Presentation Outline

- Minnesota’s Landfill Landscape
- Managing Leachate in Operation
- Leachate Treatment Solutions
Minnesota’s Landfill Landscape
Types of Permitted Landfills in MN

1. Industrial Solid Waste Landfill
   - Captive, or monofill: waste from specific corporation(s) [23]
     - May be lined or unlined
   - Merchant: open to many industries [7]
     - Liner likely required

2. Demolition Debris Landfill
   - Class 1: strict waste list, unlined [66]
   - Class 2: strict waste list + packaging + limited demo-like industrial waste; liner evaluation required [26]
   - Class 3: more diverse waste list; liner evaluation required [10]

3. Municipal Solid Waste (MSW) Landfill [21]

4. MSW Combustor Ash Landfill [8]
Unlined Landfills in MN
Lined Landfills in MN
## 2016 MN Waste Disposal Data

<table>
<thead>
<tr>
<th>Lined Tonnage</th>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSW</td>
<td>1,960,239</td>
</tr>
<tr>
<td>Industrial</td>
<td>2,223,602</td>
</tr>
<tr>
<td>Demo Class II Lined</td>
<td>50,121</td>
</tr>
<tr>
<td>Demo Class III Lined</td>
<td>785,696</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>5,019,658 (91.5%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unlined Tonnage</th>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>81,567</td>
</tr>
<tr>
<td>Demo Class I [66]</td>
<td>236,159</td>
</tr>
<tr>
<td>Demo Class II [23]</td>
<td>146,497</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>464,223 (8.5%)</td>
</tr>
</tbody>
</table>

| Total                         | 5,483,881 |
2017 Leachate Disposal Data

MSW Landfills
- Wastewater Treatment Plants (11): 67,048,627 gallons
- Land Application (8): 31,255,071 gallons
- Recirculation (3): 5,534,286 gallons
- Total: 103,837,984 gallons

Merchant Industrial Landfills
- Wastewater Treatment Plants (6): 129,494,863 gallons
- Dust Control (1): 324,000 gallons
- Total: 129,818,863 gallons
2017 Leachate Disposal Data

Captive Industrial Landfills
• Wastewater Treatment Plants (6): 36,786,664 gallons
• Land Application (1): 6,700 gallons
• On-Site Storage (2): 6,280,900 gallons
• Total: 43,074,264 gallons

Construction & Demolition Landfills
• Wastewater Treatment Plants (5): 12,267,402 gallons
• On-Site Storage (1): 120,000 gallons
• Total: 12,387,402 gallons
• *Approximately 15 gallons of leachate per ton waste
2017 Leachate Disposal Data

MSW/MSW Ash Landfills

• Wastewater Treatment Plants (8): 19,860,843 gallons
• Quench Water (2): 1,291,760 gallons
• Total: 21,153,603 gallons
2017 Leachate Disposal Data

Overall Total by Disposal Option

• Wastewater Treatment Plants: 265,458,399 gallons
• Land Application: 31,261,771 gallons
• On-Site Storage: 6,400,900 gallons
• Recirculation: 5,534,286 gallons
• WTE Ash Quench Water: 1,291,760 gallons
• Dust Control: 324,000 gallons
• Total: 310,271,116 gallons

➔ Perspective: Rochester WWTP is 13 MGD average
MCES – Empire collected 106 MGY that was generated from one source and is not included in this representation.
447 acres of open, active, lined landfill
Managing Leachate in Operation
MSW Placement Goals

- Airspace Utilization: >1,200 lb/cy
- Waste:Soil Ratio: >4:1
  - Minimize Soil Usage
  - Maximize Compaction
- Daily/Intermediate Cover ➔ ADC
- Minimize Litter
- Minimize Equipment/Fuel Costs
- Minimize Leachate Generation
  - Daily Cell Size
  - Open Lined Area
  - Manage Runoff
Landfill Cross Section
Controlling Stormwater
Takeaways

