Basis for Alternative Development

- 95% Odor Reduction at the Dewatering Facility and the Compost Facility would result in less than five (1-hour) off-site odor events (D/T > 7) in a five year period.

- Ventilation Rates (NFPA 820 and WEF Manual of Practice No. 8)
  - Dewatering Facility – 24,000 cfm
    (12 AC/h in Building; 4 AC/h in tanks)
  - Compost Facility – 131,000 cfm
    (12 AC/h in Compost Bay Area)
Odor Control Technologies

- Chemical Scrubber
- Photoionization
- Carbon Adsorber
- Bio-trickling Filter
- Liquid Sludge Treatment
- Ionization
- Biofiltration

Chemical Scrubber

Treatment Description

- Three Stage System for H₂S and NH₃ removal.
- Absorption of H₂S into alkaline liquid (NaOH)
- Oxidation of H₂S in solution (NaOCl)
- Absorption of NH₃ into water
- Chemical reaction of NH₃ with sulfuric acid (H₂SO₄)
- Oxidation of organic odorants with NaOCl
**Chemical Scrubber**

**Advantages**
- Simple and stable operation
- 99.5% removal of H₂S
- Adaptable to changes in pollutant loading
- Small footprint
- Relatively low profile
- Relatively low capital cost
- Not dependent on maintaining a biomass
- Periodic operation

**Disadvantages**
- Storage and handling of NaOH, NaOCl, H₂SO₄
- Limited effectiveness on organic-based odorants
- Water consumption (would require softening if not Reclaimed Water)
- Blowdown to treatment plant
- Particulate Matter can cause media plugging
- Freeze concerns with exterior applications

**Photoionization**

**Treatment Description**
- UV light and a catalyst breakdown odorants.
- UV light creates oxidizing agents (O²⁻, OH⁻, O₃, activated O₂ and other free radicals)
- Untreated compounds are trapped in the catalyst and broken down.
**Photoionization**

**Advantages**
- >95% odor reduction
- Simple operation and maintenance
- Adaptable to changes in pollutant loading
- Small footprint
- Not dependent on maintaining a biomass
- No water or chemical usage
- Periodic operation
- Possibility of heat recovery
- Low back pressure (2 to 3 in WC)
- Wide temperature range (-30 °C to 70 °C)

**Disadvantages**
- Limited installations in North America
- Relatively high capital cost
- Consumables (UV lights and catalyst)
- Ozone generation (captured by catalyst?)

---

**Carbon Adsorption**

**Treatment Description**
- Packed activated carbon vessels
- Adsorption – physical adherence of molecules to surface of media
- Activated carbon has very high surface area
Carbon Adsorbers

**Advantages**
- Simple and stable operation
- >95% odor reduction
- Handles changes in pollutant loading
- Small footprint
- Not dependent on maintaining a biomass
- No water or chemical usage

**Disadvantages**
- Higher pollutant loadings reduce bed life (higher frequency of media change out)
- Carbon bed replacement can be costly and labor intensive
- Spent carbon must be disposed of properly (landfill) for high capacity carbon
- Not effective at removal of ammonia
- Limited effectiveness at removal of amines

Bio-Trickling Filter

**Treatment Description**
- Natural metabolic actions of microorganisms degrade odorants
- Countercurrent flow of air and water through synthetic media
## Bio-Trickling Filter

### Advantages
- Minimal maintenance
- Synthetic media - long life (10 years)
- Programmable irrigation and nutrient control
- No chemicals

### Disadvantages
- Requires water and sometimes nutrients
- Freeze concerns
- Must maintain biological activity
- Unable to handle odor spikes
- Difficult to maintain efficient removal of reduced sulfur organic compounds

## Liquid Sludge Treatment

### Treatment Description
- VX456 – Selective Oxidant with specificity to sulfides and related organic odorants
**Liquid Sludge Treatment**

**Advantages**
- Low capital cost
- Easy to pilot
- Controls odors in building space

**Disadvantages**
- Controls odors for 24-72 hours; concern of odor release downstream
- Chemical usage substantially increased when treating storage tanks
- Chemical is highly corrosive
- Fire hazard when allowed to dry

