Planning for An Uncertain Future: Biosolids Disposal in a Bold New World
Presentation Outline

1. Introduction/Background
2. Study Phase
3. Implementation Phase
4. Conclusions
Introduction/Background
Acknowledgements

• City of Leominster
  - Mayor Mazzarella
  - Raymond Racine, DPW Director
  - Roger Brooks, General Business Manager

• Massachusetts Clean Water Trust

• MassDEP

• CDM-Smith
  - Lee Storrs

• Veolia Operations
  - Bob Chalifoux
Leominster, MA
Water Pollution Control Facility

• Average flow = 6.0 MGD
• Design flow = 9.3 MGD
• Online in 1983 with no major upgrades until 2008
• 2010 - advanced tertiary treatment plant
  - Phosphorous removal through the tertiary treatment system (ACTIFLO system).
• 2012 - Upgraded Headworks
Background

- Intermunicipal Agreement in place between Leominster and Fitchburg for merchant sludge disposal
- City of Fitchburg issued a moratorium on receiving merchant sludge effective October 1, 2012
- Leominster was faced with an opportunity to optimize biosolids disposal.
- Engineering RFP issued for a study phase to prepare and analyze alternatives to thicken, dewater, dry, or digest biosolids
Study Phase
Solids Handling Site Overview

- Primary Clarifiers
- Secondary Clarifiers
- Actiflo System
- Site
- Emergency Sludge Storage Tanks
- Secondary Clarifiers
- Vacuum Filter Room (top floor)
Existing Conditions

Primary Clarifiers

Emergency Gravity Belt Thickener

Emergency Sludge Storage

Liquid Sludge Hauling
# Sludge Estimates

## Sludge Production Values for 20-Year Flow Projections (6.58 MGD, 7 day basis)

<table>
<thead>
<tr>
<th></th>
<th>Average Annual (AVG365)</th>
<th>Maximum Month (MAX30)</th>
<th>Maximum Week (MAX7)</th>
<th>Maximum Day (MAX1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total without Actiflo</td>
<td>10,340 lb/day</td>
<td>14,170 lb/day</td>
<td>17,680 lb/day</td>
<td>22,130 lb/day</td>
</tr>
<tr>
<td>Total with Actiflo</td>
<td>10,550 lb/day</td>
<td>14,450 lb/day</td>
<td>18,040 lb/day</td>
<td>22,570 lb/day</td>
</tr>
</tbody>
</table>

## Sludge Production Values for 20-Year Flow Projections (6.58 MGD, 5 day basis)

<table>
<thead>
<tr>
<th></th>
<th>Average Annual (AVG260)</th>
<th>Maximum Month (MAX30)</th>
<th>Maximum Week (MAX7)</th>
<th>Maximum Day (MAX1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total without Actiflo</td>
<td>14,480 lb/day</td>
<td>19,840 lb/day</td>
<td>24,760 lb/day</td>
<td>30,990 lb/day</td>
</tr>
<tr>
<td>Total with Actiflo</td>
<td>14,770 lb/day</td>
<td>20,230 lb/day</td>
<td>25,260 lb/day</td>
<td>31,600 lb/day</td>
</tr>
</tbody>
</table>
Alternative 1 – Thicken and Haul

Primary Clarifiers

Thickening

Liquid Sludge Hauling

Emergency Sludge Storage

Primary sludge routing to accommodate intermittent truck loading (20 minute fill cycle)
Alternative 2 – Dewater and Haul

Primary Clarifiers

Emergency Sludge Storage

Dewatering

Cake Hauling
Alternative 3 – Digest and Haul

- Primary Clarifiers
- Thickening
- Anaerobic Digestion
- Dewatering
- Cake Hauling
Alternative 4 – Thermal Drying

Primary Clarifiers

Thickening

Anaerobic Digestion

Dewatering

Drying

Pellet Hauling
Disposal Options
## Disposal Options Vary Between Alternatives

<table>
<thead>
<tr>
<th></th>
<th>Landfill Disposal</th>
<th>Incineration</th>
<th>Composting at 22% TS</th>
<th>Composting at 28% TS</th>
<th>Beneficial Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt 1 – Thicken and Haul</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alt 2 – Dewater and Haul</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Alt 3 – Thicken, Digest, Dewater and Haul</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Alt 4 – Thicken, Digest, Dewater, Dry and Haul</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
</tbody>
</table>
For land application sewage sludge must meet certain requirements

