

FINAL REPORT

NCSU PROJECT #14313

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DATA REVIEW, SUMMARY, AND
RECOMMENDATIONS

for

POULTRY AND LIVESTOCK WASTE NUTRIENT
AND VOLUME DATA FOR NORTH CAROLINA-
PERIOD 2005-2009

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List of Acronyms that may be encountered in this report:

NCDA&CS	North Carolina Department of Agriculture and Consumer Services
DWQ	North Carolina Division of Water Quality
NRCS	Natural Resources Conservation Service
USDA	United States Department of Agriculture
N	Nitrogen
P	Phosphorus
K	Potassium
ASABE	American Society of Agricultural and Biological Engineers
ASAE	American Society of Agricultural Engineers (now ASABE)
NCSU	North Carolina State University
CES	Cooperative Extension Service

IMPORTANT NOTE ABOUT THIS REPORT AND ACCOMPANYING TABLES AND CHARTS:

All references and tables imply **plant available nitrogen, plant available phosphorus as P_2O_5 , and plant available potassium as K_2O** . This is the convention used in the NCDA&CS waste report recommendations and the convention used in the NRCS 633 Standard. The final summary and table set will be converted to **total nutrients** at the request of the Interagency Nutrient Management Committee charged with the responsibility of data management and disbursement.

INTRODUCTION

The NRCS 633 Standard provides data for waste management system design and waste management planning. These tables provide both predicted nutrient concentrations for manure as well as predicted manure generation volumes. The existing tables for North Carolina cover the major waste management systems for dairy, swine, and poultry, as well as several types of waste management systems that are used very little, if at all, in North Carolina today.

The current tables are populated with compiled data from a variety of studies performed in the 1970's and 1980's. Much of this data was based on research studies, as the animal industry at that time did not routinely sample manure for nutrient value. In 1997, legislation was enacted requiring waste sampling for liquid swine, dairy, and poultry operations. In 2000, further legislation was adopted requiring waste sampling for dry poultry litter operations with over 30,000 birds. The result of this legislation is that a tremendous number of waste samples have been analyzed over the past 10 years. This data reflects the entire animal and poultry industry with a tremendous number of data points. Use of this data may offer a reliable tool for planning manure management decisions in the future. The vast majority of these manure samples are analyzed by the Plant, Waste, Solution, and Media Section of the Agronomic Division of the North Carolina Department of Agriculture and Consumer Services. It is the database from this agency that will be used as the focal point to assess the livestock and poultry industries for waste nutrient concentrations. Industry records will be used for assessing manure generation volumes.

Important Note: The tables and summaries that are attached or included electronically with this report should not be used or transferred without the accompanying written report. The report explains the possible use and limitations of the tabulated data. In some cases, the tables are based on limited data inputs and more study may be warranted.

GOAL OF THE PROJECT

The goal of the project is to review recent data to support revisions to the Natural Resources Conservation Service (NRCS) waste utilization database. This includes data supporting waste nutrient concentrations along with data supporting manure generation volumes for all types of waste management systems in North Carolina. The recent data will be summarized and statistically analyzed to present to the key agencies responsible for making waste management decisions in North Carolina. These agencies include the North Carolina Division of Water Quality, North Carolina Division of Soil and Water Conservation, North Carolina Department of Agriculture and Consumer Services, North Carolina State University-Cooperative Extension Service, and USDA-Natural Resources Conservation Service. Other interested parties that are often consulted include commodity groups such as the North Carolina Pork Council, North Carolina Poultry Federation, North Carolina Dairyman's Association, North Carolina Cattleman's Association, North Carolina Farm Bureau Federation, and a number of industry production managers and waste management specialists. The ultimate goal is to populate the waste utilization tables with data for manure generation and nutrient value that, as accurately as possible, reflect the industries today.

NEED FOR THE PROJECT

The data that were developed for the current standard are based on production systems that are 15 to 30 years old. There have been many changes in the animal and poultry industries over the past 15 years. In general, market (kill) weights have increased while maintaining similar animal grow-out times; feeding and watering systems have improved; and the poultry industry has adopted the use of phytase in the diets to increase phosphorus uptake efficiency. Perhaps the most significant issue is that now there are many thousands of waste samples from operating production systems that allow a better sample population for which to study the industry.

