APPENDIX M

Workshop Handouts
Madison Metropolitan Sewer District

Solids Handling Facilities Plan

Kickoff Meeting
June 4, 2008
Influent BOD

ADW = 265 mg/L
Max Month = 284 mg/L

Influent Ammonia

ADW = 34.4 mg/L
Max Month = 35.8 mg/L

Influent Phosphorus

ADW = 6.4 mg/L
Max Month = 6.8 mg/L

Influent Summary

<table>
<thead>
<tr>
<th>Process Parameter</th>
<th>Average Dry Weather (mg/L)</th>
<th>Maximum Month (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent ADW Flow</td>
<td>38.3</td>
<td>58.8</td>
</tr>
<tr>
<td>Influent ADW TSS</td>
<td>233</td>
<td>287</td>
</tr>
<tr>
<td>Loading, lb/day</td>
<td>76,000</td>
<td>91,000</td>
</tr>
<tr>
<td>Influent ADW BOD</td>
<td>261</td>
<td>284</td>
</tr>
<tr>
<td>Loading, lb/day</td>
<td>88,950</td>
<td>94,900</td>
</tr>
<tr>
<td>Influent ADW NH4</td>
<td>24.4</td>
<td>25.8</td>
</tr>
<tr>
<td>Influent ADW P</td>
<td>6.4</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Notes:
(1) Average dry weather influent characteristics for the period of 01/00 to 05/00.
Advanced Digestion Improves Gas Production Efficiency

Digestion Process Alternatives
**Digestion Process Alternatives**

- **Class B Alternatives (all mesophilic)**
  - Conventional digestion
  - Staged digestion
  - Two-phase digestion

- **Class A Alternatives**
  - Temperature-phase anaerobic digestion (TPAD) with thermophilic batch digesters
  - Two-phase digestion (meso-thermo)

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**Digester Process Comparison**

<table>
<thead>
<tr>
<th>Process</th>
<th>SRT per Tank at Max Month (days)</th>
<th>Total SRT at Max Month (days)</th>
<th>Operating Temperature</th>
<th>VS Loading at Max Month (lb/af/day)</th>
<th>Pathogen Level Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Digestion</td>
<td>15</td>
<td>15</td>
<td>Mesophilic</td>
<td>0.18</td>
<td>Class B</td>
</tr>
<tr>
<td>Stage Digestion</td>
<td>15/5</td>
<td>20</td>
<td>Mesophilic</td>
<td>0.18</td>
<td>Class B</td>
</tr>
<tr>
<td>Two-Phase Digestion</td>
<td>2/12</td>
<td>14</td>
<td>Mesophilic</td>
<td>1.3-2.5</td>
<td>Class B</td>
</tr>
<tr>
<td>Temperature Phase Digestion</td>
<td>5/10</td>
<td>15</td>
<td>Thermophilic-Mesophilic</td>
<td>0.3</td>
<td>Class A</td>
</tr>
<tr>
<td>Two-Phase Digestion</td>
<td>2/12</td>
<td>14</td>
<td>Mesophilic-Thermophilic</td>
<td>1.5-2.5</td>
<td>Class A</td>
</tr>
</tbody>
</table>

---

**Anaerobic Digestion is Naturally a Two Step Process**

- Acid bacteria convert volatile suspended solids to volatile fatty acids (VFA)
  - Relies on fast growing bacteria (1-2 days SRT)
  - Like pH ~ 5

- Methane bacteria convert VFA to methane and carbon dioxide
  - Relies on slower growing bacteria (10-12 days SRT)
  - Like pH ~ 8

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**Conventional Digestion Process (Class B)**

- Acid and methane bacteria live and compete in same tank
- Currently used at DSRSD

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**Conventional Digestion Process**

- Raw Sludge
- Acid Formers
- Methane Formers
- Dewatering/Disposal
- Digested Sludge
- Volatile Begasing Solids
- Methane Formers
- pH ~ 7.9
- Metaphilic

---
**Staged Digestion Process (Class B)**
- Similar to conventional digestion except operated in series instead of parallel configuration
- Can be used at DSRSD

**Temperature-Phase Digestion Process (Class A)**
- Thermophilic temperature provides enhanced digestion
- Currently used at Sturgeon Bay, WI

**Two-Phase Digestion Process (Class B)**
- Acid and methane bacteria live and thrive in separate tanks
- Currently used at City of Turlock and Inland Empire Utilities Agency, CA

**Two-Phase Digestion Process (Class A)**
- Same as two-phase digestion for Class B except change methane-phase digesters to thermophilic operation
- Currently used at DuPage County (IL) and can be used at Inland Empire (CA)
So How Will MMSD Decide Which Digestion Process to Use?

- Will depend on near-term and long-term goals
- Can implement improvements in phases?

<table>
<thead>
<tr>
<th>Goal</th>
<th>Digestion Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add reliability and redundancy</td>
<td>Conventional digestion</td>
</tr>
<tr>
<td>Increase volatile solids destruction and gas production and reduce O&amp;M costs</td>
<td>Two-phase digestion (mesophilic)</td>
</tr>
<tr>
<td>Implement FOG digestion</td>
<td>Conventional digestion, two-phase digestion, or temperature-phase digestion</td>
</tr>
<tr>
<td>Plan for Class A biosolids</td>
<td>Two-phase digestion or temperature-phase digestion</td>
</tr>
</tbody>
</table>

Site Visit Opportunities

- Objective
  - Learn first-hand about advanced digestion processes and FOG/septage facilities
- Two-phase Digestion
  - DuPage, IL
- Thermophilic Digestion
  - EBMUD, CA
- FOG/Septage Facilities
  - Watsonville, CA
  - South Bayside Sewer Authority, CA

Effective Digester Mixing Is Important Because...

