



SLUDGE ANNUAL AGRONOMIC LOADING RATE WORKSHEET

(To be completed prior to each application)

Permit No: _____
 Field _____
 Calendar Year _____
 Site _____

Crop _____
 *Yield Goal _____

1. Total crop nitrogen requirement
(From the Plant Nutrient Element Management of Agricultural Soils in South Carolina by Clemson University 2007) 1 _____ lb/acre
(not to exceed 240 lbs/acre)

2. Nitrogen provided from other sources either added to or mineralized in the soil

a. Nitrogen contributions from previous years activities

1. N from previous legume crop
(Clemson University 2007 Guide- Part IV.2.a "....When a non-legume crop follows a legume crop, the nitrogen fertilizer recommendation is reduced by 25 pounds nitrogen per acre.....") _____ lb/acre
2. Estimate of mineralized organic N from previous sludge applications
(Calculating Mineralized Organic Nitrogen from Previous Sludge Application Worksheet) _____ lb/acre
3. Estimate of available residual N from **historical** manure applications
(Manure Application Supplemental Worksheet.) _____ lb/acre

Sum of (a.1. + a.2. + a.3.) 2a _____ lb/acre
(Use greater of 2b or 2c below)

b. Nitrogen contributions from current year's activities

1. Estimate of available N from **current** manure application
(Manure Application Supplemental Worksheet.) _____ lb/acre
2. N from chemical fertilizers _____ lb/acre
3. N from other sources (e.g. food processing waste) _____ lb/acre
4. PAN from current calendar year's sludge application (if applicable) _____ lb/acre

Sum of (b.1. + b.2. + b.3. + b.4.) 2b _____ lb/acre
(OR)

c. Current Available Nitrogen in Soil (from soil test results) 2c _____ lb/acre
(Current Available Nitrogen in Soil Worksheet).

If current available nitrogen in soil is greater than 240 lbs PAN/acre, then no land application can occur.)
 Plant available nitrogen from other sources [2a + (Greater of 2b or 2c)] 2 _____ lb/acre

3. Adjusted crop nitrogen requirement (Subtract 2 from 1) 3 _____ lb/acre

4. Total plant available nitrogen (PAN) from sludge (based on sludge analysis)
 (_____ K_{vol} (Vol. Factor Table) x _____ NH₃-N lb/ton) + _____ NO₃-N lb/ton + _____ lb/ton
 _____ K_{min} (Min. Factor Table) x (_____ TKN lb/ton - _____ NH₃-N lb/ton) = 4 _____ PAN

5. Calculate the agronomic loading rate for sludge application (Divide 3 by 4) 5 _____ dry tons/acre

6. Calculate amount of sludge to be applied

_____ lbs PAN/ton (item 4) x _____ dry tons/acre (item 5) = _____ lbs PAN/acre **(not to exceed 240 lbs PAN/acre)**

_____ dry tons/acre (item 5) ÷ _____ % solids x 100 = _____ **wet tons/acre**

_____ wet tons/acre x 2,000 lb/ton ÷ 8.5 lbs/gallon = _____ **gallons/acre**

6 _____
 wet tons/acre or gallons/acre

*See Application Requirements to Meet Agronomic Rate on following page.

Application Requirements to Meet Agronomic Rate

1. The timing of sludge application should be relevant to the time when selected crops will uptake nitrogen.
2. Splitting applications of the total allowable loading (from worksheet) should be performed consistent with typical crop management practices.
3. Crop removal (e.g., hay harvesting, yield goal) shall be integral to site management.

This document and associated attachments were prepared under my direction or supervision:

Print Name: _____ Title: _____

Signature: _____ Date: _____

CALCULATING MINERALIZED ORGANIC NITROGEN FROM PREVIOUS SLUDGE APPLICATION WORKSHEET

Permit No. _____

Field _____

Site _____

Calendar Year _____

4 th Year					
1. Year	2. Starting Org- N (lbs/acre)	3. Mineralization Factor (K _{min} decimal) <i>(Min. Factors Table)</i>	4. Mineralized Org- N in lbs/acre (PAN) <i>(Column 2 times 3)</i>	5. Org- N Remaining (lbs/acre) <i>(Column 2 minus 4)</i>	6. Final Mineralized Org- N in Lbs/acre PAN <i>(from Column 4)</i>
0-1 (first application Year _____)					
1-2 (Year _____)					
2-3 (Year _____)					
3-4 (Year _____)					
3 rd Year					
0-1 (first application Year _____)					
1-2 (Year _____)					
2-3 (Year _____)					
2 nd Year					
0-1 (first application Year _____)					
1-2 (Year _____)					
Sum of Final Mineralized Org-N in lbs/acre PAN					