A change in animal waste rules in 2006 requires poultry litter that is stockpiled longer than 2 weeks to be covered. The existing standard reflects 50% loss of N due to uncovered litter stockpiles. Nutrient differences in stockpiled litter are expected due to this rule change.

MATERIALS AND METHODS

The scope of the project can be simplified into two goals:

1. Update manure nutrient characterization data
2. Update manure generation volume data

1. **Manure nutrient characterization.** Manure nutrient concentrations have been analyzed, as required by law, for over 10 years for the major types of animal operations in North Carolina. This data is available through the Plant, Waste, Solution, and Media Section of NCDA&CS. This data was acquired from NCDA&CS for this project. This lab analyzes manure samples for a large variety of parameters, including the three major plant nutrients nitrogen (N), phosphorus (P), and potassium (K), but also dry matter, pH, calcium, magnesium, and a host of micronutrients. As this project's scope is focused on revising the NRCS 633 standard tables, the only parameters that were evaluated were those found in the existing standard- those being N, P, and K. The most recent 5 years of data was retrieved and reviewed for purpose of this study (2005-2009).

The waste lab at NCDA&CS has organized the data by animal species type and waste code. The waste code reflects the manure handling system and method of manure land application. These two factors are critical for assessing the nutrient availability coefficients applied to the raw sample data.

Most of the swine manure is handled in North Carolina with a flush type of waste system with the manure captured in an anaerobic lagoon. There are seven types of swine production systems all using this waste management method. The NRCS standards separate the different types of swine production systems, and thus to revise the NRCS tables, it is crucial to separate the waste samples received into the corresponding swine production system. This separation is not done by the NCDA&CS waste lab. The correlation between the waste sample data and the production system was made several ways. A database of swine producers categorized by production system was acquired from the North Carolina Division of Water Quality. Where possible, some links were made back to the NCDA&CS database to correlate the data. For the most part, the data correlation was obtained by visiting with integrators and producers and reviewing and compiling their waste analysis records for individual farms.

Production systems for dairy, cattle, and poultry are not as varied as the swine systems, and further, there are specific waste analysis codes that relate to these production systems. Thus, the waste sample data for these fields readily matches the production unit.

A cursory review of manure sample data shows a tremendous range in results for nitrogen (N), phosphorus (P), and potassium (K). This is a function of several circumstances: age of operation, type of feeding system, waste system operation and management, sample collection technique, and the likelihood that a few submitted samples have been improperly coded for waste type. This last issue, however, should not be significant as the lab staff performs a physical sample assessment prior to chemical analyses to see if the material is consistent with the typical form of the sample, and contacts the animal producer in the case of questions.

Once the data were separated into waste type, the data were summarized with these statistical analyses:

- Range (minimum and maximum)
- Mean
- Median
- Standard Deviation
- 10% , 25%, 50%, 75%, and 90% confidence interval (quantiles)
- Normalcy of distribution
- Number of samples represented

With the large standard deviation and wide data ranges present across the sample types, some professional judgment must be applied as to what level of confidence should be selected for populating future waste utilization tables. This is why the various confidence interval selections are shown. Ultimately, it will be the decision of the Interagency Nutrient Management Committee to select the data points that are used to populate the new nutrient management databases. Following previous protocol, the mean of each sample best reflects the industry average in each case. The mean, as mentioned above and below, was calculated after data outliers and other statistical summaries were evaluated.

A small number of sample data points were deleted from the study. The number of deleted samples will be shown on the data plots in the results section. The reasons for deleting sample data include:

- If any parameters showed a concentration of zero for N, P, or K the sample was deleted
- If the dry matter content was clearly outside the range for a given type of waste material, the sample was deleted. For example- a dry matter percentage above 50% is not feasible for an anaerobic lagoon sample.
- If the N, P, or K data points are 25% higher than the closest lower point, the sample was deleted. This refers to the maximum end of the scale, as no such variation occurs at the minimum end.
- Any data that cannot be clearly tied to a specific production system and waste handling technique was deleted.

The existing NRCS 633 standard has a large variety of waste handling and waste application options that either do not exist in North Carolina, or the use of these systems is so limited that substantial data sets do not exist. For example- very few deep pit waste slurry systems exist in North Carolina for swine and wet poultry manure. Very little swine manure lagoon liquid is applied by any technique other than irrigation. Therefore, although recent laboratory data have substantial information for the major types of waste management systems, there remain some areas where predicting future waste concentrations and volumes will continue to rely on historic and/or predictive calculations such as the ASABE revised tables.