- Non-Hazardous

- Criteria Pollutants

- Pathogen Content

- Vector Attraction Reduction
Disposal Option Considerations

• How is flexibility and reliability defined?
• How important is flexibility in disposal options?
• Is cost the primary consideration?
## Disposal Cost Assumptions

Based on information provided by VNA

<table>
<thead>
<tr>
<th></th>
<th>Landfill Disposal</th>
<th>Incineration</th>
<th>Composting at 22% TS</th>
<th>Composting at 28% TS</th>
<th>Beneficial Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Costs ($/dry ton)</td>
<td>$250</td>
<td>$453 – liquid</td>
<td>$496</td>
<td>$323</td>
<td>$0 - pellets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$515 – undigested cake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$545 – digested cake</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No current information available at this time. Can be modified in the future if additional information becomes available.
Major Equipment Options
## Thickening Equipment

<table>
<thead>
<tr>
<th>Potential Suppliers</th>
<th>RDT</th>
<th>Centrifuge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkson, Ashbrook, Huber, BDP</td>
<td></td>
<td>Centrisys, Andritz, Alfa-Laval, Flotwegg, Westfalia</td>
</tr>
</tbody>
</table>

| Number of Duty Units Required | 1 | 1 |
| Number of Standby Units Required | 1 | 1 |
| Budget Equipment Supply Cost, per unit | $200,000 | $395,000 |
| Max Hydraulic Loading Rate, gallons/minute (each) | 200 | 400 |
| Max Solids Loading Rate, lbs(dry)/hour (each) | 3,300 | Not indicated |
| Connected Horsepower, HP | 8.5 | 70 |
| Polymer Dose, lbs(active)/dry ton | 5 to 10 | 0 |
| Anticipated Thickened Solids Concentration, %TS | 5% to 10% | ~6% |
Conceptual Rotary Drum Thickener Layout

Process Building - Second Floor - Dewatering Room
# Dewatering Equipment

<table>
<thead>
<tr>
<th></th>
<th>Screw Press</th>
<th>Rotary Press</th>
<th>Centrifuge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Suppliers</td>
<td>Huber, FKC, BDP, Schwing</td>
<td>Fournier</td>
<td>Centrysis, Andritz, Alfa-Laval, Flottwegg, Westfalia</td>
</tr>
<tr>
<td>Number of Duty Units Required</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Number of Standby Units Required</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Budget Equipment Supply Cost, per unit</td>
<td>$365,000</td>
<td>$325,000</td>
<td>$360,000</td>
</tr>
<tr>
<td>Hydraulic Loading Rate, gallons/minute (each)</td>
<td>52</td>
<td>Not available</td>
<td>140</td>
</tr>
<tr>
<td>Solids Loading Rate, lbs(dry)/hour (each)</td>
<td>850</td>
<td>1,500 dry lb/hr/unit</td>
<td>2,430</td>
</tr>
<tr>
<td>Connected Horsepower, HP per unit</td>
<td>5</td>
<td>24</td>
<td>75</td>
</tr>
<tr>
<td>Polymer Dose, lbs(active)/dry ton</td>
<td>24 (max)</td>
<td>5 - 15</td>
<td>18 - 22</td>
</tr>
<tr>
<td>Anticipated Dewatered Cake Concentration, %TS</td>
<td>19% (average)</td>
<td>24 - 28%</td>
<td>20 - 25%</td>
</tr>
</tbody>
</table>
Conceptual Centrifuge Dewatering Layout