- Provides good mixing of active biomass and incoming feed sludge
- Increase volatile solids reduction efficiency
- Increase potential for higher gas production
- Minimizes foam/grit accumulation
**Digester Mixing Alternatives**

Draft tube mixing  
Pump mixing

**Draft Tube Mixing**
- Technology currently used at DSRSD
- Reversible mixing pattern
- Internal (roof-mounted) or external mounted design
- Digester operating liquid elevation must remain constant

**Pump Mixing**
- Axial flow, screw centrifugal, or chopper type pumps
- Draw sludge from bottom or top of digester
- High-velocity discharge through perimeter or internal nozzles
- Allows variable digester operating liquid elevation
- Continuous or intermittent operation

**Preliminary Digester Mixing Technology Comparison**

<table>
<thead>
<tr>
<th>Plant</th>
<th>Pump Mixing</th>
<th>Draft Tube Mixing</th>
<th>$/MG Mixed (Capital Cost)</th>
<th>$/MG Mixed (20-yr Life Cycle Cost)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eugene, OR</td>
<td>N/A</td>
<td>4 external 24-inch diameter draft tubes 45 hp total</td>
<td>$577,160</td>
<td>$1,085,000</td>
</tr>
<tr>
<td>Monterey, CA</td>
<td>1 Vaughan Chopper Pump 55 to 100 hp total</td>
<td>N/A</td>
<td>$591,050</td>
<td>$1,205,000 to $1,488,000</td>
</tr>
<tr>
<td>DSRSD, CA</td>
<td>1 Vaughan Chopper Pump 37 5 to 75 hp total</td>
<td>3 roof mounted 24-inch diameter draft tubes 30 hp total</td>
<td>$575,000 (draft tube mixing) $500,000 (pump mixing)</td>
<td>$963,000 (draft tube mixing) $626,000 (pump mixing)</td>
</tr>
</tbody>
</table>

12
### Preliminary Digester Mixing Technology Comparison

<table>
<thead>
<tr>
<th>Mixing Technology</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft Tube Mixing</td>
<td>- Plant staff familiar with operating procedures</td>
<td>- Large dome/wall penetrations</td>
</tr>
<tr>
<td></td>
<td>- Multiple mixers provide added reliability</td>
<td>- Root mounted motors are more difficult to access and maintain</td>
</tr>
<tr>
<td></td>
<td>- Lower slime formation potential than pump mixing</td>
<td>- Impeller can be prone to clogging with rags</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Must run continuously</td>
</tr>
<tr>
<td>Pump Mixing</td>
<td>- Easier access to equipment for routine maintenance</td>
<td>- Higher slime formation potential than draft tube mixing</td>
</tr>
<tr>
<td></td>
<td>- Chopper pumps moderate rags and debris to reduce clogging</td>
<td>- Internal piping and nozzle mixing systems are located inside the digester</td>
</tr>
<tr>
<td></td>
<td>- Allows variable digester operating liquid elevation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Can operate pump intermittently to reduce energy cost</td>
<td></td>
</tr>
</tbody>
</table>

### Digester Heating Design
- Spiral heat exchanger
- Others?

### FOG Digestion Increases Gas Production

### FOG Receiving Facility
Characterization of High Strength Wastes is Critical for the Estimation of Performance

Next Steps
**Madison Metropolitan Sewer District**

**Solids Handling Facilities Plan**

Workshop No 2a
Interim Operation

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**Agenda**

1. Current Operation
2. Recent Problems
3. Operating the Digestion System for the Next 2-3 years
4. Alternative Operating Strategies
5. Field Visit
6. Post Field Visit Wrap-up

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**Current foaming events may be attributed to clarifier scum.**

1. Foaming events associated with WAS digestion. WAS and scum are sent to DAFT.
2. Less grease problems in heat exchangers under acid-phase mode.
   a. Scum accumulation with gas mixing systems.
   b. Acid digester retains the scum. Increased foaming in acid digester and less grease problems downstream.
3. Poor Mixing in Acid Digester
   a. Operation at low-liquid level may reduce the mixing efficiency.
   b. Gas mixing in acid digester undermines benefit of low gas production during acidification.
   c. Interior columns may interfere with mixing.
Interim Operation in Conventional Digestion Mode

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Avg</th>
<th>Max Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRT</td>
<td>13.6</td>
<td>15.0</td>
</tr>
<tr>
<td>VSLR</td>
<td>0.16</td>
<td>0.15</td>
</tr>
</tbody>
</table>

- Meets criteria of 0.18 (basic max VSLR)
- Meets criteria of 15-day min HRT at max month flow with all tanks in service
- Close to criteria of 15-day min HRT at average flow with largest out of service

Interim Operation in Staged Digestion Mode

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Avg</th>
<th>Max Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary HRT</td>
<td>13.3</td>
<td>11.7</td>
</tr>
<tr>
<td>VSLR</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>Secondary HRT</td>
<td>5.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

- Does not meet criteria of 0.18 (basic max VSLR) at average flow with largest unit out of service
- Does not meet criteria of 15-day min HRT in primary digesters
- Meets criteria of 5-day max HRT in secondary digester