**Ionization**

**Treatment Description**
- Ionization systems supply highly ionized air with $O^{2-}$ and $O^2$ ions to the application areas
- Ions form molecular ion clusters with high oxidizing power.
Ionization

**Advantages**
- Improves indoor air quality
- Interior dust control
- Interior corrosion control
- Ion generators sized for each discrete space
- Potential for heat recovery
- Ion Generator serves as make-up air unit
- Low pressure drop systems
- Low footprint and low profile

**Disadvantages**
- Relatively high capital cost
- ~90% H2S and NH3 reduction
- Consumables (ion tubes)
- Air distribution laterals in building space

Biofiltration

**Treatment Description**
- Natural metabolic actions of microorganisms degrade odorants
- Organic or mineral based media
Biofiltration

Advantages
• Low operation and maintenance costs
• 90-95% odor reduction
• No chemical usage
• Relatively high static pressures (5 – 9 in WC)
• Low profile
• Lowest life cycle costs for high ventilation rates (> 50,000 cfm)

Disadvantages
• Low to high capital cost depending on system sophistication
• Media replacement (3-5 years for organic media)
• High water consumption (humidification)
• Poor response to changes in pollutant loading
• Large footprint
• Background odor of media
• Short circuiting for traditional open bed filters

Opinion of Probable Project Costs

Assumptions

<table>
<thead>
<tr>
<th>Cost Description</th>
<th>Cost</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost for 25% Sodium Hydroxide</td>
<td>0.95</td>
<td>$/gal</td>
</tr>
<tr>
<td>Cost for 12.5% Hypochlorite</td>
<td>0.91</td>
<td>$/gal</td>
</tr>
<tr>
<td>Cost for 93% Sulfuric Acid</td>
<td>3.53</td>
<td>$/gal</td>
</tr>
<tr>
<td>Cost for Water (Reclaimed)</td>
<td>0.00</td>
<td>$/gal</td>
</tr>
<tr>
<td>Cost for Electricity</td>
<td>0.0602</td>
<td>$/kWh</td>
</tr>
</tbody>
</table>

Consumables
Manufacturer’s Input

Technician labor rate 50 $/hr
Life Cycle 20 years
Interest rate 5.0% per year
Contingency 15%
Summary of Alternatives for the Dewatering Facility

Alternative No. D1 - Chemical Scrubber
Alternative No. D2 - Photoionization
Alternative No. D3 - Carbon Adsorber
Alternative No. D4 - Bio-Trickling Filter
Alternative No. D5 - Liquid Sludge Treatment
Alternative No. D6 - Ionization

Dewatering: Alternative No. D1 - Chemical Scrubber

Opinion of Costs Summary

Construction Capital Cost: $ 486,000
Engineering/Administrative: $ 97,320
Contingency: $ 87,590
Project Capital Cost: $ 671,508
Annual Operating Cost: $ 130,510
Annual Debt Service: $ 53,884
Present Value: $2,297,945
**Dewatering: Alternative No. D2 - Photoionization**

**Opinion of Costs Summary**

<table>
<thead>
<tr>
<th>Cost Type</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Capital</td>
<td>$881,600</td>
</tr>
<tr>
<td>Engineering/Administrative</td>
<td>$88,160</td>
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<tr>
<td>Contingency</td>
<td>$145,500</td>
</tr>
<tr>
<td>Project Capital Cost</td>
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<tr>
<td>Annual Operating Cost</td>
<td>$101,641</td>
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<td>Annual Debt Service</td>
<td>$89,488</td>
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<tr>
<td><strong>Present Value</strong></td>
<td><strong>$2,381,897</strong></td>
</tr>
</tbody>
</table>

**Dewatering: Alternative No. D3 - Carbon Adsorber**

**Opinion of Costs Summary**

<table>
<thead>
<tr>
<th>Cost Type</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Capital</td>
<td>$659,500</td>
</tr>
<tr>
<td>Engineering/Administrative</td>
<td>$79,140</td>
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<tr>
<td>Contingency</td>
<td>$110,800</td>
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<tr>
<td>Project Capital Cost</td>
<td>$849,436</td>
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<tr>
<td>Annual Operating Cost</td>
<td>$65,139</td>
</tr>
<tr>
<td>Annual Debt Service</td>
<td>$68,161</td>
</tr>
<tr>
<td><strong>Present Value</strong></td>
<td><strong>$1,661,206</strong></td>
</tr>
</tbody>
</table>
Dewatering: Alternative No. D4 - Bio-Trickling Filter

