THE POTENTIAL ECONOMIC IMPACTS OF PROPOSED CONCENTRATED ANIMAL FEEDING OPERATIONS REGULATIONS ON THE SWINE/PORK INDUSTRY

By

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CHAPTER I

INTRODUCTION

Introduction

An examination of hog and pig inventories in the United States will show that there has been a fairly steady increase in those numbers from 51 million head in 1986, to the recent peak of 62 million in 1998 (see Figure 1-1). Concurrent to this rise in hog and pig numbers, there has been a notable change in the structure of the swine industry. Increasingly, swine production is occurring on large confinement operations. Not only are these production operations growing more management- and capital-intensive, but they continue to grow in capacity. While these larger operations enjoy a number of improved efficiencies, they also pose potential environmental hazards unless properly managed.

As a result of these trends, the swine industry has been subject to a significantly increased amount of regulatory scrutiny in recent years, at both state and federal levels. As further regulatory actions seem likely, public decision-makers and producers alike need to be aware of the impacts such regulations can have on the costs of swine production. Thus, this research will seek to answer the question "What are the likely firm-level economic impacts of proposed environmental regulations for the swine industry?"

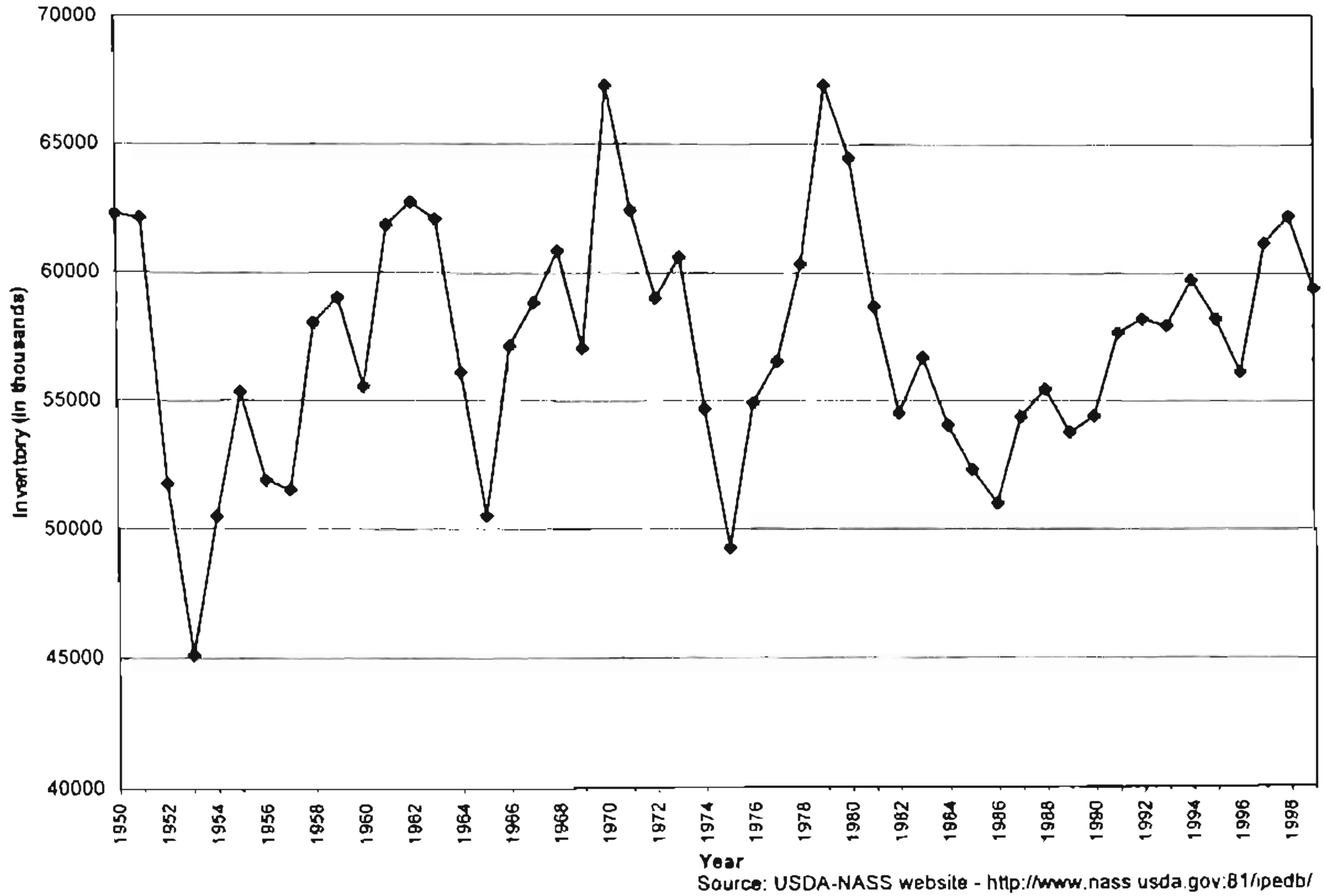


Figure 1-1. United States Hog and Pig Inventory, 1950 – 1999

Problem Statement

The swine industry has long been an important component of the United States' agriculture sector. As an animal that can efficiently convert a number of feedstuffs into meat, hogs have been used on a broad array of farms to add value to grain and forage production, and to diversify the farms' enterprise mixes. While this function of swine in the agricultural economy was prominent for many decades, recent times have brought pronounced changes in the swine industry. The reader may observe such changes to be analogous to the revolutionary innovation in both production technology and industry structure experienced by the poultry industry beginning in the 1950's.

Advancements in agricultural technology have led to farms that, like manufacturing operations, have substituted capital for labor, thereby producing operations which require a large amount of investment in production assets such as facilities. equipment, and (though more financially liquid than the previously mentioned items) genetically advanced breeding stock. As microeconomic theory would predict, agricultural producers have begun to increase the scales of their operations to spread the fixed ownership costs of such assets over a greater volume of commodity production. Accordingly, the swine industry has seen a shift away from small operations that raise hogs and pigs in open conditions as an auxiliary enterprise to large scale operations that may house a thousand or more of these animals in enclosed environments specifically engineered to maximize the animals' productive potential.

While such intensive operations seem prudent from an economic perspective by increasing the efficiency of labor, management, and financial resources, they also pose environmental challenges. In the case of well-managed range livestock production, the stocking rate of animals per unit of land is carefully balanced so that here the number of animals is roughly equivalent to the carrying capacity of the land they occupy. This is not the case with confinement swine operations. Obviously, a swine finishing operation that houses four thousand pigs in facilities occupying sixteen acres of land vastly exceeds the natural carrying capacity of that land. As feeds are imported to support the swine, they produce more waste than can be absorbed and utilized by the vegetation on the land they occupy. In turn, both environmental and economic factors dictate that the waste produced by the swine be managed in such a way that it may be efficiently utilized by other production activities while not posing significant negative environmental impacts.

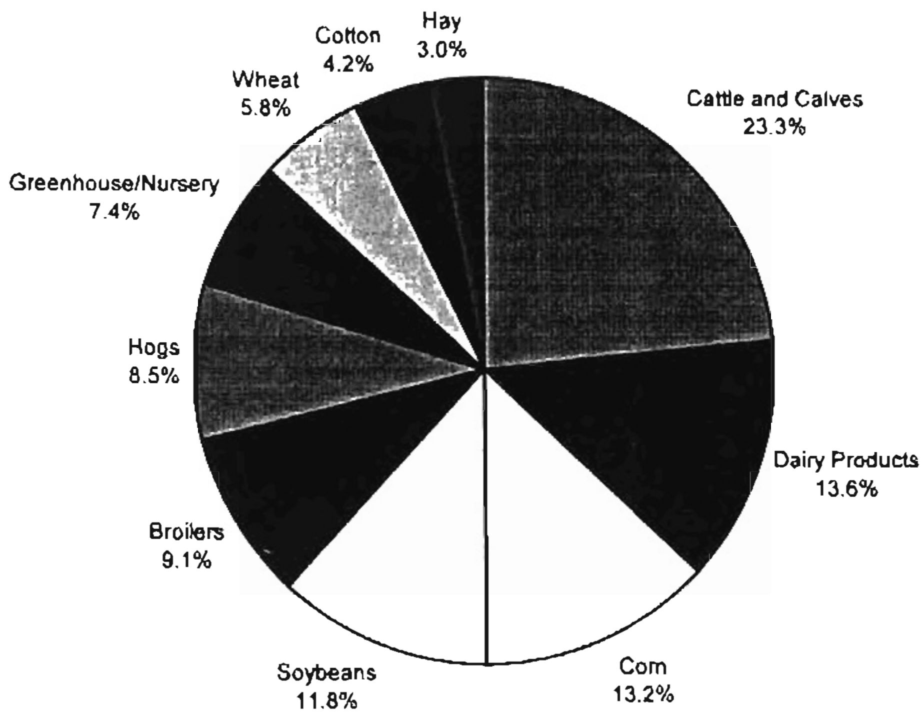
The issue of waste management mentioned above has attracted a great deal of legislative attention of late, particularly in those areas where the swine industry has experienced dramatic growth in a relatively short time. This growth was not necessarily unanticipated; in some cases, it was even invited. Seeking to provide opportunities for economic development and a way to stabilize farm incomes, many rural communities actively recruited large-scale swine operations (Luce and Williams). While the growth of such operations has, in some cases, generated improved farm incomes and economic growth for rural communities, it has also posed concerns about environmental issues such as air and water quality. Some of the communities that solicited these operations are now reeling from public discontent at the perceived hazards attendant to the presence of CAFOs. In response to these concerns, legislators in several states have passed a variety of measures both prescribing certain management practices for swine production operations and banning others. As the regulatory environment in which swine production operates grows increasingly restrictive, policy makers must begin to determine the point at which environmental and economic concerns come into equilibrium.

The Swine Industry in the United States

An understanding of the swine industry's development is fundamental to predictions of its future. As mentioned previously, pork has long been an important agricultural commodity in the United States. According to USDA-NASS, the total value of U.S. swine and pork products sold in 1997 (the most recent year for which complete data is available) was $13.1 billion. This placed swine commodities fourth overall in the value of livestock products sold in that year and sixth overall in all agricultural commodities, as depicted in Figure 1-2. In that year, 34.9 million head of feeder pigs and 107.6 million head of other pigs were sold.

The most recent estimates by USDA-NASS placed the December 1, 1999 inventory of all hogs and pigs in the United States at 59.4 million head. Referring back to Figure 1-1, the U.S. hog and pig inventory has seen a good deal of variation over the past fifty years, ranging from a low of 45.1 million head in 1953 to a high of 67.3 million head in 1979. In a matter similar to the cattle inventories, swine inventories and prices seem to exhibit a cyclical nature: an eight-year cycle, and a four-year sub-cycle. While inventory numbers in recent years have remained relatively high, the most interesting aspect of swine inventories lies not in the national figures, but in the increasing concentration of swine among production operations and regions.

These shifts in production concentration become evident upon examination of the relevant data. In 1974, there were 470,258 U.S. farm operations with hogs and pigs.



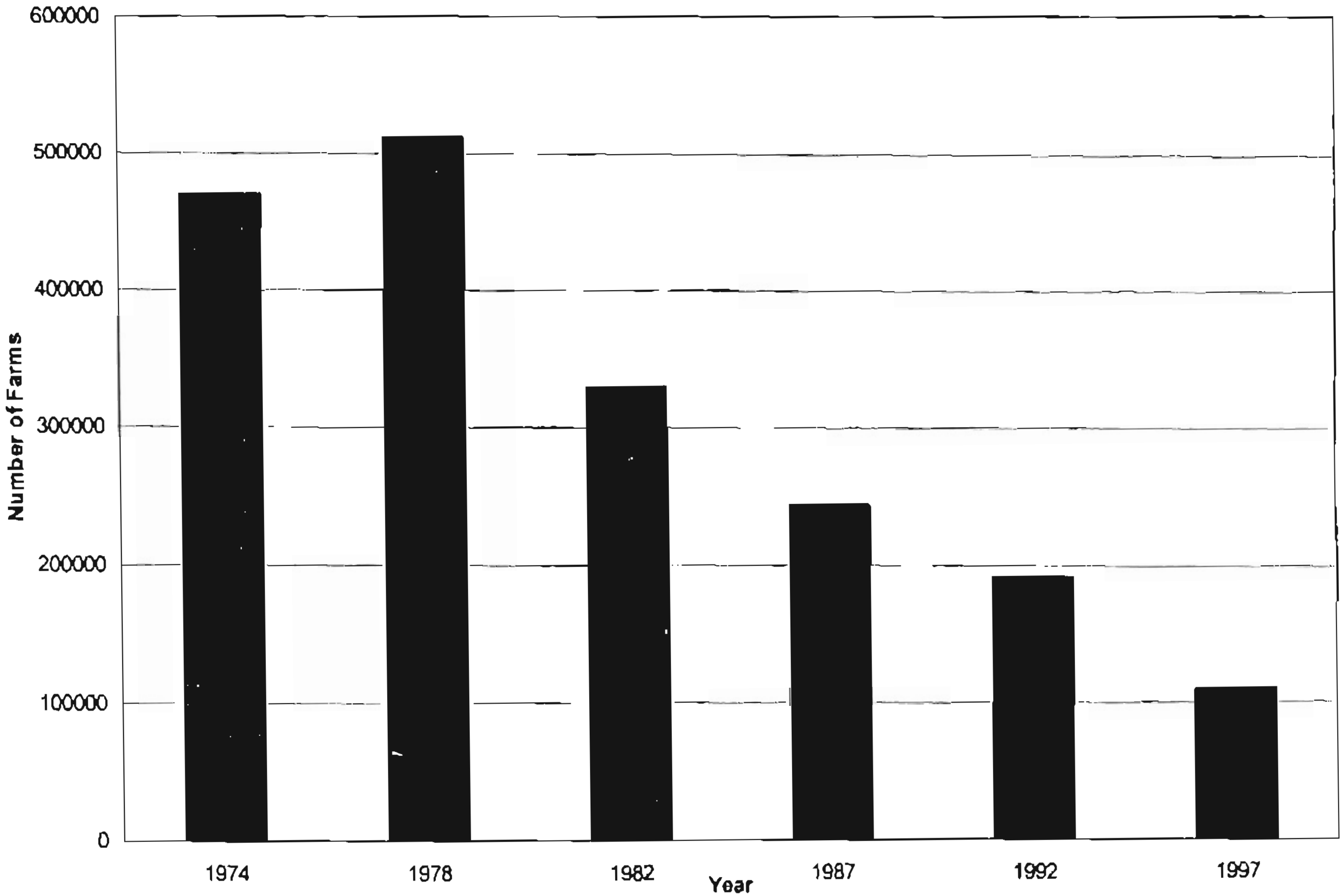
Source: 1999 Statistical Highlights, USDA-

Figure 1-2. United States: Top Ten Agricultural Commodites by Cash Receipts, 1997

Referring to Figure 1-3, on can see that since that time, there has been a steady decline in this number with each census assessment, with the exception of the 1978 census (the reader may recall that this was a time of near-record farm profits. which lead to increased firm entry into a number of agricultural sectors). In 1997, the number of operations with hogs and pigs had declined to 109,754 – a decrease of 76.6%. While this might be expected in a period of contracting inventories, hog and pig inventories have been increasing since 1986. Thus, it can be seen that the swine industry has become more concentrated, and implies that a number of swine production operations have grown in scale.

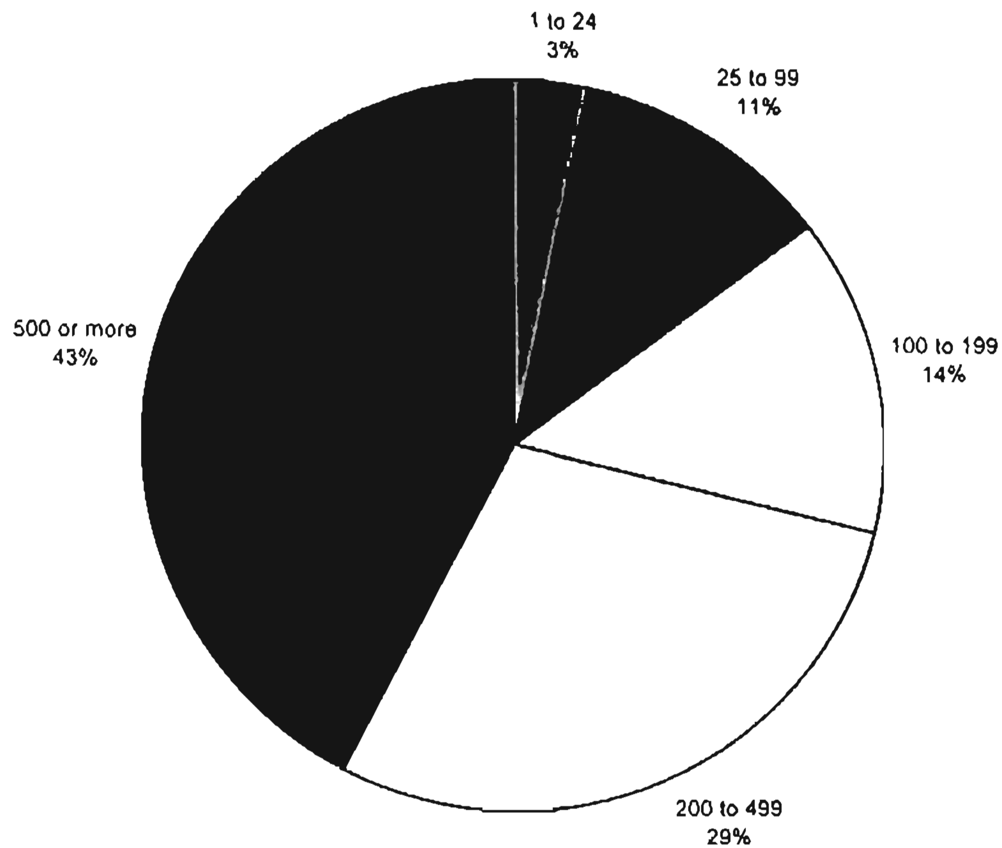
As shown in Figure 1-4, all farms with inventories from one to 199 hogs and pigs accounted for about 28% of the total U.S. hog and pig inventory in 1978 (the Agricultural Census year with the largest number of swine operations in recent times), roughly equal to the proportion of inventory held by farms with 200 to 499 head (29%). Farms with more than 500 head accounted for 43%. Figure 1-5 shows that, by 1997, this picture had changed radically. Farms with one to 199 head accounted for only 4.1% of the U.S. inventory, farms with 200 to 499 head accounted for 8.5%, and farms with 500 or more head accounted for an overwhelming 87.4%.

If one were to break the inventory data down to smaller strata, it could be seen that farms with 1000 head or more accounted for 75.3% of the national inventory. Figure 1-6 shows the increasing hog and pig inventories on these farms, and Figure 1-7 illustrates the increasing number of such operations. While there have been dramatic changes in the concentration of swine production with larger operations, noticeable changes have taken place in the geographic concentration of swine production as well.



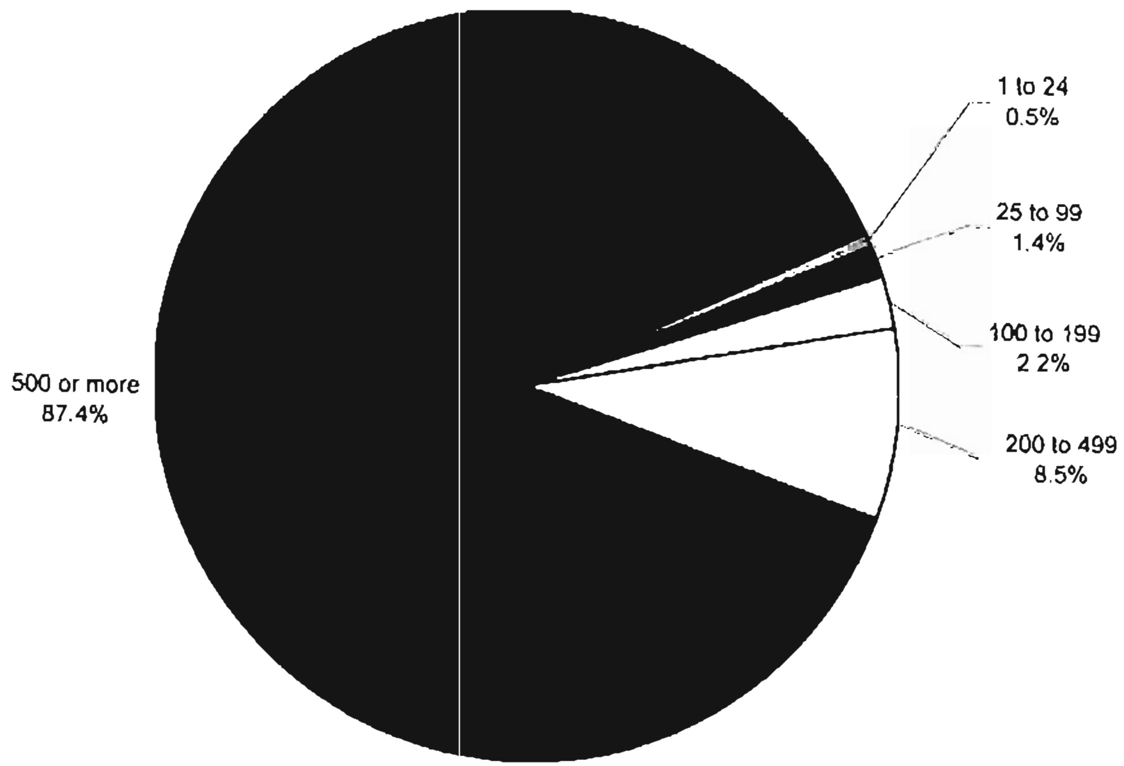
Source: USDA-NASS Census of Agriculture, 1978, 1982, 1987, 1992, 1997

Figure 1-3. Number of United States Farms with Hogs and Pigs, 1974 - 1997



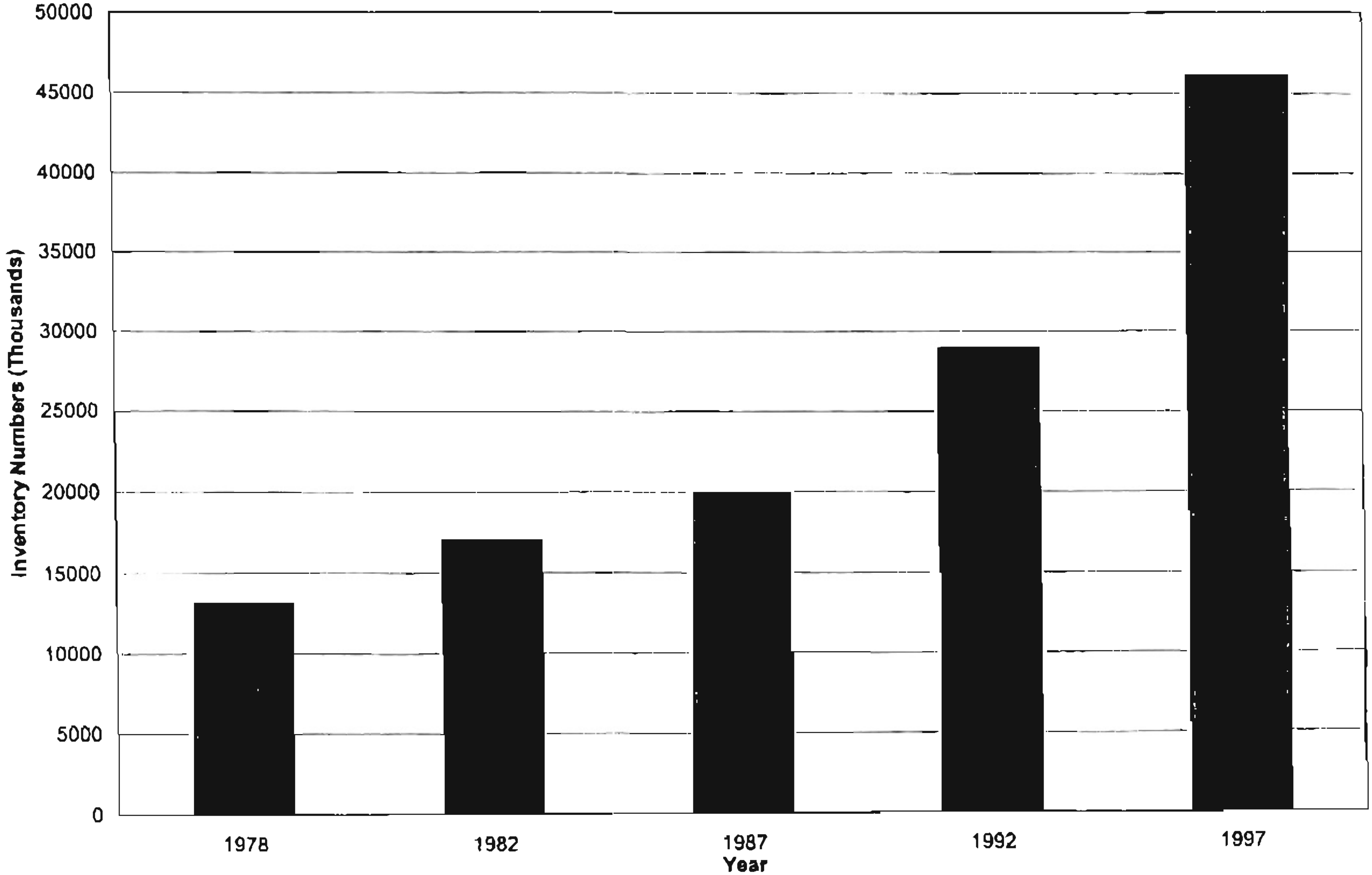
Source: USDA-NASS Census of Agriculture, 1978

Figure 1-4. United States Hog and Pig Inventory by Herd Size, 1978



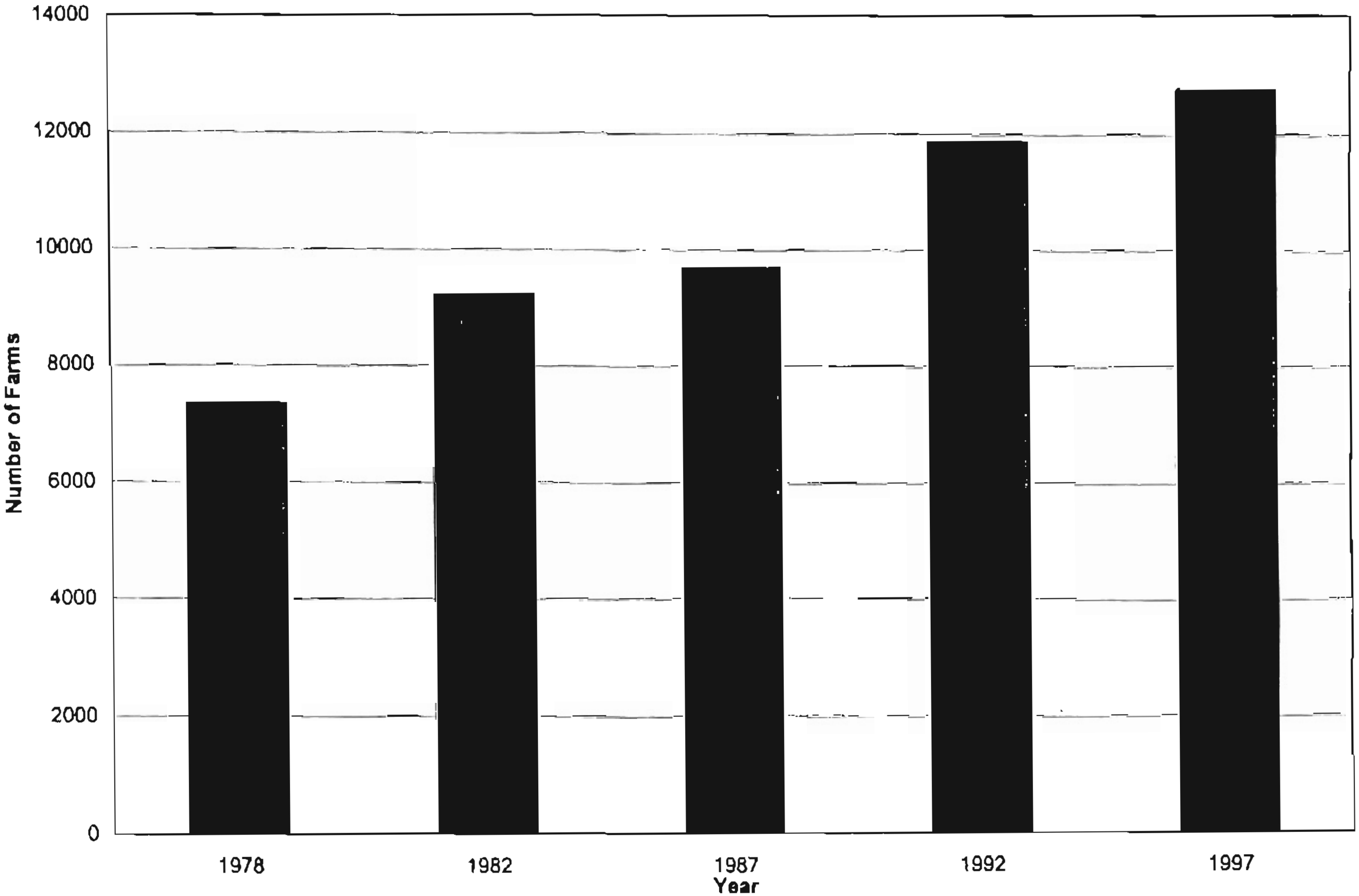
Source: USDA-NASS Census of Agriculture, 1997

Figure 1-5. United States Hog and Pig Inventory by Farm Size, 1997



Source: USDA-NASS Census of Agriculture, 1978, 1982, 1987, 1992, 1997

Figure 1-6. United States Hogs and Pigs Inventory on Farms with More than 1000 Hogs and Pigs



Source: USDA-NASS Census of Agriculture, 1978, 1982, 1987, 1992, 1997

Figure 1-7. Number of United States Farms with 1000 or more Hogs and Pigs, 1978 - 1997

Traditionally, swine production has been concentrated in the Corn Belt states. (Mathis). In 1987, Iowa, Illinois, and Indiana accounted for approximately 44% of the national hog inventory. Again in 1991, three states accounted for nearly 50% of the national hog inventory. Two of these states were traditional Corn Belt leaders in swine production – Iowa and Minnesota. However, the state with the second highest inventory of hogs and pigs was now North Carolina.

Another notable newcomer to the top ten states in swine production was Oklahoma, which, although historically fairly consistent in ranking near 23rd among states in swine production, was now suddenly ninth (and has moved into eighth place since the 1997 Census of Agriculture data were compiled). Figure 1-8 shows the hog and pig inventories of Iowa, North Carolina, and Oklahoma. The traditional leadership of Iowa in swine production, and the recent prominence of North Carolina and Oklahoma, lead to their closer examination in the course of this research.

The Importance of the Swine Industry in Iowa, North Carolina, and Oklahoma

In each of the states examined, the swine industry is a significant contributor to the agriculture industry, and even to the overall state economy in some instances. The following sections will give a more detailed description of the swine industry in each state examined in the research.

Iowa For many years, Iowa has led the nation in swine production, a position usually ascribed to the state's proximity to corn and other operational inputs at affordable costs. Over the past fifty years, Iowa alone has accounted for an average of approximately 24% of all swine production in the United States. Within the state of Iowa

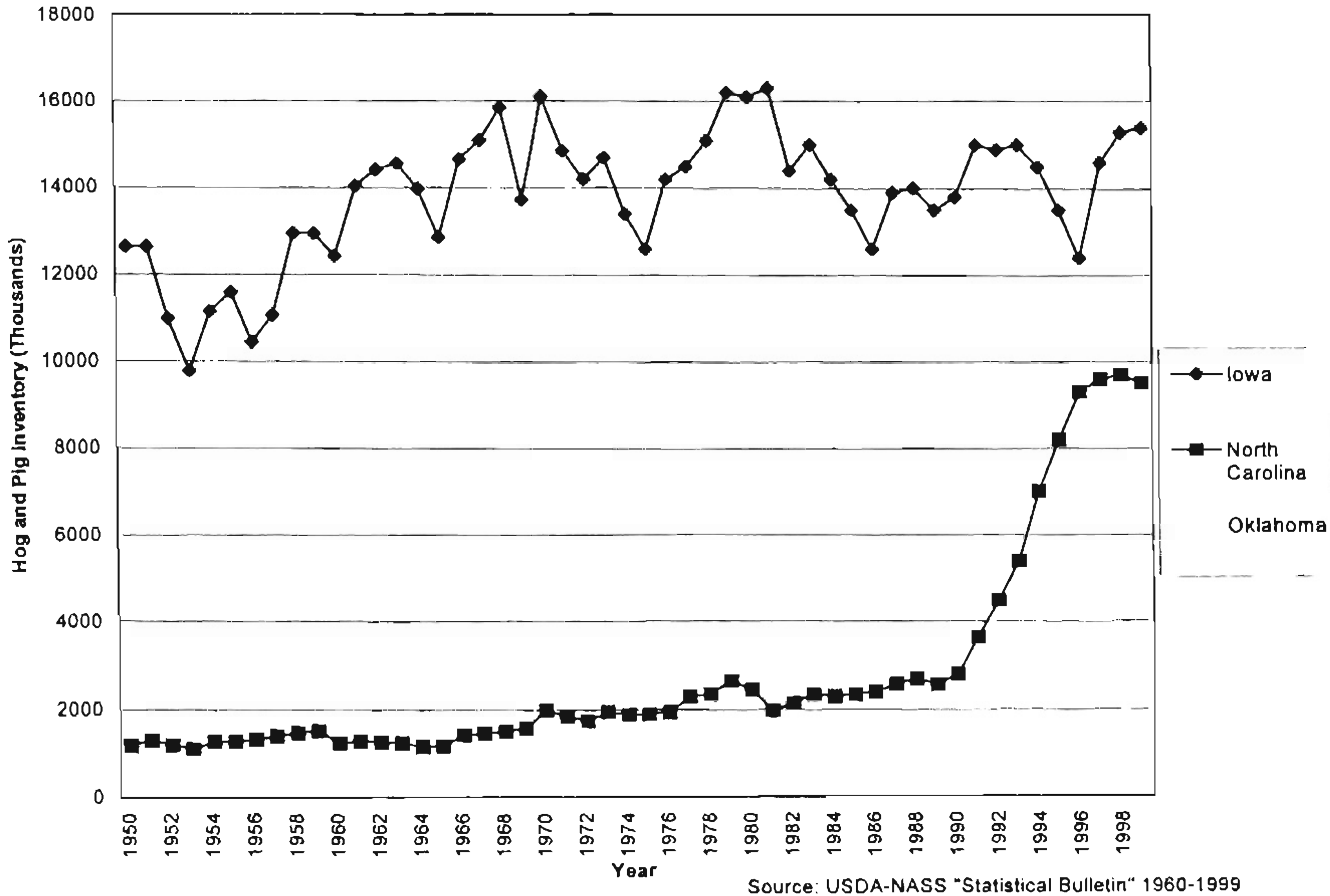


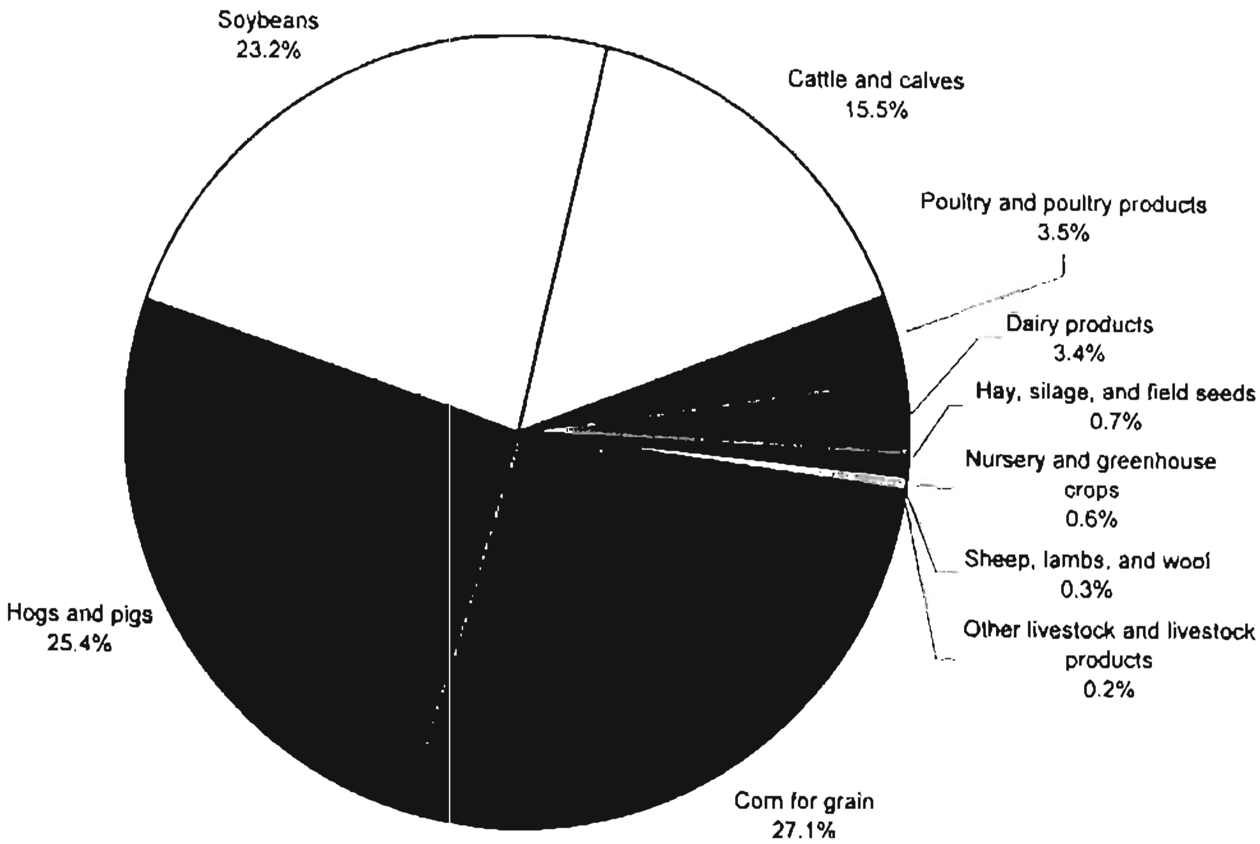
Figure 1-8. Hog and Pig Inventories for Iowa, North Carolina, and Oklahoma, 1950 - 1999

itself, swine production ranks second only to corn in the value of production according to the 1997 Census of Agriculture, with census year sales of $3.0 billion, accounting for 25.4% of the value of all agricultural commodity sales in the state (as illustrated in Figure 1-9).

