

ECONOMIC IMPACT OF ENVIRONMENTAL QUALITY
LEGISLATION ON CONFINED ANIMAL FEEDING
OPERATIONS IN OKLAHOMA

By

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CHAPTER I

INTRODUCTION

Description of the Problem

Traditionally, livestock production in Oklahoma has been oriented toward raising animals in native forage. When using a pasture system, the operators have not been overly concerned with environmental considerations. As the demand for meat to feed a growing population has steadily grown and the number and size of feed yards have increased the operators have had to become concerned about the effects of feed yard operations on the environment. Six important factors appear to be responsible for increased confinement feeding in the Southwest:

(1) the development of grain sorghum; (2) increases in irrigation; (3) shifts of population to the Southwest; (4) favorable climate for feed yards; (5) new highways and (6) community support (Swackhamer and Bickel, 1970).

A factor which has increased the possibility of environmental problems is that many of the feed yards in Oklahoma have been enlarging their size of operation. In the Tenth Federal Reserve District beef feed yards of 1,000 to 7,999 head capacity accounted for 77 percent of the increase in numbers of lots during the 1962-69 period. Twenty-three percent of the growth was from lots greater than 8,000 head capacity (Swackhamer and Bickel, 1970). The large increase in numbers

of animals on Oklahoma farms which has occurred over the last decade is presented in Table I.

TABLE I
NUMBER OF ANIMALS ON OKLAHOMA FARMS

Class	1959	1964	1969	1970	1971
Beef Cattle ^a	3,217,000	4,106,000	4,659,000	4,985,000	5,085,000
Hogs	444,000	293,000	399,000	375,000	506,000 ^b
Dairy Cattle	318,000	224,000	166,000	161,000	146,000
Laying Hens	5,110,000	3,269,000	3,037,000	3,409,000	3,490,000

^aIncludes cows and heifers 2 years + for milk.

^bJan. 1 inventory no longer available.

Source: Livestock Inventory, Oklahoma Crop and Livestock Reporting Service, Jan. 1, 1964; LV #69-7, Jan. 1, 1969; LV #76-8, Jan. 1, 1971

The rations used in Oklahoma feed yards have reduced beef animal excretion some, but with the marked increase in animal numbers, the total amount of waste excreted has increased substantially. The increasing size of feed yards has resulted in more wastes at each operation.

Recently there has been an increasing awareness of the degraded quality of the environment. This plus the facts that: (1) animal numbers are increasing in Oklahoma, (2) animal wastes are water soluble

and (3) animals such as beef are raised in uncovered pens, give some indication of the animal production problems related to environmental quality. Pollution of water courses particularly would increase unless methods to control the runoff of wastes were adopted.

The Water Quality Act of 1965 required the states to establish and enforce water quality standards for all interstate water within their boundaries. The deadline for compliance was June 30, 1967 (Section 5, 1965).

The state of Oklahoma met the deadline for compliance with the requirements of the 1965 law. Oklahoma's water quality standards are primarily enforced by the Department of Water Pollution Control.

In 1969 the Oklahoma legislature passed the Oklahoma Feed Yards Act. This Act applied to operators of beef, hog, sheep and horse feed yards who have raised 250 head or more at one time. Sheep and horses are not generally raised in confinement in Oklahoma. Briefly, the law required feed yard operators to register and purchase a license. Before receiving the license the state inspects the feed yard for compliance with the Act.

The Oklahoma Feed Yards Act of 1969 required that feed yard operators prevent runoff from their feed yards. In many cases this required building expensive waste retention structures. At present there are no specific requirements regarding waste handling methods. The specific problem of this study was to analyze the economic impact of the Oklahoma Feed Yards Act of 1969 on confined animal feeding operations in Oklahoma.

Objectives of the Study

The study had three main objectives: to examine the (1) technical, (2) legal and (3) economic aspects of the passage of the Oklahoma Feed Yards Act of 1969 as related to confined animal feeding and waste handling.

Technical aspects of wastes are many and complex. The study investigated how pollution resulted from livestock. Terms used in discussing pollution and waste degradation were examined. Attention was directed to some of the biological processes involved in the breakdown of the wastes and the mechanical processes used to prevent or control pollution of running streams. Oklahoma's situation regarding pollution potential and the relation of animals to stream pollution in the state was examined. Variability in the quantity of annual rainfall over the state and the amount of evapotranspiration were examined to detect possible areas which might have a pollution problem. Maps of the state were utilized to locate possible excessive concentrations of animals in relation to both streams and cities.

Legal aspects of the problem included the interaction of the Feed Yards Act with other environmental quality legislation. The effects of related water and air quality legislation, including tax incentives and cost sharing provisions on animal feeding operations in Oklahoma were also examined.

Economic aspects were studied to determine the present costs of waste disposal methods and additional costs operators have incurred as a result of the Feed Yards Act. Returns from feed yard wastes were also analyzed.

Importance of the Study

The trend to larger size feed yards was pointed out earlier in this chapter. The percent increase in hogs in Oklahoma has been greater than the percent increase in cattle even though the absolute numbers have not been as great. Hog wastes are even more concentrated than are cattle wastes. Many hogs are still raised in pastures or on slatted feeding floors where the wastes drop onto the ground.

Dairy cattle are generally fed at bunks outside rather than in barns, leaving the wastes exposed to rainfall. The cattle are also put into holding pens before each milking, resulting in another source of wastes in a small area. The milking operation also results in a large quantity of cleaning and flushing water which must be disposed.

Broilers, chickens and turkeys are all important in the economies of local areas in Oklahoma. The broiler industry is expanding into the second tier of counties on the eastern side of the state. Poultry wastes are extremely concentrated wastes. The birds are generally housed in buildings holding about 15,000 birds and the waste has to be handled and disposed of after each flock of layers or broilers are sold.

There are two reasons for being concerned about the concentration of feed yards. The first is that a stream must have four to five milligrams of dissolved oxygen per liter of water to enable aquatic life to exist (Loehr, 1968). Over a reasonable time aquatic life can adjust to changes in the level of the dissolved oxygen in the water. If the stream is subjected to large inflows of waste-laden runoff water, the slug effect causes the dissolved oxygen to drop rapidly and thus kill the aquatic life.

The second reason for concern about the concentration of feed yards is the effect of eutrophication on streams and reservoirs. A clear, clean, nutrient-poor lake is termed oligotrophic. Such a lake would have little algae, low phosphorus content and the dissolved oxygen would be fairly uniform from surface to floor of the lake or reservoir. If nutrients such as runoff from feed yards are allowed into such a lake, the nutrient content, especially phosphorus, would increase. The amount of algae produced would rise markedly, the dissolved oxygen would become very low in the bottom of the lake and the fish population would change from whitefish to a coarser species (McGauhey, 1968). In Oklahoma there are several reservoirs which are on major streams draining areas with high animal waste population equivalents.

Canton reservoir is on the North Canadian River in Blaine County. The reservoir is used to augment the water supply for Oklahoma City, Oklahoma. The city pays \$148,500 annually for the water it receives (U.S. Army Corps of Engineers, 1969). If this water were to get high amounts of feed yard runoff, the water would have to be treated to remove taste, odor, and impurities. This would result in additional treatment cost to the city.

These and other downstream effects are important because of their effect on others. This concept is called "externalities" by economists (Kneese and Bower, 1968).

While feed yard runoff can cause problems downstream, the solving of the problems also results in additional costs to the feed yards. These costs are for the construction of lagoons and waste retention structures to keep the wastes from going downstream. Many of these costs cannot be passed on to the consumer of the meat, but must be

absorbed by a reduction in profits. They will be reflected in higher retail costs of beef in the long run, but not in the short run because an increase in fixed costs will not result in changes in the level of production (Leftwich, 1966).

The preceding material has pointed to the importance of examining the effect of the Act. The following material will present the procedure of the study.

Procedure

With passage of the Oklahoma Feed Yards Act in 1969 it was obvious that some changes by the feed yards would be required. Since information was needed by the agricultural industry regarding the magnitude and direction of the effects of the Act, it was decided to initiate this study. The first step was to identify which feed yards were affected by the Act.

The Population

The population which the study examined consisted of all the feed yards licensed in the state of Oklahoma. The four geographic areas were determined on the basis of similar characteristics of rainfall patterns (Figure 1). The first area consisted of the panhandle counties, the second included the counties generally west of Interstate 35. The division between Area 3 and 4 was approximately where the mean annual rainfall was 40 inches per year (Figure 1). The area distribution of the 144 license holders as of January 1, 1971 is indicated in Table II.

The initial list was updated late in April 1970 with the inclusion of 15 more feed yards, bringing the total number to 129. Later in 1970

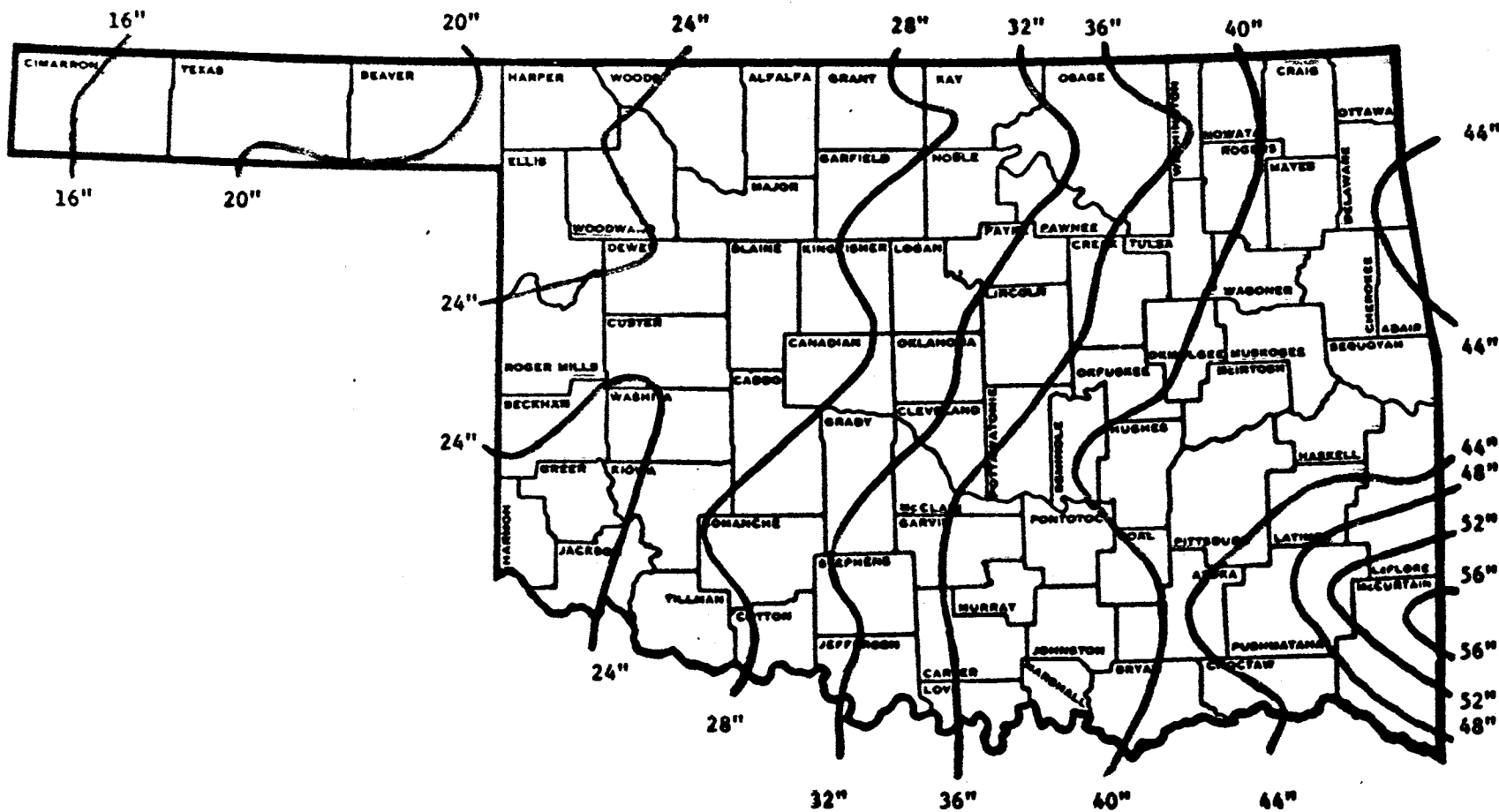


Figure 1. Oklahoma Mean Annual Precipitation (25 Years of Data)

the list was further updated with the addition of 15 more operations. The final total as of January 1, 1971 was 144 feed yards with licenses.

TABLE II
NUMBER OF ANIMALS, BY CLASSES AND AREAS, LICENSED
UNDER OKLAHOMA FEED YARDS ACT

Area	Numbers			
	Operators	Cattle	Hogs	Sheep
1	18	167,000	3,250	---
2	82	112,325	34,052	12,200
3	34	16,112	12,720	1,000
4	<u>10</u>	<u>13,600</u>	<u>2,100</u>	<u>---</u>
Total	144	309,037	52,122	13,200

Using the list of feed yards licensed under the Act and the number of animals by type, it was possible to convert the different classes of animals to population equivalents (P.E.). Loehr (1969) assigned a P.E. of 1.0 to a human equivalent by the use of the five day biochemical oxygen demand (BOD) and assigned population equivalents to the different classes of animals.

