New Dischargers Tackle Issue of Stricter Phosphorus Limits

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Overview

- Wisconsin phosphorus regulatory update
- Big Bend Facilities Plan
- Phosphorus removal alternatives and evaluation
- Alternative recommendation
Phosphorus Rules

- Revisions to Wisconsin’s Phosphorus Water Quality Standard became effective on December 1, 2010
- Reflected in Wisconsin Administrative Code - Chapter NR 102 and Chapter NR 217
Exclusions: ephemeral streams, limited aquatic life, wetlands, small lakes less than 5 acres in surface area
NR 217.17 Schedule of Compliance

(2) Maximum Compliance Schedule Period – Where compliance with the water quality based phosphorus limit requires the construction of filtration or a similar phosphorus removal process, the department may grant a compliance schedule not to exceed nine years from the date that the permit is first reissued or modified to include effluent limitations developed under provisions of this subchapter.
New Dischargers

NR 217.17 Schedules of Compliance

(4) New Dischargers. Any new discharger may not receive a compliance schedule to achieve compliance with a phosphorus water quality based effluent limitation.
Village of Big Bend
Statistics

- No current wastewater treatment plant
- No current collection system
- Original Facilities Plan written in 2007, approved in November 2010
  - Recommended alternative is construction of a new treatment plant
Original Playbook (Facilities Plan)

- New treatment plant
- Extended aeration activated sludge
- Design annual average flow: 366,000 gpd
- Two phases – First phase: 100,000 gpd from commercial area
- Discharge to Fox River
- Phosphorus limit of 1.0 established
Facilities Planning Area
Rules Updates

NR 102.06 Phosphorus

(3) (a) A total phosphorus criterion of 100 ug/L is established for the following rivers or other unidirectional flowing waters

15. Fox River from confluence with Mukwonago River near Mukwonago to state line, excluding Tichigan Lake
New Rules

- Must meet new phosphorus effluent limit on Day 1
  - Permit will be expressed as an annual average concentration limit of 0.1 mg/L and an annual mass limit
    - Monthly average concentration limit of 0.3 mg/L
  - 1/10 of the previous effluent limit
  - Treatment technology included in 2007 Facilities Plan is not sufficient to meet limit
Challenges

- No ability to pilot test
- Phased construction
Phosphorus Removal Alternatives
Alternatives

1. Disc Filters
2. Ballasted Flocculation
3. Upflow Gravity Filter
4. Membrane Filtration
5. Membrane Bioreactor
Disc Filters

- Tertiary treatment
- Cloth filters with approximate 10 μm pore size
- Backwashing to remove deposited solids
- Modular for easy expansion
- Chemical addition required
Disc Filters

(Courtesy of Veolia)
Ballasted Flocculation

- Tertiary treatment
- Polymer coated sand or magnetite (proprietary) added
- High rate clarification
- Ballasted floc rapidly settles
- Chemical addition required
Ballasted Flocculation

(Courtesy of WesTech)
Ballasted Flocculation

- Advantages
  - Treat wide range of flows without reducing removal efficiency

- Disadvantages
  - Limited growth potential
  - Large amount operator judgment and attention
  - Long startup time
Upflow Gravity Filter

- Tertiary Treatment
- Chemical addition required
- Modular for easy expansion
- Lower operator attention
  - No moving parts, screens, level controllers, or valves
Upflow Gravity Filter
Membrane Filtration

- Tertiary treatment
- Chemical addition required
- Ultrafiltration: ~0.04 to 0.4 μm pore size
- Sized to handle peak flow of twice the daily influent flow
  - Less flexibility adapting to flow rates
- Modular for easy expansion
- Automated for reduced operator attention
Membrane Filtration
Membrane Bioreactor

- Activated sludge reactor
- Functions of biological treatment, secondary clarification, tertiary filtration combined on one unit
  - Eliminates construction of extended aeration and final clarifier
- Ultrafiltration: ~0.04 to 0.4 μm pore size
- Sized to handle peak flow of twice the daily influent flow
Original Facilities Plan
Membrane Bioreactor

- **Advantages**
  - High effluent quality
  - Lower space requirement
    - Lower HRT
    - Combine functions of biological treatment, secondary clarification and tertiary filtration
  - Automated process
  - Higher SRT = Reduced sludge production and hauling
  - Modular for easy expansion
  - Tertiary disinfection?
Membrane Bioreactor

- Disadvantages
  - Less flexibility adapting to flow rates
  - WAS has lower settling rate
  - Maintenance
    - Air scouring
    - Cleaning
## Monetary Cost Evaluation