Interim Operation in D7 Cold Storage Mode

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Avg</th>
<th>Max Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 HRT</td>
<td>3.9</td>
<td>3.3</td>
</tr>
<tr>
<td>VSLR</td>
<td>0.56</td>
<td>0.66</td>
</tr>
<tr>
<td>Stage 2 HRT</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Field Visit
Post Field Visit Wrap-Up

1. Feasibility of Interim Operation Alternatives
2. Additional Alternatives
3. Addressing Operating Problems
   a. Foaming
   b. Struvite/Vivianite formation
   c. Stable Digestion
4. Other Issues
5. Adjourn

Agenda

1. Conclusions from TM 1 and 2
2. TM 3 Selected Alternative Evaluation
   a. Differences between operation and Master Plan assumptions - Effect on Process Sizing
   b. Other improvements required for long term acid phase operation
3. TM 4 Interim Operation
4. Wrap-up

Madison Metropolitan Sewer District
Solids Handling Facilities Plan
Workshop No 2b
Project Update

Applied Technologies
Engineers - Architects

TM 1 Identifies the Design Criteria

<table>
<thead>
<tr>
<th>Process Parameter</th>
<th>2007 Conditions</th>
<th>2030 Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Max Monthly</td>
</tr>
<tr>
<td>Plant Influent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow, mgd</td>
<td>42.9</td>
<td>53.0</td>
</tr>
<tr>
<td>TSS Loading, gpd</td>
<td>77,700</td>
<td>33,300</td>
</tr>
<tr>
<td>BOD Loading, gpd</td>
<td>85,100</td>
<td>190,100</td>
</tr>
<tr>
<td>COD Loading, gpd</td>
<td>13,900</td>
<td>14,500</td>
</tr>
<tr>
<td>Oil Loading, gpd</td>
<td>2,100</td>
<td>2,300</td>
</tr>
<tr>
<td>Solid Sludge %</td>
<td>65.400</td>
<td>76.500</td>
</tr>
<tr>
<td>Waste Activated Sludge to Primary</td>
<td>60,200</td>
<td>45,800</td>
</tr>
<tr>
<td>Thickened Sludge to Digestion</td>
<td>151,100</td>
<td>117,100</td>
</tr>
<tr>
<td>Thickened Solids, gpd</td>
<td>76,900</td>
<td>89,900</td>
</tr>
</tbody>
</table>

Notes:
1. Design on the 30-Year Master Plan: recommended loads assuming flows for
   - Individual buildings: 10% TSS, 25% BOD, 10% COD, 10% oil, and
     50% solids for solids handling facilities
   - TSS (104) loading
   - BOD (104) loading
   - COD (104) loading
   - Oil (104) loading
   - Solids (104) loading
2. Based on 2007 average solids capture efficiency of 91% for solids handling.
   - Proposed solids handling solids capture efficiency of 97% for solids handling.
3. Based on 2007 average solids capture efficiency of 91% for solids handling.
   - Proposed solids handling solids capture efficiency of 97% for solids handling.
4. Based on 2007 average solids capture efficiency of 91% for solids handling.
   - Proposed solids handling solids capture efficiency of 97% for solids handling.
**TM 2 Presents Class A Biosolids Processing Technology Screening**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Activated Carbon</th>
<th>Biofiltration</th>
<th>Membrane</th>
<th>Nozzles</th>
<th>Spouts</th>
<th>Sludge Age</th>
<th>Additional Operational Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composting</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low energy consumption, no change in odours, reduced solids content, and reduced odour.</td>
</tr>
<tr>
<td>Membrane</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low energy consumption, no change in odours, reduced solids content, and reduced odour.</td>
</tr>
<tr>
<td>Biofiltration</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Low energy consumption, no change in odours, reduced solids content, and reduced odour.</td>
</tr>
<tr>
<td>Membrane</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low energy consumption, no change in odours, reduced solids content, and reduced odour.</td>
</tr>
<tr>
<td>Activated Carbon</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low energy consumption, no change in odours, reduced solids content, and reduced odour.</td>
</tr>
</tbody>
</table>

**DAFT units receive WAS and clarifier scum.**

**Consistency between WAS and DAFT**

**Inconsistency between Primary Sludge and Gravity Thickeners**
Technical Memorandum No. 3
Presents Evaluation of Cambi and Acid Phase MTM

Conventional Digestion with Cambi THP Requires Less Tankage than Acid Digestion.

<table>
<thead>
<tr>
<th>Future Flow (20.7 mgd)</th>
<th>Conventional Digestion with Cambi THP</th>
<th>Acid Phase Digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6% Solids Feed</td>
<td>6% Solids Feed</td>
</tr>
<tr>
<td></td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td></td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Existing digester</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>New 0.5 MG Acid Digester</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>New Cambi THP System</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>New Methane Digester Required for Solids Concentration less than 6%</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

Sludge Thickening Improvements Required for Modified Digestion Facility.

<table>
<thead>
<tr>
<th>Table 4.1 Existing Sludge Thickening Units</th>
<th>Madison Metropolitan Sewer District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity Thickener</td>
<td>DAFT</td>
</tr>
<tr>
<td>Number of Units</td>
<td>2</td>
</tr>
<tr>
<td>Diameter, ft</td>
<td>55</td>
</tr>
<tr>
<td>Total Surface Area, sqf</td>
<td>4,752</td>
</tr>
<tr>
<td>Solids Loading, ppm</td>
<td>65,400 (1)</td>
</tr>
<tr>
<td>Solids Capture Efficiency, %</td>
<td>98.3</td>
</tr>
<tr>
<td>Thickened Sludge Solids, %</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Notes:
(1) Primary sludge
(2) Wastewater sludge

Internal structure of digesters may affect the mixing system design.
Temperature input to estimate the digester heating requirements.