The pollution potential of confined feeding operations depends upon the number of animals in any given watershed. The animal waste population equivalents of the feed yards which were licensed in Oklahoma as

of January 1, 1971 are presented in Figure 2. The major river basins of the state are also shown on this figure.

The Water Resources Council of the Federal government divided the country's river basins into watersheds, and the watersheds were subdivided into reaches. A map of Oklahoma, obtained from the Soil Conservation Service (SCS) of the United States Department of Agriculture, depicted the river basins, watersheds and reaches of Oklahoma's streams. The location of the feed yards and their population equivalents were plotted on the watershed map, and the number and population equivalents of animals of different kinds were tabulated for each watershed. When all the feed yards had been plotted, it was possible to see areas where a pollution problem might exist from large quantities of waste in small areas (see Figure 2). High population equivalents were found in the western counties of Oklahoma.

The main part of the study was the economic impact of environmental legislation in Oklahoma. Two methods of securing the information were evaluated, but a lack of adequate data precluded the use of economic engineering. Interviewing feed yard operators was deemed the best method to obtain current, adequate data to accomplish the objectives and thus provide answers to the stated problem. The writing of the questionnaire was begun in the Spring of 1970.

Four kinds of animals are covered by the Feed Yards Act, and the questionnaire was designed to secure data from operators of the various types of operations. Preliminary talks with managers of several large feed yards provided some information regarding the kinds of questions which should be asked. Extension personnel, both on the Oklahoma State University campus and in the counties, provided additional

information regarding the basic methods of waste handling being used in Oklahoma.

State office personnel of the Agricultural Stabilization and Conservation Service (ASCS) and SCS were contacted regarding the activities of their agencies in animal waste management. ASCS had had a number of inquiries from operators relating to the possibilities of cost sharing, and SCS had received questions about designs of structures used to prevent pollution. Names of operators with recent construction of pollution control facilities were obtained from both agencies and some of these operators were visited.

With the views of the various specialists mentioned above, a preliminary questionnaire was developed. In addition to including animals covered by the Feed Yards Act, it was decided to interview some operators of dairy, poultry and turkey farms. The names of these operators were obtained from various sources.

The questionnaire was circulated among the staff of the Department of Agricultural Economics at Oklahoma State University. Certain changes were suggested and most were incorporated. The tentative questionnaire was administered to five selected confined animal feeding operators. Shortcomings in the questionnaire were detected as a result of the pre-test and final changes were made.

The feed yard operators registered under the Feed Yards Act became the population for the study. A stratified random sample was drawn from the population. The sample was stratified by size of operation within kinds of animals and by regions of Oklahoma. All feed yards with a one time capacity equal to or greater than 10,000 cattle or 1,000 hogs were included in the sample. If the region had four or

more operators with less than 10,000 cattle or 1,000 hogs, 50 percent of the operators were drawn for the sample. If the region had less than four operators with less than 10,000 cattle or 1,000 hogs, all the operators were included in the sample. All sheep feed yard operators were included in the sample.

Interviews

Interviewing began the second week of June, 1970 and was completed the first week of August, 1970. A comparison of the number chosen for the sample and the number of respondents, by classes of animals is presented in Table III. Several reasons exist for the discrepancies. Several of the respondents would take the time to answer questions regarding their main enterprise, but would not spend another 45 minutes for the minor enterprise. In some cases the feed yard operator had applied for a license for animals it did not feed, so as to be able to add that enterprise later without having to reapply under possibly different legislation.

Analysis of Data

The answers to questions of a non-quantifiable nature were analyzed first. These were categorized by areas and classes of animals. The results of this analysis will be found in Chapters III and IV of the study.

Quantifiable data were then analyzed. Physical data were examined. The amount of labor used was calculated separately and was later costed separately from other items.

TABLE III
NUMBER OF FEEDING OPERATORS IN SAMPLE AND NUMBER OF INTERVIEWS
OBTAINED, BY CLASS OF LIVESTOCK FED

	Cattle	Hogs	Sheep	Cattle & Hogs	Cattle & Sheep
Sample	35	30	1	3	3
Respondents	31	25	1	1	-
	<u>Dairies</u>	<u>Layers</u>		<u>Broilers</u>	<u>Turkeys</u>
Respondents	9	3		11	4

When considering expansion of a feed yard, all costs are variable; however, when considering the individual feed yard in the short run some costs are fixed and some are variable. The data obtained by the researcher was for a given moment in time and was assumed to represent a point on the operator's short run cost curve. It was not possible to vary the production of a feed yard and thus study the shape of the short run cost curve. Because the curve could not be established for an operator, the average costs of feed yard operators interviewed in one of the established intervals were assumed to be representative of all feed yards in the interval.

Numbers of animals and their weights were calculated. The original plan had been to relate the data to the number of animals on a one time capacity; however, one cooperator pointed out that the feeders think in terms of pounds of gain. This proved to be a better measure of the size of a feed yard because the different classes of animals

could also be compared. Equipment used in cleaning the yard was determined and the hours of use in cleaning were calculated. Many of the feed yards had structures to catch waste and runoff. The capacity of storage was calculated as accurately as possible. This proved to be a very elusive figure due to the apparent error in the guesses of the operators.

Each respondent was asked for an estimate of the quantity of waste produced and handled. He was also asked for an estimate of the acres used and the rate of application if he spread the waste on fields. These estimates were cross checked with the number of loads hauled and the capacity of the spreaders. Great variation existed among these separate estimates. Later a computer program was written to calculate an estimate of waste produced and available for hauling based on the weight of beef animals. The size of the yard was determined to get estimates of the productive capacity of the various machines.

After completing the analysis of physical data the costs were calculated. The operators were asked what they paid for labor if they hired it. Any operations carried out by family labor were charged at the average of all the hired rates. No weighting of the rates by hours hired was done.

A computer program developed by Kletke (1970) was used to obtain costs of operation of the various kinds of machinery used to clean the yards. This program calculated fixed and variable costs.

Structures were a problem in that most operators had no idea of their cost. If a cost was available it was used, otherwise an estimate based on the type and quantity was calculated by charging 25 cents a cubic yard for excavation or fill if it was a dam. After obtaining

estimates of costs of labor, operation of equipment and hours involved, the cost to clean, haul and spread was calculated. The cost for structures was amortized over ten years and this cost was also added to the other costs.

The operations which hauled wastes received a return from the waste if it was used on land which yielded a crop. The value of the waste was set at the equivalent value for similar analysis fertilizer, because this was the opportunity cost of the waste. All of the costs and the returns were divided by the pounds of gain to obtain a common figure of dollars per pound of gain. As was mentioned earlier, a computer program in PL/1 was written which calculated average weight, total amount of wastes produced, value of the waste produced and then calculated the amount actually hauled out. The program was given the moisture content of the hauled out waste and it determined the value of the waste hauled out. The last part of the study involved determining the additional expense which the feed yards incurred as a result of passage of the Oklahoma Feed Yards Act. These data were used to estimate the extra cost of the Feed Yards Act to the state's feed yard operators.

CHAPTER II

REVIEW OF LITERATURE

The major literature relating to animal pollution is presented in three sections in this chapter: (1) the technical aspects of the confined animal feeding pollution problem; (2) the legal aspects of the animal waste disposal problem; and (3) the economic theory related to confined animal feeding pollution.

Technical Aspects

Pollution is defined as making unclean, impure or contaminated. Quality is "that which makes something what it is" (Webster, 1959, p. 1189). The quality of water is said to be lowered or degraded when it is polluted. "The idea that quality is a dimension of water that requires measurement in precise numbers is of quite recent origin" (McGauhey, 1968, p. 1). McGauhey continues by pointing out that quality has been referred to repeatedly but that no definitions of quality are given. During the early history of the United States quantity of water was a key policy issue but quality was alluded to only indirectly.

The wastes from a feed yard are only potential pollutants. The pollution problem derives from the fact that the animal wastes are water soluble. If rain falls on the wastes, the resulting runoff may run into a stream. Runoff which reaches the stream will lower the quality of the stream's water. Quality of water can be lowered or

raised; therefore, the level of quality must be measurable.

This study will not describe all of the different quality parameters but will briefly touch on the following: (1) biochemical oxygen demand (BOD), (2) chemical oxygen demand (COD), (3) dissolved oxygen (DO) and (4) total solids (TS). The first three all relate to the reaction of water and oxygen. The last parameter relates to the level of solids in a waste. Loehr (1968, p. 37) points out that "animal wastes differ significantly from conventional municipal and industrial wastes in that they are solid matter which contains some water." In contrast municipal waste from humans is \pm 99.9 percent water (Pelczar and Reid, 1958).

A waste may be degradable or nondegradable. A nondegradable waste is one which can not be broken down through the action of bacteria (Kneese and Bower, 1968). The degradable wastes can be broken down by the action of bacteria. Animal wastes fall into the latter category. Oxygen from the stream water is also used to break down a degradable waste.

Any system of waste breakdown depends upon lowering the energy level of the waste. In most systems used for the breakdown of animal wastes, biological agents (bacteria) are used to accomplish the energy reduction (McGauhey, 1968). The sanitary or agricultural engineer when referring to anaerobic or aerobic waste systems is distinguishing between the type of bacterial agent involved in the breakdown.

The anaerobic bacteria unlock the oxygen they use to live on from the waste product itself by an oxidation process. McGauhey (1968, p. 9-10) states

...since a great deal less carbon is oxidized in anaerobic decomposition than in aerobic, anaerobes release much less energy in the degradation process. In fact, the energy released under aerobic conditions is about thirty times that available to bacteria under anaerobic conditions. Consequently, the speed of aerobic degradation is much the greater, and there is an absence of odor in the process.

BOD is "a measure of organic waste load ... which indicates the amount of oxygen drawn upon in the process of decomposition of the waste" (Kneese and Bower, 1968, p. 19). The rate of oxygen used by the bacteria is a function of the temperature of the water and of a number of other factors such as the level of other gases and products in the water (McGauhey, 1968). If the level of lethal products in the water rises too high, it is possible that the microbe population will be exterminated and therefore show a zero BOD when tested.

COD is the amount of oxygen used in oxidation of the waste to carbon dioxide and water by the use of a strong oxidizing agent. The test for COD is much faster than the test used for BOD and can be used on products that would be toxic to the bacteria in the BOD test.

The measure of DO is important because the amount of oxygen in the water determines the amount of oxygen available for bacteria to breakdown wastes in the water and also for the use of the aquatic life in the stream (Kneese and Bower, 1968). The interaction of the factors mentioned is illustrated by the following statement.

At higher temperatures, when the oxygen saturation level of water is relatively low, bacterial action is accelerated, wastes are degraded more rapidly and dissolved oxygen in the water is drawn upon more rapidly. The imbalance between available oxygen and oxygen demand may proceed to the point where septic (anaerobic) conditions result (Kneese and Bower, 1968, p. 19).

TS is the solid material remaining after all the liquid is evaporated from the waste. In a beef feed yard or any feeding operation

where the animals are confined outside, much of the liquid will evaporate or drain away leaving mostly the total solids.

The characteristics of the waste to be handled will determine some of the methods which can be used to move the waste. A number of factors have a bearing on the characteristics of animal wastes. The ration fed is one determinant of the characteristics of the wastes. The concentration of pollutants in the runoff will vary somewhat depending upon the ration fed (Grub, 1969).

In reviewing the literature it was found that estimates of waste production vary widely. The best estimate for beef animals appears to be that the amount of waste deposited per day equals seven percent of the animal's body weight (Sampier, 1969). D. Jones (1969) indicates that a hog produces wastes equal to eight percent of its body weight.

Grub (1969) estimates a beef animal produces about 20 pounds of urine a day and Sampier (1969) estimates that 28.3 percent of the beef waste is urine. Combining the estimates results in a 1000 pound beef animal producing 70 pounds of waste of which 19.8 pounds is urine.

The previous material has helped to establish some guides to the quantity of wastes produced by various animals. Runoff from the feed yards may seep into the ground, enter a stream or be collected by a waste retention structure.

Methods of Disposal

Three basic disposal systems treated in this section are:

(1) anaerobic holding system; (2) aerobic disposal system and (3) integrated farming disposal system (P. Jones, 1969). The research effort

devoted to anaerobic lagoons has been less than that devoted to aerobic lagoons.