Additional Information

(Phosphorus/Potassium : Nutrient management information for the farmer)

P₂O₅ and K₂O fertilizer equivalent in sludge (based on sludge analysis)

a.	_____ % P in sludge	x	2.29	=	_____	% P ₂ O ₅ in sludge
	_____ % P ₂ O ₅	x	2,000 lb/ton	=	_____	lb/ton P ₂ O ₅
b.	_____ % K in sludge	x	1.2	=	_____	% K ₂ O in sludge
	_____ % K ₂ O	x	2,000 lb/ton	=	_____	lb/ton K ₂ O

VOLATILIZATION AND MINERALIZATION FACTORS TABLES

Volatilization Factors (K_{vol}) Table ¹

If sludge application method is:	Factor K_{vol} is:
Surface spreading	.50
Surface spreading followed by incorporation	.75
Subsurface injection	1.0

Mineralization Factors (K_{min}) Table ²

Time after Sludge Application (Year)	% of Org-N Mineralized from				
	Unstabilized Primary and Waste Activated Sewage Sludge	Alkaline stabilized Sludge	Aerobically Digested Sludge	Anaerobically Digested Sludge	Composted Sludge
0-1	40	30	30	20	10
1-2	20	15	15	10	5
2-3	10	8	8	5	_*
3-4	5	4	4	_*	_*

¹ Percentage of Ammonia/Ammonium Nitrogen applied that volatilizes after application

² Percentage of Org-N mineralized during the time interval shown

*Once the mineralization rate becomes less than 3% (i.e., 0.03), no net gain of PAN above that normally obtained from the mineralization of soil organic matter is typically expected. Therefore, additional credits for residual sludge N do not need to be calculated.

MANURE APPLICATION SUPPLEMENTAL WORKSHEET

Permit No. _____

Field _____

Site _____

Calendar Year _____

AVAILABLE RESIDUAL NITROGEN FROM HISTORICAL MANURE APPLICATIONS

Residual N Availability (lb/acre)*

Rarely received manure in the past (<2 out of 5 years)	0
Frequently received manure (2-3 out of 5 years)	10
Continuously received manure (4-5 out of 5 years)	20

*The value from the table above should be recorded in item 2.a.3. on the Sludge Annual Agronomic Loading Rate Worksheet of this document.

AVAILABLE NITROGEN FROM CURRENT MANURE APPLICATIONS

(Includes Previous Fall and Winter Applications For Spring Grain or Summer Annuals)

Expected Manure Application Rate <input type="checkbox"/> tons/acre or <input type="checkbox"/> 1,000 gallons/acre	Nitrogen lb/ton or lb/1,000 gal <i>(Clemson University Cooperative Extension Service or manure analysis)</i>	Available Nitrogen lb/acre**

Enter the expected manure application rate in either tons/acre or 1000 gallons/acre and enter the nitrogen in lbs/ton or lb/1000 gallons. Calculate the Available Nitrogen in lbs/acre.

** This manure loading value goes in item 2.b.1 on the Sludge Annual Agronomic Loading Rate Worksheet of this document.

CURRENT AVAILABLE NITROGEN IN SOIL WORKSHEET

Permit No. _____
 Field _____
 Site _____

Calendar Year _____

Soil Sampling Procedure:

- (1) The number of samples should be either a minimum of one composite sample per field (as described below) or no less than one composite sample per twenty (20) cropland acres.
- (2) Samples should be collected from the surface to 12 inch depth. A minimum of ten (10) discrete samples for each composite should be taken at randomly selected locations within the field. Soil samples collected must be mixed together forming a single composite sample.
- (3) If one field is being managed differently (e.g. multiple crops are being grown), then a single composite soil sample from each managed area (with at least one per twenty (20) cropland acres) should be provided.
- (4) The soil scoop for any composite soil test should be approximately the same volume.
- (5) Changes to the soils sampling plan based on specific requested circumstances may be approved.