- Plan Cell Construction
- Minimize Contact Water
- Have Tight Final Intermediate Cover
- Keep the Leachate Collection System Open
- Don’t Trap Water…Do Promote Runoff
- Strip Daily/Intermediate Cover
- Remove Haul Roads
- Control Gas
Leachate Treatment Solutions
Leachate Disposal Hurdles

• Wastewater Treatment Plants
  – Volume Limits
  – Available Haulers
  – Metals Limits (arsenic, chromium, mercury)
  – Organics Loading (BOD, ammonia)

• Land Application
  – Hydraulic Loading (Moisture checkbook method)
  – Nitrogen Loading
  – Boron Loading
  – Metals Loading
  – Potential PFAS Groundwater Impacts
Options for Volume Reduction
More Aggressive Evaporation

Process flow

A. Supply
B. Distribution
C. Wind / Evaporation
D. Circulation

Few moving parts with low effort of skilled labor to O&M

https://twitter.com/encone evaporator

Recirculation (Storage)
Recirculation Benefits

► Waste/Leachate Stability
► Leachate Volume Storage/Reduction
► Additional Leachate Treatment
► Enhanced LFG/GHG Destruction
► Accelerated Waste Settlement
  • Airspace Recapture
  • Permit/Construction Savings
► Leachate Management Savings
► Reduced Long-Term Liability
Leachate Treatment Pond

► Aeration
  • Reduce VOC’s/Organics
  • Promote Precipitation of Metals
  • Promote Nitrification of Ammonia

► Addition of Carbon and Denitrifying Bugs to Promote Anoxic Denitrification

► Significant Nitrogen Reduction
  • 500 to 800 mg/L ammonia-N to ND

► Metals Reduction

► Little Boron or PFAS Treatment
Reverse Osmosis

# Reverse Osmosis Demonstration

<table>
<thead>
<tr>
<th>PFAS (ug/L)</th>
<th>Raw</th>
<th>Permeate</th>
<th>Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFBS</td>
<td>0.714</td>
<td>ND</td>
<td>1.15</td>
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<tr>
<td>PFBA</td>
<td>1.46</td>
<td>ND</td>
<td>2.02</td>
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<tr>
<td>PFOA</td>
<td>1.05</td>
<td>ND</td>
<td>3.36</td>
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<tr>
<td>PFOS</td>
<td>0.13</td>
<td>ND</td>
<td>0.413</td>
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</table>

<table>
<thead>
<tr>
<th>VOCs (ug/L)</th>
<th>Raw</th>
<th>Permeate</th>
<th>Concentrate</th>
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<tbody>
<tr>
<td>Tetrahydrofuran</td>
<td>66.5</td>
<td>21.2</td>
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<table>
<thead>
<tr>
<th>Anions (mg/L)</th>
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<th>Permeate</th>
<th>Concentrate</th>
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<tbody>
<tr>
<td>Chloride</td>
<td>1,160</td>
<td>88.1</td>
<td>3,880</td>
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<tr>
<td>Sulfate</td>
<td>26</td>
<td>ND</td>
<td>87.5</td>
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</table>

