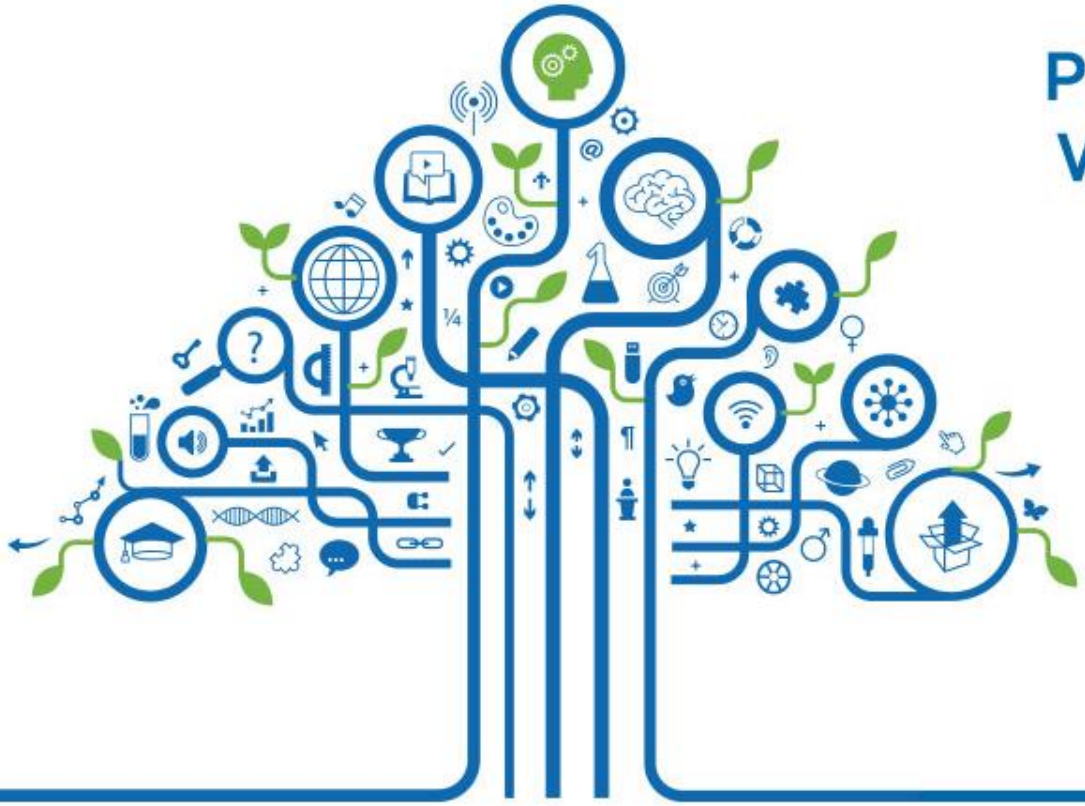
Changing Trends in Water Use



Planning & Design of Water & Wastewater Infrastructure

February 27, 2019

CWN Webinars

Connecting water professionals to decision-ready knowledge

Canadian Water Network

Insights for the water sector

helping decision-makers move forward

Canadian Water Network frames what is known and unknown in a way that usefully informs the choices being made.

cwn-rce.ca

Canadian Trends in Water Use

From 2011 to 2015

- The number of people served by WTPs increased by 6% ⬆
- Potable water volume processed by WTPs decreased by 2% ⬇
- Average per capital daily residential water use decreased by 6.5% ⬇

(Statistics Canada)

Implications of decreasing water use on planning and design of infrastructure

Webinar Speakers

Nicole Sapeta
Region of Waterloo

Kaoru Yajima
Region of Waterloo

Heather Zarski
EPCOR

Jack Kiefer
Hazen and Sawyer

Linda Sawyer
Brown and Caldwell

Region of Waterloo

Changing water use trends

Outline

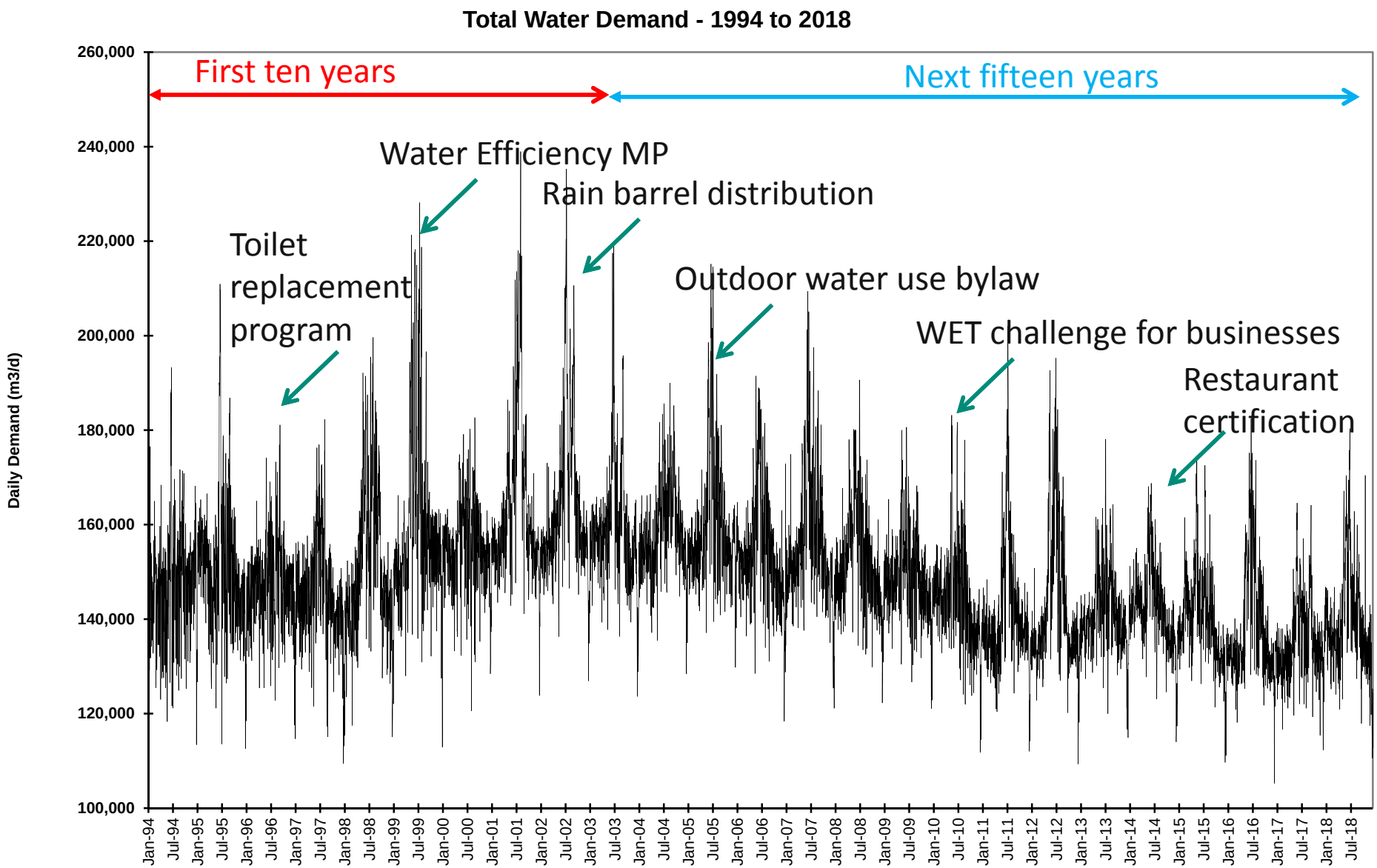
1. Background
2. Approach for water planning
3. Approach for wastewater planning
4. Moving forward

Background

Region of Waterloo

Region of Waterloo is here

Historical water use



Approach for changing trends

Supply Protection Conservation Wastewater

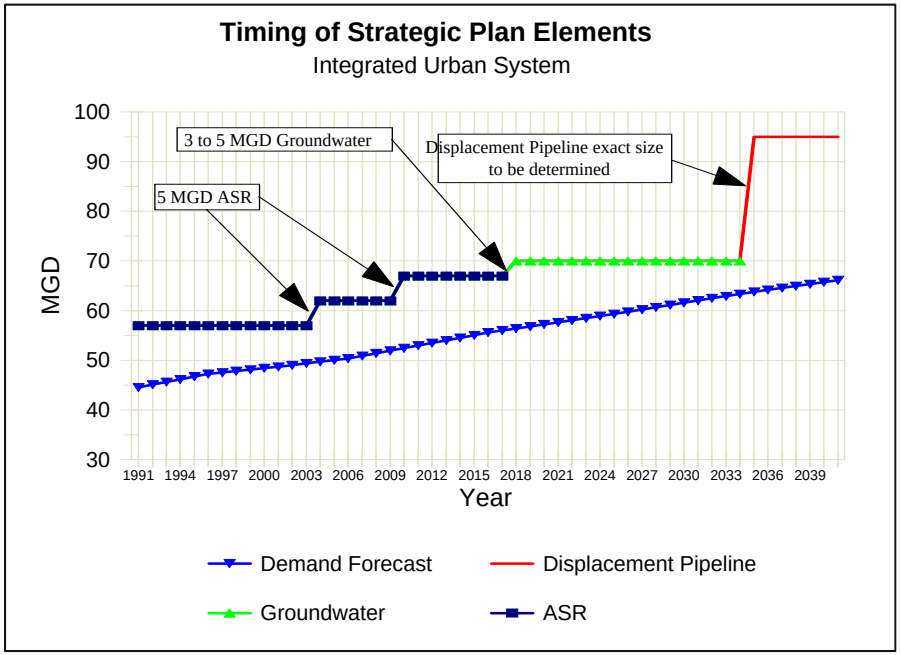
Think differently about future water use

Opportunity to focus on optimization

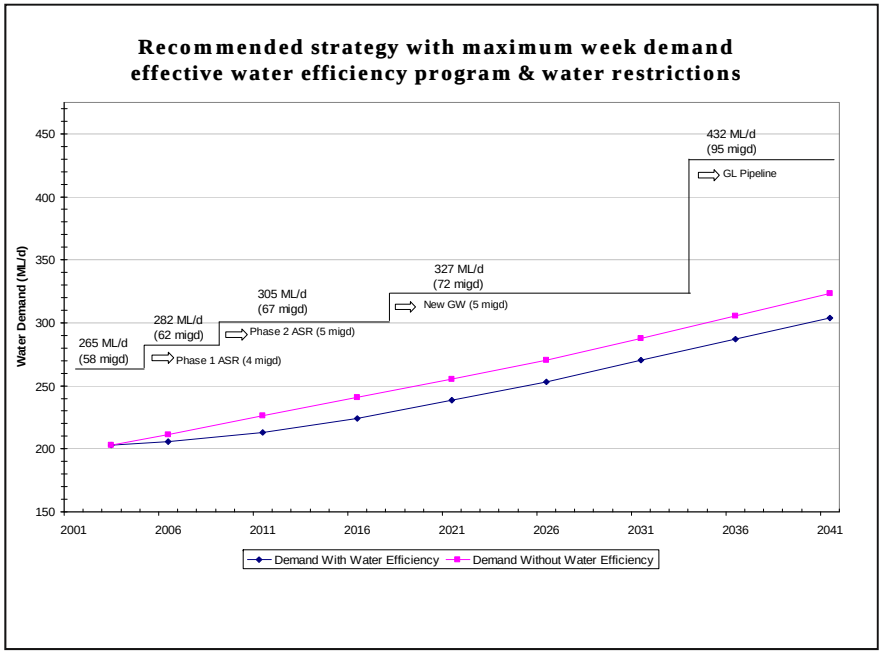
Master planning provides opportunity to account for new trends

Approach for water planning

Typical forecast approach

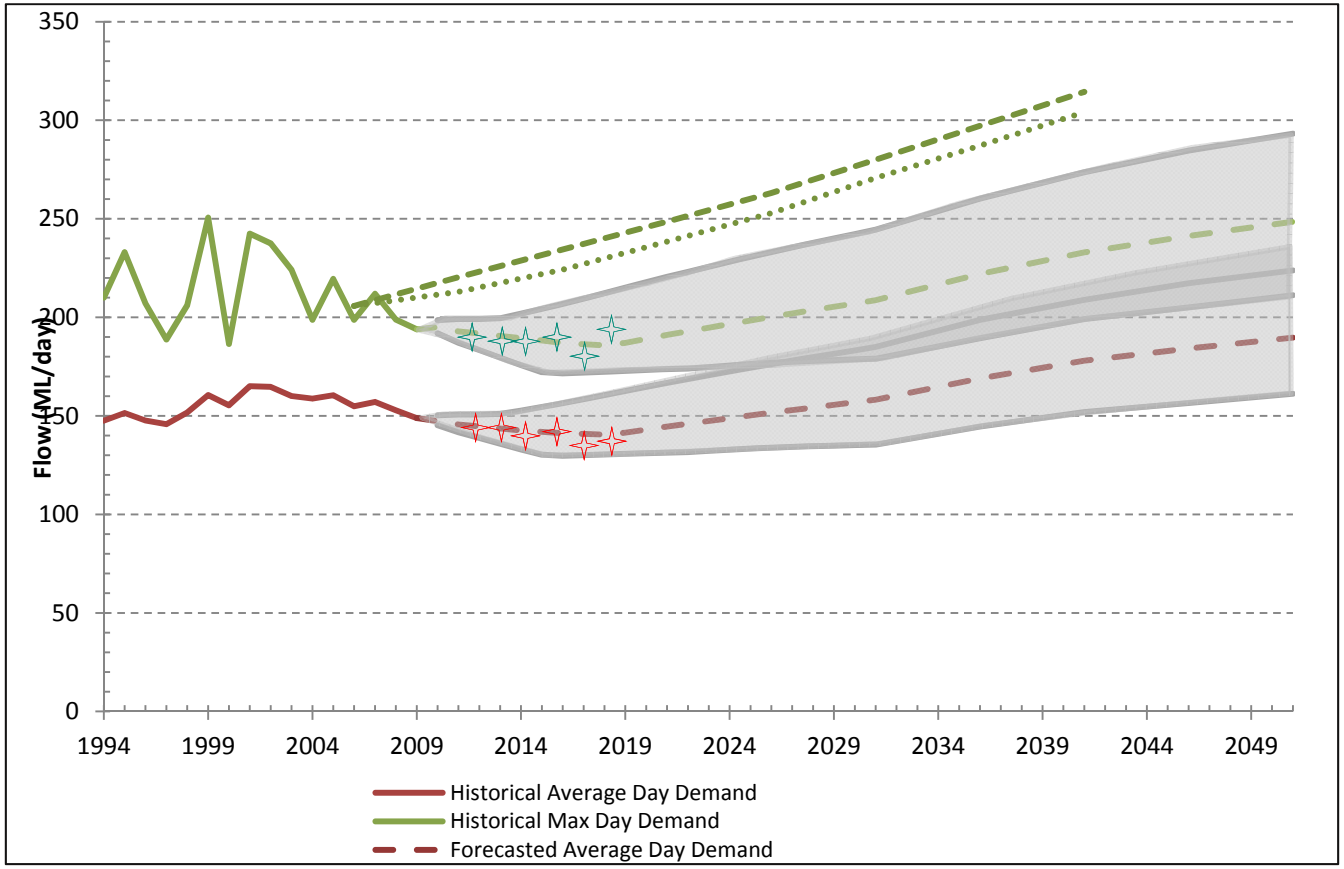


1999 Master Plan



2007 Master Plan

Modified forecast approach



actual demand

2013 Master Plan

Opportunities for optimization

Optimization opportunities arise with the lower demands.

Well optimization

Pumping optimization

Distribution System optimization

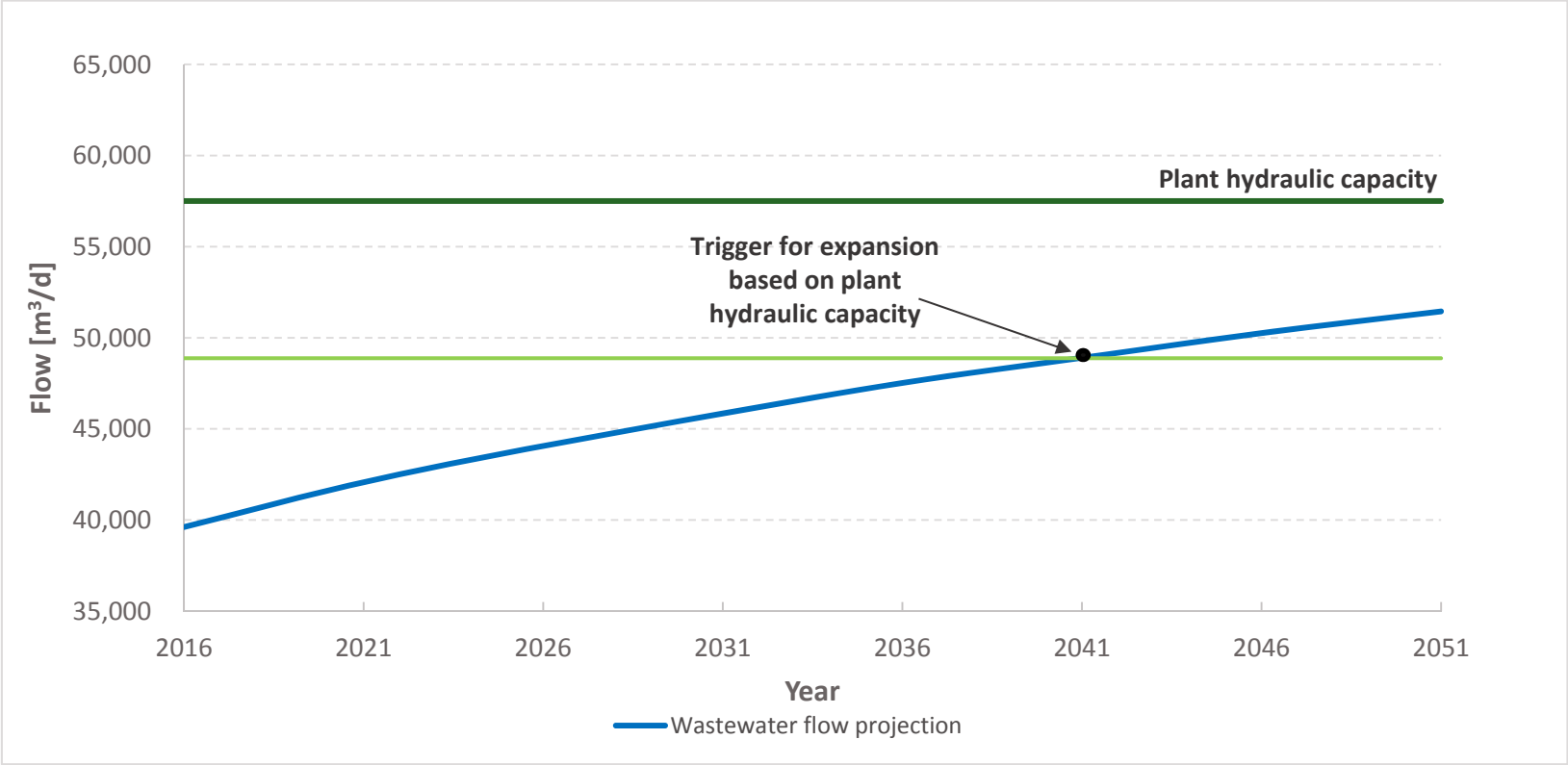
Value of master planning

Doing the right projects at the right times

- Deferring new water supply infrastructure
- Alignment with related Region initiatives: water efficiency, asset management, etc.
- Impact on user rates

