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Costs Associated With Development and Implementation of Comprehensive Nutrient Management Plans

Part I—Nutrient Management, Land Treatment, Manure and Wastewater Handling and Storage, and Recordkeeping

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Acknowledgments

This publication presents the results of USDA's assessment of the costs for developing and implementing Comprehensive Nutrient Management Plans (CNMPs) with a focus on manure and wastewater handling and storage, nutrient management, land treatment, and record keeping. A subsequent publication (Part II) will detail the costs for addressing the CNMP planning consideration elements—feed management and alternative use options. The assessment was conducted by the following team:

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Introduction

Animal agriculture has changed dramatically over the last two decades (Kellogg et al., 2000). Livestock populations have become more spatially concentrated in high-production areas. Small- and medium-sized livestock operations have been replaced by large operations at a steady rate. The total number of livestock has remained relatively unchanged, but the average number of livestock per operation has increased and more livestock are kept in confinement. These changes in animal agriculture have resulted in increased concern about the utilization and disposal of animal waste. As livestock production has become more spatially concentrated, the amount of manure nutrients relative to the land available for application has grown. In some high-production areas, the amount of manure produced exceeds the capacity of the land to assimilate manure nutrients (Lander et al., 1998; Kellogg et al., 2000).

In October 1997, the U.S. Department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA) were directed to work with other Federal agencies and the public to develop a Clean Water Action Plan (CWAP) that would chart a course toward fulfilling the goal of the Clean Water Act–"fishable and swimmable" water for all Americans. One of the key actions in the Clean Water Action Plan, released in February 1998, called for USDA and EPA to develop a joint unified national strategy to minimize the environmental and public health impacts of animal feeding operations. USDA and EPA released the *Unified National Strategy for Animal Feeding Operations* in March 1999 (USDA-EPA, 1999). The Strategy established a national performance expectation that all animal-feeding operations should develop and implement technically sound, economically feasible, and site-specific Comprehensive Nutrient Management Plans (CNMPs) to minimize impacts on water quality. It envisioned that this accomplishment should be achieved over a 10-year implementation period. The Strategy also called for a cost analysis to define the potential financial impacts of the initiative.

In December 2000, the Natural Resources Conservation Service (NRCS) released the *Comprehensive Nutrient Management Planning Technical Guidance* to provide guidance for the development of CNMPs, whether they are developed in the context of a USDA voluntary incentive program or as a means to help a livestock operation comply with the EPA's National Pollutant Discharge Elimination System permit requirements (USDA, NRCS, 2000a). The Technical Guidance is not a sole source reference for developing CNMPs. Rather, it is used in conjunction with the NRCS conservation planning process, as contained in the NRCS National Planning Procedures Handbook.

As defined in the Technical Guidance, a Comprehensive Nutrient Management Plan is a conservation system that is unique to animal feeding operations. It includes a set of conservation practices and management activities that address natural resource concerns dealing with manure and organic by-products and their potential impacts on water quality. A CNMP addresses the following elements:

1. Manure and Wastewater Handling and Storage. This element addresses 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. Generally, a combination of conservation practices and management activities are needed, such as manure storage, clean and contaminated water diversions, manure collection and transfer, runoff storage ponds, and mortality management.

2. Land Treatment Practices. This element addresses activities associated with fields where manure and organic by-products are applied. Generally, this element deals with the establishment of erosion control practices on land receiving manure, such as residue management, contouring, and terraces.

3. Nutrient Management. This element addresses activities associated with land application of all nutrients and organic by-products to meet crop needs and minimize potential adverse impacts to the environment and public health. Generally, this includes planning and applying nutrients with consideration of form (e.g., manure, wastewater, commercial fertilizer, crop residue, legumes, and irrigation water), time of application, application rate, and application method.

4. Recordkeeping. This element addresses the documentation of management and implementation activities associated with a CNMP. Typically, this includes recording soil tests, manure tests, manure and wastewater field application dates and rates, acres applied, manure transfers, and operations and maintenance activities.

5. Feed Management. This element addresses activities that improve feed delivery, reduced feed wastage, or increased nutrient uptake by livestock to reduce the nutrient content of manure. Feed management is a planning consideration and is not based on specific criteria.

6. Other Utilization Activities. This element addresses alternatives to land application of manure, such as energy production (e.g., burning, methane generation and conversion to other fuels), nutrient stabilization and extraction for commercial fertilizers or other products, composting or pelletizing, and mixing or co-composting with other by-products to produce specialized use materials. Alternatives to land application are planning considerations and are not based on specific criteria.

A CNMP would be constructed to meet specific criteria for the first four elements. The last two elements, however, are planning considerations, and do not have a specific set of criteria associated with them. That is, feed management and alternatives to land application may be part of an individual CNMP depending on the producer's goals and preferences, but if the producer is not interested in these alternatives, the objectives of the CNMP would be met using only the first four elements.

This publication (Part I) presents the results of USDA's assessment of the costs for developing and implementing CNMPs based on NRCS criteria for the first four elements. Definitive information on CNMP costs is needed to develop policy, formulate budgets, and provide insight for the implementation of financial assistance programs, such as the Environmental Quality Incentive Program (EQIP). In a subsequent publication (Part II), the potential for reducing CNMP costs with feed management options and the additional costs associated with alternatives to land application of manure will be explored. In addition to presenting the results of the cost assessment, Part I also provides a detailed documentation of data sources, modeling assumptions, and other information on how the assessment was conducted.

The first step in the assessment process is to identify the number of livestock operations that are expected to need a CNMP, which is presented in the next section. This is followed by an overview of the cost assessment process, and then by sections that present the cost estimates and detailed methods and assumptions used to estimate costs for each of the four elements. Also estimated are CNMP development costs, off-farm transport costs, and costs associated with off-farm land application. This publication concludes with a summary of CNMP costs broken down by livestock sector, farm size, and region of the country.

Livestock operations that are expected to need a CNMP

Assessing CNMP costs begins with estimating the number of livestock operations that are expected to need a CNMP. As indicated in the introduction, the *Unified National Strategy for Animal Feeding Operations* stipulated that all animal feeding operations should have CNMPs to minimize the impacts of manure and manure nutrients on water quality. EPA defines an animal feeding operation as a "Lot or facility where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and where crops, vegetation forage growth, or post-harvest residues are not sustained over any portion of the lot or facility in the normal growing season."

The best information source available on farms and characteristics of farms in the United States is the Census of Agriculture. The Census of Agriculture has information about the number and types of livestock on each farm. However, the census provides no information on how the animals are raised or to what extent or how long animals are held in confinement. Consequently, it is not possible to identify whether or not a farm in the census database is an animal feeding operation.

Farms that are expected to need a CNMP were therefore identified on the basis of the number and types of livestock on the farm and an estimate of the amount of manure produced annually by those livestock. The 1997 Census of Agriculture, which is the most recent census available, was used to make the determination. Farms with significant numbers of fattened cattle, poultry, and swine would clearly need a CNMP, since these livestock types are almost always raised in a confined setting. Dairies would also be expected to need a CNMP, since milk cows are confined for at least portions of the time each day for milking. Farms with an incidental number of these confined livestock types, however, would not be expected to implement a CNMP, even if the animals were confined. Similarly, most farms with pastured livestock types, such as beef cattle, horses, and sheep, would not meet the EPA definition of an animal feeding operation, and so would not need a CNMP. However, some of the farms with pastured livestock types would be expected to need a CNMP if a significant amount of recoverable manure is produced on the farm.

Three criteria were developed to identify farms that may need a CNMP, with each criterion addressing a separate segment of the livestock operations as represented in the census database.

The first criterion is used to identify farms with too few livestock to be considered as a farm that would need a CNMP. It is based on a profile of farms with livestock in the United States, presented in appendix A. The profile reveals that, of the 1,911,859 farms in the United States in 1997, two-thirds—1,315,051 farms (69%)—reported some kind of livestock on the farm or reported livestock sales. About 27 percent of these farms (361,031 farms) were "farms with few livestock." Farms with few livestock were farms with

- less than 4 animal units of any combination of fattened cattle, milk cows, swine, chickens, and turkeys; and
- less than 8 animal units of cattle other than fattened cattle or milk cows; and
- less than 10 horses, ponies, mules, burros, or donkeys; and
- less than 25 sheep, lambs, or goats; and
- less than $5,000 in gross sales of specialty livestock products.

An animal unit (AU) represents 1,000 pounds of live weight.

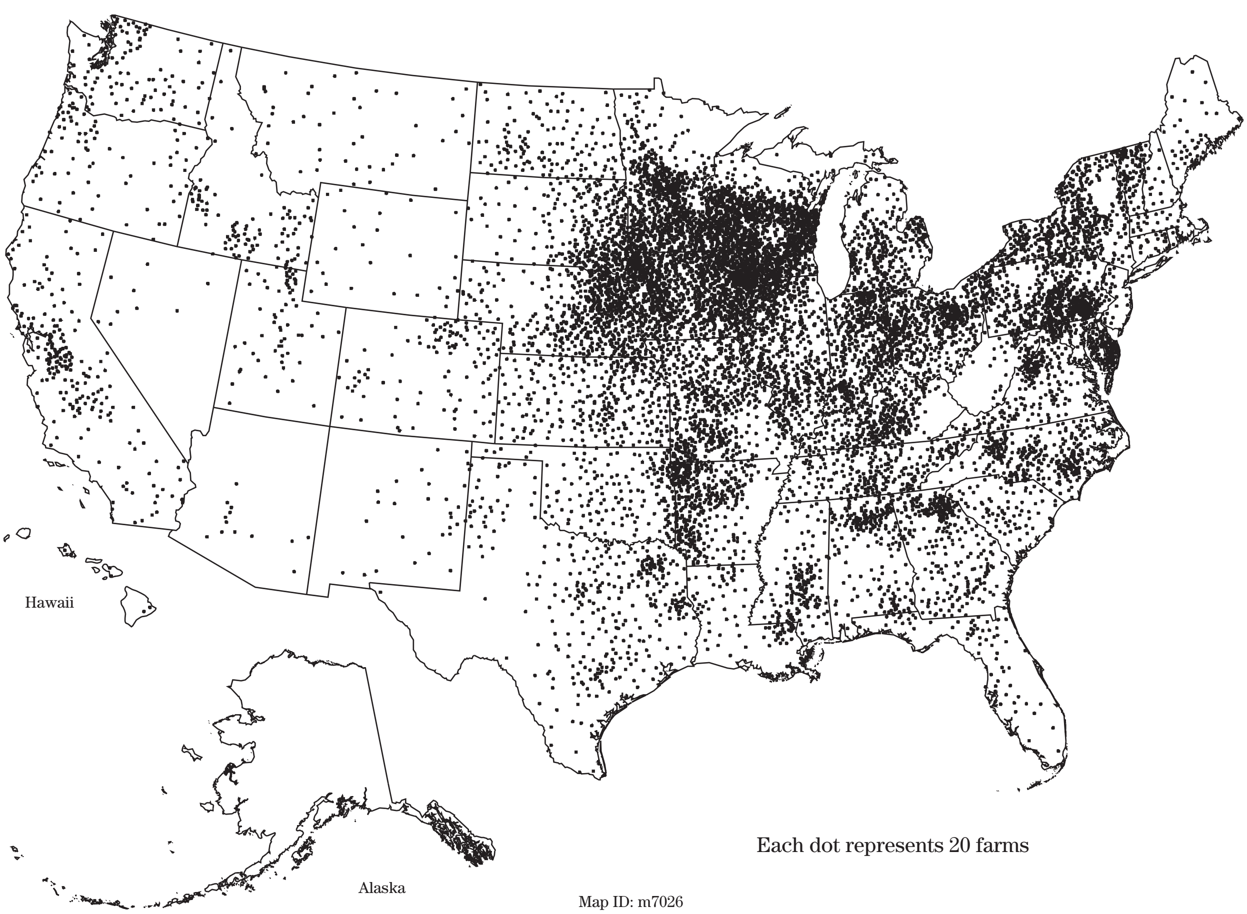
About 75 percent of the farms with few livestock had only pastured livestock types; 23 percent had at least some fattened cattle, milk cows, swine, chickens, or turkeys; and about 2 percent primarily had specialty livestock with gross sales of specialty livestock products below $5,000. The average of gross livestock sales per farm was only $2,149, and no livestock sales were reported for 34 percent of the farms. These farms are expected to be too small to need a CNMP.

The second criterion for a farm that would need a CNMP was based on the amount of recoverable manure produced. Recoverable manure is the portion of manure that could be collected from the facility for land application or other use. Recoverable manure and manure nutrients were estimated for each farm in the census using procedures presented in appendix B. Included are estimates of recoverable manure for beef cattle and other pastured livestock types. The calculation is heavily influenced by recoverability factors, which range from 5 percent to 20 percent for pastured livestock types with more than 1 AU per acre of pastureland and rangeland. (Recoverability factors are presented in appendix B.) The criterion used to identify a farm expected to need a CNMP is the same as the criterion used in appendix B for a manure-producing farm, which is production of more than 200 pounds of recoverable manure nitrogen annually. This criterion is equivalent to production of more than about 120 pounds of recoverable manure phosphorous annually. Farms at this threshold generate about 11 tons of manure (transport and handling weight) per year, which is less than a pickup truck load per month. (The actual amount varies by livestock type. The 11-ton estimate was empirically obtained by summarizing estimates from 3,218 farms with 190 to 200 pounds of recoverable manure nitrogen.)

Using this criterion, 255,070 farms were identified as farms that are expected to need a CNMP based on the amount of recoverable manure produced. However, this does not include farms with specialty livestock types because recoverable manure was not estimated for specialty livestock types.

The third criterion was developed to identify farms with specialty livestock types that may need a CNMP. Farms with specialty livestock types were defined to be farms with $5,000 or more in gross sales of livestock products from fish, bees, rabbits, mink, poultry other than chickens and turkeys, and exotic livestock, and had few other livestock types on the farm (see appendix A). There were 8,834 of these farms in 1997. The dominant specialty livestock type—based on gross sales—was fish and other aquaculture species on 2,449 farms (28 percent), colonies of bees on 2,331 farms (26 percent), poultry other than chickens and

Figure 1 CNMP farms (257,201 farms)



turkeys (such as ducks and geese) on 1,490 farms (17 percent), mink and rabbits on 641 farms (7 percent), and other exotic livestock on 1,923 farms (22 percent). Obviously, farms specializing in aquaculture or honey production would not need a CNMP. Furthermore, farms with other exotic livestock types would be expected to be largely pasture-based, and so would not likely need a CNMP. The two remaining groups—farms with poultry other than chickens and turkeys and farms with mink and rabbits—are most likely to be raising animals in confined settings, and so were identified as farms that may need a CNMP.

Including these 2,131 farms with specialty livestock types, the total number of census farms that are expected to need a CNMP is 257,201. These farms are referred to as **CNMP farms** throughout this publication. Figure 1 presents a map showing the geographical distribution of CNMP farms, and table 1 provides a breakdown by livestock type. The CNMP costs presented in this study are based on the assumption that all of these 257,201 farms would implement a CNMP.

Overview of the cost assessment approach

The objective of this assessment is to estimate the costs of implementing CNMPs on all livestock operations in the United States that are expected to need a CNMP, assuming a 10-year implementation period. CNMP-related costs are those costs that would be incurred as a direct result of upgrading the livestock facility or modifying management practices to meet NRCS criteria for a CNMP. Costs associated with facility upgrades that are production-related and not directly related to meeting CNMP criteria are not included. The cost of development of the CNMP is also included, which covers alternatives development and evaluation, design, implementation, and followup. The assessment also does not address who would pay for the CNMP; the full cost is estimated without adjustment for government subsidies or technical assistance provided by USDA or other programs.

Table 1 CNMP farms by dominant livestock type*

Category of CNMP farm	Number of CNMP farms
Farms with more than 35 AU of the dominant livestock type	
Fattened cattle	10,159
Milk cows	79,318
Swine	32,955
Turkeys	3,213
Broilers	16,251
Layers/pullets	5,326
Confined heifers/veal	4,011
Small farms with confined livestock types dominant	42,565
Farms with pastured livestock types dominant**	61,272
Farms with specialty livestock types	2,131
All CNMP farms	**257,201**

* Source: Appendix A, tables A-7 and A-8.
** Includes 24,697 farms with pastured livestock types and few other livestock and 36,575 farms with 4-35 AU of confined livestock types with beef cattle (other than fattened cattle) as the dominant livestock type.

A CNMP is customized to meet the specific needs of each livestock operation within the context of the production goals of the operator. Consequently, the need for modifications to meet CNMP criteria varies widely among operations. Some operations will require only modest changes to meet criteria. Other operations will require extensive modifications. CNMP needs will vary among farms because of siting characteristics, the condition of the facility, previous manure handling and land application practices, runoff and drainage features at the site, the scale of operation relative to the capacity of the facility, and availability of land for application of manure on the farm or on surrounding properties. To precisely calculate the costs of CNMP development and implementation would thus require knowledge of the present condition of each operation, which is clearly beyond the scope of this study.

This assessment represents an **approximation** of the costs that would be expected if CNMPs were fully implemented. To incorporate as much farm-specific information as possible, the assessment is based on a microsimulation model built around the 1997 Census of Agriculture. Using an approach similar to that presented in Kellogg et al. (2000), the amount of recoverable manure nutrients generated by each livestock operation and the acres required for manure application were estimated. Assumptions about likely production technologies and assumptions of expected CNMP needs and per unit costs were integrated with the farm-level census data to provide the information base for making the assessment. The simulation model is therefore a mix of precise information from the Census of Agriculture and generalized information on manure handling practices and CNMP needs. It is recognized that errors will be made in linking information on manure handling practices and CNMP needs to specific farms in the Census of Agriculture. However, the expectation is that underestimates of CNMP costs for specific farms will balance against overestimates for other farms, and that the final result will be a reasonable cost estimate at the national and regional level.

Because the cost assessment is based on the 1997 Census of Agriculture, cost estimates may be overstated somewhat because of changes in the livestock industry since 1997. In the 5 years since 1997, it is likely, given the trends reported in Kellogg et al. (2000), that concentration of the industry has continued to occur. It is expected that there are now more large livestock operations and fewer small livestock operations, and that the new facilities would have fewer CNMP needs than the operations they replaced.

Using the simulation model, unique estimates of CNMP costs were obtained for each of the 257,201 CNMP farms. CNMP-related cost estimates for each CNMP farm were made for six categories:

- Onfarm nutrient management costs
- Off-farm transport costs
- Land treatment costs
- Manure and wastewater handling and storage costs
- Recordkeeping costs
- CNMP development costs

In addition, costs associated with off-farm land application were estimated for each county. One of the outcomes of CNMP implementation is that more manure needs to be exported off the farm as livestock operations reduce application rates to meet nutrient management criteria. The costs of transporting manure to off-farm recipients are included in the estimates of CNMP costs, but costs associated with off-farm land application are not a direct CNMP cost. Nonetheless, they are real costs that, if not incurred, diminish the environmental benefits associated with CNMP implementation. Consequently, costs associated with off-farm land application were calculated, and assumed to be borne by the manure-receiving farms.

Specialty livestock farms (2,131 farms producing mostly ducks, geese, rabbits, and mink) were included in the assessment, but costs were not based on farm-specific information because appropriate conversion factors were not available for estimating the amount of manure nutrients produced. CNMP cost estimates for all cost categories for specialty livestock farms were based on the average CNMP costs for small broiler farms (i.e., farms with 35 to 60 broiler animal units).

Considerations not addressed in the cost assessment

The assessment did not address Federal, State, and local regulatory requirements associated with animal feeding operations. Many States have, or are in the process of, adopting regulations that would require some livestock operations to implement systems that are equivalent to a CNMP or part of a CNMP. Some of these regulations impose stricter requirements than represented by the NRCS CNMP guidelines. Consideration of regulatory trends was given, however, to the determination of CNMP needs, particularly for large operations.

This assessment did not attempt to account for the implementation of CNMPs or elements of CNMPs since 1997. Consequently, part of the costs presented in this assessment may have already been borne by some livestock operations.

Cost estimates may be overstated somewhat because they do not account for innovation and technological advances that are expected to occur as the CNMP initiative is implemented. Implementing CNMPs on nearly 260,000 livestock operations within a 10-year period is an ambitious undertaking. It is expected that efficiencies will arise both in CNMP development and in implementing manure-handling practices during the implementation. Technological advancements in equipment and in the design of structures for handling and treating manure may also arise, reducing costs. It is impossible to foresee where these innovations and efficiencies will occur or how much they may reduce the total costs, but cost savings could occur.

No attempt was made to account for payment by recipients for manure exported off the farm or charges to the livestock operation by recipients for accepting the manure. A variety of payment arrangements presently exist, depending on traditions and markets established in the production region, the type of manure, and existing State and local regulations. In some cases the livestock operator is responsible for applying the manure to the recipient's land. For the purposes of this cost assessment, it is assumed that all manure exported off the farm would be given and accepted without payment, the livestock operation bears the cost of transporting the manure to the manure-receiving farm, and the off-farm land application cost is borne by the recipient.

CNMP development and implementation costs are not estimates of the costs to producers of complying with EPA regulations

The largest livestock operations and operations that may pose a risk to the environment because of location are regulated by the U.S. Environmental Protection Agency. Under the National Pollutant Discharge Elimination System (NPDES), Concentrated Animal Feeding Operations (CAFOs) are required to have permits to ensure that the operation of the facility does not threaten water quality. In December 2002, EPA announced revisions to the CAFO rule. Under the new rule all large CAFOs will be required to apply for a permit, submit an annual report, and develop and follow a plan for handling manure and wastewater. EPA estimates that the CAFO rule will affect about 15,500 operations nationwide.

It was **not** the purpose of this publication to estimate the costs to livestock operations of complying with EPA regulations, but rather to estimate the costs for the development and implementation of Comprehensive Nutrient Management Plans (CNMPs). The costs associated with regulation may be more or less than the costs of developing and implementing a CNMP, depending on the specific location and characteristics of the facility. Cost estimates presented in this publication are for the 257,201 operations with confined livestock that are expected to need a CNMP.

No account was made of the financial benefits that may be realized because of CNMP implementation, including any savings in commercial fertilizer costs on the additional acreage that will receive manure applications. The nutrient value of manure is considered one of the many benefits of implementing CNMPs. Other benefits, which are more difficult to put into economic terms, include the value of manure as a soil amendment, enhanced waterholding capacity of the soil due to increased organic matter in the soil, enhancement of animal health with improved manure handling, water quality enhancement both on the farm and off the farm, and soil erosion reduction associated with the land treatment practices installed on acres receiving manure. No attempt was made to offset CNMP costs for any of these benefits.

No attempt was made to adjust costs for inflation, even though it is recognized that some cost increases will occur over the 10-year implementation period. To make this adjustment, one would need to know the rate at which CNMPs would be implemented, which will depend on regulatory incentives, financial incentives, and the availability of technical assistance. Cost estimates reported here may therefore be understated to some extent, depending on the rate of inflation and implementation over the next 10 years.

This cost assessment also does not account for cost savings that could be realized by improvements in feed management. Agricultural research has shown that the amount of nitrogen and phosphorus in animal feed can sometimes be reduced without endangering animal health. For some livestock types, feed additives have been developed (such as phytase) that enable livestock to convert more of the phosphorus in animal feed to animal tissue, thereby reducing the quantity of phosphorus needed in the feed and the resulting amount of phosphorus that is excreted. Feed management practices can reduce the number of acres required to meet CNMP land application criteria. No attempt was made in this assessment to adjust the calculations of recoverable manure nutrients for feed management practices. To the extent that feed management practices are already in place, the cost estimate presented here will overstate costs. (An assessment of the potential reductions in CNMP costs associated with feed management practices will be addressed in Part II, which will be published subsequent to this publication.)

The model simulation shows that alternatives to land application of manure are needed in some regions of the country. Under the assumptions of the model simulation, 248 counties do not have adequate land to assimilate the manure produced in those counties when applied at rates that meet CNMP criteria (see appendix B). Most of these counties are co-located, reducing the opportunity to transport the manure to surrounding counties for land application. The amount of county-level excess manure represents about 16 percent of the total recoverable manure nutrients produced by all CNMP farms in the country. Included in the cost assessment are estimates of the cost of transporting this county-level excess manure off the farm, but no other costs are estimated for the disposal or use of this manure. (The costs of alternatives to land application that are associated with CNMP implementation will also be addressed in Part II.)

Approach used to determine CNMP needs

The most challenging aspect of the cost assessment is defining CNMP needs. Different approaches were used for each of the CNMP elements, taking advantage of as much farm-specific information as possible.

CNMP needs for the nutrient management element and off-farm transport

CNMP needs for the nutrient management element were determined by the amount of manure produced on each farm and the additional number of acres required to meet CNMP land application criteria on each farm. Two land application scenarios were constructed:

- A baseline scenario, designed to simulate land application of manure before implementation of CNMPs, and
- An after CNMP scenario, designed to simulate land application at rates that correspond to NRCS nutrient management criteria.

The difference in the number of acres with manure applied between the two scenarios defines the additional acres needed to meet CNMP criteria. Estimates were also made for the amount of manure exported off the farm to surrounding properties, defining CNMP needs for off-farm transport. The number of acres required for off-farm land application of the exported manure were determined and used to estimate off-farm land application costs associated with CNMP implementation.

CNMP needs for the land treatment element

A CNMP includes criteria for erosion control on acres receiving manure to protect water quality. The National Resources Inventory (NRI) provides estimates of sheet and rill erosion at the county level, which were used to assess the need for land treatment practices. NRI data for the year 1997 were used to correspond to the timeframe represented by the census database.

CNMP needs for the manure and wastewater handling and storage element

Manure and wastewater storage and handling includes components and activities associated with the production facility, feedlot, storage structures and areas, and any areas or mechanisms used to facilitate transfer of manure and wastewater. Manure and wastewater storage and handling needs are specific to the production technology on the farm. Data at the national level are not available on CNMP needs for this element, nor can CNMP needs be derived from other databases, as was done for nutrient management, land treatment, and off-farm export. CNMP needs for manure and wastewater handling and storage components were estimated by a team of experts using a consensus approach to approximate what the needs might be. The team of experts consisted of agricultural engineers, environmental engineers, economists, and agronomists with extensive experience working with livestock producers and government technical assistance programs. Team members also consulted with other experts who had knowledge about specific industries or areas of the country.

CNMP needs for the manure and wastewater handling and storage element were defined based on typical, or dominant, production technologies, livestock type, farm size, and production region. Production technologies ranged from simple (no storage, daily spreading, for example) to complex (liquid collection systems with lagoons, for example). These production technologies were then assigned to farms in the census based on the dominant livestock type, farm size, and production region for the census farm. In many cases a single production technology was assigned to a census farm. In other cases, however, there was more than one production technology that would be expected for a given farm size in a given production region. Where more than one production technology was assigned to a census farm, the probability that each production technology would occur was also assigned.

The basic set of production technologies was defined in terms of **representative farms** for each livestock type. Representative farms define broad groups of livestock production facilities that, within a livestock sector, have similar characteristics for managing the livestock and managing the manure; in other words, a hypothetical farm with a typical animal waste handling system for a given livestock type. This set of representative farms was expanded to a larger set of **model farms** by adding the dimensions of size and location. Size categories for the dominant livestock type were selected to reflect differences in production technologies by farm size. Geographic regions generally reflected major production regions with further delineation by climate, where climate would be expected to influence the kind of production system found in the region. Not all representative farms are present in each size class and location. Each model farm is thus a representative farm of a certain size in a specified location.

Representative farms were derived from two sources of information—farmer surveys and expert judgment. Results from farmer surveys were available for dairies, swine, and layers. These surveys were not conducted for the specific purpose of inventorying manure-handling practices on farms, but did include questions about the production technologies in use and a few questions about manure management. A team of USDA experts evaluated the survey results and identified the dominant manure management technologies, basing them on manure handling characteristics as much as possible. Only the most dominant technologies were included; technologies that occurred relatively infrequently in survey results were discarded. Farmer survey results were not available for fattened cattle, veal, confined heifers, broilers, pullets, or turkeys. For these livestock types, representative farms were derived by the team of USDA experts based on their knowledge of industry practices.

In addition to providing a structure for deriving CNMP needs for the manure and wastewater handling and storage element, this analytical framework was used to assign costs related to manure testing and recordkeeping. A slightly expanded version of the framework was used to estimate CNMP development costs and used in appendix B to parameterize the simulation model for estimating recoverable manure nutrients and tons of manure for handling and transport.

Model farms for dairy. Five representative farms were derived for dairy based on a 1996 National Animal Health Monitoring System (NAHMS) survey of 2,542 dairies in 20 states (USDA, APHIS, 1996). The survey included questions about the manure storage facilities on the farm and the frequency of manure spreading. Production technologies for dairies were therefore defined in terms of manure storage. The five representative farms are:

- #1. Essentially no storage, frequent spreading.
- #2. Solids storage (typically outside separate from pens, but may include some manure pack and dry lot conditions); no appreciable liquid storage.
- #3. Liquid to slurry storage in deep pit or aboveground tank; some solids storage; no earthen basins, ponds, or lagoons; typically less than monthly spreading.
- #4. Primarily liquid manure stored in basin, pond, or lagoon; some solids storage for outside areas; typically less than monthly spreading.
- #5. Liquid system (any combination of 3 and 4) primarily used in the West and Southeast; often associated with manure pack and solids spreading in the West.

Survey results were obtained for three size classes (35 to 135 milk cow AU, 135 to 270 milk cow AU, and more than 270 milk cow AU) in the North Central and Northeast States and in the West. Survey results for the Southeast could be obtained only for two size classes (35 to 135 AU and more than 135 AU) because of the small sample size in that region. The combinations of representative farms, production regions, and size classes produced 20 model farms for dairies. The percentage of the dairies in each region and size class that corresponded to a particular representative farm was determined from the survey results. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 2 along with an estimate of the number of model farms, extrapolating from census farm counts. The three production regions are shown in figure 2 along with the location of CNMP farms with milk cows as the dominant livestock type.

Figure 2 CNMP farms with milk cows as the dominant livestock type and more than 35 milk cow animal units (79,318 farms)

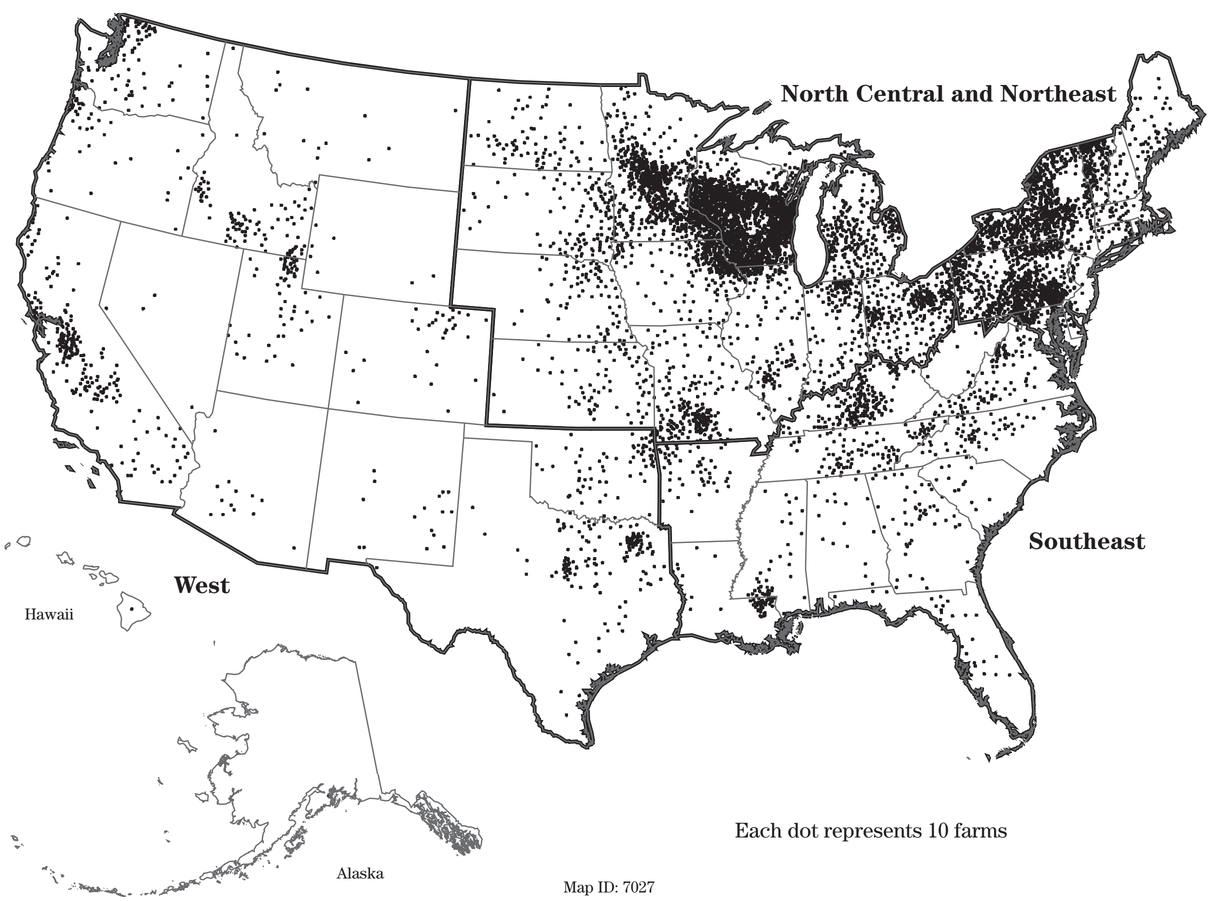


Table 2 Model farms for dairies

Region and size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
North Central and Northeast*				
35-135 AU	#1: no storage	29	—	15,385
	#2: solids storage	47	—	24,935
	#3: liquid storage—deep pit or slurry	7	—	3,714
	#4: liquid storage—basin, pond, lagoon	17	—	9,019
	All	100	53,053	
135-270 AU	#1: no storage	15	—	1,303
	#2: solids storage	28	—	2,433
	#3: liquid storage—deep pit or slurry	14	—	1,216
	#4: liquid storage—basin, pond, lagoon	43	—	3,736
	All	100	8,688	
> 270 AU	#2: solids storage	14	—	366
	#3: liquid storage—deep pit or slurry	18	—	471
	#4: liquid storage—basin, pond, lagoon	68	—	1,779
	All	100	2,616	
Southeast**				
35-135 AU	#2: solids storage	59	—	2,566
	#5: any liquid storage	41	—	1,783
	All	100	4,349	
> 135 AU	#2: solids storage	30	—	845
	#5: any liquid storage	70	—	1,970
	All	100	2,815	
West***				
35-135 AU	#2: solids storage	50	—	1,175
	#5: any liquid storage, manure pack	50	—	1,174
	All	100	2,349	
135-270 AU	#2: solids storage	11	—	200
	#5: any liquid storage, manure pack	89	—	1,625
	All	100	1,825	
> 270 AU	#5: any liquid storage, manure pack	100	3,623	3,623
All farms			79,318	79,318

* NAHMS survey states include MN, IA, MO, WI, IL, MI, IN, OH, PA, NY, IL, and VT. States added to the group include ND, SD, NE, KS, NJ, MD, DE, MA, CT, RI, NH, and ME.
** NAHMS survey states include KY, TN, and FL. States added to the group include VA, WV, NC, SC, GA, AL, MS, AR, and LA.
*** NAHMS survey states include CA, OR, WA, ID, NM, and TX. States added to the group include HI, AK, AZ, UT, NV, MT, WY, CO, and OK.

Model farms for layers. Three representative farms were derived for layers based on a 1999 NAHMS survey of 526 layer farms in 15 states (USDA, APHIS, 1999). The survey included a question about the type of facility used relative to manure collection and handling. Production technologies for layers were therefore defined in these terms. Five types of systems were identified in the survey, but were combined into three groups of representative farms because of similar CNMP needs and cost assumptions. The three representative farms are:

- High rise (pit at ground level with elevated house) or shallow pit (house not elevated)
- Flush system to lagoon
- Manure belt or scraper system

Survey results were obtained for two size classes (35 to 400 layer AU and more than 400 layer AU) for each of four regions: Southeast, West, South Central, and North Central and Northeast. The combinations of representative farms, production regions, and size classes produced 15 model farms for layers. The percentage of the layer farms in each region and size class that corresponded to a particular representative farm was determined from the survey results. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 3 along with an estimate of the number of model farms, extrapolating from census farm counts. The four production regions are shown in figure 3 along with the location of CNMP farms with layers as the dominant livestock type.

Figure 3 CNMP farms with layers as the dominant livestock type and more than 35 layer animal units (4,052 farms)

Table 3 Model farms for layers

Region and size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
North Central and Northeast*				
35-400 AU	#1: high rise or shallow pit	80	—	762
	#3: manure belt or scraper system	20	—	191
	All	100	953	
> 400 AU	#1: high rise or shallow pit	81	—	234
	#3: manure belt or scraper system	19	—	55
	All	100	289	
Southeast**				
35-400 AU	#1: high rise or shallow pit	57	—	916
	#2: flush with lagoon	43	—	691
	All	100	1,607	
> 400 AU	#1: high rise or shallow pit	52	—	42
	#2: flush with lagoon	48	—	38
	All	100	80	
West***				
35-400 AU	#1: high rise or shallow pit	49	—	51
	#3: manure belt or scraper system	51	—	53
	All	100	103	
> 400 AU	#1: high rise or shallow pit	18	—	18
	#3: manure belt or scraper system	82	—	83
	All	100	102	
South Central****				
35-400 AU	#1: high rise or shallow pit	45	—	396
	#3: manure belt or scraper system	55	—	483
	All	100	879	
> 400 AU	#2: flush with lagoon	100	39	39
All farms			4,052	4,052

* NAHMS survey states include MN, MO, NE, IA, PA, OH, and IN. States added to the group include SD, ND, KS, MI, WI, IL, KY, WV, VA, MD, DE, NJ, NY, and New England States.
** NAHMS survey states include AL, FL, GA, and NC. States added to the group include SC, MS, and TN.
*** NAHMS survey states include CA and WA. States added to the group include AK, AZ, HI, ID, NV, NM, OR, UT, MT, CO, and WY.
**** NAHMS survey states include TX and AR. States added to the group include OK and LA.

Model farms for swine. Five representative farms were derived for swine based on two farmer surveys: a 1995 NAHMS survey of 1,477 swine farms in 16 states (USDA, APHIS, 1995), and a 1998 Agricultural Resource Management Study (ARMS) survey on 1,600 swine farms in 21 states (USDA, ERS, 2000). The surveys included questions about the type of facility used to rear swine and the type of manure handling and storage system. Production technologies for swine were therefore defined in these terms. The initial breakdown was made using the NAHMS survey results. The ARMS survey results were used to update the representation of confinement facilities that had storage ponds or lagoons and used to estimate representation in the West. The representative farms are:

- #1 Total confinement with liquid system including lagoon.
- #2 Total confinement with slurry system, no lagoon.
- #3 Open building with outside access and liquid to slurry system (holding pit under slat or open flush gutter).
- #4 Open building with outside access and semi-solid to solid wastes (mechanical scraper/ tractor scrape/hand clean).
- #5 Pasture or lot with or without hut.

Survey results were obtained for two size classes (35 to 500 swine AU and more than 500 swine AU) in the West and the North Central and Northeast. A different size class breakdown (35 to 100 swine AU and more than 100 swine AU) was necessary for the Southeast because production technologies for farms with more than 100 swine AU were not diverse in that region. The survey showed that production technologies also varied according to the type of swine facility. Thus, survey results were also broken down by farms that were primarily farrowing operations, primarily grower-feeder operations, or a combination of both (farrow-to-finish operations). The combinations of type of operation, region, size class, and representative farms produced 36 model farms for swine. The type of operation for census farms was inferred based on the relative numbers of breeding hogs and hogs for slaughter reported for each farm. Farms with more than 75 percent of the swine AU consisting of breeding hogs were identified as farrowing operations. Farms with more than 75 percent of the swine AU consisting of hogs for slaughter were identified as grower-feeder operations. All other swine farms were identified as farrow-to-finish operations.

The percentage of the swine farms in each region, size class, and type of operation that corresponded to a particular representative farm was determined from the survey results. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 4 along with an estimate of the number of model farms, extrapolating from census farm counts. The three production regions are shown in figure 4 along with the location of CNMP farms with swine as the dominant livestock type.

Figure 4 CNMP farms with swine as the dominant livestock type and more than 35 swine animal units (32,955 farms)

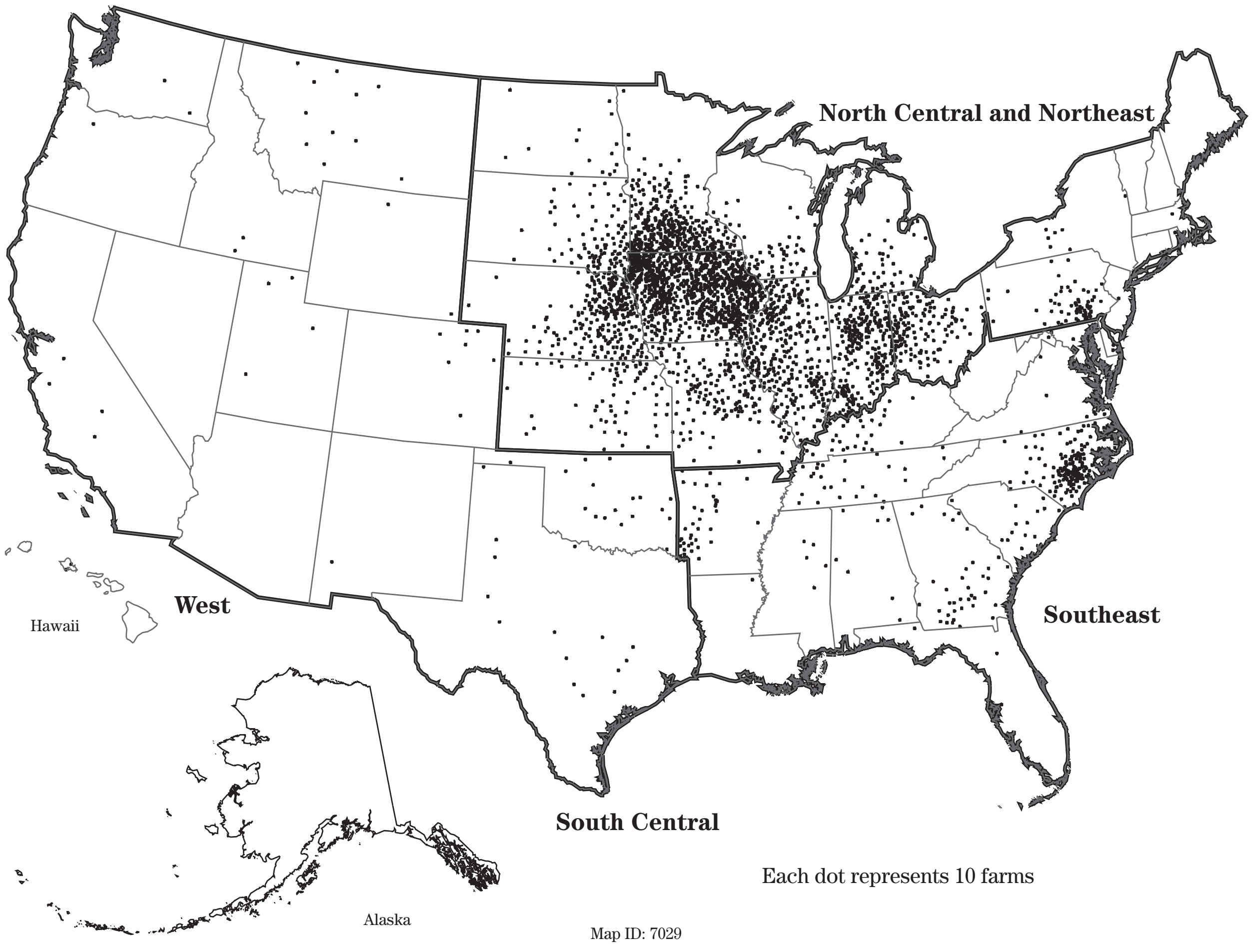


Table 4 Model farms for swine

Region and type of operation	Size class (AU)	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Southeast*					
Farrowing	35–100	#1: total confinement, liquid, lagoon	100	43	43
	> 100	#1: total confinement, liquid, lagoon	100	270	270
Grower-feeder	35-100	#1: total confinement, liquid, lagoon	90	—	254
		#2: total confinement, slurry, no lagoon	10	—	28
		All	100	282	
	> 100	#1: total confinement, liquid, lagoon	100	1,389	1,389
Farrow-to-finish	35–100	#1: total confinement, liquid, lagoon	40	—	233
		#2: total confinement, slurry, no lagoon	10	—	58
		#5: pasture or lot	50	—	292
		All	100	583	
	> 100	#1: total confinement, liquid, lagoon	90	—	782
		#2: total confinement, slurry, no lagoon	10	—	87
		All	100	869	
North Central and Northeast**					
Farrowing	35–500	#1: total confinement, liquid, lagoon	10	—	103
		#2: total confinement, slurry, no lagoon	76	—	782
		#4: building with outside access, solids	14	—	144
		All	100	1,029	
	> 500	#1: total confinement, liquid, lagoon	85	—	101
		#2: total confinement, slurry, no lagoon	15	—	18
		All	100	119	
Grower-feeder	35–500	#1: total confinement, liquid, lagoon	6	—	560
		#2: total confinement, slurry, no lagoon	53	—	4,956
		#3: building with outside access, liquid	14	—	1,309
		#4: building with outside access, solids	27	—	2,525
		All	100	9,350	
	> 500	#1: total confinement, liquid, lagoon	27	—	119
		#2: total confinement, slurry, no lagoon	73	—	323
		All	100	442	

Table 4 Model farms for swine—Continued

Region and type of operation	Size class (AU)	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Farrow-to-finish	35–500	#1: total confinement, liquid, lagoon	15	—	2,526
		#2: total confinement, slurry, no lagoon	75	—	12,627
		#4: building with outside access, solids	10	—	1,684
		All	100	16,837	
	> 500	#1: total confinement, liquid, lagoon	40	—	428
		#2: total confinement, slurry, no lagoon	60	—	641
		All	100	1,069	
West***					
Farrowing	35–500	#1: total confinement, liquid, lagoon	45	—	40
		#2: total confinement, slurry, no lagoon	25	—	22
		#5: pasture or lot	30	—	27
		All	100	89	
	> 500	#1: total confinement, liquid, lagoon	65	—	14
		#2: total confinement, slurry, no lagoon	35	—	8
		All	100	22	
Grower-feeder	35–500	#1: total confinement, liquid, lagoon	100	113	113
	> 500	#1: total confinement, liquid, lagoon	100	39	39
Farrow-to-finish	35–500	#1: total confinement, liquid, lagoon	10	—	35
		#2: total confinement, slurry, no lagoon	90	—	316
		All	100	351	
	> 500	#1: total confinement, liquid, lagoon	10	—	6
		#2: total confinement, slurry, no lagoon	90	—	53
		All	100	59	
All farms				32,955	32,955

* NAHMS survey states include KY, TN, GA, and NC. States added to the group include MD, DE, VA, WV, SC, FL, AL, MS, LA, and AR.
** NAHMS survey states include IA, KS, MN, MO, NE, SD, IL, IN, MI, OH, PA, and WI. States added to the group include New England States, ND, NY, and NJ.
*** ARMS survey states include CO, UT, and OK. States added to the group include WA, OR, CA, NV, ID, MT, WY, NM, AZ, TX, AK, and HI.

Model farms for other confined livestock types. Survey results for the remaining confined livestock types are not available. The predominant production technologies for each livestock type were defined by the team of USDA experts. Representative farms were defined as follows:

Fattened cattle
- #1 Dry lot (small) scraped on a frequent basis, manure stacked until application
- #2 Dry lot with manure pack and occasional complete clean out and removal; at least rudimentary runoff collection/storage

Confined heifers
- #1 Confinement barns with bedded manure; solids handling
- #2 Small open lots with scraped solids and minimal runoff control

Veal
- #1 Confinement house with liquid/slurry components

Turkeys
- #1 Confinement house
- #2 Turkey ranching (building with open sides and lot)

Broilers
- #1 Standard broiler house; complete litter clean out and/or cake out

Pullets
- #1 High rise or shallow pit confinement house

Model farm regions for these livestock types were defined as shown in figures 5 to 9. Regions were defined based on production, the expected occurrence of representative farms, and climate where production technologies included open lots. CNMP needs for one or more components of the manure and wastewater handling and storage element vary among these regions. Size classes were defined only for fattened cattle, where small farms in each region were expected to have different CNMP needs than larger operations.

The percentage of the farms in each region and size class that corresponded to a particular representative farm was also defined by the team of USDA experts. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 5 along with an estimate of the number of model farms, extrapolating from census farm counts.

Table 5 Model farms for fattened cattle, confined heifers, veal, turkeys, broilers, and pullets

Dominant livestock type and region	Size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Fattened cattle					
Northeast	> 35	#1: scrape and stack	100	277	277
Southeast	> 35	#1: scrape and stack	30	—	111
		#2: manure pack, runoff collection	70	—	260
		All	100	371	
Midwest	35–500	#1: scrape and stack	30	—	748
		#2: manure pack, runoff collection	70	—	1,746
		All	100	2,494	
	> 500	#2: manure pack, runoff collection	100	1,504	1,504
North	35–500	#2: manure pack, runoff collection	100	925	925
	> 500	#2: manure pack, runoff collection	100	52	52
Central Plains	35–1,000	#2: manure pack, runoff collection	100	3,499	3,499
	> 1,000	#2: manure pack, runoff collection	100	666	666
West	35–500	#2: manure pack, runoff collection	100	252	252
	> 500	#2: manure pack, runoff collection	100	119	119
		All		10,159	10,159
Confined heifers					
Northeast	> 35	#1: confinement barn/bedded manure	70	—	117
		#2: open lots with scraped solids	30	—	50
		All	100	167	
Midwest	> 35	#1: confinement barn/bedded manure	40	—	974
		#2: open lots with scraped solids	60	—	1,462
		All	100	2,436	
South and West	> 35	#2: open lots with scraped solids	100	1,240	1,240
Veal	> 35	#1: confinement house	100	168	168
Turkeys					
East	> 35	#1: confinement houses	90	—	1,266
		#2: turkey ranch	10	—	141
		All	100	1,407	
South Central	> 35	#1: confinement houses	100	740	740

Table 5 Model farms for fattened cattle, confined heifers, veal, turkeys, broilers, and pullets—Continued

Dominant livestock type and region	Size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Midwest	> 35	#1: confinement houses	90	—	768
		#2: turkey ranch	10	—	85
		All	100	853	
West other than California	> 35	#1: confinement houses	50	—	39
		#2: turkey ranch	50	—	39
		All	100	78	
California	> 35	#1: confinement houses	80	—	108
		#2: turkey ranch	20	—	27
		All	100	135	
Broilers					
East and South	> 35	#1: confinement houses	100	15,531	15,531
West	> 35	#1: confinement houses	100	720	720
Pullets					
North Central and Northeast	> 35	#1: layer-type confinement houses	100	369	369
South and West	> 35	#1: layer-type confinement houses	100	905	905

Figure 5 CNMP farms with fattened cattle as the dominant livestock type and more than 35 fattened cattle animal units (10,159 farms)

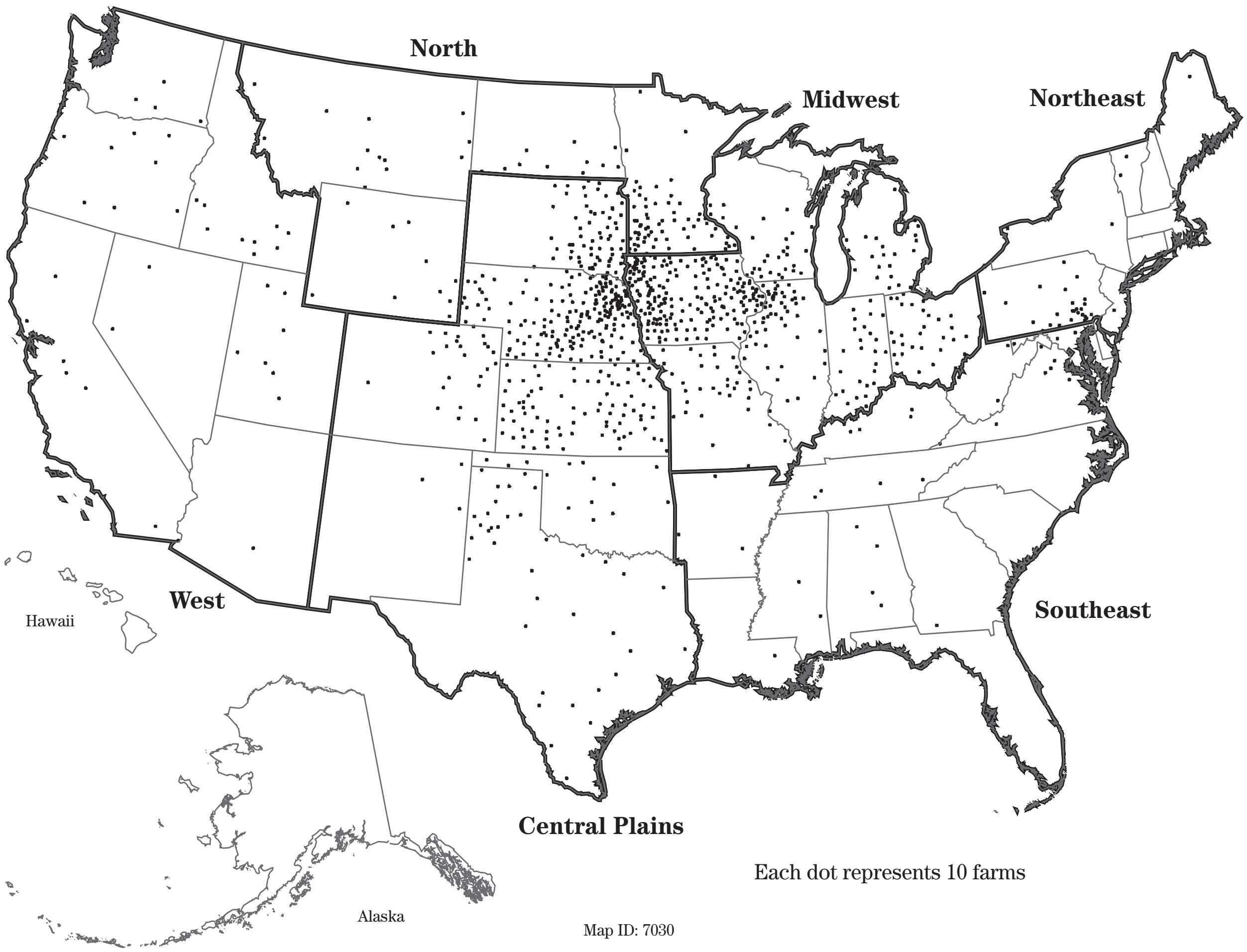


Figure 6 CNMP farms with broilers as the dominant livestock type and more than 35 broiler animal units (16,251 farms)

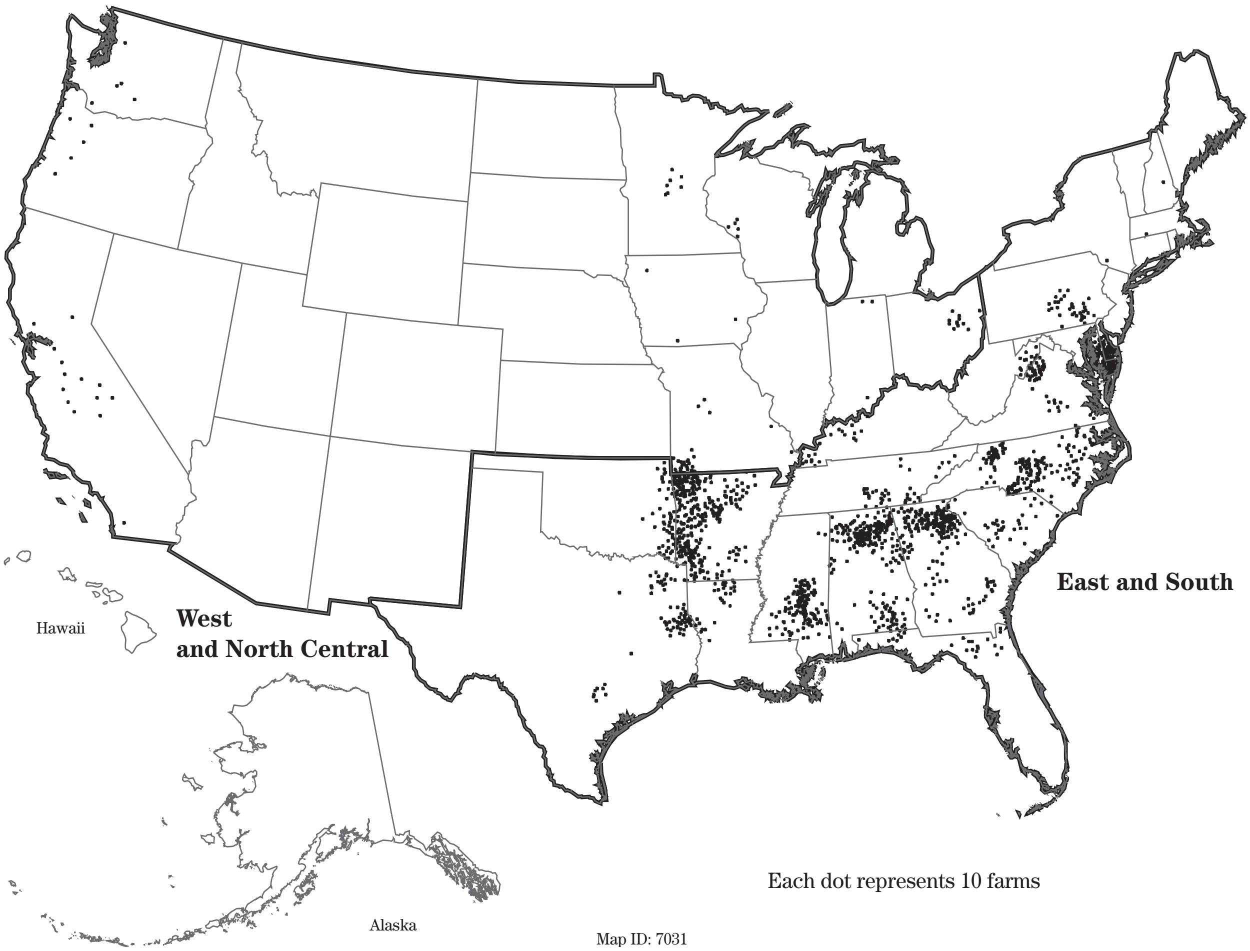


Figure 7 CNMP farms with turkeys as the dominant livestock type and more than 35 turkey animal units (3,213 farms)

Figure 8 CNMP farms with pullets as the dominant livestock type and more than 35 pullet animal units (1,274 farms)

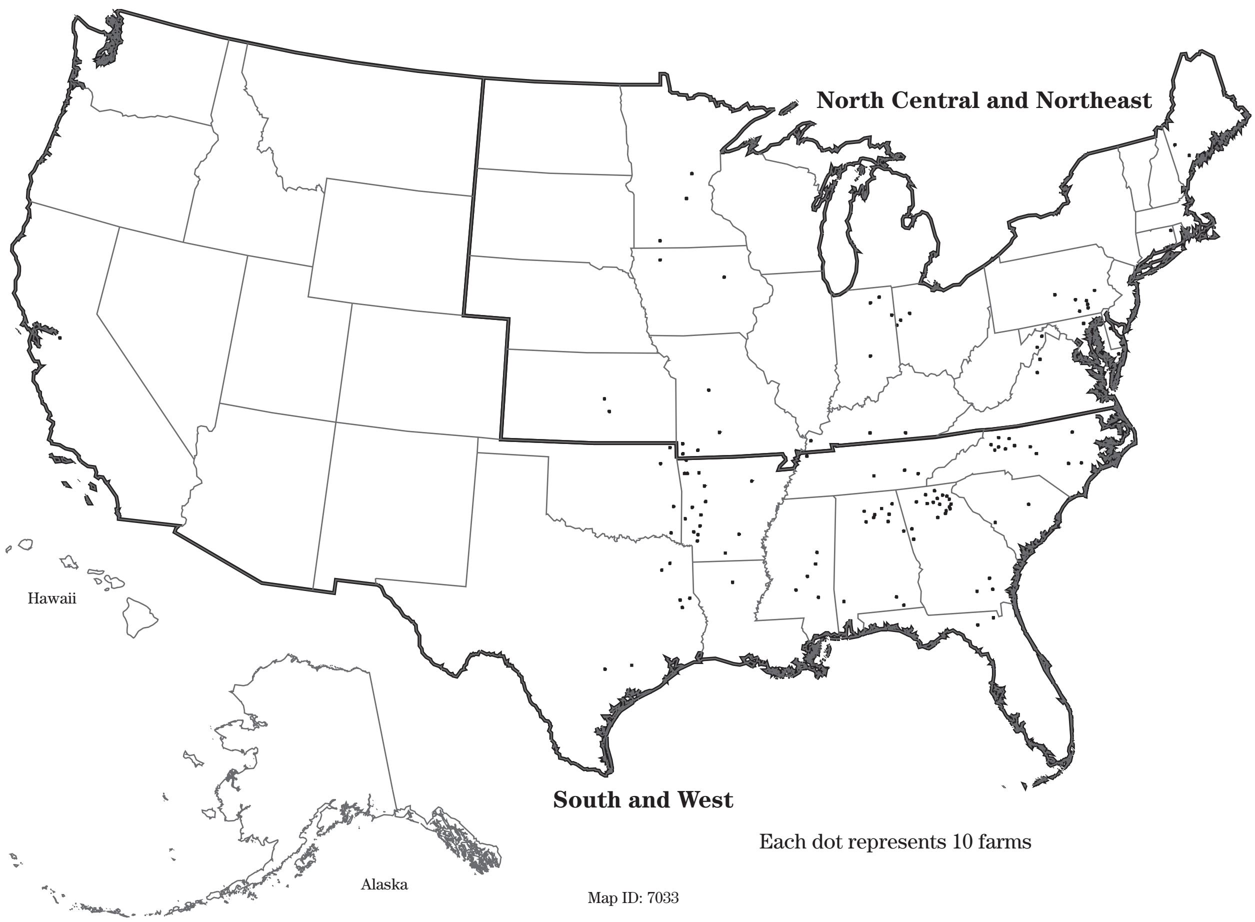
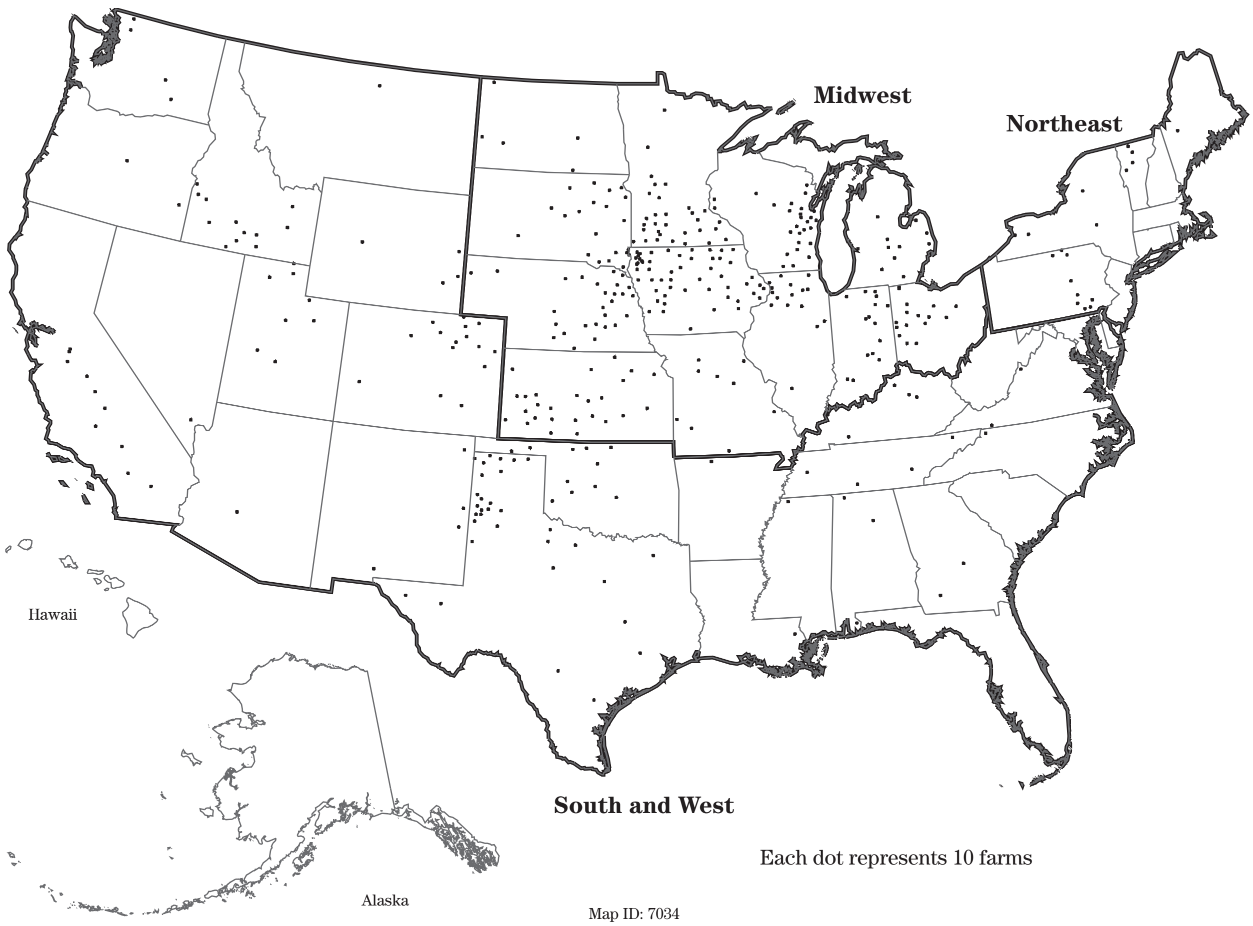


Figure 9 CNMP farms with confined heifers or veal as the dominant livestock type (4,011 farms)



Model farms for pastured livestock types. Costs associated with conservation practices for pastured livestock are grouped under the manure and wastewater storage and handling element, although they include some costs associated with pasture management that would be expected to be included in a CNMP for these farms. As shown in appendix A, 24,697 farms with pastured livestock and few other livestock qualified as farms that may need a CNMP because of the amount of recoverable manure that would potentially be produced on these farms. An additional 36,575 farms had less than 35 AU of confined livestock types, but had beef cattle as the dominant livestock type on the farm. These two groups comprise the set of farms for which CNMP needs are defined for farms with pastured livestock. Four representative farms were identified for this group of farms:

- #1 Pasture with heavy use area
- #2 Pasture with windbreak and/or shelterbelt
- #3 Pasture with lot and scrape-and-stack manure handling
- #4 Pasture with barn for shelter

Six production regions were defined, as well as two size classes for the Northeast. The six production regions are shown in figure 10. Representative farms were assigned to each region as follows:

South—#1: pasture with heavy use protection (17,731 farms)

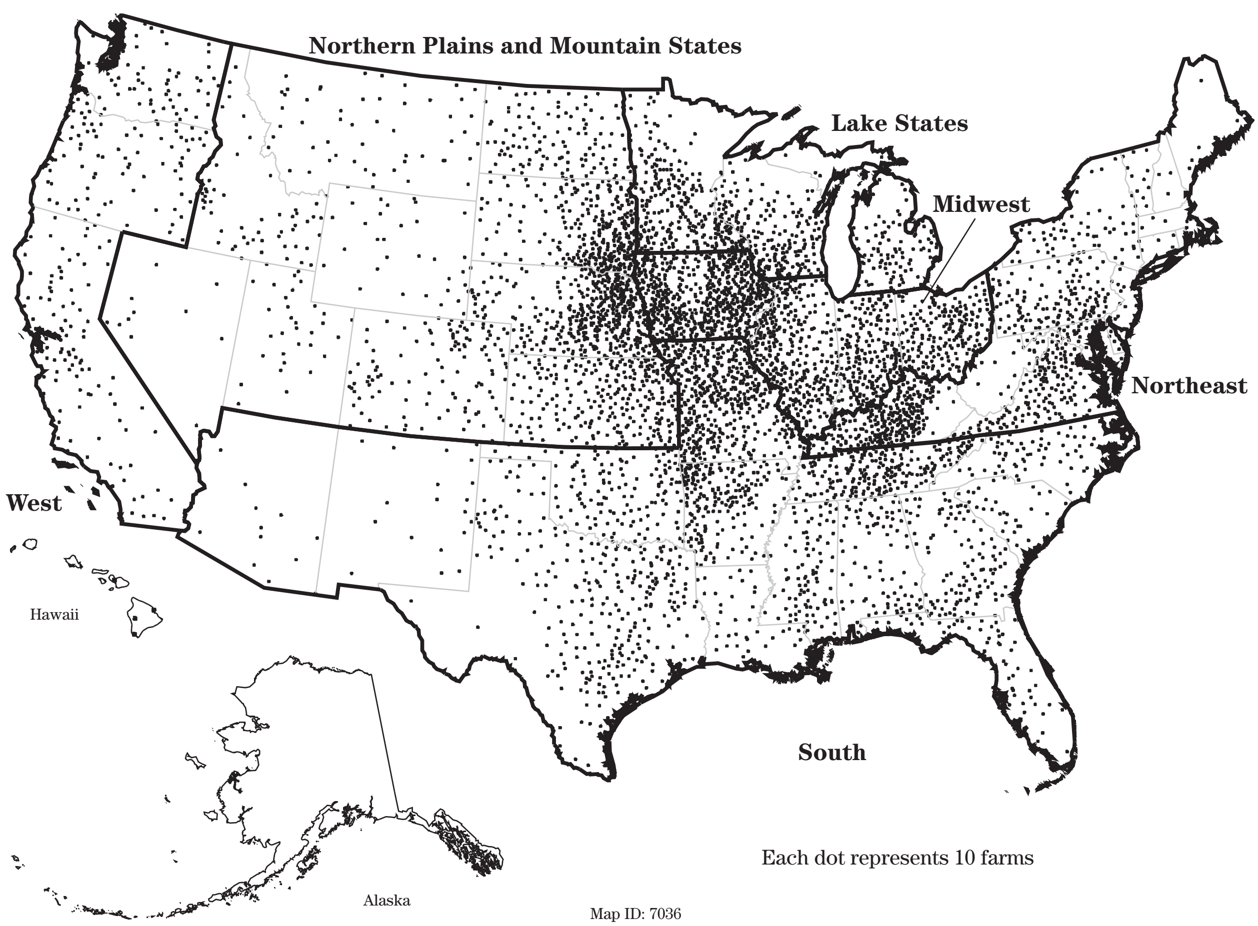
Midwest—#3: pasture with lot (13,950 farms)

Lake States—#4: pasture with barn (5,896 farms)

Northeast, less than 70 AU—#4: pasture with barn (5,299 farms)

Northeast, more than 70 AU—#1: pasture with heavy use protection (2,133 farms)

Figure 10 CNMP farms with pastured livestock types (61,272 farms)



Northern Plains and Mountain States—#2: pasture with windbreak/shelterbelt (13,840 farms)

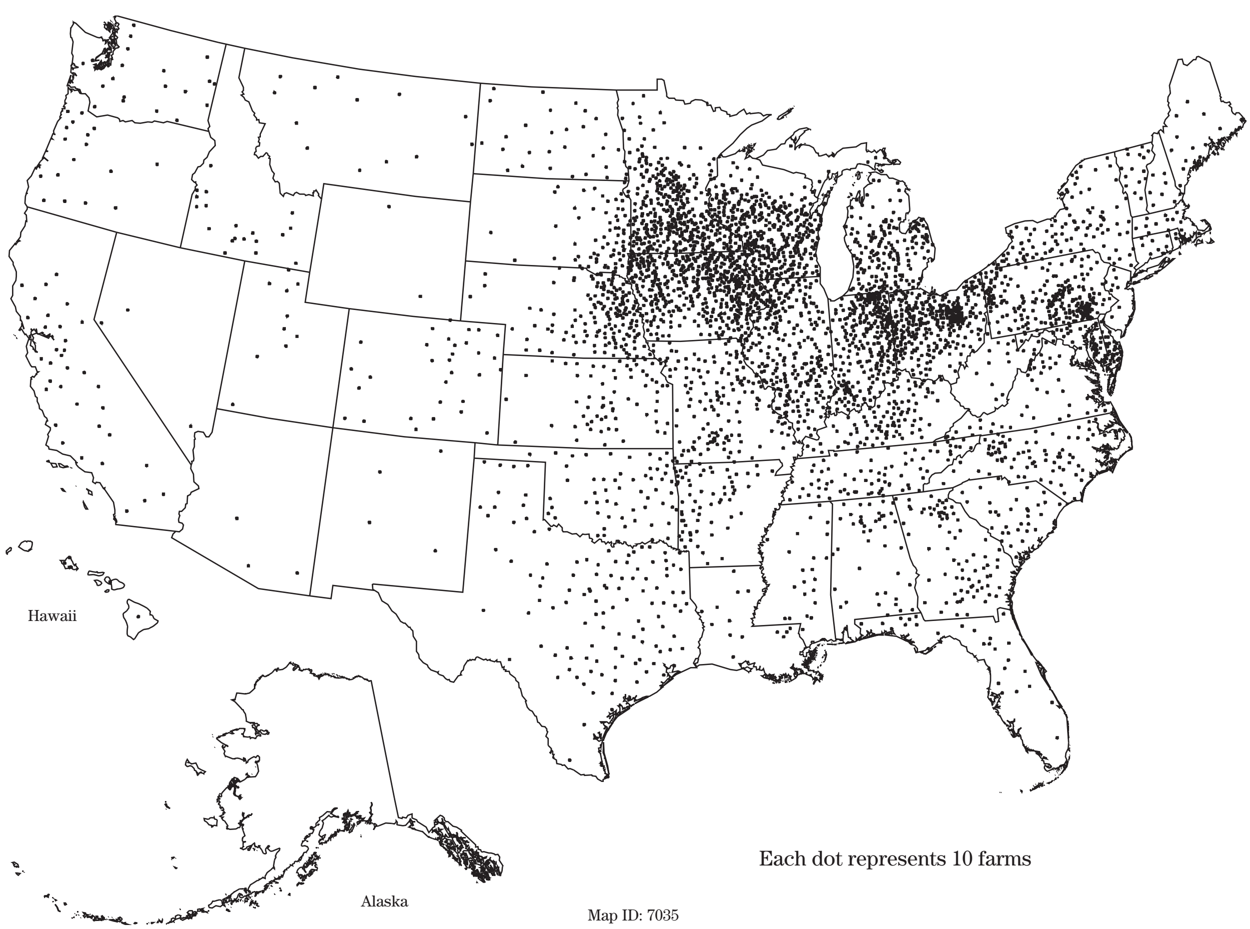
West Coast—#2: pasture with windbreak/shelterbelt (2,423 farms)

Small farms with confined livestock types. Farms with less than 35 AU where confined livestock types were dominant (42,565 farms) were judged to be too diverse with respect to the type of production technologies employed in producing livestock to apply an approach to estimating CNMP needs based on representative farms. They generally also have a more diverse collection of livestock types. These small farms tend to use small lots and pastured environments to a greater extent than larger farms. Furthermore, CNMPs for these smaller farms would likely address only a subset of the components that would be addressed for larger farms, focusing on situations and practices associated with environmental impacts. The spatial distribution of these small farms is shown in figure 11. Manure and wastewater handling and storage costs for this group of farms were based on costs derived for small dairies (see section Manure and Wastewater Handling and Storage Costs).

