NEFCO BIOSOLIDS DRYING AT GLWA

Michigan Water Environment Association
Annual Sustainable Energy Seminar
October 19, 2017
Agenda

- GLWA Background
- History of Biosolids Dryer Facility (BDF) Selection
- Biosolids Thermal Drying Process
- Class A EQ Product Marketing
- Moving to a Utility of the Future
Quick GLWA Wastewater Facts

• Service area: 1,079 square miles.

• Serves 40% of MI population - Encompasses Detroit and 76 neighboring communities ~ 3 million people

• One WRRF in the system.
  • Average Daily Flow – 650 MGD
  • Wet Weather Capacity – 1.7 BGD
  • Average Biosolids Production – 450 DTPD
  • Peak Biosolids Production – 950 DTPD

Great Lakes Water Authority officially began operation January 1, 2016
Total Solids Generation: 450 dtpd

Multiple Hearth Incineration: 301 dtpd
Class B Land Application: 50 dtpd
Landfill: 99 dtpd

Approx. 51% of the WRRF O&M costs for solids processing & disposal.
History of BDF Selection
Drivers for the Biosolids Drying Project

- ACO required peak biosolids capacity = 850 dtpd.
- Little sludge storage at the plant.
- Limited landfill space and offloading capacity.
Drivers for the Biosolids Drying Project

- Compliance with MACT 129 emission limits by March 2016 required upgrades to MHIs.
- Complex I MHIs from 1940s – at the end of their useful life.
- Desire for a sustainable product.
Decision to Thermally Dry Biosolids

- Decision process through consultation and consensus.
- Biosolids symposium in March 2012.
  - Comprised of industry experts.
  - Evaluated several technologies.
  - Recommended drying and beneficial use of product.
- PC-792 RFP advertised in August 2012 for Design-Build-Operate of biosolids drying.
Selected Technology Option – Thermal Drying

- Incineration Complex I (1940s units) to be retired.
- PC-791 separate contract to bring C-II Incinerators into Air Quality Compliance.
- GLWA to continue incineration, land application/landfilling of remaining solids.
- GLWA to cancel capital projects for Complex I refurbishment, centrifuge replacement, and biosolids storage.
Existing Solids Processes at the WRRF

- **Primary Sludge**
  - Gravity Thickening
  - Thickened Sludge Storage
  - Dewatering
    - Centrifuges/BFPs
  - Incineration
    - Ash Disposal
      - MHI Complex I
  - Off-Load Facility
    - Lime Stabilization
      - Land Application

- **Secondary Sludge**
  - Gravity Thickening
  - Thickened Sludge Storage
  - Dewatering
    - Centrifuges/BFPs
  - Incineration
    - Ash Disposal
      - MHI Complex I
  - Off-Load Facility
    - Lime Stabilization
      - Land Application
New Biosolids Drying Facility

Selected Technology Option – Thermal Drying

- Primary Sludge
- Secondary Sludge
- Gravity Thickening
- Gravity Thickening
- Thickened Sludge
- Storage
- Dewatering
  - Centrifuges/BFPs
- Complex II MHIs
  - Incineration
- Off-Load Facility
  - Lime Stabilization
- Land Application

Dewatering + Thermal Drying

MHI Complex I
• Located across the street from the WRRF.

• Four dryer trains 316 dtpd firm capacity (440 dtpd peak).

• Dewatering included in the facility.
Contract Operations of Biosolids Dryer Facility

- Design-Build with 20-year Operation/Maintenance by contractor.

- Fixed monthly price up to 73,000 DTPY with incremental unit costs per excess dry ton beneficially reused up to 140,000 DTPY (escalated at CPI).

- GLWA owns the facility and pays utilities to guaranteed caps.
  - Allows contractor to manage energy cost risk, while holding it responsible for excess consumption.

