COMPREHENSIVE NUTRIENT MANAGEMENT PLANNING

TECHNICAL GUIDANCE

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COMPREHENSIVE NUTRIENT MANAGEMENT PLANNING TECHNICAL GUIDANCE

1.0 INTRODUCTION

USDA's goal is for animal feeding operation (AFO) owners/operators to take voluntary actions to minimize potential water pollutants from confinement facilities and land application of manure and organic by-products. To accomplish this goal, it is a national expectation that all AFOs should develop and implement technically sound, economically feasible, and site-specific Comprehensive Nutrient Management Plans (CNMP)

In general terms, a CNMP identifies management and conservation actions that will be followed to meet clearly defined soil and water conservation goals, including nutrient management, at an agricultural operation. Defining soil and water conservation goals and identifying measures and schedules for attaining the goals are critical to reducing threats to water quality and public health from AFOs. The CNMP should fit within the total resource management objectives of the entire farm/animal feeding operation.

The Comprehensive Nutrient Management Planning Technical Guidance is a document intended for use by those individuals (both public and private) who develop or assist in the development of CNMPs. The purpose of this document is to provide technical guidance for the development of CNMPs, whether they are developed for USDA's voluntary programs or as a means to help satisfy the United States Environmental Protection Agency's (USEPA) National Pollutant Discharge Elimination System (NPDES) permit requirements.

This technical guidance is not intended as a sole-source reference for developing CNMPs. Rather, it is to be used as a tool in support of the conservation planning process (see Appendix A), as contained in the USDA Natural Resources Conservation Service (NRCS) National Planning Procedures Handbook (NPPH) and NRCS Technical References, Handbooks, and Policy Directives (see Appendix B).

2.0 DEFINITION

A CNMP is a conservation system that is unique to animal feeding operations. A CNMP is a grouping of conservation practices and management activities which, when implemented as part of a conservation system, will help to ensure that both production and natural resource protection goals are achieved. It incorporates practices to utilize animal manure and organic by-products as a beneficial resource. A CNMP addresses natural resource concerns dealing with soil erosion, manure, and organic by-products and their potential impacts on water quality, that may derive from an animal feeding operation. A CNMP is developed to assist an AFO owner/operator in meeting all applicable local, tribal, State, and Federal water quality goals or regulations. For nutrient impaired stream

segments or water bodies, additional management activities or conservation practices may be required by local, tribal, State**,** or Federal water quality goals or regulations.

The conservation practices and management activities planned and implemented as part of a CNMP must meet NRCS technical standards. For those components included in a CNMP where NRCS does not currently maintain technical standards (i.e., feed management, vector control, air quality, etc.), producers must meet criteria established by Land Grant Universities, Industry, or other technically qualified entities. Within each state, the NRCS State Conservationist has the authority to approve non-NRCS criteria established for use in the planning and implementation of CNMP components.

2.1 Conservation Planning Process

Conservation planning is a natural resource problem-solving process. The process integrates ecological (natural resource), economic, and production considerations in meeting both the owner's/operator's objectives and the public's resource protection needs. This approach emphasizes identifying desired future conditions, improving natural resource management, minimizing conflict, and addressing problems and opportunities.

The NRCS' NPPH provides guidance in the application of effective conservation planning procedures in the development of conservation plans. This Comprehensive Nutrient Management Planning Technical Guidance does not replace the NRCS NPPH requirements, rather, it provides complementary guidance in applying the NRCS planning process specific to the development of CNMPs. (See Appendix A, Conservation Planning Process and CNMP Development.)

3.0 OBJECTIVES

The objective of a CNMP is to provide AFO owners/operators with a plan to manage manure and organic by-products by combining conservation practices and management activities into a conservation system that, when implemented, will protect or improve water quality. The elements of a CNMP should be developed by certified specialists.

4.0 CRITERIA

This section establishes the minimum criteria to be addressed in the development and implementation of CNMPs.

4.1 General Criteria

Comprehensive Nutrient Management Plans will meet the following criteria:

- Provide documentation that addresses the outlined items provided in Appendix C (Comprehensive Nutrient Management Plan Format and Content).

- Document the consideration of the following CNMP elements (it is recognized that a CNMP may not contain all of the six following elements; however, all six

elements need to be considered by the owner/operator during plan development, and the owner/operators decisions concerning each must be documented):

1) Manure and Wastewater Handling and Storage
2) Land Treatment Practices
3) Nutrient Management
4) Record Keeping
5) Feed Management
6) Other Utilization Activities

- CNMPs will contain actions that address soil erosion and water quality criteria for the feedlot, production area, and land on which the manure and organic by-products will be applied (i.e., as a minimum the plan would address CNMP elements 1, 2, 3, and 4 listed above). For AFO owners/operators who do not land apply any manure or organic by-products, the CNMP would only address the feedlot and production areas (i.e., address CNMP elements 1,4, and 6 listed above).

- Meet requirements of NRCS Field Office Technical Guide (FOTG) conservation practice standards for practices contained in the CNMP.

- Meet all applicable local, Tribal, State, and Federal regulations.

- When applicable, ensure that USEPA NPDES or State permit requirements (i.e.) minimum standards and special conditions) are addressed.

4.2 Element Criteria

Each of the CNMP's elements will address specific criteria. The degree to which these elements are addressed in the development and implementation of a site-specific CNMP is determined by the General Criteria In Section 4.1 and the specific criteria provided for each element. The elements will address the following specific criteria:

4.2.1 Manure and Wastewater Handling and Storage

This element addresses the components and activities associated with the production facility, feedlot, manure and wastewater storage and treatment structures and areas, and any areas used to facilitate transfer of manure and wastewater. In most situations, addressing this element will require a combination of conservation practices and management activities to meet the production needs of the AFO owner/operator and environmental concerns associated with the production facility.

4.2.1.1 Criteria for Manure and Wastewater Handling and Storage

- Provide for adequate collection, storage, and/or treatment of manure and organic by-products that allows application during favorable weather conditions and at times compatible with crop management. Collection, storage, treatment, and/or transfer practices shall meet the minimum requirements as addressed in the following NRCS conservation practice standards (See Appendix D), contained in Section IV of the NRCS FOTG, as appropriate:

  - *Waste Storage Facility (Code 313)*
  - *Waste Treatment Lagoon (Code 359)*
  - *Manure Transfer (Code 634)*
  - *Heavy Use Area Protection (Code 561)*

- Comply with existing federal, Tribal, State, and local regulations, associated with the following activities:

  - Disposal of dead animals

  - Disposal of animal medical wastes

  - Spoiled feed or other contaminants that may be regulated by other than a NPDES or State concentrated animal feeding operation (CAFO) permitting program

  NRCS does not have national conservation practice standards that address all these activities. Generally, federal, Tribal, State and local regulations dictate acceptable procedures; however, NRCS in some States has developed standards that address the disposal of dead animals by incineration or freezing.

- Documentation of the following:

  - Types of animals and phases of production that exist at the facility.

  - Numbers of each animal type, average weight, and period of confinement for each phase of production.

  - Total estimated manure and wastewater volumes produced at facility. Where historical manure and wastewater production volumes are not documented, an estimate may be made using the procedures and table data provided in the NRCS Agricultural Waste Management Field Handbook (AWMFH), Chapter 4, "Waste Characteristics".

  - Manure storage type, volume, and length of storage. For more information on storage and treatment systems, how they function, their limitations, and design guidance see NRCS AWMFH, Chapter 9, "Animal Waste Management Systems", and Chapter 10, "Component Design".

  - Existing transfer equipment, system and procedures.

- Operation and maintenance activities that address the collection, storage, treatment and transfer of manure and wastewater, including associated equipment, facilities and structures.