Approach used to determine per-unit costs

Per-unit costs are the costs for specific equipment, installed structures, or activities that are needed to meet CNMP criteria. Most per-unit cost estimates were based on economic studies reported in the literature or on costs compiled in the NRCS Field Office Technical Guides. Per-unit costs from these sources often vary, reflecting regional differences in costs or differences

Figure 11 CNMP farms with less than 35 animal units of milk cows, swine, poultry, or fattened cattle (42,565 farms)



in how livestock operations are managed. The approach taken in this study was to select or derive per-unit cost values that would generally be representative of the livestock industry as a whole, and avoid per-unit cost estimates that were specific to a small set of operations. An effort was also made to keep per-unit costs consistent among the various items and activities so that differences in CNMP-related costs would be clearly attributable to differences in CNMP needs among livestock operations. The resulting cost estimates for a particular farm as estimated in this study are therefore not expected to correspond exactly to observed CNMP-related costs for individual operations. It is expected, however, that per-farm cost estimates overall will be reasonable approximations of the average CNMP costs for a group of livestock operations.

For the most part, per-unit cost estimates used in this study correspond to prices for the period 1995 to 2000. Wherever possible, per-unit costs were taken from the most recent sources. When older sources were all that were available, costs were converted to the year 2000 prices.

Conventions were adopted for per-unit costs related to labor and capital investment. The per-unit cost for labor was set at $10 per hour for all activities. The $10 per hour labor rate is intended to represent a low-skill, full time permanent employee's salary. Many of the smaller livestock operations, however, will not employ hired labor, and the activities will be performed by the operator who could have a much higher opportunity cost for time than $10 per hour.

All costs reported in the paper are annual costs. Capital costs for equipment and installed structures were converted to annual costs by amortizing the total cost over a 10-year period assuming a discount rate of 8 percent. To the extent that livestock operations receive subsidies from government programs to purchase or finance capital investment, the CNMP costs estimated in this study will be somewhat overstated.

Economies of scale are expected for most per-unit costs. Larger operations often can conduct an activity for less cost per animal unit than smaller operations. Adjustments were made for economies of scale in the per-unit cost estimates used in the study where there was a reasonable basis for making the adjustment.

Reporting results

This cost assessment was designed to provide estimates of CNMP-related costs at the national and regional level and for major livestock production regions. Whereas estimates of manure production and acres needed for manure application are reasonable estimates at the county level, the assumptions and information pertaining to CNMP needs and costs are too generalized to provide cost estimates at the county or even the state level. Extrapolation of CNMP cost estimates to states and counties is therefore not an appropriate application of the cost assessment.

CNMP cost estimates are summarized and reported by dominant livestock type, by farm size, and by the 10 USDA farm production regions.

Three size classes of farms were derived based on the amount of manure phosphorus produced on each farm. Farms producing more than 10 tons (20,000 pounds) of manure phosphorus annually were categorized as large farms, shown in figure 12. Farms producing 4 to 10 tons (8,000 to 20,000 pounds) of manure phosphorus annually were categorized as medium farms, shown in figure 13. Farms with less than 4 tons of manure phosphorus were categorized as small farms. The number of CNMP farms by farm size and dominant livestock type is presented in table 6. The set of large farms includes most of the census farms identified in appendix A as potential concentrated animal feeding operations (CAFOs) with more than 1,000 EPA animal units, plus additional farms that produce an equivalent amount of manure nutrients. The 4-ton limit used to define the set of medium-size farms corresponds roughly to the 300 EPA animal unit threshold. (A comparison to the EPA size class categories is presented in appendix C.)

States and CNMP farm counts corresponding to the 10 farm production regions are shown in table 7.

Maps of county-level estimates of farm counts, acres required for land application, and recoverable manure nutrients are also presented in this publication. Since these variables were calculated directly from data elements in the Census of Agriculture or the NRI, it is appropriate to present these data at the county level. Dots are used in these maps to represent the number of farms, acres, or amount of manure nutrients. For example, each dot in most of the farm count maps represents 10 farms. In constructing the maps, the dots are distributed randomly throughout the county. Residuals for each county are combined with residuals for other counties and assigned to a county using a ranking system. Some counties with variable values less than the limit represented by the dot appear to have zero farms, acres, or recoverable manure.

The farm-level Census of Agriculture data are protected to assure the confidentiality of respondents. All estimates reported in this paper conform to disclosure criteria.

Table 6 Number of CNMP farms by dominant livestock type and farm size class*

Livestock operations	All farms	Large farms (>10 tons manure P)	Medium-size farms (4–10 tons manure P)	Small farms (<4 tons manure P)
Farms with more than 35 AU of the dominant livestock type				
Fattened cattle	10,159	2,372	3,248	4,539
Milk cows	79,318	2,798	7,650	68,870
Swine	32,955	3,560	8,654	20,741
Turkeys	3,213	2,685	460	68
Broilers	16,251	5,032	8,773	2,446
Layers/pullets	5,326	1,376	2,336	1,614
Confined heifers/veal	4,011	317	710	2,984
Small farms with confined livestock types dominant	42,565	0	91	42,474
Farms with pastured livestock types dominant	61,272	1,606	7,515	52,151
All CNMP farms	255,070	19,746	39,437	195,887
Percent of all CNMP farms	100	8	15	77

* Excludes specialty livestock farms.
Note: Farm size classes are based on the total amount of manure phosphorus *as excreted* produced on each farm annually.

Table 7 States and number of CNMP farms corresponding to USDA Farm Production Regions

Farm production region	States	All CNMP farms #	--Large farms-- #	%	Medium-size farms #	%	--Small farms -- #	%
Appalachia States	Tennessee, Kentucky, West Virginia, North Carolina, Virginia	22,899	2,992	13.1	4,546	19.9	15,361	67.1
Corn Belt States	Iowa, Illinois, Missouri, Indiana, Ohio	71,540	3,094	4.3	9,190	12.8	59,256	82.8
Delta States	Arkansas, Louisiana, Mississippi	12,352	2,035	16.5	3,900	31.6	6,417	52.0
Lake States	Minnesota, Wisconsin, Michigan	52,817	1,155	2.2	3,358	6.4	48,304	91.5
Mountain States	Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico	7,964	1,226	15.4	1,745	21.9	4,993	62.7
Northeast States	Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, Delaware, Maryland	31,598	1,016	3.2	2,872	9.1	27,710	87.7
Northern Plains States	North Dakota, South Dakota, Nebraska, Kansas	26,309	2,230	8.5	5,226	19.9	18,853	71.7
Pacific States	Washington, Oregon, California, Hawaii, Alaska	7,974	1,982	24.9	1,682	21.1	4,310	54.1
Southeast States	Alabama, Georgia, South Carolina, Florida	12,807	2,532	19.8	4,392	34.3	5,883	45.9
Southern Plains States	Oklahoma, Texas	10,941	1,484	13.6	2,526	23.1	6,931	63.3
All regions		257,201	19,746	7.7	39,437	15.3	198,018	77.0

Note: Large farms are farms that produce more than 10 tons of manure phosphorus *as excreted* annually, medium-size farms produce 4 to 10 tons annually, and small farms produce less than 4 tons annually.

Figure 12 CNMP farms that produce more than 10 tons of phosphorus per year (19,746 farms)

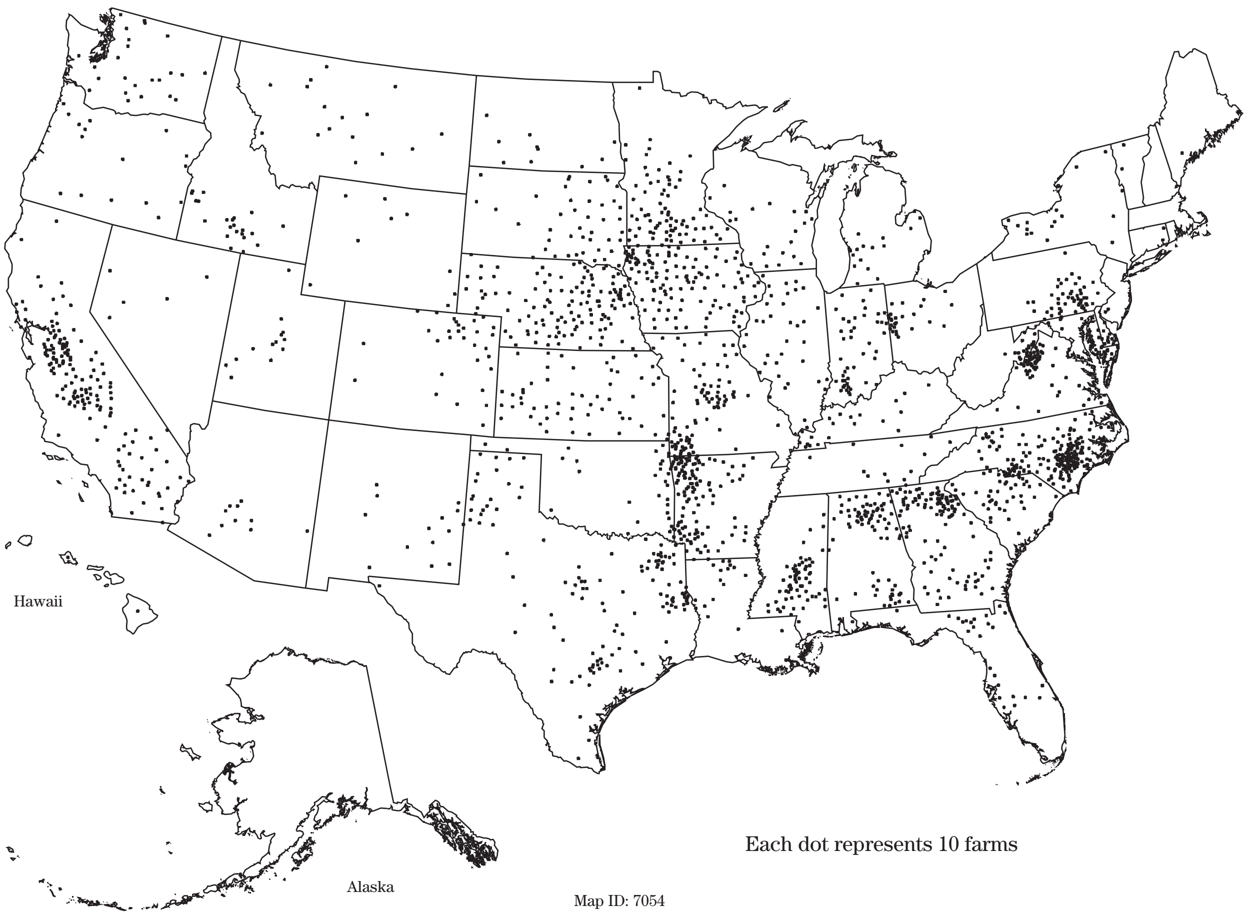
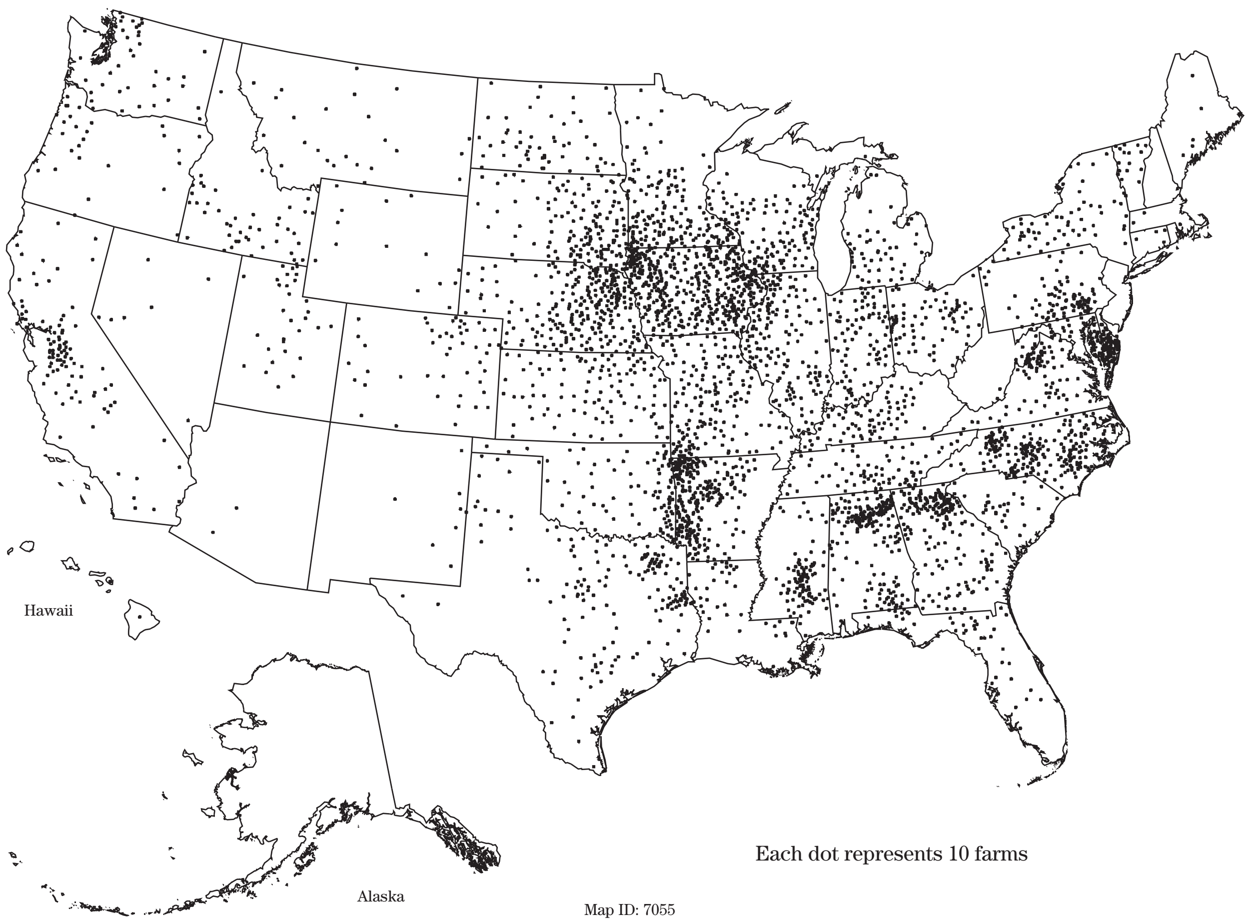


Figure 13 CNMP farms that produce 4 to 10 tons of phosphorus per year (39,437 farms)



Nutrient management costs

The nutrient management element of a CNMP addresses the requirements for land application of manure nutrients. Land application is the preferred method of utilizing manure since these materials can supply large amounts of nutrients for crop growth, thereby reducing the need to apply commercial fertilizers. CNMP criteria are established to provide for adequate nutrients for crop growth and to minimize the potential for adverse environmental effects.

Costs for nutrient management were developed based on the implementation requirements of a nutrient management plan as defined in the NRCS Nutrient Management Policy (General Manual, Title 190, Part 402) (USDA, NRCS, 1999) and the NRCS Conservation Practice Standard, Nutrient Management (Code 590). The primary criteria within these policy documents are that land application rates of nutrients be based upon Land Grant University nutrient application recommendations. The NRCS criteria for implementing a nutrient management plan include the use of current soil tests, manure testing to determine nutrient content, documented or realistic yield goals, and Land Grant University recommendations for determining nutrient application rates.

Nutrient management plans also address the method and timing of manure and wastewater application to reduce losses of valuable manure nutrients (primarily nitrogen) that occur during and after land application. By reducing these losses, the amount of manure nutrients made available for crop growth is increased and the potential for environmental impacts is decreased. For example, a common management action in a nutrient management plan would be for liquid manure applications by injection into the soil, rather than surface applied. This would minimize nitrogen losses because of volatilization and runoff and reduce the potential for phosphorus losses in runoff or soil erosion. Nutrient management plans also reflect operator decisions to change existing crop rotations to better use manure nutrients produced on the farm. (Erosion control practices, which are part of the land treatment element of a CNMP, further contribute to reducing manure nutrient losses.)

NRCS policy permits manure application rates that are determined using either a nitrogen or phosphorus standard. Manure application rates that are based on a nitrogen standard would supply all the nitrogen recommended for the crop. They also account for the nitrogen volatilization losses and other losses that occur during and after land application. Manure applied at a nitrogen standard usually results in overapplication of phosphorus. NRCS policy permits use of the nitrogen standard on sites for which there is a recommendation to apply phosphorus, or when the use of a risk assessment tool has determined that the site has acceptable risk for off-site transport of phosphorus. (The Phosphorus Index is currently the most widely used risk assessment tool for this purpose.)

Manure application rates that are based on a phosphorus standard supply only the amount of phosphorus that is recommended based on current soil tests or a function of the phosphorus content of plant biomass removed at harvest. Manure applied based on the phosphorus standard will not usually supply the recommended amount of nitrogen, necessitating the application of additional nitrogen from other sources. When using the phosphorus standard, NRCS policy permits an application of phosphorus equal to the amount of phosphorus contained in the biomass of multiple years of crops grown on the site, if the nitrogen recommendation rate for the first year is not exceeded. This allows farms that have enough land to continue to apply manure based on a nitrogen standard, but rotate manure applications to other sites so that a single site receives manure infrequently. Consequently, operations with sufficient land can meet nutrient management criteria without actually applying manure at rates based on a phosphorus standard, which is sometimes difficult to achieve with existing application equipment and is more costly to implement than a nitrogen standard. Operations without sufficient land, however, will eventually need to apply manure based on a phosphorus standard on all available onfarm acres as the phosphorus levels build up in the soil, or else export the manure off-farm for land application or alternative use.

The cost of nutrient management associated with CNMPs was determined by estimating the cost of soil testing, the cost of manure testing, the cost of transporting manure to the application site on the farm, and the cost of onfarm land application. Onfarm land application costs were based on the **additional acres** required to meet nutrient management criteria as producers shift from existing rates of application to lower rates of application. Additional acres will also be required because of the increase in the amount of manure that is recoverable as producers upgrade their manure collection and transfer equipment and practices. Onfarm transport costs were based on the **increase** in the onfarm distance manure is transported when the number of acres receiving manure increases and on the **change** in the amount of manure to be transported on the farm.

Simulating manure application criteria

The first step in estimating nutrient management costs was to estimate the amount of manure produced on each farm that would be available for land application (i.e., recoverable manure.) The second step was to estimate the acres available for manure application on each farm. The third step was to estimate the additional number of acres required to meet nutrient management criteria. The methods used to make these estimates are presented in appendix B. To determine the additional acres required, two land application scenarios were used:

- Baseline scenario, which simulates land application of manure prior to CNMP implementation
- After-CNMP scenario, which simulates land application of manure after CNMP implementation

The baseline scenario simulates manure application practices for about the year 1997, which coincides with the most recent Census of Agriculture data and pre-dates CNMP implementation. Anecdotal evidence and limited information from farmer surveys indicate that manure application practices vary considerably. In general, manure seldom is applied at rates below the nitrogen standard, even when commercial fertilizers also are applied. Application rates exceeding the nitrogen standard are common. In extreme cases manure application rates were reported to be several times greater than the nitrogen standard.

A combination of application rates similar to the nitrogen standard and application rates above the nitrogen standard were used to represent the baseline scenario. The model simulated manure application rates **above** the nitrogen standard for permanent pasture, cropland used as pasture, and nine feed and forage crops. For farms that had enough land for onfarm application, application rates for this group of crops and pastureland were set at one and one-half times the amount of nitrogen taken up and removed at harvest plus an adjustment for nitrogen loss during and after application. For farms that did not have sufficient land at these application rates, application rates were increased to twice the amount of nitrogen taken up and removed at harvest plus the adjustment for losses. Application rates similar to nitrogen-standard application rates were used for other crops. (For details on how the baseline scenario was constructed, see appendix B.)

The after-CNMP scenario simulates manure application practices after all CNMP farms have implemented CNMPs. Manure application rates depend on the amount of acreage available for manure application on each farm and whether nitrogen or phosphorus was the limiting nutrient. If phosphorus was the limiting nutrient, land application on farms **without** enough acres to meet a phosphorus standard was simulated using phosphorus-based application rates for all crops and pastureland. For manure-producing farms that had enough acres to meet a phosphorus standard, land application was simulated using nitrogen-based application rates for all crops and pastureland. For a few CNMP farms (1,379 farms), nitrogen was the limiting nutrient. For these farms, land application was simulated using a nitrogen standard. (For details on how the after-CNMP scenario was constructed, see appendix B.)

Some farms have excess manure (farm-level excess manure), which they will need to export off the farm for land application on surrounding properties or use in alternative ways. To meet CNMP application criteria on farms with excess manure in both land application scenarios, more manure will be exported off the farm after CNMPs are implemented, reducing the amount applied on the farm. Other farms will have enough land in the baseline scenario, but will have excess manure in the after-CNMP scenario. The number of farms with excess manure in the after-CNMP scenario is about 50 percent higher than in the baseline scenario, as shown below and in appendix B.

	Baseline scenario	**After-CNMP scenario**
Farms with excess manure	47,562	71,999
Farms without excess manure	207,508	183,071
All CNMP farms (excluding farms with specialty livestock types)	255,070	255,070

The majority of CNMP farms (72 percent) had enough acres to meet a phosphorus standard, and so it was assumed they could meet CNMP criteria by applying manure at nitrogen standard rates (table 8). None of these 183,071 farms has excess manure, by definition. The remaining farms—71,999 farms—would need to apply manure at phosphorus-standard rates and will have excess manure after CNMPs are implemented. About two-thirds of the farms with excess manure after CNMPs are implemented (47,562 farms) also had excess manure in the baseline scenario, indicating that they were already exporting some or all of their manure off the farm prior to CNMP implementation. The remaining one-third (24,437 farms) had enough acres for onfarm application at application rates simulated in the baseline scenario, but did not have enough acres to meet CNMP application criteria, and so must export a portion of their manure off the farm after CNMPs are implemented.

Large farms (farms with more than 10 tons of manure phosphorus produced annually) are disproportionately represented in the set of farms with excess manure. About 79 percent of the 19,746 large farms had excess manure after CNMPs were implemented (table 8). Thus, only 21 percent of large farms had enough acres to meet CNMP application criteria. About half of the medium-size farms also had excess manure after CNMPs were implemented. Most of the small farms had enough acres to meet CNMP application criteria (81 percent). Even so, about half of the farms without enough land were small farms.

This approach to simulating application rate criteria for nutrient management plans somewhat understates the onfarm acres required by the 183,071 farms with enough acres to meet a phosphorus standard and somewhat overstates the onfarm acres required by the 71,999 farms without enough acres. Some of the farms without enough acres would be able to meet nutrient

Table 8 Number of CNMP farms in relation to application rate criteria*

Farm group	All CNMP farms #	%	--Large farms-- #	%	Medium-size farms #	%	---Small farms--- #	%
Farms **with** enough acres to meet CNMP nutrient management criteria (application at nitrogen-standard rates)	183,071	71.8	4,103	20.8	20,469	51.9	158,499	80.9
Farms **without** enough acres to meet CNMP nutrient management criteria (application at phosphorus-standard rates)**	71,999	28.2	15,643	79.2	18,968	48.1	37,388	19.1
Farms **without** excess manure in the baseline scenario	24,437	9.6	4,146	21.8	5,974	15.1	14,317	7.3
Farms **with** excess manure in the baseline scenario	47,562	18.6	11,497	58.2	12,994	32.9	23,071	11.8
Farms with no acres available for application	22,101	8.7	3,907	19.8	4,913	12.5	13,281	6.8
Farms with acres available for application	25,461	9.9	7,590	38.4	8,081	20.5	9,790	5.0

* Excludes CNMP farms with specialty livestock types.
** A small number of farms with nitrogen as the limiting nutrient applied manure at nitrogen-standard rates.

management criteria using nitrogen-standard application rates rather than the phosphorus-standard application rates simulated in the model if a risk assessment tool indicates that the site has acceptable risk for off-site transport of phosphorus. Other farms in this group would be able to apply manure at nitrogen-standard rates for at least a few years until the soil phosphorus level approached the threshold. Conversely, some farms with enough acres to meet a phosphorus standard may have a long history of manure applications and if soil phosphorus tests indicate that phosphorus-standard application rates are needed on most or all of the acres, they would not be able to apply manure at nitrogen-standard rates. In the overall cost assessment, the overestimate of acres required for one group of farms is expected to offset the underestimate of acres required for the other group of farms.

Additional acres required for onfarm land application

Land application costs associated with CNMP implementation are based on the additional acres required for onfarm land application. Acres required for land application were estimated for the baseline scenario and for the after-CNMP scenario. As shown in table 9 and in appendix B, an additional 7.6 million acres on CNMP farms will have manure applied after CNMPs are implemented, averaging about 30 acres per farm. Additional acres with manure applied averaged more than 50 acres per farm for fattened cattle farms, swine farms, turkey farms, and farms with confined heifers or veal (table 10). For the set of farms that needed to apply at phosphorus-standard rates and had acres available, the additional acres with manure applied averaged 156 acres per farm (table 9). Nearly all

Table 9 Summary of onfarm acres required to meet CNMP application criteria*

Farm group	Number of CNMP farms	Total acres on farm	Onfarm acres available for manure application	Onfarm acres with manure applied, baseline scenario	Onfarm acres with manure applied, after-CNMP scenario	Additional onfarm acres with manure applied
All CNMP farms						
Total	255,070	128,884,869	84,843,415	7,187,142	14,814,334	7,627,193
Per-farm		505	333	28	58	30
Farms **with** enough acres to meet CNMP nutrient management criteria						
Total	183,071	112,198,700	77,512,694	3,678,434	7,483,613	3,805,179
Per-farm		613	423	20	41	21
Farms **without** enough acres to meet CNMP nutrient management criteria						
Total	71,999	16,686,169	7,330,722	3,508,708	7,330,722	3,822,014
Per-farm		232	102	49	102	53
Farms **without** excess in baseline scenario						
Total	24,437	9,296,904	5,850,450	2,028,436	5,850,450	3,822,014
Per-farm		380	239	83	239	156
Farms **with** excess in baseline scenario						
Farms with no acres available for application	22,101	0	0	0	0	0
Farms with acres available for application						
Total	25,461	7,389,265	1,480,272	1,480,272	1,480,272	0
Per-farm		290	58	58	58	0

* Excludes CNMP farms with specialty livestock types.

poultry farms (96.5 percent) needed to apply manure at phosphorus-standard rates because they did not have enough onfarm acres to meet the phosphorus standard (table 10). Consequently, nearly all poultry farms also had excess manure in the after-CNMP scenario.

The spatial distribution of additional acres required to meet CNMP application criteria on CNMP farms is shown in figure 14. The number of farms with excess manure in the after-CNMP scenario is shown in figure 15.

Table 10 Onfarm acres required to meet CNMP application criteria and farms with excess manure, by livestock type

Dominant livestock type	Number of CNMP farms	Farms with enough acres to meet CNMP nutrient management criteria	Total acres on farm (avg/farm)	Acres available for manure application (avg/farm)	Onfarm acres with manure applied, baseline scenario (avg/farm)	Onfarm acres with manure applied, after-CNMP scenario (avg/farm)	Additional onfarm acres with manure applied (avg/farm)	Number of farms exporting manure off the farm, baseline scenario	Number of farms exporting manure off the farm, after-CNMP scenario
Fattened cattle	10,159	8,133	2,139	893	50	119	68	1,073	2,026
Milk cows	79,318	65,782	426	325	35	77	42	4,671	13,536
Swine	32,955	20,227	637	507	45	111	66	6,720	12,728
Turkeys	3,213	43	274	172	105	161	57	2,621	3,170
Broilers	16,251	531	170	103	65	88	23	13,700	15,720
Layers/pullets	5,326	305	185	110	60	88	28	3,923	5,021
Confined heifers/veal	4,011	2,204	606	484	28	83	54	1,208	1,807
Small farms with confined livestock types	42,565	30,994	215	165	6	11	5	8,777	11,571
Pastured livestock types	61,272	54,852	590	352	5	10	5	4,869	6,420
All types	255,070	183,071	505	333	28	58	30	47,562	71,999

Figure 14 Additional onfarm acres required to meet CNMP application criteria on CNMP farms (7.6 million acres)

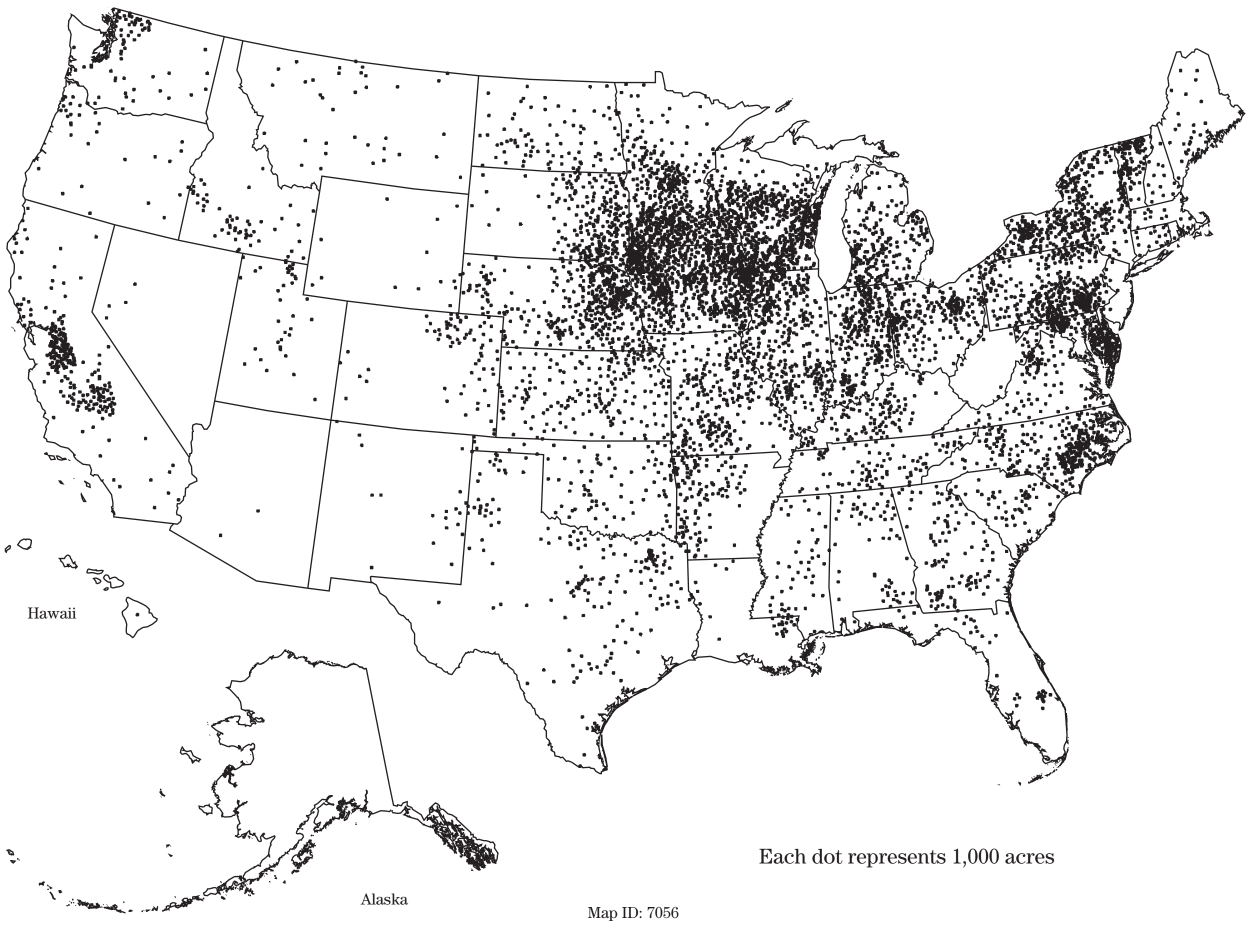
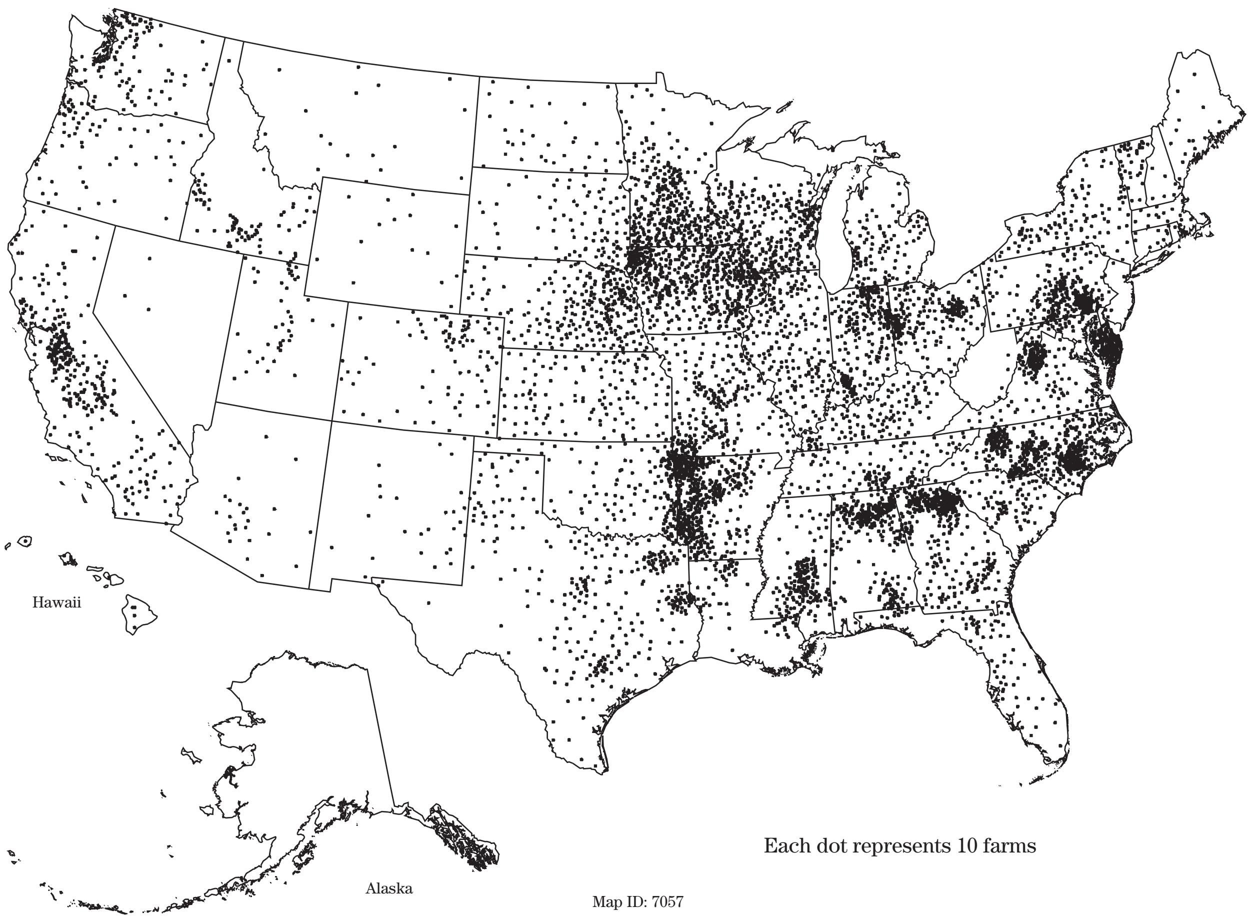


Figure 15 CNMP farms with excess manure after implementing CNMPs (71,999 farms)



Onfarm transport distance

Onfarm transport costs are determined in part by the distance manure is transported. For each CNMP farm, the average onfarm transport distance was estimated for both the baseline scenario and the after-CNMP scenario.

The average onfarm transport distance was calculated for each farm using an approach published by Fleming, Babcock, and Wang (1998). The average transport distance is derived from an estimate of the "searchable area," which is based on the proportion of land on a farm that is available for manure application. Fleming et al. defined the searchable area as a square, contiguous block. Assuming the block was **x** miles on each side, the searchable area would be $\mathbf{x}^2$. Within this block are the fields on which manure would be applied. These fields are assumed to be randomly distributed and of equal size, thus forming a grid of cells. One could calculate the distance from any cell to any other cell, sum up the distances, and divide by the number of cells in the grid to get an average distance. The shortest distance would be zero, and the longest possible distance would be 2**x**. Fleming et al. argues that as the block is divided into smaller and smaller fields, the distribution of possible distances approaches a normal distribution, and thus a median distance could be used to approximate the mean distance. The median distance is the shortest distance plus the longest distance divided by 2, which is equal to **x**. Thus, the average distance is simply the square root of the searchable area.

Fleming et al. defined the searchable area in square miles as:

$$\text{Searchable area} = NM \times \frac{Q}{640 \times \alpha \times \beta \times \gamma \times NC}$$

Where:
- Q = manure volume
- NM = manure nutrient concentration
- NC = crop nutrient uptake, or application rate criteria in quantity of nutrient per acre
- α = proportion of cropland and pastureland
- β = proportion of cropland and pastureland suitable for manure application
- γ = proportion of acres where manure is accepted

The term $(NM \times Q)/NC$ is the number of acres required for manure application to meet whatever land application criteria are used. The term 1/640 converts acres to square miles. The term $1/(\alpha \times \beta \times \gamma)$ adjusts the searchable area upward to account for the diversity of land use on the farm and the willingness of the farmer to accept manure. For CNMP farms, the willingness to accept manure was set equal to one, so this term reduces to $1/(\alpha \times \beta)$. If all of the land on the farm was either cropland or pastureland that was available for land application of manure, then $\alpha \times \beta$ would be 1 and the searchable area would simply be the acres required for manure application, and the average transport distance would be the square root of that area. In the case of a similar farm that also had a wooded area, α would be less than one and the searchable area would be larger than the area of land required for manure application; thus the average transport distance would be longer. Similarly, the average transport distance would be longer if some of the cropland and pastureland were not suitable for land application of manure (such as vegetable crops or fruit orchards) because β would be less than one. Thus, the more diverse the land use on a farm, the longer the onfarm transport distance.

This is not an ideal estimate of transport distance because the underlying assumptions would not hold for most livestock operations. Most operations would apply manure to fields that were closest to the confinement facility, rather than randomly throughout the farm. Moreover, estimating the average distance as the square root of the searchable area is strictly appropriate only when the number of fields is large. Since the function implicitly assumes that the size of a field cannot be smaller than the area where manure is applied on each trip, the number of fields will not be large for all farms. For these reasons, this function overstates the onfarm transport distance for farms that are largely contiguous and square. For farms that are not contiguous, or that are more rectangular, the function may understate the transport distance. Nevertheless, the function is readily solved with data from the Census of Agriculture and provides a consistent basis for estimating average transport distance for each farm.

For the baseline scenario, the term $(NM \times Q)/NC$ was replaced by the acres on which manure was applied on each farm. For the after-CNMP scenario, the term $(NM \times Q)/NC$ was replaced by the acres required to meet nutrient management criteria on each farm. The $\alpha \times \beta$ term was the ratio of acres available for manure application to the total acres on each farm, which is the same for both scenarios for a given farm. (See appendix B for criteria used to determine acres available for manure application.) The average transport distance is a one-way distance in miles and does not include distance traveled on the field while applying the manure. In this study, costs per mile were set to a one-way distance basis so that they would be compatible with this measure of transport distance.

The onfarm transport distance is summarized in table 11 according to groups of farms that differ significantly in onfarm transport costs. For farms with excess manure in the baseline scenario, the median distance hauled was the same in both land use scenarios because all the available land for onfarm manure application was already in use in the baseline scenario. These farms thus will not have any increased cost associated with transport distance. For all other farms, however, the average distance in the after-CNMP scenario was more than in the baseline scenario because of the increase in the number of onfarm acres receiving manure. The median onfarm transport distance for farms with enough acres to meet CNMP application criteria was 0.16 mile for the baseline scenario, which increased to 0.23 mile for the after-CNMP scenario. Onfarm transport distance for this group of farms ranged from 0.04 mile to 0.59 mile in the baseline scenario and 0.05 mile to 0.82 mile in the after-CNMP scenario, where the range is represented by the 1 percentile to the 99th percentile. The greatest increase in onfarm transport distance was for farms without excess manure in the baseline scenario, but without enough acres to meet CNMP application criteria.

Table 11 Onfarm transport distance*

Farm group	Number of farms	Baseline scenario, median transport distance (mi)	Baseline scenario, range of transport distance (mi)	After-CNMP scenario, median transport distance (mi)	After-CNMP scenario, range of transport distance (mi)	Increase in median transport distance (mi)
Farms **with** enough acres to meet CNMP nutrient management criteria (application at nitrogen-standard rates)	183,071	0.16	0.04–0.59	0.23	0.05–0.82	0.07
Farms **without** enough acres to meet CNMP nutrient management criteria (application at phosphorus-standard rates)**						
Farms **without** excess manure in the baseline scenario	24,437	0.33	0.07–1.49	0.54	0.10–2.34	0.21
Farms **with** excess manure in the baseline scenario						
Farms with no acres available for application	22,101	0	0	0	0	0
Farms with acres available for application	25,461	0.33	0.04–1.71	0.33	0.04–1.71	0

* Excludes CNMP farms with specialty livestock types.
** A few farms with nitrogen as the limiting nutrient applied manure at nitrogen-standard rates.
Note: Range is 1 percentile to 99th percentile.

Amount of manure to be transported on the farm

In addition to the transport distance, onfarm transport costs are also determined by the amount of manure transported for onfarm application. Separate estimates were made for solids and for manure handled as a liquid or slurry. Estimates were made by converting tons of recoverable manure to tons at hauling weight for solids and to tons of manure and wastewater for farms with liquid or slurry systems. The amount of wastewater collected in runoff storage ponds was also estimated, allowing for regional differences in precipitation. The hauling weight for solids includes the weight of bedding. The methods used to make these estimates are presented in appendix B.

For farms without enough acres available to apply all of the manure produced, only a portion of the recoverable manure was transported on the farm. The remaining manure and wastewater were transported off the farm. (Costs associated with off-farm transport are addressed in the next section.) The quantity of manure to be applied on each farm was determined based on the percentage of manure nutrients that was applied on the farm to meet the criteria established for each of the two land application scenarios.

The amount of manure for onfarm transport and application is shown in table 12. For farms that did not have enough acres to meet application criteria in the after-CNMP scenario, the amount of manure transported on farm was less in the after-CNMP scenario than in the baseline scenario. To meet nutrient management criteria, these farms were applying manure at lower rates in the after-CNMP scenario than in the baseline scenario, and since onfarm acres were limited, had to export more of their manure off the farm. (A decrease in the amount of solids for onfarm transport and application also occurred because of a change in the consistency of manure for some dairies as a result of CNMP implementation. See the section Manure and Wastewater Handling and Storage and appendix B for details about the calculation of recoverable manure for model farms.)

Manure testing costs

Land application of manure should be based on manure testing to make sure the appropriate amount of nutrients are applied and the need for supplemental commercial fertilizer applications is identified. Testing provides a nutrient analysis of the manure, thus allowing producers to make the best use of onfarm acreage for land application and minimize off-farm export. If manure is exported to manure receiving farms, the recipients will most likely require a nutrient analysis. Producers employing feed management practices to reduce manure nutrients also would benefit from manure testing. Calculations of manure nutrients using standard conversion factors or table values are suitable for design and planning, but manure testing is expected to be a component of most CNMPs. The need for accurate information for farms with small amounts of manure, however, is not critical, and use of table values generally would be acceptable. Thus, it was assumed that all farms with more than 35 animal units would conduct manure testing. Smaller farms would use table values, and thus would have no manure testing costs.

The need for manure testing is determined by the timing of manure application to the land, which is in turn influenced by manure storage capacity. The frequency of manure sampling varies according to the type of manure handling system on the farm. Poultry farms that handle manure as a solid would generally have a 365-day storage capacity under CNMP guidelines, and thus would be expected to land apply manure only once a year. Thus, manure testing for nutrient content would be done only once per year for these farms. For most other farms that primarily handle manure as a solid, manure application is assumed to occur twice per year (180 days of storage), and thus manure testing would be done twice per year. Because of the potential for year-round cropping in the Southeast, minimum storage capacity needs were assumed to be 90 days, and manure testing would be expected four times a year. For liquid systems and operations with runoff collection ponds, minimum storage capacity was assumed to be 180 days, and manure sampling would coincide with the land application of the collected wastewater twice per year. Slurry systems were generally defined as having storage equivalent to 120 days, resulting in manure sampling three times per year.

For each sampling event, a single composite sample consisting of several grab samples from different areas within the manure storage facility was assumed to be adequate. Based on costs found in typical university laboratory price lists, the total cost was assumed to be $50 per composite manure sample, which included a $40 analysis cost and a $10 collection and transfer cost (1 hour labor at $10/hour). Thus, the total annual cost was $200 for farms sampling four times per year, $150 for farms sampling three times per year, $100 for farms sampling two times per year, and $50 per year for poultry farms handling manure as a solid.

While some operations already are testing manure for nutrient content, most do not take manure samples, and of those who do, most do not sample frequently enough. It was judged that about 90 percent of CNMP farms would need to take additional manure samples to meet the CNMP guidelines.

Table 12 Amount of manure for onfarm transport and application*

	Number of farms	Tons of manure for transport onfarm, solids			Tons of manure for transport onfarm, liquid and slurry systems		
		baseline scenario	after-CNMP scenario	change	baseline scenario	after-CNMP scenario**	change
All CNMP farms							
Total	255,070	35,269,938	30,883,243	–4,386,694	312,256,067	751,660,965	439,404,898
Per farm		808	455	-353	7,712	11,642	3,930
Farms with enough acres to meet CNMP nutrient management criteria							
Total	183,071	20,640,269	23,866,400	3,226,131	162,131,411	556,491,110	394,359,699
Per farm		113	130	18	886	3,040	2,154
Farms without enough acres to meet CNMP nutrient management criteria							
Farms **without** excess manure in the baseline scenario							
Total	24,437	9,723,418	5,444,511	–4,278,907	113,452,758	173,549,846	60,097,089
Per farm		398	223	-175	4,643	7,102	2,459
Farms **with** excess manure in the baseline scenario							
Farms with no acres available for application	22,101	0	0	0	0	0	0
Farms with acres available for application							
Total	25,461	4,906,251	1,572,332	–3,333,919	36,671,899	21,620,009	–15,051,890
Per farm		193	62	–131	1,440	849	–591

* Excludes CNMP farms with specialty livestock types.
** Includes additional tons of wastewater from runoff storage ponds.
Note: Manure for off-farm transport is presented in table 17. Total manure production is presented in appendix B, table B–8.

Soil testing costs

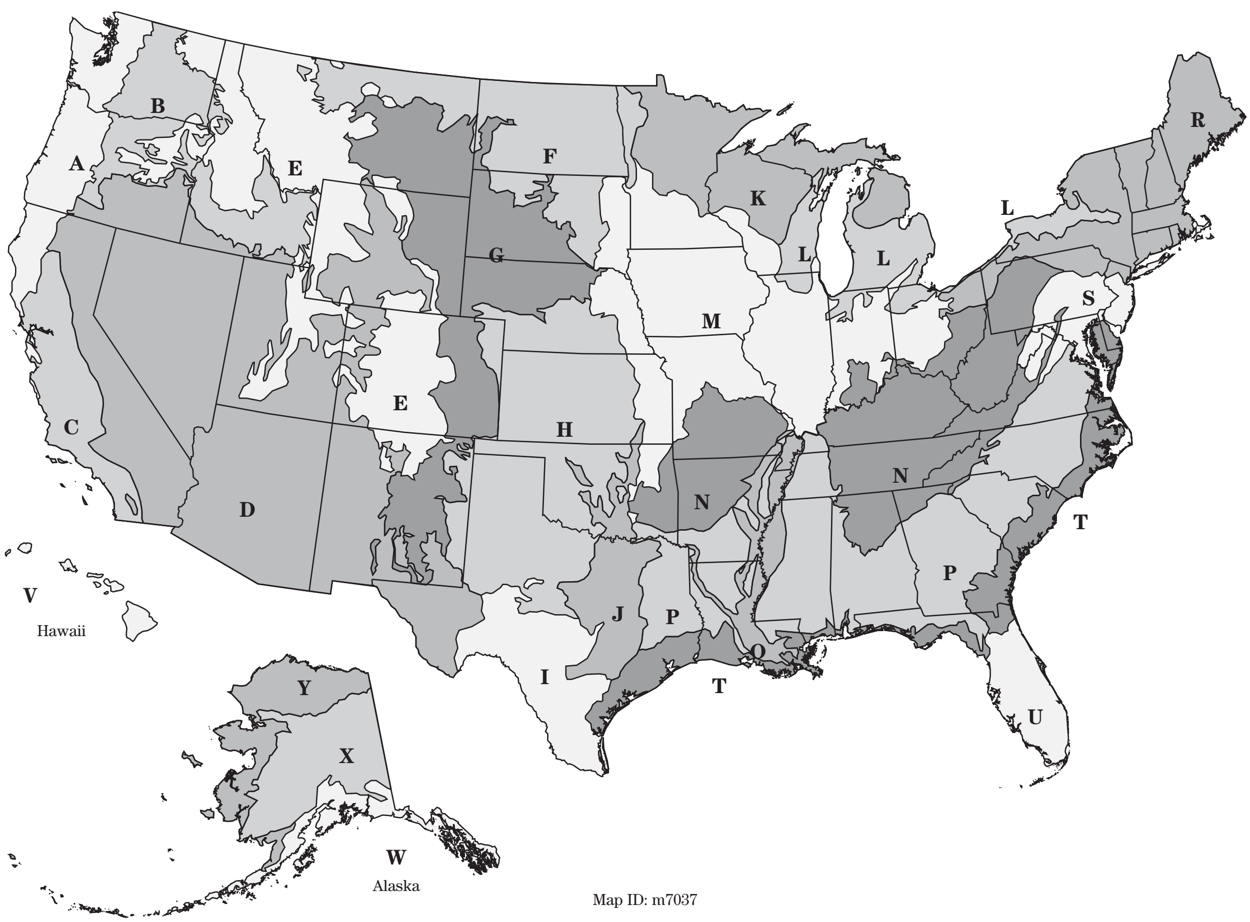
Soil testing is necessary to determine whether a nitrogen standard or phosphorus standard should be used and to determine the need for supplemental commercial fertilizer applications. Soil testing costs are determined by:

- Frequency of sampling over time.
- The number of soil samples needed per acre.
- The number of acres receiving manure.

Nutrient management plans require that application rates be based on current soil tests, which are soil tests that are no older than 5 years. To determine CNMP costs, it was thus assumed that the frequency of soil testing would be once every 5 years. It is recognized, however, that some situations will require more frequent sampling, and some States currently require annual samples.

The number of soil samples required per acre depends on the diversity of soil types and topography and on the history of previous nutrient applications. More samples per acre are needed in fields where soil types are diverse and/or previous applications were variable. To account for the diversity of soil types and topography, the number of acres per soil test was based on the Land Resource Region (LRR) where the farm is located. LRRs are geographic areas made up of an aggregation of Major Land Resource Areas (MLRA) that are characterized by a particular pattern of soils, climate, water resources, land uses, and type of farming (USDA, SCS, 1981). There are 25 LRRs in the United States (fig. 16). LRRs that tend to have more homogeneous soil types had a higher number of acres per sample (less sampling), whereas LRRs that tend to be more heterogeneous had a lower number of acres per sample (more sampling). The number of acres per soil test for each LRR was determined with the assistance

Figure 16 Land resource regions



of The Fertilizer Institute (TFI), the national trade association for the fertilizer industry, and is shown in table 13.

The total number of soil samples needed was determined by dividing the acres with manure applied by the number of acres per soil sample for each farm. All of the additional acres receiving manure applications in the after-CNMP scenario would require soil samples. Although many farmers currently take soil samples, few do so in the context of a nutrient management plan where more systematic sampling is needed. It was therefore judged that about 80 percent of the acres already receiving manure (baseline scenario acres) would also need soil tests to meet CNMP criteria.

Based on costs found in typical university laboratory price lists, the cost per soil sample was assumed to be $20, consisting of $10 per sample for analysis and $10 per sample for sample collection and handling (1 hr labor at $10/hr). The annual cost per farm for soil testing was obtained by multiplying the $20 per sample cost times the total number of samples needed times 0.2 to account for the 1-in-5 year sampling frequency.

Table 13 Number of acres per soil test according to Land Resource Region

Land resource region	Acres per soil test	Land resource region	Acres per soil test
A	20	N	10
B	50	O	10
C	10	P	10
D	50	R	10
E	50	S	10
F	50	T	10
G	50	U	10
H	50	V	5
I	50	W	10
J	10	X	50
K	10	Y	10
L	10	Z	5
M	20		

Onfarm transport costs

CNMP related onfarm transport costs include only the costs associated with the additional acres required for manure application. Costs were estimated for the baseline scenario and for the after-CNMP scenario, and the difference was used to represent expected onfarm transport costs associated with CNMP implementation. As noted above, farms that do not have enough acres to meet CNMP application criteria export a portion of their manure and wastewater off the farm. Most of these farms will transport less manure on the farm after CNMP implementation as producers shift from current application rates in the baseline scenario to lower rates of application in the after-CNMP scenario, as shown in table 12. Consequently, the onfarm transport costs will be lower after CNMP implementation, resulting in a negative cost estimate (i.e., an apparent savings). This "savings" is offset, however, by increased off-farm transport costs, which are presented in the next section.

Separate cost estimates were made for solids and for manure and wastewater handled as a liquid or slurry, including wastewater from runoff storage ponds.

Solids

Onfarm transport costs for solids were determined for each CNMP farm as follows:

Onfarm transport costs = loading cost
+ (ton-miles)(cost per ton-mile)

Where:
ton-miles = average onfarm transport distance in miles multiplied times the tons of manure for onfarm transport for solids.

Transport costs for solids were based on two generalized application systems, one for small farms (less than 750 tons annually of manure for transport) where a manure spreader is used to transport the manure to the field, and another for the largest farms (more than 7,000 tons annually of manure for transport) where a semi-tractor and trailer is used to transport manure to the field. Assuming a linear relationship between cost per ton per mile and the quantity of manure to be hauled, an equation was developed from these two cases to generate estimates of cost per ton per mile for other size farms.

Capital costs for the small farm system were based on a 138-bushel (4.1 ton) manure spreader with an annual cost of $2,344 and a 105-horsepower (hp) tractor used 10 percent of the time for manure transport with an annual cost of $655, amortizing the total cost over 10 years with an 8 percent interest rate. The total annual capital cost is thus $2,999 per year. Operating costs were based on a study by Oregon State University Extension Service (1982), which reported annual operating costs of $2,277 for this kind of system, including 123 hours of operator time per year to transfer the manure from the farm to the field. Operating costs reported in that study were converted to 2000 costs using a suitable price index. The total annual capital and operating cost converts to $42.89 per hour. Assuming a typical travel speed for onfarm hauling of 10 miles per hour, the cost is $1.03 per ton per mile.

Capital and operating costs for the large farm system were based on contract transport using a large semi-truck. The contract cost for this system was reported by Wimberly and Goodwin (2000) to be $0.24 per ton per mile.

The following function was used to estimate the cost per ton per mile for solids transport as a function of the amount of solids to be hauled on the farm.

x = tons of solids hauled on farm
a = $ per ton per mile

If x < 750, then a = $1.03
If x > 7,000, then a = $0.24
If 750 < x < 7,000, then

$$a=1.03-\left[\frac{(x-750)}{(7{,}000-750)}\times(1.03-0.24)\right]$$

In addition to the cost per ton per mile, solids systems also have a cost associated with loading, which is a function of the tons hauled. The loading cost used for all sizes of operations was $1.00 per ton, which was also taken from Wimberley and Goodwin (2000).

Manure and wastewater handled as a liquid or slurry
Cost estimates for the transport of manure and wastewater as a liquid or slurry (including wastewater from runoff storage ponds) were based on two generalized application systems: for farms with less than 1,000 tons of liquid or slurry manure to be transported annually, and for farms with more than 1,000 tons. The small farm system is based on using a tank wagon to transport the manure and wastewater, which was also used for land application. The system for larger farms assumes the wastewater would be pumped through pipes to the application site and applied using an irrigation system.

Onfarm transport costs for the small farms were determined for each CNMP farm as follows:

Onfarm transport costs = ton-miles × cost per ton-mile

where ton-miles is the average onfarm transport distance in miles multiplied times the tons of wastewater for onfarm transport in a tank wagon.

For the larger farms where pumping is used to transport liquids, onfarm transport costs are estimated as the cost per mile of pipe multiplied by the maximum distance that the wastewater is transported on the farm.

A pump is needed to transfer the wastewater from the storage pond to the tank wagon for the smaller farms, and to transport the wastewater to the field application site for the larger farms. The cost of the pump is included in the transfer component of the manure and wastewater handling and storage element, and so is not included here.

Capital costs for the small farm system (<1,000 tons) were based on a 3,200-gallon (12 ton) tank wagon with an annual cost of $2,780 and a 105-hp tractor used 20 percent of the time for manure transport with an annual cost of $1,309, amortizing the total cost over 10 years with an 8 percent interest rate. Total annual capital cost is thus $4,089. Operating costs were based on the study by Oregon State University Extension Service (1982), which reported annual operating costs of $5,344 for this kind of system (after converting to 2000 costs). Based on the 314 hours of operation per year reported in the study, total capital and operating costs convert to $30.03 per hour. Assuming a typical travel speed for onfarm hauling of 10 miles per hour, the cost is $0.23 per ton per mile.

For the larger farms, transport cost was based on the length of installed pipe needed to transport wastes to the furthest point of application. The distance to the furthest point of application on each farm, following from the modeling assumptions used to estimate the average transport distance, is two times the average transport distance. (The maximum possible distance, assuming the farm is square-shaped with a distance of **x** on each side, would be 2**x**, where **x** is estimated as the square root of the searchable area.)

Pipe and installation costs were taken from the NRCS Field Office Technical Guide, average cost lists. The pipe was assumed to be polyvinyl chloride (PVC) pipe 6 inches in diameter, which costs about $1.50 per foot. The installation cost (including trenching, bedding, fitting, backfilling, and concrete thrust blocks) was estimated to be $2.34 per foot. A contingency factor of 20 percent was applied to account for variations in pipe size, added costs for road crossings, and more difficult installation sites. (Most NRCS planning engineering cost estimates of this nature include a 20 percent contingency factor to cover unforeseen items not identified in the preliminary investigations.) Thus, the average cost per foot is expected to be about $4.61. One mile of installed pipe (5,280 feet) thus costs $24,340. The annual cost (amortized over 10 years at 8 percent interest) is $3,626 per mile.

Land application costs

Land application costs associated with CNMP implementation are determined by:

- Acres required for land application
- Cost per acre for land application
- Loading costs for application of solids on large farms
- Calibration costs for land application equipment

Costs were estimated for the baseline scenario and for the after-CNMP scenario, and the difference was used to represent expected onfarm land application costs related to CNMP implementation. Separate cost estimates were made for solids and for manure and wastewater handled as a liquid or slurry, including wastewater from runoff storage ponds.

Solids

The cost per acre for land application of solids was based on two generalized application systems: for small farms (less than 750 tons annually of manure for transport) where a small manure spreader is used (the same system used for onfarm transport costs), and for the larger farms with more than 7,000 tons annually of manure for transport where a large manure spreader is used. Assuming a linear relationship between cost per acre and the volume of manure to be applied, an equation was developed from these two cases to generate estimates of cost per acre for other size farms.

Capital and operating costs for the small farm system (<750 tons) are the same as those reported above for the small farm system used to estimate transport costs (138 bushel manure spreader), which were $42.89 per hour. Assuming a travel speed for application of 4 miles per hour and a 15-foot spread width provides a cost estimate of $5.90 per acre.

