United States Environmental Protection Agency

Office of Research and Development

Free Water Research Webinar Series

Safe and Sustainable Water Resources Research Program

October 31, 2018 from 2:00-3:30 pm ET

Water Reuse and Reclaimed Water:

Onsite Non-Potable Water Reuse with Expert Panel Discussion

A certificate of attendance will be provided for attending this webinar

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Webinar Summary

The reuse of alternative water sources (e.g., graywater, stormwater, roof runoff) within single buildings or urban districts for non-potable purposes such as toilet flushing or landscape irrigation is gaining popularity across the country.

A group of public utilities and health agencies seeking uniform guidance on treatment requirements and monitoring approaches has recently released a Guidebook for Developing and Implementing Regulations for Onsite Non-potable Water Systems. This presentation will provide the technical basis to understand the risk-based approach emphasized within the guidebook.

The rationale and nature of quantitative microbial risks assessment models used to generate treatment targets within the Guidebook for Developing and Implementing Regulations for Onsite Non-potable Water Systems will be presented, as well as how the targets are used to develop and permit treatment systems.

Best approaches for effective monitoring of the systems to ensure safe operation will be discussed, emphasizing the linkage of the most recent advancements in microbiology with simple, on-line sensors. In addition, approaches for monitoring treatment performance for pathogen removal will be discussed, emphasizing the limitation of traditional fecal indicators and the potential use of more commonly occurring and abundant microorganisms as process indicators.

Photo credit: San Francisco Public Utilities Commission

EPA

EPA Presenter

Jay L. Garland, Ph.D. | Contact: garland.jay@epa.gov

Jay joined EPA in 2011 as a Division Director within the Office of Research and Development. He received a Ph.D. in Environment Science from the University of Virginia, and spent over 20 years working on NASA's efforts to develop closed, bioregenerative life support systems for extended human spaceflight. NASA recognized him for creative technology innovation on four separate occasions. Jay has authored over 100 scientific papers on a range of topics, including methods for microbial community analysis, factors affecting survival of human associated pathogens, and various biological approaches for recycling wastes. He has completed visiting fellowships and professorships at the Institute for Environment Sciences in Japan, the University of Innsbruck in Austria, and the University of Buenos Aires in Argentina. Jay is currently serving on the National Blue Ribbon Commission for Onsite Non-potable Water Systems.

Collaborators

EPA-ORD: Nichole Brinkman, Michael Jahne, Scott Keely, Emily Anneken, Jennifer Cashdollar, Ardra Morgan, Michael Nye, Brian Zimmerman, Brian Crone, Cissy Ma

EPA Region 9: Matt Small, Charlotte Ely, Eugenia McNaughton, Andrew Lincoff, Jack Berges, Kate Pinkerton, Jennifer Siu, Peter Husby, Amy Wagner, Kevin Ryan, Erica Yelensky, Valentino Stagno-Cabrera

Soller Environmental: Mary Schoen

National Blue Ribbon Commission for Onsite Non-potable Water Systems: Paula Kehoe and the entire NBRC

Colorado State University: Sybil Sharvelle, Susan De Long

ERG: Sarah Cashman, Ben Morelli, Sam Arden

San Francisco Public Utilities Commission: Marsha Sukardi, Taylor Chang, Darrell Anderson, Maurice Harper Nicholas Ashbolt, University of Alberta

SUNY Albany: Xiaobo Xue

Disclaimer

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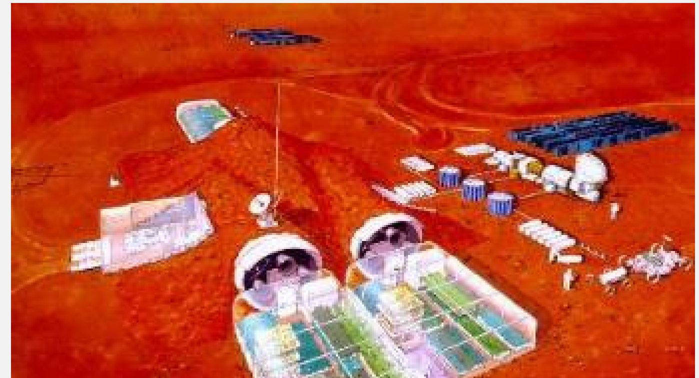
My Extraterrestrial Background



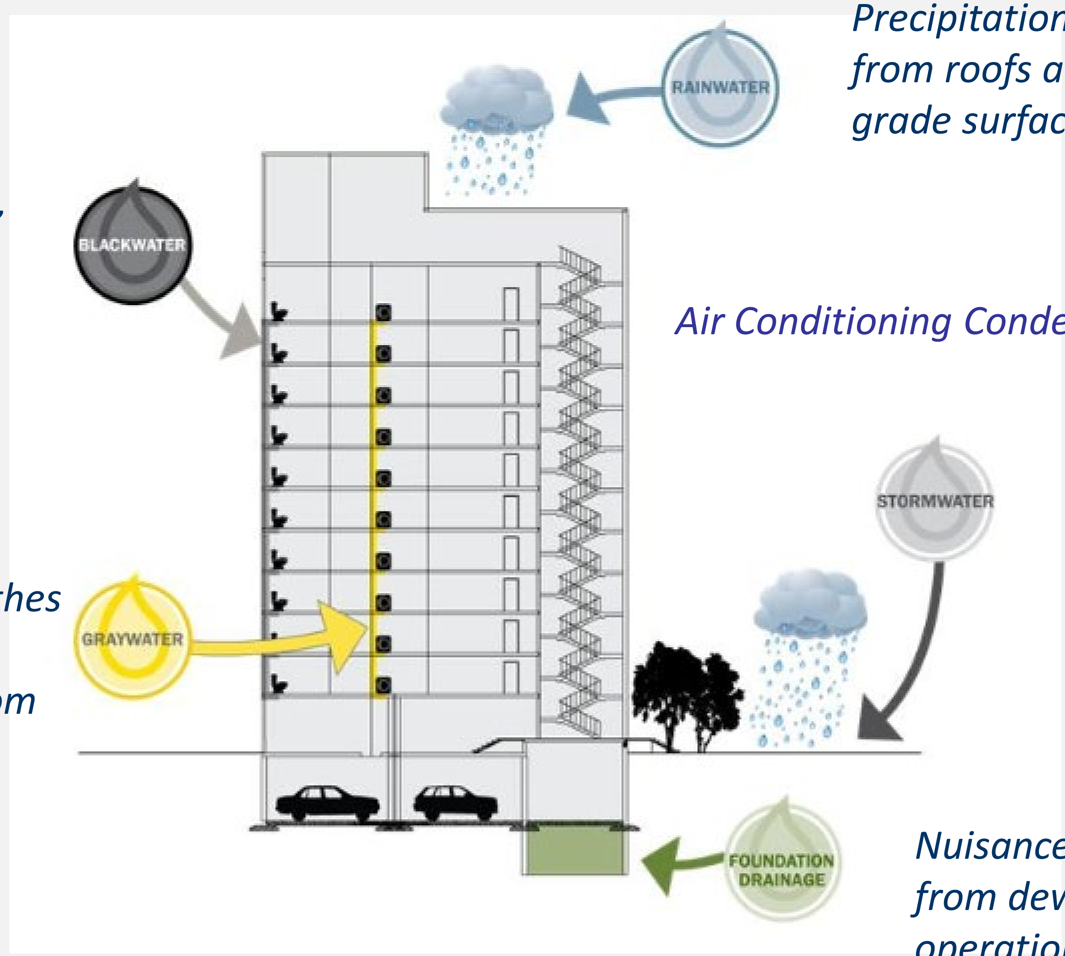
"If we knew how to live on Mars, we'd know how to reduce our footprint on Earth. Space colonization is the Rosetta stone for earthly sustainability because it's entirely about living in the absence of ecosystem services. The Moon, Mars and the asteroids are a great experimental laboratory that we're ignoring at our own peril."

Karl Schroeder

Buildings Produce Water

Precipitation collected from roofs and above-grade surfaces

Wastewater from toilets, dishwashers, kitchen sinks, and utility sinks



Air Conditioning Condensate

Precipitation collected at or below grade

Wastewater from clothes washers, bathtubs, showers, and bathroom sinks

Nuisance groundwater from dewatering operations

Reuse is not new…….

Grand Canyon Village instituted non-potable reuse of treated wastewater for toilet flush, power generation, and makeup for steam locomotives in 1926.

The Solaire: Battery Park, NYC

Produces: 25,000 gallons per day (gpd) of wastewater

Utilizes: Membrane bioreactor (MBR) treatment

Application: Toilet flushing, cooling, irrigation

Operating: Since 2004

Primary Driver: Reduced wastewater flow

San Francisco Public Utilities Headquarters

Rainwater Harvesting System

- 25,000 gallon cistern
- Reuse for irrigation

Wetland Treatment System

- Collects and treats building's wastewater
- Reuse for toilet flushing
- 5,000 gpd capacity

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181 Fremont San Francisco

706,000 sf mixed-use building

5,000 gpd graywater treatment

Membrane bioreactor system

Estimated commissioning: Late 2018

Drivers:

- Sustainability goals
- LEED

Salesforce Tower: San Francisco, CA

1.6 million ft^2 office building

Utilizes: MBR blackwater system for up to 30,000 gpd

Application: Toilet flushing, irrigation, and cooling

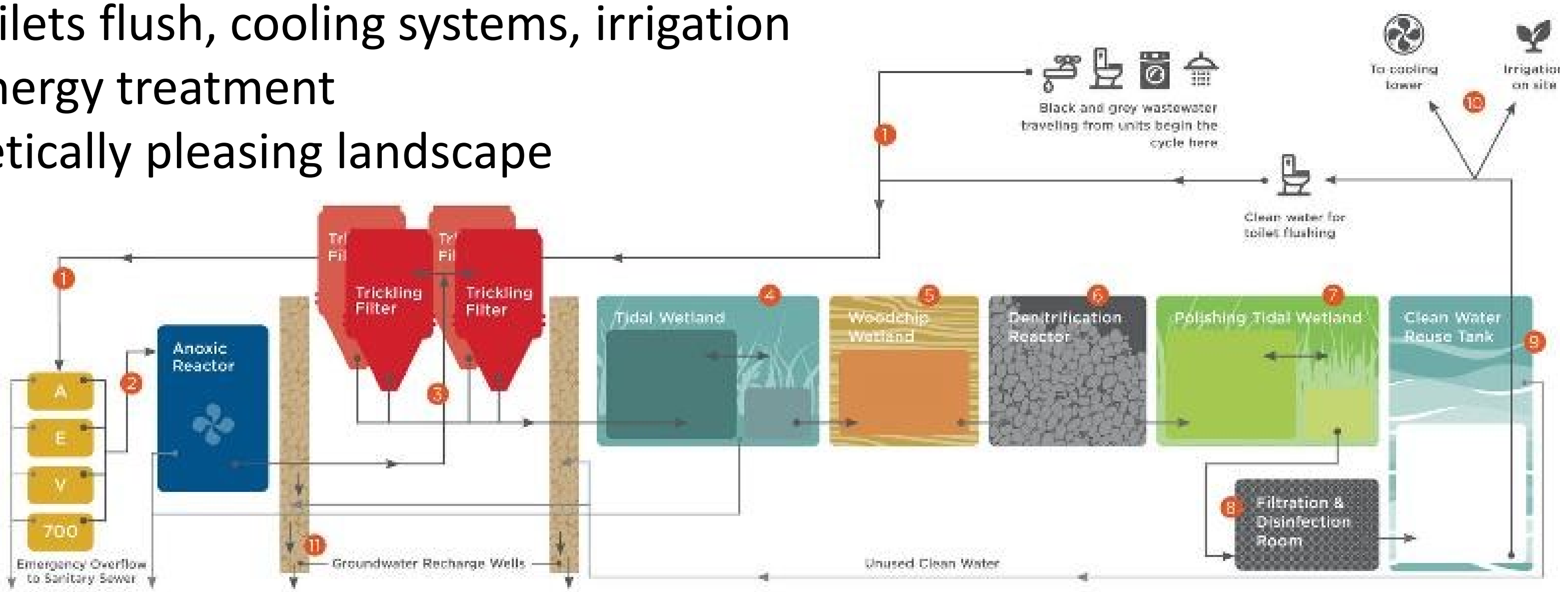
Estimated commissioning: Early 2019

Drivers:

- Sustainability goals
- LEED certification
- Utilize existing dual-plumbing

Hassalo on Eighth Portland, Oregon

- 60,000 gallons of wastewater per day
  - toilets flush, cooling systems, irrigation
- Low energy treatment
- Aesthetically pleasing landscape



Lake Vermilion State Park, Minnesota

Details: Shower building at Minnesota's newest state park

Utilizes: Graywater from showers and sinks

Application: Toilet Flushing (135,000 gallons per season)

Drivers:

- Limited drinking water due to naturally occurring arsenic

Also innovative stormwater (and melted snow) system associated with transit hub at Target field (>1 million gallons used in a local energy recovery center.

