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

- Drought
- Resilience
- New Development
- Stormwater Management
San Francisco’s Local Water Program

- 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: Single Building
2013: District-Scale
2015: Mandatory for ≥ 250,000 gsf
San Francisco’s Onsite Water Reuse Program
Barriers to Scaling Up Onsite Reuse: Governance & Water Quality

Challenges

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

AUSTIN WATER
10 mgd from decentralized systems by 2040

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

DENVER WATER
Blackwater system at new admin building

SANTA MONICA
Downtown stormwater, groundwater, wastewater reuse by 2020

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

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

VANCOUVER
Rainwater harvesting is key water conservation strategy

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)

<table>
<thead>
<tr>
<th></th>
<th>Enteric Viruses</th>
<th>Parasitic Protozoa</th>
<th>Enteric Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blackwater</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor use</td>
<td>8.0</td>
<td>7.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Indoor use</td>
<td>8.5</td>
<td>7.0</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Graywater</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor use</td>
<td>5.5</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Indoor use</td>
<td>6.0</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Roof Runoff</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor use</td>
<td>N/A</td>
<td>N/A</td>
<td>3.5</td>
</tr>
<tr>
<td>Indoor use</td>
<td>N/A</td>
<td>N/A</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Stormwater</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor use</td>
<td>3.0</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Indoor use</td>
<td>3.5</td>
<td>3.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Treatment Train to Achieve LRTs

Graywater for toilet flushing

![Diagram of treatment process]

### Pathogen Credits

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>Treatment Process</th>
<th>MBR</th>
<th>UV</th>
<th>Chlorine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virus</td>
<td></td>
<td>1.5</td>
<td>Up to 6</td>
<td>Up to 5</td>
</tr>
<tr>
<td>Protozoa</td>
<td></td>
<td>2</td>
<td>Up to 6</td>
<td>0</td>
</tr>
<tr>
<td>Bacteria</td>
<td></td>
<td>4</td>
<td>Up to 6</td>
<td>Up to 5</td>
</tr>
<tr>
<td>Ongoing Requirements</td>
<td>Operate within Tier 1 envelope</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online monitoring to confirm validated dose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demonstrate CT with verified free chlorine residual</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

H₂O
Jurisdictions Moving Forward with Risk-Based Approach

- 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

Source: San Francisco Public Utilities Commission
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/np

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

<table>
<thead>
<tr>
<th>State</th>
<th>BOD$_5$ (mg L$^{-1}$)</th>
<th>TSS (mg L$^{-1}$)</th>
<th>Turbidity (NTU)</th>
<th>Total Coliform (cfu/100ml)</th>
<th>E. Coli (cfu/100ml)</th>
<th>Disinfection</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>2.2</td>
<td>2.2</td>
<td>0.5 – 2.5 mg/L residual chlorine</td>
</tr>
<tr>
<td>New Mexico</td>
<td>30</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>200</td>
<td>-</td>
</tr>
<tr>
<td>Oregon</td>
<td>10</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>2.2</td>
<td>-</td>
</tr>
<tr>
<td>Georgia</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>500</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Texas</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>-</td>
<td>14</td>
<td>-</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>200</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.1 – 4 mg L$^{-1}$ residual chlorine</td>
</tr>
<tr>
<td>Colorado</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>-</td>
<td>2.2</td>
<td>0.5 – 2.5 mg/L residual chlorine</td>
</tr>
<tr>
<td>Typical Graywater</td>
<td>80 - 380</td>
<td>54 -280</td>
<td>28-1340</td>
<td>$10^{7.2} – 10^{8.8}$</td>
<td>$10^{5.4} – 10^{7.2}$</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Class R&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Class C&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBOD&lt;sub&gt;5&lt;/sub&gt; (mg/l)</td>
<td>Test Average</td>
<td>Single Sample</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>TSS (mg/l)</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>E. coli (MPN/100 ml)</td>
<td>14</td>
<td>240</td>
</tr>
<tr>
<td>pH (SU)</td>
<td>6.0-9.0</td>
<td>6.0-9.0</td>
</tr>
<tr>
<td>Storage vessel residual chlorine (mg/l)</td>
<td>≥ 0.5 - ≥ 2.5</td>
<td>≥ 0.5 - ≥ 2.5</td>
</tr>
</tbody>
</table>

