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GLOBAL CONNECTIONS DAY

OCTOBER 23, 2019

WATER: SAFETY, EFFICIENCY AND CONSERVATION

2019 ANNUAL CONFERENCE

Oct. 20–23, 2019 | Rio Hotel & Convention Center

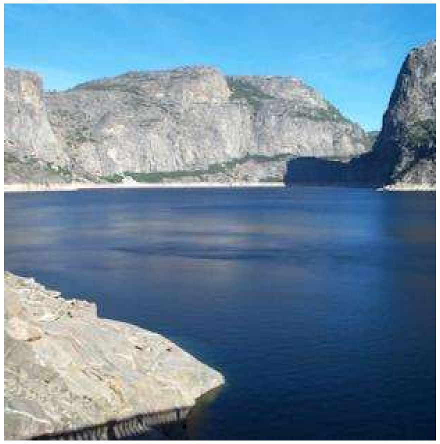
ICC 2019 LAS VEGAS NEVADA

Public Health and Utility Leaders Collaborate to Advance Onsite Water Reuse

Paula Kehoe

San Francisco Public Utilities Commission

San Francisco Public Utilities Commission



Water: delivering high quality water to 2.7 million people

Wastewater: protecting public health and the environment

Power: generating clean energy for vital City services

Challenges Facing Utilities

San Francisco's Local Water Program

HETCH HETCHY
+ LOCAL WATER
Better together.

- Conservation
- Groundwater
- Recycled Water
- Onsite Water Reuse
- Innovations Program

San Francisco knows the importance of diversifying our water portfolio… To ensure reliability—particularly in the age of climate change—we need to use every water resource available.

Harlan L. Kelly, Jr., SFPUC General Manager

An Evolving Onsite Water Reuse Program

2012 | **2013** | **2015** | **2019**

Single Building | ***District-Scale*** | ***Mandatory for ≥ 250,000 gsf*** | ***Innovations: Brewery Process Water Reuse***

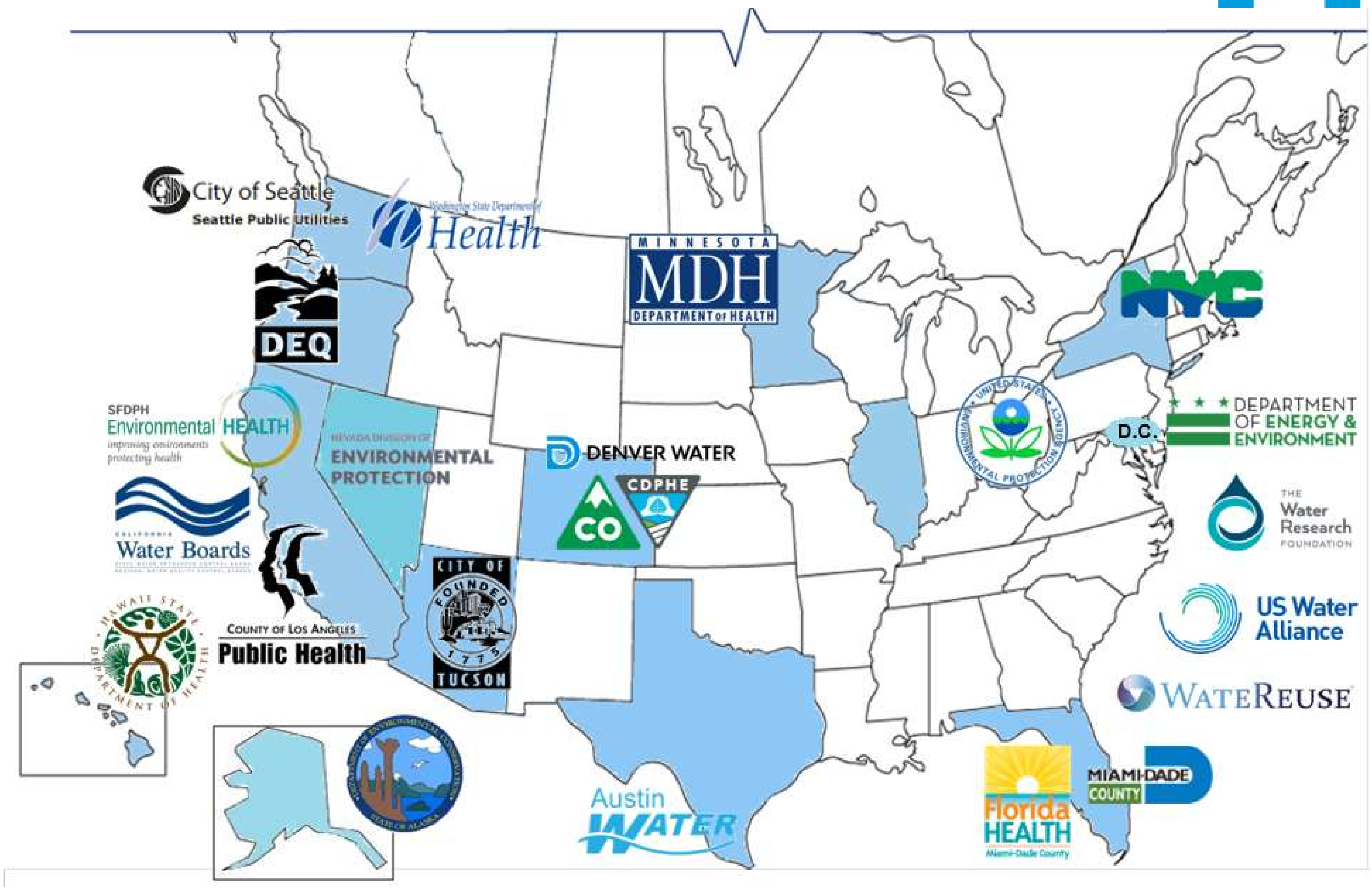
San Francisco's Onsite Water Reuse Program

...AND MORE!

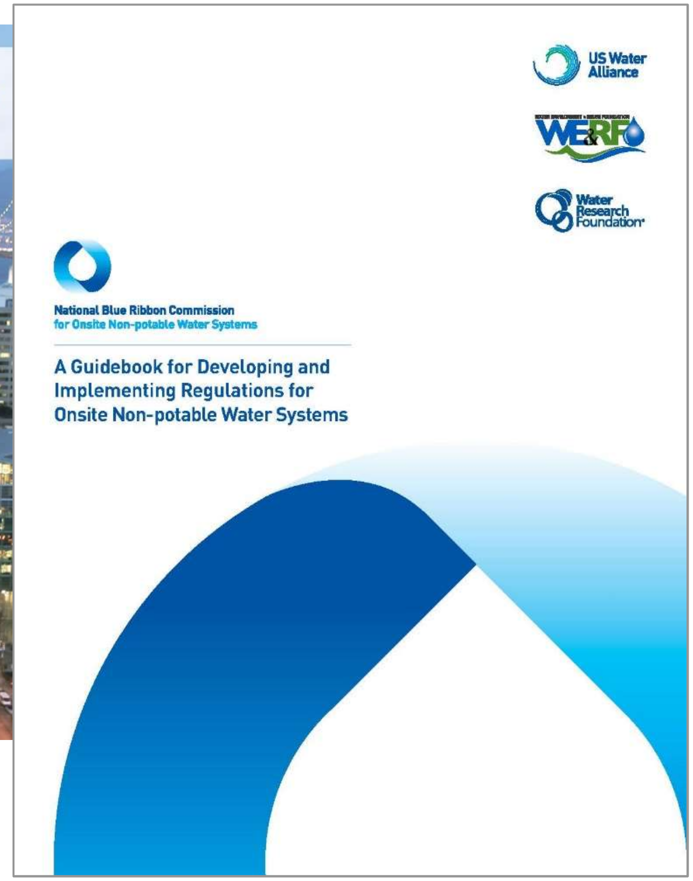
Barriers to Scaling Up Onsite Reuse: Governance & Water Quality

Source: Forbes.com

Public Health Regulator and Utility Collaboration



Advancing Local and State Oversight Programs



Utilities Incorporating Onsite Water Systems

SAN FRANCISCO
Mandatory for new development over 250,000 sq ft

DENVER WATER
Blackwater system at new admin building

CITY OF ST. PAUL
District-scale rainwater harvesting system at Allianz Field

AUSTIN WATER
10 mgd from decentralized systems by 2040

SANTA MONICA
Downtown stormwater, groundwater, wastewater reuse by 2020

VANCOUVER
Rainwater harvesting is key water conservation strategy

NEW YORK CITY
Battery Park operating decentralized system since 2003;
Grant program for onsite systems

ANAHEIM
Operating blackwater system for irrigation around City Hall and toilet flushing in Anaheim West Tower