Innovation in Urban Water Systems

San Francisco • May 2014

- State-based initiative, led by San Francisco Public Utilities Commission (SFPUC)
- Public utilities and health agencies participating
- Nationwide representation

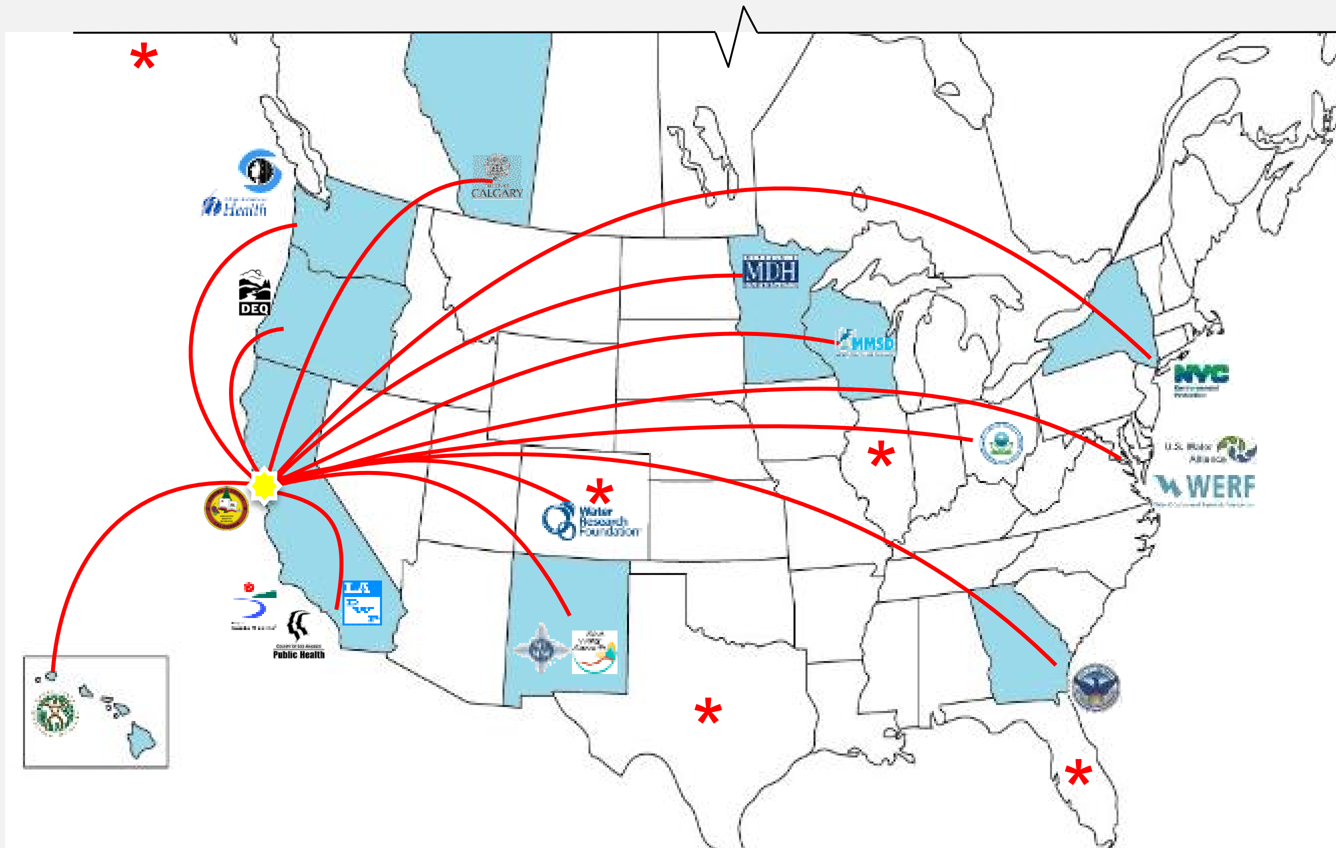
National Blue Ribbon Commission for Onsite Non-potable Water Systems

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

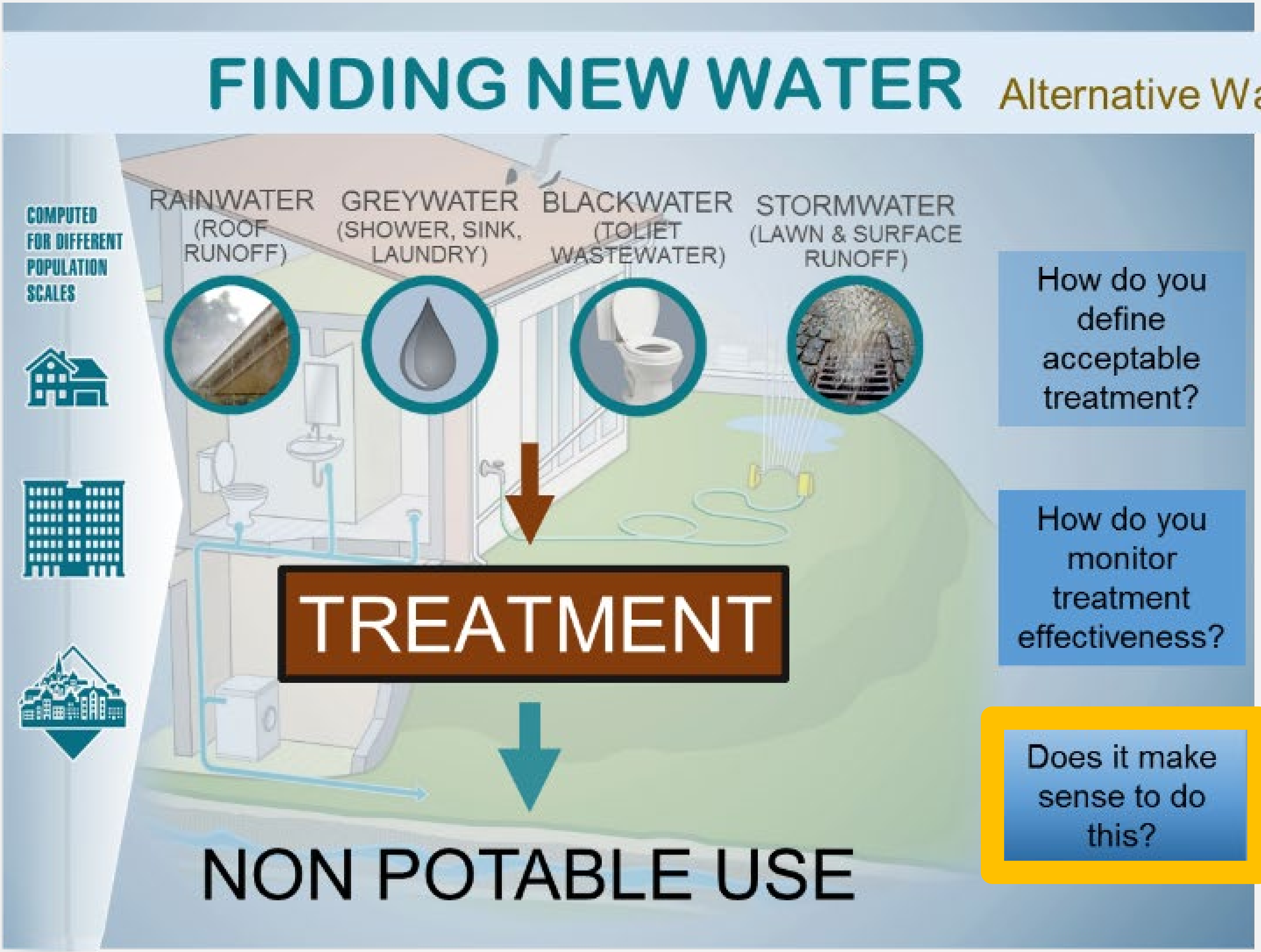
Key Needs Identified

- Local management programs are needed.
- Water quality parameters and monitoring are needed to protect public health.

US Water Alliance



First Challenge



Partners

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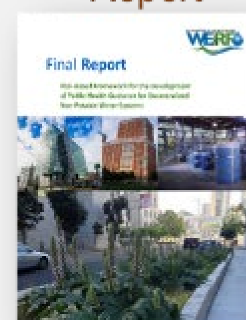
National Blue Ribbon Commission for Onsite Non-potable Water Systems

WATER ENVIRONMENT + REUSE FOUNDATION WE&RF

US Water Alliance

Report



It's complicated, lots of drivers . . .

Potential Benefits of Reuse

- **Water scarcity** (finding more water)
- **Efficiency**
  - Treating water only as needed for its end use application (fit-for purpose)
  - Reusing water close to the source, avoiding construction of recycled water pipeline
  - Defers capital costs of large-scale infrastructure
- **Reduces pollution and loading** to sewers and water bodies
- **Increases resiliency and adaptability** of our water and wastewater infrastructure
- Generates **green space** in urban corridors
- Meets and exceeds **green building goals**

Addressing the Question: What are the Life Cycle Costs/Impacts?

Analyzing Scenarios to determine "Is it worth it?"

Example Scenario:

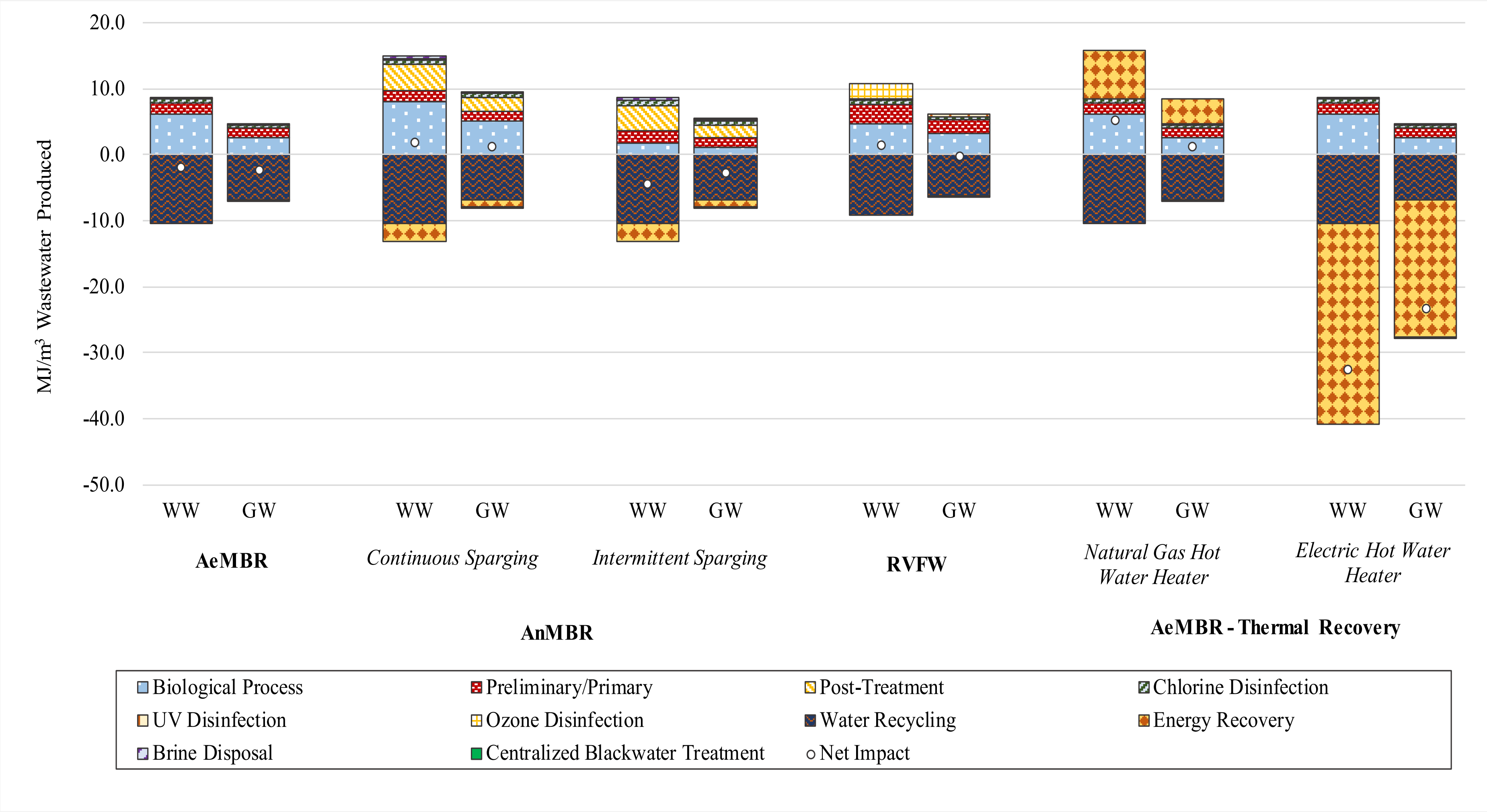
- **Details:** 19 story, 20,000 ft^2, mixed use, 1000 occupant building, ~25,000 gpd wastewater

- **Options**: Compare combined wastewater (WW) vs. source-separated greywater (GW)

Alternative treatment approaches:

- Aerobic (AeMBR) vs. Anaerobic MBR (AnMBR)
- Vertical Flow Wetland
- Heat recovery

Results: Cumulative Energy Use Tradeoffs at the Building Scale



Net benefits in energy use for most options

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Results: Systems-Level Analysis Summary

- Net benefits if account for avoided drinking water impacts.
- Recovery of thermal energy can provide significant improvements.
- System level benefits of recovering chemical energy (via anaerobic membrane bioreactors) diminished by costs of removing reduced nitrogen from produced water.

Next Steps: System level impacts of using other water sources (roof collected rainwater, local stormwater, air conditioning condensate) as a function of different climates.

