Utilizing Biotic Soil for Landfill Closure

NC Erosion and Sediment Control Design – Webinar Series
Tuesday, November 10, 2020

Presented by: Kenton Yang, PE
Agenda

• Case Study Overview
• Landfill Closure
• Design Drivers
• Soil Testing and Amendments
• Vegetation
• Erosion Control
• Results and Conclusions
Case Study – Initial Experience

• Landfill expansion - Piedmont
• Construction – protective cover
• Long interior slopes
• Weekly rain events
South Wake Landfill Closure Project
Design Drivers

- Stormwater approach
- Phased construction
- Use of on-site soils
Stormwater Approach - Berms
Stormwater Approach - Bermless
Stormwater Approach - Bermless

CRITICAL LOCATION
Design Criteria

- Minimize soil and seed loss
- Protect the rock
Phased Construction
Design Criteria

- Minimize soil and seed loss
- Protect the rock
- Identifying year round stabilization
On-site Soils

• Control costs
• Characteristics varied
Design Criteria

• Minimize soil and seed loss
• Protect the rock
• Identifying year round stabilization
• Poor soils
Critical Success Factors

• Minimize soil/seed loss
• Quick stabilization
• Protect infrastructure (rock)
• Growth in a variety of seasons
• Amend poor soils
5 Fundamentals to Successful Stabilization

• Understand Your Substrate

• Pick the Right Plant Species

• Select the Right Erosion Control Material

• Ensure Proper Installation

• Conduct Inspection and Maintenance Activities
Soil Testing

• Typically topsoil is applied - none available on-site

• Soil was available on-site
  • Would this material be suitable for use with an Engineered Soil Amendment to improve agronomics?

• 9 samples
# Soil Testing - Results

## Soil Analysis Results

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>Texture (USDA)</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Soil pH (6.3 - 7.3)</th>
<th>TDS₁ (ppm) (&lt; 256)</th>
<th>SAR² (&lt; 2)</th>
<th>Organic Matter (%) (3 - 5%)</th>
<th>CEC % Sodium⁴ (%) (&lt; 2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clay Loam</td>
<td>38.4</td>
<td>30.4</td>
<td>31.2</td>
<td>5.3</td>
<td>115.2</td>
<td>0.48</td>
<td>3.9</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>Loam</td>
<td>42.4</td>
<td>32.4</td>
<td>25.2</td>
<td>5.2</td>
<td>294.4</td>
<td>1.24</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Clay Loam</td>
<td>24.4</td>
<td>44.4</td>
<td>31.2</td>
<td>4.6</td>
<td>89.6</td>
<td>0.53</td>
<td>1.8</td>
<td>0.3</td>
</tr>
</tbody>
</table>

(Optimum Plant Growth Conditions)

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>NO₃ (lb/acre)⁵</th>
<th>PO₄ (lb/acre)⁵</th>
<th>K (lb/acre)⁵</th>
<th>Ca (lb/acre)⁵</th>
<th>Mg (lb/acre)⁵</th>
<th>Zn (lb/acre)⁵</th>
<th>Mn (lb/acre)⁵</th>
<th>Cu (lb/acre)⁵</th>
<th>Fe (lb/acre)⁵</th>
<th>B (lb/acre)⁵</th>
<th>SO₄ (lb/acre)⁵</th>
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<tbody>
<tr>
<td>1</td>
<td>2.22</td>
<td>0.62</td>
<td>23.46</td>
<td>714</td>
<td>11.42</td>
<td>0.8</td>
<td>63.6</td>
<td>2.2</td>
<td>238.8</td>
<td>0.4</td>
<td>57.64</td>
</tr>
<tr>
<td>2</td>
<td>6.9</td>
<td>1.86</td>
<td>57.08</td>
<td>1372</td>
<td>44.24</td>
<td>0.6</td>
<td>18.2</td>
<td>1.6</td>
<td>113.8</td>
<td>0.2</td>
<td>195</td>
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<tr>
<td>3</td>
<td>10.04</td>
<td>0.62</td>
<td>10.95</td>
<td>184</td>
<td>9.24</td>
<td>0.4</td>
<td>25.2</td>
<td>1</td>
<td>70</td>
<td>0.2</td>
<td>6.72</td>
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</tbody>
</table>