PORTLAND
Hassalo on Eighth recycling blackwater from four downtown city blocks

Water Quality Standards to Protect Public Health

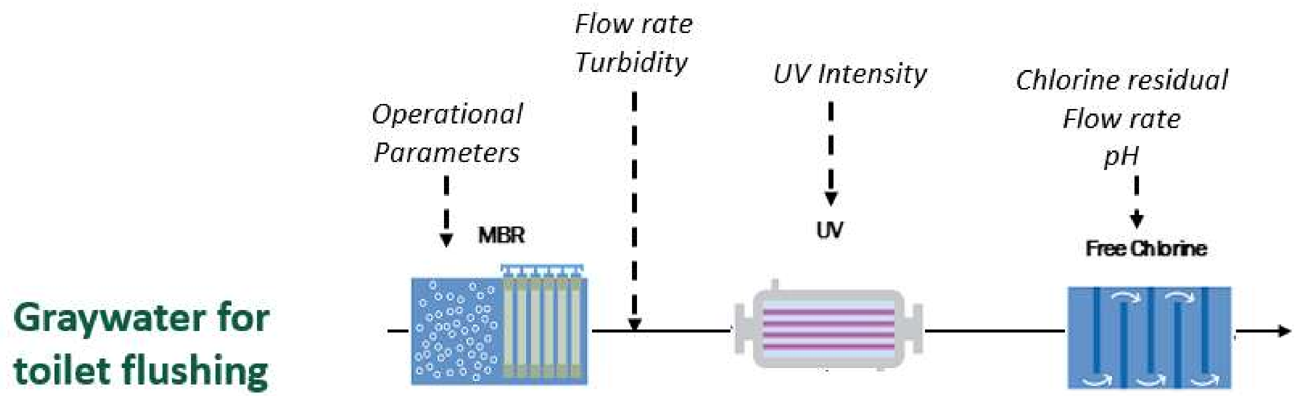
Risk-based water quality approach:

- ❖ Pathogen Log Reduction Targets (LRTs)
- ❖ Continuous online monitoring
- ❖ Treated water quality standards

Log Reduction Targets (LRTs)

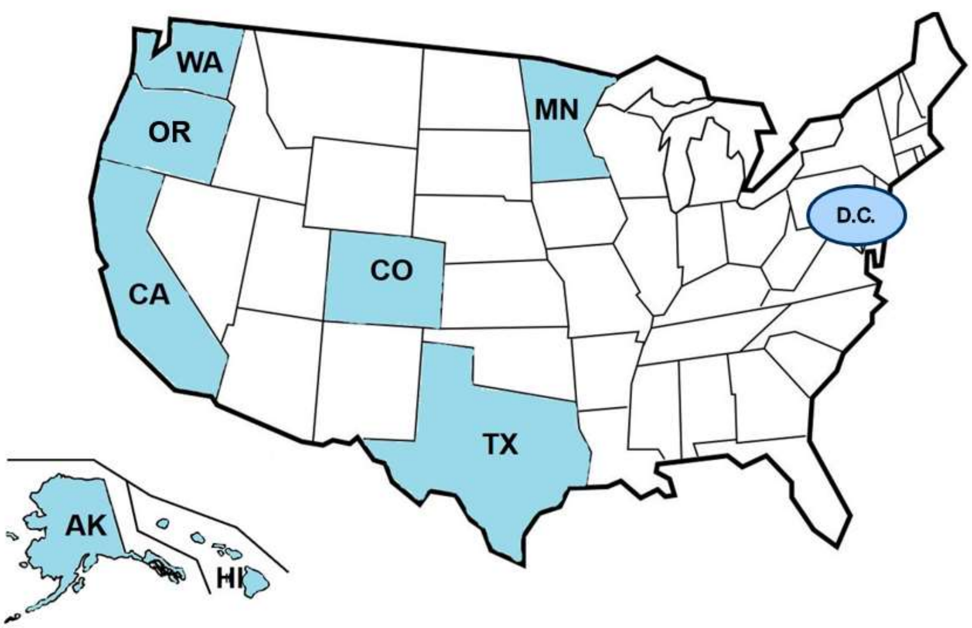
	Enteric Viruses	Parasitic Protozoa	Enteric Bacteria
Blackwater			
Outdoor use	8.0	7.0	6.0
Indoor use	8.5	7.0	6.0
Graywater			
Outdoor use	5.5	4.5	3.5
Indoor use	6.0	4.5	3.5
Roof Runoff			
Outdoor use	N/A	N/A	3.5
Indoor use	N/A	N/A	3.5
Stormwater			
Outdoor use	3.0	2.5	2.0
Indoor use	3.5	3.5	3.0

Treatment Train to Achieve LRTs



Pathogen Credits			
Treatment Process	MBR	UV	Chlorine
Virus	1.5	Up to 6	Up to 5
Protozoa	2	Up to 6	0
Bacteria	4	Up to 6	Up to 5
Ongoing Requirements	Operate within Tier 1 envelope	Online monitoring to confirm validated dose	Demonstrate CT with verified free chlorine residual

Jurisdictions Moving Forward with Risk-Based Approach



Source: San Francisco Public Utilities Commission

- San Francisco
- Colorado, Regulation #84
- California, SB 966 and Hawaii HB 444
- Minnesota and Washington D.C. Guidelines
- Washington State and Oregon
- Texas and Alaska

Guidance Manual for Designing and Implementing Onsite Systems

Beginning of Our Journey

- Consensus among public health regulators and utilities to move towards risk-based approach
- EPA Water Reuse Action Plan highlights fit-for-purpose and national framework for risk-based targets
- Consistent standards nationwide increases market demand and can lead to more cost effective and energy efficient technologies with reduced footprint
- Future plumbing codes and certifications to address risk-based approach

More Information

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www.sfwater.org/iuws

Developing Risk-Based, Fit-for-Purpose Treatment Guidance for Non-Potable Water Reuse

Jay L. Garland, PhD
Office of Research & Development
United State Environmental Protection Agency

Graywater Use to Flush Toilets

Varying Standards

	BOD_5 (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)	Total Coliform (cfu/ 100ml)	*E. Coli* (cfu/ 100ml)	Disinfection
California	10	10	2	2.2	2.2	0.5 – 2.5 mg/L residual chlorine
New Mexico	30	30	-	-	200	-
Oregon	10	10	-	-	2.2	-
Georgia	-	-	10	500	100	-
Texas	-	-	-	-	20	-
Massachusetts	10	5	2	-	14	-
Wisconsin	200	5	-	-	-	0.1 – 4 mg L^{-1} residual chlorine
Colorado	10	10	2	-	2.2	0.5 – 2.5 mg/L residual chlorine
Typical Graywater	80 - 380	54 -280	28-1340	$10^{7.2}$ – $10^{8.8}$	$10^{5.4}$ – $10^{7.2}$	N/A

Meeting standards means reducing the presence of pathogens by orders of magnitude – this informs "log reduction" targets

National Sanitation Foundation 350 Water Quality for Graywater Use for Toilet Flushing

Parameter	Class R[a]		Class C[b]	
	Test Average	Single Sample Maximum	Test Average	Single Sample Maximum
$CBOD_5$ (mg/l)	10	25	10	25
TSS (mg/l)	10	30	10	30
Turbidity (NTU)	5	10	2	5
E. coli (MPN/100 ml)	14	240	2.2	200
pH (SU)	6.0-9.0		6.0-9.0	
Storage vessel residual chlorine (mg/l)	≥ 0.5 - ≥ 2.5		≥ 0.5 - ≥ 2.5	

[a] Class R: Flows through graywater system are less than 400 gpd
[b] Class C: Flows through graywater system are less than 1500 gpd

Standardization is an improvement, but not risk based.

What do those levels of *E. coli* mean in terms of risk?

