Upgrading/Retrofitting Your WWTP with MBR Technology

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Making the Old Young Again

After 10 years of Operation

After upgrade
Retrofit Opportunities
Drivers for Retrofits

• **The Traditional Reasons**
  - Increase flow, same footprint
  - Quality discharge effluent

• **Economic Downturn**
  - Cost
  - Quicker incremental upgrade

• **Regulations**
  - Total Maximum Daily Loads (TMDL)
  - Quality driven rather than technology based.

• **Recycle, Reuse**
  - Lower potable usage
Why MBR?
Look at the whole plant to see the advantages...
Fundamental Concept

Ovivo MBR Systems
Application in Retrofits

MLSS  Volume
The Existing System

3000 mg/l  MLSS  Capacity Q (MGD)

The MBR

12,000 mg/l  MLSS  Capacity 2-3 Q (MGD)
## Ovivo MBR Systems

**Application in Retrofits**

<table>
<thead>
<tr>
<th>Conventional MBR Systems</th>
<th>Retrofit Approach</th>
</tr>
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<tr>
<td><strong>Operations at 8,000 to 18,000 MLSS</strong></td>
<td>Maximize capacity within existing trains (Minimize new construction)</td>
</tr>
<tr>
<td><strong>Process aeration with fine bubble diffusers</strong></td>
<td>- Design MLSS between 11,000 and 12,000 mg/l</td>
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<tr>
<td><strong>Peaking capacity to 2.5Q</strong></td>
<td>- Use SNdN to minimize anoxic volume</td>
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<tr>
<td><strong>BNR (TN to &lt; 3 mg/l, P to &lt; 0.03 mg/l)</strong></td>
<td>- Use MBR oxic volume to offset Pre-Aeration volume</td>
</tr>
<tr>
<td>• Bio P</td>
<td><strong>Optimize MBR Selection</strong></td>
</tr>
<tr>
<td>• SNdN</td>
<td>- Balance basin SWD + HRT + SOTE</td>
</tr>
<tr>
<td><strong>Single recycle design</strong></td>
<td><strong>Utilize basins to further optimize system NPW</strong></td>
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<tr>
<td><strong>Total system efficiency 0.5 - 0.7 kWh/m³</strong></td>
<td>- Inline EQ for operations flexibility and energy</td>
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<tr>
<td><strong>SMUs:</strong></td>
<td>- Offline EQ for peaks (minimize MBR system size)</td>
</tr>
<tr>
<td>Small systems (&lt; 2 MGD): RM or RW</td>
<td>- Install MBTs (membrane thickeners)</td>
</tr>
<tr>
<td>Large systems (&gt; 5 MGD): SP400</td>
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</tbody>
</table>
SMU Model Sampling

**ES**
50 to 200 plates

**EK**
300 to 400 plates

**RM**
150 to 200 plates

**RW**
300 to 400 plates
The SP-400 SMU

Membrane block

Aeration block

Membrane module

Diffuser
# Conventional Activated Sludge Systems

<table>
<thead>
<tr>
<th>Typical CAS Characteristics</th>
<th>Retrofit Opportunity</th>
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<tbody>
<tr>
<td>MLSS Between 2,000-4,000 mg/l SRTs Between 5 and 15 days</td>
<td>Capacity &amp; BNR within existing basins</td>
</tr>
<tr>
<td></td>
<td>• No new basins</td>
</tr>
<tr>
<td>Primary and Secondary Clarifiers</td>
<td>Ability to re-task clarifiers</td>
</tr>
<tr>
<td></td>
<td>• Equalization for reducing MBRs</td>
</tr>
<tr>
<td></td>
<td>• Sludge thickeners</td>
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<tr>
<td>Multiple Trains</td>
<td>Ability to stage construction</td>
</tr>
<tr>
<td>Diffused Aeration Systems</td>
<td>Minimizing new air system costs</td>
</tr>
<tr>
<td>Depths Between 8’ and 16’</td>
<td>Select from multiple SMUs to optimize system</td>
</tr>
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Ovivo MBR Systems
Application in Retrofits – Canton, OH

Existing Plant
- Nitrifying Activated Sludge
  - 39 mgd average flow
  - 70 mgd peak day
- Current BNR
  - No TN limit (>20)
  - No Phosphorus limit (>1.9)
  - TSS Limit < 12
  - BOD Limit < 10
  - NH₃ Limit < 3