Opinion of Costs Summary

Construction Capital Cost: $1,264,499
Engineering/Administrative: $126,450
Contingency: $208,642
Project Capital Cost: $1,599,591
Annual Operating Cost: $43,501
Annual Debt Service: $128,355
Present Value: $2,141,707

Dewatering: Alternative No. D5 - Liquid Sludge Treatment

Opinion of Costs Summary

Construction Capital Cost: $30,700
Engineering/Administrative: $20,000
Contingency: $7,605
Project Capital Cost: $58,305
Annual Operating Cost: $93,757
Annual Debt Service: $4,679
Present Value: $1,226,721
Dewatering: Alternative No. D6 - Ionization

Opinion of Costs Summary

Construction Capital Cost: $697,600
Engineering/Administrative: $104,640
Contingency: $120,340
Project Capital Cost: $922,576
Annual Operating Cost: $33,747
Annual Debt Service: $74,030
Present Value: $1,343,139

Present Value Summary for Dewatering Alternatives

- $2,141,707
- $1,343,139
- $1,226,721
- $1,661,206
- $2,381,897
- $2,297,945

$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0

$1,000,000
$1,500,000
$2,000,000
$2,500,000
$3,000,000

Alternative
D6, Ionization
D5, Ionization
D4, Ionization
D3, Ionization
D2, Ionization
D1, Ionization
Summary of Alternatives for the Composting Facility

Alternative No. C1A – Existing Biofilter Support Gravel and Media Replacement
- Remove and replace gravel and biofilter media

Alternative No. C1B – Replace Existing Biofilter Media and Improve Flushing Access
- Remove and replace gravel and biofilter media
- Modify air distribution piping at end to facilitate cleaning

Alternative No. C1C – Existing Biofilter Upgrade
- Add humidifiers
- Replace air distribution piping with slotted open floor
- Replace media with root compost

Alternative No. C2 - Concrete Biofilter with Engineered Media
- Install a new Concrete Biofilter System with Engineered Media

Alternative No. C3 – Chemical Scrubber System
- Install five (5) two-stage chemical scrubbers with chemical storage building

Alternative No. C4 – Ionization
- Ionization Generators

Composting: Alternative No. C1A - Replace Existing Biofilter Media

Opinion of Costs Summary

Construction Capital Cost: $432,876
Engineering/Administrative: $43,290
Contingency: $71,425
Project Capital Cost: $547,588
Annual Operating Cost: $187,072
Annual Debt Service: $43,940

Present Value: $2,878,919
Composting: Alternative No. C1B - Replace Existing Biofilter Media and Improve Flushing Access

Opinion of Costs Summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Construction Capital Cost</td>
<td>$736,551</td>
</tr>
<tr>
<td>Engineering/Administrative</td>
<td>$73,655</td>
</tr>
<tr>
<td>Contingency</td>
<td>$121,531</td>
</tr>
<tr>
<td>Project Capital Cost</td>
<td>$931,737</td>
</tr>
<tr>
<td>Annual Operating Cost</td>
<td>$187,072</td>
</tr>
<tr>
<td>Annual Debt Service</td>
<td>$74,765</td>
</tr>
<tr>
<td>Present Value</td>
<td>$3,263,068</td>
</tr>
</tbody>
</table>

Composting: Alternative No. C1C - Existing Biofilter Upgrade

Opinion of Costs Summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Capital Cost</td>
<td>$2,254,328</td>
</tr>
<tr>
<td>Engineering/Administrative</td>
<td>$225,433</td>
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<tr>
<td>Contingency</td>
<td>$371,964</td>
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<tr>
<td>Project Capital Cost</td>
<td>$2,851,725</td>
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<tr>
<td>Annual Operating Cost</td>
<td>$164,244</td>
</tr>
<tr>
<td>Annual Debt Service</td>
<td>$228,830</td>
</tr>
<tr>
<td>Present Value</td>
<td>$4,898,572</td>
</tr>
</tbody>
</table>