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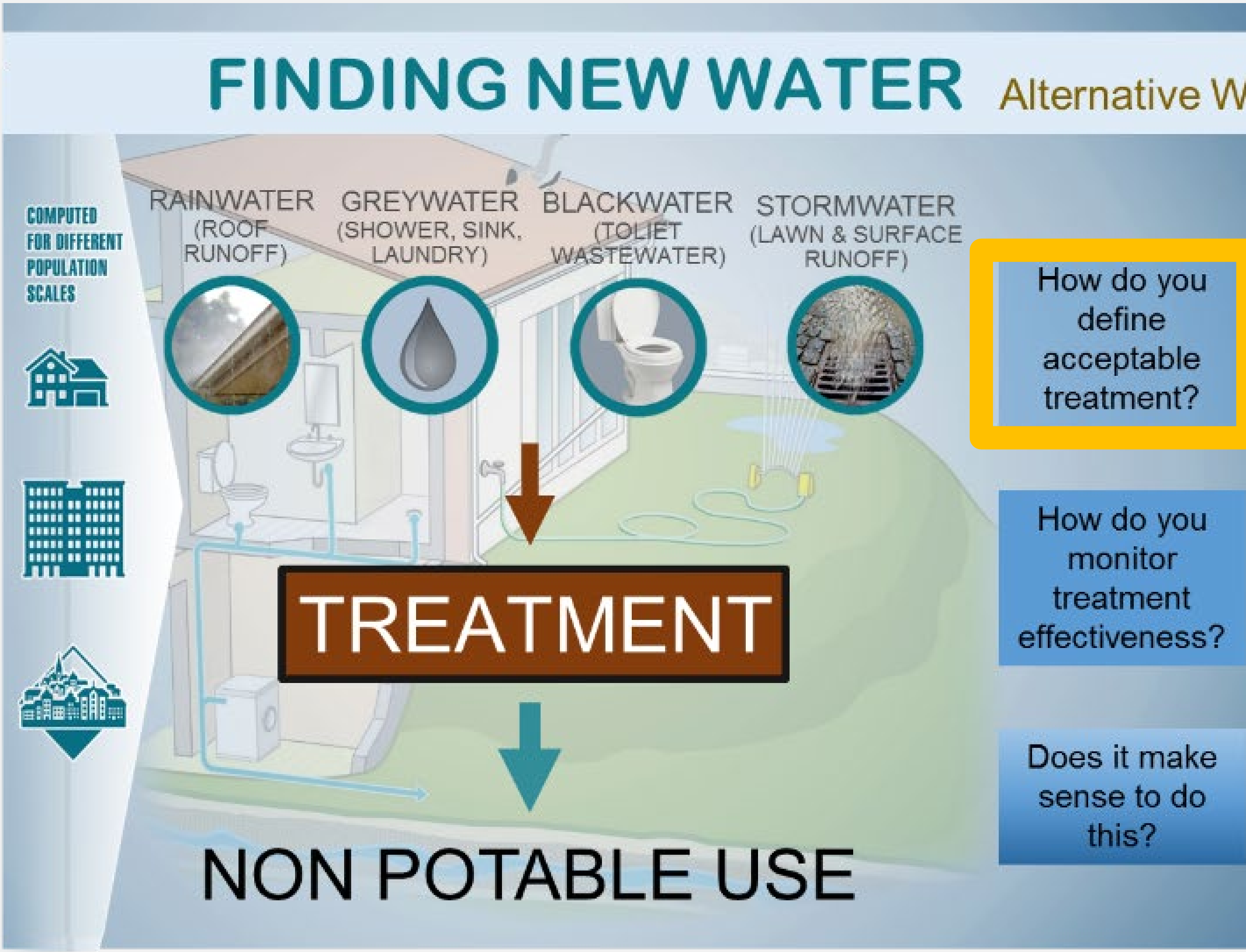
Second Challenge



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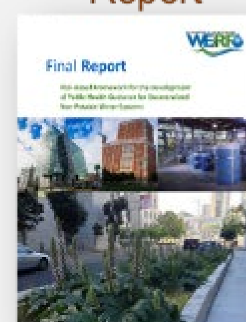
Water Environment & Reuse Foundation (WE&RF)

US Water Alliance

Report



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

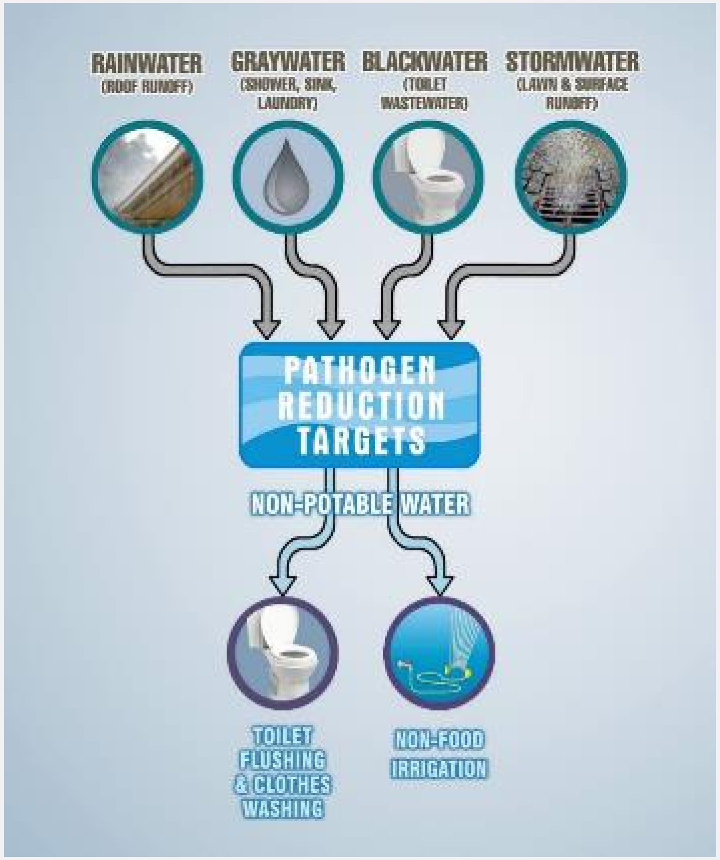
Standardization is an improvement, but not risk based.

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

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

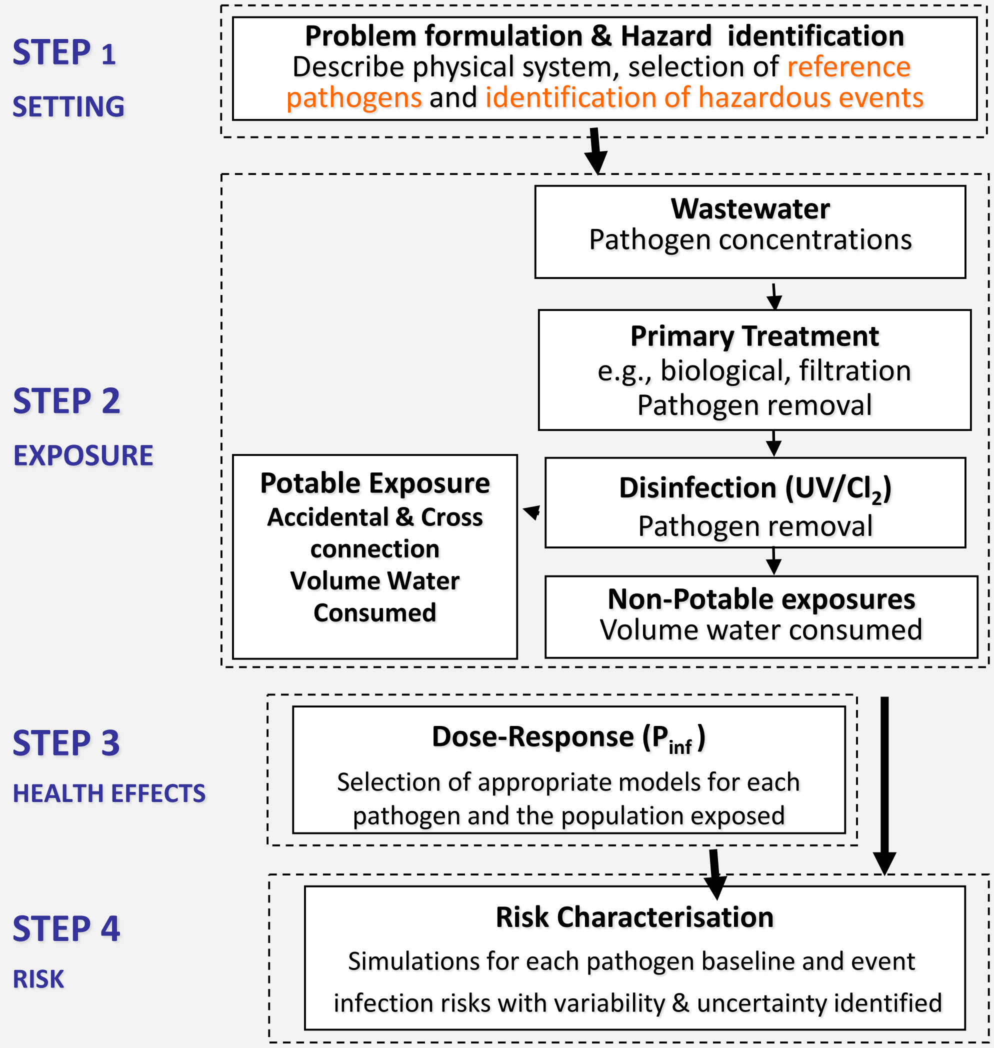
Quantitative Microbial Risk Assessment (QMRA)



QMRA process to

inform log reduction targets

Quantitative Microbial Risk Assessment (QMRA)



Reference Pathogens Needed

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

Viruses

Bacteria

Parasites/Protozoa

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 for roof runoff, stormwater, and greywater. Microbial Risk Analysis. 5, 32-43

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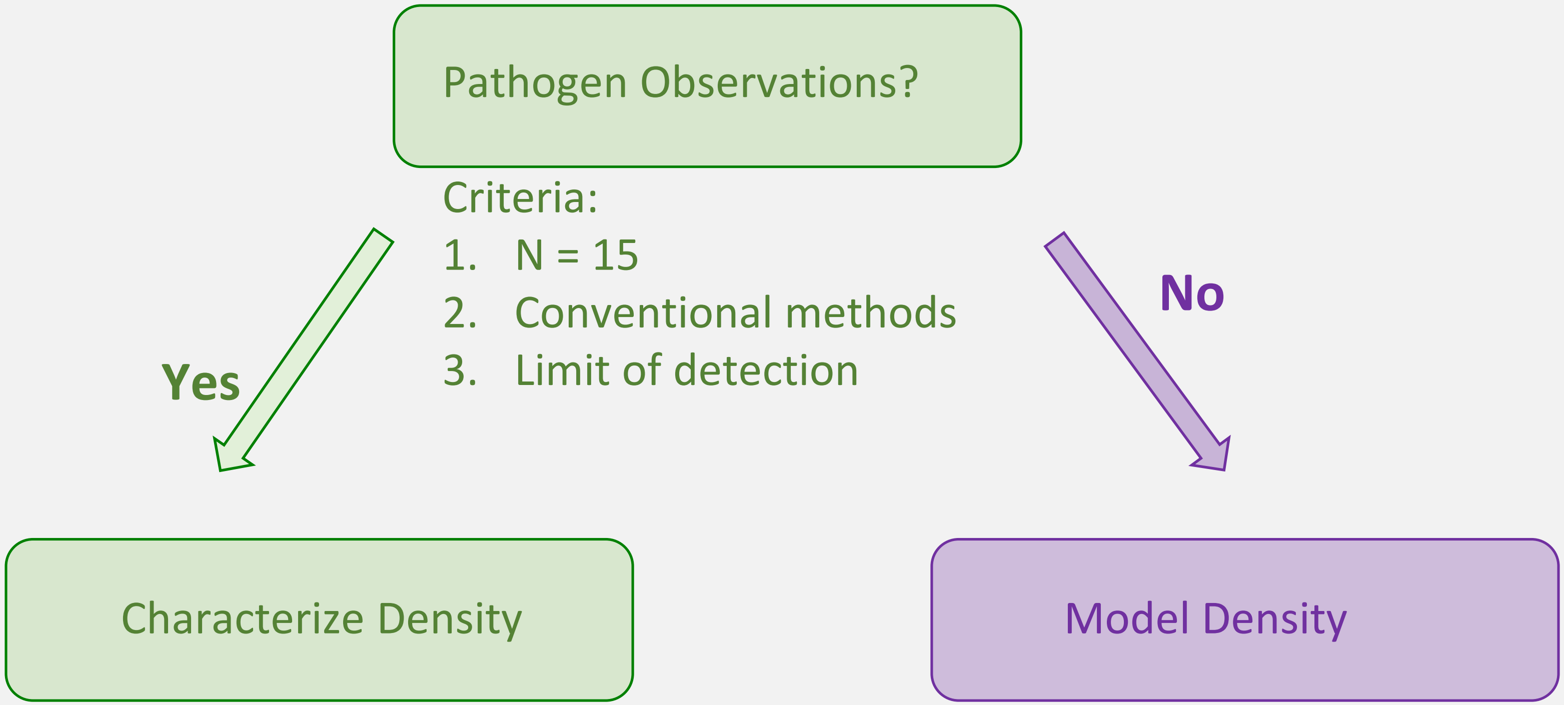
Critical First Step in Modeling: Estimating Initial Pathogen Density



