2018

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

NUTRIENT MANAGEMENT PLAN DEVELOPMENT GUIDE

FOR

LAND APPLICATION

OF

SLUDGE, WASTEWATER EFFLUENT, AND MANURE

Bureau of Water

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Appendix

1. Purpose

The purpose of this document is to assist permittees and consultants in developing a nutrient management plan (NMP) that contains the necessary information that South Carolina Department of Health and Environmental Control (SCDHEC) considers when reviewing proposals for the land application of sludge, wastewater effluent, and manure. This guidance is not a rule and is not intended to take the place of a thorough understanding of applicable laws and regulations, substitute for practical experience, or address every situation that may be encountered. The guidelines presented are intended to support the agency mission of improving the quality of life for all South Carolinians by protecting and promoting the health of the public and the environment.

SCDHEC is mandated through law to proactively maintain the quality of surface and ground water as per South Carolina Code of Laws, Pollution Control Act. Chapter 1, Section 48-1-20:

> "It is declared to be the public policy of the State to maintain reasonable standards of purity of the air and water resources of the State, consistent with the public health, safety and welfare of its citizens, maximum employment, the industrial development of the State, the propagation and protection of terrestrial and marine flora and fauna, and the protection of physical property and other resources. It is further declared that to secure these purposes and the enforcement of the provisions of this chapter, the Department of Health and Environmental Control shall have authority to abate, control and prevent pollution."

SCDHEC pursues the agency mission and legal obligation by enforcing the following and other regulations promulgated to implement the Pollution Control Act:

- Per SCDHEC Water Classifications & Standards Regulation, R.61-68 A.4:
  "It is a goal of the Department to maintain and improve all surface waters to a level to provide for the survival and propagation of a balanced indigenous aquatic community of flora and fauna and to provide for recreation in and on the water. It is also a goal to provide, where appropriate and desirable, for drinking water after conventional treatment, shellfish harvesting, and industrial and agricultural uses."
- Per SCDHEC Water Classifications & Standards Regulation, R.61-68 A.5:
  "It is a goal of the Department to maintain or restore ground water quality so it is suitable as a drinking water source without any treatment."
- Per SCDHEC Water Classifications & Standards Regulation, R.61-68 H.2:
  "All South Carolina ground water is classified Class GB effective June 28, 1985." (i.e., less than Maximum Contaminant Levels as set forth in SCDHEC State Primary Drinking Water Regulations, R.61-58)
- Per SCDHEC Water Classifications & Standards Regulation, R.61-68 A.3:
  "Recognizing the technical and economic difficulty in restoring water quality, the SCDHEC shall emphasize a preventive approach in protecting waters of the State."

Regulations for the land application of sludge and wastewater effluent can be found in SCDHEC Water Pollution Control Permits, R.61-9. Regulations for the land application of animal manure can be found in SCDHEC Standards for the Permitting of Agricultural Animal Facilities, R.61-43. These regulations establish general requirements, pollutant limits, management practices, and operational standards, for the land application of these waste products.

2. Introduction

Sludge, wastewater effluent, and manure are primarily nutrient-rich organic materials that can be used as a fertilizer source to improve and maintain productive soils and stimulate plant growth. In order to safely utilize these materials, all permitted land application activities will require a comprehensive NMP. These NMPs help identify the best management practices that prevent adverse environmental effects (i.e., surface and ground water pollution) while maintaining agricultural production.

SCDHEC recognizes the value in land application; it is however a complex endeavor requiring strategic planning to prevent potential harm to the environment and human health. Excess nutrients which are not incorporated by plants, retained in the soil, or released to the atmosphere, can runoff into surface water or leach into underlying groundwater.
In order for SCDHEC to determine if human health and the environment will be protected from contamination by land application, a NMP must address the following elements:

- Nutrient characterization
- Site selection criteria
- Crop management and nutrient application
- Monitoring program
- Record keeping

Due to the complexity of land application, NMPs must be prepared by a qualified Professional Engineer, Professional Geologist, qualified soil scientist, and/or qualified agronomist as required by R.61-9 and R.61-43. NMPs must be submitted as part of the application for a new or renewal permit, and when changes are made to land application activities.