Process Building - Second Floor - Dewatering Room

[Diagram of process building showing conveyor, centrifuge #1, and centrifuge #2]
# Anaerobic Digester Rehabilitation Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural rehab</td>
<td></td>
</tr>
<tr>
<td>Mixing</td>
<td></td>
</tr>
<tr>
<td>Boiler</td>
<td></td>
</tr>
<tr>
<td>Heat exchangers</td>
<td></td>
</tr>
<tr>
<td>Covers</td>
<td></td>
</tr>
<tr>
<td>Flare</td>
<td></td>
</tr>
<tr>
<td>Gas safety</td>
<td></td>
</tr>
<tr>
<td>Transfer pumps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NFPA 820 compliance</td>
</tr>
<tr>
<td></td>
<td>Gas monitoring</td>
</tr>
<tr>
<td></td>
<td>Electrical upgrades</td>
</tr>
<tr>
<td></td>
<td>Instrumentation</td>
</tr>
<tr>
<td></td>
<td>Gas utilization</td>
</tr>
<tr>
<td></td>
<td>Piping</td>
</tr>
<tr>
<td></td>
<td>Demo of existing equip.</td>
</tr>
<tr>
<td></td>
<td>HVAC</td>
</tr>
</tbody>
</table>
Conceptual Digester Pre/Post Handling Layout

Process Building - Second Floor - Dewatering Room
Imported Organic Material May Provide Additional Benefits

FOG at 42.5% of total VS load

FOG only

TWAS only
Considerations for Use of Additional Digester Capacity for Imported Organic Material

- Unknown cost risk for required structural rehabilitation of tanks
- Not 100% digestible, results in additional solids for final handling
- Additional investment for processing facilities
- No guarantee of market sustainability or tipping fee stability
- Benefits can only be realized with properly sized (i.e. larger) gas utilization equipment
- Not clear if additional investment can be recouped through grant funding and tipping fee income (Mass CEC Grants approx. $100k-$200k)
## Dryer Comparison

<table>
<thead>
<tr>
<th>Potential Suppliers</th>
<th>Rotary Drum Dryer</th>
<th>Paddle Dryer</th>
<th>Belt Dryer</th>
<th>Fluid Bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andritz NEFCO Berlie</td>
<td>GMF-Gouda Komline-Sanderson ThermaFlite</td>
<td>Kruger Andritz Huber Siemens</td>
<td>Andritz Schwing-Bioset</td>
<td></td>
</tr>
<tr>
<td>Supplier Used for Evaluation</td>
<td>GMF/Andritz</td>
<td>Kruger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Considered</td>
<td>10W65</td>
<td>DR3025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Used for Evaluation</td>
<td>$3.0 M</td>
<td>$3.2 M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximate Budget Equipment Supply Cost</td>
<td>2,400 lb H_2O/hr</td>
<td>2,400 lb H_2O/hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporative Capacity, lb H_2O/hour</td>
<td>92%</td>
<td>90%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticipated Dried Solids Concentration, %TS</td>
<td>Not Considered</td>
<td>Not Considered</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conceptual Thermal Drying Layout

Process Building - Second Floor - Dewatering Room

Dryer Area (31'x48')
Evaluation of Alternatives
Economic Criteria

Capital costs
- Equipment
- Mechanical components
- Electrical allowance
- Instrumentation allowance
- General requirements
- Contractor OH&P
- Mobilization/demobilization
- Insurance and bonds
- Design/construction inspection
- Construction management

Recurring costs
- Electricity
- Supplemental fuel
- Operations labor
- Maintenance labor
- Polymer
- Disposal
- Interest payments
Non-Economic Criteria

- Operator and process safety
- Process reliability
- Process redundancy
- Process flexibility
- Process operability
- Process maintainability
- Odor generation potential and mitigation
Alternative 1 – Thicken and Haul Liquid Sludge

- Install Rotary Drum Thickeners (RDTs)
- Draw sludge from PCs and thicken to 6%
- Operating Hours = 35 hrs/wk
- Thickened sludge or raw sludge sent to sludge storage tanks
- Disposal Site = Liquid Incineration (Upper Blackstone)

Primary sludge routing to accommodate intermittent truck loading (20 minute fill cycle)
Other Evaluations

• Structural
  - Equipment loading
  - Equipment location
  - Installation and maintenance
• Electrical
  - Replacement of MCC-3 and MCC-6
  - VFDs, wire and conduit
  - Standby generator
• I&C
• HVAC and Odor Control
**Alternative 2 – Dewater and Haul Cake Sludge**

- Install Centrifuges
- Draw sludge from PCs and dewater to 20-25%
- Operating Hours = 35 hrs/wk
- Dewatered cake discharged to roll-off containers or dump trucks
- Disposal Site Options
  - Landfill
  - Incineration
  - Composting

![Diagram of Alternative 2 - Dewater and Haul Cake Sludge](image)
Other Evaluations