Hazard Analysis and Critical Control Point (HACCP)

Developed by NASA (in collaboration with Pillsbury and US Army Labs) in the 1960’s

Produce safe food for astronauts

Based on an engineering approach (and munition production)

- Identify, evaluate, and control hazards

Transferred to the food industry in the 1970’s

Quantitative Microbial Risk Assessment (QMRA)

“Source” waters

(roof runoff, storm water, graywater, blackwater)

End Use

Non-Potable

Potable

A Matrix of
Log Reduction Targets
To Define
Fit-For-Purpose Reuse

United States Environmental Protection Agency

Approach: Developing Risk-based Pathogen Reduction Targets

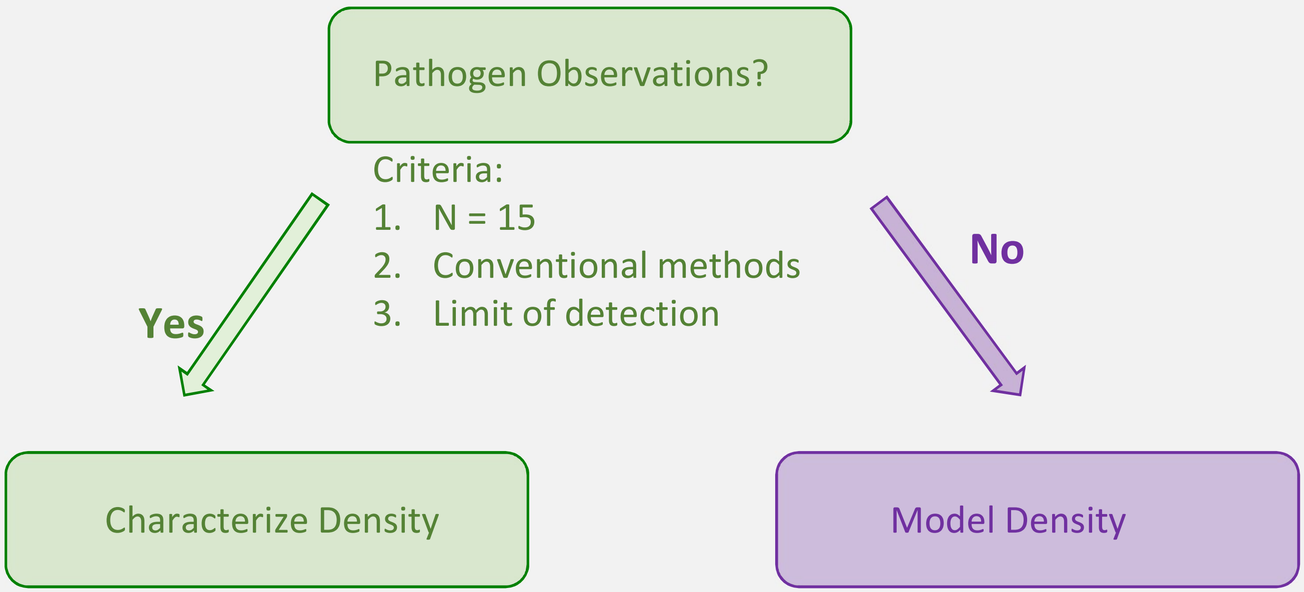
- "Risk-based" targets attempt to achieve a specific level of protection (aka tolerable risk or level of infection)
  - 10^{-4} infections per person per year (ppy)
  - 10^{-2} infections ppy
- Example: World Health Organization (2006) risk-based targets for wastewater reuse for agriculture

Reference Pathogens Needed

Each class will have different standards for necessary reductions in reused water

Viruses Bacteria Parasites/Protozoa

Critical First Step in Modeling: Estimating Initial Pathogen Density



Limited availability of data on pathogen levels for all of the water types

Pathogen Density Characterizations

- Stormwater: dilutions of municipal wastewater
- Roof runoff: animal fecal contamination
- Onsite graywater and wastewater: epidemiology-based simulation
  - Pathogen infections intermittent in small populations
  - Limited dilution effects

ZJ3

United States Environmental Protection Agency

Epidemiology-Based Approach

Fecal contamination of water

- Fecal indicator concentration in water
- Indicator content of raw feces

Number of users shedding pathogens

- Population size
- Infection rates
- Pathogen shedding durations

Pathogen concentrations in water

- Pathogen densities in feces during an infection
- Dilution by non-infected individuals

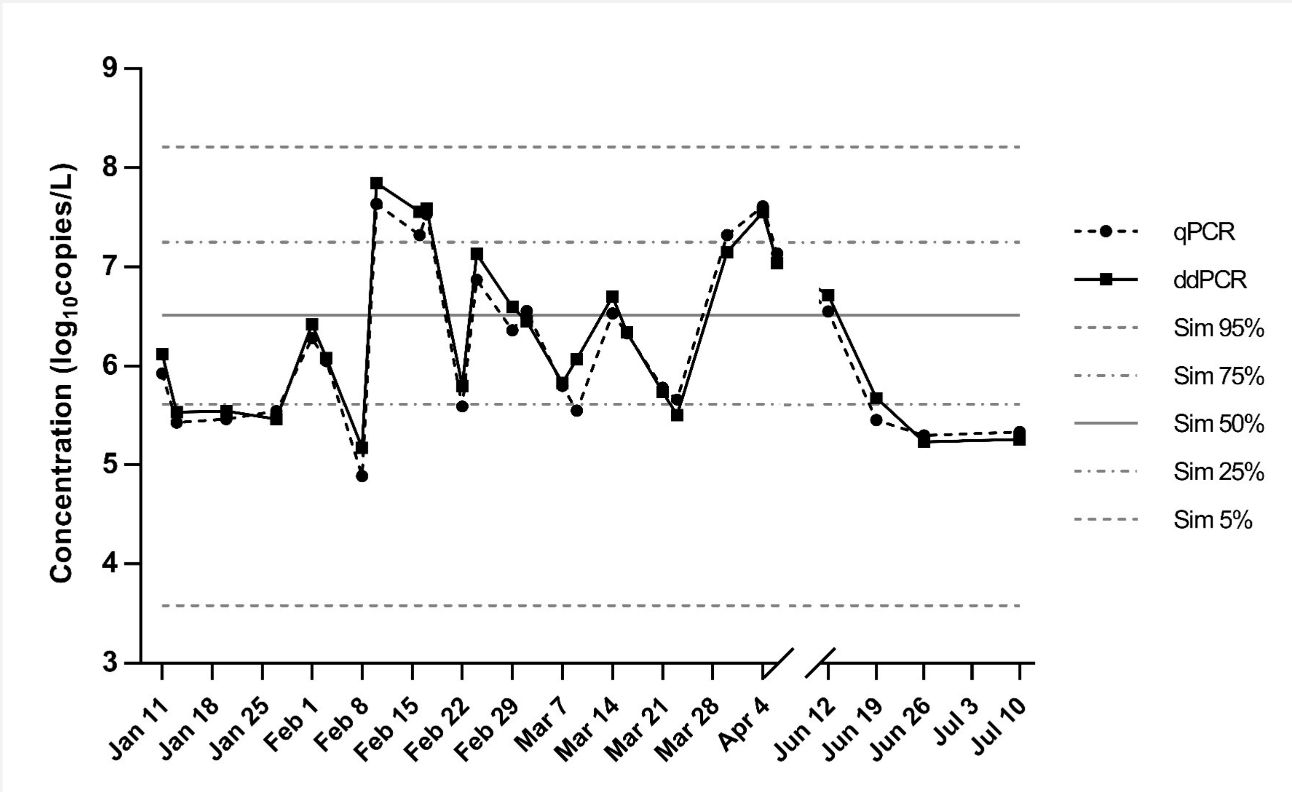
Jahne et al. (2017) Microbial Risk Analysis 5, 44-52

Slide 28

ZJ3 Not sure this slide is needed.

Zambrana, Jose, 10/3/2018

Result: Model Adequately Brackets Online Wastewater Measures from SFPUC Building



Jahne et al. (submitted)

Ingestion Exposure Volumes

Use	Volume (L)	Days/year	Fraction of pop.
Home			
Toilet flush water	0.00003	365	1
Clothes washing	0.00001	100	1
Accidental ingestion or cross-connection w/ potable	2	1	0.1
Municipal irrigation/dust suppression	0.001	50	1
Drinking	2	365	1

NRMMC, EPHC, AHMC (2006). Australian guidelines for water recycling: managing health and environmental risks (Phase 1).