Notes: 1. Total Dissolved Salts, 2. Sodium Absorption Ratio, 3. Neutral Lime is also available in a liquid form, please contact a Profile representative with questions. 4. Sodium as % Base Saturation Cation Exchange Capacity (CEC), 5. lb/acre associated with a 6-inch depth.
# Soil Testing - Results

## Soil Analysis Results

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>Texture (USDA)</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Soil pH (6.3 - 7.3)</th>
<th>TDS1 (ppm) (&lt; 256)</th>
<th>SAR2 (&lt; 2)</th>
<th>Organic Matter (%) (3 - 5%)</th>
<th>CEC % Sodium4 (%) (&lt; 2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sandy Loam</td>
<td>62.4</td>
<td>20.4</td>
<td>17.2</td>
<td>5.6</td>
<td>115.2</td>
<td>0.9</td>
<td>2.2</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>Sandy Loam</td>
<td>58.4</td>
<td>26.4</td>
<td>15.2</td>
<td>5.1</td>
<td>115.2</td>
<td>0.62</td>
<td>1.2</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>Sandy Loam</td>
<td>62.4</td>
<td>26.4</td>
<td>11.2</td>
<td>5.1</td>
<td>76.8</td>
<td>0.71</td>
<td>1.4</td>
<td>0.5</td>
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</tbody>
</table>

*(Optimum Plant Growth Conditions)*

## Nutrient Analysis Results

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>NO3 (lb/acre)5</th>
<th>PO4 (lb/acre)5</th>
<th>K (lb/acre)5</th>
<th>Ca (lb/acre)5</th>
<th>Mg (lb/acre)5</th>
<th>Zn (lb/acre)5</th>
<th>Mn (lb/acre)5</th>
<th>Cu (lb/acre)5</th>
<th>Fe (lb/acre)5</th>
<th>B (lb/acre)5</th>
<th>SO4 (lb/acre)5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.34</td>
<td>3.08</td>
<td>38.32</td>
<td>1104</td>
<td>27.22</td>
<td>1</td>
<td>7.2</td>
<td>1.4</td>
<td>78.2</td>
<td>0.2</td>
<td>41.3</td>
</tr>
<tr>
<td>2</td>
<td>3.58</td>
<td>1.24</td>
<td>23.46</td>
<td>1272</td>
<td>15.56</td>
<td>0.6</td>
<td>17.8</td>
<td>1.2</td>
<td>128.4</td>
<td>0.2</td>
<td>27.86</td>
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<tr>
<td>3</td>
<td>5.04</td>
<td>1.44</td>
<td>28.15</td>
<td>1206</td>
<td>19.93</td>
<td>0.6</td>
<td>29.4</td>
<td>1.4</td>
<td>129.6</td>
<td>0.2</td>
<td>20.18</td>
</tr>
</tbody>
</table>

*Notes: 1. Total Dissolved Salts, 2. Sodium Absorption Ratio, 3. Neutral Lime is also available in a liquid form, please contact a Profile representative with questions. 4. Sodium as % Base Saturation Cation Exchange Capacity (CEC), 5. lb/acre associated with a 6-inch depth.*
Soil Testing - Results

**SOIL ANALYSIS RESULTS**

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>Texture (USDA)</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Soil pH (6.3 - 7.3)</th>
<th>TDS¹ (&lt; 256 ppm)</th>
<th>SAR² (&lt; 2)</th>
<th>Organic Matter (%) (3 - 5%)</th>
<th>CEC % Sodium⁴ (%) (&lt; 2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sandy Loam</td>
<td>54.4</td>
<td>34.4</td>
<td>11.2</td>
<td>5.1</td>
<td>57.6</td>
<td>0.59</td>
<td>1.6</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>Sandy Loam</td>
<td>62.4</td>
<td>20.4</td>
<td>17.2</td>
<td>4.9</td>
<td>224</td>
<td>0.79</td>
<td>1.9</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>Sandy Loam</td>
<td>54.4</td>
<td>26.4</td>
<td>19.2</td>
<td>5.3</td>
<td>76.8</td>
<td>0.43</td>
<td>1.7</td>
<td>0.5</td>
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</table>