The existing NRCS 633 data tables were populated in this manner, as per personal discussion with Dr. James Barker, retired NCSU Professor and Extension Specialist, Department of Biological and Agricultural Engineering. The data were averaged and the standard deviation calculated. All data outside of the range indicated by plus/minus 3 standard deviations from the average were deleted. The remaining data were then averaged and this is the data used to populate the tables.

For purpose of presenting the data summaries for this project, the existing 633 data tables are used as a base, and the summary data is presented alongside the table data for comparison. The summary data is presented as the mean once the extraneous outliers were eliminated, as was the case with the Dr. Barker data. These tables are not presented in this printed report as they are too extensive in size to be legible when printed. These tables have been supplied electronically to NCSU- the granting agency responsible for this project. In these tables, the existing NRCS data is highlighted in yellow, and the summary new data is highlighted in green. Special notes of concern are highlighted in blue.

2. **Manure generation volume.** Obtaining manure volume data was somewhat of a challenge, therefore this data should be assumed to be best estimates due to the limited number of responses available, and the fact that many of the responses are based upon judgment and not hard data. However, this data should still be considered for the following reasons:

- Generally, poultry house cleanouts are done by removing the top manure “cake” with each flock, and whole house cleanouts occur every year or sometimes every 2 years. Many times, the cake or crust is cleaned and stored by the producer, such that a farm cleanout will result in taking the whole house litter plus the accumulated manure cake. Anecdotally, volumes are lower than existing standards by 10 to 20%.
- Feed efficiencies have improved across species over the past 15 years. This is proprietary data and thus no clear results can be shown. This statement is based on testimonials from production managers across all species.
- For liquid manure systems, water use efficiencies have been greatly improved. Also, ventilation systems have been improved, reducing or eliminating the need for water misters.

For liquid waste management systems, a number of record keeping sets were reviewed and compiled. These are segregated by operation type. This data is shown in the Results Section and compared to existing table data.

For dry waste systems, data was obtained from both poultry producers and contract manure handlers. Estimates are that about 50% of the poultry litter is handled by contractors. Since 2006, such contractors have had to register with the North Carolina Division of Water Quality and provide an annual report of their practices. These annual reports were reviewed, and the data tied back to the individual production units for correlation. This required contact directly with the producers, as the annual reports only show volumes and not the type of production system or number of animals. Also, the report does not show whether the manure is handled as a whole-house cleanout or just manure caking.

Very little information is available for manure volume generation rates for the dairy and beef industries. To obtain this information, individual visits to farms tied to required state inspections may be necessary. This effort was outside the scope of this project.

Although lagoon sludge depth measurements have been required for some time, no reliable data is available to support lagoon sludge volume generation. There are several reasons for this:

- 1) Sludge surveys indicate a very erratic sludge generation rate, even among similar operation types and similar feeding formulations.

- 2) Lagoon sludge surveys are not reliable between producers. Differing measuring techniques and operators are employed.
- 3) Many producers are using lagoon additives which affect the sludge volumes.
- 4) Cleanout records are not applicable to sludge volumes. Lagoon cleanouts cannot remove all of the lagoon sludge. Also, usually some lagoon water is moved with the lagoon sludge. The result is that sludge removal records do not truly reflect lagoon sludge volumes.

The American Society of Agricultural and Biological Engineers has recently revised their Standard Numbered D384, titled "Manure Production and Characteristics". This standard gives predicted manure characteristics (both nutrients and volumes) based on assumed animal weights and grow-out times. While this standard has not typically been used in North Carolina, its use along with historical data sets (such as the existing NRCS 633 standard) may suffice where industry data is lacking. Note that industry nutrient data for North Carolina is sufficient due to the sampling requirements. It is the volume generation data that is lacking for dry poultry systems, beef operations, and dairies. Also note that the ASABE standards are for "as-excreted" manure, and do not take into account water volumes that are added to manure via leaking waterers, rainfall into storage ponds and lagoons, etc.