Approach for wastewater planning

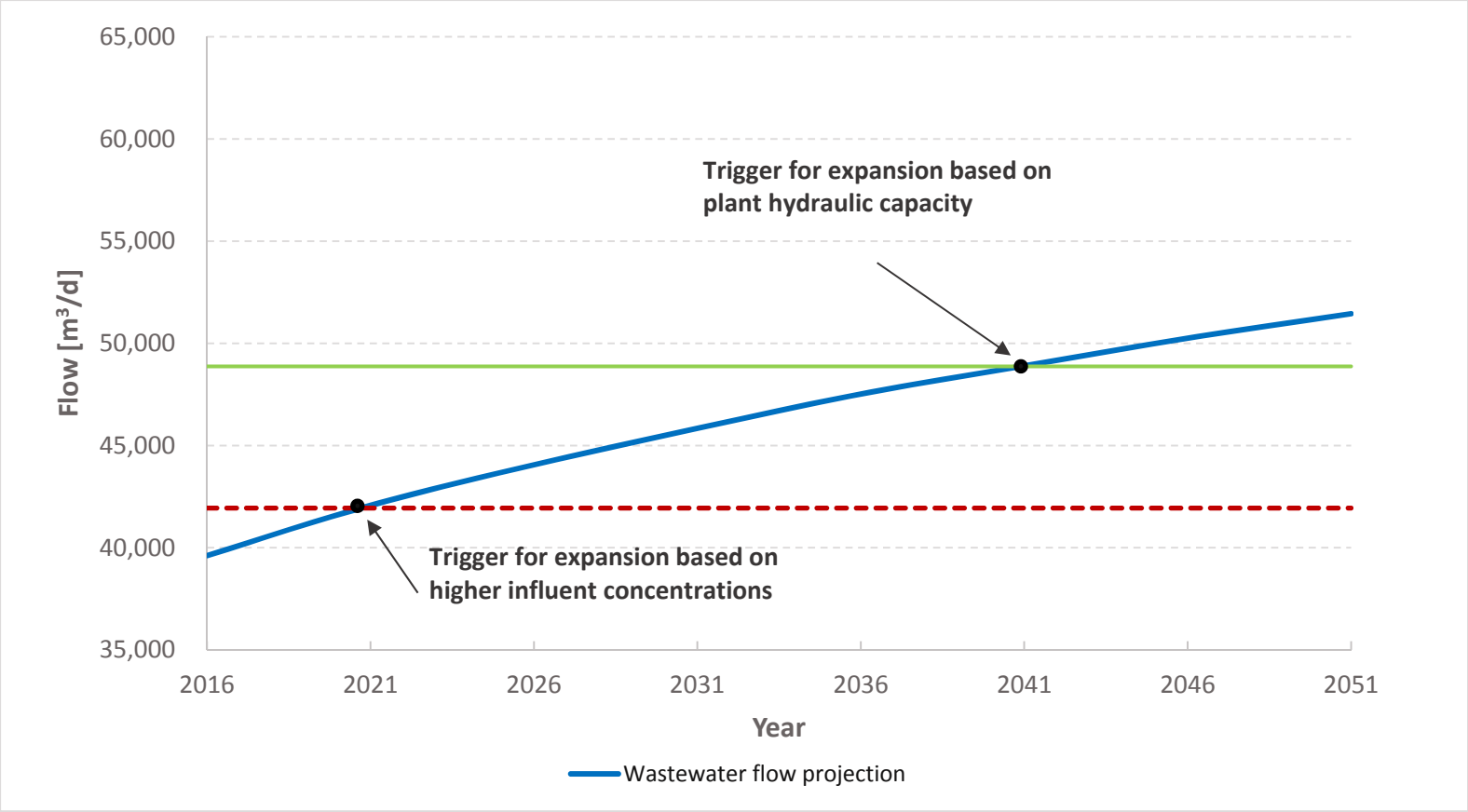
Typical engineering approach



If we know water use is declining, how will this impact our wastewater treatment plants?

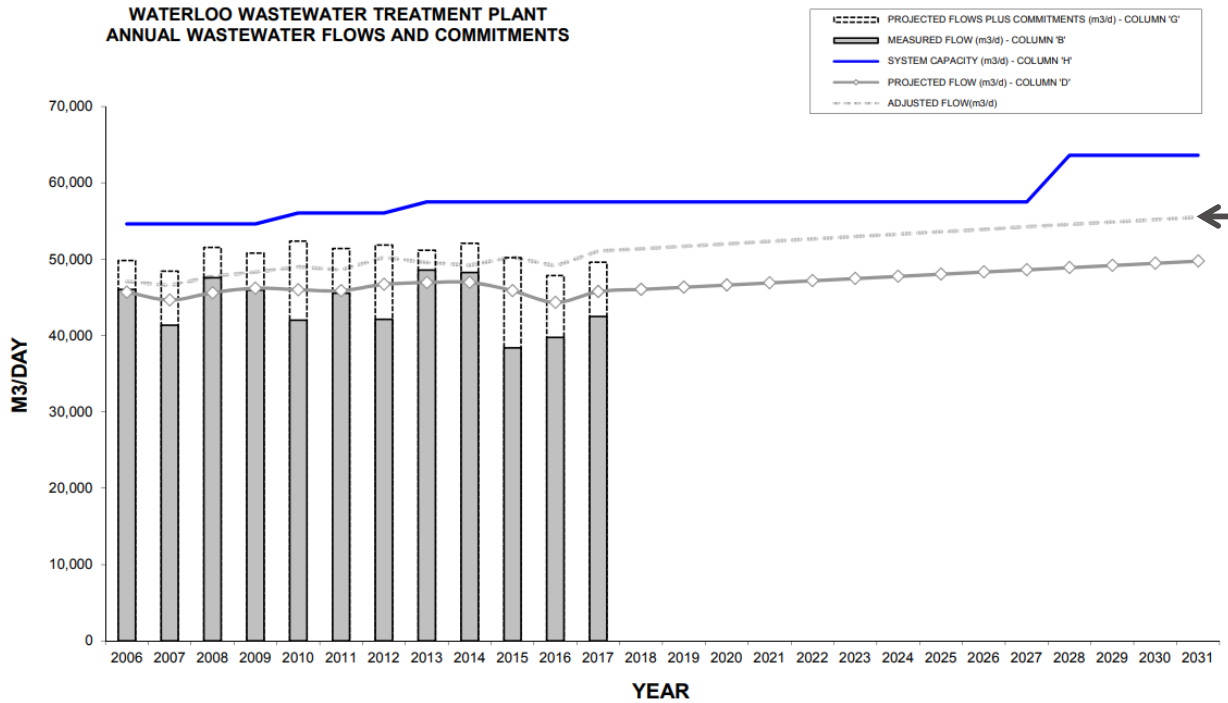
New approach

Consideration of higher influent loading rates as a result of lower water use



Uncertainty in wastewater flows

Wastewater flow rates are more influenced by weather as a result of extraneous flows, making it harder to forecast declining trends in flows



Adjusted flow accounts for seasonal variations caused by rainfall and snow thawing

Approach for wastewater planning is more conservative for timing of capital projects based on higher degree of uncertainty.

Opportunity for optimization

Opportunities for optimization as a result of lower flows:

Plant re-rating

Lower projected flows open up opportunities for re-rating plants to accommodate moderate increases rather than large plant expansions in the near future for greater flows.

Optimizing plant operations

Deferring projects provides an opportunity to look at how to make the most of existing infrastructure

Diversion of flows

More gradual rates of flow increase provided opportunities to look at diverting flows in the short-term to nearby facilities

Value of master planning

Doing the right projects at the right times

Accounting for trends in wastewater flows at a master planning level provided opportunities to:

- Defer large capital projects
- Confirm appropriate project triggers to monitor
- Review levels of uncertainty to make informed decisions on acceptable levels of risk

Moving forward

Approach for future planning

1. Be open to change

Open-minded review of information to make informed decisions on what approach makes sense for planning.

2. Look for new opportunities

Change often means new opportunities. Take the time to identify what benefits a new trends or approaches may bring your organization.

3. Adapt to new trends

Continue to use master planning to identify and adapt to new trends

Thank you

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Changing Trends In Water Use:
Planning & Design of Water & Wastewater Infrastructure

Canadian Water Network Webinar

February 27, 2019

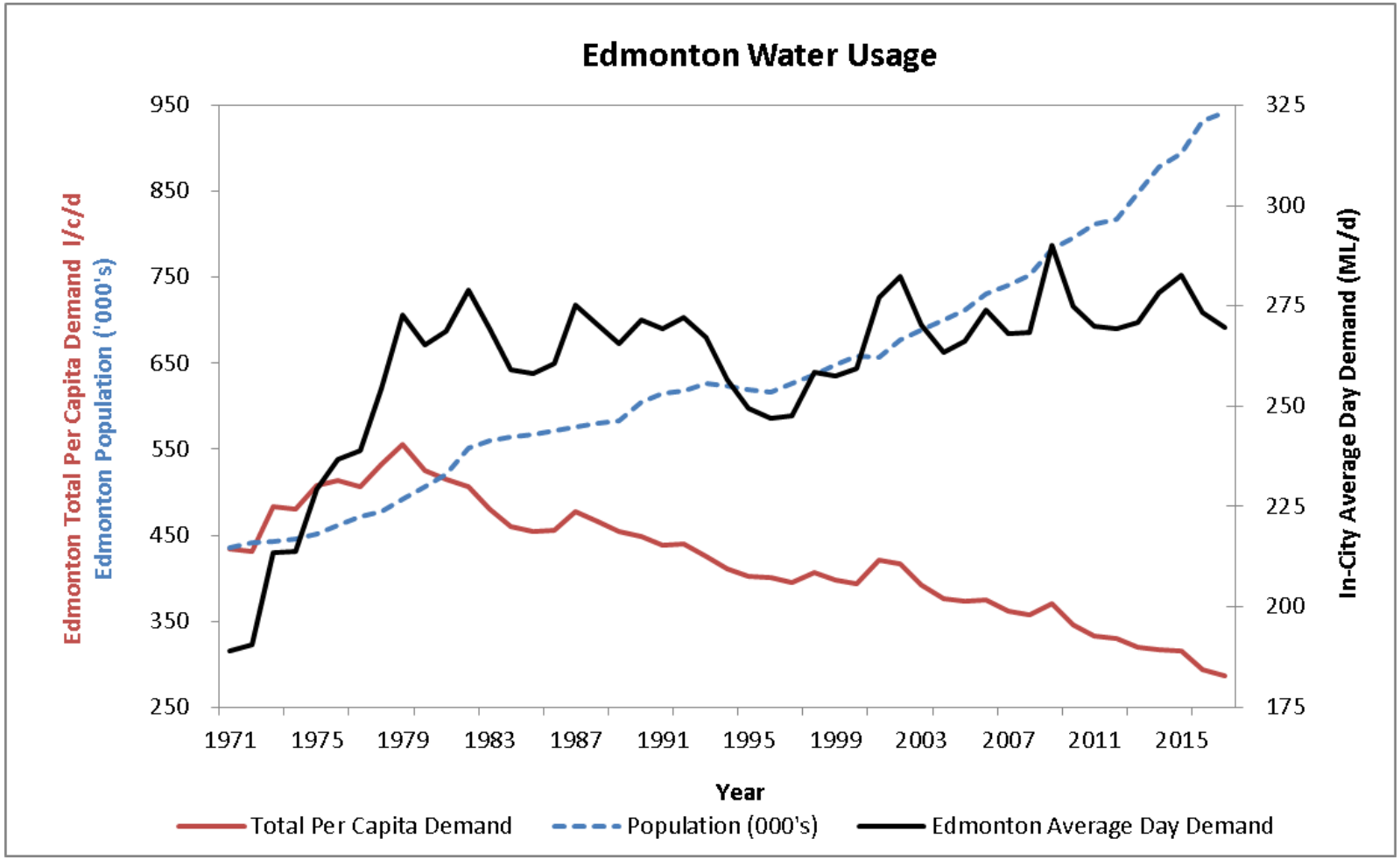
Heather Zarski, P. Eng.

Overview

- Edmonton’s declining water consumption trends
- Operational & maintenance challenges
- Planning & design opportunities

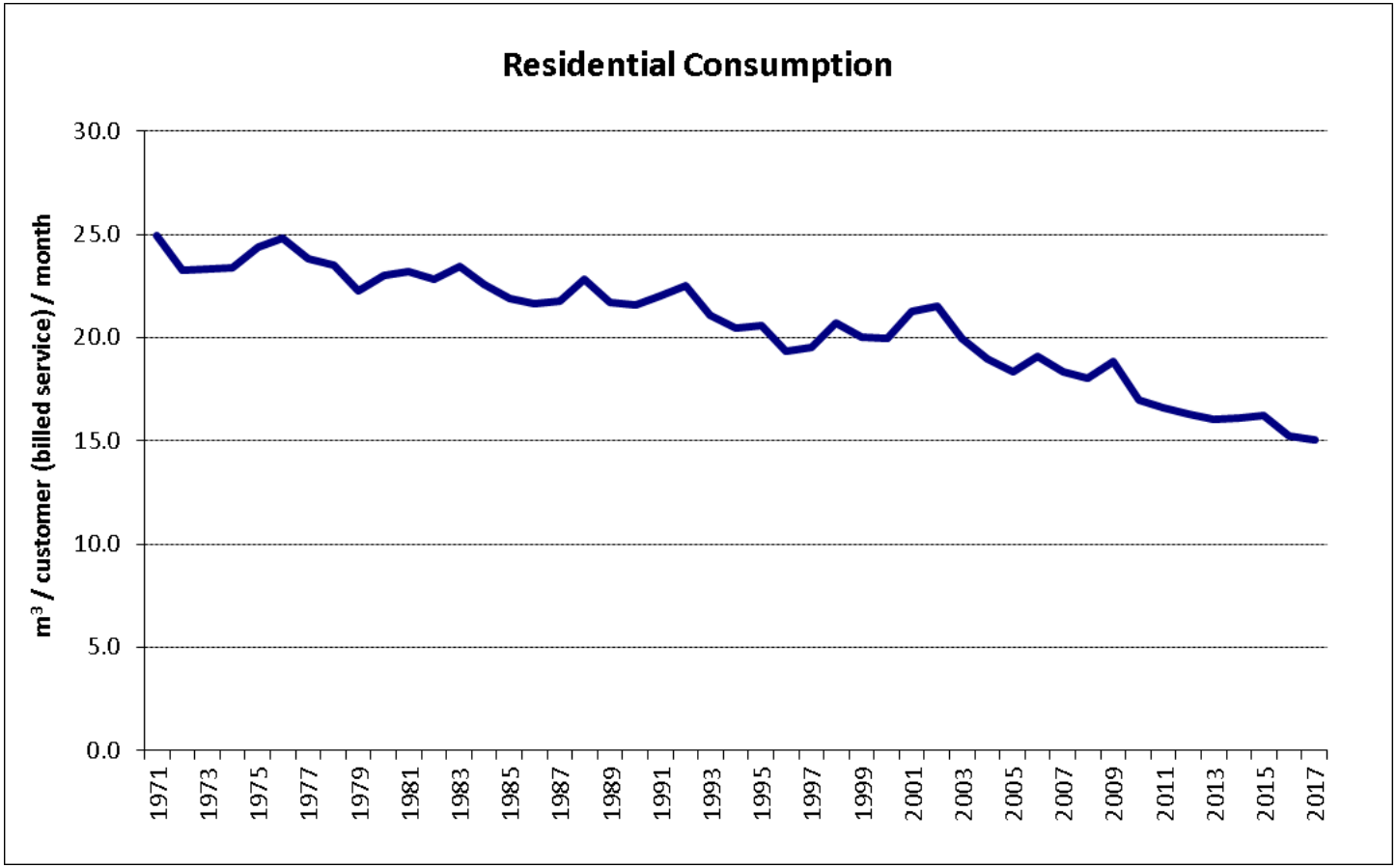

British Columbia
Fort Hills Energy LP
Shell Albian Sands-Muskeg River
Shell Albian Sands Jackpine
Fort McMurray
Alberta
Edmonton
Red Deer County
Calgary
Britannia Mine
French Creek
Vancouver
Canmore
Kananaskis
Strathmore
Chestermere
Okotoks
Teck Coal
Saskatchewan
Regina
Ontario
EPCOR OPERATIONS
Electricity
Water
Natural Gas
Drainage
Wastewater
Locations at a glance
Arizona
North Mohave
Mohave
Mohave
Willow Valley
Havasu
Anthem
Sun City West
Rio Verde
Chaparral
Agua Fria
Luke 303
Sun City
Paradise Valley
Phoenix
Tubac
New Mexico
Edgewood &
Thunder Mountain
Albuquerque
Clovis
Texas
130 Pipeline
Austin
Hughes Gas
Vista Ridge
San Antonio
Houston
Collingwood
Toronto
Southern Bruce Natural Gas *
Aylmer
* Pending OEB approval