<table>
<thead>
<tr>
<th>Item</th>
<th>Alternative 1 Disc Filters</th>
<th>Alternative 2 Ballasted Flocculation</th>
<th>Alternative 3 Upflow Gravity Filter</th>
<th>Alternative 4 Membrane Filtration</th>
<th>Alternative 5&lt;sup&gt;(1)&lt;/sup&gt; MBR</th>
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<tbody>
<tr>
<td>Initial Capital Cost</td>
<td>$370,000</td>
<td>$826,000</td>
<td>$657,000</td>
<td>$1,089,000</td>
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<tr>
<td>Present Worth O&amp;M</td>
<td>$737,000</td>
<td>$411,000</td>
<td>$379,000</td>
<td>$461,000</td>
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<tr>
<td>Less Salvage Value</td>
<td>($7,000)</td>
<td>($15,000)</td>
<td>($12,000)</td>
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<td>Total Present Worth Cost</td>
<td>$1,100,000</td>
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<td>$1,024,000</td>
<td>$1,530,000</td>
<td>$859,000</td>
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</table>

**Note:**

1) Includes the elimination of the extended aeration and final clarifier structures and equipment costs.
## Non-Monetary Cost Evaluation

<table>
<thead>
<tr>
<th>Item</th>
<th>Alternative 1 Disc Filters</th>
<th>Alternative 2 Ballasted Flocculation</th>
<th>Alternative 3 Upflow Gravity Filter</th>
<th>Alternative 4 Membrane Filtration</th>
<th>Alternative 5 MBR</th>
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<tbody>
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<td>Water Quality</td>
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<td>Ease of Operation</td>
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<tr>
<td>Flexibility</td>
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<tr>
<td>Total</td>
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Note: Higher value means more desirable.
And the winner is...
Membrane Bioreactor (MBR)

(Courtesy of GE)
Plant includes pump station, fine screen, anaerobic basin, anoxic basin, aeration basin, equalization basin, MBR, UV disinfection, aerobic digester, control building

Membrane racks and modules, air scour, compressed air, process and backpulse skids included with MBR

Costs

- Original: $5,871,000
- Increase: $981,000
- Revised: $6,852,000
MBR Xs and Os
Statistics

- MLSS is 3-4 times higher for MBR facilities
  - Conventional: 2,000 – 4000 mg/L
  - MBR: 8,000 – 12,000 mg/L
- RAS Recycle
  - Conventional: 0.5 – 1.5 times the influent flow
  - MBR: 2 – 4 times the influent flow
- Current Wisconsin installation: Stockbridge-Munsee Community WWTF
Statistics

- Big Bend will utilize biological phosphorus removal with optional chemical addition
  - Anaerobic, anoxic, and aerobic tanks
  - Equalization basin

(Crawford, Daigger, Erdal – WEFTEC 2006)
Biological Phosphorus Removal

- Microorganisms release phosphorus while consuming and storing food as PHB in anaerobic zone
- Microorganisms consume the stored food and absorb excess phosphorus in anoxic/aerobic zone
- Stored phosphorus is removed when excess sludge (WAS) is wasted
- Saves on chemical costs
- Install chemical phosphorus system for backup
Chemical Phosphorus Removal

- Coagulant addition to precipitate phosphorus
  - Aluminum: $\text{Al}^{3+}$
  - Iron: $\text{Fe}^{3+}$
  - Calcium: Typically as lime, $\text{Ca(OH)}_2$
- Precipitated material captured as part of sludge removal
- Chemical removal increases sludge production approximately 25%
Potential Design Issues

- High mixed liquor recirculation
  - Protect against excessively high MLSS concentrations in MBR
  - Highly aerated recirculating flow can consume substrate, making unavailable for PAOs
- Low HRT in anaerobic and anoxic zones
  - Provide adequate mixing to avoid short-circuiting
- Flow equalization can simplify potential design issues

(Crawford, Daigger, Erdal – WEFTEC 2006)
EBPR with MBR

- Traverse City, Michigan
  - Design average annual flow: 8.5 mgd
  - Average effluent TP: < 0.5 mg/L
  - Most successful when mixed liquor recycle rate is greater than four times the influent flow
  - Chemical addition included

(Crawford, Daigger, Erdal – WEFTEC 2006)
EBPR at Traverse City

(Crawford, Daigger, Erdal – WEFTEC 2006)
Traverse City, Michigan

(http://www.glslcities.org/TraverseCity_Treatment_Plant.pdf/)
EBPR with MBR

- Southwest Water Reclamation Facility – Henderson, Nevada
  - Initial capacity: 4.5 mgd
  - Can meet 0.1 mg/L Total P with no chemical addition

(Crawford, Daigger, Erdal – WEFTEC 2006)
Henderson, Nevada

New phosphorus regulations require Big Bend to meet 0.1 mg/L Total Phosphorus effluent limit from Day 1

MBR with biological phosphorus removal chosen as cost-effective alternative
Questions?
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