COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Dairy Waste Utilization Management Tool

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Quick tests enabling rapid, on-farm assessment of manure nutrient content can significantly enhance manure management practices. Rapid or quick tests are less accurate than standard laboratory analyses but can be useful as a manure utilization tool.

Quick tests include indirect measurement of solids and the nitrogen (N) and phosphorus (P) content of manure using hydrometers, electrical conductivity meters, and other devices such as the Agros® N Meter that operates based on the chemical reaction between ammonium and hypochlorite. These quick tests are portable, simple to use, relatively inexpensive, and take 10 minutes or less to run. They can be used right before manure is applied to grassland or agricultural fields.

Previous relationships developed for each individual quick test cannot be generalized, as manure characteristics vary with species, age, nutrition, diet of animal, production stage, type of facility, and geographical region. However, developing calibrations specific to individual farms or to regions in which common practices are used can minimize a significant portion of the variation associated with rapid testing.

This publication contains calibration curves developed for different quick tests to estimate manure nutrient contents in the Mammoth Cave area of Kentucky. It is likely that accuracy of nutrient estimates by quick tests will increase if calibration curves are developed by individual farms. This can be done by producers taking specific gravity and electrical conductivity measurements and sending manure samples to a laboratory for nutrient analysis. With several years' data, producers will be able to develop their own calibration curves.

Methodology

To develop these calibration curves, more than 100 manure samples were collected from 34 commercial dairy farms located in the Mammoth Cave area where there is a large concentration of dairy farms with similar characteristics.

According to a survey conducted among dairy producers in the Mammoth Cave area, farms had between 50 and 150 milking cows, with some being housed in freestall barns. There were a number of farms where there was only a feeding barn or shed available. In this case, cows would spend most of their time on pasture and loafing lots.

In all farms, manure was scraped to earthen basins for storage. Manure was applied by the producer or by a commercial applicator to owned cropland (mostly corn) once or twice a year. Liquid manure was usually applied to cropland through irrigation traveling guns, and solid manure was broadcast with a muck spreader. Milk house wastewater was typically collected in the manure storage, although in some farms it was applied to grass filter strips.

Samples from these dairy farms were analyzed by standard laboratory procedures and by using quick tests.

Hydrometer

The hydrometer is used to measure total N and total P indirectly in slurry samples (Figure 1). It is an indirect method based on linear relationships between the dry matter content and specific gravity of the slurry, and between the dry matter content and N and P. Combining the two relationships gives a linear relationship between both total N and total P and specific gravity of slurry.

Hydrometers can be purchased from laboratory supply dealers. Details on hydrometer types, cost, and vendors' contact information are given at the end of this publication.

Calibration curves were developed for Barren, Hart, and Monroe counties relating specific gravity to dry matter and nutrient contents of dairy manure (see Tables 1 to 3 at the end of this publication). Calibration curves for the combined data set were also developed (Table 4). Because of data variability, both low- and high-end estimates are given for each value measured by the hydrometer instead of giving one single value. Note that there is a 95% probability that dry matter and nutrient content estimates will fall within the interval given for each specific gravity measurement.

To measure the specific gravity of a manure sample, immerse the hydrometer into the slurry immediately after mixing the sample. The hydrometer scale is read at the point where the scale emerges from the slurry. Using Tables 1 to 4, you will be able to estimate the dry matter content as well as the nitrogen and phosphorus contents of your sample by finding the corresponding values to the specific gravity number you have obtained with the hydrometer.

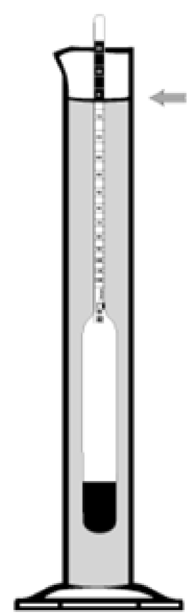

Figure 1. Measuring specific gravity with a hydrometer.

Electrical Conductivity Meters and Pens

The electrical conductivity (EC) of slurry samples gives a measure of the amount of ammonium ions in the slurry. This is also an indirect method to estimate nutrients based on linear relationships between ammonium ions and the EC of the slurry.

Conductivity meters and pens used to develop the dairy waste utilization management tool for Barren, Monroe, and Hart counties are shown in Figure 2.

Electrical conductivity meter and pens can be purchased from laboratory supply vendors. Details on costs and vendors' contact information are given at the end of this publication.