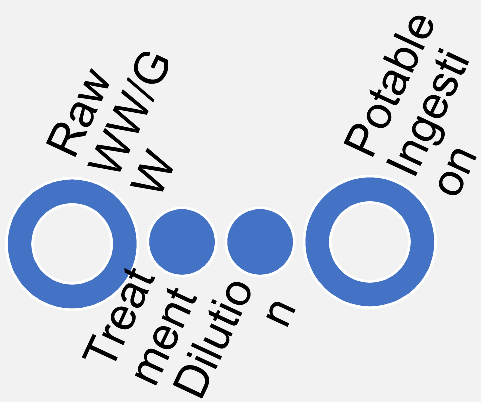
QMRA Results - Log Reduction Targets

Water Use Scenario	Log_{10} Reduction Targets for 10^{-4} (10^{-2}) Per Person Per Year Benchmarks[b,i]		
	Enteric Viruses[c]	Parasitic Protozoa[d]	Enteric Bacteria[e]
Domestic Wastewater or Blackwater			
Unrestricted irrigation	8.0 (6.0)	7.0 (5.0)	6.0 (4.0)
Indoor use[f]	8.5 (6.5)	7.0 (5.0)	6.0 (4.0)
Graywater			
Unrestricted irrigation	5.5 (3.5)	4.5 (2.5)	3.5 (1.5)
Indoor use[g]	6.0 (4.0)	4.5 (2.5)	3.5 (1.5)
Stormwater (10^{-1} Dilution)			
Unrestricted irrigation	5.0 (3.0)	4.5 (2.5)	4.0 (2.0)
Indoor use	5.5 (3.5)	5.5 (3.5)	5.0 (3.0)
Stormwater (10^{-3} Dilution)			
Unrestricted irrigation	3.0 (1.0)	2.5 (0.5)	2.0 (0.0)
Indoor use	3.5 (1.5)	3.5 (1.5)	3.0 (1.0)
Roof Runoff Water[h]			
Unrestricted irrigation	Not applicable	No data	3.5 (1.5)
Indoor use	Not applicable	No data	3.5 (1.5)

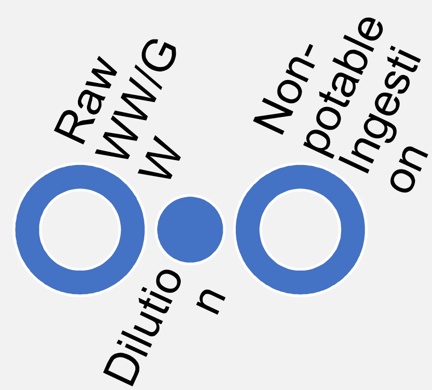
Sharvelle et al. (2017). Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems.
Schoen et al. (2017) Risk-based enteric pathogen reduction targets for non-potable and direct potable use fo roof runoff, stormwater, and greywater. Microbial Risk Analysis. 5, 32-43

Cross-Connection QMRA

- Two unique scenarios for non-potable water systems
- What event durations, intrusion dilutions, and fractions of users exposed are considered “safe”?
- Is the built-in safety factor sufficient?



Reclaimed to potable



Raw to non-potable

Summary: Cross-Connection QMRA

- Generally low risks for short duration (<5-day); small exposed population (<1%); and high intrusion dilution (>1:1,000)
- Higher risks for cross-connection of waste-/graywater to reclaimed water than for reclaimed to potable
  - Small exposure volume but high pathogen load
- Built-in protection effective for short-term, low magnitude reclaimed to potable cross-connection events
  - There is <1 log decrease in LRTs if ingestion safety factor is omitted

Schoen et al. (2018) Water 10, 1352-1366

Application of QMRA NSF350 Validated Systems

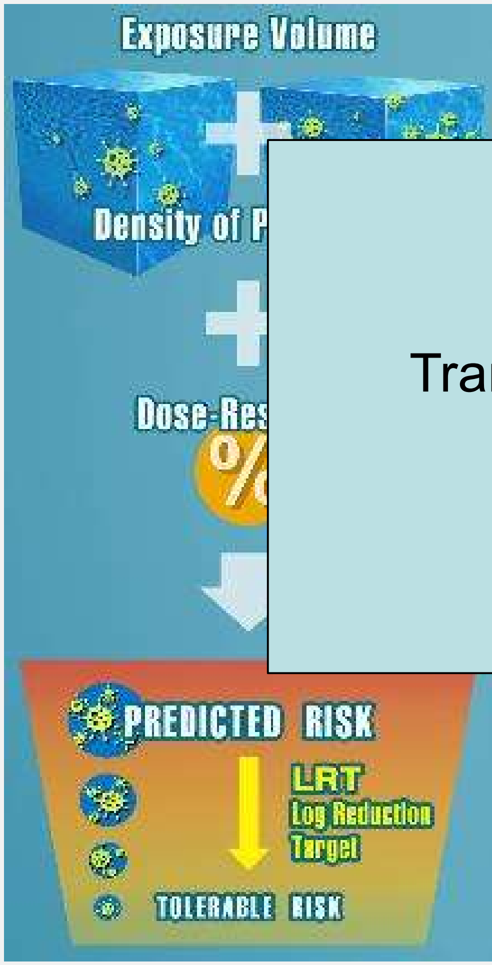
- NSF-certified systems comply with FIB requirements, but the treatment removal of pathogens was not explicitly considered in certification
- FIB removal does not ensure adequate removal of the pathogens of interest, i.e. viruses and protozoa.
- As a result, the predicted annual health risk of certified systems varies from low to extremely high, relative to the health benchmark
- Treatment performance data are required, particularly for virus and parasite removal
- Uncertainty in log removal values (LRV) for unit proceess

Example Residential $\log_{10}$ reduction targets

Water	Virus	Protozoa
Wastewater	8.0	6.5
Greywater	5.5	4.0

Intermediate (between 10^{-2} and 10^{-4} for GW
High ($>10^{-2}$) for combined wastewater
Increase with larger size (> people, > risk of infection)

Quantitative Microbial Risk Assessment (QMRA)



A Structured Framework

Transparent underlying assumptions

Flexible and Adaptable

En

Potable

United States Environmental Protection Agency

Areas for Improvement

- Refinement of model inputs
  - Initial pathogen concentrations, exposure volumes (including accidental ingestion),dose-response ratios, acceptable level of risk
    - Largest uncertainty? Stormwater pathogen concentrations

- Definition of system performance
  - Improved library of log reduction value for key unit processes

- Monitoring (for validation purposes)
  - Simple surrogates for viral and protozoan removal
    - And bacteria, but de-emphasize reliance on traditional fecal indicators

Contact

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Resources for Additional Information

Resources for Onsite Non-Potable Water Programs

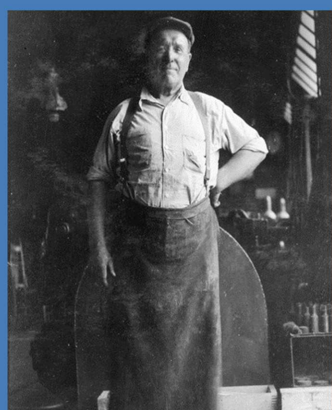
- http://uswateralliance.org/initiatives/commission/resources

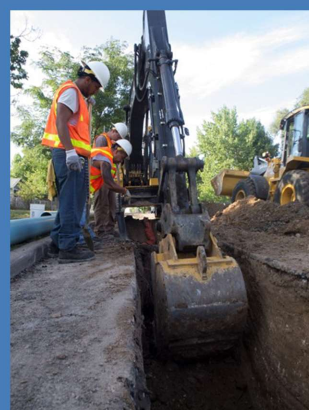
  (All the documents produced by the National Blue Ribbon Commission)

EPA Water Reuse Research Resources

- Onsite Non-Potable Water Reuse Research Website
- Onsite Non-Potable Water Reuse Research Technical Brief
- Water Reuse Research Website

