City of Hamilton, Ohio

Wastewater Biosolids and Energy Master Planning

David Jenkins
City of Hamilton, Ohio

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Strand Associates, Inc.
Presentation Outline

• Hamilton WWTP History and Background

• Project Drivers

• Approach and Technologies

• Analyses and Recommendations
City of Hamilton
Overview – City of Hamilton WRF 1958-1976

• The Water Reclamation Facility was constructed in 1958.
• Located south of downtown Hamilton
• On the east bank of the Great Miami River
• 18 MGD Designed Capacity
• 12 MGD received primary treatment only
• 6 MGD received primary and secondary treatment
• Designed for 65% removal of TSS & BOD
• Primary Sludge + WAS anaerobically digested
• Sludge Dewatered with Rotary Vacuum Filters
• Sludge was Landfilled
Overview - City of Hamilton WRF 1976-1988

Champion Paper Mill Primary Plant

- Built in 1960
- Champion paper mill provided primary treatment
- Primary Effluent discharged to the Great Miami
- Clean Water Act of 1972
- Champion Paper Mill had to provide secondary treatment
- Provide secondary treatment to Hamilton’s Influent
- In 1976 the City started to operate the primary plant
- 30” primary effluent force main installed
- 3 MGD from Champion
Overview-City of Hamilton WRF 1976-1988

- Champion PE + City of Hamilton Influent
- New aeration tanks were built
- Total capacity of 5.97 MG
- Plant Capacity 32 MGD
- In 1978 two (2) of the anaerobic digesters were converted to gravity thickeners
- Primary Sludge + WAS sent to gravity thickeners
- Sludge was dewatered with rotary vacuum filters
- Sludge was landfilled
Overview - City of Hamilton WRF 1988-2000

- In 1988 the composting facility was complete
  - Process 60 to 70% of the sludge solids
  - 40 to 30% Lime Stabilized
  - Composting Produced an Exceptional Quality Biosolid
  - Class A Pathogen Reduction
    - Heated for 3 days at 55°C
  - Vector Attraction Reduction
    - Aerobic environment for 14 days
    - Maintain a temperature >40°C
- Primary Sludge + WAS sent to gravity thickeners
- Sludge dewatered by rotary vacuum filters until 1999
- In 1999 three (3) Komline-Sanderson presses were installed
- Lime Stabilized Sludge Land Applied
Overview-City of Hamilton WRF 2000-2012

- New Influent pump station
  - 2 Climber Bar Screens
  - 2-350 hp pumps (13,200 gpm)
  - 1-200 hp pump (8,333 gpm)
- Parshall Flume flow measurement
- New aerated grit tanks
- 3 New Primary Clarifiers
  - 524,000 gallons each
- New Chlorination Tank
- New Dechlorination Tank
- Wet Weather Capacity
  - 62 MGD can receive primary treatment and disinfection
  - 32 MGD will receive full secondary treatment
Overview – City of Hamilton WRF 2000-2012

• Solids Handling
  • Primary Sludge + WAS sent to gravity thickeners
  • Sludge dewatered with belt filter presses
  • Sludge composted + lime stabilized
  • Stabilized sludge land applied
  • Composted Sludge hauled off site by landscaping contractor

• The compost facility was shut down in 2012
Overview – City of Hamilton WRF 2012-Present

- Aeration Tanks
  - Mechanical aerators removed
  - Fine bubble diffuser system installed
- Secondary Clarifiers
  - The draft tube collection system removed
  - New drives installed
- No major modifications since 2014
Overview – City of Hamilton WRF
2012-Present Solids Handling

- The PS + WAS are thickened in the gravity thickeners
- Primary sludge: approximately 150,000 GPD
- Waste activated sludge: approximately 120,000 GPD
- Typically, the thickened sludge has a solids concentration of 2.5% - 3%, but the solids can vary from 1.5% to 6%
- The thickened sludge is then dewatered by 3 belt filter presses
- The thickened sludge to the belt filter press: approximately 70,000 GPD
Overview – City of Hamilton WRF
2012-Present Solids Handling