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

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Epidemiology-Based Approach

Fecal contamination of water

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

Number of users shedding pathogens

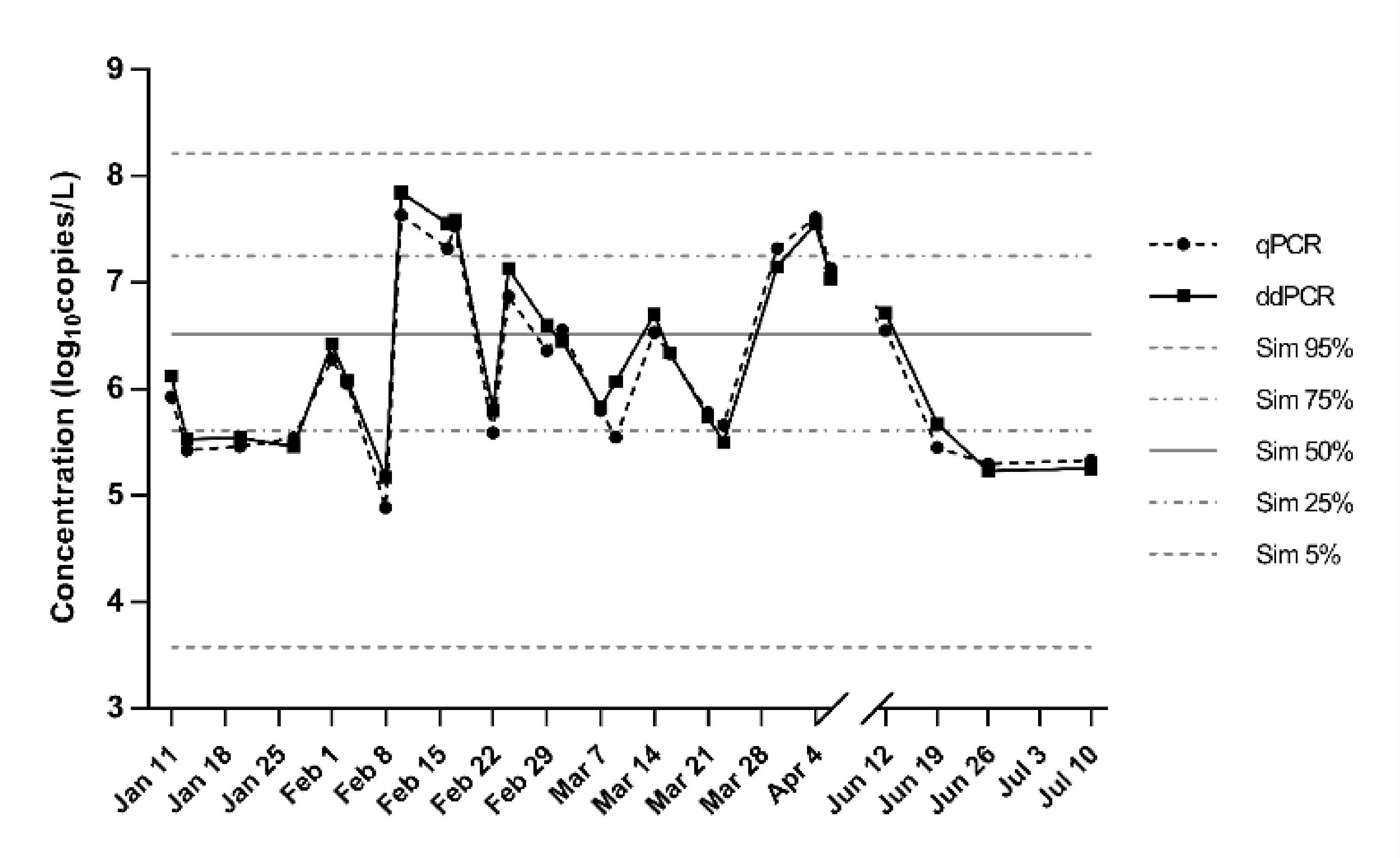
- Population size
- Infection rates
- Pathogen shedding durations

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

Result: Model Adequately Brackets Online Wastewater Measures from SFPUC Building



Jahne et al. (submitted)

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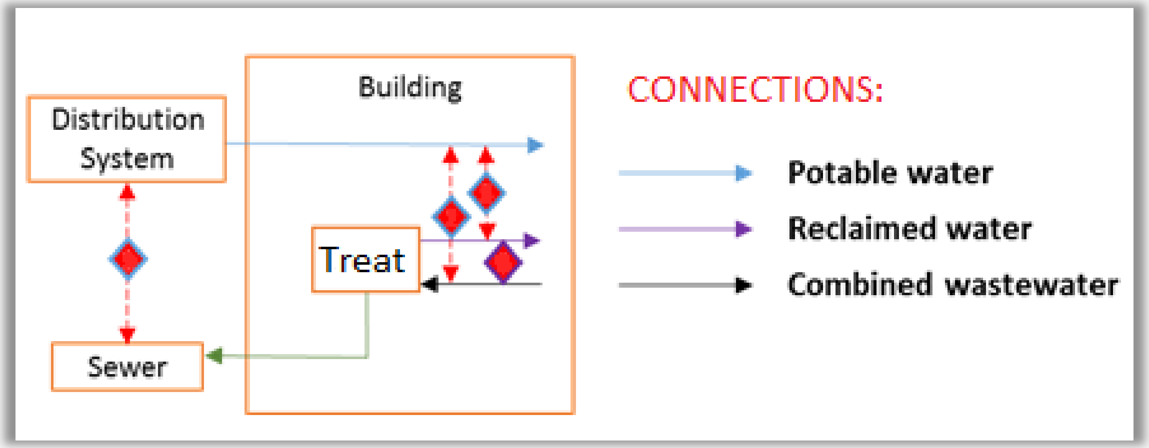
Ingestion Exposure Volumes

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).

Cross-Connection QMRA

- Two unique scenarios for non-potable water systems:
  - Contamination of potable water by reclaimed water
  - Contamination of reclaimed water by waste-/graywater
- Limited data available for these event types
  - What event durations, intrusion dilutions, and fractions of users exposed are considered "safe" (i.e. acceptable risk)?



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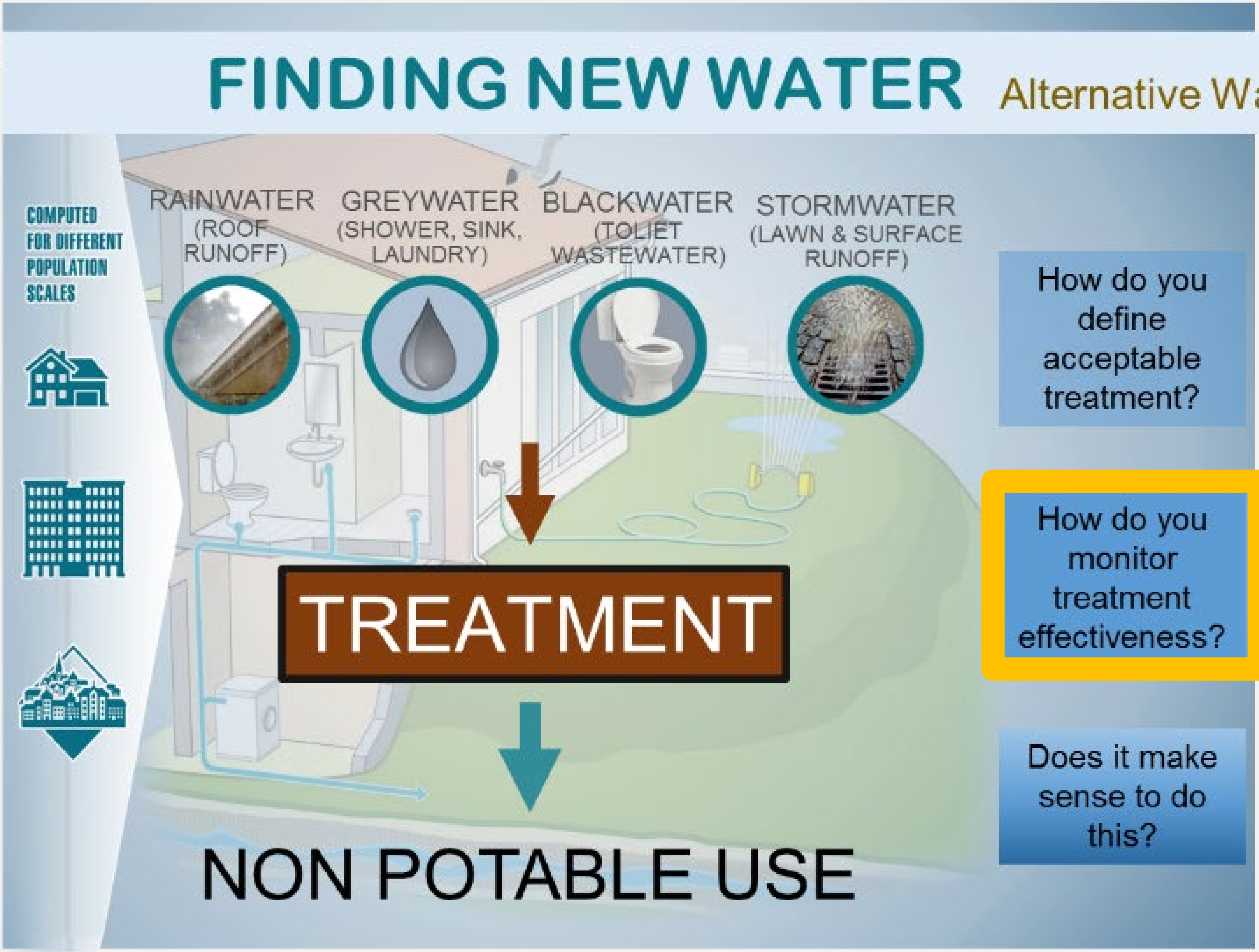
Cross-Connection QMRA - Results

- Generally low risks for short duration events (<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
- Non-potable LRTs already include built-in protection against limited cross-connections
  - <1 log decrease in LRTs if cross-connection is omitted
- Acceptable risk if (assuming LRTs met):
  - 0.01% exposed for 5-day undiluted wastewater to reclaimed
  - 0.1% exposed for 5-day undiluted reclaimed to potable

Schoen, Jahne, & Garland et al. 2018 Water 10(10):1352

Third Challenge



Partners

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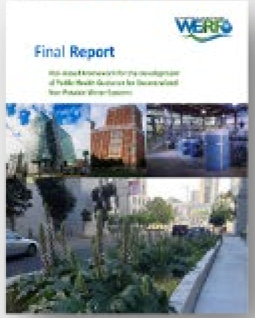
National Blue Ribbon Commission for Onsite Non-potable Water Systems

WATER ENVIRONMENT + REUSE FOUNDATION WE&RF

US Water Alliance

Report



Monitoring

- You design a system to meet the risk based performance targets
  - A treatment train with multiple barriers with sufficient log reduction credits
- How do you verify performance?
- Routine monitoring of indicator organisms does not provide real time, risk-based information required for operation of non-potable reuse systems
- Proposed monitoring approach
  - Operational Monitoring
    - Ongoing verification of system performance
    - Continuous observations
    - Surrogate parameters correlated with LRTs
  - Start-up and Commissioning
    - Validation monitoring
  - Controls for out of specification
    - "Revalidation"

EPA United States Environmental Protection Agency

But What Biological Target?

- Measure pathogens
  - Hundreds of potential pathogens
  - Sporadic occurrence
  - Can be expensive
  - Negative results
- Measure biological surrogates that represent pathogens
  - Typical surrogates (fecal indicator organisms) too dilute
  - Spike with surrogate, calculate reduction
    - Challenge to spike large systems
  - *Endogenous microbes as alternative biological surrogates*

Research Strategy to Identify Endogenous Biological Surrogates

Age of the Microbiome

1. Discovery of endogenous biological surrogates
   - What microbes are present?
   - Community profiling using sequencing technologies

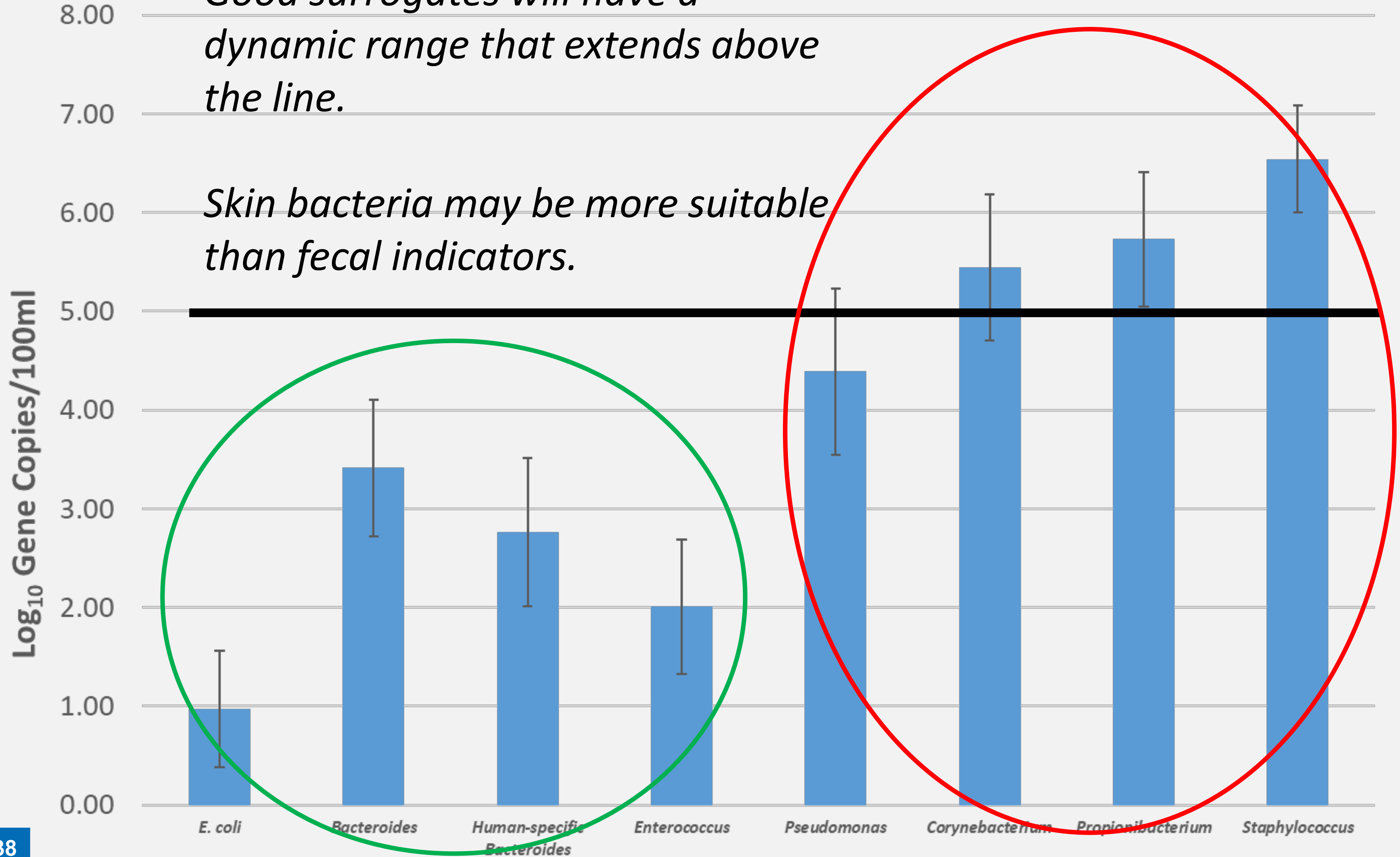
Quantify endogenous biological surrogates
   - How abundant are the candidate surrogates? Must be at or above LRT
   - Are candidate surrogates consistently present in influent?