1. Coarse shredded, composted, tree root media
2. Water scrubber (humidifier) on each fan
3. Add Variable Frequency Drives
4. Secondary humidification system (grid of soaker hoses)
Composting: Alternative No. C2 - Concrete Biofilter with Engineered Media

Opinion of Costs Summary

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Capital Cost:</td>
<td>$5,284,910</td>
</tr>
<tr>
<td>Engineering/Administrative:</td>
<td>$528,500</td>
</tr>
<tr>
<td>Contingency:</td>
<td>$872,010</td>
</tr>
<tr>
<td>Project Capital Cost:</td>
<td>$6,685,411</td>
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<tr>
<td>Annual Operating Cost:</td>
<td>$141,141</td>
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<td>Annual Debt Service:</td>
<td>$536,455</td>
</tr>
<tr>
<td>Present Value:</td>
<td>$8,444,342</td>
</tr>
</tbody>
</table>

Composting: Alternative No. C3 - Chemical Scrubber System

Opinion of Costs Summary

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Capital Cost:</td>
<td>$2,298,010</td>
</tr>
<tr>
<td>Engineering/Administrative:</td>
<td>$344,702</td>
</tr>
<tr>
<td>Contingency:</td>
<td>$396,410</td>
</tr>
<tr>
<td>Project Capital Cost:</td>
<td>$3,039,118</td>
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<tr>
<td>Annual Operating Cost:</td>
<td>$2,310,421</td>
</tr>
<tr>
<td>Annual Debt Service:</td>
<td>$243,867</td>
</tr>
<tr>
<td>Present Value:</td>
<td>$31,832,071</td>
</tr>
</tbody>
</table>
**Composting: Alternative No. C4 - Ionization**

**Opinion of Costs Summary**

Construction Capital Cost: $2,429,300  
Engineering/Administrative: $364,395  
Contingency: $419,055  
Project Capital Cost: $3,212,749  
Annual Operating Cost: $94,894  
Annual Debt Service: $257,799

Present Value: $4,395,340

---

**Present Value Summary for Compost Facility Alternatives**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Present Value</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1A Replace Biofilter Media</td>
<td>$2,878,919</td>
<td>$2,878,919</td>
</tr>
<tr>
<td>C1B Replace Biofilter Media and Improve Flushing Access</td>
<td>$3,263,068</td>
<td>$3,263,068</td>
</tr>
<tr>
<td>C1C Existing Biofilter Upgrade</td>
<td>$4,898,572</td>
<td>$4,898,572</td>
</tr>
<tr>
<td>C2 Concrete Biofilter with Engineered Media</td>
<td>$8,444,342</td>
<td>$8,444,342</td>
</tr>
<tr>
<td>C3 Chemical Scrubber System</td>
<td>$31,832,071</td>
<td>$31,832,071</td>
</tr>
<tr>
<td>C4 Ionization</td>
<td>$4,395,340</td>
<td>$4,395,340</td>
</tr>
</tbody>
</table>
Dewatering and Composting: Alternative No. DC1 - Concrete Biofilter with Engineered Media

Opinion of Costs Summary

Construction Capital Cost: $6,350,180
Engineering/Administrative: $635,018
Contingency: $1,047,780
Project Capital Cost: $8,032,978
Annual Operating Cost: $173,223
Annual Debt Service: $644,587
Present Value: $10,191,724
### Table 1: Air Industry Reduces Media Consumables

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual O&amp;M Costs</td>
<td>$1,226,738</td>
<td>$1,226,738</td>
<td>$1,226,738</td>
<td>$1,226,738</td>
</tr>
<tr>
<td>Odor Reduction</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Confined Space Entry</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Industry Experience</td>
<td>Well established</td>
<td>Well established</td>
<td>Well established</td>
<td>Moderately established</td>
</tr>
<tr>
<td>Media Handling</td>
<td>Periodic cleaning (if required based on air quality and water quality)</td>
<td>Periodic cleaning (if required based on air quality and water quality)</td>
<td>Periodic cleaning (if required based on air quality and water quality)</td>
<td>Periodic cleaning (if required based on air quality and water quality)</td>
</tr>
<tr>
<td>Media Removal</td>
<td>Chemicals as required, Methane is removed every 5 years.</td>
<td>Chemicals as required, Methane is removed every 5 years.</td>
<td>Chemicals as required, Methane is removed every 5 years.</td>
<td>Chemicals as required, Methane is removed every 5 years.</td>
</tr>
<tr>
<td>Annual Water Usage (gallons)</td>
<td>26,215</td>
<td>26,215</td>
<td>26,215</td>
<td>26,215</td>
</tr>
<tr>
<td>Chemicals</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Total Cost of Operational Use (chemical adjustment)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>O&amp;M Cost-Benefit with Varying Odorant Concentrations</td>
<td>Low - Highest odorant loadings can increase chemical usage and O&amp;M costs.</td>
<td>Low - Highest odorant loadings can increase chemical usage and O&amp;M costs.</td>
<td>Low - Highest odorant loadings can increase chemical usage and O&amp;M costs.</td>
<td>Low - Highest odorant loadings can increase chemical usage and O&amp;M costs.</td>
</tr>
</tbody>
</table>