( Optimum Plant Growth Conditions)

<table>
<thead>
<tr>
<th>Sample (#)</th>
<th>NO₃⁵ (lb/acre)</th>
<th>PO₄⁵ (lb/acre)</th>
<th>K (lb/acre)</th>
<th>Ca (lb/acre)</th>
<th>Mg (lb/acre)</th>
<th>Zn (lb/acre)</th>
<th>Mn (lb/acre)</th>
<th>Cu (lb/acre)</th>
<th>Fe (lb/acre)</th>
<th>B (lb/acre)</th>
<th>SO₄ (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.32</td>
<td>0.82</td>
<td>15.64</td>
<td>312</td>
<td>11.18</td>
<td>0.8</td>
<td>19</td>
<td>1.2</td>
<td>30.8</td>
<td>0.2</td>
<td>0.96</td>
</tr>
<tr>
<td>2</td>
<td>17.24</td>
<td>0.42</td>
<td>32.84</td>
<td>716</td>
<td>22.85</td>
<td>0.8</td>
<td>36.8</td>
<td>1.6</td>
<td>772</td>
<td>0.8</td>
<td>48.04</td>
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<tr>
<td>3</td>
<td>5.52</td>
<td>0.2</td>
<td>14.08</td>
<td>692</td>
<td>8.02</td>
<td>1</td>
<td>99.4</td>
<td>1.4</td>
<td>220.2</td>
<td>0.4</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Notes: 1. Total Dissolved Salts, 2. Sodium Absorption Ratio, 3. NeutraLime is also available in a liquid form, please contact a Profile representative with questions. 4. Sodium as % Base Saturation Cation Exchange Capacity (CEC), 5. lb/acre associated with a 6-inch depth.
Soil Testing – Amendment Selection

- Organic Deficiency
  - Biotic Soil Media
  - Biostimulants

- Nutrient Deficiency
  - N-P-K Fertilizer
  - Lime Material

- pH Imbalance
  - Lime Material
Soil Testing – Organic Deficiency

- Biotic Soil Media
- Biostimulants

<table>
<thead>
<tr>
<th>Aqua-pHix™ (gal/acre)</th>
<th>NeutraLime™ (lb/acre)</th>
<th>JumpStart™ (gal/acre)</th>
<th>BioPrime™ (lb/acre)</th>
<th>Soluble Gypsum (lb/acre)</th>
<th>ProGanics™ BSM (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
<td>2.5</td>
<td>80</td>
<td>0</td>
<td>4000</td>
</tr>
</tbody>
</table>
Biotic Soil Media

• Biotic Soil Media (BSM) is designed to accelerate development of soils.
• BSM improves the soil profile and composition by adding organic matter, biostimulants and soil building components to create a more favorable growing environment.
Soil Testing – Nutrient Deficiency

• N-P-K Fertilizer
  • Balanced “Triple 19” applied with BSM

• Lime Material - adds Calcium
  • Micronized Lime – applied with BSM
  • Agricultural Lime – Incorporated to a 6-inch depth

19-19-19

GUARANTEED ANALYSIS

TOTAL NITROGEN (N) .................................................. 19.00%
  7.30% Ammoniacal Nitrogen
  11.70% Urea Nitrogen
AVAILABLE PHOSPHATE (P₂O₅) .................................. 19.00%
SOLUBLE POTASH (K₂O) ........................................... 19.00%
DERIVED FROM: Urea, Ammonium Phosphate, Muriate of Potash.
CHLORINE (Cl) Max ................................................. 15.00%
Soil Testing – pH Imbalance

- Fast-Acting soil pH Modifier – NeutraLime™ Dry
  - 80 lb/acre applied with BSM

- Agricultural Lime
  - 6,500 lb/acre incorporated to a depth of 6 inches
  - Based on 100% Calcium Carbonate Equivalence (CCE)
Soil Testing – Amendment Specification

