Natural Resource Solutions LLC
6950 Dickinson Road
Greenleaf, WI 54126

Memorandum

To: Chris Stempa, Appleton Wastewater Treatment Plant

From: Steven Shimek

CC: Terry Stebor, AECOM

Date: 10/24/2011

Re: Compost Greenhouse Study

An eight-week greenhouse study was completed using City of Appleton Trial 2 biosolids compost and Waymor topsoil (mesic Haplic Glossudalf). The primary goal of the greenhouse study was to determine how heavy applications of compost would impact vegetative growth. A secondary goal was to evaluate weed seed survival.

Table 1 includes the treatments that were evaluated. The 100% soil treatment was the control (Pot 16). Two treatments were prepared with a 50% compost and 50% soil volumetric mix (Pots 17 and 19). One of these treatments also received the equivalent of 100 pounds of soluble nitrogen per acre (Pot 19). One treatment included 100% compost (Pot 18). The calculated dry tons of compost per acre are based on the attached solids and density data.

Table 1 – Greenhouse Treatments with Pot Identification

Pot Identification	Treatment Mix by Volume	Compost Dry Tons/Acre	Nitrogen Pounds/Acre
16	100% Soil	0	0
17	50% Compost - 50% Soil	181	0
18	100% Compost	362	0
19	50% Compost - 50% Soil + N	181	100

The greenhouse study was completed under a combination of artificial light (mercury halide lamp) and natural light for approximately 15 hours per day. The temperature during the greenhouse study generally ranged from 21° to 29° Celsius. Pots were seeded on August 28, 2011 with 0.5 gram of hard fescue (*Festuca longifolia)*. This is a rate of approximately 12 pounds per 1,000 square feet. Chopped straw mulch was applied to approximately three thicknesses. The pots were watered with 200 milliliters (ml) of water initially. During the study 50 ml of water were added every two to three days. The volume of water added did not exceed the soil field capacity. No percolate was lost from the pots.

During the first two weeks of the greenhouse study the pots were placed on a germination pad set at 27° Celsius. Germination was first noted September 1, 2011, four days after seeding. No significant difference

in the rate or density of germination was noted between treatments. There was no indication of broadleaf weed germination.

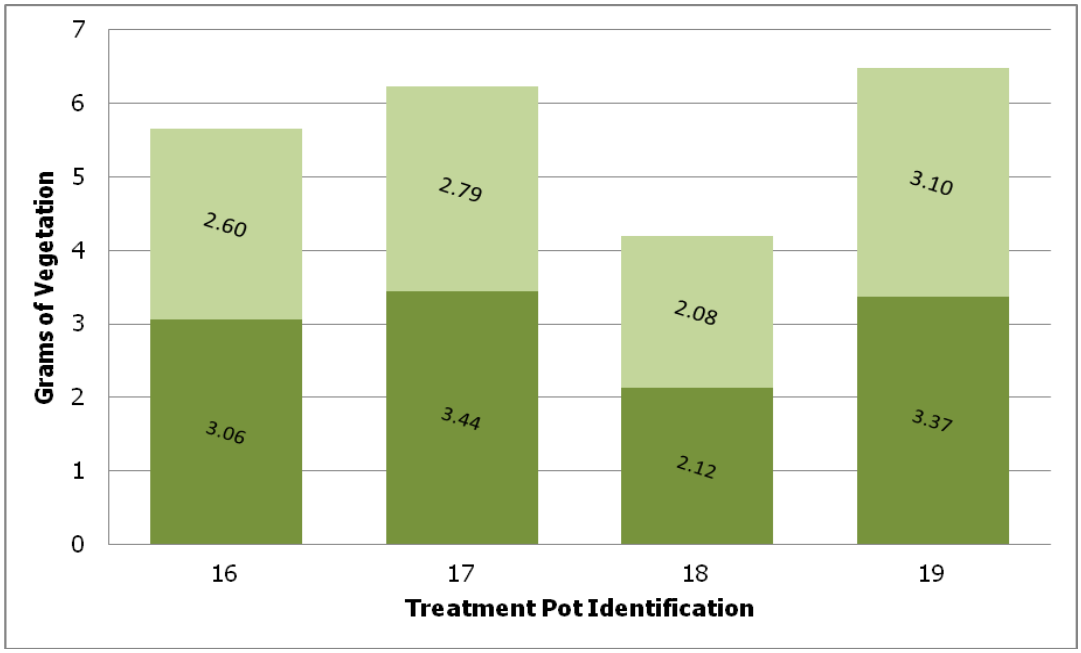
The vegetative growth was periodically viewed and photographs were taken. The photographs are attached. At Week 3 there was little difference in the appearance of the treatments. However, it did appear the vegetation was somewhat more vigorous in the soil control (Pot 16) and the 50% compost and 50% soil mix with nitrogen (Pot 19). There were no apparent indications of toxicity or significant nutrient deficiency, such as yellowing, streaking or purple margins. There were no broadleaf weeds observed and all grass appeared to be fescue. An exception was in the soil control (Pot 16), which contained a broadleaf seedling.