An anaerobic holding system uses an anaerobic pit or lagoon to store and decompose the animal wastes. The true anaerobic lagoon has a different purpose and is designed on a different basis from an aerobic lagoon (Loehr, 1968). The anaerobic system is more complex to operate and creates more odors than an aerobic system (Loehr, 1969). In an anaerobic treatment system for hogs, the solids are removed from the waste. The incoming waste is then mixed with the waste in the digester. The raw undiluted hog waste can not be put in the digester without solids separation because the methane forming bacteria are inhibited by the high ammonia concentration. Schmid and Lipper (1969) found that even after anaerobic treatment the waste could not be discharged to a water course without additional treatment. Loehr reports he used a combination anaerobic-aerobic system to treat beef cattle wastes. This system demonstrates that the combination system reduces the pollution from feedlot runoff (Loehr, 1969).

The aerobic system of waste disposal has been studied more intensively than has the anaerobic disposal method because the aerobic method: (1) allows more complete decomposition; (2) proceeds under more nearly odor free conditions and (3) is an easier method to keep in equilibrium. Equilibrium means that the amount and kind of bacteria are at an optimum level. A study using aerobic decomposition for poultry wastes found that the system is limited to the partial treatment of the slurry. The waste has to be disposed of in some other manner (Vickers and Genetelli, 1969). Another form of aerobic decomposition of beef wastes studied is composting of the wastes. Wells (1969) does

not give specific conclusions but implies that the system is successful. Dairy wastes were aerobically disposed of in a system tested by Bloodgood and Robson (1969). They reported that the system is effective in minimizing the odor problem. Hog wastes have been aerobically decomposed by using the oxidation ditch (D. Jones, 1969). This method helps prevent objectionable gases and odors while it efficiently decomposes the wastes.

The integrated farming method of waste disposal has been used for a long time in some types of animal feeding operations. Dairies, in stanchion barns, used to have to be cleaned every day. The wastes were loaded, hauled and spread in one operation (Worthen and Aldrich, 1956).

Ostrander (1969) indicates that no poultry waste system is universally best and until cheaper processing techniques are developed it may be best to spread waste on the land. The delivery of animal wastes to the land takes a number of forms.

A plow furrow cover (P-F-C) method of waste disposal consists of a tank trailer with an attached single bottom plow to cover the wastes and leave a trough for the next load of waste (Reed, 1969). Another type of vehicle to haul wastes is a slinger. This is a truck mounted tank with a whirling distributor to sling the wastes over the land (Funk and Lehman, 1968). Both types of vehicles could be filled from either an anaerobic or aerobic lagoon.

An alternate method of delivery of wastes to the land is to irrigate from a lagoon. At Purdue University, Dale and others (1969) used irrigation from an aerobic lagoon which treated dairy wastes. They feel that a maximum of two to three percent total solids can be

handled by an irrigation system; therefore, the wastes should be diluted. An irrigation system from an aerobic lagoon is odorless and places the nutrients on the land. The required labor and the costs of installation and operation are not excessive. All of the above studies have referred to the technical aspect of waste disposal. Legal aspects are also important.

Legal Aspects

This section will present some of the legal aspects of the pollution problems related to confined animal feeding operations. The general order will be to proceed from the Federal laws to state laws and then to a consideration of the Agricultural Stabilization and Conservation Service pollution abatement practices.

Federal Laws

One of the earliest laws relating to pollution was the Rivers and Harbors Act of 1899. The reason the law was not used extensively before now was because it was written to insure clear "anchorage and navigation." Recently attention has turned to Section 13: "it shall not be lawful to throw, discharge or deposit ... any refuse matter of any kind or description whatever ... into any navigable water of the United States." It also extended its conditions to any tributary of any navigable river.

Another provision of the 1899 Act required permits from the Army Corps of Engineers for any dumping which was allowed. Conceivably this would require confined animal feeding operations to obtain Federal permits for any waste runoff that might escape into streams.

In 1948 pollution of streams by confined animal feed yards was not considered significant, in part, because there were very few large sized operations in the country. Before passage of the Water Pollution Control Act in 1948 (P.L. 80-845) three pieces of legislation defined Federal responsibility in the area of water pollution (Rademacher and Resnik, 1969).

The Federal Water Pollution Control Act of 1948 established the principle of limited Federal assistance to municipalities for the planning and the construction of sewage treatment plants, by authorizing annual appropriations of one million dollars for planning grants and 22.5 million dollars for construction loans (Schwob, 1955, p. 641).

The 1948 law did not have a large impact on pollution abatement because no funds were appropriated.

The next water quality legislation came in 1956. That legislation included the concept of Federal assistance to municipalities and was "the basis for the Federal role and responsibility in water pollution control and prevention" (Rademacher and Resnik, 1969, p. 196). The law also stressed recognition of the state's responsibility in water pollution control. Some monies were appropriated for this law. During the next nine years the nation's attention was directed toward other goals and no additional significant pollution legislation was passed.

The Water Quality Act of 1965, Public Law 89-234, became a law on October 2, 1965. The Act had three basic requirements: (1) water quality criteria was to be commensurate with present and future water use, (2) a plan for implementing water quality criteria had to be developed by the states and (3) a plan for enforcing the water quality criteria had to be developed.

The Federal Water Quality Control Administration (FWPCA) would not approve any state's standard which did not require waste treatment of a

treatable waste, compatible with the quality of the receiving stream for both present and future uses. The Secretary of the Interior had to determine that the state's standards met the 1965 Act's requirements before he approved them (Bernard, 1969).

With the passage of the 1965 Act the mechanism was set for the establishment of a national policy for water resources. The new policy stressed keeping wastes out of streams rather than the previous policy which was concerned with the level of pollution streams could tolerate.

Oklahoma Laws

The 1965 Act required the states to draw up detailed standards and methods to enforce them. Oklahoma drew up a set of standards and they were approved.

The Department of Pollution Control in Oklahoma was established with the passage of the Pollution Control Coordinating Act of 1968 on May 2, 1968. The Pollution Control Coordinating Board administers the Department. The five members of the Board are the State Commissioner of Health, the President of the State Board of Agriculture, the Director of the Water Resources Board, the Director of the Department of Wildlife Conservation and the Chairman of the Oklahoma Corporation Commission. At this time, the law is in the process of being revised to add members and to broaden their authority.

Of special importance to animal feeding operators in Oklahoma was Section 935(d):

...when the disposal of waste through a disposal system or the discharge either directly or indirectly of any untreated or inadequately treated water waste reduces the quality of any waters of the State below the water quality standards established for such waters under the provisions of this

Act, it shall be prima facie evidence of water pollution and the board shall request the appropriate state agency to take immediate action to secure such corrections as necessary to prohibit further pollution.

A violation of the Act could result in a fine up to \$500 and a prison sentence not more than 90 days. Each day the violation occurred would be a separate violation [Section 937(d)]. The water quality standards required that treatment and control of feed yard runoff must be a part of animal feed yard management.

The Oklahoma Feed Yards Act was passed in 1969. This act applied to feed yards, excepting public livestock auction markets, which fed two hundred fifty or more head of livestock at one time during a licensed year. The Act further defined livestock as cattle, swine, sheep and horses. The operators of feed yards covered by the Act must obtain a license from the Board. The license fees vary from \$10 to \$150 depending on the number of animals fed at any one time.

Responsibilities of the operator as indicated in the Act that are of importance to this study are to:

- (1) provide reasonable methods for the disposal of animal excrement ... (3) provide adequate drainage from feed yards premises of surface waters falling upon the area occupied by such feed yards; take such action as may be necessary to avoid pollution of any stream, lake, river, or creek ... (5) have available for use at all necessary times mechanical means of scraping, cleaning, and grading feed yards premises ... (7) conduct feed yards operations in conformity with established practices in the feed yards industry as approved by regulations made and promulgated by the Board and in accordance with the standards set forth in this act.

A violator of the Act can be fined up to and including \$100 for each violation. Each day of violation is a separate violation.

ASCS Cost Sharing and SCS

This section will explore some alternatives available to the feed yard operator in his effort to combat pollution. The Agricultural Stabilization and Conservation Service (ASCS) in Oklahoma will approve cost-sharing for water pollution abatement practices that qualify. At present three pollution abatement practices have been approved for cost-sharing. The operator must be able to meet the requirements for eligibility to be considered for partial payment.

The first practice, I-1, is for construction of lagoons and connecting pipe. An operator who is eligible for cost-sharing is not restricted in the kind of animals he can raise and be eligible for the practice.

The second practice, I-2, is for animal waste storage facilities and is for construction of a pit, or tank for waste storage. A diversion, I-3, is for transporting water around animal pens to prevent pollution or to carry polluted water to a disposal area. A practice for concrete lining of diversions has been discontinued (ASCS State Program Handbook, 1971).

These practices will assist the feed yard operator to meet the requirements of the Feed Yards Act. The design of pollution control facilities should be done by a qualified person rather than by the feed yard operator. The feed yard operator should contact either a qualified professional engineer or one of the government agencies such as the Soil Conservation Service or the Cooperative Extension Service. The above information has referred to the legal aspects of waste disposal. Economic aspects are also important and will be considered next.

Economic Aspects

The Oklahoma Feed Yards Act requires confined animal feeding operations apply for a license and to meet certain requirements relating to feed yard wastes. In several cases operators have constructed expensive detention structures. In other cases operators have built new facilities with lagoons and/or waste storage systems. Some of the new systems have resulted in changes in labor and equipment requirements for waste handling.

All of the changes mentioned have a bearing on the economics of operating a confined animal feeding operation. Economics deals with choices among feasible alternatives. The entrepreneur is not given a choice between obeying or not obeying the law. If the operator is to continue in business he must meet the law's requirements. He is, however, given the choice of how he will meet the requirements of the law. This section will explore some of the economic theory the entrepreneur applies in deciding how to meet the law's requirements.

The first concept to be considered in analyzing an economic decision is the opportunity cost of each of the resources involved. The opportunity cost of a resource is the return the resource can earn when put to its best alternative use. Costs may be fixed or variable. Total fixed costs are costs which do not vary in the short run, as output is varied and the size of the plant is constant. Total variable costs are a function of the output of the firm. Total costs are the sum of fixed and variable costs. The economist considers cost from both a short run and a long run viewpoint. The short run requires that the size of plant can not be varied while in the long run the size of plant can be varied. In the long run all costs become variable.

Average costs are found by dividing the total cost curves by the quantity of product produced. In the short run, each size of plant will result in separate: (1) average total costs; (2) average total variable costs; (3) average total fixed cost curves. In the long run only one average cost curve results because all costs are variable.

The long run curve is useful to the feed yard operator only when planning what to do. When the plant is built the short run curves are the relevant curves (Heady, 1952).

Value of a Feed Yard's Wastes

The operator must move the wastes from his pens and thus incur both fixed and variable costs for waste handling. When the operator feels there is no available way to recover the incurred costs he will dump his wastes. Most feed yard operators try to sell their wastes if they do not have fields on which to spread them.

The farmer must fertilize crops he raises to sell or use. When deciding what to use as a source of nutrients, the farmer must first determine the optimum amount of nutrients. He then compares the cost of obtaining the required nutrients from different sources. Assuming the sources of nutrients are equally available to the crops, he then chooses the least expensive source.

Feed yard wastes contain fertilizer nutrients and when applied to soil will replace fertilizer. The feed yard operator who can utilize the wastes on his land should compute the additional cost of delivering a unit of nutrient to his fields. When the cost per unit of nutrient from wastes is less than a comparable cost per unit of fertilizer, the feed yard manager should use the waste on his fields.

When the feed yard owner has no fields he should calculate the fertilizer per unit cost of nutrients and this becomes the maximum amount for which the comparable unit of nutrients of waste can be sold. The minimum price which the feed yard operator can accept for a waste per unit cost of nutrients is the additional cost of moving the wastes from the feed yard to the farmer's fields. The minimum price equals the additional transportation cost in most instances. The price which is established for the waste falls between the upper and lower limits and depends upon the bargaining power of the operator and the farmer.

Economics of Pollution Control

Before the passage of the Feed Yards Act the firms disposed of wastes in some manner. They had these costs built into their production process and presumably were receiving enough for their animals sold to meet expenses. The economic effect of the Feed Yards Act has been the absorption of additional costs by the feed yard operator.

The first obvious fixed expense is the purchase of the annual license. The feed yard close to one of the division points could reduce his size a few head and come under the next lower cost of license, but generally this is not a large cost factor that would alter the size of feeding operation.

The feed yard operators are required to prevent runoff from reaching streams. This requirement forces the operators, in some cases, to build waste retention structures. Most feed yards would not have such facilities in place before passage of the Act. The expenditure for these facilities are also fixed costs because once built, the expenditure could only be recaptured by depreciation.

If a feed yard installs an irrigation pump as a primary drawdown for its waste retention structure, the cost of purchase and operation also becomes a fixed cost to the operation. While probabilities can be determined for the chance of rain on any day, the amount of rain that will fall can not be predicted in advance with any degree of certainty. This means that the feed yard can not wait to irrigate when convenient, but must pump out the structure immediately to maintain the structure's capacity. The pump costs thus become fixed costs to the operation.

Another cost to be considered is the effect on the feed yard which institutes a new method of waste handling. This new method might result in more or less labor required. It might also change the amount of machinery running time and thus change the firm's variable costs. What are the effects of these different additional costs on the decisions of the firm?