Once the NMP is approved by the Department, it should be made available to all individuals and responsible parties who use/manage the site. A complete understanding of the NMP promotes successful implementation and prevents unnecessary environmental contamination.

Guidance on addressing these elements is provided in the remainder of this document. A NMP Checklist has been included (Appendix A) to assist in the development of a successful NMP.

3. Nutrient Characterization

In order to develop a successful NMP, a full characterization of the nutrient source (i.e., sludge, wastewater effluent, or manure) is required. At a minimum, provide the following:

- Contact information (i.e., name, address, phone number, email) for all owners/operators of waste producing / treatment facilities and land application site(s)
- Describe nutrient source type (i.e., Sludge, Wastewater Effluent, and Manure) and annual volume/mass generated
- A description of the waste treatment process used to produce the nutrient source. Include a list of chemical additions that are used for treatment/disinfection.
- A description of storage requirements (if required) including, but not limited to, the maximum volume that could be stored during non-application periods (e.g., inclement weather, site limits reached, etc.)
- Nutrient source chemical evaluation. See appropriate nutrient source in Sections 3.1 - 3.3 for required parameter list.

3.1 Chemical Characterization of the Sludge

Sludge is a solid, semi-solid, or liquid residue generated during the treatment of domestic or industrial wastewater. Land application of sludge is regulated under the following sections of R.61-9:

- Section 503 (Standards For the Use or Disposal of Sewage Sludge)
- Section 504 (Standards For the Use or Disposal of Industrial Sludge)
- Section 505 (Land Application Permits and State Permits)

The sludge must be analyzed for the parameters shown in Table 3.1, as well as any other constituents of concern specific to the wastewater being processed as defined in R.61-9 503.12/504.12.

Sludge that exceeds the regulatory limits for PCBs established in R.61-9, Sections 503.6 and 504.6, may not be land applied. Sludge that exceeds the regulatory limits for inorganic constituents established in R.61-9, Sections 503.13 and 504.13, should be evaluated as a solid waste and, potentially, a hazardous waste. Generators of solid waste are required by state and federal regulations to determine if their waste is hazardous. Please contact the regional SCDHEC office for assistance with solid waste and hazardous waste requirements.

Table 3.1. Sludge characterization parameters*

pH	Standard Units
Total Solids	Percent
Volatile Solids	mg/kg
Total Inorganic Nitrogen	mg/kg
Total Kjeldahl Nitrogen (TKN)	mg/kg
Total Ammonia Nitrogen	mg/kg
Nitrate/Nitrite Nitrogen	mg/kg
Total Phosphorus	mg/kg
Total Potassium	mg/kg
Calcium Carbonate Equivalency	Percent
Arsenic	mg/kg
Cadmium	mg/kg
Copper	mg/kg
Lead	mg/kg
Mercury	mg/kg
Molybdenum	mg/kg
Nickel	mg/kg
Selenium	mg/kg
Zinc	mg/kg
PCBs	mg/kg

* List is subject to change due to revision of regulations

3.2 Chemical Characterization of the Wastewater Effluent

Wastewater effluent is the treated wastewater that is discharged from an industrial or domestic wastewater treatment facility. Regulations for the land application of wastewater effluent can be found under Section 505 (Land Application Permits and State Permits) of R.61-9.

The wastewater effluent should be analyzed for the nutrient constituents shown in Table 3.2 as well as any other constituents of concern specific to the wastewater being processed.

Table 3.2. Minimum wastewater effluent characterization parameters

pH	Standard Units
Total Nitrogen	mg/L
Total Kjeldahl Nitrogen (TKN)	mg/L
Total Ammonia-N	mg/L
Nitrate/Nitrite-N	mg/L
Total Phosphorus	mg/L
Total Potassium	mg/L
Chloride	mg/L
Sodium	mg/L

3.3 Chemical Characterization of the Manure

Manure is the fecal or urinary animal excretion or other associated organic materials including, but not limited to, bedding, spilled feed, water or soil mixed with the manure. Regulations for the land application of manure can be found under R.61-43.