As with hydrometers, calibration curves were developed for Barren, Hart, and Monroe counties relating electrical conductivity (mS/cm) to ammoniacal nitrogen (NH_4-N) (Tables 5 to 7). Calibration curves for the combined data set were also developed (Table 8). Both low- and high-end estimates are given for each value measured by the conductivity meter and pens. There is a 95% probability that NH_4-N will fall within the interval given for each conductivity measurement. Also note that you will most likely obtain more reliable estimates if you use the table developed for your own county (when available) instead of using the combined data set table.

To measure the EC of a manure sample, you simply place the EC probe in the slurry and read the EC from the meter. Mix the sample thoroughly before placing the probe in the slurry. Using Tables 5 to 8, you will be able to estimate the NH_4-N content of your sample by finding the corresponding values to the EC number you have just obtained from the conductivity meter or pens. Electrical conductivity meters/pens need to be periodically calibrated. Calibration kits can be purchased from laboratory supply dealers.

Figure 2. Conductivity meter (Hanna) and conductivity pens (Oakton, Orion).

Agros N Meter

The operation of the Agros N Meter is based on the reaction between ammonium ions and hypochlorite. Hypochlorite oxidizes the ammonium ion in slurry, and nitrogen gas (N_2) is produced. The pressure of the nitrogen gas provides a measure of the NH_4-N content in slurry.

The Agros N Meter used to develop the dairy waste utilization management tool for Barren, Monroe and Hart counties is shown in Figure 3.

Figure 3. Agros® N Meter.

The Agros N Meter can be purchased from Sylvette Corporation located in Minneapolis, Minnesota. Details on costs and vendors' contact information are given at the end of this publication.

As with the other two quick tests, calibration curves were developed for Barren, Hart, and Monroe counties (Table 9) relating the pressure gauge value of the Agros N Meter to NH_4-N. Calibration curves for the combined data set were also developed (Table 9). Both low- and high-end estimates are given for each value measured by the conductivity meter and pens instead of giving one single value. There is a 95% probability that NH_4-N will fall within the interval given for each Agros N Meter measurement. Also note that you will obtain more reliable estimates if you use the table developed for your own county (when available) instead of using the combined data set table.

A powdered reagent containing calcium hypochlorite, calcium chloride, and calcium hydroxide is mixed with the slurry in a sealed chamber, and the N_2 gas produced is measured with a pressure gauge. Using Table 9, you will be able to estimate the NH_4-N content of your sample by finding the corresponding values to the pressure gauge value you have just obtained with the Agros N Meter.

Plant-Available Nitrogen

Plant-available nitrogen (PAN) can be estimated using quick test results. Nitrogen availability is mainly affected by animal species, manure characteristics, method, and time of application. Other factors include the crop being grown, rainfall amounts, and soil characteristics. Of the various factors that affect manure's nitrogen availability, the method and time of application are the most influential factors that producers can control.

Researchers have combined methods of application, along with generalized organic nitrogen to inorganic nitrogen ratios that are a function of livestock species, to estimate PAN and loss percentages (Table 10).

If a producer estimates that dairy liquid manure contains 2.5 lb N/1000 gal., and the plan is to sweep inject manure on land, the amount of nitrogen available the year of application can be calculated as follows:

Loss correction =
2.5 lb x (1 - 0.05) = 2.38 lb N/1000 gal.

PAN the year of application =
2.38 lb N/1000 gal. x 0.55 = 1.31 lb N/1000 gal.

Acknowledgments

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Quick Test Costs and Vendors' Contact Information

Hydrometers (polycarbonate construction)
Specific gravity values: ranges from 1.000 to 1.220 and from 1.200 to 1.420.
Cost: $45 to $50

Hydrometer jar (polycarbonate construction)
Cost: $15 to $20

Hanna conductivity meter
Cost: $300

Orion QuiKcheK®
Cost: $75

Oakton Conductivity Tester®
Cost: $65 to $85

Oakton Replacement Electrode
Cost: $40 to $45

Oakton Calibration Kit
Cost: $30

Ben Meadows Company
1-800-241-6401
www.benmeadows.com

Cole-Parmer
1-800-323-4340
www.coleparmer.com

Agros® N Meter
Cost: $335

Reagent Refills
Cost: $50

Sylvette Corporation
3758 West Calhoun Parkway
Minneapolis, MN 55410
1-800-788-7218
E-mail: danielledona1@msn.com
http://www.sylvette.com/ordersub.asp?category=Nitrogen+%26+Phosphorus

Table 1. Estimates (low to high) of manure dry matter and nutrient content using hydrometers (Barren County).