Assume that a new method raises only fixed costs. The increase in fixed costs of waste handling will force the total fixed costs higher. Since the feed yard's marginal cost curve will not change slope, shape or size, the amount of output of meat from the feed yard will be unchanged. Profit of the feed yard operator will be reduced. If the fixed costs decrease, possibly due to new technology, output still remains constant but profit increases. The new method has an effect on the variable and marginal costs of operating a feed yard; therefore, the amount of meat produced would be changed. The amount and direction of change in production would depend on the amount of increase or decrease in the marginal cost.

The information presented above illustrates that animal waste handling technology has been moving forward. Some of the advanced systems of animal waste handling have been introduced by feed yard managers in Oklahoma. Results and an analysis of a survey done in the summer of 1970 are presented in Chapters III and IV. It must be remembered that new technology used for animal waste handling may have been introduced in Oklahoma since 1970.

CHAPTER III

ANALYSIS OF BEEF FEEDING OPERATIONS

Description of Feeding Operations

There are many measures of the size of operation of a beef feed yard; however, pounds of beef gained appeared to be the best measure of efficiency and for determining beef wastes handling costs and returns per pound of gain. Information about the average size of beef feed yard in the sample interviewed is presented in Table IV. Based on an average annual gain per animal of 400 pounds per feeding period, and a $2\frac{1}{2}$ time annual turnover, one head of capacity was equal to 1,000 pounds of gain per year. When calculating the conversion from number of head to pounds of gain for a beef feed yard, multiply the yard one time capacity by the percent of capacity fed to compute the average number of head per feeding period. The average number of head per feeding period is then multiplied by the number of days fed and the pounds of gain per day to yield the required figure.

The size of feed yard in Area 1 was larger than the operations in the other three areas. Animals in Area 1 feed yards gained more weight than did animals in the other areas; however, beef animals in Area 1 were on feed slightly longer. Beef animals in both Areas 1 and 2 had similar gains per day.

TABLE IV
SELECTED SIZE INDICATORS FOR BEEF FEEDING OPERATIONS,
BY AREA IN OKLAHOMA, 1970

	Unit	Area 1	Area 2	Area 3	Area 4
Sold per year	Head	42,438	10,498	3,335	4,455
Average gain per head	Pounds	430	393	217	219
Average days on feed	Days	147	134	105	90
Average gain per day	Pounds	2.92	2.93	2.06	2.43

Usable records were obtained from feed yard operators as follows: six from those producing less than one million pounds of gain per year; seven from those producing one to two million pounds of gain per year; six from feed yards producing from two to 10 million pounds of gain and five usable records were obtained from operators producing over 10 million pounds of gain per year. One reason there were not more large feed yards was that a number of these lots were new and had not established a waste handling program.

All of the beef feed yard operators were asked when they had last expanded their operation. Eighty percent of the feed yards had been expanded in the five years from 1966 to 1970. Almost 65 percent had been expanded in the three years, 1968 to 1970. Beef feeding in Oklahoma had increased most rapidly in the western part of the state. In Area 3 only one-third of the feed yards had been expanded during 1968 to 1970 while nearly 90 percent had done so in Area 1 during the

same time. As a feed yard operator expanded his operation he used different equipment for waste handling.

The waste handling equipment which the feed yard had available for cleaning varied according to the size of the feed yard. A small feed yard characteristically used a general farm tractor with a scoop and/or blade to clean and scrape the pens. The waste was loaded into a farm spreader and hauled to the feed yard owner's fields for disposal. This system was used by a feed yard with a yearly production of beef less than 500,000 pounds or less than 500 head capacity.

Beef feeding operators producing between 500,000 and 10 million pounds of gain per year had one or two trucks with or without a spreader body in place of the farm manure spreader. A farm tractor with a scoop was used to load the trucks and the wastes were disposed of on the owner's land.

Beef feeding operators producing greater than 10 million pounds of beef per year generally had two or three trucks with spreader bodies, a large rubber-tired loader and a bulldozer which was used to push the waste into piles in the pen during the cleaning operation. The large operations generally sold the wastes to farmers in the surrounding area.

The operators were asked where the wastes accumulated in the operation. Several feed yards were relatively new operations and the operators had not established policies regarding the waste handling strategy they would follow. Between clean out periods during the feeding period, the most popular waste handling method was to leave the wastes in the pens. Fifty percent favored leaving the wastes and 43 percent piled the wastes in mounds in the pens. The remaining seven percent periodically hauled the waste to a pile outside the feed

yard and then hauled the wastes away from the feed lot at a more convenient time.

Cleaning of the feed yards was being done by all the respondents except one. The majority of the beef feed yard operators cleaned the pens once per year while 22 percent cleaned twice a year (Table V). The typical system could be said to be one where the feed yard operator hauled the waste to a field once a year and either mounded the wastes up or left the wastes in the pen during the remainder of the year.

TABLE V
NUMBER OF TIMES PER YEAR BEEF WASTES ARE CLEANED
FROM PENS IN OKLAHOMA

Number	Area 1	Area 2	Area 3	Area 4	Total	Percent
0	-	1	-	-	1	3.7
<1	-	-	1	-	1	3.7
1	1	10	2	1	14	51.9
2	4	2	-	-	6	22.2
3	-	2	1	-	3	11.1
>3	-	-	2	-	2	7.4
Total	5	15	6	1	27	100.0

Eighty-four percent of the beef animal operators used the wastes on their own land. Three other producers stockpiled the wastes beside

the feed yard and one operator said he did not clean his pens. Cattle wastes were easier to handle than manure produced by hogs or chickens.

Sixteen beef feed yard operators, out of the 24 usable responses, used the beef wastes on either cropland or Bermuda grass. The 16 responses are presented, by size category, in Table VI.

TABLE VI
USE OF BEEF WASTES BY NUMBER AND SIZE OF BEEF FEED YARD
OPERATORS IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Number Operators Applying Waste To Cropland	Number Operators Applying Waste to Bermuda Grass	Total
458,071	4	1	5
1,361,064	6	-	6
5,376,319	1	2	3
<u>20,773,900</u>	<u>2</u>	<u>-</u>	<u>2</u>
Total	13	3	16

Information on the type of land used for spreading beef wastes is presented in Table VII. The category labeled nothing included those operators who either did not remove the wastes, or in some way got rid of their wastes without applying the wastes to their land. All the feed yard operators were asked if they gave the wastes away to get rid of them. Almost all the operators indicated they would give wastes away if the user came and got the wastes, but most did not encourage this practice.

TABLE VII
TYPE OF LAND USED FOR SPREADING BEEF WASTES IN OKLAHOMA, 1970

Type	Area 1	Area 2	Area 3	Area 4	Total	Percent
Crop	2	11	3	-	16	51.5
Hay	1	1	-	-	2	6.5
Pasture	-	-	2	1	3	9.7
<u>Nothing</u>	<u>4</u>	<u>5</u>	<u>1</u>	<u>-</u>	<u>10</u>	<u>32.3</u>
Total	7	17	6	1	31	100.0

If the feed yard operator raised crops on fields where wastes were spread but did not use fertilizer it could be surmised that he felt the waste had considerable nutrient value. The number of operators who spread wastes on their land and the number who did and did not apply fertilizer in addition to spreading wastes are presented in Table VIII.

TABLE VIII
APPLICATION OF FERTILIZER ON LAND SPREAD WITH BEEF WASTES
IN OKLAHOMA

Use Fertilizer	Area 1	Area 2	Area 3	Area 4	Total	Percent
Yes	3	5	4	-	12	57.2
<u>No</u>	<u>-</u>	<u>7</u>	<u>1</u>	<u>1</u>	<u>9</u>	<u>42.8</u>
Total	3	12	5	1	21	100.0

The operators were asked if they had purchased special equipment for handling wastes from the feed yard. Sixty-two percent replied they had bought specialized equipment for waste handling (Table IX). Most of the equipment purchased was for spreading.

TABLE IX
SPECIAL EQUIPMENT PURCHASES FOR BEEF WASTE HANDLING,
BY AREA IN OKLAHOMA, 1970

Response	Area 1	Area 2	Area 3	Area 4	Total	Percent
Yes	3	10	5	-	18	62.1
<u>No</u>	<u>3</u>	<u>6</u>	<u>1</u>	<u>1</u>	<u>11</u>	<u>37.9</u>
Total	6	16	6	1	29	100.0

Another related question raised was whether the feed yard had been specifically designed with waste removal in mind. Sixty percent of the feed yards did not specifically design the feeding operation to facilitate the handling of wastes (Table X).

Obsolescence and equipment deterioration was surmized to be a problem for all feed yards. Not one of the operators in Area 1 indicated a problem with obsolescence or deterioration. In Areas 2 and 3, five and one operators respectively indicated a problem with equipment. Sixty-five percent of the respondents in these areas answered, "no", to the question. Some of the operators who did complain about equipment

indicated that the chains in some makes of truck spreaders were lightweight. Another example of a problem was in liquid manure spreaders which have a pump in the front of the tank. In a number of pumps the back bearing which is removed into the manure tank, failed prematurely and it was unpleasant changing it.

TABLE X
BEEF FEED YARDS INCORPORATING SPECIFIC WASTE HANDLING DESIGNS,
BY AREA IN OKLAHOMA, 1970

Response	Area 1	Area 2	Area 3	Area 4	Total	Percent
Yes	3	5	3	-	11	39.3
<u>No</u>	<u>2</u>	<u>11</u>	<u>3</u>	<u>1</u>	<u>17</u>	<u>60.7</u>
Total	5	16	6	1	28	100.0

All operators were asked the type of floor that the animals were on. None of the lots visited used the slatted floor type of operation. All had dirt or caliche floors in the lots except for one which had a roof and concrete floor for the cattle. The number of feed lots with a lagoon or waste retention structure is presented in Table XI.

One suggested solution to the waste disposal problem has been to irrigate from a waste lagoon. All the respondents were asked if they irrigated their own land. Sixty-eight percent did not irrigate anywhere. There were 18 feed yards which had lagoons. These operators were asked

if they irrigated from their lagoon. Only two of the 18 used the lagoon for a source of irrigation water and nutrients. Both managers mixed fresh water with the waste while irrigating to dilute the strength of the material.

TABLE XI

NUMBER OF BEEF FEED YARDS WITH LAGOONS, BY AREAS IN OKLAHOMA, 1970

Number of Lagoons	Area 1	Area 2	Area 3	Area 4	Total	Percent
0	-	6	4	1	11	37.9
1	1	5	1	-	7	24.1
2	2	4	-	-	6	20.7
3	-	-	-	-	0	0.0
4	2	1	-	-	3	10.3
5	1	-	-	-	1	3.5
<u>>5</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>-</u>	<u>1</u>	<u>3.5</u>
Total	6	16	6	1	29	100.0

Another waste which feed yard operators had to dispose of was dead animals. Four methods of disposal were used by the respondents. The first and most popular was to call the rendering service. The second most popular method of disposal was to bury the remains. A few operators hauled the remains away from the operation but did not bury them, and others burned the carcasses.

Variable Costs

Labor

Labor was a variable cost to the feed yard waste handling operation. The number of workers and the wage paid was determined if the operator hired labor. If the operator did not hire labor, the average wage for all hired labor, \$1.71 per hour, was used as the cost of labor for the owner.

The total cost of labor for each operation was calculated based on the description and hours required for different jobs given by the respondent during the interview. The total labor costs were then divided by the pounds of gain to calculate a labor cost per pound of gain per year. The total labor costs and average labor cost per pound of gain for labor by size class of beef feed yards are presented in Table XII.

TABLE XII

TOTAL COSTS AND AVERAGE COSTS PER POUND OF GAIN FOR
LABOR HANDLING BEEF WASTES IN BEEF FEED YARDS,
IN OKLAHOMA, BY SIZE CLASS, 1970

Average Size (Lbs. Gain Per Year)	Total Cost of Waste Handling	Average Cost Per Pound of Gain
458,071	\$ 407	\$.0009
1,361,064	661	.0005
5,376,319	1,626	.0003
20,773,900	4,902	.0002

The average cost per pound of gain for labor showed a decline because as the size of operation increased, the productivity of the machines used increased. The large loaders and trucks of the large feed yards loaded and hauled much more waste per hour of labor than could be done by the smaller equipment.

Custom Waste Hauling

Feedlot operators appeared to favor increasing their variable costs as the operation grew in size. One way the fixed costs were kept down in relation to the variable costs was to hire the waste hauling operation done and not incur the fixed cost of cleaning equipment.

A number of different plans were used to compensate the custom waste haulers. The simple plan was to hire a firm to clean the feed yard and apply the wastes to the other land which the feed yard owner had. This plan was used by only one feed yard operator. One other man, who would not consent to be interviewed, said that a custom hauler had quoted a fixed price to him to clean his pens.

Another method of paying a custom hauler to clean the feed yard's pens was to sell the manure for a low price and then charge the cleaner for loading his trucks with the operator's loader. This method did require that ownership of the loader and excess loader capacity exist. If the feed yard operator received enough to pay for the variable costs of operation of the loader then he might feel that this method freed his employees for other work and reduced supervision.

