IPR to DPR: Balancing treatment, monitoring, and storage

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Indirect Potable Reuse (IPR) Components

- Source Control
- WWTP
- Advanced Water Treatment
- Aquifer Injection / Spreading
- Reservoir Augmentation
- WTP / Distribution
DPR: no environmental buffer
Role of environmental buffer in IPR

- Contaminant removal
- Dilution / blending
- Storage capacity
- Time to detect & respond to failures
Role of environmental buffer in IPR

• Contaminant removal
• Dilution / blending
• Storage capacity
• Time to detect & respond to failures

How do maintain these protections without an environmental buffer?

What are the key issues?
Moving from IPR to DPR

- A clear requirement for DPR: protect public health

- Main challenge identified by CDPH: loss of environmental buffer $\rightarrow$ reduced storage $\rightarrow$ less response time

- Reduced response retention time is the key issue in transition to DPR
Fundamental Question

*How do we justify shorter response retention times for DPR?*
Balancing Potable Reuse Elements

• All 3 elements—treatment, monitoring, and retention time—contribute to public health

• No “ideal” combination; involves trade-offs

• Precedents? Groundwater Recharge Regulations

Option 1
Higher treatment – full adv. treatment
Lower retention time – 2-6 months

Option 2
Lower treatment – tertiary, disinfected
Higher retention time – 6+ months
Potable Reuse
Risk
(Pathogens, Chemicals)

Public Health Protection
Public Health Protection
Public Health Protection

- IPR
  - Treatment
  - Retention Time
  - Monitoring
- DPR
  - Retention Time
  - Monitoring
  - Treatment

Decreased retention time
Main two things we are losing:
- Retention time for **treatment**
- Retention time for **failure response**
Main two things we are losing:
- Retention time for **treatment**
  Enhance treatment above ground
- Retention time for **failure response**
  Decrease time needed to detect compromise or failure
Main two things we are losing:  
- Retention time for **treatment**  
  Enhance treatment above ground  
- Retention time for **failure response**  
  Or, Make system FAILSAFE
Main two things we are losing:
- Retention time for **treatment**
  Enhance treatment above ground
- Retention time for **failure response**
  Or, reduce response time **and** reduce risk of failure at the same time
Public Health Protection

Enhanced Treatment

Enhanced Monitoring

Decreased retention time

Retention Time

Monitoring

Retention Time

Treatment

Monitoring

Treatment
Goals for today’s presentation

• Discuss balance of 3 potable reuse elements

• How shorter response retention time (RRT) can be compensated with:
  – Enhanced treatment
  – Enhanced monitoring

• Discuss trade-offs of different options
Enhanced Treatment

How does enhanced treatment work?
*By reducing the risk of treatment failures*

What is the key to treatment reliability?
*Redundancy with multiple barriers*
Types of Treatment Redundancy

1. Multiple barrier approach

3 barriers $\rightarrow$ 6-log performance

(requirement: 6-log removal)
Types of Treatment Redundancy

1. Multiple barrier approach

Benefit: minimizes risk of complete failure

3 barriers $\rightarrow$ 6-log performance

(requirement: 6-log removal)
Types of Treatment Redundancy

1. Multiple barrier approach

2. Greater than minimum performance

3 barriers $\rightarrow$ 6-log performance

1 barrier $\rightarrow$ 8-log performance

(requirement: 6-log removal)
1. Multiple barrier approach

```
2-log ▶ 2-log ▶ 2-log → 3 barriers → 6-log performance
(requirement: 6-log removal)
```

2. Greater than minimum performance

```
8-log → 1 barrier → 8-log performance
(requirement: 6-log removal)
```

Benefit: small failures can occur without any compromise to performance goals
Treatment Concept for DPR

Employ **both** forms to ensure treatment **reliability**

3 barriers $\rightarrow$ 8-log performance

(requirement: 6-log removal)

**Benefits**

- Meets performance goals, even during failure events
- Reduces need for rapid response to failure
- No new technology required
Example: reliability thru multiple barriers

Design pathogen removal: 12-log

Goal: 12-Log

Example: reliability thru multiple barriers

Treatment and monitoring

Storage and monitoring
Design pathogen removal: 12-log

Loss of chlorination

Even with loss of chlorination, 10-log removal is still provided
Example: add reliability thru redundancy