<table>
<thead>
<tr>
<th>Nutrients (mg/L)</th>
<th>Raw</th>
<th>Permeate</th>
<th>Concentrate</th>
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</thead>
<tbody>
<tr>
<td>Ammonia-N</td>
<td>158</td>
<td>30.4</td>
<td>481</td>
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<tr>
<td>NO3+NO2-N</td>
<td>189</td>
<td>57.5</td>
<td>747</td>
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<tr>
<td>TKN</td>
<td>172</td>
<td>31.6</td>
<td>533</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metals (ug/L)</th>
<th>Raw</th>
<th>Permeate</th>
<th>Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>47.8</td>
<td>ND</td>
<td>141</td>
</tr>
<tr>
<td>Barium</td>
<td>214</td>
<td>3.39</td>
<td>445</td>
</tr>
<tr>
<td>Boron</td>
<td>8,430</td>
<td>5,620</td>
<td>14,700</td>
</tr>
<tr>
<td>Chromium</td>
<td>54.7</td>
<td>ND</td>
<td>175</td>
</tr>
<tr>
<td>Iron</td>
<td>6,460</td>
<td>105</td>
<td>13,000</td>
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<tr>
<td>Lead</td>
<td>0.585</td>
<td>ND</td>
<td>1.83</td>
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<tr>
<td>Manganese</td>
<td>992</td>
<td>ND</td>
<td>1,600</td>
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<tr>
<td>Nickel</td>
<td>192</td>
<td>ND</td>
<td>679</td>
</tr>
<tr>
<td>Silver</td>
<td>ND</td>
<td>ND</td>
<td>8.01</td>
</tr>
<tr>
<td>Zinc</td>
<td>30.5</td>
<td>76.4</td>
<td>100</td>
</tr>
</tbody>
</table>
Electro-Coagulation Demonstration

1. Raw Leachate
2. pH Adjustments
3. Air Stripping
4. Electric Precipitation

- Oxidation With NaOCl
- Activated Carbon & Ion Exchange
- Discharge
There’s No Free Lunch

- Leachate generation is small, but ‘intense’
  - Emerging contaminants
  - Regulations
- Minimizing leachate generation
  - Good planning
  - Good execution
- Leachate treatment
  - Multiple options
  - Treatment level vs. cost
  - Residuals management
Questions?

Mike Cook, PE
Senior Civil Engineer
(952) 656-2693 – Office
(651) 274-1298 – Cell
micook@burnsmcd.com
MSW Area Fill Working Face
Electrical Conductance Testing
Typical Daily Cell
Leachate Rock Prevention
Leachate Rock (Cholesterol)
Pump Clogging
System Cleaning/Video
Takeaways

► Minimize Fines into Collection System
► Limit Air Intrusion
► Separate LFG Collection
► Reduce Pipe Weld Height
► Minimize Turbulence
► Avoid Stagnant Pipes
► Clean Pipes After Construction and Annually
► CLEANOUTS!
Evaporation and Aeration
Annual Airspace Utilization Factor

Source: Crow Wing County Landfill
Long-Term Benefits

- Reduced Post-Closure Cost & Liability
  - Leachate Quality
  - Leachate Generation
  - Landfill Gas Generation
  - Settlement
Land Application Options
Raincoat Option
MCES – Empire collected 100 MGY that was generated from one source and is not included in this representation.
447 Acres of Open, active landfill and 28 acres of open, closed landfill
<table>
<thead>
<tr>
<th></th>
<th>MSW Landfills</th>
<th>Merchant Industrial LF's</th>
<th>Captive Industrial LF's</th>
<th>C&amp;D LF's</th>
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<tr>
<td>WWTP</td>
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<td>Recirc</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust Control</td>
<td></td>
<td></td>
<td></td>
<td>324,000</td>
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<tr>
<td>On-site Storage</td>
<td></td>
<td></td>
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<td>6,280,900</td>
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<td><strong>Total</strong></td>
<td>103,837,984</td>
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<tr>
<td><strong>Tons</strong></td>
<td>1,960,239</td>
<td>2,223,602</td>
<td></td>
<td>835,817</td>
</tr>
<tr>
<td><strong>Gal/Ton</strong></td>
<td>53.0</td>
<td>77.8</td>
<td></td>
<td>14.8</td>
</tr>
<tr>
<td><strong>Tons/acre</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gal/acre</strong></td>
<td></td>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td><strong>Tons Unlined LF</strong></td>
<td></td>
<td></td>
<td></td>
<td>81,567</td>
</tr>
<tr>
<td><strong>Total gallons</strong></td>
<td></td>
<td></td>
<td></td>
<td>5,671,234</td>
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