A refinement of the preceding method was to sell the annual waste to the custom hauler for a low price, with the hauler bringing his own

loader to the yard. This method was followed by several of the larger lots. The feed yard operator and his employees concentrated on the feeding and care of cattle and did not use any of their equipment in the manure operation. In both of these methods the cleaner was the owner of the waste when it was loaded onto his truck and he could sell or use it as he desired.

Several other operators interviewed indicated that they loaded the hauler's truck for free and then received one load of the waste on their fields for two loads which the cleaner could sell. One feed yard operator interviewed indicated his feed yard was one of several belonging to a parent corporation. He had to purchase his cleaning from the parent corporation which had a crew of men who did only cleaning. The number of commercial haulers working with different sizes of operations are presented in Table XIII.

TABLE XIII

CUSTOM HAULING OF BEEF WASTES IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Number of Records	Number Using Custom Haulers	Average Cost of Custom Hauler	Percent of Operations Using Custom Hauler
458,071	6	1	\$ 51	16.7
1,361,064	7	2	465	28.6
5,376,319	6	4	1,673	66.7
<u>20,773,900</u>	<u>5</u>	<u>3</u>	<u>11,591</u>	<u>60.0</u>
Total	24	10	-	-
Average	-	-	-	41.7

Equipment

After considering the hiring of cleaning, the equipment variable costs incurred by the feed yard operator were examined. The operator was asked for a list of all the equipment used and whether it was new or used. The time required for various cleaning operations and for the annual hours of use of the machine in all uses was secured.

Most of the variation in the variable costs of equipment was due to such factors as age, type and general efficiency in the use of the equipment. Operators of feed yards, especially in the smaller size operations, typically engaged in other operations in addition to feeding cattle. If these managers had an extensive operation they used a larger than optimum size tractor in cleaning the feed yard because this was the tractor they had available.

As indicated earlier the larger feedlots had a higher percentage of variable costs than did the smaller operations. This appeared in the variable equipment costs of the large size feed yards. The average variable costs per pound of gain for the first three groupings of feed yards examined showed that they were less than or very close in magnitude to the average fixed costs. In the fourth class, over 10 million pounds of gain per year, the variable costs were 2.5 times as great as the average fixed costs. The total variable costs and average variable costs per pound of gain are presented by size interval in Table XIV.

TABLE XIV
EQUIPMENT VARIABLE COSTS, BY SIZE OF BEEF FEEDING
OPERATIONS IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Total Variable Costs	Average Variable Costs/Lb. of Gain
458,071	\$ 430	\$.00094
1,361,064	1,065	.00078
5,376,319	1,580	.00029
20,773,900	18,990	.00091

Total Variable Costs

As previously mentioned all costs are variable when looking at the costs as a feed yard operator would if he were considering expansion. The costs in this report have been separated to present costs as an individual operator would view his own operation. Three categories of costs which made up the total variable costs of waste handling were labor, custom hauling and equipment. The total variable costs increased first at a decreasing rate and then at an increasing rate. The average variable costs expressed in dollars per pound of gain exhibited the characteristic "U" shape suggested by economic theory.

Operators of the largest feed yards appeared to utilize larger equipment than seemed necessary for the animal waste handling operation. The reason they used the large equipment was that most of the operators of large feed yards sold and delivered the wastes they sold. The delivery truck variable expense was also included in the total equipment cost. Total variable costs, average variable costs and

the total and average variable costs for waste handling equipment are presented in Table XV.

TABLE XV

TOTAL AND AVERAGE VARIABLE COSTS PER POUND OF GAIN FOR ALL VARIABLE WASTE HANDLING COSTS AND FOR EQUIPMENT, BY SIZE OF BEEF FEEDING OPERATIONS IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Total Variable Costs	Total Equipment Variable Costs	Total Average Variable Costs	Total Equipment Average Variable Costs	Percent Equipment is of T.V.C.
458,071	\$ 888	\$ 430	\$.00193	\$.00094	48.5
1,361,064	2,190	1,065	.00161	.00078	48.8
5,376,319	4,879	1,580	.00091	.00029	32.4
20,773,900	35,484	18,990	.00171	.00091	53.8

Fixed Costs

The author also considered the level and type of fixed costs. Fixed costs are those costs which are not affected by the quantity of beef produced. The fixed costs examined were equipment, license and the fixed costs associated with runoff control structures.

Equipment

Equipment used to clean a feed yard had both fixed and variable costs associated with its use. The type of costs which were fixed costs were depreciation, insurance, taxes, rent and interest on the

investment. The computer program developed by Kletke (1970) was used to calculate the fixed costs of ownership of the cleaning equipment.

The age and type of equipment affected the fixed costs the most. As a machine became older its calculated fixed costs declined because both the depreciation and interest on investment were declining with age of the machine. The type of machine affected the fixed costs because a machine without an engine did not require fuel and usually the repair costs as a percent of its initial cost were lower from the beginning. The majority of the cleaning equipment used had its own source of power.

The fixed costs of waste cleaning equipment ownership for beef feed yards, by size categories are presented in Table XVI. The size of operation was derived by adding all the individual sizes of operations in each of the established classes and then dividing by the number of usable records in that class. The prediction equation for equipment fixed costs is as follows:

$$Y = .000333 X + 565.77$$

where: Y = the fixed cost of equipment ownership, in dollars.

X = the size of the feed yard, in pounds of gain per year.

License

An annual license is required for producing beef in Oklahoma if the feed yard has over 250 head of livestock in the yard at any one time. The price of a license varies between 10 and 150 dollars. The license does not represent a large cost to the feed yard. Two feed yard operators paid a 25 dollar license fee, 11 operators paid 50 dollars,

five paid 100 dollars, and six paid 150 dollars per year.

TABLE XVI
FIXED COSTS OF EQUIPMENT USED FOR CLEANING BEEF FEED YARDS,
BY SIZE OF OPERATION IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Total Equipment Fixed Costs	Equipment Fixed Cost Per Pound of Gain
458,071	\$ 497	\$.00108
1,361,064	1,019	.00075
5,376,319	2,304	.00043
20,773,900	7,490	.00036

Structures

All of the feed yard operators were asked if they had a waste retention structure or a lagoon to catch runoff from the feed yard. Very few of the smallest class feed yards had runoff structures in place. Sixty-two percent of the respondent beef feed yard operators had lagoons for their operations. These lagoons represented a fixed cost to the feed yard because the cost of the lagoon was depreciation plus interest on the remaining investment. Some maintenance might be necessary but the amount was very small.

The maintenance was computed as two percent of the initial price of the structure. If the operator did not know the price of the structure, an estimate was made by determining as nearly as possible the amount of earth moved to create the structure. This amount of earth

was then priced at 25 cents per yard of earth moved. If irrigation was done from the structure the pumps and pipe were treated as equipment. If the feed yard owner irrigated at his convenience rather than using the pumps as the primary drawdown structure of the lagoon, the costs of pumping were variable costs of waste handling, but if the lagoon was designed as a five year, 48 hour storm structure, the lagoon had to be emptied to its designed low water storage capacity after each storm. To prevent the runoff waste from reaching a stream it was necessary to use a pump as the primary drawdown and put the wastes on the land. If this system were used, the pump operation would be a fixed cost to the waste operation.

Several factors influenced the ultimate cost of a waste retention structure. The size of the structure was the most important factor and the second was the efficiency of the site. If the site had a large natural storage and required a small structure to utilize that storage then the cost of the structure was low. The number of operators with structures, the annual cost of structures and the average cost of structures per pound of gain is presented in Table XVII.

Total Fixed Costs

Fixed costs, as viewed by the individual feed yard manager would have economies of size as the size of the feed yard increased. Total fixed costs consisted of adding all the fixed costs together. The total and average costs figures for cleaning the beef animal wastes are presented in Table XVIII.

TABLE XVII

NUMBER AND COST OF STRUCTURES FOR RUNOFF CONTROL OF BEEF FEED YARDS,
BY SIZE OF OPERATION IN OKLAHOMA

Average Size (Lbs. Gain Per Year)	Number of Operators With Structures	Annual Cost of Structures (Dollars)	Average Cost of Structure Per Lb. Gain
458,071	2	\$ 24	\$.00005
1,361,064	1	82	.00006
5,376,319	5	581	.00108
20,773,900	2	312	.00002

TABLE XVIII

FIXED COSTS OF CLEANING BEEF FEED YARDS, BY SIZE OF OPERATION
IN OKLAHOMA

Average Size (Lbs. Gain Per Year)	Total Fixed Costs	Average Fixed Costs
458,071	\$ 562	\$.00123
1,361,064	1,152	.00085
5,376,319	2,993	.00056
20,773,900	7,952	.00036

Operators of the three larger size feed yards had fixed costs which were almost a fixed relationship to the size of the feed yard pounds of gain per year; therefore, an equation was fitted using the value of the largest feed yards and the figures of the next to the smallest feed yard. The prediction equation used to estimate total fixed costs of waste handling for a feed yard in Oklahoma was as follows:

$$Y_2 = .0003503 X + 675.90$$

where Y_2 = total fixed cost of beef feed yard cleaning.

X = size of feed yard in pounds of gain per year.

The estimated average fixed cost per pound of gain was found by dividing the prediction equation by X ; therefore,

$$\frac{Y_2}{X} = .0003503 + \frac{675.90}{X}$$

Total Costs of Beef Waste Handling

The total costs of beef waste handling were calculated by adding the total variable costs and the total fixed costs. Average total costs were derived by dividing the total costs by the average pounds of gain per year. Total costs of beef waste handling are presented below in Table XIX.

TABLE XIX
TOTAL COSTS AND AVERAGE TOTAL COSTS OF BEEF WASTE HANDLING,
BY SIZE IN OKLAHOMA

Average Size (Lbs. Gain Per Year)	Total Costs of Beef Waste Handling	Average Total Costs of Beef Waste Handling
458,071	\$ 1,450	\$.0032
1,361,064	3,341	.0025
5,376,319	7,871	.0015
20,773,900	43,436	.0021

Prevention of runoff required many operators to build waste retention structures. The cost of the license and the waste retention structures appeared to be the costs to the operators which were induced by the Act (Table XX).

TABLE XX
ADDITIONAL COSTS TO BEEF FEED YARD OPERATORS AS A RESULT OF
THE OKLAHOMA FEED YARDS ACT OF 1969

Average Size (Lbs. Gain Per Year)	Additional Total Costs	Additional Average Total Costs/Lb. of Gain
458,071	\$ 66	\$.00014
1,361,064	132	.00010
5,376,319	689	.00013
20,773,900	462	.00002

Returns

The beef feed yard operators sometimes sold the wastes from their feed yards. Previously the study mentioned that custom waste haulers were employed to clean the operation and that these haulers bought the waste and resold it to its final user. An attempt was made to determine the amount realized by the managers from the sale of the waste to either the cleaners or to the final users.

A method to check the amounts produced and available for sale was desired. A PL/1 program was written to calculate the amount of wastes produced. The program utilized the number of animals, the weight of

the cattle into the feed yard, the weight of the cattle out of the yard and the days on feed to calculate the amount of wastes produced, the amount of fertilizer nutrients, the value of those fertilizer elements and the amount of waste hauled to the field when given the moisture percentage of the waste.

The assumption was that the waste was a substitute for fertilizer. When the waste was used as fertilizer, the farmer did not have to buy that fertilizer. If the waste had to be removed, the use of it as fertilizer appeared to be the logical use.

The dollars realized from the sale of waste, the estimated value realized from the wastes as fertilizer and the estimated total value which could be realized by the use of the waste as a fertilizer are presented in Table XXI.

TABLE XXI

RETURNS FROM BEEF WASTES, BY SIZE OF OPERATION, IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Total Cost of Waste Removal	Amount of Sales of Wastes	Value of Wastes as Fertilizer and Sale	Possible Total Value of Waste as Fertilizer
458,071	\$ 1,450	\$ 699	\$ 5,394	\$ 6,712
1,361,064	3,341	-	11,835	13,101
5,376,319	7,071	2,696	21,747	72,534
20,773,900	43,436	52,502	94,783	257,840

This chapter has investigated the costs and returns of waste handling to beef feed yard operators. The costs and returns for hog feed yard operators will be explored in Chapter IV.

CHAPTER IV

ANALYSIS OF HOG FEEDING OPERATIONS

Description of Feeding Operations

Hog feeding operations in Oklahoma are located in all four areas of the state. There are very few operations in Area 1 and only one producer in that area had registered under the Act; therefore, no production figures are presented to prevent identification. In an earlier chapter, the researcher indicated 25 respondents for hog feeding operations. One of these was a state institution which was judged atypical and the record was not used.