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>71</td>
<td>16</td>
</tr>
<tr>
<td>Ground</td>
<td>70</td>
<td>40</td>
</tr>
<tr>
<td>Raw Sludge</td>
<td>70?</td>
<td>65?</td>
</tr>
</tbody>
</table>

Temperature in degrees Fahrenheit.

TM4 Identifies Interim Operation Modifications

1. Boundary Conditions
   a. Must be In-Place before Winter 2008
   b. Must improve:
      - Reliability
      - Foaming
      - Struvite/Vivianite
      - Grease in Heat Exchangers
   c. Must not require large capital expenses

Current Operation D7 as Acid Phase

Interim Operation in Staged Digestion Mode (Alternate)
Summary of Interim Operation

1. Operating D3 as an acid phase will not be possible before winter, requires significant piping modifications.
2. Operating in staged digestion mode will not resolve operating challenges.
3. Operation in single stage mesophilic digestion for the interim period resolves operational issues and can be implemented before winter.
MADISON METROPOLITAN
SEWERAGE SYSTEM

SOLIDS HANDLING
FACILITIES PLAN

WORKSHOP 3: PROGRESS MEETING
November 5, 2008

Agenda
- Workshop Goals
- Interim Operation - Update
- TM 03 – Anaerobic Digestion Process Evaluation
- Anaerobic Digestion Process Selection
- TM 04 – Digester Ancillary Systems Evaluation
- Next Steps and Wrap-up

Workshop No. 3 Goals
1. Select Sludge Stabilization Process
2. Key Decision to Finalize TM No. 3
3. Future Technical Memoranda
4. Define Next Steps and Timeline

Conventional Digestion was
Selected for Interim Operation
Lessons Learned

1. Conventional mesophilic has provided stable operation at Nine Springs.
2. Struvite problems have been mitigated
3. Vivianite?
4. Digester gas production has dropped from 800 kcf/d to 700 cf/d
5. Foam has not been detected in 1,2,3 and 7. 4,5,6 show minimal foam.
6. Propionate in Digester 7 took approximately 2 months to subside.
Technical Memorandum 3: Anaerobic Digestion Process Evaluation

Three proven technologies were compatible with MMSD’s goals.

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>CLASS A/G</th>
<th>MMSD PROGRAMS</th>
<th>FULLSCALE INSTALLATIONS</th>
<th>ENERGY RECOVERY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Digestion with Cambi THP</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Anaerobic Digestion (mesophilic-thermophilic)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TPAD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Conventional Digestion with Cambi THP

THICKENING (17% SOLIDS) → CAMBI → DEWATERING

CURRENT FLOW AND LOAD CONDITIONS

Non-Economic Evaluation
Acid Phase Digestion

**Advantages**
- Solids Reduction
- Dewaterability
- Class A
- U.S. Installations

**Disadvantages**
- Site Constraints
- Thickening
- Hydrogen Sulfide
- Monitoring

**2020 Flow and Load Conditions**

**Acid Phase Digestion can operate without acid digester redundancy**

IEUA 40 MGD
RENO/SPARKS 33 MGD
TURLOCK 13 MGD
BLACK RIVER 40 MGD
DU PAGE 30 MGD
Acid Phase Digestion can operate without acid digester redundancy

1. Digester design prevents grit accumulation
2. Methane Phase satisfies minimum HRT for digestion

Multi-Cell Design Provides Redundancy Without Extra Tank

Acid Phase Design Criteria is Consistent with Existing Facilities

Acid Phase Design Criteria is Consistent with Existing Facilities

IEUA
MMSD
Turlock
Volatile Acids are Good Indicators of Acid Phase Performance

IEUA  MMSD  Turlock

TPAD

THICKENING
(4.6% SOLIDS)

1  2

DEWATERING

CURRENT FLOW AND LOAD CONDITIONS

Thermophilic Stage

Mesophilic Stage

TPAD

THICKENING
(4.6% SOLIDS)

DEWATERING

2030 FLOW AND LOAD CONDITIONS

Thermophilic Stage

Mesophilic Stage

TPAD

THICKENING
(4.6% SOLIDS)

DEWATERING

2030 FLOW AND LOAD CONDITIONS

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids Reduction</td>
<td>Site Constraints</td>
</tr>
<tr>
<td>Biogas Production</td>
<td>Biodiesel Quality</td>
</tr>
<tr>
<td>Deammonification</td>
<td>Current Design</td>
</tr>
<tr>
<td>Class A</td>
<td>U.S. Installations</td>
</tr>
<tr>
<td>Testing</td>
<td></td>
</tr>
</tbody>
</table>
Batch Configuration Presents Significant Operational Challenges

1. Nine Springs first full-scale installation.
2. Bench-scale operation at Iowa State University.
3. Sequencing batch configuration problems:
   a. Preheating Issues
      - Raw Sludge
      - 300% Increase in heat demand
   b. Instantaneous gas production
   c. Balance gas with draw digester
4. Thermal capacity of heat supply system needs to match thermal loads

Pre-treatment Process required to destroy *Microthrix*

Proven Technologies
1. Cambi Thermal Hydrolysis Process
2. Crown Sludge Disintegration (Cavitation)

New Technologies
1. Micro-Sludge (Pressure + Chemicals)
2. OpenCEL – Electroporation
3. Other