Capital costs for the large farm system (>7,000 tons) were based on a 510-bushel (15.3 ton) manure spreader with an annual cost of $3,708 and a 105-hp tractor used 10 percent of the time for transport of manure with an annual cost of $655, amortizing the total cost over 10 years with an 8 percent interest rate. The total annual capital cost is thus $4,363. Operating costs were based on the study by Oregon State University Extension Service (1982), which reported annual operating costs of $4,720 for this kind of system after converting to 2000 costs. Operating costs included 255 operating hours per year, as well as fuel, oil, and other costs. Based on 255 hours of operation per year, total capital and operating costs are $35.62 per hour. Assuming a travel speed for application of 4 miles per hour and a 20-foot spread width provides a cost estimate of $3.67 per acre.

The following function was used to estimate the cost per acre for solids according to the amount of solids to be applied on the farm:

x=tons of solids applied on the farm
a= $ per acre

If x < 750, then a= $5.90
If x > 7,000, then a=$3.67
If 750 < x < 7,000, then

$$a = 5.90 - \left[\left(\frac{x-750}{(7{,}000-750)} \right) \times (5.90-3.67) \right]$$

In addition to the costs per acre, solids systems also have a cost associated with calibration of the manure spreader. Sometimes these services can be obtained free from local extension services or other programs. It was therefore assumed that 10 percent of the farms either were obtaining this service free or had already incorporated the practice into their routine. For the remaining 90 percent of the farms, an annual cost of $190 per farm was assigned to cover manure calibration. This cost assumes the purchase of two wheel scales for $1,000, which converts to $150 annual capital cost, and two calibration events per year each requiring 2 hours at $10 per hour, which results in $40 annual operating cost.

For farms with less than 7,000 tons of solids to be land applied annually, it was assumed that the manure spreader would be used to transport the manure from the farm to the field, requiring no additional handling. For farms with more than 7,000 tons of solids, however, it was assumed that a large semi-truck would be used to transport the manure (see previous section on onfarm transport costs) because of the greater capacity of the semi-truck and thus the lower transport cost. In this case the manure would be off-loaded at the edge of the field and then re-loaded into a manure spreader for application. Thus, for farms with more than 7,000 tons of solids, an additional re-loading cost of $1.00 per ton would be incurred.

Manure and wastewater handled as a liquid or slurry

Cost estimates for land application of manure and wastewater as a liquid or slurry (including wastewater form runoff storage ponds) were based on the same two generalized application systems used to estimate onfarm transport costs—one for farms with less than 1,000 tons of liquid or slurry manure to be transported annually and one for farms with more than 1,000 tons. The small farm system is based on using a tank wagon to transport and apply the manure and wastewater. The system for larger farms assumes the wastewater would be pumped through pipes to the application site and applied using an irrigation system.

Capital and operating costs for the small farm system (<1,000 tons) are the same as those reported above for the small farm system used to estimate transport costs (3,200 gallon tank wagon), which were $30.03 per hour. Assuming a travel speed for application of 4 miles per hour and a 10-foot spread width provides a cost of $6.19 per acre.

In addition to the costs per acre, small liquid systems also have a cost associated with calibration of the liquid manure spreader. It is assumed calibration takes 1 hour per calibration and two calibration events per year. At an operator cost of $10 per hour, the calibration cost is $20 per farm.

The cost estimate for larger farms (>1,000 tons) was based on a study by Bennett, Osburn, Fulhage, and Pfost (1994) on waste handling and application costs for pumped irrigation systems. Costs reported in that study were converted to 2000 costs using a suitable price index. The cost of the pump is included in the transfer component of the manure and wastewater handling and storage element, and so is not included here. Capital costs were based on the costs of a traveling fixed spray gun with 500 gallon per minute capacity. The annual cost for this spray gun is $2,969 after amortizing the total cost over 10 years with an 8 percent interest rate. To convert this cost to a cost per acre basis, the capacity of the system was assumed to be 2,000 acres per year (assuming the application rate of the traveling gun was 500 gallons per minute and the gun could be used 180 days per year at 16 hours per day). The capital costs were thus $1.48 per acre.

Operating costs were computed based on information reported in table 17 by Bennett, Osburn, Fulhage, and Pfost for a 100-cow herd. The following table values were used: 57 acre-inches pumped per year, 22 acres used for land application, and 16 hours annually for set up times. These values were used to calculate a set time of 0.73 hour per acre. Pipe laying and check time were 25 percent and 12.5 percent, respectively, of the set-up time. Total labor time was thus 22 hours, or 1 hour per acre. Using a labor rate of $10 per hour, the total operating cost for a 100-cow herd was $10 per acre.

Bennett, Osburn, Fulhage, and Pfost also reported significant per unit operating cost reductions as the scale of the operation increased. The relationship they found between farm size and total operating costs of the irrigation system is shown below.

Cows per farm	Acres w/manure applied per farm	Total operating cost	Operating cost per head	Size adjustment factor
100	22	1,098	10.98	1.000
200	33	1,683	8.42	0.766
300	41	2,156	7.19	0.655
500	61	3,213	6.43	0.585
750	80	4,316	5.75	0.524
1,000	100	5,515	5.52	0.502

(This information includes some operating costs we included in transport costs and in the manure and wastewater handling and storage element.)

This relationship was used to adjust the $10 per acre cost estimate for a small farm applying wastewater on 22 acres (100-cow herd) to a medium-size farm applying wastewater on 41 acres (300-cow herd) and a larger farm applying wastewater on 100 acres (1,000-cow herd). The per-acre estimate for the medium size farm is $6.55, and the per-acre estimate for the larger farm is $5.02. Using these three estimates of per-acre costs, the following function was derived for use in estimating the operating cost per acre according to the number of acres with manure applied on the farm:

x = acres with manure applied on the farm

a = operating cost per acre

If x < 22, then a= $10

If 22< x <41, then $a=10-\left[\frac{(x-22)}{(41-22)}\times(10-6.55)\right]$

If 41< x< 100, then $a=6.55-\left[\frac{(x-41)}{(100-41)}\times(6.55-5.02)\right]$

If x > 100, then a=$5.02

Calibration costs for the larger farms that use a big gun application method were assumed incidental to the cost of the big gun. It was assumed that a flow meter on the gun or pump would be used to determine the amount of application. Calculating wastewater applied over a measured area is a simple calibration. No calibration costs were assigned to the larger farms that apply their liquid using a big gun.

Summary of CNMP costs for nutrient management

The annual average cost for the nutrient management element of a CNMP was estimated to be $1,043 per farm (table 14). This breaks down into an average of $15 per farm for soil testing costs, $54 per farm for manure testing costs, $636 per farm for onfarm transport costs, and $338 per farm for land application costs on additional onfarm acres needed to meet CNMP criteria. The highest per-farm cost was for dairies, which averaged $2,101 per farm per year. Fattened cattle farms and swine farms were also high, averaging $1,655 and $1,601 per farm respectively. Confined heifer farms and veal farms were the next highest, averaging $1,153 per farm. The relatively high nutrient management cost for confined heifers and veal is not unexpected because one of the criteria used to identify a confined heifer or veal farm in the census was few pastureland or rangeland acres (see appendix A.) The remaining farms had low nutrient management costs ranging from $180 to $248 per farm. These estimates are deceptive for poultry farms and large farms generally, however, because many have negative costs (i.e., "savings") for onfarm transport that will be offset by higher off-farm transport costs.

Differences in nutrient management costs according to farm size were not pronounced (table 14). Large farms had the highest average cost, but small farms averaged within $100 of the cost for medium-size farms. Onfarm transport costs for small farms actually averaged more than for large farms, reflecting the "savings" that occurs for large farms with few acres available for land application. Differences by farm size were pronounced for land application costs, as would be expected.

On a per-farm basis, nutrient management costs were highest in the Northeast and lowest in the Delta States (table 15). Most regional differences in costs reflect differences in onfarm transport costs, which in turn are heavily influenced by the proportion of large farms and poultry farms in the region. Land application costs were about the same for all regions, varying by less than $150 per farm among the 10 regions.

Overall, annual nutrient management costs totaled $268 million. Costs in the Corn Belt region, the Lake States, and the Northeast region comprised about three-fourths of this total cost.

Table 14 Annual nutrient management costs per farm, by livestock type and farm size

Dominant livestock type or farm size class	Number of farms	Soil testing costs	Manure testing costs	Onfarm transport costs, baseline scenario	Onfarm transport costs, after-CNMP scenario	CNMP-related onfarm transport costs	Onfarm land application costs, baseline scenario	Onfarm land application costs, after-CNMP scenario	CNMP-related onfarm land application costs	Total cost for nutrient mgt. element
Fattened cattle	10,159	18	94	866	1,953	1,088	406	860	455	1,655
Milk cows	79,318	24	94	1,152	2,712	1,560	223	646	423	2,101
Swine	32,955	24	117	1,558	2,461	903	303	860	557	1,601
Turkeys	3,213	45	45	811	478	–333	606	1,080	474	230
Broilers	16,251	30	45	298	196	–102	382	657	276	248
Layers/Pullets	5,326	27	51	950	745	–204	377	647	270	144
Confined heifers/ veal	4,011	14	100	551	1,151	600	185	623	438	1,153
Small farms with confined live-stock types	42,565	3	0	37	41	4	37	232	196	203
Pastured live-stock types	61,272	2	0	34	38	3	31	236	205	211
Specialty live-stock types*	2,131	14	0	96	64	–32	167	365	198	180
Large farms (>10 tons P)	19,746	59	67	2,130	2,755	625	793	1,567	775	1,526
Medium-size farms (4-10 tons P)	39,437	24	67	1,133	1,683	549	265	710	444	1,085
Small farms (<4 tons P)	198,018	10	50	421	1,075	654	103	377	274	987
All CNMP farms	257,201	15	54	662	1,297	636	181	519	338	1,043

* Cost estimates were based on average costs for small broiler farms (35–60 broiler AU).

Table 15 Annual nutrient management costs per farm, by farm production region

Farm production region	Number of farms	Soil testing costs	Manure testing costs	Onfarm transport costs, baseline scenario	Onfarm transport costs, after-CNMP scenario	CNMP-related onfarm transport costs	Onfarm land application costs, baseline scenario	Onfarm land application costs, after-CNMP scenario	CNMP-related onfarm land application costs	Total cost for nutrient mgt. element
Appalachian	22,899	20	39	768	995	227	195	515	320	607
Corn Belt	71,540	12	54	597	1,162	565	148	491	343	973
Delta States	12,352	22	40	609	682	73	300	552	252	387
Lake States	52,817	14	67	556	1,564	1,007	135	476	341	1,430
Mountain	7,964	5	41	999	1,362	363	214	518	304	713
Northeast	31,598	25	68	644	1,864	1,220	180	579	400	1,713
Northern Plains	26,309	8	47	581	1,180	599	200	548	348	1,000
Pacific	7,974	23	48	1,421	1,772	351	230	621	391	813
Southeast	12,807	21	40	627	712	84	246	521	275	420
Southern Plains	10,941	17	44	914	1,158	245	273	564	291	597
All CNMP farms	257,201	15	54	662	1,297	636	181	519	338	1,043

Off-farm transport costs

Farms with excess manure after CNMPs are implemented need to transport the excess manure to surrounding properties for land application. Although the cost of off-farm land application is not included as a direct CNMP-related cost, it is assumed in this assessment that the livestock operation would bear the cost of off-farm transport.

As shown in table 8 and figure 15, 71,999 farms have CNMP-related off-farm transport costs. About two-thirds of these farms were already exporting some or all of their manure off the farm in the baseline scenario. As shown in the previous section, some of these farms exhibited a "cost savings" in terms of onfarm transport costs because the amount of manure applied on the farm decreased as producers shifted from current application rates to lower application rates in the after-CNMP scenario. This cost savings is offset by higher off-farm transport costs.

Off-farm transport costs are determined by the amount of manure to be exported and the off-farm distance the manure is transported. The distance manure is transported is a function of the acres required for manure application on manure receiving farms, which in turn is determined by the number of acres available for manure application and the application rate criteria. Application rate criteria for manure receiving farms were modeled the same as for CNMP farms in the after-CNMP scenario—application at nitrogen-standard rates. These application rate criteria for manure receiving farms were the same for both land application scenarios. (For details on land available for manure application and application rate criteria for manure receiving farms, see appendix B.)

In most counties sufficient acreage exists for off-farm land application of manure in accordance with NRCS nutrient management criteria. However, in some areas of the country the production of manure nutrients is so large that even if all the land available for manure application (under the assumptions of the model simulation) had manure applied, there would still be excess manure. This excess manure is categorized as county-level excess manure. There were 248 counties that had county-level excess manure in the after-CNMP scenario. (For more details on the calculation of county-level excess manure and the counties with excess manure, see appendix B.)

Altogether, the 71,999 farms without enough acres to meet CNMP application criteria export off the farm about two-thirds of all the recoverable manure produced after CNMPs are implemented (see appendix B, table B–13). About half of the recoverable manure nutrients are transported off the farm for application on surrounding properties within the county, and the remainder—about 16 percent—is county-level excess. Costs associated with manure exported off the farm for land application are called **within-county transport costs**.

County-level excess manure cannot be land applied within the county, but in most cases still must be transported off the farm. Costs associated with disposal and utilization of this county-level excess manure will be evaluated in Part II of this study, forthcoming. For the present study, however, a rough estimate is made for the costs of transporting the manure off the farm to a central processing facility in an adjacent county. Costs associated with export of county-level excess manure are called **out-of-county transport costs**.

Estimating off-farm transport costs

Off-farm transport costs were estimated for the baseline scenario and for the after-CNMP scenario, and the difference was used to represent expected off-farm transport costs associated with CNMP implementation. This approach was modified for farms in counties with excess manure. In these counties each farm's share of the county-level excess manure in the after-CNMP scenario was estimated and used to calculate out-of-county transport costs for each farm. For the portion of manure applied within the county, off-farm export costs were calculated as the difference between the baseline scenario and the after-CNMP scenario, as in counties without excess manure. For county-level excess manure, however, off-farm transport costs were based on **all** of the county-level excess manure estimated for each farm in the after-CNMP scenario. The transport distance used in the calculation for out-of-county export was the maximum off-farm transport distance in the county increased by 25 percent to simulate transporting the waste to a central processing facility in an adjacent county.

Separate cost estimates were made for solids and for manure and wastewater handled as a liquid or slurry using the same costs used to estimate onfarm transport costs. Within-county transport costs for solids were determined for each CNMP farm as follows:

Within-county transport costs = loading cost + (ton-miles)(cost per ton-mile)

where ton-miles is the average off-farm transport distance in miles multiplied times the tons of manure for within-county transport. Out-of-county transport costs for solids are calculated in the same manner except that the transport distance was based on the maximum off-farm transport distance increased by 25 percent and the tons of manure for out-of-county transport. The cost per ton mile is the same as for onfarm transport.

Off-farm transport costs for manure as a liquid or slurry, including wastewater from runoff storage ponds, were also calculated in the same manner as for onfarm transport costs. For the larger farms where pumping is used to transport liquids, off-farm transport costs are estimated as the cost per mile of pipe multiplied by the maximum distance that the wastewater is transported, and then increasing that estimate by 25 percent.

The average off-farm hauling distance was calculated for each farm using the same formula used to calculate onfarm hauling distance, but the terms in the equation were estimated differently. The term $N_M \times Q$, the amount of manure nutrients available for application, was estimated as the amount of farm-level excess manure nitrogen for each farm **excluding** the farm's share of county-level excess manure nitrogen. N_C is the average nitrogen application rate on acres in the county receiving manure. Since manure-receiving farms applied manure at nitrogen-standard rates in both scenarios, this term is about the same for both scenarios. (The after-CNMP scenario included additional acres on manure-receiving farms that could have yields different from the acres included in the baseline scenario, thus resulting in slightly different values of N_C for the two scenarios.) The willingness to accept manure, measured by γ was set at 0.5 to simulate that only 50 percent of the suitable manure-receiving farm acres in the county were used for manure application in the model simulation. The $\frac{1}{\alpha \times \beta}$ term was estimated using county-level statistics on total acres and cropland and pastureland acres available for land application of manure.

The willingness to accept manure can have a significant impact on the off-farm transport distance calculation, and thus on off-farm transport costs. It is not known what the willingness to accept is, but it is unlikely that it will be much higher than 50 percent in most areas of the country. Farmer survey results suggest that the percentage of acres actually receiving manure is much lower (Padgitt et al., 2000). In areas of high livestock production, however, the willingness to accept manure by nonlivestock producers is expected to be higher than in other areas because manure has been exported to surrounding properties for several years. To the extent that the 50 percent level is too high, these estimates of transport costs will be understated.

In counties with concentrated livestock production, the distance estimates are also likely to be understated. Livestock operations will be competing for a relatively scarce supply of off-farm acres available for application. The distance function does not account for this competition; it implicitly assumes that livestock operations are dispersed enough so that the off-farm acres needed would not be in use by another livestock operation.

Average off-farm transport distances were calculated for both the baseline scenario and the after-CNMP scenario. Table 16 summarizes the off-farm transport distance for counties with and without enough land. Farms **without** excess manure in the baseline scenario did not export manure off the farm prior to implementing a CNMP, so transport distance for the baseline scenario was zero. The median transport distance for these farms after CNMP implementation was about 0.4 mile both in counties with and without enough land. Farms **with** excess manure in the baseline scenario were already exporting manure off the farm, and needed to increase the amount exported after CNMP implementation. Median off-farm transport distance for farms with excess manure in the baseline scenario was higher—0.6 mile in counties with enough land and 0.8 mile in counties without enough land. Farms with excess manure in the baseline scenario in counties without enough land had almost no increase in transport distance because all of the available land was already receiving manure. (There were 64 counties without enough land after CNMPs were implemented that had enough land in the baseline scenario; farms in these counties had some off-farm capacity for land application, thus explaining the slight increase in transport distance for these farms. See appendix B for more details on off-farm land application.) Farm-level excess manure on farms in counties without enough land was exported out of the county in the simulation model using the maximum transport distance in the county, which ranged from 0.7 to 12.6 miles among counties without enough land. (These estimates do not include the 25 percent increase used for the cost calculations.)

The amount of manure to be transported off the farm was calculated as the difference between total manure produced and the amount applied on the farm. The out-of-county portion was calculated for each farm by distributing the total amount for the county to each farm in proportion to the amount of recoverable manure produced on each farm. Table 17 presents per-farm estimates of the tons of manure for off-farm transport both within the county and out of the county. (For farms with excess manure in the baseline scenario in counties without enough land, there was a slight decrease in the solids exported within the county, reflecting a change in the consistency of manure for some dairies as a result of CNMP implementation. The increase in liquid and slurry manure exported for application within the county for these farms reflects the additional land application capacity in the 64 additional counties without enough land in the after-CNMP scenario.)

Table 16 Off-farm transport distance*

Farm group	Number of farms	Baseline scenario, median transport distance (miles)	Baseline scenario, range of transport distance (miles)	After-CNMP scenario, median transport distance (miles)	After-CNMP scenario, range of transport distance (miles)	Increase in the median transport distance (miles)	Maximum transport distance in county, median (miles)	Maximum transport distance in county, range (miles)
Farms **without** excess manure in the baseline scenario								
Counties with enough land	18,481	0	0	0.38	0.06-2.71	0.38	NA	NA
Counties without enough land	5,956	0	0	0.37	0.04-1.98	0.37	3.31	0.69-12.62
Farms **with** excess manure in the baseline scenario								
Counties with enough land	28,362	0.46	0.08-5.63	0.57	0.09-6.52	0.11	NA	NA
Counties without enough land**	19,200	0.76	0.10-3.59	0.77	0.11-3.52	0.01	2.68	0.95-12.62

* Excludes CNMP farms with specialty livestock types.
** 64 of these counties did not have county-level excess manure in the baseline scenario and so had some additional capacity to receive off-farm manure applications in the after-CNMP scenario, explaining the slight increase in the average transport distance for this group.
Notes: Counties without enough land pertain to the after-CNMP scenario.
NA=not applicable.
Range is 1 percentile to 99th percentile.

Table 17 Amount of manure for off-farm transport*

	Number of CNMP farms	Within county transport						Out-of-county transport	
		Solids			Liquid and slurry			Solids	Liquid and slurry
		baseline scenario	after-CNMP scenario	change	baseline scenario	after-CNMP scenario**	change	after-CNMP scenario	after-CNMP scenario**
All CNMP farms									
Total	71,999	25,502,456	38,154,690	12,652,234	128,457,934	523,834,330	395,376,396	9,476,428	127,555,359
Per farm		354	530	176	1,784	7,276	5,491	132	1,772
Farms without excess manure in the baseline scenario									
Counties with enough land									
Total	18,481	0	4,615,217	4,615,217	0	122,611,788	122,611,788	0	0
Per farm		0	250	250	0	6,634	6,634	0	0
Counties without enough land									
Total	5,956	0	701,805	701,805	0	23,658,990	23,658,990	813,336	26,328,966
Per farm		0	118	118	0	3,972	3,972	137	4,421
Farms with excess manure in the baseline scenario									
Counties with enough land									
Total	28,362	19,895,674	27,258,182	7,362,509	96,025,905	306,936,870	210,910,965	0	0
Per farm		701	961	260	3,386	10,822	7,436	0	0
Counties without enough land***									
Total	19,200	5,606,081	5,578,158	-27,924	32,428,643	70,605,252	38,176,609	8,662,956	101,221,972
Per farm		292	291	-1	1,689	3,677	1,988	451	5,272

* Excludes CNMP farms with specialty livestock types.
** Includes additional tons of wastewater from runoff storage ponds installed to meet CNMP criteria.
*** 64 of these counties did not have county-level excess manure in the baseline scenario and so had some additional capacity to receive off-farm manure applications in the after-CNMP scenario.
Note: Counties without enough land pertain to the after-CNMP scenario.

Summary of CNMP costs for off-farm transport

The annual average cost for the additional off-farm export of manure that would occur because of CNMP implementation was estimated to be $1,358 per farm averaged over all CNMP farms (table 18), although as shown previously, only 28 percent of CNMP farms would have off-farm transport costs. When averaged over only the farms with off-farm transport costs, the average annual cost per farm was $4,851. Less than half of this cost was for within-county transport—$509 per farm averaged over all farms, or $1,818 per farm for the 71,999 farms with off-farm export. The majority of the cost was for out-of-county transport of county-level excess manure, averaging $849 per farm when averaged over all CNMP farms and averaging $8,680 per farm for the 25,156 farms with off-farm export in the 248 counties without enough land.

Poultry farms had the largest off-farm transport costs when averaged over all CNMP farms because most of the poultry farms had excess manure, as shown in table 10. The annual average cost was $7,414 per farm for layer and pullet farms, $6,169 per farm for turkey farms, and $1,667 per farm for broiler farms (table 18). The per-farm cost for broilers was much lower than that for layers, pullets, and turkeys because the average broiler farm is much smaller. When adjusted for the number of animal units on the farm, the broiler costs were similar to the costs for turkey farms (see appendix B, table B–8 for estimates of AU per farm.) These high off-farm export costs more than offset the "savings" calculated for onfarm transport costs for poultry. The highest annual off-farm transport costs for farms with excess manure were for fattened cattle, averaging $23,297 for the 2,026 fattened cattle farms with excess manure.

Table 18 Annual off-farm transport costs per farm, by livestock type and farm size

Dominant livestock type or farm size class	Number of farms	In-county off-farm transport costs, baseline scenario	In-county off-farm transport costs, after-CNMP scenario	CNMP-related in-county off-farm transport costs	Transport costs for county-level excess manure	Total off-farm transport cost, projected over all CNMP farms	Total off-farm transport cost, projected over CNMP farms with excess manure
Fattened cattle	10,159	2,984	7,326	4,342	304	4,646	23,297
Milk cows	79,318	418	916	497	1,121	1,619	9,487
Swine	32,955	1,053	1,876	823	1,627	2,450	6,343
Turkeys	3,213	2,828	4,774	1,946	4,223	6,169	6,253
Broilers	16,251	764	961	197	1,470	1,667	1,723
Layers/Pullets	5,326	2,990	4,141	1,151	6,263	7,414	7,864
Confined heifers/veal	4,011	525	1,633	1,108	302	1,410	3,130
Small farms with confined livestock types	42,565	9	12	3	13	16	59
Pastured livestock types	61,272	4	6	1	2	3	29
Specialty livestock types	2,131	0	0	0	0	0	0
Large farms (>10 tons P)	19,746	5,125	9,493	4,368	5,311	9,679	12,218
Medium-size farms (4–10 tons P)	39,437	572	1,114	542	1,739	2,281	4,743
Small farms (<4 tons P)	198,018	75	193	118	227	345	1,827
All CNMP farms	257,201	539	1,049	509	849	1,358	4,851

Large farms had the highest off-farm transport costs. Farms that produce more than 10 tons of phosphorus annually had an annual average off-farm transport cost of $9,679 (table 18). The annual average cost was $2,281 per farm for medium-size farms and $345 per farm for small farms. When projected only over the farms with excess manure, the annual average cost was $12,218 per farm for large farms, $4,743 per farm for medium-size farms, and $1,827 per farm for small farms.

The regional distribution of off-farm transport costs is presented in table 19. The highest average cost was for livestock operations in the Pacific region, which proportionately has more large farms than other regions. (About 25 percent of the 7,974 CNMP farms in the Pacific States are large farms, which is three times the national percentage. See table 6.). The lowest off-farm transport costs were in the Lake States, the Corn Belt, the Northern Plains, and the Northeast, where there is generally more land available for manure application on livestock operations and the proportion of large farms is low (less than 9 percent for all four regions).

Overall, annual off-farm transport costs totaled $349 million. Costs in the Pacific region, the Southeast region, and the Appalachian region comprised over half of this total cost.

Table 19 Annual off-farm transport costs per farm, by farm production region

Farm production region	Number of farms	In-county off-farm transport costs, baseline scenario	In-county off-farm transport costs, after-CNMP scenario	CNMP-related in-county off-farm transport costs	Transport costs for county-level excess manure	Total off-farm transport cost
Appalachian	22,899	527	832	305	2,417	2,722
Corn Belt	71,540	270	572	302	78	380
Delta States	12,352	449	678	229	1,637	1,865
Lake States	52,817	162	372	210	48	258
Mountain	7,964	2,579	4,729	2,150	123	2,274
Northeast	31,598	127	367	241	790	1,031
Northern Plains	26,309	598	1,468	870	107	977
Pacific	7,974	2,870	5,004	2,134	8,564	10,698
Southeast	12,807	906	1,303	397	2,556	2,953
Southern Plains	10,941	1,686	3,400	1,714	450	2,164
All CNMP farms	257,201	539	1,049	509	849	1,358

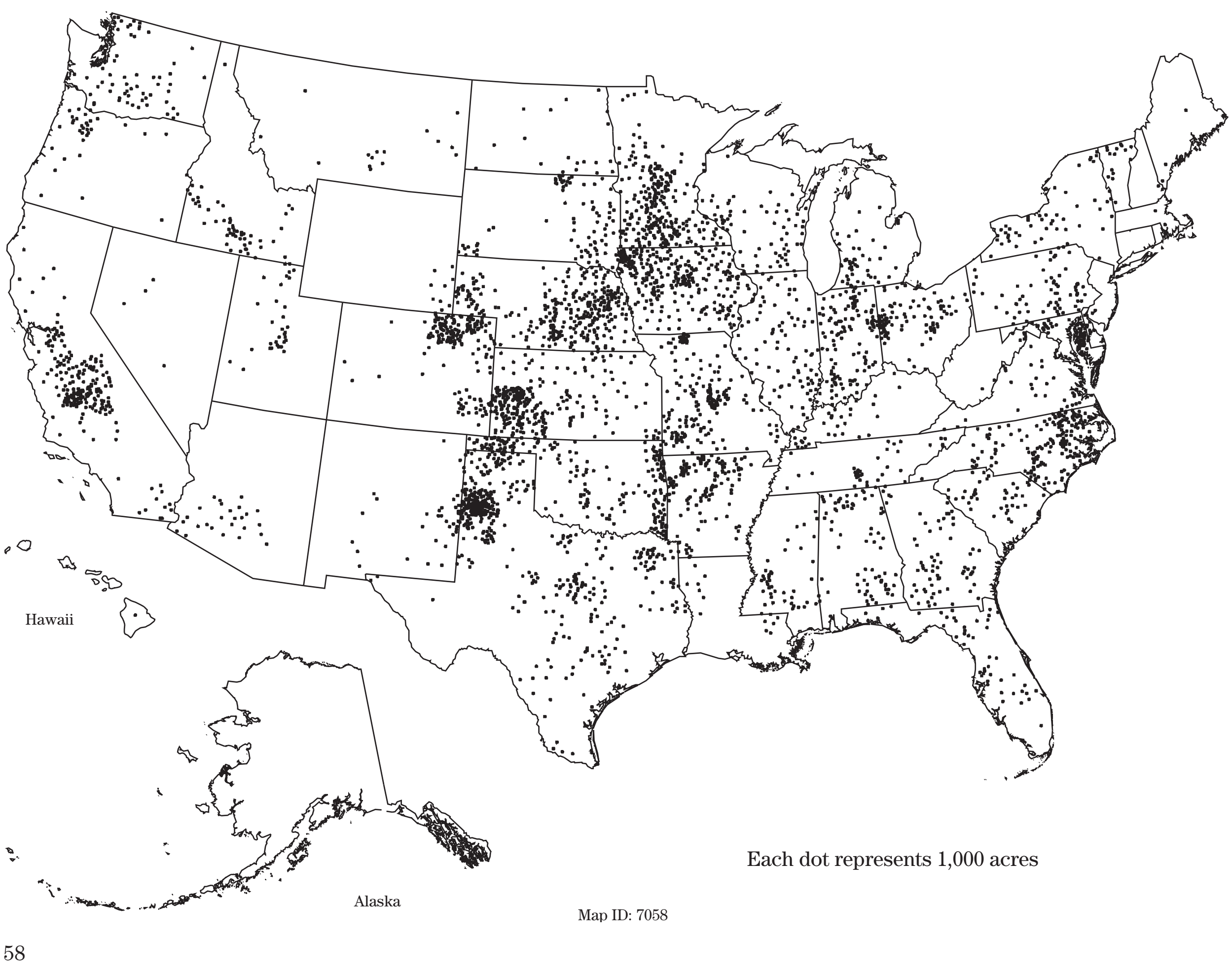
Off-farm nutrient management costs

As indicated in the previous chapter and in appendix B, about half of all the recoverable manure produced after CNMPs are implemented is transported off the farm for land application on surrounding properties within the county (i.e., acres on manure receiving farms). This represents an increase of about 20 percent over the amount exported for land application within the county in the baseline scenario (appendix B, table B–13). The additional acres required for land application of this manure is about 4 million acres, shown in figure 17. It is expected that manure-receiving farms will adopt the appropriate nutrient management practices on acres with manure applied. Thus, application rate criteria for manure receiving farms were modeled the same as for CNMP farms with enough land to meet nutrient management criteria in the after-CNMP scenario—application at nitrogen-standard rates. (See appendix B for a detailed documentation.)

Under the assumptions of this assessment, costs associated with off-farm land application of manure on these additional acres would be borne by the manure-receiving farm and not the livestock operation. Some of these costs will be offset by reductions in the cost of commercial fertilizer and benefits from enhanced soil quality. No adjustment was made for these benefits.

Costs included land application costs and soil testing costs for additional acres with manure applied. Specific manure receiving farms that had manure applied

Figure 17 Additional off-farm acres required to meet CNMP application criteria (4.0 million acres)



were not identified. Instead, all available acres on manure-receiving farms in the county were treated as if they were all on one large farm. Land application costs and soil testing costs were estimated in the same manner and with the same per-unit costs as used to calculate onfarm land application and soil testing costs. The application costs per acre used for onfarm land application were lower for farms with larger volumes of manure. The proportion of acres in each cost category for manure-receiving farms was estimated based on the proportion of acres in each cost category among the livestock operations in the county.

Off-farm land application costs and soil testing costs are shown in table 20. Costs are expressed as a per-farm cost for CNMP farms so that estimates can readily be compared to CNMP-related costs. Averaged over all CNMP farms, the number of additional acres with manure applied is 16 acres per farm and the average annual off-farm nutrient management cost was $98 per farm. When averaged over only the 71,999 farms with off-farm export of manure, the number of additional acres with manure applied is 56 acres per farm and the average annual off-farm nutrient management cost was $351 per farm. The highest cost per CNMP farm was in the Southern Plains, the Northern Plains, and the Mountain states.

The total cost over all regions was $25.3 million. The highest total costs were for the Corn Belt region—$4.8 million—because of the large number of farms with excess manure. The second highest total cost was for the Southern Plains—$4.3 million. The lowest regional costs were for the Northeast ($1.2 million), the Delta States ($1.3 million), the Southeast ($1.6 million), and the Appalachian region ($1.9 million).

Table 20 Nutrient management costs for additional acres on manure receiving farms with manure applied because of CNMP implementation

Farm production region	Number of CNMP farms	Off-farm acres with manure applied, baseline scenario	Off-farm acres with manure applied, after-CNMP scenario	Additional off-farm acres with manure applied	Off-farm land application costs, baseline scenario	Off-farm land application costs, after-CNMP scenario	Off-farm land application costs	Soil testing costs	Total costs
	Average annual costs per CNMP farm, projected over all CNMP farms								
Appalachian	22,899	40	52	12	235	312	77	5	82
Corn Belt	71,540	19	29	11	110	175	65	3	67
Delta States	12,352	78	93	15	450	546	96	6	102
Lake States	52,817	12	19	7	71	112	40	2	42
Mountain	7,964	81	125	44	440	699	259	4	262
Northeast	31,598	14	20	6	80	117	37	2	40
Northern Plains	26,309	33	58	25	174	317	143	3	146
Pacific	7,974	111	150	39	575	825	249	12	262
Southeast	12,807	99	116	18	567	684	117	7	124
Southern Plains	10,941	138	200	62	741	1,118	377	12	389
All regions	257,201	37	52	16	207	301	94	4	98
	Average annual cost per CNMP farm, projected over CNMP farms with excess manure								
Appalachian	9,269	99	129	30	580	771	191	12	203
Corn Belt	14,738	91	143	52	535	849	314	13	327
Delta States	7,447	129	154	25	747	906	159	10	169
Lake States	7,267	89	137	48	519	811	291	14	305
Mountain	2,837	228	352	124	1,235	1,961	726	10	736
Northeast	7,816	56	81	25	323	473	150	10	160
Northern Plains	5,014	174	307	133	913	1,662	749	14	764
Pacific	4,746	186	253	66	966	1,385	419	21	440
Southeast	8,392	151	177	27	866	1,044	178	11	189
Southern Plains	4,473	337	488	152	1,814	2,736	922	29	951
All regions	71,999	132	187	56	738	1,076	337	13	351

Land treatment costs

Runoff and soil erosion need to be at acceptable levels on fields where manure is applied to prevent manure and manure nutrients from being carried to rivers and streams with the runoff. A CNMP therefore includes criteria for soil erosion control on land on which manure is applied. At a minimum the conservation systems that need to be installed as part of a CNMP must meet NRCS Quality Criteria for soil erosion (see section III of the Field Office Technical Guide). Presently, States have established that the quality criterion for soil erosion is the sustainability level for crop production. The sustainability level of soil for crop production is also referred to as the soil loss tolerance level, or T. Fields with erosion rates greater than T need to have conservation practices installed that would reduce the erosion rate to T or less before manure can be applied.

Land treatment costs were calculated for all onfarm acres where manure would be applied after CNMP implementation. Erosion controls would also be expected to apply to off-farm land application. In the model simulation, however, it was assumed that land on manure-receiving farms with erosion rates greater than T would not be available for manure application because of the potential for additional costs. (See appendix B for criteria on land available for manure application.) It was also assumed that CNMP farms would bear the costs of land treatment rather than seek options to onfarm land application.

Estimating acres required for land treatment

The number of acres for which land treatment practices would be expected depends on the number of onfarm acres needed for manure application to meet CNMP application criteria and the portion of those acres that have soil erosion rates greater than T.

For calculating land treatment costs, application rate criteria for the after-CNMP scenario differed from criteria used to calculate nutrient management costs. Acres that would potentially need land treatment would include **all** the acres that would receive manure over **all** the years. Thus, for calculating land treatment costs, application rate criteria for the after-CNMP scenario were simulated using phosphorus-based application rates for all farms where phosphorus was the limiting nutrient. Nitrogen-based application rates were used only for farms where nitrogen was the limiting nutrient. (Nitrogen was the limiting nutrient on only a few farms.) The number of acres that would receive manure over time includes about 9.8 million more acres than the 14.8 million used to calculate nutrient management costs in the after-CNMP scenario. (See appendix B for details on how land with manure applied was estimated.)

The number of acres with manure applied over time is presented in table 21, categorized by Land Resource Regions. The Land Resource Region was the geographic unit used to define land treatment needs and costs because soils, climate, water resources, land uses, and type of farming tend to be similar within each region. (A map of Land Resource Regions is presented in figure 16.) The model simulation shows that manure would be applied on 24.6 million onfarm acres over time, equivalent to an average of 96 acres per CNMP farm. The vast majority was cropland acres; pastureland acres comprised only about 11 percent of the total.

Only a portion of these acres, however, would have erosion at rates greater than T. The National Resources Inventory (NRI) was used to obtain estimates of existing soil erosion rates (USDA, ERS, 2000b). The soil erosion rates contained in the NRI were calculated using the Universal Soil Loss Equation (USLE), which is an estimate of sheet and rill erosion that is caused by rainfall and runoff. (Land treatment to control wind erosion was not included in the analysis since the purpose of a CNMP is to protect water quality.)

NRI data for the year 1997 were used, which is the most recent year for which NRI data exist for the full set of NRI sample points. County-level estimates of the number of acres with erosion rates of T to 2T, 2T to 4T, and greater than 4T were obtained from the NRI database. Separate estimates were made for cropland and pastureland. The percentage of cropland and pastureland acres in each county that was in each erosion category was calculated. These percentages were then applied to the cropland and pastureland acreage on each farm in the Census of Agriculture to estimate the acres on each farm that were in each erosion category. Since NRI data are for counties, and not individual farms, it was necessary to assume that all acres receiving manure on a farm had the same erosion profile as the county.

About 5.9 million onfarm acres are expected to have manure applied **and** have sheet and rill erosion rates greater than T after CNMPs are implemented (table 22). This subset represents about 24 percent of the acres with manure applied on CNMPs over time. The Land Resource Region **S**, which is in the Northeast, had the highest proportion of manured acres with erosion rates above T—47 percent. Other regions with relatively high proportions of manured acres with erosion rates greater than T were **R** (34 percent, also in the Northeast), **N** (31 percent), **P** (29 percent), and **M** (27 percent). These five regions contain 82 percent of all the manured acres with erosion rates above T. Onfarm acres with manure applied and sheet and rill erosion rates above T are shown in figure 18. There are few acres in the West because of low rainfall and few cropland acres.

As shown in table 22, the bulk (55 percent) of the manured acres with erosion rates above T were for cropland with sheet and rill erosion rates between T and 2T. Cropland acres with erosion rates between 2T

Table 21 Total acres that would receive manure over time after CNMP implementation

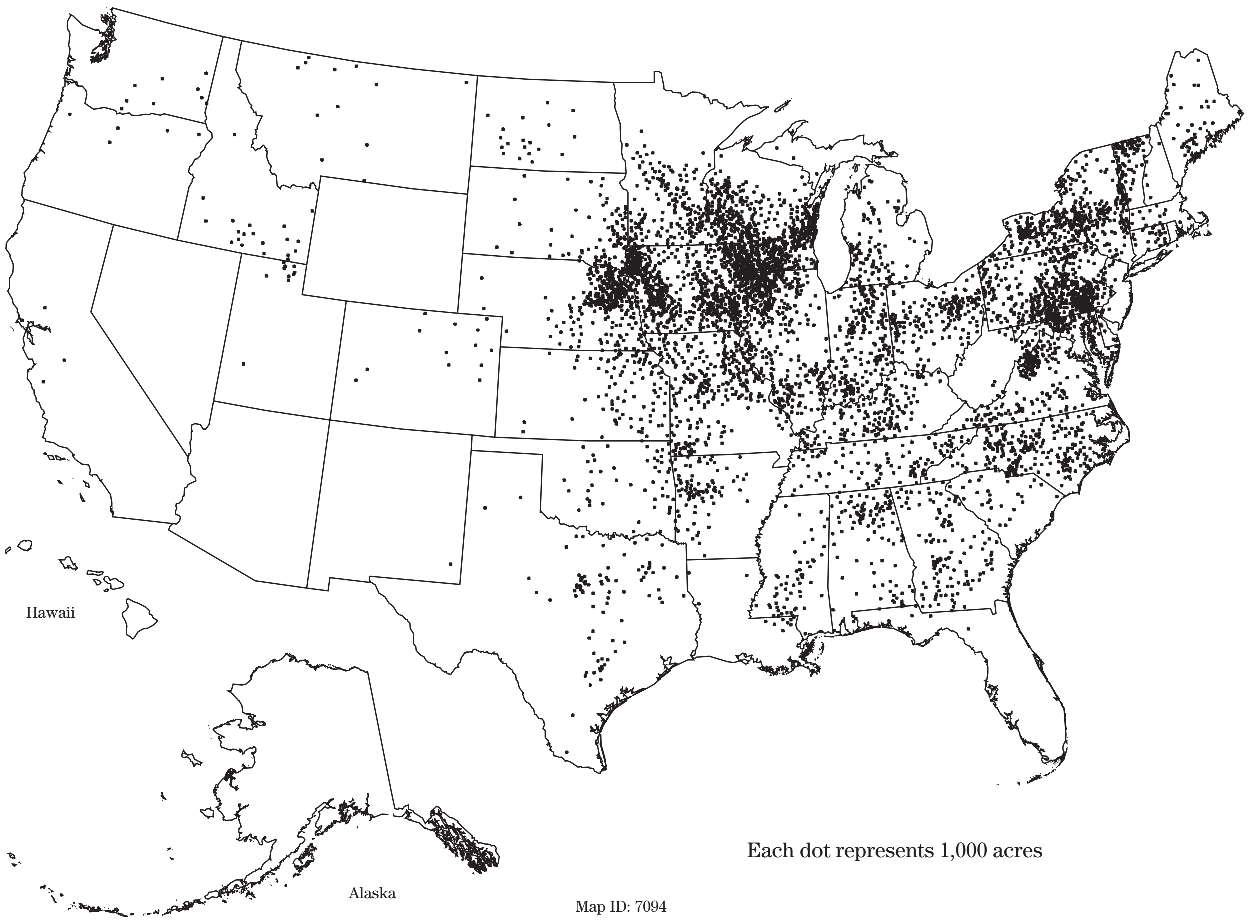
Land resource region	Number of farms	Cropland acres with manure applied	Pastureland acres with manure applied	Total	Acres per CNMP farm
A	2,127	135,372	59,057	194,429	91
B	2,849	170,870	41,705	212,575	75
C	3,432	432,909	65,148	498,057	145
D	3,050	206,426	39,302	245,729	81
E	1,211	76,555	18,451	95,006	78
F	5,476	667,232	45,477	712,709	130
G	3,597	348,381	36,013	384,394	107
H	11,358	1,077,157	141,890	1,219,047	107
I	707	26,549	15,642	42,192	60
J	3,243	153,430	101,452	254,882	79
K	26,870	2,463,985	108,785	2,572,770	96
L	11,504	1,274,577	60,164	1,334,741	116
M	89,240	8,758,072	429,473	9,187,545	103
N	32,171	1,514,743	607,140	2,121,884	66
O	1,041	40,110	21,818	61,928	59
P	23,770	1,365,719	579,174	1,944,893	82
R	14,694	1,500,260	105,557	1,605,817	109
S	13,429	1,160,135	149,806	1,309,941	98
T	4,508	492,651	42,335	534,986	119
U	608	27,523	30,469	57,992	95
V	154	13	6,291	6,304	41
W	31	3,350	10	3,360	108
All regions	255,070	21,896,019	2,705,160	24,601,179	96

and 4T comprised 29 percent, and cropland acres with erosion rates greater than 4T comprised 14 percent. Only about 3 percent of the 5.9 million acres with erosion rates above T were pastureland acres.

Table 22 Acres with manure applied **and** with sheet and rill erosion rates above T

Land resource region (LRR)	Cropland acres with manure applied — erosion rate 1–2 T	2–4 T	>4 T	Pastureland acres with manure applied — erosion rate 1–2 T	2–4 T	>4 T	All acres with manure applied and erosion rate above T — total acres	% of total	% of acres in each LRR
A	3,272	501	385	170	201	88	4,617	0.1	2.4
B	19,462	9,005	854	336	366	22	30,044	0.5	14.1
C	1,864	351	691	776	215	0	3,897	0.1	0.8
D	9,760	3,249	1,706	374	238	5	15,332	0.3	6.2
E	4,359	1,153	951	60	12	4	6,539	0.1	6.9
F	26,758	5,225	1,194	544	140	0	33,861	0.6	4.8
G	9,977	3,516	1,548	93	108	25	15,267	0.3	4.0
H	82,521	23,390	6,440	4,299	52	0	116,702	2.0	9.6
I	5,069	755	207	45	5	10	6,091	0.1	14.4
J	33,768	14,059	2,427	2,263	1,268	173	53,959	0.9	21.2
K	288,667	129,927	49,594	998	569	0	469,756	7.9	18.3
L	147,049	81,486	37,206	1,154	149	33	267,077	4.5	20.0
M	1,382,185	714,559	325,550	14,423	4,765	757	2,442,239	41.3	26.6
N	303,485	194,390	99,295	38,389	18,506	6,582	660,647	11.2	31.1
O	4,623	397	191	578	51	2	5,842	0.1	9.4
P	291,612	144,029	110,146	14,621	6,876	2,355	569,640	9.6	29.3
R	298,759	162,399	80,675	828	189	92	542,941	9.2	33.8
S	270,700	202,425	111,397	14,014	10,807	4,120	613,463	10.4	46.8
T	40,841	7,649	2,344	64	53	0	50,950	0.9	9.5
U	741	0	0	2	0	0	743	0.0	1.3
V	1	0	0	412	80	53	546	0.0	8.7
W	335	0	0	1	0	0	336	0.0	10.0
All regions	3,225,809	1,698,465	832,801	94,442	44,650	14,322	5,910,488	100.0	24.0

Figure 18 Onfarm acres with manure applied and sheet and rill erosion rates above T (5.9 million acres)



Estimating per-acre costs for conservation systems

Land treatment costs were determined by estimating the cost of installing conservation systems, consisting of a collection of conservation practices, needed to reduce sheet and rill erosion to T on the 5.9 million acres with manure applied and with erosion rates above T. Generally, a conservation system needed to control erosion for acres with rates between 1 and 2 T would be less extensive and cost less to implement than a conservation system needed to control erosion for acres with higher erosion rates. The collection of conservation practices that comprise a conservation system vary according to the characteristics of the resource base—such as the soil type, climate, and topography—and the crops grown.

To capture these regional differences in the conservation systems needed to control erosion, conservation systems were derived for each state or groups of states in each Land Resource Region and for each of the three erosion categories. Separate conservation systems were derived for cropland and pastureland. Examples of these conservation systems for cropland are shown in appendix D, table D–1 for region **S** in the Northeast, table D–2 for region **M** in the Midwest, and table D–3 for region **R**, also in the Northeast. (Cropland acres in these three regions accounted for about 75 percent of the total land treatment cost.) To account for differences in soil types, topography, and climate, more than one conservation system were often derived for a given State and Land Resource Region. Where this occurred, an estimate was made of the proportion of the acres that would be expected to need each conservation system, which was then used to calculate a weighted average cost for the State.

A per-acre cost of implementing each conservation practice was estimated (see tables D–1 to D–3 in appendix D). Conservation practice costs were obtained from state costs lists in the NRCS Field Office Technical Guides. State cost lists contain the typical cost of implementing a conservation practice and its components in that state. Cost lists reflect current information based on actual installations associated with various USDA programs, and are updated frequently. Thus, the cost of a particular conservation practice will often vary from state to state. Structural practices were annualized by amortizing over 10 years at 8 percent interest, as was done in this study for other capital investment items. A summary of per-acre costs for each land use and erosion category is presented in table 23.

Table 23 Average cost per acre for conservation systems needed to control sheet and rill erosion

Land Resource Region	State	Cropland with erosion rate 1-2T	Cropland with erosion rate 2-4T	Cropland with erosion rate >4T	Pastureland with erosion rate 1-2T	Pastureland with erosion rate 2-4T	Pastureland with erosion rate >4T
A	California	54.12	54.12	54.12	0.00	0.00	0.00
A	Oregon	38.74	38.74	38.74	0.00	0.00	0.00
A	Washington	29.00	29.00	29.00	0.00	0.00	0.00
B	Idaho	5.28	5.61	5.61	0.00	0.00	0.00
B	Oregon	17.29	21.43	21.43	0.00	0.00	0.00
B	Washington	6.94	7.85	7.85	0.00	0.00	0.00
C	California	24.16	24.16	24.16	0.00	0.00	0.00
D	Arizona	6.81	6.81	6.81	0.00	0.00	0.00
D	California	24.16	24.16	24.16	0.00	0.00	0.00
D	Colorado	9.04	9.04	9.04	2.14	2.14	2.14
D	Idaho	5.65	5.65	5.65	0.00	0.00	0.00
D	Nevada	13.50	13.50	13.50	0.00	0.00	0.00
D	New Mexico	10.65	10.65	10.65	0.00	0.00	0.00
D	Oregon	16.56	16.56	16.56	0.00	0.00	0.00

Table 23 Average cost per acre for conservation systems needed to control sheet and rill erosion—Continued

Land Resource Region	State	Cropland with erosion rate 1-2T	Cropland with erosion rate 2-4T	Cropland with erosion rate >4T	Pastureland with erosion rate 1-2T	Pastureland with erosion rate 2-4T	Pastureland with erosion rate >4T
D	Texas	21.46	21.93	21.93	10.04	15.52	15.52
D	Utah	12.38	12.38	12.38	0.00	0.00	0.00
D	Wyoming	7.40	7.40	7.40	7.47	7.47	7.47
E	Colorado	8.80	14.42	14.42	2.47	2.47	2.47
E	Idaho	1.94	1.94	1.94	0.00	0.00	0.00
E	Montana	5.16	12.76	12.76	5.81	5.81	5.81
E	New Mexico	2.70	2.70	2.70	0.00	0.00	0.00
E	Oregon	7.10	7.10	7.10	0.00	0.00	0.00
E	Utah	1.64	1.64	1.64	0.00	0.00	0.00
E	Washington	1.52	1.52	1.52	0.00	0.00	0.00
E	Wyoming	8.02	10.68	10.68	6.49	6.49	6.49
F	Minnesota	22.27	22.27	35.77	6.10	6.10	6.10
F	Montana	7.14	7.14	7.14	5.81	5.81	5.81
F	North Dakota	15.63	15.63	15.63	5.42	5.42	5.42
F	South Dakota	13.47	13.47	13.47	14.76	14.76	14.76
G	Colorado	4.51	4.51	4.51	2.14	2.14	2.14
G	Montana	2.52	2.52	2.52	3.38	3.38	3.38
G	Nebraska	6.89	6.89	6.89	8.75	8.75	8.75
G	New Mexico	11.20	11.20	11.20	0.00	0.00	0.00
G	South Dakota	5.78	5.78	5.78	14.22	14.22	14.22
G	Wyoming	6.32	6.32	6.32	7.47	7.47	7.47
H	Colorado	17.32	40.86	40.86	7.39	7.39	7.39
H	Kansas	14.91	45.27	45.27	12.83	12.83	12.83
H	Nebraska	16.48	36.40	36.40	20.43	20.43	20.43
H	New Mexico	54.61	59.52	59.52	0.00	0.00	0.00
H	Oklahoma	28.65	28.65	30.68	50.57	63.68	63.68
H	Texas	40.48	40.48	44.72	53.88	83.47	83.47
I	Texas	20.59	42.65	47.87	43.88	73.47	83.47
J	Kansas	24.35	52.96	62.92	66.03	78.58	95.15
J	Oklahoma	19.24	19.40	30.55	50.47	62.84	82.41
J	Texas	22.31	28.89	51.30	58.10	82.70	111.02
K	Illinois	51.66	64.18	64.18	31.37	42.86	93.38
K	Michigan	37.15	48.33	48.33	83.08	116.61	163.18
K	Minnesota	55.35	73.80	73.80	38.81	58.02	132.15
K	Wisconsin	47.90	47.90	47.90	36.83	51.22	129.88
L	Indiana	45.22	45.22	45.22	46.63	67.39	301.36
L	Michigan	37.15	37.15	37.15	83.08	116.61	206.03
L	New York	36.87	36.87	36.87	59.89	87.36	165.68
L	Ohio	31.19	31.19	31.19	84.79	108.63	321.79
L	Wisconsin	35.70	35.70	37.63	42.68	57.07	152.40

Table 23 Average cost per acre for conservation systems needed to control sheet and rill erosion—Continued

Land Resource Region	State	Cropland with erosion rate 1-2T	Cropland with erosion rate 2-4T	Cropland with erosion rate >4T	Pastureland with erosion rate 1-2T	Pastureland with erosion rate 2-4T	Pastureland with erosion rate >4T
M	Illinois	155.61	155.61	155.61	30.53	49.56	93.42
M	Indiana	70.55	70.55	70.55	68.85	70.82	70.82
M	Iowa	67.19	90.70	222.63	51.37	113.83	172.78
M	Kansas	11.54	28.19	78.30	8.90	17.09	23.58
M	Michigan	61.50	71.40	90.16	78.48	97.12	156.87
M	Minnesota	113.98	116.00	120.84	46.31	58.05	132.18
M	Missouri	51.76	99.42	117.47	41.20	57.63	107.14
M	Nebraska	13.06	38.12	68.48	12.63	37.99	46.72
M	Ohio	35.37	36.95	44.85	78.29	102.20	142.86
M	Oklahoma	16.90	27.16	39.23	24.11	39.84	50.64
M	South Dakota	12.52	37.58	88.23	15.17	24.72	35.15
M	Wisconsin	51.78	52.84	64.60	21.86	48.77	129.95
N	Alabama	60.04	63.97	63.97	83.91	83.91	83.91
N	Arkansas	25.48	42.26	44.07	49.04	58.35	64.92
N	Georgia	38.50	57.79	57.79	71.00	71.00	71.00
N	Illinois	35.46	68.19	102.01	30.53	45.79	97.61
N	Indiana	35.07	65.87	97.78	39.57	65.00	127.06
N	Kentucky	47.30	47.30	47.30	79.19	79.19	79.19
N	Maryland	44.72	51.50	90.24	71.70	81.99	99.91
N	Missouri	30.15	58.27	86.40	41.20	53.05	110.44
N	N. Carolina	53.68	53.68	53.68	67.82	527.29	527.29
N	Ohio	35.37	36.95	44.85	78.29	102.13	142.79
N	Oklahoma	21.57	32.77	33.95	50.47	62.84	74.09
N	Pennsylvania	65.18	74.04	113.98	61.12	67.40	78.71
N	Tennessee	67.57	67.57	67.57	102.44	102.44	102.44
N	Virginia	78.00	85.28	85.28	114.35	114.35	114.35
N	West Virginia	54.21	57.26	108.82	39.30	46.31	59.84
O	Arkansas	18.21	25.33	58.78	49.04	58.35	58.35
O	Illinois	35.35	59.16	152.27	54.18	61.29	61.29
O	Louisiana	22.87	24.14	65.45	49.93	60.84	60.84
O	Mississippi	43.94	57.45	163.35	77.11	91.12	91.12
O	Missouri	20.64	42.15	175.92	43.00	69.83	69.83
O	Tennessee	32.78	44.26	111.47	87.23	100.59	100.59
P	Alabama	39.20	83.86	83.86	55.91	56.99	56.99
P	Arkansas	30.18	30.18	44.56	49.04	58.35	64.92
P	Florida	55.29	90.53	90.53	48.39	49.37	49.37
P	Georgia	38.50	72.15	72.15	68.47	68.47	68.47
P	Illinois	41.48	155.89	160.02	54.18	61.29	66.02
P	Kentucky	125.82	162.48	201.53	60.33	65.54	67.78
P	Louisiana	29.53	29.53	49.66	49.93	60.84	69.73
P	Mississippi	0.00	0.00	0.00	71.74	72.72	72.72
P	N. Carolina	34.13	42.95	42.95	646.29	670.71	670.71
P	Oklahoma	21.69	21.69	32.84	50.47	62.84	74.09

Table 23 Average cost per acre for conservation systems needed to control sheet and rill erosion—Continued

Land Resource Region	State	Cropland with erosion rate 1-2T	Cropland with erosion rate 2-4T	Cropland with erosion rate >4T	Pastureland with erosion rate 1-2T	Pastureland with erosion rate 2-4T	Pastureland with erosion rate >4T
P	S. Carolina	167.16	212.98	261.23	79.19	102.74	104.68
P	Tennessee	108.49	138.32	170.07	94.99	100.51	102.44
P	Texas	31.45	35.56	57.05	58.10	82.70	99.84
P	Virginia	48.45	64.10	64.10	93.20	121.03	121.03
R	Connecticut	80.93	220.51	306.73	147.33	370.40	473.12
R	Maine	84.50	228.46	288.92	162.74	424.21	521.57
R	Massachusetts	75.84	257.79	401.50	99.65	371.91	470.48
R	N. Hampshire	89.40	396.49	407.16	164.97	641.82	834.19
R	New Jersey	75.50	226.57	280.64	145.86	391.17	496.91
R	New York	59.36	183.01	215.80	114.33	284.41	366.04
R	Ohio	55.37	258.25	417.77	276.13	653.21	887.11
R	Pennsylvania	85.95	188.83	316.70	149.43	300.74	345.54
R	Rhode Island	89.47	245.08	307.54	346.78	638.14	774.89
R	Vermont	66.73	182.51	243.06	157.20	374.21	491.73
S	Delaware	75.32	162.63	162.63	106.50	209.57	237.28
S	Maryland	76.92	135.37	135.37	138.73	244.22	273.12
S	Massachusetts	89.16	205.58	205.58	264.51	288.27	288.27
S	New Jersey	77.06	143.27	143.27	78.87	142.46	159.02
S	New York	62.19	173.46	173.46	122.12	131.40	131.40
S	Pennsylvania	86.50	226.21	226.21	78.87	142.46	159.02
S	Virginia	70.79	135.27	135.27	129.64	407.31	487.96
S	West Virginia	68.88	164.96	164.96	59.99	100.67	111.92
T	Delaware	60.90	90.11	142.49	57.48	116.25	116.25
T	Florida	58.85	58.85	58.85	52.49	75.31	75.31
T	Georgia	38.50	57.79	57.79	69.74	69.74	69.74
T	Louisiana	22.87	24.14	65.45	60.84	60.84	60.84
T	Maryland	58.02	92.33	154.17	54.35	138.59	138.59
T	Mississippi	37.99	37.99	37.99	79.19	102.74	102.74
T	N. Carolina	60.43	60.43	60.43	50.55	74.97	74.97
T	New Jersey	73.62	127.80	237.64	53.25	53.25	53.25
T	S. Carolina	48.79	48.79	48.79	79.19	102.74	102.74
T	Texas	14.00	22.23	74.68	0.00	82.70	82.70
T	Virginia	49.53	49.53	49.53	93.20	117.89	117.89
U	Florida	54.16	54.16	54.16	46.96	46.96	46.96
V	Hawaii	24.16	24.16	24.16	0.00	0.00	0.00
W	Alaska	24.16	24.16	24.16	0.00	0.00	0.00

Note: A zero cost was used for some states where there were very few pastureland acres with manure applied and with erosion rates above T.

Summary of land treatment costs

Land treatment costs were estimated by multiplying the number of acres expected to need erosion control times the per-acre cost for the conservation systems required. An adjustment factor was applied to the number of manured acres in each erosion category to account for erosion control practices that have been implemented since 1997. It was judged that about 10 percent of the acres with erosion rates above T have had conservation systems installed or adopted since 1997.

The annual average cost for the land treatment element of a CNMP was estimated to be $1,721 per farm (table 24). Costs ranged from an average of $1,267 for small farms to $3,925 for large farms. The highest average cost was for swine farms ($3,615 per farm) because most swine are produced in the Midwest and the East where most of the acres with sheet and rill erosion occur. Land treatment costs were highest in the Northeast region where the average cost was $4,465 per farm (table 25). Average cost exceeded the national average in the Appalachian and Corn Belt regions. The lowest land treatment costs were in the Pacific ($67 per farm) and Mountain regions ($77 per farm).

Overall, annual land treatment costs totaled $443 million. Costs in the Northeast and the Corn Belt regions comprised over two-thirds of this total cost.

Table 24 Annual land treatment costs per farm, by livestock type and farm size

Dominant livestock type or farm size class	Number of farms	Land treatment costs on cropland	Land treatment costs on pastureland	Total land treatment costs
Fattened cattle	10,159	2,586	27	2,613
Milk cows	79,318	2,606	54	2,660
Swine	32,955	3,576	39	3,615
Turkeys	3,213	2,407	985	3,391
Broilers	16,251	826	393	1,220
Layers/Pullets	5,326	1,429	256	1,685
Confined heifers/veal	4,011	2,026	0	2,026
Small farms with confined livestock types	42,565	336	15	351
Pastured livestock types	61,272	344	13	357
Specialty livestock types	2,131	390	244	634
Large	19,746	3,565	359	3,925
Medium	39,437	2,749	147	2,897
Small	198,018	1,238	29	1,267
All CNMP farms	257,201	1,648	73	1,721

Table 25 Annual land treatment costs per farm, by farm production region

Farm production region	Number of farms	Land treatment costs on cropland	Land treatment costs on pastureland	Total land treatment costs
Appalachian	22,899	1,582	572	2,154
Corn Belt	71,540	2,286	26	2,312
Delta States	12,352	175	128	302
Lake States	52,817	983	6	990
Mountain	7,964	68	9	77
Northeast	31,598	4,447	18	4,465
Northern Plains	26,309	392	3	395
Pacific	7,974	58	10	67
Southeast	12,807	1,181	42	1,223
Southern Plains	10,941	283	51	334
All CNMP farms	257,201	1,648	73	1,721

Manure and wastewater handling and storage costs

Manure and wastewater storage and handling includes components and activities associated with the production facility, feedlot, manure and wastewater storage and treatment structures and areas, and any areas or mechanisms used to facilitate transfer of manure and wastewater. For most CNMPs, addressing this element requires a combination of conservation practices, management activities, and facility upgrades designed to meet the production needs of the livestock operation while addressing environmental concerns specific to each operation. Manure and wastewater storage and handling needs are highly specific to the condition and location of each facility, and differ from farm to farm.

This study adopts a generalized approach to estimating needs and costs for this element by identifying major cost items and making broad assumptions about CNMP needs. There are many types of CNMP-related costs on specific farms, and it is impractical to simulate the full array of potential cost items. This analysis focuses on the needs and costs that generally would be representative of the industry. Needs and costs were identified so that they would reasonably represent alternatives. For example, composting was selected as the basis for estimating the costs of managing mortality on poultry and swine farms. There are acceptable alternatives to composting, but the costs generally are about the same. The needs and costs assigned to a specific farm in the model simulation may differ from those that would be identified for a specific farm in an actual CNMP. However, it is expected that the overall estimates derived from the model simulation will be representative of the total CNMP costs for this element.

The analytical framework used to derive CNMP needs and costs for the manure and wastewater handling and storage element is based on the model farms described previously (see tables 2–5). Components of the manure and wastewater storage and handling element were identified for each model farm. Not every model farm has every component. The objective was to define adequate components to meet the criteria established in the NRCS CNMP Technical Guidance and applicable NRCS conservation practice standards. The team was guided by the NRCS Agricultural Waste Management Field Handbook (AWMFH) (NRCS, 1992). The appropriate components of a typical manure management system for each model farm were based on chapter 9 of the AWMFH. Major cost items for manure and wastewater storage and handling are broken down into the following components:

- Mortality management (poultry and swine)
- Lot upgrades
- Clean water diversions (including roof runoff management, earthen berms, and grassed waterways)
- Liquid treatment (small dairies)
- Collection and transfer (including solids, liquid, contaminated runoff, and pumping)
- Settling basins
- Solids storage
- Liquid storage
- Slurry storage
- Runoff storage ponds

In all but one case, it was assumed that farms would not switch from one production system to another (i.e., switch from one representative farm to another) because of implementing a CNMP. An exception was made, however, for large dairies in the Dairy Belt that reported a solids-based manure handling system in the farmer surveys. The team felt that these large dairies would find it too labor intensive to continue to handle manure as a solid and meet CNMP criteria, and would convert to a liquid system with a waste storage pond.

Cost estimates for conservation practices for pastured livestock are included in the manure and wastewater handling and storage element. Components for farms with pastured livestock types include:

- Fencing
- Water well
- Watering facility
- Heavy use area protection
- Windbreak or shelter break establishment
- Solids storage
- Filter strip

Manure and wastewater handling and storage costs were estimated for the system associated with the dominant livestock type on each farm. Many of these farms, however, have other confined livestock types on the farm. The assumption was made that costs associated with addressing CNMP needs for the secondary livestock types on the farm, for the most part, could be incorporated into the system costs for the dominant livestock type. Any additional costs were assumed minor and were not estimated. For several components, however, costs were based on the amount of recoverable manure produced on the farm (handling and transport weight), which included recoverable manure from all livestock types on the farm. (See appendix B for details on the calculation of recoverable manure and the amount for handling and transport.)

CNMP costs for the manure and wastewater storage and handling element were estimated for each farm. Costs were defined on a per-animal or per-animal-unit basis wherever possible so that the final cost estimate would more closely represent the existing production capacity of each individual operation. For poultry, costs were estimated on a per-house basis. For this purpose it was assumed a broiler house would hold 25,000 birds, a layer or pullet house would hold 50,000 birds, and a turkey house would hold 5,000 birds for slaughter or 8,000 birds for breeding.

To obtain estimates of CNMP-related costs for manure and wastewater handling and storage components, information is needed on per-unit costs and on CNMP needs for each component. Most per-unit cost estimates were based on literature values or values taken from the NRCS Field Office Technical Guide.

However, no data are available on CNMP needs for this element, nor can CNMP needs be derived from other databases, as was done for nutrient management costs, land treatment costs, and off-farm export costs. CNMP needs for manure and wastewater handling and storage components were estimated by a team of experts using a consensus approach to approximate what the needs might be. The team of experts consisted of agricultural engineers, environmental engineers, economists, and agronomists with extensive experience working with livestock producers and government technical assistance programs. Team members also consulted with other experts who had knowledge about specific industries or areas of the country.

To simplify the process of estimating CNMP needs for this element, three groups of "virtual" farms were established: the 25 percent of farms with the lowest needs, the 25 percent of farms with the highest needs, and the 50 percent of farms with average needs. For each of the three groups, the percentage of farms needing upgrades was estimated by the team. The final estimate of CNMP needs for each component was then obtained as a weighted total. CNMP needs were estimated as percentages that can be interpreted in two ways:

- The percentage of the total cost that the average farm would incur in upgrading facilities to meet CNMP guidelines.
- The percentage of farms in a group that would need to add a component, incurring the full cost.

These two interpretations of the needs percentages are analytically equivalent. However, one of these two interpretations may be more appropriate than the other for specific components.

Separate cost estimates were made for capital expenditures (equipment and structures), operating costs, and maintenance costs. All costs are presented as annual costs. Capital costs are converted to annual costs by amortizing the total cost over 10 years with an 8 percent interest rate. Operating costs are largely labor costs, but also include fuel and other costs where appropriate. The standard wage rate used for labor was $10 per hour. Maintenance costs were estimated as 3 percent of the capital costs.

Specific estimates of CNMP needs and costs for each component were made for farms with more than 35 AU of confined livestock types. Farms with less than 35 AU where confined livestock types were dominant (42,565 farms) were judged to be too diverse with respect to the type of production technologies employed in producing livestock to apply the standard set of representative farms. Small farms tend to use small lots and pastured environments to a greater extent than the larger farms for which the set of representative farms were derived. Furthermore, CNMPs for these smaller farms would most likely address only a subset of the components that would be addressed for larger farms, focusing on situations and practices associated with environmental impacts. (Pastured livestock farms with less than 35 AU were not explicitly excluded, but few were included in the set of farms that may need a CNMP because of the small quantities of recoverable manure produced.)