3.01 ADDITIONAL AMENDMENTS

A. All of the amendments in this section must be applied prior to the BSM installation.

1. Agricultural Limestone with a Calcium Carbonate Equivalency (CCE) rating of 100% shall be topically applied to the site at a rate of 6,500 lb/acre and disked into the substrate to a depth of 6 inches.
   i. Agricultural Limestone may be utilized if the CCE is less than 100% however the Application rate must be changed accordingly to equal the same neutralizing effectiveness.
      1. In Example: 80% CCE Agricultural Limestone would have to be applied at approximately 8,125 lb/acre (6,500/0.80)

B. All of the amendments in this section must be incorporated in the hydraulic application of BSM.

1. Long-Term Soil Bio-Stimulant shall be BioPrime™ by PROFILE® Products LLC, or approved equal, and be applied at a rate of 80 lb/acre, and have the following composition:
   i. Materials: Cold water processed Ascophyllum nodosum (seaweed extract), Humic Acid, Slow-Release Nitrogen source and Endo-Mycorrhizal spores

2. Fast-Acting Soil Bio-Stimulant shall be JumpStart™ by PROFILE® Products LLC, or approved equal, and be applied at a rate of 2.5 gallons/acre, and have the following component characteristics:
   i. Materials: Beneficial soil bacteria, Humic Acid, and Soil Penetrants

3. Fact-Acting soil neutralizer shall be NeutraLime™ Dry by PROFILE® Products LLC, or approved equal, and be applied at a rate of 80 lb/acre, and have the following composition:
   i. Calcium Carbonate content \( \geq 97.8\% \)
   ii. % Passing #35 Mesh Sieve -100%

4. Fertilizer with a Guaranteed N-P-K Analysis of 19-19-19 shall be applied at a rate of 500 lb/acre.
Vegetation Selection

- Project Located in the Transition Zone of the U.S.
  - Blend of Cool and Warm-Season Species
- Hardy, low maintenance grasses to form a dense vegetative cover
- Nitrogen Fixing species for long term source of N
- Seeding will occur at various times throughout the year
Vegetation Selection

3.02 VEGETATION SPECIES SELECTION

A. Vegetative Species and Application rates shall vary based on annual time of seeding. Listed below are the dates, vegetative species, and application rates in Pure Live Seed (PLS) of each species

1. March 1 – August 31
   i. KY-31 Tall Fescue - 50 lb/acre of PLS
   ii. Pensacola Bahia - 15 lb/acre of PLS
   iii. Hulled Bermudagrass - 15 lb/acre of PLS
   iv. Medium Red Clover - 10 lb/acre of PLS
   v. German Millet - 10 lb/acre of PLS

2. September 1 – February 28
   i. KY-31 Tall Fescue - 50 lb/acre of PLS
   ii. Pensacola Bahia - 15 lb/acre of PLS
   iii. Unhulled Bermudagrass - 21 lb/acre of PLS
   iv. Medium Red Clover - 10 lb/acre of PLS
   v. Annual Ryegrass - 10 lb/acre of PLS

B. The proper seed mix, dependent on date of installation, shall be incorporated into the BSM Application.
Erosion Control Selection

- Max. Slope Gradient 3H:1V
- Slope Lengths up to 150 ft
- Slopes to be Cat-Trackerd
- Flexterra HP-FGM or Approved Equivalent Selected
Traditional Cover System

Standard design is 18” cover soil and ~6” topsoil
Updated Cover System

Engineered Soil Cover System

- 1. Waste
- 2. Barrier
- 3. Drainage
- 4. Cover Soil
- 5. Engineered Soil Media™
- 6. Erosion Control Material

24”
Phased Construction

Stabilization Schedule

Area 2: Oct. 2017 - 4.5 AC
Area 3: Nov. 2017 - 4 AC
Area 1: Jan. 2018 - 3.2 AC
Area 4: Apr. 2018 - 4.4 AC
Area 5: May 2018 - 4.3 AC
Updated Landfill Cover – Oct 2017
Updated Landfill Cover – Nov 2017
Updated Landfill Cover – Aug 2018
Updated Landfill Cover – Aug 2019
Updated Landfill Cover – Aug 2019
## Tracking Soil Health – Aug 2019

