Asset Management and Rehabilitation
Approaches for our Aging Infrastructure

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Vice President, ASCE Phoenix Branch
Chair, EWRI Desalination and Water Reuse Committee

September 11, 2015, Desert Willow Conference Center, Phoenix, Arizona
Presentation Takeaways

- The Need for WWTP Rehabilitation
- The Big Four
- Strategic Asset Management
- Goals & Overview
- Approach
- Deferred Maintenance Considerations
- Approaching Capacity
- Aging Infrastructure
- Increasing Need for Water Reuse
120 WWTP in AZ

12+ more WWTP planned in the next decade +

Vary in size from 10,000 gpd to 160+ mgd

State avg. daily treated flow of 419 mgd (2008)
“... a need for rehabilitation or replacement of existing facilities that are nearing or past the end of their expected useful life” ... ”many portions of the wastewater systems are 50 years old or more”

“many of Arizona’s wastewater plants suffer from deferred maintenance” ... “many utilities’ revenues and budgets were significantly reduced during the downturn, with needed projects deferred or cancelled”

“1 in 5 of the State’s WWTPs reported receiving flows at or beyond their permitted capacity”

“as environmental standards tighten, and” ... “water reuses expand and become more sophisticated, the result is” ... “higher levels of treatment and more robust treatment processes”

- 2015 REPORT CARD FOR ARIZONA’S INFRASTRUCTURE
The Big Four

Aging Infrastructure
Approaching Capacity
Deferred Maintenance
Increasing Need for Water Reuse

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Strategic Asset Management

- Approach and techniques vary by community and application
- Need to prioritize systems critical components
- Need to develop the right rehabilitation project is key for compliance and budget goals

Asset Management Planning should be based on critical goals:

1) Compliance (Capacity, Permit/Regulatory)
2) Reliability/criticality
3) Budgets (Capital and O&M)
Strategic Asset Management

- Asset Management Planning can be at the:
  - System Level
    - (WWTP – Compliance)
  - Sub-system Level
    - (i.e. headwords, primary, secondary, tertiary, solids – Performance)
  - Component Level
    - (i.e. basin, pump, blower, tank, controls – Performance and Reliability)
Strategic Asset Management

Protect your biggest investments:

- Public Health and Safety
- WWTP and Collection System Worker Health and Safety
- WWTP Infrastructure
- Conveyance Systems

Proactively safeguard against:

- Service disruption
- Compliance Issues

*Find your weakest link and predict critical components.*
Strategic Asset Management Approach

Functional Requirements
Monitoring and Controls
Asset Planning

Costs (Budgeted/Actual)
Sampling Testing

System Evaluation

Work Practice Efficiency
Maintenance Efficiency

Motor Efficiency
Chemical Efficiency
Blower Efficiency

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Strategic Asset Management Approach

Functional Requirements

- Design Criteria
  - Design Report
- Reliability/Criticality
  - Redundancy
    - Critical Spare Parts
- O&M Manual
  - Operating Procedures
    - Operating/Control Strategies
- Process Requirements
  - Design
    - Actual
  - Effluent
    - Biosolids
    - Odor
    - other
- Performance Requirements
  - Permit Requirements
  - Compliance

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Strategic Asset Management Approach

- Asset Planning
  - Replacement Schedule
  - Rehab/Refurbish Schedule
  - Consequence of Failure (Criticality)
  - Asset Inventory

- Leads to capital budget planning and deferred maintenance decisions
Deferred Maintenance

Deciding not to spend, does not always equate to saving
Deferred Maintenance
Replacement Planning

USEPA - SSO Fact Sheet—Asset Management

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Deferred Maintenance
Replacement Planning Optimization

Excellent

Failing

20-Year Planning Cycles

Cost for Rehabilitation

Peak Condition
Asset Decay Rate
O&M Cost
Rehab/Replacement Cost

Equal to Full Replacement
Deferred Maintenance
Replacement Planning Optimization
Approaching Capacity
Local, Regional and National Trends
Approaching Capacity Concerns – Overview

- Hydraulic Capacity
  - Expansion required as 80% of design hydraulic capacity is approached

- Loading Capacity (concentration)
  - Permit Requirements
  - Local Limits

- Coupling of Capacity Concerns
  - Hydraulic capacity impacts loading capacity
  - Loading capacity (conc.) limits hydraulic loading
  - Bio-solids become the limiting factor for compliance
Approaching Capacity
Concerns – Regional Example 1, National Trend

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## Approaching Capacity Concerns – Regional Example 2, National Trend

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Approaching Capacity Concerns – Regional Example 3, Compliance Limits

60% of MAHL

Need for Change to Local Limit

Average Influent Concentration Percent of MAHL

POCs

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Approaching Capacity
Concerns – Regional Example 4, Compliance Limits

80% of MAHL

Maximum Influent Concentration Percent of MAHL

POCs

Need for Change to Local Limit

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Approaching Capacity
Expansion Planning Optimization

Existing

Conventional

MBR/MBBR/IFAS

Front Royal, VA. Expansion from 4 to 5 MGD and upgrade to Advanced Nutrient Removal

Site Footprint Comparison
Aging Infrastructure
Nothing Last but Change
Aging Infrastructure
Approach

Typically infrastructure rehabilitation starts after major compliance and regulatory issues have been addressed.

