W 796

Litter Land Application Management

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TENNESSEE POULTRY LITTER LAND APPLICATION RATE WORKSHEET

(Complete this form each time you land apply litter; retain for recording keeping.)

FARM: _____ **FIELD:** _____

1. SOIL TEST

Year: _____ **P:** ☐Low ☐Medium ☐High ☐Very High **K:** ☐Low ☐Medium ☐High ☐Very High

2. LITTER TEST (report "as is" values per ton of litter)

Source: _____ **Sample Year(s):**_____

Litter Nitrogen (LN): _____ lb-N/ton **Litter Phosphorus (LP):** _____ lb-P_2O_5/ton

Available Nitrogen (AvN): LN × 0.45 = _____ lb-N/ton **Litter Potassium (LK):** _____ lb-K_2O/ton

3. CROP INFORMATION

Crop: _____ **Yield Goal (YG):** _____ per acre

Application Time: ☐ Establish ☐ Maintain ☐ Renovate ☐ Topdress ☐ Corn-Split ☐ Double Crop

Harvest Form: ☐ Grain/Seed ☐Silage ☐ Green Chop ☐ Pasture ☐ Hay ☐ Biofuel

Crop Nutrient Application Recommendations – in Appendix **Table 4**:

N = _____ lb-N/ac **P** = _____ lb-P_2O_5/ac **K** = _____ lb-K_2O/ac

Phosphorus Removal (PR) – lookup Crop Phosphorus Removal Rate (CPRR) in Appendix **Table 7**:

PR = **YG** × **CPRR** = _____ × _____ = _____ lb-P_2O_5/ac

4. FIELD NITROGEN CREDIT (FNC)

Litter Applied To Field ≤ 1 Year Ago	+	**Litter Applied to Field 1-2 Years Ago**	=	**FNC**
_____ tons/ac × 5 = _____ lbs-N/ac	+	_____ tons/ac × 2.5 = _____ lbs-N/ac	=	_____ lbs-N/ac

5. AGRONOMIC LITTER APPLICATION PLANNING

Step 1. Calculate **N-Rate**: (**N** - **FNC**) ÷ **AvN** = (_____ - _____) ÷ _____ = _____ ton/ac

Step 2. Calculate **PR-Rate**: **PR** ÷ **LP** = _____ ÷ _____ = _____ ton/ac

Step 3. Identify Maximum Rate: ☐ Soil **P** < Very High = **N-Rate**

☐ Soil **P** is Very High = **N-Rate** or **PR-Rate**, whichever is lower

Step 4. Decide what Litter Application Rate (**LAR**) you will use: _____ ton/ac

6. SUPPLEMENTARY NUTRIENTS *(Maximum additional chemical or other fertilizer N-P-K needed)*

☐ Nitrogen: (**N** - **FNC**) - (**LAR** × **AvN**) = (_____ - _____) - (_____ × _____) = _____ lb-N/ac

☐ Phosphorus: **P** - (**LAR** × **LP**) = _____ - (_____ × _____) = _____ lb-P_2O_5/ac

☐ Potassium: **K** - (**LAR** × **LK**) = _____ - (_____ × _____) = _____ lb-K_2O/ac

Other N & P fertilizers used (type & units/ac): _____

7. SITE SPECIFIC CONSERVATION PRACTICES

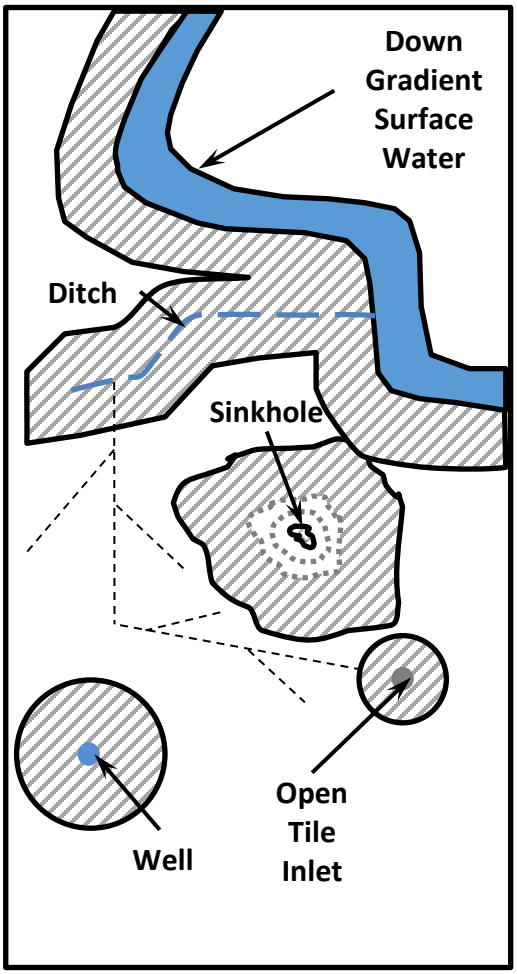
☐ **Application Rate:** Follow spreading equipment directions to target your litter application rate (**LAR**).

☐ **Application Timing:** Apply litter to agronomic crops within four weeks of planting or the target application dates listed in the Appendix **Table 4** footnotes. Apply litter to forages with the onset of favorable growth conditions or immediately after harvest when an additional harvest is expected.

