Ballasted Clarification with Enhanced MLSS (BioMag) Doubles Plant Capacity within Existing Activated Sludge System-A Pilot Study at Kemptville, ON
Project Team

• Project Coordination: City of North Grenville, ON
• Project Engineering: XCG Consultants-Oakville, ON
• Equipment and Support: Evoqua Water Technologies
• Funding: Ontario Ministry of the Environment-Innovative Technology Grant Program
Presentation Outline

• Background and Project Objectives
• BioMag™ Process Overview
• Demonstration Methodology
• Results
  • Biological Treatment Performance
  • Clarifier Stress Testing
• Conclusions
Background and Project Objectives

Existing Kemptville WPCP
- CAS with tertiary filtration
- Built 1993
- ADF capacity 1.2 MGD
- Peak capacity 3.0 MGD (exceeded)

Environmental Assessment 2010 (future needs/growth)
Study Recommendations:

- Equalization to attenuate peak flows and minimize footprint for expansion
- Expand CAS process (2 X); aeration and clarification to 2.4 MGD
- Expand filtration system
- Land Acquisition likely necessary
- Evaluate Alternative Technologies
BioMag Pilots & Resulting Installations

• Sturbridge, MA
• Allenstown, NH
• Mystic, CT
• Marlborough East, MA
• Upper Gwynedd, PA
• Taneytown, MD
• Smithburg, MD
• Winebrenner, MD
• Berkeley County, VA
BioMag Interest & Potential Benefits

• Improved Secondary Settling; Increased Capacity & Reliability of Clarifiers
• Ability to Operate at Higher MLSS; Increased Capacity of Biological System
• Reduced Footprint; Use Existing Tankage
• Longer Sludge Age; Improved Nitrification
• Reduced Lifecycle Costs
• No additional land acquisition
MOE Innovative Technology Grant-Demonstration Project Objectives

- Evaluate BioMag as an alternative to conventional expansion
- Determine feasibility of converting CAS to BioMag™-full scale demonstration
- Confirm treatment capacity (average and peak)-BioWin model and stress test
- Achieve secondary effluent targets: 10 BOD; 10 TSS; 1 NH3-N; 0.3 P
- Potential elimination of EQ and land acquisition
BioMag™ Process Overview
Magnetite: $\text{Fe}_3\text{O}_4$

- Fully oxidized iron ore
- Completely inert (NSF cert.)
- Non-abrasive (10 - 30 microns)

Four compelling properties

- Specific Gravity= 5.2
- Hydrophobic: affinity to embed in floc
- Magnetically retrievable
- Inexpensive ~30¢/lb
Clarifiers determine the capacity of a WWTP
Methodology

• Full-scale demonstration
  • Installation of magnetite ballast feed & recovery system using on-site trailer
  • Removal of one bioreactor and one clarifier from service; isolate single train for treatment
  • Acclimation period to build MLSS and magnetite level
  • Long-term (3 month) test
  • Short-term peak flow testing (PDA & PHR)
Kemptville WPCP – Process Schematic

- Raw Sewage
  - Mechanical Bar Screen
  - Wet Wells
  - Raw Sewage Pumps
  - Grit Channels
  - Flash
  - Mix
  - Grit to Landfill
  - Primary Clarifiers
  - Raw Sludge and Scum to Primary Digester
  - Aeration Tanks
  - Secondary Clarifiers
  - Secondary Digester Supernatant
  - Alum Flocculation Tanks
  - Ultraviolet Disinfection Chamber
  - Effluent Holding Tanks
  - Effluent Pumps
  - To Outfall Diffuser
  - Effluent Pumps
  - Tertiary Filters
  - Tertiary Filter Bypass
  - Equinelle SPS
  - Ryan's Well Drive SPS
  - Primary Clarifiers
  - Raw Sludge and Scum to Primary Digester
  - Alum
  - RAS
  - WAS
  - Aeration Tanks
  - Primary Clarifiers
  - Secondary Clarifiers
  - Flash Mix
  - Flocculation Tanks
  - Ultraviolet Disinfection Chamber
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- Raw Sewage
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  - Wet Wells
  - Raw Sewage Pumps
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  - Raw Sludge and Scum to Primary Digester
  - Aeration Tanks
  - Secondary Clarifiers
  - Secondary Digester Supernatant
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  - Tertiary Filters
  - Ultraviolet Disinfection Chamber
  - Effluent Holding Tanks
  - Effluent Pumps
  - To Outfall Diffuser
  - Effluent
  - Pumps