By Week 5 there was a notable difference in the appearance between the treatments. The vegetation in the 100% compost treatment (Pot 18) was underperforming all other treatments. Both 50% compost and 50% soil treatments (Pots 17 and 19) appeared to be somewhat more vigorous than the soil control treatment (Pot 16).

In Week 8 the differences in the appearance between the treatments were more subdued than noted in Week 5. Although the vegetation in the 100% compost treatment (Pot 18) appeared to be somewhat less vigorous than seen in the other treatments, there was a noticeable improvement since Week 5. Again, there were no apparent indications of toxicity or significant nutrient deficiency. There were no broadleaf weeds observed, with the exception of the broadleaf plant in the control (Pot 16). The grass was all fescue with the exception of one to three individual plants in each treatment that appeared to be Kentucky bluegrass (*Poa pratensis*).

Vegetation was clipped and weighed in Week 5 and Week 8. The yield from each treatment is graphically shown in Figure 1. The yield data from the first clipping in Week 5 supported the visual observations. The yield on the 100% compost treatment (Pot 18) was lower than all other treatments by at least 30%. The two treatments with 50% compost and 50% soil (Pots 17 and 19) had similar yields and both had yields that were greater than the soil control treatment (Pot 16).

FIGURE 1 – GREENHOUSE YIELDS



The yield data from the second clipping in Week 8 shows a pattern similar to Week 5. The highest yield was on the treatment consisting of 50% compost and 50% soil with nitrogen (Pot 19). Both soil treatments amended with compost resulted in increased yields (Pots 17 and 19). Amending the soil with the equivalence of 181 dry tons per acre of compost (Pot 17) increased yield 10% over the control (Pot 16) and by adding the equivalence of 100 pounds of nitrogen per acre (Pot 19) the yield increased another 5%, or 15% total over the soil control (Pot 16). The greatest percentage increase in yield between Week 5 and Week 8 was noted in the 100% compost treatment (Pot 18).

In general, the greenhouse study found compost amendments up to 181 dry tons per acre were beneficial and improved vegetative yields, as compared to a soil control. The vegetative yield in compost alone was lower than the soil control and soil amended with compost. This may have been due to a lower nutrient content of the compost and it could be the compost was not fully stabilized, as suggested by the late stage increase in yield of the 100% compost treatment. The vegetation on soil amended with compost did not show any indications of toxicity or nutrient deficiency. There did not appear to be any contribution of weed seeds by the compost amendment. A few individual grass plants were noted in all treatments that were not fescue. These other grasses were likely from the seed mix, based on observations of past greenhouse studies completed with the same grass seed lot.

The results and interpretations provided are specific to the soil and compost sample utilized in this greenhouse study. As with most organic materials, there will be variations in biological, physical and chemical characteristics that will provide different results.

The soil from each treatment will be air-dried and retained for 60 days before disposal.

Attachments: Solids and Density Data
Photographs

Natural Resource Solutions LLC

Solids Content and Bulk Density

Sample Identification: Appleton Compost

Sample Source: Outagamie County Landfill Stockpile North of Pad

Date Collected: 26-Aug-11

Date Tested: 28-Aug-11

Submitted By
Name: Shimek
Company: NRS
Address:

Solids Content

Replicate	As-Received (g)	Tare (g)	Dry Weight (g)	Solids
Compost < 1/2 ", loose	53.40	0.82	35.08	65.2%
Average				

Bulk Density

Sample	As-Received (g)	Tare (g)	Volume (cc)	Bulk Density (g/cc)		Bulk Density (PCF)	
				As-Received	Dry	As-Received	Dry
Compost < 1/2 ", loose	842.51	38.86	1148	0.70	0.46	43.7	28.5
Compost < 1/2 ", dense	247.1	38.88	250	0.83	0.54	52.0	33.9
Compost > 1/2", loose	575.69	21.64	1050	0.53		32.9	
Mineral* > 1/2"	151.24	10.82	125	1.12		70.1	
Average							

* Mineral includes stones and concrete fragments.

Relative Weight and Volume

Sample	Weight	Volume
Compost < 1/2 ", loose	53.7%	49.4%
Compost > 1/2", loose	36.7%	45.2%
Mineral > 1/2"	9.6%	5.4%