The manure must be analyzed for the constituents shown in Table 3.3 as well as any other constituents of concern specific to the animal feed being used as required by R.61-43 100.50/200.50.

Table 3.3. Manure characterization parameters*

pH	Standard Units
Total Nitrogen	mg/kg
Total Kjeldahl Nitrogen (TKN)	mg/kg
Ammonium-N	mg/kg
Nitrate/Nitrite-N	mg/kg
Total Phosphorus	mg/kg
Total Potassium	mg/kg
Copper	mg/kg
Zinc	mg/kg

Additional requirements for non-swine animals

Arsenic	mg/kg
Calcium Carbonate Equivalency	percent

* List is subject to change due to revision of regulations

4. Site Selection Criteria

Site characteristics are instrumental in determining the site's potential for effective land application and in determining the potential for the transport of constituents from the site to surface or ground water. Use the criteria in Sections 4.1 - 4.7 when evaluating the suitability of a site.

4.1 Geologic Features

Identify the general geologic location (e.g., Upper Coastal Plain, Lower Coastal Plain, Piedmont/Mountains, Sandhills, etc.) and aquifer vulnerability (e.g., aquifer recharge areas, sensitive drinking water areas, source water protection areas, etc.) of the land application site(s).

4.2 Topography

The purpose of topographic information is to address surface shape, relief, and features to assist in understanding how contaminates could migrate from the site.
Submit a topographic site map that extends one-mile beyond the site(s) boundaries and includes the following information:

- All drinking water receptors (e.g., wells, surface water intakes, etc.)
- All surface water bodies (e.g., springs, streams (ephemeral and intermittent), rivers, wetlands, lakes, reservoirs, 25-year flood plain, 100-year flood plain, etc.)

4.3 Soil Description

Describe the soil properties instrumental to assessing the site's potential for accepting nutrients. Soil borings may be used to depict the lithologic and hydrogeologic characteristics of the subsurface. At a minimum, the soil description must include the following:

- U.S. Department of Agriculture soil map
- Chemical analysis (e.g., all forms of nitrogen and other pertinent nutrients, pH, heavy metals, cation exchange capacity, assimilative capacity, etc.)
- Physical properties (e.g., permeability, porosity, seasonal high water table, soil moisture, hydraulic loading limitations, depth to bedrock, etc.)
- Historical uses of the property (e.g., prior land application, farming, industry, etc.)

4.4 Groundwater Evaluation

The purpose of a groundwater evaluation is to assist in understanding how land application practices can:

- Introduce contaminants to local aquifers (e.g., nitrate and heavy metal contamination, etc.).
- Geochemically alter local aquifers (e.g., desorption of naturally-occurring elements etc.).

The groundwater evaluation should include the following:

- Groundwater table elevation(s) and depth(s), groundwater flow direction(s) and background geochemistry
- A description of the area potentially affected by contaminant migration via groundwater movement. The size of the potentially affected area will depend upon nutrient application rates, site characteristics and management, and aquifer characteristics
- The location, construction details, static water level, geologic information from driller's logs, and hydrogeologic position (up-gradient or down-gradient) of water wells within a one-mile radius of the nutrient application site(s)

4.5 Surface Water Evaluation

The purpose of a surface water evaluation is to assist in understanding how land application practices can introduce contaminants (e.g., nitrate, phosphorus, *E. coli,* sediment, etc.) to surface water bodies. In general, land application has not been permitted on slopes greater than 10%, due to the potential for off-site migration of nutrients to surface water bodies (e.g., springs, streams (ephemeral and intermittent), rivers, wetlands, lakes, reservoirs, 25-year flood plain, 100-year flood plain, etc.). At a minimum, the surface water evaluation must include the following:

- The proximity and potential impacts to surface water, drainage ways, floodplains, and wetlands
- Runoff and erosion potential including any necessary prevention measures (e.g., berming, terracing, strip cropping, etc.)