Manure and wastewater handling and storage costs for farms with **less** than 35 AU of confined livestock types (and where pastured livestock were not dominant) were estimated based on costs derived for small dairies. (Most of these farms either had milk cows or swine as the dominant livestock type. See appendix A, table A–5.) Operating costs per AU were estimated using the average capital cost for dairies with 35 to 60 AU. Capital costs per AU were estimated as 50 percent of the average capital cost for dairies with 35 to 60 AU. The total manure and wastewater handling and storage costs for these small farms were obtained by multiplying the per-AU costs times the number of AU for confined livestock types on the farm.

A description of each component and how the costs were derived follows. The per-unit costs and assumptions of CNMP needs derived by the team of experts for each model farm are summarized in appendix E. The overall cost estimates for manure and wastewater handling and storage are presented in the last part of this section.

Mortality management

The cost of mortality management is included for all poultry and swine farms. For dairy and fattened cattle, it was assumed that existing mortality management practices would be adequate in most cases. Various acceptable methods are used to manage poultry and swine mortality, such as composting, incineration, burial pits, and freezing. Composting was selected as the representative technology for assessing CNMP costs.

Poultry

The cost of mortality management for poultry was determined on a per-house basis. A concrete slab covered with a timber structure comprised the composting facility. Capital and operating costs of the structure were based on costs reported by the North Carolina Cooperative Extension (1999) for a 100,000-bird broiler flock. The cost of the timber structure and concrete floor was $3,600, and the cost of water service for the facility was $150, resulting in an annual capital cost of $559. Operating costs included labor (27.5 hours per flock at $10 per hour) and machinery rental ($20 per hour at 51 hours per year), for a total of $2,533 per year. For the 25,000-bird broiler house used as the standard house size in this study, annual costs were $140 for capital and $633 for operating costs.

Costs for the other poultry livestock types were estimated by prorating the cost for broilers based on capacity needed for the other poultry types. The capacity needed was estimated using a method published by the North Carolina Cooperative Extension (1996). Maximum capacity was estimated by multiplying the expected daily death rate by the market weight (maximum weight), and then multiplying by the number of birds per house. Although mortality takes place throughout the production cycle with birds at various weights, for most operations the majority of the mass that must be dealt with occurs near the end of the production cycle when birds are closest to their market weight. To ensure adequate composter space, capacity needed is based on the greatest demand in order to handle the larger bird mortality. Calculations are shown in the chart that follows:

Poultry type	Birds per house	Market weight (lb/bird)	Mortality rate (%)	Mortality rate (lb/d)	Ann. capital cost per house ($)	Ann. operating cost per house ($)
Broilers	25,000	4.5	0.1	113	140	633
Layers & pullets	50,000	4.0	0.033	66	82	371
Turkeys for slaughter	5,000	19.2	0.080	77	96	433
Turkeys for breeding	8,000	18.8	0.100	150	187	846

CNMP needs for mortality management for poultry were judged to be lower for the larger operations and higher for turkey operations. CNMP needs were assigned as follows:

- 45 percent for broiler and pullet farms with less than 220 AU
- 15 percent for broiler and pullet farms with more than 220 AU
- 45 percent for layer farms with less than 400 AU
- 15 percent for layer farms with more than 400 AU
- 60 percent for turkey farms with less than 220 AU
- 30 percent for turkey farms with more than 220 AU

Swine
Estimates of mortality management costs for swine were based on a composting facility consisting of a concrete pad with walls constructed of large round bales and covered with a tarp, and a fence to keep animals out. Included in the system are a carcass cutter and grinder. (Costs for this system are described by Ken Foster in *Cost Analysis of Swine Mortality Composting*, Purdue University.)

The annual cost of the cutter and grinder is $1,248, which would need to be incurred only once per operation regardless of the size of the operation. Other capital costs (concrete slab, fence, tarp, bales) were reported by Foster for a farrow-to-finish operation with a maximum capacity of about 250 animal units to be $549 per year. Annual operating costs (labor, sawdust, fuel, and utilities) for this system were reported to be $350 per year. On an animal unit basis, these costs convert to $2.20 per animal unit for the additional capital costs and $1.40 per animal unit for operating costs.

Because swine operations have only recently begun to address mortality management practices as an integral part of their operation, CNMP needs were set at 70 percent for all sizes and types of swine operations.

Feedlot upgrades

The cost of feedlot upgrades was applied only to cattle on feed (fattened cattle and confined heifers) and consists of improving the open lot area where cattle are held to ensure the proper functioning of collection systems. It includes grading to enhance drainage and a concrete pad to protect drainage collection and diversion areas during manure collection activities. (These lot upgrades exclude the costs of berm construction for diverting contaminated water into the storage pond, which are costed separately.)

A 750-head fattened cattle operation was used as a basis for deriving representative costs for this component. Costs were estimated assuming installation of 111 cubic yards of concrete (6,000 square feet) at $200 per cubic yard, and 1,700 cubic yards of earthmoving and shaping at $2.00 per cubic yard. (These costs were taken from the Iowa State Beef Feedlot System Manual—PM 1867, January 2001.) The total capital cost is thus $25,600 per 750-head operation, or $34 per head. The amortized annual cost is $5.09 per head.

Most operations typically have addressed this component as a part of their existing management systems, so needs were judged to be comparatively low, as follows:

- 15 percent for fattened cattle farms with a scrape and stack operation
- 30 percent for confined heifer farms with a scrape and stack operation
- 30 percent for the smaller fattened cattle farms with manure pack
- 5 percent for the larger fattened cattle farms with manure pack

Clean water diversions

Clean water diversions are used to minimize the amount of rainfall runoff that can come in contact with areas of the animal production operation where manure and wastewater are present, primarily the open lot areas. The types of clean water diversions used in this study were roof runoff management, earthen berms with a surface outlet, earthen berms with underground pipe outlets, and grassed waterways. Because diversions were only essential for operations with an open lot, clean water diversions were not applied to operations that only confined animals in buildings.

Roof runoff management
Gutters and downspouts were used to capture rainfall on the roofs of buildings to route the water from the production area. This kind of clean water diversion was applied to dairy, turkey, and swine operations that provided outside access to animals. Fattened cattle operations were not included because typically these animals are raised in a feedlot without any buildings or structures within the confinement area.

The per-unit costs used were taken from the NRCS Field Office Technical Guide, Section 1, Annual Cost List. The installation cost for a standard gutter and downspout used in most areas of the United States is $2.25 per foot. In areas of higher rainfall, such as the Southeast, a larger gutter is needed at a cost of $4.50 per foot. Since downspouts are often damaged by animals and machinery, repairs and maintenance were assumed to be an additional 7 percent of the installation cost. (This 7 percent is in addition to the maintenance costs estimated as 3 percent of all capital costs, bringing the total percentage for maintenance cost for this component to 10 percent.) The estimated quantities of gutters and downspouts used per type and location of facility were based on average building size and typical building capacities. Dairy costs were based on 200 feet of gutters and 40 feet of downspouts for a 100-cow dairy, and converted to a per-head basis. The annual capital cost for dairies, including maintenance and repair, was $2.37 per head in the Southeast and $1.18 per head for other regions. For turkey ranches, the annual capital cost was $473 per house, assuming 800 feet of gutter and 160 feet of downspouts per house. For swine farms with buildings and outside access, the annual capital cost was $0.85 per animal unit, based on 200 feet of gutter and 40 feet of downspouts for a 140-AU operation.

Roof runoff management has been a neglected component on some systems, but is commonly present on other systems. Larger operations are expected to have fewer needs than smaller operations. CNMP needs were assigned as follows:

- 30 percent for swine farms with buildings and outside access
- 90 percent for turkey ranches
- 80 percent for Dairy Belt dairies #1 and #2 (solids systems) with up to 270 AU
- 45 percent for Dairy Belt dairies #1 and #2 with more than 270 AU
- 40 percent for all other dairies

Earthen berms with underground pipe outlets

This type of clean water diversion was used for fattened cattle operations with a manure pack method of managing waste as well as for all dairy operations. These operations generally take advantage of the relief of the land to provide drainage within the lot. Often, these operations have dry or intermittent streams (swales) that run through the feedlot areas. To control clean water upgradient of the lot, a small earthen berm is installed across the swale above the feedlot or lot to catch the clean runoff and then outlet the water through an underground pipe to some point downstream of the feedlot area.

The cost of installing the earthen berm associated with this system addressed the cost of hauling and shaping activities. The berm used for this type of system is considerably shorter than those for other diversion practices because its only function is to create a temporary pool that will drain out through the underground pipe. Although the berm length is considerably shorter than the other berms described in this section, it is usually higher to create sufficient hydraulic pressure to discharge through a long pipeline. The assumed dimensions of the berm were based on a trapezoidal shape with an 8-foot top width, 3 horizontal to 1 vertical side slopes, and 3 feet of average height (1.9 cubic yards per foot of length) for a length of 30 feet per berm. The cost per cubic yard was $2 installed, or $115 per berm. The estimate for the underground outlet pipe was based on a 12-inch diameter corrugated metal pipe, and unit costs reflect the cost of pipe and installation activities, such as excavation, laying the pipe, and backfill. Lengths were estimated based on professional judgment of a typical distance through a feedlot based on a particular size of operation. Larger operations could require more than one berm and pipe outlet per feedlot. Per-unit costs were taken from the NRCS Field Office Technical Guide, Section 1, Annual Cost List. Cost estimates were developed for three different-sized operations as follows.

Number of animals	Linear feet of pipe	Pipe cost per foot ($)	Number of 30-foot berms	Berm cost ($)	Total cost installed ($)	Cost per animal ($)	Annual cost per animal ($)
75	200	12	1	115	2,515	34	5.07
150	360	12	1	115	4,435	30	4.47
600	1,200	12	3	345	14,745	25	3.58

Using these three cost estimates, the following rules were established for assigning costs to farms on a per-head basis:

- If the number of head is less than 100, then the cost per head is $5.07.
- If the number of head is between 100 and 300, then the cost per head is $4.47.
- If the number of head is more than 300, then the cost per head is $3.58.

Most of these operations already have this practice in place or do not need it because of the characteristics of the terrain near the facility. Some systems in some regions of the country, however, were judged to have relatively high needs. CNMP needs were assigned as follows:

- 20 percent for the smaller fattened cattle farms
- 10 percent for the larger fattened cattle farms

- 50 percent for dairy representative farm #1 (Dairy Belt)
- 50 percent for dairy representative farm #2 in Dairy Belt with <270 AU
- 30 percent for dairy representative farm #2 in Dairy Belt with >270 AU
- 20 percent for dairy representative farm #2 in West and Southeast
- 30 percent for dairy representative farm #3
- 40 percent for dairy representative farm #4
- 20 percent for dairy representative farm #5 in Southeast and in West with <270 AU
- 10 percent for dairy representative farm #5 in West with >270 AU

Grassed waterways

Grassed waterways are shaped channels that are seeded to establish vegetation. They are used for clean water diversion in areas that receive sufficient annual rainfall that vegetation can be maintained naturally and where the runoff-contributing watershed is relatively small. These waterways are more efficient than an earthen berm because they can handle larger flows without concern of erosion. This is a typical practice used east of the Mississippi River. This practice was used to represent the clean water diversion treatment needs for fattened cattle operations and confined heifer operations that utilize a stack and scrape manure management system. Only 15 percent of these operations were assumed to need to install this practice because of its common use.

All grassed waterways were assumed to be 30 feet wide. The length varies by the size of the operation. Per-unit costs were taken from the NRCS Field Office Technical Guide, Section 1, Annual Cost List. The cost of installing a grassed waterway involves grading and shaping the channel, which costs $115 per acre, and seeding, which costs $125 per acre. The total cost is $240 an acre or $36 per acre annually. Lengths were estimated based on professional judgment of a typical distance to bypass a feedlot for two sizes of farms and then converted to a per-head cost, as follows:

Number of animals	Linear feet of waterway	Acres	Total cost installed ($)	Annual cost ($)	Annual cost per animal ($)
150	1,200	0.83	199	30	0.20
600	1,800	1.24	298	44	0.08

The $0.20 cost per head was assigned to all operations with less than 500 head, and the $0.08 cost per head was assigned to operations with more than 500 head.

Earthen berms with surface outlet

Earthen berms with a surface outlet are shaped mounds of uniform cross section made of soil to serve as an intercept upslope of an open lot to divert clean water around the lot to a stable natural outlet. This clean water diversion practice was used only on turkey and swine operations that have an open lot as part of the production area. Per-unit costs were taken from the NRCS Field Office Technical Guide, Section 1, Annual Cost List.

All open lots were assumed to have a diversion along two sides. Installation involved primarily earth hauling and shaping activities. The assumed dimensions of the berm were based on a trapezoidal shape with an 8-foot top width, 3 horizontal to 1 vertical side slopes, and 2 feet of height for a running volume of 1 cubic yard of diversion per foot of length. The cost per linear foot was $2.00 installed.

For a swine operation with open lot access and 900 animals (100 animal units), typically 460 square feet of loafing area is provided per animal unit, or 46,000 square feet. Assuming a square lot, the dimension of a side would be 214 feet. Assuming the diversion would be wrapped around two sides, the total length would be 428 feet for a total cost of $856. The amortized annual cost would be $128 per year or $1.28 per animal unit per year. CNMP needs for these operations were judged to be 20 percent for swine representative farm #4 (building with outside access) and 50 percent for swine farm #5 (pasture or lot).

A typical turkey operation would raise approximately 5,000 birds per house. One house is equivalent to 75 animal units. Assuming the lot area provided 460 square feet per animal unit (the same as the proportional area per animal unit provided for swine) the area of a turkey lot would be 34,500 square feet, or a lot with sides measuring 185 feet. The total length of the berm would be 370 feet and would cost $740. The amortized annual cost would be $111 per year per house. CNMP needs were judged to be 40 percent for turkey ranches.

Liquid treatment

Small dairy operations that remove solids daily or weekly would continue to handle their manure as a solid and use a liquid treatment approach to handle the liquid component. Generally, cows on these operations are kept on pasture most of the day. However, they are brought in to be milked, and as a result spend some time in an open lot. During storms, runoff from the open lot would contain manure and related wastes, but this would normally be a small volume. Milk-house washings would also generate small amounts of wastewater. For these operations it was assumed that the runoff and milk-house washings could be handled with a biofilter. A biofilter is a small, vegetated area that functions similar to a wetland by capturing the runoff and bioprocessing it through infiltration of nutrients into the soil for use by the vegetation. Use of a biofilter for liquid treatment precludes the need for collection, transfer, or storage of liquid wastes on these farms.

For the purposes of this simulation, the biofilter was assumed to be a vegetated filter strip of 12,000 square feet, at $0.25 per square foot for a cost of $3,000. The construction of the filter would be accomplished by land grading equipment. Based on an average size operation of 75 milk cows, the capital cost is $6.00 per cow annually.

A liquid treatment component was included for dairy representative farms #1 and #2 with less than 135 AU per farm. CNMP needs were judged to be high for this component; 65 percent for farm #1 and 75 percent for farm #2.

Collection and transfer

The collection and transfer component addresses the installation and operation of practices associated with handling the manure and wastewater within the production area. The type of collection used depends on the type of animal feeding operation, consistency of the manure handled, and the type of management system used. Management systems for animals raised in buildings address a single manure consistency, either a liquid/slurry or a solid. Operations that use open lots generally need to address both solids and liquids because manure and contaminated runoff are generally handled separately.

CNMP costs were determined for three types of collection systems: solids collection, liquid collection with flush systems, and contaminated runoff collection. For the last two types of collection systems, a liquid pumping system is needed to transfer the wastewater to a storage structure and/or from the storage structure to land application equipment. For solids, manure is transferred to a solids storage facility during collection.

Almost all model farms include either a collection or a transfer component, or both. Representative farms that predominantly handle manure as a slurry, however, have storage pits either under the building or adjacent to the housing facility, requiring only rinsing to collect the manure. For these representative farms, it was assumed that the collection structures would be adequate and that only a transfer component may be needed. These farms include veal, swine representative farms #2 and #3, dairy representative farms #1 and #2 with more than 135 AU, and dairy representative farm #3. Dairy representative farms #1 and #2 with less than 135 AU have a liquid treatment component (filter strip for milk-house washings) and so would not need a collection or transfer component.

Solids collection

Solids collection is a component for all operations **except** for swine and dairy farms with complete liquid or slurry systems, layer farms with liquid systems, and veal farms. Generally, most operations have an adequate collection system already in place, so CNMP needs are expected to be low. CNMP needs were judged to be 10 percent for all but the cases listed below:

- 2 percent for broiler farms
- 15 percent for turkey farms (representative farms #1 and #2)

Solids collection for dairy, fattened cattle, confined heifers, and for swine raised in a building with outside access or in a pasture or lot was assumed to consist of a tractor scraper used to collect and pile the manure on a concrete slab. Costs are based on the amount of manure to be handled, which is estimated in appendix B. The scrape operation costs are based on a 37-hp tractor with scraper at a purchase price of $22,000. Assuming this equipment is dedicated 80 percent to this function, the annual cost is $3,591. Conventional guidelines for estimating annual operating costs—fuel, oil, and labor—for equipment used on an intermittent basis, as in this case, is 15 percent of the purchase price (Tilmon and German, 1997). Thus, the annual operating costs were estimated to be $3,300 per year. The cost per ton was determined for a 150-head dairy operation, which was then used for all dairy, fattened cattle, confined heifer, and swine farms that had a solids collection component. A 150-head dairy operation has about 200 animal units and produces about 580 tons of manure at transport and handling weight (assuming about 2.2 tons of manure as excreted at oven-dry weight, converting to a handling weight by multiplying by 2, and adjusting for recoverability with a 0.65 recovery factor). Thus, capital costs are $6.20 per ton of solids and operating costs are $5.70 per ton.

The cost of solids collection for broilers, pullets, turkeys, and layers with a high-rise or shallow pit production system that raise poultry in confinement buildings was based on the assumption that the buildings are partly cleaned out after each flock and completely cleaned out once per year. A custom rate was used, and since most of the cost is labor, it was categorized as an operating cost, even though a portion of the cost covers the cost of the equipment. The custom rate used was determined based on several sources of information obtained from University Extension Service and private industry sources. The rates varied from $0.02 to $0.07 per square foot depending on the size of the house and regional location. However, the predominant price range was from $0.04 to $0.065 (including both annual cleanout and four to five cake-outs per year.) Averaging the costs from the sources considered provided a custom rate of $0.053 cents per square foot of house. An average size broiler and turkey house is about 20,000 square feet, producing an annual cleanout cost estimate of $1,060 per house. The average size of a layer or pullet house with a 50,000-bird capacity is about 24,000 square feet, producing an annual cleanout cost of $1,272 per house.

For layer operations that use a mechanical belt system installed beneath the layer cages, manure falls directly onto the belt, and periodically the belt empties itself onto a stacking area. For layer operations that use a scraper type system, the litter produced is removed from the building by mechanical scrapers and deposited in a stacking area. Solids collection for these two types of operations was viewed as the activity to move the litter deposited in the stacking areas at the ends of buildings to a central storage area or directly into trucks for transport off-farm. Cost was based on equipment rental rates for a 150-hp front-end loader (3 yard bucket) at $15.08 per hour and an operator cost of $10.00 per hour. Based on a weekly manure production of about 42 tons of litter per house (50,000 birds), the time needed to move the litter is approximately 1.5 hours per week per house for 78 hours per year, or $1,956 per house annually.

Liquid collection with flush systems

The flush system is used commonly by dairy, swine, and layer operations that handle their wastes as a liquid. Waste is collected by the flushing of floor gutters within the barn to move waste and water to a collection tank, where it is transferred to a holding pond or lagoon by gravity or a transfer pump. Existing flush operations are assumed to have most of the system in place. Therefore, systems would only need to be upgraded to be consistent with any modifications in the storage and handling systems. Components assumed to be needed were a flush tank, collection tank, transfer pipe, and a pit agitation pump. CNMP needs were judged to be comparatively low for the following representative farms with flush systems:

- 10 percent for swine representative farm #1 (liquid system with lagoon or storage pond)
- 10 percent for layer representative farm #2 (flush to lagoon)
- 30 percent for dairy representative farm #4 (liquid system with lagoon or storage pond) with less than 270 AU
- 40 percent for dairy representative farm #5 (liquid system with lagoon or storage pond) with less than 270 AU
- 20 percent for dairy representative farm #4 or #5 with more than 270 AU

Costs for three sizes of dairy farms were used as the basis for flush cost systems. The base system for the smallest operations included two collection tanks (10 feet wide by 20 feet long and 8 feet deep); a transfer pipe (50 feet of 100-lb/in^2 PVC); and an agitation pump (PTO driven impeller). Costs for larger systems would account for the increased size needed to handle more animals. Operating costs cover fuel, oil, electricity, and pump maintenance. For these systems, the cost of the pipe used to transfer the waste to the field for application was treated as a hauling cost, and the cost of pumping to the field for irrigation is covered under the pumping transfer system costs. The dairy liquid collection costs are summarized in table 26.

The costs shown in table 26 were applied to dairy representative farms #4 and #5. Dairies with less than 150 head were assigned a capital cost of $28.99 per head. Dairies with 150 to 250 head were assigned a capital cost of $24.57 per head. Dairies with more than 250 head were assigned a capital cost of $23.10 per head. Operating costs for all size farms were $11.84 per head.

The same components are also needed for swine operations with liquid wastes (swine representative farm #1) and layer farms with liquid wastes (layer representative farm #2). The costs above were converted to an animal unit basis for these swine farms and to a per-house basis for the layer farms. The annual capital cost was $20.70 per AU for swine farms with less than 200 animal units, $17.55 per AU for farms with 200 to 400AU, $16.50 per AU for farms with more than 400 AU, and annual operating costs were $8.46 per AU for all size groups. For layers, the annual capital cost was $3,157 per house, and the annual operating cost was $1,291 per house.

Contaminated runoff collection

Earthen berms are used to divert rainfall runoff that has come in contact with manure in the production area to a storage pond. These contaminated water divisions would be located on the down-gradient end of the production area. The types of contaminated water diversions typically used are earthen berms with a surface outlet and earthen berms with pipe outlets.

Table 26 Cost estimates for liquid collection with flush systems for dairy farms

Cost component	---------- Operation ---------- 100-head ($)	200-head ($)	300-head ($)
Flush tank	7,801	15,602	23,403
Collection tanks	5,721	11,442	17,163
Collection pipe	562	562	562
PTO impeller	5,367	5,367	5,367
Total capital cost	19,451	32,973	46,495
Annual capital cost	2,899	4,914	6,929
Annual operating cost	1,185	2,369	3,554
Annual capital cost/head	28.99	24.57	23.10
Annual operating cost/head	11.84	11.84	11.84

Contaminated water diversions are necessary components for all fattened cattle and confined heifer representative farms as well as turkey ranches and swine farms with a pasture or lot (swine farm #5). It was assumed that lots on dairy farms and swine farms with a building and open access would be small enough that contaminated water diversions would not be needed or would be incorporated into the structure of the runoff storage pond.

Typically, turkey operations and swine raised in a pasture or lot would use an earthen berm with a surface outlet that diverts the runoff to a small storage pond. The construction is similar to earthen berms with surface outlets used for clean water diversion. Based on costs used for the clean water diversion berms presented previously, the annual capital cost would be $111 per house for turkey ranches and $1.28 per animal unit for swine. CNMP needs were judged to be comparatively high for these farms, as follows:

- 50 percent for swine representative farm #5
- 90 percent for turkey ranches

Fattened cattle and confined heifer operations use a similar system; however, they would generally outlet the captured contaminated runoff through a pipe into a holding pond. These types of operations generally take advantage of the relief of the land to provide drainage within the lot. On the downslope end of the lot, an earthen berm is constructed that channels all lot rainfall runoff to a pipe outlet that conveys the contaminated runoff water to a holding pond or lagoon.

The cost of the earthen berm was calculated based on the following assumptions: the shape was trapezoidal with an 8-foot top width, the side slopes were 3 horizontal to 1 vertical, and the height was 2 feet. The unit cost of the berm is $2.00 per linear foot, taken from the NRCS Field Office Technical Guide, Section 1, Annual Cost List. The length of the berm was equal to the downslope width of the lot. The following approach was used to determine the length of berm: first it was assumed that each animal unit was provided 460 square feet of lot space, then the total lot size was computed by multiplying the number of animal units by 460, and then the square root of the area was taken to represent the berm length. The outlet pipe was assumed to be a 12-inch diameter corrugated metal pipe (CMP). The unit cost for pipe, $12 per foot, reflects the cost of the pipe and installation activities, such as excavation, laying the pipe, and backfill. The length of pipe needed on any particular site varies depending on the distance from the berm to the storage pond. To simulate this variation, it was assumed the length of pipe was 20 percent of the length of diversion.

Three size categories were used for assigning costs to the fattened cattle and heifer farms:

	Size 1	Size 2	Size 3
Animal number (head)	116	308	616
Area of lot (ft^2)	53,130	141,080	283,360
Length of berm (ft)	230	376	532
Cost of berm ($)	460	752	1,064
Cost of berm per head ($)	3.96	2.44	1.72
Linear feet of pipe	46	75	106
CMP cost per foot ($)	12	12	12
Cost of pipe installed per head ($)	4.76	2.93	2.07
Annual cost per head ($)	1.31	0.80	0.56

Using these three cost estimates, the following rules were established for assigning capital costs to farms on a per-head basis:

- If the number of head is less than 200 then the cost per head is $1.31.
- If the number of head is between 200 and 450 then the cost per head is $0.80.
- If the number of head is more than 450 then the cost per head is $0.56.

It was judged that the majority of fattened cattle and confined heifer operations would need contaminated water diversions. CNMP needs were assigned as follows:

- 55 percent for confined heifer and fattened cattle farms with a scrape and stack manure handling system in the South and West
- 40 percent for confined heifer and fattened cattle farms with a scrape and stack manure handling system in the Midwest and the Northeast
- 60 percent of the smaller fattened cattle operations with manure pack
- 50 percent of the larger fattened cattle operations with manure pack

Pumping transfer system

All model farms that must handle waste or wastewater in a liquid or slurry form will need to facilitate the transfer of that liquid or slurry from the storage structure (storage pit, holding pond, lagoon, or runoff storage pond) to the appropriate conveyance for land application. Some operations will own a pump for this purpose, but the smaller operations would likely rent the equipment. Costs were therefore estimated on a per-ton basis using a standard rental rate. Several rental rates were obtained from the literature. Rental rates varied depending on the geographic location, but the rates were all within about 15 percent of each other. The average rate was $140 per 8-hour day, or $17.50 per hour. The pumping rate used in the land application section was 500 gallons per minute, which converts to about 1.5 tons per minute (267 gallons per ton), or 90 tons per hour, after allowing for about 20 percent down time for setup or for moving the pump. Thus, the capital cost of the pump would be about $0.20 per ton. Operating costs would be minimal, consisting primarily of fuel costs. An operating cost of $0.06 per ton was based on the cost of 3 gallons of fuel ($1.65 per gallon) per hour.

These costs would be appropriate for operations that use irrigation systems to land apply the wastewater. However, for smaller operations that use a tank truck and sprayer to land apply wastes, additional down time needs to be factored into the costs to account for the multiple trips to the field needed to empty the liquid storage facility. During these trips, the operator would still pay a rental charge but the pump would be idle. In the section on nutrient management costs, we assumed that operations with less than 1,000 tons of liquid wastes per year would use a tank truck and sprayer for land application. Assuming the pump would only be operated 40 percent of the time for these smaller operations, the pumping rate would be about 45 tons per hour and thus capital costs would be $0.40 per ton. Operating costs would remain the same at $0.06 per ton.

CNMP needs for pumping transfer systems were assumed to be the same as the needs for storage (i.e., runoff storage pond, slurry storage, or liquid storage ponds or lagoons).

Storage of solid wastes

The part of the manure that can be handled as a solid, including bedding material, is collected from production areas and stored until it can be land applied. To efficiently use manure nutrients to fertilize crops, the window of opportunity to land apply manure is limited. Therefore, an essential part of a CNMP is manure storage facilities that have enough capacity to hold manure until the proper time for land application.

Solids storage is included as a CNMP component for dairy representative farms #1 and #2, fattened cattle and confined heifer farms with a scrape and stack system for manure handling, swine representative farm #4 (building with outside access), and for all poultry except layer farms with a flush to lagoon system. Fattened cattle farms and dairy farms in the West with a manure pack system do not need a separate solids storage component, since the manure pack is the method of storage. Similarly, swine farm #5 does not need a storage component because the solids can be collected from the lot or pasture at the time of application.

Conservation practice standards used in CNMP development do not require a minimum period of storage because the storage requirements would vary depending on the crop growing season, the crops being grown, climate, and type of management system in place. These factors determine what the storage capacity should be on a particular farm. For purposes of this assessment, however, general minimum storage capacities were established so that cost estimates could be made. Consistent with typical management practices used in the poultry industry, the storage capacity is assumed to be 1 year of litter production for all poultry types. For other animal sectors the storage period is generally less than 1 year because the solids can be handled more frequently and the limiting period of storage would be dictated by availability of cropland to receive the manure. For most of the country, it was assumed that 180 days (50 percent of the storage period for poultry) represented the typical length of storage because it would allow storage of manure through the winter and wet months of the year. Model farms in the Southeast, in most cases, can produce some type of crop year around, so would not need a 180-day storage capacity. In the Southeast storage time was set at 90 days. (For this purpose, the Southeast States are Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, and South Carolina.)

Storage costs were determined as the cost per ton of solids using the hauling weight to approximate the tons to be stored. The cost per ton was determined using a typical storage facility for a broiler operation. This cost per ton was then applied to all livestock types after adjusting for storage time needed. For example, the cost per ton, which was based on a 365-day storage capacity, was multiplied by 0.5 to estimate the cost per ton for operations that only needed a 180-day storage capacity.

The solid storage structure for a typical broiler house was used as the basis for calculating the costs of storage needs for all model farms. The storage cost for broilers was based on a 1,600-square-foot timber shed with end bays, push walls, and a concrete floor. The shed cost $12,403, or $1,863 per year per house. Using the information presented in appendix B, table B–7, on tons of manure at transport weight, it was determined that the average amount of manure per poultry house was about 267 tons per year, including bedding. Thus, the cost per ton is about $7 for all poultry farms. For other livestock types except the Southeast, the cost per ton is $3.50 after adjusting for the needed storage capacity. Similarly, the cost per ton in the Southeast is $1.75 per ton. The total storage cost for each operation was determined by multiplying these cost per ton values times the total tons of recoverable solid manure (at hauling weight) produced in a year.

Generally, the majority of operations are expected to have an adequate solids storage system already in place. The major exception is dairy farms in the Dairy Belt that reported no solids storage in the NAHMS farmer survey. CNMP needs for solids storage were judged to be as follows:

- 100 percent for dairy farm #1 in the Dairy Belt
- 20 percent for dairy farm #2 with 35 to 135 AU and all sizes in the West
- 40 percent for dairy farm #2 in the Dairy Belt with 135 to 270 AU
- 10 percent for dairy farm #2 in the Southeast with more than 135 AU
- 25 percent for fattened cattle and confined heifer farms with a scrape and stack system
- 40 percent for confined heifers in confinement barns
- 60 percent for swine representative farm #4

- 55 percent for layer farms in the Southeast, West, and South Central regions with less than 400 AU
- 30 percent for layer farms in the Southeast, West, and South Central regions with more than 400 AU
- 40 percent for layer farms in the North Central and Northeast region with less than 400 AU
- 20 percent for layer farms in the North Central and Northeast region with more than 400 AU
- 40 percent for broiler farms in the East and pullet farms in the North with less than 440 AU
- 50 percent for broiler farms in the West and turkey farms with less than 440 AU
- 60 percent for pullet farms in the South and West with less than 440 AU
- 25 percent for all broiler farms, pullet farms, and turkey farms with more than 440 AU

Storage of slurry wastes, liquid wastes, and contaminated runoff

Slurry wastes, liquid wastes, and contaminated runoff are normally stored in earthen or fabricated structures. Earthen structures are also used to treat manure in an anaerobic, aerobic, or aerated lagoon. While lagoons and earthen storages look similar, the design process for each is different.

In this study, the nonsolid storage facilities were designated as liquid storage, slurry storage, and runoff storage ponds. Liquid and slurry systems are differentiated by the consistency of the material being stored as determined by the livestock type and the total solids content of the manure. The breakpoint between liquid and slurry manure varies by livestock type. Liquid storages and runoff storage ponds are identical in appearance. Liquid storage ponds as described here generally store more wash water than runoff water, while the runoff storage ponds generally store more runoff water than wash water. Thus, a runoff storage pond for a small dairy will capture wash water as well.

Liquid storage

The category of liquid storage includes both liquid storage and treatment lagoons. Most treatment lagoons provide a storage function as well as a treatment function. The design concept for anaerobic lagoons is to size the structure based on the treatment volume needed to degrade the organic material. Additional volume is added for long-term storage of sludge (decay residuals) and storage volumes.

Liquid storage in ponds or lagoons is a component of manure management systems for some swine, dairy, and layer model farms. These typically are flush systems where wastewater is gravity fed or pumped to storage ponds or lagoons. Most of these operations are assumed to have adequate liquid storage or treatment systems in place. However, some may be in disrepair, under-capacity, or may need to be replaced entirely. CNMP needs for liquid storage, with the exception noted below, were judged to be the following:

- 20 percent for dairy farm #4 in the Dairy Belt with 35 to 135 AU
- 30 percent for dairy farm #4 in the Dairy Belt with135 to 270 AU
- 40 percent for dairy farm #4 in the Dairy Belt with more than 270 AU
- 30 percent for dairy farm #5 in the Southeast
- 30 percent for dairy farm #5 in the West with less than 270 AU
- 20 percent for dairy farm #5 in the West with more than 270 AU
- 40 percent for layer farm #3 (flush to lagoon)
- 20 percent for swine farm #1 for all sizes and regions

It was recognized that a portion of the operations would choose to convert from one method of handling manure to another method as long as improvements are being made to the operation. Changes that will take place cannot be predicted, so the general assumption was that the method of handling manure would remain the same after CNMP implementation. In the case of representative farm #2 for the largest dairies in the Dairy Belt, however, labor costs associated with properly handling the manure as a solid would be too high, and the operator would most likely convert to a liquid system. Thus, CNMP needs are 100 percent for the liquid storage component on these farms.

The cost of constructing a pond or lagoon was estimated for each model farm using a representative number of animals per farm for each model farm. For dairy farms, the representative number of animals was estimated as 137 percent of the number of milk cows, which accounts for the dairy herd plus dry cows (17 percent) and calves and heifers (20 percent). Storage capacity was assumed to be 180 days for all systems. The calculated annual cost was then converted to a per head basis (dairy), a per animal-unit basis (fattened cattle), or a per house basis (layers).

Pond or lagoon sizes were developed using the NRCS Animal Waste Management (AWM) engineering design program. AWM integrates all aspects of the sizing process to meet current NRCS conservation practice standard criteria for Waste Storage Facility and Waste Treatment Lagoon. Where appropriate, a treatment component was included in the design. Categories were further defined to reflect regional differences. A typical set of climate data (monthly precipitation and evaporation) was selected for each region representative of the model farm. AWM then calculated manure volume for 180-day storage, 180-day normal rainfall on the pond surface, the rainfall on the pond surface from a 25-year 24-hour storm event, and as appropriate, the 180-day runoff volume, for the most critical 6-month period of the year based on location. Where the liquid is recycled for flushing, AWM allows the designer to reduce inputs. The AWM program also adjusted volumes for evaporation. The results from AWM gave pond/lagoon dimensions and final volume in gallons.

The installation costs were based on actual cost data for equivalent systems. The costs per gallon were calculated from the total cost of an installed pond/lagoon by the design storage volume. Costs were obtained from various locations across the country from NRCS engineers that had first-hand knowledge of an actual system. The costs used in this assessment reflect averages of the information received from across the country. Various systems were included in the development of costs that included partially excavated ponds, complete earthen fill ponds, and flexible membrane lined ponds. Installation costs per gallon were: 2.2 cents per gallon for pond/lagoons with a capacity of less than 1 million gallons, 1.8 cents per gallon for capacities from 1 million to 3 million gallons, and 1.5 cents per gallon for greater than 3 million gallons.

Costs associated with liquid storage are shown in table 27 for each model farm.

Slurry storage

Slurry storage in earthen pits, concrete tanks, or small storage ponds is a component of manure management systems for some swine, dairy, and veal model farms. These often are storage facilities beneath a slatted floor. Storage facilities were designed for 120 days of storage to reflect common practice in the industry. Most of the dairy operations for representative farm number 3 and veal farms originally were slurry systems, so most are assumed to already have adequate storage systems. For swine farms with slurry systems, it was assumed that the majority would need extensive upgrades to meet the 120-day storage requirement. CNMP needs for slurry storage were judged to be as follows:

- 20 percent for dairy farm #3 in the Dairy Belt with 35 to 135 AU
- 30 percent for dairy farm #3 in the Dairy Belt with 135 to 270 AU
- 40 percent for dairy farm #3 in the Dairy Belt with more than 270 AU
- 30 percent for veal farms
- 50 percent for swine farm #3
- 60 percent for swine farm #2

Slurry storage facility costs were estimated in the same manner as liquid storage ponds and lagoons, using the same approach and the same costs per gallon. Costs associated with slurry storage are shown in table 28 for each model farm.

Table 27 Per-unit cost estimates for liquid storage

Livestock type	Represent-ative farm	Region	Number animals per farm used to design pond	Storage unit size (gal)	Total installation cost ($)	Annual installation cost ($)	Cost per unit ($)
Dairy	2,4	Dairy Belt	300	4,342,477	65,137	9,707	32.36 per head
Dairy	4	Dairy Belt	200	2,893,414	52,081	7,762	38.81 per head
Dairy	4	Dairy Belt	100	1,321,828	23,793	3,546	35.46 per head
Dairy	5	SE	100	1,580,733	28,453	4,240	42.40 per head
Dairy	5	SE	300	4,573,781	68,607	10,224	34.08 per head
Dairy	5	West	100	1,607,863	28,942	4,313	43.13 per head
Dairy	5	West	200	3,130,253	46,954	6,997	34.99 per head
Dairy	5	West	300	5,216,732	78,251	11,662	38.87 per head
Layers	2	SE	50,000	7,054,470	105,817	15,770	15,770 per house
Layers	2	SE	200,000	26,515,403	397,731	59,274	14,818 per house
Layers	2	SC	200,000	25,387,588	380,814	56,752	14,188 per house
Swine	1	SE	83 AU	1,165,377	17,481	2,605	31.39 per AU
Swine	1	SE	248 AU	3,222,244	48,334	7,203	29.04 per AU
Swine	1	NC-NE	415 AU	5,384,140	80,762	12,036	29.00 per AU
Swine	1	NC-NE	2,075 AU	26,408,062	396,121	59,034	28.45 per AU
Swine	1	West	415 AU	6,577,275	98,659	14,703	35.43 per AU
Swine	1	West	2,075 AU	32,348,499	485,227	72,313	34.85 per AU

Table 28 Per-unit cost estimate for slurry storage

Livestock type	Represent-ative farm	Region	Number AU per farm used to design storage unit	Storage unit size (gal)	Total installation cost ($)	Annual installation cost ($)	Cost per unit ($)
Dairy	3	Dairy Belt	200 Head	1,122,000	20,196	3,010	15.05 per head
Dairy	3	Dairy Belt	300 Head	1,683,000	30,294	4,515	15.05 per head
Dairy	3	Dairy Belt	100 Head	561,000	12,342	1,839	18.39 per head
Swine	2	SE	83	287,363	6,322	942	11.35 per AU
Swine	2	SE	248	708,225	15,581	2,322	9.36 per AU
Swine	2	NC-NE	415	1,101,176	19,821	2,954	7.12 per AU
Swine	2	NC-NE	2,075	5,245,933	78,689	11,727	5.65 per AU
Swine	2	West	415	1,068,808	19,239	2,867	6.91 per AU
Swine	2	West	2,075	5,037,143	75,557	11,260	5.43 per AU
Swine	3	NC-NE	450	2,148,585	32,229	4,803	10.67 per AU
Veal	1	All	415	1,101,176	19,821	2,954	7.12 per AU

Runoff storage ponds

Open lots where animals are held produce contaminated water during rainfall events in the form of runoff. Runoff storage ponds are constructed to capture and store this contaminated water. They are needed for pasture-based swine operations (swine farm #5) and swine operations with a lot (swine farm #4), turkey ranches, dairy farms #1 and #2, fattened cattle and confined heifer farms with a scrape and stack manure management system, and fattened cattle feedlots with manure pack. These ponds will also collect the wash water used around dairies.

A majority of these farms do not have runoff storage ponds, or the existing pond is inadequate. CNMP needs for these farms were judged to be high, as follows:

- 80 percent for dairy farms #1 and #2
- 90 percent for turkey ranches
- 70 percent for fattened cattle farm #2
- 40 percent for fattened cattle farm #1 and confined heifer farm #2 (scrape and stack) in the Northeast and Midwest.
- 50 percent for fattened cattle farm #1 and confined heifer farm #2 (scrape and stack) in the Southeast and West.
- 50 percent for swine farms #4 and #5

Costs for runoff storage ponds for dairy, fattened cattle, swine farms, and confined heifer farms were estimated in the same manner as liquid storage ponds and lagoons, using the same approach and the same costs per gallon. Costs associated with runoff storage ponds are shown in table 29 for each model farm.

Settling basins

Settling basins are expected to be a component for all farms with runoff storage ponds. Runoff from open lots generally carries manure solids and sometimes soil particles with it. If these solids are allowed to reach the runoff storage ponds, the operator of the system is faced with the problem of handling a primarily liquid wastewater that contains some solids, making land application of the liquid more difficult because of plugging of irrigation or spray nozzles. The operator also must address the removal of residual solids from the liquid holding pond periodically to ensure design capacity is maintained, which is another cost to the operator. Because animal operations that use open lots must already handle both solids and liquids, most operations would prefer to separate solids from the lot runoff before it can enter the runoff storage pond. By separating the solids from the runoff, the solids can be managed more effectively and the storage pond can be sized and operated more efficiently. While it is recognized that some operations would continue to handle the runoff as a composite mixture, the added costs of dealing with the solids in the runoff storage pond would easily offset the cost of installing a settling basin. CNMP needs for settling basins were the same as those for runoff storage ponds.

A settling basin consists of a small holding pond with a concrete floor and an outlet structure to allow the liquid to pass through the basin. The outlet structure is a pipe that has a perforated riser at the inlet that allows water level control to enhance settlement of solids. Before entering the storage pond, runoff passes through the settling basin where the solids are settled out and the liquid is outlet to the storage pond. Solids are periodically removed and land applied or stored with other manure solids on the farm.

The sizing of settling basins was based on a typical open lot area size for a given animal operation size and the expected routed rainfall runoff volume associated with a 10 year-24 hour rainfall event on the open lot. Four size classes of operations—100 AU, 200 AU, 500 AU, and 1,000 AU—were used to calculate costs on a per AU basis. The cost of the basin construction (land grading, excavation, placing of earthen fill) would be about $0.04 per gallon of temporary storage volume. The concrete bottom was assumed to be 6 inches thick, with wire mesh reinforcement, at a cost of $200 per cubic yard ($3.70 per square foot) installed. The outlet structure was cost at $780. The costs per AU follow:

AUs used for sizing	Storage volume (gal)	Size of concrete bottom (ft^2)	Total cost ($)	Annual cost per AU ($)
100	17,000	600	3,682	5.49
200	50,000	800	5,743	4.28
500	108,600	1,000	8,828	2.63
1,000	206,700	1,200	13,492	2.01

These costs were assigned to CNMP farms based on the size of operation, as follows:

- $5.49 per AU for farms with less than 135 AU
- $4.28 per AU for farms with 135 to 300 AU
- $2.63 per AU for farms with 300 to 1,000 AU
- $2.01 per AU for farms with more than 1,000 AU

Table 29 Per-unit cost estimates for runoff storage ponds

Livestock type	Represent-ative farm	Region	Number AU per farm used to design pond	Pond size (gal)	Total installation cost ($)	Annual installation cost ($)	Cost per unit ($)
Dairy	1,2	Dairy Belt	200 head	1,355,750	24,404	3,637	18.18 per head
Dairy	2	Southeast	200 head	1,337,331	24,072	3,587	17.94 per head
Dairy	2	West	200 head	731,983	16,104	2,400	12.00 per head
Swine	5	Southeast	83	241,281	5,308	791	9.53 per AU
Swine	5	West	450	632,799	13,922	2,075	4.61 per AU
Swine	4	Midwest	450	1,398,349	25,170	3,751	8.34 per AU
Confined heifers	1	Northeast	50	395,232	8,695	1,296	25.92 per AU
Confined heifers	1	Southeast	50	400,076	8,802	1,312	26.23 per AU
Confined heifers	1	Midwest	50	308,505	6,787	1,011	20.23 per AU
Fattened cattle	1	Northeast	50	395,232	8,695	1,296	25.92 per AU
Fattened cattle	1	Southeast	50	400,076	8,802	1,312	26.23 per AU
Fattened cattle	1	Midwest	50	308,505	6,787	1,011	20.23 per AU
Fattened cattle	2	Southeast	100	535,736	11,786	1,756	17.56 per AU
Fattened cattle	2	Midwest	50	234,919	5,168	770	15.40 per AU
Fattened cattle	2	Midwest	100	399,713	8,794	1,311	13.11 per AU
Fattened cattle	2	Northern Plains	350	791,552	17,414	2,595	7.41 per AU
Fattened cattle	2	Northern Plains	750	1,608,964	28,961	4,316	5.75 per AU
Fattened cattle	2	Central Plains	750	1,673,838	30,129	4,490	5.99 per AU
Fattened cattle	2	Central Plains	1,500	3,321,639	49,825	7,425	4.95 per AU
Fattened cattle	2	West	250	317,391	6,983	1,041	4.16 per AU
Fattened cattle	2	West	750	1,136,631	20,459	3,049	4.07 per AU
Turkeys	2	East	500	1,350,897	24,316	3,624	540.87 per house
Turkeys	2	Midwest	500	1,167,101	21,008	3,131	467.28 per house
Turkeys	2	California	1100	2,285,140	41,133	6,130	415.87 per house
Turkeys	2	West other than California	600	1,374,213	24,736	3,686	458.50 per house

Conservation practices for pastured livestock

Pastured livestock operations differ from conventional feeding operations in that the animals are raised primarily on pasture or range, rather than in a confined environment. However, pastured and range animals sometimes are confined in the more conventional sense to provide for ease of management. For example, in areas of the country where winter is severe, a common practice is to keep pastured or range animals in a confined area with a dependable water supply and access by the farmer to provide supplemental feed. As a result, concentrations of manure are accumulated in these confined areas, generally near feed bunks and watering sources. Sometimes these confinement areas are located adjacent to streams and watercourses. The focus of a CNMP for these types of operations is to ensure a dependable source of water away from the streams to eliminate direct contact with watercourses and provide for collection and handling of recoverable manure generated in these concentrated areas.

Costs associated with conservation practices for pastured livestock are grouped under the manure and wastewater storage and handling element, although they include some costs associated with pasture management that would be expected to be included in a CNMP for these farms. As shown in appendix A, 24,697 farms with pastured livestock and few other livestock qualified as farms that may need a CNMP because of the amount of recoverable manure that would potentially be produced on these farms. An additional 36,575 farms had less than 35 AU of confined livestock types, but had beef cattle as the dominant livestock type on the farm. These two groups of farms comprise the set of farms for which CNMP components for pastured livestock are applied.

CNMP needs and costs associated with conservation practices for pastured livestock were derived using the same approach as used for the manure and wastewater storage and handling element. The methods used to estimate CNMP-related costs are presented in the following sections for each component. All costs, except where noted otherwise, were based on the Natural Resources Conservation Service's Field Office Technical Guide's average cost lists for individual components or practices. All capital costs were amortized over 10 years at 8 percent interest. Cost and needs assumptions are summarized in appendix E, table E–1.

Fencing

To properly control the access of animals to water, feed, and loafing areas, a planned system of fencing is needed that is consistent with each individual animal feeding operation's management strategy. Often the need is primarily focused to exclude animals from direct access to a stream. However, with exclusion from the stream, alternative water sources need to be provided, and generally, additional fencing is needed to control the movement of animals relative to the new water sources. It was judged that about a third of the pastured livestock operations would need additional fencing.

The amount of fencing needed is dependant on the particular operation. For a typical 150-AU cattle operation, it was assumed that about a mile of fence would be needed to supplement existing fencing and replace fencing in disrepair, or 35.2 feet per AU. Based on NRCS Conservation Practice Standard *Fence* (Code 382), the cost of fencing was $0.80 per foot of fence for a total cost of $28.16 per AU, or $4.20 annually per AU.

Water well

An alternative water source needs to be provided if livestock are excluded from direct access to streams and watercourses. Numerous methods are used to provide this alternative water source, with no consistency of method demonstrated in any particular region of the country. Methods include the installation of water wells dedicated to providing water for the pasture confinement area, utilizing instream pumps to transfer water from the immediate stream corridor, developing natural spring areas that are located away from the stream corridor, and pumping and piping water from an existing water system. For this assessment, it was assumed that a new well would be installed. The use of a dedicated well is generally the method of choice because of its reliability in providing a consistent quantity and quality of water (springs go dry, stream flows and quality fluctuate). Costs were based on criteria for well development in NRCS Conservation Practice Standard *Water Well* (Code 642). The depth of the well was assumed to be 250 feet. (Actual depths vary from 100 feet to over 1,000 feet around the country; however, most wells used for livestock watering are installed near riparian areas where the depth to a reliable, potable water table is relatively shallow.) Using $22 per foot as the cost of installing a well, the average cost of a well 250 feet deep is $5,500, or $820 annually per farm. It was judged that representative farms #3 and #4 would not need to construct a well, as an alternative water source will most likely be readily available. For representative farms #1 and #2, it was judged that about 40 percent of the operations would need to implement this practice.

Watering facility

Along with the need to provide an additional source of water is the need to provide temporary water storage and a watering facility for the animals. The amount of water storage needed is dependant on the source and reliability of water and the size of the herd. Watering facility design is based on the criteria established in NRCS Conservation Practice Standard *Watering Facility* (Code 614). In most situations the watering facility consists of a corrugated metal trough with a concrete bottom and pad that stores the equivalent of 1 day of water needs. Storage needs were based on 30 gallons per animal unit. For this assessment, costs per animal unit were based on storage requirements for a 150-AU herd, which would be 4,500 gallons. The watering facility would consist of a circular corrugated metal tank 1.5 feet deep and 23 feet in diameter. The cost is $0.75 per gallon for a total cost per AU of $22.50, or an annual cost of $3.35 per AU.

In the Northern Plains and Mountain States where winter confinement areas tend to be located a considerable distance from the operations' headquarters and where winter temperatures can drop and remain below freezing, special "frost free" watering facilities are needed. This type of facility is an enclosed fiberglass, insulated tank with a small drinking area for cow access. The need for more than 1 day of storage would depend on how remote and accessible the confinement site is. For the purposes of this assessment, 1 day of storage was used to calculate the cost. Based on a per-unit cost of $3 per gallon, the total cost per AU is $90, or $13.41 per AU annually.

In some areas of the upper Midwest or New England, winter temperatures also drop to below freezing; however, because of the close proximity of the headquarters area to the confinement areas, more cost-effective alternative methods are available to ensure the water does not freeze (such as manual clearing of ice, electric heaters).

CNMP needs for watering facilities are the same as those for water wells.

Heavy use area protection

The purpose of heavy use area protection is to stabilize areas of high traffic or use by equipment and animals. Associated with a CNMP for pastured livestock, this generally would address the area surrounding the watering facility. The practice would not only protect the integrity of the watering facility, but also provide an area for easier recoverability of manure. For the purposes of this assessment, heavy use area protection will consist of a concrete pad surrounding the watering facility. Costs per animal unit were based on a 150-AU herd. The heavy use area would be a square pad, 43 feet on a side or 1,815 square feet, 6 inches thick. Subtracting out the area of the tank, the required installation is 1,414 square feet, or 26.2 cubic yards of concrete. Based on an installation cost of $120 per cubic yard (which includes the minor grading and shaping required, forming, cost of concrete, and labor), the cost of the pad for the 150-AU herd would be $3,141, or $3.12 per AU annually. Using the same approach, per-AU costs would be $6.35 for a 50-AU herd and $2.32 for a 250-AU herd. The following function was derived for use in estimating the cost per AU:

x = herd size
a = annual cost per AU

If $x \leq 50$, then a=$6.35
If $x \geq 250$, then a=$2.32

If $50 < x < 150$, then $a=6.35-\left[\frac{(x\text{-}50)}{(150\text{-}50)}\times(6.35\text{-}3.12)\right]$

If $150 < x < 250$, then $a=3.12-\left[\frac{(x\text{-}150)}{(250\text{-}150)}\times(3.12\text{-}2.32)\right]$

Heavy use area protection is needed only for representative farm #1. CNMP needs were judged to be 50 percent for these operations.

Windbreak or shelterbelt establishment

One of the primary reasons that pastured livestock have been wintered in riparian areas is to provide shelter from the wind and weather. In moving pastured livestock directly out of the immediate stream corridor, certain regions of the country will be moving their animals away from natural cover and protection from the elements. Replacement of the needed protection is essential in implementing a CNMP. The windbreaks or shelterbelts are installed along the edge of the confinement area on the side of the prevailing winds expected in the winter. The windbreaks or shelterbelts generally consist of from three to seven parallel rows of trees of varying species. This is primarily a concern in the West, Northern Plains, and Mountain States.

The criteria used to determine the size and type of protection needed were based on NRCS Conservation Practice Standard *Windbreak/Shelterbelt Establishment* (Code 380). Cost estimates were estimated for three herd size categories: 50, 150, and 250 AU. For these herd sizes, the length of the windbreak or shelter break would be 600, 1,200, and 1,800 feet, respectively. Installation cost is $4.20 per foot. Thus, the annual cost per AU is $7.51 per AU for a 50-AU herd, $5.01 per AU for a 150-AU herd, and $4.51 per AU for a 250-AU herd. The following function was derived for use in estimating the cost per AU:

x = herd size
a = annual cost per head

If x <= 50, then a=$7.51
If x >=250, then a=$4.51

If 50 < x < 150, then $a=7.51-\left[\frac{(x\text{-}50)}{(150\text{-}50)}\times(7.51\text{-}5.01)\right]$

If 150 < x < 250, then $a=5.01-\left[\frac{(x\text{-}150)}{(250\text{-}150)}\times(5.01\text{-}4.51)\right]$

Windbreak or shelter break establishment is only needed for representative farm #2. CNMP needs were judged to be 50 percent for these operations.

Solids storage

Most pasture operations would allow manure to accumulate through the period of temporary confinement, periodically removing the manure as it accumulates. A designated storage area is generally not needed to manage the manure produced. However, in regions such as the Midwest, Lake States, and the Northeast, manure cannot be periodically spread because of frozen and snow covered ground. In these regions temporary storage is needed for about 2 to 3 months while the animals are temporarily confined. Because the period of storage is during the winter when the only precipitation expected is in the form of snow, a cover for the storage area is not considered essential. Therefore, a concrete slab 6 inches thick was used for estimation. For a 150-AU herd, the relative size of a solid storage pad would be 1,600 square feet. A 1,600 square foot pad 6 inches thick would require 29.6 cubic yards of concrete. Based on a per-unit cost of $120 per cubic yard (which includes the minor grading and shaping required, forming, cost of concrete, and labor), the total cost of the storage pad would be $3,556, which equates to about $1.85 per ton of recoverable solids. CNMP needs were judged to be 50 percent for operations in the Midwest, Northeast, and Lake States.

Filter strip

For pasture operations in the Midwest, Lake, and Northeast States, filter strips on the downslope edge of the temporary confinement area would be needed to prevent removal of solids and dissolved nutrients from the lot with the runoff from snowmelt and spring rains. Costs per AU were based on a 50-AU herd size. It was assumed that the filter strip would need to be 30 feet wide by 400 feet long, resulting in a treatment area of 12,000 square feet, or 0.28 acres. The average cost of shaping and seeding is $1,500 per acre. Thus, the total cost of the filter strip is $413, which is equivalent to an annual cost of $1.23 per AU. Because the typical location of these pasture operations is near stream corridors, vegetated areas are often already in place, assuming the lot areas have been set back from the stream. CNMP needs were therefore judged to be only 30 percent for representative farms #3 and #4.

Summary of CNMP costs for manure and wastewater handling and storage

Estimates of CNMP costs for each model farm were used to calculate estimates for each CNMP farm in the Census of Agriculture in the same way as cost estimates were calculated for recoverable manure estimates in appendix B. For farms with more than one representative farm assigned to it, the probabilities associated with each representative farm were used as weights to obtain a weighted total. The probabilities associated with each model farm are presented in tables 2 through 5.

The average annual per-farm cost estimates for each of the manure and wastewater handling and storage components are presented in table 30 according to livestock type. Manure storage components (solids, liquid, slurry, and runoff ponds) had the highest cost per farm for all but pastured livestock and swine farms. Liquid transfer costs were slightly higher than storage costs for swine farms. For dairies, liquid transfer costs were nearly as high as storage costs. Collection costs were a significant portion of the total costs for fattened cattle and turkey farms, and mortality management costs were a significant portion for swine, broiler, and turkey farms.

The annual average cost for the manure and wastewater handling and storage element was estimated to be $2,509 per farm (table 31). Capital costs were nearly 75 percent of the total cost, overall. The highest cost was for fattened cattle farms at $9,112 per farm and for turkey farms at $7,940 per farm, reflecting the larger number of animal units per farm for these two types of farms. Dairy farms had the highest cost per animal unit at $22 per milk cow animal unit. Swine farms had the next highest cost per animal unit at $18 per swine animal unit.

Table 30 Annual cost per farm for each manure and wastewater handling and storage component

Dominant livestock type	Number of farms	Mortality mgt.		Lot upgrades	Clean water diversions			Collection					Liquid treatment
					Grassed waterway	Earthen berm	Roof runoff	Contaminated water diversions	Solids		Liquid or slurry		
		capital ($)	operating ($)	capital ($)	capital ($)	capital ($)	capital ($)	capital ($)	capital ($)	operating ($)	operating ($)	capital ($)	capital ($)
Fattened cattle	10,159	0	0	405	1	399	0	304	1,216	1,118	0	0	0
Milk cows	79,318	0	0	0	0	159	75	0	157	144	218	458	128
Swine	32,955	1,236	231	0	0	4	4	0	2	2	82	165	0
Turkeys	3,213	256	1,155	0	0	36	346	81	0	1,320	0	0	0
Broilers	16,251	128	577	0	0	0	0	0	0	58	0	0	0
Layers/pullets	5,326	26	119	0	0	0	0	0	0	163	21	52	0
Confined heifers/veal	4,011	0	0	327	4	0	0	46	402	370	0	0	0
Small farms w/ confined livestock types	42,565	0	0	0	0	19	7	0	16	29	13	15	27
Pastured livestock types	61,272	0	0	0	0	0	0	0	0	0	0	0	0
Specialty livestock types	2,131	54	245	0	0	0	0	0	0	18	0	0	0

Costs differed most by farm size (table 31). Large farms (producing more than 10 tons of phosphorus annually) had an average annual cost of $15,167 per farm, compared to an average annual cost of $3,397 per farm for medium-size farms and $1,070 per farm for small farms. The cost per animal unit on large farms, however, was lower than for medium-size and small farms because of the economies of scale embodied in the assignment of per unit costs and the lower CNMP needs expected for the largest farms.

Per-farm costs were highest in the Pacific, Mountain, and Southern Plains regions (table 32) and lowest in the Lake States and the Corn Belt regions. Total costs were highest in the Corn Belt, the Lake States, and the Northern Plains, which together represented about 45 percent of the total costs for manure and wastewater handling and storage.

Overall, annual manure and wastewater handling and storage costs totaled $645 million.

Table 30 Annual cost per farm for each manure and wastewater handling and storage component—Continued

Dominant livestock type	Solids storage	Liquid storage	Slurry storage	Liquid transfer		Runoff storage pond	Settling basin	Fence	Heavy use area	Well	Watering facility	Wind-break	Filter strip
	capital ($)	capital ($)	capital ($)	capital ($)	operating ($)	capital ($)	capital ($)	($)	($)	($)	($)	($)	($)
Fattened cattle	31	0	0	484	136	3,457	1,332	0	0	0	0	0	0
Milk cows	223	606	21	630	189	125	38	0	0	0	0	0	0
Swine	8	568	511	904	270	31	16	0	0	0	0	0	0
Turkeys	4,085	0	0	7	1	354	140	0	0	0	0	0	0
Broilers	1,539	0	0	0	0	0	0	0	0	0	0	0	0
Layers/pullets	2,490	663	0	288	86	0	0	0	0	0	0	0	0
Confined heifers/veal	632	10	0	120	31	934	236	0	0	0	0	0	0
Small farms w/ confined livestock types	41	13	2	7	4	0	0	0	0	0	0	0	0
Pastured livestock types	11	0	0	0	0	0	0	147	80	203	263	109	10
Specialty livestock types	509	0	0	0	0	0	0	0	0	0	0	0	0

Table 31 Annual manure and wastewater handling and storage cost per farm, by livestock type and farm size

Dominant livestock type or farm size class	Number of farms	AU for dominant livestock type	AU for other livestock types*	Capital cost** ($)	Operating cost** ($)	Maintenance cost** ($)	Total cost ($)	Cost per AU of dominant livestock type ($)
Fattened cattle	10,159	858	440	7,629	1,254	229	9,112	11
Milk cows	79,318	149	46	2,620	551	79	3,249	22
Swine	32,955	236	40	3,451	585	104	4,139	18
Turkeys	3,213	638	49	5,305	2,476	159	7,940	12
Broilers	16,251	150	33	1,666	635	50	2,351	16
Layers/pullets	5,326	258	39	3,519	390	106	4,015	16
Confined heifers/veal	4,011	237	64	2,710	401	81	3,192	13
Small farms with confined livestock types	42,565	18	7	149	46	4	199	11
Pastured livestock types	61,272	107	10	NA	NA	NA	823	8
Specialty livestock types	2,131	NA	17	563	263	17	843	NA
Large farms	19,746	1,129	290	11,627	2,721	349	15,167	13
Medium-size farms	39,437	191	61	2,477	543	74	3,397	18
Small farms	198,018	63	17	773	126	23	1,070	17
All types	257,201	165	45	1,867	389	56	2,509	15

NA Not available.
* Includes pastured livestock types.
** Costs for farms with pastured livestock types dominant were not broken down into capital and operating costs. Costs for these farms are presented in the Total cost column.

Table 32 Annual manure and wastewater handling and storage cost per farm, by farm production region

Farm production region	Number of farms	Capital cost ($)	Operating cost ($)	Maintenance cost ($)	Total cost ($)
Appalachian	22,899	2,155	545	65	2,987
Corn Belt	71,540	1,312	214	39	1,647
Delta States	12,352	1,468	436	44	2,181
Lake States	52,817	1,363	250	41	1,669
Mountain	7,964	4,184	980	126	6,177
Northeast	31,598	1,595	303	48	1,976
Northern Plains	26,309	2,012	345	60	3,088
Pacific	7,974	5,684	1,479	171	7,731
Southeast	12,807	2,074	549	62	2,901
Southern Plains	10,941	3,508	775	105	4,776
All types	257,201	1,867	389	56	2,509

Recordkeeping Costs

The *Comprehensive Nutrient Management Plan Technical Guidance* identifies a variety of recordkeeping activities that are expected to be included in a CNMP. These can be grouped into three categories:

1. **Annual activities**
   - Results of manure tests for nutrient content
   - Field records of crops planted and harvested and other annual activity records
   - Records associated with evaluations by NRCS, third-party consultants, or regulatory agencies
   - Records of land application equipment calibration
   - Alterations to the CNMP
   - Update of site information and production information, as needed.

2. **Monthly activities**
   - Records of management of manure storage facilities (dates of emptying, discharge or overflow events, and record of monthly levels)
   - Records of operation and maintenance

3. **Per-event activities**
   - Application records for each land application event, including the amount applied, acres applied, application method, time and date of application, weather conditions during application, and soil moisture condition
   - Off-site transfer records, including manure nutrient content, amount of manure transferred, date, and recipient of manure
   - Activities associated with emergency spill response plan

Recordkeeping costs for annual, monthly, and per-event activities depend on the type and size of the animal feeding operation. Operations that handle manure as a solid would not typically incur a cost for monthly activities, except possibly maintenance, because waste would be stockpiled and would not require as much monitoring as a liquid holding pond or lagoon. Broiler operations typically would remove the crust from a house after each flock and perform a complete house cleanout only once a year. Operations with more frequent removal and land application would incur higher recordkeeping costs. Generally, liquid systems would have greater recordkeeping requirements than solid handling systems. Larger systems would generally incur a higher monthly cost than smaller systems because of the greater complexity of the operation.

Recordkeeping costs were assigned as follows:

- $80 per year for annual recordkeeping activities (8 hours per year at $10 per hour). This cost would be incurred by all operations with more than 35 animal units.
- $120 per year for monthly activities (1 hour per month at $10 per hour) associated with liquid/slurry handling on small systems, and $240 per year for monthly activities associated with liquid/slurry handling on larger systems (2 hours per month at $10 per hour).
- $120 per year for monthly activities (1 hour per month at $10 per hour) for the larger fattened cattle operations with manure pack. For other solid systems, monthly recordkeeping is minor, and costs are incorporated into the per-event cost.
- $40 per year for per-event activities (16 days per year for land application of manure, 15 minutes per day for recordkeeping, at $10 per hour) for nonpoultry operations that land apply manure, including layer farms with shallow pit or flush-to-lagoon systems. For the remaining poultry farms, per-event recordkeeping costs were assumed to be $20 per year (8 days per year for land application of manure, 15 minutes per day for recordkeeping, at $10 per hour).
- Recordkeeping costs for pastured livestock farms and small farms with confined livestock types (less than 35 animal units) consisted of $40 per year for annual costs and $20 per year for monthly and per-event costs.

Most, if not all, of the costs associated with setting up recordkeeping would be covered in the technical assistance provided to the producer, and so setup costs are not included here. Setup might include establishing the necessary forms to document actions and activities and providing software programs to aid in more comprehensive recordkeeping activities.

Although many operators keep some records, most operators are not expected to be keeping sufficient records to provide adequate information for maintaining a nutrient management plan. It was thus judged that CNMP needs would be 90 percent for recordkeeping activities.

Overall, annual recordkeeping costs totaled $30 million. The annual average cost was $117 per farm (table 33). Recordkeeping costs were highest for swine farms, averaging $224 per farm. Costs were lowest for poultry farms ($90 per farm), small farms with confined livestock types ($54 per farm), farms with pastured livestock types ($54 per farm), and specialty livestock farms ($54 per farm).

Table 33 Annual average recordkeeping costs per farm, by livestock type and farm size

Dominant livestock type or farm	Number of farms	Recordkeeping costs
Fattened cattle	10,159	142
Milk cows	79,318	160
Swine	32,955	224
Turkeys	3,213	90
Broilers	16,251	90
Layers/pullets	5,326	136
Confined heifers/veal	4,011	117
Small farms with confined livestock types	42,565	54
Pastured livestock types	61,272	54
Specialty livestock types	2,131	54
Large	19,746	168
Medium	39,437	150
Small	198,018	106
All CNMP farms	257,201	117

CNMP development costs

A significant part of the cost of CNMPs is the cost of developing the CNMP for each livestock operation. CNMP development includes

- working with farmers to define objectives, develop and evaluate alternatives, and finalize a plan;
- designing the conservation practices identified in the CNMP plan;
- assisting with and inspecting the installation of the conservation practices and identified management activities; and
- following up with the producer to address questions and to assure that the practices are being carried out as intended.