In Area 2 the largest hog feeding operation produced 1,352,000 pounds of pork per year, while the smallest produced 70,800 pounds of pork. The factor for converting numbers of hogs to pounds of gain is one hog equals approximately 440 pounds of gain per year. The average production for Area 2 was 358,103 pounds of pork and the average number of pigs sold for the area was 2,017. The distribution and size of hog feeders in Area 3 was similar. The hog feeding operations in Area 4 were quite similar in size to each other and the average production of pork was 255,487 pounds with 2,194 pigs sold. The average production of pork for all the feeders from the three areas was 367,593 pounds and an average of 2,044 pigs were sold. The average number of man years involved in waste handling was 1.1.

The number of pigs sold in an area is affected by the number of operators who sell feeder pigs. The feeder pigs are sold at about 40 pounds, thus the number of pigs sold would be high yet the pounds of pork sold would be low for areas with a high proportion of operators selling feeder pigs. Another factor which affects the number of pounds of pork sold is that different areas prefer different weight hogs for market.

Almost one-half of the producers expanded their operations in 1969. All but four of the operators had expanded since 1966. The fact that about 46 percent had not expanded recently might mean that these managers try to expand on the bottom of the hog cycle and therefore were not tempted by the high prices of 1969.

Systems for Hog Operations

Several separate production stages occur within a typical hog operation in Oklahoma. The farrowing operation was usually carried on in a building because of the fragile baby pigs. Most of the operators interviewed used a house without a lagoon under the house. This insured that drafts did not reach the pigs.

After the baby pigs were about three weeks to a month old, they were moved to a nursery. The nursery was one of a slatted floor platform in a pasture, a solid floor house, a partial slatted floor over a lagoon or a full slatted floor. Generally the pigs were kept in the nursery area until they weighed about 40 pounds.

After reaching 40 pounds the pigs were moved to the feeding floor. This was one of the types mentioned above for the nursery. Some

operations held the pigs out of their feeding floor until the pig weighed 100 pounds.

The type of housing used by the hog farmers determined the type of waste disposal system used. Information on the type of housing for the nursery and/or feeding floor used by the operators is presented in Table XXII. In the pasture system the animals were kept outside in an open pen or in movable farrowing or feeding floors. In the house system, the operator cleaned the house, loaded the waste into a spreader and hauled it away. The lagoon system had a lagoon larger than the house or separate from the house; all the wastes went into the lagoon. A cross section of a lagoon system is shown in Figure 3. The pit system is an operation with a house over a pit or a closed underground tank beside the house.

TABLE XXII

NUMBER OF HOG SYSTEMS, BY TYPE, FOR NURSERIES AND FEEDING FLOORS
BY AREA IN OKLAHOMA, 1970

System	Area 1	Area 2	Area 3	Area 4	Total	Percent
Pasture	1	8	1	1	11	45.8
House	-	-	-	-	-	0.0
Lagoon	-	2	5	3	10	41.7
<u>Pit</u>	<u>-</u>	<u>3</u>	<u>-</u>	<u>-</u>	<u>3</u>	<u>12.5</u>
Total	1	13	6	4	24	100.0

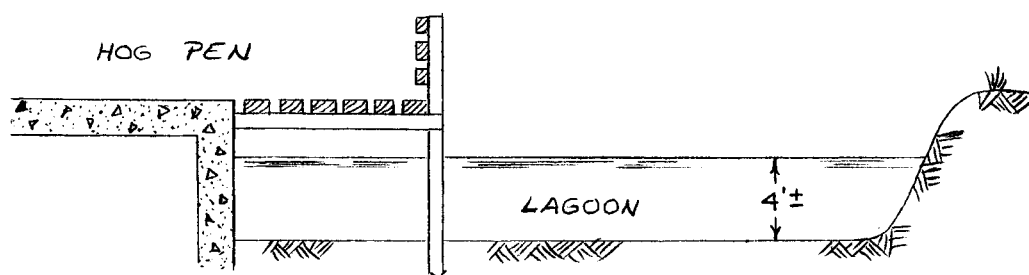


Figure 3. Cross Section of a Hog Waste Lagoon

Almost one-half of the producers used a pasture or modification of the basic pasture system for the feeder pigs. The next most popular system was to use a lagoon for storage of the wastes. One interesting fact was that the eastern two areas had a preponderance of lagoons compared to the western areas. Annual rainfall was greater in these areas than in Area 1 or 2.

Many different production and facility combinations were possible between the farrowing house and the feeding floor. One of the big problems of the study was to find homogeneous operations (Table XXIII). About one-third of the respondents did not farrow their pigs, but rather bought feeder pigs at a weight of about 40 pounds. Forty-two percent of the operations interviewed used a farrowing house of a type that required them to clean out the wastes. Some operations also had their farrowing crates on a slatted floor over a lagoon or pit.

Because of the large number of combinations used in the state and the few observations within each combination, some of the combinations were aggregated. The three combinations which appeared most appropriate to analyze were: (1) operations using the pasture system for most of

the feeding pigs; (2) operations using the lagoon, either attached to the house or separate but connected by a pipe; and (3) the system with a pit under the house.

TABLE XXIII
HOG SYSTEMS FOR FARROWING BY AREA IN OKLAHOMA, 1970

System	Area 1	Area 2	Area 3	Area 4	Total	Percent
None	1	4	2	1	8	33.4
Pasture	-	-	-	-	-	0.0
House	-	6	2	2	10	41.7
Lagoon	-	1	2	1	4	16.6
<u>Pit</u>	<u>-</u>	<u>2</u>	<u>-</u>	<u>-</u>	<u>2</u>	<u>8.3</u>
Total	1	13	6	4	24	100.0

Methods for Cleaning Wastes From Hog Systems

The pasture system was sometimes not cleaned at all and in other cases the ground was plowed up occasionally to turn under worms. The land used for the pasture system was not used, usually for a period of about six months after each lot of pigs had been removed. The managers who used the slatted floored farrowing crates or nursery pens towed the pens to a different spot in the pasture after a period of time so the waste did not build up into the slats. This operation replaced the

plowing in some cases. In others the wastes were plowed under and a crop was raised in the field.

The house system mentioned as being used primarily for the farrowing operation was cleaned every day into a spreader parked at the end of the building. There was no lagoon associated with the house type of operation. No house systems were observed being used for feeding floors. The labor for waste cleaning would be too much for raising larger hogs by this method.

The cleaning of a hog operation is essential for the health of the hogs as well as for sanitary reasons in the surrounding area. The hog is physically strong but is quite susceptible to diseases from almost any source; therefore, methods of cleaning must not expose the hog to the possibility of disease.

Each operator in the study had some system of waste handling. None of the farmers indicated that they sold any hog manure. One respondent mentioned that a greenhouse near him tried to obtain hog wastes free but was unwilling to pay for the wastes. The uses farmers made of their wastes are summarized in Table XXIV.

Over one-third of the producers spread their wastes on the fields as fertilizer. The second most popular disposal system was the lagoon. One producer in Area 3 and two in Area 2 indicated they gave some hog wastes to people for use on gardens. It appeared that most non-farm people do not want hog wastes because of the handling and the odor problems.

Producers who spread wastes from their operation on land were asked if they used fertilizer along with the waste to promote growth of their crops. In Area 2, seven operators hauled wastes and four of the

seven did not use fertilizer. Area 4 had only two operators who spread wastes. One of these used fertilizer and one did not.

TABLE XXIV
DISPOSITION OF HOG WASTES, BY AREAS IN OKLAHOMA, 1970

Disposition	Area 1	Area 2	Area 3	Area 4	Total	Percent
Stock Pile	-	1	1	1	3	12.5
Spread on Land	-	7	-	2	9	37.5
Leave	1	2	1	-	4	16.6
Lagoon	-	2	4	1	7	29.2
<u>Plow Under</u>	<u>-</u>	<u>1</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>4.2</u>
Total	1	13	6	4	24	100.0

Sixty-three percent of the hog feed yard operators did not spread hog wastes. In Area 1 and 3 no one indicated they spread wastes and in Areas 2 and 4 the responses were about evenly divided between spreading and not spreading.

When asked whether the operation had purchased special equipment for waste handling, 75 percent answered, "no," (Table XXV).

Nearly all producers indicated they did not have any problems with obsolescence or deterioration of equipment. One factor might be that most of the equipment was owned by operations in the western part of

the state where it is very dry. This might markedly slow the deterioration of the equipment due to rusting.

TABLE XXV
SPECIAL EQUIPMENT PURCHASES FOR HANDLING HOG WASTES,
BY AREAS IN OKLAHOMA, 1970

Response	Area 1	Area 2	Area 3	Area 4	Total	Percent
Yes	-	4	1	1	6	25
<u>No</u>	<u>1</u>	<u>9</u>	<u>5</u>	<u>3</u>	<u>18</u>	<u>75</u>
Total	1	13	6	4	24	100

If the operator indicated he had a pit or lagoon of some type for wastes to be stored, he was asked if he had ever emptied it. The majority of producers with lagoons had not emptied them (Table XXVI). The two producers who had emptied their lagoons were asked how they handled the waste. Both operators had used a liquid manure spreader to haul the waste. One other hog feeder had cleaned his lagoon with a backhoe. This was to clean out the bottom and he did not think that they would do it again for a long time. None of the operators used the water from the lagoon for irrigation of crops or pasture land.

TABLE XXVI
HOG FEEDING OPERATIONS WHICH HAVE EMPTIED LAGOONS,
BY AREAS IN OKLAHOMA

Response	Area 1	Area 2	Area 3	Area 4	Total	Percent
Yes	-	2	-	-	2	13.5
<u>No</u>	<u>-</u>	<u>3</u>	<u>6</u>	<u>4</u>	<u>13</u>	<u>86.5</u>
Total	-	5	6	4	15	100.0

Another potential pollution problem which had to be handled was dead animals. Several respondents mentioned the problem encountered in getting a rendering service to come and take the animals. Most of the rendering services would not pay for the animals or would charge the producer for taking the animal. If the rendering company came it apparently took quite a while and the carcass began to smell as it deteriorated. Farmers have a number of odors which they must tolerate, but they do not like extremely unpleasant odors. The methods used to dispose of dead animals are presented in Table XXVII.

Variable Costs

The different systems used will affect the level of costs measurably for any given hog producer. The same situation exists for the hog costs as was true for the cattle costs. The only costs useful for planning for waste handling as an operation is enlarged are the long run total costs and the long run average cost curve. Distinction between fixed and variable costs in this section and the following

sections allow an individual producer to assess the costs for his enterprise.

TABLE XXVII
METHOD OF DISPOSAL OF DEAD HOGS, BY AREA IN OKLAHOMA, 1970

Method	Area 1	Area 2	Area 3	Area 4	Total	Percent
Rendering	-	2	-	-	2	8.3
Burn	-	1	2	2	5	20.8
Bury	-	5	3	1	9	37.5
Haul, No Bury	1	4	1	1	7	29.2
<u>Miscellaneous</u>	<u>-</u>	<u>1</u>	<u>-</u>	<u>-</u>	<u>1</u>	<u>4.2</u>
Total	1	13	6	4	24	100.0

Labor

Labor was least expensive for those producers using the pasture system. The operators using the lagoon system spent the most for labor. The reason the labor of the pit system was less costly was that the whole floor was slatted and the waste fell through the slats. Several managers had learned to toilet train their hogs in the lagoon system. These operators experienced sharply lower costs as a result of their efforts.

The method used to train the hogs in using the slatted area of the pen over a lagoon was to erect a fence which kept the little pigs over the slats for the first few weeks that the pigs were in the pen. As the hogs grew the fence was moved farther up into the pen and they habitually went to the slatted part of the pen. Hogs are clean animals if given the chance to be and once trained, they kept the pen very clean. Thus the operator did not have to scrape the pen very often.

Custom Waste Hauling

There were no respondents who used hired cleaning for their hog operations. One of the reasons advanced by some of the managers was the problem of disease. A crew of men and equipment going from one operation to another could carry such diseases as cholera and infect another herd. Another reason was that the amounts of wastes were quite small and it required a large size operation to produce enough waste to make it worth moving equipment in to do the cleaning. Possibly with certain types of systems such as a lagoon, which was isolated from the hog feeding operation, and with a sufficiently large number of hogs, the idea of hired cleaning would be feasible.

Equipment

Equipment used in the hog waste handling operation typically was a farm tractor which hauled a solid waste spreader or a liquid spreader. The spreader was the other piece of equipment which contributed to the equipment variable costs. The average equipment variable costs for the operator using the pasture system was \$48, while the pit operation had equipment variable costs of \$41. The operator of a lagoon system had

average equipment variable costs of \$68. This figure appears high but it may be caused by the operators who used oversize tractors or a liquid manure spreader. The average variable costs for both labor and equipment are presented in Table XXVIII.

TABLE XXVIII

LABOR AND EQUIPMENT VARIABLE COSTS FOR HOG WASTE HANDLING SYSTEMS
IN OKLAHOMA, 1970

System	Labor Costs	Equipment Variable Costs	Total Variable Costs
Pasture	\$ 288	\$48	\$ 336
Lagoon	1,040	68	1,108
Pit	725	41	766

Total Variable Costs

The variable costs for the pasture system were the lowest of the systems analyzed. Annual production for operators using this system was less than for operators using the pit system, but it averaged greater than the ones using the lagoon.