Goal of Upgrade
- Extend hydraulic capacity to
  - 42 mgd MMF
  - 88 mgd peak day
  - 110 mgd peak instantaneous
- Improve BNR to
  - TN < 8 mg/l
  - Phosphorus < 1 mg/l
Ovivo MBR Systems
Application in Retrofits – Canton, OH
Ovivo MBR Systems
Application in Retrofits – Canton, OH

Request for Proposal
• No single SMU technology specified
• No MLSS cap
• No flux cap
• Process design with supporting model (optimized per technology)

Present Worth Evaluation
• Total Plant
  • Capital Equipment
  • New tankage
  • Operations
    • Screening
    • Chemicals
    • Solids handling
Ovivo MBR Systems
Application in Retrofits – Canton, OH

Proposed MBR
- SP400 SMUs (12’ SWD)
- Single recycle for MBR process
- Bio P phosphorus removal
- 12,000 MLSS design concentration
- Pump assisted gravity permeate configuration
- Biological nutrient removal (BNR)

- No new basins
- Ability for phased construction
- Clarifiers available for EQ
- Supplementing existing air system
## Present Worth Summary of Alternatives

<table>
<thead>
<tr>
<th></th>
<th>Alt 1</th>
<th>Alt 2</th>
<th>Alt 3</th>
<th>Alt 4</th>
<th>Alt 5</th>
<th>Alt 6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Present Worth Cost</strong></td>
<td>Chem P</td>
<td>Bio P</td>
<td>Chem P &amp; BNR</td>
<td>Bio P &amp; BNR</td>
<td>IFAS</td>
<td>MBR</td>
</tr>
<tr>
<td><strong>Total Project Cost both Phase I and Phase II</strong></td>
<td>$107,575,000</td>
<td>$115,685,000</td>
<td>$103,700,000</td>
<td>$109,425,000</td>
<td>$100,635,000</td>
<td>$72,120,000</td>
</tr>
<tr>
<td><strong>Operation and Maintenance Cost</strong></td>
<td>$34,206,717</td>
<td>$38,765,693</td>
<td>$41,852,273</td>
<td>$45,355,979</td>
<td>$48,722,387</td>
<td>$43,332,085</td>
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<tr>
<td><strong>Total Present Worth All Cost</strong></td>
<td>$141,781,717</td>
<td>$154,450,693</td>
<td>$145,552,273</td>
<td>$154,780,979</td>
<td>$149,357,387</td>
<td>$115,452,085</td>
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Ovivo MBR Systems
Application in Retrofits – Rio Del Oro, NM

Rio Del Oro, NM
100,000 gpd Conventional Activated Sludge System

Existing system basins allowed for phasing of construction while continuing to treat wastewater through current system
Ovivo MBR Systems
Application in Retrofits – Rio Del Oro, NM

• **Phase 1 (200,000 gpd, completed)** converted existing clarifier to MBR basins
  single stack SMUs

• **Phase 2 (400,000 gpd)**, to convert premix channel and chlorine contact basin to an AX basin. Add upper decks to MBRs

• **Phase 3 – (future) 800,000 gpd**, will convert existing Pre-Air basin to a second MBR facility

• Class A1 effluent for reuse
• **Phase 1 in at $13/gallon**
• **Phase 2 planned for $5/gallon**
Existing Circular SBR Basins
Sequencing Batch Reactors

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<tr>
<td>• MLSS Between 2,000-4,500 mg/l</td>
<td>Capacity &amp; BNR within existing basins</td>
</tr>
<tr>
<td>• SRTs Greater than 12 Days</td>
<td>• No new basins</td>
</tr>
<tr>
<td>• Higher HRT to Accommodate Decant</td>
<td>Ability to re-task equalization</td>
</tr>
<tr>
<td>Discharge Equalization to Accommodate Decant Rate</td>
<td>• Additional BNR volume</td>
</tr>
<tr>
<td></td>
<td>• Influent equalization for reducing MBRs</td>
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<td></td>
<td>• Sludge thickener</td>
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<tr>
<td>Multiple Trains</td>
<td>Ability to stage construction</td>
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<tr>
<td>Aeration Systems Sized to Accommodate Batch Sequencing</td>
<td>Minimizing new air system costs</td>
</tr>
<tr>
<td>Deep Tanks (15’ -21’ )</td>
<td>• Select from multiple SMUs</td>
</tr>
<tr>
<td></td>
<td>• Gravity and PAG Designs</td>
</tr>
<tr>
<td>Square, Round, and Rectangular Tanks</td>
<td>Longer aspect ratios simplify retrofits</td>
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Ovivo MBR Systems
Application in Retrofits – Spirit Mtn, OR