Because of the technical complexities that must be addressed in developing and implementing a CNMP, most producers need assistance from technical specialists to ensure that sustainable systems will be installed and operated, and that those systems meet the objectives of a CNMP and are consistent with the production goals of the farmer. This assistance could be provided by technical specialists from either the public or private sectors.

Alternatives development and evaluation involves meeting with the livestock operator to determine resource concerns related to the operation, obtain pertinent operational data (such as the number of animals and plans for expansion), and identify present practices for handling manure. Resource concerns include potential environmental risks, such as runoff from feedlots, proximity to streams and lakes, and eroding cropland. Based on this information the planner would develop several alternatives the operation could use to meet CNMP criteria. The preparation of the alternatives would involve developing preliminary designs for structural practices, estimating the acres and cropping practices needed to utilize manure nutrients efficiently, and determining the conservation system needed to control erosion on acres receiving manure. The planner would then meet with the operator again to review alternatives and assist with the selection. A CNMP would then be prepared.

Once a CNMP has been planned and an alternative selected by the operator, it is necessary to **design** the structures that need to be installed or practices that need to be implemented. For structures this involves taking soil borings in areas where ponds and lagoons will be built, performing a detailed survey (with surveyor instruments) of all production areas including areas proposed for structure locations, and surveys for land treatment practices. Design would also involve plotting of the surveys, making the necessary structure design calculations, and drafting the final design that will be used to guide construction, including the necessary construction specifications to support the drawings. For nutrient management it would involve developing the nutrient balance calculations and specification of a nutrient management plan.

Implementation involves the assistance needed to ensure that the installation of practices and structures meet the designs and specifications developed. It generally involves providing layout stakes for a contractor to follow, performing necessary material tests onsite (soil compaction tests, for example), performing periodic spot surveys to ensure constructed practices are being installed according to designs, and performing a final checkout survey after the practice is installed. It would also involve working with the operator to calibrate manure-spreading equipment.

After a practice or a plan has been installed, it is necessary to **follow up** by returning to the operation to ensure the practice is working properly and to make changes or adjustments to the CNMP if needed.

CNMP development costs were estimated in terms of technical assistance hours needed to accomplish the four primary functions defined above. Separate estimates were made for land treatment practices, nutrient management, and manure and wastewater handling and storage. Technical assistance associated with recordkeeping is embedded in the estimates for these three elements, and could not be estimated separately.

The technical assistance generally associated with the **land treatment practices element** can involve a range of technical disciplines from engineering to soil conservation. Practices used to satisfy the criteria established for this element are management practices (residue management, stripcropping) and structural practices (terraces, divisions, sediment basins). Assistance would typically be provided by soil conservationists, agronomists, nutrient management specialists, rangeland specialists, and engineers.

Technical assistance for the **manure and wastewater handling and storage element** is primarily engineering. The majority of the time accounted for under this element involves the design and installation assistance associated with waste handling, storage, and treatment structural practices. Many of the practices covered under this element require a licensed engineer's involvement by State Law. However, some of the resource assessment and preliminary design calculations associated with the volume of waste generated, proportion of nutrients in manure, and locating clean water diversions can be performed by soil conservationists, agronomists, or nutrient management specialists.

Technical assistance for the **nutrient management element** is generally associated with technical disciplines trained in crop management activities. Typically, this element of a CNMP would be addressed by a nutrient management specialist or agronomist. However, because of the close interaction between nutrient management and soil erosion, it is anticipated that many soil conservationists would also fill this role.

Estimates of technical assistance hours do **not** include administrative time associated with carrying out various additional functions that usually take place as part of the overall implementation process, such as making Federal, State, Tribal, or local incentive program eligibility determinations, assisting operators with the completion of State, Tribal, and local permit applications, and various agency performance reporting and documentation activities.

Estimates of CNMP development costs also do **not** include the time spent by the operator working with the technical specialists to produce the plan. Depending on the complexity of the operation and the availability of records, the economic value of time spent by the operator could be significant.

Estimating the costs of developing CNMPs

Estimates of technical assistance hours were based on the Fiscal Year 2001 National NRCS/Partnership Workload Analysis (2001 WLA). In fiscal year 2001, the NRCS conducted a workload analysis of the technical assistance time associated with assisting producers to plan and implement various conservation systems and practices. The purpose of the 2001 WLA was to analyze the conservation workload of NRCS and its conservation partners using 44 Core Work Products (CWPs) to define field activities. These 44 CWPs capture a broad range of activities from systems planning to various administrative and program support functions. Each CWP activity is further defined by specific tasks associated with its completion. From 5 to 10 tasks define a CWP. The 2001 WLA database was developed by 218 Regional Time Teams (RTTs) consisting of NRCS and technical staff from partner organizations familiar with that region's specific conservation operations.

At the time the 2001 WLA was conducted, the technical requirements associated with a CNMP had not yet been defined. Therefore, the 2001 WLA did not contain a specific CWP that addressed CNMPs. However, by combining time estimates from 15 of the relevant CWPs and selecting specific tasks that would be included in development of a CNMP, an estimate was made of technical assistance hours associated with CNMP development. A list of the 15 CWPs and specific tasks that were used to estimate CNMP technical assistance hours for each of the three CNMP elements is presented in table 34. Technical assistance hours were estimated for each of the four primary functions —alternatives development, design, implementation, and followup—by assigning the various tasks to each function.

Table 34 Core work products (CWPs) and specific tasks associated with CNMP elements

CWP number	CWP Title	CNMP Element	Specific tasks*
01a	Conservation Systems on Cropland (Planning)	Land Treatment Practices	Recognize problems, determine land user needs, resource assessment, resource evaluation, evaluate data, develop alternatives, formulate decisions, travel time, followup.
01b	Conservation Systems on Cropland (Application)	Land Treatment Practices	Prepare designs, provide maintenance information, solicit necessary reviews, travel time, layout practices, check out practices, certify practices.
02a	Conservation Systems on Rangeland (Planning)	Land Treatment Practices	Recognize problems, determine land user needs, resource assessment, resource evaluation, evaluate data, develop alternatives, formulate decisions, travel time, followup.
02b	Conservation Systems on Rangeland (Application)	Land Treatment Practices	Prepare designs, provide maintenance information, solicit necessary reviews, travel time, layout practices, check out practices, certify practices.
03a	Conservation Systems on Pastureland (Planning)	Land Treatment Practices	Recognize problems, determine land user needs, resource assessment, resource evaluation, evaluate data, develop alternatives, formulate decisions, travel time, followup.
03b	Conservation Systems on Pastureland (Application)	Land Treatment Practices	Prepare designs, provide maintenance information, solicit necessary reviews, travel time, layout practices, check out practices, certify practices.

See footnote at end of table.

Table 34 Core work products (CWPs) and specific tasks associated with CNMP elements—Continued

CWP number	CWP Title	CNMP Element	Specific tasks*
04a	Conservation Systems on Forest Land (Planning)	Land Treatment Practices	Recognize problems, determine land user needs, resource assessment, resource evaluation, evaluate data, develop alternatives, formulate decisions, travel time, followup.
04b	Conservation Systems on Forest Land (Application)	Land Treatment Practices	Prepare designs, provide maintenance information, solicit necessary reviews, travel time, layout practices, check out practices, certify practices.
06a	Irrigation Systems	Land Treatment Practices	Design survey, prepare designs, provide maintenance information, travel time, lay out practices, check out practices, certify practices.
06b	Irrigation Water Management	Nutrient Management	Evaluate soil, plant, water relationship/needs, efficiency determination, develop water management plan, provide maintenance information, travel time, followup.
07a	Dry Waste Management Systems (collection, storage, and/or treatment)	Manure and Wastewater Handling and Storage	Resource assessment, travel time, prepare designs, provide maintenance information, layout practices, check out practices, certify practices.
07b	Dry Waste Management Systems (waste application)	Nutrient Management	Resource assessment, develop waste utilization, plan, travel time, run waste utilization program, soils information and testing, followup.
08a	Wet Waste Management Systems (collection, storage, and/or treatment)	Manure and Wastewater Handling and Storage	Resource assessment, travel time, prepare designs, provide maintenance information, layout practices, check out practices, certify practices
08b	Wet Waste Management Systems (waste application)	Nutrient Management	Resource assessment, develop waste utilization, plan, travel time, run waste utilization program, soils information and testing, followup.
25	State & Local Reviews,	Land Treatment Practices Inspections & Permits	Meet with Applicant/Other, Receive/Process Application, Review Plan and Calculations, Conduct Inspections, Develop Recommendations, Review Revisions, Issue Permit

* To estimate technical assistance hours for design, the following specific tasks were used: prepare designs, provide maintenance information, solicit necessary reviews, travel time, design survey, and run waste utilization program. To estimate technical assistance for implementation, the following specific tasks were used: layout practices, checkout practices, certify practices, soil information and testing. To estimate technical assistance for followup, the following specific tasks were used: followup activities and issue report. The remaining tasks listed above were used to estimate technical assistance hours for alternatives development.

Adjustments were made to account for specific CNMP-related tasks that had not been incorporated into the original CWP estimates. Adjustments to the 2001 WLA data were based on a subset of 20 RTTs in regions with significant livestock production. Each of the 20 representative RTTs evaluated the original data in the 2001 WLA for the 15 CWPs associated with a CNMP by comparing the original assumptions to the new technical requirements for CNMP development and implementation. The adjustments developed by each ranged from zero (no change) to an increase of 400 percent; the average adjustment was 17 percent.

For the land treatment practices element, technical assistance hours were based on the incremental change calculated using the adjustment factors. The total time estimate in the 2001 WLA database would overstate the hours needed specifically to develop a CNMP. For example, consider CWP-01, Conservation Systems on Cropland (Planning). Under existing USDA programs, most cropland already has some kind of plan to address soil erosion criteria. By using the incremental change the estimation would capture only the time associated with adjusting the existing plan where needed to address the higher standards established by the CNMP. The total time associated with land treatment for each of the technical assistance functions is the sum of the incremental changes for all the CWPs used to define this element.

Two CWPs were used to define the manure and wastewater storage and handling element, CWP–07a and CWP–08a. The difference between the two is that one is representative of animal feeding operations that manage their manure primarily as a solid (dry), and the other is representative of operations that primarily manage their manure as a liquid (wet). The total time used for estimation of this element was the base time established in the 2001 WLA plus the incremental change. The base time identified in the 2001 WLA for these CWPs was included in the time accounting because, unlike the CWPs for land treatment, these CWPs are dedicated to animal feeding operations. The incremental change that is applied to these CWPs reflects the comparison of the new CNMP requirements and new conservation practice standards to the waste management system criteria that existed at the time the 2001 WLA was conducted.

The technical assistance time used for the nutrient management element was based on three CWPs: CWP–06b Irrigation Water Management, CWP–07b Dry Waste Management Systems (waste application), and CWP–08b Wet Waste Management Systems (waste application). Only the incremental change associated with CWP–06b was included. It was assumed that for irrigation water management to apply, an irrigation system would already be in place. If an irrigation system was in place, some form of irrigation water management was already in use. For CWP–07b and CWP–08b, the estimation used the sum of the 2001 WLA base time plus the incremental change because these CWPs were dedicated to animal feeding operations in the 2001 WLA.

Separate estimates were made for each of the model farms described previously (see tables 2 to 5). (The model farm structure was the same as that used to estimate recoverable manure in appendix B.) The 2001 WLA database provided descriptions of the farms that were used as a basis for the time estimates. The descriptions included the size of the operation, type of manure management system (wet or dry), and dominant livestock type. Because these were not exactly the same as the definitions for model farms, some RTT estimates were assigned to more than one model farm. The number of RTT estimates assigned to a model farm ranged from 1 to 34. The average of the RTT estimates was used to represent technical assistance hours for each model farm. Technical assistance estimates for each model farm are presented in table 35.

An additional adjustment factor was developed to account for mismatches between the size of operations specified in the 2001 WLA database and the model farm size. In some cases the size of the model farm was smaller than most of the RTT estimates assigned to it, so the number of hours needed to be adjusted downward. In other cases the size of the model farm was larger than most of the RTT estimates assigned to it, so the number of hours needed to be adjusted upward. In yet other cases the match was close enough to need only a small, or no, adjustment. Adjustment factors ranged from 0.6 for some small model farms to 1.7 for large model farms. The final estimate of technical assistance hours for each model farm was obtained by multiplying the estimate of hours in table 35 by the size adjustment factor, also presented in table 35.

Table 35 Technical assistance hours per farm as derived from RTT estimates and size adjustment factor for model farms (heading abbreviations: AD=alternatives development, D=design, I=implementation, F=followup)

Model farm regions & livestock type	Model farm size class	Representative farm	Probability (%)	Size adjustment factor	Manure & wastewater handling & storage				- - Land treatment - -				Nutrient management			
					AD	D	I	F	AD	D	I	F	AD	D	I	F
Dairy farms																
North Central & Northeast	35-135	#1: no storage	29	0.8	30.7	72.1	41.6	3.2	21.6	1.3	4.2	1.4	40.9	5.5	9.8	11.5
		#2: solids storage	47	0.8	30.7	72.1	41.6	3.2	21.6	1.3	4.2	1.4	40.9	5.5	9.8	11.5
		#3: liquid storage—deep pit or slurry	7	0.7	45.8	74.7	73.5	9.1	13.1	4.1	2.6	2.4	34.0	4.1	9.3	9.6
		#4: liquid storage—basin, pond, lagoon	17	0.7	44.1	75.4	67.9	8.4	12.2	3.8	2.4	2.2	32.5	4.5	8.9	9.1
	135-270	#1: no storage	15	1.0	21.2	73.0	38.0	3.3	9.8	3.0	2.1	1.5	21.0	4.1	3.2	6.6
		#2: solids storage	28	1.0	21.2	73.0	38.0	3.3	9.8	3.0	2.1	1.5	21.0	4.1	3.2	6.6
		#3: liquid storage—deep pit or slurry	14	1.0	44.0	85.4	63.3	5.1	19.5	3.6	4.1	2.3	41.3	6.1	11.7	10.8
		#4: liquid storage—basin, pond, lagoon	43	1.0	44.0	85.4	63.3	5.1	19.5	3.6	4.1	2.3	41.3	6.1	11.7	10.8
	> 270	#2: solids storage	14	1.3	25.9	65.6	33.5	4.4	10.8	1.4	0.6	1.0	21.9	6.7	4.3	6.9
		#3: liquid storage—deep pit or slurry	18	1.3	44.2	92.2	70.4	6.2	14.6	2.2	2.9	1.5	42.6	5.6	11.9	12.4
		#4: liquid storage—basin, pond, lagoon	68	1.3	42.7	89.9	67.5	6.0	13.9	2.1	2.8	1.4	41.2	5.4	11.4	12.1
Southeast	35-135	#2: solids storage	59	0.9	11.9	12.3	12.1	2.7	2.5	0.9	0.5	0.3	13.8	2.5	3.7	5.0
		#5: any liquid storage	41	0.9	22.0	69.3	32.3	2.5	6.7	1.0	1.8	3.9	19.8	4.0	6.1	4.9
	> 135	#2: solids storage	30	1.4	27.7	30.2	30.1	0.9	3.0	0.5	0.6	0.2	35.1	2.1	4.3	15.3
		#5: any liquid storage	70	1.4	30.0	66.8	52.5	3.1	2.6	0.3	0.7	0.2	28.6	2.7	6.3	8.9
West	35-135	#2: solids storage	50	0.8	23.1	27.5	22.6	1.1	15.2	6.3	4.7	1.6	32.9	5.4	7.5	7.3
		#5: any liquid storage	50	0.8	33.9	64.7	42.2	5.2	17.6	8.4	4.6	2.2	40.0	6.1	9.9	17.4
	135-270	#2: solids storage	11	1.0	17.3	18.8	18.5	1.4	7.2	5.1	4.0	1.1	33.3	4.1	7.6	3.8
		#5: any liquid storage	89	1.0	35.2	63.6	47.9	2.8	28.4	8.3	5.0	3.4	46.5	6.0	10.7	21.8
	> 270	#5: any liquid storage	100	1.2	37.3	64.5	45.2	4.8	15.0	7.3	5.2	2.0	47.1	10.8	11.4	12.4
Fattened cattle farms																
New England	> 35	#1: scrape and stack	100	1.1	27.7	43.9	34.0	3.7	46.9	16.7	10.5	3.2	50.8	4.9	15.2	16.6
PA, NY, NJ	> 35	#1: scrape and stack	100	1.3	50.7	87.2	71.5	8.4	14.7	0.8	1.6	5.2	41.8	5.8	10.4	15.0
Southeast	> 35	#1: scrape and stack	30	1.2	16.1	12.6	17.5	2.1	4.5	0.4	1.0	5.7	17.4	3.8	3.5	3.9
		#2: manure pack, runoff collection	70	1.2	15.3	12.2	15.5	3.2	4.7	0.3	1.2	4.4	17.5	3.3	3.7	4.7
Midwest	35-500	#1: scrape and stack	30	0.8	37.1	47.9	39.3	1.1	9.1	1.6	0.8	0.9	22.8	2.8	4.1	5.0
		#2: manure pack, runoff collection	70	0.8	37.1	47.9	39.3	1.1	9.1	1.6	0.8	0.9	22.8	2.8	4.1	5.0
	> 500	#2: manure pack, runoff collection	100	1.3	33.6	51.4	30.6	2.3	6.5	1.8	0.9	1.0	25.1	2.4	3.4	2.6
Northern Plains	35-500	#2: manure pack, runoff collection	100	1.0	66.3	111.9	51.6	6.0	19.0	9.4	6.4	2.5	22.2	4.7	4.0	3.5
	> 500	#2: manure pack, runoff collection	100	1.1	33.4	96.9	61.0	3.2	23.3	14.7	11.4	3.5	28.3	6.1	7.2	10.2

Table 35 Technical assistance hours per farm as derived from RTT estimates and size adjustment factor for model farms (heading abbreviations: AD=alternatives development, D=design, I=implementation, F=followup)—Continued

Model farm regions & livestock type	Model farm size class	Representative farm	Probability (%)	Size adjustment factor	Manure & wastewater handling & storage				- - Land treatment - -				Nutrient management			
					AD	D	I	F	AD	D	I	F	AD	D	I	F
Central Plains	35-1000	#2: manure pack, runoff collection	100	0.6	17.8	34.0	33.5	6.0	0.0	0.0	0.0	0.0	18.0	5.0	5.5	6.0
	> 1000	#2: manure pack, runoff collection	100	1.0	24.8	45.0	28.7	7.0	15.0	11.6	9.8	2.3	22.3	3.3	9.1	7.6
South Central	35-1000	#2: manure pack, runoff collection	100	0.8	33.9	32.0	32.1	2.3	1.2	0.0	0.3	0.4	58.1	15.1	13.9	9.8
	> 1000	#2: manure pack, runoff collection	100	1.3	35.9	30.9	34.6	1.9	1.4	0.0	0.3	0.4	54.3	12.0	12.8	10.5
West	35-500	#2: manure pack, runoff collection	100	1.0	35.6	76.5	49.7	2.0	33.5	15.1	7.7	4.2	41.7	5.1	8.8	17.7
	> 500	#2: manure pack, runoff collection	100	1.2	22.8	59.0	61.4	0.0	23.3	16.8	13.1	3.1	28.5	9.0	4.0	6.0
Confined heifer farms																
Northeast	> 35	#1: confinement barn/ bedded manure	70	1.2	28.4	36.5	29.2	2.5	59.2	9.9	12.7	3.1	53.1	4.4	17.3	15.3
		#2: open lots with scraped solids	30	1.2	28.4	36.5	29.2	2.5	59.2	9.9	12.7	3.1	53.1	4.4	17.3	15.3
Midwest	> 35	#1: confinement barn/ bedded manure	40	1.0	42.0	47.9	45.3	1.0	10.7	1.0	0.5	1.9	29.9	3.0	5.1	4.7
		#2: open lots with scraped solids	60	1.0	39.0	44.7	41.4	0.8	9.2	0.9	0.5	1.6	28.7	4.3	4.9	5.4
Southeast	> 35	#2: open lots with scraped solids	100	1.2	12.8	10.8	9.8	6.5	5.2	0.2	1.9	0.5	18.1	1.7	4.3	7.1
West	> 35	#2: open lots with scraped solids	100	1.0	27.6	56.7	33.3	3.4	35.9	21.6	20.3	6.6	30.4	4.6	11.3	10.4
Veal Farms																
All states	> 35	#1: confinement house	100	1.1	35.3	58.0	60.0	0.0	17.0	1.0	2.0	3.0	25.3	7.0	6.0	9.3
Broiler Farms																
Northeast	> 35	#1: confinement houses	100	1.2	26.6	33.9	26.3	3.5	11.0	1.9	0.7	1.7	20.2	3.8	5.6	12.1
Southeast	> 35	#1: confinement houses	100	1.1	12.3	13.7	9.6	1.9	2.4	0.6	0.5	0.3	18.7	2.5	4.0	6.4
Northwest	> 35	#1: confinement houses	100	1.1	13.6	27.3	19.3	0.2	4.2	2.7	2.7	1.6	17.9	3.3	5.1	2.7
Southwest	> 35	#1: confinement houses	100	0.8	12.3	13.7	9.6	1.9	2.4	0.6	0.5	0.3	18.7	2.5	4.0	6.4
Layer Farms																
Southeast	35-400	#1: high rise	30	0.9	13.5	22.3	9.7	0.8	3.5	0.4	1.1	0.4	26.0	2.8	3.6	7.0
		#2: shallow pit	27	0.9	13.5	22.3	9.7	0.8	3.5	0.4	1.1	0.4	26.0	2.8	3.6	7.0
		#3: flush with lagoon	43	0.9	12.9	22.2	9.7	0.5	1.8	0.4	0.5	0.2	25.0	2.6	3.3	6.7
	> 400	#1: high rise	52	1.5	15.4	26.1	7.9	0.9	4.3	0.2	1.7	0.4	29.6	3.1	3.6	7.2
		#3: flush with lagoon	48	1.3	14.7	26.6	7.7	0.3	1.6	0.1	0.8	0.2	28.6	2.8	3.1	6.7

Table 35 Technical assistance hours per farm as derived from RTT estimates and size adjustment factor for model farms (heading abbreviations: AD=alternatives development, D=design, I=implementation, F=followup)—Continued

Model farm regions & livestock type	Model farm size class	Representative farm	Probability (%)	Size adjustment factor	Manure & wastewater handling & storage				- - Land treatment - -				Nutrient management			
					AD	D	I	F	AD	D	I	F	AD	D	I	F
West	35-400	#2: shallow pit	49	0.9	24.5	50.2	35.9	3.3	22.2	20.5	14.2	3.8	27.3	4.3	15.0	6.6
		#5: scraper system	51	0.9	24.5	50.2	35.9	3.3	22.2	20.5	14.2	3.8	27.3	4.3	15.0	6.6
	> 400	#1: high rise	18	1.2	19.5	58.0	56.7	0.0	44.6	33.6	26.2	6.3	17.0	8.0	5.0	0.0
		#4: manure belt	14	1.2	19.5	58.0	56.7	0.0	44.6	33.6	26.2	6.3	17.0	8.0	5.0	0.0
		#5: scraper system	68	1.2	19.5	58.0	56.7	0.0	44.6	33.6	26.2	6.3	17.0	8.0	5.0	0.0
South Central	35-400	#2: shallow pit	45	0.9	16.2	14.6	9.2	1.1	1.9	0.6	0.2	0.1	17.5	3.5	5.7	5.7
		#5: scraper system	55	0.9	16.2	14.6	9.2	1.1	1.9	0.6	0.2	0.1	17.5	3.5	5.7	5.7
	> 400	#3: flush with lagoon	100	1.4	25.2	67.2	22.5	0.0	2.0	4.8	1.6	0.0	33.5	11.2	15.3	7.2
North Central, Northeast	35-400	#1: high rise	55	0.9	19.8	28.9	22.7	1.5	7.9	2.3	1.6	2.9	19.0	4.4	4.7	6.1
		#2: shallow pit	25	0.9	19.8	28.9	22.7	1.5	7.9	2.3	1.6	2.9	19.0	4.4	4.7	6.1
		#4: manure belt	20	0.9	19.9	30.3	23.7	1.0	8.3	2.5	1.7	3.0	18.9	4.2	4.5	5.7
	> 400	#1: high rise	81	1.7	18.8	25.1	16.7	1.4	9.9	2.0	0.7	2.9	17.8	4.5	3.7	5.9
		#4: manure belt	19	1.7	22.4	33.9	25.0	1.4	9.8	1.9	0.7	3.2	17.6	4.4	3.6	6.6
Farms with pullets																
North Central, Northeast	> 35	#2: layer-type confinement houses	100	1.1	21.4	30.6	23.5	2.3	8.0	2.5	1.7	2.7	19.0	3.5	5.2	7.7
Southeast	> 35	#2: layer-type confinement houses	100	1.2	12.3	21.4	8.3	0.8	2.9	0.4	0.8	0.3	25.8	2.4	3.2	7.3
West	> 35	#2: layer-type confinement houses	100	1.0	14.6	11.8	14.3	0.2	1.1	1.0	0.5	0.1	19.4	1.9	4.5	4.2
South Central	> 35	#2: layer-type confinement houses	100	1.0	14.6	11.8	14.3	0.2	1.1	1.0	0.5	0.1	19.4	1.9	4.5	4.2
Turkey Farms																
East	> 35	#1: confinement houses	90	1.2	19.9	30.0	9.8	0.8	2.5	0.1	1.1	0.3	15.8	1.6	2.2	4.3
		#2: turkey ranch	10	1.2	19.6	25.7	8.8	2.3	2.1	0.1	0.9	0.2	16.8	2.6	3.1	5.8
South Central	> 35	#1: confinement houses	100	1.0	21.0	52.0	30.0	6.0	11.8	2.0	2.3	1.7	15.3	1.5	4.0	3.4
Western Midwest	> 35	#1: confinement houses	50	1.0	26.0	33.1	28.0	0.0	0.0	0.0	0.0	0.0	36.0	20.0	5.0	4.0
		#2: turkey ranch	50	1.0	26.0	33.1	28.0	0.0	0.0	0.0	0.0	0.0	36.0	20.0	5.0	4.0
Eastern Midwest	> 35	#1: confinement houses	80	1.4	22.0	18.0	11.0	6.0	0.0	0.0	0.0	0.0	11.0	1.0	2.0	4.0
		#2: turkey ranch	20	1.4	22.0	18.0	11.0	6.0	0.0	0.0	0.0	0.0	11.0	1.0	2.0	4.0
West except CA	> 35	#1: confinement houses	90	1.0	16.0	58.0	41.7	0.0	57.1	19.0	31.2	7.0	11.0	4.0	6.0	0.0
		#2: turkey ranch	10	1.0	22.0	18.0	11.0	6.0	0.0	0.0	0.0	0.0	11.0	1.0	2.0	4.0
California	> 35	#1: confinement houses	80	0.9	16.0	58.0	41.7	0.0	57.1	19.0	31.2	7.0	11.0	4.0	6.0	0.0
		#2: turkey ranch	20	0.9	22.0	18.0	11.0	6.0	0.0	0.0	0.0	0.0	11.0	1.0	2.0	4.0
Swine farrowing farms																
Southeast	35-100	#1: total confinement, liquid, lagoon	100	1.2	15.8	28.1	18.4	4.8	4.6	0.7	1.8	0.4	20.6	5.7	5.9	7.1
	> 100	#1: total confinement, liquid, lagoon	100	1.4	16.1	37.5	18.7	4.5	5.1	0.8	1.9	0.6	25.3	4.0	7.4	4.2
Midwest, Northeast	35-500	#1: total confinement, liquid, lagoon	10	0.9	37.8	66.5	50.7	3.0	8.2	2.2	2.4	1.2	34.3	4.8	5.8	8.2
		#2: total confinement, slurry, no lagoon	76	0.9	37.3	68.7	48.9	2.5	7.2	2.0	2.3	1.1	31.8	4.5	5.6	7.7

Table 35 Technical assistance hours per farm as derived from RTT estimates and size adjustment factor for model farms (heading abbreviations: AD=alternatives development, D=design, I=implementation, F=followup)—Continued

Model farm regions & livestock type	Model farm size class	Representative farm	Probability (%)	Size adjustment factor	Manure & wastewater handling & storage				- - Land treatment - -				Nutrient management			
					AD	D	I	F	AD	D	I	F	AD	D	I	F
		#4: building with outside access, solids	14	0.9	38.7	70.1	50.5	2.8	7.5	2.0	2.2	1.1	32.6	4.6	5.7	7.8
	> 500	#1: total confinement, liquid, lagoon	85	1.3	36.2	93.3	54.2	4.3	3.5	3.7	4.7	1.1	26.8	3.3	4.2	7.5
		#2: total confinement, slurry, no lagoon	15	1.3	36.6	96.5	58.0	5.3	4.0	4.3	5.5	1.2	29.0	3.4	4.2	8.2
West	35-500	#1: total confinement, liquid, lagoon	45	0.9	51.2	59.6	48.4	0.8	12.6	5.9	6.4	1.8	29.4	8.0	5.7	9.6
		#2: total confinement, slurry, no lagoon	25	0.9	51.2	59.6	48.4	0.8	12.6	5.9	6.4	1.8	29.4	8.0	5.7	9.6
		#5: pasture or lot	30	0.9	50.2	57.0	48.4	0.0	18.1	7.8	9.3	2.6	34.2	6.0	7.3	8.0
	> 500	#1: total confinement, liquid, lagoon	65	1.2	54.6	119.6	77.5	1.0	32.7	16.8	20.7	4.9	28.9	3.0	2.5	10.0
		#2: total confinement, slurry, no lagoon	35	1.2	54.6	119.6	77.5	1.0	32.7	16.8	20.7	4.9	28.9	3.0	2.5	10.0
Swine grower farms																
Southeast	35-100	#1: total confinement, liquid, lagoon	90	1.2	15.8	28.1	18.4	4.8	4.6	0.7	1.8	0.4	20.6	5.7	5.9	7.1
		#2: total confinement, slurry, no lagoon	10	1.2	14.2	26.1	14.8	4.4	4.6	0.7	1.8	0.4	17.8	5.3	5.5	5.7
	> 100	#1: total confinement, liquid, lagoon	100	1.4	19.3	33.8	26.3	5.0	3.5	0.4	1.3	0.4	31.4	4.8	6.3	8.7
Midwest, Northeast	35-500	#1: total confinement, liquid, lagoon	6	0.9	45.3	76.5	57.1	2.8	8.7	2.0	2.2	1.5	33.7	4.3	6.0	8.5
		#2: total confinement, slurry, no lagoon	53	0.9	45.3	76.5	57.1	2.8	8.7	2.0	2.2	1.5	33.7	4.3	6.0	8.5
		#3: building with outside access, liquid	14	0.9	45.5	78.3	57.5	2.8	8.7	2.0	2.2	1.5	34.0	4.3	6.1	8.4
		#4: building with outside access, solids	27	0.9	43.4	74.8	58.2	3.0	9.4	2.2	2.4	1.6	33.5	4.2	6.1	8.8
	> 500	#1: total confinement, liquid, lagoon	27	1.3	30.1	80.1	43.0	3.9	2.7	2.8	3.6	0.8	23.8	3.0	3.7	6.7
		#2: total confinement, slurry, no lagoon	73	1.3	31.5	83.0	45.8	4.0	2.9	3.0	3.9	0.9	24.7	3.1	3.9	6.7
West	35-500	#1: total confinement, liquid, lagoon	100	0.9	53.2	74.1	54.3	1.0	18.1	7.8	9.3	2.6	31.0	7.5	7.0	9.0
	> 500	#1: total confinement, liquid, lagoon	100	1.2	90.8	163.8	109.9	1.0	50.5	24.6	30.0	7.4	46.1	3.0	3.8	15.0
Swine farrow-to-finish farms																
Southeast	35-100	#1: total confinement, liquid, lagoon	40	1.2	14.5	26.0	16.0	4.0	4.0	0.6	1.6	0.3	19.1	5.4	6.0	6.1
		#2: total confinement, slurry, no lagoon	10	1.2	16.5	21.2	19.0	6.0	5.4	0.2	2.1	0.5	21.2	5.1	4.7	8.0
		#5: pasture or lot	50	0.9	16.9	30.7	21.0	5.4	3.1	0.8	1.3	0.3	20.8	6.1	7.0	7.4

Table 35 Technical assistance hours per farm as derived from RTT estimates and size adjustment factor for model farms (heading abbreviations: AD=alternatives development, D=design, I=implementation, F=followup)—Continued

Model farm regions & livestock type	Model farm size class	Representative farm	Probability (%)	Size adjustment factor	Manure & wastewater handling & storage				Land treatment				Nutrient management			
					AD	D	I	F	AD	D	I	F	AD	D	I	F
	> 100	#1: total confinement, liquid, lagoon	90	1.4	17.8	36.6	24.1	6.2	4.4	0.5	1.7	0.5	23.1	4.5	5.2	5.4
		#2: total confinement, slurry, no lagoon	10	1.4	17.8	36.6	24.1	6.2	4.4	0.5	1.7	0.5	23.1	4.5	5.2	5.4
Midwest, Northeast	35-500	#1: total confinement, liquid, lagoon	15	0.9	40.8	72.0	52.6	3.0	7.9	3.3	3.1	1.3	27.9	3.6	6.4	7.9
		#2: total confinement, slurry, no lagoon	75	0.9	40.8	72.0	52.6	3.0	7.9	3.3	3.1	1.3	27.9	3.6	6.4	7.9
		#4: building with outside access, solids	10	0.9	40.8	72.0	52.6	3.0	7.9	3.3	3.1	1.3	27.9	3.6	6.4	7.9
	> 500	#1: total confinement, liquid, lagoon	40	1.3	37.7	81.2	54.2	4.1	3.6	2.8	3.7	0.9	30.6	3.9	4.8	7.3
		#2: total confinement, slurry, no lagoon	60	1.3	39.8	84.2	57.9	4.2	3.9	3.1	4.0	1.0	32.1	4.1	5.0	7.4
West	35-500	#1: total confinement, liquid, lagoon	10	0.9	53.2	74.1	54.3	1.0	18.1	7.8	9.3	2.6	31.0	7.5	7.0	9.0
		#2: total confinement, slurry, no lagoon	90	0.9	53.2	74.1	54.3	1.0	18.1	7.8	9.3	2.6	31.0	7.5	7.0	9.0
	> 500	#1: total confinement, liquid, lagoon	10	1.2	90.8	163.8	109.9	1.0	50.5	24.6	30.0	7.4	46.1	3.0	3.8	15.0
		#2: total confinement, slurry, no lagoon	90	1.2	51.6	102.4	71.7	0.0	32.7	16.8	20.7	4.9	32.0	1.5	2.8	9.0
Small farms with confined livestock types	All	none	100	1.0	20.4	48.0	27.7	2.1	14.4	0.9	2.8	0.9	27.2	3.7	6.5	7.7
Farms with pastured livestock types	All	none	100	1.0	16.0	8.0	7.0	2.0	12.0	5.0	3.0	1.0	10.0	3.0	3.0	3.0
Specialty livestock farms	All	none	100	1.0	13.6	27.3	19.3	0.2	4.2	2.7	2.7	1.6	17.9	3.3	5.1	2.7

Estimates of technical assistance hours for each model farm were used to calculate estimates for each CNMP farm in the Census of Agriculture in the same way as cost estimates were calculated for the manure and wastewater handling and storage element and as recoverable manure estimates were calculated in appendix B. For farms with more than one representative farm assigned to it, the probabilities associated with each representative farm were used as weights to obtain a weighted total. The probabilities associated with each model farm are also presented in table 35.

Summary of costs for CNMP development

CNMP development costs, in terms of technical assistance hours, averaged 149 hours per farm (table 36). This breaks down into 57 hours per farm for alternatives development, 46 hours per farm for design, 35 hours per farm for implementation, and 10 hours per farm for followup. For the three CNMP elements, it breaks down into 92 hours per farm for manure and wastewater handling and storage, 18 hours per farm for land treatment, and 39 hours per farm for nutrient management.

Technical assistance hours were highest for dairies, swine farms, and farms with confined heifers and veal, averaging over 190 hours per farm. Broiler farms and

Table 36 CNMP development hours per farm, by livestock type and farm size

Dominant livestock type or farm size class	Number of farms	CNMP elements: Manure & wastewater handling & storage hours	CNMP elements: Land treatment hours	CNMP elements: Nutrient management hours	Technical assistance functions: Alternative development hours	Technical assistance functions: Design hours	Technical assistance functions: Implementation hours	Technical assistance functions: Followup hours	Total hours
Fattened cattle	10,159	101	13	33	54	47	37	9	147
Milk cows	79,318	123	19	50	69	62	47	13	192
Swine	32,955	145	13	43	68	68	53	11	201
Turkeys	3,213	84	11	31	49	43	25	8	126
Broilers	16,251	52	7	37	41	24	19	11	95
Layers/pullets	5,326	55	11	34	42	29	21	8	100
Confined heifers/veal	4,011	116	33	46	79	55	49	12	195
Small farms with confined livestock types	42,565	98	19	45	62	53	37	11	163
Pastured livestock types	61,272	33	21	19	38	16	13	6	73
Specialty livestock types	2,131	60	11	29	36	33	27	5	101
Large	19,746	107	16	47	64	54	40	13	170
Medium	39,437	96	15	40	58	46	36	11	151
Small	198,018	90	18	37	57	45	34	10	146
All CNMP farms	257,201	92	18	39	57	46	35	10	149

farms with pastured livestock types had the lowest number of hours, averaging 95 hours per farm and 73 hours per farm, respectively. The difference by farm size was not pronounced; large farms averaged 170 hours per farm and small farms averaged 146 hours per farm.

Technical assistance hours also varied regionally (table 37). The highest estimate was for farms in the Pacific region, averaging 184 hours per farm. The next highest was the Northeast region with 179 hours per farm, followed by the Lake States with 170 hours per farm. The lowest estimates were for farms in the Delta States (99 hours per farm) and the Southeast region (104 hours per farm).

Overall, technical assistance hours totaled 38.2 million. The Corn Belt region, the Lake States, and the Northeast region accounted for two-thirds of these hours.

To convert these estimates of technical assistance hours into dollar estimates requires a further breakdown of the tasks that need to be performed and the level of technical skills required, which was not done. However, a rough estimate can be made based on a few simple assumptions.

Establishing an hourly cost of technical assistance involves accounting for more than the time involved with performing the task. Support costs also need to be taken into account, such as tools and equipment needed to perform the task (i.e., engineering survey instruments, measuring equipment, vehicles, office space), expertise support costs (training and continuing education, license fees), and employment benefits (leave, retirement, insurance). Estimates of these support costs can range from 20 to 50 percent of salary costs depending on the technical discipline and the specific support needs of that trade. Based on information obtained from private sector sources, the hourly rate charged for technical services can range from $20 to $100 per hour or more, including support costs. The average cost is approximately $60 per hour. Budgets developed by Federal agencies that provide technical services (such as the Natural Resources Conservation Service, U.S. Corp of Engineers, Bureau of Reclamation) show national average hourly rates of about $50,

Table 37 CNMP development hours per farm, by farm production region

Farm production region	Number of farms	CNMP elements: Manure & wastewater handling & storage hours	CNMP elements: Land treatment hours	CNMP elements: Nutrient management hours	Technical assistance functions: Alternative development hours	Technical assistance functions: Design hours	Technical assistance functions: Implementation hours	Technical assistance functions: Followup	Total hours
Appalachian	22,899	69	13	34	47	34	26	10	117
Corn Belt	71,540	98	17	36	58	48	37	9	152
Delta States	12,352	56	11	32	42	27	21	9	99
Lake States	52,817	109	18	42	63	55	41	11	170
Mountain	7,964	87	29	42	63	47	36	12	158
Northeast	31,598	113	20	46	66	57	43	13	179
Northern Plains	26,309	78	17	31	49	38	30	8	125
Pacific	7,974	104	31	54	74	57	44	14	189
Southeast	12,807	59	10	35	44	29	22	9	104
Southern Plains	10,941	74	22	41	57	39	30	11	137
All CNMP farms	257,201	92	18	39	57	46	35	10	149

including support costs. These average cost estimates are very general; hourly rates vary substantially among livestock operations depending on the complexity of the site-specific practices that are needed.

Averaging the two estimates, an hourly rate of $55 was selected to approximate the dollar value of technical assistance hours. Applying the $55 hourly rate to the 38.2 million hours results in an estimate of about $2.1 billion, or about $8,126 per farm for the 257,201 CNMP farms.

Summary of CNMP development and implementation costs

The annual CNMP implementation cost for all four CNMP elements averaged $6,748 per farm for the 257,201 farms that are expected to need a CNMP, and CNMP development costs, in terms of technical assistance hours, averaged 149 hours per farm (table 38). In addition, off-farm land application costs, which are assumed to be borne by the manure-receiving farms in this assessment, averaged $98 per CNMP farm. The

Table 38 CNMP costs per farm, by livestock type and farm size

Dominant livestock type or farm size	Number of farms	Animal units per farm*	Record-keeping costs per farm ($/yr)	Nutrient management costs per farm ($/yr)	Off-farm transport costs per farm ($/yr)	Land treatment costs per farm ($/yr)	Manure & wastewater handling & storage costs per farm ($/yr)	- - - - Total CNMP implementation costs per farm - - - - Average ($/yr)	Low** ($/yr)	High** ($/yr)	Per animal unit ($/yr)	CNMP development costs (hr/farm)
Fattened cattle	10,159	1,298	142	1,655	4,646	2,613	9,112	18,167	1,026	308,005	14	147
Milk cows	79,318	195	160	2,101	1,619	2,660	3,249	9,788	2,362	97,013	50	192
Swine	32,955	276	224	1,601	2,450	3,615	4,139	12,029	2,060	75,159	44	201
Turkeys	3,213	687	90	230	6,169	3,391	7,940	17,820	1,643	122,412	26	126
Broilers	16,251	183	90	248	1,667	1,220	2,351	5,576	1,128	36,187	30	95
Layers/pullets	5,326	297	136	144	7,414	1,685	4,015	13,394	342	95,887	45	100
Confined heifers/ veal	4,011	301	117	1,153	1,410	2,026	3,192	7,898	594	76,660	26	195
Small farms with confined livestock types	42,565	25	54	203	16	351	199	823	102	4,953	33	163
Pastured livestock types	61,272	117	54	211	3	357	823	1,448	280	7,757	12	73
Specialty livestock types	2,131	17	54	180	0	634	843	1,691	1,711	3,256	NA	101
Large farms	19,746	1,419	168	1,526	9,679	3,925	15,167	30,465	2,199	252,014	21	170
Medium farms	39,437	252	150	1,085	2,281	2,897	3,397	9,809	1,210	64,426	39	151
Small farms	198,018	80	106	987	345	1,267	1,070	3,773	161	25,298	47	146
All types	257,201	210	117	1,043	1,358	1,721	2,509	6,748	195	67,429	32	149

* Represents **all** animal units on the farm, but does not include animal units for specialty livestock types, which were not estimated.
** The **low** estimate corresponds to the one-percentile value for the farms in each group, and the **high** estimate corresponds to the 99th-percentile value.

manure and wastewater handling and storage element represented the largest portion of implementation costs at 37 percent, followed by 26 percent for land treatment, 20 percent for off-farm transport, 15 percent for nutrient management, and 2 percent for recordkeeping.

Determination of which farm group had the highest average cost depends on whether the cost is based on a per-farm average or a per-animal-unit average. The average annual implementation cost per farm was highest for fattened cattle farms and turkey farms ($18,167 and $17,820 per farm, respectively). However, these two groups of farms also had the most animal units per farm, on average (table 38). On a per animal unit basis, dairies had the highest cost at $50 per animal unit, followed by layer and pullet farms at $45 per animal unit and swine farms at $44 per animal unit. Turkey farms had a moderate cost per animal unit of $26, and fattened cattle farms averaged only $14 per animal unit, the lowest of all the farm groups except farms with pastured livestock types. The lowest annual average cost per farm was for small farms with confined livestock ($823 per farm), which also had the fewest animal units per farm. CNMP costs for small farms with confined livestock averaged $30 per animal unit. The average cost per animal unit for all farms was $32.

CNMP implementation costs varied greatly among farms. This variation is shown in table 38 by the differences between the low and high cost estimates for each of the farm groups. The low estimate corresponds to the one-percentile value for the specified farm group, and the high estimate corresponds to the 99th percentile estimate. Costs were generally highest for the largest farms, averaging $30,465 per farm annually for farms that produced more than 10 tons of manure phosphorus annually. The average annual cost was $9,809 per farm for medium-size farms, which produced 4 to10 tons of manure phosphorus annually, and $3,773 per farm for small farms, which produced less than 4 tons of manure phosphorus annually. However, among the large farms the annual per-farm cost ranged from a low of about $2,199 per farm to a high of about $252,014 per farm. This wide range in costs per farm among the largest farms reflects differences in livestock types and manure management and handling systems, but also reflects differences in CNMP needs. For example, farms with enough onfarm land to meet CNMP application criteria would not incur any off-farm export costs, whereas farms with few onfarm acres available for land application could incur large off-farm transport costs. Farms in counties that do not have enough acres to apply all of the manure according to CNMP application criteria have an additional off-farm transport cost associated with transporting the excess manure to a central processing facility.

CNMP implementation costs per farm also varied regionally (table 39). The Pacific region had the highest annual average cost at $19,464 per farm, reflecting a predominance of large farms in that region and relatively high costs associated with off-farm transport. The lowest implementation cost per farm was for CNMP farms in the Lake States region and the Delta States region, averaging $4,469 per farm and $4,832 per farm, respectively.

The cost of developing a CNMP also varied by livestock type, farm size, region, and manure management and handling systems, but not as dramatically as implementation costs. There is a practical minimum cost for developing a CNMP because, regardless of how small the farm is, a basic set of tasks needs to be performed. Larger farms generally have more complex situations and more acres that need to have nutrient management plans, but the technical assistance required is not proportional to the size of the operation. The highest average CNMP development cost was for swine farms at 201 hours per farm, followed by confined heifer and veal farms at 195 hours per farm and dairies at 192 hours per farm. The lowest per-farm estimates of CNMP development costs were for broiler farms (95 hours per farm), farms with pastured livestock types (73 hours per farm), and specialty livestock farms (101 hours per farm). CNMP development costs were highest on a per-farm basis in the Pacific, Northeast, and Lake States regions, and lowest in the Delta States, Southeast, and Appalachia regions.

Over half of the total CNMP implementation costs and two-thirds of the CNMP development costs were accounted for in three regions—the Corn Belt, Lake States, and Northeast. These three regions also had the largest number of CNMP farms, representing 61 percent of the 257,201 CNMP farms. The Delta States, Mountain, Southeast, and Southern Plains regions had the lowest proportion of total costs, collectively representing only 18 percent of CNMP implementation costs and 14 percent of CNMP development costs.

CNMP implementation costs for the 257,201 CNMP farms totaled $1.736 billion per year. Over the 10-year implementation period, the total cost would be $17.36 billion. This extrapolation is appropriate for capital costs because a 10-year recovery period was used in the calculations. For annual operating costs, however, the extrapolation is based on an additional assumption that annual operating costs would be defined as CNMP costs for 10 years following CNMP implementation, after which the operating costs would become absorbed into the production costs as one of the costs of doing business.

CNMP development costs totaled 38.2 million technical assistance hours spread over the 10-year implementation period. Assuming an average hourly cost of $55 for the technical assistance hours, the total cost for CNMP development for the 257,201 CNMP farms would be about $2.1 billion over 10 years.

Overall, CNMP development and implementation costs are expected to be about $19.5 billion. About 10 percent is for CNMP development ($2.1 billion), and about 90 percent is for CNMP implementation ($17.4 billion). The average cost per farm would be about $76,000 spread out over 10 years, or $7,600 per farm per year for 10 years.

Table 39 Annual CNMP costs per farm, by farm production region

Farm production region	Number of farms	Record-keeping costs per farm ($/yr)	Nutrient management costs per farm ($/yr)	Off-farm transport costs per farm ($/yr)	Land treatment costs per farm ($/yr)	Manure & wastewater handling & storage costs per farm ($/yr)	Total CNMP implementation costs per farm: Average ($/yr)	Low* ($/yr)	High* ($/yr)	CNMP development costs (hr/farm)
Appalachian	22,899	110	606	2,722	2,154	2,987	8,579	211	72,434	117
Corn Belt	71,540	120	973	380	2,312	1,647	5,432	163	43,143	152
Delta States	12,352	97	387	1,865	302	2,181	4,832	298	45,575	99
Lake States	52,817	123	1,430	257	990	1,669	4,469	254	29,559	170
Mountain	7,964	119	713	2,272	77	6,177	9,358	172	122,031	158
Northeast	31,598	124	1,712	1,030	4,465	1,976	9,307	296	65,715	179
Northern Plains	26,309	105	1,000	977	395	3,088	5,566	266	79,763	125
Pacific	7,974	157	812	10,697	67	7,731	19,464	134	161,378	189
Southeast	12,807	101	419	2,952	1,223	2,901	7,596	182	65,524	104
Southern Plains	10,941	106	597	2,163	334	4,776	7,976	125	143,563	137
All regions	257,201	117	1,043	1,358	1,721	2,509	6,748	195	67,429	149

* The **low** estimate corresponds to the one-percentile value for the farms in each group, and the **high** estimate corresponds to the 99th-percentile value.

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Appendix A Profile of Farms with Livestock, 1997

Introduction

The Census of Agriculture shows that 1,315,051 farms in the United States in 1997 had some kind of livestock on the farm or had sales from livestock products, representing about two of every three farms in the country. These farms vary from primarily crop-producing farms with a few livestock, to farms with large numbers of confined livestock, to producers of specialty livestock (ducks, geese, fur-bearing animals, and exotic livestock), to farms with large numbers of pastured livestock, to small farms with few acres and few livestock.

The purpose of this appendix is to identify the predominant groups of livestock farms in the United States and to summarize the number and kind of livestock and the amount of livestock sales associated with each farm group.

Classification of farms with livestock

A farm is defined for purposes of the Census of Agriculture as an enterprise with $1,000 or more of gross agricultural product sales, or has enough land and/or livestock to generate sales at this level. Some of the farms in the Census of Agriculture report no sales, but have a combination of acres and livestock that still qualify them as a farm. (For example, an enterprise with 5 cattle of any kind, 5 horses, 7 hogs and pigs, 142 poultry of any kind, or 25 sheep and goats qualifies as a farm even without any sales or farmland. For criteria used to define farms without reported sales, see USDA NASS, 1997.)

The Census of Agriculture reports end-of-year inventories and sometimes the number of animals sold during the year for the following livestock types:

- Beef cows
- Milk cows
- Heifers and heifer calves
- Steers and bulls of all ages
- Hogs and pigs used for breeding
- Other hogs and pigs
- Sheep and lambs
- Chicken layers 20 weeks old and older
- Chicken pullets for laying flock replacement
- Chicken broilers
- Turkeys for slaughter
- Turkeys for breeding
- Other poultry, including ducks, geese, pigeons, pheasants, quail, and other
- Poultry hatched and placed or sold
- Horses and ponies
- Colonies of bees
- Milk, Angora, and other goats
- Mules, burros, and donkeys
- Mink and rabbits
- Fish and aquaculture products
- Other livestock

The average number of cattle, swine, chickens, and turkeys on the farm during the year was estimated from sales and end-of-year inventory according to procedures described in Kellogg et al. (2000). The estimates were in the form of USDA animal units (AU), where an animal unit is equivalent to 1,000 pounds of live weight. For the other livestock types, end-of-year inventories were used to represent livestock populations on the farm.

Using this information on livestock types and number on each farm, farms with livestock were uniquely categorized into the following four groups:

- Farms with few livestock of all types
- Farms with specialty livestock types
- Farms with pastured livestock types and few other livestock
- Farms with confined livestock types

Farms with few livestock were defined to be farms with

- less than 4 animal units of any combination of fattened cattle, milk cows, swine, chickens, or turkeys;
- less than 8 animal units of cattle other than fattened cattle or milk cows;
- less than 10 horses, ponies, mules, burros, or donkeys;
- less than 25 sheep, lambs, or goats; and
- less than $5,000 in sales of specialty livestock products.

Farms with specialty livestock types were defined to be farms with

- few livestock (as defined above), but with sales of livestock products from fish, bees, rabbits, mink, poultry other than chickens and turkeys, and exotic livestock of more than $5,000, or

- significant number of other livestock, but sales from specialty livestock that were more than 75 percent of the total livestock sales for the farm.

Farms with confined livestock types were defined to be farms with
- 4 or more animal units of any combination of fattened cattle, milk cows, swine, chickens, or turkeys, or
- calves or heifers that appeared to be raised in confinement.

Farms with pastured livestock types and few other livestock were defined to be farms with
- less than 4 animal units of any combination of fattened cattle, milk cows, swine, chickens, or turkeys;
- 8 or more animal units of cattle other than milk cows and fattened cattle;
- 10 or more horses, ponies, mules, burros, or donkeys; or
- 25 or more sheep, lambs, or goats.

Farms that met criteria for veal farms or confined heifer farms were excluded from this group and counted as ***farms with confined livestock types***.

Veal farms were identified in the Census of Agriculture as farms with annual sales of more than 210 calves and no beef cow or milk cow end-of-year inventory and little or no land available for grazing. Confined heifer farms were identified as farms with annual sales of more than 50 heifers and no beef cow or milk cow end-of-year inventory and little or no land available for grazing. Veal and confined heifers were identified only on farms with less than 5 acres of rangeland and pastureland and without grazing land permits. There are undoubtedly additional veal and confined heifer farms, but they could not be distinguished from farms with pastured animals based on the information available in the Census of Agriculture. It is also likely that some of these farms did not raise confined heifers or veal. Nevertheless, the census data suggest that calves or heifers on all of these farms were being held in confinement.

The dominant livestock type on each farm was defined as the livestock type with the most animal units.

Farms with confined livestock types also may have significant populations of pastured livestock types, which were sometimes the dominant livestock type on the farm. If more than 35 animal units of any fattened cattle, milk cows, swine, chickens, or turkeys were present on the farm, they were used to define the dominant livestock type, even if cattle (excluding milk cows and fattened cattle) were the most abundant livestock type on the farm.

Included in ***farms with confined livestock types*** were a small number of farms (2,291 farms) that did not meet the criteria listed above. These three special cases are
- Farms with no chicken layers, pullets, broilers, or turkeys, but more than 5,000 poultry hatched and placed or sold, or more than 10,000 incubator-egg capacity. Most of these farms produce chicks for the broiler industry. Poultry sales for these farms totaled $1.6 billion dollars.
- Farms that had more than $5,000 in dairy products sold, but no end-of-year milk cow inventory. These are most likely dairies that went out of business in 1997. (Farms with other livestock types that had no end-of-year inventories, but reported livestock sales were automatically classified as farms with confined livestock types because data on the number of animals sold was incorporated into the calculation of animal units. Milk cow animal units, however, are only based on the end-of-year inventory.)
- Farms with sales of feeder pigs, but no other hogs or pigs on the farm. Animal units are not estimated for feeder pigs because the calculation for hogs for slaughter assumes the animals were on the farm from birth to market. A separate calculation for feeder pigs would therefore result in an unknown amount of double counting. Only 15 of these farms had significant numbers of feeder pigs, and were most likely swine nursery operations that raise weaned pigs to feeder pig size.

Farms that met criteria for special cases, but had more than four animal units of fattened cattle, milk cows, swine, chickens, or turkeys were classified according to the dominant confined livestock type, and were thus not categorized as a "special case" farm.

Profile of farms with few livestock

Farms with few livestock numbered 361,031, comprising 27 percent of all farms with livestock or livestock sales (table A–1). About 75 percent of ***farms with few livestock*** had only pastured livestock types; 23 percent had at least some fattened cattle, milk cows, swine, chickens, or turkeys; and about 2 percent primarily had specialty livestock with specialty livestock sales below $5,000 (table A–2). Even on the farms that also had confined livestock types, most of the livestock were pastured livestock types. Gross livestock sales for ***farms with few livestock*** totaled $776 million, representing less than 1 percent of livestock sales for all farms with livestock. Of this, $48 million was reported for about 300 farms with high-value livestock sales such as horses or breeding stock, most of which were horse sales. The average gross livestock sales per farm were only $2,149 ($2,017 excluding the 300 farms with high value livestock sales). No livestock sales were reported for 34 percent of the farms, 50 percent had gross livestock sales less than $900, and 75 percent had gross livestock sales less than $2,450. Five percent of the farms had gross livestock sales more than $8,000.

The total number of livestock on all ***farms with few livestock*** is almost negligible when compared to the number of livestock on other farms (table A–2). These 361,031 farms accounted for only 1 percent of cattle (all types), swine, turkey, and chicken animal units on all farms and 3.6 percent of sheep and goats. Horses are the exception. About one-fourth of all the horses, ponies, mules, burros, and donkeys were on ***farms with few livestock*** (even though the maximum number on any farm was less than 10). On average, ***farms with few livestock*** have about 2.3 animal units of beef cattle, 0.2 animal units of fattened cattle, swine, turkeys, and chickens combined; 1 to 2 horses, ponies, mules, burros, and donkeys; and 1 sheep or goat.

Table A–1 Number of farms with livestock or livestock sales in the 1997 Census of Agriculture, categorized into four farm groups, by State

	Farms with few livestock	Farms with specialty livestock types	Farms with pastured livestock types & few other livestock	Farms with confined livestock types	All farms with livestock
Alabama	8,142	236	21,415	4,038	33,831
Alaska	192	38	85	37	352
Arizona	1,603	67	2,338	233	4,241
Arkansas	7,209	314	21,391	6,491	35,405
California	10,881	817	12,964	3,478	28,140
Colorado	6,576	166	12,905	1,457	21,104
Connecticut	1,052	38	592	400	2,082
Delaware	314	8	186	981	1,489
Florida	6,670	673	11,812	1,241	20,396
Georgia	7,100	177	15,950	4,984	28,211
Hawaii	752	50	498	147	1,447
Idaho	5,936	169	8,460	1,644	16,209
Illinois	10,403	135	13,128	11,197	34,863
Indiana	11,573	164	11,207	10,006	32,950
Iowa	9,697	156	19,354	26,081	55,288
Kansas	8,465	100	28,483	4,939	41,987
Kentucky	16,044	45	36,138	4,816	57,043
Louisiana	4,327	305	11,277	1,254	17,163
Maine	1,474	58	818	709	3,059

Table A–1 Number of farms with livestock or livestock sales in the 1997 Census of Agriculture, categorized into four farm groups, by State—Continued

	Farms with few livestock	Farms with specialty livestock types	Farms with pastured livestock types & few other livestock	Farms with confined livestock types	All farms with livestock
Maryland	2,732	73	2,554	2,440	7,799
Massachusetts	1,555	71	689	541	2,856
Michigan	10,466	326	6,958	6,565	24,315
Minnesota	10,554	330	12,930	19,171	42,985
Mississippi	5,025	411	15,089	2,578	23,103
Missouri	16,608	139	49,727	9,627	76,101
Montana	4,120	141	13,078	772	18,111
North Carolina	9,447	187	15,309	6,435	31,378
New Hampshire	997	32	460	315	1,804
Nebraska	5,011	101	19,929	9,893	34,934
Nevada	764	13	1,418	141	2,336
New Jersey	2,862	65	1,193	374	4,494
New Mexico	3,674	41	6,661	454	10,830
New York	6,709	211	5,626	9,076	21,622
North Dakota	2,184	195	12,114	2,269	16,762
Ohio	15,088	203	13,937	10,996	40,224
Oklahoma	15,166	91	46,256	3,440	64,953
Oregon	11,570	278	11,367	1,093	24,308
Pennsylvania	10,122	247	9,306	14,215	33,890
Rhode Island	218	10	107	65	400
South Carolina	4,561	71	7,410	1,415	13,457
South Dakota	2,782	147	15,293	5,789	24,011
Tennessee	18,530	107	38,217	3,566	60,420
Texas	42,210	495	114,373	6,516	163,594
Utah	4,117	193	5,907	1,197	11,414
Vermont	1,305	40	943	1,940	4,228
Virginia	8,599	91	20,178	3,359	32,227
Washington	8,262	249	7,577	1,497	17,585
West Virginia	5,304	34	8,368	959	14,665
Wisconsin	10,483	471	9,250	26,628	46,832
Wyoming	1,596	55	6,140	362	8,153
All states	361,031	8,834	707,365	237,821	1,315,051

Table A–2 Profile of ***farms with few livestock*** in the 1997 Census of Agriculture

	Farms with sales of specialty livestock products >75% of livestock sales*	Farms with only sheep and goats**	Farms with only horses, ponies, mules, burros, or donkeys**		Farms with beef cattle or a mix of cattle and other pastured livestock types**		Farms with any fattened cattle, milk cows, swine, chickens, or turkeys*	All farms with few livestock	% of total for all farms with livestock
			Farms with <$50,000 in livestock sales	Farms with $50,000 or more in livestock sales	Farms with <$50,000 in livestock sales	Farms with $50,000 or more in livestock sales			
Number of farms	9,194	8,752	78,645	188	181,763	107	82,382	361,031	27.5
Percent	2.5	2.4	21.8	0.1	50.3	<0.1	22.8	100.0	
Total agricultural sales ($)	135,718,022	181,653,572	1,645,568,234	30,153,774	1,856,154,469	21,109,205	1,002,993,042	4,873,350,318	3.8
Sales per farm	14,762	20,756	20,924	160,392	10,212	197,282	12,175	13,498	13.7
Livestock sales ($)	14,968,005	7,744,496	84,862,759	30,004,565	437,748,522	18,245,588	182,304,685	775,878,620	0.8
Sales per farm									
Mean	1,628	885	1,079	159,599	2,408	170,520	2,213	2,149	2.9
25th percentile	300	10	0	60,000	0	57,100	278	0	
50th percentile	1,260	516	0	76,250	1,200	75,000	1,318	900	
75th percentile	2,513	1,235	500	127,500	2,815	135,000	2,936	2,450	
90th percentile	3,995	2,000	3,000	235,986	6,122	250,000	5,298	5,189	
95th percentile	4,500	2,662	5,600	476,000	9,568	536,350	7,181	8,000	
Dollar value for sale of:									
Cattle other than fattened cattle	34,973	0	0	0	403,024,176	1,635,840	61,610,241	466,305,230	2.3
Fattened cattle	1,200	0	0	0	0	0	56,183,340	56,184,540	0.3
Dairy products	0	0	0	0	0	0	1,026,771	1,026,771	<0.1
Hogs and pigs	7,549	0	0	0	0	0	29,237,942	29,245,491	0.2
Chicken & turkey products	56,259	0	0	0	0	0	16,730,861	16,787,120	0.1
Specialty livestock products	14,813,081	109,107	152,301	0	603,955	4,800	1,741,800	17,425,044	1.0
Horses, ponies, mules, burros, donkeys	9,520	103,757	84,082,849	29,552,605	25,775,947	13,629,797	10,009,346	163,163,821	15.8
Sheep & goat products	45,423	7,531,632	627,609	451,960	8,344,444	2,975,151	5,764,384	25,740,603	3.4
Animal units									
Fattened cattle	1	0	0	0	0	0	28,502	28,503	0.3
Beef cows	1,041	0	0	0	305,721	5	88,563	395,331	1.1
Other beef cattle	584	0	0	0	355,645	216	85,880	442,325	2.2
Milk cows	99	0	0	0	0	0	11,142	11,241	0.1
Other dairy cattle	21	0	0	0	0	0	5,768	5,789	0.2
Hogs and pigs	46	0	0	0	0	0	24,936	24,981	0.3
Chickens	79	0	0	0	0	0	3,840	3,919	0.1
Turkeys	12	0	0	0	0	0	592	605	<0.1
All types	1,882	0	0	0	661,367	222	249,223	912,693	1.0

Table A–2 Profile of ***farms with few livestock*** in the 1997 Census of Agriculture

	Farms with sales of specialty livestock products >75% of live-stock sales*	Farms with only sheep and goats**	Farms with only horses, ponies, mules, burros, or donkeys**		Farms with beef cattle or a mix of cattle and other pastured livestock types**		Farms with any fattened cattle, milk cows, swine, chickens, or turkeys*	All farms with few livestock	% of total for all farms with live-stock
			Farms with <$50,000 in livestock sales	Farms with $50,000 or more in livestock sales	Farms with <$50,000 in livestock sales	Farms with $50,000 or more in livestock sales			
End-of-year inventory									
Sheep & goats	4,325	102,379	0	0	123,271	42	120,203	350,220	3.6
Horses, ponies, mules, burros, donkeys	4,754	0	348,723	1,076	154,444	147	87,223	596,367	23.6

* Farms may also have any of the other livestock types.
** Farms may also have specialty livestock where sales of specialty livestock products are less than 75 percent of total livestock sales.

Profile of farms with specialty livestock types

In the 1997 Census of Agriculture, there were 8,834 farms with specialty livestock types, comprising 0.7 percent of all farms with livestock (table A–1). These 8,834 farms accounted for $1.6 billion in gross livestock sales (table A–3). Most of these farms (91 percent) had few other livestock, but 786 farms would also qualify as ***farms with pastured livestock types and few other livestock*** and 50 farms would also qualify as ***farms with confined livestock types***. Overall, ***farms with specialty livestock types*** had negligible amounts of other livestock types (table A–3). Although the other three farm groups all had some specialty livestock, ***farms with specialty livestock types*** accounted for 96 percent of all specialty livestock sales. The dominant specialty livestock types on these farms—based on sales—were fish and other aquaculture species on 2,449 farms (28 percent), colonies of bees on 2,331 farms (26 percent), poultry other than chickens and turkeys (such as ducks and geese) on 1,490 farms (17 percent), mink and rabbits on 641 farms (7 percent), and other exotic livestock on 1,923 farms (22 percent).

Table A–3 Profile of ***farms with specialty livestock types*** in the 1997 Census of Agriculture

	Farms that meet criteria for "farms with few livestock," but specialty livestock sales were >$5,000		Farms that meet criteria for farms with pastured livestock types & few other livestock, but specialty livestock sales were >75% of total livestock sales	Farms that meet criteria for farms with confined livestock types, but specialty livestock sales were >75% of total livestock sales	All farms with specialty livestock types	Percent of total for all farms with livestock
	Farms with only specialty livestock types	Farms with a mix of specialty livestock types & other livestock types				
Number of farms	6,826	1,172	786	50	8,834	0.7
Percent	77.3	13.3	8.9	0.6	100.0	
Total agricultural sales ($)	1,533,175,707	106,925,267	214,946,962	65,420,064	1,920,468,000	1.5
Sales per farm	224,608	91,233	273,469	1,308,401	217,395	221.4
Livestock sales ($)	1,263,909,162	90,662,252	202,967,572	57,702,731	1,615,241,717	1.6
Sales per farm						
Mean	185,161	77,357	258,228	1,154,055	182,844	243.3
25th percentile	12,000	10,000	3,400	65,979	11,016	
50th percentile	30,000	20,051	26,796	228,802	28,900	
75th percentile	99,385	50,000	112,991	469,551	94,200	
90th percentile	300,000	160,000	356,402	2,209,875	298,262	
95th percentile	700,000	315,000	902,522	6,642,000	650,000	
Dollar value for sale of						
Cattle other than fattened cattle	0	749,928	5,736,573	1,153,934	7,640,435	<0.1
Fattened cattle	0	65,217	47,517	544,658	657,392	<0.1
Dairy products	0	2,952	55,267	383,339	441,558	<0.1
Hogs and pigs	0	119,838	11,095	190,073	321,006	<0.1
Chicken and turkey products	867	457,055	20,231	446,235	924,389	<0.1

Table A–3 Profile of ***farms with specialty livestock types*** in the 1997 Census of Agriculture—Continued

	Farms that meet criteria for "farms with few livestock," but specialty livestock sales were >$5,000		Farms that meet criteria for farms with pastured livestock types & few other livestock, but specialty livestock sales were >75% of total livestock sales	Farms that meet criteria for farms with confined livestock types, but specialty livestock sales were >75% of total livestock sales	All farms with specialty livestock types	Percent of total for all farms with livestock
	Farms with only specialty livestock types	Farms with a mix of specialty livestock types & other livestock types				
Dollar value for sale of (cont.)						
Specialty livestock products	1,263,891,745	88,808,094	196,659,443	54,955,942	1,604,315,223	96.1
Horses, ponies, mules, burros, & donkeys	12,650	331,078	230,195	6,037	579,960	0.1
Sheep & goat products	3,900	128,090	207,251	22,513	361,754	<0.1
Animal units						
Fattened cattle	0	35	21	200	256	<0.1
Beef cows	0	372	18,261	379	19,012	0.1
Other beef cattle	0	584	6,772	828	8,184	<0.1
Milk cows	0	36	16	459	512	<0.1
Other dairy cattle	0	12	17	116	145	<0.1
Hogs & pigs	0	63	17	246	326	<0.1
Chickens	0	69	11	227	307	<0.1
Turkeys	0	24	4	0	27	<0.1
All types	0	1,196	25,119	2,456	28,771	<0.1
End-of-year inventory						
Sheep & goats	0	2,271	8,712	317	11,300	0.1
Horses, ponies, mules, burros, & donkeys	0	2,173	6,465	150	8,788	0.3

Profile of farms with pastured livestock types and few other livestock

Farms with pastured livestock types and few other livestock comprised the largest group of farms, consisting of 707,365 farms representing 54 percent of all farms with livestock (table A–1). The majority of farms in this group—59 percent—were farms with only beef cattle other than fattened cattle (table A–4). About 2 percent of the farms had only sheep and goats, and about 4 percent had only horses, ponies, mules, burros, or donkeys. The remaining 35 percent of these farms had a mixture of pastured livestock types, of which about 40 percent also had up to 4 animal units of fattened cattle, milk cows, swine, chickens, or turkeys. ***Farms with pastured livestock types and few other livestock*** accounted for about 86 percent of all beef cow animal units on all farms, about 68 percent of all beef cattle animal units other than fattened cattle or beef cows, about 88 percent of all sheep and goats, and about 68 percent of all horses, ponies, mules, burros, and donkeys. Fattened cattle, milk cows, other dairy cattle, swine, chickens, and turkeys totaled only 82,186 animal units, which is a negligible proportion (0.2 percent) of these livestock types on all farms.