- Nutrient content and volume of manure, if transferred to others.

- An emergency plan that addresses spills and catastrophic events.

4.2.1.2 Considerations for Manure and Wastewater Handling and Storage

There are additional considerations associated with CNMP development and implementation that should to be addressed. However, NRCS does not have specific technical criteria for these considerations that are required for CNMPs.

Air Quality

AFO operators/owners need to consider the impact of selected conservation practices on air quality during the CNMP development process. Air quality in and around structures, waste storage areas and treatment sites may be impaired by excessive dust, gaseous emissions such as ammonia, and odors. Poor air quality may impact the health of workers, animals and persons living in the surrounding areas. Ammonia emissions from animal operations may be deposited to surface waters, increasing the nutrient load to these regions. Proper siting of structures and waste storage facilities can enhance dispersion and dilution of odorous gases. Enclosing waste storage or treatment facilities can reduce gaseous emissions from AFOs in areas with residential development in the region. Background information on the current state of the knowledge, research gaps, and on-going research projects being carried out on air quality at USDA are provided in Appendix F.

Pathogens

AFO operators/owners need to consider the impact of selected conservation practices on pathogen control during the CNMP development process. Pathogenic organisms occur naturally in animal wastes. Exposure to some pathogens by humans and animals can cause illness, especially for immune-deficient populations. Many of the same conservation practices used to prevent nutrient movement from animal operations, such as leaching, runoff and erosion control are likely to prevent the movement of pathogens. Background information on the current state of the knowledge, research gaps, and on-going research projects being carried out on pathogens at USDA are given in Appendix F.

4.2.2 Land Treatment Practices

This element addresses evaluation and implementation of appropriate conservation practices on sites proposed for land application of manure and organic by-products from an AFO. On fields where manure and organic by-products are applied as beneficial nutrients, it is essential that runoff and soil erosion be minimized to allow for plant uptake

of these nutrients. An understanding of the present land use of these fields is essential in developing a conservation system to address runoff and soil erosion.

4.2.2.1 Criteria for Land Treatment Practices

- An on-site visit is required to identify existing and potential natural resource concerns, problems, and opportunities for the conservation management unit (CMU).

- Identification of the potential for nitrogen or phosphorus losses from the site.

- As a minimum, the conservation system developed for this element will address NRCS Quality Criteria for water quality and soil erosion, found in Section Ill of the FOTG. (See Appendix A for an example of how a conservation system is developed within the framework of the NRCS conservation planning process.) Typical NRCS conservation practices, and their corresponding NRCS conservation practice standard code number, used as part of a conservation system to minimize runoff and soil erosion are:
  - *Conservation Crop Rotation* (Code 328)
  - *Residue Management, No Till and Strip Till* (Code 329A)
  - *Residue Management, Mulch Till* (Code 329B)
  - *Residue Management, Ridge Till* (Code 329C)
  - *Contour Buffer Strips* (Code 332)
  - *Cover Crop* (Code 340)
  - *Residue Management, Seasonal* (Code 344)
  - *Diversion* (Code 362)
  - *Windbreak/shelterbelt Establishment* (Code 380)
  - *Riparian Forest Buffer* (Code 390)
  - *Filter Strip* (Code 393)
  - *Grassed Waterway* (Code 412)
  - *Prescribed Grazing* (Code 528A)
  - *Contour Stripcropping* (Code 585)
  - *Stripcropping, Field* (Code 586)
  - *Pest Management* (Code 595)
  - *Terrace (Code 600)*

  <u>Notes</u>:

  The FOTG, Section IV, contains a complete list of NRCS conservation practices and the criteria associated with their design and implementation.

  The conservation practice physical effects of individual practices on the natural resources (soil, water, air, plants, and animals) are found in the FOTG, Section V.

- Comply with existing, federal, Tribal, State and Local regulations or ordinances associated with soil erosion and runoff.

- Document the following:
  - Aerial maps of land application areas
  - Individual field maps with marked setbacks, buffers, waterways, and other conservation practices planned
  - Soils information associated with fields (i.e., features, limitations)
  - Design information associated with planned and implemented conservation practices
  - Identification of sensitive areas such as, streams, springs, lakes, ponds, wells, gullies, and drinking water sources
- Other site information features of significance, such as property boundaries.
- Identification of operation and maintenance (O&M) practices/activities.

4.2.3 Nutrient Management

This element addresses the requirements for land application of all nutrients and organic by-products (e.g., animal manure, wastewater, commercial fertilizers, crop residues, legume credits, irrigation water, etc.) that must be evaluated and documented for each CMU.

Land application of manure and organic by-products is the most common method of manure utilization due to the nutrients and organic matter content of the material. Land application procedures must be planned and implemented in a way that minimizes potential adverse impacts to the environment and public health.

4.2.3.1 Criteria for Nutrient Management

- Meet the NRCS Nutrient Management Policy as contained in the NRCS General Manual. Title 190, Part 402, dated May 1999. (See Appendix B)
- Meet criteria in NRCS conservation practice standard *Nutrient Management* (Code 590) and, as appropriate, *Irrigation Water Management* (Code 449). (See Appendix D)
- Develop a nutrient budget for nitrogen, phosphorus, and potassium that includes all potential sources of nutrients.
- Document the following:
  - Planned crop types, cropping sequence, and realistic yield targets

- Current soil test results (nitrogen, phosphorus, potassium, heavy metals, and sodic condition)
- Manure and organic by-product source testing results
- Form, source, amount, timing and method of application of nutrients, by field
- Description of application equipment and method used for calibration

4.2.3.2 Considerations for Nutrient Management

There are additional considerations associated with CNMP development and implementation that should to be addressed. However, NRCS does not have specific technical criteria for these considerations that are required for CNMPs.

Air Quality

AFO operators/owners should consider the impact of selected conservation practices on air quality during the CNMP development process. Air quality on land application sites may be impaired by excessive dust, gaseous emissions such as ammonia, and odors. Poor air quality may impact the health of workers, animals and persons living in the surrounding areas. Ammonia emissions from animal operations may be deposited to surface waters, increasing the nutrient load to these regions. Soil incorporation of manure and organic by-products on land application sites can reduce gaseous emissions. Background information on the current state of the knowledge, research gaps, and on-going research projects being carried out on air quality at USDA are given in Appendix F.

Pathogens

AFO operators/owner should consider the impact of selected conservation practices on pathogen control during the CNMP development process. Pathogenic organisms occur naturally in animal waste. Exposure to some pathogens by humans and animals can cause illness, especially for immune-deficient populations. Many of the same conservation practices used to prevent nutrient movement from animal operations, such as leaching, runoff and erosion control, are likely to prevent the movement of pathogens. Background information on the current state of the knowledge, research gaps, and on-going research projects being carried out on pathogens at USDA are given in Appendix F.

Salt and Heavy Metals

Build up of salt and heavy metals (i.e., arsenic, selenium, cadmium, molybdenum, zinc) in soils can create a potential for human and animal health problems and threaten soil productivity and crop marketability. Federal and State regulations do not address the heavy metal content associated with agricultural by-products. In developing a CNMP, the build-up of salt and heavy metals should

be tracked through soil testing. Additional guidance on salt and heavy metal contamination from manure Is available In the following:

NRCS Agricultural Waste Management Field Handbook. Sections 651.1103 and 651.0604(b), deal with the salt content of agricultural waste.

NRCS Agricultural Waste Management Field Handbook. Sections 651.0603(g) and 651.0605(a and b), deal with the heavy metal content of agricultural waste.

USEPA Title 40 Part 503 – Standards for the Use or Disposal of Sewage Sludge, Section 503.13, contains pollutant limits for biosolids heavy metal content and cumulative loading rates. This rule does not address resident levels of metals in the soil.