- NEFCO responsible for marketing and disposal of biosolids.
Contract Operations of Biosolids Dryer Facility

- Brings specialized expertise to the complex operating environment.
- Shifts risk of meeting environmental standards to the private sector.
- Long-term cost certainty - Offers predictable operations budgeting process.
  - Commodities – electricity, fuel chemicals
    - Escalation tied to Indices
    - Pass-throughs with guarantees
- Mutual trust between NEFCO and GLWA
Solids O&M Savings Using Dryers

<table>
<thead>
<tr>
<th></th>
<th>Incineration</th>
<th>Dewatering</th>
<th>COF &amp; Residuals</th>
<th>Total Solids Handling</th>
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</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$(7.16)</td>
<td>$(7.15)</td>
<td>$(0.38)</td>
<td>$(14.69)</td>
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<tr>
<td>Natural Gas</td>
<td>$(7.88)</td>
<td>$ -</td>
<td>$ -</td>
<td>$(7.88)</td>
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<tr>
<td>Electricity</td>
<td>$(1.55)</td>
<td>$(0.33)</td>
<td>$ -</td>
<td>$(1.88)</td>
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<tr>
<td>Polymer</td>
<td>$ -</td>
<td>$(3.85)</td>
<td>$ -</td>
<td>$(3.85)</td>
</tr>
<tr>
<td>Lime</td>
<td>$ -</td>
<td>$ -</td>
<td>$(0.91)</td>
<td>$(0.91)</td>
</tr>
<tr>
<td>Hauling/Disposal</td>
<td>$(0.65)</td>
<td>$ -</td>
<td>$(5.10)</td>
<td>$(5.75)</td>
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<tr>
<td>Parts, Services &amp; Other</td>
<td>$(2.32)</td>
<td>$(3.11)</td>
<td>$ -</td>
<td>$(5.43)</td>
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<tr>
<td><strong>Subtotal WRRF O&amp;M</strong></td>
<td>$(19.56)</td>
<td>$(14.44)</td>
<td>$(6.39)</td>
<td>$(40.39)</td>
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<tr>
<td>Dryer Facility O&amp;M Cost</td>
<td></td>
<td></td>
<td></td>
<td>$15.89</td>
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<tr>
<td>Natural Gas For Dryers</td>
<td></td>
<td></td>
<td></td>
<td>$5.47</td>
</tr>
<tr>
<td>Electricity For Dryers</td>
<td></td>
<td></td>
<td></td>
<td>$2.16</td>
</tr>
<tr>
<td><strong>Subtotal Dryers O&amp;M</strong></td>
<td></td>
<td></td>
<td></td>
<td>$23.52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>$(16.87)</td>
</tr>
</tbody>
</table>

Annual O&M savings: $16.9 million
20 year O&M savings: $337.3 million (in 2013 dollars)
Payback period on $143 million capital cost: 8.5 years
Air Emissions Reduction

- Emissions aggregated from all GLWA facilities.
- Start-up of BDF requires permanent shut-down of incinerators in Incineration Complex I.
- Reduction in emissions with thermal drying.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Reduction in Emissions Compared to Complex I MHIs</th>
<th>BDF Emissions as a % of Total¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>90.4%</td>
<td>11.9%</td>
</tr>
<tr>
<td>CO</td>
<td>95.9%</td>
<td>4.7%</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>--</td>
<td>84.4%</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>--</td>
<td>79.2%</td>
</tr>
</tbody>
</table>

¹ Includes Complex II MHIs with pollution control upgrades
Project Schedule – 22 months

- Piles installed – December 2013 – March 2014
- Concrete foundation poured – April - May 2014
- Major Equipment Installed – June – August 2014
- Structural Steel Erection – August – October 2014
- Install Piping – August – September 2014
- Mechanical Install – September 2014 – June 2015
- Electrical Install – October 2014 – July 2015
- Administration area – December 2014 – May 2015
- Equipment Checkout and Startup – June – September 2015

Project completed 7 months ahead of schedule!
Schedule Challenges

- House of cards
- On time fabrication / delivery of equipment meet project needs
- Winter 2014 coldest record
- Pre-caster has fire and his erector goes out of business just before scheduled start
- Get building closed up by late Fall 2014
- Mr. Murphy is my BFF…
Thermal Drying Technology

• Class A EQ Product with multiple outlets.

• Proven Technology

• Nutrients in biosolids remain available after drying – product suitable for beneficial use.

• Nutrients in biosolids not water soluble – No runoff

• No additional need for bulk chemical addition to stabilize cake
Product Quality Considerations

- Pellets shaped during the mixing step.
- Eliminates “plastic” or “sticky” phase during drying.
- Easy drying of surface moisture.
Product Quality Considerations

- Establish product quality standards based on market requirements and process capability.
- Ensure upstream solids processing facilities are operational for consistent feed to drying.
- Determine optimum dewatered cake characteristics for good pellet quality.
- Optimize operating parameters to determine acceptable operating ranges.
Class A EQ Dried Biosolids Product Marketing

City of Cadillac, MI
Biosolids are not a waste to be managed but a beneficial product we make with intent.

