A Transition from Indirect to Direct Potable Reuse in California

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CWEA Specialty Conference
Impact of Climate Change on California Wastewater Facilities
March 17, 2016
Potable Reuse Has a 50+ Year History In California
Montebello Forebay

- Operating since 1962
- Surface spreading
  - 560 acres
  - ~44 MGD
- Extensive testing
  - Epidemiology
  - Trace organics
- Expansion now underway
Water Factory 21
Water Factory 21 Project (1976)

- First ever application using Reverse Osmosis (RO) on municipal wastewater
- Design Criteria:
  - 5mgd capacity, 90% salt rejection, 85% recovery
  - "low pressure" 400psi cellulose acetate (4,000gpd) 8150HR membrane
  - 3-stage configuration: 20-10-5
- Municipal wastewater quality was unpredictable, making designing membrane criteria/performance challenging
Current CA Potable Reuse Projects
2014 Groundwater Recharge Regulation

- Source Control
- WWTP
- Advanced Water Treatment
- Injection Wells
- Spreading Basins
- WTP / Distribution
Groundwater Recharge: Surface Spreading

**Soil Aquifer Treatment**

**Biological Treatment**

**Granular Media Filtration**

**Disinfection**

**Soil Aquifer Treatment**
Current potable reuse projects are doing groundwater recharge.
## California IPR Overview

<table>
<thead>
<tr>
<th>Facility</th>
<th>Technology</th>
<th>Production (MGD)</th>
<th>Production (AF/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montebello Forebay</td>
<td>Spreading</td>
<td>44.6</td>
<td>50,000</td>
</tr>
<tr>
<td>Groundwater Replenishment System</td>
<td>Spreading / Injection</td>
<td>100</td>
<td>112,000</td>
</tr>
<tr>
<td>West Coast Basin Barrier</td>
<td>Injection</td>
<td>22.6</td>
<td>25,315</td>
</tr>
<tr>
<td>Chino Basin</td>
<td>Spreading</td>
<td>18.7</td>
<td>21,000</td>
</tr>
<tr>
<td>Alamitos Barrier</td>
<td>Injection</td>
<td>8</td>
<td>8,970</td>
</tr>
<tr>
<td>Dominguez Gap Barrier</td>
<td>Injection</td>
<td>5</td>
<td>5,600</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td>~200</td>
<td>~220,000</td>
</tr>
</tbody>
</table>
An International Leader in Potable Reuse – Orange County Water District

Commissioned 70 MGD in 2008 and expanded to 100 MGD in 2015
San Diego’s Pursuit of a Reservoir
Senate Bill 918

- Passed in 2010
- Required the adoption of groundwater recharge regulations by 2013
- Required the adoption of surface water augmentation regulations by the end of 2016
- Required an assessment on the feasibility of direct potable reuse by 2016
- Required a State Expert Panel
Groundwater Recharge: Surface Spreading (Ch 3, Article 5.1)

- 2ndry Treatment
- Tertiary Treatment
- Chlorination
- Water Consumers

Groundwater Recharge: Subsurface Injection (Ch 3, Article 5.2)

- 2ndry Treatment
- Full Advanced Treatment
- Chlorination
- Water Consumers

Surface Water Augmentation (Ch 3, Article 5.3 & Ch 17, Article 9 – both in draft)

- 2ndry Treatment
- Advanced Treatment
- Reservoir
- Potable Water Treatment Plant
- Water Consumers

Source Water Augmentation (no reservoir)

- 2ndry Treatment
- Advanced Treatment
- Source water Aqueduct
- Potable Water Treatment Plant
- Water Consumers

AWT water as an approved drinking water supply

- 2ndry Treatment
- New, Advanced Potable Water Treatment
- Water Consumers
When John Q Public Hears, “Direct Potable Reuse”, He Sees This

AWT water as an approved drinking water supply
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Defined as DPR by Senate Bill 918

AWT water as an approved drinking water supply
• Retention time:
  - At least 6 months

• Dilution:
  - 100-fold dilution, or
  - 10-fold dilution with +1-log treatment
**Groundwater Recharge: Surface Spreading (Ch 3, Article 5.1)**

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“**The Gap**”

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• Dilution:  
  100-fold dilution, or  
  – 10-fold dilution with +1-log treatment
White Paper on Alternatives Clause
Limitations of V/Q criterion

• “Theoretical retention time” concept (V/Q) brings value when recycled water mixes with the entire volume of the reservoir to provide dilution

• Most CA reservoirs stratify throughout much of the year

• Even during turnover, wind, reservoir configuration, inlet and outlet location and other factors can lead to short-circuiting

Under many conditions, purified water input to a reservoir only actually mixes with only a portion of the reservoir volume
Comparing Two Hypothetical Reservoirs

**Reservoir 1**
- $V_{\text{total}} = 10$
- $Q_{\text{out}} = 5$
- $V_{\text{total}} / Q_{\text{out}} = 2$

**Reservoir 2**
- $V_{\text{total}} = 100$
- $Q_{\text{out}} = 5$
- $V_{\text{total}} / Q_{\text{out}} = 20$
Comparing Two Hypothetical Reservoirs