**ANAEROBIC DIGESTION DOES NOT DESTROY MICROTHRIX!**
Modifications to mixing system may reduce foaming potential

1. Gas mixing systems
2. Nine Springs Eductor Tubes are short
   a. Decreased mixing efficiency
   b. Gas bubble dispersion
3. Alternative analysis is not impacted by mixing alternatives
4. Ultimate mixing system change dependant on MMSD decision.
**Conventional Digestion with Cambi Requires Less Tankage**

<table>
<thead>
<tr>
<th>Conventional Digestion with Cambi THP</th>
<th>Acid Phase Digestion (Meso-Thermo-Meso)</th>
<th>TPAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 5 6 7</td>
<td>4 8</td>
<td>7 8</td>
</tr>
<tr>
<td>17% SOLIDS FEED</td>
<td>6% SOLIDS FEED</td>
<td>4.8% SOLIDS FEED</td>
</tr>
<tr>
<td>$ XX,XXX,000</td>
<td>$ XX,XXX,000</td>
<td>$ XX,XXX,000</td>
</tr>
</tbody>
</table>

---

**Process Selection Group Discussion**

---

**RP-1 Operations**

- Raw Sludge
- Meso Acid
- Low Thermal HIGH Meso Gas
- Truck to Composting
- Belt Press
- Thermo Gas
- Cow Manure

---

**Increasing Solids Concentration has Upper Limit under Conventional Digestion**

<table>
<thead>
<tr>
<th>% Solids</th>
<th>Organic Loading @ 15 day HRT</th>
<th>Limiting Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.03</td>
<td>Hydraulic Limited</td>
</tr>
<tr>
<td>2</td>
<td>0.07</td>
<td>Hydraulic Limited</td>
</tr>
<tr>
<td>3</td>
<td>0.10</td>
<td>Hydraulic Limited</td>
</tr>
<tr>
<td>4</td>
<td>0.13</td>
<td>Hydraulic Limited</td>
</tr>
<tr>
<td>5</td>
<td>0.17</td>
<td>Solids Limited</td>
</tr>
<tr>
<td>6</td>
<td>0.20</td>
<td>Solids Limited</td>
</tr>
<tr>
<td>7</td>
<td>0.23</td>
<td>Solids Limited</td>
</tr>
<tr>
<td>8</td>
<td>0.27</td>
<td>Solids Limited</td>
</tr>
<tr>
<td>9</td>
<td>0.30</td>
<td>Solids Limited</td>
</tr>
<tr>
<td>10</td>
<td>0.33</td>
<td>Solids Limited</td>
</tr>
</tbody>
</table>

1. Assumes 80% Volatile Suspended Solids
Two Phase Systems Maximize the Production of High-Quality “Useful” Gas

Acid Phase Gas

- Hydrogen
- Sulfide
- Nitrogen: 2%
- Other: 0%
- Methane: 30%

1.6 ft³ ~ 10%
IEUA Ave. 8%

Methane Phase Gas

- Other: 0.00%
- Nitrogen: 0.00%
- Carbon Dioxide: 29.90%
- Hydrogen: 0.10%
- Methane: 70.00%

16.6 ft³ ~ 90%
IEUA Ave. 92%

Acid Phase Digester Sampling

1. Daily Samples
   a. Total solids, volatile solids, pH, volatile acids, alkalinity
2. Weekly Samples
   a. Ammonia
3. Revised sampling protocol to process samples within 15 minutes of receiving them

Temperature Effects on Acidogenesis

69% of products are easily Biodegradable

- Isovaleric: 7%
- Valeric: 7%
- Butyric: 13%
- Isobutyric: 3%
- Propionic: 23%
- Acetic: 46%

35°C 98°F

49% of products are easily Biodegradable

- Isovaleric: 20%
- Valeric: 3%
- Butyric: 22%
- Isobutyric: 5%
- Propionic: 15%
- Acetic: 34%

55°C 133°F

250% Increase in Offensive Odor Acids

Next Steps
Technical Memoranda

TM01 - Basis of Design
TM02 - Sludge Stabilization Alternatives
TM03 - Anaerobic Digestion Processes
TM04 - Digester Ancillary Systems
TM05 - Mitigation of Scale Formation
TM06 - Biogas Utilization
TM07 - Implementation Plan

Technical Memorandum No. 4
Digester Ancillary Systems

Next Meeting
MADISON METROPOLITAN SEWERAGE SYSTEM

SOLIDS HANDLING FACILITIES PLAN

WORKSHOP 4: PROGRESS MEETING
May 8, 2009

Agenda
- Workshop Goals
- TM 03 – Anaerobic Digestion Process Evaluation
- Class A Biosolids
- TM 05 – Foaming Mitigation
- TM 06 – Struvite Mitigation
- TM 07 – Grease Co-digestion
- Anaerobic Digestion Process Selection
- Next Steps

Workshop No. 4 Goals
1. Compare Sludge Stabilization Alternatives
   a. Class A Biosolids
   b. Digester Foaming
   c. Struvite
   d. Grease Co-digestion
2. Select Sludge Stabilization Process
3. Define Next Steps and Timeline

Technical Memorandum 3: Anaerobic Digestion Process Evaluation
Alternatives compatible with the District's goals

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>CLASS A EQ</th>
<th>MSW DISPOSAL PROGRAMS</th>
<th>FULL-SCALE INSTALLATIONS</th>
<th>ENERGY RECOVERY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Digestion (Comb THP)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Acid Phase Digestion (Mesophilic-Thermophilic)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TPAD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conventional Digestion with Heat Drying</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conventional Digestion with En-Vessel P</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conventional Digestion with Batch Thermo</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