### Soil Analysis Results

#### (Optimal Plant Growth Conditions)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Nitrate N ppm</th>
<th>Phosphorus ppm</th>
<th>Potassium ppm</th>
<th>Magnesium ppm</th>
<th>Calcium ppm</th>
<th>Sulfur ppm</th>
<th>Zinc ppm</th>
<th>Manganese ppm</th>
<th>Copper ppm</th>
<th>Iron ppm</th>
<th>Boron ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>5</td>
<td>85</td>
<td>188</td>
<td>1057</td>
<td>3</td>
<td>0.55</td>
<td>4</td>
<td>0.6</td>
<td>37.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

- (10-30) IF pH < 7.1 (20-40) IF pH > 7.1 (10-25)
- (30-250) (60-300) (4-400) (5-20) (1-3-30) (4.1-12.0) (1.0-2.0) (7.1-20.0) (+ 2.0)

<table>
<thead>
<tr>
<th>Sample</th>
<th>% Organic Matter</th>
<th>Soil Respiration (mg CO2/kg soil/week)</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
<th>Texture USDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.6</td>
<td>1692.6</td>
<td>54.4</td>
<td>38.4</td>
<td>7.2</td>
<td>Sandy Loam</td>
</tr>
<tr>
<td>(+ 5%)</td>
<td>(+ 1000)</td>
<td></td>
<td>(20-60%)</td>
<td>Silt &amp; Clay (40-80%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes:
1. Soil Respiration ppm = mg/kg

#### Bulk Density

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH</th>
<th>Buffer Index</th>
<th>TDS</th>
<th>Soluble Salts mmhos/cm</th>
<th>Sodium ppm</th>
<th>SAR</th>
<th>g/cm³</th>
<th>oz/in³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>7</td>
<td>76.8</td>
<td>0.14</td>
<td>11</td>
<td>0.39</td>
<td>1.04</td>
<td>0.6</td>
</tr>
<tr>
<td>(+ 5%)</td>
<td>(+ 254)</td>
<td>(+ 0.75)</td>
<td>(+ 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Notes:
6. Contact Techpro@Techroducts.com if pH is < 4.2 or > 9.2 for specific site recommendation.
7. Total Dissolved Salts.
8. Sodium Adsorption Ratio.

### Cation Exchange Capacity: Actual % of Total CEC

<table>
<thead>
<tr>
<th>Sample</th>
<th>% K</th>
<th>% Mg</th>
<th>% Ca</th>
<th>% Na</th>
<th>% H</th>
<th>Total CEC</th>
<th>Bicarbonate ppm</th>
<th>Chloride ppm</th>
<th>Silicon ppm</th>
<th>SO₄ ppm</th>
<th>Zinc ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.4</td>
<td>17.5</td>
<td>58.9</td>
<td>0.5</td>
<td>20.6</td>
<td>9</td>
<td>33.6</td>
<td>12.3</td>
<td>22.2</td>
<td>9.6</td>
<td>0</td>
</tr>
</tbody>
</table>

- (3-7%) (15-20%) (65-75%) (10-4%) (0-5%) (10-30)
Tracking Soil Health – Aug 2019

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>2016</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Classification</td>
<td>n/a</td>
<td>Sandy Loam</td>
<td>Sandy Loam</td>
</tr>
<tr>
<td>pH</td>
<td>n/a</td>
<td>4.6 - 5.6</td>
<td>6.0</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>%</td>
<td>1.2 - 2.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>ppm</td>
<td>30.8 - 772</td>
<td>37.2</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>ppm</td>
<td>7.2 - 99.4</td>
<td>4.0</td>
</tr>
</tbody>
</table>
Conclusions

• Success in demanding environments

• Being receptive to technologies
Questions

For additional questions or information contact:
Kenton Yang – SCS Engineers
(919) 397-5863
kyang@scsengineers.com