### Table 2: Odor Control Technologies

<table>
<thead>
<tr>
<th>Criteria</th>
<th>CER</th>
<th>CER</th>
<th>CER</th>
<th>CER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Units/Sites</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Unit Dimensions (in ft)</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Overall Flow Rate (gpm)</td>
<td>26,215</td>
<td>26,215</td>
<td>26,215</td>
<td>26,215</td>
</tr>
<tr>
<td>Odor Reduction</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Odor Control Technology</td>
<td>Functional</td>
<td>Functional</td>
<td>Functional</td>
<td>Functional</td>
</tr>
<tr>
<td>Media</td>
<td>Organic – wood chip and wood compost</td>
<td>Organic – wood chip and wood compost</td>
<td>Organic – composted tree logs</td>
<td>Mineral based - Synthetic</td>
</tr>
<tr>
<td>Media Replacement (years)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Odor Control Technology</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Media</td>
<td>Organic – wood chip and wood compost</td>
<td>Organic – wood chip and wood compost</td>
<td>Organic – composted tree logs</td>
<td>Mineral based - Synthetic</td>
</tr>
<tr>
<td>Media Replacement (years)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Odor Control Technology</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

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**9/19/2016**
<table>
<thead>
<tr>
<th>Criteria</th>
<th>DC1 Concrete Biofilter with Engineered Media</th>
<th>DC2A Concrete Biofilter with Organic Media</th>
<th>Lined Biofilter with Organic Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Units/Cells</td>
<td>46</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Unit Dimensions (L x W)</td>
<td>80 ft x 60 ft</td>
<td>70 ft x 74 ft</td>
<td>70 ft x 74 ft</td>
</tr>
<tr>
<td>Overall Foot Print (ft²)</td>
<td>19,200 (80 ft x 240 ft)</td>
<td>31,080 (440 ft x 70 ft)</td>
<td>31,080 (440 ft x 70 ft)</td>
</tr>
<tr>
<td>Odor Reduction</td>
<td>95-96%</td>
<td>90-95%</td>
<td>90-95%</td>
</tr>
<tr>
<td>Industry Experience</td>
<td>Well established</td>
<td>Well established</td>
<td>Well established</td>
</tr>
<tr>
<td>Air Distribution</td>
<td>Open, down forced</td>
<td>Open floor, upflow</td>
<td>Open floor, upflow</td>
</tr>
<tr>
<td>Media Replacement (years)</td>
<td>20</td>
<td>3-5</td>
<td>3-5</td>
</tr>
<tr>
<td>Consumables</td>
<td>Media</td>
<td>Media</td>
<td>Media</td>
</tr>
<tr>
<td>Annual Water Usage (gallons)</td>
<td>2,652,063</td>
<td>3,732,060</td>
<td>3,732,060</td>
</tr>
<tr>
<td>Chemicals</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Potential for Operational Upset</td>
<td>Low-Medium, biological process subject to variable environmental conditions.</td>
<td>High – biological process subject to variable environmental conditions.</td>
<td>High – biological process subject to variable environmental conditions.</td>
</tr>
<tr>
<td>Present Value Rank (1 lowest to 6 highest)</td>
<td>$10,866,432 ($13,063,401)</td>
<td>$9,122,615 ($14,143,401)</td>
<td>$6,916,523 ($6,916,523)</td>
</tr>
</tbody>
</table>

9/19/2016