Overall, ***farms with pastured livestock types and few other livestock*** accounted for only 17 percent of all livestock sales ($17.2 billion) even though this group represented over half of all farms with livestock (table A–4). Twenty-five percent had livestock sales less than $2,800, 50 percent had livestock sales less than $6,250, and 75 percent had livestock sales less than $15,400. In general, ***farms with pastured livestock types and few other livestock*** are dominated by small farms that primarily raise livestock (mostly beef cattle) and have low gross livestock sales. A significant minority, however, raises large numbers of livestock and has relatively high gross livestock sales.

Table A–4 Profile of ***farms with pastured livestock types and few other livestock*** in the 1997 Census of Agriculture

	Farms with only sheep & goats	Farms with only horses, ponies, mules, burros, & donkeys	Farms with only beef cattle (other than fattened cattle)	Farms with mixture of pastured livestock, but no fattened cattle, milk cows, swine, chickens, or turkeys	Farms with mixture of pastured livestock & up to 4 AU of fattened cattle, milk cows, swine, chickens, or turkeys	All farms with pastured livestock	Percent of total for all farms with livestock
Number of farms	11,937	30,083	417,066	147,665	100,614	707,365	53.8
Percent	1.7	4.3	59.0	20.9	14.2	100.0	
Total agricultural sales ($)	542,999,683	795,274,493	18,074,489,373	9,114,058,317	3,576,474,880	32,103,296,746	24.9
Sales per farm	45,489	26,436	43,337	61,721	35,546	45,384	46.2
Livestock sales ($)	259,647,277	561,468,897	8,454,255,790	6,157,315,387	1,758,488,797	17,191,176,148	17.4
Sales per farm							
Mean	21,751	18,664	20,271	41,698	17,478	24,303	32.3
25th percentile	1,060	0	3,000	3,300	2,800	2,800	
50th percentile	2,500	1,000	6,400	8,423	5,720	6,250	
75th percentile	5,879	6,000	14,854	25,800	12,464	15,400	
90th percentile	16,000	20,000	35,000	79,758	31,000	40,200	
95th percentile	32,000	42,000	61,600	152,378	59,856	78,108	

Table A–4 Profile of ***farms with pastured livestock types and few other livestock*** in the 1997 Census of Agriculture—Continued

	Farms with only sheep & goats	Farms with only horses, ponies, mules, burros, & donkeys	Farms with only beef cattle (other than fattened cattle)	Farms with mixture of pastured livestock, but no fattened cattle, milk cows, swine, chickens, or turkeys	Farms with mixture of pastured livestock & up to 4 AU of fattened cattle, milk cows, swine, chickens, or turkeys	All farms with pastured livestock	Percent of total for all farms with livestock
Dollar value for sale of:							
Cattle other than fattened cattle	0	0	8,441,232,799	5,595,179,752	1,545,594,644	15,582,007,195	77.3
Fattened cattle	0	0	0	0	87,335,894	87,335,894	0.4
Dairy products	0	0	0	0	2,520,548	2,520,548	<0.1
Hogs & pigs	0	0	0	0	18,421,074	18,421,074	0.1
Chicken & turkey products	0	0	0	0	5,325,405	5,325,405	<0.1
Specialty livestock products	343,747	1,211,586	7,138,540	7,576,669	3,568,821	19,839,363	1.2
Horses, ponies, mules, burros, & donkeys	35,778	560,090,350	3,032,335	239,052,983	39,944,522	842,155,968	81.3
Sheep and goat products	259,267,752	166,961	2,852,116	315,505,983	55,777,889	633,570,701	84.7
Animal units							
Fattened cattle	0	0	0	0	44,361	44,361	0.5
Beef cows	0	0	16,651,685	10,305,181	3,630,671	30,587,537	86.0
Other beef cattle	0	0	7,527,475	4,819,392	1,566,561	13,913,428	68.3
Milk cows	0	0	0	0	10,834	10,834	0.1
Other dairy cattle	0	0	0	0	8,346	8,346	0.3
Hogs & pigs	0	0	0	0	15,857	15,857	0.2
Chickens	0	0	0	0	2,466	2,466	0.1
Turkeys	0	0	0	0	322	322	<0.1
All types	0	0	24,179,160	15,124,573	5,279,417	44,583,150	46.8
End-of-year inventory							
Sheep & goats	2,202,044	0	0	5,532,589	924,664	8,659,297	88.3
Horses, ponies, mules, burros, & donkeys	0	666,526	0	848,530	212,227	1,727,283	68.3

Profile of farms with confined livestock types

Of the 1,315,051 farms with livestock, 18 percent (237,821 farms) were ***farms with confined livestock types*** (table A–1). These 237,821 farms accounted for $79 billion in gross livestock sales, which was 80 percent of gross livestock sales for all farms (table A–5). Of the ***farms with confined livestock types,*** 25 percent had gross livestock sales above $223,870, 50 percent had sales above $93,620, and 75 percent had sales above $33,204. The top 5 percent had gross livestock sales above $1 million.

Farms with confined livestock types accounted for 99 percent or more of all animal units on all farms with livestock for each of fattened cattle, milk cows, other dairy cattle, swine, chickens, and turkeys (table A–5). Dairies comprised 40 percent of the farms (94,787 farms), swine were the dominant livestock type on 22 percent of the farms (51,772 farms), poultry were dominant on 12 percent (27,530 farms), fattened cattle were dominant on 8 percent (17,796 farms), and veal and confined heifers were dominant on about 2 percent (4,011 farms). The remaining farms were special cases (1 percent) or small farms where beef cattle (other than fattened cattle) were the dominant livestock type (17 percent).

Farms with confined livestock types were broken down into two groups: farms with less than 35 animal units of either fattened cattle, milk cows, swine, chickens, or turkeys, and farms with more than 35 AU of either fattened cattle, milk cows, swine, chickens, or turkeys, or were defined as veal or confined heifer farms. The 35-AU threshold was selected to correspond to the lower threshold used to derive representative farms in the main body of this report.

Farms with less than 35 AU of confined livestock types totaled 84,297, representing about 35 percent of ***farms with confined livestock types***. This group accounted for only 4 percent of livestock sales and only 8 percent of the animal units among ***farms with confined livestock types***. The median per-farm livestock sales were about $23,000 for these small farms.

There were 151,233 of the larger ***farms with confined livestock types.*** These farms accounted for the bulk of fattened cattle, milk cow, swine, and poultry animal units on all farms (table A–5). The median per-farm livestock sales were about $165,000. Of these farms, 10 percent had livestock sales above $835,000.

Table A–5 Profile of ***farms with confined livestock types*** in the 1997 Census of Agriculture

	Farms with < 35 AU of each livestock type	Farms with > 35 AU of one or more livestock types	Special cases*	All farms with confined livestock types	Percent of total for all farms with livestock
Number of farms	84,297	151,233	2,291	237,821	18.1
Percent	35.4	63.6	1.0	100.0	
Number of farms by dominant livestock type					
Fattened cattle	7,637	10,159	0	17,796	
Milk cows	15,469	79,318	0	94,787	
Swine	18,817	32,955	0	51,772	
Turkeys	96	3,213	0	3,309	
Broilers	1,525	16,251	0	17,776	
Layers	862	4,052	0	4,914	
Pullets	257	1,274	0	1,531	
Cattle other than fattened cattle or milk cows	39,634	**	0	39,634	
Veal	***	168	0	168	
Confined heifers	***	3,843	0	3,843	

Table A–5 Profile of ***farms with confined livestock types*** in the 1997 Census of Agriculture—Continued

	Farms with < 35 AU of each live-stock type	Farms with > 35 AU of one or more livestock types	Special cases*	All farms with confined livestock types	Percent of total for all farms with livestock
Total agricultural sales ($)	6,148,781,785	82,190,842,232	1,874,465,200	90,214,089,217	69.9
Sales per farm	72,942	543,472	818,186	379,336	386.4
Livestock sales ($)	2,857,757,966	74,547,113,675	1,821,824,733	79,226,696,374	80.2
Sales per farm					
Mean	33,901	492,929	795,209	333,136	443.4
25th percentile	11,748	94,000	37,444	33,204	
50th percentile	22,718	164,950	73,150	93,620	
75th percentile	41,254	367,850	150,000	223,870	
90th percentile	67,500	834,707	825,800	588,052	
95th percentile	94,536	1,340,075	6,026,130	1,002,200	
Dollar value for sale of:					
Cattle other than fattened cattle	677,436,808	3,335,114,564	90,437,150	4,102,988,522	20.4
Fattened cattle	754,433,949	19,466,751,517	531,036	20,221,716,502	99.3
Dairy products	370,748,781	18,504,517,230	118,079,251	18,993,345,262	100.0
Hogs & pigs	673,213,197	13,081,903,100	1,731,127	13,756,847,424	99.7
Chicken & turkey products	337,894,928	20,057,865,509	1,609,770,017	22,005,530,454	99.9
Specialty livestock products	5,308,151	22,493,827	191,020	27,992,998	1.7
Horses, ponies, mules, burros, & donkeys	12,959,394	16,483,323	473,954	29,916,671	2.9
Sheep and goat products	25,762,758	61,984,605	611,178	88,358,541	11.8
Animal units					
Fattened cattle	369,674	9,145,786	260	9,515,719	99.2
Beef cows	1,829,930	2,709,553	31,725	4,571,207	12.9
Other beef cattle	889,940	5,069,077	40,766	5,999,783	29.5
Milk cows	385,541	11,883,007	0	12,268,547	99.8
Other dairy cattle	102,206	2,697,856	0	2,800,062	99.5
Hogs & pigs	479,683	8,008,825	41	8,488,548	99.5
Chickens	82,454	3,929,991	7	4,012,452	99.8
Turkeys	1,839	2,103,032	0	2,104,871	100.0
All types	4,141,265	45,547,126	72,798	49,761,190	52.2
End-of-year inventory					
Sheep and goats	350,843	413,664	16,460	780,967	8.0
Horses, ponies, mules, burros, & donkeys	89,262	104,716	1,449	195,427	7.7

* Farms classified as special cases include dairies that went out of business, farms with only feeder pigs, and egg-hatching operations (see text).
** If more than 35 animal units of any fattened cattle, milk cows, swine, chickens, or turkeys were present on the farm, they were used to define the dominant livestock type, even if cattle were the most abundant livestock type on the farm. There were 11,782 farms that met this condition, of which 34 percent were classified as fattened cattle farms, 31 percent were classified as swine farms, and 22 percent were classified as dairies.
*** For small farms, veal and confined heifers are included with cattle other than fattened cattle or milk cows.
Note: Confined livestock types include fattened cattle, milk cows, swine, chickens, turkeys, veal, and confined heifers.

Profile of potential concentrated animal feeding operations

Potential Concentrated Animal Feeding Operations (CAFOs) are an important subset of ***farms with confined livestock.*** Under the National Pollutant Discharge Elimination System (NPDES) program, CAFOs are defined as livestock operations that (USEPA, 2000)

- Confine more than 1,000 animal units, where 1,000 AUs are defined as 1,000 slaughter and feeder cattle, 700 mature dairy cows, 2,500 swine (other than feeder pigs), 30,000 laying hens or broilers if facility uses a liquid system, and 100,000 laying hens or broilers if facility uses continuous overflow watering.
- Confine between 300 and 1,000 animal units (as defined above) and discharge pollutants into water through a constructed ditch, flushing system, or similar manufactured device, or directly into water that passes through the facility.

CAFOs are required to have NPDES permits, which restrict discharge of pollutants to water except in the event of a 25-year, 24-hour storm.

EPA uses the following headcount thresholds to define the 1,000 and 300 animal unit categories (USEPA, 2001).

Number of animals needed to qualify as a CAFO:

	1,000 EPA AU	300 EPA AU
Cattle and heifers	1,000 head	300 head
Veal	1,000 head	300 head
Mature dairy cattle	700 head	200 head
Swine over 55 pounds	2,500 head	750 head
Immature swine	10,000 head	3,000 head
Chickens	100,000 head	30,000 head
Turkeys	55,000 head	16,500 head

EPA animal units are thus different from USDA animal units. A USDA animal unit is 1,000 pounds of live weight. The table below presents equivalent thresholds in terms of USDA animal units for each of the two EPA thresholds. Animals per USDA animal unit were taken from Kellogg et al. (2000) and are presented in appendix B, table B–1. The comparison assumes that the number of animals represented by the EPA headcount thresholds is the average number of animals on the farm throughout the year. The EPA thresholds are actually more restrictive since they apply to the maximum number of animals in confinement on the farm in any 45 days within a year.

USDA animal units (1,000 lb of live weight) equivalent to EPA's headcount thresholds for CAFOs:

	1,000 EPA AU criteria	300 EPA AU criteria
Fattened cattle	877	263
Milk cows	946	270
Confined heifers	1,064	319
Veal	250	75
Breeding hogs	936	281
Hogs for slaughter	275	83
Chicken layers	400	120
Chicken broilers	220	66
Turkeys for breeding	1,100	330
Turkeys for slaughter	821	246

Although the information in the Census of Agriculture is not adequate to identify a farm as a CAFO, **potential** CAFOs can be estimated based on the livestock type and the estimated number of animals on the farm. Results indicate that in 1997 there were 11,398 potential CAFOs at the 1,000 EPA animal unit level, representing about 5 percent of all farms with confined livestock types (table A–6). There were 44,366 potential CAFOs at the 300 EPA animal unit level (19 percent of all farms with confined livestock types).

For potential CAFOs at the 1,000 EPA animal unit level, median gross livestock sales per farm were $1.5 million (table A–6). Seventy-five percent had gross livestock sales above $1 million, and 25 percent had gross livestock sales above $2.6 million. Livestock sales for this collection of farms are about $40 billion, which is 41 percent of the total livestock sales for all farms with livestock. Of these 11,398 farms, 34 percent are swine farms, 26 percent are broiler farms, 15 percent are fattened cattle farms, 13 percent are dairies, and the remaining 12 percent are farms with turkeys, layers, pullets, veal, or confined heifers (table A–6). Overall, these farms accounted for 85 percent of all fattened cattle on ***farms with confined livestock types***, 23 percent of milk cows, 54 percent of swine, 46 percent of turkeys, and 51 percent of chickens (table A–6).

At the 300 EPA animal unit level, the number of potential CAFOs increases to nearly 4 times the number of potential CAFOs at the 1,000 EPA animal unit level, and account for an additional $18 billion in livestock sales (table A–6). Overall, these farms accounted for 91 percent of all fattened cattle on ***farms with confined livestock types***, 44 percent of milk cows, 78 percent of swine, 89 percent of turkeys, and 90 percent of chickens.

Correspondence between farm groups and CNMP farms

In the main body of the publication, criteria were presented for identifying farms that are expected to need a CNMP. Of the 237,821 ***farms with confined livestock types***, 230,373 farms (97 percent) were identified as CNMP farms (table A–7). Of the 707,365 ***farms with pastured livestock types and few other livestock***, 24,697 farms (3 percent) were identified as CNMP farms. Including the 2,131 farms with specialty livestock types, the total number of CNMP farms is 257,201, which represents about 13 percent of all farms in the 1997 Census of Agriculture. Table A–8 provides a breakdown of CNMP farms by livestock type and farm size for the 237,821 ***farms with confined livestock types***.

Table A–6 Profile of potential CAFOs, derived from the 1997 Census of Agriculture*

	- - - - - - - 1,000 EPA animal units - - - - - - -		- - - - - - - 300 EPA animal units - - - - - - -	
	Amount	Percent of total for farms with confined livestock types	Amount	Percent of total for farms with confined livestock types
Number of farms	11,398	4.8	44,366	18.7
Number of farms by dominant livestock type				
Fattened cattle	1,766	9.9	4,448	25.0
Milk cows	1,450	1.5	7,230	7.6
Swine	3,924	7.6	13,825	26.7
Turkeys	388	11.7	2,003	60.5
Broilers	2,945	16.6	13,694	77.0
Layers	546	11.1	1,420	28.9
Pullets	125	8.2	711	46.4
Veal	12	7.1	69	41.1
Confined heifers	242	6.3	966	25.1
Total agricultural sales ($)	41,612,719,837	46.1	62,247,146,870	69.0
Sales per farm	3,650,879		1,403,037	
Livestock sales ($)	40,421,733,048	51.0	58,823,823,880	74.2
Sales per farm				
Mean	3,546,388		1,325,876	
25th percentile	1,059,606		373,287	
50th percentile (median)	1,510,469		607,611	
75th percentile	2,614,725		1,031,801	
90th percentile	5,500,000		1,946,800	
95th percentile	10,983,000		3,240,000	

Table A–6 Profile of potential CAFOs, derived from the 1997 Census of Agriculture*—Continued

	1,000 EPA animal units		300 EPA animal units	
	Amount	Percent of total for farms with confined livestock types	Amount	Percent of total for farms with confined livestock types
Dollar value for sale of:				
Cattle other than fattened cattle	1,023,604,897	24.9	1,877,369,257	45.8
Fattened cattle	17,122,605,326	84.7	18,427,802,297	91.1
Dairy products	4,817,922,724	25.4	9,040,243,783	47.6
Hogs & pigs	7,676,788,204	55.8	11,007,852,819	80.0
Chicken & turkey products	9,752,180,693	44.3	18,410,985,099	83.7
Specialty livestock products	6,003,016	21.4	16,734,000	59.8
Horses, ponies, mules, burros, & donkeys	1,282,479	4.3	5,257,772	17.6
Sheep & goat products	21,345,709	24.2	37,578,853	42.5
Animal units				
Fattened cattle	8,054,276	84.6	8,657,463	91.0
Beef cows	580,686	12.7	1,394,393	30.5
Other beef cattle	3,238,360	54.0	4,053,264	67.6
Milk cows	2,798,343	22.8	5,359,939	43.7
Other dairy cattle	562,326	20.1	1,109,515	39.6
Hogs and pigs	4,559,021	53.7	6,610,933	77.9
Chickens	2,032,327	50.7	3,595,434	89.6
Turkeys	962,703	45.7	1,864,350	88.6
All types	22,788,043	45.8	32,645,291	65.6
End-of-year inventory				
Sheep and goats	69,723	8.9	175,755	22.5
Horses, ponies, mules, burros, & donkeys	10,866	5.6	31,604	16.2

* Information in the Census of Agriculture is not adequate to precisely identify a farm as a CAFO. Potential CAFOs were estimated based on the livestock type and the estimated number of animals on the farm.

Table A–7 Breakdown of farms that are expected to need CNMPs (i.e., CNMP farms) according to farm group

Farm group	Number of farms	Farms identified as CNMP farms number	percent
Farms with no livestock	596,808	0	0
Farms with few livestock	361,031	0	0
Farms with specialty livestock types	8,834	2,131	24
Farms with pastured livestock types and few other livestock	707,365	24,697	3
Farms with confined livestock types	237,821	230,373	97
Total	1,911,859	257,201	13

Table A–8 Breakdown of farms that are expected to need CNMPs (i.e., CNMP farms) according to farm size and livestock type for ***farms with confined livestock types***

Category	Number of farms	Farms identified as CNMP farms number	percent
Farms with >35 animal units of the dominant livestock type, by dominant livestock type	151,233	151,233	100
Fattened cattle	10,159	10,159	100
Milk cows	79,318	79,318	100
Swine	32,955	32,955	100
Turkeys	3,213	3,213	100
Broilers	16,251	16,251	100
Layers/pullets	5,326	5,326	100
Confined heifers/veal	4,011	4,011	100
Farms with <35 animal units of any livestock type	84,297	79,140	94
Confined livestock types dominant	44,663	42,565	95
Beef cattle dominant (other than fattened cattle)	39,634	36,575	92
Special cases	2,291	0	0
Total	237,821	230,373	97

Appendix B Estimating Recoverable Manure and Modeling Land Application

The Census of Agriculture includes enough information on the number and type of livestock, crop production, and cropland and pastureland acreage to make reasonable estimates of the amount of manure produced and the potential for land application on each farm. This appendix presents the methods for making these estimates, the assumptions and rationale underlying the estimates, and a summary of the results that were used in calculations of CNMP costs.

An earlier version of this simulation model was used to generate the estimates published in *Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients: Spatial and Temporal Trends for the United States*, December 2000, by Robert L. Kellogg, Charles H. Lander, David C. Moffitt, and Noel Gollehon. The main differences between the estimates made in this study and those reported in Kellogg, et al. (2000) are

- Recoverability factors and nutrient recovery parameters were revised to be consistent with the representative farms used in this study to characterize manure management and handling on CNMP farms, and
- Land application assumptions were tailored to the two scenarios used to estimate CNMP costs. (The two land application scenarios are described in the main body of this report.)

All measures of nitrogen and phosphorus in this report—manure nutrients *as excreted*, recoverable manure nutrients, excess manure nutrients, and application rates—are in terms of **elemental nitrogen** and **elemental phosphorus**.

Manure and manure nutrients

The amount of manure and manure nutrients produced on livestock operations was estimated using the Census of Agriculture database and generalizations regarding the amount of manure produced per animal and the amount of nitrogen and phosphorus in the manure. The amount of manure produced and the amount of manure nutrients produced per animal actually varies from farm to farm depending on the how much and how often the animals are fed, the quality of the feed and grazing materials (especially the nitrogen and phosphorus content), the extent to which the animals are held in confinement, and the extent to which animals are allowed access to grazing land. Actual values for specific farms are expected to differ from estimates based on the Census of Agriculture database. Overall, however, it is believed that these estimates are good approximations to the total amounts of manure produced on livestock operations.

The amount of manure *as excreted* that is produced on a farm is calculated as the number of animal units times the amount of manure produced by an animal unit. The amount of manure nutrients is then calculated as a percentage of the amount of manure *as excreted*. An animal unit (AU) is 1,000 pounds of live weight. Census of Agriculture information on livestock sales during the year and end-of-year inventory was used to estimate the average annual number of AUs of each livestock type on each farm using procedures described in Kellogg, et al. (2000). Some of the algorithms used to estimate beef cattle AUs were refined and improved. The major modification was to estimate veal and confined heifer farms separately from other cattle farms, as described in appendix A. Conversion factors for grass-fed beef cattle were used to estimate manure produced by sheep, goats, horses, ponies, mules, donkeys, and burros. Manure production was not calculated for specialty livestock types because appropriate conversion factors were not available. Conversion factors used to estimate the amount of *as excreted* manure and manure nutrients by livestock type are presented in table B–1. The resulting estimates of manure nutrients *as excreted* are shown in table B–2 for all farms in all 50 states. Estimates could not be made for farms in the Pacific Basin or in Puerto Rico because Census of Agriculture information for these areas was not readily available. National totals are nearly the same as those previously reported in Kellogg et al. (2000) for all livestock.

Table B–1 Parameters used to calculate the quantity of manure and manure nutrients *as excreted*

Livestock type	Number of animals per AU	Tons of manure per AU per year: wet weight	Tons of manure per AU per year: oven-dry weight	Pounds of nutrient per wet weight ton of manure*: nitrogen	Pounds of nutrient per wet weight ton of manure*: phosphorus
Fattened cattle	1.14	10.59	1.27	10.98	3.37
Beef calves	4	11.32	1.36	8.52	2.33
Beef heifers	1.14	12.05	1.45	6.06	1.30
Beef breeding cows and bulls	1	11.50	1.33	10.95	3.79
Beef stockers and grass-fed beef	1.73	11.32	1.36	8.52	2.33
Horses, ponies, mules, donkeys, & burros	1.25	11.32	1.36	8.52	2.33
Sheep and goats	8	11.32	1.36	8.52	2.33
Milk cows	0.74	15.24	2.20	10.69	1.92
Dairy calves	4	12.05	1.45	6.06	1.30
Dairy heifers	0.94	12.05	1.45	6.06	1.30
Dairy stockers & grass-fed animals marketed as beef	1.73	12.05	1.45	6.06	1.30
Hogs for breeding	2.67	6.11	0.55	13.26	4.28
Hogs for slaughter	9.09	14.69	1.33	11.30	3.29
Chicken layers	250	11.45	2.86	26.93	9.98
Chicken pullets, less than 3 months old	455	8.32	2.08	27.20	10.53
Chicken pullets, more than 3 months old	250	8.32	2.08	27.20	10.53
Chicken broilers	455	14.97	3.74	26.83	7.80
Turkeys for breeding	50	9.12	2.28	22.41	13.21
Turkeys for slaughter	67	8.18	2.04	30.36	11.83

* Includes nitrogen and phosphorus in urine.

Table B–2 Number of farms, animal units, and quantities of manure nutrients *as excreted* for all livestock on all farms

Farm group and dominant livestock type*	Number of farms	Animal units	Pounds of manure nitrogen	Pounds of manure phosphorus
Farms with no livestock	596,808	0	0	0
Farms with few livestock	361,031	1,433,564	152,597,724	45,476,482
Farms with specialty livestock types**	8,834	37,214	4,255,609	1,337,147
Farms with pastured livestock types and few other livestock	707,365	47,047,388	5,412,011,193	1,755,347,275
Farms with confined livestock types				
Farms with >35 AU of the dominant livestock type, by dominant livestock type				
Fattened cattle	10,159	13,193,896	1,481,784,875	449,201,459
Milk cows	79,318	15,448,663	2,235,427,462	425,073,626
Swine	32,955	9,073,203	1,256,177,612	375,873,882
Turkeys	3,213	2,206,628	525,875,015	207,734,091
Broilers	16,251	2,966,935	1,041,747,587	305,145,588
Layers	4,052	1,374,533	398,365,032	146,767,400
Pullets	1,274	209,374	44,011,426	16,582,152
Confined heifers	168	26,827	2,962,551	882,549
Veal	3,843	1,182,548	120,000,451	33,802,682
Farms with <35 AU of any livestock type				
Confined livestock types dominant	44,663	1,054,576	154,107,500	39,981,908
Beef cattle dominant (other than fattened cattle)	39,634	3,277,969	389,252,366	123,422,081
Special cases	2,291	0	0	0
All farms	1,911,859	98,533,319	13,218,576,402	3,926,628,320

* See appendix A for definitions of farm groups.
** Excludes AU and manure produced by specialty livestock types. Values reported in table represent nonspecialty livestock types on these farms.

Recoverable manure and recoverable manure nutrients

Recoverable manure is the portion of manure *as excreted* that could be collected from buildings and lots where livestock are held, and thus would be available for land application. Recoverable manure nutrients are the amounts of manure nitrogen and phosphorus that would be expected to be available for land application. They are estimated by adjusting the quantity of recoverable manure for nutrient loss during collection, transfer, storage, and treatment. Recoverable manure nutrients are **not** adjusted for losses of nutrients at the time of land application.

Estimates of manure produced *as excreted* were converted to estimates of recoverable manure using recoverability factors. The **manure recoverability factor** is the proportion of manure *as excreted* that can be collected and made available for land application or other use. **Nutrient recovery parameters** are the proportions of nitrogen and phosphorus in the recoverable manure relative to the amount of manure nutrients *as excreted*. Recoverability factors were derived for each model farm. Model farms are defined in the main body of this publication. The model farm analytical structure was expanded somewhat to account for recoverable manure on small farms and regional variability.

Manure recoverability factors and nutrient recovery parameters for fattened cattle, milk cows, veal, confined heifers, swine, chickens, and turkeys are presented in table B–3. Separate estimates of recoverable manure and manure nutrients were made for each of the two land application scenarios defined in the main body of this publication. Estimates for the **baseline scenario** were made using manure recoverability factors and nutrient recovery parameters that are expected to generally represent conditions in about 1997, prior to implementation of CNMPs and most State and local regulations. Estimates for the **after-CNMP scenario** reflect adjustments for improved manure management and handling. Manure recoverability factors were higher for most model farms in the after-CNMP scenario. Most nutrient recovery parameters were the same in both land application scenarios. Nitrogen recovery parameters were lower in the after-CNMP scenario for some liquid waste handling systems (dairies) under the assumption that more of the solid manure on the farm would be incorporated into the liquid system where volatilization rates are higher. For some liquid systems, the system changes typically needed to meet CNMP criteria would significantly increase the storage time, and wastewater would be more dilute. This would be especially true upgrading a storage pond to a storage lagoon. The longer storage time provides more time for volatilization, so N losses in the after-CNMP scenario could be greater.

Estimates of recoverable manure for pastured livestock types (e.g., beef cattle, horses, sheep, and goats) were limited to farms with more than one animal unit of these types per acre of pastureland and rangeland. Recoverability factors reflect the extent to which these livestock are expected to be held in confinement or the extent that the livestock are expected to congregate in lots and barnyards for shelter or feeding. Recoverability factors for beef cows, calves, heifers, and stockers presented in Kellogg et al. (2000) were adjusted upward to account for the exclusion of farms with less than one animal unit per acre of pastureland and rangeland. Manure recoverability factors for this group were 0.05 (5 percent) for 17 states (mostly in the West, Southeast, and South Central States), 0.10 for 29 states, and 0.15 or 0.20 for four states (mostly in the Northeast). Nutrient recovery parameters for beef cattle are the same as those reported in Kellogg et al. (2000), table 8.

Estimates of recoverable manure for dairy cattle other than milk cows (exclusive of dairy calves and dairy heifers on veal and confined heifer farms) were based on recoverability factors and nutrient recovery parameters reported in Kellogg et al. (2000) for these livestock types. Recoverable manure for sheep, goats, horses, ponies, mules, donkeys, and burros was estimated using manure recoverability factors and nutrient recovery parameters for grass-fed beef cattle.

Recoverable manure was not calculated for farms with few livestock or for farms with specialty livestock types (ducks, geese, mink, and rabbits). Farms with few livestock, as described in appendix A, have less than 4 AU of fattened cattle, milk cows, swine, or poultry and small numbers of pastured livestock types. Since few livestock on these farms are raised in confined settings, the amount of recoverable manure is expected to be negligible. Significant amounts of recoverable manure are expected on most farms with specialty livestock types, but appropriate conversion factors were not available at the time the study was conducted.

Recoverable manure and recoverable manure nutrients were estimated for each livestock type on each farm using the manure recoverability factors and nutrient recovery parameters described above, and then aggregated for each farm. For farms with more than one assigned representative farm, the probabilities associated with each representative farm were used as weights to obtain the farm totals. These probabilities are included in table B–3. For example, there are two possible representative farms for larger dairies in the Southeast (dairies with more than 135 milk cow animal units): a solids system, with a probability of 0.3 (representative farm #2 for dairies), and a liquid waste handling system, with a probability of 0.7 (representative farm #5 for dairies). Each of the manure-handling systems has different manure recoverability and nutrient recovery parameters. Recoverable manure nutrients were calculated for each system and then multiplied by the probabilities associated with each system. These weighted totals for each system were then added to represent the estimate of recoverable manure nutrients for a specific farm.

Recoverable manure and recoverable manure nutrients were estimated in this manner for **all** livestock types on each farm. For example, assume the large dairy farm described above also had 80 animal units of fattened cattle. In the Southeast, the two representative farm possibilities for farms with more than 35 animal units of fattened cattle are a scrape and stack system, with a probability of 0.3, and a manure pack system, with a probability of 0.7. Recoverable manure and manure nutrients would be estimated for these fattened cattle in the same manner as for the dairy (i.e., a weighted total). The estimates for the dairy and the fattened cattle would be added to obtain the total amount of recoverable manure and manure nutrients for the farm.

Table B–3 Manure recoverability factors and nutrient recovery parameters used to estimate manure nutrients available for application for fattened cattle, milk cows, veal, confined heifers, swine, chickens, and turkeys

Livestock type and region	Size class (AU)	Representative farm (RF)	Probability (%)	Before CNMPs			After CNMPs		
				Proportion of manure that is recoverable	Proportion of N retained in recoverable manure	Proportion of P retained in recoverable manure	Proportion of manure that is recoverable	Proportion of N retained in recoverable manure	Proportion of P retained in recoverable manure
Milk cows									
All Regions	<35	RF #1: no storage	100	0.45	0.60	0.80	0.50	0.60	0.80
North Central, Northeast	35-135	RF #1: no storage	29	0.45	0.60	0.80	0.50	0.60	0.80
		RF #2: solids storage	47	0.60	0.80	0.90	0.75	0.80	0.90
		RF #3: liquid storage in deep pit or slurry	7	0.55	0.75	0.90	0.75	0.75	0.90
		RF #4: liquid storage—basin, pond, lagoon	17	0.60	0.40	0.90	0.75	0.30	0.90
	135-270	RF #1: no storage	15	0.50	0.60	0.85	0.50	0.80	0.90
		RF #2: solids storage	28	0.55	0.80	0.90	0.75	0.80	0.90
		RF #3: liquid storage in deep pit or slurry	14	0.55	0.75	0.90	0.75	0.75	0.90
		RF #4: liquid storage—basin, pond, lagoon	43	0.60	0.40	0.90	0.75	0.30	0.90
	>270	RF #2: solids storage (converted to liquid)	14	0.50	0.70	0.90	0.75	0.40	0.90
		RF #3: liquid storage in deep pit or slurry	18	0.55	0.75	0.90	0.75	0.75	0.90

Table B–3 Manure recoverability factors and nutrient recovery parameters used to estimate manure nutrients available for application for fattened cattle, milk cows, veal, confined heifers, swine, chickens, and turkeys—Continued

Livestock type and region	Size class (AU)	Representative farm (RF)	Probability (%)	Before CNMPs: Proportion of manure that is recoverable	Before CNMPs: Proportion of N retained in recoverable manure	Before CNMPs: Proportion of P retained in recoverable manure	After CNMPs: Proportion of manure that is recoverable	After CNMPs: Proportion of N retained in recoverable manure	After CNMPs: Proportion of P retained in recoverable manure
		RF #4: liquid storage—basin, pond, lagoon	68	0.55	0.40	0.90	0.75	0.30	0.90
Southeast	35-135	RF #2: solids storage	59	0.50	0.65	0.80	0.65	0.60	0.80
		RF #5: any liquid storage	41	0.55	0.65	0.90	0.70	0.65	0.90
	>135	RF #2: solids storage	30	0.50	0.70	0.85	0.65	0.67	0.90
		RF #5: any liquid storage	70	0.55	0.35	0.90	0.70	0.25	0.90
West	35-135	RF #2: solids storage	50	0.55	0.55	0.90	0.65	0.55	0.90
		RF #5: any liquid storage, with manure pack	50	0.50	0.65	0.90	0.75	0.65	0.90
	135-270	RF #2: solids storage	11	0.50	0.65	0.85	0.65	0.55	0.90
		RF #5: any liquid storage, with manure pack	89	0.55	0.40	0.85	0.75	0.30	0.90
	>270	RF #5: any liquid storage, with manure pack	100	0.60	0.40	0.85	0.75	0.30	0.90
Fattened cattle									
All Regions	<35	RF #1: feedlot scrape, stack	100	0.60	0.60	0.80	0.75	0.60	0.80
New England	>35	RF #1: feedlot scrape, stack	100	0.55	0.70	0.85	0.75	0.70	0.85
PA, NY, NJ	>35	RF #1: feedlot scrape, stack	100	0.60	0.70	0.85	0.75	0.70	0.85
Southeast	>35	RF #1: feedlot scrape, stack	30	0.55	0.60	0.80	0.75	0.60	0.80
		RF #2: feedlot with manure pack, runoff	70	0.60	0.55	0.75	0.80	0.55	0.75
Midwest	35-500	RF #1: feedlot scrape, stack	30	0.60	0.60	0.80	0.75	0.60	0.80
		RF #2: feedlot with manure pack, runoff	70	0.60	0.50	0.80	0.80	0.50	0.80
	> 500	RF #2: feedlot with manure pack, runoff	100	0.65	0.50	0.80	0.80	0.50	0.80
MT, WY, SD, MN	35-500	RF #2: feedlot with manure pack, runoff	100	0.60	0.55	0.80	0.80	0.55	0.80
	>500	RF #2: feedlot with manure pack, runoff	100	0.65	0.55	0.80	0.80	0.55	0.80
CO, KS, NE, SD	35-1000	RF #2: feedlot with manure pack, runoff	100	0.60	0.50	0.80	0.80	0.50	0.80
	>1000	RF #2: feedlot with manure pack, runoff	100	0.60	0.50	0.80	0.80	0.50	0.80
TX, OK, NM	35-1000	RF #2: feedlot with manure pack, runoff	100	0.60	0.45	0.80	0.80	0.45	0.80

Table B–3 Manure recoverability factors and nutrient recovery parameters used to estimate manure nutrients available for application for fattened cattle, milk cows, veal, confined heifers, swine, chickens, and turkeys—Continued

Livestock type and region	Size class (AU)	Representative farm (RF)	Probability (%)	Before CNMPs: Proportion of manure that is recoverable	Before CNMPs: Proportion of N retained in recoverable manure	Before CNMPs: Proportion of P retained in recoverable manure	After CNMPs: Proportion of manure that is recoverable	After CNMPs: Proportion of N retained in recoverable manure	After CNMPs: Proportion of P retained in recoverable manure
	>1000	RF #2: feedlot with manure pack, runoff	100	0.60	0.45	0.80	0.80	0.45	0.80
West	35-500	RF #2: feedlot with manure pack, runoff	100	0.60	0.45	0.80	0.80	0.45	0.80
	>500	RF #2: feedlot with manure pack, runoff	100	0.60	0.45	0.80	0.80	0.45	0.80
Confined heifers									
Northeast	All	RF #1: confinement barn/ bedded manure	70	0.65	0.70	0.85	0.85	0.70	0.85
	All	RF #2: feedlot scrape, stack	30	0.60	0.65	0.80	0.80	0.65	0.80
Midwest	All	RF #1: confinement barn/ bedded manure	40	0.65	0.65	0.85	0.85	0.65	0.85
	All	RF #2: feedlot scrape, stack	60	0.65	0.45	0.80	0.80	0.45	0.80
Southeast	All	RF #2: feedlot scrape, stack	100	0.65	0.50	0.80	0.80	0.50	0.80
West	All	RF #2: feedlot scrape, stack	100	0.65	0.45	0.80	0.80	0.45	0.80
Veal									
All Regions	All	RF #1: confinement house with liquid manure	100	0.75	0.50	0.80	0.95	0.50	0.80
Broilers									
Northeast	All	RF #1: confinement, standard broiler house	100	0.75	0.70	0.95	0.98	0.70	0.95
Southeast	All	RF #1: confinement, standard broiler house	100	0.85	0.60	0.95	0.98	0.60	0.95
Northwest	All	RF #1: confinement, standard broiler house	100	0.75	0.70	0.95	0.98	0.70	0.95
Southwest	All	RF #1: confinement, standard broiler house	100	0.75	0.55	0.95	0.98	0.55	0.95
Layers									
All Regions	<35	RF #1: shallow pit, ground level	100	0.75	0.80	0.90	0.95	0.80	0.90
Southeast	35-400	RF #1: high rise, pit at ground level	30	0.75	0.60	0.95	0.95	0.60	0.95
		RF #1: shallow pit, ground level	27	0.75	0.80	0.90	0.95	0.80	0.90
		RF #2: flush system with lagoon	43	0.80	0.35	0.50	0.95	0.25	0.90
	> 400	RF #1: high rise, pit at ground level	52	0.75	0.60	0.95	0.95	0.60	0.95

Table B–3 Manure recoverability factors and nutrient recovery parameters used to estimate manure nutrients available for application for fattened cattle, milk cows, veal, confined heifers, swine, chickens, and turkeys—Continued

Livestock type and region	Size class (AU)	Representative farm (RF)	Probability (%)	Before CNMPs: Proportion of manure that is recoverable	Before CNMPs: Proportion of N retained in recoverable manure	Before CNMPs: Proportion of P retained in recoverable manure	After CNMPs: Proportion of manure that is recoverable	After CNMPs: Proportion of N retained in recoverable manure	After CNMPs: Proportion of P retained in recoverable manure
		RF #2: flush system with lagoon	48	0.80	0.35	0.90	0.95	0.25	0.90
West	35-400	RF #1: shallow pit, ground level	49	0.75	0.80	0.90	0.95	0.80	0.90
		RF #3: scraper system	51	0.75	0.60	0.95	0.95	0.60	0.95
	> 400	RF #1: high rise, pit at ground level	18	0.75	0.60	0.95	0.95	0.60	0.95
		RF #3: manure belt	14	0.75	0.60	0.95	0.95	0.60	0.95
		RF #3: scraper system	68	0.75	0.55	0.95	0.95	0.55	0.95
South Central	35-400	RF #1: shallow pit, ground level	45	0.75	0.80	0.90	0.95	0.80	0.90
		RF #3: scraper system	55	0.75	0.55	0.95	0.95	0.55	0.95
	> 400	RF #2: flush system with lagoon	100	0.80	0.25	0.90	0.95	0.25	0.90
North Central & Northeast	35-400	RF #1: high rise, pit at ground level	55	0.85	0.70	0.95	0.95	0.70	0.95
		RF #1: shallow pit, ground level	25	0.85	0.85	0.90	0.95	0.85	0.90
		RF #3: manure belt	20	0.85	0.70	0.95	0.95	0.70	0.95
	>400	RF #1: high rise, pit at ground level	81	0.85	0.70	0.95	0.95	0.70	0.95
		RF #3: manure belt	19	0.85	0.70	0.95	0.95	0.70	0.95
Pullets									
North central & Northeast	All	RF #1: layer-type confinement houses	100	0.85	0.70	0.90	0.95	0.70	0.90
Southeast	All	RF #1: layer-type confinement houses	100	0.80	0.60	0.90	0.95	0.60	0.90
West	All	RF #1: layer-type confinement houses	100	0.80	0.55	0.90	0.95	0.55	0.90
South Central	All	RF #1: layer-type confinement houses	100	0.80	0.55	0.90	0.95	0.55	0.90
Turkeys									
All Regions	<35	RF #2: turkey ranch	100	0.45	0.60	0.75	0.50	0.60	0.75
East	>35	RF #1: confinement houses	90	0.80	0.60	0.95	0.98	0.60	0.95
		RF #2: turkey ranch	10	0.45	0.60	0.75	0.50	0.60	0.75
South Central	>35	RF #1: confinement houses	100	0.80	0.55	0.95	0.98	0.55	0.95
North central	>35	RF #1: confinement houses	90	0.80	0.65	0.95	0.98	0.65	0.95
		RF #2: turkey ranch	10	0.45	0.65	0.75	0.50	0.65	0.75

Table B–3 Manure recoverability factors and nutrient recovery parameters used to estimate manure nutrients available for application for fattened cattle, milk cows, veal, confined heifers, swine, chickens, and turkeys—Continued

Livestock type and region	Size class (AU)	Representative farm (RF)	Probability (%)	Before CNMPs: Proportion of manure that is recoverable	Before CNMPs: Proportion of N retained in recoverable manure	Before CNMPs: Proportion of P retained in recoverable manure	After CNMPs: Proportion of manure that is recoverable	After CNMPs: Proportion of N retained in recoverable manure	After CNMPs: Proportion of P retained in recoverable manure
West other than CA	>35	RF #1: confinement houses	50	0.80	0.55	0.95	0.98	0.55	0.95
		RF #2: turkey ranch	50	0.40	0.50	0.75	0.50	0.50	0.75
California	>35	RF #1: confinement houses	80	0.80	0.55	0.95	0.98	0.55	0.95
		RF #2: turkey ranch	20	0.40	0.50	0.75	0.50	0.50	0.75
Hogs for breeding									
All Regions	<35	RF #5: pasture or lot, with or without hut	100	0.50	0.45	0.75	0.50	0.45	0.75
North Central, Northeast	35-500	RF #1: confinement, liquid, lagoon	10	0.85	0.25	0.85	0.97	0.25	0.85
		RF #2: confinement, slurry, no lagoon	76	0.80	0.80	0.90	0.97	0.80	0.90
		RF #4: building with outside access, solids	14	0.75	0.70	0.80	0.90	0.70	0.80
	>500	RF #1: confinement, liquid, lagoon	85	0.85	0.25	0.85	0.97	0.25	0.85
		RF #2: confinement, slurry, no lagoon	15	0.80	0.80	0.90	0.97	0.80	0.90
Southeast	35-100	RF #1: confinement, liquid, lagoon	70	0.85	0.20	0.85	0.97	0.20	0.85
		RF #2: confinement, slurry, no lagoon	5	0.80	0.70	0.90	0.97	0.70	0.90
		RF #5: pasture or lot, with or without hut	25	0.50	0.45	0.75	0.50	0.45	0.75
	>100	RF #1: confinement, liquid, lagoon	95	0.85	0.20	0.85	0.97	0.20	0.85
		RF #2: confinement, slurry, no lagoon	5	0.80	0.80	0.90	0.97	0.80	0.90
West	35-500	RF #1: confinement, liquid, lagoon	45	0.85	0.25	0.85	0.97	0.25	0.85
		RF #2: confinement, slurry, no lagoon	25	0.80	0.70	0.90	0.97	0.70	0.90
		RF #5: pasture or lot	30	0.50	0.40	0.75	0.50	0.40	0.75
	>500	RF #1: confinement, liquid, lagoon	65	0.85	0.20	0.85	0.97	0.20	0.85
		RF #2: confinement, slurry, no lagoon	35	0.80	0.70	0.90	0.97	0.70	0.90
Hogs for slaughter									
All Regions	<35	RF #4: building with outside access, solids	100	0.75	0.70	0.80	0.90	0.70	0.80

Table B–3 Manure recoverability factors and nutrient recovery parameters used to estimate manure nutrients available for application for fattened cattle, milk cows, veal, confined heifers, swine, chickens, and turkeys—Continued

Livestock type and region	Size class (AU)	Representative farm (RF)	Probability (%)	-------- Before CNMPs --------			--------- After CNMPs --------		
				Proportion of manure that is recoverable	Proportion of N retained in recoverable manure	Proportion of P retained in recoverable manure	Proportion of manure that is recoverable	Proportion of N retained in recoverable manure	Proportion of P retained in recoverable manure
North Central, Northeast	35-500	RF #1: confinement, liquid, lagoon	6	0.85	0.25	0.85	0.97	0.25	0.85
		RF #2: confinement, slurry, no lagoon	53	0.80	0.80	0.90	0.97	0.80	0.90
		RF #3: building with outside access, liquid	14	0.70	0.75	0.90	0.95	0.75	0.90
		RF #4: building with outside access, solids	27	0.75	0.70	0.80	0.90	0.70	0.80
	>500	RF #1: confinement, liquid, lagoon	27	0.85	0.25	0.85	0.97	0.25	0.85
		RF #2: confinement, slurry, no lagoon	73	0.80	0.80	0.90	0.97	0.80	0.90
Southeast	35-100	RF #1: confinement, liquid, lagoon	90	0.85	0.20	0.85	0.97	0.20	0.85
		RF #2: confinement, slurry, no lagoon	10	0.80	0.70	0.90	0.97	0.70	0.90
	>100	RF #1: confinement, liquid, lagoon	100	0.85	0.20	0.85	0.97	0.20	0.85
West	35-500	RF #1: confinement, liquid, lagoon	50	0.85	0.25	0.85	0.97	0.25	0.85
		RF #2: confinement, slurry, no lagoon	50	0.80	0.70	0.90	0.97	0.70	0.90
	>500	RF #1: confinement, liquid, lagoon	50	0.85	0.20	0.85	0.97	0.20	0.85
		RF #2: confinement, slurry, no lagoon	50	0.80	0.70	0.90	0.97	0.70	0.90

Farms with a minimum amount of total recoverable manure produced annually were classified as **manure-producing farms**. Manure-producing farms were defined to be farms that produce more than 200 pounds of recoverable manure nitrogen annually. Farms at this threshold generate about 45 tons of recoverable manure, *as excreted*, which is equivalent to about 11 tons of manure for land application (transport weight), or less than a pickup truck load per month. This lower threshold was used as a practical matter to exclude numerous small farms that produced no more recoverable manure than the largest of the farms with few livestock. It is also questionable that the manure recovery factors and manure nutrient recovery parameters would apply to these small farms since they were derived for larger operations. Recoverable manure for farms below this threshold was set equal to zero for all subsequent calculations. There were 255,070 manure-producing farms in 1997, excluding specialty livestock farms.

Estimates of recoverable manure nutrients for the baseline scenario and for the after-CNMP scenario are compared to estimates previously published in Kellogg et al. (2000) in table B–4. The largest difference in recoverable manure between the revised estimates

Table B–4 Estimates of recoverable manure and recoverable manure nutrients for manure-producing farms, 1997*

	Published in Kellogg et al. (2000)	Baseline scenario	After-CNMP scenario	Percent change in the after-CNMP scenario as compared to the baseline scenario
Number of manure-producing farms	529,658**	255,070	255,070	0
Pounds of recoverable manure nitrogen				
Fattened cattle	389,900,000	327,007,586	432,098,907	32
Milk cows	635,700,000	601,051,133	673,290,892	12
Swine	274,100,000	521,975,775	629,395,784	21
Poultry	1,152,900,000	977,656,262	1,160,981,406	19
Other beef and dairy	130,600,000	105,383,686	113,076,052	7
Horses, sheep, goats	No estimate	713,584	713,584	0
All types	2,583,200,000	2,533,788,026	3,009,556,624	19
Pounds of recoverable manure phosphorus				
Fattened cattle	254,000,000	163,443,118	216,222,176	32
Milk cows	243,900,000	175,074,365	225,637,803	29
Swine	276,800,000	245,696,950	291,700,481	19
Poultry	553,900,000	501,727,122	600,495,014	20
Other beef and dairy	108,200,000	64,651,344	68,014,510	5
Horses, sheep, goats	No estimate	551,913	551,913	0
All types	1,436,800,000	1,151,144,811	1,402,621,897	22
Tons of recoverable manure, *as excreted* wet weight	Not reported	355,033,803	430,173,338	21
Tons of recoverable manure, *as excreted* oven-dry weight	Not reported	50,178,583	60,823,028	21

* Excludes 2,131 specialty livestock farms.
** Previously published estimates of the number of farms are not directly comparable to the revised estimates because they apply to livestock that were treated as confined livestock in Kellogg et al. (2000). About half of the farms in Kellogg et al. (2000) with confined livestock produced negligible amounts of recoverable manure.

and the previously published estimates is for swine. For the previously published estimates, the nutrient loss parameters for swine were based on the presence of a lagoon, which has higher nitrogen volatilization losses than other manure handling technologies for swine. The revised parameters for swine are specific to lagoon systems only for farm sizes and regions of the country where survey information indicated lagoon systems were typically present. Overall, recoverable manure nutrients are about 20 percent higher in the after-CNMP scenario than in the baseline scenario, reflecting CNMP-related improvements in practices and facilities.

The spatial distribution of the amount of recoverable manure nutrients produced by manure-producing farms is shown in figures B-1 and B-2 for the baseline scenario. The spatial distribution is the same for the after-CNMP scenario, but the amount of recoverable manure nutrients is about 20 percent higher, overall. Recoverable manure and manure nutrient estimates by model farm are presented in table B–5.

Table B–5 Per-farm estimates of recoverable manure nutrients and farm-level excess manure nutrients by model farm region and size class*

Dominant livestock type	Model farm region	Model farm size class (AU)	Number of farms	Recoverable manure N (lb)		Recoverable manure P (lb)		Farm-level excess manure N (lb)		Farm-level excess manure P (lb)		Number farms with excess manure	
				Baseline scenario	After-CNMP scenario	Baseline scenario	After-CNMP scenario	Baseline scenario	After-CNMP scenario	Baseline scenario	After-CNMP scenario	Baseline scenario	After-CNMP scenario
Fattened cattle	Central Plains	35-1000	3,499	6,557	8,619	3,232	4,237	666	1,590	339	794	310	601
		>1000	666	341,424	448,462	176,789	231,498	266,766	417,930	139,005	216,013	405	615
	Midwest	35-500	3,765	5,001	6,388	2,273	2,898	149	430	70	197	122	285
		>500	233	51,332	62,586	25,193	30,630	8,344	29,538	4,187	14,542	26	135
	Northern Plains	35-500	925	4,746	6,199	2,120	2,754	243	500	114	228	41	83
		>500	52	76,524	93,532	34,836	42,369	32,377	56,560	14,913	25,783	12	27
	Northeast	>35	277	6,889	8,521	2,660	3,281	496	2,023	190	789	27	85
	Southeast	>35	371	4,804	6,319	2,123	2,760	391	960	171	420	25	48
	West	35-500	278	4,118	5,396	2,316	3,011	925	1,605	539	913	48	69
		>500	93	285,282	373,779	157,790	206,096	248,619	357,764	137,243	197,160	57	78
Milk cows	N. Central, Northeast	35-135	53,053	4,765	5,647	1,232	1,475	99	257	26	68	1,649	5,548
		135-270	8,688	10,220	12,385	3,067	3,791	189	682	56	212	227	1,143
		>270	2,616	22,919	24,817	7,872	10,473	1,310	3,825	442	1,606	111	748
	Southeast	35-135	4,349	4,706	5,743	1,213	1,520	181	510	50	149	275	797
		>135	2,815	13,071	13,823	4,865	6,187	1,254	3,087	459	1,372	215	695
	West	35-135	2,349	4,356	5,766	1,278	1,647	538	1,118	159	323	406	808
		135-270	1,825	7,608	7,865	2,879	3,983	1,154	2,359	437	1,194	356	896
		>270	3,623	41,119	38,783	16,388	21,102	15,845	26,891	6,290	14,627	1,432	2,901
Swine farrowing farms	N. Central, Northeast	35-500	1,029	7,652	9,275	2,926	3,534	3,356	5,018	1,284	1,911	366	512
		>500	119	33,017	38,974	22,468	26,089	19,875	33,984	13,484	22,819	89	112
	Southeast	35-100	43	1,524	1,759	1,354	1,548	323	871	285	701	10	25
		>100	270	12,337	14,244	13,588	15,594	6,710	12,210	7,483	13,565	157	238
	West	35-500	89	5,537	6,397	3,488	3,988	1,888	3,688	1,165	2,277	38	65
		>500	22	62,956	74,864	44,833	52,379	53,523	71,352	38,118	49,897	18	22
Swine grower farms	N. Central, Northeast	35-500	9,350	11,088	13,589	3,893	4,758	2,338	4,679	816	1,633	1,906	3,515
		>500	442	116,627	140,394	48,280	57,528	71,727	113,199	29,807	46,389	222	395
	Southeast	35-100	282	2,415	2,807	2,306	2,649	703	1,305	643	1,194	90	151
		>100	1,389	21,533	24,779	23,887	27,386	11,263	22,110	12,469	24,403	909	1,321
	West	35-500	113	9,671	11,512	5,227	6,159	4,001	6,601	2,181	3,547	55	74
		>500	39	181,225	216,418	106,009	124,810	153,248	200,920	90,250	116,156	27	32

Table B–5 Per-farm estimates of recoverable manure nutrients and farm-level excess manure nutrients by model farm region and size class*—Continued

Dominant livestock type	Model farm region	Model farm size class (AU)	Number of farms	Recoverable manure N (lb) Baseline scenario	Recoverable manure N (lb) After-CNMP scenario	Recoverable manure P (lb) Baseline scenario	Recoverable manure P (lb) After-CNMP scenario	Farm-level excess manure N (lb) Baseline scenario	Farm-level excess manure N (lb) After-CNMP scenario	Farm-level excess manure P (lb) Baseline scenario	Farm-level excess manure P (lb) After-CNMP scenario	Number farms with excess manure Baseline scenario	Number farms with excess manure After-CNMP scenario
Swine farrow-to-finish farms	N. Central, Northeast	35-500	16,837	9,407	11,496	3,383	4,120	1,004	2,314	361	829	1,746	4,273
		>500	1,069	82,659	99,179	38,036	45,030	47,264	74,608	21,797	33,937	493	915
	Southeast	35-100	583	1,811	2,089	1,740	1,989	196	492	195	469	79	203
		>100	869	22,377	25,675	26,278	30,056	11,128	21,091	13,222	24,846	338	629
	West	35-500	351	6,220	7,373	3,489	4,090	2,226	3,458	1,268	1,941	140	201
		>500	59	229,640	274,190	142,521	167,440	192,669	252,019	119,620	154,447	37	45
Turkeys	California	>35	135	123,339	151,351	84,587	103,814	120,085	150,714	82,422	103,389	132	135
	East	>35	1,408	57,922	70,529	36,119	44,023	43,147	66,704	26,969	41,648	1,209	1,399
	N. Central	>35	852	98,486	119,823	56,205	68,461	74,545	112,749	42,758	64,531	588	834
	S. Central	>35	740	65,522	80,246	45,168	55,320	49,203	74,270	33,972	51,216	637	729
	West except CA	>35	78	58,629	72,278	38,210	47,076	45,049	67,195	29,373	43,781	55	73
	N. Central & West	>35	836	49,997	65,271	21,558	28,144	40,460	60,134	17,782	26,117	660	814
	East & South	>35	15,415	29,750	35,002	13,417	15,748	21,241	30,285	9,593	13,623	13,040	14,906
Layers	N. Central, Northeast	<400	953	26,938	30,164	12,667	14,176	16,215	25,603	7,647	12,046	652	886
		>400	289	338,433	378,483	169,917	190,036	273,916	366,518	137,673	184,056	241	289
	S. Central	<400	879	13,452	17,005	7,056	8,911	6,812	12,555	3,579	6,586	610	805
		>400	39	113,140	134,235	144,179	170,953	86,926	128,583	110,111	163,665	35	38
	Southeast	<400	1,607	11,242	12,879	5,709	8,653	7,010	10,978	3,560	7,374	1,258	1,553
		>400	80	151,633	169,156	108,288	132,927	128,965	164,945	92,449	129,658	79	80
	West	<400	103	34,335	43,452	17,212	21,753	32,381	42,789	16,185	21,405	102	103
		>400	102	220,397	278,434	137,302	173,194	209,415	277,142	130,463	172,392	102	102
Pullets	N. Central & Northeast	>35	369	25,338	28,067	12,948	14,273	15,059	23,854	7,701	12,130	233	340
	South & West	>35	905	12,263	14,350	7,445	8,633	7,430	11,581	4,501	6,956	611	825
Veal	All	All	168	4,995	6,284	2,478	3,107	3,734	5,561	1,854	2,752	135	147
Confined heifers	Midwest	All	2,436	10,414	13,192	4,498	5,674	2,614	5,310	1,165	2,329	525	898
	Northeast	All	167	5,504	7,077	1,998	2,531	2,290	4,099	851	1,494	62	90
	South & West	All	1,240	10,817	13,311	5,362	6,581	5,963	9,364	3,001	4,668	486	672
Small farms with confined livestock types	All states	All	42,565	1,229	1,443	437	513	313	466	125	186	8,777	11,571
Pastured livestock types	All states	All	61,272	689	781	379	414	51	78	36	51	4,869	6,420
All manure-producing farms			255,070	9,934	11,799	4,513	5,499	4,678	7,230	2,406	3,769	47,562	71,999

* Excludes 2,131 specialty livestock farms.

Figure B–1 Recoverable manure nitrogen, baseline scenario

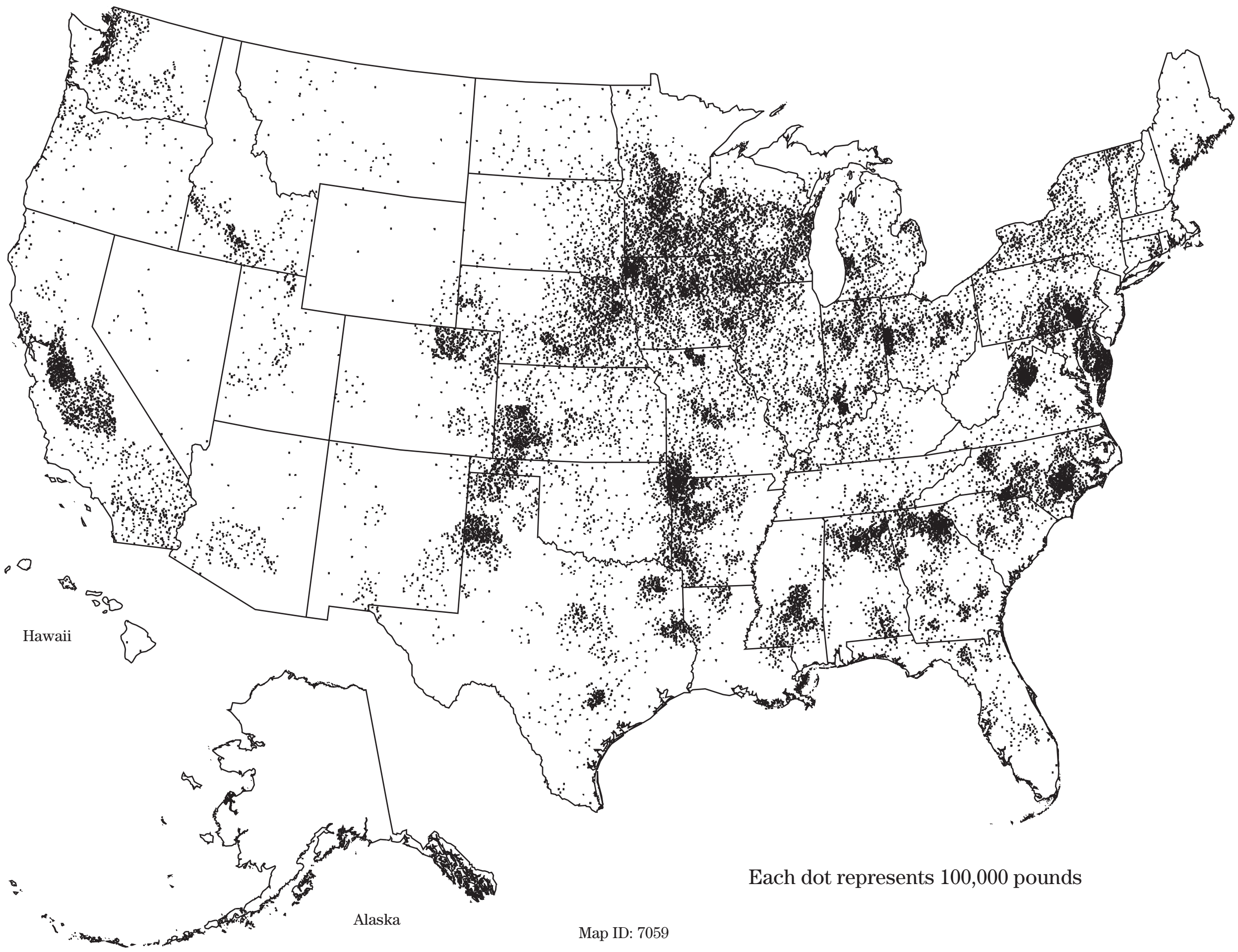
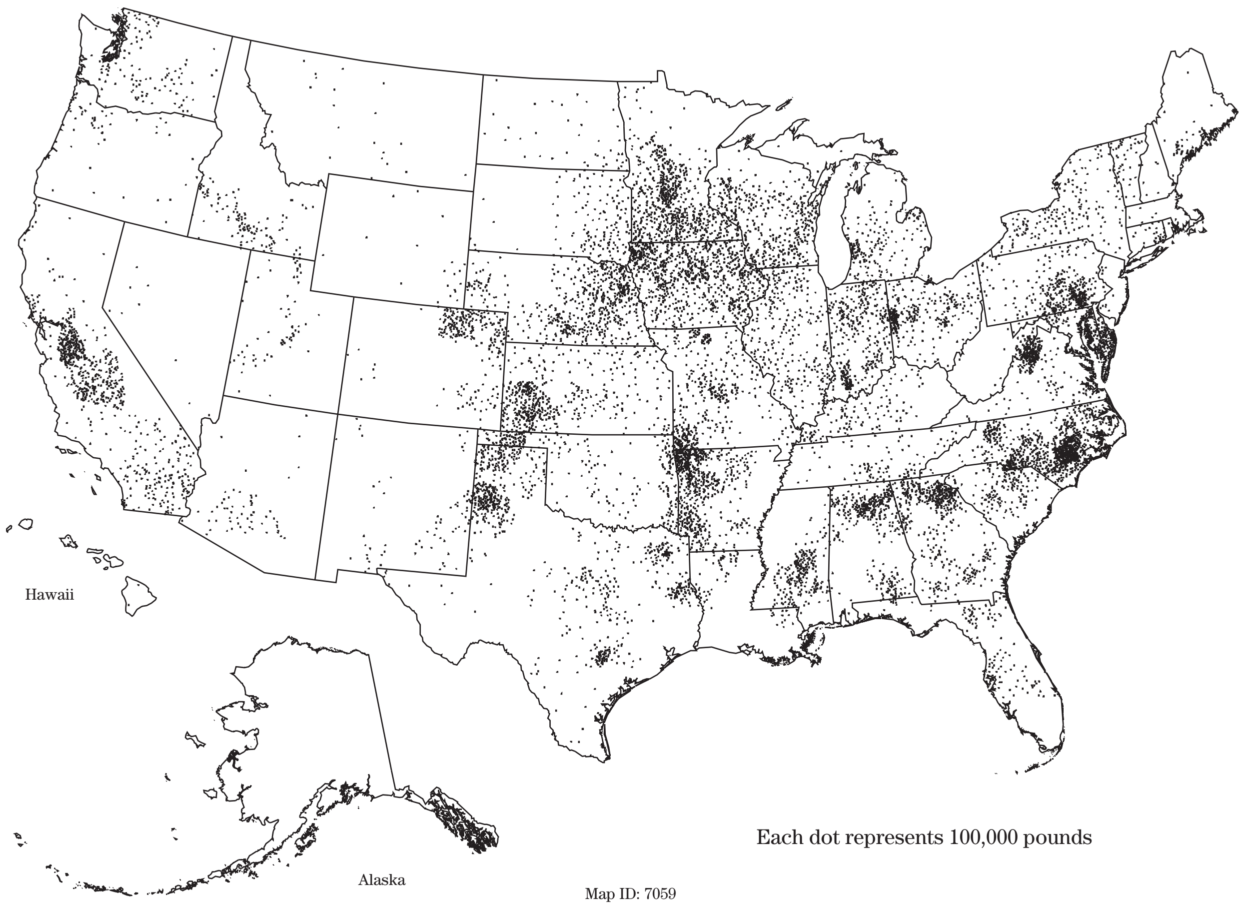


Figure B–2 Recoverable manure phosphorus, baseline scenario



Tons of recoverable manure for handling and transport

The CNMP cost assessment requires estimates of the tons of manure to be collected, stored, and transported to the field for application. Neither the wet as excreted weight nor the oven-dry weight estimate is appropriate for these calculations because the moisture content does not represent the moisture content of the manure that is actually handled. For solids, the weight would be something between the dry and wet weights. For manure handled as a liquid or slurry, additional water is added to the manure during collection. Wastewater collected in runoff storage ponds is largely runoff from rainfall.