Specific Gravity	DM (%)		Total P (lb/1000 gal.)		Total N (lb/1000 gal.)	
	Low	High	Low	High	Low	High
1.000	0.2	1.2	0.9	2.1	1.0	6.5
1.001	0.4	1.3	1.1	2.2	1.7	6.8
1.002	0.6	1.5	1.2	2.3	2.4	7.2
1.004	1.0	1.7	1.6	2.5	3.8	7.9
1.005	1.2	1.9	1.7	2.6	4.5	8.3
1.006	1.3	2.0	1.9	2.7	5.1	8.7
1.007	1.5	2.2	2.0	2.8	5.7	9.1
1.008	1.7	2.3	2.2	2.9	6.4	9.5
1.009	1.9	2.5	2.3	3.0	7.0	10.0
1.010	2.1	2.6	2.4	3.1	7.5	10.4
1.011	2.2	2.8	2.6	3.2	8.1	10.9
1.012	2.4	3.0	2.7	3.3	8.6	11.5
1.013	2.6	3.1	2.8	3.5	9.1	12.0
1.014	2.7	3.3	2.9	3.6	9.6	12.6
1.015	2.9	3.5	3.0	3.8	10.0	13.2
1.016	3.0	3.7	3.1	3.9	10.4	13.8
1.017	3.1	3.9	3.2	4.1	10.8	14.5
1.018	3.3	4.1	3.3	4.2	11.2	15.1
1.019	3.4	4.3	3.4	4.4	11.6	15.8
1.020	3.5	4.5	3.5	4.5	12.0	16.5
1.022	3.8	4.8	3.7	4.9	12.7	17.8
1.024	4.1	5.2	3.9	5.2	13.4	19.2
1.026	4.3	5.7	4.0	5.5	14.1	20.6
1.028	4.6	6.1	4.2	5.9	14.7	22.0
1.030	4.9	6.5	4.4	6.2	15.4	23.5
1.032	5.1	6.9	4.5	6.5	16.1	24.9
1.034	5.4	7.3	4.7	6.9	16.7	26.3
1.036	5.6	7.7	4.8	7.2	17.4	27.8
1.038	5.9	8.1	5.0	7.5	18.0	29.2
1.040	6.1	8.5	5.2	7.9	18.7	30.6
1.042	6.4	8.9	5.3	8.2	19.3	32.1
1.044	6.6	9.3	5.5	8.6	20.0	33.5
1.046	6.9	9.7	5.6	8.9	20.6	35.0
1.048	7.1	10.1	5.8	9.2	21.3	36.4
1.050	7.4	10.5	6.0	9.6	21.9	37.9

Table 2. Estimates (low to high) of manure dry matter and nutrient content using hydrometers (Hart County).

Specific Gravity	DM (%)		Total P (lb/1000 gal.)		Total N (lb/1000 gal.)	
	Low	High	Low	High	Low	High
1.000	0.1	0.6	0.5	1.0	0.7	1.7
1.001	0.4	0.8	0.8	1.1	1.4	2.2
1.002	0.7	1.0	1.0	1.3	2.1	2.8
1.004	1.1	1.5	1.2	1.8	3.1	4.3
1.005	1.3	1.8	1.3	2.1	3.5	5.1
1.006	1.5	2.1	1.3	2.3	3.9	5.9
1.007	1.7	2.4	1.4	2.6	4.4	6.8
1.008	1.8	2.7	1.5	2.9	4.8	7.6
1.009	2.0	3.0	1.6	3.2	5.2	8.4
1.010	2.2	3.3	1.6	3.4	5.6	9.3
1.011	2.4	3.6	1.7	3.7	6.0	10.1
1.012	2.5	3.9	1.8	4.0	6.4	10.9
1.013	2.7	4.2	1.8	4.3	6.9	11.8
1.014	2.9	4.5	1.9	4.6	7.3	12.6
1.015	3.0	4.8	2.0	4.9	7.7	13.4
1.016	3.2	5.1	2.0	5.1	8.1	14.3
1.017	3.4	5.4	2.1	5.4	8.5	15.1
1.018	3.5	5.7	2.2	5.7	8.9	16.0
1.019	3.7	6.0	2.2	6.0	9.3	16.8
1.020	3.9	6.4	2.3	6.3	9.7	17.6
1.022	4.2	7.0	2.5	6.8	10.6	19.3
1.024	4.6	7.6	2.6	7.4	11.4	21.0
1.026	4.9	8.2	2.7	8.0	12.2	22.7
1.028	5.3	8.8	2.9	8.5	13.0	24.3
1.030	5.6	9.4	3.0	9.1	13.8	26.0
1.032	5.9	10.0	3.1	9.6	14.7	27.7
1.034	6.3	10.7	3.3	10.2	15.5	29.4
1.036	6.6	11.3	3.4	10.8	16.3	31.0
1.038	7.0	11.9	3.5	11.3	17.1	32.7
1.040	7.3	12.5	3.7	11.9	18.0	34.4
1.042	7.6	13.1	3.8	12.5	18.8	36.1
1.044	8.0	13.7	4.0	13.0	19.6	37.8
1.046	8.3	14.3	4.1	13.6	20.4	39.4
1.048	8.6	15.0	4.2	14.2	21.2	41.1
1.050	9.0	15.6	4.4	14.7	22.1	42.8