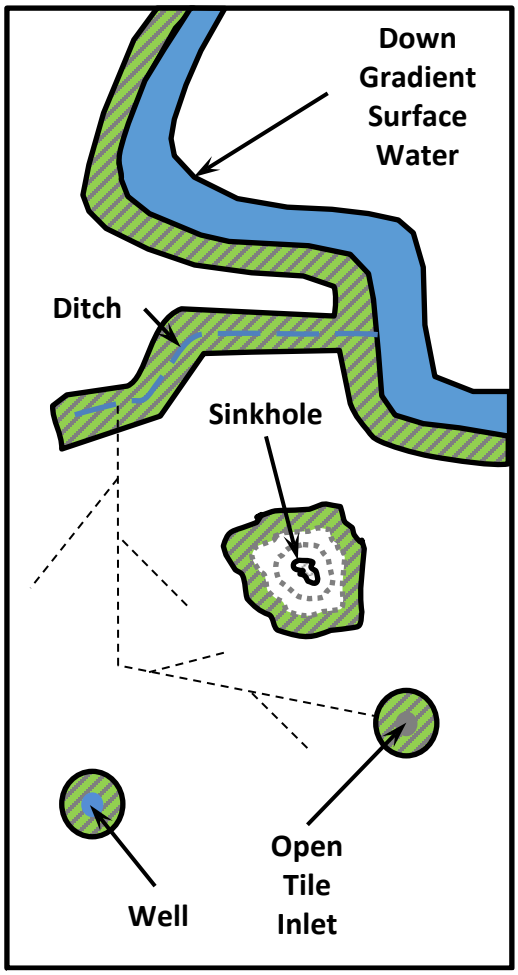
☐ **Field Conditions:** Don't apply litter to frozen, snow covered, or wet soil or steep (≥ 20%) slopes.

☐ **Weather Forecast:** Don't apply litter if precipitation capable of producing runoff (1/4" + rainfall) is likely (≥ 50% local forecast) within 24 hours of the planned application time.

☐ **Setbacks/Buffers:** Don't apply litter within 100 ft of the sensitive areas below or any conduit or drainage to surface or groundwater. You can reduce the setback to 35 feet if the sensitive area/conduit are protected by a 35 ft wide vegetated buffer.



Don't apply litter within 100 ft of un-buffered sensitive areas



Don't apply litter within 35 ft of sensitive areas with 35 ft buffers

☐ **Spreadable area (SAc)= _____ acres:** Use a field overhead image/map to estimate the area in acres litter can be applied to outside of the field setbacks/buffers. The maximum amount of litter you can apply to the field is: **LAR** x **SAc** = _____ x _____ = _____ tons.

SIGNATURE: _____ **Date(s) Litter Applied:** _____

Your signature attests to your good faith effort to use this Worksheet to apply litter nutrients agronomically and verifies that you have implemented the site specific conservations practices in Step 7

LITTER LAND APPLICATION MANAGEMENT

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INTRODUCTION

This publication provides Tennessee poultry producers who do not have a Concentrated Animal Feeding Operation (CAFO) permit with a litter land application rate Worksheet to set agronomic litter land application rates. The entire document should be read prior to using the Worksheet for the first time. After you are familiar with the Worksheet, use this publication as a reference resource. The Worksheet is designed to meet the objectives described below.

Maximize Litter Value. Agricultural producers need to control production costs. The Worksheet maximizes the value of litter nutrients and minimizes costs for commercial fertilizers without sacrificing economic crop returns.

Environmental Regulations. Stormwater runoff that contains land-applied litter, or excess nutrients from land-applied litter, can be considered an illegal discharge by the Environmental Protection Agency (EPA). To avoid being considered an illegal discharge, litter must be "***land applied in accordance with site-specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients***" (**40 C.F.R. § 122.23(e)(1)**). This regulatory requirement applies to poultry farms that confine 82,000+ laying hens or 125,000+ of any other type of chicken (**40 C.F.R. §122.23(b)(4)**). This Worksheet provides poultry producers with a field-specific nutrient management system for agricultural utilization of litter nutrients, as well as a required recordkeeping form (**40 C.F.R. §122.23(e)(2)**).

This Worksheet should **NOT** be used by poultry farms required to have a CAFO permit or that voluntarily choose to operate with a CAFO permit. Permitted farms **MUST** follow the Nutrient Management Plan (NMP) approved with their permit.

Minimize the Negative Environmental Impact of Land Applied Litter. Applying more nutrients than your crop demands can enrich surface waters with nutrients that degrade both local and distant receiving waters. The Worksheet sets litter application rates that minimize the possible negative environmental impacts of litter nutrients.

INFORMATION REQUIRED TO USE WORKSHEET

Assemble the following information prior to using this Worksheet:

- Field soil test(s).
- Litter test(s).
- Field crop history and yield data (five years).
- Field litter application records for the prior two years.
- Field images/maps that show the field area in acres — obtain from your local USDA Natural Resources Conservation Service or Farm Service Agency office.

PART 1. SOIL TEST

Why soil sample? Soil tests enable poultry producers to manage litter nutrients efficiently. The **University of Tennessee Extension Publication PB 1061** describes how to properly collect soil samples [1]. Follow the area frequency recommendation in PB 1061, collecting a composite soil sample for every 10 acres, which is required to effectively manage soil pH (e.g., with variable rate lime applications). However, you can use an average soil test result per field or 100 acres, whichever is smaller, when calculating your litter application rate with this Worksheet. Collect soil samples every one to five years, depending on which crop you are growing, as recommended in Appendix **Table 1**. Identify the year you collected your field soils samples in **Part 1** of the Worksheet.

Which lab should I use to analyze my soil samples? Send your soil samples to a lab that participates in the **North American Proficiency Testing Program** for the **Mehlich-1** extraction procedure. Both the **University of Tennessee Extension Soil, Plant and Pest Lab** in Nashville, Tennessee, and **Waypoint Analytical** in Memphis, Tennessee, participate in this program that validates soil testing procedures.

Which soil test method should I use? Different soil test procedures have been developed for different regions of the United States. Generally, these procedures mix soil samples with a dilute acid and then measure the **P** and **K** in the acid solution [2]. The intent is to create an index of your crop's ability to use **P** and **K** from your field soils. Specify that your lab uses the **Mehlich-1** analysis procedure to test your soils.

Crop P and K application rates are based on your soil test results. University of Tennessee Extension recommends crop application rates of phosphorus and potassium fertilizer based on **Mehlich-1** soil **P** and **K** concentration categories: Low-L, Medium-M, High-H and Very High-VH [2]. The **University of Tennessee Extension Soil, Plant and Pest Lab** specifies the **P** and **K** concentration categories on your soil test report. You can use Appendix **Table 2** to identify the **P** and **K** concentration categories using your soil test report(s) [3]. Mark the average **P** and **K** concentration category for your field soils in **Part 1** of the Worksheet.