Iowa's inventory of swine has been fairly consistent for a number of years. Over the last fifty years, swine numbers in the state have had a minimum of 9.7 million head, and a maximum of 16.3 million head. Relative to North Carolina and Oklahoma, Iowa's swine inventory over the past 50 years has had a smaller standard deviation; this is noteworthy given Iowa's consistent domination of the other states in inventory numbers.

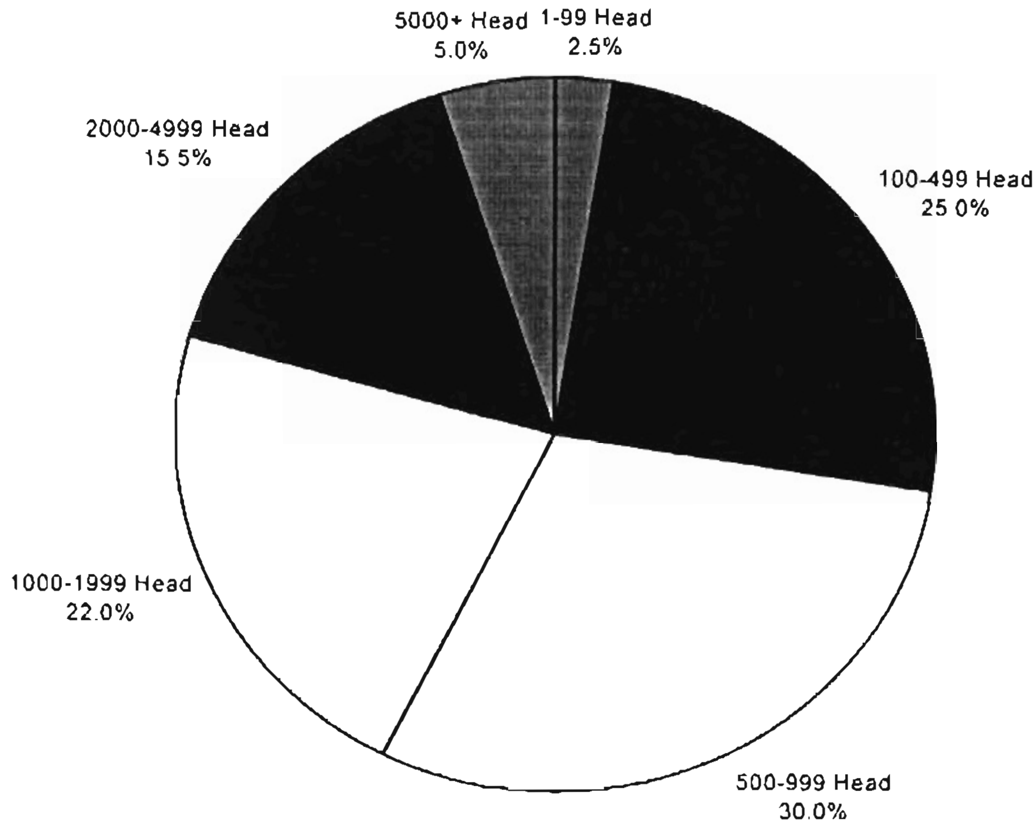
While the swine industry in Iowa may not have experienced the same rapid increase as North Carolina and Oklahoma, it has seen a trend towards a greater concentration of production in larger operations. In 1993 (the earliest year in which the current inventory strata were employed by the USDA-NASS), the inventory of hogs and pigs in the state was not dominated by any one size category. Farms in the 100-499 head class accounted for 25% of the state inventory, farms in the 500-999 head class, 30%, farms in the 1000-1999 head class, 22%, and farms in the 2000-4999 head class, 15.5%. At that point in time, farms with more than 5000 head of hogs and pigs accounted for only five percent of the state inventory. Figure 1-10 illustrates these relative inventories. In 1997, however, this picture had changed, as operations with more than 5000 head then held 35% of the state hog and pig inventory, as illustrated in Figure 1-11.

Given that Iowa has historically dominated all other states, and that its inventory of hogs and pigs continues to trend generally upward, an analysis of swine production would be remiss not to account for Iowa's influence on the national scope of the industry.



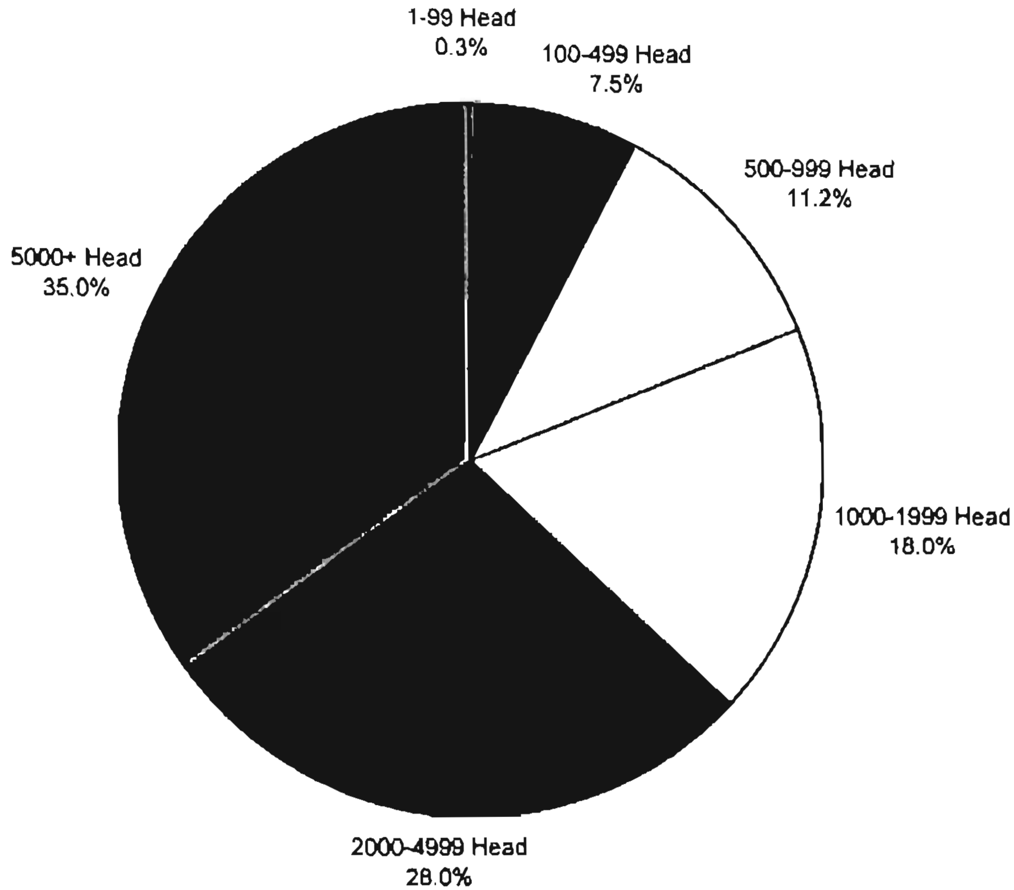
Source. USDA-NASS "Statistical Bulletin" - http://www nass.usda.gov

Figure 1-9. Iowa - Top Ten Agricultural Commodities by Sales, 1997



Source: USDA-NASS "Statistical Bulletin" - http //www.nass usda gov

Figure 1-10. Iowa Hog and Pig Inventory by Farm Size, 1993

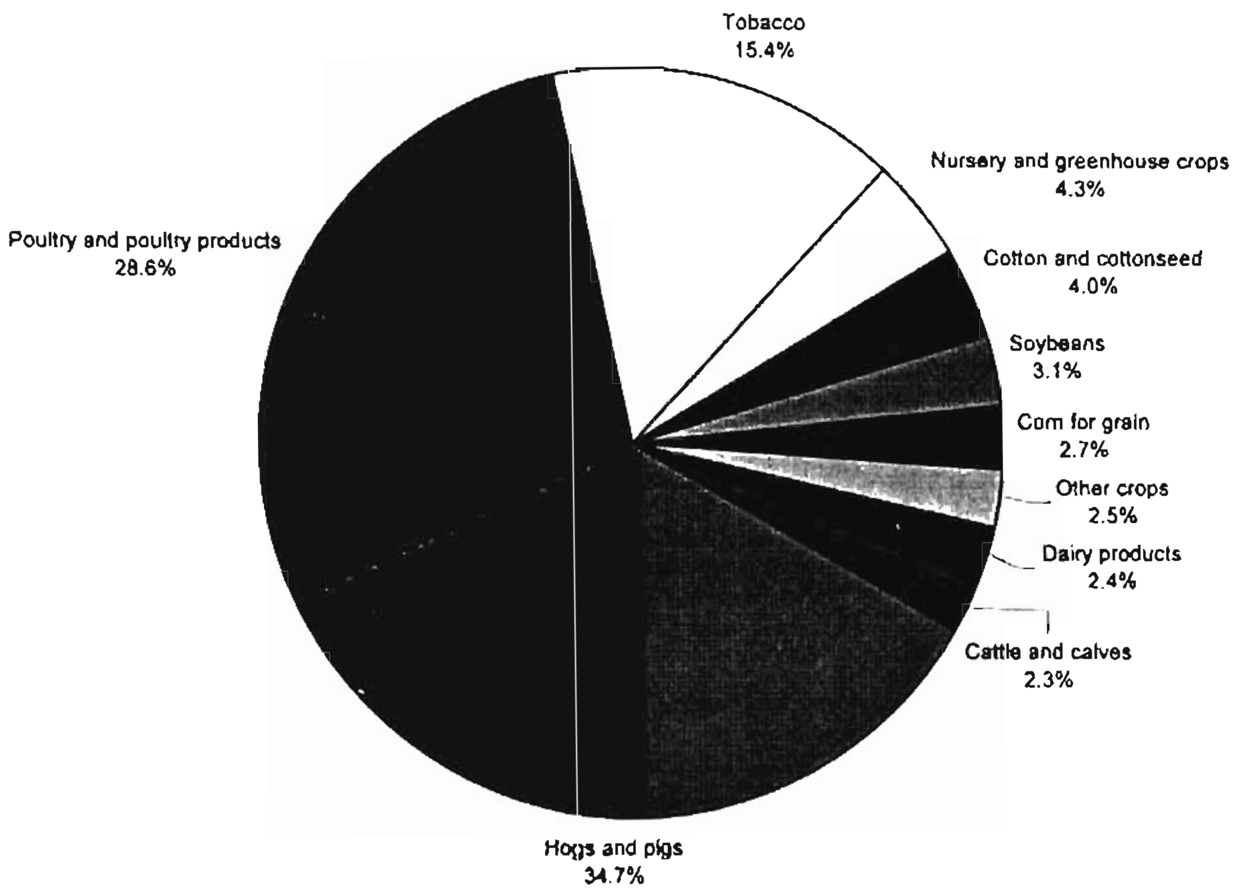


Source: USDA-NASS "Statistical Bulletin" - http://www.nass.usda.gov

Figure 1-11. Iowa Hog and Pig Inventory by Farm Size, 1999

North Carolina Referring back to Figure 1-8, it can be seen that, although North Carolina's inventory of hogs and pigs has been steadily increasing over the past fifty years, it has been in a period of dramatic increase since 1990, going from 2.8 million head in that year to a peak of 9.7 million in 1998. This has propelled hogs and pigs to the position of most important agricultural commodity for the state by cash receipts, as shown by Figure 1-12. Over the course of the 1990's, the state's swine industry has been dominated by larger operations, with farms in the 5000+ head class accounting for 63% of the inventory of hogs and pigs in 1993, and for 73% in 1999.

According to Zering (2000), the rapid growth of pig production in North Carolina can be attributed primarily to three factors, some of which are unique North Carolina's environment, while others are due to the influence of development efforts. First, the land base for a large number of North Carolina farms is relatively small (averaging about 160 acres). Historically, North Carolina farmers have relied on the tobacco industry to provide viable incomes. Realizing the hazard of single-enterprise dependence, agricultural economists determined in the early 1960's that pig production offered the best hope for North Carolina farmers to diversify out of reliance on tobacco production; accordingly, state officials worked to place a significant amount of resources and personnel into swine research. As a result, the state developed a number of production technologies and management practices that are now staples in concentrated swine feeding, such as concrete gang slats, indoor farrowing facilities, and more recently, improved nurseries, all-in, all-out pig movements and three site production protocols. These innovations created feed conversion rates, farrowing performance, and livability levels that were far superior to the standards set by traditional farrow to finish farms.



Source: USDA-NASS "Statistical Bulletin" - http://www.nass.usda.gov

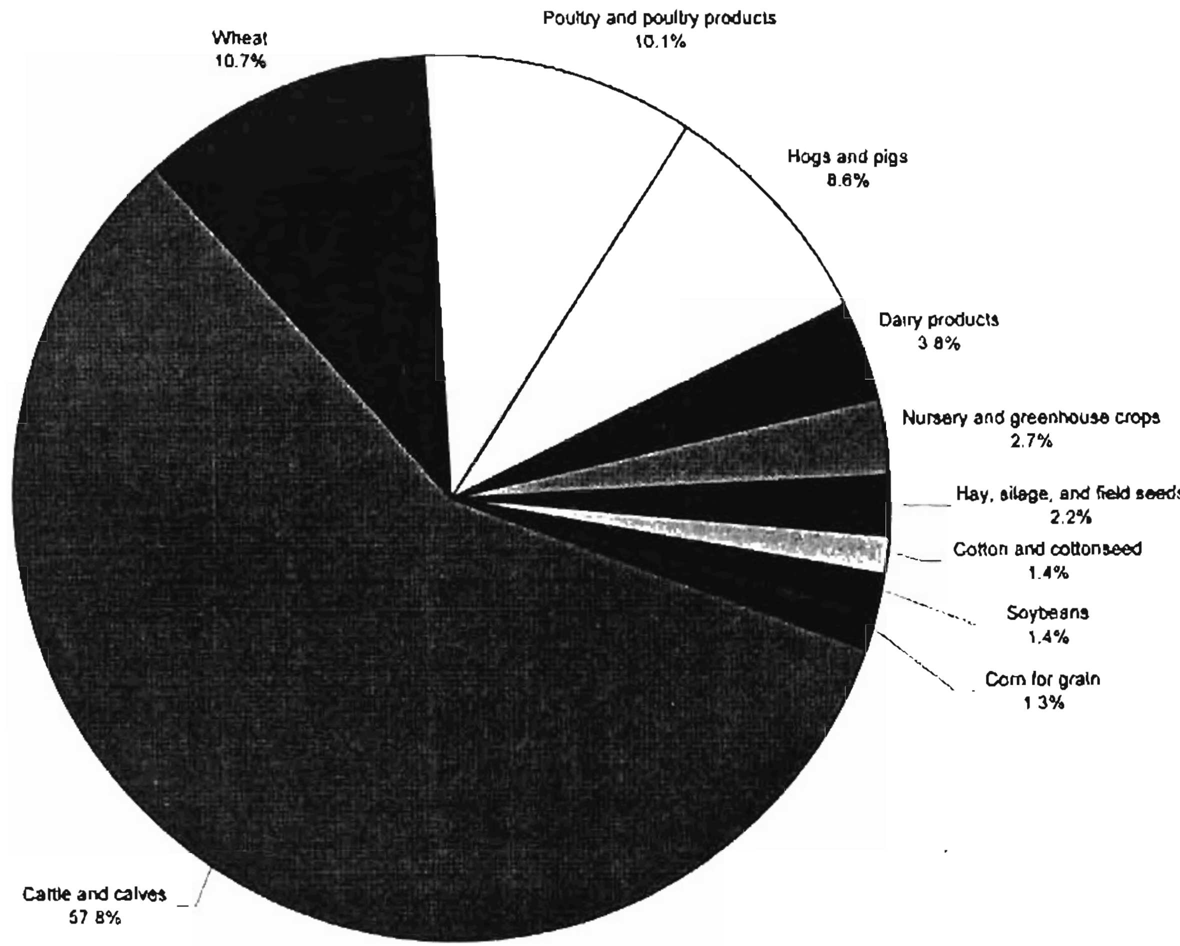
Figure 1-12. North Carolina - Top Ten Agricultural Commodities by Sales, 1997

Secondly, many rural communities offered a receptive political environment, since their condition (among some of the poorest counties in the state and the country) begged for development initiatives. Large-scale production operations offered employment opportunities where other industries had been reduced or eliminated. Also, although some of the work associated with concentrated, intensive feeding operations requires previous training, such operations still offer many other tasks are suitable for individuals with little formal education.

Finally, the opening of a Smithfield Foods processing plant facilitated large-scale expansion of the North Carolina swine industry, along with the fact that North Carolina does not have anti-corporate farming regulations and until recently had 'right-to-farm' laws.

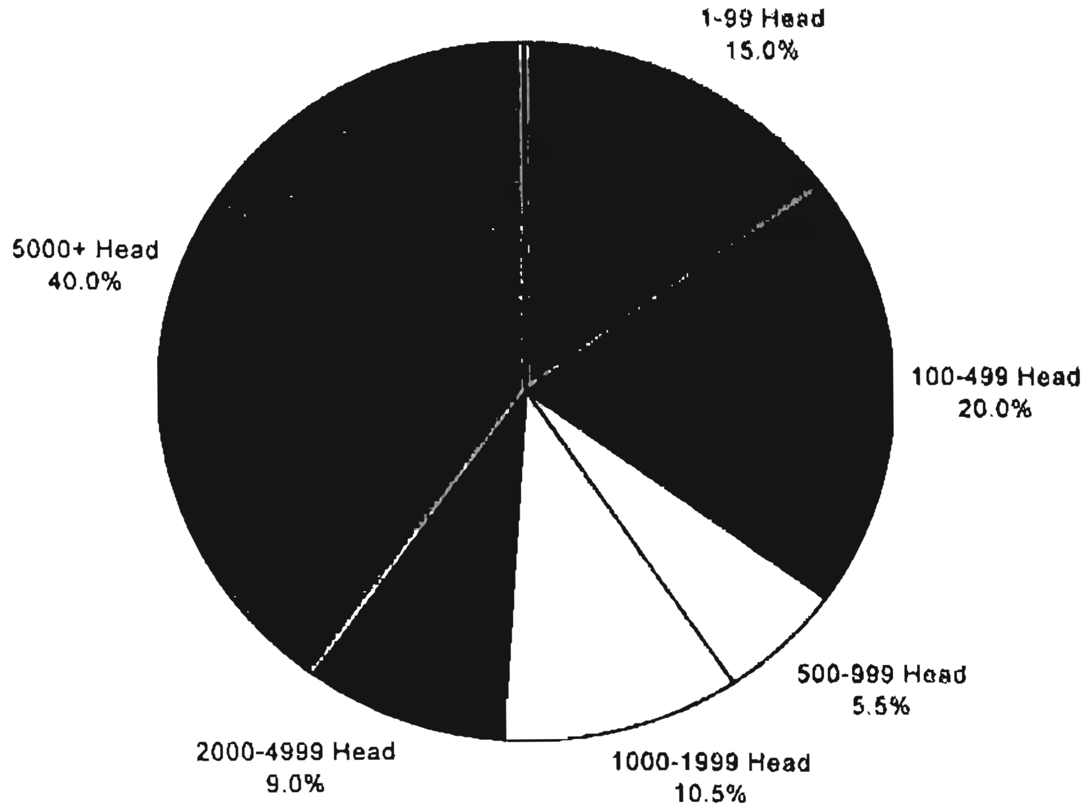
<u>Oklahoma</u> The swine industry has grown from a relatively small part of Oklahoma's agricultural sector to become the state's fifth most important agricultural commodity, as depicted in Figure 1-13. Referring back to Figure 8, it can be seen that the rapid increase in Oklahoma hog and pig inventories began in 1991. The state's inventory of hogs and pigs increased by 832% from December of that year to March of 1998. Virtually all of the increase in Oklahoma swine inventories came in large confinement operations, as illustrated by the shifts in inventory share depicted in Figures 1-14 and 1-15.

Luce and Williams (1999) set forth a number of state aspects that make Oklahoma favorable for swine production. First, it has a mild climate, with generally warmer winters than those typically experienced by Corn Belt states. This not only serves to reduce the costs of environmental control in swine production facilities, but also tends to



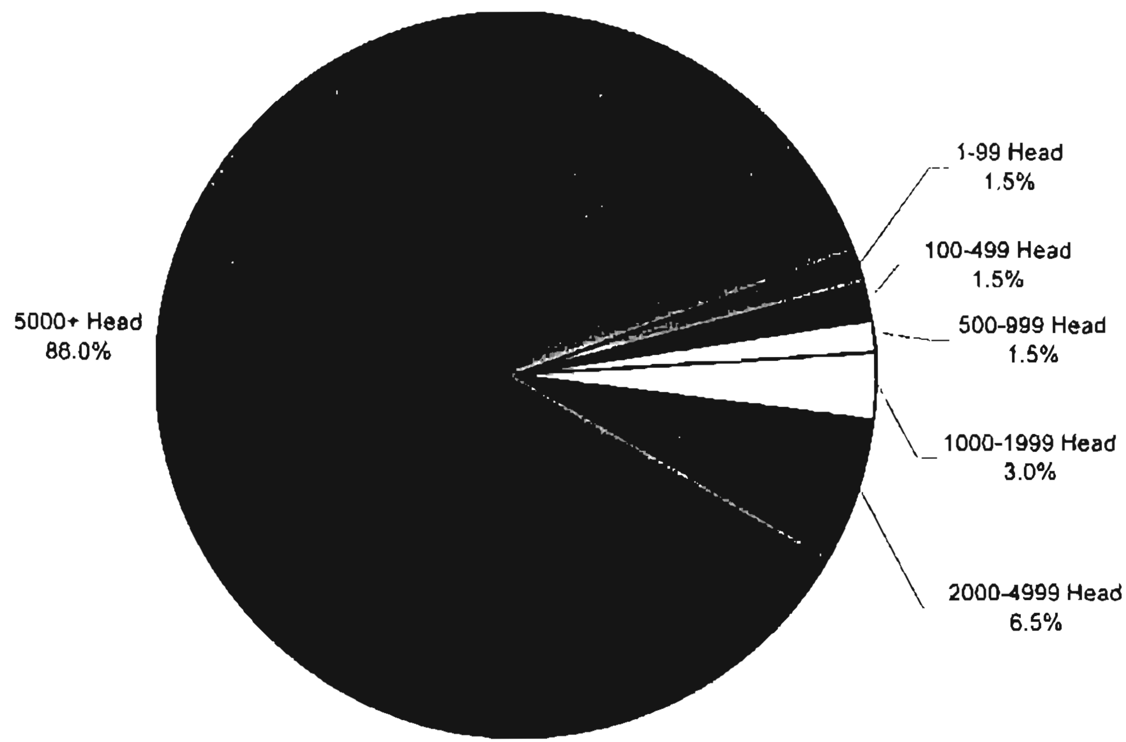
Source: USDA-NASS "Statistical Bulletin" - http://www.nass.usda.gov

Figure 1-13. Oklahoma Top Ten Commodites by Sales, 1997



Source: USDA-NASS "Statistical Bulletin" - http //www nass usda gov

Figure 1-14. Oklahoma Hog and Pig Inventory by Farm Size, 1993



Source: USDA-NASS "Statistical Bulletin" - http://www.nass.usda.gov

Figure 1-15. Oklahoma Hog Inventory by Farm Size, 1999 to feed grains produced in the state's panhandle and northwest quadrant. Another geographic factor working in Oklahoma's favor is actually its distance from other swine production regions, which retards the spread of disease to the state swine herd.

Demographic and economic factors have also fostered the growth of the swine industry in Oklahoma. Labor costs within the state are relatively low, as are land costs, (particularly in the Panhandle). Many rural communities in the state actively recruited large confinement operations, for many of the same reasons mentioned in the discussion of North Carolina. Faced with such pressing issues as rural depopulation, school consolidation, and insufficient public revenues to provide county and municipal services, a development mechanism suited to the area's physical and human resources was desperately needed in many circumstances. In some cases, communities made large concessions to swine producers and processors willing to locate in their areas. Such concessions eventually attracted Seabord Farms' processing plant to the city of Guymon, Oklahoma.

The one factor that truly opened the door for the expansion of large-scale swine production in the state of Oklahoma and focused that expansion's starting point to the early 1990's was the revision of the state's corporate farming legislation. Prior to this date, the Oklahoma statutes prohibited corporations (with the exception of closely-held family corporations) from owning most types of agricultural production operations. Senate Bill 518, passed by the Oklahoma Legislature in April of 1991, removed the majority of these restrictions, and thus removed the primary barrier to entry of large corporations with interests in beginning operations in the state.

The incredibly rapid expansion of the swine industry in the Oklahoma, while providing some economic benefits, has also sparked a number of controversies regarding large confinement operations' environmental impacts. The location of such operations near residences and recreational areas have led to complaints regarding the odor generated by animal waste storage areas and the potential contamination of ground- and surface-water resources with nitrates and bacteria in the event of a loss of containment in an operation's waste retention structure. Additionally, the application of animal waste to cropland in efforts to recapture some of the waste's economic value is also cited as cause for concern, given the possibility of nutrient leaching into nearby waters. Phosphates pose a particular hazard in the eastern portion of the state, where some waters have already been impaired by wastes from large poultry operations.

Perhaps paradoxically, the expansion of the swine industry has also generated economic concerns. Many farmers are concerned that the increasing concentration of the swine industry will eventually lead to oligopolistic or monopolistic conditions, which, in turn, could lead to increased consumer prices and the elimination of many independent producers. The current levels of integration and concentration have already raised concerns among a number of agricultural economists who feel that such an environment may have given rise to the near-ruinous prices for hogs in 1999.

Another economic concern comes from the "growing pains" associated with the rapid introduction of large-scale production and processing operations into areas. The city of Guymon, for example, has struggled to increase the capacity of its utilities and transportation infrastructure to cope with the increased demands of both the new Seaboard plant, and all of the new citizens that serve as its workforce. Due to the tax concessions granted to the Seaboard plant, the city has had a difficult time raising the revenues needed to upgrade city services and the aforementioned infrastructures to cope with the situation.

In the late 1990's, the Oklahoma Legislature began to examine a number of possible legislative responses to the aforementioned concerns. In 1997 and 1998, the Oklahoma Concentrated Animal Feeding Operations Act (OCAFOA) was passed to provide a number of environmental guidelines for the operation of large confinement operations. Prescribing a number of conditions to be met prior to the construction of CAFO facilities and procedures for their continued operation, the OCAFOA also empowered the Oklahoma State Department of Agriculture (ODA) to promulgate regulations needed to fulfill the legislative intent of the Act. Since that time, the ODA has formed a number of Best Management Practices to facilitate the safe operation of CAFOs. Still, there are many citizens who feel that the current regulations are not sufficiently restrictive. Further regulations have been proposed in the state legislature, including the elimination of lagoons as a waste storage system and the elimination of surface application of effluent. According to Massey (1999), the Environmental Protection Agency has contemplated similar measures, and is due to issue a new set of rules in relation to its Unified National Strategy for Animal Feeding Operations within the next three years.

Review of Literature

While there is a fair amount of information available on animal waste, there is not a great deal available regarding its economic management, nor its management subject to regulatory constraints that prohibit certain management practices. The issue is attracting greater attention, though. Luce and Williams, as well as Plain, have examined the recent trends in swine production in the Mid-west and South, with particular attention paid to the smaller number of operations and increasing head-counts per operation.

Perhaps the most rapidly growing area within the topic of waste management comes from those legislative acts and rules that govern it. The recently-passed amendments to the Oklahoma Statutes and rules set forth by the ODA in the Oklahoma Administrative Code have set the constraints for waste management in Oklahoma. While the regulations have been fast in coming, there is little publicly available information regarding their interpretation. Todd discusses the possibilities for misinterpretation of regulations and the need for caution on behalf of producers, and Ferrell, Petermann, and Tilley summarize the most recent legislative movements in Oklahoma.

With respect to the treatment of animal waste, considerable attention has been given to the storage of waste in a lagoon system for eventual application to croplands. Safely and Nye compiled a summary of the energy requirements of such systems, and Koelsch summarizes some of the environmental considerations of land application. Dougherty et al discusses the basics of land application systems. Harrigan and Sutton et al, respectively, discuss specific systems in more detail, and Ackerman discusses common reasons for system failures.

Aside from these land application systems, the body of literature is not exhaustive, but is expanding. El-Ahraf and Sneath address some alternative systems, ranging from extensive mechanical manipulation to pyrolysis and the derivation of commercial organic compounds from wastes.

Unfortunately, in all of the above-mentioned literature, there is only one mention of true economic analysis applied to the system, found in Sutton et al. This is perhaps the clearest indication of need for the research in this subject. Fortunately, the seeds of research into the selection of optimal systems do exist. Though it does not deal specifically with environmental constraints, such decision models are described in Kim's work.

Objectives

The overall objective of this project is to increase the amount of information available to policymakers and agricultural producers when evaluating the potential economic impacts of changes in the regulation of swine-producing CAFOs. This overall objective will be met with the completion of two specific objectives.

1. Estimate the current cost of production, as represented by breakeven cost of live hogs sold to cover variable and fixed costs, for a given set of modeled swine production operations in the states of Iowa, North Carolina, and Oklahoma. Specifically, the modeled operations will be a 1200 sow farrow-to-finish operation, a 1200 sow farrow-to-feeder operation, and a 4000 head finishing operation.
2. Estimate the new breakeven cost per hundredweight of live hogs sold under the conditions of the hypothesized regulatory changes and evaluate other economic impacts of operational modifications needed to come into compliance with the hypothesized regulations.

Procedures

While the specific procedures used to meet the objectives of the project will be discussed in detail in Chapter 3, a brief overview is presented here.

To determine the basic characteristics of the modeled operations, the details of the agriculture sector in each modeled area were examined. The location of the modeled operations in each state was the county with the largest inventory of hogs and pigs in the states of Iowa, North Carolina, and Oklahoma according to the data contained in the 1997 Census of Agriculture. For objectives one and two, the focus was to determine the acreage of typical farms in the area, their crop enterprise mix, and the cost of swine production inputs. These characteristics were then incorporated into the Swine Production Budget model developed by the Commercial Agriculture Task Force at the University of Missouri to form enterprise budgets for the modeled operations.

The information gathered during this phase of the research was also be incorporated into the Swine Waste Management Program designed by the Departments of Agricultural Economics and Biosystems and Agricultural Engineering at Oklahoma State University to provide an estimated cost per unit of capacity for waste management at each operation. This cost was then prorated over each operation's capacity to estimate a line-item cost of waste management for the operation's enterprise budget.

After arriving at the base-scenario cost structure for each operation, a set of hypothesized regulations was imposed on each operation, and the cost of waste management re-estimated for each scenario. Specifically, the regulations imposed were a) the elimination of lagoons as a waste storage system, and b) the elimination of surface application of effluent to land as a means of waste disposal (which, conversely, could be construed as a requirement that effluent be injected or incorporated into the soil directly, if it is to be land-applied), and c) the imposition of a crop-removal based phosphorous restriction on the application of animal waste to cropland. Given the projected cost of waste management under the hypothesized regulations, a new breakeven cost will be calculated for each operation.

Limitations

As is the case with all simulation models, the accuracy of the results generated are hampered by a number of inherent limitations on the models used. Of necessity, a number of complex production variables are reduced to simplistic assumptions to make their simulation feasible. For example, an enterprise budgeting model that accounted for every production input and output on a swine production enterprise would have to be of equal or even greater complexity than the entire set of financial and production records for an actual operation. Since such information is proprietary, the only other way to obtain such detailed information would be to keep such records for an actual operation, which was not feasible for this particular project.

Another limiting factor is fact that while probable responses to a set of regulatory changes can be estimated, it is not possible to forecast all the possible responses a producer could initiate in response to such a change. For the purposes of this study, it is assumed that a producer will shift to a different technology if his current operation would not be compliant with the proposed regulations. However, there are a nearly infinite number of possible responses involving any combination of shifts in technology and management, up to and including industry exit.

Overview of Following Chapters

In the following chapters, the set of modeled farms will be developed, subjected to the hypothesized regulatory changes, and evaluated for profitability.

Chapter two will present the theoretical aspects and perspectives from which the problem will be viewed. Economic models and their application to this specific research problem will be presented, along with the economic problems inherent to the scenarios under investigation. Finally, the application of economic principles to enterprise budgeting and partial budgeting analysis will be demonstrated.

Chapter three will outline the procedures used to answer the research question. Specifically, it will address the assumptions used in the modeling of the swine production operations and the rationale behind the assumptions. The hypothesized regulations and their selection will be discussed, followed by the baseline costs for each modeled operation in each state.

Chapter four will present the findings from the trials of each operation under the hypothesized regulations, by operation type for each state and for each regulatory change.

Chapter five will summarize the results and the potential implications for each state's swine industry, present the conclusions gained from the research, and make recommendations for further study.

CHAPTER II

ECONOMIC THEORY

Economic Problems

When evaluating the effects of possible legislative and regulatory changes on the swine and pork industry, the overall policy question is whether the marginal societal benefits of additional regulations outweigh the marginal costs of those regulations to society as a whole. Though this may sound simple, deriving the appropriate values for the "costs" and "benefits" is a complex matter. For the purposes of this research, the explicit quantitative costs of compliance with additional regulations to the swine production firm will be examined. The project will not address estimation of the costs of promulgating and enforcing regulations, nor will it attempt to quantify changes in social welfare as a result of the regulations. Instead, the microeconomic aspects of the problem at hand will be addressed; thus, the majority of the theoretical framework for the project will be microeconomic in nature.

Prior to examining the economic problems of swine production operations in the states examined in this research, a number of assumptions should be established. First, *ceteris paribus* conditions are assumed for each trial; all factors except those under examination are presumed to be constant over the period of investigation. Producers are assumed to be able to make instantaneous decisions and have those decisions implemented immediately (if a new production technology is used, it is assumed that it can be installed and utilized as soon as it is chosen for integration into the operation). Producers are also presumed to have perfect knowledge of all relevant economic factors and to execute their decisions accordingly.

According to economic theory, the capacity of the set of resources held by a production operation to produce a commodity can be expressed in terms of a production function, generally expressed in algebraic form as:

$$Y = f(x_1 \mid x_2, \ldots, x_n) \quad (1)$$

where Y is a given output, x_1 is a variable input, and inputs x_2 through x_n are fixed for the purpose of analysis. In the long term, however, all inputs become variable as the producer has time to respond to the universe of market forces and adjust even "fixed" asset inputs accordingly. This allows the production function to provide the optimal output for each combination of available resources.

The physical production function may be coupled with information regarding the prices of inputs and outputs to provide information regarding the profitability of the production operation, expressed mathematically as the operation's profit function:

$$\pi = P_y Y - (P_{x1}x1 + P_{x2}x2 + \ldots + P_{xn}x_n) \quad (2)$$

where π represents the operation's profit, P_y is the price of the firm's output (in this case, expressed as Y), and P_{xn} represents the cost of input x_n. In other words, the price of the product multiplied by the amount of product produced, less the sum of the costs of the inputs multiplied by their respective levels of use, equals the profit for the production operation. As a result, one could also express the profit function as

$$\pi = TR - TC \qquad (3)$$

indicating, in simplistic terms, that the firm's profit equals the sum of its revenues less the sum of its expenses. Microeconomic theory dictates that in the short term, the firm will continue to operate so long as total revenues cover the expenses of variable inputs (those inputs that can be varied in the short term), and will continue to operate in the long run only if total revenues are able to meet the expenses of all inputs (since, as the reader will recall, all inputs become variable in the long term).

Bearing these economic relationships in mind, it is then necessary to establish a perspective on the environment in which they operate in order to form a meaningful estimate of the impact of regulatory changes on producers. It is reasonable to assume the situation faced by swine producers is one of perfect competition, as the individual, independent producers have very little market power, if any. While it has been hypothesized that the level of concentration in the swine industry is now sufficient for some larger firms to begin to exercise a small amount of market power, it shall be assumed for the purposes of this research that even producers in contract arrangements with large integrators will face the market price for their product as independent producers do. It may also be assumed that the individual producers and their actions can be described by the theory of the firm; their goal is to maximize profits, and they are subjectively rational in their management decisions. Given these conditions, it can be reasonably predicted that, when faced with additional environmental regulations, producers will seek the minimum-cost method to achieve compliance with those regulations.

The basis of this assumption again stems from basic microeconomic theory. Given that a firm operates in perfectly competitive conditions, it has no ability to influence prices by varying its output. Therefore, at any level of output, the firm will receive the same price (P_y) in the short term for all output. Under such conditions, the firm can do two things to increase profitability at any given level of output. It can seek to improve the productive efficiency of its resources, thereby garnering more output per unit of input. Alternatively, the firm can maintain the current level of output and seek means of reducing the costs of producing that level of output.

As a result, when faced with the hypothesized regulations of this research, the modeled swine producers will have to adapt their operations in a manner that will enable them to maximize profits by minimizing costs. Waste management costs present an interesting challenge, since they will increase with increased swine production. Therefore, it is reasonable to assume that instead of producing more pigs and thus trying to spread out fixed costs, producers will instead choose to adopt technologies and protocols that will minimize the costs of waste management for a given level of output.

Economic Models

To achieve the objectives of the project, it was decided to create a system of modeled farms which approximated the operations and behavior of actual swine production operations as closely as possible, given the resources and information available to the researcher. A number of economic models are available to agricultural economists for estimating how producers can best use available resources, in some form of optimal combination, to meet the producers' goals. Those goals can be almost as numerous as the producers themselves, as they seek to attain profit, equity growth, income stability, or a number of other economic or non-economic goals. While there are a number of perspectives from which farm management decisions can be viewed, a purely quantitative, economic one was necessary for the purposes of this research in order to make the modeling process manageable and to reasonably estimate producer responses.

As stated in Mathis (1991), virtually all economic models share three common elements: 1) the *ceteris paribus* condition; 2) assumption of rational decision-making on the part of the producer, and 3) the distinction between positive and normative questions. The models in this research pose no exception to these elements.