Rehabilitation approach starts with:

- Data gathering (as-builts and mapping the facilities)
- Condition Assessment
- Criticality Rating
- MOPOs
- Budgets

- Prioritize systems critical components
Aging Infrastructure
As-builts and Mapping

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Aging Infrastructure
As-builts and Mapping

CONFINED SPACES

3D-SCAN
Aging Infrastructure
As-builts and Mapping
Aging Infrastructure
Condition Assessment – CCTV Process Piping
Aging Infrastructure
Condition Assessment – Structural Inspections

INTRUSIVE TESTING
Aging Infrastructure
Planning and Design - Prioritizing

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Solids Thickening Facility
Solids Handling Facility
Aging Infrastructure
Execution

Structural Inspection

DOME REMOVAL

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Aging Infrastructure
Execution

BEFORE REPAIRS

AFTER REPAIRS
Increasing Need for Water Reuse

Wastewater treatment needs are evolving to become water reuse needs
Increasing Need for Water Reuse
Water / Energy Nexus

91st Avenue WWTP
~200 MGD Capacity
~135 MG Daily Avg.

~59.5 MGD to Palo Verde Nuclear Power Plant
~26.7 MGD to Buckeye Irrigation District

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Increasing Need for Water Reuse
Diversify Water Resources Portfolio


Projected Capacity Challenge
- Expand water portfolio to increase or add reliance includes reclamation
- Reclamation inherently considers desalination

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Increasing Need for Water Reuse
Complexity Coupling

The ability to implement water reuse technologies become fiscally challenging and compound when coupled with rehabilitation or expansion needs of existing municipal wastewater treatment facilities.
Increasing Need for Water Reuse
The questions then become:

1) What regulations or guidelines exist for implementing direct potable, indirect potable, and non-potable (direct) reuse projects?

2) What alternative technologies are effective to polish effluent to reuse standards, while maintaining existing conventional treatment processes?

3) How cost effective is it to maintain conventional treatment facility and implement alternative treatment technologies for expansion of municipal facilities?
# Increasing Need for Water Reuse

## 1) Reuse Regulations and Guidelines

Summary of State and U.S. Territory Reuse Regulations and Guidelines

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- The state’s regulations or guidelines intent is for the oversight of water reuse
- The state’s regulations or guidelines intent is for the oversight of disposal and water reuse is incidental
- The state does not have water reuse regulations or guidelines but may permit reuse on a case-by-case basis

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Increasing Need for Water Reuse

1) Direct Potable Reuse Quality Goals

Based on WRRF 11-02:
- 12-log enteric virus
- 10-log Cryptosporidium (Giardia implied)
- 9-log bacteria


Based on CDPH:
- 12-log viruses
- 10-log Giardia and Cryptosporidium


- plus both have requirements for trace chemicals
- plus concerns of emerging contaminants
Increasing Need for Water Reuse

2) Reuse Technologies

- Membrane Technologies
- Advanced Oxidation
- Biologically Active Filers
Increasing Need for Water Reuse

2) Reuse Technologies

Potential Treatment Trains for IPR, NPR, DPR to existing CAS facilities:
Increasing Need for Water Reuse

2) Reuse Technologies - Membranes

**Processes for Separation**

- Reverse Osmosis
- Nanofiltration
- Microfiltration
- Ultrafiltration

**Desalination**

- CaCO₃
- MgSO₄
- NaCl

**Aquatic Salts**

- AQ. SALTS
- CARBON
- VIRUS
- BACTERIA
- BEACH SAND

**Ions**

- IONS
- T&O
- POLLEN

**Herbicide**

- HERBICIDE

**Pharmaceuticals**

- MILLED FLOUR

**Processes for Separation**

- Desalination
- Reverse Osmosis
- Nanofiltration
- Microfiltration
- Ultrafiltration

- Particle Filtration

**Concentrations**

- 0.001
- 0.01
- 0.1
- 10
- 100
- 1000
Increasing Need for Water Reuse

2) Reuse Technologies – Advanced Oxidation

- $O_3 + UV$ is an advanced oxidation process (AOP) for disinfection.
  
  Synergies of UV Disinfection and Ozone can be cost-effective.

- When temperature are 15°C, CT value for 3-log inactivation of Giardia Cysts by ozone is 0.95mg/min-L, for viruses is 0.5mg/min-L.

Common ozone dissolution methods include:

- Bubble diffuser contactors;
- Injectors;
- Turbine mixers

- If bromide ion is present in the raw water, halogenated DBPs may be formed which may pose a greater health risk than non-brominated DBPs.