4.2.4 Record Keeping

It is important that records are kept to effectively document and demonstrate implementation activities associated with CNMPs. Documentation of management and implementation activities associated with a CNMP provides valuable benchmark information for the AFO owner/operator that can be used to adjust his/her CNMP to better meet production objectives. It is the responsibility of AFO owners/operators to maintain records that document the implementation of CNMPs.

Documentation will include:

- Annual manure tests for nutrient contents for each manure storage containment, or documentation explaining why manure test can be used for more than one year but not for more than 5 years (i.e. No change in management of manure, bedding, and feed).
- Application records for each application event, including (this also applies to commercial fertilizers that are applied to supplement manure):
  - Containment source or type and form of commercial fertilizer
  - Field(s) where manure or organic by-products are applied
  - Amount applied per acre
  - Time and date of application
  - Weather conditions during nutrient application
  - General soil moisture condition at time of application (i.e., saturated, wet, moist, dry)
  - Application method and equipment used
- Crops planted and planting/harvesting dates, by field**.**

- Records that address storage containment structures:
  - Dates of emptying, level before emptying, and level after emptying
  - Discharge or overflow events, level before and after event
- Transfer of manure off-site or to third parties:
  - Manure nutrient content
  - Amount of manure transferred
  - Date of transfer
  - Recipient of manure
- Activities associated with emergency spill response plan.
- Records associated with any reviews by NRCS, third-party consultants, or representatives of regulatory agencies:
  - Dates of review
  - Name of reviewer and purpose of the review
  - Recommendations or follow-up requirements resulting from the review
  - Actions taken as a result of the review
- Records of maintenance performed associated with operation and maintenance Plans.
- Nutrient application equipment calibration.
- Changes made in CNMP.

4.2.5 Feed Management

Feed management activities may be used to reduce the nutrient content of manure, which may result in less land being required to effectively utilize the manure. Feed management activities may be dealt with as a planning consideration and not as a requirement that addresses specific criteria; however, AFO owners/operators are encouraged to incorporate feed management as part of their nutrient management strategy. Specific information and recommendations should be obtained from Land Grant Universities, industry, the Agricultural Research Service, or professional societies such as the Federation of Animal Science Societies (FASS) or American Registry of Professional Animal Scientists (ARPAS), or other technically qualified entitles.

An example of the effective use of feed management is presented as follows:

"If a dairy cow is fed 0.04 percent above recommended levels of dietary phosphorus she will excrete an additional six pounds of phosphorus annually. For a herd of 500 cows, this is an additional 3,000 pounds of phosphorus per year. In a single cropping system, corn silage is about 0.2 percent phosphorus on a dry matter basis. For a field yielding 30 tons of silage per acre at 30 percent dry matter this is 36 pounds of phosphorus in the crop. If an additional 3,000 pounds of phosphorus are recovered in manure it takes considerably more land for application if manure is applied on a phosphorus basis." Dr. Deanne Meyer, Livestock Waste Management Specialist, Cooperative Extension, University of California.

Specific feed management activities to address nutrient reduction in manure may include phase feeding, amino acid supplemented low crude protein diets, and the use of low phytin phosphorus grain and enzymes, such as phytase or other additives.

Feed management can be an effective approach to addressing excess nutrient production and should be encouraged; however, it is also recognized that feed management may not be a viable or acceptable alternative for all AFOs. A professional animal nutritionist should be consulted before making any recommendations associated with feed ration adjustment.

4.2.6 Other Utilization Activities

Using environmentally-safe alternatives to land application of manure and organic by-products could be an integral part of the overall CNMP. Alternative uses are needed for animal manure in areas where nutrient supply exceeds available land and/or where land application would cause significant environmental risk. Manure use for energy production, including burning, methane generation and conversion to other fuels, is being investigated and even commercially tested as a viable source of energy. Methods to reduce the weight. volume, or form of manure, such as composting or pelletizing, can reduce transportation cost, and create a more valuable product. Manure can be mixed or co-composted with industrial or municipal by-products to produce value-added material for specialized uses. Transportation options are needed to move manure from areas of over supply to areas with nutrient deficiencies (i.e., manure brokering).

More efficient and cost-effective methods are needed for manure handling, treatment, and storage. Areas in need of targeting include: (1) improved systems for solids removal from liquid manure; (2) improved manure handling, storage, and treatment methods to reduce ammonia volatilization; (3) treatment systems that transform and/or capture nutrients, trace elements, and pharmaceutically active chemicals from manure; (4) improved composting and other manure stabilization techniques; and, (5) treatment systems to remediate or replace anaerobic lagoons.

As many of these alternatives to conventional manure management activities have not been fully developed or refined, industry standards do not always exist that provide for their consistent implementation. Except for the NRCS conservation practice standard *Composting Facility* (Code 317), NRCS does not have conservation practice standards that address these other utilization options.

This element of a CNMP should be presented as a consideration for the AFO owner/operator in his/her decision-making process. No specific criteria need to be addressed unless an alternative utilization option is decided upon by the AFO owner/operator. When an AFO owner/operator implements this element, applicable industry standards and all federal, Tribal, State, and local regulations must be met.

5.0 CERTIFICATION

Providing conservation planning and other technical assistance to AFO owners/operators through voluntary programs or to help satisfy regulatory requirements presents a potentially tremendous workload. NRCS traditionally has been the primary provider of conservation planning and other technical assistance to agricultural producers. In an effort to build capacity to meet this potential workload, NRCS will establish a process for certifying approved sources of conservation assistance. An individual who is appropriately certified through an USDA-recognized certification organization is referred to as either a "certified specialist" or a "certified conservation planner."

Certifying organizations (approved sources) can come from the private or public sectors. Private consultants, employees of agribusiness, and others who hold appropriate certifications through an approved independent certification organization or state licensing agency can be approved as certified specialists. Employees of natural resource conservation agencies, departments, or other entities organized under federal, Tribal, State, or local law who have planning and technical assistance functions as part of their assigned responsibilities can also be approved as certified specialists. Other non-commercial sources, as determined by the NRCS state conservationist, also can be approved.

Individuals can be recognized as providers of conservation planning assistance by obtaining a certified conservation planner designation, or as providers of technical assistance for developing components of a conservation plan by obtaining a certified specialist designation. An individual that is qualified to develop a complete CNMP would be designated as a certified conservation planner. To develop a specific element of a CNMP would require a certified specialist designation. (For specific requirements associated with establishing a certification process, and the minimum national demonstrated competencies associated with obtaining a certified specialist designation, see the NRCS General Manual 180 Part 409.)

In the development of a CNMP, as a minimum, the elements Manure and Wastewater Handling and Storage, Land Treatment Practices, and Nutrient Management must be developed by certified specialists. Because of the diversity and complexity of specific skills associated with each element of the CNMP, most individuals will pursue "certification" for only one of the elements. Therefore, to achieve a CNMP could require the interaction of three separate certified specialists, each addressing only one of the three elements.

It is envisioned that a certified conservation planner, assisting the AFO owner/operator, would facilitate the CNMP development process, with "certified specialists" developing the more detailed specifics associated with the element they are certified to help produce.

APPENDIX A

THE NRCS CONSERVATION PLANNING PROCESS AND CNMP DEVELOPMENT

This Appendix describes the NRCS conservation planning process and shows how a comprehensive nutrient management plan (CNMP) is developed using this established planning process.

Conservation planning is a natural resource problem-solving process. The process integrates ecological (natural resource), economic, and social considerations to meet both the owner's/operator's objectives and public resource protection needs. This approach emphasizes identifying desired future conditions, improving natural resource management, minimizing conflict, and addressing problems and opportunities. The NRCS National Planning Procedures Handbook (NPPH) provides guidance in the application of effective conservation planning procedures in the development of conservation plans.