RESULTS

At the end of the results section, the summary data can be located. The summary is presented in two ways:

- 1) A summary table for each species showing existing NRCS 633 data points alongside the data summaries with columns for number of samples, mean, standard deviation, and several statistically significant data points.
- 2) A data plot showing all statistics for each animal species and waste code. These are segregated for N, P, and K such that each animal type will show 3 plots. Also, the plots are separated for a species where waste is handled both in liquid and solid form, such as chickens and beef. Liquid manures are shown as pounds of plant available nutrient per 1000 gallons of liquid manure. Solid manures are shown as pounds of plant available nutrient per ton of manure. These are the units used by both the NRCS 633 standard and the NCDA&CS waste analysis laboratory.

SWINE INDUSTRY

Swine Manure Nutrient Characterization

For anaerobic lagoon liquid, nitrogen and phosphorus concentrations across all production systems except farrow to feeder are significantly lower than current standards predict. N and P concentrations are very slightly elevated for the farrow to feeder operations. Potassium (K) concentrations are significantly higher across all production systems as compared to current standards. One scientist suggests that the reduction in liquid volume would concentrate the K, thus resulting in higher concentrations.

For anaerobic lagoon sludge, concentrations of N, P, and K are significantly higher than existing standards predict. The concentrations are 250% to 300% higher for all three major nutrients.

Swine Manure Generation Volume

Data was gathered from industry for periods ranging from three to five years. Data were only gathered at single-type production facilities to match the existing NRCS 633 standard list of operation types. For example, manure volume data for facilities such as farrow to finish, was not used as it is impossible to separate out the corresponding volumes to production phases. A relatively large data set was compiled for this study. The standard deviation for the means across the spectrum of production units is 27% to 37%, with an average deviation of about 31%. Based on the dynamics of this industry, it is felt that this data reliably reflects manure generation rates. Industry production managers have been stating for the past several years that water use efficiency at farms has increased, resulting in less water used per animal.

Table 1 shows the summaries of manure generation for the main types of swine operations, along with a comparison to currently used data.

Table 1.

Operation Type	Average Volume (gal/head/year)	Standard Deviation	Current Volume (NRCS 633) gal/head/year	Difference 2010 data versus existing 633 data
wean-feeder.	231	71	191	+ 18%
feeder-finish	524	142	927	- 77%
farrow - wean	2182	686	3203	- 47%
farrow - feeder	2741	1029	3861	- 41%
farrow - finish	4949	1410	10478	- 112%

No parallel data was gathered for swine lagoon sludge generation. Individual data points were reviewed at facilities that had obtained sludge cleanouts. The volumes were not consistent among animal production systems. There are a number of factors that, in combination, may make it very difficult to acquire accurate lagoon sludge generation volumes:

- 1) Although sludge surveys are conducted typically annually at swine facilities, results show erratic levels at the same facility and among comparable facilities.
- 2) There is no standard for measuring lagoon sludge. Further, there is much individual bias when measuring lagoon sludge, even with the same tools. Therefore, there is not a good correlation among measurements.
- 3) Many producers are using lagoon additives to decrease the sludge volume. These additives serve to further digest the material, volatilizing some organic material, and decreasing the sludge volume.
- 4) Sludge cleanouts are not designed to totally remove lagoon sludge, and further often take 10% to 40% non-sludge effluent along with the cleanout. Therefore, using sludge cleanout records is not an appropriate tool to measure sludge accumulation.
- 5) Sludge generation is a function of feed efficiency and lagoon management, and different companies employ different practices that might affect sludge generation.

The sludge generation rates from the existing standard will be applied to the sludge nutrient data that has been compiled for purpose of this report.

DAIRY INDUSTRY

Dairy Manure Nutrient Characterization

Dairy manure is managed in a variety of ways.

Dairy Daily Scrape- The results for N and P are very similar, and not statistically different, than current standards predict. Results for K are slightly higher-about 27% higher than predicted.

Dairy Flush/Scrape to Manure Storage Structure- The results for all three nutrients show concentrations well below the current standard. These levels are 25-30% below predicted levels.

Dairy Anaerobic Lagoon Liquid – The results show that all three nutrients are significantly higher than predicted. The difference is 200% or higher. See comments below after the dairy lagoon sludge section.

Dairy Anaerobic Lagoon Sludge- The results show all three nutrients at levels significantly below the current standards. This level ranges to over 200%. Further, the N and K concentrations are well below that which is found in the lagoon liquid which is highly unusual.