Crop N application rates are not based on a soil test. Soil tests for nitrogen are not used in Tennessee because total N in soil is not well correlated with crop yield. Instead, it is widely accepted that N rate studies for each non-legume crop is the proper way to estimate nitrogen need. Thus, recommended nitrogen application rates in Tennessee are based on replicated yield studies that use a range of nitrogen application rates to soils that have **P** and **K** concentrations that will not limit yield.

PART 2. LITTER TEST

Collect litter samples. Litter nutrient concentrations vary between farms because bedding materials and management practices vary among producers. Do not use assumed or "book" values for your litter nutrient concentrations.

Collect representative samples from each unique source of litter (e.g., different farms) at least yearly following the instructions in Appendix **Table 3**. Use either the most recent analysis or the average of the previous two to three analyses in the Worksheet. For stockpiled litter, try to collect samples two to three weeks prior to land application so you'll have enough time to receive and use the results to set your current application rate**.** Identify the litter source and sample analysis year(s) in **Part 2** of the Worksheet.

Which lab should I use to analyze my litter samples? Send your litter samples to a lab certified by the **Minnesota Department of Agriculture Manure Testing Laboratory Certification Program**. **Waypoint Analytical** in Memphis, Tennessee, and **Waters Agricultural Laboratory** in Owensboro, Kentucky, are currently certified manure analysis laboratories.

Your lab report will quantify your litter N, P and K on an "as is" basis per ton of litter. In **Part 2** of the Worksheet, list the "as is" litter sample analysis results for **total nitrogen (LN)**, **total phosphorus (LP)**, and **total potassium (LK).**

Litter available nitrogen. The litter application rate calculated with this Worksheet uses recommended chemical fertilizer rates as a reference standard for crop production. Chemical fertilizers are a "100 percent plant available" meaning that all the applied N, P and K can be used to grow crops [4]. Litter phosphorus and potassium are approximately "100 percent plant available" [5]. However, the nitrogen in litter is never "100 percent plant available." Estimate your litter available nitrogen (**AvN**) by multiplying **LN** by 0.45 in **Part 2** of the Worksheet.

PART 3. CROP INFORMATION

Crop-Yield Goal. You must consider the nutrient needs for the specific crop you will be producing, along with a realistic **Yield Goal** (**YG**) for that crop. To set your **YG**, average the yields obtained in the last five cropping cycles after dropping the lowest and highest yields. If you don't have yield data, use yields for nearby fields, **UT Extension variety trial data**, or your **USDA-NASS** county yield average increased by 10 percent.

Application Time and Harvest Form. Time your litter applications for when your crop needs nutrients as recommended in Appendix **Table 4**. For agronomic crops, apply nutrients at establishment, as a split application for corn grain (at planting and then again when the corn is about 16 inches tall), as a fall and/or spring topdress for small grains, and to establish a double crop. For forages, apply litter to establish new forage stands, maintain an established stand, renovate a declining stand, and as a split application for corn silage. You can also apply litter to topdress small grain forages in spring and/or fall, or to forages immediately after harvest when an additional cutting is expected. Identify your litter application time and the crop harvest form in **Part 3** of the Worksheet.

Nitrogen (**N**). In **Part 3**, list the recommended crop **N** application rate (lbs-N/ac) using the condensed UT Extension fertilizer application rate recommendations in Appendix **Table 4** [6, 7]; the recommended rates generally don't depend on your **YG** or a soil test. However, for corn the **YG** does affect the recommended **N** application rate. Also, be aware that you can use a Pre-Sidedress Nitrate soil test to refine the **N** application rate during the split application of **N** to corn when it is approximately 16 inches tall [8].

Legumes. Legumes are plants that supply their own nitrogen by hosting special bacteria in root nodules. The **N** application rate you enter in Step 1 should reflect a Legume Nitrogen Credit (**LNC**) if your preceding crop was a soybean or a single species legume cover crop or if you are interseeding legumes into your current crop. See Appendix **Table 5** and **Table 6** to determine what **LNC** you should use.

Phosphorus (**P**) and **Potassium** (**K**). In **Part 3**, list the recommended application rates for phosphorus (**P** - lbs P_2O_5/ac) and potassium (**K** – lbs K_2O)/ac) using Appendix **Table 4**. The recommended rates depend on your soil test results in Worksheet **Part 1**. The recommended **P** and **K** application rates assure these elements will not limit crop yield.

Phosphorus Removal (PR). An estimate of your **PR** is one basis to set your litter application rate in **Part 5** of the Worksheet. Look up your crop phosphorus removal rate (**CPRR**) in Appendix **Table 7**, making sure to match the harvest form you will use. In **Part 3**, multiply your **YG** by the **CPRR** to estimate your **PR**.

PART 4. FIELD NITROGEN CREDIT

What is a Field Nitrogen Credit? Anytime organic fertilizers are applied to fields, some part of the nitrogen present in that organic material will likely become available to help produce future crops. This occurs as the organic material is decomposed in the soil by bacteria in a process called mineralization that slowly releases plant-available nitrogen. This "residual" or "carryover" nitrogen from previous organic fertilizer applications is estimated in Worksheet **Part 4** as a Field Nitrogen Credit (**FNC**). The **FNC** reduces the amount of nitrogen (**N**) required to produce your current crop.

Estimating the Field Nitrogen Credit for Prior Litter Applications. The **FNC** is difficult to predict accurately, partly because mineralization rates are affected by soil moisture (rainfall) and temperature that vary from year to year and within crop-growing seasons [5, 9]. Research has shown that a **FNC** is quantifiable within one to two years following manure applications and that the residual credit is more reliable and may increase with repeated manure applications [9-11]. Given that most poultry producers only apply one form of organic fertilizer (litter) to grow their crops, a reasonable estimate of the **FNC** can be made by simply knowing the amount of litter that has been applied to your field within the prior year as well as between one and two years ago. The **FNC** is estimated in Worksheet **Part 4** in lbs-N/ac in two parts. The first part multiplies the litter you applied to your field during the prior year (tons/ac) by 5. The second part multiplies the litter you applied to your field between one and two years ago (tons/ac) by 2.5. The **FNC** is simply the sum of the estimated nitrogen provided by the litter you applied last year and the year before.