City of Appleton

2011 Compost Evaluation - Greenhouse Photographs

Greenhouse Setup

Pot ID	Treatment	Compost Dry Tons/Acre	Nitrogen Pounds/Acre
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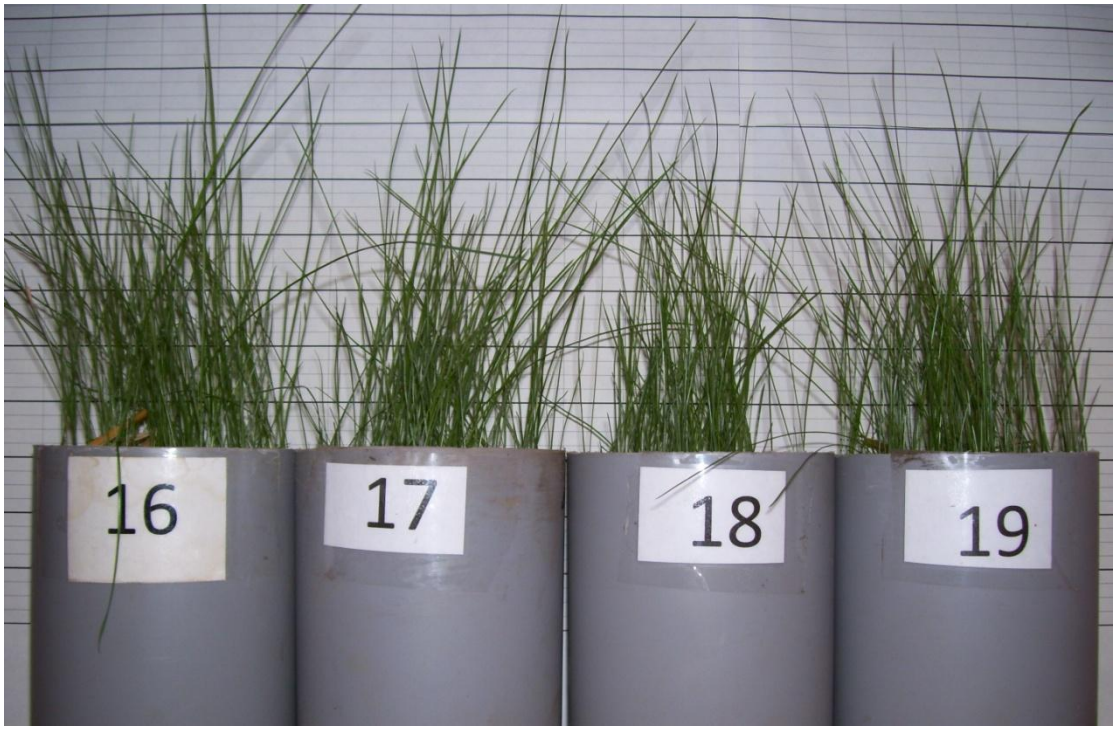

Week 3

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2011 Compost Evaluation - Greenhouse Photographs

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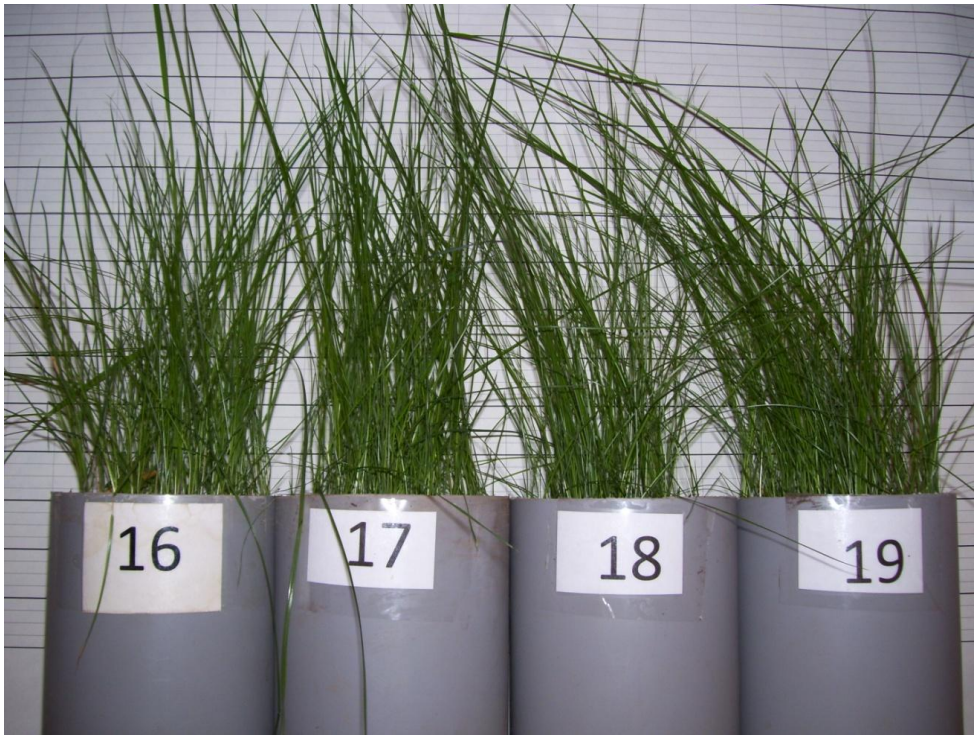

Week 5

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2011 Compost Evaluation - Greenhouse Photographs

Week 8

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