Compare log reduction profiles of candidate surrogates and pathogens through treatment processes

Quantification of Candidate Bacterial Surrogates in Laundry Graywater

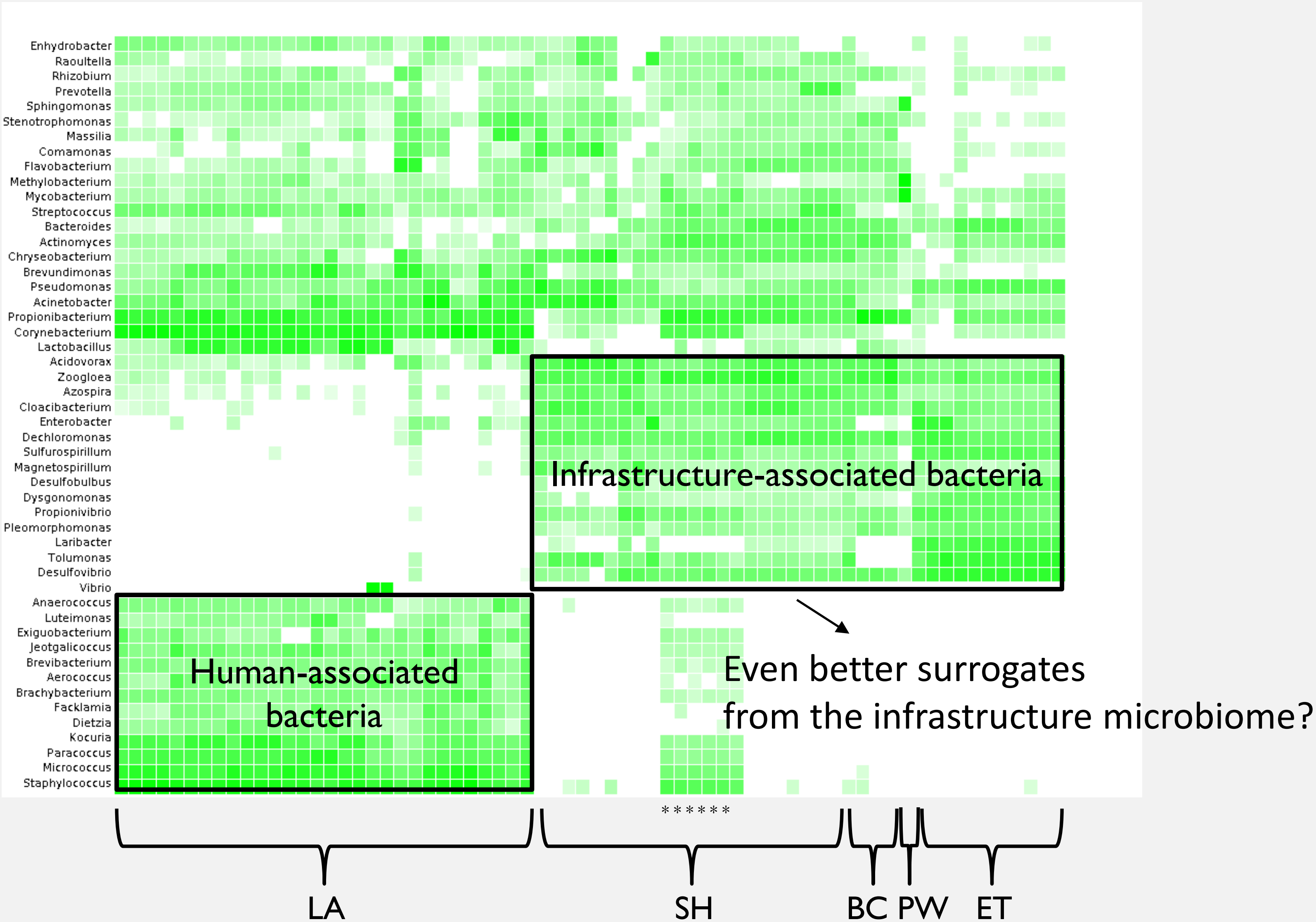
Good surrogates will have a dynamic range that extends above the line.

Skin bacteria may be more suitable than fecal indicators.



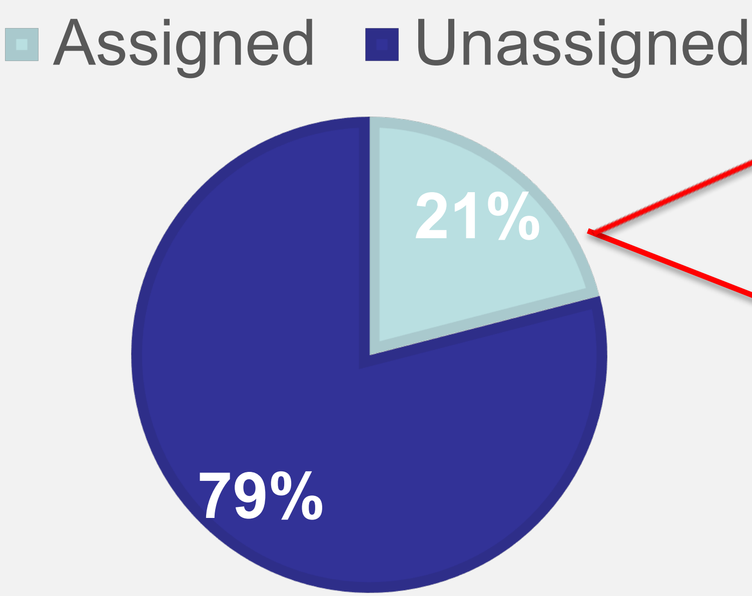
Zimmerman et al. 2014. *Environmental Science and Technology* 48, 7993

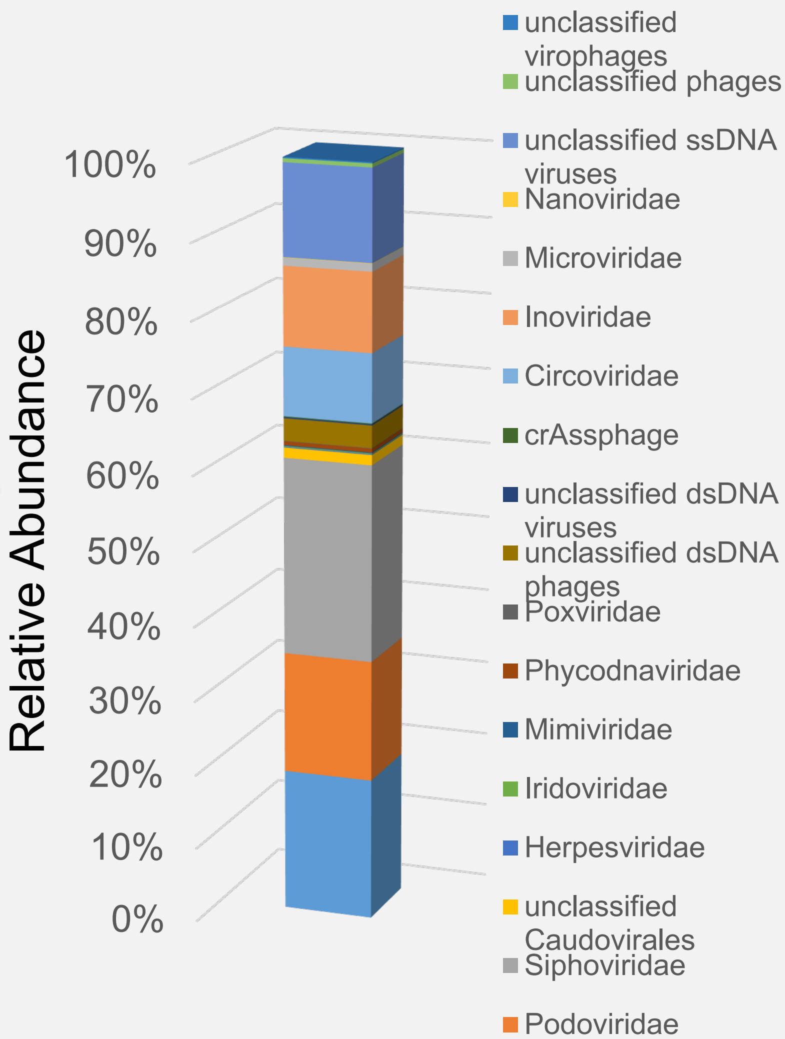
Analysis of "Graywater" Microbiome



Keely et al. 2015. *Journal of Applied Microbiology* 119: 289

Searching for Viral Surrogates



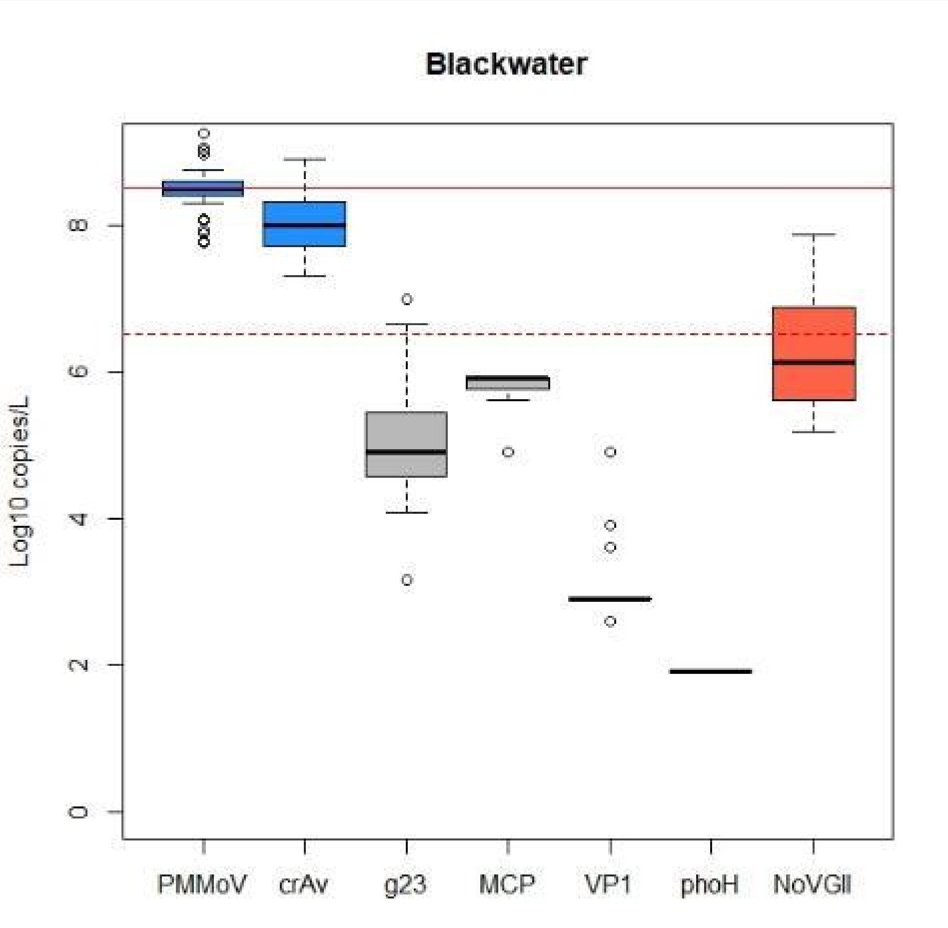


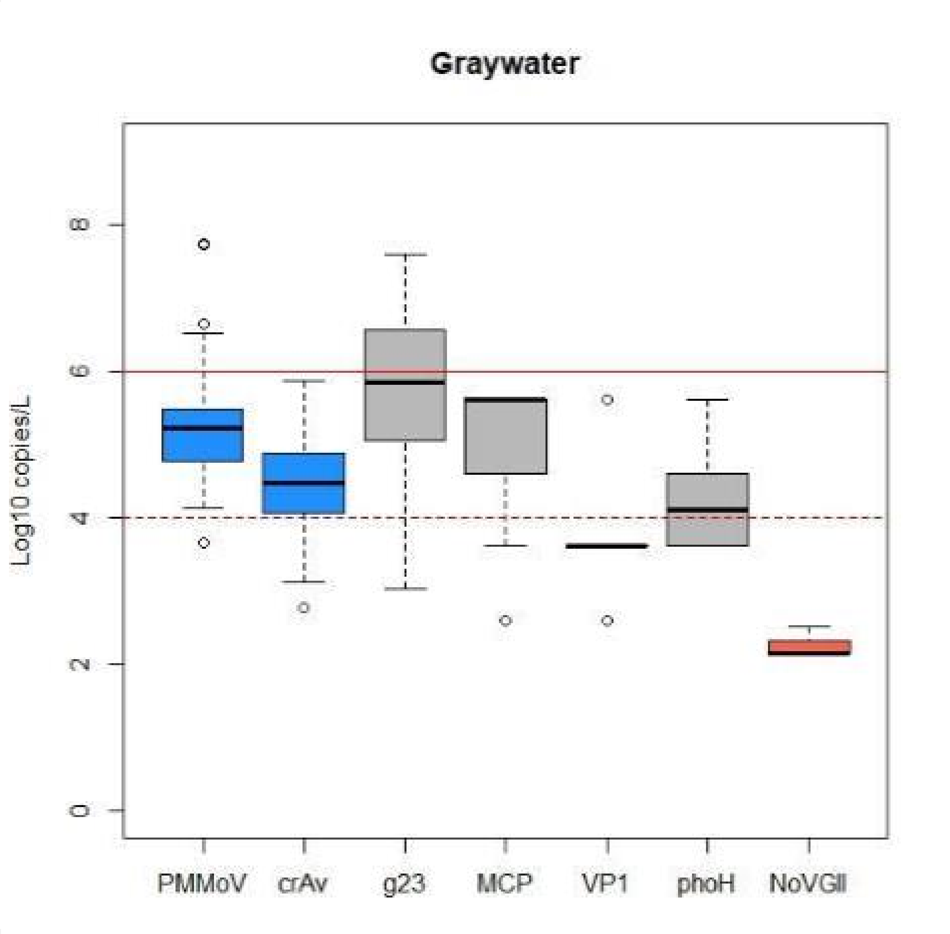
Brinkman et al. (2018) Plos One 12(4)