Tons of recoverable manure for handling and transport were calculated by adjusting either the wet weight estimate or the dry weight estimate for moisture content. The literature contains a wide range of estimates of moisture content for manure handled as a solid, slurry, or liquid. Table B–6 presents the typical moisture content of manure by livestock type and manure consistency used here, in part, as a basis for developing the algorithms used to convert wet or dry weight to handling and transport weight. Algorithms were devised for each model farm to reflect characteristics of the manure management systems specific to each representative farm as well as for expected runoff that would be collected in runoff storage ponds. For most solids, handling and transport weight is about equal to two times the dry weight, and includes the weight of bedding. For systems producing manure as a slurry, handling and transport weight was typically calculated as one or two times the wet weight, depending on how much wash water would be used. Liquid manure was generally assumed to be 1 percent solids for most systems, accounting for the additional water used to flush the system and, in some cases, runoff from the lot. However, a higher percentage of solids was assumed for some systems that would be expected to have less dilute liquid wastes.

Separate algorithms for estimating tons of manure at handling and transport weight were constructed for the baseline scenario and for the after-CNMP scenario. The specific algorithms and assumptions used for each system are presented in table B–7. These algorithms were used to make estimates of tons of solid, slurry, and liquid manure generated on each farm. The estimates were higher for the after-CNMP scenario than for the baseline scenario for most liquid systems, reflecting more recoverable manure and additional flush or wash water. For wastewater collected in runoff storage ponds, an estimate was needed only for the additional volume expected as a result of CNMP implementation. This was estimated by multiplying the volume expected to be collected in runoff storage ponds times the CNMP needs percentage for runoff storage ponds. CNMP needs for runoff storage ponds were taken from appendix D, table D–1.

Table B–6 Assumptions about moisture content in manure used a basis for calculating tons of manure at handling and transport weight

Livestock type	Manure consistency	Percent moisture
Dairy	Solid	50
	Slurry	90
	Liquid	99
Beef	Solid	50
	Slurry	90
	Liquid	99
Swine	Solid	50
	Slurry	90
	Liquid	99
Broilers	Solid	76
Layers and pullets	Solid	50
	Liquid	99
Turkeys	Solid	66

Table B–7 Algorithms used to convert tons of recoverable manure as either wet weight (as excreted weight) or dry weight (oven-dry weight) to tons at handling and transport weight

Livestock type	Representative farm	Model farm region	Model farm size class (AU)	Consistency of recoverable manure	- - -Algorithm for calculating handling and transport weight - - -			
							Wastwater from runoff - - - - storage pond - - - -	
					baseline scenario	after-CNMP scenario	quantity	CNMP needs
Milk cows	#1: no storage	N. Central, Northeast	35–135	Solids	2×dry weight	no change (filter strip used for milkhouse washings & runoff)	none	
	#2: solids storage	All regions	35–135	Solids	2×dry weight	no change (filter strip used for milkhouse washings & runoff)	none	
	#1: no storage	N. Central, Northeast	135–270	Solids (replace filter strip with liquid components for milkhouse washings)	2×dry weight	2×dry weight + wet weight	9×dry weight	80
	#2: solids storage	N. Central, Northeast	135–270	Solids (replace filter strip with liquid components for milkhouse washings)	2×dry weight	2×dry weight + wet weight	9×dry weight	80
	#2: solids storage	Southeast	>135	Solids (replace filter strip with liquid components for milkhouse washings)	2×dry weight	2×dry weight + wet weight	13×dry weight	80
	#2: solids storage	West	135–270	Solids (replace filter strip with liquid components for milkhouse washings)	2×dry weight	2×dry weight + wet weight	1.5×dry weight	80
	#2: solids storage	N. Central, Northeast	>270	Solids (convert to liquid system)	2×dry weight	dryweight/.01	none	
	#3: liquid storage–deep pit or slurry	N. Central, Northeast	All	Slurry (runoff included)	wet weight	2×wet weight	none	
	#4: liquid storage–basin, pond, lagoon	N. Central, Northeast	All	Liquid (runoff included)	dryweight/0.03	dryweight/0.01	none	

Table B–7 Algorithms used to convert tons of recoverable manure as either wet weight (as excreted weight) or dry weight (oven-dry weight) to tons at handling and transport weight—Continued

Livestock type	Representative farm	Model farm region	Model farm size class (AU)	Consistency of recoverable manure	- - -Algorithm for calculating handling and transport weight - - - baseline scenario	after-CNMP scenario	Wastwater from runoff - - - - storage pond - - - - quantity	CNMP needs
	#5: any liquid storage	Southeast	All	Liquid (runoff included)	dryweight/0.03	dryweight/0.01	none	
	#5: any liquid storage, manure pack	West	All	1/2 liquid, 1/2 solids, runoff	half dryweight/ 0.03 + half 2× dry weight + dry weight	half dryweight/ 0.01" + half 2× dry weight + 2×dry weight	none	
Fattened cattle	#1: scrape & stack	Southeast	All	Solids	2×dry weight	no change	18×dry weight	50
	#1: scrape & stack	Midwest	All	Solids	2×dry weight	no change	18×dry weight	40
	#1: scrape & stack	Northeast	All	Solids	2×dry weight	no change	18×dry weight	40
	#2: manure pack, runoff collection	Midwest, Southeast	All	Solids	2×dry weight	no change	18×dry weight	70
	#2: manure pack, runoff collection	Northern Plains	All	Solids	2×dry weight	no change	3×dry weight	70
	#2: manure pack, runoff collection	Central Plains, West	All	Solids	2×dry weight	no change	2×dry weight	70
Confined heifers	#1: confinement barn/bedded manure	Northeast, Midwest	All	Solids	2×dry weight	no change	none	
	#2: open lots with scraped solids	Northeast	All	Solids	2×dry weight	no change	13×dry weight	40
	#2: open lots with scraped solids	Midwest	All	Solids	2×dry weight	no change	9×dry weight	40
	#2: open lots with scraped solids	Southeast	All	Solids	2×dry weight	no change	15×dry weight	50
	#2: open lots with scraped solids	West	All	Solids	2×dry weight	no change	1.5×dry weight	50
Veal	#1: confinement house	All	All	Slurry	wet weight	no change	none	
Broilers	#1: confinement houses	All	All	Solids	dry weight/0.76	no change	none	
Layers	#1: high-rise or shallow pit	All	All	Solids	2×dry weight	no change	none	
	#2: flush with lagoon	All	All	Liquid	dry weight/0.02	dry weight/0.01	none	
	#3: manure belt or scraper system	All	All	Solids	2×dry weight	no change	none	
Pullets	#1: layer-type confinement houses	All	All	Solids	2×dry weight	no change	none	
	#2: turkey ranch	East	All	Solids	dry weight/0.65	no change	3.5×dry weight	90
	#2: turkey ranch	WI, IA, MN, NE, SD, ND	All	Solids	dry weight/0.65	no change	2×dry weight	90
	#2: turkey ranch	OH, IN, KY, IL, MI	All	Solids	dry weight/0.65	no change	3.3×dry weight	90
	#2: turkey ranch	West other than CA	All	Solids	dry weight/0.65	no change	0.2×dry weight	90
	#2: turkey ranch	California	All	Solids	dry weight/0.65	no change	2×dry weight	90

Table B–7 Algorithms used to convert tons of recoverable manure as either wet weight (as excreted weight) or dry weight (oven-dry weight) to tons at handling and transport weight—Continued

Livestock type	Representative farm	Model farm region	Model farm size class (AU)	Consistency of recoverable manure	- - -Algorithm for calculating handling and transport weight - - - baseline scenario	after-CNMP scenario	Wastwater from runoff - - - - storage pond - - - - quantity	CNMP needs
Swine	#1: total confinement, liquid, lagoon	All	All	Liquid	dry weight/0.02	dry weight/0.01	none	
	#2: total confinement, slurry, no lagoon	All	All	Slurry	wet	no change	none	
	#3: building with outside access, liquid	Midwest, Northeast	All	Liquid (runoff included)	dry weight/0.01 + dry weight	dry weight/0.01 + 2×dry weight	none	
	#4: building with outside access, solids	Midwest, Northeast	All	Solids	2×dry weight	no change	2×dry weight	20
	#5: pasture or lot	West	All	Solids	2×dry weight	no change	3×dry weight	50
	#5: pasture or lot	Southeast	All	Solids	2×dry weight	no change	6×dry weight	50
Pastured livestock	All	All	All	Solids	2×dry weight	no change	none	

Estimates of the tons of recoverable manure as solids, slurry, and liquid for model farms are presented in table B–8. These estimates include manure and wastewater from all livestock on each manure-producing farm. Consequently, it is possible for a farm to have manure of all three consistencies—solids, slurry, and liquid. For example, if a farm in the Southeast with broilers as the dominant livestock type also has layers on the farm, a portion of the manure generated for layers will be for a flush-to-lagoon system (representative farm #2 for layers), which handles manure as a liquid. If this farm also has swine, a portion of the manure will be for swine representative farm #2, which handles manure as a slurry. The average number of AU for the dominant livestock type and for other livestock types on the farm is included in table B–8 to provide a perspective on the amount of manure as a solid, slurry, or liquid reported for each model farm.

Table B–8 Per farm estimates of animal units and tons of recoverable manure at handling and transport weight as solids, slurry, and liquid for model farm regions and size classes

Dominant livestock type	Model farm region	Model farm size class	Number of farms	AU for dominant type	AU for other types	Tons of manure - - - as solids - - -		Tons of manure - - - as slurry- - -		Tons of manure - - - as liquid - - -		Increase in tons of waste-water from runoff storage pond
						baseline scenario	after-CNMP scenario	baseline scenario	after-CNMP scenario	baseline scenario	after-CNMP scenario	after-CNMP scenario
Fattened cattle	Central Plains	35-1000	3,499	169	252	282	369	28	35	70	123	350
		>1000	666	9,575	3,348	17,132	21,998	22	24	139	447	17,786
	Midwest	35-500	3,765	105	108	186	237	50	62	123	209	1,159
		>500	233	1,192	495	2,260	2,717	268	329	769	1,619	15,264
	Northern plains	35-500	925	104	189	184	239	26	35	79	171	224
		>500	52	1,695	1,181	3,071	3,720	247	319	706	1,438	5,182
	Northeast	>35	277	116	73	223	270	16	30	123	510	801
	Southeast	>35	371	111	220	189	247	0	0	97	221	1,278
	West	35-500	278	121	509	207	269	4	5	23	59	172
		>500	93	8,457	3,836	15,175	19,472	205	206	82	276	12,029
Milk cows	N. Central, Northeast	35-135	53,053	72	26	178	205	45	118	543	2,022	1
		135-270	8,688	172	56	286	330	212	1,311	3,281	12,255	785
		>270	2,616	469	126	417	274	721	1,946	12,899	63,529	22
	Southeast	35-135	4,349	79	34	135	166	0	0	2,605	9,938	0
		>135	2,815	307	92	313	376	0	912	8,709	33,183	1,372
	West	35-135	2,349	79	45	180	219	0	0	1,620	6,854	0
		135-270	1,825	185	64	333	420	1	204	3,741	14,440	35
		>270	3,623	972	230	1,743	2,066	1	1	23,529	83,415	2
Swine farrowing farms	N. Central, Northeast	35-500	1,029	140	22	31	37	566	688	588	1,165	12
		>500	119	1,062	16	15	18	1,831	2,222	20,504	46,818	16
	Southeast	35-100	43	63	22	13	15	25	30	1,369	3,124	11
		>100	270	600	39	42	50	128	157	15,965	36,469	5
	West	35-500	89	183	34	42	44	284	345	2,154	4,917	21
		>500	22	2,148	29	0	0	4,795	5,814	36,149	82,505	0
Swine grower farms	N. Central, Northeast	35-500	9,350	116	34	76	91	711	864	1,870	2,953	41
		>500	442	1,421	51	59	70	11,065	13,433	22,492	51,639	71
	Southeast	35-100	282	63	40	9	10	73	88	3,159	7,211	2
		>100	1,389	625	52	85	102	2	3	35,060	80,031	13

Table B–8 Per farm estimates of animal units and tons of recoverable manure at handling and transport weight as solids, slurry, and liquid for model farm regions and size classes—Continued

Dominant livestock type	Model farm region	Model farm size class	Number of farms	AU for dominant type	AU for other types	Tons of manure - - - as solids - - -		Tons of manure - - - as slurry- - -		Tons of manure - - - as liquid - - -		Increase in tons of waste-water from runoff storage pond
						baseline scenario	after-CNMP scenario	baseline scenario	after-CNMP scenario	baseline scenario	after-CNMP scenario	after-CNMP scenario
	West	35-500	113	145	82	23	27	816	992	4,036	9,342	2
		>500	39	3,216	194	115	142	16,938	20,569	85,540	196,429	8
Swine farrow-to-finish farms	N. Central, Northeast	35-500	16,837	118	39	60	71	627	763	1,347	2,206	34
		>500	1,069	1,285	40	48	58	7,259	8,813	21,878	50,013	82
	Southeast	35-100	583	59	50	9	10	48	58	2,227	5,091	6
		>100	869	912	65	39	46	98	123	37,866	86,517	18
	West	35-500	351	120	100	23	26	485	591	2,628	6,129	7
		>500	59	4,971	262	151	182	20,241	24,559	115,223	264,084	3
Turkeys	California	>35	135	1,283	14	2,933	3,601	0	0	111	395	526
	East	>35	1,408	505	45	1,233	1,502	2	12	834	2,091	201
	N. Central	>35	852	778	43	1,934	2,351	124	159	346	762	243
	S. Central	>35	740	601	69	1,535	1,880	5	9	47	152	6
	West except CA	>35	78	740	45	1,400	1,726	0	0	0	0	76
	N. Central & West	>35	836	257	29	962	1,255	5	9	30	93	1
	East & South	>35	15,415	144	33	596	699	1	1	47	126	1
Layers	N. Central, Northeast	<400	953	135	24	677	757	16	23	54	122	10
		>400	289	1,776	131	8,932	9,982	131	195	605	1,986	61
	S. Central	<400	879	87	40	375	474	0	0	161	389	0
		>400	39	1,688	192	257	303	6	7	193,114	458,643	0
	Southeast	<400	1,607	86	23	215	272	0	0	4,227	10,041	0
		>400	80	1,284	153	3,024	3,818	1	96	71,825	171,853	143
	West	<400	103	209	11	926	1,171	0	0	0	0	0
		>400	102	1,609	104	7,227	9,128	8	10	70	218	0
Pullets	N. Central, Northeast	>35	369	179	33	583	653	18	33	96	283	13
	South & West	>35	905	109	36	350	415	0	1	81	206	1
Veal	All	All	168	108	52	16	17	863	1,093	10	16	7
Confined heifers	Midwest	All	2,436	217	73	503	638	101	112	129	210	883
	Northeast	All	167	107	17	211	277	96	96	8	12	220
	South & West	All	1,240	311	56	651	807	120	120	1	2	486
Small farms with confined l ivestock types	All states	All	42,565	18	7	40	46	0	0	0	0	0
Pastured livestock types	All states	All	61,272	107	10	33	35	0	0	0	0	0
All manure-producing farms			255,070	166	45	258	308	158	264	1,663	5,084	152

Land available for manure application

The land base defined to be potentially available for manure application consisted of cropland, cropland used as pasture, and half of permanent pasture, as in Kellogg et al. (2000). For cropland, the acreage considered is defined by the production of 24 crops including corn for silage, corn for grain, small grain hay, other tame hay, wild hay, grass silage, sorghum hay, sorghum for silage, sorghum for grain, alfalfa hay, winter wheat, barley, soybeans, durum wheat, other spring wheat, oats, rye, Irish potatoes, sweet potatoes, cotton, sugar beets, rice, peanuts, and tobacco. (The census does not identify the acreage of these crops that are double cropped. Where double cropping occurs, it is assumed that each crop would be potentially available for manure application, which may result in more than one manure application per field in the model simulation.) Cropland used as pasture is a specific land use category in the Census of Agriculture database. Permanent pasture is not reported in the census, but was derived from acres of rangeland and pastureland combined (a land use category in the census) and separate estimates of pastureland and rangeland acres by county as reported in the 1997 National Resources Inventory (NRI). The NRI was used to determine the percentage of pastureland and rangeland that is pastureland in each county. This percentage was then applied to the census acres for pastureland and rangeland combined for each farm to estimate the acres of permanent pastureland on each farm. In the East, most of the pastureland and rangeland combined, as reported in the census, was classified as permanent pastureland with this calculation, while few of the acres in the West were classified as permanent pastureland. It was assumed that one-half of the permanent pastureland would not be accessible by manure spreading equipment because of location, terrain, or trees and other plant growth.

In the simulation model, the land available for manure application depends on whether the farm was a manure-producing farm or a manure-receiving farm. **Manure-receiving farms** are defined to be farms that are not manure-producing farms, have at least 10 acres of land potentially available for manure application, and are located in the same county as a manure-producing farm. All of the potentially available acres on manure-producing farms were assumed available for onfarm application. On manure-receiving farms, however, only a portion of the potentially available land was assumed available for off-farm manure application.

Acres with water erosion rates above the soil loss tolerance level, or T, were assumed unavailable on manure-receiving farms because of the potential for additional costs for installation or adoption of erosion control practices. The 1997 NRI was used to determine the proportion of cropland and pastureland acres in each county with sheet and rill erosion rates less than T. Separate proportions were obtained for cropland and pastureland. This proportion was multiplied times the number of cropland acres (each of 24 crops) or pastureland acres (cropland used as pasture and half of the permanent pasture) on manure-receiving farms to determine the potential number of acres suitable for manure application. This calculation implicitly assumes that the acres with sheet and rill erosion less than T were equally distributed among the various crops and pastureland types.

Another assumption was that some manure-receiving farms would be unwilling to accept manure because of odor or other undesirable aspects, timing problems related to climate or crop stage, soil phosphorus levels at or near threshold limits, or other factors making manure more costly than application of commercial fertilizers. To account for this willingness-to-accept factor, it was assumed that 50 percent of the acres potentially available with acceptable erosion rates would actually be available for land application of manure on manure-receiving farms. The 50-percent constraint was applied to the acreage for each of the 24 crops as well as cropland used as pasture and permanent pasture.

The analysis implicitly assumes that manure-producing farms would not accept manure from other manure-producing farms. That is, manure-producing farms and manure-receiving farms are mutually exclusive sets. This is a simplifying assumption that facilitates the construction of the simulation model. In actuality, some manure-producing farms would have additional acres available for manure application by other manure-producing farms, especially those livestock operations that primarily produce crops. In the model simulation, about 80 percent of the total acres available for land application on manure-producing farms is not needed for manure application even after CNMPs are fully implemented. However, the bulk of these acres are in areas of the country where more than enough land is available for manure application on manure-receiving farms. Because of disease and other biosecurity concerns, some livestock producers would not be willing to accept manure from other livestock operations.

Acres available for manure application are summarized in table B–9. Acres available by model farm are presented with acres required for manure application in table B–11.

Acres required for onfarm manure application

Acres required for onfarm manure application depend on the amount of recoverable manure nitrogen and phosphorus produced on the farm, the acres harvested and yields of each crop available for application, and the application rate criteria.

Application rate criteria for the after-CNMP scenario depend on how the calculation will be used in the cost assessment, as described in the main body of this publication. For land application costs associated with the nutrient management element, only the acres receiving manure in a given year are needed. For land treatment costs, however, the total acres that would receive manure over time are required. The difference arises because farms with enough acres to meet a phosphorus standard can apply at nitrogen-standard rates in any given year and rotate to other sites when soil phosphorus levels approach the threshold. Acres that would potentially need land treatment would include all the acres that would receive manure over all the years.

For calculating land application costs, application rate criteria for the after-CNMP scenario depends on how many acres are available for manure application and whether phosphorus or nitrogen is the limiting nutrient. If phosphorus is the limiting nutrient, land application on farms without enough acres to meet a phosphorus standard was simulated using phosphorus-based application rates for all crops and pastureland.

Table B–9 Summary of acres available for manure application based on assumptions in the simulation model

	Million acres	Percent of total
Total acres of 24 crops, cropland used as pasture, and half of permanent pasture on all farms	389.8	100
Acres available for manure application on manure-producing farms	84.8	22
Acres potentially available for manure application on manure-receiving farms	294.6	76
Acres unavailable on manure-receiving farms because sheet and rill erosion rates are greater than T	46.8	12
Acres available for manure application on manure-receiving farms assuming willingness to accept is 50 percent	124.0	32
Acres not available for manure application (non-livestock operations with less than 10 acres available for manure application or farms in counties without any manure-producing farms)	10.4	3

For manure-producing farms that had enough acres to meet a phosphorus standard, land application was simulated using nitrogen-based application rates for all crops and pastureland. For a few manure-producing farms, nitrogen was the limiting nutrient, so land application was simulated using a nitrogen standard. **For calculating land treatment costs**, application rate criteria for the after-CNMP scenario were simulated using phosphorus-based application rates for all farms where phosphorus was the limiting nutrient and nitrogen-based application rates for all farms where nitrogen was the limiting nutrient.

Nitrogen-based application rates and phosphorus-based application rates that constitute application rate criteria for nutrient management plans are defined by Land Grant Universities and called **recommended rates**. Recommended rates are crop specific and vary from state to state and sometimes within a state. Recommended rates are set at a level that will provide the plant nutrients to achieve a desired yield, after accounting for nutrient losses from the crop system from volatilization, denitrification, erosion, leaching, and runoff. Since these recommended rates are not readily available in database form, recommended rates for use in the simulation model were approximated as a function of the amount of nutrients taken up by the crop and removed at harvest.

The phosphorus standard used in the after-CNMP scenario was approximated as the amount of phosphorus taken up and removed by the crop at harvest. Phosphorus uptake parameters are presented in table B–10 for each of the 24 crops. The amount of phosphorus taken up and removed at harvest per acre depends on the yield. The higher the yield, the more phosphorus removed at harvest. Thus, manure application rates per acre based on a phosphorus standard, as simulated in the model, are higher for farms with higher yields than for farms with lower yields. Limiting the phosphorus application to the amount taken up and removed at harvest guarantees that phosphorus levels will not continue to build up in the soil.

The nitrogen standard used in the after-CNMP scenario was approximated similar to that for the phosphorus standard, but included an additional nitrogen recovery factor to adjust for losses during and after application. Nitrogen uptake parameters for the 24 crops are presented in table B–10. Recommended rates were approximated by multiplying the amount of nitrogen taken up by the crop and removed at harvest by 1.43, which reflects a nitrogen recovery factor of 70 percent ($1.43=1\div0.70$). That is, recommended rates were simulated assuming that 70 percent of the manure nitrogen applied is available for crop growth. The nitrogen recovery factor is largely determined by volatilization losses during and after application, but also includes losses that are due to denitrification, erosion, leaching, and runoff. Nutrient management plans include provisions for keeping these losses at a minimum by addressing the method and timing of application, winter cover crops, and crop rotations, and by stipulating erosion control practices on acres with sheet and rill erosion rates greater than T.

Recommended rates of application for pastureland could not be established based on crop uptake and removal since a crop is not harvested. For pastureland, nitrogen and phosphorus rates of application were set at levels expected to provide the nutrients necessary for good levels of grass production assuming the pastureland is being grazed and accounting for the additional manure nutrients contributed by manure produced by the grazing animals. For model simulation, the nitrogen standard was defined to be 75 pounds of nitrogen per acre for cropland used as pasture and 30 pounds per acre for permanent pastureland. The lower rate for permanent pastureland reflects the generally lower productivity associated with permanent pastureland as compared to cropland used as pastureland. (The nitrogen recovery factor was not applied to pastureland.) The phosphorus rate was set at approximately equivalent levels after adjusting for the ratio of phosphorus to nitrogen in beef cattle manure. The phosphorus standard was defined to be 28 pounds of phosphorus per acre for cropland used as pasture and 11 pounds per acre for permanent pastureland.

A portion of manure nitrogen and phosphorus is bound up in organic compounds, which may not be available for the crop during the same year that manure is applied. In this simulation, no adjustment was made to account for the rate of mineralization of organic nutrients in the manure applied. The assumption is that the amount of manure nutrients not available to the crop during the year of application would be offset by nutrients available from manure applications in previous years.

For a few manure-producing farms (1,379 farms), more acres were required to meet a nitrogen standard than were required to meet a phosphorus standard, indicating that nitrogen was the limiting nutrient. For these farms, 97 percent of the acres with manure applied were for four crops—other tame hay, wild hay, cropland used as pasture, and permanent pasture. For the two pasture types, the difference in application rates for nitrogen and phosphorus generally reflected the proportion of nitrogen to phosphorus in manure. For other tame hay and wild hay, the uptake of phosphorus approached the uptake for nitrogen (table B–10) more closely than other crops. When the ratio of recoverable nitrogen to recoverable phosphorus in the manure is relatively high, as would be the case for systems with higher nitrogen recovery parameters, more acres may be required to meet a nitrogen standard than are required to meet a phosphorus standard on these crops and pastureland.

Application rate criteria for the baseline scenario are applications at rates above the nitrogen standard for some crops and pastureland and applications at rates similar to the nitrogen-standard rates for other crops, emulating pre-CNMP land application practices. For the baseline scenario, the model simulated manure application rates on manure-producing farms at the nitrogen standard with a 50 percent nitrogen recovery factor for 15 of the 24 crops (alfalfa hay, winter wheat, barley, soybeans, durum wheat, other spring wheat,

Table B–10 Nutrient uptake and removal at harvest for 24 crops

Crop	Yield unit	Nutrient uptake per yield unit (lb)		Acres receiving manure on manure-producing farms		
		nitrogen	phosphorus	avg yield	avg lb N uptake per acre	avg lb P uptake per acre
Sorghum for silage	Tons/acre	14.76	2.440	13.4	198	33
Alfalfa hay	Tons/acre	50.40	4.720	3.3	166	16
Potatoes	100 pound bags/acre	0.36	0.060	322.1	116	19
Soybeans	Bushels/acre	3.55	0.360	32.4	115	12
Corn for silage	Tons/acre	7.09	1.050	14.3	101	15
Corn for grain	Bushels/acre	0.80	0.150	117.4	94	18
Sugar beets for sugar	Tons/acre	4.76	0.940	19.2	91	18
Rice	100-lb bags/acre	1.25	0.290	70.4	88	20
Peanuts for nuts (with pods)	Pounds/acre	0.04	0.003	2,198.3	88	7
Grass silage	Tons/acre	13.60	1.600	5.9	80	9
Tobacco	Pounds/acre	0.03	0.002	2,149.0	64	4
Sorghum for grain	Bushels/acre	0.98	0.180	65.4	64	12
Barley	Bushels/acre	0.90	0.180	60.1	54	11
Small grain hay	Tons/acre	25.60	4.480	1.9	49	9
Other spring wheat	Bushels/acre	1.39	0.230	31.4	44	7
Other tame hay	Tons/acre	19.80	15.300	2.1	42	32
Winter wheat	Bushels/acre	1.02	0.200	39.5	40	8
Durum wheat	Bushels/acre	1.29	0.220	27.6	36	6
Oats	Bushels/acre	0.59	0.110	54.5	32	6
Wild hay	Tons/acre	19.80	15.300	1.5	30	23
Sweet potatoes	Bushels/acre	0.13	0.020	217.2	28	4
Rye for grain	Bushels/acre	1.07	0.180	24.4	26	4
Cotton (lint and seed)	500-lb bales/acre	15.19	1.890	1.3	20	2
Sorghum hay	Tons/acre	2.39	1.010	2.7	6	3

Note: Taken from Kellogg et al. (2000), table 9.

oats, rye, Irish potatoes, sweet potatoes, cotton, sugar beets, rice, peanuts, and tobacco). Application rates above the nitrogen standard on these crops could result in impairment of crop quality. The nitrogen recovery factor was set at 50 percent instead of the 70 percent used in the after-CNMP scenario under the assumption that, prior to a CNMP, appropriate erosion controls would generally not be in place, nor would application timing, application method, crop rotations, or cover crops be tailored to minimize manure nutrient losses on fields receiving manure. At 50 percent, the nitrogen recovery factor is thus equal to the amount of nitrogen taken up and removed at harvest.

Higher application rates were simulated for permanent pasture, cropland used as pasture, and the remaining nine feed and forage crops (corn for silage, corn for grain, small grain hay, other tame hay, wild hay, grass silage, sorghum hay, sorghum for silage, sorghum for grain). Application rates for this latter group of crops were set at one and a half times the amount of nitrogen taken up and removed at harvest for farms that had enough land for onfarm application, plus the 50 percent nitrogen recovery factor. For pastureland, nitrogen-standard application rates were increased 50 percent. For farms that did not have sufficient land at these application rates, application rates were further increased to two times the amount of nitrogen taken up and removed at harvest for these nine crops, plus the 50 percent nitrogen recovery factor. Nitrogen standard application rates for pastureland were doubled. The upper limit for application rates under this application scheme—three times the amount of nitrogen taken up and removed at harvest—was established to be below rates that would result in poor crop quality or the possibility of yield reductions because of nitrogen intolerance.

Before estimating the assimilative capacity of each crop, the farm-level yields were adjusted to eliminate very high and very low yields. Some of the very low yields reported in the Census of Agriculture were the result of local droughts or other detrimental weather conditions and are not representative of the assimilative capacity of the land under normal conditions. Similarly, some of the very high yields might also not be sustainable and would lead to an overestimation of the assimilative capacity of the land. The 10th percentile yield and the 95th percentile yield for each crop was determined for each Land Resource Region. (A map of Land Resource Regions is presented in figure 16 in the main body of this publication.) Each Land Resource Region is characterized by a particular pattern of soils, climate, water resources, and land use, so would generally be expected to have a sustainable yield potential different from other Land Resource Regions. Farm-level yields below the 10th percentile yield for the region were adjusted upward to equal the 10th percentile yield. Farm-level yields above the 95th percentile yield for the region were adjusted downward to equal the 95th percentile yield. All yields were adjusted in this way, including crop yields on manure-receiving farms.

The model allocates manure to each crop separately. To estimate the acres required to meet CNMP application criteria on each farm, it is necessary to first establish the order in which crops are selected for application on the farm. For a manure-producing farm, the model allocates manure to crops according to a set of priorities established by NRCS agronomists. These priorities generally represent current practices on livestock operations. The highest to lowest priorities established for manure application by crop type are corn for silage, corn for grain, small grain hay, other tame hay, wild hay, grass silage, sorghum hay, cropland used as pasture, permanent pasture, sorghum for silage, sorghum for grain, alfalfa hay, winter wheat, barley, soybeans, durum wheat, other spring wheat, oats, rye, Irish potatoes, sweet potatoes, cotton, sugar beets, rice, peanuts, and tobacco. The model allocates manure to the highest priority crop present on the farm and applies manure to that crop according to the appropriate application rate criteria. If the acres of the first priority crop are insufficient to assimilate all of the manure produced on the farm, the model allocates manure to the next priority crop. This allocation process is repeated for each of the 24 crops and pastureland on the farm or until all of the manure has been allocated. Sensitivity analysis showed that reasonable changes in the priority order of crops had a trivial effect on estimates of total acres with manure applied.

Farms that do not have enough acres available to meet land application criteria have **farm-level excess manure**. Farm-level excess manure must either be exported off the farm for land application on surrounding properties or used in some manner other than land application. A portion of the farms in both land application scenarios will have excess manure and thus excess manure nutrients. Excess manure phosphorus and excess manure nitrogen were calculated jointly as a function of excess manure. For example, when a phosphorus standard is being simulated, manure is applied to each crop at a rate that does not exceed the uptake and removal of phosphorus by the crop, and manure nitrogen is applied proportionately (i.e., at a rate proportional to the ratio of phosphorus to nitrogen in the recoverable manure). Similarly, when a nitrogen standard is simulated, the manure phosphorus rate is determined by the acres applied to meet the nitrogen standard. Thus, farm-level excess manure contains both nitrogen and phosphorus in a proportion determined by the mix of livestock on the farm and the manure handling and storage systems assigned to the farm. (Farm-level excess manure nutrients were not calculated this way in Kellogg et al. (2000). In that publication farm-level excess manure nutrients were calculated separately for nitrogen and phosphorus, simulating a nitrogen standard for nitrogen and a phosphorus standard for phosphorus. Whereas in Kellogg et al. (2000) a farm may have excess phosphorus, but no excess nitrogen, in this study every farm with excess manure has both excess phosphorus and excess nitrogen.)

To prevent the count of farms with excess manure from being artificially inflated by farms with small amounts of excess manure, a farm was classified as having excess manure if the amount of excess manure nitrogen produced annually exceeded 100 pounds. (The model is a precise calculator; however, it is questionable that farms with very small amounts of excess manure as calculated by the model would actually have any excess manure. It is even more questionable that these farms would actually export that small amount to surrounding properties. The cutoff used for identifying farms with excess manure is half the amount used to identify a CNMP farm, and so is small enough to be considered a trivial amount.)

The number of onfarm acres required to meet CNMP application criteria is the difference between baseline acres with manure applied and the after-CNMP scenario acres with manure applied. Estimates of additional acres required for estimating onfarm land application costs and additional acres required for estimating onfarm land treatment costs are both shown in table B–11. Farm-level excess manure nutrients and the number of farms with excess manure are shown in table B–5 along with estimates of recoverable manure nutrients. (Additional summary tables are provided in the main body of this publication.)

Table B–11 Per-farm estimates of total acres on farms, acres available for application of manure, acres with manure applied, and acres required to meet CNMP application criteria on manure-producing farms*

Dominant livestock type	Model farm region	Model farm size class	Number of farms	Total acres on farm	Acres available for land application	Acres with manure applied, baseline scenario	Acres with manure applied in a given year, after-CNMP scenario	Additional acres required for estimating land application costs	Total acres that would receive manure over time, after-CNMP scenario	Additional acres required for estimating land treatment costs
Fattened cattle	Central Plains	35-1000	3,499	2,895	1,016	33	85	52	197	164
		>1000	666	4,719	1,076	311	650	339	781	469
	Midwest	35-500	3,765	871	761	20	48	28	144	124
		>500	233	1,459	1,205	164	506	342	830	666
	Northern Plains	35-500	925	2,550	917	24	58	34	153	129
		>500	52	4,737	1,570	184	585	400	944	760
	Northeast	>35	277	497	415	28	79	51	150	122
	Southeast	>35	371	1,202	858	35	74	40	128	93
	West	35-500	278	4,151	770	26	52	26	104	78
		>500	93	5,304	871	148	281	133	380	232

Table B–11 Per-farm estimates of total acres on farms, acres available for application of manure, acres with manure applied, and acres required to meet CNMP application criteria on manure-producing farms*—Continued

Dominant livestock type	Model farm region	Model farm size class	Number of farms	Total acres on farm	Acres available for land application	Acres with manure applied, baseline scenario	Acres with manure applied in a given year, after-CNMP scenario	Additional acres required for estimating land application costs	Total acres that would receive manure over time, after-CNMP scenario	Additional acres required for estimating land treatment costs
Milk cows	N.Central, Northeast	35-135	53,053	340	264	25	53	28	90	65
		135-270	8,688	644	536	46	107	61	222	176
		>270	2,616	1,117	936	85	250	165	531	446
	Southeast	35-135	4,349	300	216	33	66	32	74	41
		>135	2,815	679	498	73	145	71	247	174
	West	35-135	2,349	475	217	33	62	30	66	34
		135-270	1,825	470	274	43	85	42	125	81
		>270	3,623	568	361	90	204	113	267	177
Swine farrowing farms	N. Central, Northeast	35-500	1,029	363	289	21	47	25	88	67
		>500	119	270	213	63	128	65	163	100
	Southeast	35-100	43	200	130	10	25	15	52	42
		>100	270	227	113	41	67	26	80	39
	West	35-500	89	529	134	40	61	21	72	32
		>500	22	1,142	146	122	146	24	146	24
Swine grower farms	N. Central, Northeast	35-500	9,350	575	501	37	90	53	169	132
		>500	442	810	678	203	472	269	578	374
	Southeast	35-100	282	425	343	14	44	30	105	91
		>100	1,389	356	254	73	173	99	204	131
	West	35-500	113	1,528	608	65	129	64	192	127
		>500	39	2,941	1,357	204	284	80	735	531
Swine farrow-to-finish farms	N. Central, Northeast	35-500	16,837	631	528	36	89	52	179	143
		>500	1,069	863	746	145	462	317	603	458
	Southeast	35-100	583	565	438	12	38	26	113	101
		>100	869	793	589	78	208	130	329	252
	West	35-500	351	2,664	562	36	81	45	162	126
		>500	59	5,311	1,942	325	518	194	899	574
Turkeys	California	>35	135	172	17	17	17	0	17	0
	East	>35	1,408	220	143	95	137	41	141	46
	N. Central	>35	852	348	247	107	233	127	241	134
	S. Central	>35	740	300	166	139	157	18	162	23
	West except CA	>35	78	396	186	76	113	37	130	53
	N. Central, West	>35	836	173	104	61	87	26	91	30
	East, South	>35	15,415	170	103	65	88	23	92	27
Layers	N. Central, Northeast	<400	953	199	141	55	102	47	117	63
		>400	289	436	333	244	333	89	333	89
	S. Central	<400	879	174	97	61	81	20	83	22
		>400	39	898	360	234	264	30	340	106
	Southeast	<400	1,607	125	66	35	51	15	55	19
		>400	80	386	157	149	157	8	157	8
	West	<400	103	60	13	13	13	0	13	0
		>400	102	178	40	40	40	0	40	0

Table B–11 Per-farm estimates of total acres on farms, acres available for application of manure, acres with manure applied, and acres required to meet CNMP application criteria on manure-producing farms*—Continued

Dominant livestock type	Model farm region	Model farm size class	Number of farms	Total acres on farm	Acres available for land application	Acres with manure applied, baseline scenario	Acres with manure applied in a given year, after-CNMP scenario	Additional acres required for estimating land application costs	Total acres that would receive manure over time, after-CNMP scenario	Additional acres required for estimating land treatment costs
Pullets	N. Central, Northeast	>35	369	199	144	55	100	45	112	57
	South & West	>35	905	165	84	43	61	18	65	22
Veal	All	All	168	182	77	6	11	5	19	13
Confined heifers	Midwest	All	2,436	662	565	31	94	63	188	157
	Northeast	All	167	267	200	15	39	24	70	55
	South & West	All	1,240	597	419	28	76	48	135	107
Small farms with confined livestock types	All states	All	42,565	215	165	6	11	5	20	14
Pastured livestock types	All States	All	61,272	590	352	5	10	5	22	17
All manure-producing farms			255,070	505	333	28	58	30	96	68

* Excludes 2,131 specialty livestock farms.

Acres required for off-farm manure application

Farm-level excess manure is transported off the farm for land application on manure-receiving farms located in the same county as the manure-producing farms if sufficient land is available, or is transported off the farm for alternative uses in counties where land is not available. Acres with manure applied on manure-receiving farms were calculated on a county basis. That is, all available acres on manure-receiving farms in the county were combined for making the calculation, thereby treating the county as if it was one large farm. Consequently, the acres required for manure application on manure-receiving farms depends on the amount of farm-level excess manure produced in each county, the acres of each crop available on manure-receiving farms in each county, and the application rate criteria.

Application rate criteria for manure-receiving farms were modeled the same as for manure-producing farms in the after-CNMP scenario with enough land to meet nutrient management criteria—application at nitrogen standard rates. The nitrogen recovery factor was set at 70 percent for both land application scenarios. Manure-receiving farms were treated the same in the simulation model as manure-producing farms after CNMP implementation for several reasons. First, it was assumed that manure-receiving farms would be unwilling to accept manure if they had to apply at phosphorus-standard rates because commercial fertilizers may offer a less costly option for providing the needed nutrients for crop production. Second, as presented earlier, it was assumed that manure-receiving farms would not be willing to accept manure on land with water erosion rates such that implementation of conservation practices might be required. Third, because manure-receiving farms are in the business of producing crops for profit and are not also concerned about manure disposal, it is assumed that manure-receiving farms would generally value the nutrient content of manure more than manure-producing farms and would take measures necessary to get the most benefit from the manure nutrients. Use of conservation tillage and crop residue management, especially no-till, is expected to be more prevalent on crop-producing farms. And last, if manure was applied off-farm using more relaxed practices than are used for onfarm application, CNMP implementation to some extent would simply move the potential pollution problem off the farm to surrounding properties. In simulating CNMP implementation, it is therefore assumed that other programs and policies, including State regulations, will be implemented to assure that land application of manure adheres to the same criteria regardless of where the manure is applied.

The crop priority used to similate manure application is different for manure-receiving farms than for manure-producing farms. Grain crops and other high-value crops have a higher priority than forage crops and pastureland. The highest to lowest priorities for manure application on manure-receiving farms are corn for grain, sorghum for grain, soybeans, winter wheat, barley, durum wheat, other spring wheat, oats, rye, Irish potatoes, sweet potatoes, cotton, corn for silage, small grain hay, other tame hay, wild hay, grass silage, sorghum hay, cropland used as pasture, permanent pasture, sorghum for silage, alfalfa hay, sugar beets, rice, peanuts, and tobacco.

In most counties sufficient acreage exists for off-farm land application of manure in accordance with NRCS nutrient management criteria. However, in some areas of the country, the production of manure nutrients exceeds the capacity of the land to assimilate nutrients (under the assumptions of the model simulation) resulting in excess manure. This excess manure is categorized as **county-level excess manure**.

Acres with manure applied and estimates of county-level excess manure for off-farm application are presented in table B–12. In the baseline scenario 2,707 counties had farm-level excess manure. In these counties 1,167,309 farms were classified as manure-receiving farms with about 121 million acres available for manure application. In the after-CNMP scenario, 1,198,371 manure-receiving farms had about 124 million acres available for manure application. (There were more manure-receiving farms for the after-CNMP scenario because 113 additional counties had farms with farm-level excess manure after CNMP implementation.)

About 9.5 million acres on manure-receiving farms had manure applied in the baseline scenario, compared to about 13.5 million acres in the after-CNMP scenario. Thus, about 4 million additional off-farm acres are required to meet CNMP application criteria.

In the baseline scenario, 184 counties had excess manure. County-level excess manure nitrogen totaled 238 million pounds in the baseline scenario, and excess manure phosphorus totaled 124 million pounds (table B–12), representing about 10 percent of the total recoverable manure nutrients. The presumption is that either this manure is presently being transported to areas outside of the county for application, is being used for purposes other than land application, is fed to animals as a feed supplement, or is held in storage temporarily. Lagoons, for example, accumulate manure nutrients as the solids settle to the bottom and the liquid is pumped off for land application. These solids are retained in the lagoon sometimes for many years before being cleaned out and applied to the land. In addition, manure is sometimes allowed to stack up for long periods in arid regions of the country, and is not removed for land application every year. It is also possible that some of this county-level excess manure, as measured by the simulation model, is actually land applied, but at rates higher than simulated in the baseline scenario.

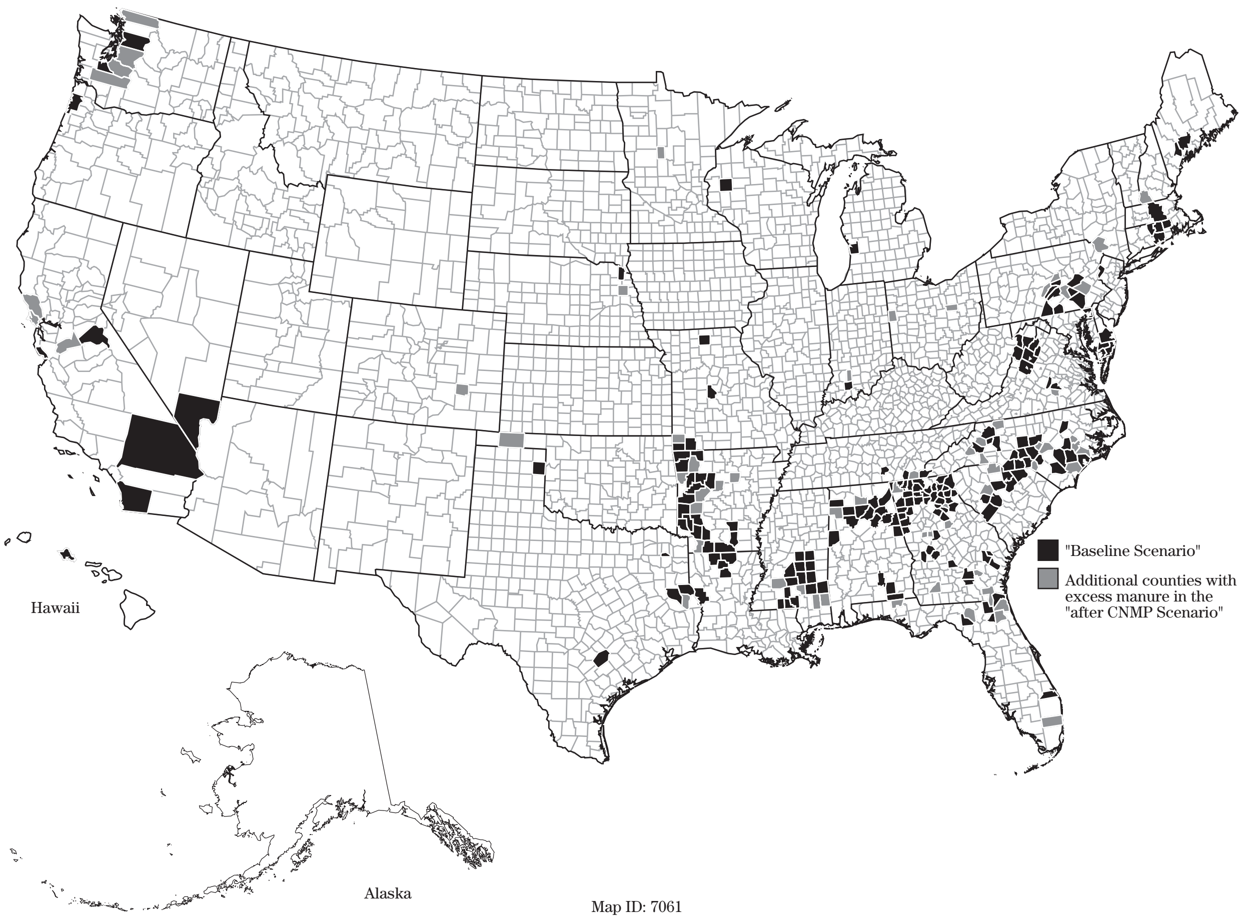
In the after-CNMP scenario, the number of counties with excess manure increased by 64 counties, shown in figure B–3. County-level excess manure increased to about 16 percent of the total amount of recoverable manure nutrients (table B–12). County-level excess manure in the after-CNMP scenario was 454 million pounds of nitrogen and 243 million pounds of phosphorus. This excess manure cannot be land applied under the assumptions of the model, and therefore must be disposed of using alternative methods or addressed through feed management options that decrease the nutrient content in manure.

Table B–12 Acres with manure applied and estimates of excess manure for manure-receiving farms

	Baseline scenario	After-CNMP scenario
Number of counties with manure-receiving farms*	2,707	2,820
Number of manure-receiving farms in these counties	1,167,309	1,198,371
Farm-level excess manure nitrogen, pounds	1,193,141,133	1,844,146,884
Farm-level excess manure phosphorus, pounds	613,628,308	961,462,003
Total acres of 24 crops and pastureland**	287,149,756	294,579,460
Acres available for manure application***	120,947,562	123,985,962
Acres with manure applied in a given year	9,474,818	13,486,869
Percent of total acres of 24 crops and pastureland	3.3	4.6
Percent of acres available for manure application	7.8	10.9
County-level excess manure nitrogen, pounds	237,595,809	454,286,181
Percent of farm-level excess manure nitrogen	19.9	24.6
Percent of recoverable manure nitrogen	9.4	15.1
County-level excess manure phosphorus, pounds	123,813,042	243,301,550
Percent of farm-level excess manure phosphorus	20.2	25.3
Percent of recoverable manure phosphorus	10.8	17.3
Number of counties with excess manure	184	248

* Counties with manure-receiving farms are counties that have one or more manure-producing farms with farm-level excess manure.
** Excludes half of permanent pasture acreage.
*** Excludes acres with sheet and rill erosion above T, 50 percent of the remaining acreage for each crop and cropland used as pasture, and 75 percent of permanent pastureland.

Figure B–3 Counties with county-level excess manure

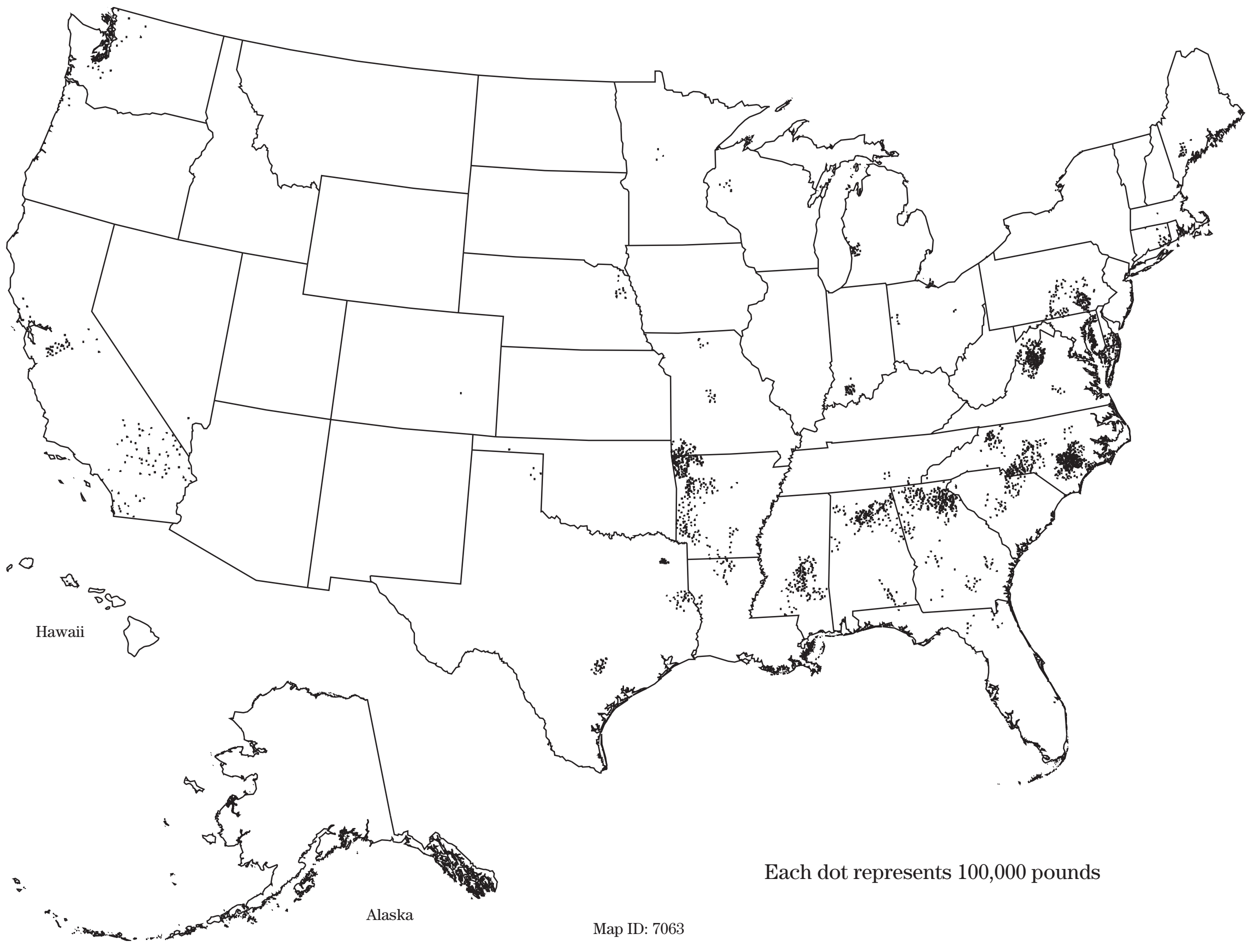


Figures B–4 and B–5 show the amount of county-level excess manure nitrogen and phosphorus expected after CNMP implementation, presented in the same units as in figures B–1 and B–2 for comparison to the amount of recoverable manure nutrients.

(Kellogg et al. (2000) reported that 73 counties had county level excess manure nitrogen and 160 counties had county-level excess manure phosphorus, simulating a nitrogen standard for nitrogen and a phosphorus standard for phosphorus. The results reported in the present study are not directly comparable to results in Kellogg et al. because the land application criteria are different and because excess manure is determined for nitrogen and phosphorus simultaneously.)

Figure B–4 County-level excess manure nitrogen after implementing CNMPs

Figure B–5 County-level excess manure phosphorus after implementing CNMPs



Acres required for both onfarm and off-farm manure application are summarized in table B–13. Off-farm acres with manure applied were about the same as onfarm acres with manure applied, with off-farm acres being slightly higher in the baseline scenario and onfarm acres being slightly higher in the after-CNMP scenario. Overall, an additional 11.6 million acres are required to meet CNMP application criteria. About two-thirds of these are for onfarm application and the rest for off-farm application.

Included in table B–13 is the amount of recoverable manure nutrients that would be applied on the farm, applied off the farm, and the amount that would remain as county-level excess manure. Overall, the percentage of recoverable manure nitrogen that would be applied on the farm falls from 53 percent in the baseline scenario to 39 percent in the after-CNMP scenario, whereas the percentage for off-farm application increases from 38 percent in the baseline scenario to 46 percent in the after-CNMP scenario. Similar changes are shown for manure phosphorus. County-level excess manure increases from about 10 percent in the baseline scenario to about 16 percent in the after-CNMP scenario as a result of CNMP implementation.

Table B–13 Summary of acres with manure applied and recoverable manure nutrients applied

Category	Onfarm application (manure-producing farms)	Off-farm application (manure-receiving farms)	Excess manure (county-level)	Total
Recoverable manure nitrogen, pounds				
Baseline scenario	1,340,621,108	955,543,104	237,595,809	2,533,788,026
Percent of total	52.9	37.7	9.4	100.0
After-CNMP scenario				
Farms applying at nitrogen-standard rates	871,617,297	1,389,860,703	NA	
Farms applying at phosphorus-standard rates	293,774,939	NA	NA	
Sum	1,165,392,236	1,389,860,703	454,286,181	3,009,556,624
Percent of total	38.7	46.2	15.1	100.0
Recoverable manure phosphorus, pounds				
Baseline scenario	537,504,867	489,814,215	123,813,042	1,151,144,811
Percent of total	46.7	42.6	10.8	100.0
After-CNMP scenario				
Farms applying at nitrogen-standard rates	306,991,912	718,160,454	NA	
Farms applying at phosphorus-standard rates	134,162,240	NA	NA	
Sum	441,154,152	718,160,454	243,301,550	1,402,621,897
Percent of total	31.5	51.2	17.3	100.0
Acres with manure applied in a given year				
Baseline scenario	7,187,142	9,474,818	NA	16,661,960
Percent of total	43.1	56.9	NA	100.0
After-CNMP scenario				
Farms applying at nitrogen-standard rates	7,580,869	13,486,869	NA	
Farms applying at phosphorus-standard rates	7,233,466	NA	NA	
Sum	14,814,335	13,486,869	NA	28,301,204
Percent of total	52.3	47.7	NA	100.0
Additional acres required	7,627,193	4,012,051	NA	11,639,244
Percent of total	65.5	34.5	NA	100.0

NA = not applicable.

Crop-specific manure application rates

The model simulated manure application for each crop on each manure-producing farm and for manure-receiving farms in each county to determine the number of acres required to meet CNMP application criteria. The percentage of each crop with manure applied is also obtained where not all of the acres of a particular crop are needed for manure application. The average application rates and percentage of acres with manure applied by crop for each group of farms are presented in tables B–14 through B–18. For the baseline scenario, average application rates are presented separately for manure-producing farms and manure-receiving farms. The same is done for the after-CNMP scenario except that the manure-producing farms are divided into two groups: farms that applied manure at nitrogen-standard rates and farms that applied manure at phosphorus-standard rates. The average yields on acres with manure applied are also presented for perspective. The average yields vary among groups because different farms are represented, which may come from different parts of the country.

Table B–14 Average manure nutrient application rates and acres with manure applied by crop for manure-producing farms, baseline scenario

Crop	Acres available for land application	Acres with manure applied	Percent of acres available	Percent of recoverable manure N **	Percent of recoverable manure P **	Pounds manure N per acre	Pounds manure P per acre	Average yield on acres with manure applied*	Yield units
Corn for silage	4,287,343	1,899,610	44.3	19.1	14.1	255	85	14.3	Tons/acre
Corn for grain	22,881,599	1,933,339	8.4	18.1	16.3	237	97	117.4	Bushels/acre
Small grain hay	755,959	128,610	17.0	0.6	0.6	123	55	1.9	Tons/acre
Other tame hay	4,898,893	1,048,467	21.4	4.6	4.9	112	53	2.1	Tons/acre
Wild hay	1,198,953	185,212	15.4	0.6	0.6	78	35	1.5	Tons/acre
Grass silage	3,652,969	124,404	3.4	1.0	0.9	209	81	5.9	Tons/acre
Sorghum hay	9,401	2,369	25.2	0.0	0.0	17	9	2.7	Tons/acre
Cropland used as pasture	9,744,642	936,085	9.6	4.6	4.8	124	59	—	—
Permanent pasture	3,363,277	497,714	14.8	0.9	1.0	47	22	—	—
Sorghum for silage	158,242	7,069	4.5	0.1	0.1	522	229	13.4	Tons/acre
Sorghum for grain	1,208,881	32,024	2.6	0.2	0.2	166	75	65.4	Bushels/acre
Alfalfa hay	6,882,979	84,423	1.2	1.1	1.1	335	150	3.3	Tons/acre
Soybeans	15,867,295	154,084	1.0	1.4	1.6	231	122	32.4	Bushels/acre
Winter wheat	4,902,025	73,925	1.5	0.2	0.3	81	44	39.5	Bushels/acre
Barley	874,271	10,279	1.2	0.0	0.0	109	51	60.1	Bushels/acre
Durum wheat	167,444	664	0.4	0.0	0.0	71	30	27.6	Bushels/acre
Other spring wheat	1,561,062	6,416	0.4	0.0	0.0	88	46	31.4	Bushels/acre
Oats	1,096,722	5,049	0.5	0.0	0.0	65	31	54.5	Bushels/acre
Rye	71,061	2,812	4.0	0.0	0.0	52	29	24.4	Bushels/acre
Irish potatoes	82,603	270	0.3	0.0	0.0	232	112	322.1	100-lb bags/acre
Sweet potatoes	3,880	494	12.7	0.0	0.0	57	39	217.2	Bushels/acre
Cotton	697,463	38,079	5.5	0.1	0.1	40	24	1.3	500-lb bales/acre
Sugar beets	131,035	467	0.4	0.0	0.0	183	83	19.2	Tons/acre
Rice	51,748	117	0.2	0.0	0.0	176	94	70.4	100-lb bags/acre
Peanuts	181,438	6,074	3.3	0.0	0.0	176	88	2,198.3	Pounds/acre
Tobacco	112,230	9,087	8.1	0.1	0.1	141	94	2,149.0	Pounds/acre
All crops	84,843,415	7,187,142	8.5	52.9	46.7				

* Farm-level yields below the 10th percentile yield within a land resource region were adjusted upward to equal the 10th percentile yield. Farm-level yields above the 95th percentile yield within a land resource region were adjusted downward to equal the 95th percentile yield.

** The percentage of manure nutrients applied is the amount applied on these farms divided by the total amount of recoverable manure nutrients for the baseline scenario. The sum is the percentage of recoverable manure nutrients applied to manure-producing farms. The column does not sum to 100 percent because additional manure was applied to manure-receiving farms or is county-level excess manure.

Table B–15 Average manure nutrient application rates and acres with manure applied by crop for manure-receiving farms, baseline scenario

Crop	Acres available for land application	Acres with manure applied	Percent of acres available	Percent of recov-erable manure N **	Percent of recov-erable manure P **	Pounds manure N per acre	Pounds manure P per acre	Average yield on acres with manure applied*	Yield units
Corn for silage	1,403,339	95,912	6.8	0.7	0.8	198	100	19.5	Tons/acre
Corn for grain	46,133,556	3,335,505	7.2	18.8	20.8	143	72	125.1	Bushels/acre
Small grain hay	2,041,118	90,963	4.5	0.3	0.3	70	38	1.9	Tons/acre
Other tame hay	17,707,616	813,819	4.6	1.9	2.2	60	31	2.1	Tons/acre
Wild hay	6,462,708	152,383	2.4	0.3	0.3	44	23	1.5	Tons/acre
Grass silage	960,757	39,965	4.2	0.2	0.3	143	74	7.3	Tons/acre
Sorghum hay	72,892	857	1.2	0.0	0.0	11	6	3.2	Tons/acre
Cropland used as pasture	51,427,685	1,892,175	3.7	5.6	6.3	75	38	—	—
Permanent pasture	19,603,370	465,740	2.4	0.5	0.6	28	14	—	—
Sorghum for silage	218,357	2,106	1.0	0.0	0.0	316	138	15.0	Tons/acre
Sorghum for grain	6,963,989	365,616	5.3	1.1	1.3	78	42	55.7	Bushels/acre
Alfalfa hay	13,420,362	70,124	0.5	1.0	1.1	346	179	4.8	Tons/acre
Soybeans	47,371,268	526,902	1.1	3.1	3.7	148	82	29.1	Bushels/acre
Winter wheat	31,878,378	827,459	2.6	2.0	2.4	63	33	42.8	Bushels/acre
Barley	4,651,474	82,074	1.8	0.3	0.3	98	48	76.5	Bushels/acre
Durum wheat	2,488,967	60,250	2.4	0.4	0.4	166	84	90.2	Bushels/acre
Other spring wheat	14,561,081	15,421	0.1	0.1	0.1	119	58	60.0	Bushels/acre
Oats	1,497,311	37,037	2.5	0.1	0.1	50	26	58.8	Bushels/acre
Rye	189,812	9,525	5.0	0.0	0.0	38	21	24.7	Bushels/acre
Irish potatoes	1,221,360	21,598	1.8	0.1	0.2	171	89	332.7	100-lb bags/acre
Sweet potatoes	68,382	8,447	12.4	0.0	0.0	55	35	295.7	Bushels/acre
Cotton	11,253,997	518,885	4.6	0.9	1.1	43	24	2.0	500-lb bales/acre
Sugar beets	1,311,671	51	0.0	0.0	0.0	192	86	28.2	Tons/acre
Rice	2,462,287	169	0.0	0.0	0.0	89	48	49.7	100-lb bags/acre
Peanuts	1,125,771	22,054	2.0	0.1	0.1	134	67	2,334.9	Pounds/acre
Tobacco	652,249	19,782	3.0	0.1	0.1	107	77	2,273.5	Pounds/acre
All crops	287,149,756	9,474,818	3.3	37.7	42.6				

* Farm-level yields below the 10th percentile yield within a land resource region were adjusted upward to equal the 10th percentile yield. Farm-level yields above the 95th percentile yield within a land resource region were adjusted downward to equal the 95th percentile yield.

** The percentage of manure nutrients applied is the amount applied on these farms divided by the total amount of recoverable manure nutrients for the baseline scenario. The sum is the percentage of recoverable manure nutrients applied to manure-receiving farms. The column does not sum to 100 percent because additional manure was applied to manure-producing farms or is county-level excess manure.

Table B–16 Average manure nutrient application rates and acres with manure applied by crop for manure-producing farms applying manure at nitrogen-standard rates in the after-CNMP scenario

Crop	Acres available for land application	Acres with manure applied	Percent of acres available	Percent of recov- erable manure N **	Percent of recov- erable manure P **	Pounds manure N per acre	Pounds manure P per acre	Average yield on acres with manure applied*	Yield units
Corn for silage	3,622,421	2,415,051	66.7	11.4	8.1	142	47	14.0	Tons/acre
Corn for grain	21,229,624	2,813,636	13.3	12.6	9.8	135	49	118.1	Bushels/acre
Small grain hay	653,199	125,757	19.3	0.3	0.2	66	26	1.8	Tons/acre
Other tame hay	4,323,377	996,098	23.0	1.8	1.5	55	22	2.0	Tons/acre
Wild hay	1,106,977	195,107	17.6	0.2	0.2	38	15	1.4	Tons/acre
Grass silage	3,204,386	160,983	5.0	0.5	0.3	91	29	4.7	Tons/acre
Sorghum hay	8,339	2,505	30.0	0.0	0.0	10	5	2.8	Tons/acre
Cropland used as pasture	8,783,328	560,576	6.4	1.4	1.1	75	28	—	—
Permanent pasture	2,802,556	193,622	6.9	0.2	0.2	28	11	—	—
Sorghum for silage	137,878	4,359	3.2	0.0	0.0	272	116	12.9	Tons/acre
Sorghum for grain	1,153,352	26,614	2.3	0.1	0.1	99	39	70.9	Bushels/acre
Alfalfa hay	6,465,021	40,126	0.6	0.3	0.2	195	73	2.7	Tons/acre
Soybeans	14,876,457	8,013	0.1	0.0	0.0	171	73	33.7	Bushels/acre
Winter wheat	4,577,969	20,485	0.4	0.0	0.0	50	25	34.5	Bushels/acre
Barley	829,783	11,374	1.4	0.0	0.0	61	29	47.7	Bushels/acre
Durum wheat	164,485	456	0.3	0.0	0.0	48	19	26.0	Bushels/acre
Other spring wheat	1,524,741	2,778	0.2	0.0	0.0	56	21	28.0	Bushels/acre
Oats	1,053,140	731	0.1	0.0	0.0	40	13	46.8	Bushels/acre
Rye	62,717	532	0.8	0.0	0.0	38	19	24.9	Bushels/acre
Irish potatoes	79,068	5	0.0	0.0	0.0	75	23	145.6	100-lb bags/acre
Sweet potatoes	2,307	0	0.0	0.0	0.0	0	0	—	Bushels/acre
Cotton	550,136	1,627	0.3	0.0	0.0	23	12	1.1	500-lb bales/acre
Sugar beets	122,682	79	0.1	0.0	0.0	133	62	19.6	Tons/acre
Rice	51,273	83	0.2	0.0	0.0	110	77	61.4	100-lb bags/acre
Peanuts	149,046	81	0.1	0.0	0.0	124	53	2,164.9	Pounds/acre
Tobacco	75,687	190	0.3	0.0	0.0	84	23	1,954.4	Pounds/acre
All crops	77,609,949	7,580,869	9.8	29.0	21.9				

* Farm-level yields below the 10th percentile yield within a land resource region were adjusted upward to equal the 10th percentile yield. Farm-level yields above the 95th percentile yield within a land resource region were adjusted downward to equal the 95th percentile yield.
** The percentage of manure nutrients applied is the amount applied on these farms divided by the total amount of recoverable manure nutrients for the after-CNMP scenario. The sum is the percentage of recoverable manure nutrients applied to manure-producing farms applying at nitrogen-standard rates. The column does not sum to 100 percent because additional manure was applied to farms at phosphorus-standard rates and to manure-receiving farms, or is county-level excess manure.