Water Use in Edmonton



PROVIDING MORE EPCOR

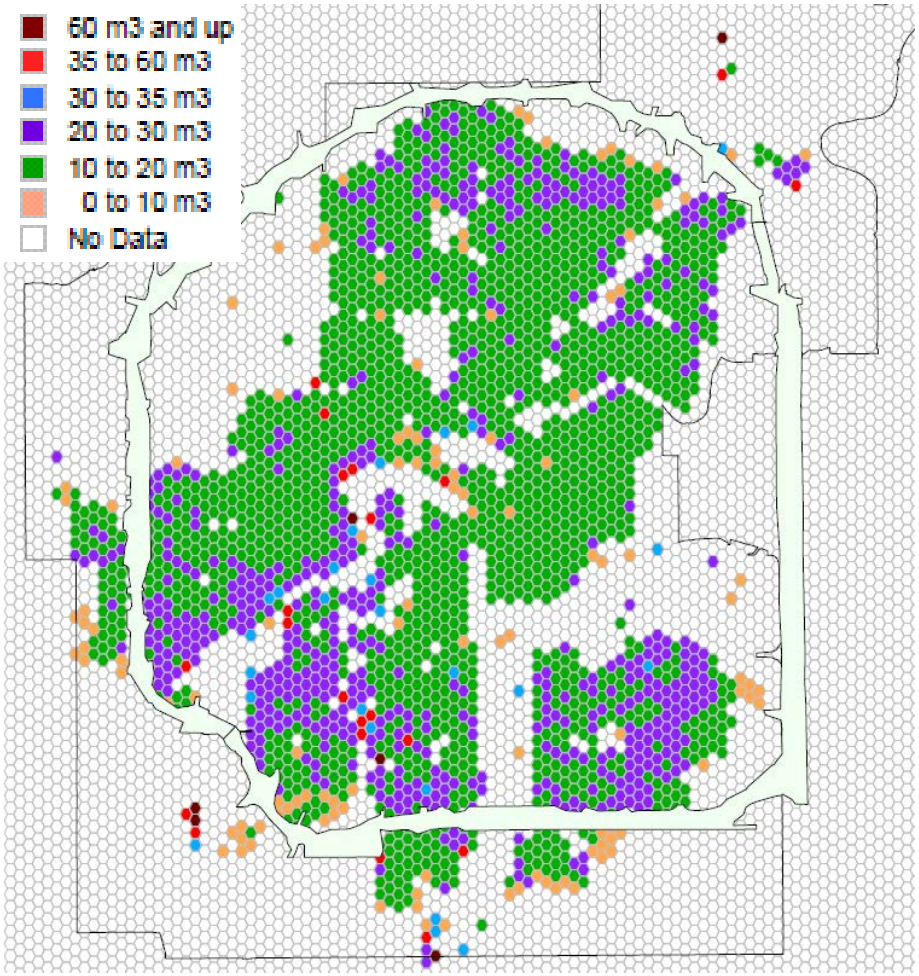
Residential Water Usage



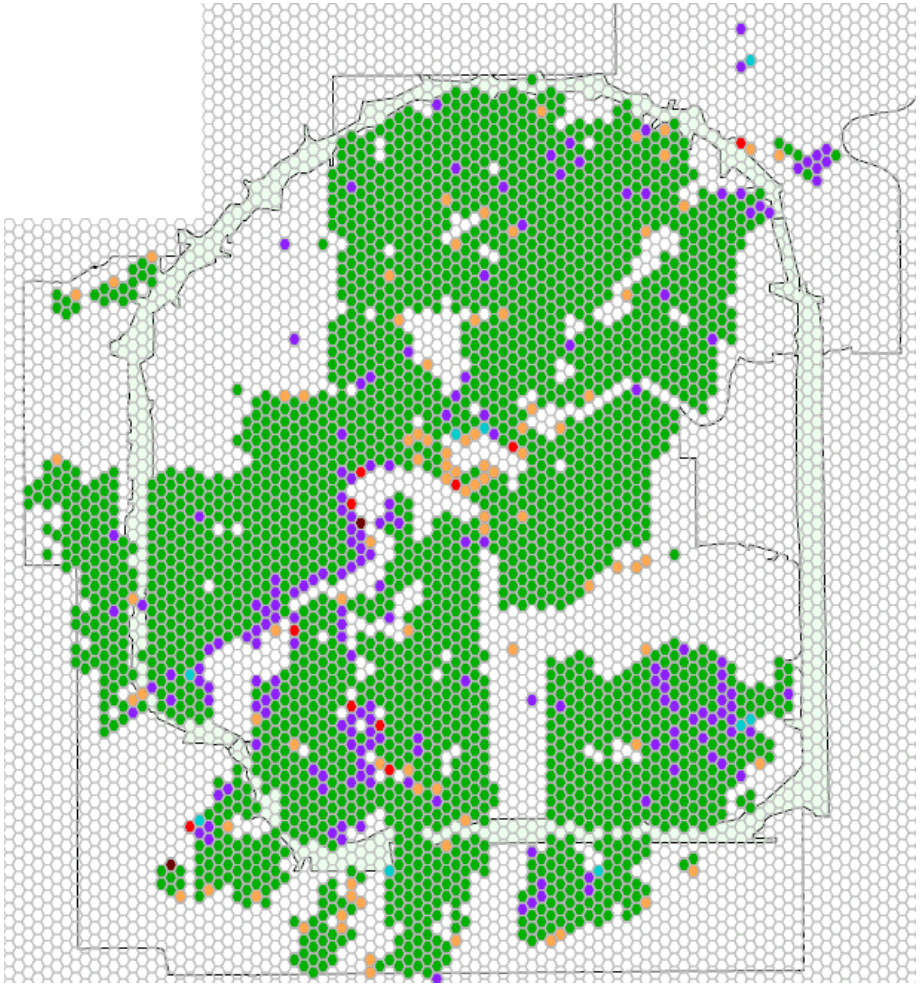
40% reduction per account since 1971

PROVIDING MORE EPCOR

Residential Water Usage

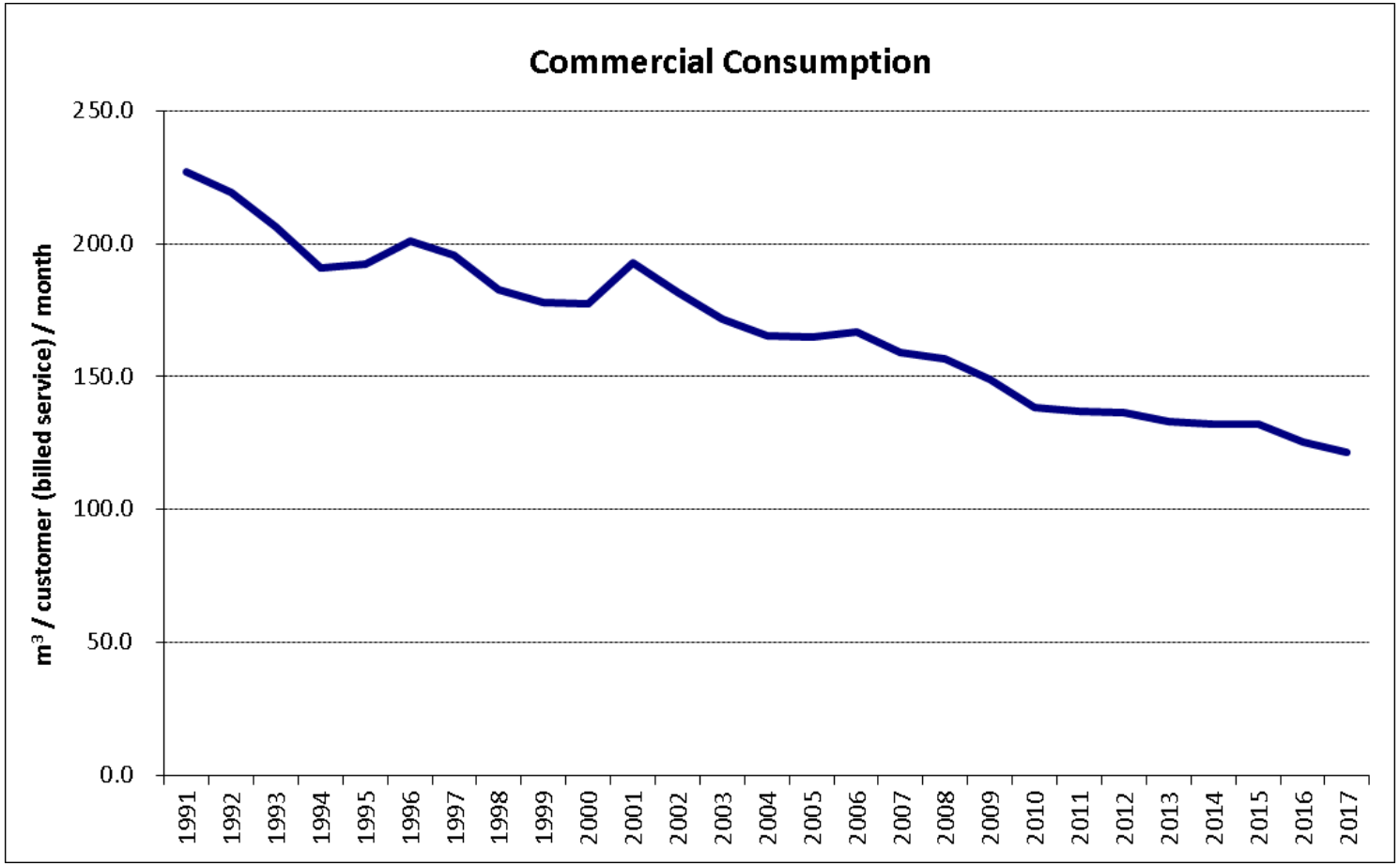


2008 Average Monthly Consumption



2016 Average Monthly Consumption

Commercial Water Usage



46% reduction per account since 1991

PROVIDING MORE EPCOR

Declining Demand Effects on an Interconnected Water System

- Benefits:
  - Reduced, deferred or avoided capital expenditure of water and wastewater infrastructure
  - Extension of water supplies and maintain aquatic ecosystems
  - Reducing environmental impacts (i.e. GHG emissions)

- Risks:
  - Water distribution:
    - quality/age issues due to increased detention times
  - Wastewater conveyance:
    - increased odour production
    - increased rate of corrosion
    - settling and blockages

Source:. Adapting to Change: Utility Systems and Declining Flows. (2017), Denver, CO: Water Research Foundation.

Declining Demand Effects on an Interconnected Water System

"An ounce of prevention is worth a pound of cure."

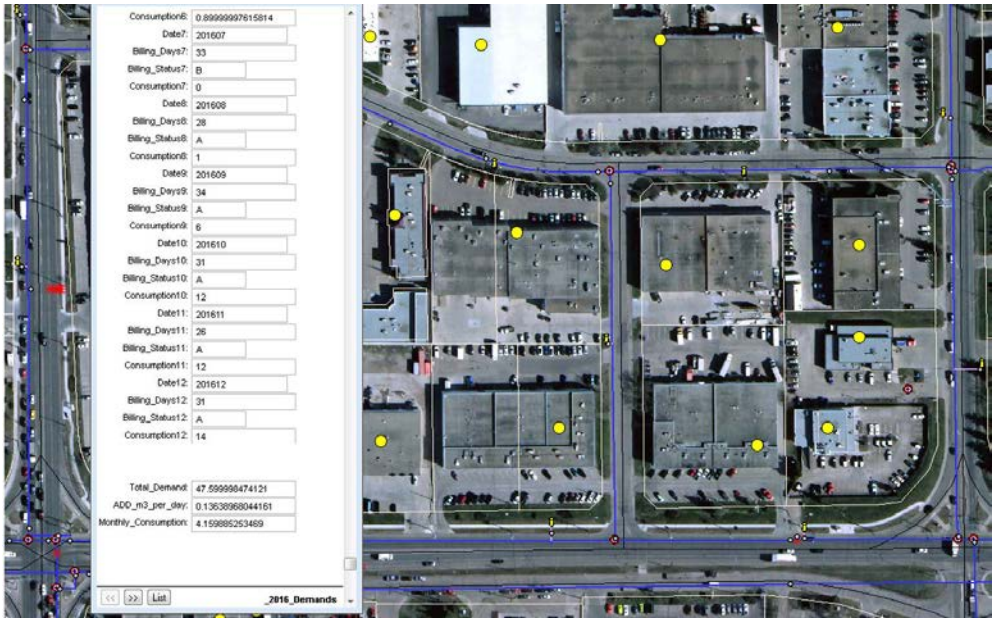
- Benjamin Franklin

- Mitigation (reactive)
  - Capital projects
  - Operational changes
  - Maintenance
- Prevention (proactive)
  - Planning and design changes
    - Master Plan forecasting
    - Per capita design standard changes

Water Use Assessment

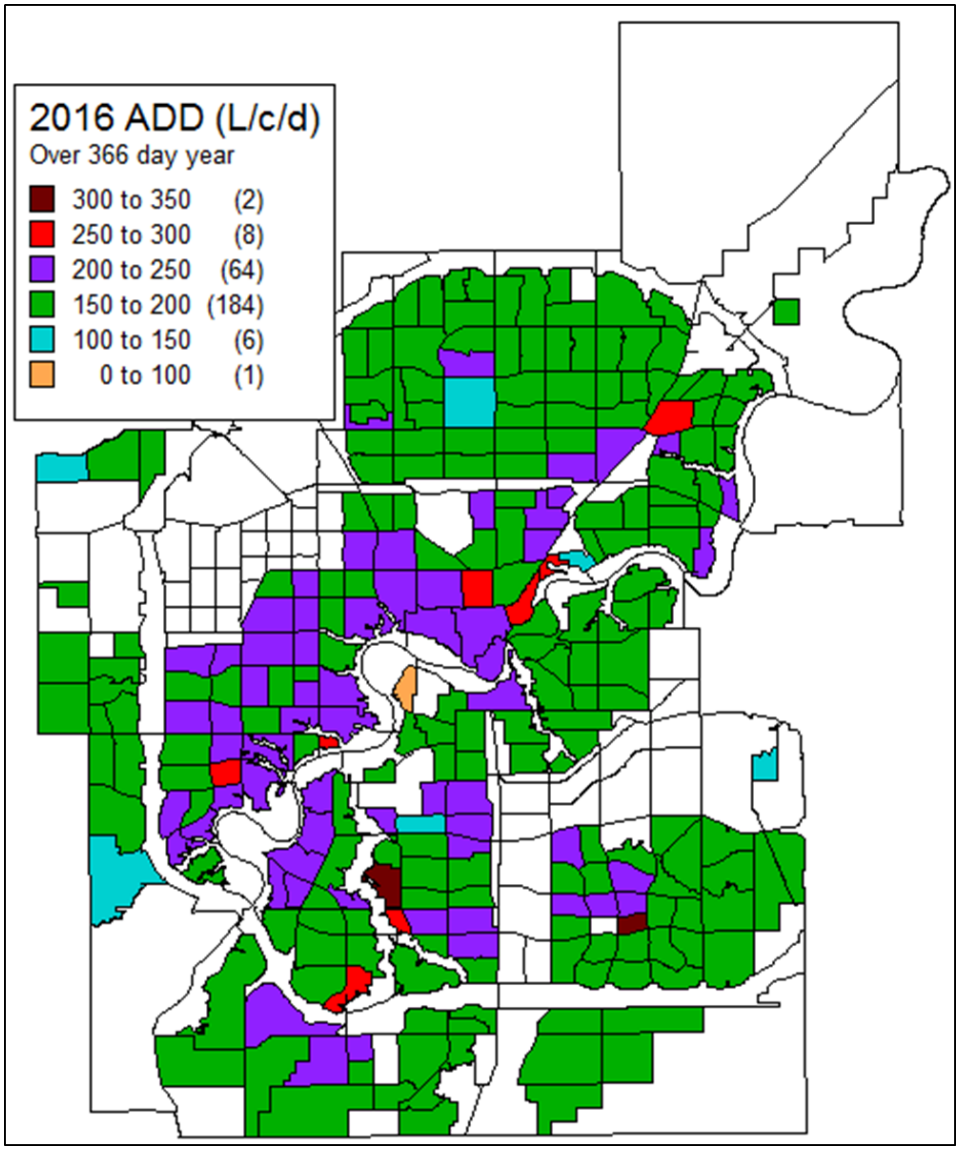
- Water consumption patterns have changed and design standards are outdated
  - Water consumption: 250 l/c/d
  - Wastewater generation: 300 l/c/d

- Conduct a consumption assessment to propose updated water consumption & sewer generation standards



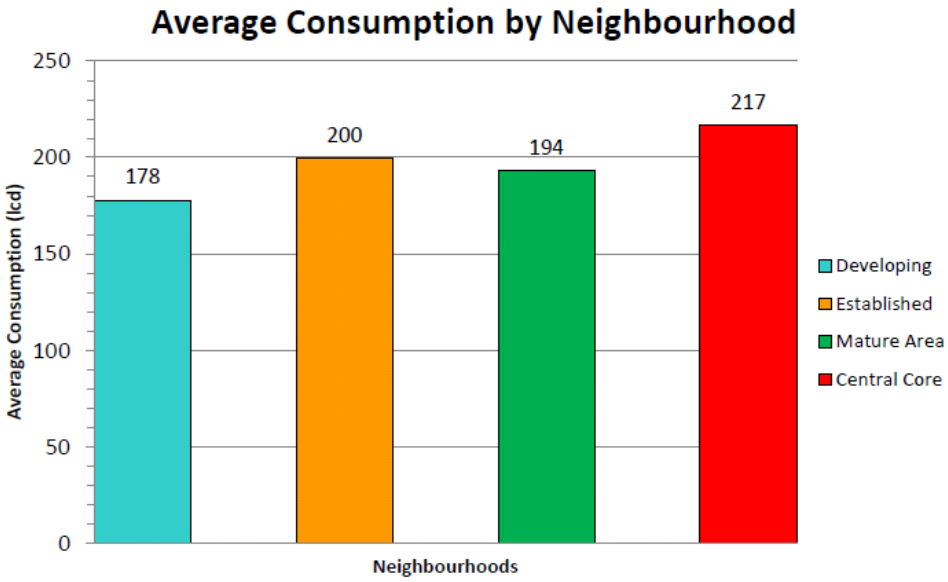
PROVIDING MORE EPCOR

Results: Residential Consumption



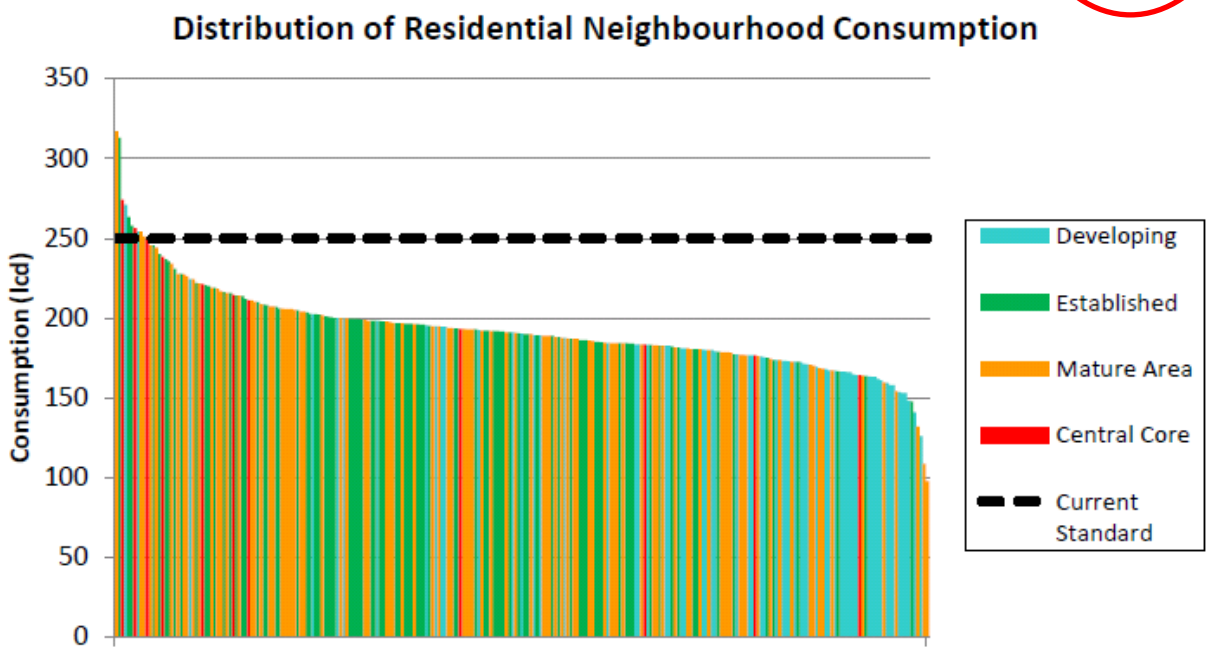
Neighbourhood Classifications by Era

Core:	Oldest Neighbourhoods
Mature:	Prior to 1970
Established:	1970-1990
Developing:	1990+



Results: Residential Consumption

Neighbourhood Type	Count	Average (lcd)	Percentile (%) at:				
			Average	250	235	225	200
Developing	66	178	56	98	97	97	93
Established	91	200	64	97	93	91	65
Mature Area	97	194	57	98	95	91	69
Mature Area - Central	11	217	53	81	68	62	34
All	265	193	56	96	93	91	72