• When weather conditions are suitable and cropping schedules allow, the dewatered sludge is mixed with lime to produce a Class B sludge, which is land applied.
• At all other times the dewatered sludge is transported directly to a landfill for disposal
• All sludge is removed from the plant within 24 after being dewatered
• Over the past several years approximately 45% is land applied and 55% is landfilled.
• From 1988 to present Synagro has handled the disposal of the city’s biosolids.
• Synagro also manages the city’s land application program
Main Driver – Cost of Existing Sludge Management

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Cake Hauled (tons)</th>
<th>Cake Landfilled (tons)</th>
<th>Cake Landfilled (%)</th>
<th>Cake Land Applied (tons)</th>
<th>Cake Land Applied (%)</th>
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<tbody>
<tr>
<td>2014</td>
<td>9,615</td>
<td>5,200</td>
<td>54%</td>
<td>4,414</td>
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<td>2015</td>
<td>8,829</td>
<td>5,809</td>
<td>66%</td>
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<td>2016</td>
<td>8,583</td>
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<td>2017</td>
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<td>5,850</td>
<td>70%</td>
<td>2,564</td>
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<td>Average</td>
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<td>5,192</td>
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<td>3,668</td>
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<table>
<thead>
<tr>
<th>Year</th>
<th>Cake Landfilled Unit Price ($/ton)</th>
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<td>$60.79</td>
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<td>2018</td>
<td>$61.70</td>
<td>$24.76</td>
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<td>2019</td>
<td>$62.62</td>
<td>$25.13</td>
<td>$417,304*</td>
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<td>2020</td>
<td>$63.87</td>
<td>$25.63</td>
<td>$425,628*</td>
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*Estimated based on 2014 through 2017 average.
Additional Drivers for the Study

• Condition assessment of existing facilities and equipment
• Identify potential risks
  • Regulatory
  • Equipment Failure
  • Disposal
• Assessment of current operating cost/future cost
• Investigate alternatives for sludge management and disposal
• Focus on bioenergy and resource management and recovery
Future Growth Projections and Outside Wastes

- Growth through 2040 - See Below
- Impact of Future Effluent Phosphorus Limits - 10-25% impact
  - 1 mg/L
  - Lower limit ~ 0.1 to 0.2 mg/L
- Butler County Biosolids - 2x more solids than City
- Other Feedstocks - High-strength waste directly to digestion

<table>
<thead>
<tr>
<th>Year</th>
<th>Population 0.3% Growth Rate</th>
<th>Households 0.2% Growth Rate</th>
<th>Customer Accounts 0.3% Growth Rate</th>
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<tr>
<td>2018</td>
<td>64,107</td>
<td>25,033</td>
<td>23,393</td>
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<td>2023</td>
<td>65,074</td>
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<td>2028</td>
<td>66,056</td>
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<td>67,053</td>
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<td>2038</td>
<td>68,065</td>
<td>26,054</td>
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Condition and Capacity Assessments

- Process equipment.
- Evaluated age, condition and capacity.

Thickened sludge pumps in basement of digester control building
Capacity of existing tanks quantified to determine potential capacity
Existing belt filter press
Non-Process Assessments

• Ancillary equipment evaluated
  — HVAC
  — Electrical and controls
  — Structural components

• “Big Picture” building code issues considered – e.g. chemical storage locations, condition of handrail, stairs, etc.

• Summary of NPFA 820 compliance issues noted.

Stairs, handrail and building components were evaluated

Polymer storage tank and feed system in basement of dewatering building

Existing HVAC boiler
Condition Assessments Included Condition and Criticality Factors

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<th>Equipment</th>
<th>Type / Manufacturer</th>
<th>Condition Factor</th>
<th>Need Factor</th>
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<td>4</td>
<td>12</td>
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<td>4</td>
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<tr>
<td>Primary Sludge Pump</td>
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<td>4</td>
<td>12</td>
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<tr>
<td>WAS Pump</td>
<td>Centrifugal</td>
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<td>Splitter Structure</td>
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<td>Peroxide Feed System</td>
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<td>progressive cavity moyno</td>
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<td>4</td>
<td>12</td>
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<tr>
<td>Thickened Sludge Pump</td>
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<td>Pug Mill</td>
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<td>4</td>
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<tr>
<td>Polymer Feed Pump/Mixer</td>
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<td>8</td>
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<td>Polymer Feed Pump/Mixer</td>
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<td>Polymer Tank Mixer</td>
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<td>12</td>
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<td>Lime Silo and Conveyor</td>
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<tr>
<td>Lime Silo and Conveyor</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>
Existing Solid Processing Schematic