<i>SOIL DEPTH (inches)</i>	<i>AVAILABLE NITROGEN* FROM SOIL ANALYSIS (ppm)</i>	<i>AVAILABLE NITROGEN IN LBS/ACRE (lbs/acre = ppm x 4)**</i>	<i>EXCEEDS 240 LBS/ACRE? (Yes/No) If yes, then no land application</i>
0-12			

*Current Available N from Soil will include NO₃-N (Nitrate Nitrogen) and NH₄-N (Ammonia/Ammonium Nitrogen). See example below.

** This value should be reported in item 2c on the Sludge Annual Agronomic Loading Rate Worksheet

EXAMPLE SOIL ANALYSIS CONVERSION (ppm to lbs/acre):

CALCULATION: Available N (lb/acre) = [NO₃-N (Nitrate Nitrogen) concentration (ppm) +
 Ammonia/Ammonium -N (NH₄-N)] x 4
 (Assuming 2 million pounds of dry soil in upper 6 in/acre)

EXAMPLE:

<u>Depth</u>	<u>NO₃-N + NH₄-N</u>
0-12 inch	4 ppm

N in 0-12 inch increment = 4 x 4 = 16 lb N/acre (Total N in soil profile)

SLUDGE ANNUAL AGRONOMIC LOADING RATE WORKSHEET (EXAMPLE)

Permit No. ND0012345
 Field 01
 Calendar Year 2013
 Site SC-LC

Crop Coastal Bermudagrass for Pasture
 Yield Goal NA

<p>1. Total crop nitrogen requirement <i>(From the Plant Nutrient Element Management of Agricultural Soils in South Carolina by Clemson University 2007)</i></p>	<p>1 <u>150</u> lb/acre (not to exceed 240 lbs/acre)</p>
<p>2. Nitrogen provided from other sources either added to or mineralized in the soil</p> <p>a. Nitrogen contributions from previous years activities</p> <p>1. N from previous legume crop <i>(Clemson University 2007 Guide- Part IV.2.a "....When a non-legume crop follows a legume crop, the nitrogen fertilizer recommendation is reduced by 25 pounds nitrogen per acre.....")</i></p> <p>2. Estimate of mineralized organic N from previous sludge applications <i>(Calculating Mineralized Organic Nitrogen from Previous Sludge Application Worksheet)</i></p> <p>3. Estimate of available residual N from historical manure applications <i>(Manure Application Supplemental Worksheet.)</i></p> <p>Sum of (a.1. + a.2. + a.3.)</p> <p><i>(Use greater of 2b or 2c below)</i></p> <p>b. Nitrogen contributions from current year's activities</p> <p>1. Estimate of available N from current manure application <i>(Manure Application Supplemental Worksheet.)</i></p> <p>2. N from chemical fertilizers</p> <p>3. N from other sources (eg. food processing waste)</p> <p>4. PAN from current calendar year's sludge application (if applicable)</p> <p>Sum of (b.1. + b.2. + b.3. + b.4.)</p> <p>(OR)</p> <p>c. Current Available Nitrogen in Soil (from soil test results) <i>(Current Available Nitrogen in Soil Worksheet). If current available nitrogen in soil is greater than 240 lbs PAN/acre, then no land application can occur)</i></p> <p>Total available nitrogen from other sources [2a + (Greater of 2b or 2c)]</p>	<p><u>0</u> lb/acre</p> <p><u>10.08</u> lb/acre</p> <p><u>0</u> lb/acre</p> <p>2a <u>10.08</u> lb/acre</p> <p><u>0</u> lb/acre</p> <p><u>0</u> lb/acre</p> <p><u>0</u> lb/acre</p> <p><u>0</u> lb/acre</p> <p>2b <u>0</u> lb/acre</p> <p>2c <u>16</u> lb/acre</p> <p>2 <u>26.08</u> lb/acre</p>
<p>3. Adjusted crop nitrogen requirement (Subtract 2 from 1)</p>	<p>3 <u>123.9</u> lb/acre</p>
<p>4. Total available nitrogen from sludge (based on sludge analysis) (<u>0.5</u> k_{vol} (Vol. Factors Table) x <u>5.2</u> NH_3-N lb/ton) + <u>0.002</u> NO_3-N lb/ton + <u>0.3</u> k_{min} (Min. Factors Table) x (<u>121</u> TKN lb/ton - <u>5.2</u> NH_3-N lb/ton) =</p>	<p>4 <u>37.34</u> lb/ton PAN</p>
<p>5. Calculate the agronomic loading rate for sludge application (Divide 3 by 4)</p>	<p>5 <u>3.32</u> dry tons/acre</p>
<p>6. Calculate amount of sludge to be applied</p> <p><u>37.34</u> lbs PAN/ton (item 4) x <u>3.32</u> dry tons/acre (item 5) = <u>123.9</u> lbs PAN/acre (not to exceed 240 lbs PAN/acre)</p> <p><u>3.32</u> dry tons/acre ÷ <u>3.02</u> % solids X 100 = <u>109.93</u> wet tons/acre</p> <p><u>109.93</u> wet tons/acre x 2,000 lb/ton ÷ 8.5 lbs/gallon = <u>25,866</u> gallons/acre</p>	<p>6 <u>25,866</u> <input type="checkbox"/> wet tons/acre or X gallons/acre</p>