- WAS
- ML Return
- BWA
- S
- ML
- Polymer
- Offline
- BioMag™ Trailer
- ML

- Equinelle SPS
- Ryan’s Well Drive SPS
- Tertiary Filter Bypass
- Kemptville WPCP
Trailer with ballast mix tank
BioMag™ Demonstration at Kemptville WPCP
BioMag™ Demonstration at Kemptville WPCP
Magnetite Recovery Drum – How it Works

- The magnetite recovery drum receives the ballasted WAS.
- The sludge then flows down through the sump.
- Magnetite is captured onto the rotating drum surface by a stationary array of magnets.
- Magnets are located just inside of the cylindrical stainless steel shell that rotates around the magnets.
- Recovered magnetite flows to the ballast mix tank.
- Waste sludge flows by gravity and is discharged into the WAS tank.
Long-Term Test Results

Primary Effluent During Test

• BOD-132 mg/l
• TSS-115 mg/l
• TKN-36 mg/l
• TP-4 mg/l
Long-Term Test Results

• Operating Conditions:
  • Total MLSS: 20,036 mg/L
  • Magnetite: 13,091 mg/L
  • Effective MLSS: 6,945 mg/L
  • ADF: 0.55 MGD

• Performance - Secondary Effluent:
  • TSS: 7.7 mg/L 10 target
  • cBOD5 3.9 mg/L 10
  • TAN 0.10 mg/L 1
  • TP 0.18 mg/L 0.3

Average SVI: 50 mL/g
Long Term Test Results

Figure 5.1  *BioMag™ Demonstration Secondary Effluent cBOD₅ Concentration*
Long-Term Test Results

*BioMag™ Demonstration Secondary Effluent TSS Concentration*
Long-Term Test Results

![Graph showing phosphorus concentration over time](image)

**BioMag™ Demonstration Secondary Effluent TP Concentration**
BioMag™ – Microscopic Mixed Liquor Analysis

5,900 mg/L MLSS
2,150 mg/L magnetite
Magnetite:MLSS ratio
0.36
BioMag™ – Microscopic Mixed Liquor Analysis

8,600 mg/L MLSS
10,000 mg/L magnetite
Magnetite:MLSS ratio 1.2
## MODELING RESULTS @ 7000 mg/l Bio MLSS

<table>
<thead>
<tr>
<th>Flow</th>
<th>NH3-N Objective</th>
<th>Model Prediction</th>
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</thead>
<tbody>
<tr>
<td>ADF 2.4 MGD</td>
<td>4 mg/l (winter)</td>
<td>1.34 mg/l</td>
</tr>
<tr>
<td>ADF 2.4 MGD</td>
<td>1 mg/l (summer)</td>
<td>0.53 mg/l</td>
</tr>
<tr>
<td>Max Mo 4.0 MGD</td>
<td>4 mg/l (winter)</td>
<td>2.71 mg/l</td>
</tr>
<tr>
<td>Max Mo 4.0 MGD</td>
<td>1 mg/l (summer)</td>
<td>0.73 mg/l</td>
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</tbody>
</table>
Stress Testing

- 2 day simulation; PkDay; PkHour
- Recirculate from tertiary floc tank
Stress Test Targets

• Flow 3.96 MGD (1 hr.) / 2.64 MGD (3 hr.)
• Flow 1.85 MGD (6 hrs)
• SOR max: 883 gpd/sf (1 hr.)
• SLR max: 57-80 lb/da/sf (1 hr.)
Flow Ramp-Up

• Day-1: Flow increased on hourly intervals from 1.0 MGD to 2.0 MGD

• Day-2: Brought flow up to approximately 2.64 MGD for a sustained 3 hours
Stress Test Results

Day 1 – Surface Overflow Rate

- 945 gpd/sf; 2 MGD
- 859 gpd/sf
- 883 gpd/sf
- 982 gpd/sf

Current Design 720 gpd/sf (29)