Spirit Mountain Casino, OR
• ABJ SBR
• 195,800 gpd AAF
• 432,300 gpd MMF

New System
• Extended hydraulic capacity to
  • 300,000 gpd AAF
  • 600,000 gpd MMF
• Improve BNR to
  • BOD5 < 5 mg/l
  • TSS < 5 mg/l
  • Nitrate < 5 mg/l
  • Ammonia < 1 mg/l
Ovivo MBR Systems
Application in Retrofits – Spirit Mtn, OR

- ES200 SMUs
- Single recycle
- Pre React zone converted to anoxic
- Gravity permeate configuration
- Only new wall added was to create the MBR basin
### Oxidation Ditches

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| • MLSS Between 2,000-4,500 mg/l  
  • SRTs 15-30 Days | Biological capacity and improve BNR without adding process tankage |

**Clarifiers**

- Ability to re-task clarifier
  - Additional BNR volume
  - Influent equalization for reducing MBRs
  - Sludge thickener or sludge holding

**Shallow Tanks (10’ – 15’)**

- Select from multiple SMUs

**Surface Aerators or Brushes**

**Racetrack Configuration**

- Challenge with regard to retrofitting SMUs
Ovivo MBR Systems
Application in Retrofits - Oxidation Ditches
Ovivo MBR Systems
Application in Retrofits - Oxidation Ditches
**Retrofit Approach**

Maximize capacity within existing trains (Minimize new construction)
- Design MLSS between 11,000 and 12,000 mg/l
- Use SNdN to minimize anoxic volume
- Use MBR oxic volume to offset PA volume

Optimize MBR Selection
- Balance basin  SWD + HRT + SOTE

Utilize basins to further optimize system NPW
- Inline EQ for operations flexibility and energy
- Offline EQ for peaks (minimize MBR system size)
- Install MBTs (membrane thickeners)
Case Study - Wilbarger Creek MUD No. 2 MBR

- Hydraulic Loading
  - designed for 0.5 MGD

- Biological Loading
  - Designed for 200 mg/L BOD and 40 mg/L TKN

- Two Process Trains
  - Each with one anaerobic, anoxic, pre-air, and membrane zones

- Air supply system on common header
  - Membrane air scour
  - Pre-air zone course bubble diffusers
  - Multiple air lift pumps
Findings

- Influent flow 0.15-0.20 MGD (0.5 design)
- Influent BOD 300 and TKN 60 mg/L (200 and 30 design)
- Course bubble diffuses in pre-air basin limiting oxygen uptake
- Frequent membrane cleaning
  - Hard water
  - Dewatered sludge
  - CDS system designed to only fill 200 plates at a time
- Diffuser Cleaning Operation Inefficient
  - No ability to adjust air flow, high air flow (pressure) prevents efficient solids flow through diffuser
  - Fouled diffusers lead to dewatered sludge which leads to ineffective cleans
- Control System Malfunctions
  - Allowed permeate flow without air scour
- Hair and fiber agglomeration
- Energy Inefficient
  - 4.0kwHr/m³ (should be targeting 1.4)
Proposed Modifications

- Energy Pro Conversion
  - Allows using one or both process trains as required
  - Only requires addition of four electrical actuators and some programming
- Install fine bubble diffusers
  - Increased oxygen uptake efficiency
  - Less blower load
- Provide separate air flow setpoint for diffuser cleaning cycle
  - Allows for optimization of solids back flow through diffusers
- Increase CDS system to allow cleaning 5 units simultaneously
  - Implement 2/yr acid cleans to address hard water
- Verify and/or modify control system to ensure protective membrane interlocks
- Install dedicated drain pump to allow for proactive tank inspections
Questions?

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