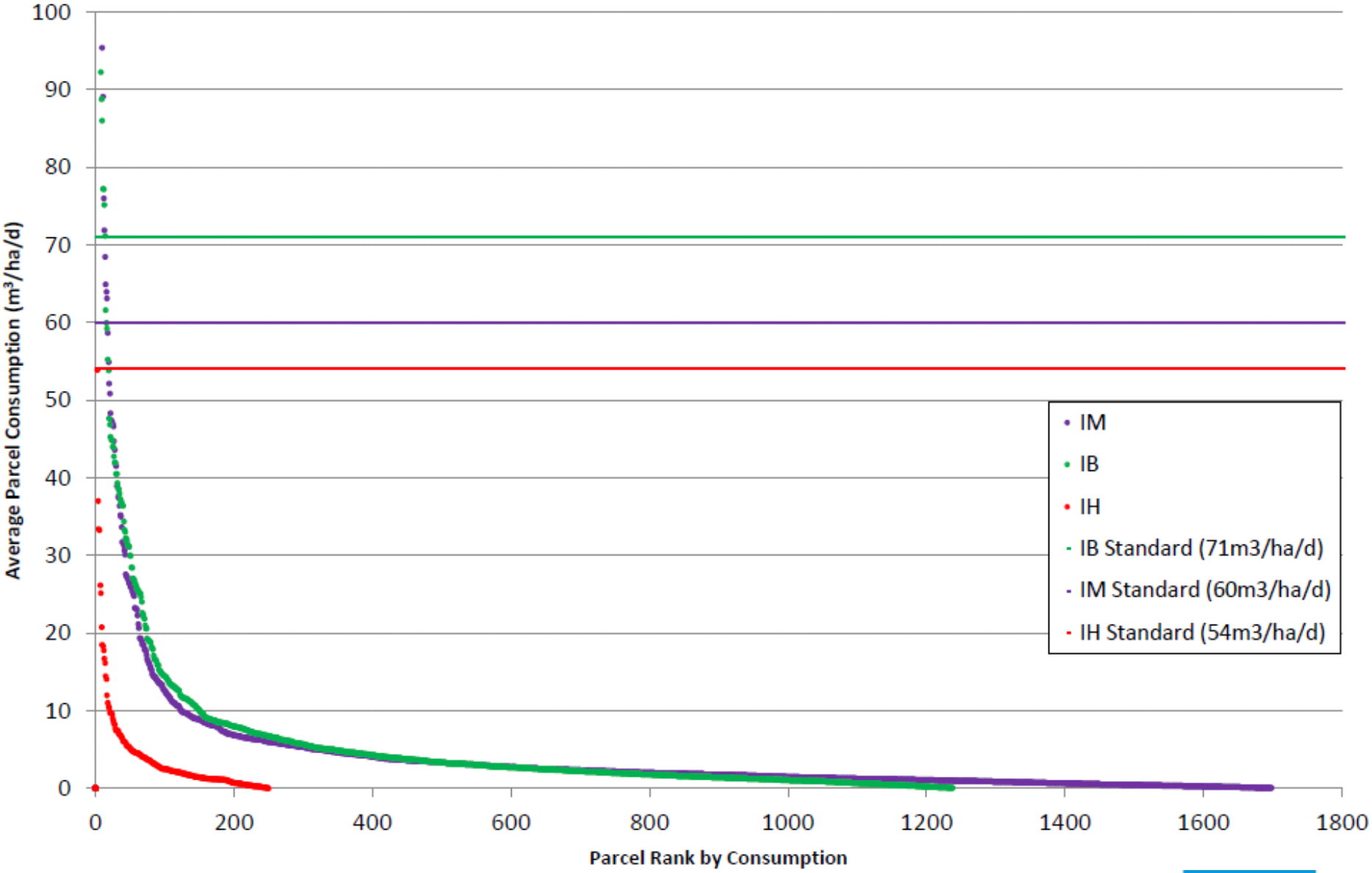
Results: Commercial, Industrial, Institutional (CII) Consumption

	Zoning	Count of Parcels	Average Flow Generation Values [1] (m3/ha/d)					
			Standard (Table A3)	Calculated Average	Median	90%ile	95%ile	99%ile
Commercial	CNC	312	85	20	13	47	68	99
	CHY	72	85	28	22	52	68	109
	CSC	287	80	18	11	37	53	138
	CB-1	450	108	22	10	51	82	175
	CB-2	580	108	31	11	73	118	291
	CO	21	108	44	26	106	149	152
Industrial	IB	1238	71	7	3	12	25	74
	IM	1698	60	6	2	8	14	59
	IH	250	54	6	2	9	16	46

[1] All values reported in terms of Net Area.

- Analysis shows that all zonings over-estimate sewer generation
  - Commercial is less problematic than industrial

Distribution of Industrially Zoned Parcels in Table A3



Conclusions & Next Steps

- Declining demand is positive with respect to water management, however operational, maintenance and design considerations can't be overlooked
- Residential per capita water consumption & sanitary generation usage metrics are not reflective of current consumption/generation trends
- Created a working group with Water, Drainage and consulting industry to determine updated per capita metrics
- A standard review should occur every 5-10 years to keep metrics current for design of water & sewer infrastructure

Hazen

Knowledge Building and Adaptive Management Practices for Water Demand Forecasting

Jack C. Kiefer, Ph.D.
618.889.0498
jkiefer@hazenandsawyer.com

Main Messages

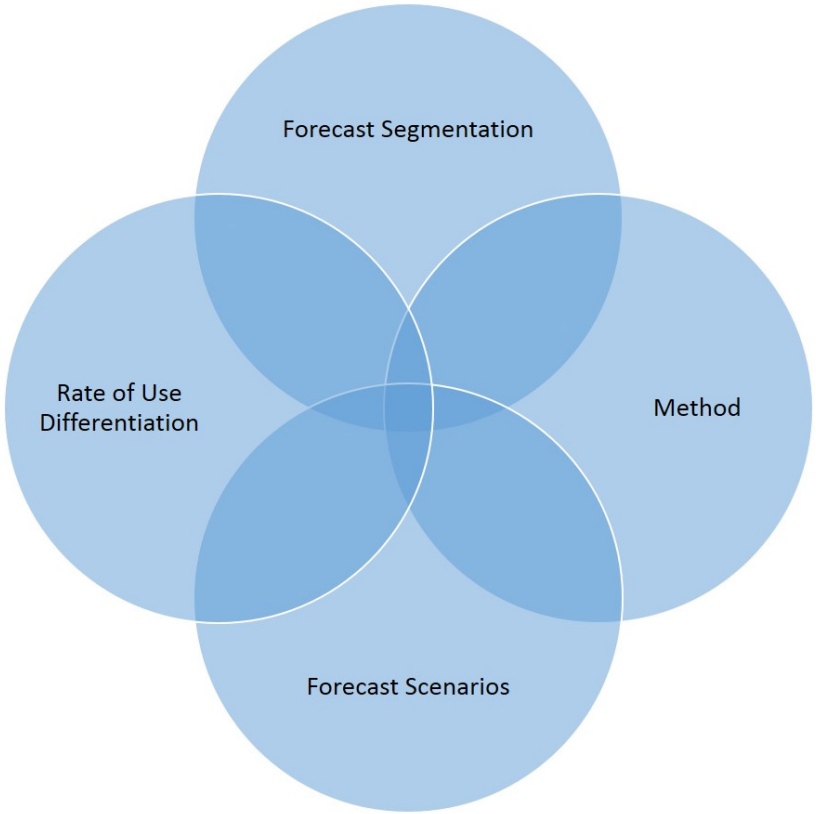
Demand forecasting is highly nuanced

Forecasts will be inaccurate because of myriad uncertainties

Knowledge building and adaptive management processes offer advantages for coping with uncertainty

Approaches to Forecasting Vary Widely

- Planning objectives
- Geographical and sector segmentation
- Modeling methods
- Influential factors considered
- Knowledge, skill, and resources



"Different horses for different courses"

Source: Kiefer, J.C., Dziegielewski, B., and C. Jones. [N.d.]. *Long Term Water Demand Forecasting Practices for Water Resources and Infrastructure Planning* . Denver, Colo.: Water Research Foundation, forthcoming.

The Facts about Forecasts

- Forecast “numbers” will inherently be inaccurate (except by chance)
- Decisions still have to be made
- Addressing forecast uncertainties helps us define
  - Potential risks
  - Ways and costs to reduce or mitigate them
- “Risk-informed” decisions convey the appetite or tolerance for different risks

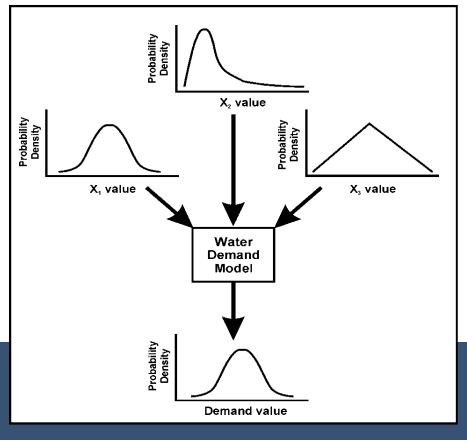
Technical methods for addressing forecast uncertainty

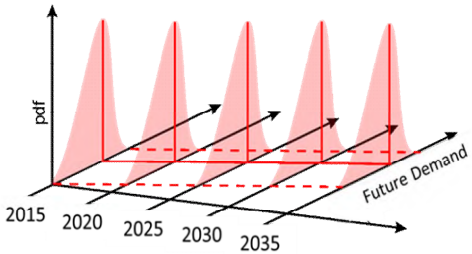
Rules of thumb $Q_{Predicted} \pm z\ \%$

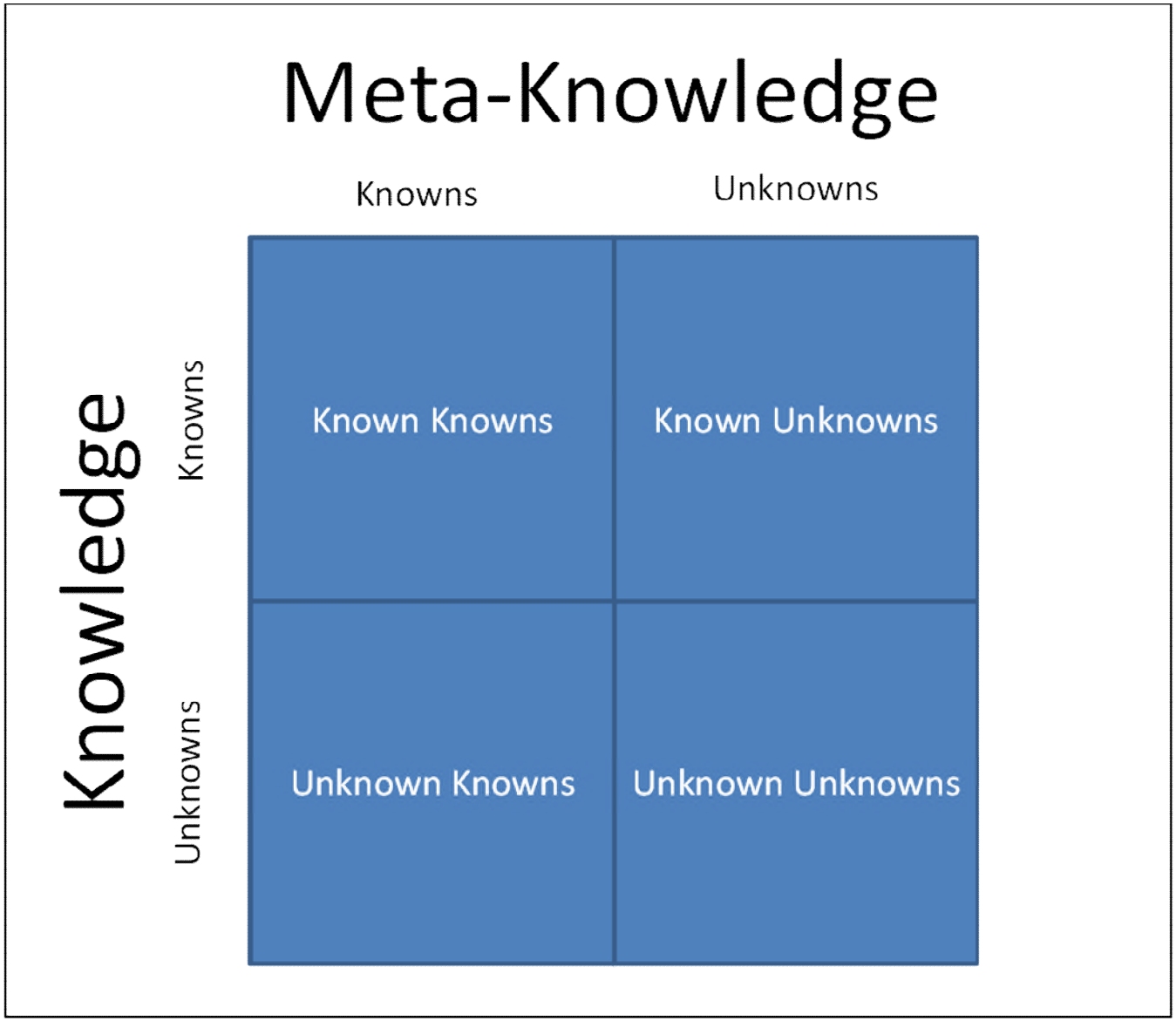
Qualitative scenarios $X_{Expected} \pm z\% \xrightarrow{\text{yields}} Q_{Predicted} \pm z'\%$

Statistical scenarios $\left(\hat{Q} - t_{(1-\alpha)/2} * \sqrt{s_f^2}\right) \leq Q_{Actual} \leq \left(\hat{Q} + t_{(1-\alpha)/2} * \sqrt{s_f^2}\right)$