Similar to Alt. 1

Structural
• Centrifuge Vibrations

I&C
• More I/Os required

Electrical
• Higher HP VFDs recommend stand alone construction
## Capital Cost Comparison

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Est. Project Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td></td>
</tr>
<tr>
<td>Thicken and Haul</td>
<td>$4,900,000</td>
</tr>
<tr>
<td>Alternative 2</td>
<td></td>
</tr>
<tr>
<td>Dewater and Haul</td>
<td>$6,400,000</td>
</tr>
</tbody>
</table>
Net Present Cost Sensitivity Analysis

• Dependent on final solids disposal
• Alternative 1: Thickening and Haul
  - To sludge incineration
  - Baseline transportation and disposal costs of $453/\text{dt}$
• Alternative 2: Dewater and Haul
  - To cake composting
  - Baseline transportation and disposal costs of $450/\text{dt}$
  - Tipping fee of $55/\text{wet ton}$
  - Hauling distance approx. 100 miles roundtrip
Cumulative Net Present Cost Sensitivity Analysis over 10 years
Conclusions

Alternative 1: Thicken and Haul

- Equipment reduced O&M costs due to lower energy consumption and slower rotational speed
- More viable economic alternative over a 10-year analysis period based on current disposal costs
- Confined to single outlet for disposal
- SSI Regulatory impacts
Implementation Phase
Implementation

- Remove vacuum filters and install 2 RDTs
- Replace primary and stored sludge pumps
- Add storage tank mixing and thickened sludge equipment
- Install polymer mix/feed equipment
- Install odor control system

- Pre-purchase RDTs
  - Site Visits
  - Competitive bidding
  - Expedite schedule
  - 2 dual 4x10 BDP RDTs
- Contractor mobilized 1/26/15
Long Term Recommendation

• Dependent on future economics of digestion
  - Grant contributions
  - Other incentives to rehabilitate digesters

• Three options:
  - Continue with thickening
  - Add centrifuges for dewatering and haul cake
  - Implement anaerobic digestion (with thickening) to produce Class B material
Conclusions

- While the alternatives are similar for other facilities various factors influence decision:
  - Capital expenditures
  - Hauling distances
  - Long term reliability
  - Wastewater sludge characteristics

- While today’s Biosolids processing and disposal options offer a larger variety of choices, costs (10-year assessment) still driver.
THANK YOU...

- Roger Brooks, City of Leominster RBrooks@dpw.LEOMINSTER-MA.GOV
- Hans Tuneblom, P.E., Veolia North America hans.Tuneblom@Veolia.com
- Deborah Mahoney, Hazen and Sawyer dmahoney@hazenandsawyer.com
- Matthew Van Horne, P.E., Hazen and Sawyer mvanhorne@hazenandsawyer.com
Bullpen
Equipment Categories

• Sludge pumps
• Thickening
• Dewatering
  • Polymer systems
  • Digester covers
  • Heat exchangers
  • Boilers
  • Cake conveyors
Equipment Categories

- Sludge pumps
- Thickening
- Dewatering
- Polymer systems – assumed dry feeders
- Digester covers – assumed floating gas holder
- Heat exchangers – assumed spiral
- Boilers – assumed DG/NG capable
- Cake conveyors – could be shafted or shaftless
Potential Pump Alternatives

Hose Pump

Progressive Cavity Pump

Double Disc Pump

Rotary Lobe Pump

Recessed Impeller Pump

Plunger Pump
Thickening Equipment Recommendation

• Rotary Drum Thickener
  - Available in horizontal or inclined configurations
  - Attractive capital cost and low operating costs
Screw Press Pilot Testing

Leominster WWTP
Mechanical Review

- Two RDTs
- Piping and valve configuration
- Primary sludge pumps (4) with grinders
  - Progressive cavity
- Sludge storage mixing
  - Chopper pumps (3) each and nozzles
- Stored sludge pumps (3) with grinders
  - Progressive cavity or rotary lobe
- Thickened sludge pumps (2)
- Polymer systems (2)
  - Dry polymer, Acrison type
- 5-Ton bridge crane
- Odor control
  - Activated carbon
- HVAC
Schematic of Alternative 1
Structural Review