Estimating the Field Nitrogen Credit for Organic Fertilizers Other Than Litter. If you applied other organic fertilizers (e.g., other types of liquid or solid manure or biosolids) over the past two years, the **FNC** for those materials should be estimated separately and added to the litter **FNC** computed in **Part 4** of the Worksheet. To estimate the **FNC** for other types of organic fertilizers, multiply the organic nitrogen applied (lbs-N/ac) within the past year by 0.1, and the organic nitrogen applied from one to two years ago by 0.05, and then add these values together. This will require a manure/lab analysis that measures both the ammonia nitrogen and the organic nitrogen in the products, rather than simply the total nitrogen.

PART 5. AGRONOMIC LITTER APPLICATION RATE PLANNING

There must be a dividing line between what can be justified as an agronomic litter application rate, which naturally has a maximum value, and higher rates that are inefficient and prone to be interpreted as land disposal and potentially polluting. In **Part 5** of the Worksheet you will calculate and evaluate two possible maximum agronomic rates as you consider which litter application rate you'd like to use to produce your crop.

Step 1. Calculate Nitrogen Litter Application Rate. Your crop nitrogen need is the recommended **N** from **Part 3** of the Worksheet minus the field nitrogen credit (**FNC**) from **Part 4** of the Worksheet. The nitrogen litter application rate (**N-Rate**) is the crop nitrogen need (**N** - **FNC**) divided by your litter available nitrogen (**AvN**) from **Part 2** of the Worksheet. Your litter application rate must not provide more nitrogen than is needed to produce your crop because the excess nitrogen can degrade water quality.

Step 2. Calculate Phosphorus Removal Litter Application Rate. If you land apply litter at an **N**-Rate you will likely overapply phosphorus to your field. Over repeated crop cycles, litter applications at an **N**-Rate will produce a buildup of soil **P** that can degrade water quality. Therefore, you need to know how much phosphorus your crop will remove and correspondingly how much litter is needed to replace that phosphorus. Applying litter to replace the phosphorus removed by crops will likely prevent soil **P** buildup over time. The phosphorus removal litter application rate (**PR-Rate**) is the crop phosphorus removal (**PR**) from Worksheet **Part 3** divided by your litter phosphorus concentration (**LP**) from Worksheet **Part 2**.

Step 3. Identify Maximum Litter Application Rate. You need to know whether the **N-Rate** or **PR-Rate** is the maximum agronomic litter application rate. If your soil **P** concentration is lower than Very High, your maximum litter application rate is the **N**-Rate. Typically, the **N-Rate** will overapply phosphorus, but this is acceptable because the risk for phosphorus loss to the environment is low so long as the field soil **P** concentration remains lower than Very High. If your soil test **P** concentration is in the Very High range, your maximum litter application rate is either the **N-Rate** or the **PR-Rate**, whichever is lower. Be aware that in certain cases (e.g., when erosion losses are very low) the **Revised Tennessee Phosphorus Risk Index** [12] can be used to justify litter application rates higher that the **PR**-Rate when soil **P** is Very High.

Step 4. Decide which litter application rate you'll use. Your litter application rate has a maximum value that should not be exceeded as identified in Step 3. Litter should never supply more nitrogen than your crop needs, and when the soil **P** is Very High your litter shouldn't supply more phosphorus than the estimated crop phosphorus removal. You can choose to use lower rates; for example, to meet recommended crop **P** or **K** application rates. List the litter application rate (**LAR**) you decide to use in Step 4.

PART 6. SUPPLEMENTARY NUTRIENTS

Litter is an unbalanced fertilizer. In **Part 6** of the Worksheet, you will calculate supplemental N, P and K that may be needed to produce your crop and that should be supplied, for example, by chemical fertilizer.

Nitrogen. If you land apply litter at the **N-Rate** calculated in Worksheet **Part 5**, you don't need additional nitrogen from chemical or other fertilizers to maximize economic crop yields. Applying additional nitrogen will increase crop production cost without a reasonable expectation of an economic yield return and may cause the litter application to be considered a disposal practice and/or polluting.

When your soil test **P** is Very High, you will typically land apply litter at a rate that replaces the estimated crop phosphorus removal at the **PR-Rate** calculated in Worksheet **Part 5**. In this case, supplemental nitrogen will likely be required to produce your crop. Calculate the supplemental nitrogen you need by subtracting the amount of nitrogen that will be supplied by your litter (**LAR** x **AvN**) from the nitrogen needed to produce your crop (**N** - **FNC**). The supplemental nitrogen is a maximum application rate in lb-N/ac of chemical or other nitrogen fertilizer. Application of nitrogen fertilizer beyond the supplementary rate may cause the litter application to be considered a disposal practice and/or polluting.

Phosphorus and Potassium. Calculate the supplemental phosphorus you need to produce your crop by subtracting the phosphorus your litter application will provide (**LAR** x **LP**) from the **P** needed to produce your crop. Likewise, the supplemental potassium you need is calculated by subtracting the potassium your litter will supply (**LAR** x **LK**) from the **K** needed to produce your crop.

For some fields, the crop recommendations for phosphorus (**P**) and potassium (**K**) will likely be "0" because your field soils will already contain enough **P** and **K** to produce your crop. In this case, the supplemental P and/or K calculation will result in a negative number representing application of P and/or K when none is needed. Applying additional phosphorus will increase crop production cost without a reasonable expectation of an economic yield return. Any calculated supplemental phosphorus is a maximum application rate in lb-P_2O_5/ac that should not be exceeded.

List Additional Fertilizers Used. The intent of this Worksheet is to assure that your litter application rate is agronomic and that you take full credit for the nutrients provided by your litter. Thus, you need to document all supplementary N (lb-N/ac) and P (lb-P_2O_5/ac) fertilizers applied to the field because these are the nutrients that, when applied in excess, degrade water quality. At the end of **Part 6** of the Worksheet list all additional N, P and K fertilizers that you use to produce your crop.