Anticipated BioMag™ Pilot Maximum
SOR of 36 m³/m²/d
Stress Test Results

Day 1 – Solids Loading Rate

67 lb/da/sf

80 lb/da/sf

57 lb/da/sf

Current Design 26 lb/da/sf (127)
Stress Test Results

Day 1 – Effluent TSS Concentrations and Turbidity
Stress Test Results

Day 1 – Effluent TP and Orthophosphate Concentrations
Stress Test Results

1369 gpd/sf; 2.64 MGD

883 gpd/sf, MOE guideline (36)
Stress Test Results

98 lb/da/sf; 80 lb/da/sf; 57 lb/da/sf

MOE guideline 35 lbs/da/sf (170)
Stress Test Results

Day 2 – Effluent TSS Concentrations and Turbidity
Stress Test Results

Day 2 – Effluent TP and Orthophosphate Concentrations
## Stress Test Results

<table>
<thead>
<tr>
<th>Day of testing</th>
<th>Max SOR Gpd/sf</th>
<th>Max SLR Lb/da/sf</th>
<th>Sec Effluent TSS (mg/l)</th>
<th>Sec Effluent TP (mg/l)</th>
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</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>945</td>
<td>67</td>
<td>5.4</td>
<td>0.14</td>
</tr>
<tr>
<td>Day 2</td>
<td>1369</td>
<td>98</td>
<td>12</td>
<td>0.17</td>
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<tr>
<td>Target</td>
<td>883</td>
<td>57-80</td>
<td>10</td>
<td>0.3</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow</th>
<th>Limiting SOR</th>
<th>SOR Capacity</th>
<th>Limiting SLR</th>
<th>SLR Capacity</th>
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</thead>
<tbody>
<tr>
<td>Peak Day</td>
<td>945</td>
<td>3.94 MGD</td>
<td>67</td>
<td>4.23 MGD</td>
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<tr>
<td>Peak Hour</td>
<td>1369</td>
<td>5.71 MGD</td>
<td>98</td>
<td>5.88 MGD</td>
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</table>
# PLANT CAPACITY SUMMARY

<table>
<thead>
<tr>
<th></th>
<th>AVE DA Flow</th>
<th>MAX DA FLOW</th>
<th>PHR FLOW</th>
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</thead>
<tbody>
<tr>
<td>Bioreactors</td>
<td>2.4 MGD</td>
<td>4.0 MGD (Mmo)</td>
<td></td>
</tr>
<tr>
<td>Sec. Clarifiers</td>
<td>4.2 MGD</td>
<td></td>
<td>5.88 MGD</td>
</tr>
<tr>
<td>Overall Secondary</td>
<td>2.4 MGD</td>
<td>4.2 MGD</td>
<td>5.88 MGD</td>
</tr>
<tr>
<td>Existing Rated Capacity</td>
<td>1.2 MGD</td>
<td>3.0 MGD</td>
<td>3.0 MGD</td>
</tr>
</tbody>
</table>
Conclusions

• Conversion of CAS process to BioMag™ is a very feasible option, eliminating additional CAS and clarification tank expansion, saving space and land $.

• Potential capacity of existing bioreactor and secondary clarifier tankage operated as BioMag™:
  – ADF: 2.4 MGD (200% of existing rated capacity)
  – Peak flow: > 5.8 MGD (193% of existing rated capacity)
  – Able to meet MOE effluent requirements

• Potential cost savings for secondary treatment expansion
  – Estimated 25% to 40% capital cost savings BioMag™ retrofit vs. expanding CAS
Conclusions

• No major EQ required
• Magnetite recovery 95%
• Work required to implement:
  • Ballast storage and feed systems
  • Ballast recovery system
  • Polymer feed system
  • Mixers in bioreactors
  • Aeration system upgrade (diffusers, blowers)
  • Electrical and control upgrade
MORE OUT OF YOUR TANKS!

- MLSS: 3,500
- 2xQ
- SLR: 40-50
- RAS
- WAS
- Magnetite Recovery
- Magnetite Recycle
- Magnetite Feed

- Flow
- 8,000+
- 100-120
- 40-50
- WAS
BIOMAG APPLICATIONS

- Capacity increase: 2X – 3X
- TN removal within existing tanks
- Ultra low TP without filters
- High peaking factors
- Process stability
- Site constraints
- Tight budgets

The cheapest concrete is the one you own!
BioMag / CoMag Installations, Experience

- Developed in the US in the late 90s
- 50 Projects sold up to date
- 48 Pilots conducted
THANK YOU FOR YOUR ATTENTION

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