The *ceteris paribus* condition is one of the first economic concepts taught to students in the field of agricultural economics. Indeed, it is perhaps one of the most critical assumptions in virtually all economic modeling. Put simply, it requires that all variables in a model, whether they are implicit or explicit, be held constant, with the exception of those variables whose marginal impacts are being investigated. This condition allows for more precise measurement of the variables being examined, with a minimization of interference from other factors whose interactions with the choice variables could make results ambiguous. An example relevant to the research would be the investigation of the change in cost of production for a given swine operation given a change in regulatory constraints, and holding all other factors, like feed inputs, labor costs, and interest rates constant. If these other variables were not controlled, it would be difficult to determine what the true impact of the regulatory change would be on the cost of production for the operation.

Another critical element to modeling production operations is the assumption of rational decision-making on the part of the agricultural producer. Rational decision-making, in the economic context, simply means that the objective of the producer is to maximize profits given the external constraints placed on his/her decision-making capacity and economic resources. This assumption is critical to the feasibility of modeling producer behavior. While it is true that many producers in the real world might have any number of goals, it must be assumed that the paramount goal of the producer is to maximize economic returns. Such an assumption facilitates the use of mathematical analysis of production decisions and allows reasonable optimal solutions to be calculated, as will be demonstrated later.

A final critical element to the success of quantitative modeling efforts is the use of positive, as opposed to normative, questions in seeking to predict producer behavior. In lay terms, positive questions ask "What is?" while normative questions ask "What should be?" For example, a positive economic question might be "What is cost of installing and operating a sub-surface injection system for swine effluent?" whereas a normative economic question might be "What proportion of the cost of environmental protection should producers have to bear?" The qualitative nature of many normative questions makes them difficult to answer empirically. Furthermore, a successful solution to a normative question depends, to a large extent, on the individual asking the question, since a normative question inherently has a moral component defined by the belief system of the investigator. As a result, this project focuses on positive analysis to provide objective empirical results that can then be viewed by others in the normative context they choose.

To allow such economic analysis in this research, two models were manually integrated. This arrangement allowed the researcher to estimate one of the production costs, namely that of swine waste management, and then examine the impacts of fluctuations in that cost on the total production costs and relative competitiveness of a given swine production firm.

The Missouri Swine Budget Generator

The first of these models was an enterprise budget generator developed at the University of Missouri. Taking information provided by the user, this software uses integrated information regarding physical, technical, and economic production relationships to estimate the production and costs of the specified operation. Accordingly, the user must provide information regarding what is known about the operation's physical production capacities and efficiencies, its input costs, and the assets that comprise its physical plant. Figure 2-1 displays how the budget generator utilizes this information to calculate production costs, based on the component worksheets of the Excel© template.

The Missouri Swine Budget Generator (MSBG) requests general information about the particular swine production operation to be modeled. Depending on whether the operation entails farrowing operations (as is the case for the farrow to feeder and farrow to finish operations), the template will allow user-specified inputs of the number of sows in each breeding group, the frequency of farrowing on the operation, and the

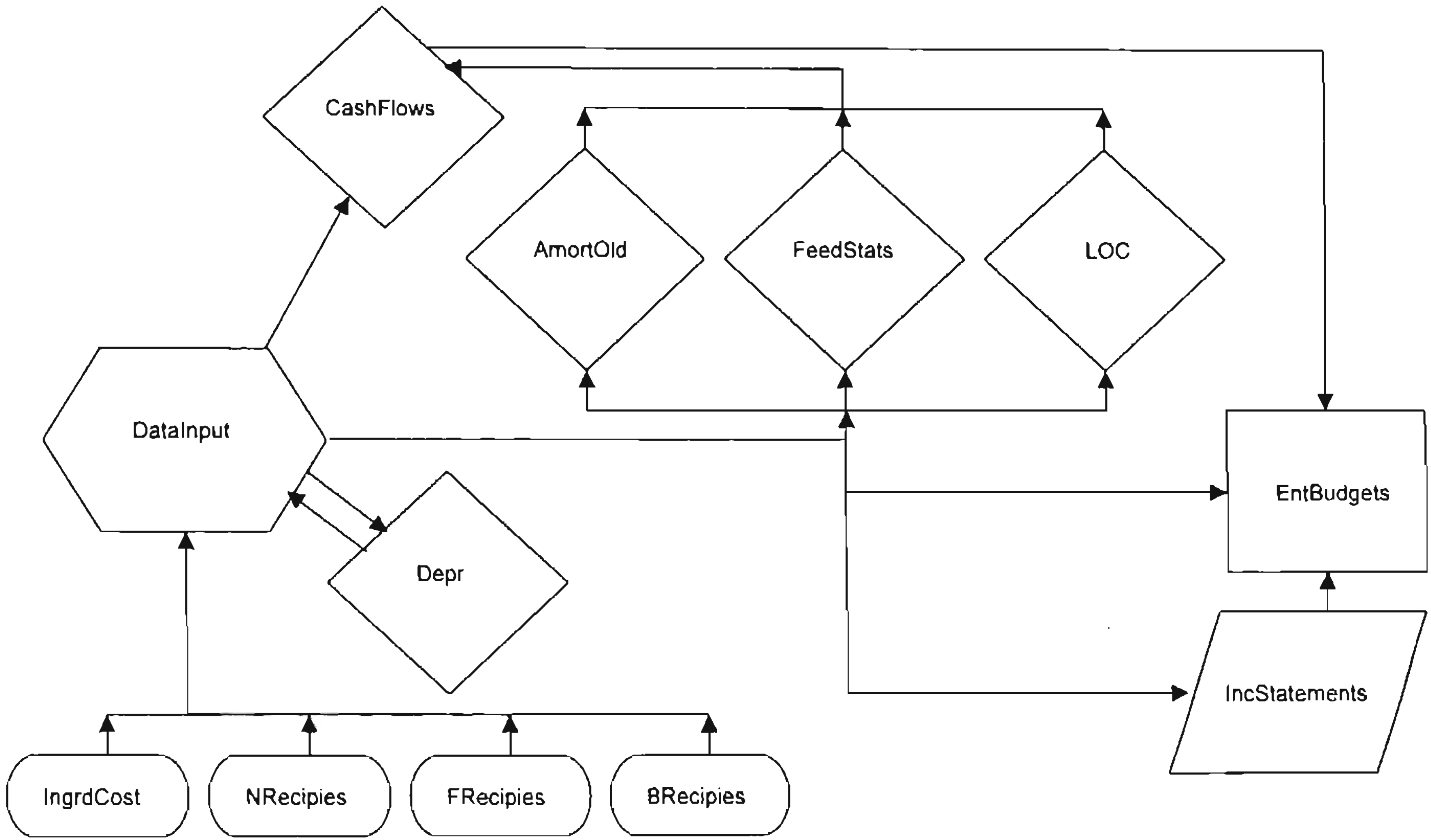
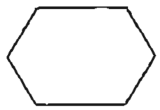


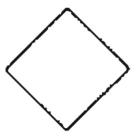
Figure 2-1. Missouri Swine Budget Generator Model Schematic

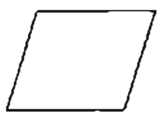
Figure 2-1 (continued)

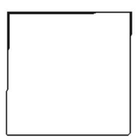
Explanation of Schematic Symbols


Data Input


Data Input / Calculation


Calculation


Output / Calculation


Output

Worksheet Title	Description
DataInput	Primary sheet for user data input
IngrdCost	Allows user specification of feed ingredient costs
NRecipies	Allows user specification of nursery rations
FRecipies	Allows user specification of finisher pig rations
BRecipies	Allows user specification of breeding herd rations
FeedStats	Calculates production based on herd dynamics and feed efficiencies
EntBudget	Final output of production costs on per head, cwt. or litter basis (depending on operation type)
LOC	Line of credit analysis
CashFlows	Cash flow for modeled operation over ten year span
IncStatements	Income statements for modeled operation, averaged over ten year span
AmortOld	Amortization schedule modeled operation's existing debt
GP	Presents data regarding modeled operation's internal grandparent system, if so chosen
Depr	Calculates depreciation of modeled operation's equipment, facilities, and breeding stock

reproductive efficiency of the breeding herd (*i.e.* the number of piglets weaned per litter, average weaning weight, etc.) to estimate the annual throughput of the operation. In the case of a finisher operation, the number of pigs introduced to the operation in each "batch," along with the frequency of batch arrival, is substituted for the reproductive information to enable the program to estimate throughput.

After supplying the program with throughput information, the user may input estimated annual average costs for a number of items involved in the farm's production operations. These cover the usual items found in an enterprise budget for swine production: breeding costs, veterinary costs, utilities, labor, marketing costs, and so on. The user can also enter the total costs of buildings and equipment for the operation.

The user is also required to enter information regarding the nutrition program used for the operation. Here, there are two options for determining the cost of feed for the operation. The user may choose to enter in costs for each feed ingredient used by the operation, and then enter the amount of each ingredient used in the ration for each phase of the nutrition program, or the user may simply enter the total cost of each ration used. Along with this information, the user will need to specify how long the swine will remain on each ration used, and the expected average daily gain of the swine on each ration.

Given this information the MSBG will then calculate the total annual costs of operation for the operation, and summarize them in the form of an operational enterprise budget that includes the costs on a per-head-sold, per-litter, per-hundredweight, or per litter basis in the case of the farrow to feeder and farrow to finish operations, or a per-head-sold, or per hundred weight basis. In both cases, the program also shows the percentage of total variable costs accounted for by each item.

The Swine Waste Management Program

The second model, the Swine Waste Management Program (SWMP) was created in a cooperative venture between Oklahoma State University and the University of Missouri, and calculates the estimated cost of swine waste management for a specified operation. While the MSBG is highly dependent on user-specified inputs, the SWMP contains a great deal of integrated information regarding the specifications of a number of available waste storage, treatment, and application technologies. Therefore, the user need only enter a few specifications about the swine "throughput" capacity of the operation under investigation, the physical arrangement of the operation, available cropland information, and the desired type of waste management system. The SWMP is shown in Figure 2-2.

Using the information provided by the user, the SWMP then executes a substantial number of calculations to determine the exact configuration of the waste management system and its attendant costs. Specifically, the program determines the size of the waste storage facility needed to contain the wastes generated by operation, given the number and type of swine (larger pigs will naturally generate a greater volume of waste per unit time than smaller pigs). The program also contains construction cost coefficients that enable it to determine the construction costs necessary for the storage facility (and, as a result, the depreciation costs for the facility). It should be noted that the SWMP calculates the appropriate size for the waste management system type specified; if the use wishes to conduct cost-minimization analysis, they will need to run multiple

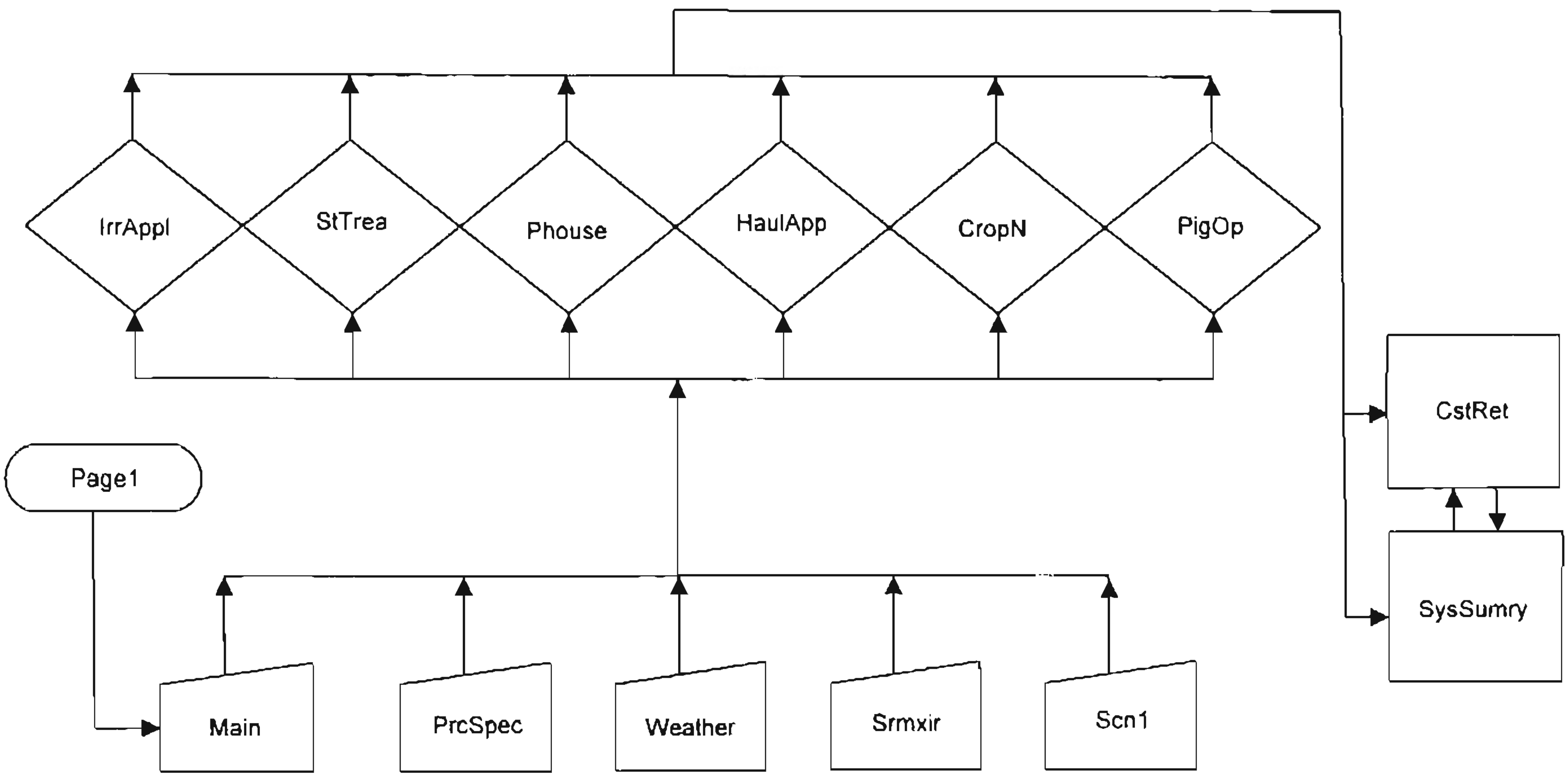
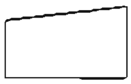


Figure 2-2. Swine Waste Management Program Model Schematic

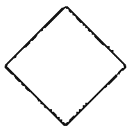
Figure 2-2 (continued)

Explanation of Schematic Symbols

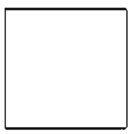
Data Input



Data Storage



Calculation



Worksheet Title	Description
Main	Collection / storage of user inputs and calculated values
Page1	Primary user input page
PrcSpec	Stores price specifications for system facilities, components, and supplies
SysSumry	Output summary specifications of waste management system calculated by SWMP
CstRet	Output summary of operation costs for waste management system and returns from recovered nutrient values
Phouse	Calculates waste amounts generated by modeled operation
StTrea	Calculates needed capacities of modeled operation's waste storage and treatment facilities
IrrAppl	Calculates dimensions and capacities of land application system for modeled operation if an irrigation system is specified by user for land application of wastes
HaulAp	Calculates dimensions and capacities of haul-tanker application system for modeled operation if such a system is specified by user
CropN	Calculates nutrient removal rates of modeled farm based on crop mix specified by user
Weather	Data storage array for climatologic data in modeled regions
PigOp	Calculates flow of livestock through modeled operation
Scn1	Data storage array for specifications of alternative waste storage structures for modeled operation
Srmxir	Data storage array for information regarding the timing of land application of wastes

iterations of the program while manually modifying their choice variables between iterations.

In addition to calculations relating to the storage of animal wastes, the SWMP also determines the appropriate design characteristics of the operation's waste application system. The user may specify up to six different crops to receive the wastes; information regarding the crops would include the acres of each crop to be used, the distance from the swine operation to each field, and other field characteristics. The user must also specify a yield goal, which is important in allowing the program to calculate how much of the wastes can be used by the given crops.

The crop information provided, along with the data regarding the waste generated by the operation, allows the SWMP to calculate the dimensions of the land application system needed to handle the appropriate waste volume. While the user must specify the type of system to be used (for example, the user may select a center-pivot system, a drag-hose injection system, or a haul-tanker wagon), the program will calculate the capacity of the system in terms of the specific system chosen. That is to say, in the example of a center-pivot system an irrigation system, the needed volume per-unit-time capacity of the piping to the field, the size of pumps needed to transport the waste effluent from the operation to the field, etc.

The SWMP compiles the information regarding both the waste storage facilities and land-application systems to estimate an annual cost of waste management for the operation. In its system summary, the program presents the system dimensions and annual operating costs, along with the total capital investment in the system, as well as information on the depreciation of the system components.

Integrating the Models

The two models were manually integrated by the author to estimate how the costs of waste management (under both the baseline conditions and the hypothesized regulations) would impact the overall costs of production for the operation. First, data regarding the costs of production for each modeled operation were accumulated. Then, the SWMP was used to calculate the costs of waste management for the operation. This information, combined with the previously mentioned production cost data, was then included in the inputs of the MSBG to calculate the costs of production for each operation, first under the baseline conditions, and then under the influence of the hypothesized regulations.

Applications to Farm Management

While the theories and assumptions used in the economic modeling of swine production operations may seem somewhat abstract to the layman, they have led to the development of a number of practical tools that can be used by the producer to run such enterprises in an economically efficient manner.

Enterprise Budgeting

The practice of enterprise budgeting was conceived to aid producers in planning their whole-farm operations by providing generalized cost and revenue information in a format that facilitates the adaptation of the information to the scale needed by the operator. It is with this intent in mind that enterprise budgets were used in this research. Given the differences among the operations in physical location, input costs, and scale, enterprise budgeting provided an excellent tool by which to model these similar but unique operations.

Enterprise Selection

Naturally, an increased amount of enterprise budget information availability will facilitate the optimization of enterprise selection on the part of those producers who choose to avail themselves of such information. Whether applied through mathematical programming or comparative methods, enhanced budgeting information helps producers achieve a true optimization of their profit function, as they become increasingly accurate in their estimate of appropriate input mixes (in terms of a factor-factor input choice) to produce an optimal compliment of commodities (selected in a product-product context) given both resource and product price conditions.

The issue of swine waste management poses a special challenge to optimization of the farm's enterprise mix. It is a common practice in the state of Oklahoma to apply swine waste to agronomic crops or pasture. As regulations become more restrictive of nutrient balances (specifically nitrogen and phosphorous), farmers must either find ways of modifying nutrient content of these wastes, adopt technology that will reduce the nutrient content, or apply the wastes to crops that will utilize greater amounts of nutrients so as to alleviate the threat of runoff or impairment of water resources. In this context, the producer must marshal capital resources carefully and examine whether changing the waste management technology or adapting the crop mix is more economically feasible. The additional restrictions on waste application thus act as an additional constraint to the programming scenario in optimizing farm output. Here again, accurate enterprise budgeting information, inclusive of data regarding alternative waste management procedures and costs, is vital to the optimization of farm profits.

CHAPTER III

PROCEDURES

Swine Production Operation Modeling

In forecasting the reactions of producers to regulatory changes and the economic impacts of those reactions, it is important to model the producers' operations as accurately as time and resource constraints will allow. To this end, a number of data sources, as well as experts in animal science, agricultural engineering, and agricultural economics were consulted to make the modeled swine production operations as realistic as possible given the aforementioned constraints.

This chapter will detail the assumptions behind the establishment of the modeled operations. The selection of the hypothesized regulations will then be discussed, followed by the procedures used to estimate how the modeled operations would react to the new regulatory environment.

Location of Modeled Operations

As mentioned in the introduction, the objectives of the project were to be met through the modeling of swine production operations in the states of Oklahoma, North Carolina, and Iowa. Oklahoma was selected for many of the same reasons as North Carolina, plus the added relevance of information regarding the state to its policy-makers.

North Carolina was selected due to the rapid expansion of its swine industry (placing it second among all states in hog and pig inventory), and the dramatic increase in its prominence among agricultural products in cash receipts for the state. Iowa was selected for its historic dominance of other states in swine production.

Within each production region, a base county was selected. This was the county in each production region that had the highest inventory of hogs and pigs according to the 1997 Census of Agriculture, conducted by the United States Department of Agriculture. The base city for the county is the incorporated city with the largest population in each county. A map showing the relative locations of the modeled operations is found in Figure 3-1.

Physical Characteristics of Modeled Operations

The first step in the modeling of each region's swine production operations, was to establish the physical characteristics of the modeled operations. The first of these characteristics was the arrangement of the operation itself, *i.e.* its size and the types of crop and animal production conducted on them.

Farm Size The first of these parameters to be established was the farms' size. For a given county, the 1997 Census of Agriculture presents the number farms in each of a number of size ranges, detailed in Table 3-1. Since the acreages of farm operations with swine enterprises was not available as a separate data set, it was assumed that the a commercial swine operation would likely be placed on an operation larger than the average for the county, but not necessarily a farm in the largest range.

Thus, to estimate the typical acreage for a farm with a swine enterprise, the cumulative number of farms in each size class was calculated, from largest to smallest.

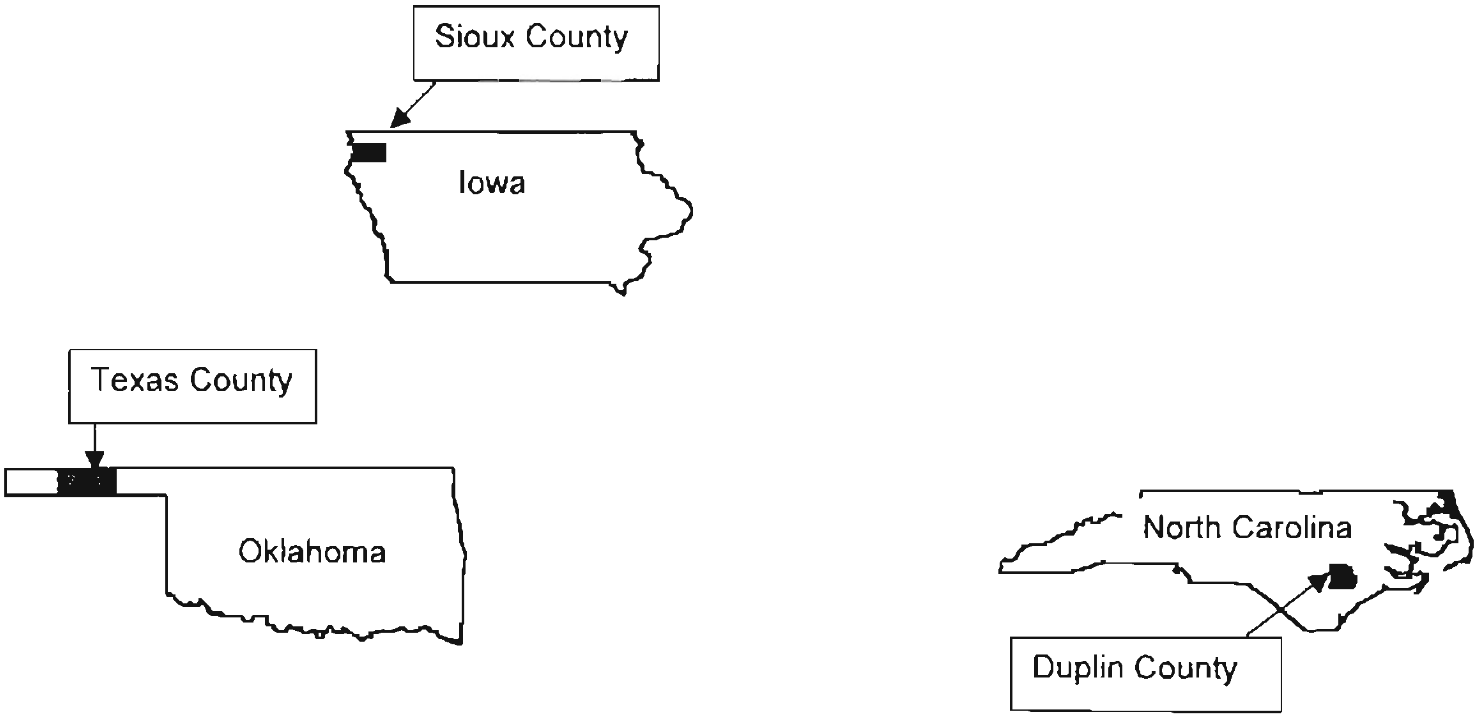


Figure 3-1. Relative Locations of Modeled Swine Operations in Iowa, North Carolina, and Oklahoma

TABLE 3-1

USDA Census of Agriculture Farm Size Ranges

Size Range	Midpoint
1 to 9 acres	5
10 to 49 acres	30
50 to 69 acres	60
70 to 99 acres	85
100 to 139 acres	120
140 to 179 acres	160
180 to 219 acres	200
220 to 259 acres	240
260 to 499 acres	380
500 to 999 acres	750
1,000 to 1,999 acres	1,500
2,000 acres or more	2,500*

* A figure of 2,500 was arbitrarily assigned to this class for the purposes of calculations.

Source: 1997 Census of Agriculture, USDA

The typical farm acreage for a production region was then defined as the midpoint of the Census size range which represented at least the 66th percentile of farms in the county. Table 3-2 presents the farm size data for the modeled regions. An example would be Texas County, Oklahoma. In this case, the typical farm size would be set at 1500 acres, since this is the midpoint of the range that would account for at least 66.66% of the cumulative total (in this instance, a total of 67.1%). The typical farm sizes for Iowa and North Carolina were 380 and 200 acres, respectively.

Table 3-2

Distribution of Farms by Size in Oklahoma, North Carolina, and Iowa

State		Oklahoma			North Carolina			Iowa		
Size Range	Midpoint	Number of Farms in Range	Cumulative Total of Farms	Cumulative Proportion of Farms	Number of Farms in Range	Cumulative Total of Farms	Cumulative Proportion of Farms	Number of Farms in Range	Cumulative Total of Farms	Cumulative Proportion of Farms
2,000 or more acres	2500	159	484	100.0%	14	890	100.0%	5	1570	100.0%
1,000 – 1,999 acres	1500	126	325	67.1%	26	876	98.4%	52	1565	99.7%
500 - 999 acres	750	94	199	41.1%	81	850	95.5%	236	1513	96.4%
260 - 499 acres	380	62	105	21.7%	110	769	86.4%	408	1277	81.3%
220 to 259 acres	240	7	43	8.9%	48	659	74.0%	130	869	55.4%
180 - 219 acres	200	3	36	7.4%	46	611	68.7%	73	739	47.1%
140 - 179 acres	160	12	33	6.8%	65	565	63.5%	173	666	42.4%
100 - 139 acres	120	9	21	4.3%	79	500	56.2%	96	493	31.4%
70 – 99 acres	85	4	12	2.5%	90	421	47.3%	97	397	25.3%
50 – 69 acres	60	2	8	1.7%	76	331	37.2%	30	300	19.1%
10 – 49 acres	30	5	6	1.2%	200	255	28.7%	108	270	17.2%
1 - 9 acres	5	1	1	0.2%	55	55	6.2%	162	162	10.3%

Source: 1997 Census of Agriculture, USDA

Cropland Acreage The establishment of an overall farm size was necessary prior to the next step: determining the acreage of cropland and the crops utilized on it. To arrive at the acreage devoted to cropland for each typical farm, the acreage of total harvested cropland was divided by the acreage of land in farms to form a ratio. The typical farm size was multiplied by this ratio to arrive at the typical farm cropland acreage. For example, in Sioux County, Iowa, the acreage of land in farms was 493,556 acres and the acreage of total harvested cropland equaled 432,087 acres, giving a ratio of 1.14:1. Applied to the typical farm size for Sioux County (380 acres), this gives a cropland acreage of approximately 333 acres. Table 3-3 shows the overall size of the modeled farms and the acreages of their crops.

Table 3-3

Sizes and Crop Acreages for Modeled Operations

Oklahoma	Total Farm Size		1500 acres
	Total Cropland Acreage		640 acres
	Component Crops' Acreages		
		Wheat	320 acres
		Grain Sorghum	160 acres
		Corn	160 acres
North Carolina	Total Farm Size		200 acres
	Total Cropland Acreage		120 acres
	Component Crops' Acreages		
		Bermudagrass	120 acres
Iowa	Total Farm Size		380 acres
	Total Cropland Acreage		320 acres
	Component Crops' Acreages		
		Corn	160 acres
		Soybeans	160 acres

In order to determine which crop enterprises would be used on the modeled swine production operations, swine waste management experts in the selected states were interviewed regarding the crop enterprises most prevalent on concentrated swine production operations in that state. The modeled operations in Texas County, Oklahoma had cropland acreages were divided among wheat, corn, and grain sorghum. A unique characteristic of waste application in this portion of the state dictated a modification of the cropland acreages devoted to waste application, however. For the most part, swine waste application in Texas County is accomplished through the use of pre-existing center-pivot irrigation systems, based around quarter-sections of land. It was decided to acknowledge this practice in the modeling of the waste application systems. Census of Agriculture data were used to determine the relative proportion of each of the three crops by harvested acreages, and these proportions were used to allocate 160 acre fields. This resulted in 320 acres of wheat, 160 acres of corn, and 160 acres of grain sorghum.

It is important to note here that a center pivot irrigation system located on a 160 acre portion of land will not irrigate the entire field; this is the cause of "corners" in such systems. The actual irrigated area of a center pivot irrigation system on a 160 acre field is approximately 128 acres. Thus, for the purposes of calculations with the SWMP, this was the acreage used for every 160 acre center pivot system.

To facilitate the calculation of waste application system dimensions and costs, the cropland acreages in North Carolina and Iowa were also rounded to the nearest even fraction of a standard 640 acre section of land. Thus, two quarters of land in Iowa, and an eighth and a sixteenth in North Carolina were allocated to cropland.

For the modeled operations in Duplin County, North Carolina, this procedure resulted in the allocation of the entire cropland acreage to bermudagrass production. Waste management experts from North Carolina stated that the overwhelming majority of swine waste application to cropland occurred on bermudagrass acreages, owing to the yield response of this forage crop to nitrogen, and its removal capacity of that nutrient. Since data on bermudagrass yields is not recorded in the annual Agricultural Statistics of North Carolina, an estimate was used from the North Carolina State University Department of Crop Science.

In Sioux County, Iowa, a corn-soybean rotation was used on the modeled farms. While this may represent a two-year rotation schedule in actual agronomic practice, it was necessary to modify this operation for input into the SWMP, which executes crop calculations on the basis of a crop year. Half of the cropland acreages for the farms were entered as corn (for grain production), with the other half entered as soybeans. This provides a reasonable approximation of the corn-soybean rotation. The yield goals used in the SWMP for these crops were the five-year average yields calculated from figures contained in the annual Agricultural Statistics report for Iowa.

There were a number of reasons for using the above crop-allocation procedures. While in times past, the animal wastes generated by swine production would be simply stored and perhaps spread as dry manure on available cropland, the increasing size and concentration of swine production dictates a different protocol of waste application to cropland. In some cases, the need for nutrient uptake and removal may actually dictate the crops raised on a swine-producing farm. In other cases, the economics of modifying previously-existing irrigation systems to apply waste (rather than constructing an entirely new system) may determine the waste management practices of the producer. In any case, these factors, combined with the inherent difficulties and inaccuracies of establishing an "average" cropland allocation, led to the selection of the procedure used for this research as the most intuitively satisfying.

Selection of Swine Enterprises

To model the swine production enterprises on each typical farm, it was necessary for the sake of feasibility to choose a type of operation that could be readily replicated on each farm with a minimum of adjustments, while still being able to fairly approximate production practices and their attendant costs. To accomplish this, the swine production operation interactive enterprise budget program developed by the University of Missouri Commercial Agriculture Program Swine Focus Team was chosen (Massey, 1998).

This program is comprised of a number of Excel© spreadsheet program templates designed to collect information about the swine enterprise to be modeled. Separate programs were constructed to model three types of swine production programs – a 600 sow farrow to feeder operation, a 1200 sow farrow to finish operation, and a 4000 head feeder operation. These operations represent what are believed to be common sizes for their respective enterprises. Even in those cases where a swine production operation chooses to operate at a larger scale, they are likely to choose an operation that represents a multiple of these operations' scale (2400 sow farrow to finish operations, 1200 sow farrow to feeder operations, etc.). For the purposes of this research, it was decided that a 1200 sow farrow to finish operation would be more appropriate for the purposes of the research, and thus, the 600 sow farrow to feeder operation was modified for this increase in scale.

These budgets were based upon conditions in Missouri; since this state was not modeled, the operations' budgets had to be modified from these base conditions, using regional indices or available price data for the cost of feedstuffs, labor, building costs, land valuations, etc. The following section will present these adaptations in their aggregate form, by difference from the Missouri baseline values.

<u>Modification of Feed Costs</u> The cost of feed is one of the most important factors in modeling a swine production operation's expenses, for two reasons. First, the cost of many feed components vary by region, contributing to the comparative advantage of some areas in swine production. In some cases, feed costs alone can account for the majority of the total costs of swine production and so lower costs of feeding may explain much of the difference of production costs between regions. Second, as the size of swine operations increase and thus reduce fixed costs per head of production, variable costs account for an increasing proportion of the total costs of production.

To establish a swine nutrition program for the modeled operations, it was decided to follow the example program presented in *The Missouri System of Swine Production* (MSSP) (DiPietrie). Swine production operations use a variety of nutritional programs ranging from a single ration for each phase of growth to split-sex multi-phase feeding programs containing nearly a dozen different rations. The nutrition program outlined in the MSSP represents a reasonably sophisticated nutritional strategy while remaining relatively easy to calculate.

The MSSP nutritional program is comprised of single diets for gestating sows, lactating sows, breeding sows, and boars, respectively. A three-phase starter program is used for nursery pigs, which is then followed by a three-phase grower-finisher program. In the case of the gestation, lactation, and grower-finisher rations, the MSSP presents a number of possible formulations (for the purposes of the research, it was assumed that nursery rations were purchased complete). In each case, the formulation selected represents the least-cost formulation given the cost of ingredients in each modeled region.

To estimate such regional feed ingredient costs, a number of data sources were consulted. Whenever possible, data from USDA-NASS were used. However, USDA-NASS cannot record data for all feed ingredients; thus, in some cases, it was necessary to use individual price estimates or bids for ingredients in markets outside of the modeled region and then adjust such prices by a regional index. This index was constructed using NASS price data for 14-16% hog concentrate feed. For each NASS reporting region, a five-year average price for this feed was calculated. A matrix of the relative cost of this feed between the reporting regions was then formed and used to adjust feed ingredients as needed. For example, the 5-year regional average cost for the concentrate in the Corn Belt region (which contains Missouri and Iowa) was $227.20 per ton, whereas the 5-year average for the Southern Plains region (containing Oklahoma), was $251.60 per ton, or 110.7% of the Corn Belt average. Thus, when an ingredient price needed adjustment from its cost in Missouri to an estimated cost in Oklahoma, the Missouri price would be multiplied by 110.7%.

Table 3-4 presents this regional feed cost adjustment matrix, and Table 3-5 shows the data sources used to estimate ingredient costs.

Table 3-4

Regional Adjustment Matrix for Swine Ration Costs

(Row as percent of column heading's 5yr average)

Region*	App	CrnBlt	Delt	Lake	Mtn	NE	NorPl	Pac	SE	SoPln
App		110.04%	106.56%	112.11%	94.13%	106.02%	107.48%	110.72%	94.55%	99.36%
CrnBlt	90.88%		96.85%	101.88%	85.54%	96.35%	97.68%	100.62%	85.93%	90.30%
Delt	93.84%	103.26%		105.20%	88.33%	99.49%	100.86%	103.90%	88.73%	93.24%
Lake	89.20%	98.15%	95.06%		83.96%	94.57%	95.87%	98.76%	84.34%	88.63%
Mtn	106.24%	116.90%	113.21%	119.10%		112.64%	114.19%	117.63%	100.45%	105.56%
NE	94.32%	103.79%	100.51%	105.74%	88.78%		101.38%	104.43%	89.18%	93.72%
NorPl	93.04%	102.38%	99.15%	104.30%	87.58%	98.64%		103.01%	87.97%	92.45%
Pac	90.32%	99.38%	96.25%	101.26%	85.02%	95.76%	97.08%		85.40%	89.75%
SE	105.76%	116.37%	112.70%	118.57%	99.55%	112.13%	113.67%	117.09%		105.09%
SoPln	100.64%	110.74%	107.25%	112.83%	94.73%	106.70%	108.17%	111.43%	95.16%	

Source: Agricultural Prices 1997 and 1998, USDA

*Explanation of Regional Abbreviations:

App	Appalachian Region (Kentucky, Tennessee, Virginia, West Virginia, and North Carolina
CrnBlt	Corn Belt Region (Illinois, Indiana, Iowa, Missouri, and Ohio)
Delt	Delta Region (Arkansas, Mississippi, and Louisiana)
Lake	Lake Region (Michigan, Wisconsin, and Minnesota)
Mtn	Mountain Region (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming)
NE	Northeastern Region (Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont)
NorPl	Northern Plains Region (Kansas, North Dakota, Nebraska, and South Dakota)
SE	Southeastern Region (Alabama, Georgia, Florida, and South Carolina)
SoPln	Southern Plains Region (Oklahoma and Texas)

Table 3-5

Data Sources for Feed Ingredient Costs

Ingredient	Derivation of Cost Data
Corn	5 year average price (by state) of prices received by farmers, *Agricultural Prices* 1999-1998, pg. A-31
Wheat Midds	Nearest-market bid for each region according to Feedstuffs Magazine, March 27th, 2000
	IA (Minneapolis)
	NC (Memphis)
	OK (Kansas City)
Dehydrated alfalfa meal	5 year average price by region of prices paid by farmers, *Agricultural Statistics* 1999
Soybean Meal (44%)	5 year average price by region of prices paid by farmers, *Agricultural Prices* 1998
Soybean Meal (48%)	Nearest-market bid (high-protein soybean meal) for each region according to *Feedstuffs Magazine*, March 27th, 2000
	IA (Minneapolis)
	NC (Okeechobee)
	OK (KC)
Soy Hulls	Nearest-market bid for each region according to *Feedstuffs Magazine*, March 27th, 2000
	IA (Minneapolis)
	NC (Okeechobee)
	OK (Ft. Worth)
L-lysine mono-hydrochloride	Independent bid provided by Heartland Lysine - 20,000kg lots FOB
	IA (Prince Agri Products, Inc. - Quincy, IL)
	NC (No response from independent vendor - used average of other vendor bids)
	OK (Bill Barr & Co., Inc. - Lenexa, KS)
Fat	Nearest-market bid (choice white grease) for each region according to *Feedstuffs Magazine*, March 27th, 2000
	IA (Minneapolis)
	NC (Memphis)
	OK (Memphis)
Salt	Nearest-market bid for each region according to Feedstuffs Magazine, March 27th, 2000
	IA (KC)
	NC (KC)
	OK (KC)
Vitamin, T/M premix	Independent bid provided by Sunrise feeds, Cheyenne, Oklahoma
Dicalcium Phosphate	Independent bid provided by Sunrise feeds, Cheyenne, Oklahoma
Limestone	Independent bid provided by Sunrise feeds, Cheyenne, Oklahoma

Modification of Labor Costs Labor costs are difficult to estimate for modeled operations such as these due to a number of factors. In many cases, unpaid family labor may be used, which would not be recorded in financial records for the farm. In other cases, workers may receive an annual salary and benefit package not based on the throughput of the farm during that time period. In still other instances, farm or personal financial information may be proprietary and unavailable for review.