Comments on dairy lagoons: It is possible that dairy lagoons and dairy storage structures are improperly labeled when collecting and submitting samples for waste analysis. Storage structures are often agitated, and some producers irrigate out of storage structures and may believe it is thus a lagoon. Also, lagoons are sometimes agitated prior to irrigation as dairy lagoons tend to have higher solids than other animal species. Agitation prior to irrigation allows for better distribution and less equipment clogging. The data are not consistent with what is predicted and what would be expected in normal lagoon operation, and thus are suspect.

Dairy Manure Generation Volume

No input was received from producers or others associated with the dairy industry that would allow for correction of existing standards with respect to manure volume generation. Therefore, existing volume data is the best tool for the revised standard, unless additional studies are undertaken.

See discussion on swine anaerobic lagoon sludge. Parallel issues apply to dairy lagoons. Also, in North Carolina, many dairy lagoons are not of the age to have sludge removed yet.

POULTRY INDUSTRY

Turkey Manure Nutrient Characterization

The current manure standards segregate turkeys by animal type: poult, hen, tom, and breeder. There is no laboratory separation of these manures, thus one waste code is applied to all turkeys. Therefore, a segregation of data was not possible.

The data summary for whole house litter show that results for N and K are very close, with no significant difference, to predicted concentrations. Phosphorus levels are lower than predicted, by 15% to 77% depending on animal type. For the larger market birds, the phosphorus decrease is 77%. The industry has predicted this change as diets have been changed over the past 10 years to reduce P excretion in manure.

For stockpiled turkey litter, N is 157% higher than predicted concentrations, P is an average of 36% lower, and K is 24% higher. It appears for both turkeys and broilers that N loss predicted from manure stockpiles is much lower than expected. This could be a result of covered stockpiles, or limited use or age of stockpiles.

Existing standard data supports the need to segregate turkeys by animal type and weight. Since there is no laboratory segregation, it is recommended the existing standard segregations be used until such time as samples can be tied to specific production facilities.

Turkey Manure Generation Volume

No reliable data was obtained to better predict manure generation volumes for any of the dry poultry systems. Data obtained was highly erratic and often anecdotal. Therefore, existing volume data is recommended for standard revisions, or additional studies are warranted.

Following are some comments as to possible nature of inconsistent volume data being seen:

- 1) Inconsistency among cleanout methods and frequency- some producers remove manure “cake” or “crust” with every flock. Some do not. Producers will remove the whole house litter on a frequency often dictated by the company they contract with. This occurs once every 8 to 24 months.
- 2) Manure volumes are recorded by contract manure haulers who perform most of this work. These volumes are recorded for requirements for annual reports. However, the volumes are not tied to any particular production unit or grower. Growers raising birds for various companies have different feed formulations and bird weights. Contract manure hauler records are not tied to bird weights and turn (grow-out) times.
- 3) Some producers do their own manure caking and store the material on-site until a contractor comes for a whole-farm cleanout. It is highly possible that these two materials: the stored manure cake and whole house litter, are not well combined for sampling or spreading.
- 4) Data received support a 2.5 X range in litter volumes produced, so volumes are not easy to predict.
- 5) At least one company no longer uses bedding material (the birds are on bare ground) so that manure volumes should be much less (and nutrient concentrations should be much higher).
- 6) Anecdotal reports from industry and cooperating government agencies suggest that volumes are lower than current standards predict by anywhere from 10 to 50%.

Broiler Manure Nutrient Characterization

Current standard table data suggests that there are significant differences in nutrient values for the various broiler production systems of broilers, roasters, and breeders, and also between whole house, manure cake, and stockpiled manures. The review of laboratory suggests that there is very little difference between these categories for N and P, and moderate differences in K. One consideration might be to eliminate the various systems and define one type of manure for all production systems and manure management styles. The data review has many data points with a fairly normal data distribution and thus is recommended for standard revisions.

Broiler Manure Generation Volume

No reliable data was obtained to better predict manure generation volumes for any of the dry poultry systems. Data obtained was highly erratic and often anecdotal. Therefore, existing volume data is recommended for standard revisions, or additional studies are warranted. See further comments under the turkey manure volume section.

Layer Manure Nutrient Characterization

The current standard does not distinguish between the various types of birds for manure nutrient generation. Likewise, the NCDA&CS laboratory does not distinguish between animal types at layer operations. The current standard shows several production system possibilities. Surface scraped,

deep pit, and manure slurry systems either do not exist in North Carolina, or are in such low numbers that adequate data is not available to justify revising the standards in these areas. North Carolina mainly uses lagoon systems for layer manure management.