Table B–17 Average manure nutrient application rates and acres with manure applied by crop for manure-producing farms applying manure at phosphorus-standard rates in the after-CNMP scenario

Crop	Acres available for land application	Acres with manure applied	Percent of acres available	Percent of recov-erable manure N **	Percent of recov-erable manure P **	Pounds manure N per acre	Pounds manure P per acre	Average yield on acres with manure applied*	Yield units
Corn for silage	664,922	664,922	100.0	0.9	0.9	43	19	17.8	Tons/acre
Corn for grain	1,651,975	1,651,975	100.0	2.3	2.1	43	18	121.4	Bushels/acre
Small grain hay	102,760	102,760	100.0	0.1	0.1	21	10	2.3	Tons/acre
Other tame hay	575,516	575,516	100.0	1.3	1.5	70	35	2.3	Tons/acre
Wild hay	91,976	91,976	100.0	0.2	0.2	52	25	1.6	Tons/acre
Grass silage	448,583	448,583	100.0	0.4	0.4	28	12	7.5	Tons/acre
Sorghum hay	1,062	1,062	100.0	0.0	0.0	6	3	2.8	Tons/acre
Cropland used as pasture	961,314	961,314	100.0	2.0	2.1	62	30	—	—
Permanent pasture	560,720	560,720	100.0	0.5	0.4	25	11	—	—
Sorghum for silage	20,364	20,364	100.0	0.0	0.0	66	33	13.3	Tons/acre
Sorghum for grain	55,529	55,529	100.0	0.0	0.0	27	12	66.4	Bushels/acre
Alfalfa hay	417,958	417,958	100.0	0.5	0.5	39	17	3.6	Tons/acre
Soybeans	990,838	990,838	100.0	1.1	1.0	33	14	39.0	Bushels/acre
Winter wheat	324,056	324,056	100.0	0.2	0.2	19	9	46.7	Bushels/acre
Barley	44,488	44,488	100.0	0.0	0.0	27	12	67.0	Bushels/acre
Durum wheat	2,959	2,959	100.0	0.0	0.0	19	9	42.9	Bushels/acre
Other spring wheat	36,321	36,321	100.0	0.0	0.0	15	7	31.6	Bushels/acre
Oats	43,582	43,582	100.0	0.0	0.0	18	7	63.2	Bushels/acre
Rye	8,344	8,344	100.0	0.0	0.0	11	5	26.4	Bushels/acre
Irish potatoes	3,535	3,535	100.0	0.0	0.0	36	16	266.5	100-lb bags/acre
Sweet potatoes	1,573	1,573	100.0	0.0	0.0	6	5	243.4	Bushels/acre
Cotton	147,327	147,327	100.0	0.0	0.0	4	3	1.4	500-lb bales/acre
Sugar beets	8,353	8,353	100.0	0.0	0.0	40	18	18.8	Tons/acre
Rice	475	475	100.0	0.0	0.0	39	18	62.0	100-lb bags/acre
Peanuts	32,392	32,392	100.0	0.0	0.0	12	7	2,492.9	Pounds/acre
Tobacco	36,543	36,543	100.0	0.0	0.0	7	5	2,249.2	Pounds/acre
All crops	7,233,466	7,233,466	100.0	9.8	9.6				

* Farm-level yields below the 10th percentile yield within a land resource region were adjusted upward to equal the 10th percentile yield. Farm-level yields above the 95th percentile yield within a land resource region were adjusted downward to equal the 95th percentile yield.
** The percentage of manure nutrients applied is the amount applied on these farms divided by the total amount of recoverable manure nutrients for the after-CNMP scenario. The sum is the percentage of recoverable manure nutrients applied to manure-producing farms applying at phosphorus-standard rates. The column does not sum to 100 percent because additional manure was applied to farms with enough acres and to manure-receiving farms, or is county-level excess manure.

Table B–18 Average manure nutrient application rates and acres with manure applied by crop for manure-receiving farms, after-CNMP scenario

Crop	Acres available for land application	Acres with manure applied	Percent of acres available	Percent of recov-erable manure N **	Percent of recov-erable manure P **	Pounds manure N per acre	Pounds manure P per acre	Average yield on acres with manure applied*	Yield units
Corn for silage	1,423,856	126,400	8.9	0.8	0.9	193	103	19.1	Tons/acre
Corn for grain	46,362,105	4,792,009	10.3	22.8	24.1	143	71	125.1	Bushels/acre
Small grain hay	2,114,320	126,059	6.0	0.3	0.4	70	39	1.9	Tons/acre
Other tame hay	18,280,501	1,075,882	5.9	2.1	2.4	59	31	2.1	Tons/acre
Wild hay	6,645,415	202,261	3.0	0.3	0.3	43	23	1.5	Tons/acre
Grass silage	979,247	72,936	7.4	0.3	0.4	143	79	7.4	Tons/acre
Sorghum hay	73,920	1,602	2.2	0.0	0.0	9	5	2.8	Tons/acre
Cropland used as pasture	52,900,255	2,485,118	4.7	6.2	7.0	75	39	—	—
Permanent pasture	20,231,074	663,704	3.3	0.6	0.7	28	15	—	—
Sorghum for silage	222,114	7,332	3.3	0.1	0.1	299	162	14.2	Tons/acre
Sorghum for grain	7,038,302	543,628	7.7	1.4	1.7	80	43	56.7	Bushels/acre
Alfalfa hay	13,901,766	143,736	1.0	1.7	2.0	351	195	4.9	Tons/acre
Soybeans	47,988,525	847,963	1.8	4.4	5.1	157	85	30.8	Bushels/acre
Winter wheat	32,520,009	1,299,863	4.0	2.7	3.1	62	34	42.5	Bushels/acre
Barley	4,869,278	109,059	2.2	0.3	0.4	96	52	74.8	Bushels/acre
Durum wheat	2,917,644	78,962	2.7	0.4	0.5	168	93	90.9	Bushels/acre
Other spring wheat	15,471,323	40,236	0.3	0.1	0.2	109	59	54.8	Bushels/acre
Oats	1,546,402	50,931	3.3	0.1	0.1	50	26	58.8	Bushels/acre
Rye	194,433	13,192	6.8	0.0	0.0	37	20	23.9	Bushels/acre
Irish potatoes	1,247,337	35,826	2.9	0.2	0.2	171	91	332.2	100-lb bags/acre
Sweet potatoes	71,602	9,230	12.9	0.0	0.0	55	37	294.6	Bushels/acre
Cotton	11,808,195	695,752	5.9	1.0	1.2	41	24	1.9	500-lb bales/acre
Sugar beets	1,321,949	216	0.0	0.0	0.0	173	97	25.4	Tons/acre
Rice	2,617,406	3,149	0.1	0.0	0.0	112	59	62.7	100-lb bags/acre
Peanuts	1,162,324	29,536	2.5	0.1	0.1	137	71	2,386.2	Pounds/acre
Tobacco	670,158	32,289	4.8	0.1	0.2	106	79	2,260.8	Pounds/acre
All crops	294,579,461	13,486,869	4.6	46.2	51.2				

* Farm-level yields below the 10th percentile yield within a land resource region were adjusted upward to equal the 10th percentile yield. Farm-level yields above the 95th percentile yield within a land resource region were adjusted downward to equal the 95th percentile yield.

** The percentage of manure nutrients applied is the amount applied on these farms divided by the total amount of recoverable manure nutrients for the after-CNMP scenario. The sum is the percentage of recoverable manure nutrients applied to manure-receiving farms. The column does not sum to 100 percent because additional manure was applied to manure-producing farms or is county-level excess manure.

Simulation results for acres with manure applied are generally supported by information from farmer surveys. Model simulation results for the baseline scenario are compared to the 1995 Cropping Practice Survey results (Padgitt et al., 2000) in table B–19 for crops and states that were included in the survey. For these crops and states, survey data show that, overall, 8.1 percent of the acres had manure applied in 1995. This compares to 4.9 percent for the same states and crops in the model simulation for the baseline scenario. The survey results overstate the number of acres with manure applied because the questionnaire only asked if manure was applied on the field, not what proportion of the field received manure. (In subsequent surveys, the question has been changed to obtain a more precise response.) Some of the survey results for specific crops are also suspect because the crop for which manure applications were intended was not always clear. For example, agronomists suspect that some soybean acres the survey shows receiving manure were probably for corn or other crops planted in rotation following the soybean harvest. Given the vagaries of the survey data, however, and the artificial nature of the model simulation, the correspondence between survey results and model simulation results is surprisingly close, indicating that the results of the simulation model are a reasonable representation of manure application rates for the baseline scenario.

Table B–19 Comparison of simulation model results for the baseline scenario to 1995 survey data for acres where manure was applied*

Crop	1995 survey results			Model simulation results for baseline scenario			
	Planted acres (1,000 acres)	Acres with livestock manure applied (1,000 ac)	Percent of planted acres with livestock manure applied	Total acres from the 1997 census (1,000 ac)	Acres with livestock manure applied on manure-producing farms (1,000 ac)	Acres with livestock manure applied on manure-receiving farms (1,000 ac)	Percent of acres with livestock manure applied
Corn (18 states)	64,105	9,562	14.9	67,511	3,942.40	2,928.16	10.2
Cotton (4 states)	9,395	337	3.5	7,556	4.61	321.40	4.3
Durum wheat (1 state)	2,950	102	3.4	2,541	0.98	0.00	0.0
Fall potatoes (10 states)	1,000	27	2.7	960	0.23	11.79	1.3
Spring wheat (3 states)	11,800	278	2.3	12,452	7.52	2.81	0.1
Soybeans (11 states)	47,790	2,408	5.0	39,675	135.05	374.91	1.3
Wheat (11 states)	30,745	853	2.7	28,413	53.03	557.63	2.1
All survey crops	167,785	13,567	8.1	168,933	4,149.23	4,196.70	4.9

* Model simulation results are for the specific states for which farmer survey results were available. Survey results were reported by Padgitt et al. (2000).

Appendix C — Comparison of Size Class Categories Used in the Report to EPA Size Class Categories

Three size classes of farms were derived to summarize results of the cost assessment. Size class categories were based on the total amount of manure phosphorus produced on a farm, *as excreted*. This measure of farm size is more appropriate than a measure based on the number of animals or animal units on the farm because, as shown in appendix B, different animal types produce different amounts of manure and manure nutrients after adjusting for live weight. Manure nitrogen could also have been used to define size classes, but phosphorus was chosen because of its importance in determining CNMP land application criteria. Total manure phosphorus *as excreted* was used rather than recoverable manure phosphorus because recoverable manure does not include the amount produced when animals are not held in confinement, and would thus not be a reliable measure of the overall size of the livestock operation. In addition, the amount of recoverable manure can change with CNMP implementation as better management practices improve manure recoverability on the farm.

The three size classes were defined as follows:

- Large farms are operations that produce more than 10 tons (20,000 pounds) of manure phosphorus annually.
- Medium-size farms are operations that produce between 4 and 10 tons (8,000 to 20,000 pounds) of manure phosphorus annually.
- Small farms are operations that produce less than 4 tons (8,000 pounds) of manure phosphorus annually.

The number of farms by size class and the spatial distribution is presented in the main body of this publication (tables 6 and 7, and figures 12 and 13).

The large farm size class was derived to correspond roughly to concentrated animal feeding operations (CAFOs) with more than 1,000 EPA animal units since these operations present the greatest potential threat to environmental quality and require a National Pollutant Discharge Elimination System (NPDES) permit to operate. (See appendix A for a definition of CAFOs and the relationship between USDA animal units and EPA animal units.) Table C–1 presents estimates of the total pounds of manure phosphorus that would be produced on a farm annually at the 1,000 EPA animal unit threshold (column 7), assuming a farm had livestock at that level throughout the entire year. As shown in the table, the EPA CAFO criteria are not consistent with respect to phosphorus production across the various livestock types. Choosing a cutoff that would closely represent the number of fattened cattle or dairy CAFOs would account for too few swine CAFOs, for example. The EPA CAFO criteria also have the disadvantage of not accounting for multiple livestock types on an operation.

The 10-ton threshold (20,000 pounds) used to define large operations was selected to include the bulk of swine operations that would be classified as a CAFO with more than 1,000 EPA AU plus additional farms of an equivalent size in terms of manure production. Table C–2 shows that of the 11,398 potential CAFOs, 91 percent are included in the large farm size class. (See appendix A for definition of potential CAFOs as derived from the Census of Agriculture.) The 1,044 potential CAFOs not included were predominantly swine farms. An additional 9,392 livestock operations were also included that produced an equivalent amount of manure. The total number of farms in the large size class was 19,746, of which 59 percent were potential CAFOs with more than 1,000 EPA animal units.

A similar approach was used to derive the cutoff for medium size farms, where the 4-ton threshold corresponds roughly to the 300 EPA animal unit threshold. Table C–3 shows that of the 32,968 operations that would potentially have 300 to 1,000 EPA animal units, 64 percent are included in the medium farm size class, whereas 19 percent were included in the large farm size class and 17 percent were included in the small farm size class. An additional 18,365 farms that produced an equivalent amount of manure were also included in the medium farm size class including the 1,044 farms with more than 1,000 EPA animal units that were not included in the large farm size class. The total number of farms in the medium farm size class was 39,437, of which 53 percent have 300 to 1,000 EPA animal units.

Table C–1 Estimation of the pounds of phosphorus (*as excreted*) produced annually that corresponds to EPA head-count criteria for 1,000 EPA animal units, assuming a farm had livestock at that level throughout the entire year*

	Tons of manure as excreted per USDA AU (1)	Pounds of P per ton of manure (2)	Pounds of P per USDA AU (3)=(1)(2)	Number of animals per USDA AU (4)	Pounds of P per head (5)=(3)/(4)	Head count corresponding to 1,000 EPA AU (6)	Pounds of P corresponding to 1,000 EPA AU (7)=(5)(6)
Fattened cattle	10.59	3.37	35.69	1.14	31.3055	1,000	31,306
Milk cows	15.24	1.92	29.26	0.74	39.5416	700	27,679
Breeding hogs	6.11	4.28	26.15	2.67	9.7943	2,500	24,486
Hogs for slaughter	14.69	3.29	48.33	9.09	5.3168	2,500	13,292
Chicken layers	11.45	9.98	114.27	250.0	0.4571	100,000	45,710
Chicken broilers	14.97	7.80	116.77	455.0	0.2566	100,000	25,660
Pullets	8.32	10.53	87.61	250.0	0.3504	100,000	35,040
Turkeys for breeding	9.12	13.21	120.48	50.0	2.4095	55,000	132,523
Turkeys for slaughter	8.18	11.83	96.77	67.0	1.4443	55,000	79,437

* Parameters used to calculate manure phosphorus are taken from appendix B, table B–1.

Table C–2 Comparison of the number of potential CAFOs in the EPA 1,000 animal unit category to the number of farms in the large farm size class

Dominant livestock type	Potential CAFOs, 1,000 EPA AU*	Number of potential CAFOs in large farm size class	Number of potential CAFOs **not** in large farm size class	Number of additional farms in large farm size class	Total number of farms in large farm size class
Fattened cattle	1,766	1,562	204	810	2,372
Milk cows	1,450	1,450	0	1,348	2,798
Swine	3,924	3,096	828	464	3,560
Turkeys	388	388	0	2,297	2,685
Broilers	2,945	2,945	0	2,087	5,032
Layers/Pullets	671	671	0	705	1,376
Confined heifers/veal	254	242	12	75	317
Pastured livestock types	0	0	0	1,606	1,606
Total	11,398	10,354	1,044	9,392	19,746

* Taken from appendix A, table A–6.

Table C–3 Comparison of the number of farms in the 300 to 1,000 EPA animal unit category to the number of farms in the medium farm size class

Dominant livestock type	Farms with 300 to 1,000 EPA AU*	Farms with 300 to 1,000 EPA AU & in medium farm size class	Farms with 300 to 1,000 EPA AU & in large farm size class	Farms with 300 to 1,000 EPA AU and in small farm size class	Additional farms in medium farm size class: Potential CAFOs, 1,000 EPA AU	Additional farms in medium farm size class: Farms with less than 300 EPA AU	Total number of farms in medium farm size class
Fattened cattle	2,682	1,423	465	794	204	1,621	3,248
Milk cows	5,780	4,552	1,227	1	0	3,098	7,650
Swine	9,901	5,568	317	4,016	828	2,258	8,654
Turkeys	1,615	0	1,615	0	0	460	460
Broilers	10,749	8,218	2,080	451	0	555	8,773
Layers/pullets	1,460	751	638	71	0	1,585	2,336
Confined heifers/veal	781	560	73	148	12	138	710
Small farms with confined livestock types	0	0	0	0	0	91	91
Pastured livestock types	0	0	0	0	0	7,515	7,515
Total	32,968	21,072	6,415	5,481	1,044	17,321	39,437

* Taken from appendix A, table A–6.

Appendix D Conservation Systems for Cropland in Land Resource Regions S, M, and R

Table D–1 Conservation systems for cropland in Land Resource Region S

Erosion class & conser-vation system number	Pro-portion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre by state DE	MA	MD	NJ	NY	PA	WV	VA
1–2T													
1	0.5	328	Conservation Crop Rotation	acre	1	8.83	8.83	5.00	8.83	6.00	19.32	8.83	9.20
		329B	Residue Management (Mulch-till)	acre	1	30.89	35.00	30.89	30.89	18.55	30.89	30.89	21.64
		340	Cover Crop	acre	1	1.04	4.47	1.94	1.84	2.95	3.05	2.95	2.98
		412	Grassed Waterway	acre	0.1	26.07	27.54	27.54	27.54	27.54	27.54	21.50	35.39
		585/ 586	Contour Stripcropping or Field Stripcropping	acre	1	5.50	6.71	2.98	4.38	4.69	1.90	5.50	0.37
			Total			72.33	82.55	68.35	73.47	59.74	82.69	69.68	69.59
2	0.5	328	Conservation Crop Rotation	acre	1	8.83	8.83	5.00	8.83	6.00	19.32	8.83	9.20
		329B	Residue Management (Mulch-till)	acre	1	30.89	35.00	30.89	30.89	18.55	30.89	30.89	21.64
		330	Contour Farming	acre	0.8	7.41	8.00	15.57	8.00	4.45	6.21	0.43	4.00
		332	Contour Buffer Strips	acre	0.2	4.08	11.92	4.56	3.54	5.16	3.30	3.49	1.19
		340	Cover Crop	acre	1	1.04	4.47	1.94	1.84	2.95	3.05	2.95	2.98
		412	Grassed Waterway	acre	0.1	26.07	27.54	27.54	27.54	27.54	27.54	21.50	35.39
			Total			78.31	95.76	85.49	80.64	64.65	90.30	68.09	74.41
			Weighted total			75.32	89.16	76.92	77.06	62.19	86.50	68.88	70.79
2–4T, >4T													
1	0.75	328	Conservation Crop Rotation	acre	1	8.83	8.83	5.00	8.83	6.00	19.32	8.83	9.20
		329A,B	Residue Management (No-till & Strip-till)	acre	1	16.57	35.00	12.18	23.88	19.00	18.32	23.88	15.00
		340	Cover Crop	acre	1	1.04	4.47	1.94	1.84	2.95	3.05	2.95	2.98
		412	Grassed Waterway	acre	0.1	26.07	27.54	27.54	27.54	27.54	27.54	21.50	70.79
		585/586	Contour Stripcropping or Field Stripcropping	acre	1	5.50	6.71	2.98	4.38	4.69	1.90	5.50	0.37
		600	Terrace	feet	200	102.66	119.22	80.48	74.51	111.77	153.80	102.66	34.28
			Total			160.67	201.77	130.11	140.98	171.96	223.92	165.33	132.62
2	0.25	328	Conservation Crop Rotation	acre	1	8.83	8.83	5.00	8.83	6.00	19.32	8.83	9.20
		329A,B	Residue Management (No-till & Strip-till)	acre	1	16.57	35.00	12.18	23.88	19.00	18.32	23.88	15.00
		330	Contour Farming	acre	1	9.26	10.00	19.46	10.00	5.56	7.76	0.54	5.00
		332	Contour Buffer Strips	acre	0.2	4.08	11.92	4.56	3.54	5.16	3.30	3.49	5.96
		340	Cover Crop	acre	1	1.04	4.47	1.94	1.84	2.95	3.05	2.95	2.98
		412	Grassed Waterway	acre	0.1	26.07	27.54	27.54	27.54	27.54	27.54	21.50	70.79
		600	Terrace	feet	200	102.66	119.22	80.48	74.51	111.77	153.80	102.66	34.28
			Total			168.50	216.99	151.15	150.14	177.98	233.08	163.85	143.21
			Weighted total			162.63	205.58	135.37	143.27	173.46	226.21	164.96	135.27

Table D–2 Conservation systems for cropland in Land Resource Region M

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Indiana							
1–4T, >4T	1	1	328	Conservation Crop Rotation	acre	1	18.59
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.21
			410	Grade Stabilization Structure	each	0.005	2.93
			412	Grassed Waterway	acre	0.05	18.46
			620	Underground Outlet	feet	30	17.21
			638	Water & Sediment Control Basin	each	0.01	1.16
				Total			70.55
Illinois							
1–4T, >4T	1	1	328	Conservation Crop Rotation	acre	1	18.59
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.21
			330	Contour Farming	acre	0.5	5.38
			410	Grade Stabilization Structure	each	0.05	24.50
			412	Grassed Waterway	acre	0.05	20.86
			600	Terrace	feet	100	74.07
				Total			155.61
Iowa							
1–2T	1	1	328	Conservation Cropping System	acre	1	38.73
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	10.00
			412	Grassed Waterway	acre	0.05	18.46
				Total			67.19
2–4T	1	1	328	Conservation Crop Rotation	acre	1	38.73
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	10.00
			330	Contour Farming	acre	0.5	2.79
			332	Contour Buffer Strips	acre	0.1	2.27
			412	Grassed Waterway	acre	0.1	36.91
				Total			90.70
>4T	1	1	328	Conservation Crop Rotation	acre	1	38.73
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	10.00
			330	Contour Farming	acre	0.5	2.79
			412	Grassed Waterway	acre	0.1	36.91
			600	Terrace	feet	120	105.51
			620	Underground Outlet	feet	50	28.69
				Total			222.63

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Minnesota							
1–2T	1	1	328	Conservation Crop Rotation	acre	1	19.95
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	16.94
			410	Grade Stabilization Structure	each	0.005	3.54
			412	Grassed Waterway	acre	0.05	18.46
			590	Nutrient Management	acre	1	7.50
			620	Underground Outlet	feet	30	12.34
			638	Water & Sediment Control Basin	each	0.1	35.25
				Total			113.98
2–4T	1	1	328	Conservation Crop Rotation	acre	1	19.95
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	16.94
			330	Contour Farming	acre	1	11.79
			412	Grassed Waterway	acre	0.05	18.46
			585	Contour Strip-cropping	acre	1	1.27
			620	Underground Outlet	feet	30	12.34
			638	Water & Sediment Control Basin	each	0.1	35.25
				Total			116.00
>4T	1	0.15	328	Conservation Crop Rotation	acre	1	19.95
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	16.94
			410	Grade Stabilization Structure	each	0.005	3.54
			412	Grassed Waterway	acre	0.05	18.46
			620	Underground Outlet	feet	30	12.34
			638	Water & Sediment Control Basin	each	0.01	3.52
				Total			74.75
	2	0.25	328	Conservation Crop Rotation	acre	1	19.95
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	16.94
			330	Contour Farming	acre	0.5	5.90
			410	Grade Stabilization Structure	each	0.05	35.44
			411	Grasses & Legumes in Rotation	acre	1	0.00
			412	Grassed Waterway	acre	0.1	36.91
			528A	Prescribed Grazing	acre	1	4.95
				Total			120.09

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Minnesota (continued)							
	3	0.15	328	Conservation Crop Rotation	acre	1	19.95
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	16.94
			330	Contour Farming	acre	0.5	5.90
			412	Grassed Waterway	acre	0.1	36.91
			600	Terrace	feet	120	66.17
			620	Underground Outlet	feet	50	20.57
				Total			166.43
	4	0.2	328	Conservation Crop Rotation	acre	1	19.95
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	16.94
			330	Contour Farming	acre	0.75	8.84
			412	Grassed Waterway	acre	0.05	18.46
			585	Contour Stripcropping	acre	0.75	0.96
				Total			65.14
	5	0.25	328	Conservation Crop Rotation	acre	1	19.95
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	16.94
			330	Contour Farming	acre	0.5	5.90
			412	Grassed Waterway	acre	0.1	36.91
			600	Terrace	feet	120	66.17
			620	Underground Outlet	feet	50	20.57
				Total			166.43
				Weighted total			120.84
Missouri							
1–2T	1	1	328	Conservation Crop Rotation	acre	1	18.59
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.21
			412	Grassed Waterway	acre	0.05	20.86
				Total			51.66
2–4T	1	1	328	Conservation Crop Rotation	acre	1	16.93
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	13.22
			330	Contour Farming	acre	0.5	8.47
			412	Grassed Waterway	acre	0.1	43.22
			600	Terrace	feet	100	17.59
				Total			99.42

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Missouri (continued)							
> 4T	1	1	328	Conservation Crop Rotation	acre	1	16.93
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	13.22
			330	Contour Farming	acre	0.5	8.47
			412	Grassed Waterway	acre	0.1	43.22
			600	Terrace	feet	120	21.10
			620	Underground Outlet	feet	50	14.53
				Total			117.47
Ohio							
1–2T	1	1	328	Conservation Crop Rotation	acre	1	10.80
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	8.88
			410	Grade Stabilization Structure	dach	0.005	1.61
			412	Grassed Waterway	acre	0.05	14.08
				Total			35.37
2–4T	1	1	328	Conservation Crop Rotation	acre	1	10.80
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	8.88
			330	Contour Farming	acre	0.2	2.15
			332	Contour Buffer Strips	acre	0.1	1.04
			412	Grassed Waterway	acre	0.05	14.08
				Total			36.95
> 4T	1	1	328	Conservation Crop Rotation	acre	1	10.80
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	8.88
			330	Contour Farming	acre	0.75	8.07
			412	Grassed Waterway	acre	0.05	14.08
			585	Contour Strip-cropping	acre	0.75	3.02
				Total			44.85
Wisconsin							
1–2T	1	1	328	Conservation Crop Rotation	acre	1	18.59
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.21
			410	Grade Stabilization Structure	each	0.005	3.89
			412	Grassed Waterway	acre	0.05	17.10
				Total			51.78

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Wisconsin (continued)							
2–4T	1	1	328	Conservation Crop Rotation	acre	1	18.59
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.21
			330	Contour Farming	acre	0.2	3.90
			332	Contour Buffer Strips	acre	0.1	1.04
			412	Grassed Waterway	acre	0.05	17.10
				Total			52.84
> 4T	1	1	328	Conservation Crop Rotation	acre	1	18.59
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.21
			330	Contour Farming	acre	0.75	14.64
			412	Grassed Waterway	acre	0.05	17.10
			585	Contour Strip-cropping	acre	0.75	2.07
				Total			64.60
Kansas							
1–2T	1	1	328	Conservation Crop Rotation	acre	1	4.83
			329C	Residue Management (Ridge-till)	acre	1	3.30
			412	Grassed Waterway	acre	0.01	3.41
				Total			11.54
2–4T	1	1	328	Conservation Crop Rotation	acre	1	4.83
			329A,B	Residue Management (No-till & Strip-till)	acre	1	10.00
			330	Contour Farming	acre	1	3.95
			332	Contour Buffer Strips	acre	0.2	6.00
			412	Grassed Waterway	acre	0.01	3.41
				Total			28.19
> 4T	1	1	328	Conservation Crop Rotation	acre	1	4.83
			329A,B	Residue Management (No-till & Strip-till)	acre	1	10.00
			330	Contour Farming	acre	1	3.95
			412	Grassed Waterway	acre	0.01	3.41
			600	Terrace	feet	150	15.20
			620	Underground Outlet	feet	50	40.91
				Total			78.30
Oklahoma							
1–2T	1	1	328	Conservation Cropping System	acre	1	5.00
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	0.3	2.40
			344	Residue Management (Seasonal)	acre	0.7	9.50
				Total			16.90

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Oklahoma (continued)							
2–4T	1	1	328	Conservation Crop Rotation	acre	1	5.00
			329A,B	Residue Management (No-till & Strip-till)	acre	1	8.00
			412	Grassed Waterway	acre	0.05	4.10
			600	Terrace	feet	150	10.06
				Total			27.16
> 4T	1	1	328	Conservation Crop Rotation	acre	1	5.00
			329A,C	Residue Management (No-till & Strip-till, Ridge-till)	acre	1	8.00
			362	Diversion	feet	110	14.75
			412	Grassed Waterway	acre	0.05	4.10
			600	Terrace	feet	110	7.38
				Total			39.23
South Dakota							
1–2T	1	1	328	Conservation Crop Rotation	acre	1	3.85
			329C	Residue Management (Ridge-till)	acre	1	4.65
			412	Grassed Waterway	acre	0.01	4.02
				Total			12.52
2–4T	1	1	328	Conservation Crop Rotation	acre	1	3.85
			329A,B	Residue Management (No-till & Strip-till)	acre	1	10.78
			330	Contour Farming	acre	1	12.93
			332	Contour Buffer Strips	acre	0.2	6.00
			412	Grassed Waterway	acre	0.01	4.02
				Total			37.58
> 4T	1	1	328	Conservation Crop Rotation	acre	1	3.85
			329A,B	Residue Management (No-till & Strip-till)	acre	1	10.78
			330	Contour Farming	acre	1	12.93
			412	Grassed Waterway	acre	0.01	4.02
			600	Terrace	feet	150	31.30
			620	Underground Outlet	feet	50	25.36
				Total			88.23
Nebraska							
1–2T	1	1	328	Conservation Crop Rotation	acre	1	5.00
			329C	Residue Management (Ridge-till)	acre	1	4.65
			412	Grassed Waterway	acre	0.01	3.41
				Total			13.06

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Nebraska (continued)							
2–4T	1	1	328	Conservation Crop Rotation	acre	1	5.00
			329A,B	Residue Management (No-till & Strip-till)	acre	1	10.78
			330	Contour Farming	acre	1	12.93
			332	Contour Buffer Strips	acre	0.2	6.00
			412	Grassed Waterway	acre	0.01	3.41
				Total			38.12
> 4T	1	1	328	Conservation Crop Rotation	acre	1	5.00
			329A,B	Residue Management (No-till & Strip-till)	acre	1	10.78
			330	Contour Farming	acre	1	12.93
			412	Grassed Waterway	acre	0.01	3.41
			600	Terrace	feet	150	12.07
			620	Underground Outlet	feet	50	24.29
				Total			68.48
Michigan							
1–2T	1	0.15	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			410	Grade Stabilization Structure	each	0.005	2.24
			412	Grassed Waterway	acre	0.05	18.63
			620	Underground Outlet	feet	30	22.35
			638	Water & Sediment Control Basin	each	0.1	17.88
				Total			79.62
	2	0.2	328	Conservation Cropping System	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			410	Grade Stabilization Structure	each	0.05	22.35
			412	Grassed Waterway	acre	0.1	37.26
			600	Terrace	feet	100	22.95
				Total			101.08
	3	0.1	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			410	Grade Stabilization Structure	each	0.005	2.24
			412	Grassed Waterway	acre	0.05	18.63
			590	Nutrient Management	acre	1	5.00
			620	Underground Outlet	feet	30	22.35
			638	Water & Sediment Control Basin	each	0.1	17.88
				Total			84.62

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Michigan (continued)							
	4	0.35	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			412	Grassed Waterway	acre	0.05	18.63
				Total			37.15
	5	0.2	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			410	Grade Stabilization Structure	each	0.005	2.24
			412	Grassed Waterway	acre	0.05	18.63
				Total			39.38
				Weighted total			61.50
2–4T	1	0.15	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			410	Grade Stabilization Structure	each	0.005	2.24
			412	Grassed Waterway	acre	0.05	18.63
			620	Underground Outlet	feet	30	22.35
			638	Water & Sediment Control Basin	each	0.1	17.88
				Total			79.62
	2	0.2	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.5	5.38
			410	Grade Stabilization Structure	each	0.05	22.35
			412	Grassed Waterway	acre	0.05	18.63
			600	Terrace	feet	100	22.95
				Total			87.84
	3	0.1	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	1	10.77
			412	Grassed Waterway	acre	0.05	18.63
			585	Contour Strip-cropping	acre	1	1.58
			620	Underground Outlet	feet	30	22.35
			638	Water & Sediment Control Basin	each	0.1	17.88
				Total			89.73

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

State and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Michigan (continued)							
	4	0.15	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.5	5.38
			412	Grassed Waterway	acre	0.1	37.26
			600	Terrace	feet	100	22.95
				Total			84.11
	5	0.1	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.2	2.15
			332	Contour Buffer Strips	acre	0.1	0.52
			412	Grassed Waterway	acre	0.05	18.63
				Total			39.82
	6	0.1	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.2	2.15
			332	Contour Buffer Strips	acre	0.1	0.52
			412	Grassed Waterway	acre	0.05	18.63
				Total			39.82
	7	0.2	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.5	5.38
			332	Contour Buffer Strips	acre	0.1	0.52
			412	Grassed Waterway	acre	0.1	37.26
				Total			61.68
				Weighted total			71.40
>4T	1	0.15	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			410	Grade Stabilization Structure	each	0.005	2.24
			412	Grassed Waterway	acre	0.05	18.63
			620	Underground Outlet	feet	30	22.35
			638	Water & Sediment Control Basin	each	0.01	1.79
				Total			63.53

Table D–2 Conservation systems for cropland in Land Resource Region M—Continued

SState and erosion class	Conservation system number	Proportion of acres needing system	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre
Michigan (continued)							
	2	0.25	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.5	5.38
			410	Grade Stabilization Structure	each	0.05	22.35
			411	Grasses & Legumes in Rotation	acre	1	0.00
			412	Grassed Waterway	acre	0.1	37.26
			528A	Prescribed Grazing	acre	1	0.37
				Total			83.88
	3	0.15	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.5	5.38
			412	Grassed Waterway	acre	0.1	37.26
			600	Terrace	feet	120	27.54
			620	Underground Outlet	feet	50	37.26
				Total			125.96
	4	0.2	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.75	8.07
			412	Grassed Waterway	acre	0.05	18.63
			585	Contour Strip-cropping	acre	0.75	1.18
				Total			46.41
	5	0.25	328	Conservation Crop Rotation	acre	1	6.52
			329A,B	Residue Management (No-till & Strip-till, Mulch-till)	acre	1	12.00
			330	Contour Farming	acre	0.5	5.38
			412	Grassed Waterway	acre	0.1	37.26
			600	Terrace	feet	120	27.54
			620	Underground Outlet	feet	50	37.26
				Total			125.96
				Weighted total			90.16

Table D–3 Conservation systems for cropland in Land Resource Region R

Erosion class & conser-vation sys. no.	Pro-portion of acres needing ststem	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre by state CT	MA	ME	NH	NY	NJ	PA	RI	VT	OH
1–2T															
1	0.5	328	Conservation Crop Rotation	acre	1	8.83	8.83	8.83	8.83	6.00	8.83	19.32	8.83	5.00	10.80
		329B	Residue Mgt (No-till & Strip-till, Mulch-till, Ridge-till)	acre	1	35.00	35.00	30.89	30.89	18.55	30.89	30.89	35.00	30.89	8.88
		330	Contour Farming	acre	0.8	8.00	8.00	8.00	7.41	4.45	8.00	6.21	8.00	7.41	8.61
		332	Contour Buffer Strips	acre	0.2	4.80	11.92	5.54	7.69	5.16	3.54	3.30	11.92	5.42	2.08
		412	Grassed Waterway	acre	0.1	27.54	27.54	27.54	40.49	27.54	27.54	27.54	27.54	22.10	28.15
		557	Row Arrangement	acre	1	1.49	1.49	1.12	0.30	2.01	0.43	1.09	0.54	0.48	0.37
			Total			85.66	92.78	81.92	95.60	63.71	79.23	88.34	91.83	71.30	58.89
2	0.5	328	Conservation Crop Rotation	acre	1	8.83	8.83	8.83	8.83	6.00	8.83	19.32	8.83	5.00	10.80
		329B	Residue Mgt (No-till & Strip-till, Mulch-till, Ridge-till)	acre	1	35.00	35.00	30.89	30.89	18.55	30.89	30.89	35.00	30.89	8.88
		412	Grassed Waterway	acre	0.1	27.54	27.54	27.54	40.49	27.54	27.54	27.54	27.54	22.10	28.15
		585	Contour Stripcropping	acre	1	4.84	4.84	2.49	2.98	2.92	4.51	5.81	15.74	4.16	4.02
			Total			76.21	76.21	69.75	83.19	55.01	71.77	83.56	87.11	62.15	51.86
			Weighted total			80.93	84.50	75.84	89.40	59.36	75.50	85.95	89.47	66.73	55.37
2–4T															
1	0.4	328	Conservation Crop Rotation	acre	1	8.83	8.83	8.83	8.83	6.00	8.83	19.32	8.83	5.00	10.80
		329B	Residue Mgt (No-till & Strip-till, Mulch-till, Ridge-till)	acre	1	35.00	35.00	30.89	30.89	18.55	30.89	30.89	35.00	30.89	8.88
		330	Contour Farming	acre	0.8	8.00	8.00	8.00	7.41	4.45	8.00	6.21	8.00	7.41	8.61
		332	Contour Buffer Strips	acre	0.2	4.80	11.92	5.54	7.69	5.16	3.54	3.30	11.92	5.42	2.08
		362	Diversion	feet	200	119.22	119.22	186.58	312.96	102.83	117.44	79.88	119.22	77.50	136.81
		412	Grassed Waterway	acre	0.1	27.54	27.54	27.54	40.49	27.54	27.54	27.54	27.54	22.10	56.30
		557	Row Arrangement	acre	1	1.49	1.49	1.12	0.30	2.01	0.43	1.09	0.54	0.48	0.37

See footnote at end of table.

Table D–3 Conservation systems for cropland in Land Resource Region R—Continued

Erosion class & conser-vation sys. no.	Pro-portion of acres needing ststem	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre by state: CT	MA	ME	NH	NY	NJ	PA	RI	VT	OH
2–4T (cont.)															
		638	Water & Sedi-ment Control Basin	each	0.1	25.38	25.38	8.94	14.90	25.38	41.13	28.06	25.38	33.87	35.77
			Total			230.26	237.39	277.45	423.47	191.92	237.80	196.28	236.44	182.67	259.62
2	0.5	328	Conservation Crop Rotation	acre	1	8.83	8.83	8.83	8.83	6.00	8.83	19.32	8.83	5.00	10.80
		329B	Residue Mgt (No-till & Strip-till, Mulch-till, Ridge-till)	acre	1	35.00	35.00	30.89	30.89	18.55	30.89	30.89	35.00	30.89	8.88
		362	Diversion	feet	200	119.22	119.22	186.58	312.96	102.83	117.44	79.88	119.22	77.50	136.81
		412	Grassed Waterway	acre	0.1	27.54	27.54	27.54	40.49	27.54	27.54	27.54	27.54	22.10	56.30
		585/ 586	Contour Strip-cropping or Field Strip-cropping	acre	1	6.71	6.71	5.50	5.59	4.69	4.38	1.90	3.90	12.67	2.71
		638	Water & Sedi-ment Control Basin	each	0.1	25.38	25.38	8.94	14.90	25.38	41.13	28.06	25.38	33.87	35.77
			Total			222.68	222.68	268.29	413.66	185.00	230.20	187.59	219.88	182.03	251.27
3*	0.05	382	Fence	feet	40	10.73	11.92	7.45	32.55	5.96	17.88	7.33	14.55	5.96	16.81
		512	Pastureland & Hayland Planting	acre	1	23.98	59.61	27.72	38.45	25.78	17.70	16.49	59.61	27.12	11.51
		516	Pipeline	feet	50	6.71	19.82	4.62	14.01	18.03	11.55	10.36	12.89	4.84	11.18
		528A	Prescribed Grazing	acre	1	1.49	1.49	1.12	0.30	2.01	0.43	1.09	0.54	0.48	0.37
		574	Spring Devel-opment	each	0.025	7.84	9.92	6.50	5.33	10.95	4.47	2.63	7.84	10.77	6.50
		575	Animal Trails & Walkways	feet	50	41.35	41.35	38.67	62.15	15.72	41.35	23.55	69.37	68.33	172.50
		580	Streambank & Shoreline Protection	feet	15	72.58	72.58	37.42	44.71	43.81	67.62	87.18	236.06	62.46	60.36
		614	Watering Facility	each	0.025	1.49	1.49	1.17	2.40	3.27	1.69	4.46	0.39	2.79	1.85
			Total			166.16	218.18	124.67	199.89	125.55	162.69	153.09	401.25	182.76	281.07

See footnote at end of table.

Table D–3 Conservation systems for cropland in Land Resource Region R—Continued

Erosion class & conser-vation sys. no.	Pro-portion of acres needing ststem	Practice code	Practice name	Unit	Amount per acre	CT	MA	ME	NH	NY	NJ	PA	RI	VT	OH
						Annualized cost per acre by state									
2–4T (cont.)															
4*	0.05	378	Pond	each	0.025	16.73	16.86	10.50	10.99	34.65	6.11	26.89	16.73	13.86	19.63
		382	Fence	feet	40	10.73	11.92	7.45	32.55	5.96	17.88	7.33	14.55	5.96	16.81
		512	Pastureland & Hayland Planting	acre	1	23.98	59.61	27.72	38.45	25.78	17.70	16.49	59.61	27.12	11.51
		516	Pipeline	feet	50	6.71	19.82	4.62	14.01	18.03	11.55	10.36	12.89	4.84	11.18
		528A	Prescribed Grazing	acre	1	1.49	1.49	1.12	0.30	2.01	0.43	1.09	0.54	0.48	0.37
		575	Animal Trails & Walkways	feet	50	41.35	41.35	38.67	62.15	15.72	41.35	23.55	69.37	68.33	172.50
		580	Streambank & Shoreline Protection	feet	15	72.58	72.58	37.42	44.71	43.81	67.62	87.18	236.06	62.46	60.36
		614	Watering Facility	each	0.025	1.49	1.49	1.17	2.40	3.27	1.69	4.46	0.39	2.79	1.85
			Total			175.05	225.12	128.67	205.55	149.24	164.33	177.35	410.14	185.85	294.21
			Weighted total			220.51	228.46	257.79	396.49	183.01	226.57	188.83	245.08	182.51	258.25
>4T															
1	0.4	328	Conservation Crop Rotation	acre	1	8.83	8.83	8.83	8.83	6.00	8.83	19.32	8.83	5.00	10.80
		329B	Residue Mgt (No-till & Strip-till, Mulch-till, Ridge-till)	acre	1	35.00	35.00	30.89	30.89	18.55	30.89	30.89	35.00	30.89	8.88
		330	Contour Farming	acre	0.8	8.00	8.00	8.00	7.41	4.45	8.00	6.21	8.00	7.41	8.61
		332	Contour Buf-fer Strips	acre	0.2	4.80	11.92	5.54	7.69	5.16	3.54	3.30	11.92	5.42	2.08
		340	Cover Crop	acre	1	4.47	4.47	4.11	1.49	2.95	1.84	3.05	4.47	2.64	3.05
		362	Diversion	feet	200	119.22	119.22	186.58	312.96	102.83	117.44	79.88	119.22	77.50	136.81
		412	Grassed Waterway	acre	0.1	27.54	27.54	27.54	40.49	27.54	27.54	27.54	27.54	22.10	56.30
		468	Lined Water-way or Outlet	feet	25	86.33	85.69	120.94	25.48	47.80	60.43	39.38	47.54	55.74	428.37
		638	Water & Sedi-ment Control Basin	each	0.1	25.38	25.38	8.94	14.90	25.38	41.13	28.06	25.38	33.87	35.77
			Total			319.57	326.06	401.37	450.14	240.66	299.64	237.62	287.91	240.56	690.68

See footnote at end of table.

Table D–3 Conservation systems for cropland in Land Resource Region R—Continued

Erosion class & conser-vation sys. no.	Pro-portion of acres needing ststem	Practice code	Practice name	Unit	Amount per acre	CT	MA	ME	NH	NY	NJ	PA	RI	VT	OH
						Annualized cost per acre by state									
>4T (cont.)															
2	0.4	328	Conservation Crop Rotation	acre	1	8.83	8.83	8.83	8.83	6.00	8.83	19.32	8.83	5.00	10.80
		329B	Residue Mgt (No-till & Strip-till, Mulch-till, Ridge-till)	acre	1	35.00	35.00	30.89	30.89	18.55	30.89	30.89	35.00	30.89	8.88
		330	Contour Farming	acre	0.8	8.00	8.00	8.00	7.41	4.45	8.00	6.21	8.00	7.41	8.61
		340	Cover Crop	acre	1	4.47	4.47	4.11	1.49	2.95	1.84	3.05	4.47	2.64	3.05
		600	Terrace	feet	210	125.18	125.18	107.79	107.79	117.36	78.24	161.49	62.59	107.79	108.24
		620	Underground Outlet	feet	100	155.09	78.54	370.49	295.08	55.44	151.26	222.50	133.83	87.33	34.57
		638	Water & Sedi-ment Control Basin	each	0.1	25.38	25.38	8.94	14.90	25.38	41.13	28.06	25.38	33.87	35.77
			Total			361.96	285.41	539.05	466.39	230.13	320.20	471.51	278.10	274.93	209.93
3*	0.1	382	Fence	feet	40	10.73	11.92	7.45	32.55	5.96	17.88	7.33	14.55	5.96	16.81
		512	Pastureland & Hayland Planting	acre	1	23.98	59.61	27.72	38.45	25.78	17.70	16.49	59.61	27.12	11.51
		516	Pipeline	feet	50	6.71	19.82	4.62	14.01	18.03	11.55	10.36	12.89	4.84	11.18
		528A	Prescribed Grazing	acre	1	1.49	1.49	1.12	0.30	2.01	0.43	1.09	0.54	0.48	0.37
		574	Spring Development	each	0.025	7.84	9.92	6.50	5.33	10.95	4.47	2.63	7.84	10.77	6.50
		575	Animal Trails & Walkways	feet	50	41.35	41.35	38.67	62.15	15.72	41.35	23.55	69.37	68.33	172.50
		580	Streambank & Shoreline Protection	feet	15	72.58	72.58	37.42	44.71	43.81	67.62	87.18	236.06	62.46	60.36
		614	Watering Facility	each	0.025	1.49	1.49	1.17	2.40	3.27	1.69	4.46	0.39	2.79	1.85
			Total			166.16	218.18	124.67	199.89	125.55	162.69	153.09	401.25	182.76	281.07
4*	0.1	378	Pond	each	0.025	16.73	16.86	10.50	10.99	34.65	6.11	26.89	16.73	13.86	19.63
		382	Fence	feet	40	10.73	11.92	7.45	32.55	5.96	17.88	7.33	14.55	5.96	16.81
		512	Pastureland & Hayland Planting	acre	1	23.98	59.61	27.72	38.45	25.78	17.70	16.49	59.61	27.12	11.51
		516	Pipeline	feet	50	6.71	19.82	4.62	14.01	18.03	11.55	10.36	12.89	4.84	11.18
		528A	Prescribed Grazing	acre	1	1.49	1.49	1.12	0.30	2.01	0.43	1.09	0.54	0.48	0.37

See footnote at end of table.

Table D–3 Conservation systems for cropland in Land Resource Region R—Continued

Erosion class & conser-vation sys. no.	Pro-portion of acres needing ststem	Practice code	Practice name	Unit	Amount per acre	Annualized cost per acre by state									
						CT	MA	ME	NH	NY	NJ	PA	RI	VT	OH
>4T (cont.)															
		575	Animal Trails & Walkways	feet	50	41.35	41.35	38.67	62.15	15.72	41.35	23.55	69.37	68.33	172.50
		580	Streambank & Shoreline Protection	feet	15	72.58	72.58	37.42	44.71	43.81	67.62	87.18	236.06	62.46	60.36
		614	Watering Facility	each	0.025	1.49	1.49	1.17	2.40	3.27	1.69	4.46	0.39	2.79	1.85
			Total			175.05	225.12	128.67	205.55	149.24	164.33	177.35	410.14	185.85	294.21
			Weighted total			306.73	288.92	401.50	407.16	215.80	280.64	316.70	307.54	243.06	417.77

* Conservation system represents a land use change from cropland to pastureland.

Appendix E CNMP Needs and Costs for Manure and Wastewater Storage and Handling

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Fattened cattle #1: scrape and stack						
Lot upgrade	All	All	15	Head	5.09	0.00
Grassed waterway diversion	All	All	15	Head	.08–.20	0.00
Solids collection	All	All	10	Solids tons	6.20	5.70
Solids storage	Northeast	>35	25	Solids tons	3.50	0.00
	Southeast	>35	25	Solids tons	1.75	0.00
	Midwest	35–500	25	Solids tons	3.50	0.00
Contaminated runoff collection	Northeast	>35	40	Head	0.56–1.31	0.00
	Southeast	>35	55	Head	0.56–1.31	0.00
	Midwest	35–500	40	Head	0.56–1.31	0.00
Runoff storage pond	Northeast	>35	40	AU	25.92	0.00
	Southeast	>35	50	AU	26.23	0.00
	Midwest	35–500	40	AU	20.23	0.00
Liquid transfer	Northeast	>35	40	Liquid tons	0.20–0.40	0.06
	Southeast	>35	50	Liquid tons	0.20–0.40	0.06
	Midwest	35–500	40	Liquid tons	0.20–0.40	0.06
Settling basin	Northeast	>35	40	AU	2.01–5.49	0.00
	Southeast	>35	50	AU	2.01–5.49	0.00
	Midwest	35–500	40	AU	2.01–5.49	0.00
Fattened cattle #2: manure pack						
Lot upgrade	Southeast	>35	30	Head	5.09	0.00
	Midwest	35–500	30	Head	5.09	0.00
	Midwest	>500	5	Head	5.09	0.00
	Northern Plains	35–500	30	Head	5.09	0.00
	Northern Plains	>500	5	Head	5.09	0.00
	Central Plains	35–1,000	30	Head	5.09	0.00
	Central Plains	>1,000	5	Head	5.09	0.00
	West	35–500	30	Head	5.09	0.00
	West	>500	5	Head	5.09	0.00
Earth berm, undergound outlet	Southeast	>35	20	Head	3.58–5.07	0.00
	Midwest	35–500	20	Head	3.58–5.07	0.00
	Midwest	>500	10	Head	3.58–5.07	0.00
	Northern Plains	35–500	20	Head	3.58–5.07	0.00
	Northern Plains	>500	10	Head	3.58–5.07	0.00
	Central Plains	35–1,000	20	Head	3.58–5.07	0.00
	Central Plains	>1,000	10	Head	3.58–5.07	0.00
	West	35–500	20	Head	3.58–5.07	0.00
	West	>500	10	Head	3.58–5.07	0.00
Solids collection	All	All	10	Solids tons	6.20	5.70

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component —Continued

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Contaminated runoff collection	Southeast	>35	60	Head	0.56–1.31	0.00
	Midwest	35–500	60	Head	0.56–1.31	0.00
	Midwest	>500	50	Head	0.56–1.31	0.00
	Northern Plains	35–500	60	Head	0.56–1.31	0.00
	Northern Plains	>500	50	Head	0.56–1.31	0.00
	Central Plains	35–1,000	60	Head	0.56–1.31	0.00
	Central Plains	>1,000	50	Head	0.56–1.31	0.00
	West	35–500	60	Head	0.56–1.31	0.00
	West	>500	50	Head	0.56–1.31	0.00
Runoff storage pond	Southeast	>35	70	AU	17.56	0.00
	Midwest	35–500	70	AU	15.40	0.00
	Midwest	>500	70	AU	13.11	0.00
	Northern Plains	35–500	70	AU	7.41	0.00
	Northern Plains	>500	70	AU	5.75	0.00
	Central Plains	35–1,000	70	AU	5.99	0.00
	Central Plains	>1,000	70	AU	4.95	0.00
	West	35–500	70	AU	4.16	0.00
	West	>500	70	AU	4.07	0.00
Liquid transfer	All	All	70	Liquid tons	0.20–0.40	0.06
Settling basin	All	All	70	AU	2.01–5.49	0.00
Confined heifers # 1: Confinement barn						
Solids collection	All	>35	10	Solids tons	6.20	5.70
Solids storage	All	>35	40	Solids tons	3.50	0.00
Confined heifers # 2: Small lot, scraped						
Lot upgrade	All	All	30	Head	5.09	0.00
Grassed waterway diversion	All	All	15	Head	.08–.20	0.00
Solids collection	All	All	10	Solids tons	6.20	5.70
Solids storage	All but SE	All	25	Solids tons	3.50	0.00
	Southeast	All	25	Solids tons	1.75	0.00
Contaminated runoff collection	Northeast	>35	40	Head	0.56–1.31	0.00
	Midwest	>35	40	Head	0.56–1.31	0.00
	South, West	>35	55	Head	0.56–1.31	0.00
Runoff storage pond	Northeast	>35	40	AU	25.92	0.00
	Midwest	>35	40	AU	20.23	0.00
	Southeast	>35	50	AU	26.23	0.00
	West	>35	50	AU	4.16	0.00
Liquid transfer	Northeast	>35	40	Liquid tons	0.20–0.40	0.06
	Midwest	>35	40	Liquid tons	0.20–0.40	0.06
	South, West	>35	50	Liquid tons	0.20–0.40	0.06
Settling basin	Northeast	>35	40	AU	2.01–5.49	0.00
	Midwest	>35	40	AU	2.01–5.49	0.00
	South, West	>35	50	AU	2.01–5.49	0.00

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component —Continued

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Veal # 1: Confinement house						
Liquid storage	All	All	30	AU	7.12	0.00
Liquid transfer	All	All	30	Liquid tons	0.20–0.40	0.06
Swine # 1: Confinement, liquid system, lagoon						
Mortality management	All	All	70	Farm	1,248.00	0.00
			70	AU	2.20	1.40
Liquid collection	All	All	10	AU	16.50–20.70	8.46
Liquid storage	Southeast	35–100	20	AU	31.39	0.00
	Southeast	>100	20	AU	29.04	0.00
	Midwest, NE	35–500	20	AU	29.00	0.00
	Midwest, NE	>500	20	AU	28.45	0.00
	West	35–500	20	AU	35.43	0.00
	West	>500	20	AU	34.85	0.00
Liquid transfer	All	All	20	Liquid tons	0.20–0.40	0.06
Swine #2: Confinement, slurry system						
Mortality management	All	All	70	Farm	1,248.00	0.00
			70	AU	2.20	1.40
Slurry Storage	Southeast	35–100	60	AU	11.35	0.00
	Southeast	>100	60	AU	9.36	0.00
	Midwest, NE	35–500	60	AU	7.12	0.00
	Midwest, NE	>500	60	AU	5.65	0.00
	West	35–500	60	AU	6.91	0.00
	West	>500	60	AU	5.43	0.00
Liquid transfer	All	All	60	Liquid tons	0.20–0.40	0.06
Swine #3: Open building, slurry pit or flush gutter						
Mortality management	Midwest, NE	35–500	70	Farm	1,248.00	0.00
			70	AU	2.20	1.40
Earthen berm, surface outlet	Midwest, NE	35–500	20	AU	1.28	0.00
Roof runoff management	Midwest, NE	35–500	30	AU	0.85	0.00
Slurry storage	Midwest, NE	35–500	50	AU	10.67	0.00
Liquid transfer	Midwest, NE	35–500	50	Liquid tons	0.20–0.40	0.06
Swine #4: Open building, solids						
Mortality management	Midwest, NE	35–500	70	Farm	1,248.00	0.00
			70	AU	2.20	1.40
Earthen berm, surface outlet	Midwest, NE	35–500	20	AU	1.28	0.00
Roof runoff management	Midwest, NE	35–500	30	AU	0.85	0.00
Solids collection	Midwest, NE	35–500	10	Solids tons	6.20	5.70
Solids storage	Midwest, NE	35–500	60	Solids tons	3.50	0.00
Runoff storage pond	Midwest, NE	35–500	50	AU	8.34	0.00
Liquid transfer	Midwest, NE	35–500	50	Liquid tons	0.20–0.40	0.06
Settling basin	Midwest, NE	35–500	50	AU	2.01–5.49	0.00

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component —Continued

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Swine #5: Pasture or lot						
Mortality management	All	All	70	Farm	1,248.00	0.00
			70	AU	2.20	1.40
Earthen berm, surface outlet	All	All	50	AU	1.28	0.00
Solids collection	All	All	10	Solids tons	6.20	5.70
Contaminated runoff collection	Southeast	35–100	50	AU	1.28	0.00
	West	35–500	50	AU	1.28	0.00
Runoff storage pond	Southeast	35–100	50	AU	9.53	0.00
	West	35–500	50	AU	4.61	0.00
Liquid transfer	All	All	50	Liquid tons	0.20–0.40	0.06
Settling basin	All	All	50	AU	2.01–5.49	0.00
Layer #1: High rise and shallow pit						
Mortality management	All	35–400	45	House	82.00	371.00
	All	>400	15	House	82.00	371.00
Solids collection	All	All	10	House	0.00	1,272.00
Solids storage	All but NE	35–400	55	Solids tons	7.00	0.00
	All but NE	>400	30	Solids tons	7.00	0.00
	Northeast	35–400	40	Solids tons	7.00	0.00
	Northeast	>400	20	Solids tons	7.00	0.00
Layer #2: Flush system to lagoon						
Mortality management	All	35–400	45	House	82.00	371.00
	All	>400	15	House	82.00	371.00
Liquid collection	All	All	10	House	3,157.00	1,291.00
Liquid storage	Southeast	35–400	40	House	15,770.00	0.00
	Southeast	>400	20	House	14,818.00	0.00
	South Central	>400	20	House	14,188.00	0.00
Liquid transfer	All	<400	40	Liquid tons	0.20–0.40	0.06
	All	>400	20	Liquid tons	0.20–0.40	0.06
Layer #3: Manure belt or scraper system						
Mortality management	All	35–400	15	House	82.00	371.00
	All	>400	15	House	82.00	371.00
Solids collection	All	All	10	House	0.00	1,956.00
Solids storage	All but NE	35–400	55	Solids tons	7.00	0.00
	All but NE	>400	55	Solids tons	7.00	0.00
	Northeast	35–400	40	Solids tons	7.00	0.00
	Northeast	>400	20	Solids tons	7.00	0.00
Broilers #1: Broiler house						
Mortality management	All	<220	45	House	140.00	633.00
		>220	15	House	140.00	633.00
Solids collection	All	All	2	House	0.00	1,060.00

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component —Continued

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Solids storage	East	<440	30	Solids tons	7.00	0.00
	West	<440	50	Solids tons	7.00	0.00
	All	>440	25	Solids tons	7.00	0.00
Pullets #1: High rise or shallow pit						
Mortality management	All	<220	45	House	82.00	371.00
	All	>220	15	House	82.00	371.00
Solids collection	All	All	10	House	0.00	1,272.00
Solids storage	N. Central, NE	<440	40	Solids tons	7.00	0.00
	South, West	<440	55	Solids tons	7.00	0.00
	All	>440	25	Solids tons	7.00	0.00
Turkeys #1: Confinement house						
Mortality management	All	<220	60	House	96–187	433–846
		>220	30	House	96–187	433–846
Solids collection	All	All	15	House	0.00	1,060.00
Solids storage	All	<440	50	Solids tons	7.00	0.00
		>440	25	Solids tons	7.00	0.00
Turkeys #2: Turkey ranch						
Mortality management	All	<220	60	House	96–187	433–846
	All	>220	30	House	96–187	433–846
Solids collection	All	All	15	House	0.00	1,060.00
Solids storage	All	<440	50	Solids tons	7.00	0.00
		>440	2	Solids tons	7.00	0.00
Earthen berm, surface outlet	All	All	40	House	111.00	0.00
Roof runoff management	All	All	90	House	473.00	0.00
Contaminated runoff collection	All	All	90	House	111.00	0.00
Runoff storage pond	East	All	90	House	540.87	0.00
	Midwest	All	90	House	467.28	0.00
	CA	All	90	House	415.87	0.00
	West other than CA	All	90	House	458.50	0.00
Liquid transfer	All	All	90	Liquid tons	0.20–0.40	0.06
Settling basin	All	All	90	AU	2.01–5.49	0.00
Dairy #1: no storage						
Roof runoff management	Dairy Belt	All	80	Head	1.18	0.00
Earth berm, undergound outlet	Dairy Belt	All	50	Head	3.58–5.07	0.00
Solids collection	Dairy Belt	All	10	Solids tons	6.20	5.70
Solids storage	Dairy Belt	35–135	100	Solids tons	3.50	0.00
	Dairy Belt	135–270	100	Solids tons	3.50	0.00
Liquid treatment	Dairy Belt	35–135	65	Head	6.00	0.00
Runoff storage pond	Dairy Belt	135–270	80	Head	18.18	0.00
Liquid transfer	Dairy Belt	135–270	80	Liquid tons	0.20–0.40	0.06
Settling basin	Dairy Belt	135–270	80	AU	2.01–5.49	0.00

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component —Continued

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Dairy#2: Solids storage						
Roof runoff management	Dairy Belt	<270	80	Head	1.18	0.00
	Dairy Belt	>270	45	Head	1.18	0.00
	Southeast	All	40	Head	3.77	0.00
	West	All	40	Head	1.18	0.00
Earth berm, undergound outlet	Dairy Belt	<270	50	Head	3.58–5.07	0.00
	Dairy Belt	>270	30	Head	3.58–5.07	0.00
	Southeast	All	20	Head	3.58–5.07	0.00
	West	All	20	Head	3.58–5.07	0.00
Solids collection	All	<270	10	Solids tons	6.20	5.70
Solids storage	Dairy Belt	35–135	20	Solids tons	3.50	0.00
	Dairy Belt	135–270	40	Solids tons	3.50	0.00
	Southeast	35–135	20	Solids tons	1.75	0.00
	Southeast	>135	10	Solids tons	1.75	0.00
	West	35–135	20	Solids tons	3.50	0.00
	West	135–270	20	Solids tons	3.50	0.00
Liquid treatment	All	35–135	75	head	6.00	0.00
Liquid storage	Dairy Belt	>270	100	Head	32.36	0.00
Liquid collection	Dairy Belt	>270	100	Head	23.10	11.84
Runoff storage pond	Dairy Belt	135–270	80	Head	18.18	0.00
	Southeast	>135	80	Head	17.94	0.00
	West	135–270	80	Head	12.00	0.00
Liquid transfer	Dairy Belt	135–270	80	Liquid tons	0.20–0.40	0.06
	Dairy Belt	>270	100	Liquid tons	0.20–0.40	0.06
	Southeast	>135	80	Liquid tons	0.20–0.40	0.06
	West	135–270	80	Liquid tons	0.20–0.40	0.06
Settling basin	Dairy Belt	135–270	80	AU	2.01–5.49	0.00
	Southeast	>135	80	AU	2.01–5.49	0.00
	West	135–270	80	AU	2.01–5.49	0.00
Dairy #3: Liquid/slurry storage in pit or tank						
Roof runoff management	Dairy Belt	All	40	Head	1.18	0.00
Earth berm, undergound outlet	Dairy Belt	All	30	Head	3.58–5.07	0.00
Slurry storage	Dairy Belt	35–135	20	Head	18.39	0.00
	Dairy Belt	135–270	30	Head	15.05	0.00
	Dairy Belt	>270	20	Head	15.05	0.00
Liquid transfer	Dairy Belt	35–135	30	Liquid tons	0.20–0.40	0.06
	Dairy Belt	135–270	30	Liquid tons	0.20–0.40	0.06
	Dairy Belt	>270	20	Liquid tons	0.20–0.40	0.06
Dairy #4: Liquid system, pond or lagoon						
Roof runoff management	Dairy Belt	All	40	Head	1.18	0.00
Earth berm, undergound outlet	Dairy Belt	All	40	Head	3.58–5.07	0.00

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component —Continued

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Liquid collection	Dairy Belt	35–135	30	Head	23.10–28.99	11.84
	Dairy Belt	135–270	30	Head	23.10–28.100	11.84
	Dairy Belt	>270	20	Head	23.10	11.84
Liquid storage	Dairy Belt	35–135	20	Head	35.46	0.00
	Dairy Belt	135–270	30	Head	38.81	0.00
	Dairy Belt	>270	40	Head	32.36	0.00
Liquid transfer	Dairy Belt	35–135	30	Liquid tons	0.20–0.40	0.06
	Dairy Belt	135–270	30	Liquid tons	0.20–0.40	0.06
	Dairy Belt	>270	20	Liquid tons	0.20–0.40	0.06
Dairy #5: Liquid or slurry system (West, Southeast)						
Roof runoff management	Southeast	All	40	Head	2.37	0.00
	West	All	40	Head	1.18	0.00
Earth berm, undergound outlet	Southeast	All	20	Head	3.58–5.07	0.00
	West	<270	20	Head	3.58–5.07	0.00
	West	>270	15	Head	3.58–5.07	0.00
Solids collection	All	All	10	Solids tons	6.20	5.70
Liquid collection	Southeast	All	40	Head	23.10–28.99	11.84
	West	35–135	40	Head	23.10–28.99	11.84
	West	135–270	40	Head	23.10–28.99	11.84
	West	>270	20	Head	23.10	11.84
Liquid storage	Southeast	35–135	30	Head	42.40	0.00
	Southeast	>135	30	Head	34.08	0.00
	West	35–135	30	Head	43.13	0.00
	West	135–270	30	Head	34.99	0.00
	West	>270	20	Head	38.87	0.00
Liquid transfer	Southeast	35–135	30	Liquid tons	0.20–0.40	0.06
	Southeast	>135	30	Liquid tons	0.20–0.40	0.06
	West	35–135	30	Liquid tons	0.20–0.40	0.06
	West	135–270	30	Liquid tons	0.20–0.40	0.06
	West	>270	20	Liquid tons	0.20–0.40	0.06
Pastured livestock #1: Pasture with heavy use protection						
Fence	South	All	30	AU	4.20	0.00
	Northeast	>70 AU	30	AU	4.20	0.00
Heavy Use Area Protection	South	All	50	AU	2.32–6.35	0.00
	Northeast	>70 AU	50	AU	2.32–6.35	0.00
Water Well	South	All	40	Farm	820.00	0.00
	Northeast	>70 AU	40	Farm	820.00	0.00
Watering Facility	South	All	40	AU	3.35	0.00
	Northeast	>70 AU	40	AU	3.35	0.00

Table E–1 CNMP needs and costs for manure and wastewater handling and storage, by representative farm and component —Continued

Representative farm and component	Model farm region	Model farm size class (AU)	CNMP needs (%)	Cost unit	Capital cost per unit ($)	Operating cost per unit ($)
Pastured livestock #2: Pasture with windbreak/shelter						
Fence	West Coast States	All	30	AU	4.20	0.00
	Northern Plains, Mountain States	All	30	AU	4.20	0.00
Water Well	West Coast States	All	40	Farm	820.00	0.00
	Northern Plains, Mountain States	All	40	Farm	820.00	0.00
Watering Facility	West Coast States	All	40	AU	3.35	0.00
Watering Facility, frost free	Northern Plains, Mountain States	All	40	AU	13.41	0.00
Windbreak/Shelterbelt	West Coast States	All	50	AU	4.51–7.51	0.00
	Northern Plains, Mountain States	All	50	AU	4.51–7.51	0.00
Pastured livestock #3: Pasture, lot and scrape–and–stack						
Fence	Midwest	All	30	AU	4.20	0.00
Filter strip	Midwest	All	30	AU	1.23	0.00
Solids storage	Midwest	All	50	Solids tons	1.85	0.00
Pastured livestock #4: Pasture with barn for shelter						
Fence	Lake States	All	30	AU	4.20	0.00
	Northeast	<70 AU	30	AU	4.20	0.00
Filter strip	Lake States	All	30	AU	1.23	0.00
	Northeast	<70 AU	30	AU	1.23	0.00
Solids storage	Lake States	All	50	Solids tons	1.85	0.00
	Northeast	<70 AU	50	Solids tons	1.85	0.00