In spite of these considerations, some attempts at labor use and costs for large-scale swine production operations have been made, and the labor cost estimates used in this research reflect a synthesis of these findings. In their respective work regarding swine production costs, both Lazarus and Zering, respectively, estimated the overall cost of labor for operations comparable to those modeled in this research. Their estimates were averaged to set a figure for the amount of labor required per sow in the farrow-to-feeder and farrow-to-finish operations, or per head in the finisher operations.

Since working with pigs in the breeding, gestation, farrowing, and nursery portions of the operations can be more complicated, it was expected that there would be a differential between wages for workers in each of these areas. The wage figures found in the work of Lazarus and Zering were averaged to find a base wage rate for workers in farrowing, nursery, and finisher operations. These base rates were then modified using a regional wage adjustment matrix (based on the 1998 annual average wage for farm laborers), in a manner similar to the adjustment of feedstuffs. Table 3-6 presents the regional labor matrix. Missouri and Minnesota are included in the matrix to accommodate the use of labor figures from those states in calculating the average wage rates which were then adapted to the modeled regions.

Modeling of Waste Management Costs The Departments of Agricultural Economics and Agricultural Engineering at both Oklahoma State University and the University of Missouri recently worked jointly to develop a computer program that could easily and accurately estimate the costs of waste management for specified types of swine production operations. The result of these efforts is the Swine Waste Management Program (SWMP), and this program was used in this research to model the waste management technologies likely to be employed by the modeled swine production operations.

Table 3-6

Regional Adjustment Matrix for Labor Costs

Row as percent of state column heading's annual average farm labor wage rate

	Missouri	Iowa	North Carolina	Oklahoma	Minnesota
Missouri		100.00%	112.09%	115.61%	92.59%
Iowa	100.00%		112.09%	115.61%	92.59%
North Carolina	89.21%	89.21%		103.14%	82.60%
Oklahoma	86.50%	86.50%	96.96%		80.09%
Minnesota	108.01%	108.01%	121.06%	124.86%	

Source: 1998 Agricultural Statistics, USDA

The SWMP requires a number of inputs to be provided by the operator, including the one-time swine capacity of the operation, the specific scope of the operation (farrowing, nursery, finishing, or a combination of these enterprises, etc.), details regarding the flow of animals through the operation, the type of waste management system employed, available cropland, type of crops, and yield goals. Drawing on large arrays of climatic data, engineering algorithms, and cost estimates, this program provides as output the estimated cost of waste management for the given facility on a per-unit-of-capacity basis.

Modification of Other Costs Combined feed and labor costs accounted for between 75.3% and 81.7% of total variable costs in the modeled farrow to feeder operations, 76.9% and 82.7% in the modeled farrow to finish operations, and 77.0% to 83.7% in the modeled finisher operations (after costs of purchasing feeder pigs). While these costs were important, attention was paid to the other cost components of the modeled operations as well. With the exception of the cost of utilities, which were easily modified from Census of Agriculture data in a manner similar to the indexing of feed and labor costs, most of the remaining items in the enterprise budgets were left at their levels in the Missouri budget model. Some, like animal health, breeding costs, insurance, repairs, and pork check-off were believed to be reasonably consistent regardless of the operation's locations. Others, such as taxes and fuel, oil, & gasoline, were thought to be so highly location-specific as to be impractical to modify relative to their importance for the overall costs of production.

Establishment of Hypothesized Regulations

After establishing the modeled operations, it was then necessary to establish a set of hypothesized regulations which would then be imposed on them. The following section details both how the hypothesized regulations were established and how their impacts on the modeled operations would be measured.

Selection of Hypothesized Regulations Admittedly, predicting the movements of political forces at both the federal and state level is a daunting task for the most seasoned analyst, and there is little in the way of objective, quantitative means of forecasting such phenomena. However, polling is a frequently used method for "gauging" the sentiments of policy makers. This method, combined with a thorough understanding of the issues at hand, can help one predict what legislative proposals may be likely in the near future. A combination of such polling (of sorts) and situational analysis was used in the course of this research, as detailed below.

The CAFO Regulatory Environment Recent years have seen a surge in the amount of regulatory attention paid to CAFOs and the animal wastes they produce. Since the growth in the prominence of these operations has been so sudden, many state legislatures and state regulatory agencies have struggled to update previously existing laws or to create entirely new ones. Dealing with such a specialized issue can pose problems for legislative officials who may not have experience in agricultural production or environmental science.

In the past, the majority of Americans (and legislators) were from an agricultural background, or were no more than a generation removed from such experience. As the nation grows increasingly urban, however, the same no longer holds true, and an increasing proportion of legislators no longer have any personal experience with animal or crop production practices. In regard to environmental science, it is also difficult to find legislators with experience in the area unless they have worked in the discipline prior to their current vocation. The result of these factors is an increasing reliance upon consulting groups to provide recommendations regarding possible regulatory responses to issues, and to estimate their probable effects of those responses. For example, in Oklahoma, legislators have consulted with the Natural Resources Conservation Service (NRCS) for technical advice regarding the CAFO issue, directly incorporating some NRCS guidelines into legislation (OCAFOA cite). The faculty and staff of land-grant universities and the Cooperative State Research, Education, and Extension Service (CSREES) have also played a role in the formation of CAFO regulations, providing similar guidance regarding the technical implications of such regulations.

These conditions lead to a number of CSREES staff providing technical assistance to other government agencies and legislators as they examine possible regulatory amendments and their changes. Bearing this in mind, a number of such staff from the University of Missouri and Oklahoma State University, along with staff from the Oklahoma Department of Agriculture (the Oklahoma state agency with regulatory authority over CAFO operations) were contacted in the preliminary phases of this research and asked to give their perspectives on likely regulatory changes in the next five years with regard to swine-producing CAFOs.

The overwhelming majority of these experts agreed that phosphorous limitations were quite likely, as a follow-up to the nitrogen restrictions in place for many states. These experts also believed that concerns about groundwater quality and odor would lead to the elimination of animal wastes' surface application, restricting land application of such wastes to sub-surface injection, incorporation, or underground irrigation systems. Furthermore, following a series of stories covered in newspapers and television regarding accidents involving lagoons and their leaks or failures, they also assigned a high likelihood to the elimination of lagoons as a waste storage system.

Recent Legislative Initiatives The veracity of these predictions was proved early in the 2000 session of the Oklahoma Legislature. Senate Bill 1051 during year's session called for the elimination of lagoons as a waste storage device by the year 2005. This measure would also prohibit the surface application of animal wastes by 2005 as well. Although the measure was never reported out of committee, its introduction lends credence to the perception that increasingly strict CAFO regulations are a very real possibility.

Hypothesized Regulations and their Implications A set of three regulations were chosen and imposed as a group on the modeled operations. Each of these regulations carries a number of implications for the farms who seek to comply with them. Specifically, they were:

1) The elimination of lagoons as a waste storage system
2) The prohibition of surface application of animal wastes
3) The restriction of waste application based on the phosphorous removal rate of the relevant crop.

Under the lagoon elimination regulation, producers would have to find a new waste storage and treatment technology. The NRCS definition of a lagoon is "an impoundment made by excavation or earth-fill for biological treatment of animal or other agricultural waste...[to] biologically treat waste such as manure and wastewater, as a function of a planned waste management system." Thus, the elimination of lagoons would force producers to seek some other method of waste storage and treatment. Among their options would be concrete tanks, steel tanks, or deep-pit in-house waste storage.

The second regulation, eliminating the surface application of animal wastes, would compel producers to either find alternative methods of land application or eliminate it altogether. If the producers chose to continue in land application, they could use sub-surface injection technology with drag-hose implements or tank wagons. Alternatively, they could use a sub-surface irrigation system. If, on the other hand, the producers chose to eliminate surface application of wastes, they would have to remove the liquid components of the waste, presumably by some method of evaporation. The result of this process would be a residue of waste solids, which would then have to be disposed of in a manner reminiscent of hazardous biological waste.

The restriction of waste application to the phosphorous removal capability of the given crop will hold different meanings for different producers, based on the crops that receive their animal wastes. If producer crops remove a sufficient amount of phosphorous each year, the producer could continue to apply such wastes on their initial land area. If, however, the initial crop acreage cannot remove all the phosphorous applied by waste, the producer must either find a more phosphorous-intensive crop or acquire more land area to receive the waste. Alternatively, another agricultural operator willing to receive the waste for application to their crops would have to be found, or the waste would have to be disposed of as an biologic waste product.

Methods for Forecasting Producer Response to Hypothesized Regulations

Ideally, one would like to form a comprehensive model to simulate all available technologies from which a swine producer could choose in order to comply with the hypothesized regulations. While such a model was beyond the scope of this project, a sample of available waste management technologies was evaluated, and each alternative's cost calculated to determine the most cost-efficient response for each modeled operation. To limit the field of possible alternative waste management systems for each modeled operation, the baseline scenario (inasmuch as waste management practices and technologies were concerned) was considered, along with the readily available alternative technologies that a producer might reasonably consider for implementation.

In the sections that follow, the baseline conditions in each state are discussed, along with the chosen alternative system to be implemented in response to the proposed regulations. Unless otherwise stated, all modeled operations in the state (farrow to feeder, farrow to finish, and finisher) all used identical waste management technologies, with the only differences among them being those of scale.

Adaptation of Oklahoma Operations

Consultation with experts and producers in Oklahoma indicated that a representative waste management system for Texas County would center around an anaerobic treatment lagoon, with land application of effluent accomplished through the previously mentioned center pivot system. In-house waste management would be accomplished through fully slatted houses using a pit recharge system that utilized both fresh water and recycled effluent from the treatment lagoon.

The land application of wastes under both the baseline and alternative conditions would be made to a crop mix of wheat, grain sorghum, and corn. Specifically, the crop mix for the Oklahoma operation included 320 acres of wheat, 120 acres of grain sorghum, and 120 acres of corn, for a total of 640 acres. However, since the land was irrigated utilizing center pivot systems, the effective cropland acreages of the crops were

256 acres of wheat, and 128 acres for grain sorghum, and 128 acres of corn. It should be noted that, using the drag-hose system employed under the alternative waste management system, the entire acreages of the fields could have been cultivated. However, it was presumed that the farm operators would confine cultivation efforts to those areas of the fields that could still benefit from the irrigation provided by the center pivot systems. The yield goals for each crop were 41.9 bushels per acre for wheat, 85.9 bushels per acre for grain sorghum, and 174.9 bushels per acre for corn.

Texas County's annual rainfall is considerably exceeded by its annual evaporative potential. As a result, all the modeled Oklahoma operations would have to actually add freshwater to their lagoons to maintain a viable treatment depth. While this posed a challenge to the baseline systems, it would prove to be an asset to the alternative systems.

In order to comply with the hypothesized regulations, the modeled Oklahoma Operations would need to make a number of modifications. Consultation with experts and some preliminary runs of the SWMP indicated that the best alternative setup would be the construction of cement above –ground storage tanks. To accommodate the new storage system, pig houses would utilize scraper systems to evacuate wastes. Waste would be applied through the use of drag-hose systems.

The Oklahoma Panhandle is noted for its relatively sparse rainfall, which leads to the prevalence of irrigation systems among its crop production operations. These systems are so widespread (especially in Texas County) that the modeled Oklahoma swine production operations were assumed to have such a system prior to the introduction of the swine enterprise to the farm. As a result, it was specified in the SWMP parameters that the Oklahoma operations (farrow to feeder, farrow to finish, and finisher) would only be charged 10% of the operating costs of the irrigation system and transfer piping, since such a system would have been in place regardless of the presence of a swine production operation on the given farm.

Adaptation of North Carolina Operations

The baseline systems for the North Carolina operations was, in many respects, very much like that of Oklahoma's operations, given the similarities in their current waste management technologies. Again, in house waste management was accomplished using pit recharge systems using both fresh water and recycled effluent. Waste storage and treatment was accomplished through the use of an anaerobic lagoon. The primary difference between the North Carolina operations and Oklahoma was found in their waste application systems. In North Carolina, travelling irrigation guns (commonly referred to as "big guns") are used to apply effluent from the lagoon to cropland. Under both baseline and alternative conditions, the crop base used for the North Carolina operations consisted of 120 acres of bermudagrass with a yield goal of eight tons per acre.

Using a procedure similar to that of Oklahoma, it was determined that the alternative system for North Carolina under the new regulations would also be very similar to Oklahoma's; in fact, it was virtually identical. A cement above-ground storage tank would be used for waste storage, with scrapers used as the method of in-house waste management. The application of wastes to cropland would be accomplished via a drag-hose injection system.

Adaptation of Iowa Operations

The modeled operations in Iowa would require very little modification, if any, to come into compliance with the lagoon elimination and surface application elimination requirements. Although lagoons are used by some Iowa swine production operations, that use has been severely curtailed by current Iowa legislation. Thus, they were not included in the setup of the modeled operation. Instead, cement above-ground tanks were used in the baseline and alternative scenarios as the waste storage system for the Iowa operations. Similarly, state regulations require incorporation of wastes into the soil, and thus, subsurface injection is commonplace. Again, in both the baseline and alternative situations, haul-tankers were used as the land-application system for all the Iowa operations, since this was deemed the most common means of waste application by those experts consulted, and the savings to be had under the alternative conditions by switching to drag-hose applicators were exceedingly small.

Consultation with experts indicated that the most common crop system to receive wastes from a swine production operation would consist of a corn/soybean rotation. Waste would be applied to the corn crop one year, and then a soybean crop would be planted in the following year. Since the SWMP was designed to make calculations base on a one-year cycle, however, it was decided to divide the crop area in two and plant each crop on half of the acreage. Thus, the crop base for each Iowa operation consisted of 160 acres of corn with a yield goal of 149.9 bushels per acre and 160 acres of soybeans with a yield goal of 50.5 bushels per acre.

Analytic Methods to Evaluate Impacts of Hypothetical Regulations

After preparing the baseline configurations of the modeled operations and running the SWMP for both the baseline scenarios and the scenarios imposing the hypothesized regulations, the output of the SWMP was examined to determine the impacts of the regulations on the costs of waste management. These costs can be broken into three major components: the cost of acquiring land to receive waste in excess of the current land base's nutrient uptake capacity, the cost of capital modifications to the physical plant of the operation, and the costs of annual operations needed to remain in compliance with the regulations.

Analysis of Land Requirements

The most easily analyzed results from the SWMP are the land requirements for the amount of waste produced by the given operation. The SWMP will flag an operation if a crop acreage with the specified crops and yield goal will not be able to utilize the amount of nutrients provided by the animal wastes. Thus, the amount of additional land needed would be that acreage of the given crop needed to utilize the remainder of the waste. To determine how much additional land would be required for each operation to meet the crop-removal standard, multiple iterations of the SWMP (with increasing cropland acreages) were conducted until the program determined that all the waste had been safely applied.

Analysis of Capital Requirements for Operation Modifications

Another output provided by the SWMP is a calculation of the capital needed to construct and install alternative waste management technologies. As a result, one can calculate the amount of capital that an operation would need to acquire (either from equity sources or by borrowing) to implement a given alternative technology. The capital requirements of implementing an alternative waste management technology may be crucial to a swine producer. Even if the fixed costs of the new assets associated with the system can be spread over a number of head sold, the need to implement the new technology could come a time when the financial assets of the producer are stretched thin, such as the hog price crisis of 1999. In such an event, the producer might not have any other alternative than to cease operations.

There are two principal capital requirements in the analysis of the response scenarios examined in this research. For Oklahoma and North Carolina operations, there will be the expense of shutting down a lagoon (the reader will recall that Iowa's baseline operations use a cement above ground tank for waste storage). To estimate the costs of lagoon closure for the modeled operations, CAFO licensing applications submitted to the Oklahoma Department of Agriculture were examined (which must include provisions for a lagoon shutdown procedure), and an average cost of lagoon shutdown per unit volume was calculated, then adapted to the respective modeled operations using the same regional construction cost indices employed to modify building costs for the operations.

The second component is the creation of a new waste management system. The SWMP incorporates the "opportunity cost" of the capital entailed in the waste management system as part of the annual operating expense of each system component; the total investment required will also be presented separately.

Analysis of Compliance Impacts on Annual Operating Costs

Finally, the SWMP also provides information regarding the annual operating costs of the waste management system, placed on a cost-per-pig-space basis. This information is synthesized by the program and provided as a separate output for the user. This can be taken as a line-item that can be added to the operation's enterprise budget. This information is particularly valuable for rapid analysis of the effects of a shift in waste management costs coupled with given market fluctuations. Once the costs of waste management have been incorporated into the enterprise budget and a breakeven cost has been calculated, one need only compare the breakeven with the current market price to determine the short-run profitability of the operation. This type of measure is easily understood, even by those with little experience in the industry, and can be used to quickly demonstrate the impact of further regulations.

CHAPTER IV

RESULTS

Introduction to Results

This chapter will present the results of the interface between the SWMP program and the University of Missouri Swine Production Budgeting program. A baseline scenario was run for each modeled operation. The hypothesized regulations were then imposed on the operation, the needed technological and management changes made, and a new scenario run for each model. Since it would be somewhat cumbersome to the reader to present the computer output for each of these model runs in this chapter, they have been included in Appendix 1. Additionally, the basic crop and waste generation characteristics of the modeled operations may be found in Table 4-1.

Baseline Costs for Farrow to Feeder Operations

The following section will present the costs of the baseline systems for the modeled farrow to feeder operations in Oklahoma, North Carolina, and Iowa. The particular waste management systems. structures, and procedures used to calculate the costs of these baseline operations were determined through consultation with Cooperative Extension service staff from each of the represented states. The tables included in this chapter present details of the costs of waste management for each modeled farrow to

Table 4-1

Crop and Waste Removal Characteristics of Modeled Operations

	Oklahoma		North Carolina		Iowa	
Total Farm Size	380 acres		200 acres		380 acres	
Total Cropland Acreage	320 acres		120 acres		320 acres	
Crops Selected	Wheat		Bermudagrass		Corn	
	Grain Sorghum				Soybeans	
	Corn					
Crop Acreages	Wheat	320	Bermudagrass	120	Corn	160
	Grain Sorghum	160			Soybeans	160
	Corn	160				
Crop Yield Goals	Wheat	41.9 bu/ac	Bermudagrass	8 tons/ac	Corn	149 9 bu/ac
	Grain Sorghum	85.9 bu/ac			Soybeans	50 5 bu/ac
	Corn	174 9 bu/ac				
Nitrogen Removal Capacities (lbs)	Wheat	16,736	Bermudagrass	36,096	Corn	21,616
	Grain Sorghum	12,848			Soybeans	30,304
	Corn	25,232				
Phosphorous Removal Capacities (lbs)	Wheat	11,424	Bermudagrass	8,352	Corn	8,608
	Grain Sorghum	6,352			Soybeans	7,104
	Corn	10,048				
Potassium Removal Capacities (lbs)	Wheat	5,024	Bermudagrass	32,256	Corn	6,448
	Grain Sorghum	3,872			Soybeans	11,056
	Corn	7,520				
Farrow to Feeder Operations						
Nitrogen Generated by Operation (lbs)	5,424		10,826		37,318	
Phosphorous Generated by Operation (lbs)	10,119		10,119		45,535	
Potassium Generated by Operation (lbs)	24,515		24,515		40,115	
Farrow to Finish Operations						
Nitrogen Generated by Operation (lbs)	16,723		33,352		114,973	
Phosphorous Generated by Operation (lbs)	31,677		31,677		142,547	
Potassium Generated by Operation (lbs)	68,008		68,008		111,286	
Finisher Operations						
Nitrogen Generated by Operation (lbs)	4,741		9,452		32,583	
Phosphorous Generated by Operation (lbs)	9,046		9,046		40,705	
Potassium Generated by Operation (lbs)	18,249		18,249		29,862	

feeder operation, along with comparisons between the operations in the represented states. Specifically, Table 4-2 presents the enterprise budgets for the baseline versions of the modeled farrow to feeder operations, and Table 4-3 displays the general specifications and expenses of the operations' waste management systems, while Table 4-4 shows the initial investment costs for each operations' waste management system.

Oklahoma Farrow to Feeder Operation

Enterprise Costs   Overall, the Oklahoma farrow to feeder operation had the second lowest cost of production. As was the case with all the farrow to feeder operations, feed was the single largest cost component , and accounted for 60.5% of the total variable costs of the Oklahoma operation. On a per head basis. Oklahoma's feed costs were $0.10 less expensive than North Carolina, but still $1.77 more than Iowa. In other areas not held constant across states, the Oklahoma farrow to feeder operation compared favorably with Iowa and North Carolina. with lower labor costs ($5.62 per head), and utilities that were less expensive than North Carolina but slightly more expensive than Iowa. In the base scenario, Oklahoma had the second-lowest breakeven cost per hundredweight, at $36.51.

Waste Management Costs   The initial investment in the Oklahoma farrow to feeder operation's waste management system was $137,365, and the annual operating costs were $32,349 when one accounts for the value of fertilizer ($1,392) recovered by the operation from waste application. This gave the Oklahoma operation

Table 4-2

Enterprise Budget Comparison for Baseline Farrow to Feeder Operations in Oklahoma, North Carolina, and Iowa

VARIABLE COSTS	Oklahoma (per head)	North Carolina (per head)	Iowa (per head)
Feed Costs			
Feeder Hogs	$9.41	$9.35	$8.50
Breeding Stock	$7.60	$7.76	$6.74
TOTAL FEED COSTS/HEAD MARKETED	$17.01	$17.11	$15.24
OTHER VARIABLE COSTS	HEAD	HEAD	HEAD
Animal Health	$2.34	$2.34	$2.34
Breeding Costs	$0.37	$0.37	$0.37
Fuel, Oil & Gasoline	$0.74	$0.74	$0.74
Insurance	$0.07	$0.07	$0.07
Hired Labor	$4.64	$5.62	$5.37
Repairs	$1.15	$1.15	$1.15
Taxes	$0.06	$0.06	$0.06
Utilities	$0.29	$0.40	$0.28
Pork Check-Off	$0.19	$0.19	$0.19
Waste Management	$1.24	$1.49	$1.71
TOTAL OTHER VARIABLE COSTS	$11.09	$12.43	$12.28
TOTAL FEED COSTS	$17.01	$17.11	$15.24
PRODUCTION BREAKEVEN BEFORE DEPRECIATION & INTEREST	$28.10	$29.53	$27.52
Depreciation	$7.49	$7.54	$7.57
PRODUCTION BREAKEVEN	$35.59	$37.08	$35.09
Line of Credit Interest	$0.10	$0.31	$0.09
Interest on Term Debt	$0.82	$0.84	$0.84
TOTAL BREAKEVEN	$36.51	$38.22	$36.02
BREAKEVEN W/O WASTE MGMT.	$35.27	$36.73	$34.31

Table 4-3

Cost Comparison for Baseline Farrow to Feeder Operations in Oklahoma, North Carolina, and Iowa

Cost Component	Oklahoma	North Carolina	Iowa
Initial Investment Cost	$137,365	$177,635	$278,967
Annual Operation Costs			
Waste Storage	$23,444	$28,205	$36,391
Application System	$1,910	$7,139	$14,070
Fresh Water	$8,387	$6,276	$4,936
Cost Before Fertilizer Credit	$33,742	$41,620	$55,396
Fertilizer Credit	-$1,392	-$2,771	-$10,817
Total Annual Cost	$32,349	$38,849	$44,579
Waste Management Costs / hd	$1.24	$1.49	$1.71
Waste Management Costs / cwt	$2.17	$2.61	$2.65
Waste Management Costs / litter	$11.44	$13.73	$13.94
Average Daily Inventory (head)	4,281	4,281	4,281
Annual Waste Volume (cubic feet)	848,497	870,904	222,505
Waste Storage System - Type	Anaerobic Lagoon	Anaerobic Lagoon	Above-ground tank
Waste Storage System - Volume (cubic feet)	1,343,559	1,562,149	269,750
Land Application System - Type	Center Pivot Irrigation	Traveling Gun Irrigation	Haul-tanker wagon
Land Application System - Volume Applied (acre inches)	33.9	67.0	55.3

Table 4-4

Comparison of Initial Investment Costs for Baseline Farrow to Feeder Operations in Oklahoma, North Carolina, and Iowa

Oklahoma		
Land for Anaerobic Lagoon (3.58 acres @ \$511/ac)		\$1,830
Lagoon Construction (1,343,559 ft^3 @ \$0.07/ft^3)		\$97,547
Lagoon Recirculation Pipe, Pumps		\$18,017
Center Pivot System		\$3,608
Buried PVC Pipe		\$1,416
Pumps (to fields)		\$2,791
Motors:pump to field		\$2,136
Fresh Water Wells		\$3,080
Fresh Water Pumps		\$6,100
Fresh Water Well Pipe		\$840
	Total	\$137,365
North Carolina		
Land for Anaerobic Lagoon (4.06 acres @ \$2,305/ac)		\$9,373
Lagoon Cosntruction (1,562,149 ft^3 @ \$0.07/ft^3)		\$104,618
Recirculation Pipe, Pumps		\$18,017
Hose Traveler		\$26,080
Buried PVC Pipe		\$1,098
Pumps (to fields)		\$5,261
Motors:pump to field		\$3,169
Fresh Water Wells		\$3,080
Fresh Water Pumps		\$6,100
Fresh Water Well Pipe		\$840
	Total	\$177,635
Iowa		
Land for Cement Above Ground Tank (0.84 acres @ \$2,428/ac)		\$2,034
Cement Above-Ground Tank Construction (269750 ft^3 @ \$0.56/ft^3)		\$163,394
Tractors		\$43,767
Aeration, Agitation Equipment		\$7,000
Haul-Tanker		\$16,460
Scrapers		\$36,292
Fresh Water Wells		\$3,080
Fresh Water Pumps		\$6,100
Fresh Water Well Pipe		\$840
	Total	\$278,967

the lowest annual waste management costs among all modeled farrow to feeder operations, with annual operating expenses of $1.24 per feeder pig sold.

The waste management system of the Oklahoma farrow to feeder operation owes its comparatively lower costs to a number of factors. The per-acre cost of land for the 3.6 acre lagoon's construction was significantly lower than land for the other systems - $511 in Oklahoma, compared to $2,305 in North Carolina and $2,428 in Iowa. Construction costs in Oklahoma were also favorable compared to Iowa, and slightly higher than North Carolina. The RS Means Construction Cost Index, used to adjust the costs of construction based on regional location, was 85.6 for Texas County, Oklahoma; 81.5 for Duplin County, North Carolina; and 93.4 for Sioux County, IA.

The lower costs of waste application also provide Oklahoma with lower overall waste management expenses. The annual costs associated with the operation of the waste application system (interest, depreciation on equipment, energy, etc.) totaled to $1,910 for the Oklahoma operation. However, a good portion of the difference between Oklahoma's waste application costs and those of other states can be attributed to the 10% charge of waste application equipment assumed. If 100% of these costs were attributed to the operation, it would then be slightly more expensive than the North Carolina operation. For more detail regarding the annual costs of the Oklahoma farrow to feeder operation, refer to Table 4-5.

The one factor that detracted from Oklahoma's cost advantage was the cost of fresh water for the waste management system. The cost of providing fresh water was appreciable for all Oklahoma baseline operations, as shown in Table 4-6. The total annual expense for this item was $8,387, significantly more than either the North

Table 4-5

Waste Management System Annual Costs – Baseline
Oklahoma Farrow to Feeder Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Anaerobic Lagoon Land	$273
Principle and Interest for Anaerobic Lagoon Construction	$14,537
Maintenance and Repair for Anaerobic Lagoon	$293
Principle and Interest for Recirculation Equipment	$2,685
Energy for Recirculation Equipment	$5,160
Maintenance and Repair for Recirculation Equipment	$497
Subtotal	$23,444
Application System	
Principle and Interest for Center-pivot Irrigation System	$448
Maintenance and Repair for Center-pivot Irrigation System	$150
Labor for Irrigation System	$1
Principle and interest for Pumps and Motors	$719
Maintenance and Repairs for Pumps and Motors	$167
Energy for Center-pivot Irrigation System	$199
Principle and Interest on Pipes and Hoses	$218
Maintenance and Repairs for Pipes and Hoses	$7
Subtotal	$1,910
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$6,711
Subtotal	$8,387
Recovered Fertilizer Value Credit	-$1,392
Total Annual Operating Costs	$32,349

* System specifications
In-house Waste Management System: Pit-recharge
Waste Storage Structure: Anaerobic Lagoon
Land Application System: Center-pivot Irrigation

Table 4-6

Freshwater Requirements for Modeled Operations' Waste Management Systems in Oklahoma, North Carolina, and Iowa

Baseline Operations	Oklahoma	North Carolina	Iowa
Farrow to Feeder	5,766,651	5,306,155	89,081
Farrow to Finish	14,120.073	12,766.039	231,244
Finisher	3.849,039	3,130,021	59,649
Modified Operations			
Farrow to Feeder	89,081	89,081	89,081
Farrow to Finish	231,244	231,244	231,244
Finisher	59,649	59,649	59,649

(All amounts in cubic feet)

Carolina or Iowa operations. This can be attributed to the need of the Oklahoma lagoon for additional fresh water to replace water removed through evaporation. Since evaporation exceeds rainfall in the Oklahoma Panhandle, fresh water must be added to lagoons to maintain the appropriate treatment depth for anaerobic processing of effluent. As a result, nearly 460,500 cubic feet of fresh water are added to the requirements of the Oklahoma operation. Thus, in order to meet the needs of the animals, to operate the pit-recharge system, and to keep the lagoon at acceptable levels (given the net loss of water from the lagoon due to evaporation), a total of 924,641 cubic feet of water was required per year for the operation. The energy costs associated with providing this amount of water, combined with the annual interest, maintenance, and repair costs of the water pumping system, amounted to $8,387. The reader will note that North Carolina and Iowa (both of which receive rainfall in excess of evaporation) have much lower water costs.

North Carolina Farrow to Feeder Operation

Enterprise Costs North Carolina had the highest breakeven price of the three states examined, but not by a great margin. Prior to the introduction of the waste management cost component, the breakeven price for the North Carolina farrow to feeder was $36.73 per head. The gap between the before-waste-management breakeven costs of Iowa and Oklahoma was $0.96 on a per head basis, while the gap between Oklahoma and North Carolina was $1.46. In each of the differential cost factors (feed, labor, and utilities), North Carolina had the highest costs of all three states. though it is interesting to note that their per head feed costs, at $17.11, were only $0.10 more than Oklahoma.

Waste Management Costs The initial investment in the North Carolina farrow to feeder operation's waste management system was $177,635, roughly $40,000 more than Oklahoma and $101,000 cheaper than Iowa. Accounting for the value of recovered fertilizer, the annual waste management costs for the North Carolina operation were $38,849, or $1.49 per feeder pig sold.

The expenses of the North Carolina system were between those of the Oklahoma operation and the Iowa operation, in every category. While the greater rainfall amounts received by the Duplin County, North Carolina area relative to Texas County, Oklahoma, dictated a larger lagoon, and the cost of land was higher than in Oklahoma, the lower Means Construction Cost Index for the area mitigated these factors slightly. Overall, the annual costs of maintaining and operating the lagoon were $28,205.

The travelling gun application system specified for waste application was more expensive than the Oklahoma center pivot system, but this was due to the reduced charge of waste application systems to the swine enterprise on the part of Oklahoma. Had the

Oklahoma swine enterprise been charged for the full cost of its waste application system, the North Carolina system would have been $644 cheaper on an annual basis.

The costs of providing fresh water to the operation, $6,276, were slightly less than Oklahoma, given the higher rainfall and lower evaporation. Since rainfall at the North Carolina operation exceeded evaporation, no additional freshwater had to be added to the lagoon; only drinking water and wash water were required.

After the introduction of the waste management cost component, the North Carolina farrow to feeder operation still had the highest breakeven price, at $38.22 per hundredweight before waste management costs. Table 4-7 presents the annual costs of waste management for the North Carolina farrow to feeder operation in more detail.

Iowa Farrow to Feeder Operation

The Iowa farrow to feeder operation was located near Sioux Center, in Sioux County, found in the northwest portion of the state.

Enterprise Costs The advantage with regards to lower costs of production seemed to bounce back and forth between Iowa and Oklahoma, with Iowa holding a distinct advantage in feed costs per head ($15.24, compared to Oklahoma's $0.49) and a smaller advantage in utilities. Oklahoma posed lower costs for hired labor and waste management. Still, overall, Iowa had the lowest breakeven price prior to the introduction of waste management costs, at $36.02, leading Oklahoma by $0.49 per hundredweight.

Waste Management Costs The initial investment in the Iowa operation totals $278,967 and is mostly comprised of the construction costs of the cement above-ground tank. When the value of recovered fertilizer is acknowledged, the annual costs of waste management are $44,579 or $1.71 per feeder pig sold.

Table 4-7

Waste Management System Annual Costs - Baseline
North Carolina Farrow to Feeder Operation

Waste Storage		Annual Cost
Principle and Interest for Anaerobic Lagoon Land		$1.397
Principle and Interest for Anaerobic Lagoon Construction		$15.591
Maintenance and Repair for Anaerobic Lagoon		$314
Principle and Interest for Recirculation Equipment		$2.685
Energy for Recirculation Equipment		$7.721
Maintenance and Repair for Recirculation Equipment		$497
	Subtotal	$28.205
Application System		
Principle and Interest for Hose Traveler		$3.707
Maintenance and Repair for Hose Traveler		$1.304
Labor for Irrigation System		$53
Principle and interest for Pumps and Motors		$1.234
Maintenance and Repairs for Pumps and Motors		$316
Energy for Traveling Gun Irrigation Sytem		$351
Principle and Interest on Pipes and Hoses		$169
Maintenance and Repairs for Pipes and Hoses		$5
	Subtotal	$7.139
Fresh Water		
Principle and Interest on Fresh Water Wells, Pumps, and Pipes		$1.493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes		$183
Energy for Fresh Water System		$4.600
	Subtotal	$6.276
Recovered Fertilizer Value Credit		-$2.771
	Total Annual Operating Costs	$38.849

In-house Waste Management System: Pit-recharge
Waste Storage Structure: Anaerobic Lagoon
Land Application System: Traveling-gun Irrigation

At virtually every level, the Iowa waste management system is more intensive in terms of either financial or human capital, or both. The costs inherent to the cement storage tank account for the higher costs of waste storage for the Iowa operation relative to its Oklahoma and North Carolina counterparts. The use of haul tankers for waste application requires vastly more labor than the irrigation systems employed by Oklahoma and North Carolina. The only cost dimension in which the Iowa system was not the most expensive was the cost of fresh water. Since the storage tank need not maintain a given treatment depth (and since annual rainfall in Sioux County exceeds annual evaporation), no additional water beyond drinking and washing requirements is needed.

Given the corn/soybean rotation's ability to utilize the nutrients provided by the swine enterprise, the Iowa operation enjoys a large fertilizer credit of $10,817, without which the costs of waste management would be $55,396. After the introduction of waste management costs, the Iowa farrow to feeder had a breakeven price of $36.02 per head, letting it retain its position as lowest-cost among the farrow to feeder operations. The introduction of waste management costs to the respective Iowa and Oklahoma swine enterprise budgets actually closed the gap between the two, from $0.96 prior to waste management, to $0.49 afterward, a narrowing of $0.47. For more information regarding the Iowa farrow to feeder operation's annual waste management costs, consult Table 4-8.

Baseline Costs for Farrow to Finish Operations

The following section will present the costs of the baseline setups for the modeled farrow to finish operations in Oklahoma, North Carolina, and Iowa. As in the case of the farrow to feeder operations, the waste management systems, structures, and procedures used to calculate the costs of these baseline operations were determined through

Table 4-8

Waste Management System Annual Costs – Baseline
Iowa Farrow to Feeder Operations*

		Annual Cost
Waste Storage		
Principle and Interest for Cement Above-ground Tank Land		$303
Principle and Interest for Cement Above-ground Tank Construction		$24,351
Maintenance and Repair for Cement Above-ground Tank		$490
Principle and Interest for Recirculation Equipment		$5,409
Energy for Recirculation Equipment		$669
Maintenance and Repair for Recirculation Equipment		$5,169
	Subtotal	$36,391
Application System		
Principle and Interest for Haul-tanker		$2,453
Maintenance and Repair for Haul-tanker		$791
Labor for Haul-tanker		$1,612
Principle and interest for Pumps and Motors		$4,701
Maintenance and Repairs for Pumps and Motors		$610
Energy for Haul-tanker System		$2,495
Principle and Interest on Pipes and Hoses		$1,345
Maintenance and Repairs for Pipes and Hoses		$63
	Subtotal	$14,070
Fresh Water		
Principle and Interest on Fresh Water Wells, Pumps, and Pipes		$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes		$183
Energy for Fresh Water System		$3,260
	Subtotal	$4,936
Recovered Fertilizer Value Credit		-$10,817
	Total Annual Operating Costs	$44,579

* System specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Haul-Tanker Wagon

consultation with Cooperative Extension service staff from each of the represented states, and staff on campus at Oklahoma State University.