<sup>a</sup> Class R: Flows through graywater system are less than 400 gpd

<sup>b</sup> 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)

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

“Source” waters
(roof runoff, storm water, graywater, blackwater)
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

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

Pathogen Observations?
Criteria:
1. N = 15
2. Conventional methods
3. Limit of detection

Yes
Characterize Density

No
Model 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
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
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

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

# QMRA Results - Log Reduction Targets

<table>
<thead>
<tr>
<th>Water Use Scenario</th>
<th>Log Reduction Targets for $10^{-4}$ ($10^{-5}$) Per Person Per Year Benchmarks&lt;sup&gt;h,i&lt;/sup&gt;</th>
<th>Enteric Viruses&lt;sup&gt;i&lt;/sup&gt;</th>
<th>Parasitic Protozoa&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Enteric Bacteria&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Wastewater or Blackwater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrestricted irrigation</td>
<td>8.0 (6.0)</td>
<td>7.0 (5.0)</td>
<td>6.0 (4.0)</td>
<td></td>
</tr>
<tr>
<td>Indoor use&lt;sup&gt;f&lt;/sup&gt;</td>
<td>8.5 (6.5)</td>
<td>7.0 (5.0)</td>
<td>6.0 (4.0)</td>
<td></td>
</tr>
<tr>
<td>Graywater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrestricted irrigation</td>
<td>5.5 (3.5)</td>
<td>4.5 (2.5)</td>
<td>3.5 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Indoor use&lt;sup&gt;k&lt;/sup&gt;</td>
<td>6.0 (4.0)</td>
<td>4.5 (2.5)</td>
<td>3.5 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Stormwater ($10^{-1}$ Dilution)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrestricted irrigation</td>
<td>5.0 (3.0)</td>
<td>4.5 (2.5)</td>
<td>4.0 (2.0)</td>
<td></td>
</tr>
<tr>
<td>Indoor use</td>
<td>5.5 (3.5)</td>
<td>5.5 (3.5)</td>
<td>5.0 (3.0)</td>
<td></td>
</tr>
<tr>
<td>Stormwater ($10^{-3}$ Dilution)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrestricted irrigation</td>
<td>3.0 (1.0)</td>
<td>2.5 (0.5)</td>
<td>2.0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Indoor use</td>
<td>3.5 (1.5)</td>
<td>3.5 (1.5)</td>
<td>3.0 (1.0)</td>
<td></td>
</tr>
<tr>
<td>Roof Runoff Water&lt;sup&gt;h&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrestricted irrigation</td>
<td>Not applicable</td>
<td>No data</td>
<td>3.5 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Indoor use</td>
<td>Not applicable</td>
<td>No data</td>
<td>3.5 (1.5)</td>
<td></td>
</tr>
</tbody>
</table>

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
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

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 process.

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**Example Residential log\(_{10}\) reduction targets**

<table>
<thead>
<tr>
<th>System</th>
<th>Virus</th>
<th>Protozoa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater</td>
<td>8.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Greywater</td>
<td>5.5</td>
<td>4.0</td>
</tr>
</tbody>
</table>

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

"Source" waters
- Non-Potable (roof runoff, storm water, graywater, blackwater)
- Potable

A Structured Framework
- Transparent underlying assumptions
- Flexible and Adaptable
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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Disclaimer: The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the US EPA. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.
Resources for Additional Information

Resources for Onsite Non-Potable Water Programs

• [http://uswateralliance.org/initiatives/commission/resources](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](http://uswateralliance.org/initiatives/commission/resources)
• [Onsite Non-Potable Water Reuse Research Technical Brief](http://uswateralliance.org/initiatives/commission/resources)
• [Water Reuse Research Website](http://uswateralliance.org/initiatives/commission/resources)
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
Top 5 Global Risks in Terms of Impact

1st
- 2009: Asset price collapse
- 2010: Asset price collapse
- 2011: Fiscal crises
- 2012: Major systemic financial failure
- 2013: Major systemic financial failure
- 2014: Fiscal crises
- 2015: Water crises
- 2016: Failure of climate-change mitigation and adaptation
- 2017: Weapons of mass destruction
- 2018: Weapon of mass destruction
- 2019: Weapon of mass destruction