Candidate Viral Surrogates

Gene Target	Viral Group	Function
g23	*Myoviridae*, T4-type phages	Major capsid protein
MCP	*Microviridae, Gokushovirinae*	Major capsid protein
VP1	Broad	Major capsid protein
phoH	Broad; heterotrophic and autotrophic hosts	Phosphate starvation-inducible protein
PMMoV	Pepper Mild Mottle Virus	Coat protein; virus of hot, bell and ornamental pepper plants
crAv	crAssphage	Hypothetical protein

Viral Analysis in Onsite Wastewaters





Combination of ddPCR (PMMoV, crAV, g23 and NoV) and qPCR (MCP, VP1, phoH)
BW = 28 samples from SFPUC (NoV data shown previously)
GW = 50 samples (office building = 33, College dormitory =17)

Brinkman et al. (in prep)

Summary of Monitoring

- Framework emphasizes on-line monitoring to best protect public health.
- “Off-line” biological measurements for validation
  - Typical surrogates (fecal indicators) limited
    - Too dilute (or)
    - Wrong target
- Evaluation of the microbiome provides new surrogates.
  - Working on both bacteria and viruses
  - Produce new standard methods
  - Potentially on-line biological sensors

Impact

- **Immediate**
  - Log reduction targets incorporated to

    Guidebook for Developing and Implementing Regulations for Onsite Non-potable Water Systems, December 2017, providing public health agencies direct guidance on what treatment will ensure water can be recycled safely
- **On-going**
  - Improve QMRA models
    - Initial pathogen data (measurements & models)
      - Log reduction credits
  - Defining more effective biological targets for monitoring performance & developing associated standard methods
  - Comparing cost/benefits of different non-potable reuse approaches to inform design

Resources for Additional Information

Resources for Onsite Non-Potable Water Programs

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

  (All the documents produce 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

National Blue Ribbon Commission for Onsite Non-potable Water Systems

Dr. Jay Garland will lead this special panel discussion session with other members serving on the National Blue Ribbon Commission for Onsite Non-potable Water Systems. The Commission is comprised of 30 representatives from municipalities, public health agencies, water utilities, and national organizations who are leading the industry in onsite non-potable water systems. The panelists will discuss best management practices to support the use of onsite non-potable water systems within individual buildings or at the local scale, and will interact with attendees to answer questions.

National Blue Ribbon Commission for Onsite Non-potable Water Systems

Panel Discussion

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Panelist

Paula Kehoe (NBRC Chair) | Contact: pkehoe@sfwater.org

Director of Water Resources, San Francisco Public Utilities Commission

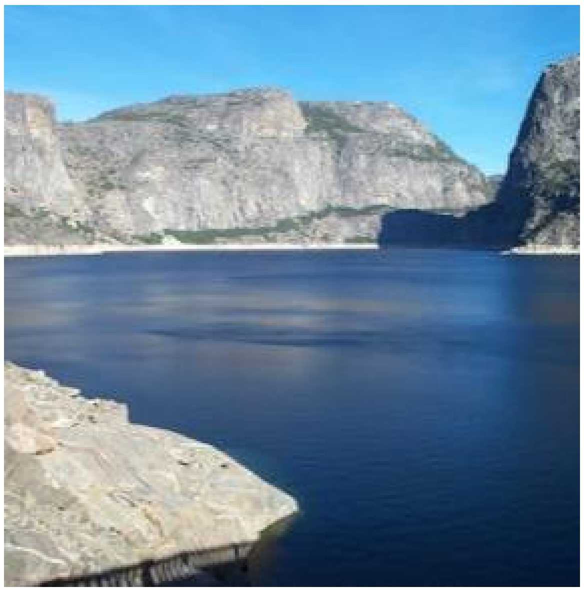
Paula is the Director of Water Resources for the San Francisco Public Utilities Commission (SFPUC). She is responsible for diversifying San Francisco's local water supply portfolio through the development and implementation of conservation, groundwater, and recycled water programs. Paula spearheaded the landmark legislation allowing for the collection, treatment, and use of alternate water sources in buildings and districts within San Francisco. Previously, she worked as the Assistant to the General Manager of the SFPUC and supported the utility's $4.8 billion capital improvement program designed to rebuild and repair the third largest water delivery system in California. As Public Education Director for the SFPUC's Water Pollution Prevention Program, Paula received six state and national awards. Paula holds a Bachelor of Arts from the University of Colorado, Boulder and a Master of Science from the University of San Francisco.

Water Reuse
in Urban Environments

Paula Kehoe
San Francisco Public Utilities Commission

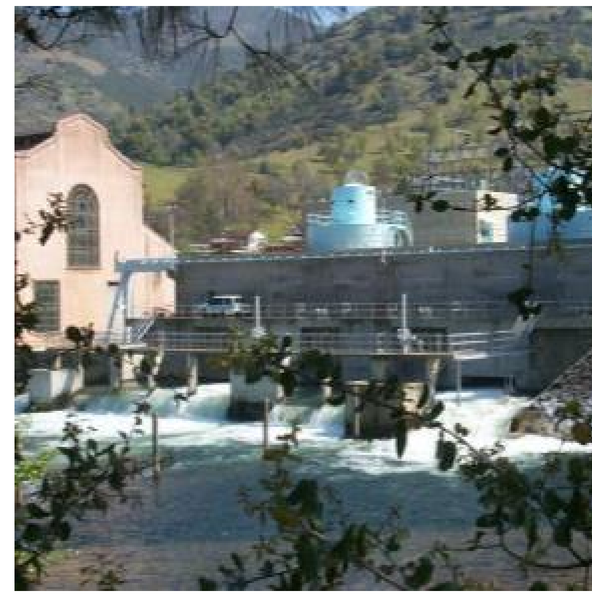
EPA Water Reuse and Reclaimed Water Webinar
October 31, 2018

San Francisco Public Utilities Commission



Water: delivering high quality water every day to 2.7 million people

Wastewater: protecting public health and the environment

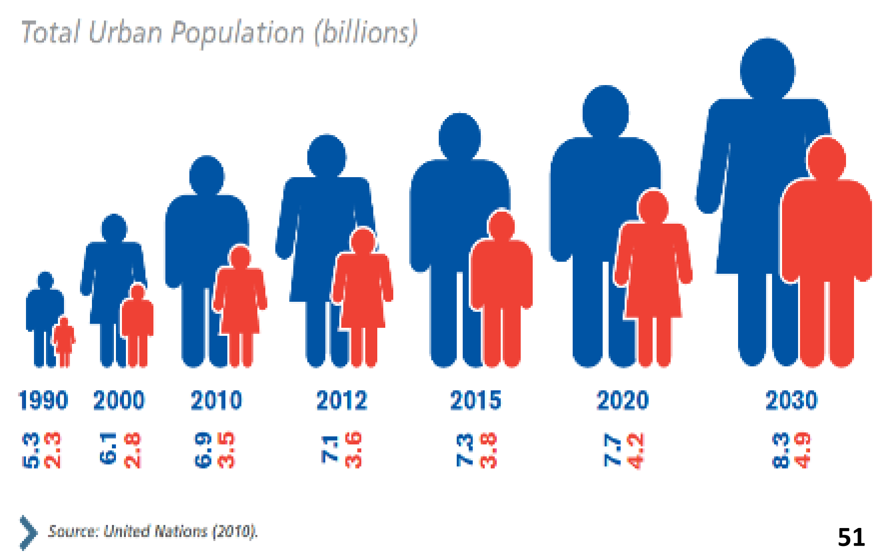


Power: generating clean energy for vital City services

San Francisco Water Power Sewer

Water Delivery 24 hours/7 Days a Week is Not an Easy Task

Sources: National Geographic, 2010, 2011; Reuters, 2006.



Upgrades, Diversification, and OneWaterSF

HETCH HETCHY
+ LOCAL WATER
Better together.

San Francisco
Water
Power
Sewer

Innovative Onsite Non-potable Water Use at SFPUC Headquarters

SF Ordinance Provides Oversight and Management

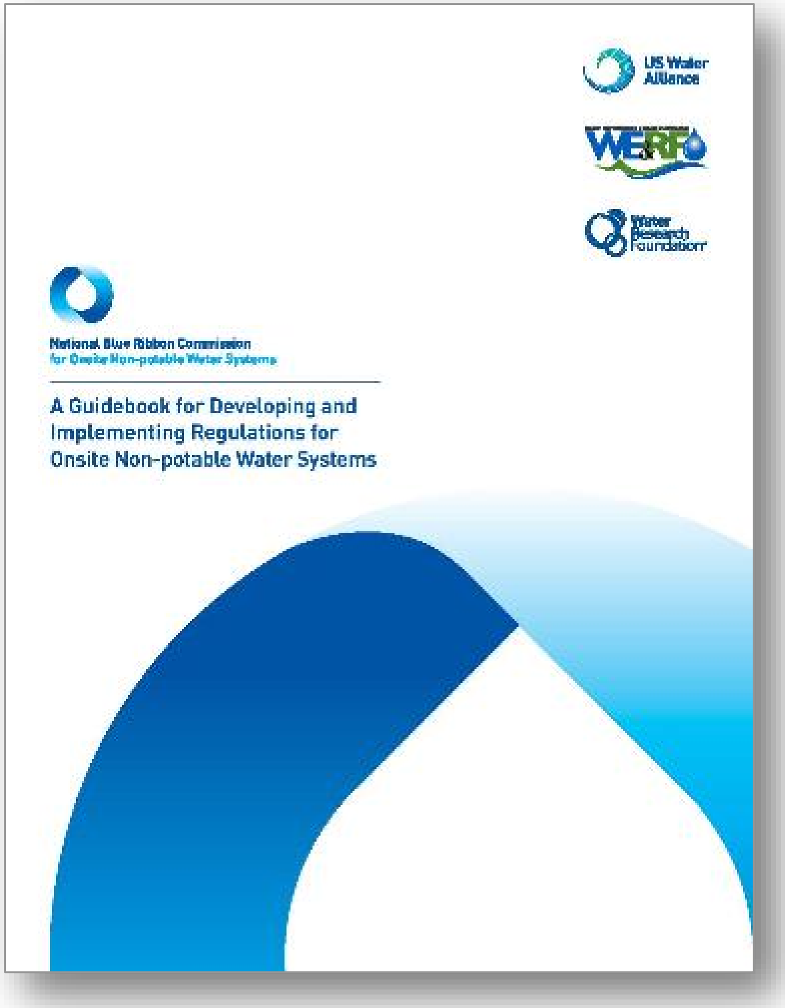
SFPUC	SFDPH	SFDBI	SFPW
Program Administration and Cross-Connection Control	Public Health	Construction	Right of Way and Mapping
Review onsite non-potable water supplies & demands Administer citywide project tracking & annual potable offset achieved Provide technical support & outreach to developers Manages Cross-Connection Control Program	Issue water quality & monitoring requirements Review and approve non-potable engineering report Issue permit to operate onsite systems Review water quality reporting	Conduct Plumbing Plan check and issue Plumbing Permit Inspect and approve system installations	Issue Encroachment Permits as needed for infrastructure in the Right-of-Way (if needed) Includes condition on a subdivision map or a parcel map requiring compliance with the Non-potable Ordinance prior to approval and issuance of said map (if applicable)