PART 7. SITE-SPECIFIC CONSERVATION PRACTICES

Application Rate. This Worksheet identifies agronomic litter application rates. To properly target the agronomic litter application rate you choose, consult the manual for your litter-spreading equipment to set, for example, gate openings and travel speeds.

Application Timing. Proper litter nutrient management is not just estimating the most efficient application rate, but also timing your application to coincide with crop nutrient demand. Poorly timed nutrient applications degrade crop nutrient use efficiency, lower crop yield, and increase nutrient loss to the environment [13]. For agronomic crops, litter application ideally occurs a week prior to or following planting, but this may not be possible. Litter should not be applied more than four weeks prior to planting an agronomic crop or the target nutrient application dates listed in Appendix **Table 4**. Timing is more variable for forages, but should precede or coincide with the seasonal onset of favorable growth conditions and occur immediately after harvest when an additional harvest is expected. In Tennessee, litter applications between December 15 and February 15 should generally be avoided [14].

Field Conditions. Field conditions that promote litter runoff must be avoided. Do not apply litter to frozen, snow-covered or saturated soils or to steep (greater than 20 percent) slopes.

Weather Forecast. Litter applications should not be made during or immediately prior to precipitation capable of producing runoff (approximately ¼-inch plus rainfall). Litter application should be delayed if precipitation is likely within 24 hours of the planned application time period (greater than or equal to 50 percent based on a local weather forecast).

Setbacks/Buffers. Setbacks are a regulatory requirement for large unpermitted poultry farms that land apply litter (**40 C.F.R. §412.4(c)(5)**). A setback is a specified distance to sensitive areas: downgradient surface waters and conduits to surface water or groundwater including ditches, open tile inlets, sinkholes and wells. Litter should not be applied within 100 feet of these unbuffered sensitive areas as illustrated in Worksheet **Part 7**. The setback distance can be reduced to 35 feet if the sensitive area is protected by a 35-feet-wide vegetated buffer as illustrated in Worksheet **Part 7** (**40 C.F.R. §412.4(c)(5)**). Vegetated buffers are dense strips of perennial vegetation planted parallel to field slopes and maintained to slow runoff, trap sediment/nutrients and enhance infiltration. Well-established natural riparian areas (streambanks hosting native grasses, shrubs and trees) that are at least 60 feet wide can serve as vegetated buffers.

Spreadable Acres. Use a field map to estimate the field spreadable area in acres (**SAc**) outside of the required setbacks and buffers. Calculate your total planned litter application to the field in tons by multiplying the field spreadable acres (**SAc**) by the Litter Application Rate (**LAR**) you choose to use in Worksheet **Part 5**. Do not apply more than this amount of litter to the field.

SIGNATURE

In order for the Worksheet to meet the objectives listed in the **Introduction**, you must sign the Worksheet, attesting to your good faith effort to use it to apply litter agronomically while abiding by site-specific conservation practices.

For proper recordkeeping, when you sign the Worksheet also list the date(s) that you land apply litter. Retain the Worksheet for each field and litter application event you perform. Recordkeeping is a regulatory requirement for large unpermitted poultry CAFOs (**40 C.F.R. §122.23(e)(2)**), and this Worksheet meets part of the recordkeeping requirements. Other records that need to be kept include those that ensure proper litter storage, disposal of mortalities, clean water diversion, and proper disposal of farm chemicals.

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APPENDIX

Table 1. How often to collect soil samples.

Cropping condition	Frequency (years)
Conventional till continuous row crops	3
Double cropping systems	2
Continuous no-till soybeans	3
Continuous no-till corn or cotton	2
Hay	3
Pastures	5
At the beginning of a different crop or crop rotation	1

Table 2. University of Tennessee Extension soil test calibration levels for soil phosphorus and potassium concentrations [3].

Test Procedure	Calibration Level	Phosphorus, lbs/acre (All crops)	Potassium, lbs/acre (All crops but Cotton)	Potassium, lbs/acre (Cotton)
Mehlich-1	Low (L)	0-18	0-90	0-140
	Medium (M)	19-30	91-160	141-280
	High (H)	31-119	161-319	281-319
	Very High (H)	120+	320+	320+
Mehlich-3	Low (L)	0-30	0-114	0-178
	Medium (M)	31-60	115-203	179-356
	High (H)	61-210	204-405	357-405
	Very High (H)	211+	406+	406+

Table 3. Methods to collect representative litter samples [16].

Stockpiled poultry litter. Collect 10 subsamples from different locations at least 12-18 inches below the pile surface. Mix the subsamples thoroughly in a bucket and place approximately 1-lb of the mixed sample in a heavy duty one-gallon sealable plastic freezer bag. Prior to sealing the bag, squeeze out excess air. Store in a freezer until the sample is shipped for analysis.
During removal from a poultry houses. Collect at least 5 subsamples from different loads of litter. Mix the subsamples thoroughly in a bucket and place approximately 1-lb of the mixed sample in a heavy duty one-gallon sealable plastic freezer bag. Prior to sealing the bag, squeeze out excess air. Store in a freezer until the sample is shipped for analysis. ***Do not collect litter samples from production houses because representative samples are difficult to obtain.***
While calibrating a litter spreader. Spread a tarp in the field at 3 different locations to collect litter from 3 separate passes/loads of a litter spreader. The samples should be gathered from the tarps as soon as practical and always within one hour of application. The weight of these samples can be used to check and/or calibrate a litter spreader's application rate. Mix the subsamples thoroughly in a bucket and place approximately 1-lb of the mixed sample in a heavy duty one-gallon sealable plastic freezer bag. Prior to sealing the bag, squeeze out excess air. Store in a freezer until the sample is shipped for analysis.

Table 4. Condensed University of Tennessee Extension crop fertilizer recommendations [6, 7].