Table 3. Estimates (low to high) of manure dry matter and nutrient content using hydrometers (Monroe County).

Specific Gravity	DM (%)		Total P (lb/1000 gal.)		Total N (lb/1000 gal.)	
	Low	High	Low	High	Low	High
1.000	0.0	1.1	0.0	1.6	0.0	5.9
1.001	0.0	1.2	0.1	1.7	0.0	6.4
1.002	0.0	1.3	0.3	1.9	0.9	7.0
1.004	0.3	1.6	0.6	2.1	2.5	8.2
1.005	0.5	1.7	0.8	2.2	3.3	8.8
1.006	0.7	1.9	1.0	2.4	4.1	9.4
1.007	0.8	2.0	1.1	2.5	4.9	10.1
1.008	1.0	2.2	1.3	2.6	5.6	10.8
1.009	1.1	2.4	1.5	2.8	6.4	11.4
1.010	1.2	2.6	1.6	2.9	7.1	12.2
1.011	1.4	2.7	1.8	3.1	7.8	12.9
1.012	1.5	2.9	1.9	3.3	8.4	13.6
1.013	1.6	3.1	2.0	3.4	9.1	14.4
1.014	1.7	3.3	2.2	3.6	9.7	15.2
1.015	1.8	3.5	2.3	3.8	10.3	16.0
1.016	1.9	3.8	2.4	4.0	10.9	16.8
1.017	2.0	4.0	2.5	4.1	11.5	17.7
1.018	2.1	4.2	2.6	4.3	12.1	18.5
1.019	2.2	4.4	2.8	4.5	12.6	19.4
1.020	2.3	4.6	2.9	4.7	13.2	20.3
1.022	2.5	5.1	3.1	5.1	14.3	22.0
1.024	2.7	5.5	3.3	5.5	15.3	23.8
1.026	2.9	5.9	3.5	5.9	16.4	25.6
1.028	3.0	6.4	3.7	6.3	17.4	27.4
1.030	3.2	6.8	3.9	6.7	18.4	29.2
1.032	3.4	7.3	4.1	7.1	19.4	31.1
1.034	3.6	7.8	4.3	7.6	20.4	32.9
1.036	3.7	8.2	4.5	8.0	21.4	34.8
1.038	3.9	8.7	4.7	8.4	22.4	36.6
1.040	4.1	9.1	4.9	8.8	23.4	38.5
1.042	4.2	9.6	5.0	9.2	24.4	40.3
1.044	4.4	10.0	5.2	9.6	25.4	42.2
1.046	4.6	10.5	5.4	10.1	26.3	44.1
1.048	4.8	10.9	5.6	10.5	27.3	45.9
1.050	4.9	11.4	5.8	10.9	28.3	47.8

Table 4. Estimates (low to high) of manure dry matter and nutrient content using hydrometers (combined data set).