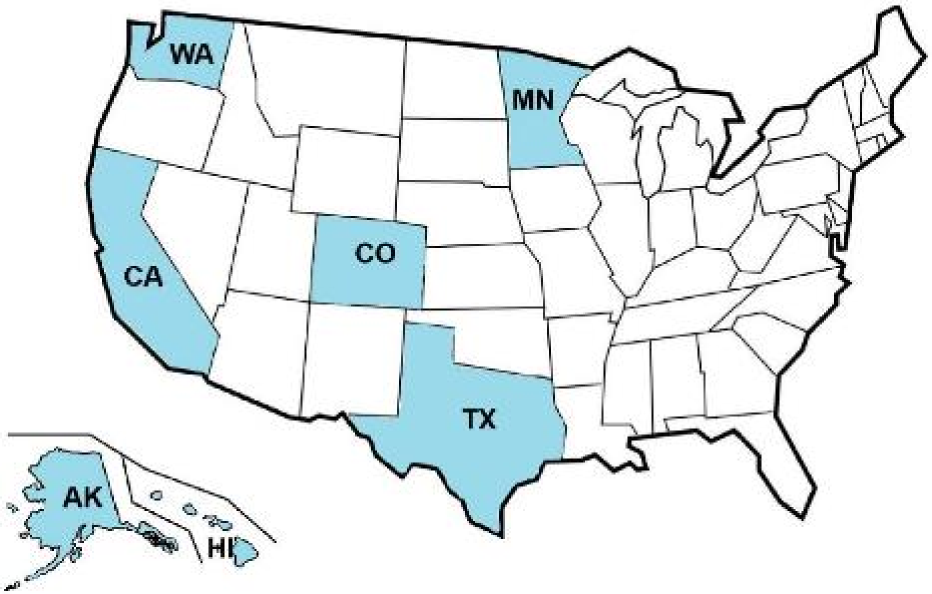
San Francisco Water Power Sewer

Innovative Water Use in Urban Environment

National Blue Ribbon Commission for Onsite Non-potable Water Systems

California and Others Moving Forward with Risk Based Approach





Adapt and Reimagine Our Water Systems

THANK YOU

sfwater.org/np

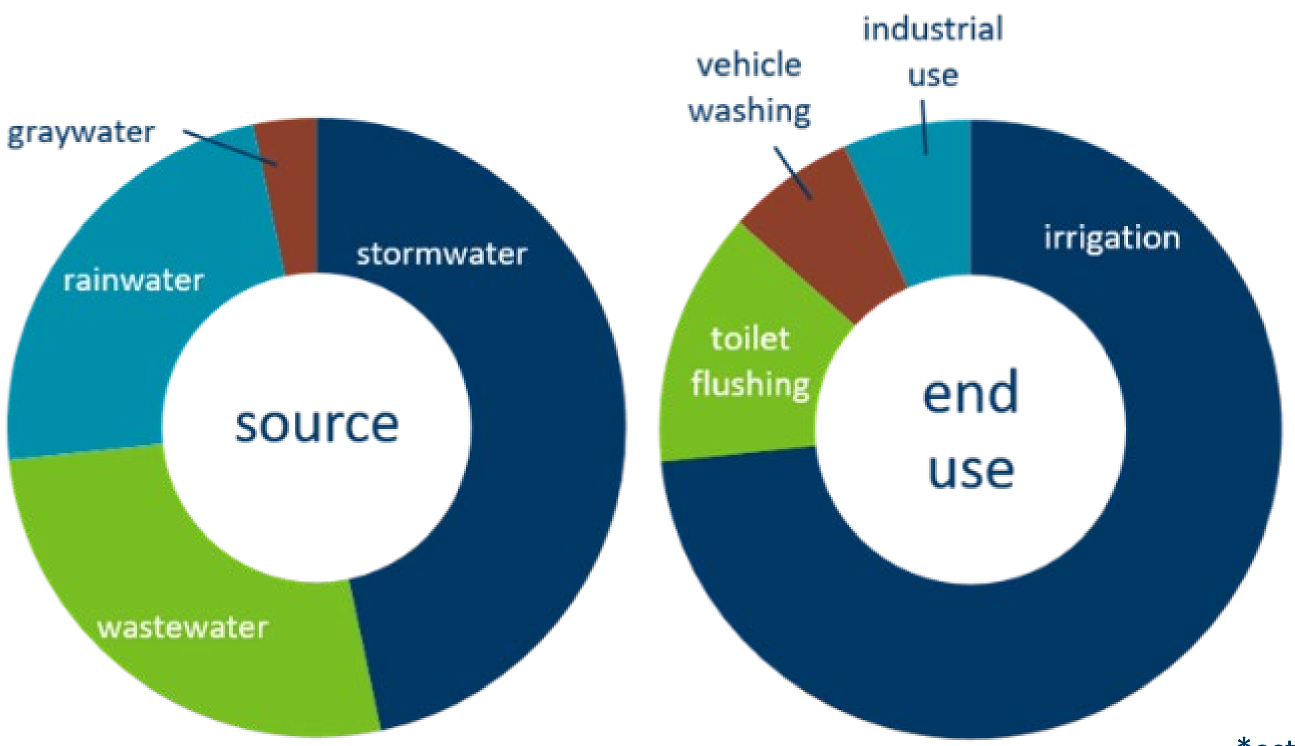
Panelist

Anita Anderson | Contact: anita.c.anderson@state.mn.us

Principal Engineer, Minnesota Department of Health

Anita has 20 years of experience as a water supply engineer with the Minnesota Department of Health. Her primary area of expertise is surface water treatment, specializing in small systems. Currently she is working on special projects to implement water reuse in Minnesota in a safe and sustainable way and to predict the vulnerability of groundwater drinking water sources to microbial pathogens. She holds a Master's degree in Environmental Engineering from the University of Minnesota and is a registered professional engineer in Minnesota.

WATER REUSE IS HAPPENING IN MINNESOTA



*estimations

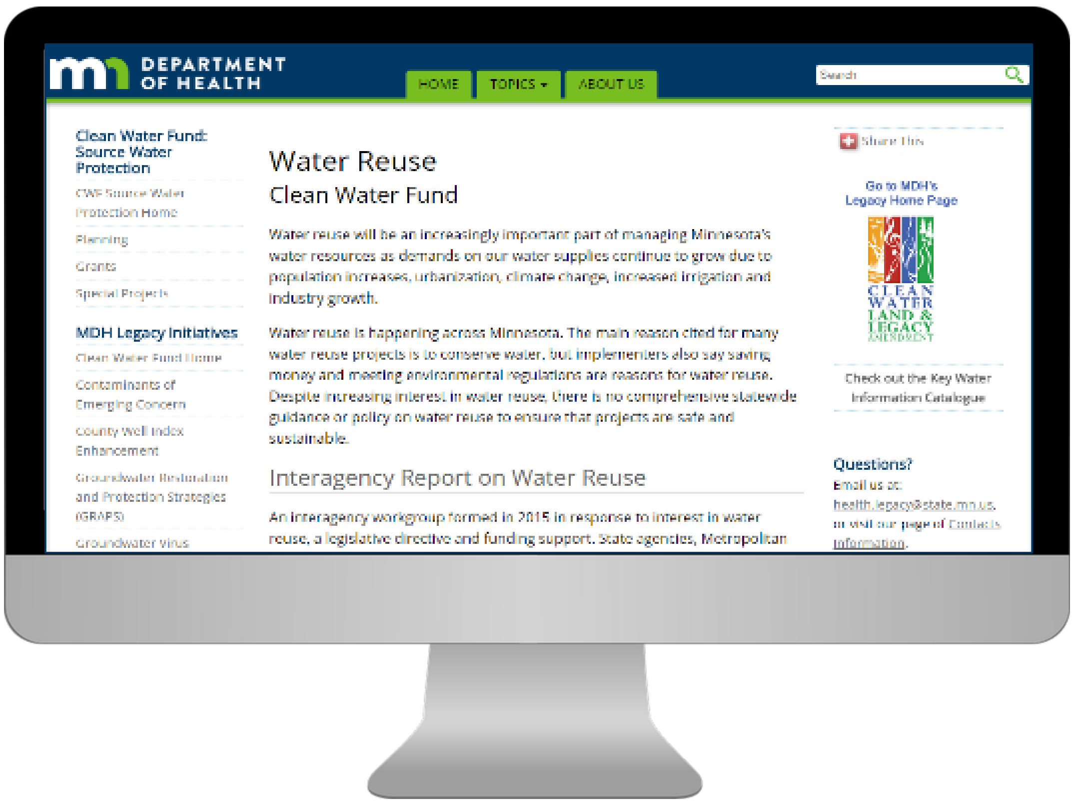
COLLABORATIVE EFFORT

- **Dates:** January 2016 - January 2018
- **Workgroup meetings (19):** Six Minnesota state agencies, Met Council, and University of MN water resources center
- **Stakeholders meetings (4)**: local governments, non-governmental organizations, businesses, cities, industries, engineers
- **Final report**: released March 2018

EIGHT RECOMMENDATIONS

a	Create an expanded workgroup with practitioners, advisors and stakeholders
b	Prioritize research needs and integrate ongoing research
c	Define roles and responsibilities
d	Establish an information and collaboration hub on the web
e	Develop a risk-based management system
f	Develop water quality criteria for a variety of reuse systems based on the log reduction target approach for pathogens
g	Resolve unique issues related to graywater reuse
h	Provide education and training

WEBSITE



- Report + info sheet + GovDelivery
- www.health.state.mn.us /waterreuse

Panelist

Stephen Deem | Contact: Steve.Deem@DOH.WA.GOV

Regional Engineer, Washington State Department of Health

Steve is a professional engineer representing the Washington State Department of Health drinking water program. Deem is also a consultant for Water 1st International, a non-profit water and sanitation development organization. His more than 25 years of experience in water and sanitation issues encompasses a myriad of settings–from the Kurdish refugee camps in Northern Iraq to post-war rehabilitation in Bosnia and Herzegovina, and from simple pipe networks in the slums of Dhaka, Bangladesh, to research efforts on ultraviolet disinfection with the Water Research Foundation. He received his Master of Science degree in environmental engineering from the University of Washington in Seattle and his Bachelor of Science degree in civil engineering from Marquette University.

Washington State Update

Washington State Department of Health

Water Reuse and Reclaimed Water Webinar 2018

https://www.doh.wa.gov/CommunityandEnvironment/WastewaterManagement/WaterReclamation

Panelist

Brian D. Good | Contact: Brian.Good@denverwater.org

Chief Administrative Officer, Denver Water

In his role as Chief Administrative Officer for Denver Water, Brian leads a diverse team whose primary focus is to provide internal service to the organization. Areas of focus include safety, security, emergency management, environmental compliance, sustainability, purchasing, contract control records and printing, and recreation. His previous roles at Denver Water include Director of Operations and Maintenance, Deputy Manager of Organizational Improvement, Water Recycling Plant Supervisor, and Assistant Supervisor of the Marston Water Treatment Plant. Prior to joining Denver Water, Brian managed source of supply, water treatment, and distribution operations for the Champaign, IL Division of Illinois American Water Corporation. Since 2012, he has also been a lecturer on water utility management for the University of Colorado, for which he coauthored a companion textbook titled The Effective Water Professional.

One Water Developments in Colorado

Brian Good

Denver Water

DENVER WATER | 100 YEARS 1918 — 2018

Three Key Developments

- Colorado Regulation Changes
- Denver Water Operations Complex Redevelopment
- City of Denver Green Roof Initiative

Colorado Regulation 84 Changes

- Adopted October 9, 2018
- Added toilet flushing as an acceptable reuse of water
- Approved ”localized treatment systems”
- Will utilize the risk-based, log-reduction criteria adopted by the National Blue Ribbon Commission