For lagoon liquid, data review shows significant changes as compared to existing standards. Nitrogen is higher by 38%, phosphorus is higher by 755%, and potassium is higher by 80%. There is no explanation for these changes, except the possibility that the lower number of samples from the study used for the current standard (6) was insufficient to adequately define these systems.

For lagoon sludge, data review shows significant changes as compared to existing standards. Nitrogen is higher by 572%, phosphorus is higher by 42%, and potassium is higher by 780%. The same comments as above for lagoon liquids apply.

Layer Manure Generation Volume

See discussion on anaerobic lagoon sludge in the swine section.

HORSE INDUSTRY

Horse Manure Nutrient Characterization

For all three major nutrients, laboratory data shows significantly lower concentrations than current standard tables. N is lower by 25 to 40% (as a function of application method), P is lower by 36%, and K is lower by 31 to 37% (as a function of application method).

Horse Manure Generation Volume

A number of Cooperative Extension Services throughout the southeast and midwest use an estimate of 50 pounds manure generation per 1000-pound horse per day. These estimates are very close to the data given in a study by Lawrence, Bicudo, and Wheeler. This reference can be found in Section 6. This study, as well as the other extension fact sheets, refers to the ASABE standards as the basis of the data.

The study has a very concise data range across several horse groupings from sedentary to intensely exercised, with manure daily generation of 23-26 Kg/day, or 50-57 pounds per day. Since the majority of Cooperative Extension Bulletins use 50 pounds per animal per day, that figure will be used in this study. No local data was gathered for horse manure volumes.

BEEF INDUSTRY

Beef Manure Nutrient Characterization

The current standard shows animal categories of stocker, feeder, and brood cow, but does not distinguish between the various sizes of animal for manure nutrient concentration. Likewise, the NCDA&CS laboratory does not distinguish between animal types at beef operations.

Review of laboratory data as compared to the current standard shows significant differences, both increases and decreases.

For scraped beef manure, N concentrations from lab data are 40% lower than current standards. P concentrations are 39% lower, and K concentrations are 10% lower.

For lagoon liquids, all three major nutrients show significant increases. N has increased by 200 to 255%, depending on application method. P has increased 70% and K by 197%.

For lagoon sludge, N has increased 11%, P has decreased 57%, and K has increased 200%.

Beef Manure Generation Volume

There are no requirements for beef operations with scraped manure to maintain records of manure volumes. There are few beef liquid operations, and they are not segregated from dairy operations by permit reference. Thus, no volume data were obtained for beef operations, and current standard manure generation rates will be used. The standard does distinguish among animal sizes for manure generation rates.

SUMMARY COMMENTS ON VOLUMES FOR ALL SPECIES

The revised proposed comprehensive NRCS 633 table has been calculated with presently known animal production weights and manure generation volumes. Since adequate data was collected only for the anaerobic lagoon section for swine volume, the data was revised for this section in a separate table for review. Summary volume tables for all species can be found at the end of Section 3.

A separate set of tables were generated for animal production weights and ages (grow-out times) for swine, turkey, and broilers as this data was acquired during the study. It cannot be assumed, however, that this data is directly correlated to manure volume. For example, swine production efficiencies have improved 5% to 12%, while water usage has declined from 41% to 112% across four of the five production systems. These tables are found at the end of Section 3 and are presented for informational purposes only, and should be integrated with future data that may be obtained on manure volumes. The swine volumes table follows the summary table for all species at the end of Section 3.

There are no significant weight and age changes for layers, dairies, cattle, and horses, and no data is reported for these species. For layers and dairies, 100% animal confinement is assumed. Overall, dairies have about 85-90% confinement, with variability across operation for pasture time (10-50%).

REFERENCES TO SIMILAR REPORTS/STUDIES

Dr. Diana Rashash performed a statistical data summary for anaerobic swine lagoon liquid data from 1999 to 2009. The data parameters that were evaluated were N, P, K, and pH from NCDA&CS waste data.

The data support two conclusions. 1) Individual data points from waste samples have a very large range with a high standard deviation. Waste samples were not segregated by swine production system. 2) Data summaries in block charts show no significant trends in the parameters over the 10-year period.

Data charts from this study are found in Section 6.