**Design pathogen removal: 17-Log**

- WRP
- HOCl
- O$_3$
- MF
- RO
- UV/AOP
- Engineered Storage Buffer

**Goal: 12-log**

**17 (total)**

- Distribution system

**Treatment and monitoring**

**Storage and monitoring**
Example: add reliability thru redundancy

**Design pathogen removal: 17-Log**

**Goal: 12-log**

*Partial chlorine failure*

- WRP
- HOCl
- $\text{O}_3$
- MF
- RO
- UV/AOP
- Engineered Storage Buffer
- Distribution system

**Same treatment failure → 12-log goal is still exceeded**
Example: add reliability thru redundancy

**Design pathogen removal: 17-Log**

**Goal: 12-log**

*Same treatment failure + monitoring failure*

Treatment + monitoring failure $\rightarrow$ 12-log goal still exceeded
Example: add reliability thru redundancy

**Design pathogen removal: 17-Log**

**Goal: 12-log**

*Same treatment failure + monitoring & storage failure*

![Diagram showing treatment and monitoring system with reliability through redundancy](image)

Treatment + monitoring + storage failures $\rightarrow$ 12-log goal is still met
Implementing improved treatment

To justify shorter retention times:

- Design treatment train to achieve above the minimum removal requirements
- Quantify performance of unit processes to demonstrate redundancy
Trade-Offs with Enhanced Treatment

Benefits:
- Ensures reliability during failure of any other potable reuse element
- Achievable with existing technologies

Disadvantages:
- Cost of additional treatment
- What level of redundancy is enough?
  - Balance of reliability vs. response time
Role of monitoring in potable reuse

• Assess process performance and reliability
• Control processes
• Verify compliance with public health and regulatory requirements
Acute vs. chronic contaminants

• Pathogen control: the most important aspect
Acute vs. chronic contaminants

- Pathogen control: the most important aspect

- Why is this the case?
Acute vs. chronic contaminants

- Pathogen control: the most important aspect

- Why is this the case?

One time exposure

Norovirus

Triclosan
Acute vs. chronic contaminants

- Pathogen control: the most important aspect

- Why is this the case?

One time exposure

Lifetime Exposure

Norovirus

Triclosan
Even Acute is a matter of degree

- Pathogen control: the most important aspect

- Why is this the case?

One time exposure

Exposure, 30-d+
Implementing Enhanced Monitoring

Compensate for shorter RRTs by ensuring proper treatment and rapid response to treatment deterioration or failure.
## Enhanced Monitoring

<table>
<thead>
<tr>
<th></th>
<th>Pathogens (Acute)</th>
<th>Chemicals (Acute)</th>
<th>Chemicals (Chronic)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example</strong></td>
<td>Virus, bacteria, <em>Giardia</em>, <em>Cryptosporidium</em></td>
<td>Nitrate, nitrite, perchlorate</td>
<td>MCLs, CECs, trace organic contaminants</td>
</tr>
<tr>
<td><strong>Priority</strong></td>
<td>Highest</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Strategy</strong></td>
<td>• Multiple barriers</td>
<td>• Multiple, robust barriers (BNR, RO)</td>
<td>• Multiple, robust barriers (biological, physical, chemical)</td>
</tr>
<tr>
<td></td>
<td>• Focus on CCPs</td>
<td>• Source control/characterization</td>
<td>• Source control/characterization</td>
</tr>
<tr>
<td></td>
<td>• Provide on-line monitoring of CCPs</td>
<td>• Routine monitoring</td>
<td>• Routine monitoring</td>
</tr>
<tr>
<td></td>
<td>• Periodic testing (DIT)</td>
<td></td>
<td>• Follow proposed CDPH regulations</td>
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</tbody>
</table>
Enhanced Monitoring – Overview

• Higher temporal sensitivity
  – Pathogens and acute chemicals – on-line surrogate measurement of all CCPs
  – Sampling location: minimize time between treatment and monitoring

• Analytical sensitivity
  – Monitoring technologies with high range and resolution
  – More precise picture of contaminant removal
Trade-Offs with Enhanced Monitoring

Benefits:
- Rapid notification of treatment lapses or failures
- Can demonstrate achievement of some WQ standards

Disadvantages:
- Cannot (yet) demonstrate finished water meets microbial water quality goals
- On-line, continuous instrumentation not available for all contaminants of concern
Public Health Protection
Conclusions

By providing:

1. High level of redundant pathogen treatment
2. Robust train for control of acute and chronic chemicals
3. Tight temporal monitoring and control of all critical control points

DPR can ensure public health at shortened response retention time
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The End