Crop Description			Nitrogen (lb/ac) (N)		P_2O_5 (lb/ac) (P)				K_2O (lb/ac) (K)			
			Establish	TopDress / Maintain	L	M	H	VH	L	M	H	VH
AGRONOMIC CROPS												
Corn Grain[1] (grain yield @ 15% moisture)	Maintain=Split Applied @V6 (≈ 16" tall)	100-125 bu/ac	120	0	100	50	0		100	50	0	
		126-150 bu/ac	50	100	120	60			120	60		
		151-175 bu/ac	60	120	140	70			140	70		
		176-200 bu/ac	70	140	160	80			160	80		
		201-225 bu/ac	80	160	180	90			180	90		
Canola[2]			30	110	30	0			30	0		
Cotton			60-80	0	90	60	0		120	90	0	
Sorghum[3]	Grain		60-90	0	60	30	0		60	30	0	
Small Grain[4]			15-30	60-90	80	40	0		40	20	0	
Soybeans[5]			0	0	40	20	0		80	40	0	
Sunflower	Seed	1st Crop	90-120	0	80	40	0		80	40	0	
		2nd Crop	45-60	0	0				0			
Switchgrass[6]	Biofuel		0	0	40	0			80	0		
Tobacco			150-200	0	150	90	30	0	300	180	90	0
FORAGE PASTURE, HAY, AND SILAGE CROPS												
Alfalfa[7]		Establish	0-15	-	150	60	0		240	190	0	
		Maintain	-	0	80	60			240	190		
Bermuda[8-10]	Establish	Common or Hybrid	30/30	-	80	40	0		80	40	0	
	Maintain Pasture	Common	-	60/0-60/0-60	60	40			120	80		
		Hybrid	-	60/60/0-60	90	60						
	Maintain Hay	Common	-	300	120	80			90	60		
		Hybrid	-	400					120			
Corn Silage[11] (silage yield @ 65% moisture)	Maintain=Split Applied @V6 (≈ 16" tall)	15-18 tons/ac	120	0	120	60	0		180	120	0	
		19-25 tons/ac	50	100	160	80			240	160		
		> 25 tons/ac	60	120	200	100			300	200		
Sorghum	Silage		90	0	120	60	0		180	120	0	
Warm Season Pasture/Hay/ Silage[12-14]	Native Grass	Establish	0	-	90	60	0		90	60	0	
		Maintain	-	0-120								
	Annual Grass	Establish	60-120	-	60	30						
	SoybeanMillet	Establish	30	-								
Cool Season Pasture/Hay Silage[15-22]	All Perennials	Establish/Renovate	0-30	-	90	60	0		90	60	0	
	Grass-Clover	Maintain Pasture	-	0-30/0-60	60	30			60	30		
		Maintain Hay	-	30/0-30/0-60								
	Tall Fescue	Maintain Pasture	-	0-60/0-60								
		Maintain Hay	-	60/0-45/0-60								
	Timothy/Orchardgrass		-	60/0-60	60	30			60	30		
	Small Grain-Ryegrass		-	30-60/45-60/45-60	80	40			80	40		
	Small Grain-Ryegrass-Legume		-	15-30/30-45/30-45								
Lespedeza	Annual	Establish	0	0	40	20	0		40	20	0	
	Sericea	Establish			60				60			
		Maintain			40				40			
Clover	Red or White	Establish	0-15	-	90	60	0		90	60	0	
		Maintain	-	0	60	30			60	30		

Table 4. Footnotes (more detail is provided in Savoy and Joines, 2016 and Savoy, 2015).