4.6 Land Use Evaluation

The purpose of a land use evaluation is to identify the potential health and environmental risks associated with the proposed land application activities. Land uses determine which buffer setbacks apply and available acreage for land application. Buffer setbacks are zones of vegetation adjacent to areas occupied or used by humans, water bodies, or possible conduits to water bodies. Buffers can prevent nuisance odors, wind drift, runoff, or infiltration to neighboring land uses. At a minimum, the land use evaluation must include the following:

- An evaluation of past and present land uses

- Buffer zones (setback distances will depend upon the method of application used, nutrient source characterization, and proximity to sensitive areas)
- A map extending one-mile from the site(s) boundaries that includes the following:
    - Land application sites including buffer zones, acreage, and latitude/longitude of each field
    - Land use structures (e.g., residences, buildings, roads, water wells, surface water bodies, and surface water intakes, etc.)
    - Locations of potential or known contaminant sources (e.g., underground storage tanks (USTs), other land application sites, etc.)
    - Environmentally sensitive areas (e.g., endangered species habitat, state and federal parks, wildlife protection areas, conservation areas, etc.)

4.7 Climate Conditions

Climate conditions must be considered as part of the plan design for land application. An evaluation of the local climate must include the following:

- Analysis of annual and monthly precipitation data for the previous 10 years
- Temperature (seasonal)
- Prevailing wind direction and velocity for odor evaluation and control
- Other climatic factors that may be considered in site selection (e.g., flooding or drought)

5. Crop Management and Nutrient Application

Beneficial land application can serve as a major source of nutrients for crops, but it should be managed responsibly in order to prevent environmental pollution. At a minimum, the following information is required for crop management and nutrient application:

- Crop(s) to be grown
- Crop rotation schedule (if applicable)
- Fertilizer (i.e., nutrient uptake ability) and lime recommendations for all crops
- Fertilization timing and frequency relative to crop type, crop planting, and harvesting schedule.
- Application methods (e.g., equipment used for transporting, spreading, etc.)
- Crop harvesting and marketing plan/schedule with realistic yield estimates (Estimates must be supported by demonstrated crop yield records or by regionally established yields.)
- Nutrient application rate
    - The proposed application rates must demonstrate that the site can operate without violating numerical standards established in SCDHEC Water Classifications and Standards, R.61-68.
    - Appropriate application rates must be determined by considering all nutrients applied, physical limitations of the site, conditions of the soil, nutrient incorporation by the crop tissue, and nutrient leaching to groundwater. (For sludge application, utilize SCDHEC Form 0874, Sludge Annual Agronomic Loading Rate Worksheet in Appendix B)

6. Monitoring Program

Describe how, where, and when all samples (e.g., nutrient source, soil, groundwater, and plant tissue, etc.) will be collected, handled, stored, and analyzed by a SCDHEC Certified Laboratory. These results help ensure that the nutrient characteristics and nutrient balance assumed in the plan accurately represent actual conditions. The degree of sampling and analysis will vary depending on the site vulnerability and nutrient loading. The sampling requirements may be adjusted over time by the Department.

7. Record Keeping

Site activity records are necessary to determine if site activities are adequately protective of human health and the environment. At a minimum, record-keeping documents should include the following:

- Sample analyses for each type of material collected (e.g., nutrient source, groundwater, soils, plant tissue, etc.)
- Nutrient application log (e.g., dates land application occurred, application method and amount of nutrients applied, etc.)

- Field activity summary (e.g., crop harvesting schedule, crop yields, crop fate and transport, etc.)
- Site management practices summary (e.g., access restrictions, animal grazing, chemical fertilizer and lime additions, erosion controls, weed control, pest control, aeration, equipment maintenance, etc.)
- How, where, and for how long records (Table 7) are maintained

Table 7. Record Retention Times by Nutrient Source*

Nutrient Source	Retention Period	Regulatory Reference
Sludge	5 Years	R.61.9, Sections 503.17 and 504.17
Wastewater Effluent	3 Years	R.61.9, Section 505.41(J)
Manure	8 Years	R.61.43, Sections 100.170 and 200.170

* It may be beneficial to keep all records for the length of the permit

8. Reporting

An annual report for the previous calendar year (Jan 1st- December 31st) must be submitted to the department. At a minimum, the report should include the following:

- Permittee name and permit number
- Contact information (i.e., name, address, phone number, email) for all owners/operators of waste producing/treatment facilities and land application site(s)
- Name and number of all sites and acres on which land application occurred
- The volume/mass of the nutrient source (i.e., sludge, wastewater effluent, or manure) land applied on each site and the application method used
- The dates on which land application occurred
- All calculations used to determine application rates
- Summary of all data collected (e.g., nutrient, soil, crop characterization, etc.) for the application rate calculations
- Additional (commercial or other) fertilizer, pH adjustments or irrigation applied to each site
- The crops grown on each site, planting dates, harvest dates, and harvest yields
- Any updates made to the NMP during the year
- Any recommendations for the following year

Appendix A. Nutrient Management Plan Checklist

At a minimum, the NMP should include the following:

Nutrient Characterization (Section 3)

- ☐ Site owner/operator information
- ☐ Nutrient source description and volume
- ☐ Description of waste treatment process
- ☐ Nutrient storage requirements
- ☐ Chemical characterization of nutrient source

Site Selection (Section 4)

- ☐ Geologic location and aquifer vulnerability
- ☐ Topography (map including drinking water receptors and surface water bodies)
- ☐ Soil description (chemical and physical characteristics and soil map)
- ☐ Groundwater evaluation (groundwater depths, flow direction, background geochemistry, and drinking water wells)
- ☐ Surface water evaluation (locations of surface water bodies and prevention measures for run-off and erosion)
- ☐ Land use evaluation (map of all proximal land use and associated buffers)
- ☐ Climate conditions (precipitation, temperature, wind, extreme weather potential)

Crop management and Nutrient Application (Section 5)

- ☐ Crop(s) to be grown
- ☐ Fertilizer and lime recommendations for all crops
- ☐ Application methods
- ☐ Harvesting schedule and yield goals
- ☐ Nutrient application rate calculation

Monitoring Program (Section 6)

- ☐ Sample type (nutrient, soil, groundwater, plant tissue)
- ☐ Sampling schedule
- ☐ Sampling locations

Record Keeping (Section 7)

- ☐ How land application records will be maintained

Appendix B. Sludge Annual Agronomic Loading Rate Worksheet

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SLUDGE ANNUAL AGRONOMIC LOADING RATE WORKSHEET

(To be completed prior to each application)

Permit No: _____
Field _____ Crop _____
Calendar Year _____ *Yield Goal _____
Site _____

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 _____ NH_3-N lb/ton) + _____ NO_3-N lb/ton +
_____ k_{min} *(Min. Factor Table)* x (_____ TKN lb/ton – _____ NH_3-N lb/ton) = **4** _____ lb/ton 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.

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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:_____

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CALCULATING MINERALIZED ORGANIC NITROGEN FROM PREVIOUS SLUDGE APPLICATION WORKSHEET

Permit No._____

Field _____ Calendar Year _____

Site _____

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)
4th Year					
0-1 (first application Year _____)					
1-2 (Year _____)					
2-3 (Year _____)					
3-4 (Year _____)					
3rd Year					
0-1 (first application Year _____)					
1-2 (Year _____)					
2-3 (Year _____)					
2nd 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)

P_2O_5 and K_2O fertilizer equivalent in sludge (based on sludge analysis)

a. _____ % P in sludge x 2.29 = _____ % P_2O_5 in sludge

_____ % P_2O_5 x 2,000 lb/ton = _____ lb/ton P_2O_5

b. _____ % K in sludge x 1.2 = _____ % K_2O in sludge

_____ % K_2O x 2,000 lb/ton = _____ lb/ton K_2O

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]

	% of Org-N Mineralized from				
Time after Sludge Application (Year)	**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_____ Calendar Year _____
Site _____

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 □ tons/acre or □ 1,000 gallons/acre	Nitrogen lb/ton or lb/1,000 gal (*Clemson University Cooperative Extension Service or manure analysis*)	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_____ Calendar Year _____
Site _____

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.