- Preliminary review of equipment loading
  - No increase in vertical loads and lateral loads
  - May require localized strengthening for concentrated loads
- Equipment location = no interferences
- Continuous support wall under each skid (2/unit)
- 5-ton bridge crane
  - Further review required, but generally appears to be feasible
Mechanical Review

Two Centrifuges
Inclined screw conveyor
Distributing screw conveyor
Primary sludge pumps (4) with grinders
  • Progressive cavity
Sludge storage mixing
  • Chopper pumps (3) each and nozzles
Thickened sludge pumps (2)

• Stored sludge pumps (3)
• Polymer system
  - Dry polymer - Acrison type
• 5-ton bridge crane
• Odor control system
  - Activated carbon
• HVAC
• Piping and valve configuration
## Total Project Capital Cost Summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Alternative 1 – Thickening</th>
<th>Alternative 2 – Dewatering</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>$272,000</td>
<td>$272,000</td>
</tr>
<tr>
<td>Equipment</td>
<td>$1,320,000</td>
<td>$2,083,000</td>
</tr>
<tr>
<td>Mechanical</td>
<td>$237,000</td>
<td>$243,000</td>
</tr>
<tr>
<td>Electrical</td>
<td>$490,000</td>
<td>$510,000</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>$84,000</td>
<td>$97,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$2,403,000</strong></td>
<td><strong>$3,205,000</strong></td>
</tr>
<tr>
<td>Contractor Costs/Insurances and Bonds/Engineering Inspections</td>
<td>$481,000</td>
<td>$641,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$2,884,000</strong></td>
<td><strong>$3,846,000</strong></td>
</tr>
<tr>
<td>General Requirements (5%)</td>
<td>$145,000</td>
<td>$193,000</td>
</tr>
<tr>
<td>Mobilization/Demobilization (2%)</td>
<td>$58,000</td>
<td>$65,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$3,087,000</strong></td>
<td><strong>$4,104,000</strong></td>
</tr>
<tr>
<td>Contractor Overhead and Profit (10%)</td>
<td>$309,000</td>
<td>$411,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$3,396,000</strong></td>
<td><strong>$4,515,000</strong></td>
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<tr>
<td>Escalation to Mid Point of Construction</td>
<td>$180,000</td>
<td>$240,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$3,576,000</strong></td>
<td><strong>$4,755,000</strong></td>
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<tr>
<td>Insurance and Bonds (3%)</td>
<td>$108,000</td>
<td>$143,000</td>
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<td><strong>Subtotal</strong></td>
<td><strong>$3,700,000</strong></td>
<td><strong>$4,900,000</strong></td>
</tr>
<tr>
<td>Design/Construction Inspection (20%)</td>
<td>$800,000</td>
<td>$1,000,000</td>
</tr>
<tr>
<td>Construction Management (10%)</td>
<td>$400,000</td>
<td>$500,000</td>
</tr>
<tr>
<td><strong>TOTAL PROJECT CAPITAL COSTS</strong></td>
<td><strong>$4,900,000</strong></td>
<td><strong>$6,400,000</strong></td>
</tr>
</tbody>
</table>
Digestion Design Criteria

- Meet Class B stabilization (15 days at 95°F)
- Provide suitable reliability

<table>
<thead>
<tr>
<th></th>
<th>Average 365</th>
<th>Maximum Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume per existing tank</td>
<td>420,000 gallons</td>
<td></td>
</tr>
<tr>
<td>Configuration</td>
<td>1 duty + 1 out of service</td>
<td></td>
</tr>
<tr>
<td>Target SRT</td>
<td>20 days</td>
<td>15 days</td>
</tr>
<tr>
<td>Feed Solids</td>
<td>6% TS</td>
<td></td>
</tr>
<tr>
<td>Feed Volume (7 day basis)</td>
<td>20,100 gpd</td>
<td>27,400 gpd</td>
</tr>
<tr>
<td>Actual SRT</td>
<td>21 days</td>
<td>15 days</td>
</tr>
<tr>
<td>Reliable Additional Feed Volume Available</td>
<td>7,300 gpd</td>
<td>0 gpd</td>
</tr>
<tr>
<td>Total Additional Feed Volume Available</td>
<td>34,700 gpd</td>
<td>27,400 gpd</td>
</tr>
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</table>