The pit system operators had the next lowest variable costs. As will be seen later, most of their costs were the result of an expensive fixed plant rather than the use of labor or equipment to handle the waste. The next most expensive system was the lagoon method of waste handling. Some of the operators had equipment which was used for

cleaning the farrowing house or in a few cases to pump wastes and haul them to a field in the liquid form. A last system which was not included in the analysis because only one firm used it was the house without any lagoon or pit. The labor cost for this operation was relatively high and the average variable cost per pound of pork produced was \$.012 which was about three times as great as the lagoon system.

Data relating to variable costs of waste handling for hog feeding operations are presented in Table XXIX.

TABLE XXIX

TOTAL VARIABLE COSTS AND AVERAGE VARIABLE COSTS OF WASTE HANDLING
FOR HOG FEEDING OPERATIONS IN OKLAHOMA, 1970

Type of Operation	Average Size (Lbs. Gain Per Year)	Total Variable Costs of Waste Handling	Average Variable Costs Per Lb. Gain
Pasture	372,888	\$ 336	\$.0009
Lagoon	283,760	1,108	.0039
Pit	559,163	766	.0014

Fixed Costs

Fixed costs are those costs which are not able to be affected by the size of the production of the firm. The items of cost which give rise to fixed costs in the hog feeding operation are equipment, the license and structures which were built to be in compliance with the Oklahoma Feed Yards Act.

Equipment

Equipment fixed costs were a small cost for most hog feeding operators interviewed. All the systems analyzed had about the same amount of equipment fixed costs. The low figure of \$106 was for the pasture system and the high figure of \$129 was for the operators of lagoon systems.

License

The license expense was not great as a percent of the total cost of waste handling for hog feeders. There were no managers who paid \$150 for a license and only two paid \$100.

Structures

Pasture operations did not have expenses for waste runoff control structures. The other two classes of operation did have high costs of structures. The cost of a lagoon constructed of earth was less expensive than the pit under the house. The pit under the house was constructed of concrete and when formed and poured properly was a very expensive investment. Information on fixed costs for the equipment, license and structures are presented in Table XXX.

Total Fixed Costs

When the total fixed costs of waste handling for hog operations were expressed as a percent of the total costs, the true importance of the fixed costs was apparent. The pasture system had fixed costs of 30.9 percent of the variable costs, while the pit system had fixed costs of 65.4 percent of the variable costs. This is directly opposite of the strategy of the large beef feed yards which emphasized increasing

the variable costs of the waste handling operation. The fixed costs for the lagoon system were 25.4 percent of the variable costs and thus were the lowest percentage of all systems. The total fixed costs and the average fixed costs of hog waste handling are presented in Table XXXI.

TABLE XXX

FIXED COSTS OF EQUIPMENT, LICENSE AND STRUCTURES FOR HOG WASTE HANDLING, BY SYSTEM IN OKLAHOMA, 1970

System	Equipment	License	Structures
Pasture	\$106	\$44	\$ -
Lagoon	129	35	214
Pit	122	62	1,265

TABLE XXXI

TOTAL FIXED COSTS AND AVERAGE FIXED COSTS OF HOG WASTE HANDLING, BY SYSTEM IN OKLAHOMA, 1970

System	Total Fixed Costs of Waste Handling	Average Fixed Costs /LB. of Gain
Pasture	\$ 150	\$.0004
Lagoon	377	.0013
Pit	1,449	.0026

Total Costs of Hog Waste Handling

Costs of waste handling were found to vary depending upon the system of waste handling used. The results of the analysis are presented in Table XXXII. No cost curves are presented because the scatter of the data is so great that no meaningful information would result. The averages have been presented to enable the reader to judge the relative magnitude of the costs of the waste handling operation.

TABLE XXXII

TOTAL COSTS AND AVERAGE TOTAL COSTS OF HOG WASTE HANDLING,
BY SYSTEM IN OKLAHOMA, 1970

System	Total Cost of Waste Handling	Average Cost Per Pound of Gain
Pasture	\$ 486	\$.0013
Lagoon	1,485	.0052
Pit	2,216	.0040

The imposition of the Oklahoma Feed Yards Act of 1969 caused the hog producers added costs for the license and for the waste retention structures which they had to build. These items were more expensive for the hog producers than for the beef feed yard operators when converted to dollars per pound of gain (Table XXXIII).

TABLE XXXIII

ADDITIONAL COSTS TO HOG FEEDERS AS A RESULT OF PASSAGE OF
THE OKLAHOMA FEED YARDS ACT

Type of Operation	Average Size (Lbs. Gain Per Year)	Additional Total Costs	Additional Average Total Costs /Lb. of Gain
Pasture	372,888	\$ 44	\$.00012
Lagoon	283,760	249	.00088
Pit	559,163	1,327	.00238

Returns

The waste product from hogs contains nitrogen (N), phosphorus (P) and potassium (K). These elements are also found in fertilizer. Through the years animal wastes have been used as a substitute for fertilizer for crops. In an effort to determine the value of animal waste, the researcher asked each manager for an estimate of the amount he used on fields as fertilizer. As a check of the estimate, the size of the spreader and the number of loads were multiplied to get a total amount hauled to the fields.

A computer program was used to estimate the amount of waste hauled by the beef feeding operators. However, only a few hog operators spread the wastes from their operation, so no program for hog wastes was written. The estimated dollar value of the wastes spread was calculated for the few operations which spread their wastes. Nine operators of the 24 usable responses spread the wastes from their operations. Implicit in using the dollar value of the fertilizer elements as a

worth figure for the waste, is the requirement that the soil and crop grown must need all the fertilizer elements spread. If a soil were not able to use the nitrogen, the value of the nitrogen would have to be subtracted from the dollar amount figured. Because the amount of the elements needed depended on the condition of the fields of the individual farms, the researcher used the calculated dollar figures for the worth of the waste.

None of the hog feed yard operators covered all the costs of the waste handling operation using the waste valued as fertilizer; however, one manager, using a liquid manure system, did cover all but \$28 of his costs. He hauled about 52 percent of the wastes generated by his hog operation. Two respondents covered all the variable costs of their operation. There were three operators who covered 90 percent or more of their variable costs.

If a hog feed yard manager did not have land to use the waste on he might still contract with a neighbor to take the waste and thus he might recover his variable costs and added fixed costs. If the variable costs and the additional fixed costs were covered, the additional would be available to help offset the original fixed costs and thus increase profits.

Odors from hog wastes were a problem for some operators. After the interview all operations were plotted on USGS 1:250,000 scale topographic maps and the distance to the nearest built up area of population was measured. It was desired to generate a measure of possible problems from air pollution. The measure derived is admittedly crude; however, after reviewing the operations, it appeared to indicate

operations which the enumerator felt did have a potential for an air pollution problem. Several simplifying assumptions were involved.

Three other factors should be included, but were not, due to lack of sufficient information. The first would be a deflator for the kind of system being used. Some hog feeding operations are much more odoriferous than are others. The feed yard with the highest pollution index was not particularly obnoxious; however, it was mostly because of the type of system being used. Another factor which needs to be allowed for is the direction, speed and probability of the wind. The third factor to consider is the location of the appropriate distance where almost no danger of pollution would occur regardless of the number of hogs being raised.

One of the assumptions was that the marginal disutility of odors between members of a population was an increasing linear function as the strength of the odor increased. This was considered incorrect; however, the exact or even approximate function was not known. The second assumption was that as the distance (D) from the feed yard increases, the strength of the odor decreases. $1/D$ was used to calculate this factor. As the size of feeding operation was increased the odors were assumed to increase as a constant value per hog. In Oklahoma most operations keep their hogs about the same length of time; therefore, the number of pigs sold per year was designated as H and used as a multiplier.

The last factor was to multiply by the population (P) of the closest city or village. The equation for the pollution index (PI) was:

$$PI = (P \cdot H/D)/10,000$$

where PI = pollution index.

P = population of nearest city.

H = hogs handled during the year.

D = distance from the feeding operation to the nearest city or town.

The divisor of 10,000 is to reduce the PI value to a manageable, yet sensitive, value.

The first step in the construction of Table XXXIV was to calculate the PI for each of the hog feeding operations. Then all the hog feeding operation PI's which had the same direction to a built up area and were within the same area were added together. This aggregated value was placed in the table. The researcher's opinion was that a pollution index greater than 30 for any one feed yard would suggest a possibility of an air pollution problem.

The preceding two chapters have analyzed the costs and returns to beef and hog feeders from their waste handling practices. The additional costs resulting from the imposition of the Oklahoma Feed Yards Act of 1969 were also computed. The material in Chapter V will summarize the study and present some conclusions and recommendations which are suggested as a result of the study.

TABLE XXXIV

POLLUTION INDEX FOR HOG OPERATIONS, BY AREA AND DIRECTION TO
NEAREST TOWN IN OKLAHOMA, 1970

Direction To Nearest Town	Area 1	Area 2	Area 3	Area 4	Total
N	-	40.30	-	-	40.30
NE	-	17.26	-	23.95	41.21
E	-	7.40	105.20	-	112.60
SE	-	1.79	-	20.30	22.09
S	-	29.06	-	-	29.06
SW	-	-	36.33	3.89	40.22
W	1.92	-	-	2.33	4.25
<u>NW</u>	<u>-</u>	<u>32.50</u>	<u>2.03</u>	<u>-</u>	<u>34.53</u>
Total	1.92	128.31	143.56	50.47	324.26
Number of Hog Feed Operations	1	13	6	4	24
Average of Feed Operations in Area	1.92	9.86	23.95	12.60	13.51

TABLE XXXIV

POLLUTION INDEX FOR HOG OPERATIONS, BY AREA AND DIRECTION TO
NEAREST TOWN IN OKLAHOMA, 1970

Direction To Nearest Town	Area 1	Area 2	Area 3	Area 4	Total	Percent
N	-	40.30	-	-	40.30	12.4
NE	-	17.26	-	23.95	41.21	12.7
E	-	7.40	105.20	-	112.60	34.8
SE	-	1.79	-	20.30	22.09	6.8
S	-	29.06	-	3.89	40.22	12.4
SW	-	-	36.33	2.33	4.25	1.3
<u>W</u>	<u>1.92</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>34.53</u>	<u>10.6</u>
Total	1.92	128.31	143.56	50.47	324.26	100.0
Number of Hog Feed Operations	1	13	6	4	24	
Average of Feed Operations in Area	1.92	9.86	23.95	12.60	13.51	

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

This study analyzed the economic impact of the Oklahoma Feed Yards Act of 1969 on confined feeding operators. The three objectives of the study were to examine the technical, legal and economic aspects of the problem.

A sample of confined animal feeding operators was drawn from a list of the registered feed yard operators of Oklahoma. These managers were contacted for an interview to obtain the data for the study. Maps and other secondary sources were utilized to augment the data obtained from the interviews. After the interviews had been completed the data were analyzed. The non-quantifiable data were tabulated and an analysis of the costs and returns was completed.

Since there was no good measure available to locate the potential pollution problems in the state of Oklahoma, the researcher calculated a measure referred to as a population equivalent (P.E.). Different kinds of animals produced different amounts and strength wastes. A system of population equivalents which placed all animals on a common base was used to determine if there were any major potential pollution problem areas in the state resulting from animal waste. The pollution potential increased as the rainfall increased and it was reduced as the rate of evapotranspiration increased. An examination of weather data for

the state disclosed that rainfall decreased from east to west while evapotranspiration rates increased from east to west. The BOD population equivalents for the feed yards in the study were plotted by watershed. The P.E.'s of the individual feed yards within a watershed were summed thus giving a watershed total P.E. Concentrations of feed yards and animals were in the western third of the state where the rainfall was less and the amount of evapotranspiration was greatest.

Another objective of the study was to examine the legal aspects of waste pollution. During most of the history of the country, little attention has been directed to wastes which have been put into streams. The water laws had a requirement that the water be undiminished in quantity and quality but the quantity aspect was most important. In the mid-1960's concern mounted regarding the quality of streams in the country, and resulting Federal legislation reflected this concern. In 1965 the Clean Water Act was passed which required states to establish standards for their streams.

Oklahoma drew up a set of standards to meet the requirements of the Federal legislation. Part of the required state standards were for methods to keep state streams unpolluted. The State Legislature passed the Oklahoma Feed Yards Act in 1969 to control feed yard runoff.

The Act required that the operator prevent feedyard runoff from reaching a stream and that a fee for a license be paid. It also required that the operator conduct

...operations in conformity with established practices in the feed yards industry as approved by regulations made and promulgated by the Board and in accordance with the standards set forth in this act (Sec. 10, part 7).

For beef feeding operations the economics of waste removal and pollution control were dependent upon the method used for the disposal

of the wastes. Methods used for waste removal did not reveal any great differences between various beef feed yards of the state. The basic system for cleaning beef feed yards, except for one operator who did not remove the waste, was to push the waste into a pile, load it into a truck or spreader and haul it to where it was to be unloaded. In some cases the wastes were piled, reloaded and hauled to fields to be spread.