The conservation planning process has not been changed by the introduction of CNMPs. However, public scrutiny of the conservation planning process has increased as a result of the introduction of CNMPs. it is essential that individuals providing technical assistance to develop CNMPs be well versed in the conservation planning process, have the skill to recognize resource concerns, and have the tools necessary to develop and evaluate treatment alternatives.

The Comprehensive Nutrient Management Planning Technical Guidance does not replace the NRCS NPPH, nor does it relieve the planner from offering conservation alternatives that address all of the resource concerns: soil, water, air, plants, and animals. Development of CNMPs will rely on the planning process and established conservation practice standards.

Conservation plans are developed with individual clients or with a group of individuals functioning as a unit. These plans are site-specific, comprehensive, and action-oriented. A conservation plan contains natural resource information and a record of decisions made by the client it describes the schedule of operations and activities needed to solve identified natural resource problems and take advantage of opportunities. A conservation system (CS) addresses treatment needs that meet the NRCS Field Office Technical Guide (FOTG), Section III, Quality Criteria, for each identified natural resource concern.

Quality criteria, in Section III of the FOTG, are quantitative or qualitative statements of treatment levels required to prevent resource degradation and enable sustained use for identified resource considerations for a particular land area. Quality criteria are established in accordance with local, State, Tribal, and federal programs and regulations in consideration of ecological, economic, and social effects. Table 1 contains typical quality criteria as presented in the FOTG, Section III, for soil and water resources, specifically soil erosion and surface water quality.

The scale of planning associated with the development of a CNMP is the Conservation Management Unit (CMU). A CMU is a field, group of fields, or other land units of the same land use and having similar natural resource conditions, treatment needs, and planned management. A CMU is defined by the planner to simplify planning activities and to

facilitate CS development. A CMU has definite boundaries, usually natural resource boundaries, such as drainage ways, vegetation, topography, or soils, but also can be based on land use.

Table 1. Example Quality Criteria

Resource	Resource Problem	Quality Criteria
Soil	Erosion: Sheet and Rill - soil erosion caused by overland water flow.	The soil loss Is reduced to tolerance "T" for the soil map unit, as listed In Section II of the FOTG.
Water	Quality Surface - pollution problems that result from the handling and use of applied nutrients, especially nitrogen, phosphorus, and total organic carbon.	Collection, transfer and storage of agricultural waste and fertilizers do not contribute contaminants that adversely affect surface water. Application of nutrients and organics are in balance with plant requirements — considering all nutrient sources, soil characteristics. optimum yields and runoff loss potential of nutrients dissolved In the runoff and/or attached to soil particles transported by water and wind.

A CNMP is a CS for animal feeding operations that addresses water quality as the primary resource concern. For AFOs that will land apply manure, the CNMP also will need to address soil erosion, condition, and deposition as a primary resource concern.

In working with an AFO owners/operators, alternatives are developed that address various treatment levels of the resources of concern. Alternatives developed for a CNMP will meet the FOTG quality criteria for soil and water concerns within all CMUs impacted by the collection, storage, and application of animal waste and organic by-products. The AFO owner/operator, as decision-maker, selects from these alternatives to create a CNMP that best meets his/her management objectives and environmental concerns.

The effect of each conservation practice on each of the resource concerns is found in the NRCS FOTG, Section V, "Conservation Practice Physical Effects." In order for a system to be an acceptable alternative, its overall impact on the resource concerns must not only be positive, but it must also satisfy the quality criteria for the RMS level, as described in the FOTG, Section III.

A broad range of technically feasible alternatives should be developed with the client. It is not merely enough to ask the producer what is being done and make a record of that as a CNMP. Alternatives need to achieve the objectives of the client solve identified problems, and treat the resources to defined quality criteria. Alternatives may include a mix of structural and/or management practices, within restrictions defined by ordinances or

regulations. It is important that the client be actively involved in the formulation of these alternatives.

CNMP implementation may require additional design, analysis or evaluations. This is particularly true for structural practices and nutrient management. Dynamics of operations, nature, infusion of real-time measurements or other unknowns may cause changes in amount, size, timing, or distribution of nutrients. These inputs may even cause complete revisions to planned alternatives. It is important for the certified conservation planner to maintain a relationship with the producer throughout CNMP implementation to address changes or new challenges.

Evaluation of the effectiveness of the CNMP may begin during the implementation phase and not end until several years after the last practice is applied. Follow-up and evaluation determines whether the implemented alternative is meeting the client needs and solving the conservation problems in a manner beneficial to the resources. If the evaluation determines that this is not taking place, adjustments to the CNMP probably will be needed.

APPENDIX B

TECHNICAL REFERENCES, HANDBOOKS, AND POLICY DIRECTIVES

Technical References and Handbooks

The Natural Resources Conservation Service has numerous technical references and handbooks that it uses to assist in the development of conservation plans and it various components. Listed below are those technical references and handbooks generally associated with the development of comprehensive nutrient management plans (CNMPs):

United States Department of Agriculture, Natural Resources Conservation Service, **Comprehensive Nutrient Management Plan Technical Guidance** is available on the NRCS website at http://www.nhq.nrcs.usda.gov/PROGRAMS/ahcwpd/AFO.html.

United States Department of Agriculture, Natural Resources Conservation Service (NRCS), National Engineering Handbook, Part *651***, Agricultural Waste Management Field Handbook**. This handbook is available on the NRCS website at http://www.ncg.nrcs.usda.gov/tech_ref.html or a paper copy of this publication can be purchased from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA. 22161, telephone: 1-800-553-6847. Order NTI Publications Numbers: PB230819 and PB97167753.

United States Department of Agriculture, Natural Resources Conservation Service, **National Agronomy Manual**. The National Agronomy Manual establishes policy for agronomy activities and provides technical procedures for uniform implementation of agronomy tools and applications. This manual is presently under revision and is scheduled for release in the fall of 2000. The draft version is available on the USDA server in Ft. Worth, Texas at ftp://ftp.ftw.nrcs.usda.gov/pub/Nat_Agron_Manual.

United States Department of Agriculture, Natural Resources Conservation Service, **National Planning Procedures Handbook (NPPH)**. The purpose of this handbook is to provide guidance on the planning process the Natural Resources Conservation Service (NRCS) uses to help develop, implement, and evaluate conservation plans for individuals, and area wide conservation plans or assessments for groups. This handbook is available on the NRCS website at http://policy.nrcs.usda.gov/scripts/lpsiis.dll/EDSnf/H.htm or from the NRCS, Conservation Operations Division, by contacting the Director, Conservation Operations Division, Natural Resources Conservation Service, 12th and Independence SW, Washington, D.C. 20013.

United States Department of Agriculture, Natural Resources Conservation Service, **"Conservation Planning Course"**. The Conservation Planning Course consists of nine modules. Part 1 of the Conservation Planning Course contains Modules 1-5, which cover the background and framework for conservation planning. These modules are included in a computer-based, self-paced version of the course. Part I of the course is available on the NRCS website at http://www.ncg.nrcs.usda.gov/start.htm. Part 2 of the course contains

Modules 6-8, which are a hands-on field application of the conservation planning process, that involves classroom and field exercises. Part 3, Module 9, is the individual application of the conservation planning process utilizing the information learned in Parts 1 and 2. Part 3 is to be completed at the participant's work location with the assistance of a coach. For more information on the availability of training on Parts 2 and 3 of the Conservation Planning Course, contact your NRCS State Conservationist

United States Department of Agriculture, Natural Resources Conservation Service, **"CORE 4 Conservation Practices Training Guide."** The purpose of this workbook is to enhance the technical knowledge of individuals that will assist landowners in effectively using conservation tillage, nutrient management, pest management, and conservation buffers. This training guide is available on the NRCS website at http://www.nhq.nrcs.usda.gov/BCS/agro/CORE4.PDF.