The respective enterprise budgets for the modeled baseline farrow to finish operations can be found in Table 4-9, with their general waste management system specifications and costs shown in Table 4-10, and initial investment costs presented in Table 4-11.

Oklahoma Farrow to Finish Operation

Enterprise Costs As was the case with the farrow to feeder operations, Oklahoma again had the second-lowest costs of it's counterparts, with a total breakeven price of $31.59 per hundredweight. The feed cost component did a great deal to contribute to the gap between Oklahoma and the least-cost operation, Iowa. Oklahoma's feed costs were $20.24 per hundredweight, while Iowa's were $18.02, a difference of $2.22. Iowa also had a slightly lower utilities charge, by $0.03 per hundredweight. This gap was narrowed, however, by Oklahoma's advantages in hired labor costs.

Waste Management Costs The waste management system employed by the Oklahoma farrow to finish operation was identical to that used by the farrow to feeder operation, with the exception of its scale. The waste system for the farrow to feeder operation was designed to support a one-time capacity of 4,282 animals, whereas the farrow to finisher system needed to support 11,862 animals. As a result, the capacity of many system components had to be more than doubled relative to those of the farrow to feeder system.

The total investment in the waste management system was $299,860, owing in a large part to the 9.4 acre anaerobic lagoon needed to accommodate the waste generated

Table 4-9
Farrow to Finish Enterprise Budget Comparison for
Baseline Farrow to Finish Operations in Oklahoma,
North Carolina, and Iowa

	Oklahoma (per cwt)	North Carolina (per cwt)	Iowa (per cwt)
VARIABLE COSTS			
Feed Costs			
Market Hogs	$16.92	$17.35	$15.07
Breeding Stock	$3.32	$3.39	$2.95
TOTAL FEED COSTS/HEAD MARKETED	$20.24	$20.75	$18.02
OTHER VARIABLE COSTS	$/CWT	$/CWT	$/CWT
Animal Health	$0.42	$0.42	$0.42
Breeding Costs	$0.16	$0.16	$0.16
Fuel, Oil & Gasoline	$0.23	$0.23	$0.23
Insurance	$0.57	$0.57	$0.57
Hired Labor	$3.70	$4.32	$4.27
Repairs	$0.36	$0.36	$0.36
Taxes	$0.12	$0.12	$0.12
Utilities	$1.09	$1.49	$1.06
Pork Check-Off	$0.19	$0.19	$0.19
Waste Management	$1.22	$1.33	$1.90
TOTAL OTHER VARIABLE COSTS	$8.06	$9.19	$9.29
TOTAL FEED COSTS	$20.24	$20.75	$18.02
PRODUCTION BREAKEVEN BEFORE DEPRECIATION & INTEREST	$28.29	$29.93	$27.31
Depreciation	$2.50	$2.59	$2.60
PRODUCTION BREAKEVEN	$30.80	$32.52	$29.91
Line of Credit Interest	$0.04	$0.08	$0.03
Interest on Term Debt	$0.75	$0.77	$0.78
TOTAL BREAKEVEN	$31.59	$33.37	$30.71
BREAKEVEN W/O WASTE MGMT.	$30.37	$32.05	$28.81

Table 4-10

Cost Comparison for Baseline Farrow to Finish Operations in Oklahoma, North Carolina, and Iowa

Cost Component	Oklahoma	North Carolina	Iowa
Initial Investment Cost	$299,860	$357,372	$645,789
Annual Operation Costs			
Waste Storage	$54,630	$65,724	$101,230
Application System	$2,525	$8,117	$17,666
Fresh Water	$20,617	$14,122	$10,496
Cost Before Fertilizer Credit	$77,772	$87,963	$129,392
Fertilizer Credit	-$5,183	-$8,536	-$15,658
Total Annual Cost	$72,589	$79,427	$113,735
Waste Management Costs / hd	$2.91	$3.16	$4.56
Waste Management Costs / cwt	$1.22	$1.32	$1.91
Waste Management Costs / litter	$25.66	$27.90	$40.20
Average Daily Inventory (head)	8,878	8,878	8,878
Annual Waste Volume (cubic feet)	2,467,977	2,369,649	665,591
Waste Storage System - Type	Anaerobic Lagoon	Anaerobic Lagoon	Above-ground Tank
Waste Storage System - Volume (cubic feet)	4,079,592	4,529,734	781,606
Land Application System - Type	Center-pivot Irrigation	Traveling Gun Irrigation	Haul-tanker wagon
Land Application System - Volume Applied (acre inches)	104.6	178.9	78.8 87.0 ac-in remaining

Table 4-11

Comparison of Initial Investment Costs for Baseline Farrow to Finish Operations in Oklahoma, North Carolina, and Iowa

Oklahoma		
Land for Anaerobic Lagoon (9.40 acres @ $511/ac)		$4,802
Lagoon Construction (4,079,591 ft^3 @ $0.06/$ft^3$)		$251,925
Lagoon Recirculation Pipe, Pumps		$20,045
Center Pivot System		$4,468
Buried PVC Pipe		$4,217
Pumps (to fields)		$2,791
Motors:pump to field		$1,592
Fresh Water Wells		$3,080
Fresh Water Pumps		$6,100
Fresh Water Well Pipe		$840
	Total	$299,860
North Carolina		
Land for Anaerobic Lagoon (10.3 acres @ $2,305/ac)		$23,795
Lagoon Cosntruction (4,529,734 ft^3 @ $0.06/$ft^3$)		$264,040
Recirculation Pipe, Pumps		$20,045
Hose Traveler		$26,080
Buried PVC Pipe		$4,962
Pumps (to fields)		$5,261
Motors:pump to field		$3,169
Fresh Water Wells		$3,080
Fresh Water Pumps		$6,100
Fresh Water Well Pipe		$840
	Total	$357,372
Iowa		
Land for Cement Above Ground Tank (1.84 acres @ $2,428/ac)		$4,466
Cement Above-Ground Tank Construction (781,606 ft^3 @ $0.53/$ft^3$)		$448,875
Tractors		$52,867
Aeration, Agitation Equipment		$7,000
Haul-Tanker		$16,460
Scrapers		$106,101
Fresh Water Wells		$3,080
Fresh Water Pumps		$6,100
Fresh Water Well Pipe		$840
	Total	$645,789

by the operation. Including the credit for the fertilizer value recovered from waste application, the annual costs of waste management for the Oklahoma operation were $72,589, or $1.22 per hundredweight.

Overall, the costs of waste storage and application for the Oklahoma Operation remained lower than those for North Carolina and Iowa for much the same reasons as were the case in the farrow to feeder operations. The need of additional water for the Oklahoma lagoon represented a significant increase in the annual costs of operations, however. Given the larger size of the lagoon, much more water had to be added to maintain a viable treatment depth (roughly 1,354,600 cubic feet for the farrow to finish operation, versus 460,000 cubic feet for the farrow to feeder). This increased the annual costs of fresh water provision to $20,617 – 146% of the North Carolina freshwater cost and 196% of the Iowa cost. This cost, combined with the lower fertilizer credit relative to North Carolina, made Oklahoma slightly more expensive than that state, and but still less expensive than Iowa. Table 4-12 presents the annual costs of the waste management system for the Oklahoma operation.

When the costs of waste management are added to the enterprise budget for Oklahoma, the breakeven price for the operation remains the second-lowest, at $31.59 per hundredweight.

North Carolina Farrow to Finish Operation

Enterprise Costs North Carolina had the highest breakeven price per head, owing to higher feed costs along every differential cost dimension, although its labor costs were not much higher than Iowa's. Overall, the breakeven price for the North

Table 4-12

Waste Management System Annual Costs – Baseline
Oklahoma Farrow to Finish Operation*

		Annual Cost
Waste Storage		
Principle and Interest for Anaerobic Lagoon Land		$716
Principle and Interest for Anaerobic Lagoon Construction		$37,544
Maintenance and Repair for Anaerobic Lagoon		$756
Principle and Interest for Recirculation Equipment		$2,987
Energy for Recirculation Equipment		$12,130
Maintenance and Repair for Recirculation Equipment		$497
	Subtotal	$54,630
Application System		
Principle and Interest for Center-pivot Irrigation System		$606
Maintenance and Repair for Center-pivot Irrigation System		$203
Labor for Irrigation System		$38
Principle and interest for Pumps and Motors		$642
Maintenance and Repairs for Pumps and Motors		$167
Energy for Center-pivot Irrigation System		$197
Principle and Interest on Pipes and Hoses		$650
Maintenance and Repairs for Pipes and Hoses		$21
	Subtotal	$2,525
Fresh Water		
Principle and Interest on Fresh Water Wells, Pumps, and Pipes		$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes		$183
Energy for Fresh Water System		$18,941
	Subtotal	$20,617
Recovered Fertilizer Value Credit		-$5,183
	Total Annual Operating Costs	$72,589

* Systems specifications
In-house Waste Management System: Pit-recharge
Waste Storage Structure: Anaerobic Lagoon
Land Application System: Center-pivot Irrigation

Carolina farrow to finisher operation was $33.37 per hundredweight excluding waste management costs.

Waste Management Costs The total initial investment for the operation was $357,372, and the annual costs of waste management with the fertilizer credit amounted to $78,930 – the second lowest of all three farrow to finish operations.

The Oklahoma farrow to finish operation realizes a cost advantage relative to its North Carolina counterpart in waste storage and application (owing primarily to the fact that the Oklahoma swine enterprise was charged less than the full cost of the system for reasons mentioned earlier). The North Carolina operation slightly erodes this advantage due to its smaller fresh water costs. Furthermore, the North Carolina operation also received a higher fertilizer credit of $8,536 compared to Oklahoma's credit of $5,929. Still, these factors were not enough to counterbalance the above-mentioned storage and application costs, and resulted in higher costs than in Oklahoma.

With the addition of waste management costs to its enterprise budget, the North Carolina farrow to finish operation had a breakeven price of $33.37 per hundredweight, leaving it with the highest breakeven price by a margin of $1.78 relative to Oklahoma, it's closest competitor. The North Carolina baseline farrow to finish operation's annual waste management costs can be seen in Table 4-13.

Iowa Farrow to Finish Operation

Enterprise Costs Again, Iowa had the lowest breakeven costs of all the modeled farrow to finish operations, with a total breakeven of $30.71 per hundredweight before waste management costs, $0.88 less than its closest competitor, Oklahoma. As

Table 4-13

Waste Management System Annual Costs - Baseline
North Carolina Farrow to Finish Operation*

		Annual Cost
Waste Storage		
Principle and Interest for Anaerobic Lagoon Land		$3.546
Principle and Interest for Anaerobic Lagoon Construction		$39.350
Maintenance and Repair for Anaerobic Lagoon		$792
Principle and Interest for Recirculation Equipment		$2.987
Energy for Recirculation Equipment		$18.552
Maintenance and Repair for Recirculation Equipment		$497
	Subtotal	$65.724
Application System		
Principle and Interest for Hose Traveler		$3.707
Maintenance and Repair for Hose Traveler		$1.304
Labor for Irrigation System		$132
Principle and interest for Pumps and Motors		$1.234
Maintenance and Repairs for Pumps and Motors		$316
Energy for Center-pivot Irrigation System		$636
Principle and Interest on Pipes and Hoses		$764
Maintenance and Repairs for Pipes and Hoses		$25
	Subtotal	$8.117
Fresh Water		
Principle and Interest on Fresh Water Wells, Pumps, and Pipes		$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes		$183
Energy for Fresh Water System		$12,445
	Subtotal	$14,122
Recovered Fertilizer Value Credit		-$8.536
	Total Annual Operating Costs	$79,427

* Systems specifications
In-house Waste Management System: Pit-recharge
Waste Storage Structure: Anaerobic Lagoon
Land Application System: Traveling-gun Irrigation

mentioned above, Iowa had a distinct advantage in lower feed costs, as well as slight relative savings in utilities.

Waste Management Costs The total initial investment in the waste management system for the Iowa farrow to finish operation was $645,789, and after accounting for the value of fertilizer recovered, the annual cost of waste management was $113,735.

As it was observed in the case of the farrow to feeder operation, the primary component of waste management costs for the operation stem from the cement storage tank, which exceeded the costs of storage for either Oklahoma or North Carolina ($101,230 for Iowa, versus $54,630 for Oklahoma and $65,227 for North Carolina). The cost of Iowa's haul-tanker application system had an annual operating cost more than double that of North Carolina and more than three times that of Oklahoma. Given the rainfall received by Sioux County, Iowa, however, water costs for the Iowa operation were comparable to those of North Carolina, and much less than those of Oklahoma. Iowa also received a greater fertilizer credit than any of the other states at $15,658. Greater detail regarding the annual waste management costs for the operation can be seen in Table 4-14.

The introduction of waste management costs into the Iowa farrow to finish enterprise budget brought its breakeven price to $30.71 per hundredweight, enabling Iowa to remain the least-cost producer. As was the case, with the farrow to feeder operations, though, the introduction of waste management costs served to narrow the gap between Oklahoma and Iowa, from $1.56 per hundredweight before waste costs to $0.88, a reduction of 44%.

Table 4-14

Waste Management System Annual Costs – Baseline
Iowa Farrow to Finish Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$666
Principle and Interest for Cement Above-ground Tank Construction	$66,896
Maintenance and Repair for Cement Above-ground Tank	$1,234
Principle and Interest for Recirculation Equipment	$15,812
Energy for Recirculation Equipment	$2,136
Maintenance and Repair for Recirculation Equipment	$14,486
Subtotal	$101,230
Application System	
Principle and Interest for Haul-tanker	$2,453
Maintenance and Repair for Haul-tanker	$1,357
Labor for Haul-tanker	$2,258
Principle and interest for Pumps and Motors	$5,679
Maintenance and Repairs for Pumps and Motors	$991
Energy for Haul-tanker System	$3,495
Principle and Interest on Pipes and Hoses	$1,345
Maintenance and Repairs for Pipes and Hoses	$89
Subtotal	$17,666
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$8,820
Subtotal	$10,496
Recovered Fertilizer Value Credit	-$15,658
Total Annual Operating Costs	$113,735

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Haul-Tanker Wagon

It should be noted here that under the baseline conditions, Iowa did not have enough land to receive all the fertilizer nutrients from the waste generated by the operation. Indeed, 78.9 acre-inches of waste remained after the nitrogen-removal capacity of the crop base had been reached. Under such conditions, the Iowa operation would need to acquire an additional 297 acres of cropland to meet this demand.

Baseline Costs for Finisher Operations

The baseline finisher operations were modeled in the same manner as the farrow to feeder and farrow to finish operations. The operations' enterprise budgets can be found in Table 4-15, with general specifications and costs of their waste management systems displayed in Table 4-16, and their comparative initial investments in Table 4-17.

Oklahoma Finisher Operation

Enterprise Costs Consistent with the farrow to feeder and farrow to finish operations, the Oklahoma finisher operation had the second-lowest breakeven price of the modeled operations. Though lagging Iowa by $1.46 per hundredweight in feed costs, Oklahoma had lower labor costs, and only slightly higher utilities expenses. Without the addition of waste management costs, the Oklahoma finisher's total breakeven price was $35.48 per hundredweight (before waste management costs), or $0.93 higher than Iowa and $0.96 lower than North Carolina.

Waste Management Costs Under these conditions, the total initial investment cost for the system was $121,475. Total annual costs of waste management, adjusted for the fertilizer credit, were $26,387, comparable to those of the Oklahoma farrow to feeder operation. The costs of waste management per market hog sold were $2.52.

Table 4-15

Enterprise Budget Comparison for Baseline Finisher Operations in Oklahoma, North Carolina, and Iowa

	Oklahoma	North Carolina	Iowa
VARIABLE COSTS	(per cwt)	(per cwt)	(per cwt)
FEED COSTS	$12.98	$13.45	$11.52
OTHER VARIABLE COSTS	$/CWT	$/CWT	$/CWT
Animal Health	$0.44	$0.44	$0.44
Fuel, Oil & Gasoline	$0.07	$0.07	$0.07
Insurance	$0.12	$0.12	$0.12
Hired Labor	$0.81	$0.83	$0.94
Repairs	$0.11	$0.11	$0.11
Taxes	$0.13	$0.13	$0.13
Utilities	$0.55	$0.75	$0.53
Pork Check-Off	$0.19	$0.19	$0.19
Waste Management	$1.07	$1.30	$1.44
Purchase Feeder Pigs	$17.59	$17.59	$17.59
TOTAL OTHER VARIABLE COSTS	$21.09	$21.54	$21.57
TOTAL FEED COSTS	$12.98	$13.45	$11.52
PRODUCTION BREAKEVEN BEFORE DEPRECIATION AND INTEREST	$34.07	$34.99	$33.08
Depreciation	$1.11	$1.15	$1.16
PRODUCTION BREAKEVEN	$35.18	$36.14	$34.24
Interest on Term Debt	$0.29	$0.29	$0.30
Line of Credit Interest	$0.01	$0.01	$0.00
TOTAL BREAKEVEN	$35.48	$36.44	$34.55
BREAKEVEN W/O WASTE MGMT.	$34.41	$35.14	$33.11

Table 4-16

Cost Comparison for Baseline Finisher Operations in Oklahoma, North Carolina, and Iowa

Cost Component	Oklahoma	North Carolina	Iowa
Initial Investment Cost	$121,475	$162,424	$239,784
Annual Operation Costs			
Waste Storage	$18,959	$22,375	$28,211
Application System	$1,536	$7,140	$12,857
Fresh Water	$7,108	$4,968	$4,009
Cost Before Fertilizer Credit	$27,603	$34,484	$45,077
Fertilizer Credit	-$1,217	-$2,419	-$9,495
Total Annual Cost	$26,387	$32,064	$35,582
Waste Management Costs / hd	$2.52	$3.07	$3.40
Waste Management Costs / cwt	$1.07	$1.30	$1.44
Average Daily Inventory (head)	3,174	3,174	3,174
Annual Waste Volume (cubic feet)	753,839	773,068	185,913
Waste Storage System - Type	Anaerobic Lagoon	Anaerobic Lagoon	Above-ground Tank
Waste Storage System - Volume (cubic feet)	1,188,246	1,388,478	214,767
Land Application System - Type	Center-pivot Irrigation	Traveling Gun Irrigation	Haul-tanker Wagon
Land Application System - Volume Applied (acre inches)	29.7	58.8	46.4

Table 4-17

Comparison of Initial Investment Costs for Baseline Finisher Operations in Oklahoma, North Carolina, and Iowa

Oklahoma	
Land for Anaerobic Lagoon (3.23 acres @ $511/ac)	$1,652
Lagoon Construction (1,188,246 ft^3 @ $0.07/$ft^3$)	$88,784
Lagoon Recirculation Pipe, Pumps	$13,023
Center Pivot System	$3,408
Buried PVC Pipe	$1,008
Pumps (to fields)	$2,226
Motors:pump to field	$1,355
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total Initial Investment	$121,475
North Carolina	
Land for Anaerobic Lagoon (3.68 acres @ $2,305/ac)	$8,486
Lagoon Cosntruction (1,388,478 ft^3 @ $0.06/$ft^3$)	$95,288
Recirculation Pipe, Pumps	$13,023
Hose Traveler	$26,080
Buried PVC Pipe	$1,098
Pumps (to fields)	$5,261
Motors:pump to field	$3,169
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total Initial Investment	$162,424
Iowa	
Land for Cement Above Ground Tank (0.72 acres @ $2,428/ac)	$1,745
Cement Above-Ground Tank Construction (214,767 ft^3 @ $0.57/$ft^3$)	$132,728
Tractors	$40,099
Aeration, Agitation Equipment	$7,000
Haul-Tanker	$16,460
Scrapers	$31,731
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total Initial Investment	$239,784

The capacity of the finisher operation was smaller than that of the farrow to feeder operation (with the waste system of the farrow to feeder operation designed for 4,283 animals, and the finisher designed for 3,180), and it required a slightly smaller lagoon than the farrow to feeder operation. The area of the finisher lagoon was 3.2 acres, compared to 3.6 for the farrow to feeder operation. It is worthwhile to note here that while this is an 11.1% reduction in the size of the lagoon, the difference between the animal capacity of the farrow to feeder relative to the finisher is 25.8%. This is due to the fact that finisher pigs, with their higher body mass than the average for a farrow to feeder operation, and more intensive feed program, produce a greater volume of waste than sows or nursery pigs.

At $18,959, Oklahoma had the lowest costs of waste storage by a margin of $3,416. The nearest competitor in this category of costs was North Carolina, followed by Iowa. Again, as was the case with the farrow to feeder and farrow to finish operations, the pre-existence of the Oklahoma finisher's waste application system gave it the advantage over the North Carolina and Iowa operations in the area of waste application costs; Oklahoma's costs for this area were $1,536. Refer to Table 4-18 for more information regarding the Oklahoma baseline finisher operation's annual waste management costs.

Also, in a manner reminiscent of the farrow to feeder and farrow to finish operations, the Oklahoma finisher operation paid well in excess of the other state's operations for freshwater, again owing to the need for additional water to be added to the operation's lagoon to maintain a viable treatment depth. In this case, the Oklahoma finisher lagoon needed 416,302 cubic feet of water added to the lagoon to replace

Table 4-18

Waste Management System Annual Costs – Baseline
Oklahoma Finisher Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Anaerobic Lagoon Land	$246
Principle and Interest for Anaerobic Lagoon Construction	$13,231
Maintenance and Repair for Anaerobic Lagoon	$266
Principle and Interest for Recirculation Equipment	$1,941
Energy for Recirculation Equipment	$2,916
Maintenance and Repair for Recirculation Equipment	$358
Subtotal	$18,959
Application System	
Principle and Interest for Center-pivot Irrigation System	$448
Maintenance and Repair for Center-pivot Irrigation System	$150
Labor for Irrigation System	$1
Principle and interest for Pumps and Motors	$524
Maintenance and Repairs for Pumps and Motors	$134
Energy for Center-pivot Irrigation System	$118
Principle and Interest on Pipes and Hoses	$155
Maintenance and Repairs for Pipes and Hoses	$5
Subtotal	$1,536
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$5,432
Subtotal	$7,108
Recovered Fertilizer Value Credit	-$1,217
Total Annual Operating Costs	$26,387

* Systems specifications
In-house Waste Management System: Pit-recharge
Waste Storage Structure: Anaerobic Lagoon
Land Application System: Center-pivot Irrigation

evaporative losses. The additional costs of providing water (total freshwater costs for the operation were $7,108), combined with the lower fertilizer credit received by the operation ($1,581) relative to the other states reduced the comparative advantage gained by the lower cost of the operation's waste storage and application systems. Nevertheless, Oklahoma had the lowest costs of all the finisher operations; North Carolina's total annual costs were $5,678 more than Oklahoma. When the overall waste management costs were put on a per hundredweight basis, Oklahoma had expenses of $1.07 and North Carolina had expenses of $1.30 per hog.

The introduction of waste management expenses to the Oklahoma finisher's enterprise budget led to a breakeven price of $35.48 per hundredweight. This left Oklahoma with the second-lowest cost of production, $0.93 higher than Iowa, but $0.96 less than North Carolina.

North Carolina Finisher Operation

Enterprise Costs Again, the North Carolina operation had the highest breakeven price of the modeled finish operations, but not by a great margin. While at a disadvantage relative to the two other states in feeds and utilities, it did have a slight advantage ($0.11 per hundredweight) over Iowa in labor costs. In total, the per hundredweight breakeven price for the finisher operation was $36.44, $0.96 more than those of Oklahoma, its closest competitor.

Waste Management Costs Again, the waste management system employed by the North Carolina finisher operation is virtually identical to that of the farrow to feeder and farrow to finisher operations. Fully slatted houses use pit-recharge flushers to send wastes to an anaerobic lagoon, effluent from which is applied to crops using a travelling gun system. Effluent was also recirculated through the pit-recharge system. The total initial investment cost for the system was calculated by the SWMP at $162,424. On a per hundredweight basis, the annual costs of waste management were $1.30 after accounting for the value of fertilizer.

The area of the lagoon for the finisher operation was 3.7 acres, compared to 4.1 acres of the farrow to feeder lagoon. The annual costs of operating the lagoon were $22,375, or $3,416 higher than the costs for the Oklahoma finisher. The North Carolina waste application system was more expensive than its Oklahoma counterpart ($7,140 for North Carolina, compared to $1,536 for Oklahoma), but one must again bear in mind the fact that the Oklahoma swine enterprise was not charged for the full cost of the application system. Had it been, the North Carolina application system would have been only $328 more expensive. Table 4-19 provides detailed information regarding the annual waste management costs for the North Carolina baseline finisher operation..

Since additional water was not needed to maintain the treatment depth of the lagoon, the fresh water costs of the North Carolina operation were modest at $4,968, compared to Oklahoma's cost of $7,108. Iowa's freshwater costs were slightly lower than those of North Carolina.

Without the benefit of their fertilizer credits, the North Carolina operation's annual waste management costs would slightly more than $6,880 per year greater than those of Oklahoma. However, the North Carolina cropping system was better able to capitalize on the fertilizer value of the wastes, and received a $2,419 fertilizer credit, thus placing the total annual costs at the previously mentioned $5,678 lower than Oklahoma.

Table 4-19

Waste Management System Annual Costs – Baseline
North Carolina Finisher Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Anaerobic Lagoon Land	$274
Principle and Interest for Anaerobic Lagoon Construction	$14,915
Maintenance and Repair for Anaerobic Lagoon	$286
Principle and Interest for Recirculation Equipment	$1,941
Energy for Recirculation Equipment	$4,601
Maintenance and Repair for Recirculation Equipment	$358
Subtotal	$22,375
Application System	
Principle and Interest for Center-pivot Irrigation System	$3,707
Maintenance and Repair for Center-pivot Irrigation System	$1,304
Labor for Irrigation System	$53
Principle and interest for Pumps and Motors	$1,234
Maintenance and Repairs for Pumps and Motors	$316
Energy for Center-pivot Irrigation System	$352
Principle and Interest on Pipes and Hoses	$169
Maintenance and Repairs for Pipes and Hoses	$5
Subtotal	$7,140
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$3,292
Subtotal	$4,968
Recovered Fertilizer Value Credit	-$2,419
Total Annual Operating Costs	$32,064

* Systems specifications
In-house Waste Management System: Pit-recharge
Waste Storage Structure: Anaerobic Lagoon
Land Application System: Traveling-gun Irrigation

The addition of waste management costs to the North Carolina finisher enterprise budget brings its breakeven price to $36.44 per hundredweight, leaving it with the highest costs of production. North Carolina trailed Oklahoma by $0.96 and Iowa by $1.89.

Iowa Finisher Operation

Enterprise Costs Following suit with the other baseline scenarios, the Iowa finisher operation had the lowest breakeven price of the modeled operations, at $34.55 per hundredweight. Again, Iowa had the cost advantage in feeds and utilities relative to Oklahoma and North Carolina. The only item in which it held the highest costs were labor, at $0.13 more per hundredweight than Oklahoma and $0.11 more than North Carolina.

Waste Management Costs The waste management system used by the Iowa finisher operation was basically the same as that used for the Iowa farrow to feeder and farrow to finisher operations. Partially slatted houses were used in combination with under-floor scrapers to extract waste from houses for storage in the cement above ground tank. Haul tanker wagons were used to apply waste to the 320 acres of corn/soybean rotation.

Again, the Iowa finisher operation was the most expensive when compared to its Oklahoma and North Carolina counterparts. The total initial investment cost for the Iowa operation's waste management system was $239,784, with an annual cost of $35,582. On a per hundredweight basis, this meant a waste management cost of $1.30 per hundredweight.

The major component of the waste management costs for the Iowa operation was waste storage, owing to the increased cost of the cement above-ground tank relative to the anaerobic lagoons utilized by Oklahoma and North Carolina. The annual costs associated with waste storage were $28,211. While this was markedly higher than the costs for either Oklahoma or North Carolina, the margin between the costs was not as great as was the case of the farrow to feeder and farrow to finisher operations.

The use of a haul-tanker system led to increased costs for the Iowa operation relative to the others as well. With annual costs of $12,857, the Iowa application system was nearly $11,320 more expensive than Oklahoma and more than $5,700 more expensive than North Carolina.

The lack of need for additional water in the cement tank storage system, combined with the lower power costs for Iowa did make it the lowest-cost state for fresh-water provision. Iowa's annual costs in this area were only $4,009; this was nearly $1,000 less than North Carolina's cost and a little more than half of Oklahoma's. More information on the annual operating costs of this operation can be found in Table 4-20.

The corn/soybean rotation served the Iowa finisher operation well, as it was able to recapture $9,495 of fertilizer value from applied effluent. This did a great deal to bring the costs of waste management closer to the other states'. Without this fertilizer value, the annual costs of waste management would have been $45,077. See Table 4-20 for more information regarding the annual waste management costs for this operation.

With the inclusion of the waste management costs in the Iowa finisher budget, it breakeven price per head rose to $34.55. Yet again, the costs of waste management served to narrow the gap between Iowa and Oklahoma. Their pre-waste-management price difference was $1.30 per hundredweight, compared to a difference of $0.93 when waste management costs were included, for a 28% reduction.

Table 4-20

Waste Management System Annual Costs – Baseline
Iowa Finisher Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$54
Principle and Interest for Cement Above-ground Tank Construction	$18,129
Maintenance and Repair for Cement Above-ground Tank	$398
Principle and Interest for Recirculation Equipment	$4,729
Energy for Recirculation Equipment	$667
Maintenance and Repair for Recirculation Equipment	$4,235
Subtotal	$28,211
Application System	
Principle and Interest for Haul-tanker	$2,453
Maintenance and Repair for Haul-tanker	$631
Labor for Haul-tanker	$1,399
Principle and interest for Pumps and Motors	$4,307
Maintenance and Repairs for Pumps and Motors	$502
Energy for Haul-tanker System	$2,166
Principle and Interest on Pipes and Hoses	$1,345
Maintenance and Repairs for Pipes and Hoses	$55
Subtotal	$12,857
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$2,333
Subtotal	$4,009
Recovered Fertilizer Value Credit	-$9,495
Total Annual Operating Costs	$35,582

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Haul-Tanker Wagon

Effects of Hypothesized Regulations on Farrow to Feeder Operations

It can be seen from the preceding narrative that the differences in waste management costs among similar operations (farrow to finish, farrow to feeder, and finisher), while not great, did have an impact in the degree of comparative advantage of the operations. This section will examine the impacts on those costs and the advantages or disadvantages they imply for the farrow to feeder operations.

Oklahoma Farrow to Feeder Operation

Information regarding the enterprise budgets of the modified farrow to feeder operations can be seen in Table 4-21. General specifications and costs of the modeled operations' waste management systems shown in Table 4-22, and their comparative initial investment costs in Table 4-23.

While having only the second-lowest initial investment cost of $258,376 relative to North Carolina's $253,704, Oklahoma did have the lowest per head costs of waste management at $1.61 when the value of recovered fertilizer is included.

Oklahoma's farrow to feeder had the lowest waste management costs of the modeled operations, owing to lower land costs and a smaller storage tank (due to having the least rainfall of all the modeled states) than any of its counterparts. Given the size of the crop base, though, the Oklahoma farrow to feeder had the highest costs of waste application at $13,566 – nearly $950 more than Iowa and almost $6,000 more than North Carolina. Oklahoma held a slight advantage over North Carolina in regard to the cost of fresh water, but still lagged Iowa. This was quite a change from the baseline scenarios, since in those situations, Oklahoma's lagoons had to receive large amounts of water to compensate for excess evaporation and maintain a viable treatment depth. Since no

Table 4-21

Enterprise Budget Comparison for Modified Farrow to Feeder Operations in Oklahoma. North Carolina. and Iowa.

	Oklahoma (per head)	North Carolina (per head)	Iowa (per head)
VARIABLE COSTS			
Feed Costs			
Feeder Pigs	$9.41	$9.35	$8.50
Breeding Stock	$7.60	$7.76	$6.74
TOTAL FEED COSTS/HEAD MARKETED	$17.01	$17.11	$15.24
OTHER VARIABLE COSTS	HEAD	HEAD	HEAD
Animal Health	$2.34	$2.34	$2.34
Breeding Costs	$0.37	$0.37	$0.37
Fuel, Oil & Gasoline	$0.74	$0.74	$0.74
Insurance	$0.07	$0.07	$0.07
Hired Labor	$4.64	$5.62	$5.37
Repairs	$1.15	$1.15	$1.15
Taxes	$0.06	$0.06	$0.06
Utilities	$0.29	$0.40	$0.28
Pork Check-Off	$0.19	$0.19	$0.19
Waste Management	$1.61	$1.75	$1.78
TOTAL OTHER VARIABLE COSTS	$11.47	$12.69	$12.35
TOTAL FEED COSTS	$17.01	$17.11	$15.24
PRODUCTION BREAKEVEN BEFORE DEPRECIATION AND INTEREST	$28.47	$29.79	$27.59
Depreciation	$7.49	$7.54	$7.57
PRODUCTION BREAKEVEN	$35.96	$37.33	$35.16
Line of Credit Interest	$0.10	$0.31	$0.09
Interest on Term Debt	$0.82	$0.84	$0.84
TOTAL BREAKEVEN	$36.89	$38.48	$36.09

Table 4-22

Cost Comparison for Modified Farrow to Feeder Operations in Oklahoma, North Carolina, and Iowa

Cost Component	Oklahoma	North Carolina	Iowa
Initial Investment Cost	$258,376	$253,704	$274,533
Annual Operation Costs			
Waste Storage	$33,339	$35,913	$36,391
Application System	$13,566	$7,589	$12,617
Fresh Water	$5,045	$6,276	$4,936
Cost Before Fertilizer Credit	$51,950	$49,778	$53,943
Fertilizer Credit	-$9,842	-$4,156	-$7,603
Total Annual Cost	$42,107	$45,622	$46,340
Waste Management Costs / hd	$1.61	$1.75	$1.78
Waste Management Costs / cwt	$2.83	$3.07	$3.11
Waste Management Costs / litter	$14.89	$16.13	$16.39
Average Daily Inventory (head)	4,281	4,281	4,281
Annual Waste Volume (cubic feet)	210,117	256,277	222,505
Waste Storage System - Type	Above-ground tank	Above-ground tank	Above-ground tank
Waste Storage System - Volume (cubic feet)	259,984	302,242	269,750
Land Application System - Type	Drag-hose Injector	Drag-hose Injector	Haul-tanker wagon
Land Application System - Volume Applied (acre inches)	23.3	11.6	19.1
Waste Volume Remaining (acre inches)	24.4	51.7	36.2

Table 4-23

Comparison of Initial Investment Costs for Modified Farrow to Feeder Operations in Oklahoma, North Carolina, and Iowa

Oklahoma	
Land for Cement Above Ground Tank (0.82 acres @ $511/ac)	$417
Cement Above-ground Tank Construction (259,984 ft3 @ $0.56/ft3)	$144,757
Tractors	$29,890
Aeration, Agitation Equipment	$9,900
Drag-house Equipment	$17,200
Pipe	$9,900
Scrapers	$36,292
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$258,376
North Carolina	
Land for Cement Above-ground Tank (0.91 acres @ $2,305/ac)	$2,089
Cement Above-ground Tank Cosntruction (302,242 ft3 @ $0.55/ft3)	$158,389
Tractors	$11,314
Aeration, Agitation Equipment	$9,900
Drag-hose Equipment	$15,800
Pipe	$9,900
Scrapers	$36,292
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$253,704
Iowa	
Land for Cement Above-ground Tank (0.84 acres @ $2,428/ac)	$2,034
Cement Above-ground Tank Cosntruction (269,750 ft3 @ $0.56/ft3)	$163,394
Tractors	$39,333
Aeration, Agitation Equipment	$7,000
Haul-tanker	$16,460
Scrapers	$36,292
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$274,533

additional water is required with the cement tank storage system, though, the primary factor differentiating the freshwater costs for the alternative operations is the cost of utilities.

The value of fertilizer recovered by the Oklahoma operation also represents a dramatic change from the baseline conditions. Whereas the baseline Oklahoma farrow to feeder operation only recovered $1,392 of fertilizer value, the alternative system was able to recover $9,842, which brought the cost of waste management down to $42,107. Table 4-24 provides more information on the modified Oklahoma farrow to feeder operation's annual waste management costs.

When the costs of the alternative waste management system were incorporated into the enterprise budget for the Oklahoma farrow to feeder operation, the new breakeven price per head rose to $36.89, a $0.38 increase on a per- hundredweight basis. This still places Oklahoma as the second-lowest cost producer among the modeled areas, led by Iowa and trailed by North Carolina.

There are additional factors to consider beyond enterprise costs, however. As it was stated above, Oklahoma had the second lowest initial investment cost of the new waste management system at $258,376. One can add to this investment the cost of a complete lagoon shutdown, which was estimated at $188,098 for the Oklahoma farrow to feeder operation. For the modeled Oklahoma operations, as well as the North Carolina operations, it was assumed that the lagoon of the baseline operation would have to be shut down, an operation that consists of pumping the lagoon's liquid off, and then grading and filling the earthen structure. Table 4-25 depicts the shutdown costs for all modeled operations. In total, shutdown costs and other waste management concerns

Table 4-24

Waste Management System Annual Costs - Modified Oklahoma Farrow to Feeder Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$62
Principle and Interest for Cement Above-ground Tank Construction	$21,573
Maintenance and Repair for Cement Above-ground Tank	$434
Principle and Interest for Recirculation Equipment	$5,409
Energy for Recirculation Equipment	$692
Maintenance and Repair for Recirculation Equipment	$5,169
Subtotal	$33,339
Application System	
Principle and Interest for Drag-hose System	$3,905
Maintenance and Repair for Drag-hose System	$331
Labor for Drag-hose System	$2,361
Principle and interest for Pumps and Motors	$3,211
Maintenance and Repairs for Pumps and Motors	$284
Energy for Drag-hose System	$1,719
Principle and Interest on Pipes and Hoses	$1,716
Maintenance and Repairs for Pipes and Hoses	$40
Subtotal	$13,566
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$3,369
Subtotal	$5,045
Recovered Fertilizer Value Credit	-$9,842
Total Annual Operating Costs	$42,107

* System specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Drag-hose Injection System

Table 4-25

Lagoon Closure Costs for Modeled Operations in
Oklahoma and North Carolina

Operation	Oklahoma	North Carolina
Farrow to Feeder	$188,098	$208,226
Farrow to Finish	$571,143	$651,496
Finisher	$166,354	$185,076

mean that the operation would have to acquire $446,474 in additional capital to come into compliance with the hypothesized regulations.