1. **Corn Grain:** Split applications of nitrogen may be beneficial when nitrogen rates are greater than 120 lb-N/ac.
2. **Canola:** Apply 30 lb-N/ac at seeding in fall and topdress with an additional 110 lb-N/ac before bolt (rapid stem elongation), usually in early to mid-March.
3. **Sorghum Grain:** Response to the higher rate of nitrogen would most likely occur when grain sorghum follows a non-legume, is grown no-till, or is grown on soils with restricted drainage or having textures with more clay than silty clay loam
4. **Small Grains:** For small grain establishment, apply 15 lb-N/ac when following soybeans and 30 lb-N/ac when following corn, grain sorghum or grasses. Topdress small grain February 15 to March 15 with 60 to 90 lb-N/ac of nitrogen. Use lower rates of nitrogen where lodging has been a problem.
5. **Soybeans:** Nitrogen is not recommended since soybeans are legumes and when properly inoculated produce their own nitrogen.
6. **Switchgrass:** Do not apply nitrogen fertilizer at seeding. Beginning in the spring following establishment apply 60 lb-N/ac when grass begins to grow in May following the establishment year.
7. **Alfalfa:** For alfalfa-grass mixtures, where alfalfa is less than 25 percent of the mixture, apply 30 lb-N/ac between March 1 and 30 and again after the first cutting if an additional cutting is expected.
8. **Bermuda (Establish):** Apply 30 lb-N/ac right before sprigging or seeding and 30 lb-N/ac one month later. A more vigorous nitrogen fertilization program may be beneficial with “improved” seeded varieties for hay production during the first year. Consult with your local county Extension office if you are not sure about whether more nitrogen may be needed.
9. **Bermuda (Maintain Pasture):** The rate of nitrogen topdressing depends on the need for forage. Apply one-half of the total recommended nitrogen on May 1 and one-half on July 1. If the higher rates of N are used, use the higher rates of P and K on the hybrid pasture. Split application of the total potash is recommended. One-half of the potash should be applied prior to first spring growth and one-half on July 1.
10. **Bermuda (Maintain Hay):** The rate of nitrogen topdressing depends on the need for forage. Apply up to one-fourth of the total recommended nitrogen May 1 and again after each cutting when conditions favor regrowth. Four cuttings per year are often possible. For better forage quality, harvests should be done within about 30 days of growth or regrowth. Split application of the total potash is recommended. One-half of the potash should be applied prior to first spring growth and one-half after the second harvest.
11. **Corn-Silage:** Split applications of nitrogen may be beneficial when nitrogen rates are greater than 120 lb-N/ac.
12. **Warm Season Pasture, Hay, Silage (Native Grass):** Warm-season perennial grasses include Switchgrass, Big bluestem, Little bluestem, Indiangrass, Eastern Gama grass and Side oats gramma. Do not apply nitrogen fertilizer at seeding. Beginning the spring following establishment, apply 60 lb-N/ac when grass begins growing in May and then again in July if additional growth is desired. No nitrogen is needed for minimal growth or wildlife cover only.
13. **Warm Season Pasture, Hay, Silage (Annual Grass):** Summer annual grasses included are Teff grass, sudangrass, pearlmillet and forage sorghum hybrids. Apply 60 lb-N/ac at time of seeding. For Teff grass apply an additional 30 lb-N/ac if conditions favor an additional cutting for hay or additional pasture growth. If pearlmillet and forage sorghum hybrids are seeded before June 20, apply an additional 60 lb-N/ac as topdressing after harvest in July.
14. **Warm Season Pasture, Hay, Silage (Soybean-Millet):** Apply only 30 lb-N/ac at seeding for soybeans and millet hay.
15. **Cool Season Pasture, Hay, Silage (Renovate Perennial Pasture/Hay Fields):** If renovation involves the addition of legumes to grass pastures/hay, the nitrogen should be omitted.
16. **Cool Season Pasture, Hay, Silage (Grass-Clover Maintain Pasture):** The nitrogen should be omitted on pastures containing more than 30 percent clover in the spring; otherwise, if clover is less than 30 percent of the pasture, apply 30 lb-N/ac between March 1-30. For fall stockpiling of fescue apply 60 pounds of N per acre August 15 to September 15 to all fescue-clover mixtures.
17. **Cool Season Pasture, Hay, Silage (Grass-Clover Maintain Hay):** Apply 30 lb-N/ac March 1-30 and again after the first cutting if an additional cutting is expected. For fall stockpiling of fescue, apply 60 lb-N/ac from August 15 to September 15 to all fescue clover mixtures
18. **Cool Season Pasture, Hay, Silage (Tall Fescue Maintain Pasture):** Apply 60 lbsN/ac from August 15 to September 15 and from March 1 to March 30. If additional growth is only needed during one season, apply nitrogen for that season only.
19. **Cool Season Pasture, Hay, Silage (Tall Fescue Maintain Hay):** Apply 60 lb-N/ac per acre March 1-30. Where a second cutting is expected, apply an additional 45 lb-N/ac immediately after the first cutting. If fescue is stockpiled in the fall, apply 60 lb-N/ac from August 15 to September 15.
20. **Cool Season Pasture, Hay, Silage (Timothy/Orchardgrass):** If renovation involves the addition of legumes, the nitrogen should be omitted. Where one cutting per year is made, apply 60 lb-N/ac from March 15 to April 1. When more than one cutting is made, apply 60 lb-N/ac from March 15 to April 1 and 60 lb-N/ac immediately after first cutting.
21. **Cool Season Pasture, Hay, Silage (Small Grain-Ryegrass):** For fall grazing, apply 60 lb-N/ac at seeding. For fall and spring grazing, apply an additional 45 lb-N/ac about March 1 and 45 lb-N/ac on April 15. For fall grazing and spring hay or silage, apply 60 lb-N/ac at seeding and 60 lb-N/ac March 1-15. For spring hay or silage only, apply 45 lb-N/ac at seeding and 60 lb-N/ac on March 15. Where ryegrass is in the mixture and an additional cutting is expected in the spring, apply an additional 60 lb-N/ac immediately after the first cutting. For spring grazing only, apply 30 lb-N/ac at seeding, 45 lb-N/ac on March 1, and 45 lb-N/ac on April 15.
22. **Cool Season Pasture, Hay, Silage (Small Grain-Ryegrass-Legume):** For fall grazing, apply 30 lb-N/ac at seeding. For fall and spring grazing, apply an additional 30 to 45 lb-N/ac about March 1 and again on April 15. Use the 45 lb-N/ac when the mixture contains less than 30 percent clover in the spring. For fall grazing and spring hay or silage, apply 30 lb-N/ac at seeding and 30 to 45 lb-N/ac March 1-15. For spring hay or silage only, apply 15 lb-N/ac and 30 to 45 lb-N/ac March 1-15. Where ryegrass is in the mixture and an additional cutting is expected in the spring, apply an additional 30 to 45 lb-N/ac immediately after the first cutting. In each case, the 45 lb-N/ac is used instead of the 30 lb-N/ac when the mixture contains less than 30 percent clover in the spring.

Table 5. University of Tennessee Extension recommendations for a legume nitrogen credit (LNC) provided by a prior soybean or legume cover crop and when legumes are interseeded into forages that do not include ryegrass and/or small grains.

<table>
<tr><th colspan="4">Prior Legume Crop N-Credit</th></tr>
<tr><th colspan="2">Legume</th><th>Crop Receiving Credit</th><th>Credit</th></tr>
<tr><td colspan="2">Soybeans > 20 bu/ac</td><td>• Small grain establishment</td><td>15 lb-N/ac</td></tr>
<tr><td colspan="2"></td><td>• Sunflower for seed</td><td>0-20 lb-N/ac</td></tr>
<tr><td colspan="2">Winter cover crop of crimson clover or hairy vetch that has reached early bloom stage</td><td>• Corn Grain & Silage
• Cotton
• Grain Sorghum
• Small Grain
• Sunflower, seed
• Tobacco</td><td>60-80 lb-N/ac</td></tr>
<tr><th colspan="4">Incorporated Legume N-Credit</th></tr>
<tr><th colspan="3">Crop</th><th>Nitrogen Credit</th></tr>
<tr><td colspan="3">Alfalfa-grass mixture</td><td>0-30 lb-N/ac
Where grass is integrated into alfalfa, nitrogen is only required for maintenance if alfalfa is < 25% of the stand. If alfalfa is present at < 25% of the stand, apply 30 lb-N/ac in March and again after the first cutting if an additional cutting is expected. A 30 lb-N/ac credit should be used if following the grass nitrogen fertilizer recommendations.</td></tr>
<tr><td colspan="3">Soybean & Millet Hay</td><td>0 lb-N/ac
See Table 3 Footnote 14. A 30 lb-N/ac credit is reflected in the nitrogen application rate recommendation.</td></tr>
<tr><td rowspan="2">Cool Season Pasture/Hay/Silage</td><td>Perennial</td><td>Renovate</td><td>0-30 lb-N/ac
See Table 3 Footnotes 15 and 20.</td></tr>
<tr><td>Grass-Clover</td><td>Maintain</td><td>0-60 lb-N/ac
See Table 3-Footnotes 16 and 17. For the March nitrogen application to pasture, apply no nitrogen when pasture contains > 30% clover; apply 30 lb-N/ac if clover is less than 30% of the stand. For the March nitrogen application to hay, apply only 30 lb-N/ac; apply only 30 lb-N/ac after the first cutting if an additional cutting is expected. A 30 lb-N/ac credit should be taken both in March and for the second cutting in April, depending on % clover in the stand.</td></tr>
</table>