- Public perception & acceptance
- Regulatory Acceptance
  - US EPA
  - Canadian Food Inspection Agency
- Proven Safe Results
- Milwaukee, WI company producing EQ level biosolids for commercial sale for 90 years!
Chain of Custody and Oversight

NEFCO BDF
Receives Sludge – Makes Pelletized Fertilizer

Truck Haul to Land Application Site – One Contractor for all of Michigan

MDEQ

EQ Reporting

Nuisance Resolution

Field Guidance and Site visits

Biosolids Broker
- Extensive Experience in Industry
- One Broker for Michigan
- Broker Performs Spreading
- Relationship with Farmer and Local Officials

Farmer
- Increased Yields
- Increased Drought Tolerance
- Lower use of commercial fertilizers
- Replaces nutrients back in Michigan, where they originated

Farmer
• Increased Yields
• Increased Drought Tolerance
• Lower use of commercial fertilizers
• Replaces nutrients back in Michigan, where they originated
Dried Product Quality Requirements

Chemical Characteristics

- **Nutrient Guarantee – Fertilizer**
- **Micronutrient analysis similar to leading bagged Class A product**

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>Average</th>
<th>Guaranteed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nitrogen</td>
<td>4.7%</td>
<td>4.0%</td>
</tr>
<tr>
<td>95% of Nitrogen is Water Insoluble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Phosphorus (as $P_2O_5$)</td>
<td>2.2%</td>
<td>2.0%</td>
</tr>
<tr>
<td>65% of Phosphorus is Water Insoluble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium (as $K_2O$)</td>
<td>0.2%</td>
<td>0%</td>
</tr>
<tr>
<td>Iron</td>
<td>2.9%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Nutrients Derived from Treated Biosolids
- Detroit, MI Product Analysis
End Uses for Dried Biosolids

- Bulk land application
- Fertilizer blending
- Land Reclamation
- Alternative Fuels
  - Cement kilns
  - Power generation
  - Renewable fuel
Dried Biosolids for Bulk Land Application

- Food crops
- Feed crops
- Turf farms
- Tree farms
- Golf courses
- Landscaping
- Soil blending

Benefits of Land Application

- High organic content
- Increased soil carbon storage
- Slow release nutrients
- Natural micronutrients
- Faster plant establishment
- Increased water retention

MichiGreen
Dried Biosolids in Fertilizer Blends

- Turf formulas
  - High value-add.
  - Nutrient-rich filler.
  - Slow-release N.
  - Particle size needs.
  - Minimal contamination.
- Specialty agricultural formulas
- Engineered soils
NEFCO BDF Land Application (August 2017 YTD)

- Corn
- Wheat
- Soybeans
- Hay

US Distribution
~40,600 DT shipped

Canadian Distribution
~16,400 DT shipped
Dried Biosolids as Fuel

• Lower cost alternative to coal.
• BTU value 6,300 – 7,600 BTU/lb.
• Chemistry similar to coal.
• Steady volumes for generator and customer.
• Helps users achieve “Green Energy” initiatives.
• Class A EQ biosolids safe and acceptable to workers and public.
Dried Biosolids Sustainability Impact

• Shipment of dried Class A product results in 25% of trucking mileage versus Class B cake land application or landfilling.
  • Approximately 15,000 gallons of diesel fuel reduction.
  • Approximately 165 tons of CO₂ emission reduction from less trucking.
• Chemical fertilizer displacement results in:
  • Reduction of energy use and greenhouse gases from fertilizer manufacturing.
    – 0.22 gallons of fuel oil used to produce a pound of nitrogen fertilizer.
    – 1.5 million gallons of fuel oil saved by BDF recycling.

Farmers achieve $20-$50 per acre savings.
Future Product Marketing Plans

- Land application trends in U.S.
  - Negative public sentiment.
  - Phosphorous limits.
  - Microconstituents.
- Exploring additional markets to increase diversification.
  - Lime kiln alternative fuel.
  - Manufactured soil blends.
  - Post-processing specialty fertilizer manufacturing.
Moving to a Utility of the Future
Utility of the Future Program

• Guide utilities to more efficient operations and a progression to full resource recovery and sustainability.