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

**Current Available N from Soil will include NO_3-N (Nitrate Nitrogen) and NH_4- 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) = [NO_3-N (Nitrate Nitrogen) concentration (ppm) + Ammonia/Ammonium –N (NH_4- N)] x 4***
(Assuming 2 million pounds of dry soil in upper 6 in/acre)

EXAMPLE:

Depth	***NO_3-N + NH_4-N***
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

1. Total crop nitrogen requirement
(*From the Plant Nutrient Element Management of Agricultural Soils in South Carolina by Clemson University 2007*) — **1** 150 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……") — 0 lb/acre

2. Estimate of mineralized organic N from previous sludge applications
(Calculating Mineralized Organic Nitrogen from Previous Sludge Application Worksheet) — 10.08 lb/acre

3. Estimate of available residual N from **historical** manure applications
(***Manure Application Supplemental Worksheet.***) — 0 lb/acre

Sum of **(a.1. + a.2. + a.3.)** — **2a** 10.08 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.***) — 0 lb/acre

2. N from chemical fertilizers — 0 lb/acre

3. N from other sources (eg. food processing waste) — 0 lb/acre

4. PAN from current calendar year's sludge application (if applicable) — 0 lb/acre

Sum of **(b.1. + b.2. + b.3. + b.4.)** — **2b** 0 lb/acre

(OR)

c. Current Available Nitrogen in Soil (from soil test results) — **2c** 16 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)

Total available nitrogen from other sources **[2a + (Greater of 2b or 2c)]** — **2** 26.08 lb/acre

3. Adjusted crop nitrogen requirement **(Subtract 2 from 1)** — **3** 123.9 lb/acre

4. Total available nitrogen from sludge (based on sludge analysis)
(0.5 k_{vol} (Vol. Factors Table) x 5.2 NH_3-N lb/ton) + 0.002 NO_3-N lb/ton +
0.3 k_{min} (Min. Factors Table) x (121 TKN lb/ton – 5.2 NH_3-N lb/ton) = — **4** 37.34 lb/ton PAN

5. **Calculate the agronomic loading rate for sludge application (Divide 3 by 4)** — **5** **3.32** **dry tons/acre**

6. **Calculate amount of sludge to be applied**

37.34 lbs PAN/ton (item 4) x 3.32 dry tons/acre (item 5) = 123.9 lbs PAN/acre **(not to exceed 240 lbs PAN/acre)**

3.32 dry tons/acre ÷ 3.02 % solids X 100 = 109.93 **wet tons/acre**

109.93 wet tons/acre x 2,000 lb/ton ÷ 8.5 lbs/gallon = 25,866 **gallons/acre**

6 25,866
☐ **wet tons/acre or X gallons/acre**

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

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)
2010 4th Year					
0-1 (first application Year 2010)	200	0.3	60	140	
1-2 (Year 2011)	140	0.15	21	119	
2-3 (Year 2012)	119	0.08	9.52	109.5	
3-4 (Year 2013)	109.5	0.04	**4.38***	105.1	**4.38**
2011 3rd Year					
0-1 (first application Year 2011)	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 2nd Year					
0-1 (first application Year NA)	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.

$$\mathbf{PAN = (k_{vol} \times NH_3\text{-}N) + NO_3\text{-}N + k_{min}\,(TKN - NH_3\text{-}N)}$$

➢ From the analysis of the sludge to be land applied, enter the appropriate values for the following parameters:
- NO_3- 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.
- NH_3-N (Ammonia - Nitrogen)
- TKN (Total Kjehldahl 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 ÷ % solids (of the sludge from the sludge analysis) = wet tons per acre
ALR (wet tons/acre) X 2000 lbs/ton ÷ % solids (of the sludge from the sludge analysis) = 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 P_2O_5 and K_2O 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)
  - % P_2O_5 calculated (Phosphorus Pentoxide)
  - % K in the sludge (Potassium, percentage)
  - % K_2O calculated (Potassium Oxide)
- Use the following formulas:
  - % P in sludge X 2.29 = % P_2O_5. Enter the result in the space provided.
  - % P_2O_5 X 2000 lbs/ton = lbs/ton P_2O_5. Enter the result in the space provided.
  - % K in sludge X 1.2 = % K_2O in sludge. Enter the result in the space provided.
  - % K_2O X 2000 lbs/ton = lbs/ton K_2O. 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.