Dr. Shaun Casteel performed comparative analyses of a number of animal waste types from NCDA&CS lab data against the existing NRCS database populated largely by Dr. James Barker-retired from NCSU. This data can be found in Section 6. Many of the waste types were not supported by lab data of a significant number. The largest numbers of samples reflect the requirements for certain segments of animal production to obtain waste samples at given intervals based on regulatory requirements.

The data support this conclusion: the data scatter from lab data is very high and does not compare with any reliability against existing table data. Some parameters are higher, some lower. Sometimes the data are only a small percentage apart, other times they are off by one or more orders of magnitude. For the swine samples, no segregation by production system was attempted.

The USDA-National Agricultural Statistics Service- maintains a database by state of commercial livestock and poultry slaughter. The data set for 2009 and 2010 is found in Section 6. The range for slaughtered swine weights is 252 to 257 pounds, which parallels industry reports during this study. There are insufficient beef slaughter records to support the beef slaughter weight of 1163-1184 pounds per animal. The turkey and chicken data cannot be correlated back to N.C. industry, as both light and heavy broilers and turkeys are slaughtered and the percentage of each is driven by market demand. The USDA statistics do support that about 75% of the poultry slaughtered, on average, are the heavy birds for both turkey and broilers.

Dr. James Barker and Dr. Michael Overcash performed a literature review on swine waste characterization in 2006. This paper, published in the ASABE Journal, is found in Section 6.

POTENTIAL ISSUES AND RECOMMENDATIONS

This section is presented for policy makers and technical professionals to review and consider as it may relate to future waste management decisions.

- 1) Poultry litter is required to be covered when stockpiled as of 2006. The current data reflects a stockpiled nitrogen concentration of 50% of the fresh litter N concentration. Much of the N in poultry litter is ammonia-nitrogen, subject to volatilization. Historically, poultry litter was stockpiled uncovered. With the advent of the 2006 rule, stockpiled poultry litter N is likely to be much higher. A separate study of pre and post 2006 litter samples may be warranted.
- 2) A typical management scenario for poultry houses is to remove manure or litter “cake” or “crust” between each flock (4-6 times per year) and remove the whole house litter to the floor once every 8 to 24 months. The litter crust is often removed by the producer and stockpiled and covered. The whole house cleanout is performed by a contractor, at which time, the contractor will also remove the stockpiled crust manure. It is unlikely that these two manure sources are blended before land application. It is highly likely that these two manure sources vary greatly in plant available nutrients. The end result is that non-uniform applications of nutrients occur. If applied at a low rate (1-2 tons/acre) without supplemental nutrients, there should not be an issue.
- 3) Covered manure lagoons are not common in North Carolina. Data is currently being assessed by Mark Rice- NCSU BAE Department. This data should be compiled and used for future design once the researchers have an adequate sample base. The same statement may be made for innovative systems that require individual permits from NC-DWQ.
- 4) Data supporting manure volume generation are in some cases anecdotal, and in my opinion insufficient for all types of operations except where consistent pumping records exist. These records can be tied to a specific operation type and number of permitted head. Good results with a reasonable range were acquired for the swine industry. Very few results were obtained from liquid poultry and dairy operations. Separate studies are needed for the liquid poultry (layer), dry poultry, beef, dairy, and all dry manure operations to obtain reliable results with which to edit the current NRCS tables.
- 5) Some of the waste codes that are used by NCDA&CS may result in duplication of some sample types. Several codes may be unclear to the animal and poultry producer, and thus the sample may be miscoded. Specific recommendations to consider:
 - a. There does not appear to be significant difference between whole and stockpiled broiler litter. Remove any stockpiled litter codes. There is a difference in the data, however, for stockpiled turkey litter as compared to un-stockpiled litter. These differences are significant across all major nutrients.
 - b. Make additional descriptive terms for manure slurries. For example, there are 313 swine liquid slurry samples but that manure system is hardly used, if at all, in North Carolina.
 - c. While potentially confusing, adding segregations for various types of animal production systems would enhance future data summaries. Currently, the NRCS standard is segregated for:
 - i. Swine production systems (5)
 - ii. Poultry –broiler bird types (5)

- iii. Poultry –turkey bird types (4)
- iv. Poultry- layers (3)
- v. Dairy cattle (3)
- vi. Beef cattle (3)

Sources of confusion include more improper waste sample coding and situations where more than one system type is included on a given waste storage pond or lagoon. The types of production systems mentioned above may change when the final tables from this study are presented.