Landfill

or

Land Application

Lime Addition
Study Focused on Solids Management
Sludge Treatment Options

Land Application

- Lime Stabilization
- Digestion

Potential for Energy Recovery

- Digestion
- Lime Stabilization/Heat
- Drying

Most Flexible End Use

Unconditioned

Class B

Class A

Landfill
Existing Operations Were Evaluated for Upgrades

- Former anaerobic digester currently used as gravity thickener.
- Facade damage on former anaerobic digester.
- Remaining cover on former anaerobic digester.
- Existing belt filter presses and dewatered sludge conveyor.
- Existing dewatered sludge conveyor loadout to hauler.
- Existing lime storage silos.
- Existing sludge and lime loadout.
Sludge Thickening Alternatives

- All technologies would produce more consistent thickened sludge for stabilization; reduce heating costs for digestion.
- Existing thickeners tanks have higher value as digesters (less costly to add thickening equipment than new digestion tanks).
WAS Conditioning – Increase Gas Production

PONDUS Step-By-Step

[1] Thickened WAS
[2] Thickened Primary
[3]
[4]
[5]
[6]
[7]

Biogas
Biosolids

Ultrawaves
**Class B Sludge Stabilization Alternatives**

- Anaerobic digestion is most common at plants above 10 mgd
- Aerobic digestion is simpler; fairly common at plants up to ~ 10 mgd
- Lime stabilization typically used if area land benefits from alkalinity
Class A Biosolids Alternatives

- Belt Dryers
- Paddle Dryers
- Lime + Heat
- TPAD and ATAD

City of Hamilton
Butler County, Ohio
Hauled / High-Strength Waste Receiving and Processing
Solids Dewatering

- BFPs probably still the most common
- Centrifuges perform better under a range of alternatives, but more power and polymer
- Screw presses have limited throughput, but produce a high quality cake
Sludge/Biosolids Storage

Existing City storage structure at the WRF.
Energy Recovery Alternatives

1. Boiler use only (baseline alternative)
2. Use in biosolids drying
3. Combined heat and power – Engines
4. RNG applications (pipeline injection)
Energy Generation / Recovery

Fond du Lac biogas engine.
Hamilton’s Ownership of Gas Utility Provides Unique Opportunity for RNG

- Major hurdle includes working with local gas utility to locate an acceptable (and affordable) connection point.
RNG Markets and Gas Value

Value of D3 RIN ~ $2.47 vs. D5 RIN ~ $0.60 (4/20/18)
RNG Markets and Gas Value

Value of D3 RIN ~ $2.07 vs. D5 RIN ~ $0.30 (10/10/18)
RNG Markets and Gas Value

Value of D3 RIN ~ $0.78 vs. D5 RIN ~ $0.46 (6/18/19)
Initial Evaluation of Alternatives

Alternatives Either:
- Not Recommended
- Similar to Another
- Further Review (no X)
Alternatives Analysis

Lime Stabilization
• LS1 - Class B
• LS2 - Exceptional Quality

Anaerobic Digestion
• AD1 – Mesophilic Anaerobic Digestion – Class B
• AD2 – Mesophilic Anaerobic Digestion with Drying – Exceptional Quality
• AD3 – Mesophilic Anaerobic Digestion with Mechanical Thickening – Class B
• AD4 – Mesophilic Anaerobic Digestion with Mechanical Thickening and Dryer – Exceptional Quality
• AD5 – Temperature Phased Anaerobic Digestion

Each Alternative had following sub-alternatives:
• 3 loading alternatives (Hamilton only, + Butler County, + High Strength Waste)
• 3 biogas reuse alternatives for anaerobic digestion (boilers, cogeneration, RNG)
• 3 storage alternatives (0, 30 and 120 day storage)

• Resulted in 145 Alternative combinations !!!
Alternatives Analysis

- Biosolids flow and mass balances.
- Site plans and schematics of all alternatives were developed.
- Capital and operational costs were developed.
Alternatives Analysis

Total Present Worth Costs for each alternative noted

- Capital Costs
- Operational, Maintenance and Replacement Costs
- Sludge hauling, landfill tipping fees, etc.
- Potential revenues and cost savings:
  - Tipping fees
  - Gas sales
  - Electrical savings
  - Etc.