Example
Calculating Mineralized Organic Nitrogen From Previous Sludge Application Worksheet

Assume aerobically digested sludge was surfaced applied to the field at a rate of 5 dt/acre with a 2% Org-N content (dry weight basis) in 2010. The following year, 2011, 3 dt/acre of sludge (same Org-N contents as 2010) was applied to the same site. No sludge was applied to the site after 2011. It is now 2013 and you want to calculate the available nitrogen from previous sludge applications and determine the total mineralized Org-N in lbs/acre PAN.

2010 – Org-N in sludge applied = (0.02) (5 dt/acre) (2000 lbs/ton) = 200 lbs/acre

2011 – Org-N in sludge applied = (0.02) (3 dt/acre) (2000 lbs/ton) = 120 lbs/acre

2010 4 th Year					
1. Year	2. Starting Org- N (lbs/acre)	3. Mineralization Factor (K _{min} decimal) (Min. Factors Table)	4. Mineralized Org- N in lbs/acre (PAN) (Column 2 times 3)	5. Org- N Remaining (lbs/acre) (Column 2 minus 4)	6. Final Mineralized Org- N in Lbs/acre PAN (from Column 4)
0-1 (first application Year <u>2010</u>)	200	0.3	60	140	
1-2 (Year <u>2011</u>)	140	0.15	21	119	
2-3 (Year <u>2012</u>)	119	0.08	9.52	109.5	
3-4 (Year <u>2013</u>)	109.5	0.04	4.38*	105.1	4.38
2011 3 rd Year					
0-1 (first application Year <u>2011</u>)	120	0.3	36	84	
1-2 (Year _____)	84	0.15	12.6	71.4	
2-3 (Year _____)	71.4	0.08	5.7*	65.7	5.7
2012 2 nd Year					
0-1 (first application Year <u>NA</u>)	0	0	0	0	
1-2 (Year _____)	0	0	0	0	0
Sum of Final Mineralized Org-N in lbs/acre PAN					10.08

No application in 2012, therefore values are zero (0). *Values used to calculate mineralized Org-N remaining.

To determine the mineralized Org-N remaining from the sludge applied in 2010 and 2011, add the last value in column 4 of the table for the 2010 sludge to the last value in column 4 of the table for the 2011 sludge (i.e., 4.38 + 5.7 = 10.08 lbs/acre). Mineralized Org-N remaining in 2013 is 10.08 lbs/acre** (**this value should be reported for item 2.a.2 on the Sludge Annual Agronomic Loading Rate Worksheet).

INSTRUCTIONS

SLUDGE ANNUAL AGRONOMIC LOADING RATE WORKSHEET

Permit No: Enter the DHEC NPDES or ND Permit number that regulates this activity that is being reported.