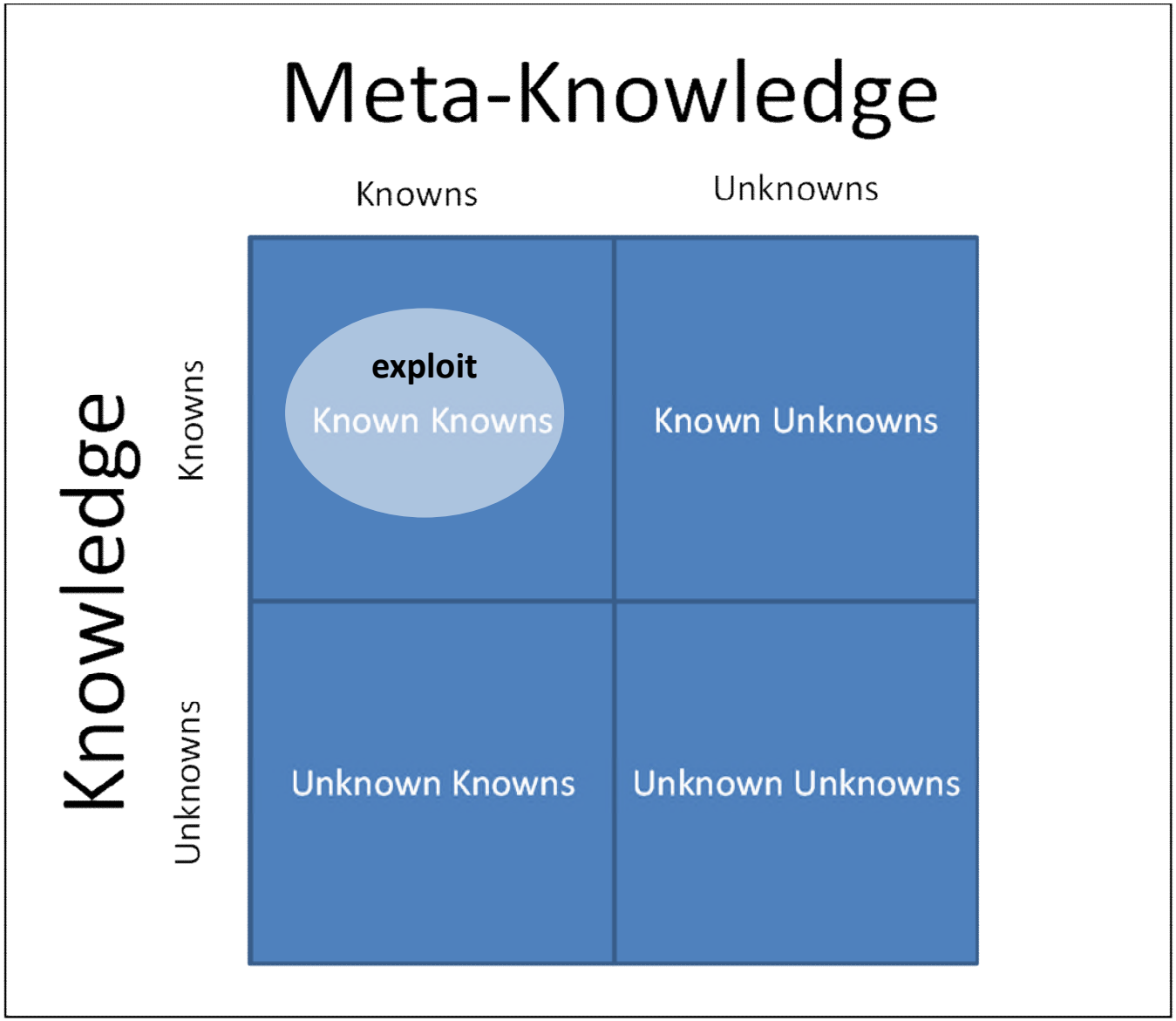
Probabilistic scenarios



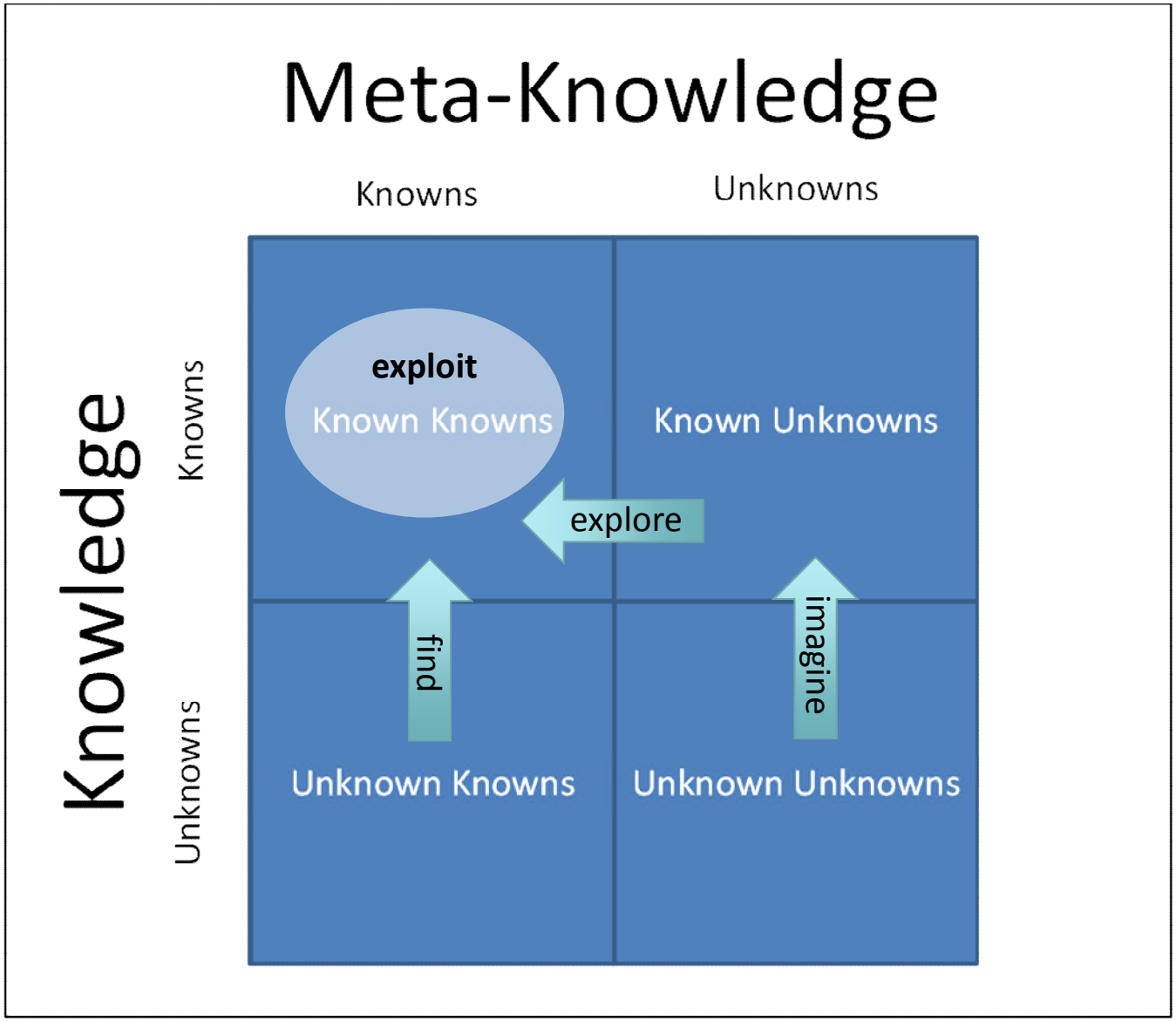




Relationships of Uncertainty to Knowledge



Relationships of Uncertainty to Knowledge



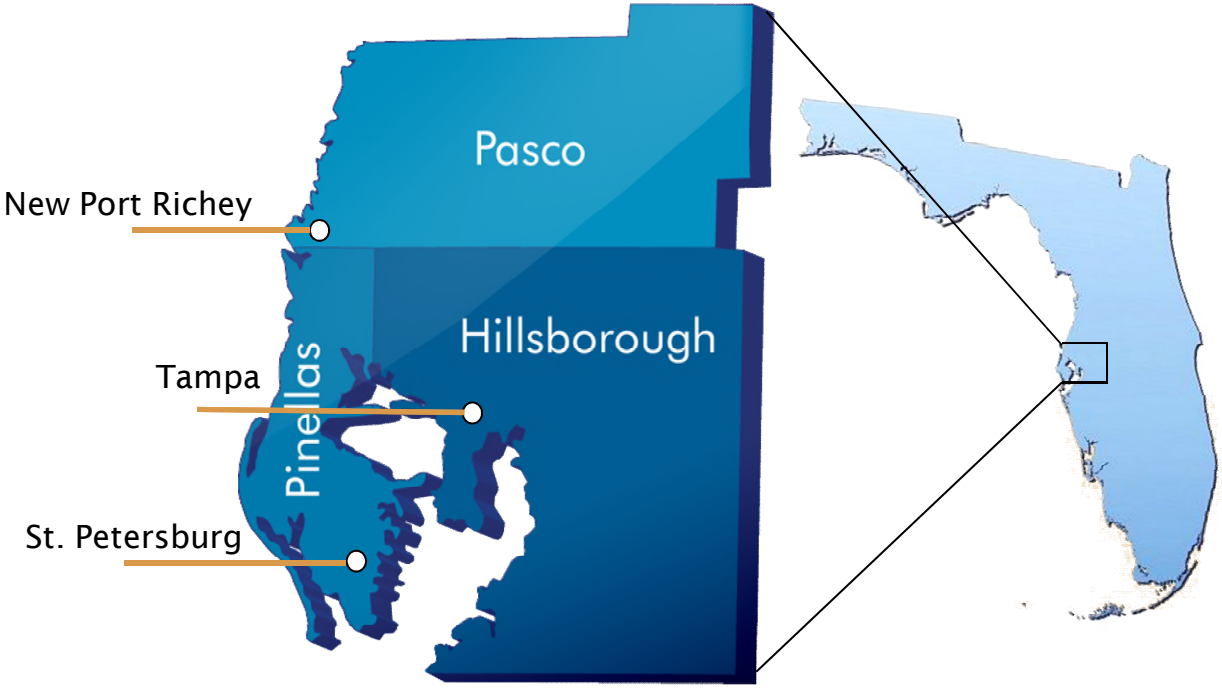
Relationships of Uncertainty to Knowledge

Case Example – Tampa Bay Water

Regional water supply authority

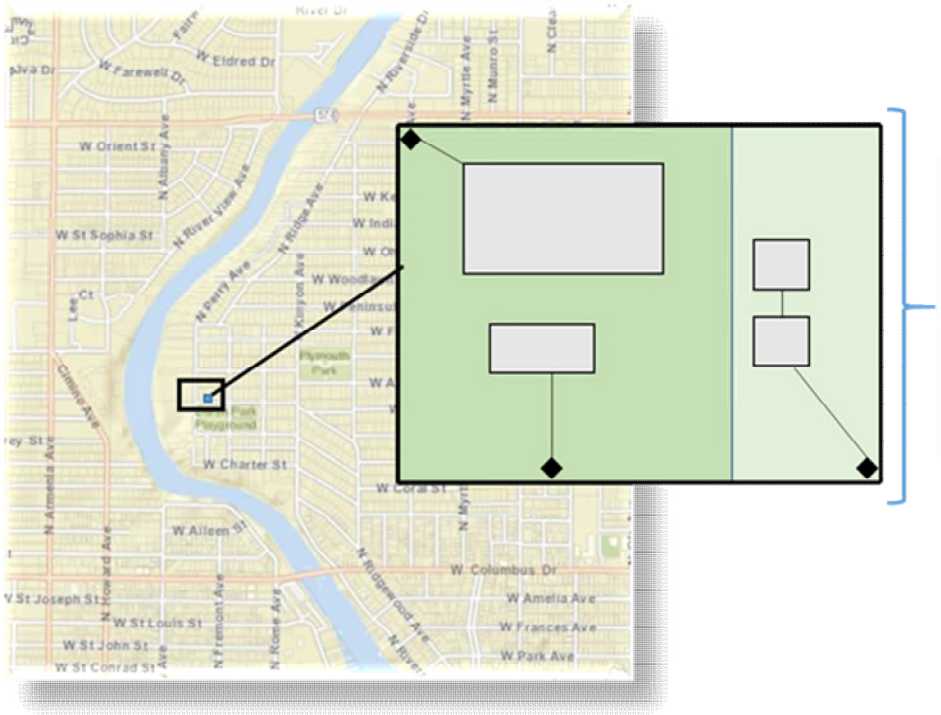
2.4 million customers

6 member governments, across three counties



TAMPA BAY WATER
Supplying Water To The Region

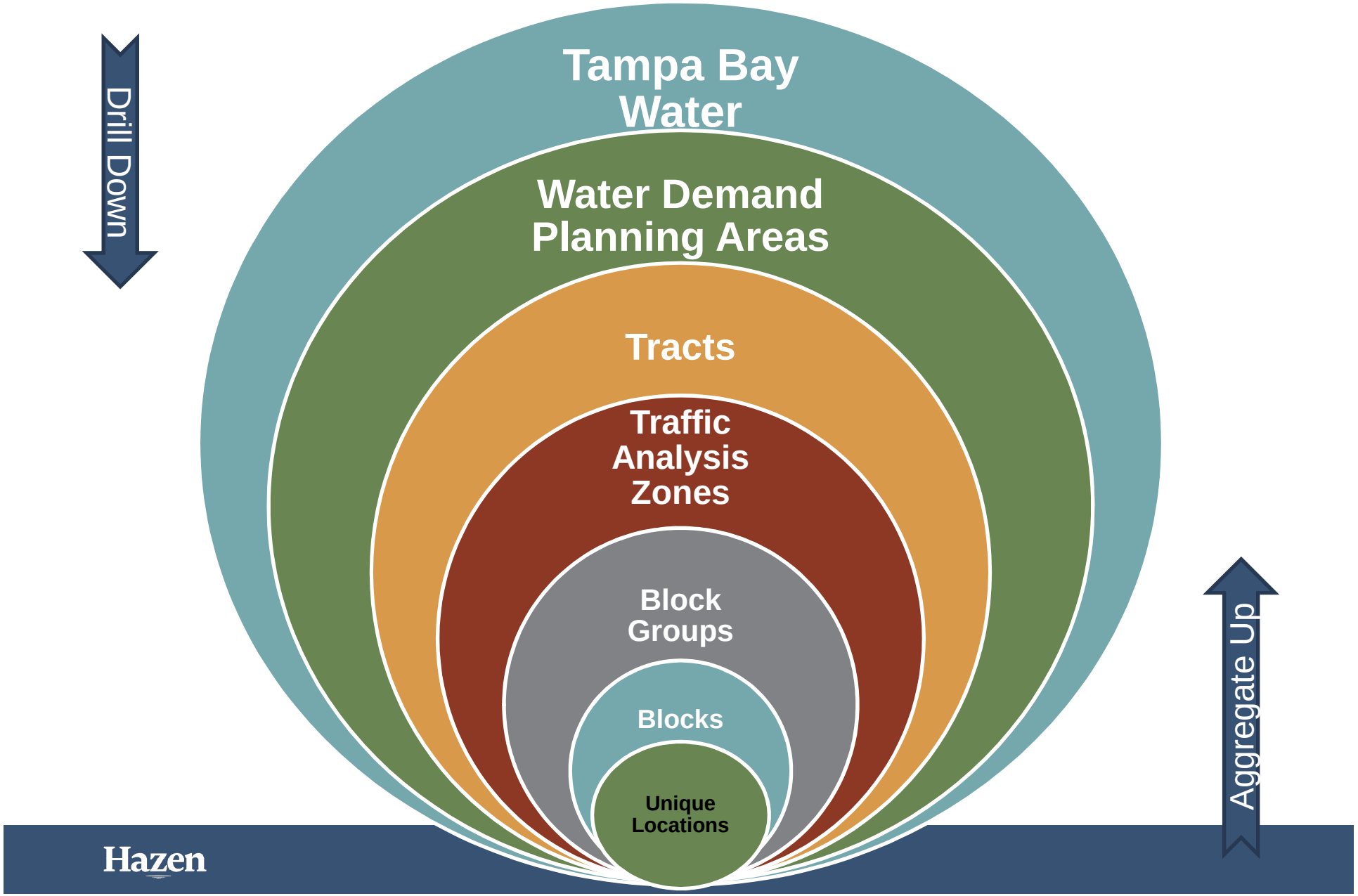
Foundation of Demand Analysis: Unique water using locations



- ❑ 1 water use **location** associated with:
  - ❑ 1 business or function associated with:
    - ❑ 4 buildings
    - ❑ 2 tax parcels
    - ❑ 3 water meters

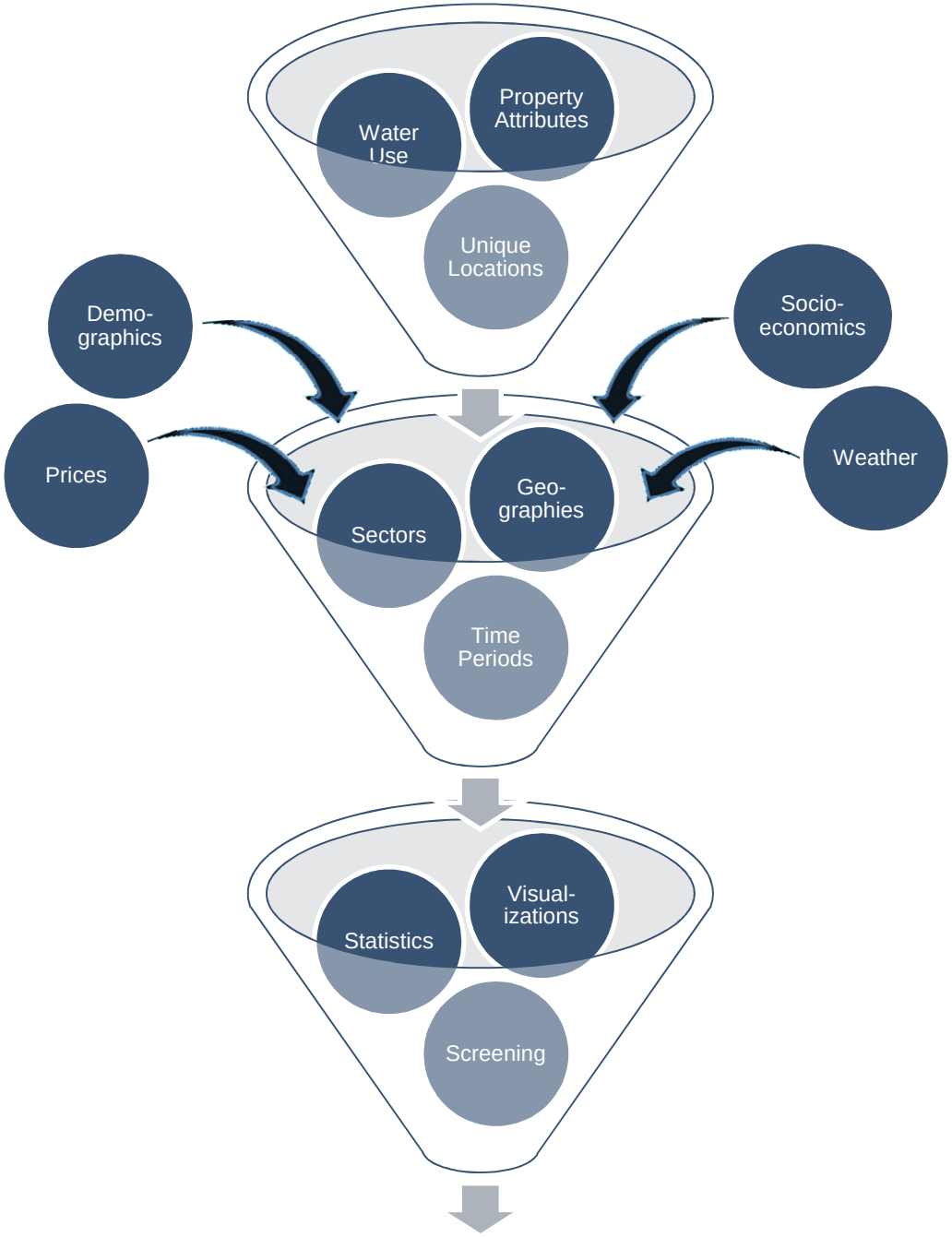
Source: Kiefer, J.C. and L.R. Krentz. 2016. *Evaluation of Customer Information and Data Processing Needs for Water Demand Analysis, Planning, and Management*. Denver: Water Research Foundation.

Geographic attributes linked to each location



Collaborative Database Design and Development

Collaborative Exploratory Data Analysis (EDA)



Key Model Features Support Scenarios and Forecast Simulations

Key Model Features Support Scenarios and Forecast Simulations

- Residential users split into single-family and multifamily sectors

Multifamily vs Single-family

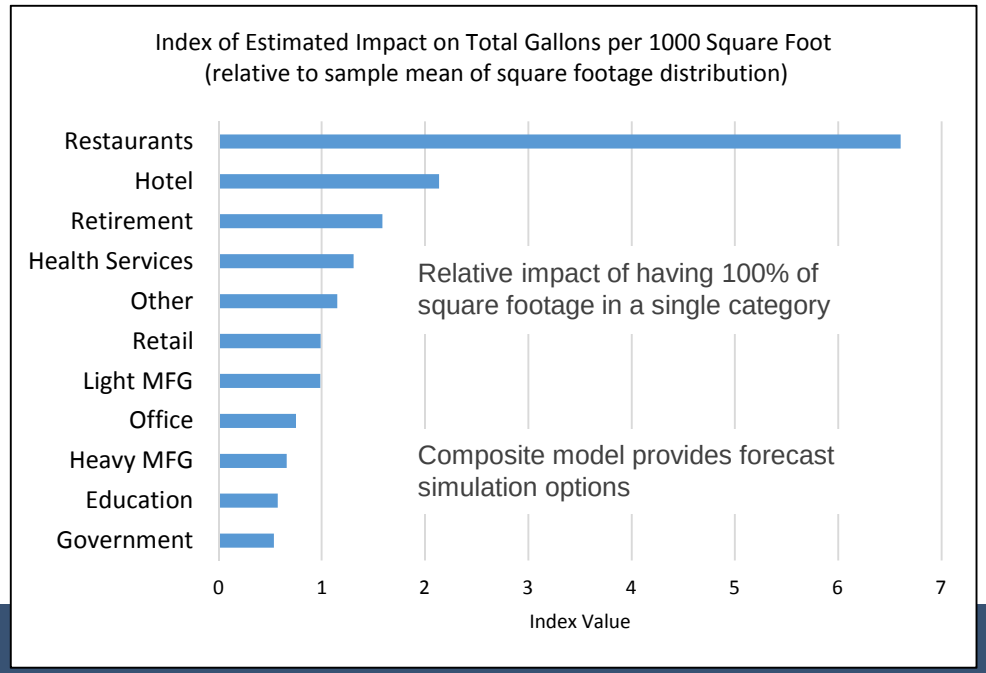
- ✓ More dense (units per acre)
- ✓ Smaller households
- ✓ Lower incomes
- ✓ Less seasonal use
- ✓ More “shared” uses

See: Kiefer, J. and L. Krentz. 2018. *Water Use in the Multi-Family Housing Sector*. Denver: Water Research Foundation.

Key Model Features Support Scenarios and Forecast Simulations

- Residential users split into single-family and multifamily sectors
- Nonresidential model accounts for mix of 10 industry groups

Multifamily vs Single-family
- ✓ More dense (units per acre)
- ✓ Smaller households
- ✓ Lower incomes
- ✓ Less seasonal use
- ✓ More “shared” uses



Key Model Features Support Scenarios and Forecast Simulations

- Water use models parameterized with:
  - ✓ Climate and weather

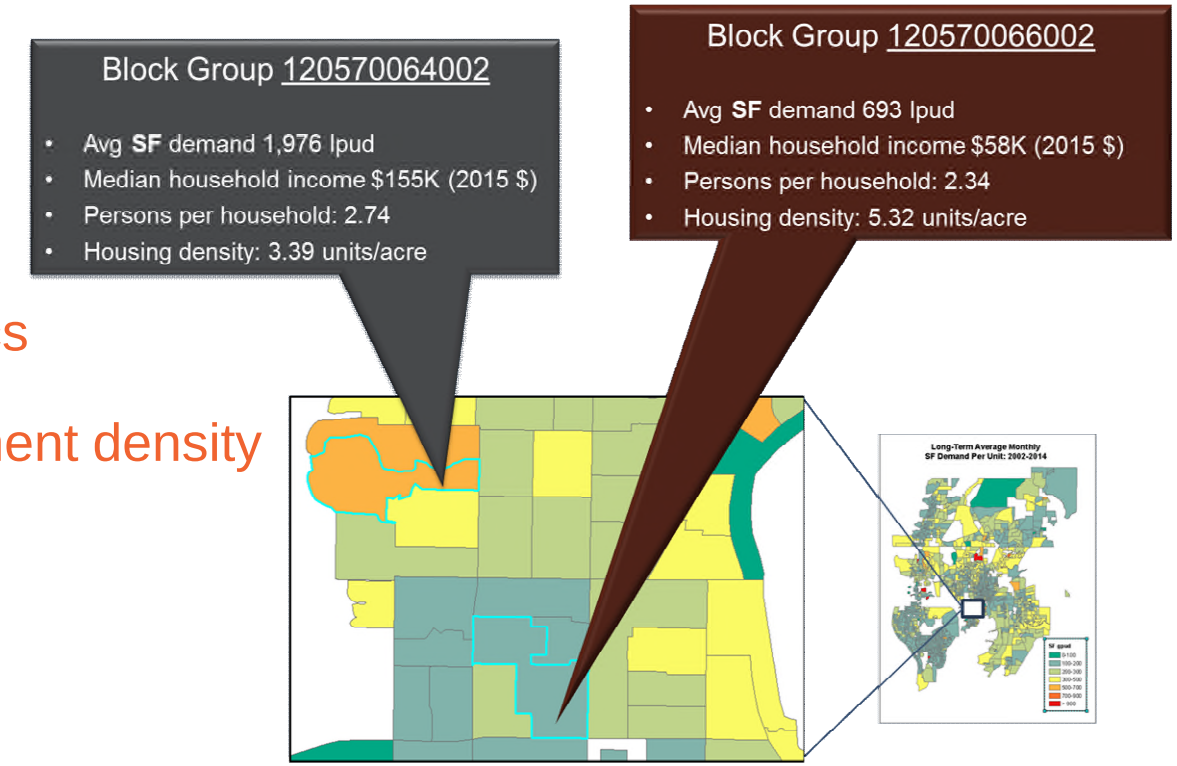
Summer Season 2090 Hot/Dry Scenario	Δ Mean Temperature		Δ Mean Precipitation	
	°F	%	Inches	%
Colorado Springs Utilities	18	22%	-2.49	-35%
Durham Region	13	17%	-3.88	-41%
Massachusetts Water Resources Authority	11	14%	-1.41	-14%
Southern Nevada Water Authority	12	12%	0.14	14%
San Diego County Water Authority	12	14%	0.23	55%
Tampa Bay Water	10	11%	-11.06	-51%

11% warmer than historical normal with half the rain!