An additional cost of adaptation to the new regulations would be utilization or disposal of excess waste. Under the phosphorous restriction, the Oklahoma farrow to feeder operation's crop base would not be sufficient for the land application of the waste generated. Under the new system, less than half of the waste generated could be applied. As a result, the operation would have to acquire at least 371 acres of additional land to apply all the waste generated by the operation in a year. Table 4-26 shows the additional cropland required by each of the modified operations to apply their wastes under the hypothesized regulations. Beyond the costs of equipment, fuel, and repairs, such application would also require a great deal of additional labor. It should be noted here that land application of waste cannot occur when the land is frozen, or when rainfall is imminent. These restrictions would limit the amount of time available for waste application.

Table 4-26

Additional Cropland Required for Compliance with Hypothesized Regulations for Modeled Oklahoma, North Carolina, and Iowa Operations (Acres)

	Oklahoma	North Carolina	Iowa
Farrow to Feeder	371	494	554
Farrow to Finish	1916	1888	2357
Finisher	294	604	465

North Carolina Farrow to Feeder Operation

The North Carolina farrow to feeder operation had the lowest initial investment cost under the alternative conditions, owing primarily to a reduced need for tractor power given its much smaller field size. North Carolina also had reduced costs of construction that enabled it to have the second lowest construction costs even though it had the largest storage tank of all modeled farrow to feeder operations. In spite of this, North Carolina had the highest per head cost of waste management, at $1.78.

The fact that the North Carolina operation had the highest annual waste storage costs is attributed to the increased costs of utilities. It had the lowest annual application costs, though, thanks to the lower labor costs and few maintenance and repair expenses relative to Oklahoma and Iowa. Higher fresh water costs can be, like the storage costs, attributed to the cost of utilities.

Given the small land base of the North Carolina operation, it was only able to capture $4,156 of fertilizer value from the waste, the least fertilizer value of all farrow to feeder operations. When this was accounted for, North Carolina had the highest per-head costs of waste management under the alternative conditions, at $1.78. This was, however, only $0.03 more than Iowa, and only $0.17 more than Oklahoma. When introduced into the North Carolina farrow to feeder operation enterprise budget, this led to a total breakeven price of $38.48, and thus remaining as the highest of the farrow to feeder operations. For more information on the annual waste management costs of this operation, see Table 4-27.

The lagoon closure costs for the North Carolina farrow to feeder operation were estimated at $208,226. Combined with the initial investment costs of the waste management and application system, the total capital costs of adapting to the new regulations would be $461,930. Furthermore, an additional 494 acres would be required for the land application of wastes under the new guidelines. For this particular operation, 51.7 acre-inches of waste remain after the application capacity of the available land base has been reached.

Iowa Farrow to Feeder Operation

The Iowa farrow to feeder operation had the highest initial investment cost, due in part to increased construction costs, land costs, and tractors for waste management operations. Thanks in part to reduced utilities costs, it had the second lowest annual costs Table 4-27 of waste management. The use of haul-tankers for waste application increased the costs of waste application relative to North Carolina, but the reduced acreage relative to Oklahoma kept the land application costs below those of that state. While the Iowa operation was not able to capture as much fertilizer as Oklahoma, it did recover $7,603. This lead to a per head waste management cost of $1.78 – slightly more

Table 4-27

Waste Management System Annual Costs - Modified
North Carolina Farrow to Feeder Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$311
Principle and Interest for Cement Above-ground Tank Construction	$23,605
Maintenance and Repair for Cement Above-ground Tank	$475
Principle and Interest for Recirculation Equipment	$5,409
Energy for Recirculation Equipment	$945
Maintenance and Repair for Recirculation Equipment	$5,169
Subtotal	$35,913
Application System	
Principle and Interest for Drag-hose System	$3,025
Maintenance and Repair for Drag-hose System	$46
Labor for Drag-hose System	$748
Principle and interest for Pumps and Motors	$1,215
Maintenance and Repairs for Pumps and Motors	$71
Energy for Drag-hose System	$760
Principle and Interest on Pipes and Hoses	$1,712
Maintenance and Repairs for Pipes and Hoses	$11
Subtotal	$7,589
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$4,600
Subtotal	$6,276
Recovered Fertilizer Value Credit	-$4,156
Total Annual Operating Costs	$45,622

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Drag-hose Injection System

than Oklahoma's and slightly less than North Carolina's. When combined with the Iowa farrow to feeder enterprise budget, this meant a breakeven price of $36.09, the lowest of all the modeled farrow to feeder operations. Table 4-28 provides details regarding the annual costs of waste management for the Iowa farrow to feeder operation.

The reader will recall that under the baseline conditions, the introduction of waste management costs narrowed the gap between Iowa and Oklahoma to $0.49. Now, the gap between those states has grown to $0.80. Under the more strict regulatory environment, the gap between Oklahoma and Iowa grows wider again.

The shifts in capital costs for the Iowa farrow to feeder operation (as well as the farrow to finish and finisher operations) cannot be viewed in the same context as those of the North Carolina and Iowa operations, since the basic waste management system remained intact from the baseline scenario, with only slight modifications. As a result, not only would the Iowa operation maintain the lowest costs of production, but it would also be spared the large capital expenditures faced by the other operations.

Iowa was not immune from all the effects of the new regulations, however. Iowa was unable to apply all the waste generated. Under the new regulatory conditions, Iowa would need to acquire an additional 554 acres of cropland to accommodate all the wastes, since 51.7 acre-inches remained after the carrying capacity of the land was reached.

Effects of Hypothesized Regulations on Farrow to Finish Operations

The enterprise budgets for the modified farrow to feeder operations is displayed in Table 4-29, with the general specifications and costs of waste management for those operations represented by Table 4-30. The details of the initial investment cost for each operation is given in Table 4-31.

Table 4-28

Waste Management System Annual Costs – Modified
Iowa Farrow to Feeder Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$303
Principle and Interest for Cement Above-ground Tank Construction	$24,351
Maintenance and Repair for Cement Above-ground Tank	$490
Principle and Interest for Recirculation Equipment	$5,409
Energy for Recirculation Equipment	$669
Maintenance and Repair for Recirculation Equipment	$5,169
Subtotal	$36,391
Application System	
Principle and Interest for Haul-tanker	$2,453
Maintenance and Repair for Haul-tanker	$601
Labor for Haul-tanker	$1,358
Principle and interest for Pumps and Motors	$4,225
Maintenance and Repairs for Pumps and Motors	$481
Energy for Haul-tanker System	$2,101
Principle and Interest on Pipes and Hoses	$1,345
Maintenance and Repairs for Pipes and Hoses	$53
Subtotal	$12,617
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$3,260
Subtotal	$4,936
Recovered Fertilizer Value Credit	-$7,603
Total Annual Operating Costs	$46,340

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Haul-tanker Wagon

Table 4-29

Enterprise Budget Comparison for Modified Farrow to Finish Operations in Oklahoma, North Carolina, and Iowa

	Oklahoma (per cwt)	North Carolina (per cwt)	Iowa (per cwt)
VARIABLE COSTS			
Feed Costs			
Market Hogs	$16.92	$17.35	$15.07
Breeding Stock	$3.32	$3.39	$2.95
TOTAL FEED COSTS/HEAD MARKETED	$20.24	$20.75	$18.02
OTHER VARIABLE COSTS	$/CWT	$/CWT	$/CWT
Animal Health	$0.42	$0.42	$0.42
Breeding Costs	$0.16	$0.16	$0.16
Fuel, Oil & Gasoline	$0.23	$0.23	$0.23
Insurance	$0.57	$0.57	$0.57
Hired Labor	$3.70	$4.32	$4.27
Repairs	$0.36	$0.36	$0.36
Taxes	$0.12	$0.12	$0.12
Utilities	$1.09	$1.49	$1.06
Pork Check-Off	$0.19	$0.19	$0.19
Waste Management	$1.84	$1.98	$1.96
TOTAL OTHER VARIABLE COSTS	$8.68	$9.85	$9.34
TOTAL FEED COSTS	$20.24	$20.75	$18.02
PRODUCTION BREAKEVEN BEFORE DEPRECIATION AND INTEREST	$28.92	$30.59	$27.36
Depreciation	$2.50	$2.59	$2.60
PRODUCTION BREAKEVEN	$31.42	$33.18	$29.96
Line of Credit Interest	$0.04	$0.08	$0.03
Interest on Term Debt	$0.75	$0.77	$0.78
TOTAL BREAKEVEN	$32.21	$34.03	$30.76

Table 4-30

Cost Comparison for Modified Farrow to Finish Operations in Oklahoma, North Carolina, and Iowa

Cost Component	Oklahoma	North Carolina	Iowa
Initial Investment Cost	$588,447	$604,795	$632,034
Annual Operation Costs			
Waste Storage	$92,986	$100,518	$101,343
Application System	$15,842	$7,483	$12,548
Fresh Water	$10,790	$14,122	$10,496
Cost Before Fertilizer Credit	$119,619	$122,122	$124,387
Fertilizer Credit	-$9,793	-$3,979	-$7,433
Total Annual Cost	$109,826	$118,143	$116,954
Waste Management Costs / hd	$4.40	$4.73	$4.69
Waste Management Costs / cwt	$1.84	$1.98	$1.96
Waste Management Costs / litter	$38.82	$41.76	$41.34
Average Daily Inventory (head)	8,878	8,878	8,878
Annual Waste Volume (cubic feet)	629,695	763,445	665,591
Waste Storage System - Type	Above-ground tank	Above-ground tank	Above-ground tank
Waste Storage System - Volume (cubic feet)	753,309	875,752	781,606
Land Application System - Type	Drag-hose Injector	Drag-hose Injector	Haul-tanker Wagon
Land Application System - Volume Applied (acre inches)	22.5	11.1	18.3
Waste Volume Remaining (acre inches)	121.4	178.1	147.6

Table 4-31

Comparison of Initial Investment Costs for Modified Farrow to Finish Operations in Oklahoma, North Carolina, and Iowa

Oklahoma	
Land for Cement Above Ground Tank (1.79 acres @ $511/ac)	$913
Cement Above-ground Tank Construction (753,309 ft^3 @ $0.53/$ft^3$)	$396,924
Tractors	$35,489
Aeration, Agitation Equipment	$10,900
Drag-house Equipment	$17,200
Pipe	$10,900
Scrapers	$106,101
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$588,447
North Carolina	
Land for Cement Above-ground Tank (2.01 acres @ $2,305/ac)	$4,640
Cement Above-ground Tank Cosntruction (875,752 ft^3 @ $0.55/$ft^3$)	$437,503
Tractors	$10,932
Aeration, Agitation Equipment	$9,900
Drag-hose Equipment	$15,800
Pipe	$9,900
Scrapers	$106,101
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$604,795
Iowa	
Land for Cement Above-ground Tank (0.84 acres @ $2,428/ac)	$4,466
Cement Above-ground Tank Cosntruction (269,750 ft^3 @ $0.56/$ft^3$)	$448,875
Tractors	$39,113
Aeration, Agitation Equipment	$7,000
Haul-tanker	$16,460
Scrapers	$106,101
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$632,034

Oklahoma Farrow to Finish Operation

The Oklahoma farrow to finish operation had the lowest initial investment cost of the modeled farrow to finish operations, at $588,447. This was the lowest of all the farrow to finish operations, as a result of Oklahoma's need for the smallest tank of the three operations, along with lower land costs and construction expenses. Overall, the annual cost of waste management was $109,826. On a per-head basis, this translated to a cost of $4.40 per head, after the value of recovered fertilizer is included.
Again, due to having the smallest storage tank and relatively low energy costs, the annual costs of waste storage were the lowest in Oklahoma's case. However, given the size of the crop base for the operation, it had the highest land application costs. Unlike its baseline counterpart, the Oklahoma farrow to finish operation had the second lowest freshwater costs, since there was no need to add water to an anaerobic lagoon. Even before accounting for the value of recovered fertilizer, the Oklahoma operation's costs were the lowest of the modeled farrow to finisher operations at $119,619. When the value of fertilizer was included, this cost was reduced to 109,826. On a per hundredweight basis, Oklahoma's annual costs of waste management were $1.84, also the lowest of the modeled operations. When incorporated into the Oklahoma farrow to finish enterprise budget, this gave Oklahoma a total breakeven price of $32.21, the second lowest after Iowa's $30.76. Table 4-32 shows the operation's detailed annual waste management cost information.

The Oklahoma farrow to finish operation faces a substantial capital investment in order to reach compliance with the new regulations. The $571,143 estimated costs of lagoon closure, added to the $588,447 initial investment cost of the alternative waste

Table 4-32

Waste Management System Annual Costs - Modified Oklahoma Farrow to Finish Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$136
Principle and Interest for Cement Above-ground Tank Construction	$59.153
Maintenance and Repair for Cement Above-ground Tank	$1.191
Principle and Interest for Recirculation Equipment	$15.812
Energy for Recirculation Equipment	$2.207
Maintenance and Repair for Recirculation Equipment	$14.486
Subtotal	$92,986
Application System	
Principle and Interest for Drag-hose System	$3.905
Maintenance and Repair for Drag-hose System	$489
Labor for Drag-hose System	$3.014
Principle and interest for Pumps and Motors	$3.812
Maintenance and Repairs for Pumps and Motors	$391
Energy for Drag-hose System	$2.269
Principle and Interest on Pipes and Hoses	$1.911
Maintenance and Repairs for Pipes and Hoses	$52
Subtotal	$15.842
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1.493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$9.114
Subtotal	$10.790
Recovered Fertilizer Value Credit	-$9.793
Total Annual Operating Costs	$109.826

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Drag-hose Injection System

management system, summed to a total of $1,159,590. This is obviously a substantial capital expenditure.

The Oklahoma farrow to finish operation also faced a pronounced shortage of cropland for waste application. Over 1,900 acres of additional cropland would be needed to accommodate the nutrients contained in the waste generated by the operation. Under the current cropping system, 121.4 acre-inches of waste would remain – over five times the amount that was actually applied.

North Carolina Farrow to Finish Operation

The North Carolina farrow to finish operation, unlike the North Carolina farrow to feeder operation, had the second-lowest initial investment costs, totaling $604,795. Lower construction and tractor costs kept this cost lower than Iowa's, but these factors were not enough to counterbalance Oklahoma's lower land costs and smaller tank size. These same factors were also responsible for North Carolina's second-place position in annual waste storage costs. As was the case in with the farrow to feeder operation, the small size of North Carolina's crop base kept waste application costs low. The costs of utilities forced the operation's freshwater costs to be the highest of the three operations, given the fact that all three use similar amounts of water. After accounting for the value of fertilizer (which was the least of the farrow to finisher operations at $3,979), the total annual costs of waste management for the North Carolina operation were $118,143, the highest of the modeled operations. On a per hundredweight basis, this cost was $1.98. This led to a breakeven cost of production of $34.03, which was $1.82 higher than nearest competitor Oklahoma and $3.27 more than Iowa. Like Oklahoma's operation, the North Carolina farrow to finish enterprise faces the daunting capital costs of $651,496 for lagoon closure and $604,795 for the implementation of a new waste management system – a total of $1,256,291. Refer to Table 4-33 for more information regarding the North Carolina farrow to finish operation's annual waste management costs.

The need for additional cropland to receive waste nutrients is dramatic in the North Carolina scenario. A total of 1,888 acres of cropland would be required to receive all the waste generated by the operation, multiplying the original crop base nearly sixteenfold. As the operation is currently situated, nearly 180 acre-inches of waste would remain after the croplands had received all waste possible under the given regulatory conditions.

Iowa Farrow to Finish Operation

The Iowa farrow to finish operation had by far the largest initial investment cost of the modeled operations, at $ 632,034. Its position relative to the other operations can be attributed to having the highest land costs, highest tractor costs, and the second largest waste storage tank. For these same reasons, the Iowa operation also had the highest annual costs of waste storage. The relative size of its crop base relative to Oklahoma and North Carolina contributed to the placing of the Iowa operation's land application costs at second, between the other two (Oklahoma's being highest). The relatively low price of utilities led to Iowa's position as least-expensive with regards to fresh water provision.

Without accounting for the credit obtained from fertilizer value, Iowa had an annual waste management cost of $124,387. With the fertilizer credit, Iowa's costs were 116,954 or $1.96 per hundredweight. When combined with the Iowa farrow to feeder enterprise budget, the breakeven price of the operation was $30.76 per head, the lowest of

Table 4-33

Waste Management System Annual Costs – Modified
North Carolina Farrow to Finish Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$691
Principle and Interest for Cement Above-ground Tank Construction	$65,201
Maintenance and Repair for Cement Above-ground Tank	$1,313
Principle and Interest for Recirculation Equipment	$15,812
Energy for Recirculation Equipment	$3,014
Maintenance and Repair for Recirculation Equipment	$14,486
Subtotal	$100,518
Application System	
Principle and Interest for Drag-hose System	$3,025
Maintenance and Repair for Drag-hose System	$43
Labor for Drag-hose System	$720
Principle and interest for Pumps and Motors	$1,174
Maintenance and Repairs for Pumps and Motors	$68
Energy for Drag-hose System	$729
Principle and Interest on Pipes and Hoses	$1,712
Maintenance and Repairs for Pipes and Hoses	$11
Subtotal	$7,483
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$12,445
Subtotal	$14,122
Recovered Fertilizer Value Credit	-$3,979
Total Annual Operating Costs	$118,143

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Drag-hose Injection System

all the farrow to feeder operations. Table 4-34 provides details for the annual waste management costs of the Iowa farrow to finish operation.

When one compares the difference between the breakeven costs of the Oklahoma and Iowa operations under the baseline conditions when Iowa's per hundredweight breakeven was $0.88 lower than Oklahoma's, to the new difference of $1.45, it can be seen that on an annual basis, some "leveling of the playing field" has occurred in relative competitiveness. However, one must consider that the Iowa operation does not face the need for more than $1 million in additional capital expenditures, as the Oklahoma operation does. However, the Iowa operation would need to acquire an additional 2,357 acres for the 148 acre-inches of waste left un-applied under the alternative scenario.

Effects of Hypothesized Regulations on Finisher Operations

Table 4-35 shows the enterprise budgets for the modified finisher operations in the modeled states, and Table 4-36 presents the general specifications and costs for their waste management systems. Table 4-37 details the initial investment costs for each operation.

Oklahoma Finisher Operation

The Oklahoma finisher operation had the second-lowest initial investment cost, with $226,379 needed to establish the new waste management system. As with the other operational scenarios, Oklahoma had the lowest land cost; however, it also required more tractor power than the North Carolina operation and had more initial investment in the waste application system than the other operations.

Table 4-34

Waste Management System Annual Costs - Modified
Iowa Farrow to Finish Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$666
Principle and Interest for Cement Above-ground Tank Construction	$66,896
Maintenance and Repair for Cement Above-ground Tank	$1,347
Principle and Interest for Recirculation Equipment	$15,812
Energy for Recirculation Equipment	$2,136
Maintenance and Repair for Recirculation Equipment	$14,486
Subtotal	$101,343
Application System	
Principle and Interest for Haul-tanker	$2,453
Maintenance and Repair for Haul-tanker	$593
Labor for Haul-tanker	$1,346
Principle and interest for Pumps and Motors	$4,201
Maintenance and Repairs for Pumps and Motors	$476
Energy for Haul-tanker System	$2,083
Principle and Interest on Pipes and Hoses	$1,345
Maintenance and Repairs for Pipes and Hoses	$53
Subtotal	$12,548
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$8,820
Subtotal	$10,496
Recovered Fertilizer Value Credit	-$7,433
Total Annual Operating Costs	$116,954

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Haul-tanker Wagon

Table 4-35

Enterprise Budget Comparison for Modified Finisher Operations in Oklahoma, North Carolina, and Iowa

	Oklahoma (per cwt)	North Carolina (per cwt)	Iowa (per cwt)
VARIABLE COSTS			
FEED COSTS	$12.98	$13.45	$11.52
OTHER VARIABLE COSTS	$/CWT	$/CWT	$/CWT
Animal Health	$0.44	$0.44	$0.44
Fuel, Oil & Gasoline	$0.07	$0.07	$0.07
Insurance	$0.12	$0.12	$0.12
Hired Labor	$0.81	$0.83	$0.94
Repairs	$0.11	$0.11	$0.11
Taxes	$0.13	$0.13	$0.13
Utilities	$0.55	$0.75	$0.53
Pork Check-Off	$0.19	$0.19	$0.19
Waste Management	$1.44	$1.58	$1.60
Purchase Feeder Pigs	$17.59	$17.59	$17.59
TOTAL OTHER VARIABLE COSTS	$21.45	$21.82	$21.57
TOTAL FEED COSTS	$12.98	$13.45	$11.52
PRODUCTION BREAKEVEN BEFORE DEPRECIATION AND INTEREST	$34.43	$35.27	$33.08
Depreciation	$1.11	$1.15	$1.16
PRODUCTION BREAKEVEN	$35.54	$36.42	$34.24
Interest on Term Debt	$0.29	$0.29	$0.30
Line of Credit Interest	$0.01	$0.01	$0.00
TOTAL BREAKEVEN	$35.84	$36.72	$34.55

Table 4-36

Cost Comparison for Modified Finisher Operations in Oklahoma, North Carolina, and Iowa

Cost Component	Oklahoma	North Carolina	Iowa
Initial Investment Cost	$226,379	$216,919	$238,693
Annual Operation Costs			
Waste Storage	$27,596	$29,693	$30,070
Application System	$13,465	$7,054	$12,516
Fresh Water	$4,087	$4,968	$4,009
Cost Before Fertilizer Credit	$45,148	$41,716	$46,595
Fertilizer Credit	-$9,747	-$2,836	-$7,328
Total Annual Cost	$35,401	$38,880	$39,267
Waste Management Costs / hd	$3.38	$3.72	$3.75
Waste Management Costs / cwt	$1.43	$1.57	$1.59
Average Daily Inventory (head)	3,174	3,174	3,174
Annual Waste Volume (cubic feet)	176,049	212,801	185,913
Waste Storage System - Type	Above-ground Tank	Above-ground Tank	Above-ground Tank
Waste Storage System - Volume (cubic feet)	206,992	240,637	214,767
Land Application System - Type	Drag-hose Injector	Drag-hose Injector	Haul-tanker Wagon
Land Application System - Volume Applied (acre inches)	22.1	7.9	17.9
Waste Volume Remaining (acre inches)	18.3	44.9	28.5

Table 4-37

Comparison of Initial Investment Costs for Modified Finisher Operations in Oklahoma, North Carolina, and Iowa

Oklahoma	
Land for Cement Above Ground Tank (0.70 acres @ $511/ac)	$358
Cement Above-ground Tank Construction (206,992 ft^3 @ $0.53/$ft^3$)	$117,669
Tractors	$29,599
Aeration, Agitation Equipment	$9,900
Drag-house Equipment	$17,200
Pipe	$9,900
Scrapers	$31,731
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$226,379
North Carolina	
Land for Cement Above-ground Tank (0.78 acres @ $2,305/ac)	$1,787
Cement Above-ground Tank Cosntruction (240,637 ft^3 @ $0.56/$ft^3$)	$128,407
Tractors	$9,373
Aeration, Agitation Equipment	$9,900
Drag-hose Equipment	$15,800
Pipe	$9,900
Scrapers	$31,731
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$216,919
Iowa	
Land for Cement Above-ground Tank (0.72 acres @ $2,428/ac)	$1,745
Cement Above-ground Tank Cosntruction (214,767 ft^3 @ $0.56/$ft^3$)	$132,728
Tractors	$39,009
Aeration, Agitation Equipment	$7,000
Haul-tanker	$16,460
Scrapers	$31,731
Fresh Water Wells	$3,080
Fresh Water Pumps	$6,100
Fresh Water Well Pipe	$840
Total	$238,693

Overall, however, the Oklahoma finisher operation had the lowest annual cost of waste management at $35,401, accounting for the value of fertilizer. One of the sources of this comparative advantage stemmed from the fact that Oklahoma had the lowest annual costs of waste storage. The antecedents of this fact include Oklahoma's lower land costs, and the fact that, as with the farrow to feeder and farrow to finish operations, Oklahoma needed the smallest tank of the modeled operations. Also, as with the other operations, Oklahoma had the highest waste application system costs, a result of its larger land base. This was somewhat balanced by the reduced costs of fresh water and the value of fertilizer recovered ($9,747). This translated to a $1.44 per hundredweight cost of waste management, the lowest waste management charge of the modeled finisher operations. This cost, combined with the rest contained in the Oklahoma finisher enterprise budget, gave Oklahoma a breakeven price of $35.84, the second-lowest of the finishers examined. For more information about the annual waste management costs of the modified Oklahoma finisher, consult Table 4-38.

The costs of lagoon closure for the Oklahoma finisher operation were estimated at $166,354, and the reader will recall that the initial investment in the alternative waste management system was $226,379 – at total of $392,733. In addition to these capital requirements, the finisher operation would need to acquire an additional 294 acres of land to receive all the waste generated by the operation on an annual basis. As the system is currently configured, 18.3 acre-inches of waste remain to be applied after the phosphorous capacity of the crop base has been met. While 294 acres is a considerable amount of land, it is the smallest additional land requirement of all the finisher

Table 4-38

Waste Management System Annual Costs – Modified Oklahoma Finisher Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$53
Principle and Interest for Cement Above-ground Tank Construction	$17,536
Maintenance and Repair for Cement Above-ground Tank	$353
Principle and Interest for Recirculation Equipment	$4,729
Energy for Recirculation Equipment	$689
Maintenance and Repair for Recirculation Equipment	$4,235
Subtotal	$27,596
Application System	
Principle and Interest for Drag-hose System	$3,905
Maintenance and Repair for Drag-hose System	$324
Labor for Drag-hose System	$2,329
Principle and interest for Pumps and Motors	$3,179
Maintenance and Repairs for Pumps and Motors	$280
Energy for Drag-hose System	$1,693
Principle and Interest on Pipes and Hoses	$1,716
Maintenance and Repairs for Pipes and Hoses	$39
Subtotal	$13,465
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$2,411
Subtotal	$4,087
Recovered Fertilizer Value Credit	-$9,747
Total Annual Operating Costs	$35,401

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Drag-hose Injection System

operations. This is due to the fact that Oklahoma is able to apply far more of its nutrients than the other operations.

North Carolina Finisher Operation

In this situation, North Carolina had the lowest initial investment in the alternative waste management system, at a total cost of $216,919. Although North Carolina required the largest storage tank due to evaporative potential, it had the second-lowest land costs, low labor costs, and low initial investment in the application system, a function of the size of the crop system.

Its annual costs of waste storage were the second lowest, $29,693. The principal reason that North Carolina's costs were not the lowest was the increased cost of utilities there relative to the other two states. As was the case with the farrow to feeder and farrow to finish operations, the smaller land base available to the North Carolina operation allowed for a lower annual cost of waste application. It had the highest costs of fresh water, though, again due to the cost of utilities. More comprehensive annual waste management cost data for the modified North Carolina finisher can be found in Table 4-39.

All in all, North Carolina had the second-lowest annual costs of waste management after accounting for waste management, $38,880. If one were to examine the costs of the finisher operations without the fertilizer credit, however, it would have the lowest costs of waste management. With the credit, though, the per hundredweight cost was $1.58. The gave the North Carolina finisher a breakeven price of $36.72, or $0.88 more than Oklahoma, it's closest competitor.

Table 4-39

Waste Management System Annual Costs - Modified
North Carolina Finisher Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$266
Principle and Interest for Cement Above-ground Tank Construction	$19,136
Maintenance and Repair for Cement Above-ground Tank	$385
Principle and Interest for Recirculation Equipment	$4,729
Energy for Recirculation Equipment	$941
Maintenance and Repair for Recirculation Equipment	$4,235
Subtotal	$29,693
Application System	
Principle and Interest for Drag-hose System	$3,025
Maintenance and Repair for Drag-hose System	$33
Labor for Drag-hose System	$608
Principle and interest for Pumps and Motors	$1,007
Maintenance and Repairs for Pumps and Motors	$56
Energy for Drag-hose System	$604
Principle and Interest on Pipes and Hoses	$1,712
Maintenance and Repairs for Pipes and Hoses	$9
Subtotal	$7,054
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$3,292
Subtotal	$4,968
Recovered Fertilizer Value Credit	-$2,836
Total Annual Operating Costs	$38,880

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Drag-hose Injection System

The total capital requirements of adaptation to the new regulatory conditions were $216,919 for the waste management system, and $185,076 for lagoon closure, totaling to $401,995 – slightly more than the Oklahoma operation. With 44.9 acre-inches of waste left under the alternative waste system, North Carolina also faces the greatest need for additional cropland to receive waste nutrients, with 604 more acres required.

<u>Iowa Finisher System</u>

The Iowa finisher operation had the highest initial investment of all the modeled finisher operations, $238,693. Higher land and labor costs, combined with the second largest tank requirement, and second largest tractor power requirement led to this placing in regard to investment costs.

The total annual waste management costs for the operation were $39,267, also the highest of the modeled finisher operations. While Iowa had the lowest fresh water costs ($4,009) and second-lowest waste application systems costs ($12,516), it had the highest costs of waste storage and recaptured less fertilizer value than did the Oklahoma finisher ($7328 for Iowa, compared to $9,747) for Oklahoma. When the annual costs of waste management were placed on a per hundredweight basis, the costs were $1.60. This, combined with the Iowa finisher budget, dictated a breakeven price of $34.55 per hundredweight, $0.88 less than Oklahoma, its closest competitor. Table 4-40 details the annual waste management costs of the operation.

Table 4-40

Waste Management System Annual Costs - Modified
Iowa Finisher Operation*

	Annual Cost
Waste Storage	
Principle and Interest for Cement Above-ground Tank Land	$260
Principle and Interest for Cement Above-ground Tank Construction	$19,780
Maintenance and Repair for Cement Above-ground Tank	$398
Principle and Interest for Recirculation Equipment	$4,729
Energy for Recirculation Equipment	$667
Maintenance and Repair for Recirculation Equipment	$4,235
Subtotal	$30,070
Application System	
Principle and Interest for Haul-tanker	$2,453
Maintenance and Repair for Haul-tanker	$589
Labor for Haul-tanker	$1,340
Principle and interest for Pumps and Motors	$4,190
Maintenance and Repairs for Pumps and Motors	$473
Energy for Haul-tanker System	$2,074
Principle and Interest on Pipes and Hoses	$1,345
Maintenance and Repairs for Pipes and Hoses	$53
Subtotal	$12,516
Fresh Water	
Principle and Interest on Fresh Water Wells, Pumps, and Pipes	$1,493
Maintenance and Repairs for Fresh Water Wells, Pumps, and Pipes	$183
Energy for Fresh Water System	$2,333
Subtotal	$4,009
Recovered Fertilizer Value Credit	-$7,328
Total Annual Operating Costs	$39,267

* Systems specifications
In-house Waste Management System: Underfloor Scraper
Waste Storage Structure: Cement Above-Ground Tank
Land Application System: Haul-tanker Wagon

As the reader may recall, the gap between the two operations under the baseline conditions was $0.93; thus, the new regulations have served to decrease Oklahoma's relative competitiveness, to an extent. One must also bear in mind that the Oklahoma operation must incur $392,733 of capital costs that the Iowa operation does not. However, the Oklahoma operation need only acquire an additional 294 acres of land for complete land application of wastes, while Iowa would need 465 acres.

Chapter V

SUMMARY AND CONCLUSIONS

The preceding chapters have detailed the background of the swine waste management issue and past legislative responses to the issue. The two computer models used to simulate swine production operations in Oklahoma, North Carolina, and Iowa were introduced, and the results of imposing the hypothetical regulations presented. This chapter will present a brief summary of the results garnered from this research, along with some possible implications for both policy-makers and producers. Finally, some suggestions for further study in this area and related disciplines will be made.

The overall objective of this project was to increase the amount of information available to policymakers and agricultural producers when evaluating the potential economic impacts of changes in the regulation of swine-producing CAFOs. Two specific objectives were pursued in order to fulfill that overall objective:

1. Estimate the current cost of production, as represented by breakeven cost of live hogs sold to cover variable and fixed costs, for a given set of modeled swine production operations in the states of Iowa, North Carolina, and Oklahoma. Specifically, the modeled operations will be a 1200 sow farrow-to-finish operation, a 1200 sow farrow-to-feeder operation, and a 4000 head finishing operation.

2. Estimate the new breakeven cost per hundredweight of live hogs sold under the conditions of the hypothesized regulatory changes and evaluate other economic impacts of operational modifications needed to come into compliance with the hypothesized regulations.

Summary of Impacts on Oklahoma Operations

Given the adjustments made to the basic enterprise budgets, the Oklahoma swine enterprises consistently had the second-lowest costs of production, with a farrow to feeder breakeven of $36.51 per head, a farrow to finish breakeven of $31.59 per hundredweight, and a finisher breakeven of $35.43 per head. Oklahoma also consistently had the lowest cost of waste management per head, owing to all the operations having smaller lagoons than their North Carolina counterparts, and the pre-existence of a land application system in the form of center-pivot irrigation systems.

Under the hypothesized regulations, the Oklahoma operations again consistently had the second lowest breakeven prices, at $36.89 per head for the farrow to finish operation (an increase of $0.38), $32.21 per hundredweight for the farrow to feeder operation (an increase of $0.62), and $35.84 for the finisher operation (an increase of $0.41).

The capital requirements of the Oklahoma operations under the baseline conditions were consistently the lowest of the examined operations, with a farrow to feeder investment of $137,365, farrow to finisher investment of $299,860, and finisher investment of $121,475. Under the alternative scenarios, these operations had investments of $258,376, $588,447, and $226,379 – indicating a notable increase. In addition to these investment costs, each of these operations would be required to conduct a lagoon shut-down, at a cost of $188,098 to the farrow to feeder, $571,143 to the farrow to finisher, and $166,354 to the finisher.

Under the hypothesized regulations, each Oklahoma production operation had an insufficient land base for the application of its wastes; however, each operation had the least waste remaining of its counterparts, and thus required less additional land for the complete application of all wastes. The Oklahoma farrow to feeder operation required 371 additional acres, the farrow to finisher operation required 1,916, and the finisher required 294 acres.

Summary of Impacts on North Carolina Operations

In each of the baseline enterprise budgets, the North Carolina operations consistently had the highest breakeven price, with a farrow to feeder breakeven of $38.22 per head, a farrow to finish breakeven of $33.37 per hundredweight, and a finisher breakeven of $36.44 per hundredweight. This resulted in gaps of $2.20 per head, $2.66 per hundredweight, and $1.89 hundredweight, respectively, between North Carolina's operations and those of Iowa, the lowest-cost producer in each case. Under the baseline conditions, North Carolina also consistently had the second-highest costs of waste management, owing to the need for a larger lagoon than Oklahoma, but using less intensive technologies than Iowa.

In the alternative scenarios, the North Carolina operations remained the highest-cost producers for each operational type, with breakeven prices of $38.48 per head for the farrow to feeder (an increase of $0.26), $34.03 per hundredweight for the farrow to finish operation (an increase of $0.66), and a finisher breakeven of $36.72 (an increase of $0.28).

In the baseline scenarios, the North Carolina operations always had the second-lowest initial investment cost, given the fact that their lagoons were larger than those of their Oklahoma counterpart operations, and yet not as intensive as the Iowa operations' management systems. The initial investment for the farrow to feeder operation was $177,635, with investments of $357,372 for the farrow to finisher, and $162,424 for the farrow to feeder. Under the alternative scenarios, the investments for these operations were $253,704 for the farrow to feeder, $604,795 for the farrow to finisher, and $216,919. Each of these operations, as in Oklahoma, would also be required to shut down their lagoons, at estimated costs of $208,226 to the farrow to feeder, $651,496 to the farrow to finisher, and $185,076 for the finisher.

Given the fact that the North Carolina operation had the smallest crop base upon which waste could be applied, it had the most waste remaining after the capacity of the land had been fulfilled, and thus also required the most additional land in each alternative scenario. 494 additional acres were required for the farrow to feeder operation, 1,888 additional acres were required for the farrow to finisher, and the finisher needed another 604 acres.

Summary of Impacts on Iowa Operations

Each of the Iowa operations had the lowest breakeven price of production of the modeled operations under both baseline and alternative conditions. In the baseline scenarios, this meant a farrow to feeder operation breakeven of $36.02 per head, a farrow to finish breakeven of $30.71 per hundredweight, and a finisher breakeven of $34.55 per hundredweight. Under alternative conditions, these breakevens were $36.09 per head,

$30.76 per hundredweight, and $34.55 per hundredweight, respectively. The reader will note that these are fairly small changes.

The effects on initial system investment were also slight, and in a different direction than those of the other operations. In the case of all three Iowa operations, the initial investment in waste management systems actually decreased by $4,434 for the farrow to feeder, $13,755 for the farrow to finisher, and $1,091 for the finisher. This was due to a reduction in the demands on the tractors used for haul-tanker application, given the fact that application of wastes based on phosphorous levels occurred at different rates than application based on nitrogen. Thus, fewer horsepower-hours were required from the tractors.

The imposition of phosphorous limitations had dilatory effects on the Iowa operations as well, however. With this restriction, each Iowa operation was able to apply less than half their waste before meeting the phosphorous capacity of its crop base. The Iowa farrow to feeder operation would require an additional 554 acres of land; the farrow to finisher would require 2,357 more acres; and the finisher would need 465 additional acres to completely apply all the wastes generated by the swine enterprise.

Conclusions

The effects of the imposition of the hypothesized regulations can be viewed along three basic dimensions for each type of operation: the change in costs of production (expressed in this research as the breakeven price for each operation), the change in capital requirements, and the changes in land requirements.

The hypothetical regulations did not affect the relative positions of the states in regard to the cost of production; in both the baseline and alternative scenarios for every type of modeled operation, Iowa held the lowest-cost position, followed by Oklahoma and North Carolina. This being said, it must be noted that the hypothetical regulations did affect the margins between each operation. With the exception of the farrow to finisher operation, the regulations narrowed the difference in breakeven price between Oklahoma and North Carolina, and widened the gap between all three operations in Oklahoma and Iowa. The regulations also served to widen the gap between all three operations in North Carolina and Iowa.

The differential impacts between operations on the capital investment needed to come into compliance with the hypothesized regulations are significant. If one combines the cost of new waste management storage and application systems with the costs of lagoon closure, the farrow to feeder operations in Oklahoma and North Carolina would be required to spend in the neighborhood of $450,000; the farrow to finish operations would have to spend approximately $1,200,000, and the finisher operations would need to spend nearly $400,000. However, as mentioned previously, the Iowa operations would actually see a decrease ranging from $1,091 for the finisher operation to $13,755 for the farrow to finisher.