Field: Enter field number as identified in the above permit.

Calendar Year: Enter the calendar year for which you are reporting.

Site: Enter the site name as identified in the above permit.

Crop: Enter the crop name grown on the referenced field.

Yield Goal: Enter the expected yield for this crop. The yield goal should be relevant to the timing of applications.

Item 1: The total crop nitrogen requirement can be assigned from the Clemson University Plant Nutrient Element Management of Agricultural Soils in SC document, 2007. (i.e. from the Clemson document, Coastal Bermudagrass (Crop Code No. 34) identifies a Nitrogen need of 150 lbs/acre.) This amount is not to exceed 240 lbs/acre. **(Enter the value in the space labeled "1")**

Item 2: This section will be used to calculate the nitrogen from other sources that is either added to the soil or mineralized in the soil.

a. Determine the nitrogen contributions from previous years activities for the identified field

1. If any planting of a legume crop on this field, identify N from the Clemson document in lbs/acre. (Refer to Part IV.2.a "...When a non-legume crop follows a legume crop, the nitrogen fertilizer recommendation is reduced by 25 pounds nitrogen per acre....Therefore, the 25 pounds nitrogen per acre is an average expected credit than can be more or less...."). Enter the value in the space provided.
 2. Use the Calculating Mineralized Organic Nitrogen from Previous Sludge Annual Application Worksheet to determine the Mineralized Org-N in lbs/acre (PAN). Enter the value in the space provided.
 3. Use the Manure Application Supplemental Worksheet to determine the available N from historical manure applications. Enter the value in the space provided.
NOTE: If any of the above is not applicable, then enter zero (0).
- Add the values from Item 2.a.1, 2 & 3 to get the sum. **(Enter the result in the space labeled "2a")**

(Use greater of 2b or 2c below)

b. Determine the nitrogen contributions from the current year's activities.

1. Use the Manure Application Supplemental Worksheet to determine the available N from current manure application to this field, if applicable, in the space provided.
 2. Enter the N from chemical fertilizers applied to this field, if applicable, in the space provided.
 3. Enter the N from other sources (e.g. Food processing waste) applied to this field, if applicable, in the space provided.
 4. Enter the PAN from the current calendar year's sludge application (if applicable). If applicable, the PAN identified on the previously completed worksheet for this calendar year should be used.
NOTE: If any of the above is not applicable, then enter zero (0) in the space provided.
- Add the values from Item 2.b.1, 2, 3 & 4 to get the sum. **(Enter the result in the space labeled "2b")**

(or)

c. Determine the current available nitrogen in soil as identified on the Current Available Nitrogen in Soil Worksheet using soil analysis. Follow the sampling procedure as shown on this worksheet. An example soil analysis conversion from ppm to lbs/acre is also shown on the Current Available Nitrogen in Soil Worksheet. **(Enter the result in the space labeled "2c")**

- The total available nitrogen from other sources will be the sums of [2a and (the Greater value of 2b or 2c)]. **(Enter the result in the space labeled "2")**

Item 3: The adjusted crop nitrogen requirement is found by subtracting the total available nitrogen from other N sources identified in Item 2 and the total nitrogen requirement identified in item 1. **(Enter the result in the space labeled "3")**

Item 4: The total plant available nitrogen (PAN) from the sludge will be determined in this section.

$$\text{PAN} = (k_{\text{vol}} \times \text{NH}_3\text{-N}) + \text{NO}_3\text{-N} + k_{\text{min}} (\text{TKN} - \text{NH}_3\text{-N})$$

- From the analysis of the sludge to be land applied, enter the appropriate values for the following parameters:
- $\text{NO}_3\text{-N}$ (Nitrate - Nitrogen)
 - k_{vol} - This value is found on the Volatilization and Mineralization Factors Tables sheet using the Volatilization Factors Table. The factor is chosen given the sludge application method.
 - $\text{NH}_3\text{-N}$ (Ammonia - Nitrogen)
 - TKN (Total Kjeldahl Nitrogen)
 - k_{min} - This value is found on the Volatilization and Mineralization Factors Tables sheet using the Mineralization Factors Table. The factor is chosen given the type of treatment the sludge receives and the growing season.
- Calculate the PAN and enter the number in the space for Item 4. **(Enter the result in the space labeled "4")**