Specific Gravity	DM (%)		Total P (lb/1000 gal.)		Total N (lb/1000 gal.)	
	Low	High	Low	High	Low	High
1.000	0.2	0.8	1.0	2.6	1.0	4.7
1.001	0.4	0.9	1.2	2.7	1.8	5.3
1.002	0.6	1.1	1.4	2.8	2.5	5.8
1.004	1.0	1.4	1.7	2.9	4.0	7.0
1.005	1.2	1.6	1.8	3.0	4.8	7.6
1.006	1.4	1.8	1.9	3.1	5.5	8.2
1.007	1.6	1.9	2.1	3.2	6.2	8.8
1.008	1.7	2.1	2.2	3.3	6.9	9.5
1.009	1.9	2.3	2.3	3.4	7.5	10.1
1.010	2.1	2.5	2.4	3.6	8.2	10.8
1.011	2.2	2.6	2.5	3.7	8.8	11.5
1.012	2.4	2.8	2.6	3.8	9.4	12.2
1.013	2.6	3.0	2.7	4.0	10.0	13.0
1.014	2.7	3.2	2.8	4.1	10.6	13.7
1.015	2.9	3.4	2.8	4.3	11.2	14.5
1.016	3.0	3.6	2.9	4.4	11.7	15.3
1.017	3.2	3.8	3.0	4.6	12.3	16.0
1.018	3.3	4.0	3.0	4.8	12.8	16.8
1.019	3.5	4.2	3.1	4.9	13.4	17.6
1.020	3.7	4.4	3.1	5.1	13.9	18.4
1.022	4.0	4.8	3.3	5.4	15.0	20.0
1.024	4.3	5.1	3.4	5.8	16.1	21.6
1.026	4.6	5.5	3.5	6.1	17.1	23.2
1.028	4.9	5.9	3.6	6.5	18.1	24.8
1.030	5.2	6.3	3.7	6.9	19.2	26.5
1.032	5.5	6.7	3.8	7.2	20.2	28.1
1.034	5.8	7.1	3.9	7.6	21.3	29.7
1.036	6.1	7.5	4.0	7.9	22.3	31.4
1.038	6.4	7.9	4.1	8.3	23.3	33.0
1.040	6.7	8.3	4.2	8.7	24.3	34.6
1.042	7.0	8.7	4.3	9.0	25.4	36.3
1.044	7.3	9.1	4.4	9.4	26.4	37.9
1.046	7.6	9.5	4.5	9.7	27.4	39.5
1.048	7.9	9.9	4.6	10.1	28.4	41.2
1.050	8.2	10.3	4.7	10.5	29.5	42.8

Table 5. Estimates (low to high) of NH_4-N content (lb/1,000 gal.) of manure using electrical conductivity meters and pens (Barren County).

	Hanna		Orion		Oakton	
mS/cm	Low	High	Low	High	Low	High
1.0	N/A	N/A	N/A	N/A	N/A	N/A
1.5	N/A	N/A	N/A	N/A	N/A	N/A
2.0	N/A	N/A	N/A	N/A	N/A	N/A
2.5	N/A	N/A	N/A	N/A	N/A	N/A
3.0	0.0	3.9	N/A	N/A	N/A	N/A
3.5	0.0	4.0	N/A	N/A	N/A	N/A
4.0	0.0	4.1	0.0	3.3	0.0	2.8
4.5	0.0	4.3	0.0	3.5	0.0	3.1
5.0	0.0	4.4	0.0	3.8	0.0	3.4
5.5	0.0	4.6	0.0	4.0	0.1	3.7
6.0	0.6	4.8	0.4	4.3	0.8	4.1
6.5	1.2	5.0	1.1	4.6	1.5	4.4
7.0	1.7	5.2	1.8	4.9	2.1	4.8
7.5	2.3	5.5	2.4	5.3	2.7	5.2
8.0	2.8	5.8	3.0	5.7	3.3	5.7
8.5	3.2	6.1	3.5	6.1	3.8	6.2
9.0	3.6	6.5	4.0	6.7	4.3	6.7
9.5	3.9	7.0	4.4	7.3	4.7	7.3
10.0	4.2	7.5	4.7	7.9	5.1	8.0
10.5	4.5	8.1	5.0	8.6	5.4	8.6
11.0	4.7	8.7	5.3	9.3	5.8	9.3
11.5	4.9	9.3	5.6	10.0	6.1	10.0
12.0	5.0	9.9	5.8	10.7	6.4	10.7
12.5	5.2	10.6	6.1	11.5	6.7	11.5
13.0	5.3	11.2	6.3	12.2	7.0	12.2
13.5	5.5	11.9	6.6	13.0	7.3	12.9
14.0	5.6	12.6	6.8	13.8	7.6	13.7
14.5	5.7	13.2	7.0	14.5	7.9	14.4
15.0	5.9	13.9	7.2	15.3	8.1	15.1
15.5	6.0	14.6	7.5	16.1	8.4	15.9
16.0	6.1	15.2	7.7	16.8	8.7	16.6
16.5	6.3	15.9	7.9	17.6	9.0	17.4
17.0	6.4	16.6	8.1	18.4	9.2	18.1
17.5	6.5	17.3	8.3	19.2	9.5	18.9
18.0	6.6	18.0	8.5	19.9	9.8	19.6
18.5	6.7	18.7	8.7	20.7	10.1	20.4
19.0	6.8	19.3	9.0	21.5	10.3	21.1
19.5	7.0	20.0	9.2	22.3	10.6	21.9
20.0	7.1	20.7	9.4	23.0	10.9	22.6

Table 6. Estimates (low to high) of NH_4-N content (lb/1,000 gal.) of manure using electrical conductivity meters and pens (Hart County).