Source: Kiefer, J., Clayton, J., Dziegielewski, B., and J. Henderson. 2013. *Changes in Water Use Under Regional Climate Change Scenarios*. Denver: Water Research Foundation.

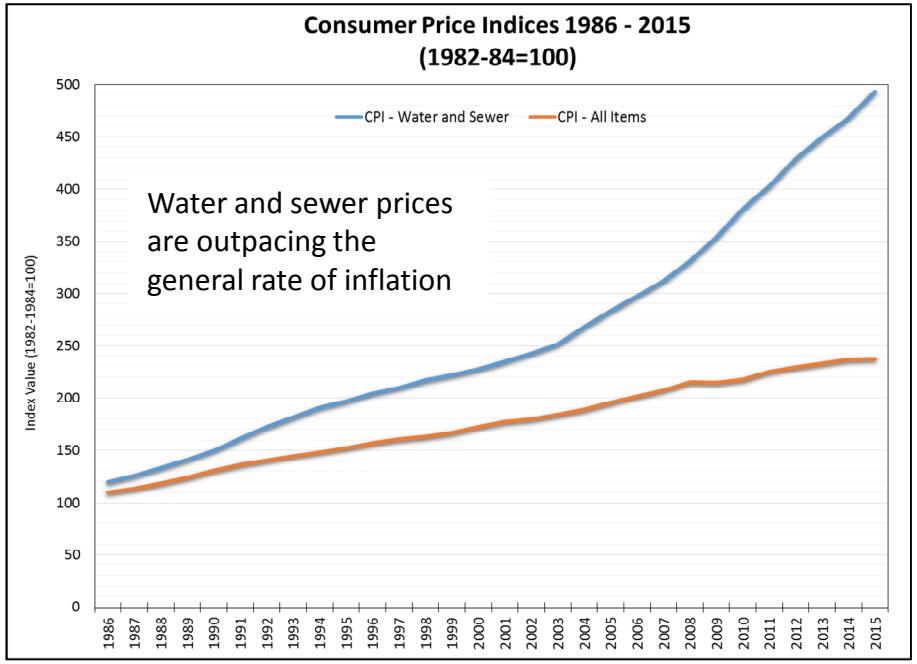
Key Model Features Support Scenarios and Forecast Simulations

- Water use models parameterized with:
  - ✓ Climate and weather
  - ✓ Socioeconomics
  - ✓ Land development density



Key Model Features Support Scenarios and Forecast Simulations

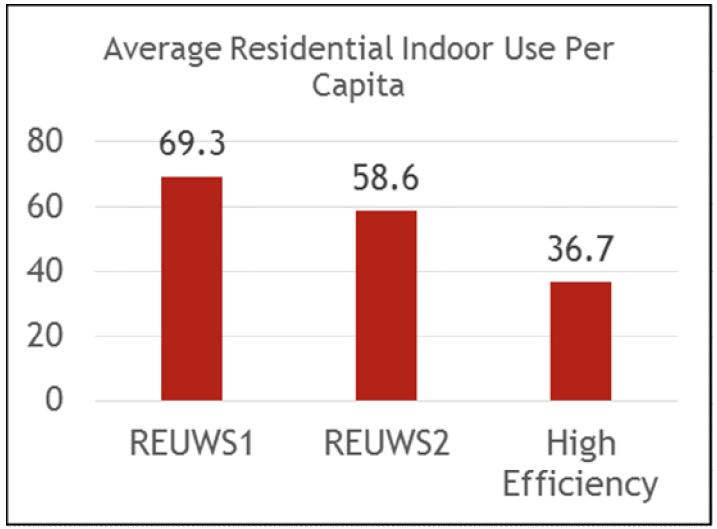
- Water use models parameterized with:
  - ✓ Climate and weather
  - ✓ Socioeconomics
  - ✓ Land development density
  - ✓ Price



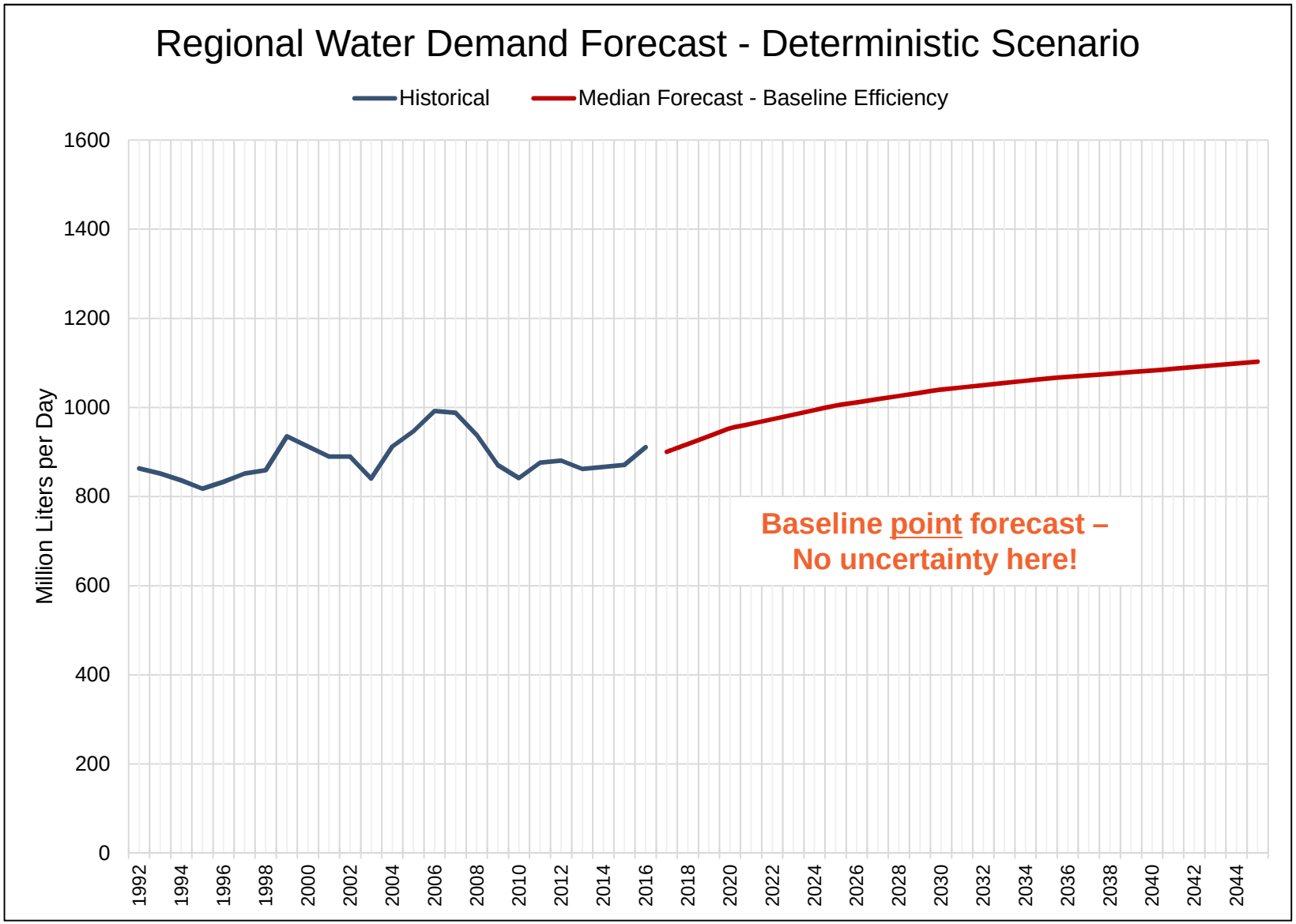
Key Model Features Support Scenarios and Forecast Simulations

- Water use models parameterized with:
  - ✓ Climate and weather
  - ✓ Socioeconomics
  - ✓ Land development density
  - ✓ Price
  - ✓ Water efficiency indices

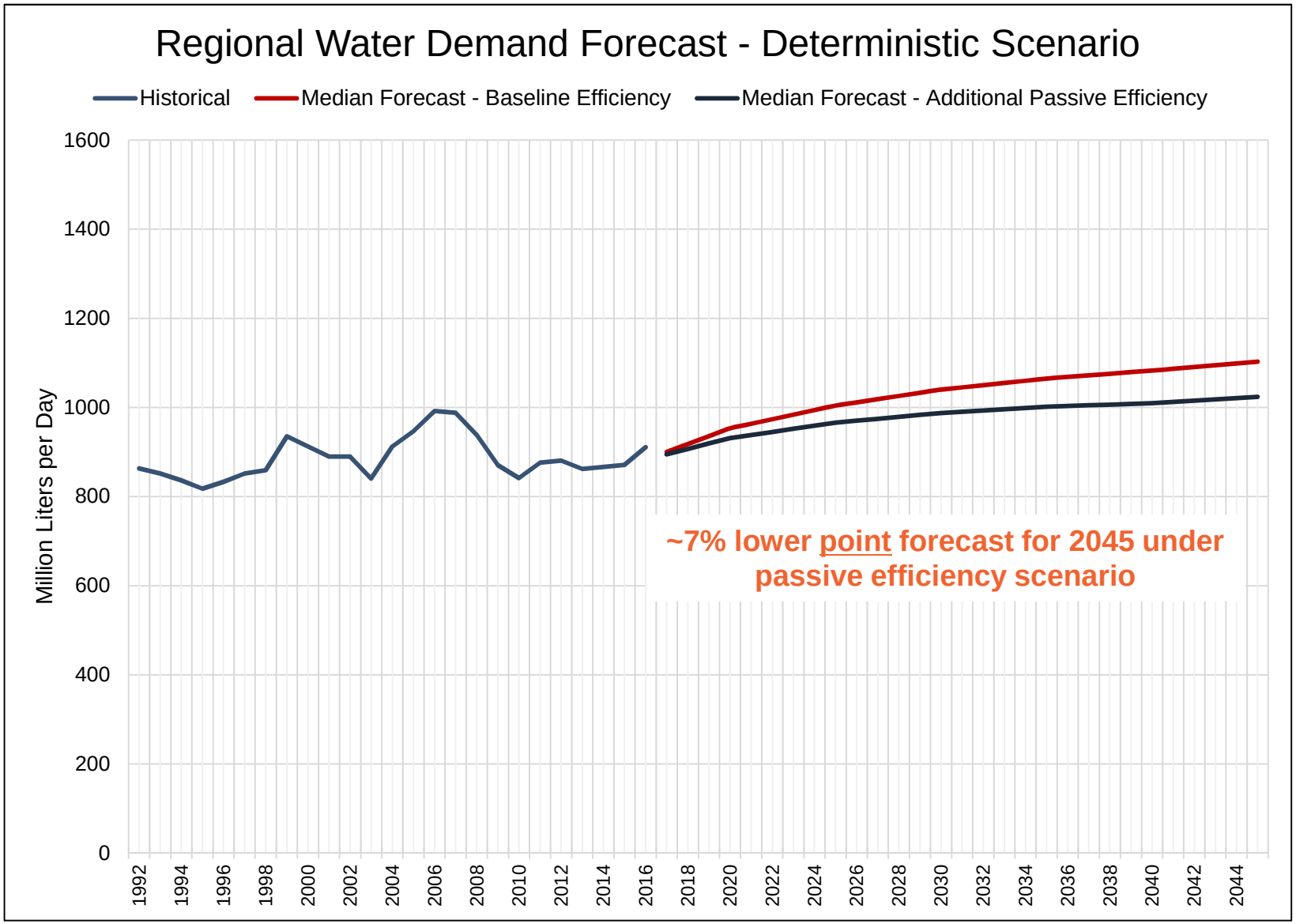
262 lpcd → 222 lpcd → 139 lpcd



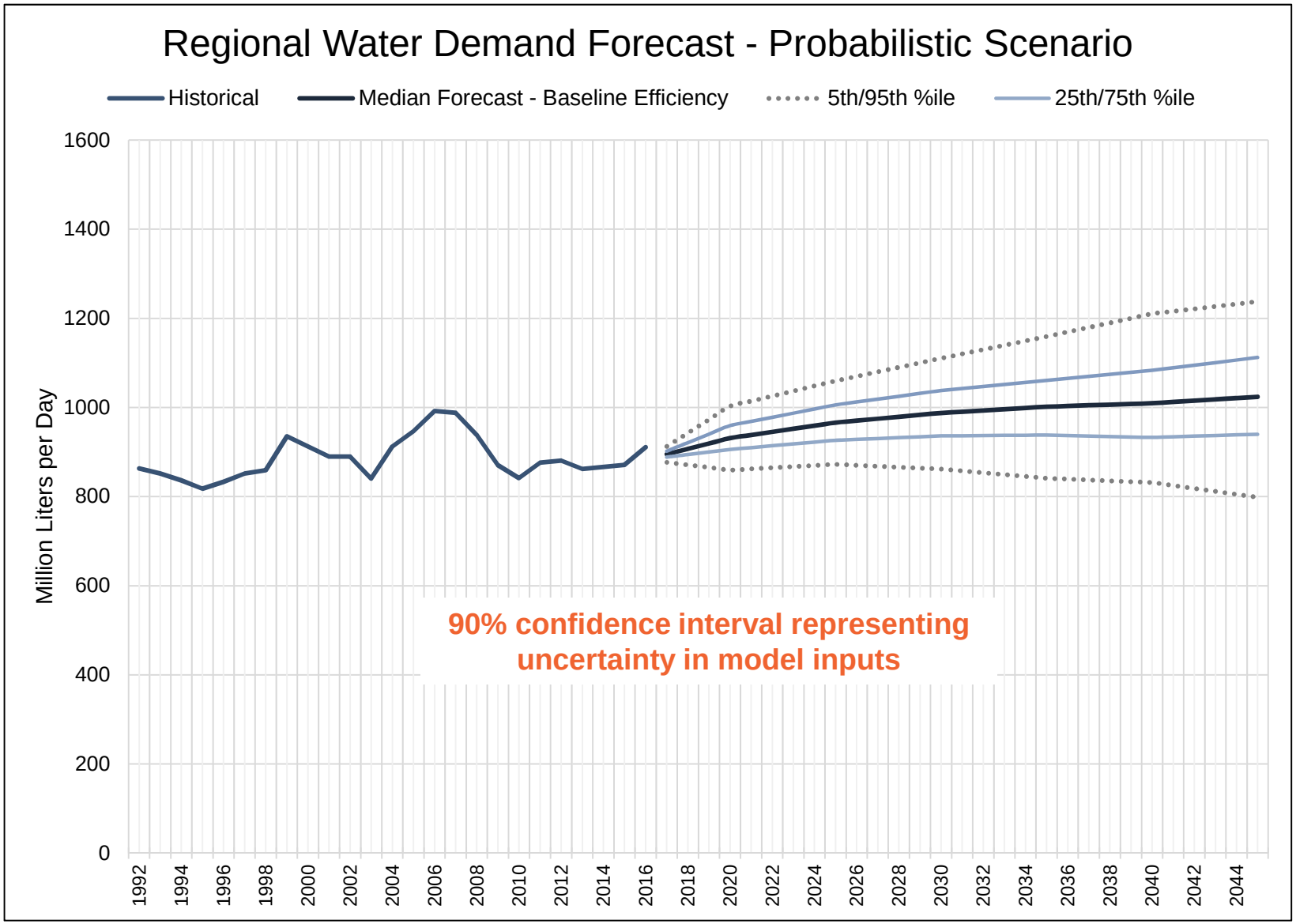
Source: DeOreo, W.B., P.W. Mayer, B. Dziegielewski, J.C. Kiefer, 2016. *Residential Uses of Water 2016*. Water Research Foundation. Denver, CO.



Working DRAFT



Working DRAFT



Working DRAFT

Long-Term Demand Forecasting System (LTDFS) Embodies an Adaptive Management Process

Planning Goals

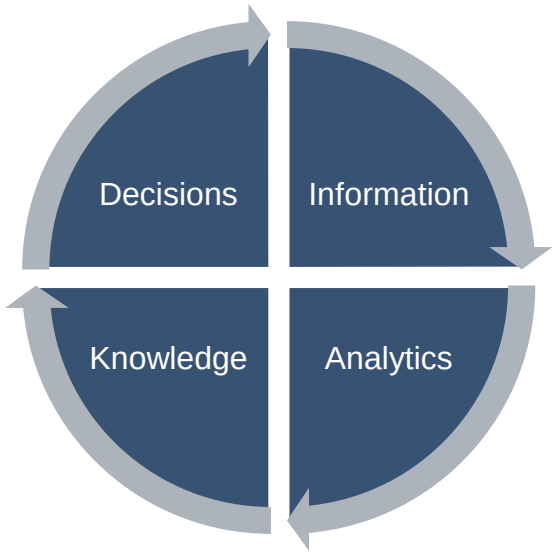
Support water supply reliability efforts ("just-in-time" supply development)

Inform regional and member-specific demand management efforts

Monitoring

- ✓ Collection and analysis of water consumption, socioeconomic, and policy conditions (devoted staff resources)

- ✓ Annual forecast assessments and updates
  - How are models performing?
  - Are we within prediction intervals?
  - Do we need to correct for systematic bias?
  - Are there changes in expectations of growth, development, and other trends?