United States Department of Agriculture, Natural Resources Conservation Service, **"Agronomy Technical Notes."** These technical notes address a wide variety of agronomy issues and are available on the NRCS website at http://www.ncg.nrcs.usda.gov/tech_notes.html. Following is a list of the Agronomy Technical Notes found at this website:

Note 1: Cover Crops

Note 2: Conservation Crop Rotation Effects on Soil Quality

Note 3: Effects of Residue Management, No-Till on Soil Quality

Note 4: Effect of Soil Quality on Nutrient Efficiency

Note *5:* Herbicides

Note 6: Legumes and Soil Quality

Note 7: Effects of Soil Erosion on Soil Productivity and Soil Quality

Note 8: Liming to Improve Soil Quality in Acid Soils

Note 9: Managing Conservation Tillage

Note 10: Sunu Hemp, a Cover Crop for Southern and Tropical Farming Systems.

Note 11: Agricultural Management Effects on Earthworm Populations

Note 12: Long-Term Agricultural Management Effects on Soil Carbon

United States Department of Agriculture, Natural Resources Conservation Service (NRCS), **National Range and Pasture Handbook**. The National Range and Pasture Handbook constitutes NRCS basic policy and procedures for assisting farmers, ranchers,

groups, organizations, units of government, and others working through conservation districts in planning and applying resource conservation on non-Federal grazing lands throughout the United States. This Handbook is available on the NRCS website at http://www.ncg.nrcs.usda.gov/tech_ref.html , or a paper copy of this publication can be purchased from the National Technical Information Service, U.S. Department of Commerce, *5285* Port Royal Road, Springfield, VA. 22161, telephone: 1-800-553-6847. Order NTI Publication Number: PB2000I05483.

Policy Directives

NRCS policy is contained in Natural Resources Conservation Service **General Manual**. The index for the entire manual can be found at the NRCS website http://policy.nrcs.usda.gov/national/gm/index.htm. Listed below are those policy directives, contained in the General Manual, generally associated with the development of comprehensive nutrient management plans:

Natural Resources Conservation Service, General Manual. Title 450, Technology, Part 401, **"Technical Guides".** This part of the General Manual is available at the NRCS website at http://policy.nrcs.usda.gov/national/gm/title450/part401/index.htm.

Natural Resources Conservation Service, General Manual. Title 190, Ecological Sciences, Part 402, **"Nutrient Management".** This part of the General Manual is available at the NRCS website at http://www.nhq.nrcs.usda.gov/BCS/nutri/gm-190.html.

Following is Maine NRCS Nutrient Management Policy Supplement dated May 2001.

PART 402 – NUTRIENT MANAGEMENT
(190-GM. Amend. ME-3, May, 2001)

ME402.03 Certification

(a) All persons who review or approve plans for nutrient management will either be Certified Specialist in the appropriate elements of Comprehensive Nutrient Management Plan for Animal Feeding Operations (see 180-GM, Part 409, ME409.10) or Certified Conservation Planner with a certification rating level of "Application" for Code 590 Nutrient Management in their "Individual Certification Rating System – Planning Certification" (see 180-GM, Part 409, ME409.10) whichever is appropriate for the Nutrient Management Plan.

ME402.04 Nutrient Management Plans

(f) The "Nitrogen and Phosphorus Manure Priority Matrix" and the Leaching Index (LI) will be used as assessment tools.

ME402.05 Soil and Plant Tissue Testing

(e) Nutrient content of animal manure and other organic by-products shall be based on a Laboratory analysis of the material.

ME402.06 Nutrient Application Rates

(d)(2) Maine NRCS uses the “Nitrogen and Phosphorus Manure Priority Matrix”.

ME402.06 Nutrient Application Rates

(d)(3)(ii) Possible forage quality and animal health issues related to excess potassium application will be reviewed with the decision-maker.

ME402.07 Special Considerations

(a)(2) See and follow “Nitrogen and Phosphorus Manure Priority Matrix” for situations involving manure.

APPENDIX C

COMPREHENSIVE NUTRIENT MANAGEMENT PLAN FORMAT AND CONTENT

INTRODUCTION

A conservation plan is developed by the landowner/operator for his/her use to record decisions for natural resource protection, conservation, and enhancement.

Decisions and resource information needed during implementation and maintenance of the plan are recorded. The plan narrative and supporting documents provide guidance for implementation and may serve as a basis for compliance with regulations and/or program finding through federal, State, or local financial support initiatives.

A comprehensive nutrient management plan (CNMP) is to include all land units on which manure and organic by-products will be generated, handled, or applied, and that the animal feeding operation (AFO) owner/operator either owns or has decision-making authority over.

The following guidance helps to maintain quality and provide appropriate documentation of a CNMP. The list shows the suggested items to be given to the AFO owner/operator. However; the CNMP content should be tailored to meet the AFO owner's/operator's needs.

Contents of a Comprehensive Nutrient Management Plan

1. Site Information

- Names, phone numbers, and addresses of the AFO owner(s) and manager(s).
- Location of production site: legal description, driving instructions from nearest post office, and/or the emergency 911 coordinates.
- Farmstead sketch.
- Plat map or local proximity map (Optional).
- Emergency action plan covering: fire, personal injury, manure storage and handling and land application operations.
- Operation procedures specific to the production site and practices.
- Existing documentation of present facility components that would aid in evaluating existing conditions, capacities, etc. (i.e., as-built plans, year installed, number of animals component was originally designed for, etc.)

2. Production Information

- Animal types, phases of production, and length of confinement for each type at this site.
- Animal count and average weight for each phase of production on this site.

- Calculated manure and wastewater volumes for this site.
- Manure storage type, volume, and approximate length of storage.

3. Applicable permits or certifications

- Federal, Tribal, State or local permits and/or ordinances.
- Operator or manager certifications.
- Manure applicator certifications (where applicable).
- Record of inspections or site assessments.
- Changes made to CNMP.

4. Land application site Information

- Date plan prepared.
- Written manure application agreements. (Where Applicable)
- Aerial maps of land application area.
- Field maps with marked setbacks, buffers, and waterways, and environmentally sensitive areas, such as wells, gullies, tile inlets, etc.
- Landowner names, addresses, and phone numbers.
- Legal description of land sites, including watershed codes.
- Specific and unique field identification codes.
- Land use designation.
- Soil map, with appropriate interpretations
- Risk assessments for potential nitrogen or phosphorus transport from fields. (See NRCS GM —190, Part 402, “Nutrient Management”, Section 402.07)
- Land treatment practices planned and applied, and level of treatment they provide.

5. Manure application plans

- Crop types, realistic yield targets, and expected nutrient uptake amounts.
- Application equipment descriptions and methods of application.
- Expected application times.
- Estimated application amounts per acre (volume in gallons or tons per acre, and pounds of plant available nitrogen, phosphorous as P_20_5, and potassium as K_20 per acre)
- Estimation of acres needed to apply manure generated on this site respecting any guidelines published for nitrogen or phosphorous soil loading limits or a whole farm budget showing if farm can utilize all nutrients produced.

6. Actual activity records

- Soil tests — not more than *5* years old.
- Manure test annually for each individual manure storage containment or documentation explaining why manure test is used for more than one year but not for more than 5 years (i.e. No change in management of manure,

bedding, and feed).