Variable Inputs for Present Worth Analysis:
(These values when toggled will update results summary)
- 20 PW Period (Years)
- 2.20% Inflation Rate (growth of fixed cash values, "g")
- 2.50% Discount Rate (approximated with bond rates, alternative use of cash, "i")
- $100,000 Additional Staff Annual Cost ($ each)
- $ 0.07 Electricity Used Unit Value ($/kWh)
- $ 0.07 Sold Electricity Unit Price ($/kWh)
- $ 3.00 Gas Used Unit Value ($/1,000cf)
- $ 10.00 Sold Gas Unit Price ($/1,000cf)
- $ 0.08 Lime Unit Cost ($/lb)
- $ 1.20 Polymer Unit Cost ($/lb)
- 50% No Storage, Class B, Percent Biosolids Land Applied
- 75% 30 Day Storage, Class B, Percent Biosolids Land Applied
- 100% 120 Day Storage, Class B, Percent Biosolids Land Applied
- 100% No Storage, Exceptional Quality, Percent Biosolids Land Applied
- 100% 30 Day Storage, Exceptional Quality, Percent Biosolids Land Applied
- 100% 120 Day Storage, Exceptional Quality, Percent Biosolids Land Applied
- 4.00 Storage Stack Height (feet)
- 20% Storage Additional Working Space
- $ 24.76 Land Apply Cost ($/wet ton)
- $ 61.70 Landfill Cost ($/wet ton)
- 10.0% Contractor’s General Conditions
- 18.0% Professional Services
- 30.0% Contingency
- $ 32.50 Butler County Sludge Tipping Fee ($/Wet Ton)
- $ 0.03 HSW Tipping Fee ($/gal)
- HSW Strength (COD mg/L), Suggested Range x to x mg/L
- 1.25% Equipment Salvage Value (% Lost per Year)
- 10.0% Service Life Equipment Maintenance, Percent Construction Cost
Present Worth Calculator Spreadsheet
20-Year Present Worth

Lime Stab.

Anaerobic Digestion Alts.

Meso AD + HSW + RNG

TPAD + HSW + RNG
## Comparison of Lime Stabilization vs. Anaerobic Digestion

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Description</th>
<th>Construction Cost Opinion</th>
<th>Annual O&amp;M Cost</th>
<th>Annual Disposal Cost</th>
<th>Annual Revenue</th>
<th>Net Annual O&amp;M and R</th>
<th>Total PW</th>
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<tr>
<td>LS 1.1-0</td>
<td>Hamilton Sludge, LS to Class B, No Storage</td>
<td>$9,077,000.00</td>
<td>$226,000.00</td>
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<td>LS 2.1-30</td>
<td>Hamilton Sludge, LS to Exceptional Quality, 30 Days Storage</td>
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<td>Hamilton Sludge, Digested, no storage, internal biogas reuse only</td>
<td>$19,334,000.00</td>
<td>$193,000.00</td>
<td>$193,000.00</td>
<td>$(386,000.00)</td>
<td>$(25,165,000.00)</td>
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</tbody>
</table>

• Conclusion - Currently, lime stabilization is more economically feasible than digestion.
# Feasibility of Butler County Sludge Receiving

<table>
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<tr>
<th>Alternative</th>
<th>Description</th>
<th>Construction Cost Opinion</th>
<th>Annual O&amp;M Cost</th>
<th>Annual Disposal Cost</th>
<th>Annual Revenue</th>
<th>Net Annual O&amp;M and R</th>
<th>Total PW</th>
<th>Total Residual Generated, wet tons/year</th>
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<td>Hamilton Sludge, Digested, no storage, internal biogas reuse only</td>
<td>$19,334,000.00</td>
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- Conclusion - Butler County Sludge Receiving would take significant additional capital costs, not likely viable unless tipping fees are high.
Parameters/Drivers to Monitor for Long-Term Decisions