Reservoir 1
\[ V_{\text{total}} = 10 \]
\[ Q_{\text{out}} = 5 \]
\[ \frac{V_{\text{total}}}{Q_{\text{out}}} = 2 \]

Reservoir 2
\[ V_{\text{total}} = 100 \]
\[ Q_{\text{out}} = 5 \]
\[ \frac{V_{\text{total}}}{Q_{\text{out}}} = 20 \]
Consider the following conditions:

• Inlet and outlet positions as shown
• Strong wind in direction

\[ \frac{V_{\text{total}}}{Q_{\text{out}}} = 2 \]

\[ \frac{V_{\text{total}}}{Q_{\text{out}}} = 20 \]
Comparing Two Hypothetical Reservoirs

Watch what happens when water enters each reservoir
Comparing Two Hypothetical Reservoirs
Comparing Two Hypothetical Reservoirs
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Comparing Two Hypothetical Reservoirs

Reservoir 1: \( V_{\text{eff}} \approx V_{\text{total}} \)

Reservoir 2: \( V_{\text{eff}} \approx V_{\text{total}}/10 \)

\[ \frac{V_{\text{eff}}}{Q_{\text{out}}} \approx 2 \]
$V_{total}/Q_{out} \approx 24 \text{ months}$

$V_{eff}/Q_{out} \approx 2.4 \text{ months}$
CONCLUSION: A reservoir with a very large theoretical retention time does not necessarily provide more public health protection than one with a smaller HRT. V/Q is an imperfect parameter to assess public health protection.
Surface Water Augmentation vs Source Water Augmentation

Dilution Is The Most Significant Public Health Benefit Unique to a Reservoir
"The Gap"
Surface Water Augmentation

Source Water Augmentation
$T = 1$ hour

**Surface Water Augmentation**

**Source Water Augmentation**
T = 2 hours

**Surface Water Augmentation**

Still in compliance

**Source Water Augmentation**

Out of compliance
Surface Water Augmentation

Source Water Augmentation

T = 3 hours
T = 4 hours

**Surface Water Augmentation**

Still in compliance

**Source Water Augmentation**

Out of compliance
$T = 5$ hours

Surface Water Augmentation

Source Water Augmentation

Still in compliance

Out of compliance
T = 6 hours

Surface Water Augmentation

Source Water Augmentation
Surface Water Augmentation

Source Water Augmentation

T = 7 hours

Still in compliance

Out of compliance
T = 8 hours

Surface Water Augmentation

Source Water Augmentation

Still in compliance

Out of compliance
$T = 9$ hours

**Surface Water Augmentation**

**Source Water Augmentation**

Still in compliance

Out of compliance
$T = 10 \text{ hours}$

Surface Water Augmentation

Source Water Augmentation

Still in compliance

Out of compliance
\( T = 11 \text{ hours} \)

**Surface Water Augmentation**

Still in compliance

**Source Water Augmentation**

Out of compliance
$T = 12 \text{ hours}$

**Surface Water Augmentation**

- AWPF
- DWTP (Still in compliance)

**Source Water Augmentation**

- AWPF
- DWTP (Out of compliance)
$T = 13$ hours

**Surface Water Augmentation**

- AWPF
  - DWTP

Still in compliance

**Source Water Augmentation**

- AWPF
  - DWTP

Out of compliance
$T = 14$ hours

**Surface Water Augmentation**

- AWPF → DWTP
- Still in compliance

**Source Water Augmentation**

- AWPF → DWTP
- Out of compliance
$T = 15 \text{ hours}$

**Surface Water Augmentation**

- AWPF → DWTP

Still in compliance

**Source Water Augmentation**

- AWPF → DWTP

Out of compliance
$T = 16 \text{ hours}$

**Surface Water Augmentation**

- **AWPF** → **DWTP**
  - Still in compliance

**Source Water Augmentation**

- **AWPF** → **DWTP**
  - Out of compliance
Surface Water Augmentation

Still in compliance

Source Water Augmentation

Out of compliance

T = 17 hours
T = 18 hours

Surface Water Augmentation

Source Water Augmentation

Still in compliance

Out of compliance
\[ T = 19 \text{ hours} \]

Surface Water Augmentation

Still in compliance

Source Water Augmentation

Out of compliance
T = 20 hours

Surface Water Augmentation

Source Water Augmentation
Surface Water Augmentation

Still in compliance

Source Water Augmentation

Out of compliance

T = 21 hours
$T = 22$ hours

**Surface Water Augmentation**

- AWPF
- DWTP

Still in compliance

**Source Water Augmentation**

- AWPF
- DWTP

Out of compliance
T = 23 hours

Surface Water Augmentation

Source Water Augmentation
Surface Water Augmentation

$T = 24\ \text{hours}$

Always providing at least 10:1 dilution

Source Water Augmentation

Has been running off-spec for 22 hours

Out of compliance

Still in compliance
T = 24 hours

Surface Water Augmentation

Always providing at least 10:1 dilution

Source Water Augmentation

Has been running off-spec for 22 hours

CONCLUSION: Reservoir provides time to respond to a failure because of dilution; both of these factors work together to distinguish SWA from more direct forms of potable reuse.
Projects are evolving toward more treatment and monitoring, but less time.
Projects will evolve over time toward more treatment and monitoring, less time, and will be more closely coupled.