	Hanna		Orion		Oakton	
mS/cm	Low	High	Low	High	Low	High
1.0	0.0	1.5	N/A	N/A	N/A	N/A
1.5	0.0	1.6	0.0	1.0	0.0	1.0
2.0	0.0	1.7	0.0	1.1	0.0	1.2
2.5	0.0	1.8	0.1	1.3	0.1	1.4
3.0	0.3	1.9	0.4	1.5	0.5	1.6
3.5	0.6	2.0	0.8	1.7	0.8	1.8
4.0	0.9	2.2	1.1	1.9	1.2	2.0
4.5	1.1	2.4	1.4	2.2	1.4	2.3
5.0	1.3	2.6	1.6	2.5	1.7	2.6
5.5	1.5	2.9	1.8	2.9	1.9	3.0
6.0	1.6	3.3	2.0	3.2	2.1	3.4
6.5	1.7	3.6	2.2	3.6	2.3	3.8
7.0	1.8	4.0	2.4	4.0	2.4	4.2
7.5	1.9	4.3	2.5	4.4	2.6	4.6
8.0	2.0	4.7	2.7	4.7	2.8	5.0
8.5	2.0	5.1	2.9	5.1	2.9	5.4
9.0	2.1	5.5	3.0	5.5	3.1	5.8
9.5	2.2	5.9	3.2	5.9	3.3	6.3
10.0	2.2	6.2	3.3	6.3	3.4	6.7
10.5	2.3	6.6	3.5	6.7	3.6	7.1
11.0	2.3	7.0	3.6	7.1	3.7	7.5
11.5	2.4	7.4	3.8	7.5	3.9	7.9
12.0	2.5	7.8	3.9	7.9	4.0	8.4
12.5	2.5	8.2	4.1	8.3	4.2	8.8
13.0	2.6	8.6	4.2	8.7	4.3	9.2
13.5	2.6	9.0	4.4	9.1	4.5	9.6
14.0	2.7	9.4	4.6	9.5	4.6	10.0
14.5	2.8	9.8	4.7	9.9	4.8	10.5
15.0	2.8	10.1	4.9	10.3	5.0	10.9
15.5	2.9	10.5	5.0	10.7	5.1	11.3
16.0	2.9	10.9	5.2	11.1	5.3	11.7
16.5	3.0	11.3	5.3	11.5	5.4	12.1
17.0	3.0	11.7	5.5	11.9	5.6	12.6
17.5	3.1	12.1	5.6	12.3	5.7	13.0
18.0	3.2	12.5	5.8	12.8	5.9	13.4
18.5	3.2	12.9	5.9	13.2	6.0	13.8
19.0	3.3	13.3	6.1	13.6	6.2	14.3
19.5	3.3	13.7	6.2	14.0	6.3	14.7
20.0	3.4	14.1	6.4	14.4	6.5	15.1

Table 7. Estimates (low to high) of NH_4-N content (lb/1,000 gal.) of manure using electrical conductivity meters and pens (Monroe County).

	Hanna		Orion		Oakton	
mS/cm	**Low**	**High**	**Low**	**High**	**Low**	**High**
1.0	N/A	N/A	N/A	N/A	N/A	N/A
1.5	N/A	N/A	N/A	N/A	N/A	N/A
2.0	N/A	N/A	N/A	N/A	N/A	N/A
2.5	0.0	1.8	0.0	4.5	0.0	2.7
3.0	0.0	2.1	0.0	4.7	0.0	3.0
3.5	0.0	2.4	0.0	4.9	0.0	3.3
4.0	0.2	2.7	0.0	5.1	0.1	3.6
4.5	0.7	3.0	0.0	5.3	0.6	3.9
5.0	1.1	3.4	0.0	5.6	1.1	4.2
5.5	1.6	3.7	0.5	5.8	1.6	4.6
6.0	2.0	4.0	1.1	6.1	2.1	4.9
6.5	2.4	4.4	1.7	6.4	2.6	5.3
7.0	2.9	4.7	2.2	6.8	3.0	5.6
7.5	3.3	5.1	2.7	7.2	3.5	6.0
8.0	3.7	5.5	3.1	7.6	3.9	6.4
8.5	4.1	5.8	3.5	8.1	4.3	6.9
9.0	4.5	6.2	3.9	8.6	4.7	7.3
9.5	4.8	6.6	4.2	9.2	5.0	7.7
10.0	5.2	7.0	4.5	9.8	5.4	8.2
10.5	5.6	7.4	4.8	10.4	5.8	8.7
11.0	5.9	7.9	5.0	11.0	6.1	9.2
11.5	6.3	8.3	5.3	11.7	6.4	9.7
12.0	6.6	8.7	5.5	12.3	6.7	10.2
12.5	6.9	9.2	5.7	13.0	7.1	10.7
13.0	7.3	9.6	5.9	13.7	7.4	11.2
13.5	7.6	10.1	6.1	14.4	7.7	11.7
14.0	7.9	10.5	6.3	15.1	8.0	12.3
14.5	8.2	11.0	6.4	15.8	8.3	12.8
15.0	8.6	11.4	6.6	16.5	8.6	13.3
15.5	8.9	11.9	6.8	17.2	8.8	13.9
16.0	9.2	12.4	6.9	18.0	9.1	14.4
16.5	9.5	12.8	7.1	18.7	9.4	14.9
17.0	9.8	13.3	7.3	19.4	9.7	15.5
17.5	10.1	13.7	7.4	20.1	10.0	16.0
18.0	10.4	14.2	7.6	20.9	10.3	16.6
18.5	10.7	14.7	7.7	21.6	10.5	17.1
19.0	11.0	15.2	7.9	22.3	10.8	17.7
19.5	11.3	15.6	8.0	23.1	11.1	18.2
20.0	11.6	16.1	8.2	23.8	11.4	18.7