1. Local/political sustainability initiatives
2. Landfill tipping fees
3. Landfill life expectancy
4. Land application costs
5. Regulatory/political concerns with land application
6. Nutrient regulations
7. Electrical costs
8. Renewable energy incentives
9. RNG markets
10. Odors
11. HSW markets
12. Butler County initiatives

Variable Inputs for Present Worth Analysis:
(These values when toggled will update results summary)

- 20 PW Period (Years)
- 2.20% Inflation Rate (growth of fixed cash values, "g")
- 2.50% Discount Rate (approximated with bond rates, alternative use of cash, "i")

$100,000 Additional Staff Annual Cost ($/each)
$ 0.07 Electricity Used Unit Value ($/kWh)
$ 0.07 Sold Electricity Unit Price ($/kWh)
$ 3.00 Gas Used Unit Value ($/1,000cf)
$ 10.00 **Sold Gas Unit Price ($/1,000cf**)
$ 0.08 Lime Unit Cost ($/lb)
$ 1.20 Polymer Unit Cost ($/lb)
50% No Storage, Class B, Percent Biosolids Land Applied
75% 30 Day Storage, Class B, Percent Biosolids Land Applied
100% 120 Day Storage, Class B, Percent Biosolids Land Applied
100% No Storage, Exceptional Quality, Percent Biosolids Land Applied
100% 30 Day Storage, Exceptional Quality, Percent Biosolids Land Applied
100% 120 Day Storage, Exceptional Quality, Percent Biosolids Land Applied
4.00 Storage Stack Height (feet)
20% Storage Additional Working Space
$ 24.76 Land Apply Cost ($/wet ton)
$ 61.70 Landfill Cost ($/wet ton)
10.0% Contractor’s General Conditions
18.0% Professional Services
30.0% Contingency
$ 32.50 Butler County Sludge Tipping Fee ($/Wet Ton)
$ 0.03 HSW Tipping Fee ($/gal)
100,000 **HSW Strength (COD mg/L), Suggested Range x to x mg/L**
1.25% Equipment Salvage Value (% Lost per Year)
10.0% Service Life Equipment Maintenance, Percent Construction Cost
## Overall Summary of Costs

### Recommended Project Phasing

<table>
<thead>
<tr>
<th></th>
<th>LS 1.1 Lime Stabilization</th>
<th>AD 1.1 Anaerobic Digestion</th>
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<tbody>
<tr>
<td>Short-Term</td>
<td>$7.2M</td>
<td>$7.2M</td>
</tr>
<tr>
<td>Long-Term</td>
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<td>$12.0M</td>
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<tr>
<td>Total</td>
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<td>$19.2M</td>
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Long-Term – Lime Stabilization Pathway

New Dewatering

Storage Lime Stab Upgrades

Gravity Thickener Upgrades

Legend:
120 – Primary Clarifier
130 – Primary Clarifier
121 – Primary Clarifier
18 – Gravity Thickener
110 – Gravity Thickener
90 – Abandoned
81 – Primary Sludge Pumping Station
82 – Waste Sludge Pumping Station
83 – Ozone Control Building
84 – Dewatering Building
85 – Proposed Polymer Storage Annex
87 – Proposed Solids Storage
And Lime Addition Building (30 day option)
88 – Proposed Solids Storage
And Lime Addition Building (120 day option)
99 – Reconstructed Sludge Loadout Annex
91 – SLG I
92 – SLG II

NECESSARY SHORT-TERM IMPROVEMENTS

NECESSARY LONG-TERM IMPROVEMENTS
Long-Term – Anaerobic Digestion Pathway

New Dewatering

Gravity Thickener Upgrades

Storage

Anaerobic Digestion Conversion
Conclusions and Next Steps

• Lime stabilization had lowest capital and present worth costs
  • Concern about long term viability due to landfill availability and costs.

• Anaerobic digestion could become cost effective if markets change, or could be the selected alternative if drivers change.

• Recommend short-term project to improve/replace dewatering, polymer addition, and other “common” items.

• Recommend continuing with current lime stabilization and monitor the markets, City sustainability goals, etc.
Thank You!

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