Perhaps the most dramatic impacts can be seen in the change of crop bases needed by the modeled operations for the application of wastes. The smallest change was found in the case of the Oklahoma finisher operation, which would have to somehow acquire 294 additional acres of land to fully utilize the nutrients of the waste generated by its swine enterprise. The most pronounced difference was that of the North Carolina operation, which would need another 1,888 acres of cropland for it's waste – more than the entire land area of the Oklahoma operation and nearly sixteen times the size of the operation itself.

From these results, it can be seen that the implementation of a set of regulations similar to those hypothesized here could cause, at the very least, a shift in the relative competitiveness of swine producers among the examined regions. It is further likely that the imposition of such regulations would demand either dramatic shifts in production practices in Oklahoma and North Carolina, while Iowa could see less dramatic effects. The following sections will discuss some of the possible implications of these findings from the perspective of policy-makers and producers.

Implications for Policy Makers

While this research was focused on the imposition of a uniform set of regulations across all operations, it holds implications for the imposition of non-uniform regulations across the examined areas. If one region were to face such regulations, while the others remained constant, that region would be at a distinct competitive disadvantage, and would face a number of managerial challenges that the other regions would not. For example, were the hypothetical regulation set imposed on Oklahoma, but not North Carolina or Iowa. The Oklahoma farrow to finish operation would have a breakeven price of $77.07 per head, now $3.59 per head more than the Iowa operation, whereas before it would have lagged Iowa by only $2.10. The Oklahoma operation would further be burdened by an additional $1.1 million dollars in additional capital requirements and the need to acquire over 1,900 more acres of land for waste application.

While environmental concerns might dictate the need for more strict regulations, policy makers should be aware of the implications such regulations have on the profitability of its swine producers. If a set of regulations similar to those used in this thesis are to be employed by a state, policy-makers may wish to consider measures to "soften the blow" of the regulations' effects, such as cost-sharing programs, low-interest loans, and long-range implementation horizons allowing producers to phase-in new waste management technologies and procedures.

Implications for Producers

Should a set of regulations such as these be imposed on a national level, producers would face the shifts mentioned in the summary section of this chapter – while there would not necessarily be a shift in the competitive position of the operations, there would likely be shifts in the gaps between the breakeven prices of the operations.

The need for additional capital to fund these changes in waste management technologies and systems could dictate shifts in the cost-sharing arrangements of contract producers, or require industry exit for some producers. For those producers that did maintain their operations, it would be necessary to somehow procure additional land for the application of wastes, either through the sale of nutrients to adjoining land-owners or the shipment of such wastes to more distant operations. This regulation might also increase the geographic dispersion of future operations (and might have a similar effect on existing operations, should industry-exit be a popular choice for producers).

If producers believe that regulations such as those hypothesized in this research, they may wish to begin investigating some of the waste management technologies and practices that would enable them to remain compliant with the relevant regulations, perhaps phasing them into their operations so as to disperse the cost of such adaptations over a longer time horizon.

Recommendations for Further Study

Given the importance of the swine waste management issue to Oklahoma and other states were the swine industry is experiencing rapid expansion, further research in a number of areas holds the promise of great benefits to policy-makers, swine producers, and other members of the agriculture industry.

Perhaps the best foundation of future research would be a more thorough investigation into the actual costs of production for various types of swine enterprises, in the different regions of the United States. The vast majority of the swine production cost information used in this research was obtained from secondary sources or synthesized based upon available data and professional estimation by experts in the fields of animal science, agricultural engineering, and agricultural economics. While these experts are in continual contact with actual producers, there can be no substitute for actual production records and cost data recorded by swine producers. An intensive survey of a sample of swine production operations with the purpose of establishing a database of production and cost information would provide for an improved base upon which simulation works such as this project could be built.

The availability of both a swine production budget generator and a swine waste management program did a great deal to facilitate this research. The two computer models were manually interfaced to generate the final enterprise budgets for the swine production operations that included costs of waste management. In the future, as the enterprise budget model is built upon and expanded, it may be worthwhile to integrate the waste management program into the budget model, enabling it to calculate the optimal waste management system for the given production parameters. As the models currently exist, it was necessary to make some manual modifications so that the numbers of swine produced under the assumptions of one model matched those of the other.

When this study imposed a regulation regarding the restriction of a waste nutrient, only technologic responses were examined. The creation of a model that examines the economic feasibility of waste nutrient management though modification of the swine diets could provide information to producers that would enable them to determine whether the best reaction to a new regulation would be technologic or biologic.

Finally, it may also be advisable to integrate a swine production budget model with an interregional trade model, with the goal of a comprehensive model that could, when provided with cost of production information and data on regional demands and elasticities, forecast shifts in production. This would be an outstanding tool for policy-makers, enabling them to examine not only the microeconomic effects of regulations, but the macroeconomic effects as well.

BIBLIOGRAPHY

Author unknown. "Ingredient Market." *Feedstuffs.* March 27th, 2000, pp. 24-25.

Ackerman, E.O. and A.G. Taylor. "Ten Reasons Why Livestock Waste Management Systems Fail." Proceedings of the 5th International Symposium on Agricultural Waste. Chicago, Illinois, 1985.

Bill Barr and Co. Sales Staff, Lenexa, Kansas. Telephone interview by author, 13 April 2000.

Dewi, Ioan A, R.F.E. Axford, I. Fayez M. Marai, and H. Omed, eds. *Pollution in Livestock Production Systems.* Proceedings of the 1992 conference on pollution in livestock production systems at the University College of Wales. Wallingford, United Kingdom: Cab International, 1994.

DiPietre, Dennis, John Hoehne, Mark Newcomb, Rick Tubbs, Tim Safranski, and Joe Zulovich. *The Missouri System of Swine Production.* Commercial Agriculture Program Manual 144. University of Missouri, 1996.

Dougherty, Mark, Larry D. Geohring, and Peter Wright. *Liquid Manure Application Systems Design Manual.* Northeast Regional Agricultural Engineering Service, publication NRAES-89.

El-Ahraf, Amer, and William V. Willis. *Management of Animal Waste: Environmental Health Problems and Solutions.* Westport: Praeger, 1996.

Ferrell, Shannon L., Chris Petermann, and Marcia Tilley. "Concentrated Animal Feeding Operations – Applying for a License." Oklahoma State University. Department of Agricultural Economics, unpublished manuscript, August, 1998.

Freese, Betsy. "Manure Storage Covers." *Successful Farming.* September, 1997, pp. 40-41.

Harrigan, T.M. "Manure Hauling Rate of Spreader Tank Systems." *Applied Engineering in Agriculture*, 13 (April, 1997): 465-472.

Jacobs, Lee W. "The Environmental Impacts and Economics of Utilizing Swine Manure." Paper presented at the Meeting the Environmental Challenge Symposium, Minneapolis, Minnesota, November. 1993.

Kim, Chang-Gil. "Evaluating Alternative Swine Waste Management." Unpublished Ph.D. Dissertation, Oklahoma State University, Stillwater, Oklahoma, 1998.

Koelsch, Rick. "Environmental Considerations for Manure Application System Selection." Publication B-6, Livestock Waste Systems, November, 1996 – http://ianr.unl.edu/PUBS/wastemgt/g1266.htm

Lawrence, John and Alan Vontalge. *Livestock Enterprise Budgets for Iowa—1999.* Iowa State University Extension Publication Fm-1815, January 1999 – http://www.extension.iastate.edu/Publications/ FM1815.pdf

Luce, William G. and Joseph E. Williams. "Status of the Oklahoma Swine Industry." Stillwater, Oklahoma: Oklahoma State University, Department of Animal Science and Department of Agricultural Economics, 1998.

Michigan State University. "Recordkeeping System for Crop Production." Michigan State University Cooperative Extension Service Extension Bulletin E-2344. February, 1993.

Mathis, Jennifer. "The Feasibility of Swine Production in Oklahoma." Unpublished Masters Thesis, Oklahoma State University, Stillwater, Oklahoma, 1991.

Massey, Ray, Joe Zulovich, John Haney, Missouri Swine Budget Generator. Excel© template. University of Missouri, 1998.

Massey, Ray, and Joe Zulovich. Personal interview by author, 7 July 1999.

Oklahoma State Department of Agriculture, Oklahoma Agricultural Statistics Service. *Oklahoma Agricultural Statistics 1998.* Oklahoma City, Oklahoma, 1999.

Oklahoma State Department of Agriculture, Oklahoma Agricultural Statistics Service. *Oklahoma Agricultural Statistics 1997.* Oklahoma City, Oklahoma, 1998.

Oklahoma State Department of Agriculture, Oklahoma Agricultural Statistics Service. *Oklahoma Agricultural Statistics 1996.* Oklahoma City, Oklahoma, 1997.

Oklahoma State Department of Agriculture, Oklahoma Agricultural Statistics Service. *Oklahoma Agricultural Statistics 1995.* Oklahoma City, Oklahoma, 1996.

Oklahoma State Department of Agriculture, Oklahoma Agricultural Statistics Service. *Oklahoma Agricultural Statistics 1994.* Oklahoma City, Oklahoma, 1995.

Plain, Ronald L. "Nationwide Trends in Pork Production." Paper presented at the Oklahoma State University Waste Management Conference, Goodwell, Oklahoma, March 5, 1997.

Prince Agri-Products Sales Staff, Quincy, Illinois. Telephone Conversation with Author. 13 April 2000.

Oklahoma Administrative Code Title 35, Chapter 17, Subchapter 3 – Oklahoma Department of Agriculture Water Quality Regulations for Concentrated Animal Feeding Operations.

Oklahoma Statutes, Title 2, Sections 9-201 et seq. The Oklahoma Concentrated Animal Feeding Operations Act.

Safley, L.M., Jr., and J.C. Nye. "Energy Data for Manure Handling Equipment." *Transactions of the ASAE*, 25(1982): 850-858.

Sneath, R.W. "One Solution to the Problem of Handling and Treating Slurry from a Pig Fattening House." *Agricultural Wastes*, 15 (1986): 289-308.

Sunrise Feeds Sales Staff, Cheyenne, Oklahoma. Telephone conversation with author. 13 April 2000.

Stoecker, Arthur, Doug W. Hamilton, Joe Zulovich, and John Haney. Swine Waste Management Program. Excel©/ Visual Basic Model. 1997.

Sutton, A.L., K.A. Foster, E.H. Underdown, and D.D. Jones. "The Environmental Impacts and Economics of the Collection, Storage, and Treatment of Swine Manure." Paper presented at the Meeting the Environmental Challenge Symposium, Minneapolis, Minnesota, November, 1993.

Todd, Jeff L. "Environmental Law: The Clean Water Act – Understanding When a Concentrated Animal Feeding Operation Should Obtain a NPDES Permit." Oklahoma Law Review 49 (1996): 481-509.

United States Department of Agriculture, Natural Resource Conservation Service (Oklahoma). NRCS Conservation Practice Standard: Waste Utilization (Code No. 633). January 1995

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Prices 1998 Summary.*

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Statistics 1999.* Washington, D.C., 1999. <http://usda.mannlib.cornell.edu/reports/nassr/price/zap-bb/agpran99.txt> 3 September 1999.

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Statistics 1990.* Washington. D.C.. 1990.

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Statistics 1980.* Washington. D.C., 1980.

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Statistics 1971.* Washington, D.C., 1999.

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Statistics 1961.* Washington, D.C., 1961.

United States Department of Agriculture, National Agricultural Statistics Service. *Agricultural Statistics 1960.* Washington, D.C., 1960.

United States Department of Agriculture, National Agricultural Statistics Service. *1992 United States Census of Agriculture.* <http://www.nass.usda.gov/census/census92/agrimenu.htm> 14 September 1999.

United States Department of Agriculture, National Agricultural Statistics Service. *1997 United States Census of Agriculture.* Washington, D.C., 1999.

United States Department of Agriculture, National Agricultural Statistics Service. *1999 Statistical Highlights.* Washington, D.C., 1999. <http://www.usda.gov/nass/pubs/stathigh/1999/ec-cr-yr.htm>. 5 September 1999

United States Department of Agriculture, National Agricultural Statistics Service. *Published Estimates Database.* <http://www.nass.usda.gov:81/ipedb/> 28 August 1999.

APPENDIX 1

Swine Waste Management Program
Outputs for Baseline and Modified
Swine Production Operations

Oklahoma Farrow to Feeder - Baseline

Waste Management System Summary

County	Oklahoma		Limiting Nutrient		Nitrogen
Type of Operation	Farrow, Sell Feeder Pigs			No. Bldgs.	Size
Maximum Daily Capacity	4282.6		Farrowing	2	176 x 40
In-House Manure Removal	PitRecharge		Gestation &Breeding	3	190 x 40
			Nursery	2	150 x 40
Waste Treatment System	Anaerobic Lagoon		Finishing	0	
Land Application Method	Irrigation System	1 - 600-	GPM System		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	126.476	46894.47
Pit or Flush water	cuft	14408.93	5259260.7
Water (cleaning + underfloor)	cuft	14537.41	5306156 1
Manure Volume	cuft	396.998	144904.27
Total Solids	lbs	2486.09	907422.85
Volatil Solids	lbs	2134.62	779136.3
BOD	lbs	2095.074	764702 05
COD	lbs	2104.479	768134.84
Nitrogen	lbs	148.2948	54127.602
Phosphorus	lbs	60.5308	22093.742
Potassium	lbs	101.764	37143 86
Percent Solids	Percent	0.002668	

Waste Storage and Treatment Structures		Cell #1	
Anaerobic Lagoon			
Width (inside top of dike)	feet	230 9501823	0
Length (inside tof of dike)	feet	567 8505468	0
Depth	feet	12.5	0
Max Water Depth	feet	10.5	0
Total Volume	cuft	1343559.348	0
Liquid Volume	cuft	1089190.314	0
Wash Water Volume	cuft	46894 47	0
Treatment/Application Volume	cuft	402758.4906	0
Sludge Storage Volume	cuft	440100.0823	0
Water in Manure	cuft	144904.27	0
Surface area at water level	sqft	123257.16	0

Application System Requirements	Irrigation System
Pipe in Fields ft	2376
Pipe to Fie Buried PVC	0
No. of Irrig. Systems	1
Type of Applic Sys	Center Pivot
Size Applic. System	600
Pipe sizedia in	8
Pumps &Motors No	1
Pump:ID,g	600
Pump Head(Tot. ft.)	127.6676
Motors, HP (each)	40
Horse P. Hours	893.8729
T.GPM	600
Appl Labor hrs	0.1
Irrigation OK	

Annual Lagoon Operations in Cubic Feet

Additions		Removals	
Wash Water Volume	46894.47	Evaporation	703593.0692
Water in Manure	144904.27		
Rainfall	196202.7767		
Add to Retain Lagoon Volume	460495.8225	Irrigation System	144904.27
Total Inflow	848497.3392	Total Outflow	848497.3392

	Recirculation	Fresh Water Requirements	
		Drinking Water	417251 1535
Total Amount Required	5259260.667	Washing Water	46894.47
From Washing, Lagoon req	460495 8225	Replace Excess Evap	460495.8225
From Lagoon	4798764.844	Tot. Fresh Water Req	924641.4463

Manure Application

Application System	Irrigation System	T.Acres	Acres	Waste application Ot/Acre				Labor	Application Time
Total Receiving Acres	crop	In field	rec Manure	Acre inch	Nitrogen	P205	K20	Days	Hours
Field 1	Wheat	256	72 615353	0.467267	32.2912	139.3497852	337.6001	0 1	35.97494
Field 2	Georghum	128	0	0	0	0	0	0	0
Field 3	Corn	128	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	512	72 615353	0 467267	62.2912	139 3497852	337 6001	0 1	35 97494

Volume of Effluent and Nutrients Per Acre

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	39.918532	54127.602	22093 742	37143.86
Volume Lost to Evaporation	Acre inches	5 9877795	1627.347404		
Total Volume Applied	Acre inches	33 930752	3797 143943	10118 93364	24514 95
Waste Remaining	Acre inches	0			

North Carolina Farrow to Feeder - Baseline

Waste Management System Summary

County	North Carolina		Limiting Nutrient		Nitrogen
				No. Bldgs.	Size
Type of Operation	Farrow, Sell Feeder Pigs		Farrowing	2	176 x 40
Maximum Daily Capacity	4282.8		Gestation &Breeding	3	190 x 40
In-House Manure Removal	PitRecharge		Nursery	2	150 x 40
			Finishing	0	
Waste Treatment System	Anaerobic Lagoon				
Land Application Method	Irrigation System	1 - 350-	GPM System		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cin	cuft	128.478	46894.47
Pit or Flush water	cuft	14408.90	5259260.7
Water (cleaning + underfloor)	cuft	14537.41	5306155.1
Manure Volume	cuft	396.998	144904.27
Total Solids	lbs	2486.09	907422.85
Volitial Solids	lbs	2134.62	779136.3
BOD	lbs	2095.074	764702.01
COD	lbs	2104.479	768134.84
Nitrogen	lbs	148.2948	54127.602
Phosphorus	lbs	60.5308	22093.742
Potassium	lbs	101.764	37143.86
Percent Solids	Percent	0.002865	

Waste Storage and Treatment Structures			
Anaerobic Lagoon		Cell #1	
Width (inside top of dike)	feet	245.76787	0
Length (inside tot of dike)	feet	612.30081	0
Depth	feet	12.5	0
Max Water Depth	feet	10.5	0
Total Volume	cuft	1562148.795	0
Liquid Volume	cuft	1269693.735	0
Wash Water Volume	cuft	46894.47	0
Treatment/Application Volume	cuft	347092.6829	0
Sludge Storage Volume	cuft	440100.0823	0
Water in Manure	cuft	144904.27	0
Surface area at water level	sqft	142003.8392	0

Annual Lagoon Operations in Cubic Feet

Additions		Removals	
Wash Water Volume	46894.47	Evaporation	497013.4372
Water In Manure	144904.27		
Rainfall	679105.1469		
Add to Retain Lagoon Volume	0	Irrigation System	373890.4497
Total Inflow	870903.8888	Total Outflow	870903.8869

Recirculation		Fresh Water Requirements	
		Drinking Water	417251.1538
Total Amount Required	5259260.667	Washing Water	46894.47
From Washing, Lagoon rep	0	Replace Excess Evap	0
From Lagoon	5259260.667	Tot. Fresh Water Req.	464145.6238

Application System Requirements		Irrigation System
Pipe in Fields ft		390
Pipe to Fields	Buried PVC	0
No. of Irrig. Systems		1
Type of Applic Sys		H.Hose Trav
Size Applic. System		350
Pipe size	dia in	4
Pumps &Motors No.		1
Pump:ID,gpm		350
Pump Head(Tot. ft.)		323.6712
Motors, HP (each)		60
Horse P. Hours		3335.066
T GPM		350
Appl Labor hrs		8
Irrigation OK		

Manure Application

Volume of Effluent and Nutrients Per Acre

Application System Total Receiving Acres	Irrigation System crop	T.Acres in field	Acres rec Manure	Waste application Qt/Acre Acre inch	Nitrogen	P205	K20	Labor Days	Application Time Hours
Field 1	Bermuda	80	23.392913	2.881981	300.8	432.5640769	1047.964719	8	124.6274
Field 2	Bermuda	40	0	0	0	0	0	0	0
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	120	23.392913	2.861981	300.8	432.5640759	1047.964719	8	124.8274

		Effluent Acre Inches	Total N lbs	Total P205 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	103.00012	54127.602	22093.742	37143.86
Volume Lost to Evaporation	Acre inches	36.050043	3788.93214		
Total Volume Applied	Acre inches	66.950081	7038.58626	10118.93384	24514.9476
Waste Remaining	Acre inches	0			

Iowa Farrow to Feeder - Baseline

Waste Management System Summary

County	Iowa	Limiting Nutrient			Nitrogen
Type of Operation	Farrow, Sell Feeder Pigs		No. Bldgs.		Size
Maximum Daily Capacity	4282.6	Farrowing		2	176 x 40
In-House Manure Removal	Underfloorscraper	Gestation &Breeding		3	190 x 40
		Nursery		2	150 x 40
Waste Treatment System	Cement Above Ground Tank	Finishing		0	
Land Application Method	Tanker - 4200-	Gallon Tanker			

In House Waste Treatment		Per Day	Per Year	Waste Storage and Treatment Structures			
Daily Quantities of				Cement Above Ground Tank		Cell #1	
Wash Down Water cin	cuft	128.478	46894.47	Width (inside top of dike)	feet	0	0
Pit or Flush water	cuft	115.5797	42186.5629	Length (inside to of dike)	feet	0	0
Water (cleaning + underfloor)	cuft	244.0577	89081.0629	Depth	feet	20	0
Manure Volume	cuft	396.998	144904.27	Max Water Depth	feet	18	0
Total Solids	lbs	2059.186	751595.59	Total Volume	cuft	269749.6277	0
Volatile Solids	lbs	1707.696	623309.04	Liquid Volume	cuft	242774.6649	0
BOD	lbs	1862.288	679735.12	Wash Water Volume	cuft	46894.47	0
COD	lbs	1670.648	662786.52	Treatment/Application Volume	cuft	0	0
Nitrogen	lbs	140.0562	51120.513	Sludge Storage Volume	cuft	0	0
Phosphorus	lbs	60.5306	22093.742	Water in Manure	cuft	144904.27	0
Potassium	lbs	101.764	37143.66	Surface area at water level	sqft	13487.46138	0
Percent Solids	Percent	5.051477					

Annual Manure Storage Operations (cubic feet)

Additions		Removals	
Wash Water Volume	46894.47	Evaporation	21917.15725
Water in Manure	144904.27		
Rainfall	30706.49929		
Add to Retain Lagoon Volume	0	Tanker	200588.082
Total Inflow	222505.2383	Total Outflow	222505.2383

Application System Requirements		
Application		Tanker Injected
Pipe to Fields	Buried PVC	
number tankers		1
Size of Applic. System		4200
Applic. Sys. Width ft		6
Tanker-Gal.	4200	
No. Tractors		2
Labor Hours		198.6402
Pump.ID,gpm		600
Fuel Req gal		2578.164
BHP req		0
Horse P. Hours		0
Crew Size		1
Appl. Labor hrs		0
Tanker OK		

Scrapers		Fresh Water Requirements	
		Drinking Water	417251.1536
No Units Required	14	Washing Water	46894.47
HpHrs/Yr	11789.86231	Replace Excess Evap	0
Labor	383.25	Tot. Fresh Water Req.	464145.6236
Maintenance Cost	5168.74722		

Manure Application

Volume of Effluent and Nutrients Per Acre

Application System	Tanker	T.Acres	Acres	Waste application Cl/Acre				Labor	Application No of
Total Receiving Acres	crop	in field	rec Manure	Acre Inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Corn	160	160	0.210665	135.14984	173.5886746	152.9271716	128.6537672	217.9281
Field 2	Soybeans	160	73.0196772	0.295176	169.376	243.2382206	214.2849975	70.18645429	139.3594
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	320	233.019677	0.237141	152.141983	195.4135497	172.1544261	198.8402215	357.2858

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	55.2584248	51120.513	22093.742	37143.66
Volume Lost to Evaporation	Acre inches	0	1655.898725		
Total Volume Applied	Acre inches	55.2584248	36452.07577	45536.20226	40115.3686
Waste Remaining	Acre inches	0			

Oklahoma Farrow to Finish - Baseline

Waste Management System Summary

County	Oklahoma		Limiting Nutrient		Nitrogen
Type of Operation	Farrow, Self Finished Pigs			No. Bldgs	Size
Maximum Daily Capacity	11861.6		Farrowing	2	178 x 40
In-House Manure Removal	PitRecharge		Gestation &Breeding	3	190 x 40
			Nursery	2	150 x 40
Waste Treatment System	Anaerobic Lagoon		Finishing	11	124 x 40
Land Application Method	Irrigation System	1 - 400-	GPM System		

In House Waste Treatment		Per Day	Per Year	Waste Storage and Treatment Structures			
Daily Quantities of				Anaerobic Lagoon		Cell #1	
Wash Down Water cln	cuft	355.848	129884.52	Width (inside top of dike)	feet	371.4986081	0
Pit or Flush water	cuft	34819.8	12836154	Length (inside tof of dike)	feet	989.4958242	0
Water (cleaning + underfloor)	cuft	34975.45	12766039	Depth	feet	12.5	0
Manure Volume	cuft	1223.928	446733.72	Max Water Depth	feet	10.5	0
Total Solids	lbs	7644.49	2790238.9	Total Volume	cuft	4078591.609	0
Volatil Solids	lbs	6777.18	2473670.7	Liquid Volume	cuft	3357942.244	0
BOD	lbs	5395.878	1969495.5	Wash Water Volume	cuft	129884.52	0
COD	lbs	6802.029	2482740.6	Treatment/Application Volume	cuft	1278713.208	0
Nitrogen	lbs	456.8623	166762.04	Sludge Storage Volume	cuft	1353263.842	0
Phosphorus	lbs	189.4906	69164.142	Water in Manure	cuft	446733.72	0
Potassium	lbs	282.308	103042.42	Surface area at water level	sqft	354066.3771	0
Percent Solids	Percent	0.003384					

Application System Requirements	Irrigation System
Pipe in Fields ft	9944
Pipe to Fie Buried PVC	2640
No. of Irrig. Systems	1
Type of Applic Sys	TowC Piv.
Size Applic. System	400
Pipe size/dia in	6
Pumps &Motors No	1
Pump ID,g	400
Pump Head(Tot. ft.)	159.2005
Motors, HP (each)	30
Horse P. Hours	1021.264
T.GPM	400
Appl. Labor hrs	6
Irrigation OK	

Annual Lagoon Operations in Cubic Feet

Additions		Removals	
Wash Water Volume	129884.52	Evaporation	2021243.069
Water in Manure	446733.72		
Rainfall	537324.0794		
Add to Retain Lagoon Volume	1354034.47	Irrigation System	446733.72
Total Inflow	2467976.789	Total Outflow	2467976.789

Recirculation		Fresh Water Requirements	
		Drinking Water	1125944.279
Total Amount Required	12836154	Washing Water	129884.52
From Washing, Lagoon rep	1354034.47	Replace Excess Evap	1354034.47
From Lagoon	11282119.53	Tot. Fresh Water Req.	2609863.269

Manure Application

Application System	Irrigation System	T.Acres	Acres	Volume of Effluent and Nutrients Per Acre Waste application Qt/Acre				Labor	Application Time
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P205	K20	Days	Hours
Field 1	Wheat	256	198.57956	0.467267	52.2912	141.4980542	303.7834	4	108.9838
Field 2	Gsorghum	128	99.289642	0.119019	13.31922561	36.04133218	77.37744	2	22.47853
Field 3	Corn	128	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/avg	512	297.86953	0.351184	39.30054167	108.3456135	228.3147	6	131.4624

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	123.06714	166762.0395	69164.142	103042.4
Volume Lost to Evaporation	Acre inches	18.460071	5017.043042		
Total Volume Applied	Acre inches	104.60707	11706.43377	31677.17704	66006
Waste Remaining	Acre inches	0			

North Carolina Farrow to Finish - Baseline

Waste Management System Summary

County	North Carolina		Limiting Nutrient		Nitrogen
Type of Operation	Farrow, Sell Finished Pigs			No. Bldgs	Size
Maximum Daily Capacity	11881.6		Farrowing	2	176 x 40
In-House Manure Removal	PitRecharge		Gestation &Breeding	3	190 x 40
			Nursery	2	150 x 40
Waste Treatment System	Anaerobic Lagoon		Finishing	11	124 x 40
Land Application Method	Irrigation System	1 - 350-	GPM System		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	355.848	129884.52
Pit or Flush water	cuft	34619.6	12636154
Water (cleaning + underfloor)	cuft	34975.45	12766039
Manure Volume	cuft	1223.928	446733.72
Total Solids	lbs	7644.49	2790238.9
Volatile Solids	lbs	6777.16	2473670.7
BOD	lbs	5395.878	1969495.5
COD	lbs	6802.029	2482740.8
Nitrogen	lbs	456.8823	166762.04
Phosphorus	lbs	189.4906	69164.142
Potassium	lbs	282.306	103042.42
Percent Solids	Percent	0.003384	

Waste Storage and Treatment Structures			
Anaerobic Lagoon		Cell #1	
Width (inside top of dike)	feet	369.219404	0
Length (inside tof of dike)	feet	1042.658212	0
Depth	feet	12.5	0
Max Water Depth	feet	10.6	0
Total Volume	cuft	4529733.945	0
Liquid Volume	cuft	3732340.439	0
Wash Water Volume	cuft	129884.52	0
Treatment/Application Volume	cuft	1101980.488	0
Sludge Storage Volume	cuft	1353765.842	0
Water in Manure	cuft	446733.72	0
Surface area at water level	sqft	391804.0318	0

Annual Lagoon Operations in Cubic Feet

Additions		Removals	
Wash Water Volume	129884.52	Evaporation	1370614.111
Water in Manure	446733.72		
Rainfall	1793030.758		
Add to Retain Lagoon Volume	0	Irrigation System	999034.8875
Total Inflow	2369648.998	Total Outflow	2369648.998

Recirculation		Fresh Water Requirements	
		Drinking Water	1125944.279
Total Amount Required	12636154	Washing Water	129884.52
From Washing, Lagoon rnp	0	Replace Excess Evap	0
From Lagoon	12636154	Tot. Fresh Water Req.	1255828.799

Application System Requirements		Irrigation System
Pipe in Fields ft		1170
Pipe to Fields	Buried PVC	0
No. of Irrig. Systems		1
Type of Applic Sys		H Hose Trav
Size Applic. System		350
Pipe size	dia in	6
Pumps &Motors No		1
Pump ID,gpm		350
Pump Head(Tot. ft.)		310.2371
Motors, HP (each)		60
Horse P. Hours		6930.938
T GPM		350
Appl. Labor hrs.		20
Irrigation OK		

Manure Application

Volume of Effluent and Nutrients Per Acre

Application System / Total Receiving Acres	Irrigation System crop	T Acres in field	Acres rec Manure	Waste application Ol/Acre Acre Inch	Nitrogen	P2O5	K2O	Labor Days	Application Time Hours
Field 1	Bermuda	60	72.07136	2.482131	300.6	439.5251729	943.6202821	20	272.8707
Field 2	Bermuda	40	0	0	0	0	0	0	0
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	120	72.07136	2.482131	300.6	439.5251729	943.6202821	20	272.8707

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	275.21622	166762.0396	69164.142	103042.42
Volume Lost to Evaporation	Acre inches	96.325678	11673.34277		
Total Volume Applied	Acre inches	178.89054	21679.06514	31677.17704	68007.9972
Waste Remaining	Acre inches	0			

Iowa Farrow to Finish - Baseline

Waste Management System Summary

			No. Bldgs.	Size
County	Iowa	Limiting Nutrient		Nitrogen
Type of Operation	Farrow, Sell Finished Pigs			
Maximum Daily Capacity	11861.6	Farrowing	2	176 x 40
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	3	190 x 40
		Nursery	2	150 x 40
Waste Treatment System	Cement Above Ground Tank	Finishing	11	124 x 40
Land Application Method	Tanker - 4200	Gallon Tanker		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	355.848	129884.52
Pit or Flush water	cuft	277.6973	101359.524
Water (cleaning + underfloor)	cuft	633.5453	231244.044
Manure Volume	cuft	1223.928	446733.72
Total Solids	lbs	6289.054	2295504.71
Volatile Solids	lbs	5421.744	1978936.56
BOD	lbs	4796.336	1750662.64
COD	lbs	6046.246	2206880.52
Nitrogen	lbs	431.5	157497.482
Phosphorus	lbs	189.4908	69164.142
Potassium	lbs	282.308	103042.42
Percent Solids	Percent	0.05428	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside tof of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	781805.646	0
Liquid Volume	cuft	703445.0814	0
Wash Water Volume	cuft	129884.52	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	446733.72	0
Surface area at water level	sqft	39080.2823	0

Application System Requirements		Tanker
Application		Injected
Pipe to Fields	Buried PVC	
number tankers		1
Size of Applic. System		4200
Applic. Sys. Width ft		8
Tanker-Gal	4200	
No. Tractors		2
Labor Hours		278.5731
Pump:ID,gpm		600
Fuel Req gal		3611.981
BHP req		0
Horse P. Hours		0
Crew Size		1
Appl. Labor hrs		0
Tanker OK		

Annual Manure Storage Operations (cubic feet)

Additions		Removals	
Wash Water Volume	129884.52	Evaporation	63505.45873
Water in Manure	446733.72		
Rainfall	88972.77803		
Add to Retain Lagoon Volume	0	Tanker	602085.5573
Total Inflow	665591.018	Total Outflow	665591.016

	Scrapers	Fresh Water Requirements	
		Drinking Water	1125944.279
No Units Required	36	Washing Water	129884.52
Hphrs/Yr	37821.91036	Replace Excess Evap	0
Labor	985.5	Tot. Fresh Water Req	1255828.799
Maintenance Cost	14486.46205		

Manure Application — Volume of Effluent and Nutrients Per Acre

Application System	Tanker	T.Acres	Acres	Waste application Qt/Acre				Labor	Application No of
Total Receiving Acres	crop	in field	rec Manure	Acre Inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Corn	160	160	0.206233	135.14984	178.3820727	137.7004189	127.0410312	212.3166
Field 2	Soybeans	160	160	0.287577	189.376	247.1506332	192.9489286	151.5320679	297.5028
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	320	320	0.246405	162.26242	211.786303	165.3248738	278.5730991	509.8196

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	165.86379	157497.4818	69164.142	103042.42
Volume Lost to Evaporation	Acre inches	0	2732.840758		
Total Volume Applied	Acre inches	78.8496867	51923.9744	67786.21696	52903.89661
Waste Remaining	Acre inches	87.0142012			

Oklahoma Finisher - Baseline

Waste Management System Summary

County	Oklahoma		Limiting Nutrient		Nitrogen
Type of Operation	Buy Feeder Pigs, Sell Finished Pigs			No Bldgs	Size
Maximum Daily Capacity	3160		Farrowing	0	
In-House Manure Removal	PitRecharge		Gestation &Breeding	0	
			Nursery	0	
Waste Treatment System	Anaerobic Lagoon		Finishing	5	124 x 40
Land Application Method	Irrigation System	1 - 400-	GPM System		

In House Waste Treatment		Per Day	Per Year	Waste Storage and Treatment Structures			
Daily Quantities of				Anaerobic Lagoon		Cell #1	
Wash Down Water dn	cuft	95.4	34821	Width (inside top of dike)	feet	219 67358	0
Pit or Flush water	cuft	8480	3095200	Length (inside tof of dike)	feet	534 02164	0
Water (cleaning + underfloor)	cuft	8575.4	3130021	Depth	feet	12.5	0
Manure Volume	cuft	346.97	126644.05	Max Water Depth	feet	10 5	0
Total Solids	lbs	2164.4	790006	Total Volume	cuft	1188248.3	0
Volital Solids	lbs	1947.96	711005.4	Liquid Volume	cuft	961095.3773	0
BOD	lbs	1384.906	505490.54	Wash Water Volume	cuft	34821	0
COD	lbs	1971.036	719428.14	Treatment/Application Volume	cuft	367539.6226	0
Nitrogen	lbs	129.4794	47259.981	Sludge Storage Volume	cuft	383132.91	0
Phosphorus	lbs	54.11	19750.15	Water in Manure	cuft	126644.05	0
Potassium	lbs	75 754	27650.21	Surface area at water level	sqft	109873 6505	0
Percent Solids	Percent	0.003888					

				Application System Requirements		Irrigation System
				Pipe in Fields ft		1876
	Annual Lagoon Operations in Cubic Feet			Pipe to Fields	Buried PVC	0
	Additions	Removals		No. of Irrig. Systems		1
Wash Water Volume	34821	Evaporation	627195.4215	Type of Applic Sys		Center Pivot
Water in Manure	126644.05			Size Applic. System		400
Rainfall	178071.9379			Pipe size	dia in	6
Add to Return Lagoon Volume	416302 4836	Irrigation System	126644.05			
Total Inflow	753839 4715	Total Outflow	753839.4715	Pumps &Motors No		1
				Pump:ID,gpm		400
	Recirculation	Fresh Water Requirements		Pump Head(Tot. ft.)		128 6152
		Drinking Water	297362.6923	Motors, HP (each)		25
Total Amount Required	3095200	Washing Water	34821	Horse P. Hours		436 329
From Washing, Lagoon rep	416302 4836	Replace Excess Evap	416302 4836	T.GPM		400
From Lagoon	2678897.516	Tot. Fresh Water Req.	748486.1759	Appl. Labor hrs		0 1
				Irrigation OK		

Manure Application				Volume of Effluent and Nutrients Per Acre						
Application System	Irrigation System	T Acres	Acres	Waste application Qt/Acre				Labor		Application Time
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P205	K20	Days		Hours
Field 1	Wheat	256	63 464675	0 487287	52.2912	142.5291699	287.5479726		0 1	33 64712
Field 2	Georghum	128	0	0	0	0	0		0	0
Field 3	Corn	128	0	0	0	0	0		0	0
Field 4	Bermuda	0	0	0	0	0	0		0	0
Field 5	Corn	0	0	0	0	0	0		0	0
Field 6	Corn	0	0	0	0	0	0		0	0
All Fields	TotalAve	512	63.464675	0.487287	52.2912	142.5291699	287.5479726		0 1	33 64712

		Effluent	Total N	Total P2O5	Total K2O
		Acre inches	lbs	lbs	lbs
Total Volume of Waste	Acre inches	34.688166	47259.981	19750 15	27650 21
Volume Lost to Evaporation	Acre inches	5.2332252	1422.276004		
Total Volume Applied	Acre inches	29 654943	3318 644006	9045.5687	16249 1366
Waste Remaining	Acre inches	0			

North Carolina Finisher - Baseline

Waste Management System Summary

County	North Carolina		Limiting Nutrient		Nitrogen	
Type of Operation	Buy Feeder Pigs, Sell Finished Pigs			No. Bldgs	Size	
Maximum Daily Capacity	3180		Farrowing	0		
In-House Manure Removal	PitRecharge		Gestation &Breeding	0		
			Nursery	0		
Waste Treatment System	Anaerobic Lagoon		Finishing	5	124 x 40	
Land Application Method	Irrigation System	1 - 350-	GPM System			