Onsite Water Reuse in Colorado





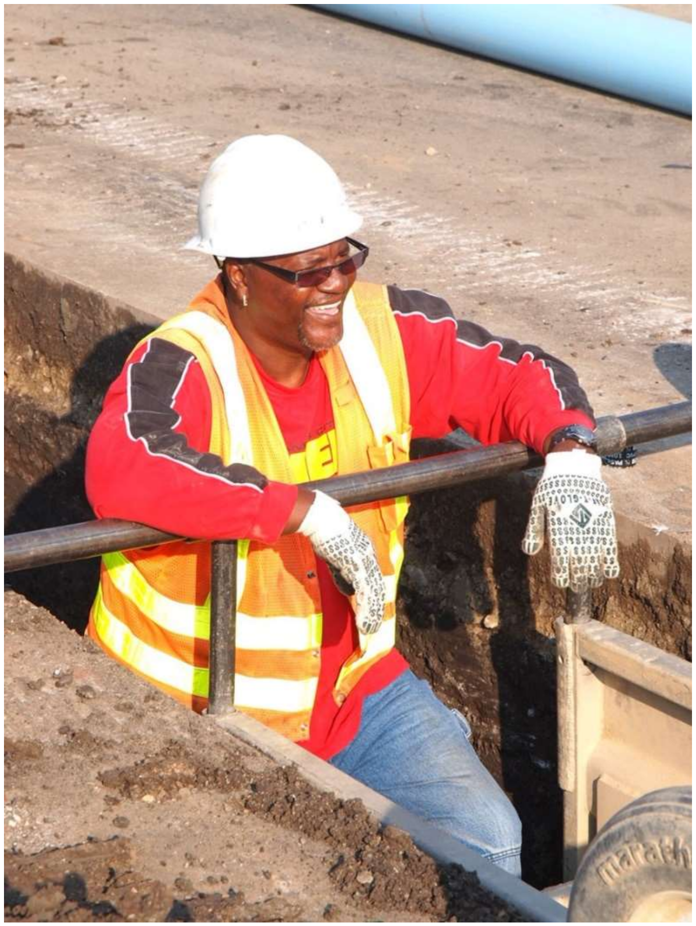
Brian Good

Denver Water

Denver Water

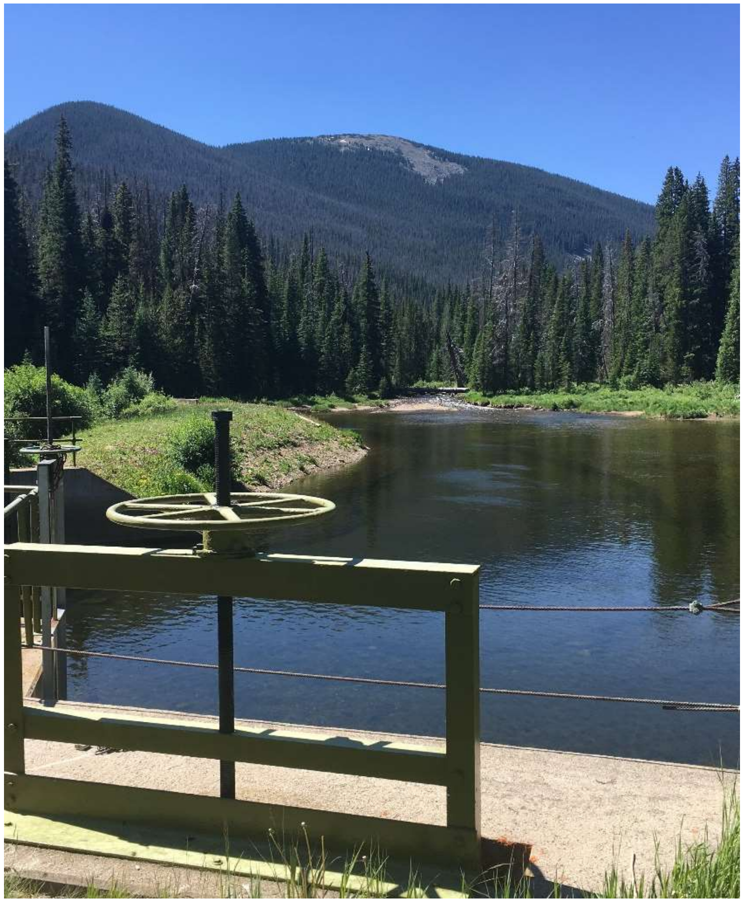
- Established in 1918
- Serve 1.4 million people; 25% of Colorado’s population
- Total watershed area: 2.5 million acres

Denver Water

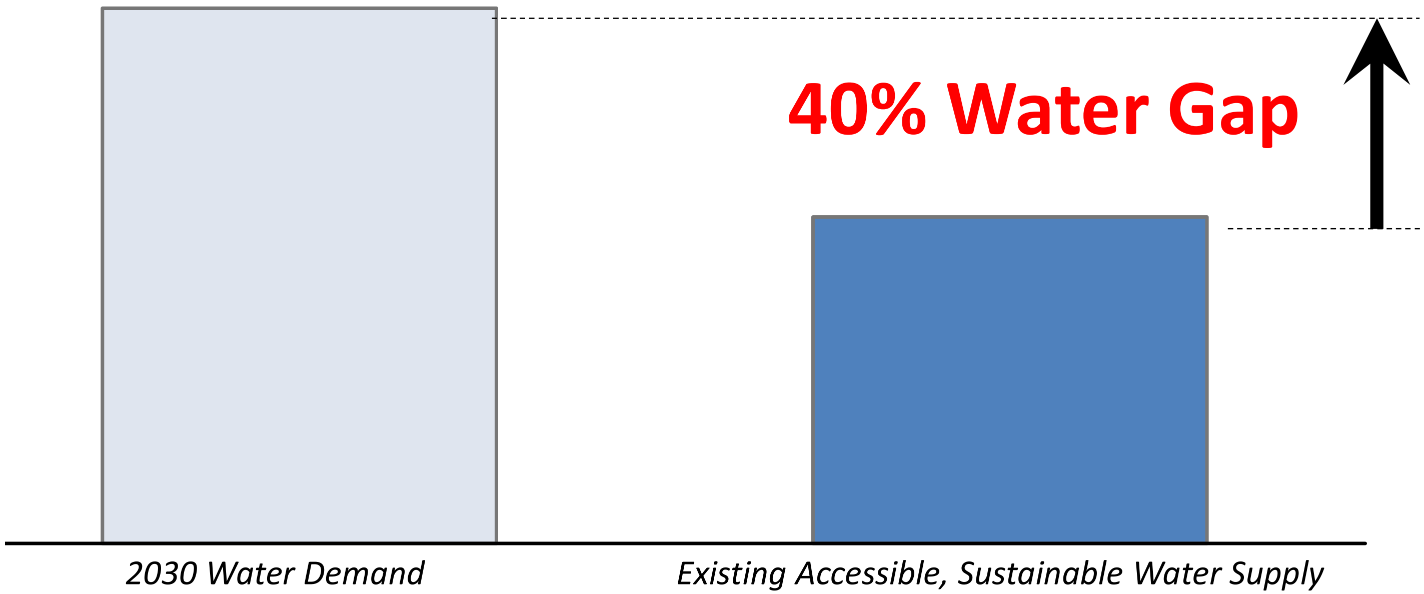


- 19 raw water reservoirs
- 4 treatment plants
- 187 million gallons delivered per day
- $509 million budget
- 1,100 employees

We Have a Unique Challenge…



- Must provide water “forever”
- Even in the face of climate change
- Must operate 24/7/365 in all conditions



"If Current Fresh-Water Consumption Trends Continue, We Could see a 40% Shortfall between Demand for Water and Supply in just 20 years" – **Peter Voser, Retired CEO, Royal Dutch Shell**

Source: 2030 Water Resources Group Report

Top 5 Global Risks in Terms of Impact

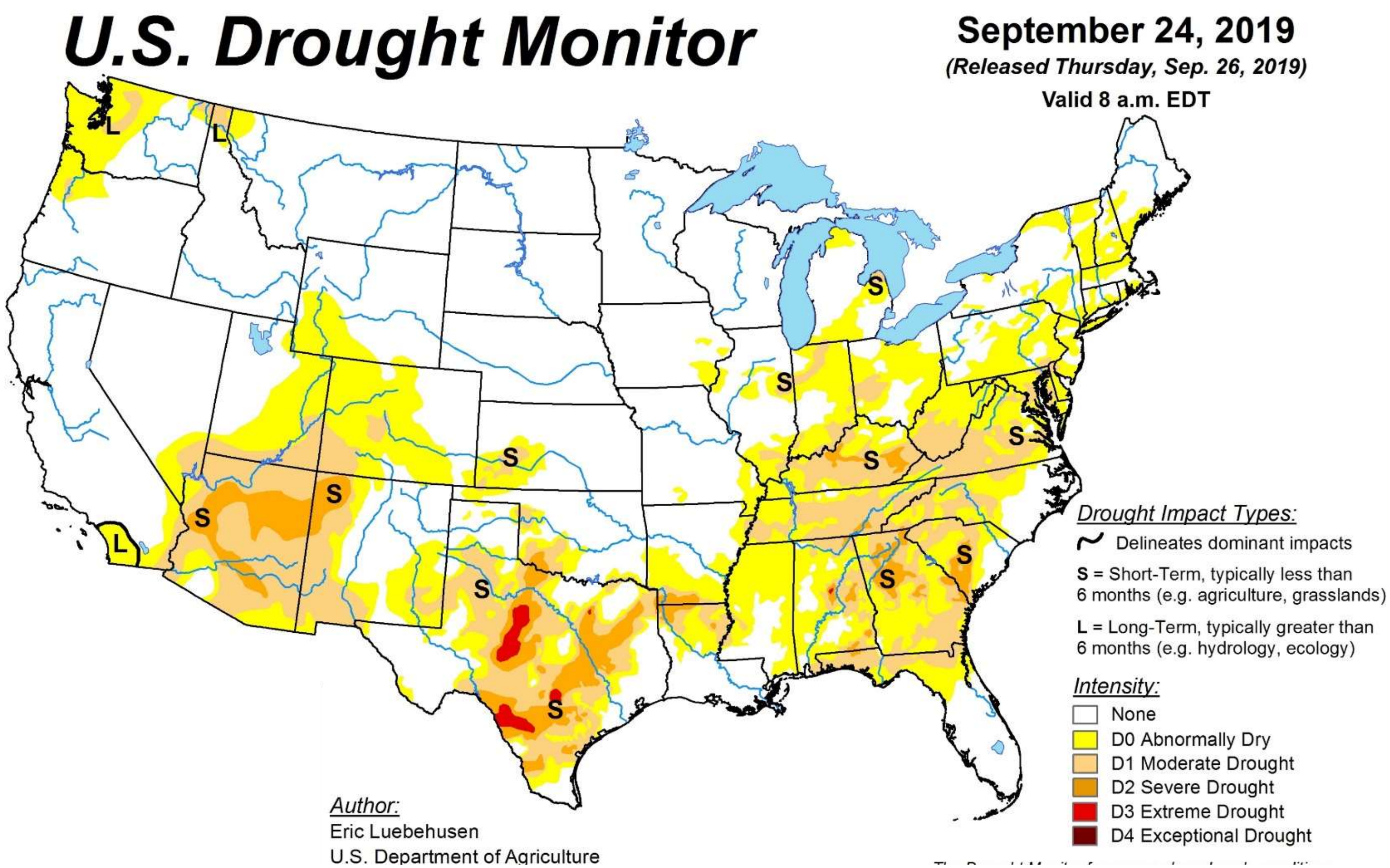
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1st	Asset price collapse	Asset price collapse	Fiscal crises	Major systemic financial failure	Major systemic financial failure	Fiscal crises	Water crises	Failure of climate-change mitigation and adaptation	Weapons of mass destruction	Weapons of mass destruction	Weapons of mass destruction
2nd	Retrenchment from globalization (developed)	Retrenchment from globalization (developed)	Climate change	Water supply crises	Water supply crises	Climate change	Rapid and massive spread of infectious diseases	Weapons of mass destruction	Extreme weather events	Extreme weather events	Failure of climate-change mitigation and adaptation
3rd	Oil and gas price spike	Oil price spikes	Geopolitical conflict	Food shortage crises	Chronic fiscal imbalances	Water crises	Weapons of mass destruction	Water crises	Water crises	Natural disasters	Extreme weather events
4th	Chronic disease	Chronic disease	Asset price collapse	Chronic fiscal imbalances	Diffusion of weapons of mass destruction	Unemployment and underemployment	Interstate conflict with regional consequences	Large-scale involuntary migration	Major natural disasters	Failure of climate-change mitigation and adapt[illegible]	Water crises
5th	Fiscal crises	Fiscal crises	Extreme energy price volatility	Extreme volatility in energy and agriculture prices	Failure of climate-change mitigation and adaptation	Critical information infrastructure breakdown	Failure of climate-change mitigation and adaptation	Severe energy price shock	Failure of climate-change mitigation and adaptation	Water crises	Natural disasters