Denver Water Operations Complex

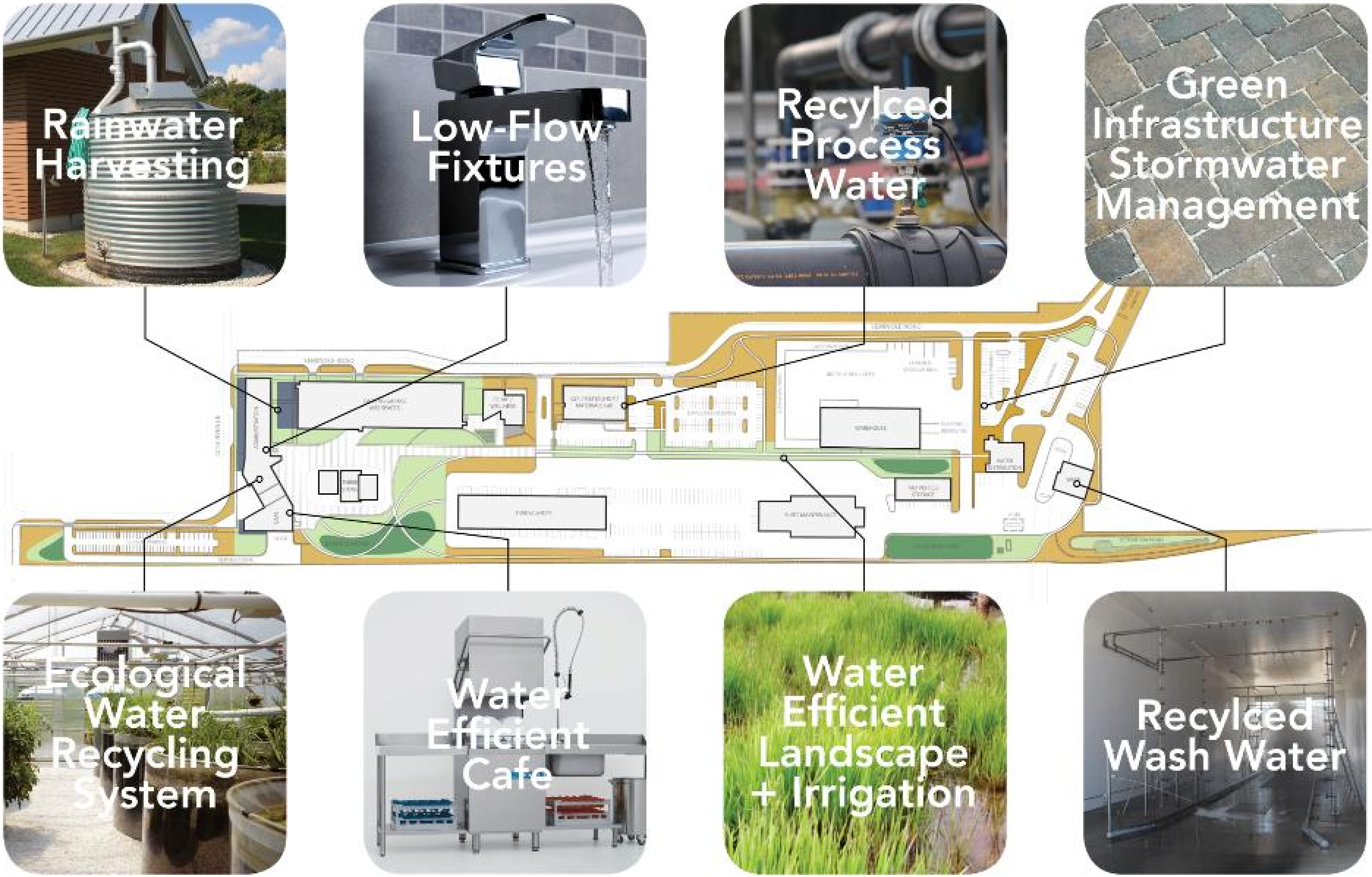
LEED PLATINUM

NET ZERO ENERGY

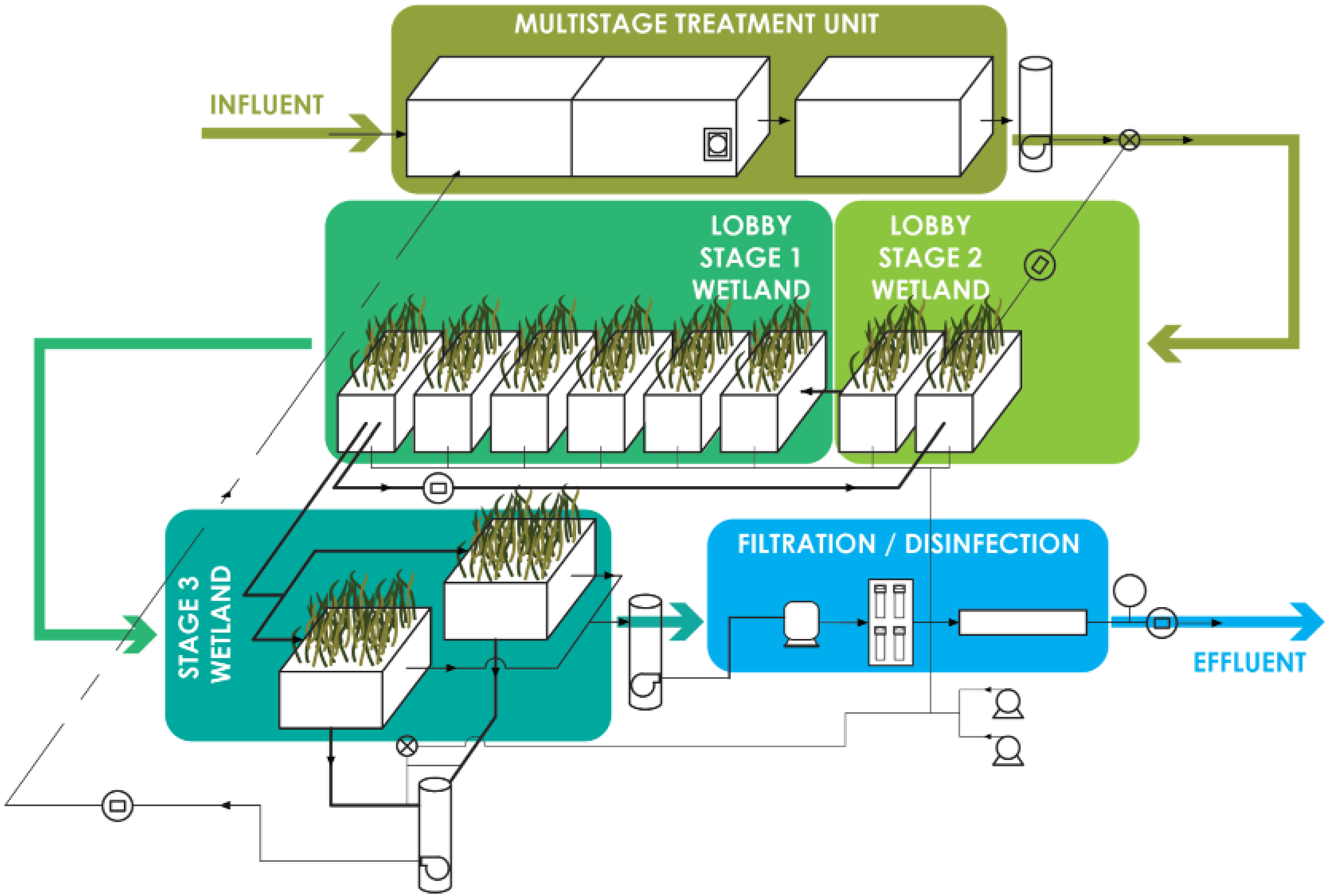
ONE WATER

PERFORMANCE GOALS

Courtesy, Tom Hootman, MKK

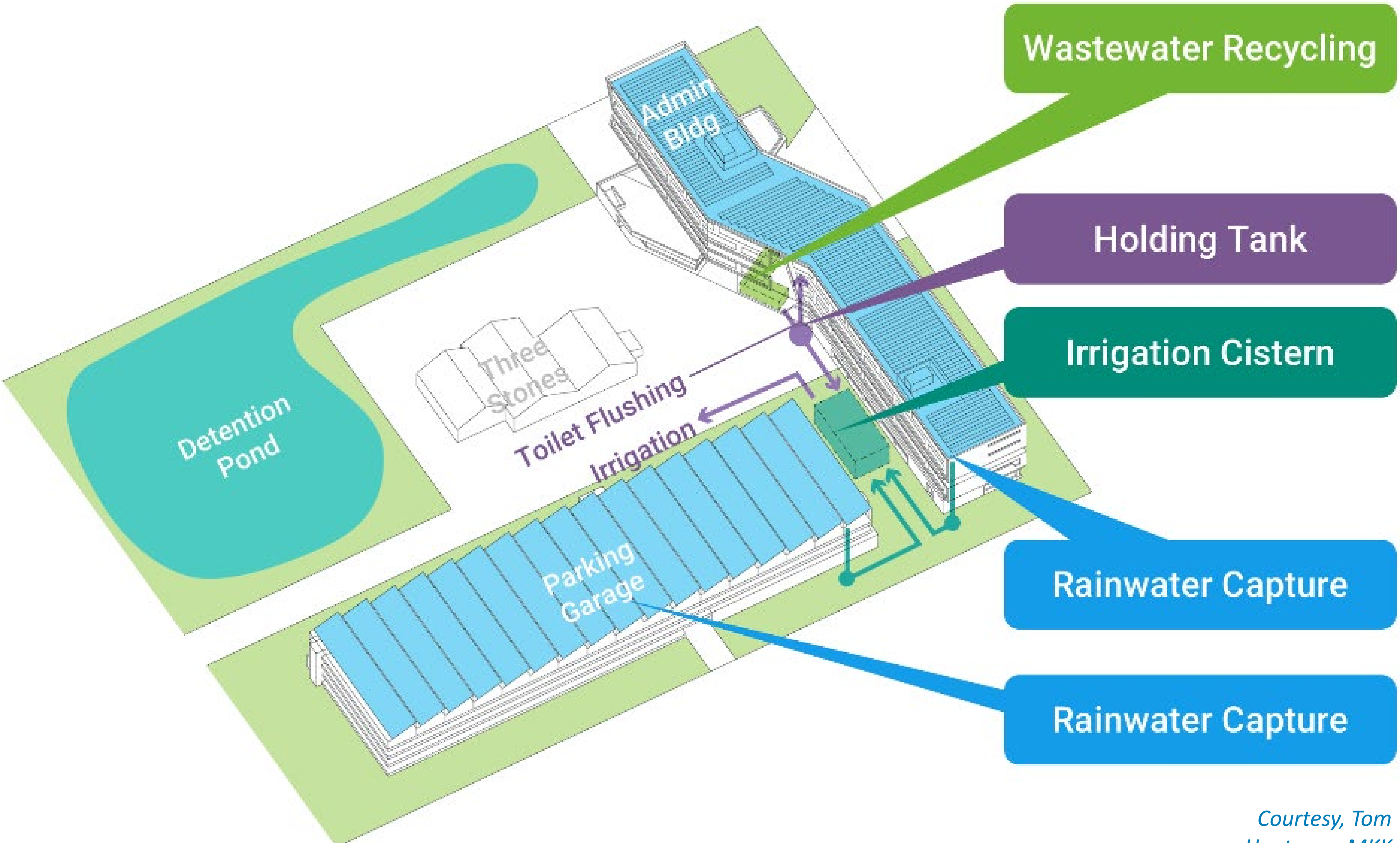


Courtesy, Tom Hootman, MKK



Courtesy, Tom Hootman, MKK


BNSF



Courtesy, Tom Hootman, MKK

City of Denver Green Roof Initiative

- Passed November 2017
- Required a green roof or combination of green roof and solar energy…
- …for every building, building addition and any roof replacement of a building with gross floor area ≥ 25,000 square feet

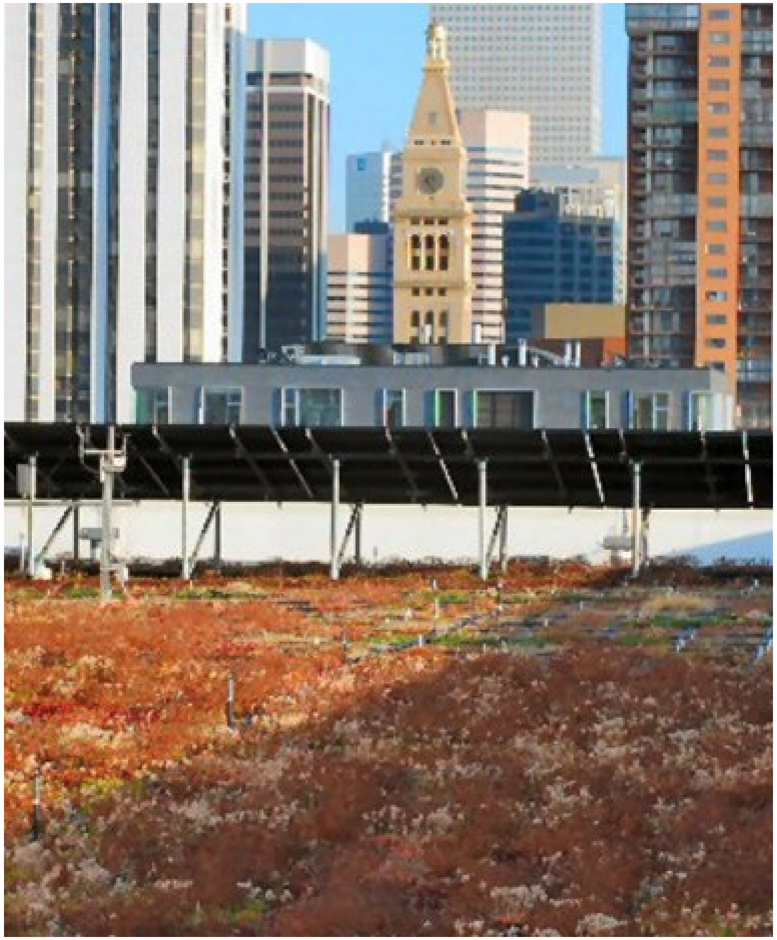


Photo credit: www.epa.gov

Green Building Ordinance - Compliance Options for New Buildings

Cool Roof Required* Plus ONE of the Following Options:

Green Roof / Green Space

Anywhere on building or zone lot

Green area equivalent to the lesser of:

- 10% of gross floor area of the building
- 60% of the total roof area
- Available roof space

Pay for Offsite Green

Payment to Green Building Fund of:

- $50.00 per square foot of green space coverage required but not provided

Green Plus Solar or Energy Efficiency

Anywhere on building or zone lot, or off-site for solar

Green area equivalent to the lesser of:

- 3% gross floor area
- 18% of total roof area
- Available roof space

COMBINED WITH ONE OF THE FOLLOWING:

1) Onsite solar equiv. to the lesser of:
   - 7% of the floor area
   - 42% of total roof area
2) Offsite solar equivalent to the to onsite solar plus a minimum 2.5% energy cost savings from energy efficiency above code
3) 5% energy cost savings from energy efficiency above code

Solar or Energy Efficiency

Anywhere on building or zone lot, or off-site

Onsite solar or other renewable equiv. to your choice of:

- 70% of the total roof area
- 100% of annual average electricity used at the building
- Proof that the building is Net Zero

OR

Offsite solar equiv. to your choice of:

- 100% of building electricity use
- Amount equivalent to required onsite solar plus minimum 6% energy cost savings from energy

OR

Minimum 12% energy cost savings from energy efficiency above code efficiency above code

Certification

One of the following:

- LEED Certification, minimum gold
- Enterprise Green Communities certification
- National Green Building Standard ICC/ASHRAE 700
- Equivalent certification approved by the building official

* If the proposed roof is a character-defining roof, CPD may allow alternative roof materials

From 10/29/18 presentation to Denver City Council

Green Building Ordinance - Compliance Options for Existing Buildings

At Roof Replacement: Cool Roof Required* plus ONE of the Following Options:

Green Roof / Green Space

Anywhere on building or zone lot

Green area equivalent to the least of:
- 2% of floor area of the building
- 18% of the total roof area
- Available roof space

Solar

Anywhere on building or zone lot

Onsite solar or other renewable equivalent to the least of:
- 5% of the floor area
- 42% of the total roof area
- An area equal to an amount required to provide 100% of building electricity use

Certification

One of the following:
- LEED Certification, minimum silver
- Enterprise Green Communities certification
- National Green Building Standard ICC/ASHRAE 700
- Equivalent certification approved by the building official

Energy Program

Enroll in a flexible energy program that includes various energy efficiency and renewable options designed to achieve similar greenhouse gas emission reductions as the on-site solar option.
- Comply with one of many pathways in the Energy Program within 5 years.
- Can enroll early to "bank" efficiency projects for next roof replacement

Pay for Offsite Green

Payment to Green Building Fund of:
- $50.00 per square foot of green space coverage required but not provided

* If the roof is a character-defining roof, CPD may allow alternative roof materials

From 10/29/18 presentation to Denver City Council

Thank you!

Brian Good
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Questions and Answers Session

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San Francisco Public Utilities Commission

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Minnesota Department of Health

Brian D. Good
Chief Administrative Officer,
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Stephen Deem
Regional Engineer,
Washington State Department of Health