- Planned and applied rates, methods of application, and timing (month and year) of nutrients applied. (Include all sources of nutrients - manure, commercial fertilizers, etc.)
- Current and/or planned crop rotation.
- Weather conditions during nutrient application (Optional)
- General soil moisture condition at time of application (i.e., saturated, wet, moist; dry) (Optional)
- Actual crop and yield harvest from manure application sites.
- Record of internal inspections for manure system components.
- Record of any spill event

7. Mortality disposal

- Plan for mortality disposal.
- Methods and equipment used to implement the disposal plan.

8. Operation and Maintenance

- Detailed operation and maintenance procedures for the conservation system, holding facility, etc., contained in the CNMP. This would include procedures such as calibration of land application equipment, storage facility emptying schedule, soil and manure sampling schedule and/or techniques, etc.

APPENDIX D

CONSERVATION PRACTICE STANDARDS

Natural Resources Conservation Service (NRCS) conservation practice standards provide guidance for applying technology on the land, and set the minimum level for acceptable application of the technology.

NRCS issues national conservation practice standards in its National Handbook of Conservation Practices (NHCP). National standards for each practice are available at the NRCS website at http://www.ncg.nrcs.usda.gov/nhcp_2.html. Each State Conservationists determines which national standards will be used in his/her state.

State Conservationists that choose to use national standards, without changes, adapt them for use in their state and issue them as state conservation practice standards. State Conservationists add the technical detail needed to effectively use the standards at the field office level. Also, State Conservationists can make their conservation practice standards more restrictive, but not less restrictive. State conservation practice standards are contained in Section IV of the Field Office Technical Guide.

Copies of Maine NRCS state conservation practice standards are available from the Maine NRCS Homepage at http://www.me.nrcs.usda.gov/STANDARD%20AND%20SPECS.HTM. The three most commonly considered conservation practice standards that may be used when developing a comprehensive nutrient management plan (CNMP) are:

Nutrient Management, Code 590
Waste Storage Facility, Code 313
Waste Utilization, Code 633

APPENDIX E

NRCS FIELD OFFICE TECHNICAL GUIDE

The Natural Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG) is an essential tool for resource planning. The FOTG contains five Sections:

I. **General Resource References** - References, maps, cost lists, typical crop budgets, and other information for use in understanding the field office working area, or in making decisions about resource use and resource management.

II. **Soil and Site Information** - Soils are described and interpreted to help make decisions about land use and management. In most cases, this will be an electronic database.

III. **Resource Management Systems** - Guidance for developing resource management systems. A description of the resource considerations and their acceptable levels of quality or criteria are included in this section. This section contains the **Comprehensive Nutrient Management Planning Technical Guidance.**

IV. **Practice Standards and Specifications** - Contains standards and specifications for conservation practices used in the field office. Conservation practice standards contain minimum quality criteria for designing and planning each practice; specifications describe requirements necessary to install a practice.

V. **Conservation Effects** - Contains Conservation Practices Physical Effects matrices that outline the impact of practices on various aspects of the five major resources —soil, air, water, plants, and animals.

The FOTG is a document that is being updated continuously to reflect changes in technology, resource information, and agency policy. The FOTG contains information that is unique to states and local field offices within states. To obtain information contained within the FOTG, contact the Maine USDA NRCS State Office in Bangor, Maine at (207) 990-9100 Ext. 3 or visit our website at http://www.me.nrcs.usda.gov.

APPENDIX F

BACKGROUND INFORMATION AND CURRENT RESEARCH ON RESOURCE CONCERNS

The information presented here was obtained from the USDA Agricultural Research Service (ARS) Manure and Byproduct Utilization National Program Action Plan. Additional Research is also being conducted under the ARS Air Quality National Program. The action plans describe, in detail, the research goals in these areas over the next five years. For the complete action plan and the most up-to-date information on ARS National programs see: http://www.nps.ars.usda.gov/.

AIR OUALITY

Air quality changes resulting from livestock operations are poorly defined because of lack of knowledge about the composition of emissions, emission rates, and dispersion of emissions across the landscape. However; the issue of air quality is one of the critical issues that must be addressed if animal feeding operations are to continue to exist in areas with increasing urban-rural populations.

There are three types of emissions from livestock operations that affect air quality: gases, particulates, and aerosols. Most gas emissions have not been examined or categorized. Known gases of particular interest include: ammonia, odorous compounds, and gases that adversely affect the atmosphere, such as methane, carbon dioxide and nitrous oxides. Ammonia emissions appear to have the greatest potential for adverse environmental and health impacts, while the generation and transport of malodorous compounds provokes the largest public concern.

Ammonia production is a consequence of bacterial activity involving organic nitrogen substrates. The primary source of ammonia production is the conversion of urea for livestock and uric acid for poultry. The process is extremely rapid, requiring only hours for substantial and days for complete conversion. A secondary source, which in this time frame can account for up to 35 percent of ammonia production, is organic nitrogen compounds in feces. In total, rapid processes convert about 35 percent of the total organic nitrogen initially in manure to ammonia. Over longer time periods, principally during storage, a total of *50* to 70 percent of the organic nitrogen can be converted to ammonia.

Odors are formed by the breakdown of manure via anaerobic digestion, and there are a wide range of volatile compounds that may potentially contribute to detection of odors by humans. Odorous compounds commonly associated with livestock facilities include: ammonia, volatile organic compounds including amines and any acids, and organic and inorganic sulfur containing compounds such as hydrogen sulfide and mercaptans.

The primary source of methane release in livestock production is ruminant animals. Release is a consequence of microbiological activity within the gastrointestinal tract necessary for breakdown of foodstuffs to compounds available for uptake by animals.

Metabolic processes of methanogens can also result in significant methane release at all stages of manure handling. Methane production from agriculture has been estimated to be around 7.8 Tg/yr, with 70 percent of this amount produced by cattle that are grazed and not in confinement feeding operations. Swine manure is estimated to produce 1.1 Tg/yr, while beef and dairy produce 0.9 Tg/yr. This difference is attributed to the manure storage and handling process variations between swine and beef.

Carbon dioxide is the normal byproduct of animal and most bacterial metabolism. Nitrogen dioxide and NOx release are normally the result of nitrification and denitrification processes whereby ammonia is converted to inorganic forms of nitrogen which, in turn, are converted to nitrogen gas. In addition, significant quantities of these gases can be released as by-products of engineering processes designed to dispose of manure or reduce odors.

Particulates are generally a consequence of interactions of animals with their environment In confined animal housing facilities, bedding, manure, litter, animal byproducts such as feathers, and feed mixing and distribution can contribute to the generation of particulates. Activity of animals during transport or other husbandry activities can help particulates to become airborne. In external housing facilities, animal movement on dry soil and manure can produce significant dust problems. Aerosols can be generated anytime there is a water source and air movement. Numerous farm management procedures generate aerosols, including misting or spraying to cool animals, manure separation techniques, spray irrigation, and spraying to control dust. The current development and implementation of the U.S. Environmental Protection Agency's PM-2.5 and PM-l0 air particulate matter standards add additional urgency to addressing the sources and amounts of particulate emission.

The goals of ARS researchers working in the area of atmospheric emissions from livestock operations are:

1. Develop certified methods to accurately measure emissions, e.g., ammonia, particulates, odors, volatile organic compounds, and other greenhouse gases (C02, CH4, N2O, and NOx), related to livestock facilities. Develop robust methods that can be used across a wide range of environments and animal production systems.

2. Understand ecology of aerobic and anaerobic microorganisms that are associated with emissions. Identify mechanisms to change the ecology or metabolism of organisms to reduce undesirable emissions. Develop methods to promote favorable changes in ecology or metabolism of microorganisms.