Table 6. University of Tennessee Extension nitrogen fertilization details for small grain and/or ryegrass forages with and without legumes interseeded both below and above 30 percent of the forage stand. Recommended nitrogen application rates are listed in lb-N/ac. Recommendations for an interseeded legume nitrogen credit (LNC) are listed in parentheses in lbs-N/ac.

Legume	Timing	Management Scenarios					
		Fall Grazing Only	Fall + Spring Grazing	Fall Grazing + Spring Hay or Silage	Spring Hay or Silage Only	Spring Hay or Silage, Ryegrass, 2 Cuts	Spring Grazing Only
No Legumes Present	Fall	60	60	60	45	45	30
	March	-	45	60	60	60	45
	April	-	45	-	-	60	45
Legumes < 30% Stand	Fall	30	30 (30)	30 (30)	15 (30)	15 (30)	15 (15)
	March	-	45 (0)	45 (15)	45 (15)	45 (15)	45 (0)
	April	-	45 (0)	-	-	45 (15)	45 (0)
Legumes > 30% Stand	Fall	30	30 (30)	30 (30)	15 (30)	15 (30)	15 (15)
	March	-	30 (15)	30 (30)	30 (30)	30 (30)	30 (15)
	April	-	30 (15)	-	-	30 (30)	30 (15)

Table 7. Estimated crop phosphorus removal rates (CPRR).

AGRONOMIC CROPS							
Crop	**Harvest**	**Unit[1]**	**CPRR**	**Small Grain**			
				Crop	**Harvest**	**Unit[1]**	**CPRR**
Corn[2]	Grain	bu	0.35	**Barley[2]**	Grain	bu	0.40
Canola[2]	Seed	bu	0.8	**Oat[2]**	Grain	bu	0.28
Cotton[2]	Lint	Bale	12	**Rye[2]**	Grain	bu	0.46
Sorghum[2]	Grain	bu	0.39	**Triticale[2]**	Grain	bu	0.48
Soybeans[2]	Grain	bu	0.73	**Wheat[2]**	Grain	bu	0.48
Sunflower[2]	Seed, Oil	cwt	0.97				
Switchgrass[2]	Biofuel	Ton (**DM**)	12				
Tobacco[2]	Burley	cwt	0.90				

FORAGE CROPS							
Crop	**Harvest**	**Unit**	**CPRR**	**Cool Season Pasture/Hay/Silage**			
				Crop	**Harvest**	**Unit[1]**	**CPRR**
Alfalfa[2]	Green chop	ton (**DM**)	12	**Grass + Clover[3]**	Hay (10% moisture)	ton	9.4
	Hay				Pasture	-	
	Silage			**Tall Fescue[2]**	Hay (10% moisture)	ton	11
Bermuda[2]	Common Hay	ton (**DM**)	12		Pasture	-	
	Common Past			**Timothy[2]**	Hay	Ton (**DM**)	11
	Hybrid Hay				Silage		
	Hybrid Past				+ Alfalfa Hay		
Clover[3] (10% moisture)	Crimson, Hay	ton	9.2		+ Clover Hay		
	Red, Hay	ton	11	**Orchardgrass**	Hay (10% moisture)	ton	12
	White, Hay	ton	15	**Small Grain[3, 6]**	Fall-Hay	ton	8.1
Corn Silage[4]	65% moisture	ton	4.4		Fall+Spring Graze	-	
Lespedeza[3] (10% moisture)	Annual, Hay	ton	12		Fall Graze+Spring Hay	ton	
	Sericea, Hay	ton	10		Spring Graze	-	
Sorghum Silage[3]	**(72% moisture)**	ton	2.7		Spring Hay	ton	
Warm Season Pasture/Hay/Silage					Silage (70% moisture)	ton	3.9
Native Grass[3,5]	Hay (10% moisture)	ton	11	**Small Grain + Ryegrass[2]**	Fall Graze+Spring Hay	Ton (**DM**)	12
	Pasture				Spring Hay		
Annual Grass[3]	Hay (10% moisture)	ton	12		+ Legume Spring Hay		
	Millet-Pearl Silage	ton	2.6	**Small Grain + Legume[3]**	Fall Graze	-	8.1
	Millet-Foxtail Silage	ton	2.3		Fall+Spring Graze		
Soybean+Millet[3]	Hay (10% moisture)	ton	10		Fall Graze+Spring Hay	ton	
					Spring Hay		

1. DM = dry matter; nutrient removal is for only the dry matter yield rather than at a specified moisture content. To correct to a specified moisture content, multiply CPRR by the %DM at harvest divided by 100.
2. International Plant Nutrition Institute Crop Nutrient Removal Calculator. Triticale values adapted from Winter Wheat.
3. USDA Crop Nutrient Tool. Eastern Gammagrass hay, boot, cut 1 values used for Native Grass. Sourgham/Sudangrass hay used for Annual Grass Hay. Soybean hay values used for Soybean+Millet hay. Wheat hay values at 10% moisture used for Small Grain Cool Season Pasture/Hay and small grain + legume.
4. University of Tennessee Extension research data.
5. The convention from the Manure Management Planner software is adopted herein to use reference values for hay for the corresponding pastured/grazed crop.
6. Wheat silage values are at 70% moisture at the soft dough stage [15].

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