1. Surface water augmentation
2. Source water augmentation
3. Finished water production
The NRC Committee on Reuse

• On environmental buffers:
  “Natural systems are employed in most potable water reuse systems to provide an environmental buffer. However, it cannot be demonstrated that such ‘natural’ barriers provide any public health protection that is not also available by other engineered processes”

• On changes in technology:
  “Retention and blending requirements for quality assurance are expected to become less significant as monitoring and attenuation* technologies improve.”

*treatment
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DPR
- AWT water as an approved drinking water supply
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Road to DPR

Public Health Protection

Dilution  OR  Treatment & Monitoring
# Does Dilution Work?

<table>
<thead>
<tr>
<th>Typical Conditions</th>
<th>Raw</th>
<th>FAT Effluent</th>
<th>Post-Dilution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe?</td>
<td><img src="thumb_down.png" alt="Thumb Down" /></td>
<td><img src="thumb_up.png" alt="Thumb Up" /></td>
<td><img src="thumb_up.png" alt="Thumb Up" /></td>
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</table>
Does Dilution Work?

<table>
<thead>
<tr>
<th>Failure Conditions</th>
<th>Raw</th>
<th>FAT Effluent</th>
<th>Post-Dilution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Failure</td>
<td></td>
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Safe?

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</tr>
</thead>
<tbody>
<tr>
<td>👎</td>
<td>👎</td>
<td>👍</td>
</tr>
</tbody>
</table>
Enhanced treatment provides same benefit

Typical Conditions

Raw

Enhanced Treatment

Safe?

thumbs down

thumbs up
Enhanced treatment provides same benefit

<table>
<thead>
<tr>
<th>Failure Conditions</th>
<th>Raw</th>
<th>Enhanced Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image1.png" alt="Image of raw water with harmful bacteria" /></td>
<td><img src="image2.png" alt="Image of clear water" /></td>
</tr>
<tr>
<td>Safe?</td>
<td><img src="image3.png" alt="Red thumbs down" /></td>
<td><img src="image4.png" alt="Green thumbs up" /></td>
</tr>
</tbody>
</table>

*Process Failure*
New treatment challenges for reuse

Pathogens

Secondary Effluent → Membrane Filtration → Reverse Osmosis → Ultraviolet Light/Advanced Oxidation → Aquifer
New treatment challenges for reuse

Pathogens

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New treatment challenges for reuse

Pathogens
- Secondary Effluent
- Membrane Filtration
- Reverse Osmosis
- Ultraviolet Light/Advanced Oxidation
- Aquifer

Toxic Chemicals
- Secondary Effluent
- Membrane Filtration
- Reverse Osmosis
New treatment challenges for reuse

**Pathogens**
- Secondary Effluent
  - Membrane Filtration
  - Reverse Osmosis
  - Ultraviolet Light/Advanced Oxidation
  - Aquifer

**Toxic Chemicals**
- 1,4-dioxane
- NDMA
- Acetone
New treatment challenges for reuse

Pathogens
- Secondary Effluent
- Membrane Filtration
- Reverse Osmosis
- Ultraviolet Light/Advanced Oxidation
- Aquifer

Toxic Chemicals
- 1,4-dioxane
- NDMA
- Acetone

Taste and Odor
- Woman holding glasses
Miramar Reservoir Augmentation

- Tertiary Effluent
- Ozone System
- Biological Activated Carbon
- Membrane Filtration
- Reverse Osmosis
- Ultraviolet Light

Conventional Water Treatment Plant

To Distribution System

Lake Miramar
WateReuse Research Project 14-12

Title: Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse
Project Goal

To leverage industry “state of the art” to demonstrate how a combination of treatment redundancy and enhanced monitoring techniques can reliably achieve potable reuse treatment objectives.
WRRF 14-12 Demonstration Project

- **Performance Assessment**
  - 24/7 Operation with real-time monitoring
  - 12 months of continuous data collection
  - Challenge testing: pathogens and chemicals
  - Performance used to assess **reliability**

- **Regulatory / Expert Review**
  - IAP/PAC meeting in Dec. 2014 including DDW staff
  - DDW Expert Panel project overview (June 2015)
  - Update on project performance (Sept. 2015)
  - Update on project performance (Jan. 2016)
DPR Must Ensure Reliability while….

- Eliminating reliance on dilution
- Reducing need for response time
- Controlling pathogens and chemicals
- Addressing aesthetics and “unknowns”
Conclusions

- Potable reuse can be done safely and has been for the past 50+ years in California
- Multiple solutions must be pursued
  - Non-potable reuse
  - Groundwater recharge
  - Surface water augmentation
- True direct potable reuse will be permitted after industry gains above ground experience
- Public acceptance is critical
Thank you for listening!