3. Quantify the emission rates in relation to handling, storage, processing. and application practices commonly used in U.S. livestock production systems. Correlate emissions with management practices to allow identification of best management practices for adoption by producers.

4. Determine environmental impacts on generation processes elucidated from Goal #2. Determine the environmental impacts on transport and dispersion of gases and

particulates from livestock production and manure application sites. Quantify the interactions of environment on generation, transport and dispersion processes. Quantify the interactions of emissions: gases, particulates, and aerosols, as factors influencing atmospheric transport and dispersion.

5. Determine the direct on-site impact of emissions on environment and health. Determine the local impact of emissions on environment and health. Determine the relative contribution of emissions from livestock facilities compared to regional and global emissions from other sources. Determine the net environmental cost of emissions related to livestock facilities and manure application.

6. Determine whether application of current best management practices can reduce emissions to acceptable on-site and off-site levels. Develop alternative management practices that can reduce emissions and achieve most efficient use of nutrients by animals. Determine the efficacy of various technologies and practices at a local, regional, and national scale.

PATHOGENS

Utilization of contaminated irrigation water or manures containing pathogenic or parasitic agents are considered to be important factors in the occurrence and epidemiology of water- and food-borne diseases. Recycling of manure to the land without adequate pathogen reduction directly increases the risks of human illness via water- or food-borne contamination, as well as cycling pathogens back to animals on the farm. This is true for pathogens associated with foods of animal origin as well as produce that may have been contaminated during production. Techniques, such as composting or deep stacking, to reduce pathogen levels in manure are often not used by producers because they require extra time, attention, special equipment or structures, and impose additional costs.

Generally, soil that has not recently received raw manure (liquid, slurry, partially dried, or improperly composted) or inadequately treated sewage has not been found to harbor indigenous populations of enteric pathogens and parasites. Manure, however is not the only on-farm source of pathogens and parasites. Other farm sources include: dust, aerosols, irrigation and runoff water, farm workers, plant residues, and the soil. For example, Bacillus cereus, Clostridium spp., and Listeria monocytogenes, can be readily found in many soils in association with plant material, vegetables, and decaying leaves and other plant parts. In addition, coliforms such as Enterobacter spp. and Klebsiella spp. are common inhabitants of soil and plant material, even in the absence of fecal material. This limits the use of traditional fecal coliform methods as indicators of fecal contamination, and reinforces the need for standard methods for the assessment of fecal contamination of produce.

It is well established that pathogen spread in the environment results from improper treatment and land application of sewage, slaughter offal, sludge, biosolids, slurry and manure, as well as from wild and domesticated animals. This may lead, by way of contamination of surface waters and colonization of birds, rodents and insects, to the contamination of animal feeds or directly contribute to the re-colonization of farm animals. Despite what is known about potential vectors of pathogen contamination, many critical questions remain to be answered. The lack of knowledge about pathogen survival in manure and about the adequacy of various manure management techniques to reduce the levels of these pathogens clearly points to the need for research on these issues. The fate of pathogens in the environment (e.g., transport and survival) after manure and other by-products have been land applied or otherwise disposed is not adequately known. In addition, better estimates of human and animal exposure are required for risk assessment to adequately assess the benefit of manure and byproduct treatment strategies.

Many of the pathogens that have emerged over the past 10 years cannot be easily detected and quantified in complex environmental samples such as manure, compost, soil, and foods. Application of current standard methods to the variety of matrices involved in determining the exposure at the farm end of the farm-to-table continuum will require adaptation and possibly development of new methods for detection and quantification of viable microorganisms.

The specific goals of ARS researchers working in the area of pathogens from livestock operations are:

1. To develop new techniques and adapt existing techniques for the detection of pathogenic bacteria and protozoans in agricultural matrices such as manure and soil. To standardize techniques for sampling and detection of each pathogen in all environmental matrices encountered in agriculture (manure, soil, runoff water and ground water) with respect to sample size, limit of detection, storage, etc., so that studies can be compared. To develop sensors (biological, molecular, chemical) for the rapid detection of pathogens in agricultural systems.
2. Determine the survival and transport of enteropathogenic bacteria in agricultural soils managed under different agricultural practices. Determine the effect of soil structure, pg temperature, etc. on pathogen survival. Determine the influence of cover crops on pathogen survival. Relate the survival of various pathogens under all these conditions to the survival of more easily measured indicator organisms. Determine the effect of manure composition on pathogen survival upon storage or on application to soil. Determine the role of biofilm formation by saprophytes and pathogens on plants, plant residues, and soil particles in the survival of pathogens derived from fresh manure and treated manures.

3. Determine pathogen/parasite levels in feces and estimate pathogen loading rates for different production systems. Develop functional relationships

between vertical versus surface pathogen transport and soil, topographic, vegetation, rainfall, and organism parameters. Determine pathogen association with organic particulates and/or sediments and the impact on transport potential/dissemination. Assess the ability of vegetative buffer strips, riparian zones, and/or wetlands to reduce pathogen runoff Integrate laboratory, field plot, and watershed scale data to describe pathogen transport in the context of hydrology. Assess the importance of wildlife/insect vectors and aerial transport. Quantify the role of on-farm practices on inter- and intra-farm pathogen dissemination (e.g., vehicular transport of incompletely disinfected manures, birds, dust, etc.).

4. Determine rates of pathogen destruction for major existing treatments, i.e., deep stacks, compost (passive aerated, windrow, static piles, in-vessel), digestion, lagoon, air drying, heat drying, and new treatments, and include pathogens and parasites recently involved in the surge of food and water-borne illness outbreaks in the U.S. Determine what protectants in manures, composts, or soils affect survival of pathogens and parasites. Quantitatively relate rates of pathogen destruction to critical environmental factors associated with each of the various treatment processes; develop destruction functions for each of the major pathogens, manure types, and treatments. Develop process quality criteria to guide operators so that pathogen destruction is achieved to the extent possible for the treatment process selected. Develop and validate appropriate quality control tests or measures for pathogen destruction for each major treatment process. Determine which indicator or surrogate organisms are appropriate for use in assessing reduction of particular pathogens in manure from various animal species, and use them in on-farm tests. Improve microbial growth, survival and thermal death models for manure and soil matrices, including species and strain differences, and nonlinear declines. Develop concepts and models of microbial exposure and risk analysis for treated manure products and link to more general microbial risk assessment models. Incorporate pathogen reduction data for major treatment methods into cost-benefit analysis models. Compare actual and predicted destruction in various on-farm treatment processes. Evaluate the use of industrial by-products to improve effectiveness of pathogen reduction treatments. Develop new methods to reduce or eliminate contaminants from establishing on plants before harvest Develop new cost-effective disinfection methods and equipment and systems modifications for processing manure that are also consistent with air and water quality and nutrient management concerns.

5. Establish assessment endpoints. Evaluate manure management strategies in the context of risk assessment.

NUTRIENT MANAGEMENT

Animal manures, applied in solid, semisolid and liquid forms contain essential nutrients that can meet crop requirements if applied to land in the proper manner at the right time and in suitable amounts. The manure generated annually in the U.S. contains about 8.3 million tons of nitrogen (N) and 2.5 million tons of phosphorus (P). However, manure in general is underutilized as a nutrient source in high density animal production areas such as dairy

farms in southern California, beef feedlots in the Southern Plains, hog operations in North Carolina and poultry houses in the Southeastern U.S. Manure can build soil organic matter reserves, resulting in improved water-holding capacity, increased water infiltration rates and improved structural stability. Manure can decrease the energy needed for tillage, reduce impedance to seedling emergence and root penetration, stimulate growth of beneficial soil microbial populations and increase beneficial mesofauna such as earthworms.

