Creating Digester Capacity Through Improved Mixing

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Overview

- Design Process
- Mix System Details
- Tracer Study Overview
- Testing and Sampling
- Results
- Conclusions and next steps
Design Process
System Characteristics

- **Digester 3**
  - Primary Digester
  - 50’ diam.
  - 52’ SWD
  - 820,000 gallons
  - Fixed Cover

- **Digester 1**
  - Secondary Digester
  - 50’ diam.
  - 26-28’ SWD
  - 409,000 gallons
  - Fixed Cover

- **Digester 2**
  - Dewatering feed tank
  - 50’ diam.
  - 18-28’ SWD
  - 409,000 gallons
  - Fixed Cover
Design Process
Existing Mix System(s)

- Digesters 1 and 2
  - Gas Mixing (Compressors with spargers)
  - Limited solids concentration
- Digester 3
  - External Pump Mix
  - Inverted Cone
Design Process
Project Goals

• Increase solids concentration (up to 4%) in digestion system by providing better mixing
  ─ Put off Digester #4 for 20 years
  ─ Eliminate mixing limitations

• Move grit through digestion process

• Minimize maintenance

• Internal city evaluation defined pump mix as preferred approach
### Design Process

#### Mix System Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Vendor 1 Pump Mix System</th>
<th>Vendor 2 Pump Mix System</th>
<th>Custom Pump Mix System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Pumps</strong></td>
<td>1 per Vessel</td>
<td>1 per Vessel</td>
<td>1 per Vessel</td>
</tr>
<tr>
<td><strong>Type of Pump</strong></td>
<td>Chopper</td>
<td>Chopper</td>
<td>Screw Centrifugal</td>
</tr>
<tr>
<td><strong>Inverted Cone</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Capital Costs</strong></td>
<td>$320,000</td>
<td>$430,000</td>
<td>$624,000</td>
</tr>
<tr>
<td><strong>Annual Operating Costs</strong></td>
<td>$26,200</td>
<td>$24,200</td>
<td>$16,100</td>
</tr>
<tr>
<td><strong>20-Year Present Worth</strong></td>
<td>$736,000</td>
<td>$814,000</td>
<td>$880,000</td>
</tr>
</tbody>
</table>

**Custom External Pump Mix with Inverted Cone**
- Energy savings are very important
- Ability to manage grit
- Compatibility with existing equipment
Design Process
Optimizing the Design

• Computational Fluid Dynamics (CFD) Modeling used to
  – Confirm effectiveness of inverted cone
  – Confirm mix rate
  – Define number of nozzles
  – Define nozzle placement
Mix System Details

• External Pump Mix System
  – Dedicated pump per digester
  – Screw Centrifugal, variable speed
  – 4,000 gpm max, 3,000 gpm each
  – Typ. Operating Horsepower - 30 hp
  – Mixing Design Criteria- 10-14 turnovers/day
Mix System Details

• Inverted Cone
  – Prevents grit deposition
  – Eliminates costly excavation

• Two nozzles/tank
Mix System Details

- HDPE internal piping
  - Reduces mixing impacts
  - Reduces opportunities for ragging
Tracer Study Overview
City’s Goals

• Verify design goals
  – Entraining/moving grit
  – Maximize active volume
  – Allow for thicker solids concentration

• Understand short circuiting so Digester 1 can be utilized as Primary Digester

• Perform test at varying solids concentrations
  – 2%
  – 4%
What is a tracer study?

- Inject a known quantity of Tracer (LiCl)
- Track washout (dilution)
Tracer Study Overview

Proof of Concept

What do we expect to see?

![Graph showing Li Concentration (mg/l) vs Time (days)]
Tracer Study Overview
Proof of Concept

What do we expect to see?

![Graph showing Li Concentration over time](image)

- **Li Concentration (mg/l)**
  - 0.5
  - 1
  - 1.5
  - 2
  - 2.5
  - 3
  - 3.5
  - 4
  - 4.5
  - 5

- **Time (days)**
  - 0
  - 5
  - 10
  - 15
  - 20
  - 25
  - 30
Tracer Study Overview

Steps

• Inject a known quantity of Tracer (LiCl)
• Sample Digester Outlet for 2-3 HRTs
• Analyze for Li ion
• Fit to a washout curve
  – Determine active volume
  – Identify short circuiting
• Methodology Assumes Idealized CSTR
Testing and Sampling

- Detailed Test Plan
- 100 lb LiCl
- Bend staff performed all test activities
- Contract lab performed all Li analysis of sludge samples
- Test lasted 26 days
Testing and Sampling
Testing and Sampling

• Sampler at Digester Overflow Box
  – Every 30 minutes initially
  – Once per day

• ISCO automatic sampler
Testing and Sampling

- **EPA Method 200.7 (ICP-MS)**
- ~ $30 per sample
Consistency during Testing is Important

Mixing and Total Solids Consistent!
Results

Conditions During the Testing

Consistency during Testing is Important

Temperature and Volume Consistent!
Results

Conditions During the Testing

Consistency during Testing is Important

Feed Rate Not Ideal, But Not Bad
Results
Washout Curve

Lithium Concentration vs. Time

Lithium Concentration (mg/L)

Time (days)
Results
Washout Curve

Data Tracks Theoretical Curve Well
Results
Washout Curve

Slope of line defines $\text{HRT}_a$

Active Volume = 96.7%

\[ y = -0.1341x + 1.7867 \]
Results

Washout Curve

Methodology to determine short circuiting
Results

Short Circuiting

Li Conc. on Day 1 of testing defines short circuiting

% bypass = 0.62%
Conclusions

• Digester is behaving as a completely mixed reactor
  – 11 turnovers / day
    • Standard criteria is 10-14 turnovers/day
  – 0.5 hp/ 1000 gallons
    • MOP 8: 0.2 – 1.5 hp/1000 gallons
• Minimal Short circuiting – use of Digester 1 as a primary digester is appropriate
• New mix system is a success!
Next Steps

- Test again at thicker solids
- Compare results
- Consider operational changes
- Report out
Questions?

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