- The bromate ion and brominated organics can be controlled during ozonation by techniques including biologically active filters (BAF).
Increasing Need for Water Reuse
2) Reuse Technologies – Advanced Oxidation

Design Example:
- Water depth 18-22ft
- 85-95% ozone transfer efficiency
- Contact time=10min
- \( V=Qt=8360\text{ft}^3 \)
- Depth=20ft
- \( A=\frac{V}{h/3}=140\text{ft}^3 \)

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<th>Advantages</th>
<th>Disadvantages</th>
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<td>No moving parts</td>
<td>Deep contact basins</td>
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<tr>
<td>Effective ozone transfer</td>
<td>Vertical channeling of bubbles</td>
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<td>Low hydraulic headloss</td>
<td>Maintenance of gaskets and piping.</td>
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<td>Operational simplicity</td>
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Increasing Need for Water Reuse

2) Reuse Technologies – Advanced Oxidation

Principal Reactions Producing Ozone Byproducts

\[
\begin{align*}
O_3 & \rightarrow HOBr & H^+ + OBr^- \\
pK_a &= 8.7 \text{ at } 25^\circ C \\
\end{align*}
\]

- Organic Precursors
- Aldehydes and Oxidized Organics
- NH_3
- NH_2Br, NHBr_2
- Brominated Organic DBPs
Increasing Need for Water Reuse

2) Reuse Technologies – Biologically active Filters

- Biologically Active Filters (BAF) are typically implemented to polish the effluent stream from Ozone (O₃)

- BAF increases particle removal while removing assimilable organic carbon (AOC) and other constituents

- Assimilable organic carbon is a measure of the growth potential of organic materials

- The biology is established naturally, which requires limited “Seeding”

- Ozonation by-products such as aldehydes, easily removed

- TOC removal is generally independent of EBCT
Increasing Need for Water Reuse

2) Reuse Technologies – Biologically active Filters

Influent from Ozone

Overflow

Effluent

Backwash

Similar treatment concept as sand filtration
Increasing Need for Water Reuse

2) Reuse Technologies – Biologically active Filters
Synergy between Ozone and BAF

- Ozone breaks macromolecular non-organic matter (NOM) and other constituents to biodegradable organic matter
- Ozonation process adds oxygen to the water improves the function of aerobic bacteria
- Bio-filter increases microbial growth
- Non biodegradable materials can be made biodegradable after partial oxidation by ozone
- Results in reduced TOC/COD/BOD concentrations
Increasing Need for Water Reuse

2) Reuse Technologies – Biologically active Filters

Effects in Contaminants

- Total Organic Carbon (TOC) removal occurs in BAF by a physical-chemical and biological processes
- AOC removals are typically very high in BAF
- Typical 20% to 30% reduction in disinfection by-product formation potential (DBPFP) when used after Ozone
- DBP precursor reduction
- Effective NDMA removal

![Graph showing TTHM (µg/L) over time](chart.png)

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How cost effective is it to maintain conventional treatment facility and implement alternative treatment technologies for expansion of municipal facilities?
Strategic Asset Management
Technology Evaluation

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<th>Scenario 1: No TN,TP limit</th>
<th>Scenario 2: No TP limit</th>
<th>Scenario 3: Baseline BNR</th>
<th>Scenario 4: Primary Clarifier</th>
<th>Scenario 5: Warm Weather</th>
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20-year NPV of Lifecycle Costs, 2012 USD, Millions

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Last Thoughts

- Beware commitments to technology with O&M costs beyond projected financial capacities
- Unplanned replacements costs of technologies early in the lifecycle can reduce the capacity to maintain long term success
- National trends in hydraulic flow reduction and an increase in loadings will require additional flexibility to be added to most existing conventional systems
- Increased flexibility typical equates to increased CAPEX and OPEX costs
- Wastewater treatment plant technology and processes needs to be evaluated differently when considering reuse
Recap Takeaways

- The Need for WWTP Rehabilitation
- Strategic Asset Management Approach

The Big Four

- Deferred Maintenance Considerations
- Approaching Capacity
- Aging Infrastructure
- Increasing Need for Water Reuse
Wastewater Treatment and Recycling Services:

- Facilities planning
- Alternatives analysis
- Life cycle assessment
- Comprehensive facility evaluations
- Bio-solids management planning
- Comparative benchmarking
- Treatability studies and pilot studies
- Process design
- Concept design
- Detailed design for bid/tender
- Construction phase engineering services
- Construction management and inspection
- Program management
- Automation/SCADA design and implementation
- Contract operations and maintenance
- O&M manuals
- Pretreatment programs
- Permitting and regulatory assistance
- Utility master planning
- Asset management
- Economic analysis and rate studies
- Startup and commissioning services
- Process and energy use optimization
- Design-build owner's engineering services
- Design-build and alliance partnerships

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