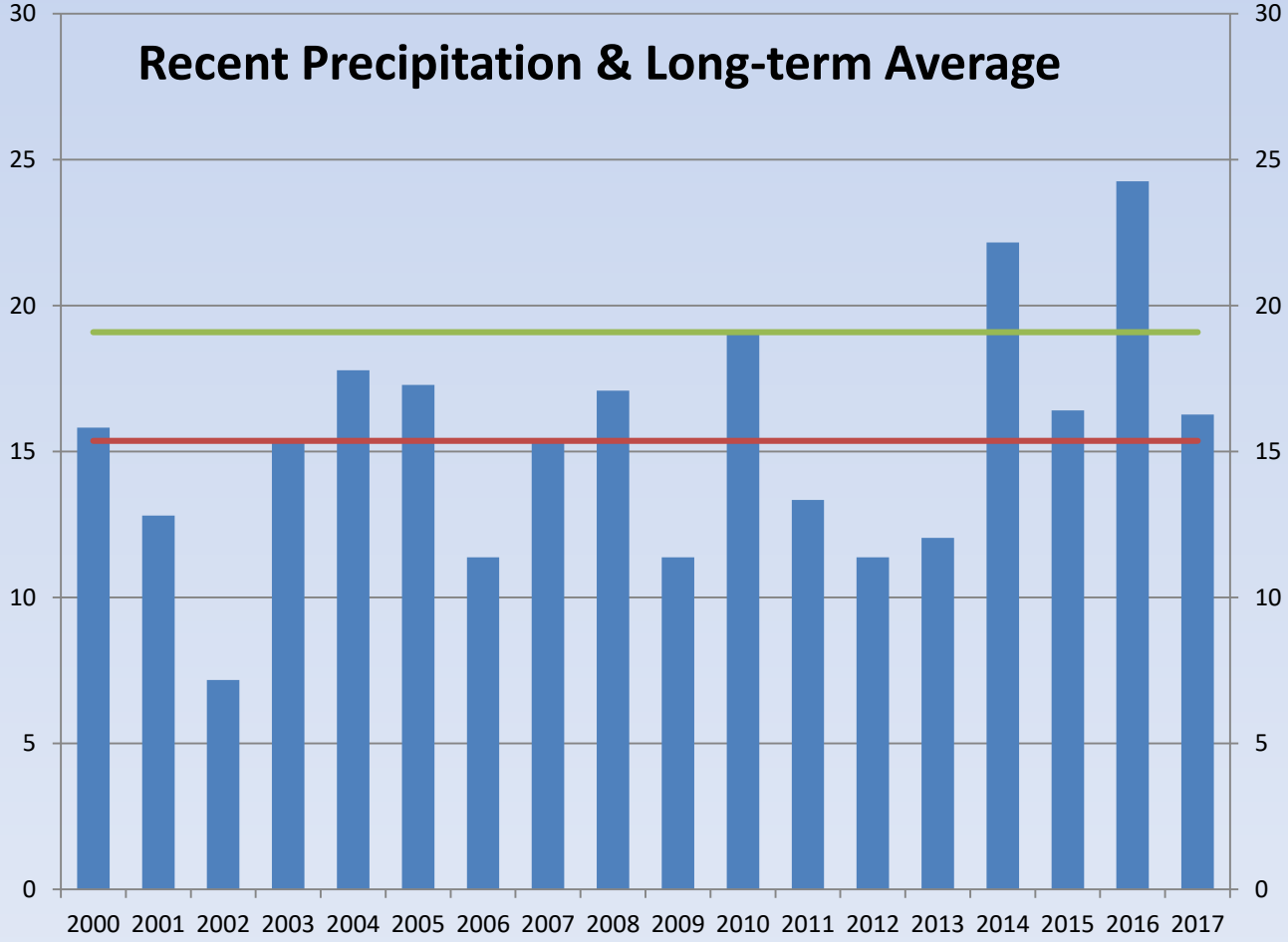
Possible factors of long-term decline:

- water (and sewer) rate increases
- more effective water conservation programs
- declining household sizes (PPH) & shifting demographics
- changing tastes in landscaping
- more water-efficient fixtures, appliances in new homes
- replacement of inefficient fixtures, appliances in older homes
- declines in popularity of backyard pools
- shrinking lot sizes and landscapable areas
- evaporative coolers replaced by AC
- more renters, more AirB&B, VRBO rentals
- more seasonal (part-time) residents

Precipitation affects Prescott's water demand and supply in multiple ways

- Rainfall, especially in summer, reduces potable and reclaimed demand for landscape irrigation
- Storm water runoff fills Watson and Willow Reservoirs, providing surface water for recharge
- Precipitation fills rainwater harvesting cisterns, providing owners with an alternate water supply
- Storm water runoff creates inflow and infiltration to Prescott's wastewater treatment plants, increasing reclaimed water for recharge

Precipitation has been reduced by drought since 2000



Precipitation has been below the long-term average for 16 of the last 18 years.

Average precipitation for 1950 to date is 19.09 inches.

Average precipitation for 2000-2017 is 15.36 inches, a 20% reduction.

Modeling isn't just about water

A complete water demand and supply analysis requires analyzing and possibly modeling 4 sets of stocks and flows:

- **Water,** including both wet water and paper water
- **Money,** including costs and revenues
- **Water users** – demographics of households, key characteristics of non-residential customers
- **Water uses** – housing stock and its water-using appliances, fixtures, and landscape features

Wet water vs. paper water

Wet water is actual water; paper water is a legal or policy right or limitation on the ownership or usage of water. Both are needed for a reliable, sustainable water supply. Examples of paper water:

- Rights to divert surface water, including D&O
- Rights to pump groundwater
- Rights to instream flows
- Credits for recharging surface water or reclaimed water
- Development rights to receive potable water or discharge wastewater

Serious problems can arise when wet water and paper water get out of sync.

Conclusions – 1 of 3

Four factors are driving declines in Prescott demand:

- Changing demographics - smaller households, more seasonal residents, fewer children & teens
- Active conservation efforts – rebate-related
- “Passive conservation” in existing homes driven by changes in tastes and preferences and more efficient devices dictated by out-of-state standards
- Adding new, water-efficient houses to existing housing stock

Conclusions – 2 of 3

Basic economic assumptions need re-examining:

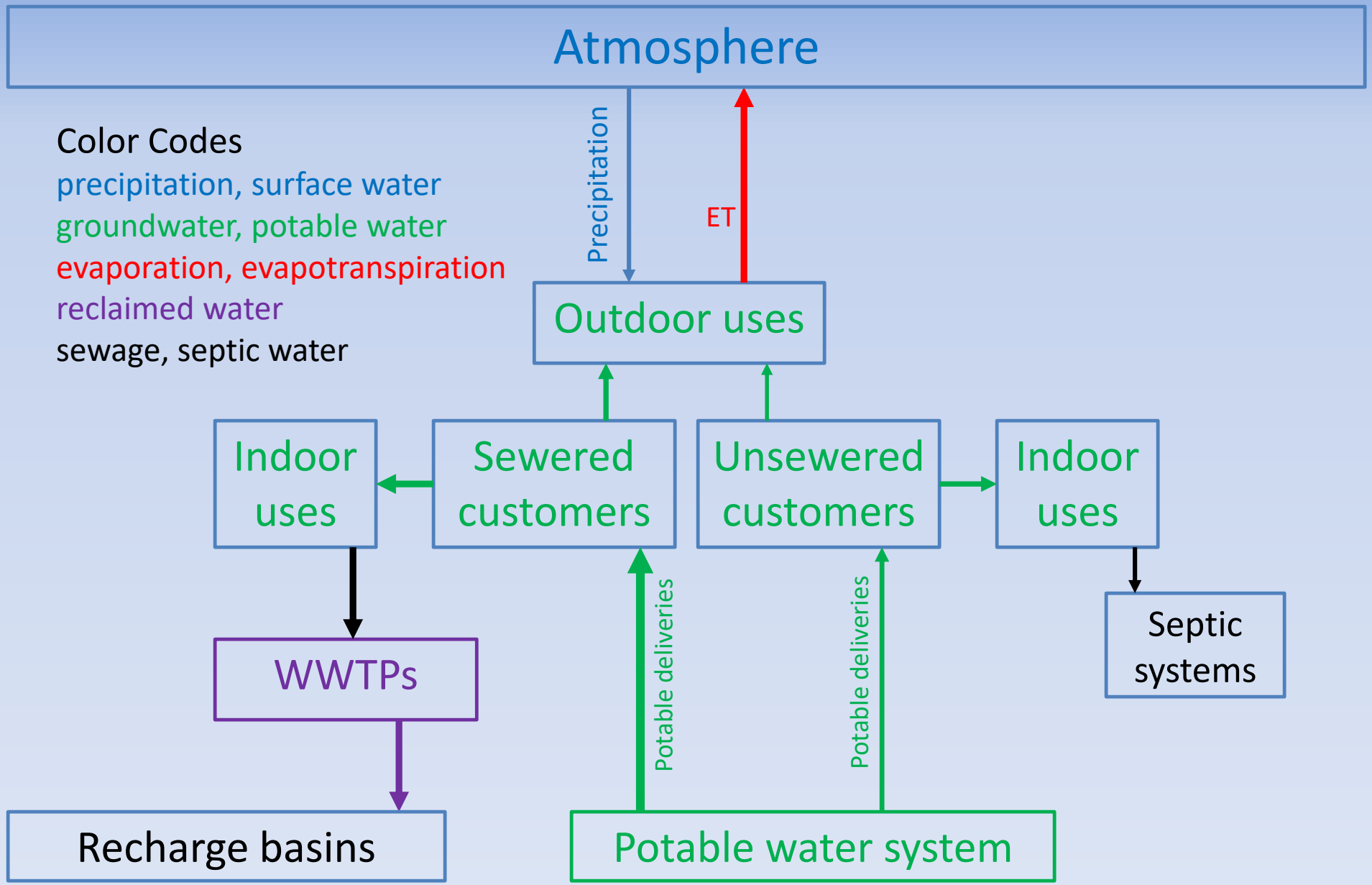
- Demand is decoupled from population, economic output, and quality of life
- most trends reducing demand are not price-driven
- decreasing demand is driving rates up; raising rates does relatively little to reduce demand
- indoor demand is becoming an inferior good – as income rises, demand drops because newer, higher-end appliances and fixtures are the most efficient.