Table 8. Estimates (low to high) of NH_4-N content (lb/1,000 gal.) of manure using electrical conductivity meters and pens (combined data set).

	Hanna		Orion		Oakton	
mS/cm	**Low**	**High**	**Low**	**High**	**Low**	**High**
1.0	N/A	N/A	N/A	N/A	N/A	N/A
1.5	N/A	N/A	N/A	N/A	N/A	N/A
2.0	N/A	N/A	N/A	N/A	N/A	N/A
2.5	0.0	1.4	0.0	1.3	0.0	1.1
3.0	0.0	1.8	0.0	1.7	0.0	1.5
3.5	0.0	2.1	0.0	2.0	0.0	1.8
4.0	0.4	2.4	0.2	2.4	0.5	2.2
4.5	0.8	2.7	0.7	2.7	1.0	2.6
5.0	1.3	3.0	1.2	3.1	1.5	2.9
5.5	1.7	3.3	1.7	3.4	1.9	3.3
6.0	2.1	3.6	2.2	3.8	2.4	3.7
6.5	2.5	4.0	2.7	4.2	2.9	4.1
7.0	2.9	4.3	3.1	4.6	3.3	4.5
7.5	3.3	4.7	3.6	5.0	3.7	4.9
8.0	3.7	5.1	4.0	5.4	4.2	5.3
8.5	4.1	5.5	4.4	5.9	4.6	5.8
9.0	4.4	5.9	4.8	6.4	4.9	6.2
9.5	4.8	6.3	5.2	6.9	5.3	6.7
10.0	5.1	6.7	5.5	7.4	5.7	7.2
10.5	5.4	7.1	5.9	7.9	6.1	7.7
11.0	5.8	7.6	6.2	8.4	6.4	8.1
11.5	6.1	8.0	6.6	8.9	6.8	8.6
12.0	6.4	8.5	6.9	9.4	7.2	9.1
12.5	6.7	8.9	7.2	9.9	7.5	9.6
13.0	7.0	9.4	7.6	10.5	7.9	10.1
13.5	7.3	9.8	7.9	11.0	8.2	10.6
14.0	7.6	10.3	8.2	11.5	8.6	11.1
14.5	7.9	10.7	8.5	12.1	8.9	11.6
15.0	8.2	11.2	8.9	12.6	9.2	12.1
15.5	8.5	11.7	9.2	13.1	9.6	12.6
16.0	8.8	12.1	9.5	13.7	9.9	13.1
16.5	9.1	12.6	9.8	14.2	10.3	13.7
17.0	9.3	13.0	10.1	14.7	10.6	14.2
17.5	9.6	13.5	10.5	15.3	11.0	14.7
18.0	9.9	14.0	10.8	15.8	11.3	15.2
18.5	10.2	14.4	11.1	16.4	11.6	15.7
19.0	10.5	14.9	11.4	16.9	12.0	16.2
19.5	10.8	15.4	11.7	17.4	12.3	16.7
20.0	11.1	15.9	12.1	18.0	12.7	17.2

Table 9. Estimates (low to high) of NH_4-N content (lb/1,000 gal.) of manure using the Agros N Meter (all counties).