Refinement

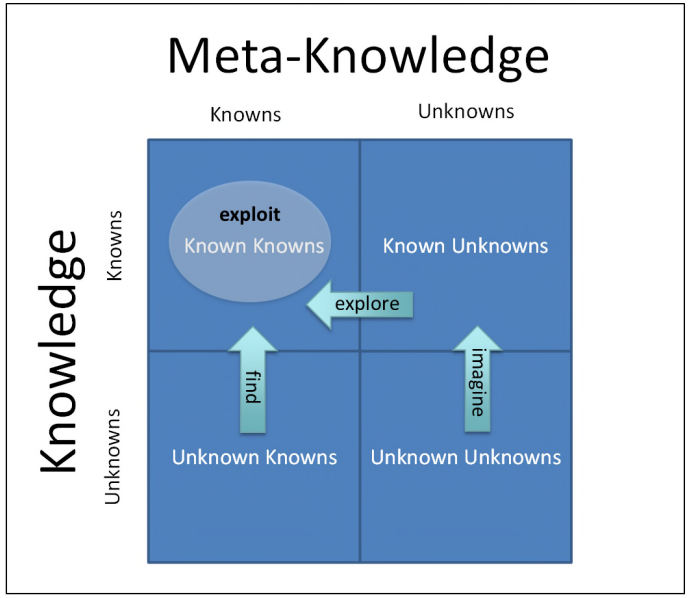
Periodic re-estimation of models with extended data series

New modeling methods and variables

Adaptive Management of Demand Uncertainty

Coping with knowledge uncertainty

- Learning more about past and current water use patterns
- Evaluating why demand varies
- Demand monitoring
- Trends monitoring
- Periodic forecast updates
- "*When the facts change, I change my mind*." (John Maynard Keynes via Nate Silver)



Areas of uncertainty and reasonable expectations

Factors to learn about and build into water demand forecasts

- Technology will continue to improve water efficiency (-)
- Prices will continue to rise (or catch up) (-)
- Economic cycles will continue (+-)
- Climate change will affect seasonal consumption patterns (+-)
- Urban areas will develop and re-develop to reflect prevailing preferences, tastes, land prices and policies (+-)

Brown AND Caldwell

Changing Trends in Water Use: Planning and Design of Water and Wastewater Infrastructure

Planning and Design for Uncertain Wastewater Flows

CWN Webinars

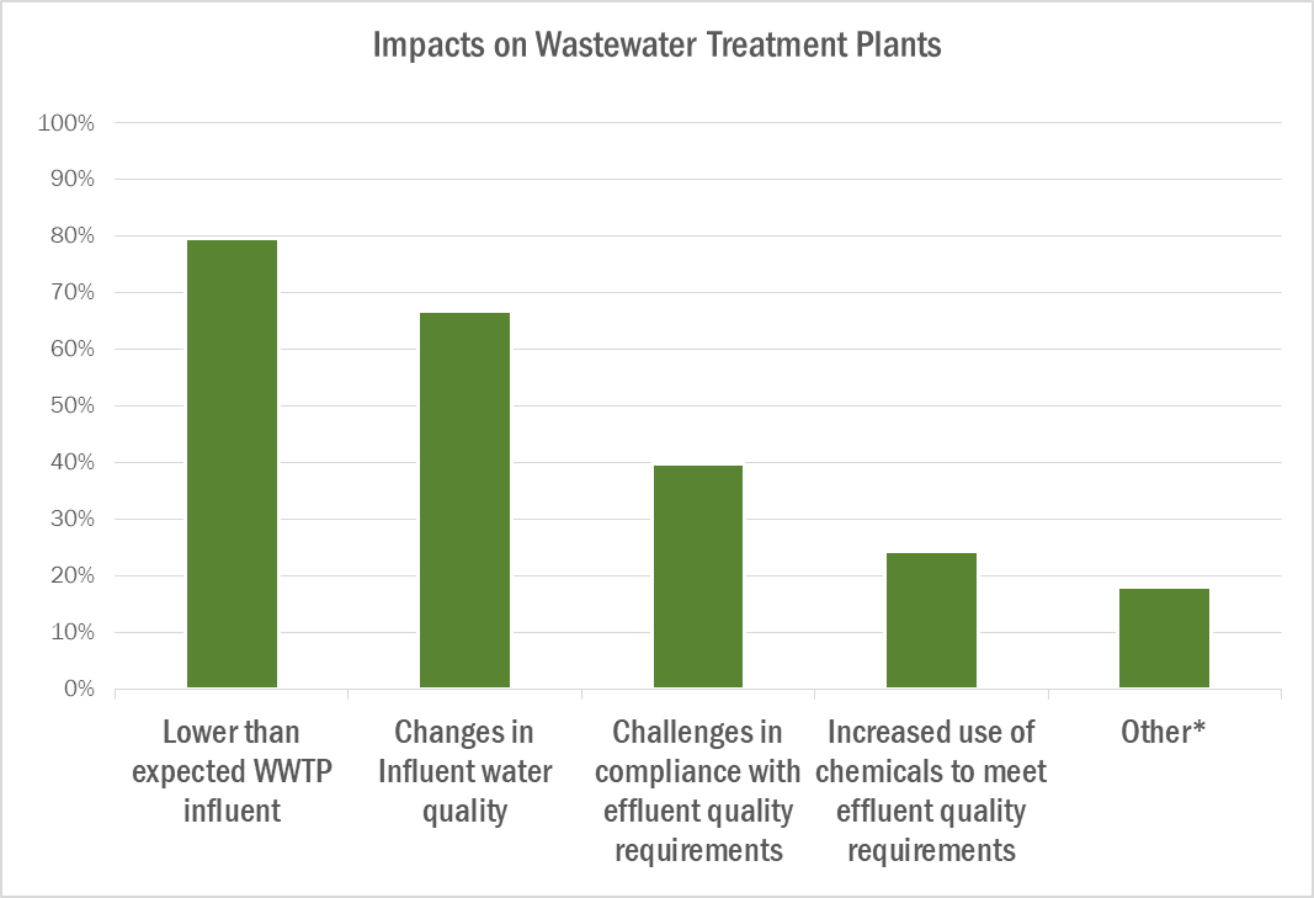
Wednesday, February 27, 2019

Background on impacts in California

Adapting to Change: Utility Systems and Declining Flows

- 2017 white paper developed by California Urban Water Agencies
- *The white paper and policy principles is available for download at the CUWA website (www.cuwa.org).*

Lower than expected WWTP influent flow has led to impacts on wastewater treatment processes



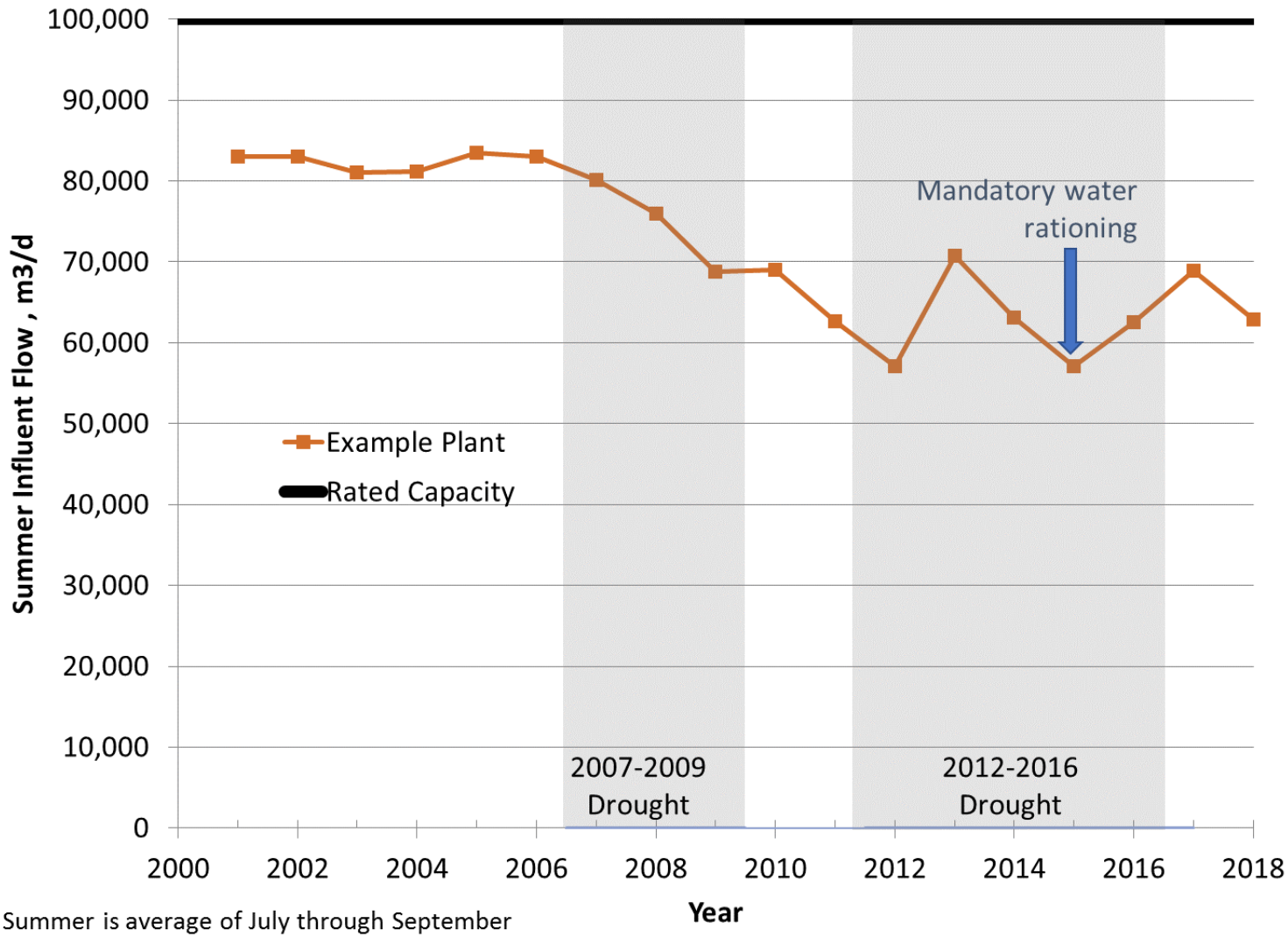
Of the impacted wastewater treatment respondents, **68% indicated changes in wastewater influent quality.**

**Some items included in other: higher recirculation flows, staffing adjustments, plant upsets.*

Lessons Learned #1:

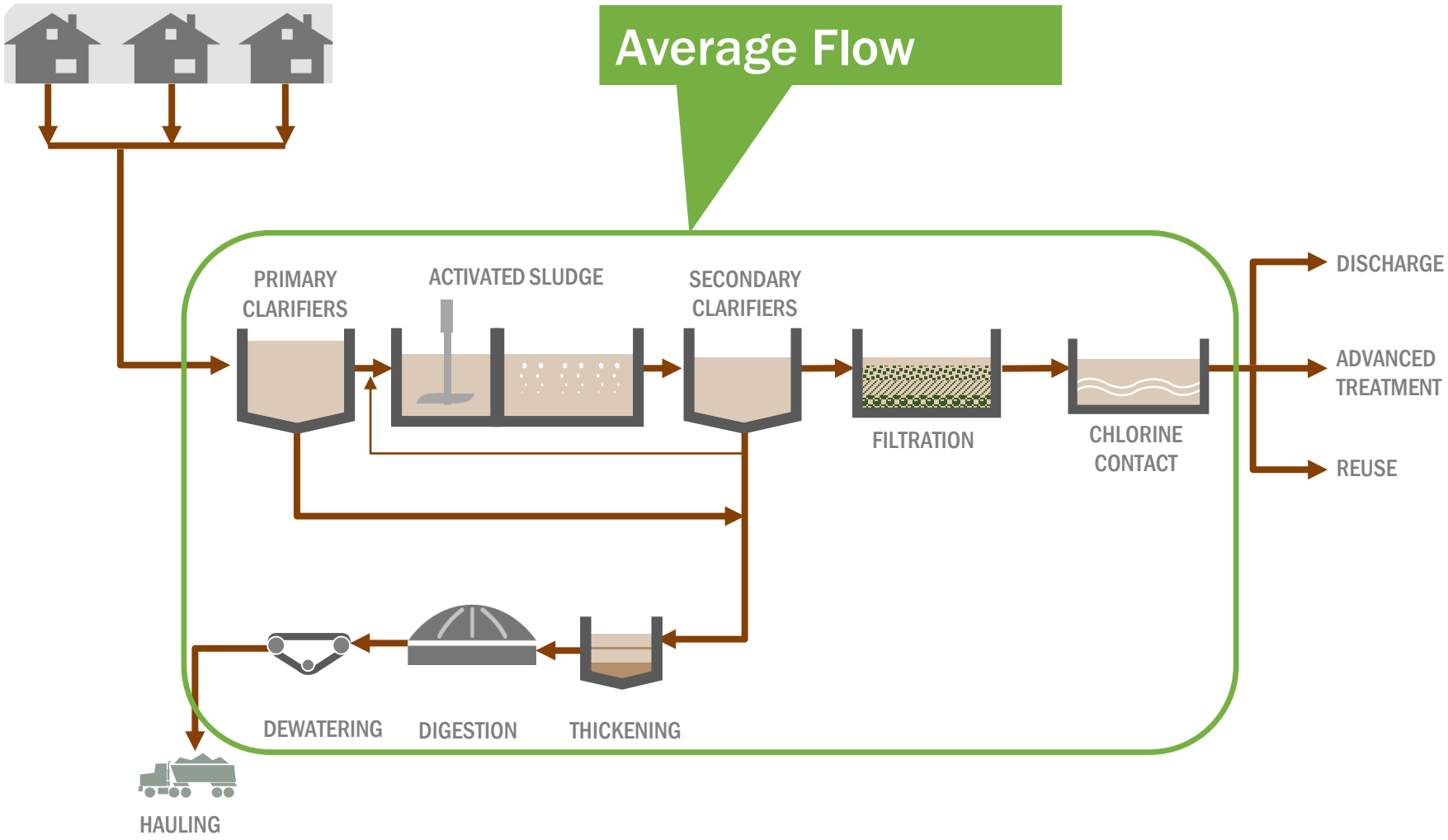
Do not rely on flow to trigger expansion

Flows decreased at many plants

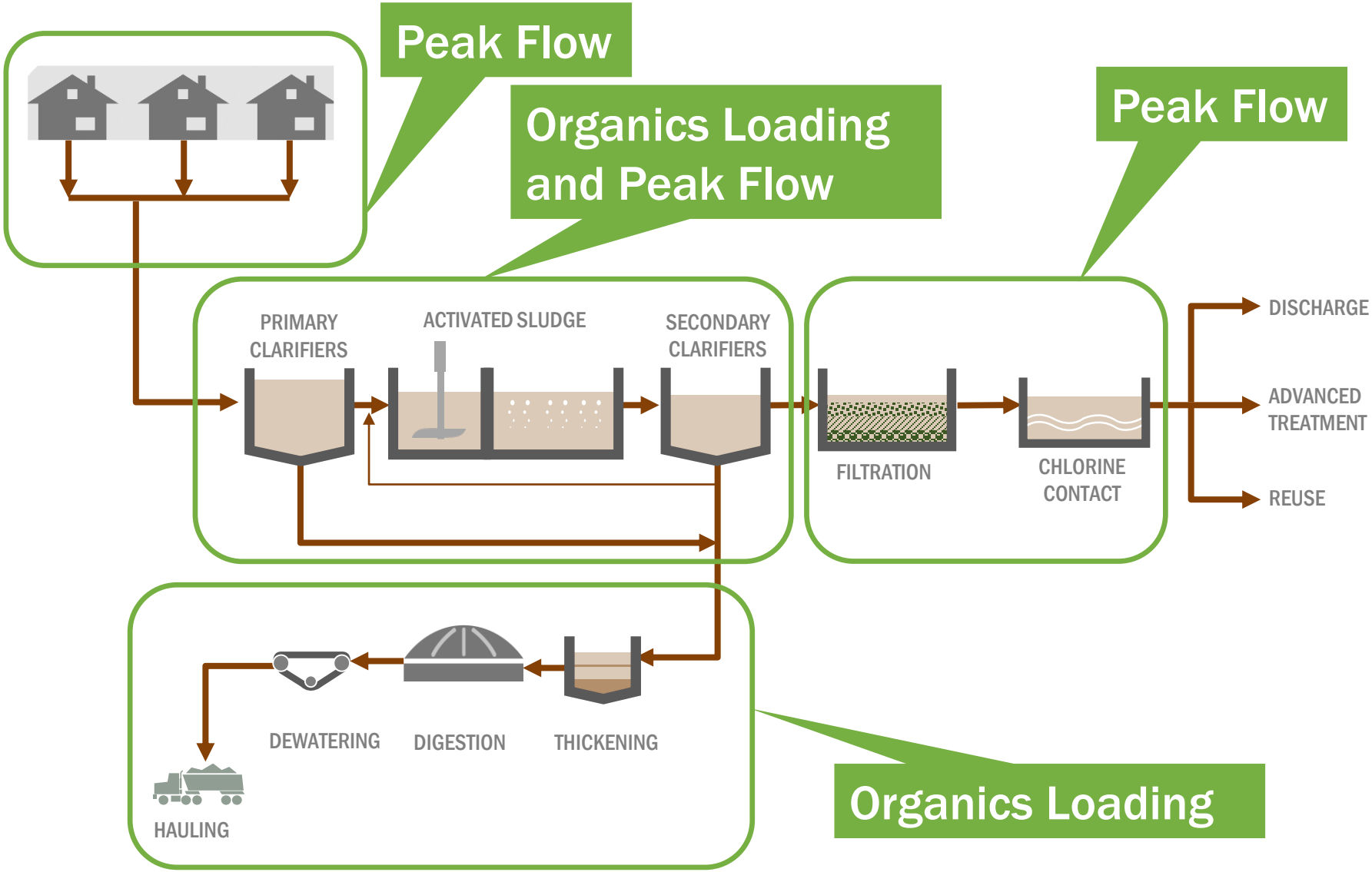


Summer is average of July through September

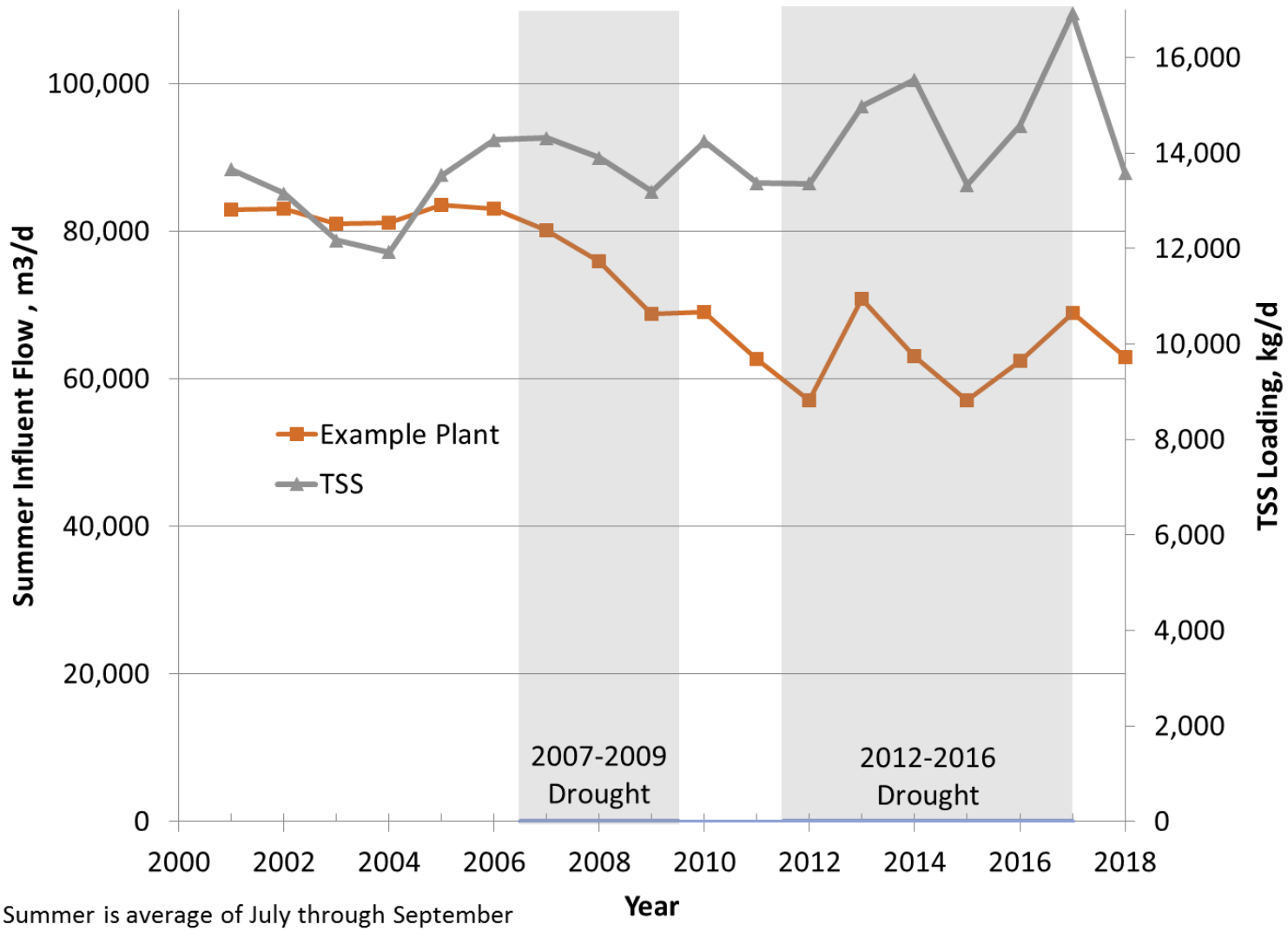
Average Flow is Typically Used to Rate Capacity



What Really Limits Plant Capacity?