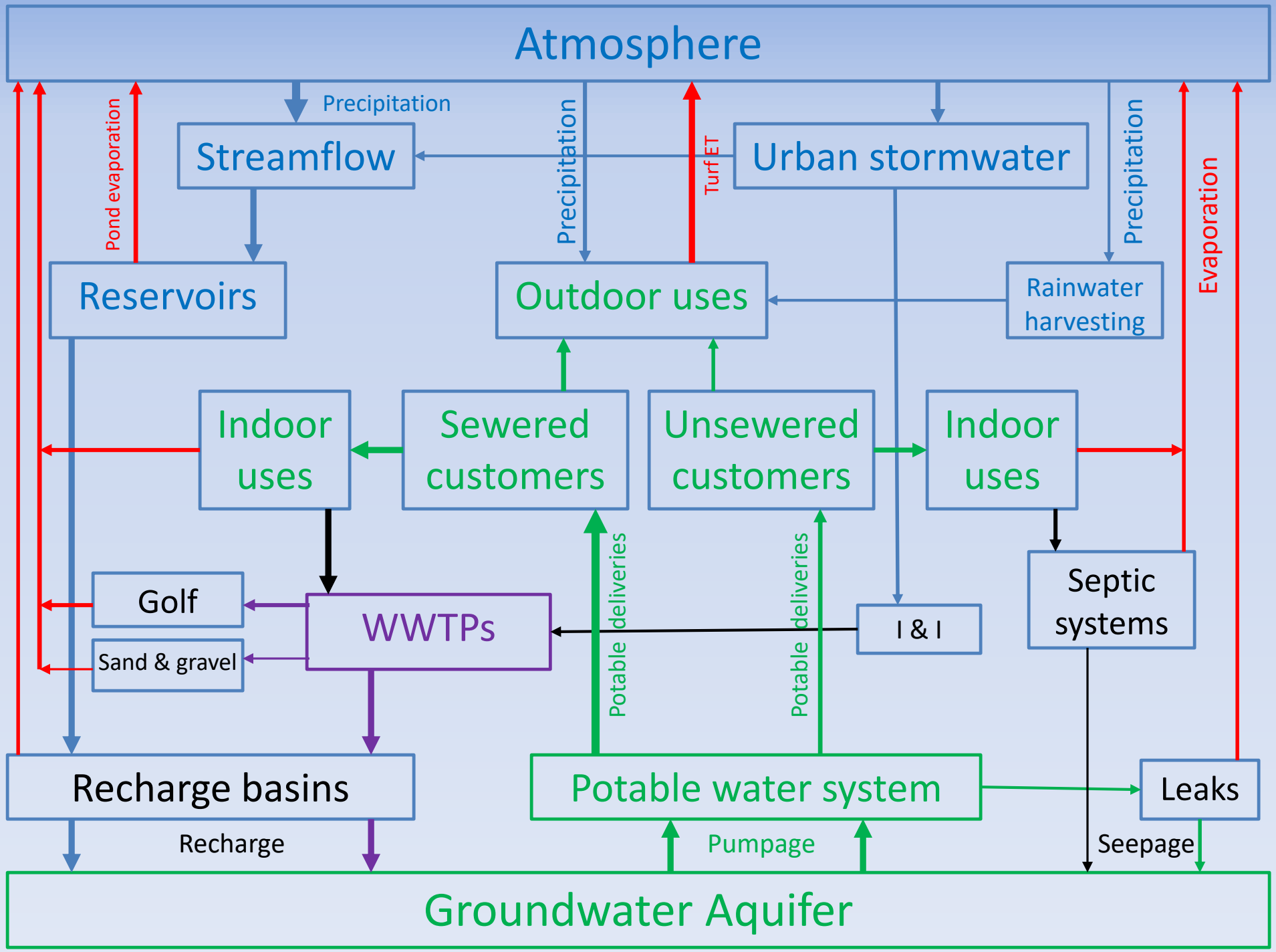
Conclusions – 3 of 3

Some conservation/supply enhancement approaches to improving the water budget:

- Enhanced conservation, focusing on outdoor demand
- Enhanced conservation, focusing on indoor demand
- Sewering customers currently on septic systems
- Encouraging those on septic to develop gray water systems
- Extend reclaimed water system to additional turfed areas
- Enhanced rainwater harvesting program; storm water usage
- Reduce potable system leaks
- Reduce leaks on customers' side of the water meter

Each of these can be done incrementally. Evaluating them requires a broader system-wide analysis.


Atmosphere
Color Codes
precipitation, surface water
groundwater, potable water
evaporation, evapotranspiration
reclaimed water
sewage, septic water
Precipitation
ET
Outdoor uses
Indoor uses
Sewered customers
Unsewered customers
Indoor uses
WWTPs
Septic systems
Potable deliveries
Potable deliveries
Recharge basins
Potable water system


Atmosphere
Precipitation
Pond evaporation
Streamflow
Precipitation
Turf ET
Urban stormwater
Precipitation
Evaporation
Reservoirs
Outdoor uses
Rainwater harvesting
Indoor uses
Sewered customers
Unsewered customers
Indoor uses
Golf
Sand & gravel
WWTPs
Potable deliveries
Potable deliveries
I & I
Septic systems
Recharge basins
Potable water system
Leaks
Recharge
Pumpage
Seepage
Groundwater Aquifer