Animal feed and animal nutrition are important components of manure management livestock and poultry diet directly influences the amount of manure produced; nutrient, trace element and pathogen concentrations in manure; and formation of volatile components. Research to increase feed use-efficiency emphasizes defining animal nutritional requirements, diet formulation, genetically altered crops, use of enzymes and alteration of intestinal microflora.

In the past, animal diets were oversupplied with nutrients to achieve maximum animal performance with little regard for nutrients excreted. As environmental concerns associated with excess manure nutrients have increased, research has turned toward more efficient use of feed and matching feed nutrient concentrations to animal requirements. This approach can reduce the volume of manure produced, reduce nutrients excreted and lower production costs.

Ineffective utilization of P, especially by monogastric animals such as poultry and swine, has resulted in excess levels of P in manure. Monogastric animals lack enzymes to effectively break down the phytic acid form of P normally found in grain. Producers routinely add inorganic P supplements to poultry and swine diets, resulting in even higher levels of P in manure. Two basic approaches are being used to increase P utilization efficiency: enzyme addition to animal feed and development of grain with P in forms more readily available to the animal.

Nitrogen is especially susceptible to losses through ammonia volatilization, denitrification, leaching, anaerobic decomposition in lagoons and during aerobic composting. Treatment technologies are being developed to control ammonia volatilization and to immobilize N and P. Management of liquid manure and wastewater from animal operations is a major concern. Research is being conducted to allow more effective use of manure resources from anaerobic and aerobic lagoons, to develop more efficient separation of manure liquids and solids, and to find improved ways to immobilize and capture manure nutrients. A combination of practices will be required to effectively manage nutrients during manure handling and storage.

A greater understanding of nutrient transformations and reactions in manure and soil treated with manure is required. Analytical methods are needed to give producers quick reliable estimates of bioavailable nutrient concentrations in manure and soil. This will allow manure application rates to be targeted to crop needs and will allow proper nutrient credits for manure.

Effective management of N and P from manure and fertilizer is essential to protect ground and surface water quality. In the past, animal manure application rates were based on crop N requirements to minimize nitrate leaching to groundwater. The mean NP ratio (4:1) in

manure is generally lower than the mean N:P ratio (8:1) taken up by major grain and hay crops. Therefore, if manure application based on N has occurred for many years, rapid build up of P levels in soils create the potential for P losses to surface waters through runoff. Although protecting groundwater from nitrate leaching and limiting ammonia volatilization are major concerns, the management emphasis has shifted to P in many areas of the U.S.

Irrigation, especially furrow irrigation, can significantly increase P losses by both surface runoff and erosion in irrigation return flows. In addition, researchers have shown that soil P moves through the soil profile to shallow subsurface water in heavily-manured areas of the Delmarva Peninsula and through the soil profile to tile drains in the Midwest and Southeast U.S. Several states have established threshold soil test P levels that are perceived to protect surface waters from runoff that would cause eutrophication. These threshold levels are based on soil tests originally designed to predict crop response to nutrient additions. At soil test values above the threshold level, additional P cannot be added to the soil or application rates are limited to crop removal rates.

However, there are a number of limitations to a regulatory approach based on soil threshold P values. Also, it has been shown that 90 percent of the P runoff from an agricultural watershed may come from only 10 percent of the land area during a few relatively large storms. Therefore, the preferred approach to preventing P loss is to define, target and remediate source areas of P that combine high soil P levels, high surface runoff and erosion potentials, and proximity to P-sensitive bodies of water. This approach addresses P management at multi-field or watershed scales. A P index has been developed to rank the vulnerability of fields as sources of P losses in surface runoff. The index accounts for and ranks transport and source factors controlling P losses in surface runoff. The P index is being evaluated and refined in 14 states. When fully developed, the P index will allow producers to identify areas in a watershed that are susceptible to P losses and will suggest management options to correct the problem.

Alternative uses are needed for animal manure in areas where supply exceeds available land and land application would cause significant environmental risk. Manure use for energy production including burning, methane generation and conversion to other fuels is being investigated. Methods to reduce the weight, volume or form of manure such as composting or pelletizing will reduce transportation costs and create a more valuable product. Manure is being mixed, blended or co-composted with industrial or municipal byproducts to produce value-added material for specialized uses. Transportation subsidies are needed to move manure from areas of over supply to areas with nutrient deficiencies.

Changes in farming practices may be needed to address manure problems. Systems that balance nutrient inputs and outputs need to be developed at the whole-farm scale. These systems would emphasize a reduction of purchased nutrient inputs and more effective use and cycling of nutrients on the farm. Alternative production systems such as hoop houses for swine need to be evaluated and used where appropriate to reduce environmental threats from animal feeding operations. Benefits to be gained in terms of improved environmental quality would partially offset any additional expenses associated with these alternative manure uses and management practices.

The specific goals of ARS researchers working in the area of nutrient management from livestock manure are:

1. Determine the minimum nutrient requirements to support optimum production while minimizing nutrient losses for modem domestic livestock species under different production systems. Determine how nutrient requirements could be manipulated through changes in animal physiological processes. Determine the effects of diet formulation, environment, and feeding strategies on nutrient use and excretion by livestock and poultry. Develop procedures for use of dietary enzymes, supplements, and metabolic modifiers to improve nutrient utilization and decrease nutrient excretion. Determine the impact of gut micro flora on nutrient excretion. Modify feedstocks, livestock, and poultry for more efficient nutrient use by the animal and reduced nutrient excretion. Develop simple, inexpensive, rapid and reliable tests to reliably determine the bioavailability of nutrients in feeds. Determine the impact of diet and feeding strategies on nonpoint source water pollution.

2. Increase understanding of manure chemistry and microbiology to reduce nutrient losses during handling and storage and to improve treatment systems. Develop improved systems for solids removal from liquid manures. Develop improved manure handling, storage, and treatment methods to reduce ammonia volatilization. Develop treatment systems that transform and/or capture nutrients, trace elements, and pharmaceutically active chemicals from manure produced in confined animal production systems. Improve composting and other manure stabilization techniques. Develop treatment systems to remediate or replace anaerobic lagoons.

3. Develop techniques to identify and quantify the important compounds in animal manure and byproducts that contribute plant-available nutrients. Develop quick, accurate, and reliable methods for manure analysis. Develop techniques to assess the dynamics of nutrient availability from manures and byproducts in specific soil-crop-climate systems.

4. Develop best management practices for manure application rate, placement, and timing to synchronize manure nutrient availability with crop nutrient demand. Develop decision support tools and production practices that integrate manure and byproduct use and balance nutrient inputs and outputs at the whole-farm scale.

5. Determine the relationship between phosphorus in soil and the movement of soluble phosphorus to surface and shallow ground water. Develop predictive tools to identify areas susceptible to phosphorus losses in a landscape. Develop comprehensive watershed-scale nutrient management practices to protect water quality.

6. Determine the influence of agronomic practices such as tillage system, surface residue, crop rotations, on movement of manure nutrients to surface and ground water. Develop and evaluate methods such as vegetative buffer zones, grass filter strips, riparian zones, and/or other vegetative filters to prevent manure nutrient movement to surface waters.

7. Determine the long-term effects of manure and byproduct application on soil physical, biological, and chemical properties. Determine the long-term effects of manure and byproduct application on crop, range, and livestock productivity. Determine the long-term effects of manure and byproduct application on adjacent ecosystems.

8. Develop soil and crop management systems that increase utilization of manure nutrients. Develop short-term remediation strategies (bio- and phyto-) to remove excess nutrients in the soil. Develop long-term soil amendments and crop management systems to remove excess nutrients from soil.

9. Develop effective methods to obtain energy from manure. Co-utilize animal manure with other organic and inorganic waste resources to produce value-added products for special uses.