• Basic UOTF Guidelines:
  • Beneficial Biosolids Reuse
  • Energy Efficiency (*Optimization of Existing Plant Ops*)
  • Energy Generation & Recovery
  • Nutrient & Materials Recovery
  • Community Partnering & Engagement
Energy Optimization & Recovery

• Evaluate energy demand and supply opportunities - two sides of the energy efficiency equation:

  Minimize energy use on liquid side.

  Increase potential for harvesting energy from solids processes.

Average electricity consumption for WW treatment in the U.S. 1750 kwh/MG - WTP AwwaRF, 2007.
Biosolids Energy Disposal Today

GLWA WWRF

➢ Utility costs (whole plant)
  • Electricity $12 Million annually
  • Natural Gas $6 Million annually

➢ Biosolids Dryer
  – Roughly $13 M (@ min)*
  – Land applied for nitrogen, phosphorous and root development

➢ Untapped Opportunities
  • heat recovery
  • anaerobic digestion
  • energy generation

*Began operation in 2016 as initial phase of a biosolids disposal plan and Clean Air Act compliance strategy - with significant annual cost avoidance/savings
Current Energy Recovery Trends in the Industry

- PS + WAS
- Pre-Treatment
- Anaerobic Digestion
- Dewatering
- Gas Cleaning
- CHP
- Dewatered Cake
- End Use
- Further Processing
- Dried Product
- Sidestream Treatment
- Struvite Recovery (w/bio-P)

Current Energy Recovery Trends in the Industry
Anaerobic Digestion w/ CHP at GLWA

Based on a 50:50 blend of PS and WAS

**PS**
- 440,000 lb/d
- 80% VS

**WAS**
- 440,000 lb/d
- 80% VS

**Anaerobic Digesters**
- Total SRT: 15 d
- VSR: 50%
- 16 scf gas/lb VSR

**Digester Gas**
- 223,000 scfh
- 134 mmBtu/h

**Dew. Cake**
- 528,000 lb/d
- 22% TS

**Heat Recovery**
- 49 – 63 mmBtu/h

**Electricity**
- 12 – 17 MW

**Dried Solids**
- 264 dtpd @ 95%TS

**Energy Requirement**
- Evap: 77,000 lb H₂O/h
- Energy: 127 mmBtu/h
Future Trends in the Use of Anaerobic Digestion

- Co-digestion for increased gas
- Enhanced primary capture
- Alternate uses for digester gas
  - Compressed natural gas for vehicle
  - Pipeline
- Product recovery from recycle stream
  - Alternate Phosphorus removal
  - Nitrogen
Research Areas

- Gasification of sludge - transformation into liquid fuels
- Fuel Cell
- Liquid Fuels
- Arrested methanogenesis for chemical feed stocks
- Pyrolysis – oil, gas and char byproducts
## Known

### The basics
- 450 Dry tons per day
- % Volatiles
- % inert
- Geographic locations
- Refinery
- Steel Mills
- Local WWTP biosolids
- Sources of food wastes

### Some constraints
- Available space
- Newer Biosolids Drying Facility and 20 year operating contract
- Aging Incinerators
- Existing regulations
- Air permitting
- Sale of electricity
- Risk considerations

### Opportunities
- New international bridge
- Utility of the future
- Carbon regulation is coming
- Migrating energy production
- Rapidly advancing technology
Unknown

**Specifics**

- Anaerobic Digestion, HTL, Pyrolysis w/wo co-processing materials
  - Energy production potential
  - Impact of recycle streams on secondary treatment
- Inventories of co-processing materials
- Availability of co-processing materials
- Regulatory requirements if co-processing
- Energy balances for different scenarios
- Markets for products

**Economics**

- Cost to construct
- Projected operation and maintenance costs
- Value of carbon credits
- Value of energy recovered
  - electricity, liquid fuels
- Value of other products
  - nitrogen
  - phosphorous
  - bioplastics
  - industrial chemicals
- Potential operational savings
The Path

Research

Elimination of scenarios

Process modeling
As the Funnel Narrows

Master Planning

Pilot scale testing

Construction