2nd Tier Evaluation for Major Operational Issues and Cost

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>FOAMING</th>
<th>STRUVITE</th>
<th>GREASE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Digestion with Comb THP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid Phase Digestion (Meso-Thermo-Blast)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional Digestion with Heat Drying</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional Digestion with En-Vessel Pasteurization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional Digestion with Batch Thermophilic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TM No. 3
Non-Economic Evaluation

Acid Phase Digestion

THICKENING (6% SOLIDS)

Mesophilic Acid Phase

DEWATERING

CURRENT FLOW AND LOAD CONDITIONS

Mesophilic Methane Phase

Thermophilic Methane Phase
Acid Phase Digestion

THICKENING
(6% SOLIDS)

A1

Mesophilic Acid Phase

2000 FLOW AND LOAD CONDITIONS

A2

Thermophilic Methane Phase

DEWATERING

Acid Phase Digestion

THICKENING
(6% SOLIDS)

A2

A1

2030 FLOW AND LOAD CONDITIONS

DEWATERING

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids Reduction</td>
<td>Site Constraints</td>
</tr>
<tr>
<td>Digestability</td>
<td>Thickening</td>
</tr>
<tr>
<td>Biogas Production</td>
<td>Hydrogen Sulfide</td>
</tr>
<tr>
<td>Class A</td>
<td>Odors</td>
</tr>
<tr>
<td>U.S. Installations</td>
<td></td>
</tr>
</tbody>
</table>

Acid Phase Digestion Full-Scale Installations

Inland Empire Utilities Agency (Chino, CA)

Woodridge-Green Valley WWTP (DuPage County, IL)

Class A Biosolids

Preliminary Layout: Acid Phase Digestion
**TPAD**

**TPAD Digestion Full-Scale Installations**

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids Reduction</td>
<td>Site Constraints</td>
</tr>
<tr>
<td>Biogas Production</td>
<td>Biogas Quality</td>
</tr>
<tr>
<td>Dewaterability</td>
<td>Monitoring Class A</td>
</tr>
<tr>
<td>Current Design</td>
<td>Sludge Preheating</td>
</tr>
<tr>
<td>Class A</td>
<td>Odors</td>
</tr>
<tr>
<td>U.S. Installations</td>
<td></td>
</tr>
</tbody>
</table>

*Western Lake Superior Sanitary District (MN)*

*Nine Springs WWTP (Madison, WI)*
Conventional Digestion with Heat Drying

2030 FLOW AND LOAD CONDITIONS

THICKENING (44% SOLIDS)

1. GBT
2. Metrogro Storage
3. Centrifuge
4. Heat Drying

ADVANTAGES
- Stable Operation
- Class A
- Energy Use
- Site Constraints
- Class B

DISADVANTAGES
- Carbon Footprint
- U.S. Installations

Conventional Digestion with Heat Drying Installations

City of Buffalo (NY)
Water Evaporation: 1,200 kg/hr

Landkreis Böblingen WWTP (Germany)
Water Evaporation: 1,700 kg/hr

Preliminary Layout: Conventional Digestion with Heat Drying

Conventional Digestion with En-Vessel Pasteurization

CURRENT FLOW AND LOAD CONDITIONS

THICKENING (4.0% SOLIDS)

1. GBT
2. Metrogro Storage
3. Centrifuge
4. EVP

METROMIX

75% LAND APPLICATION
25% LAND APPLICATION
Conventional Digestion with En-Vessel Pasteurization

1. 2030 Flow and Load Conditions
2. Thickening (4.6% Solids)
3. Centrifuge
4. Metrogro Storage
5. Land Application
6. EVP
7. METROMIX

Conventional Digestion with En-Vessel Pasteurization

1. 2030 Flow and Load Conditions
2. Thickening (4.6% Solids)
3. Centrifuge
4. Metrogro Storage
5. Land Application
6. EVP
7. METROMIX

Advantages
- State Operation
- U.S. Installations

Disadvantages
- Energy Use
- Class B
- Chemical Costs

Conventional Digestion with En-Vessel Pasteurization Installations

South Coastal WWTP (DE)
500 dry tons per year

Seymour WWTP (IN)
700 dry tons per year

Preliminary Layout: Conventional Digestion with EVP
Conventional Digestion with Batch Thermo Treatment

1. Current Flow and Load Conditions
2. Thickening (4.6% Solids)
3. GBT
4. Metrogro Storage
5. Batch Thermophilic
6. Centrifuge
7. METROMIX
8. 25% Land Application

Conventional Digestion with Batch Thermo Treatment

1. 2030 Flow and Load Conditions
2. Thickening (4.6% Solids)
3. GBT
4. Metrogro Storage
5. Batch Thermophilic
6. Centrifuge
7. METROMIX
8. 25% Land Application

Conventional Digestion with Batch Thermo Treatment

1. 2030 Flow and Load Conditions
2. Thickening (4.6% Solids)
3. GBT
4. Metrogro Storage
5. Batch Thermophilic
6. Centrifuge
7. METROMIX
8. 25% Land Application

ADVANTAGES
- Stable Operation
- Class A
- U.S. Installations
- Energy Use
- Class B
- Site Constraints
- Pathogen Regrowth

CONVENTIONAL DIGESTION WITH BATCH THERMO TREATMENT INSTALLATIONS

- Hyperion WWTP (CA)
  - Biosolids: 650 wet tons per day
- Terminal Island (CA)
  - Biosolids: 50 wet tons per day
Preliminary Layout: Conventional Digestion with Batch Thermo