Item 5: Calculate the Agronomic Loading Rate (ALR) for sludge application by dividing the value in Item 3 (Adjusted crop nitrogen requirement) by the value in Item 4 (Plant available nitrogen in the sludge). **(Enter the result in the space labeled “5”)**

Item 6: Calculate the amount of sludge to be applied to the referenced field by using the following formula: PAN in the sludge x ALR = lbs PAN/acre (This value cannot exceed 240 lbs PAN/acre)

$ALR \div \% \text{ solids (of the sludge from the sludge analysis)} = \text{wet tons per acre}$

$ALR (\text{wet tons/acre}) \times 2000 \text{ lbs/ton} \div \% \text{ solids (of the sludge from the sludge analysis)} = \text{gallons per acre}$

Enter either amount of sludge to be land applied in wet tons per acre or gallons per acre. **(Enter the result in the space labeled “6”)**

Additional Information): Based on the sludge analysis, calculate the P₂O₅ and K₂O fertilizer equivalent in the sludge. This section is nutrient management information for the farmer.

- Enter the values from the sludge analysis for the following:
 - % P in the sludge (Phosphorus, percentage)
 - % P₂O₅ calculated (Phosphorus Pentoxide)
 - % K in the sludge (Potassium, percentage)
 - % K₂O calculated (Potassium Oxide)
- Use the following formulas:
 - % P in sludge X 2.29 = % P₂O₅. Enter the result in the space provided.
 - % P₂O₅ X 2000 lbs/ton = lbs/ton P₂O₅. Enter the result in the space provided.
 - % K in sludge X 1.2 = % K₂O in sludge. Enter the result in the space provided.
 - % K₂O X 2000 lbs/ton = lbs/ton K₂O. Enter the result in the space provided.

INSTRUCTIONS

CALCULATING MINERALIZED ORGANIC NITROGEN (Org-N) FROM PREVIOUS SLUDGE APPLICATION WORKSHEET

Permit No: Enter the DHEC NPDES or ND Permit number that regulates this activity that is being reported.

Field: Enter field number as identified in the above permit.

Site: Enter the site name as identified in the above permit.

Calendar Year: Enter the calendar year for which you are reporting.

The mineralized Org-N must be calculated using the previous 3 years of applications.

- In the table in the space provided before “4th Year”, enter the calendar year for the 4th year before the current application year (i.e. Current application year is 2013. 4 years prior would be 2010.) Do the same for the other years (3rd Year, 2nd Year would be “2011”, “2012”, respectively)
- **Column “1. Year”:** Enter the first application year and following years, if applicable.
- **Column “2. Starting Org-N (lbs/acre)”:** In the first year, this equals the amount of N initially applied. In the subsequent year(s), it represents the amount of Org-N remaining from the previous year found in Column 5.
- **Column “3. Mineralization Factor (k_{min} decimal) Min. Factors Table”:** Enter the appropriate Mineralization Factor from the table found on the Volatilization and Mineralization Factors Tables page found in this document. The factor should be in decimal form and is dependent on the type of sludge treatment. (i.e. alkaline stabilized, aerobically digested, etc)
- **Column “4. Mineralized Org-N in lbs/acre (PAN)”:** This value is calculated by multiplying the Starting Org-N by the Mineralization Factor in the corresponding row.
- **Column 5. Org-N Remaining (lbs/acre):** This value is calculated by subtracting the Mineralized Org-N (Column 4) from the Starting Org-N (Column 2) in the corresponding row.
- The Column 5 value is carried over to the next year.
- The final value in Column 4 for each table (the 3 previous years prior to the current application year) should be entered in **Column 6** (in the unshaded cell)
- The sum of the values in Column 6 should be calculated and entered in the appropriate cell on the table. This value will be entered on the Sludge Annual Agronomic Loading Rate Worksheet of this document in space provided for Item 2.a.2 (Estimate of mineralized Organic-N from previous sludge applications)

A detailed example of the Sludge Annual Agronomic Rate Worksheet along with Calculating Mineralized Org-N from Previous Sludge Application Worksheet is included.