In House Waste Treatment		Per Day	Per Year	Waste Storage and Treatment Structures			
Daily Quantities of				Anaerobic Lagoon		Cell #1	
Wash Down Water cln	cuft	95.4	34821	Width (inside top of dike)	feet	234.088301	0
Pit or Flush water	cuft	8480	3095200	Length (inside tol of dike)	feet	377.284903	0
Water (cleaning + underfloor)	cuft	8575.4	3130021	Depth	feet	12.5	0
Manure Volume	cuft	346.97	126644.05	Max Water Depth	feet	10.5	0
Total Solids	lbs	2164.4	790006	Total Volume	cuft	1388478.201	0
Volatal Solids	lbs	1947.96	711005.4	Liquid Volume	cuft	1126263.146	0
BOD	lbs	1384.908	505490.54	Wash Water Volume	cuft	34821	0
COD	lbs	1971.036	719428.14	Treatment/Application Volume	cuft	318741.4634	0
Nitrogen	lbs	129.4794	47259.981	Sludge Storage Volume	cuft	363152.91	0
Phosphorus	lbs	54.11	19750.15	Water in Manure	cuft	126644.05	0
Potassium	lbs	75.754	27850.21	Surface area at water level	sqft	127117.4283	0
Percent Solids	Percent	0.003688					

Annual Lagoon Operations in Cubic Feet

	Additions	Removals	
Wash Water Volume	34821	Evaporation	444910.9992
Water in Manure	126644.05		
Rainfall	611603.1678		
Add to Retain Lagoon Volume	0	Irrigation System	328157.2185
Total Inflow	773068.2178	Total Outflow	773068.2178
	Recirculation	Fresh Water Requirements	
		Drinking Water	297362.6923
Total Amount Required	3095200	Washing Water	34821
From Washing, Lagoon rep	0	Replace Excess Evap	0
From Lagoon	3095200	Tot. Fresh Water Req.	332183.6923

Application System Requirements

		Irrigation System
Pipe in Fields ft		390
Pipe to Fields	Buried PVC	0
No. of Irrig. Systems		1
Type of Applic Sys		H Hose Trav
Size Applic. System		350
Pipe size	dia in	4
Pumps &Motors No		1
Pump:ID,gpm		350
Pump Head(Tot. ft.)		323.8712
Motors, HP (each)		60
Horse P. Hours		3352.486
T GPM		350
Appl. Labor hrs		6
Irrigation OK		

Manure Application

Volume of Effluent and Nutrients Per Acre

Application System Total Receiving Acres	Irrigation System crop	T.Acres in field	Acres rec Manure	Waste application Ot/Acre Acre inch	Nitrogen	P205	K20	Labor Days	Application Time Hours
Field 1	Bermuda	80	20.424859	2.876932	300.8	442.870562	693.4766544	8	125.2367
Field 2	Bermuda	40	0	0	0	0	0	0	0
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	TotalAve	120	20.424859	2.876932	300.8	442.870562	893.4766544	8	125.2367

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	90.401438	47259.981	19750.15	27850.21
Volume Lost to Evaporation	Acre inches	31.640503	3306.19667		
Total Volume Applied	Acre inches	58.760934	6143.79753	9045.5687	18249.1388
Waste Remaining	Acre inches	0			

Iowa Finisher - Baseline

Waste Management System Summary

County	Iowa	Limiting Nutrient	Nitrogen
Type of Operation	Buy Feeder Pigs, Sell Finished Pigs		
Maximum Daily Capacity	3180		
In-House Manure Removal	Underfloorscraper		
Waste Treatment System	Cement Above Ground Tank		
Land Application Method	Tanker	- 4200-	Gallon Tanker

	No. Bldgs.	Size
Farrowing	0	
Gestation &Breeding	0	
Nursery	0	
Finishing	5	124 x 40

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	95.4	34821
Pit or Flush water	cuft	68.02139	24827.6075
Water (cleaning + underfloor)	cuft	163.4214	59648.6075
Manure Volume	cuft	346.97	126644.05
Total Solids	lbs	1774.806	647804.82
Volatil Solids	lbs	1558.368	568804.32
BOD	lbs	1231.027	449324.926
COD	lbs	1752.032	639491.68
Nitrogen	lbs	122.2861	44634.4265
Phosphorus	lbs	54.11	19750.15
Potassium	lbs	75.754	27650.21
Percent Solids	Percent	0.056727	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside tof of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	214767.4407	0
Liquid Volume	cuft	193290.6966	0
Wash Water Volume	cuft	34821	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	126644.05	0
Surface area at water level	sqft	10738.37203	0

Application System Requirements		Tanker
Application		Injected
Pipe to Fields	Buried PVC	
number tankers		1
Size of Applic. System		4200
Applic. Sys. Width ft		8
Tanker-Gal	4200	
No Tractors		2
Labor Hours		172.5913
Pump:ID,gpm		800
Fuel Req gal		2237.82
BHP req		0
Horse P. Hours		0
Crew Size		1
Appl. Labor hrs		0
Tanker OK		

Annual Manure Storage Operations (cubic feet)

Additions		Removals	
Wash Water Volume	34821	Evaporation	17449.65456
Water in Manure	126644.06		
Rainfall	24447.68366		
Add to Retain Lagoon Volume	0	Tanker	168462.8891
Total Inflow	185912.7437	Total Outflow	185912.7437

Scrapers		Fresh Water Requirements	
		Drinking Water	297362.6823
No Units Required	10	Washing Water	34821
HpHrs/Yr	11741.93648	Replace Excess Evap	0
Labor	273.75	Tot. Fresh Water Req.	332183.6823
Maintenance Cost	4235.324623		

Manure Application

Application System	Tanker	T Acres	Acres	Volume of Effluent and Nutrients Per Acre				Labor	Application
				Waste application Qt/Acre					No of
Total Receiving Acres	crop	in field	rec Manure	Acre Inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Corn	160	160	0.202827	135.14984	177.7245821	130.3830995	126.2656869	209.6206
Field 2	Soybeans	160	49.2673267	0.283926	189.375	249.0316676	182.6957359	46.32542616	90.44402
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	320	209.267329	0.221767	147.9159454	194.5122509	142.6969439	172.591315	300.0646

		Effluent	Total N	Total P2O5	Total K2O
		Acre inches	lbs	lbs	lbs
Total Volume of Waste	Acre inches	46.4065094	44634.4265	19750.15	27650.21
Volume Lost to Evaporation	Acre inches	0	1629.158567		
Total Volume Applied	Acre inches	46.4065094	30863.97478	40705.05615	29862.2268
Waste Remaining	Acre inches	7.1054E-15			

Oklahoma Farrow to Feeder - Modified

Waste Management System Summary

County	Oklahoma	Limiting Nutrient		Phosphorus
Type of Operation	Farrow, Sell Feeder Pigs		No. Bldgs	Size
Maximum Daily Capacity	4282.6	Farrowing	2	178 x 40
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	3	180 x 40
		Nursery	2	150 x 40
Waste Treatment System	Cement Above Ground Tank	Finishing	0	
Land Application Method	Drag Hose - Large-	GPM		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cin	cuft	128.478	46894.47
Pit or Flush water	cuft	115.5797	42186.5829
Water (cleaning + underfloor)	cuft	244.0577	89081.0529
Manure Volume	cuft	396.986	144904.27
Total Solids	lbs	2059.166	751595.69
Volatile Solids	lbs	1707.698	623309.04
BOD	lbs	1662.288	679735.12
COD	lbs	1870.648	682786.52
Nitrogen	lbs	140.0562	51120.513
Phosphorus	lbs	60.5308	22093.742
Potassium	lbs	101.764	37143.86
Percent Solids	Percent	0.051477	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside tof of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	259983.6921	0
Liquid Volume	cuft	233985.3229	0
Wash Water Volume	cuft	46894.47	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	144904.27	0
Surface area at water level	sqft	12999.1846	0

Application System Requirements			Drag Hose
Application			Injected
Pipe to Fields	Flexible Hose		
No. of Applic. Systs.			1
Size of Applic. System			Large
Applic. Sys. Width ft			16
Pipe Dia to fld		8	0
Hose dia, ft		6	7920
Pumps &Motors No			1
Pump:ID,gpm	BSTRMS		141.479
Pump Head(Tot. ft.)			50.75118
Motors, HP (ea)			25
Horse P. Hours			223.4359
Crew Size			3
Appl. Labor hrs			370.3045
Drag Hose OK			

Annual Manure Storage Operations (cubic feet)

Additions		Removals	
Wash Water Volume	46894.47	Evaporation	37101.83939
Water in Manure	144904.27		
Rainfall	18318.01784		
Add to Retain Lagoon Volume	0	Drag Hose	173014.9182
Total Inflow	210116.7576	Total Outflow	210116.7576

Scrapers		Fresh Water Requirements	
		Drinking Water	417251.1536
No Units Required	14	Washing Water	46894.47
HpHrs/Yr	11789.65231	Replace Excess Evap	0
Labor	383.25	Tot. Fresh Water Req.	464145.6236
Maintenance Cost	5186.74722		

Manure Application

Application System	Drag Hose	T Acres	Acres	Volume of Effluent and Nutrients Per Acre				Labor	Application No of
Total Receiving Acres	crop	in field	rec Manure	Waste application Ot/Acre Acre inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Wheat	256	256	0.007361	27.78989104	35.683772	31.44531807	49.92294936	109852.9
Field 2	Georghum	128	128	0.04151	30.87546967	39.6569376	34.90678537	25.96147468	28103.05
Field 3	Corn	128	128	0.085736	48.89514619	62.8016926	55.32871302	36.32906698	41369.96
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	512	512	0.045482	33.63759948	43.4615436	38.28862763	112.2134807	179325.9

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	47.6625119	51120.513	22093.742	37143.86
Volume Lost to Evaporation	Acre inches	0	911.8342588		
Total Volume Applied	Acre inches	23.2918918	17324.85094	22252.31032	19603.72615
Waste Remaining	Acre inches	24.3706201			

North Carolina Farrow to Feeder - Modified

Waste Management System Summary

County	North Carolina	Limiting Nutrient			Phosphorus
Type of Operation	Farrow, Sell Feeder Pigs		No. Bldgs.		Size
Maximum Daily Capacity	4282.6	Farrowing		2	176 x 40
In-House Manure Removal	Underfloorscraper	Gestation &Breeding		3	190 x 40
		Nursery		2	150 x 40
Waste Treatment System	Cement Above Ground Tank	Finishing		0	
Land Application Method	Drag Hose - Small-	GPM			

In House Waste Treatment		Per Day	Per Year	Waste Storage and Treatment Structures			
Daily Quantities of				Cement Above Ground Tank		Cell #1	
Wash Down Water cln	cuft	128.478	46894.47	Width (inside top of dike)	feet	0	0
Pit or Flush water	cuft	115.5797	42186.6829	Length (inside tof of dike)	feet	0	0
Water (cleaning + underfloor)	cuft	244.0577	89081.0529	Depth	feet	20	0
Manure Volume	cuft	396.998	144904.27	Max Water Depth	feet	18	0
Total Solids	lbs	2059.166	751595.59	Total Volume	cuft	302241.5366	0
Volatil Solids	lbs	1707.696	623309.04	Liquid Volume	cuft	272017.3829	0
BOD	lbs	1862.288	679735.12	Wash Water Volume	cuft	46894.47	0
COD	lbs	1870.648	682786.52	Treatment/Application Volume	cuft	0	0
Nitrogen	lbs	140.0562	51120.513	Sludge Storage Volume	cuft	0	0
Phosphorus	lbs	60.5308	22093.742	Water in Manure	cuft	144904.27	0
Potassium	lbs	101.764	37143.86	Surface area at water level	sqft	15112.07683	0
Percent Solids	Percent	0.061477					

Annual Manure Storage Operations (cubic feet)				Application System Requirements			Drag Hose
				Application			Injected
	Additions	Removals		Pipe to Fields	Flexible Hose		
				No. of Applic. Systs			1
Wash Water Volume	46894.47	Evaporation	26448.13445	Size of Applic. System			Small
Water in Manure	144904.27			Applic. Sys. Width ft			10
Rainfall	64478.19447			Pipe Dia to fld		6	0
Add to Retain Lagoon Volume	0	Drag Hose	229830.8	Hose:dia, ft		6	3960
Total Inflow	256276.9345	Total Outflow	256276.9345	Pumps &Motors No			1
				Pump:ID,gpm	AR-27		205.2273
	Scrapers	Fresh Water Requirements		Pump Head(Tot. ft.)			50.58354
		Drinking Water	417251.1538	Motors, HP (ea)			25
No Units Required	14	Washing Water	46894.47	Horse P. Hours			92.90064
HpHrs/Yr	11789.65231	Replace Excess Evap	0	Crew Size			3
Labor	383.25	Tot. Fresh Water Req.	464145.6238	Appl. Labor hrs			113.7282
Maintenance Cost	5168.74722			Drag Hose OK			

Manure Application				Volume of Effluent and Nutrients Per Acre					Application
Application System	Drag Hose	T.Acres	Acres	Waste application Qt/Acre				Labor	No of
Total Receiving Acres	crop	in field	rec Manure	Acre Inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Bermuda	80	80	0.096797	54.20052144	69.816	61.32994641	22.97539464	16778.76
Field 2	Bermuda	40	40	0.096797	54.20052144	69.816	61.32994641	11.48769732	4190.939
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	120	120	0.096797	54.20052144	69.616	61.32994641	34.46309196	20969.69

		Effluent Acre Inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	63.31427	51120.513	22093.742	37143.86
Volume Lost to Evaporation	Acre inches	0	342.3190828		
Total Volume Applied	Acre inches	11.6156602	6604.062573	6353.92	7359.660569
Waste Remaining	Acre inches	51.6985698			

Iowa Farrow to Feeder - Modified

Waste Management System Summary

County		Iowa
Type of Operation		Farrow, Sell Feeder Pigs
Maximum Daily Capacity		4282.6
In-House Manure Removal		Underfloorscraper
Waste Treatment System		Cement Above Ground Tank
Land Application Method		Tanker - 4200-

Limiting Nutrient		Phosphorus
	No. Bldgs.	Size
Farrowing	2	176 x 40
Gestation &Breeding	3	190 x 40
Nursery	2	150 x 40
Finishing	0	
Gallon Tanker		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	128.478	46894.47
Pit or Flush water	cuft	115.5797	42186.5829
Water (cleaning + underfloor)	cuft	244.0577	89081.0529
Manure Volume	cuft	396.998	144904.27
Total Solids	lbs	2059.188	751595.59
Volatile Solids	lbs	1707.696	623309.04
BOD	lbs	1862.288	679735.12
COD	lbs	1870.648	682786.52
Nitrogen	lbs	140.0562	51120.513
Phosphorus	lbs	60.5308	22093.742
Potassium	lbs	101.764	37143.88
Percent Solids	Percent	0.051477	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside tof of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	269749.6277	0
Liquid Volume	cuft	242774.6649	0
Wash Water Volume	cuft	46894.47	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	144904.27	0
Surface area at water level	sqft	13467.48136	0

Annual Manure Storage Operations (cubic feet)

	Additions	Removals	
Wash Water Volume	46894.47	Evaporation	21917.15725
Water in Manure	144904.27		
Rainfall	30706.49929		
Add to Retain Lagoon Volume	0	Tanker	200588.082
Total Inflow	222505.2393	Total Outflow	222505.2393

Scrapers	
No Units Required	14
HpHrs/Yr	11789.65231
Labor	383.25
Maintenance Cost	5168.74722

Fresh Water Requirements	
Drinking Water	417251.1838
Washing Water	46894.47
Replace Excess Evap	0
Tot. Fresh Water Req.	464145.6238

Application System Requirements

Application		Tanker Injected
Pipe to Fields	Buried PVC	
number tankers		1
Size of Applic. System		4200
Applic. Sys. Width ft		8
Tanker-Gal	4200	
No.Tractors		2
Labor Hours		167.4563
Pump:ID,gpm		800
Fuel Req gal		2171.227
BHP req		0
Horse P. Hours		0
Crew Size		1
Appl. Labor hrs		0
Tanker OK		

Manure Application — Volume of Effluent and Nutrients Per Acre

Application System	Tanker	T.Acres	Acres	Waste application Ot/Acre				Labor	Application No of
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Corn	160	160	0.065318	41.90613156	53.62489928	47.41637783	85.4271569	67.57272
Field 2	Soybeans	160	160	0.05369	34.57422736	44.40768	39.12205002	82.02817728	56.75018
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	320	320	0.059504	38.24017947	49.1162864	43.27021393	167.4563332	123.3229

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre Inches	56.2584248	51120.513	22093.742	37143.88
Volume Lost to Evaporation	Acre inches	0	644.0451279		
Total Volume Applied	Acre inches	19.0733392	12238.85743	15717.21166	13848.46846
Waste Remaining	Acre inches	38.1850856			

Oklahoma Farrow to Finish - Modified

Waste Management System Summary

County	Oklahoma	Limiting Nutrient		Phosphorus
Type of Operation	Farrow, Sell Finished Pigs		No. Bldgs	Size
Maximum Daily Capacity	11661.6	Farrowing	2	176 x 40
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	3	190 x 40
		Nursery	2	150 x 40
Waste Treatment System	Cement Above Ground Tank	Finishing	11	124 x 40
Land Application Method	Drag Hose - Large-	GPM		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	356.848	129884.52
Pit or Flush water	cuft	277.6973	101359.624
Water (cleaning + underfloor)	cuft	633.5453	231244.044
Manure Volume	cuft	1223.928	446733.72
Total Solids	lbs	6289.064	2295604.71
Volital Solids	lbs	5421.744	1978936.56
BOD	lbs	4796.336	1750662.64
COD	lbs	6046.248	2206880.52
Nitrogen	lbs	431.5	157497.482
Phosphorus	lbs	189.4908	69164.142
Potassium	lbs	282.308	103042.42
Percent Solids	Percent	0.05426	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside tof of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	753308.6267	0
Liquid Volume	cuft	677977.7641	0
Wash Water Volume	cuft	129884.52	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	446733.72	0
Surface area at water level	sqft	37666.43134	0

Annual Manure Storage Operations (cubic feet)

Additions		Removals	
Wash Water Volume	129884.52	Evaporation	107503.4186
Water in Manure	446733.72		
Rainfall	53076.87033		
Add to Retain Lagoon Volume	0	Drag Hose	522191.6917
Total Inflow	629695.1103	Total Outflow	629695.1103

Scrapers		Fresh Water Requirements	
		Drinking Water	1125944.279
No Units Required	36	Washing Water	129884.52
HpHrs/Yr	37621.91036	Replace Excess Evap	0
Labor	985.6	Tot. Fresh Water Req.	1255828.799
Maintenance Cost	14488.46205		

Application System Requirements			Drag Hose
Application			Injected
Pipe to Fields	Flexible Hose		
No. of Applic. Systs.			1
Size of Applic. System			Large
Applic. Sys. Width ft			18
Pipe Dia to fld		8	0
Hose:dia, ft		6	7920
Pumps &Motors No.			1
Pump:ID,gpm	Generic		147.6341
Pump Head(Tot. ft.)			61.60049
Motors, HP (ea)			25
Horse P. Hours			369.4519
Crew Size			3
Appl. Labor hrs			472.605
Drag Hose OK			

Manure Application

Application System	Drag Hose	T.Acres	Acres	Volume of Effluent and Nutrients Per Acre				Labor	Application
				Waste application Ot/Acre					No of
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Wheat	256	256	0.036021	27.34976123	35.693772	27.86591223	99.22536454	236032.6
Field 2	Georghum	128	128	0.040021	30.38647119	39.6589376	30.95993168	18.08739233	18026.96
Field 3	Corn	128	128	0.063378	48.12075628	62.8016926	49.02890228	25.96147468	28103.05
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	512	512	0.04366	33.30168746	43.4615436	33.93016461	143.2742316	282162.6

		Effluent	Total N	Total P2O5	Total K2O
		Acre inches	lbs	lbs	lbs
Total Volume of Waste	Acre inches	143.854461	157497.4818	69164.142	103042.42
Volume Lost to Evaporation	Acre inches	0	697.3926417		
Total Volume Applied	Acre inches	22.4563648	17060.46399	22252.31032	17372.24426
Waste Remaining	Acre inches	121.398096			

North Carolina Farrow to Finish - Modified

Waste Management System Summary

County	North Carolina	Limiting Nutrient		Phosphorus
Type of Operation	Farrow, Self Finished Pigs		No. Bldgs	Size
Maximum Daily Capacity	11661.6	Farrowing	2	178 x 40
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	3	190 x 40
		Nursery	2	150 x 40
Waste Treatment System	Cement Above Ground Tank	Finishing	11	124 x 40
Land Application Method	Drag Hose - Small-	GPM		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cin	cuft	355.848	129884.52
Pit or Flush water	cuft	277.6973	101359.524
Water (cleaning + underfloor)	cuft	633.5453	231244.044
Manure Volume	cuft	1223.926	446733.72
Total Solids	lbs	6268.054	2285504.71
Volatile Solids	lbs	5421.744	1978936.56
BOD	lbs	4796.336	1750662.64
COD	lbs	6046.248	2206880.52
Nitrogen	lbs	431.5	157497.482
Phosphorus	lbs	189.4906	69164.142
Potassium	lbs	282.308	103042.42
Percent Solids	Percent	0.05428	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside top of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	875751.6666	0
Liquid Volume	cuft	786176.618	0
Wash Water Volume	cuft	129884.52	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	446733.72	0
Surface area at water level	sqft	43787.58433	0

Annual Manure Storage Operations (cubic feet)

Additions		Removals	
Wash Water Volume	129884.52	Evaporation	76626.27256
Water in Manure	446733.72		
Rainfall	186827.0266		
Add to Retain Lagoon Volume	0	Drag Hose	666818.9939
Total Inflow	763445.2666	Total Outflow	763445.2666

Scrapers		Fresh Water Requirements	
		Drinking Water	1125944.279
No Units Required	38	Washing Water	129884.52
HpHrs/Yr	37821.91036	Replace Excess Evap	0
Labor	985.5	Tot. Fresh Water Req.	1255828.799
Maintenance Cost	14486.46205		

Application System Requirements

			Drag Hose
Application			Injected
Pipe to Fields	Flexible Hose		
No. of Applic. Systs			1
Size of Applic. System			Small
Applic. Sys. Width ft			10
Pipe Dia to fld		6	0
Hose:dia, ft		6	3960
Pumps &Motors No.			1
Pump:ID,gpm	AR-427		205.228
Pump Head(Tot. ft.)			50.5837
Motors, HP (ea)			25
Horse P. Hours			86.68568
Crew Size			3
Appl. Labor hrs			109.4636
Drag Hose OK			

Manure Application

Application System	Drag Hose	T.Acres	Acres	Volume of Effluent and Nutrients Per Acre Waste application Qt/Acre				Labor	Application No of
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Bermuda	80	80	0.092403	53.34210624	69.816	54.34679076	22.11383701	16086.7
Field 2	Bermuda	40	40	0.092403	53.34210624	69.816	54.34679076	11.05691851	4021.674
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	120	120	0.092403	53.34210624	69.816	54.34679076	33.17075552	20108.37

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	189.205783	157497.4618	69164.142	103042.42
Volume Lost to Evaporation	Acre inches	0	336.6975131		
Total Volume Applied	Acre inches	11.0883196	6401.052748	6353.92	6521.654891
Waste Remaining	Acre inches	178.117464			

Iowa Farrow to Finish - Modified

Waste Management System Summary

County	Iowa	Limiting Nutrient		Phosphorus
Type of Operation	Farrow, Sell Finished Pigs		No. Bldgs.	Size
Maximum Daily Capacity	11661.6	Farrowing	2	176 x 40
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	3	190 x 40
		Nursery	2	150 x 40
Waste Treatment System	Cement Above Ground Tank	Finishing	11	124 x 40
Land Application Method	Tanker - 4200-	Gallon Tanker		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	355.848	129884.52
Pit or Flush water	cuft	277.6973	101358.524
Water (cleaning + underfloor)	cuft	633.5453	231244.044
Manure Volume	cuft	1223.926	446733.72
Total Solids	lbs	6289.054	2295504.71
Volatil Solids	lbs	5421.744	1978936.56
BOD	lbs	4796.336	1750662.64
COD	lbs	6046.248	2206880.52
Nitrogen	lbs	431.5	157497.482
Phosphorus	lbs	189.4808	69164.142
Potassium	lbs	282.306	103042.42
Percent Solids	Percent	0.05428	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside tot of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	781606.646	0
Liquid Volume	cuft	703445.0814	0
Wash Water Volume	cuft	129884.52	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	446733.72	0
Surface area at water level	sqft	39080.2823	0

Annual Manure Storage Operations (cubic feet)

Additions		Removals	
Wash Water Volume	129884.52	Evaporation	63606.45873
Water In Manure	446733.72		
Rainfall	89972.77603		
Add to Retain Lagoon Volume	0	Tanker	602085.5673
Total Inflow	665591.018	Total Outflow	665591.018

Application System Requirements		
Application		Tanker Injected
Pipe to Fields	Buried PVC	
number tankers		1
Size of Applic. System		4200
Applic. Sys. Width ft		8
Tanker-Gal.	4200	
No. Tractors		2
Labor Hours		166.9956
Pump.ID.gpm		600
Fuel Req gal		2152.3
BHP req		0
Horse P. Hours		0
Crew Size		1
Appl. Labor hrs		0
Tanker OK		

Scrapers	
No Units Required	36
HpHrs/Yr	37621.91038
Labor	886.5
Maintenance Cost	14486.48205

Fresh Water Requirements	
Drinking Water	1125944.279
Washing Water	129884.52
Replace Excess Evap	0
Tot. Fresh Water Req	1255828.799

Manure Application

Application System	Tanker	T.Acres	Acres	Volume of Effluent and Nutrients Per Acre				Labor	Application
				Waste application Ot/Acre					No of
Total Receiving Acres	crop	In field	rec Manure	Acre inch	Nitrogen	P205	K20	Days	Loads
Field 1	Corn	160	160	0.062629	41.24243206	53.6248928	42.02078874	84.62732936	64.79071
Field 2	Soybeans	160	160	0.051671	34.02664862	44.40768	34.66660756	81.36828651	53.45492
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	320	320	0.05715	37.63454044	49.1162864	38.34476616	166.9956179	118.2456

		Effluent	Total N	Total P2O5	Total K2O
		Acre inches	lbs	lbs	lbs
Total Volume of Waste	Acre Inches	165.66379	157497.4818	69164.142	103042.42
Volume Lost to Evaporation	Acre Inches	0	633.8448916		
Total Volume Applied	Acre inches	18.2880796	12043.06294	15717.21165	12270.33221
Waste Remaining	Acre inches	147.67571			

Oklahoma Finisher - Modified

Waste Management System Summary

County	Oklahoma	Limiting Nutrient		Phosphorus
Type of Operation	Buy Feeder Pigs, Sell Finished Pigs		No. Bldgs	Size
Maximum Daily Capacity	3180	Farrowing	0	
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	0	
		Nursery	0	
Waste Treatment System	Cement Above Ground Tank	Finishing	5	124 x 40
Land Application Method	Drag Hose - Large-	GPM		

In House Waste Treatment		Per Day	Per Year
Daily Quantities of			
Wash Down Water cln	cuft	95.4	34821
Pit or Flush water	cuft	68.02138	24827.8075
Water (cleaning + underfloor)	cuft	163.4214	59648.8075
Manure Volume	cuft	346.97	128644.05
Total Solids	lbs	1774.808	647804.92
Volatile Solids	lbs	1558.368	568804.32
BOD	lbs	1231.027	449324.828
COD	lbs	1752.032	639491.68
Nitrogen	lbs	122.2861	44634.4265
Phosphorus	lbs	54.11	19750.15
Potassium	lbs	75.754	27650.21
Percent Solids	Percent	0.065727	

Waste Storage and Treatment Structures			
Cement Above Ground Tank		Cell #1	
Width (inside top of dike)	feet	0	0
Length (inside tof of dike)	feet	0	0
Depth	feet	20	0
Max Water Depth	feet	18	0
Total Volume	cuft	200992.0639	0
Liquid Volume	cuft	180892.8575	0
Wash Water Volume	cuft	34821	0
Treatment/Application Volume	cuft	0	0
Sludge Storage Volume	cuft	0	0
Water in Manure	cuft	128644.05	0
Surface area at water level	sqft	10049.60319	0

Annual Manure Storage Operations (cubic feet)			
Additions		Removals	
Wash Water Volume	34821	Evaporation	29539.49245
Water in Manure	128644.05		
Rainfall	14584.31583		
Add to Retain Lagoon Volume	0	Drag Hose	148509.8734
Total Inflow	178049.3658	Total Outflow	178049.3658

Application System Requirements			Drag Hose
Application			Injected
Pipe to Fields	Flexible Hose		
No. of Applic. Systs			1
Size of Applic. System			Large
Applic. Sys. Width ft			18
Pipe Dia to fld		6	0
Hose dia, ft		6	7920
Pumps &Motors No			1
Pump ID,gpm	BSTRMS		135.9898
Pump Head(Tot. ft.)			48.97156
Motors, HP (ea)			25
Horse P. Hours			214.8825
Crew Size			3
Appl. Labor hrs			365.3771
Drag Hose OK			

Scrapers		Fresh Water Requirements	
		Drinking Water	297362.6923
No Units Required	10	Washing Water	34821
HpHrs/Yr	11741.93548	Replace Excess Evap	0
Labor	273.75	Tot. Fresh Water Req.	332183.6923
Maintenance Cost	4235.324923		

Manure Application

Application System	Drag Hose	T.Acres	Acres	Volume of Effluent and Nutrients Per Acre				Labor	Application
				Waste application Qt/Acre					No of
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Wheat	256	256	0.035392	27.14318454	35.693772	26.186624	49.92294938	109852.9
Field 2	Sorghum	128	128	0.039322	30.15693567	39.6569376	29.0932992	25.98147488	28100.05
Field 3	Corn	128	128	0.062271	47.75725608	62.8016928	46.0728578	34.63569695	39459.22
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	512	512	0.043094	33.05013068	43.4615436	31.8844812	110.72032	177418.2

		Effluent	Total N	Total P2O5	Total K2O
		Acre inches	lbs	lbs	lbs
Total Volume of Waste	Acre inches	40.3808467	44634.4265	19750.15	27650.21
Volume Lost to Evaporation	Acre inches	0	890.6140479		
Total Volume Applied	Acre inches	22.084139	16921.66691	22252.31032	16324.63901
Waste Remaining	Acre inches	18.2967076			

North Carolina Finisher - Modified

Waste Management System Summary

County	North Carolina	Limiting Nutrient		Phosphorus	
Type of Operation	Buy Feeder Pigs, Sell Finished Pigs		No. Bldgs	Size	
Maximum Daily Capacity	3180	Farrowing	0		
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	0		
		Nursery	0		
Waste Treatment System	Cement Above Ground Tank	Finishing	5	124 x 40	
Land Application Method	Drag Hose - Small -	GPM			

In House Waste Treatment		Per Day	Per Year	Waste Storage and Treatment Structures			
Daily Quantities of				Cement Above Ground Tank		Cell #1	
Wash Down Water cln	cuft	95.4	34821	Width (inside top of dike)	feet	0	0
Pit or Flush water	cuft	68.02139	24827.8075	Length (inside tof of dike)	feet	0	0
Water (cleaning + underfloor)	cuft	163.4214	59648.8075	Depth	feet	20	0
Manure Volume	cuft	346.97	126644.06	Max Water Depth	feet	18	0
Total Solids	lbs	1774.808	647804.92	Total Volume	cuft	240836.6297	0
Volital Solids	lbs	1658.368	666604.32	Liquid Volume	cuft	216572.9657	0
BOD	lbs	1231.027	449324.928	Wash Water Volume	cuft	34821	0
COD	lbs	1752.032	639491.68	Treatment/Application Volume	cuft	0	0
Nitrogen	lbs	122.2861	44634.4265	Sludge Storage Volume	cuft	0	0
Phosphorus	lbs	54.11	19750.15	Water in Manure	cuft	126644.05	0
Potassium	lbs	75.754	27650.21	Surface area at water level	sqft	12031.83148	0
Percent Solids	Percent	0.056727					

Annual Manure Storage Operations (cubic feet)

	Additions		Removals
Wash Water Volume	34821	Evaporation	21055.7061
Water in Manure	126644.05		
Rainfall	51335.61433		
Add to Retain Lagoon Volume	0	Drag Hose	191745.1582
Total Inflow	212800.8643	Total Outflow	212800.8643

Scrapers		Fresh Water Requirements	
		Drinking Water	297362.6823
No Units Required	10	Washing Water	34821
HpHrs/Yr	11741.93648	Replace Excess Evap	0
Labor	273.75	Tot. Fresh Water Req.	332183.6823
Maintenance Cost	4236.324923		

Application System Requirements

Application			Drag Hose
			Injected
Pipe to Fields	Flexible Hose		
No. of Applic. Systm			1
Size of Applic. System			Small
Applic. Sys. Width ft			10
Pipe Dia to fld		6	0
Hosedia, ft		6	3960
Pumps &Motors No			1
Pump1D,gpm	83TRMS		180.421
Pump Head(Tot. ft.)			45.2756
Motors, HP (ea)			25
Horse P. Hours			67.45684
Crew Size			3
Appl. Labor hrs			92.4
Drag Hose OK			

Manure Application

Application System	Drag Hose	T.Acres	Acres	Volume of Effluent and Nutrients Per Acre				Labor	Application
				Waste application Ot/Acre					No of
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Bermuda	80	80	0.059845	40.93089105	53.8248926	39.4872576	18.66666667	13329.71
Field 2	Bermuda	40	40	0.057827	33.78981575	44.40768	32.57858	9.333333333	3332.428
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	120	120	0.065774	38.64379982	50.68582187	37.1843584	28	16662.14

		Effluent	Total N	Total P2O5	Total K2O
		Acre inches	lbs	lbs	lbs
Total Volume of Waste	Acre inches	52.8223579	44634.4265	19750.15	27650.21
Volume Lost to Evaporation	Acre inches	0	243.4345252		
Total Volume Applied	Acre inches	7.89290987	4625.255079	6082.298624	4462.123006
Waste Remaining	Acre inches	44.9294482			

Iowa Finisher - Modified

Waste Management System Summary

County	Iowa	Limiting Nutrient		Phosphorus
Type of Operation	Buy Feeder Pigs, Sell Finished Pigs		No. Bldgs	Size
Maximum Daily Capacity	3180	Farrowing	0	
In-House Manure Removal	Underfloorscraper	Gestation &Breeding	0	
		Nursery	0	
Waste Treatment System	Cement Above Ground Tank	Finishing	5	124 x 40
Land Application Method	Tanker - 4200-	Gallon Tanker		

In House Waste Treatment		Per Day	Per Year	Waste Storage and Treatment Structures			
Daily Quantities of				Cement Above Ground Tank		Cell #1	
Wash Down Water cln	cuft	95.4	34821	Width (inside top of dike)	feet	0	0
Pit or Flush water	cuft	68.02139	24827.6075	Length (inside tot of dike)	feet	0	0
Water (cleaning + underfloor)	cuft	163.4214	59648.6075	Depth	feet	20	0
Manure Volume	cuft	348.87	126844.05	Max Water Depth	feet	18	0
Total Solids	lbs	1774.808	647804.92	Total Volume	cuft	214767.4407	0
Volatile Solids	lbs	1558.368	568804.32	Liquid Volume	cuft	193290.6966	0
BOD	lbs	1231.027	449324.928	Wash Water Volume	cuft	34821	0
COD	lbs	1752.032	639491.68	Treatment/Application Volume	cuft	0	0
Nitrogen	lbs	122.2861	44634.4266	Sludge Storage Volume	cuft	0	0
Phosphorus	lbs	54.11	19750.15	Water in Manure	cuft	126844.05	0
Potassium	lbs	75.754	27650.21	Surface area at water level	sqft	10736.37203	0
Percent Solids	Percent	0.065727					

Annual Manure Storage Operations (cubic feet)

	Additions	Removals	
Wash Water Volume	34821	Evaporation	17449.65455
Water in Manure	126844.05		
Rainfall	24447.69366		
Add to Retain Lagoon Volume	0	Tanker	168462.6891
Total Inflow	185912.7437	Total Outflow	185912.7437

	Scrapers	Fresh Water Requirements	
		Drinking Water	297362.6923
No Units Required	10	Washing Water	34821
HpHrs/Yr	11741.93548	Replace Excess Evap	0
Labor	273.75	Tot. Fresh Water Req	332183.6923
Maintenance Cost	4235.324923		

Application System Requirements

		Tanker
Application		Injected
Pipe to Fields	Buried PVC	
number tankers		1
Size of Applic. System		4200
Applic. Sys. Width ft		8
Tanker-Gal	4200	
No. Tractors		2
Labor Hours		165.3104
Pump ID,gpm		600
Fuel Req gal		2143.415
BHP req		0
Horse P. Hours		0
Crew Size		1
Appl. Labor hrs		0
Tanker OK		

Manure Application

Application System	Tanker	T Acres	Acres	Volume of Effluent and Nutrients Per Acre Waste application Ot/Acre				Labor	Application No of
Total Receiving Acres	crop	in field	rec Manure	Acre inch	Nitrogen	P2O5	K2O	Days	Loads
Field 1	Corn	160	160	0.061367	40.93089180	53.8248929	39.4672576	84.25185399	63.48474
Field 2	Soybeans	160	160	0.05063	33.76961575	44.40766	32.57866	81.05851463	52.37744
Field 3	Corn	0	0	0	0	0	0	0	0
Field 4	Bermuda	0	0	0	0	0	0	0	0
Field 5	Corn	0	0	0	0	0	0	0	0
Field 6	Corn	0	0	0	0	0	0	0	0
All Fields	Total/ave	320	320	0.055998	37.35025381	49.1162864	36.0329066	165.3103788	115.8622

		Effluent Acre inches	Total N lbs	Total P2O5 lbs	Total K2O lbs
Total Volume of Waste	Acre inches	45.4085094	44634.4265	19750.15	27650.21
Volume Lost to Evaporation	Acre inches	0	829.0669062		
Total Volume Applied	Acre inches	17.9194523	11952.08122	15717.21166	11530.53062
Waste Remaining	Acre inches	28.4890571			

VITA

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Master of Science

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