Class A Biosolids

Class A Biosolids Comparison

<table>
<thead>
<tr>
<th></th>
<th>Acid Phase</th>
<th>TPAD</th>
<th>Cambl</th>
<th>Heat Drying</th>
<th>EVP</th>
<th>Batch Thermo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A Alternative</td>
<td>3</td>
<td>3</td>
<td>1, 5</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>No Additional Monitoring</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Installations with Class A</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>100% of Solids Stream</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Class A Alternatives:
1 - Thermal Treatment
2 - High pH and High Temperature
3 - Site-Specific Permit
5 - PFPR

Site Constraints
Site Constraints and Present Worth Cost Comparison

<table>
<thead>
<tr>
<th>Acid Phase</th>
<th>TPAD</th>
<th>Cambi</th>
<th>Heat Drying</th>
<th>EVP</th>
<th>Batch Thermo</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>F</td>
<td>6</td>
<td>6</td>
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<td>6</td>
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<tr>
<td>G</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
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</tr>
<tr>
<td>H</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>CAPITAL</td>
<td>$16.5 M</td>
<td>$14.0 M</td>
<td>$20.2 M</td>
<td>$24.0 M</td>
<td>$8.6 M</td>
</tr>
<tr>
<td>O&amp;M HAULING</td>
<td>$19.9 M</td>
<td>$19.9 M</td>
<td>$16.8 M</td>
<td>$22.0 M</td>
<td>$15.7 M</td>
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<tr>
<td>TOTAL</td>
<td>$46.7 M</td>
<td>$43.0 M</td>
<td>$60.2 M</td>
<td>$51.4 M</td>
<td>$40.8 M</td>
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</table>

Digester Foaming Comparison

<table>
<thead>
<tr>
<th>Acid Phase</th>
<th>TPAD</th>
<th>Conventional with Cambi</th>
<th>Conventional with Post-Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microthrix Destruction</td>
<td>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevents Lipid and Protein Foaming</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Compatible with Cell Lysis Systems</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Compatible with Mechanical Hosing</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Overall Microthrix Foaming Risk</td>
<td>High</td>
<td>High</td>
<td>?</td>
</tr>
</tbody>
</table>

Foam Mitigation

Foam Mitigation Alternatives

<table>
<thead>
<tr>
<th>Microthrix</th>
<th>Low SRT</th>
<th>High DO</th>
<th>Chem Additon</th>
<th>WAS Treatment</th>
<th>Digester Mixing</th>
<th>WAS only AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destruction</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Compatible with BNA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB Foaming</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓ *</td>
</tr>
<tr>
<td>AD Foaming</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓ *</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>None</td>
<td>None</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>?</td>
</tr>
</tbody>
</table>
Kappala WWTP Configuration Requires Four New Digesters

THICKENED PRIMARY SLUDGE (5% SOLIDS)

TWAS (4% SOLIDS)

2020 FLOW AND LOAD CONDITIONS

Pre-treatment Process required to destroy Microthrix

Proven Technologies
1. Cambi Thermal Hydrolysis Process
2. Crown Sludge Disintegration (Cavitation)

Other Technologies
1. Micro-Sludge (Cavitation + Chemicals)
2. OpenCEL – Electric Pulsing
3. Direct Steam Injection
4. Ultrasonic Cavitation

ANAEROBIC DIGESTION ALONE DOES NOT DESTROY MICROTHRIX!

Cambi Thermal Hydrolysis Process

PULPER
Heat to 175°C, pulper is adjusted and
thermocouple is taken

REACTOR
Recirculation of the sludge

FLASH TANK
Steam at 10°C, reboil the
main reactor

Crown Sludge Disintegration System

Raw Sludge 3-5% DS

Hydrolyzed feed

Disintegrator

Relaxation Tank
60 psi

Hydrolyzed material
To digester
**MicroSludge System**

**OpenCEL System**

**Ultrasonic Cavitation Technology**

1. Vibrating probe generates high-frequency sound (20-40 kHz).
2. Formation/collapse of micro-bubbles cause localized gradients of high temperature and pressure.
3. Cells ruptured through cavitation.

**Jetcooker**

(Direct Steam Injection)

1. Used for Starch Hydrolysis in Ethanol Production.
2. Combines Mechanical Shear and temperatures up to 250 deg F.
3. Blend with primary sludge to reduce temperature.
4. Decreases digester heating requirement.
**Cell Lysis Alternatives Evaluation**

<table>
<thead>
<tr>
<th></th>
<th>Cambi</th>
<th>Crown</th>
<th>Micro Sludge</th>
<th>OpenCEL</th>
<th>Sonic</th>
<th>Steam Injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Scale Installations</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓*</td>
<td></td>
</tr>
<tr>
<td>U.S. Installations</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-Scale Trials</td>
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<td>✓</td>
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<tr>
<td>Cost Estimate</td>
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<td>$3.0 M</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Energy Usage per dry ton</td>
<td>450 kWh</td>
<td>300 kWh</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O&amp;M Cost per dry ton</td>
<td>$90</td>
<td>$30</td>
<td>$70</td>
<td>?</td>
<td></td>
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</tr>
</tbody>
</table>

**Struvite Mitigation**

**Digester P-Scaling Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Acid Phase</th>
<th>TPAD</th>
<th>Conventional with Cambi</th>
<th>Conventional with Post-Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Struvite Scaling Risk</td>
<td>High</td>
<td>High</td>
<td>?</td>
<td>Med</td>
</tr>
<tr>
<td>Vivianite Scaling Risk</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Compatible with Chemical Addition</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Compatible with Struvite Harvesting</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Provides VFAs for Secondary Release</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Phosphate Transformations in Anaerobic Digestion**