- 6) There are a number of waste sample types that are not heavily populated with data. Five years worth of data were used for this study. Thus, each of these sample numbers may represent repeated entries from the same farm. There are also other sample types that are suspect to having been improperly coded by the producer. Following is a list of sample types that have limited data or have potentially been miscoded by sample type:

Sample Type and Code	Number of samples/5 years	Comments
Aerobic swine lagoon	1357	There are very few true <i>aerobic</i> lagoons used in NC
Anaerobic beef lagoon sludge	5	Very limited data set
Anaerobic dairy lagoon sludge	56	Very limited data set
Anaerobic poultry lagoon sludge	46	Very limited data set
Aerobic swine lagoon sludge	247	There are very few true <i>aerobic</i> lagoons used in NC
Beef liquid slurry	53	Very limited data set and possibly miscoded dairy slurry
Poultry liquid slurry	35	Very limited data set and possibly miscoded poultry lagoon liquid or sludge
Swine liquid slurry	313	These are not common in NC, likely miscoded
Poultry Surface Scraped Manure	58	Very limited data set and possibly miscoded

SUMMARY AND CONCLUSIONS

The proposed NRCS 633 table revisions are only provided electronically due to the size of the printed material, and the difficulty with formatting to make it fit onto a page legibly. The tables were created with both the existing and new manure volumes, where good data was achieved during the study. Otherwise, the current manure generation volumes were used. Volume data that was obtained is printed and found at the end of Section 3.

All electronic files that were acquired or developed during this project will be submitted to Dr. Deanna Osmond-NCSU Soil Science Department- the project manager. These files include:

- 1) NRCS 633 table formatted with existing and proposed data
- 2) Manure volume summary table
- 3) Final project report
- 4) Summary table for all waste codes with mean, median, number of samples, current and proposed N, P, K concentrations, and 10% and 90% confidence intervals.
- 5) Statistical data summaries for each species for N, P, and K
- 6) Summary reports from Drs. Rashash and Casteel

Not all animal types in the current NRCS 633 standard are represented by the animal industry in North Carolina. Where there are few or no such operations, and/or few or no waste sample data available, no new material was provided in that section of the 633 table.

It was concluded that obtaining accurate manure volumes for much of the animal production sector will require additional, concerted effort. This would likely be a cooperative project between industry, the government agricultural and environmental agencies, and contract waste management companies.

REFERENCES AND CREDITS

This project could not have been completed without the generous cooperation from key individuals in both the public and private sector. The critical databases that were used were the following:

NCDA&CS- Waste, Plant, Solution, and Media Section waste analysis data summarized by waste code type and year- Brenda Cleveland

NCSU-Soil Science Department- Dr. David Crouse- summary reports of NCDA&CS database

NCDENR-Division of Water Quality- Christine Lawson and Dr. J.R. Joshi for summary livestock and poultry permit and manure hauler databases.

Hugh Harrington- private statistician

Data and/or information was received from the following individuals:

Swine Industry

Kraig Westerbeek – Murphy-Brown LLC

Glenn Clifton – Prestage Inc.

George Pettus – Goldsboro Milling, Inc.

Jim Lynch – Goldsboro Milling, Inc.

Tommy Stevens –NC Pork Council

Poultry Industry

Bob Ford – NC Poultry Federation

James Parsons- NC Cooperative Extension Service

Dan Campeau - NC Cooperative Extension Service

Richard Goforth - NC Cooperative Extension Service

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Dale Hulseby – Pilgrim's Pride

Jeff Beavers – Mountaire Farms

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Government Agencies:

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Stanley Stewart- Promise View Acres Farms, LLC

Donald Merritt- Merritt Brothers Cleaning Service

Jack Winslow – Jack H. Winslow Farms, Inc.

Jeff Long – Long Meadow Farms

Phillip Austin

Publications:

Dr. Diana Rashash- NCSU Cooperative Extension Bulletin

Dr. Shaun Casteel- Internal NCDA&CS Study Document

Drs. Barker & Overcash – *Swine Waste Characterization: A Review*. 2007 Journal of the American Society of Agricultural and Biological Engineers. Volume 50(2): 651-657

Drs. Lawrence, Bicudo, Wheeler- *Horse Manure Characteristics Literature and Database Review*. 2003 Proceedings of the Ninth International Symposium on Animal, Agricultural, and Food Processing Wastes. ASAE.