Economic | Environmental | Geopolitical | Societal | Technological

Source: World Economic Forum 2009–2019, Global Risks Reports

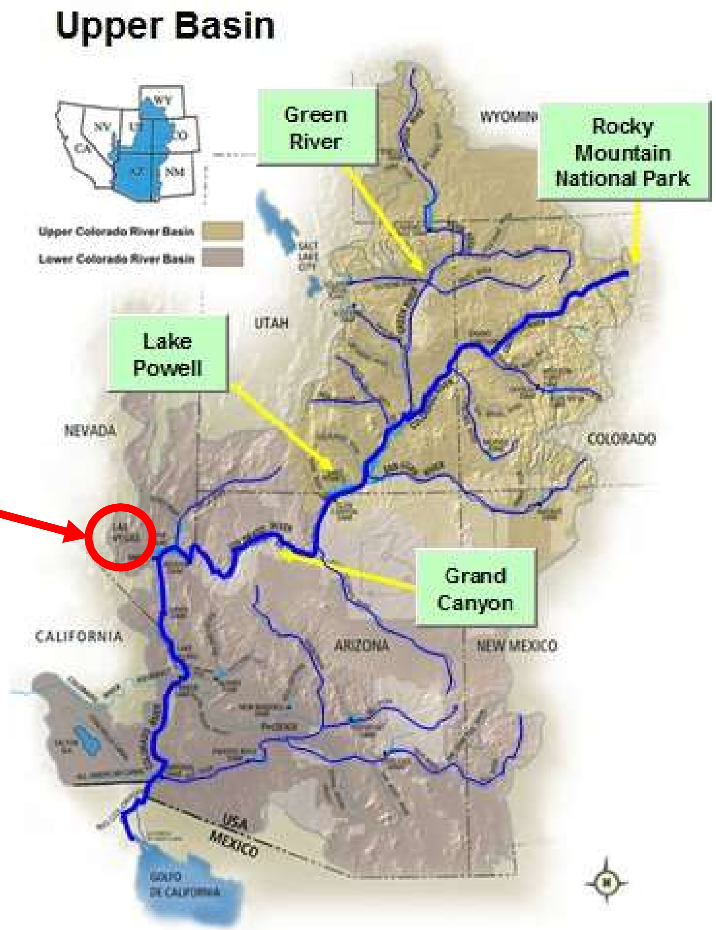
Source: World Economic Forum

Western US: Need to do Something Different

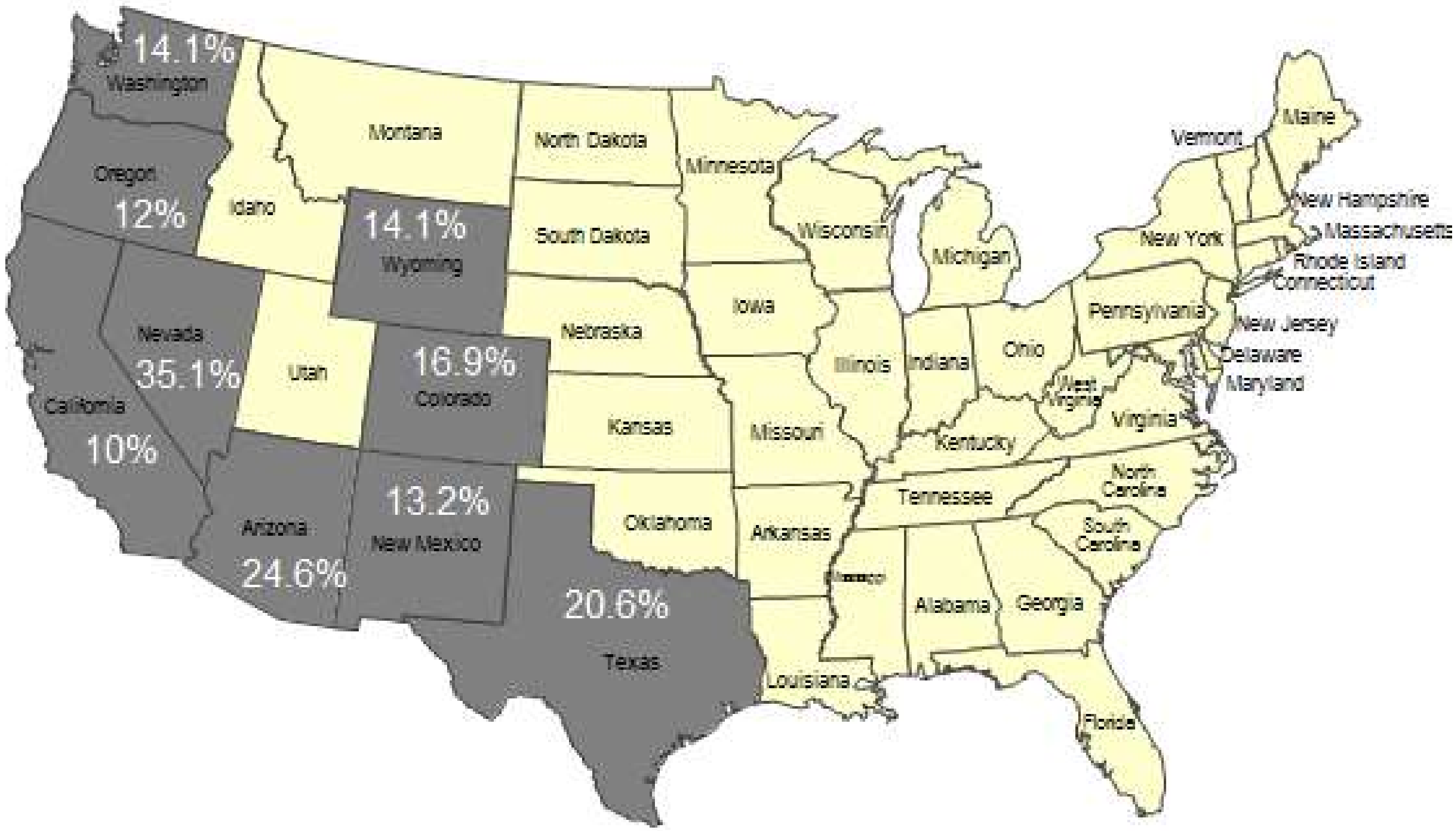


Western US: Need to do Something Different

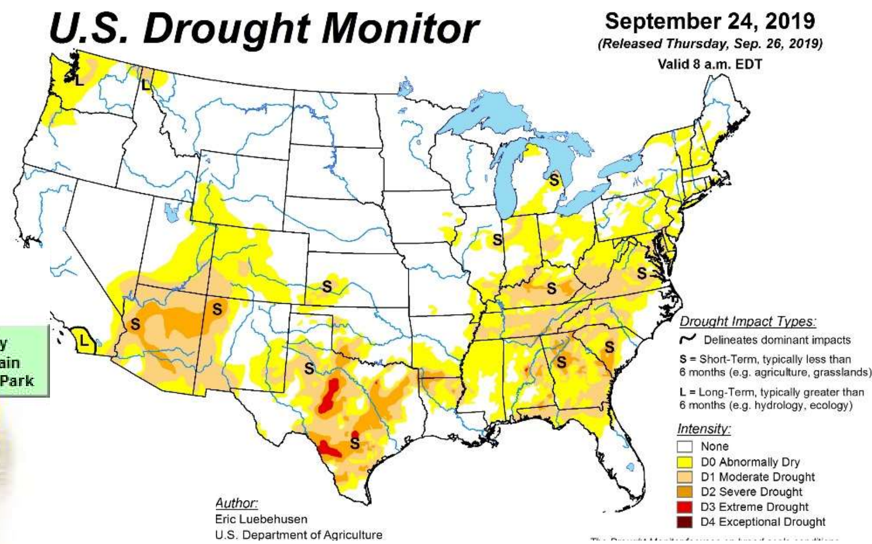
You
are
here

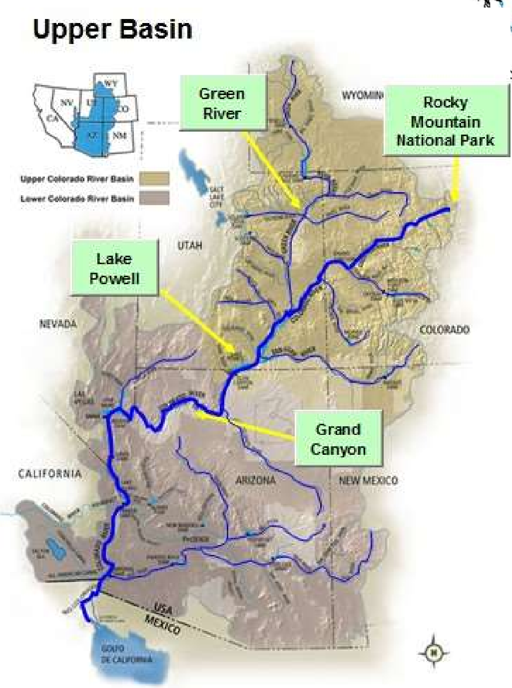


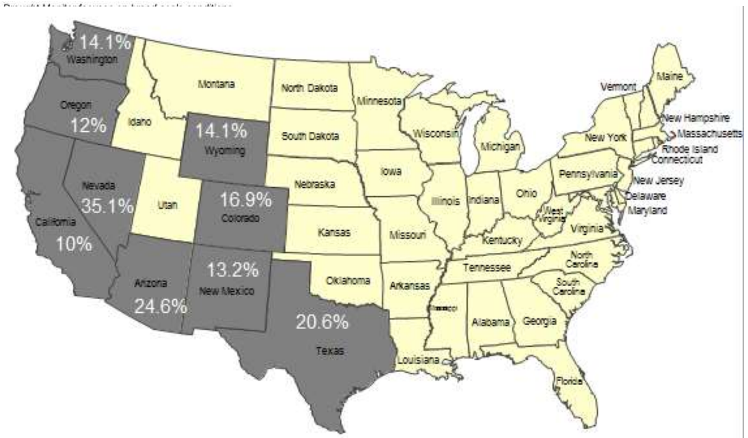
Western US: Need to do Something Different



Western US: Need to do Something Different







Something Different

One Water

- Evaluate all available water sources for a site and match the most appropriate sources and uses

- Rethinking the future of urban water use in Denver

Let’s Pilot Something!