Pressure Gauge Value	Barren County		Hart County		Monroe County		Combined	
	Low	High	Low	High	Low	High	Low	High
1.0	0.0	2.9	N/A	N/A	N/A	N/A	0.0	1.9
1.5	0.0	3.1	N/A	N/A	N/A	N/A	0.0	2.1
2.0	0.0	3.2	N/A	N/A	N/A	N/A	0.0	2.3
2.5	0.1	3.3	0.0	1.0	N/A	N/A	0.3	2.4
3.0	0.3	3.4	0.0	1.1	0.0	3.4	0.5	2.6
3.5	0.6	3.6	0.1	1.3	0.0	3.6	0.8	2.8
4.0	0.8	3.7	0.5	1.5	0.0	3.9	1.1	3.0
4.5	1.1	3.8	0.8	1.7	0.0	4.2	1.3	3.1
5.0	1.3	4.0	1.1	1.9	0.0	4.5	1.6	3.3
5.5	1.5	4.1	1.4	2.2	0.1	4.8	1.8	3.5
6.0	1.7	4.3	1.6	2.5	0.7	5.1	2.1	3.7
6.5	2.0	4.4	1.9	2.8	1.3	5.5	2.3	3.9
7.0	2.2	4.6	2.0	3.2	1.9	5.9	2.6	4.1
7.5	2.4	4.7	2.2	3.5	2.4	6.3	2.8	4.3
8.0	2.6	4.9	2.4	3.9	3.0	6.7	3.0	4.5
8.5	2.8	5.0	2.6	4.3	3.4	7.1	3.3	4.7
9.0	3.0	5.2	2.7	4.7	3.9	7.6	3.5	4.9
9.5	3.2	5.4	2.9	5.0	4.3	8.2	3.7	5.1
10.0	3.4	5.5	3.1	5.4	4.7	8.7	3.9	5.4
11.0	3.8	5.9	3.4	6.2	5.4	9.9	4.3	5.8
12.0	4.2	6.3	3.7	7.0	6.0	11.2	4.7	6.3
13.0	4.5	6.7	4.0	7.7	6.6	12.5	5.1	6.8
14.0	4.8	7.1	4.3	8.5	7.1	13.9	5.5	7.3
15.0	5.1	7.5	4.6	9.3	7.6	15.3	5.8	7.8
16.0	5.4	8.0	4.9	10.1	8.1	16.7	6.2	8.4
17.0	5.7	8.4	5.2	10.8	8.6	18.1	6.5	8.9
18.0	5.9	8.9	5.5	11.6	9.1	19.5	6.9	9.4
19.0	6.2	9.4	5.8	12.4	9.6	20.9	7.2	10.0
20.0	6.5	9.9	6.1	13.2	10.0	22.4	7.5	10.5
21.0	6.7	10.4	6.4	14.0	10.5	23.8	7.9	11.1
22.0	7.0	10.9	6.8	14.7	11.0	25.2	8.2	11.6
23.0	7.2	11.4	7.1	15.5	11.4	26.7	8.5	12.1
24.0	7.4	11.9	7.4	16.3	11.9	28.1	8.9	12.7
25.0	7.7	12.4	7.7	17.1	12.3	29.6	9.2	13.2
26.0	7.9	12.9	8.0	17.9	12.8	31.0	9.5	13.8
27.0	8.2	13.4	8.3	18.6	13.2	32.4	9.8	14.4
28.0	8.4	13.9	8.6	19.4	13.7	33.9	10.2	14.9
29.0	8.6	14.4	8.9	20.2	14.1	35.3	10.5	15.5
30.0	8.9	14.9	9.2	21.0	14.6	36.8	10.8	16.0
31.0	9.1	15.4	9.5	21.8	15.0	38.2	11.1	16.6
32.0	9.3	15.9	9.8	22.5	15.5	39.7	11.5	17.1
33.0	9.5	16.4	10.1	23.3	15.9	41.1	11.8	17.7
34.0	9.8	16.9	10.4	24.1	16.4	42.6	12.1	18.2
35.0	10.0	17.4	10.7	24.9	16.8	44.0	12.4	18.8

Table 10. Dairy manure nitrogen availability (% total N) and loss as affected by method of application for dairy manure.

	Broadcast-Incorporation[a]			Injection	
Year	**None**	**< 12 hr.**	**< 4 days**	**Sweep**	**Knife**
Average Year 1	20	55	40	55	50
Average Year 2	25	25	25	25	25
Lost[b]	40	10	20	5	10

[a] Categories refer to the length of time between manure application and incorporation.
[b] "Lost" refers to estimated volatilization and denitrification processes.
Source: Schmitt, M.A. 1999. Manure management in Minnesota. University of Minnesota Extension Service, Publ. FO-3553-C, St. Paul, Minn.

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