Loadings have not decreased



Summer is average of July through September

Plants relied on flow to trigger upgrades

Aeration capacity
Secondary clarifier capacity

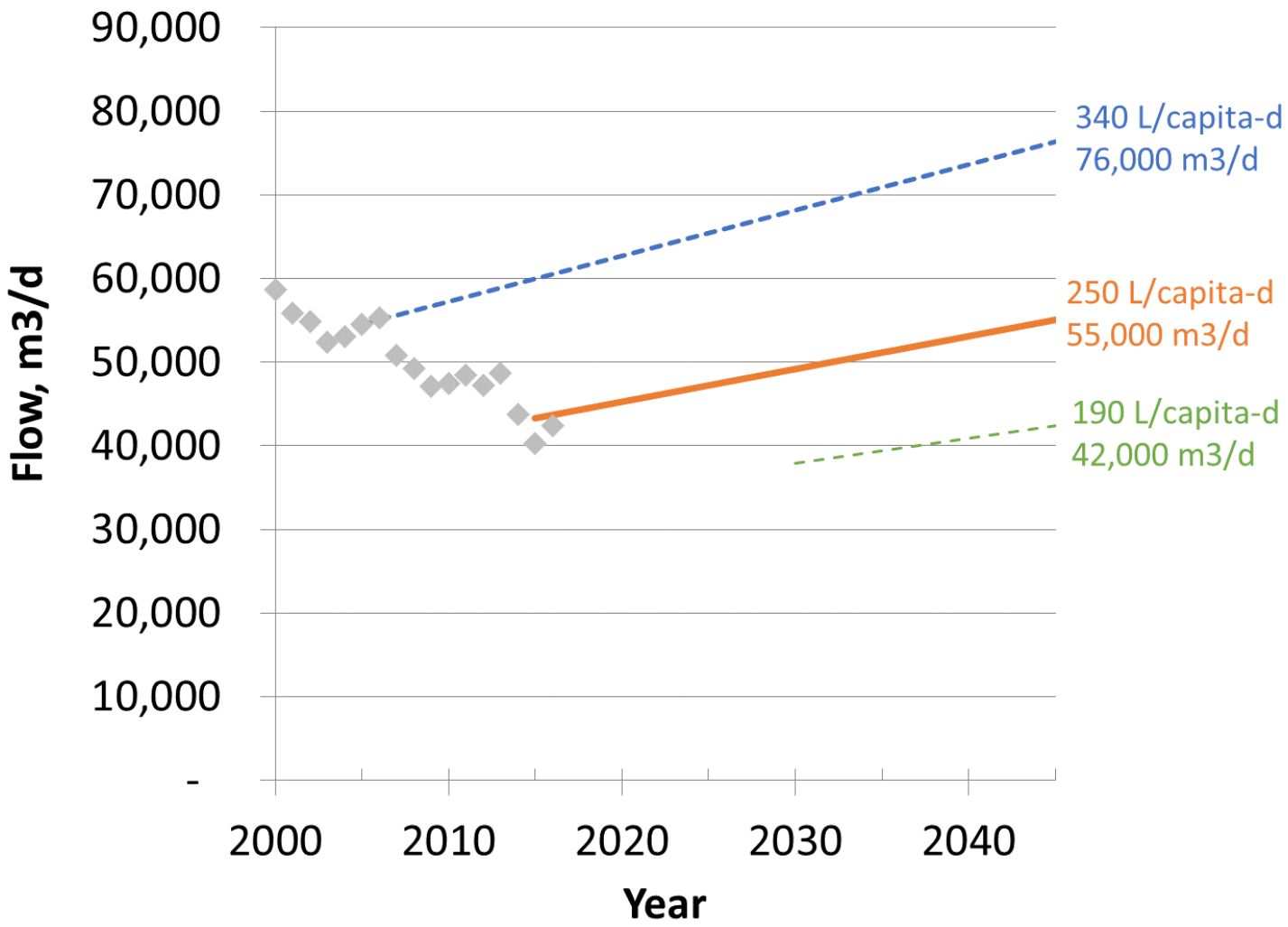
Digester capacity

Less flow does NOT mean spare capacity

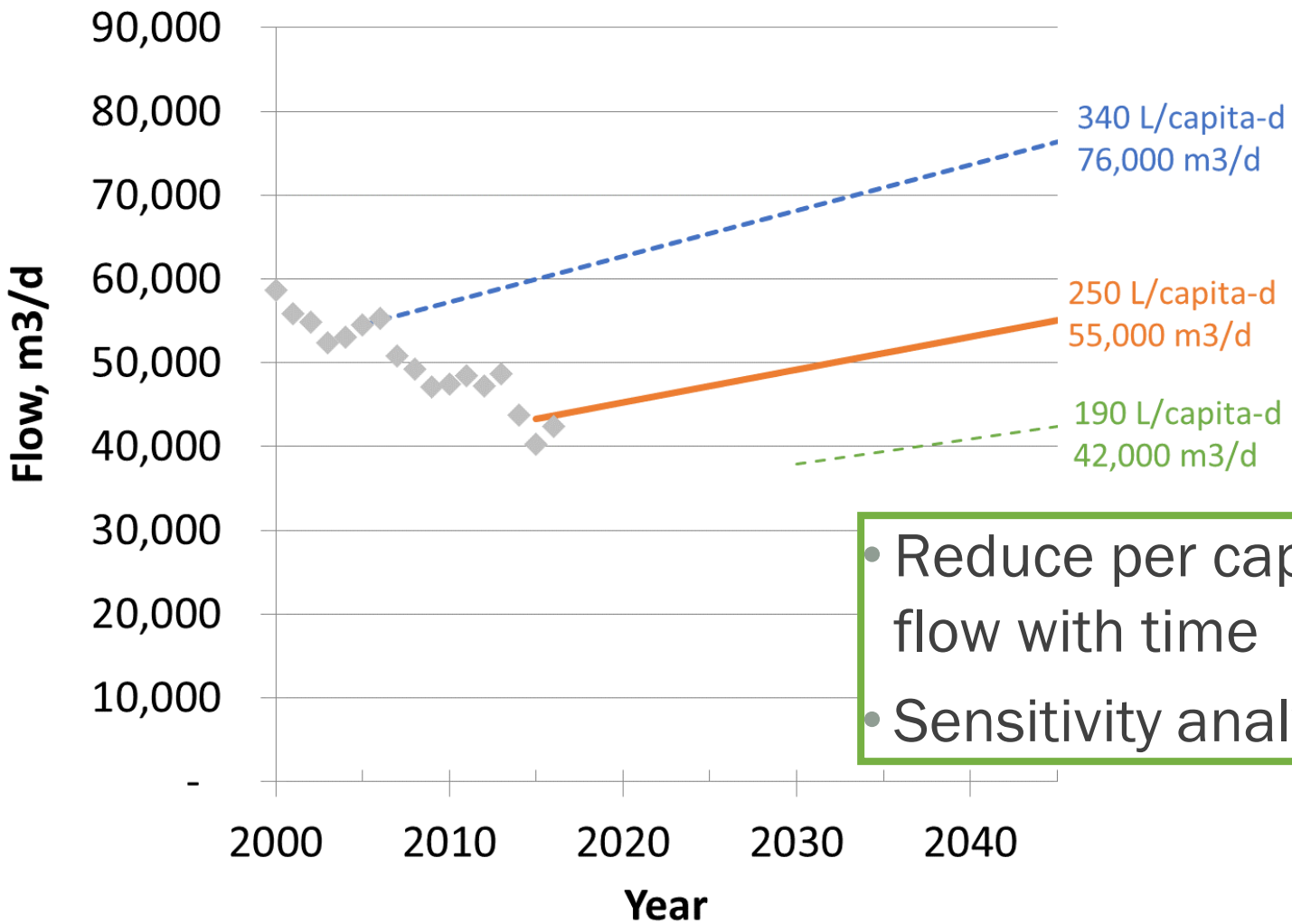
Lessons Learned #2:

Plan for decreasing per capita flows

Be prepared for decreasing flows



Be prepared for decreasing flows

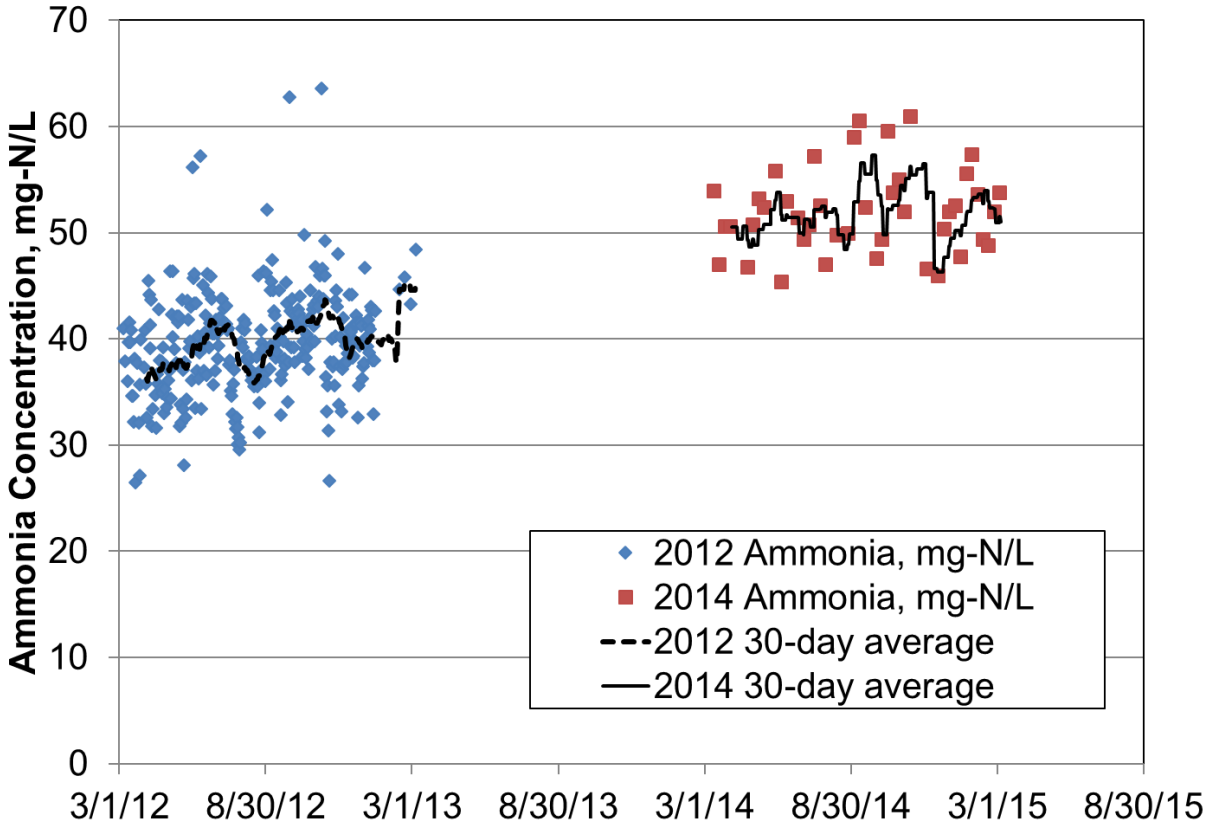


- Reduce per capita flow with time
- Sensitivity analysis

Lessons Learned #3:

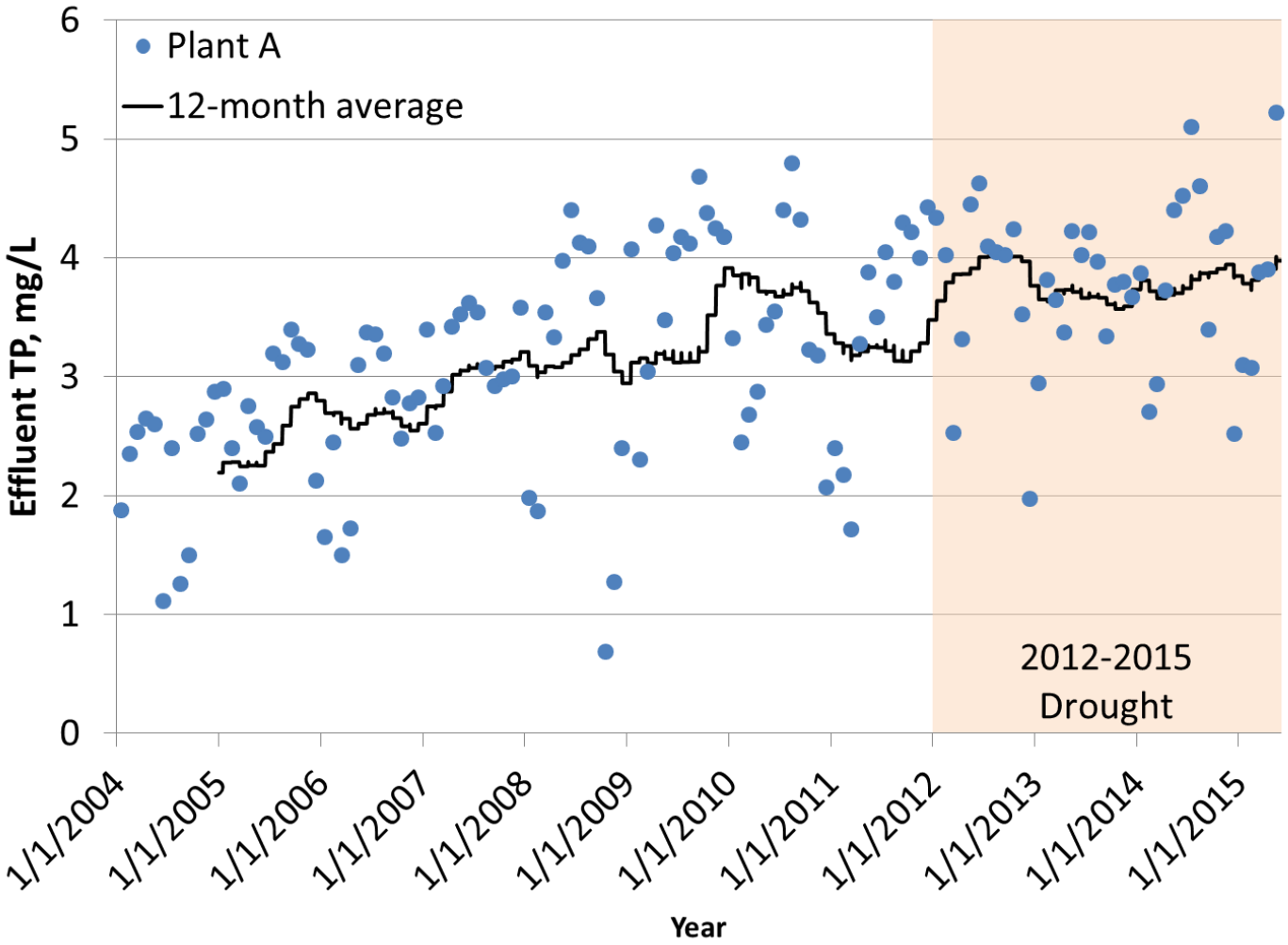
As per capita flows decrease, expect increasing concentrations

Increasing Influent Ammonia Concentrations Lead to Operational Adjustments



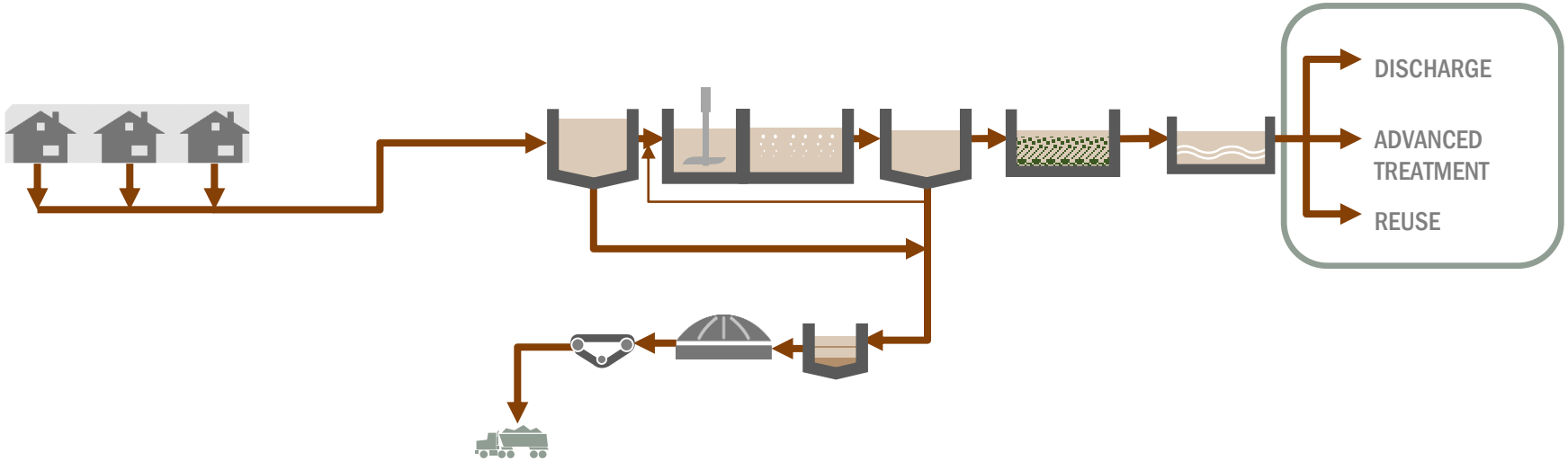
At the El Estero WWTP in Santa Barbara, **increased ammonia reveals alkalinity limitations.**

Effluent concentrations may also increase



Planning for increasing concentrations

- Sensitivity analysis in design
- Understand implications for your facility
- Provisions for:
  - Process improvements or expansion
  - Chemical addition



Lessons Learned

Less flow does NOT mean spare capacity, so track loading

Plan for decreasing per capita flows

Expect increasing concentrations

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