- Raw Sludge
- Intermediate Step
- Digested Sludge
- Adsorption
- Residual
- Struvite
- Organic-P
- Poly-P
- Ca-P
- Fe(III)-P
- Org-P
- Fe-P
- Ca-P
- Poly-P
- Adsorption
- Residual
- Struvite
- Organic-P
- Poly-P
- Ca-P
- Fe(III)-P
- Org-P
- Fe-P
- Ca-P
- Poly-P
- Adsorption
- Residual
- Struvite
- Organic-P
- Poly-P
- Ca-P
- Fe(III)-P
- Org-P
- Fe-P
- Ca-P
- Poly-P
- Adsorption
- Residual
- Struvite
- Organic-P
- Poly-P
- Ca-P
- Fe(III)-P
- Org-P
- Fe-P
- Ca-P
**pH Impacts Struvite Solubility**

![Graph showing pH impacts on struvite solubility](image)

**Temperature Impacts Struvite Solubility**

![Graph showing temperature impacts on struvite solubility](image)

**Struvite Formation in Sludge Processing**

1. Chemical Equilibrium is disturbed
2. Carbon dioxide stripping (increases pH)
3. pH elevation
4. Phosphate equilibrium shifts towards $\text{PO}_4^{3-}$
5. (Ammonia equilibrium shifts towards $\text{NH}_3$)
6. $[\text{Mg}^{2+}][\text{NH}_4^+][\text{PO}_4^{3-}]$ exceeds struvite solubility product
7. Nucleation and crystal growth
8. **Struvite precipitates**

**Nine Springs WWTP Struvite Experience**

![Images of struvite precipitates](images)
Mitigating Struvite Formation

- Struvite Harvesting Systems
  - Phosnix
  - Crystalactor
  - Ostara
- Chemical Precipitation
  - Lime
  - Aluminum
  - Iron
  - Patented Chemicals

Struvite-Harvesting Systems

Advantages
1. Valuable end product
2. No biosolids volume increase
3. Lower Phosphorus levels in Metrogro and Metrorrix

Disadvantages
1. High capital cost
2. No operational facilities in U.S.A.
3. High operational complexity
4. Large footprint
**Poly-Gone Lines Addition**

1. Patented Formulation
2. Prevents crystal agglomeration
3. Removes existing scaling
4. Volumetric Dosage
   a. Initial: 1 to 16,000
   b. Preventive: 1 to 20,000
   c. Recommended for 2030: 20 gpd

Kankakee River Metropolitan Agency (IL)
- Average flow = 13 mgd
- Primary Clarification
- Conventional Activated Sludge
- Staged Primary-Secondary Ureagen
Limited Metal Salts Compatible with Nine Springs Operation

1. Ferric salts release phosphate in anaerobic digesters and converted to ferrous.
2. Ferrous salts form vivianite at high temperatures (heat exchangers).
3. Aluminum salts require low pH to precipitate phosphate.
4. Sulfate addition results in H2S in biogas.
5. Chloride addition affects NPDES permit.
6. Lime addition increases pH to 11
**Cost and Treatment Efficiency Depend on Location of Stream**

<table>
<thead>
<tr>
<th></th>
<th>RAS</th>
<th>PS/WAS</th>
<th>Dewatering Filtrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Flow, mgd</td>
<td>37</td>
<td>2.4</td>
<td>0.37</td>
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<tr>
<td>Digester Struvite Mitigation</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Requires Additional Carbon Source</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Requires Blend Tank</td>
<td>Yes</td>
<td>Yes/No</td>
<td>No</td>
</tr>
<tr>
<td>Requires New Thickening Facility</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Struvite Mitigation Alternatives (PS/WAS) Evaluation**

<table>
<thead>
<tr>
<th></th>
<th>Poly-Gone Lines</th>
<th>Struvite Harvesting</th>
<th>Metal Salt</th>
<th>Al³⁺ Salt (APAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Scale Installations</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
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<tr>
<td>U.S. Installations</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Blend Tank</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>Reagent Tank and pump?</td>
<td>$ 9.8 M</td>
<td>Blend Tank</td>
<td>Reagent Tank and Pump?</td>
</tr>
<tr>
<td>Annual O&amp;M Cost</td>
<td>$ 0.25 M</td>
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</tbody>
</table>

**Co-Digestion Evaluation**

<table>
<thead>
<tr>
<th></th>
<th>Acid Phase</th>
<th>TPAD</th>
<th>Conventional with Cambi</th>
<th>Conventional with Post-Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Hydrolysis</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Rate Lipid and Protein Destruction</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Feeding Location</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Volatile Solids Loading Rate</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Compatible with Co-digestion</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Residual Capacity for Co-digestion</td>
<td>30,000 ppm</td>
<td>20,000 ppm</td>
<td>7,500 ppm</td>
<td>30,000 ppm</td>
</tr>
</tbody>
</table>
Technical Memoranda

✓ TM01 - Basis of Design
✓ TM02 - Sludge Stabilization Alternatives
✓ TM03 - Anaerobic Digestion Process Evaluation
  TM04 - Digester Ancillary Systems
✓ TM05 - Foaming and Scale Formation
✓ TM06 - Co-Digestion Evaluation
  TM07 - Biogas Utilization
  TM08 - Implementation Plan

Next Meeting