Denver Water Operations Complex

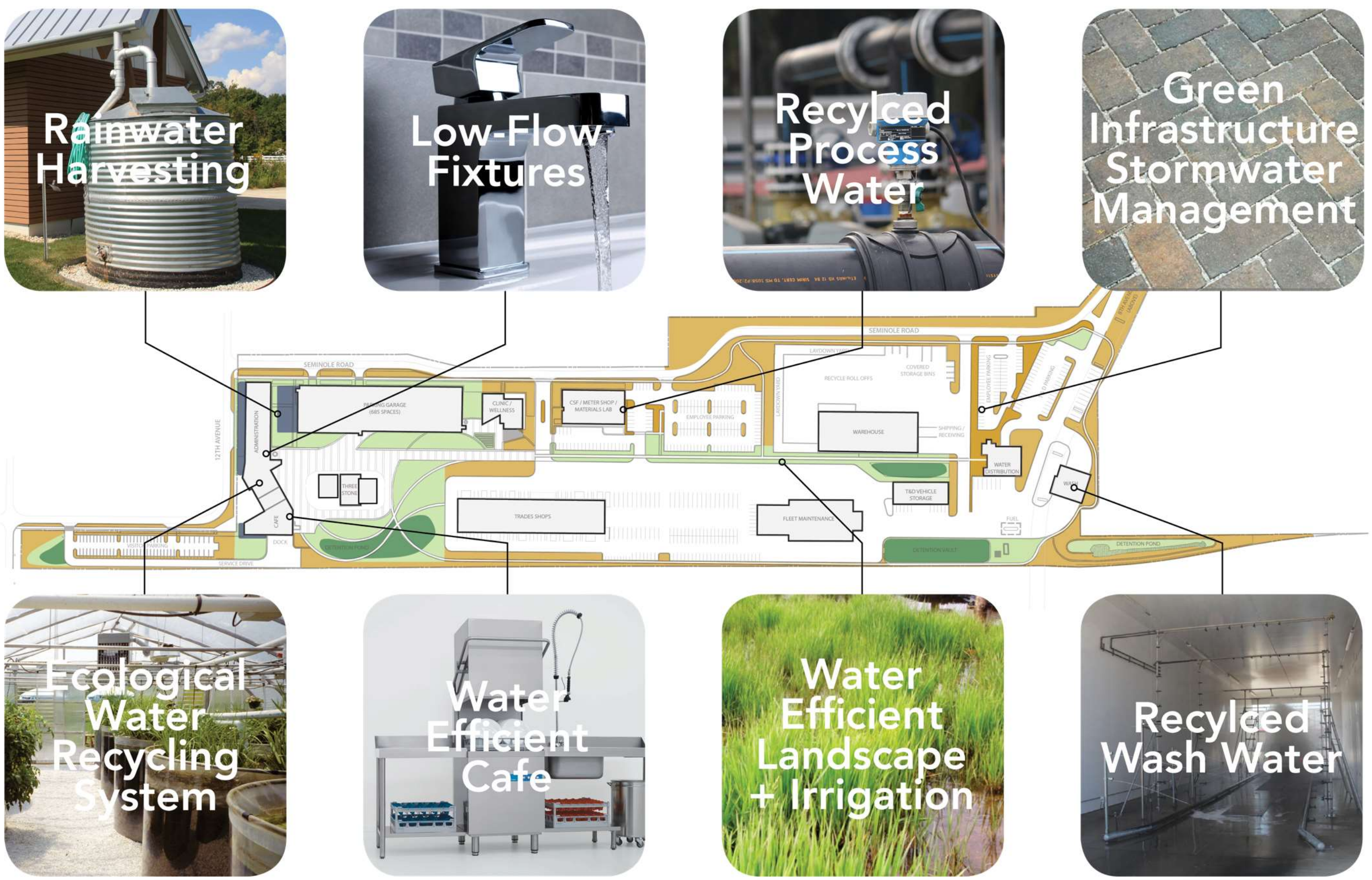
LEED PLATINUM

NET ZERO ENERGY

ONE WATER

PERFORMANCE GOALS

Courtesy, Tom Hootman, MKK



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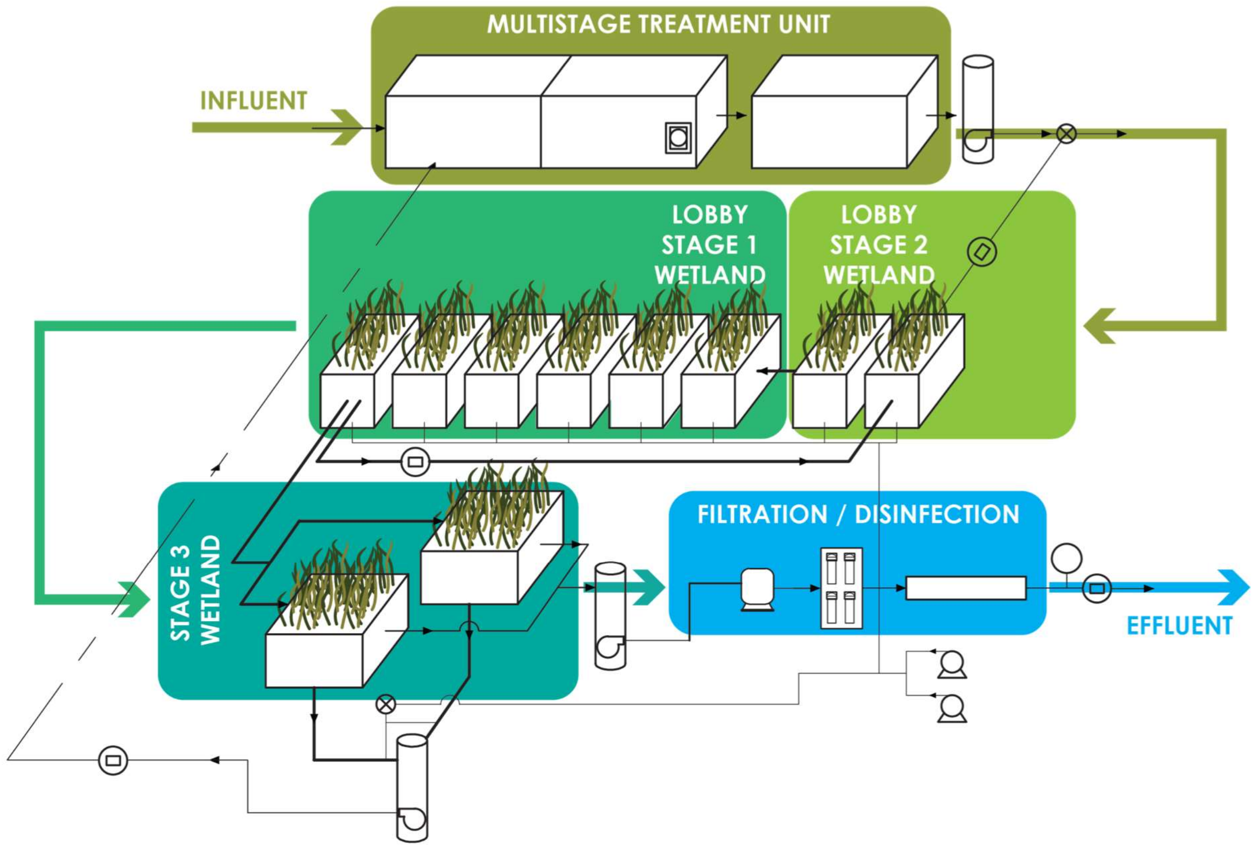

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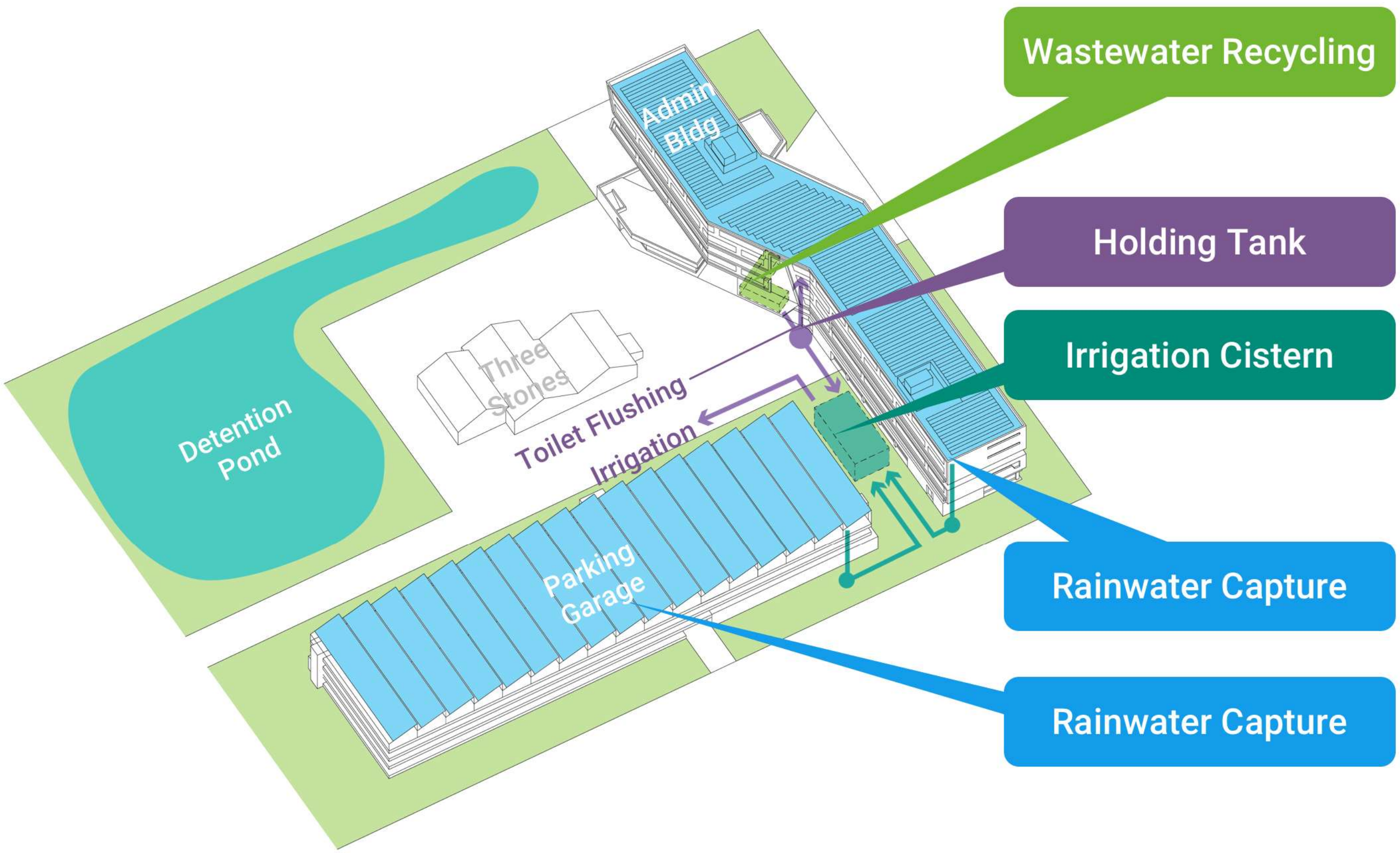

Courtesy, Tom Hootman, MKK

Not So Fast…

- Rainwater capture is not legal in Colorado
- Toilet flushing with recycled water was not legal in Colorado

Time to get to work

Rainwater

- Filed for a water right in water court
- Proposed 1:1 replacement to the river
- Received approval August 30, 2019

Recycled Water

- Legislation introduced to allow toilet flushing
- Regulation 84 updated
- CO adopted risk-based, log-reduction criteria proposed by NBRC

Colorado Log Removal Targets for Localized (onsite) Water Reuse

	Enteric Viruses	Parasitic Protozoa	Enteric Bacteria
Category 1 (10^{-2})	6.0	N/A	N/A
Category 2 (10^{-2})	6.0	5.0	4.0
Category 3 (10^{-4})	8.5	7.0	6.0

Work Begins

- Obtained building permits
- Worked with the State to submit plans for review and approval (no official processes in place yet)
- Proceeded with initial work (concrete, underground piping, MSTU installation)


BNSF

But…Unexpected Hurdles!

- City field inspectors didn't get briefed on the project (whoa – what the heck is this!)
- City of Denver issued a wastewater stop work order
- City got comfortable, but…

Unexpected Hurdles!

- Regional wastewater district noticed something on the (already approved) drawings…
- Emergency overflow from combined treated water / rainwater storage tank to sanitary
- Had to separate storage and overflows

Current Status – Progress!

- Expected building occupancy late October / early November
- Commissioning of the onsite water reuse system will take several months
- At least one other onsite reuse project in development (Pikes Peak Visitor Center)


United Rentals


4" CRESLINE® PVC DWV
TU5300 sc

Lessons Learned

- Model regulations developed by NBRC were incredibly helpful to Colorado
- There is SO MUCH to do after regulations in place!
- Independent utilities in Colorado are making this more challenging
- Need to communicate with and train field teams
- We have a ways to go…

Thank You

Brian Good
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