2nd
- 2009: Retrenchment from globalization (developed)
- 2010: Retrenchment from globalization (developed)
- 2011: Climate change
- 2012: Water supply crises
- 2013: Water supply crises
- 2014: Water crises
- 2015: Water crises
- 2016: Water crises
- 2017: Water crises
- 2018: Natural disasters
- 2019: Extreme weather events

3rd
- 2009: Oil and gas price spikes
- 2010: Oil price spikes
- 2011: Geopolitical conflict
- 2012: Food shortage crises
- 2013: Chronic fiscal imbalances
- 2014: Water crises
- 2015: Water crises
- 2016: Water crises
- 2017: Water crises
- 2018: Water crises
- 2019: Water crises

4th
- 2009: Chronic disease
- 2010: Chronic disease
- 2011: Asyst price collapse
- 2012: Chronic fiscal imbalances
- 2013: Diffusion of weapons of mass destruction
- 2014: Unemployment and underemployment
- 2015: Interstate conflict with regional consequences
- 2016: Large-scale involuntary migration
- 2017: Major natural disasters
- 2018: Failure of climate-change mitigation and adaptation
- 2019: Water crises

5th
- 2009: Fiscal crises
- 2010: Fiscal crises
- 2011: Extreme energy price volatility
- 2012: Extreme volatility in energy and agriculture prices
- 2013: Failure of climate-change mitigation and adaptation
- 2014: Critical information infrastructure breakdown
- 2015: Failure of climate-change mitigation and adaptation
- 2016: Severe energy price shock
- 2017: Failure of climate-change mitigation and adaptation
- 2018: Water crises
- 2019: Natural disasters

Western US: Need to do Something Different

U.S. Drought Monitor

September 24, 2019
(Released Thursday, Sep. 26, 2019)
Valid 8 a.m. EDT

Drought Impact Types:
- Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:
- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

Author:
Eric Luebehusen
U.S. Department of Agriculture
Western US: Need to do Something Different

You are here
Western US: Need to do Something Different
Western US: Need to do Something Different

**U.S. Drought Monitor**

*September 24, 2019*
(Released Thursday, Sep. 19, 2019)
Valid 8 a.m. EDT

**Drought Impact Types:**
- E = Extreme
- M = Moderate
- S = Severe
- D = Drought

**Author:**
Pete Leebyhousen
U.S. Department of Agriculture

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**Upper Basin**
- Green River
- Rocky Mountain National Park
- Lake Powell
- Grand Canyon

---

**States Drought Impacted:**
- Washington: 14.1%
- Oregon: 12%
- Idaho: 35.1%
- Montana: 14.1%
- Wyoming: 10%
- Utah: 13.2%
- New Mexico: 24.6%
- Texas: 20.6%

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**Legend:**
- E = Extreme
- M = Moderate
- S = Severe
- D = Drought
- N = None

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**Map Notes:**
- Upper Colorado River Basin
- Lower Colorado River Basin
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
Rainwater Harvesting

Low-Flow Fixtures

Recycled Process Water

Green Infrastructure Stormwater Management

Ecological Water Recycling System

Water Efficient Cafe

Water Efficient Landscape + Irrigation

Recycled Wash Water

Courtesy, Tom Hootman, MKK
Detention Pond

Admin Bldg

Parking Garage

Toilet Flushing

Irrigation

Three Stoves

Wastewater Recycling

Holding Tank

Irrigation Cistern

Rainwater Capture

Rainwater Capture

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Enteric Viruses</th>
<th>Parasitic Protozoa</th>
<th>Enteric Bacteria</th>
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</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>6.0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>(10^{-2})</td>
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<tr>
<td>Category 2</td>
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<td>5.0</td>
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<tr>
<td>Category 3</td>
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<td>7.0</td>
<td>6.0</td>
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<td>(10^{-4})</td>
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</tbody>
</table>
Work Begins

- Obtained building permits

- Worked with the State to submit plans for review and approval (no official processes in place yet)

- Proceedings with initial work (concrete, underground piping, MSTU installation)
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)
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

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