This study used pounds of gain per year as a measure of the size of the feed yards studied. This measure appears to have many advantages such as it is possible to correlate costs between different classes of animals such as beef and hogs. It also accounts for the differences in the methods used by producers in that some yards are used all year while others may be only used on a one time basis during the year. A rule of thumb for the conversion of one time capacity to pounds of gain per year is one animal capacity equals approximately 1,000 pounds of gain per year.

Several of the beef feeders use custom haulers to remove wastes from their feed yards. This method of handling wastes has several advantages in that the feed yard does not have money invested in equipment which is used only part of the time. It also provides the feed yard operator with help which is trained and thus he does not have to exercise as much supervision as he would with using his own help for the job. Load tickets or use of the yard scales would be used to determine payment for the waste hauled.

Due to the similarity of methods of waste removal, the significant cost items were related to the size of the feed yard. The costs were broken into variable and fixed costs because the operator viewed his

cost structure this way. A summary of the waste handling costs for beef feed yards is presented in Table XXXV.

TABLE XXXV
SUMMARY OF BEEF FEED YARD WASTE HANDLING COST DATA,
BY SIZE OF AREA IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Total Variable Costs for Waste Handling	Total Fixed Costs for Waste Handling	Total Costs for Waste Handling
458,071	\$ 888	\$ 562	\$ 1,450
1,361,064	2,190	1,152	3,341
5,376,319	4,879	2,993	7,871
20,773,900	35,484	7,952	43,436

Fixed costs appeared relatively linear over a large range of production levels. The relationship between the fixed costs in Table XXXV was given by the equation:

$$Y_2 = .0003503 X + 675.90$$

where Y_2 = total fixed costs of beef feed yard cleaning.

X = size of feed yard in pounds of gain per year.

Average variable costs (AVC) and average fixed costs (AFC) were obtained by dividing the total variable and total fixed costs by X. The average total costs (ATC) were obtained by summing the AVC and AFC. The AVC, AFC, and the average total costs (ATC) by average class size are presented in Table XXXVI.

TABLE XXXVI

LEVEL OF AVERAGE VARIABLE COSTS, AVERAGE FIXED COSTS AND AVERAGE
TOTAL COSTS PER POUND OF GAIN BY SIZE OF OPERATION FOR
BEEF FEED YARDS IN OKLAHOMA, 1970

Average Size (Lbs. Gain Per Year)	Average Variable Costs	Average Fixed Costs	Average Total Costs
Per Lb. of Gain			
458,071	\$.00193	\$.00123	\$.00316
1,361,064	.00161	.00085	.00246
5,376,319	.00091	.00056	.00147
20,773,900	.00171	.00038	.00209

Prevention of runoff required many operators to build waste retention structures. The cost of the license and the waste retention structures appeared to be the costs to the operators which were induced by the Act. The additional costs per year for the average size classes are presented in Table XXXVII.

TABLE XXXVII

ADDITIONAL COSTS TO BEEF FEED YARD OPERATORS AS A RESULT OF
PASSAGE OF THE OKLAHOMA FEED YARDS ACT OF 1969

Average Size (Lbs. Gain Per Year)	Additional Total Costs	Additional Average Total Costs/ Lb. of Gain
458,071	\$ 66	\$.00014
1,361,064	132	.00010
5,376,319	689	.00013
20,773,900	462	.00002

Lowest cost was not a good criteria for the optimum waste handling system unless the wastes were stockpiled with no future use. When the operator had an alternative use for the waste, more expensive methods were utilized because they resulted in greater net return for the waste.

A program to calculate the quantity of beef wastes and their value as fertilizer was written to aid in establishing net returns available from the wastes. After tabulating the responses of the managers who sold wastes, those who did not use the waste in any way or those who put the wastes on fields, the researcher calculated the estimated returns from the use of wastes as fertilizer and for selling it. When the operators which sold their wastes were considered alone, the large lot managers were the only producers which covered their costs of waste handling. The smaller lot operators covered approximately one-half the total cost of waste handling. The operators in the grouping with an average of 5,376,319 pounds of gain per year or approximately 5,000 head per year did recover the variable costs of waste handling.

Hog feeding operations in Oklahoma were categorized into three basic systems, pasture, lagoon and pit. There were many variations based upon the three types and each used slightly different methods of waste disposal. The different systems of disposing of the wastes had a bearing on the level of costs for the hog operation.

The total variable costs (TVC), total fixed costs (TFC) and total costs (TC) of waste handling by type of hog operation are presented in Table XXXVIII.

The average costs were derived by dividing the total costs by the average size of hog operation based on the pounds of pork produced per year. These data are presented in Table XXXIX.

TABLE XXXVIII

TOTAL VARIABLE AND FIXED COSTS AND TOTAL COSTS OF WASTE HANDLING
FOR HOGS, BY TYPE OF OPERATION IN OKLAHOMA, 1970

Type of Operation	Total Variable Costs	Total Fixed Costs	Total Costs
Pasture	\$ 336	\$ 150	\$ 486
Lagoon	1,109	377	1,485
Pit	767	1,449	2,216

TABLE XXXIX

AVERAGE COSTS PER POUND OF GAIN, BY HOG WASTE HANDLING SYSTEMS
IN OKLAHOMA, 1970

Type of Operation	Average Lbs. Gain Per Year	Average Variable Cost Per Lb. Gain	Average Fixed Cost Per Lb. Gain	Average Total Cost Per Lb. Gain
Pasture	372,888	\$.00090	\$.00041	\$.00131
Lagoon	283,760	.00390	.00133	.00523
Pit	559,163	.00137	.00259	.00396

The primary reason for the higher costs of the lagoon method was the labor used by these operators to scrape the feeding floor each day. Labor costs for these operators tended to cause the total labor bill for the lagoon hog feed yards to be higher.

After passage of the Oklahoma Feed Yards Act it was expected that hog feeders of the state would have higher production costs. The costs which the Act appeared to have caused were those associated with the

addition of waste retention structures and the license fee. These items were more expensive than for beef feed yard operators when converted to dollars per pound of gain (Table XL).

TABLE XL
ADDITIONAL COSTS TO HOG FEEDERS AS A RESULT OF PASSAGE OF
THE OKLAHOMA FEED YARDS ACT OF 1969

Type of Operation	Average Lbs. Gain Per Year	Additional Total Costs	Additional Average Total Costs
Pasture	372,888	\$ 44	\$.00012
Lagoon	283,760	249	.00088
Pit	559,163	1,327	.00238

The material presented has summarized the study. The next section will present the conclusions which are supported by the data and the analysis in the study.

Conclusions

After considering the population equivalents and weather data, the author concludes that the pollution problem from confined animal feeding is not as great as the raw numbers of animals would indicate. The large beef feed yards, which handle the majority of the feeder cattle in Oklahoma, are in the western part of the state. This area has low rainfall, high evapotranspiration and most of the beef feed yards have waste retention structures in place. Hog feeding is more uniformly

distributed over the state; however, most of the hog feeder operations in the wetter climates have lagoons or pits in place.

One problem which appeared during the interviews was that the Act specifies that runoff should not reach a stream. Because several smaller feed yard operators had a feed yard license but no structures or pumps, one can only conclude that enforcement of the law is somewhat inconsistent. It should be remembered that the Act is relatively new and it requires time and manpower to adequately inspect all the feeding operations.

Another conclusion which this study supports is that legislators must consider the effect of any legislation upon the group to be controlled. The study reveals that most of the effect of the Feed Yards Act is on the fixed costs of the feed yards and that these costs probably can not be passed on to the consumer, but must be absorbed by the feeding operation.

Methods of cleaning in the beef feed yards followed a predictable pattern dependent upon the size of operation. An examination of the costs of waste handling for the beef feed yards revealed that decreasing costs per pound of gain occurred as the size of feed yard increased from very small to about 10 million pounds of gain per year or about 10,000 head a year. Beef feed yard operators producing more than 10 million pounds of gain per year had increasing costs of waste handling; however, their sales of wastes more than compensated the operators for their costs.

Most of the wastes cleaned from beef feed yards went to cropland whether a custom hauler's or the operator's own equipment was used to move it. Almost half of the beef feed operators interviewed reported

that when wastes were spread on cropland they did not use commercial fertilizer also. The others who used wastes on their cropland, used reduced quantities of fertilizer. These results reinforce the author's opinion that the wastes have value as fertilizer.

Decreasing costs for labor in beef feed yards exist when calculated as a cost per pound of gain. Beef feed yard operators' preference for equipment, rather than labor, resulted in increasing equipment costs per pound of gain. The average waste handling cost per pound of gain for the large beef feed yards was almost as great as the small size beef feed yards.

The purchase of the large expensive equipment is not irrational when one considers the total animal feeding operation because the large equipment is used for other chores. Variable costs per pound of gain of waste handling for the larger size beef feed yard operations increase as size increases because equipment constitutes 53.8 percent of the variable costs.

Equipment fixed costs (EFC) for beef feed yards had a relatively constant slope as the larger size beef feed yards were considered. An equation fitted to this data was:

$$EFC = 565.77 + 0.000333 X$$

where EFC = equipment fixed costs for beef feed yards.

X = size of the beef feed yard, in pounds of gain per year.

Total fixed costs (TFC) of beef feed yards consisted of EFC plus the annual costs of license and waste retention structures. The total fixed costs increased at a constant rate as the size of the beef feed

yard increased; therefore, an equation was also fitted to the total fixed costs as follows:

$$TFC = 675.90 + 0.0003503 X$$

where TFC = total fixed costs of beef feed yards.

X = size of the beef feed yard, in pounds of gain per year.

As was pointed out earlier, the feed yard manager can not make a rational choice about how to dispose of the wastes unless he knows the possible returns from use of the wastes. Wastes can be (1) used as fertilizer, (2) sold or (3) dumped. When the nutrients in a unit of waste are valued at the cost of the same amount of nutrients from fertilizer then the value of waste as fertilizer was, in all sizes considered, greater than the total cost of waste disposal. The sale of the waste covered the cost of the waste handling for the largest feed yards.

Hog feeders operated a number of different type operations based on the method of waste handling. The larger feed yards generally had installed newer methods such as lagoons and pit systems to store wastes, hauling the wastes to the fields in a liquid form. The lagoon operations visited by the researcher were quite odor free and appeared to be working well for decomposing the wastes.

Variable costs of handling the wastes from hog feed yards were quite similar for the pasture and pit method. The labor cost for scraping the feeding floor raised the variable costs of the lagoon system method. Variable costs for the lagoon method were almost four tenths of a cent per pound of gain. The managers who toilet train their hogs have much lower labor costs using the lagoon system.

The fixed costs of the waste handling method for the hog feed yards were progressively higher for the pasture system, the lagoon and the pit method. The level was one-fourth of one cent per pound of gain for the pit method of waste disposal.

The total costs of the hog waste handling were highest for the pit method and lowest for the pasture method. The costs per pound were \$.00523, \$.00396 and \$.00131 for the three methods respectively.

The conclusions which have been set forth suggest some recommendations which should be instituted soon if we are to solve our potential animal waste pollution problems, before they become serious. Recommendations and some suggestions for future research which would build on the results of this study are indicated in the following sections.

Recommendations

The researcher's first recommendation is that researchers in animal waste handling relate their findings to the pounds of gain for the feeding operation rather than the one time capacity as has been done in some research. This method makes an allowance for the operator who only uses his feed yard one time per year. Also findings can be compared among different classes of animals.

Each operator of a beef feed yard should reexamine his waste handling operation with the objective of reducing costs. Most feed yard operators will discover ways to reduce waste handling costs. The large feed yard would thus increase profits from the sale of wastes. The feed yard operator producing between two million and 10 million pounds of gain per year might consider raising crops along with his feed yard operation because he can apparently earn more using the

waste for his own crops than he would through the sale of the wastes. If at present the wastes are being stockpiled then consideration should be given to finding a farmer who would take the wastes and at least pay the additional costs for waste removal.

This same recommendation also applies to the hog feeders in Oklahoma. If the feeder is contemplating changing his operation to reduce pollution he should consider the lagoon method and be alert to the labor savings when the pigs are toilet trained. If he is going to change to a method which allows him to recover the pig wastes then all the wastes should be spread. This requires that the feeder realize the value of the waste and preserve the quality of it until it is spread.

As indicated by the figures presented relating to the value of animal wastes, the feeder should preserve the quality of the wastes as much as possible until the wastes are spread. Wastes should be spread as often as is practical and should not be piled in a stockpile for prolonged periods, if the producer intends to use the wastes as fertilizer.

Several operators indicated they had designed their own waste retention structures. In general most operators did not appear to be technically competent to design waste structures. Several structures were seen during the field work which were inadequate or were built in a way that failure appears inevitable. The operators should obtain assistance from qualified engineers in designing structures before building them.

In the future air pollution will become a greater problem due to urban citizens' complaints. The researcher recommends that the

pollution index formula be used, with the mentioned refinements, to help indicate where problems with air pollution might be a problem. A similar formula could also be developed for the beef feed yards.

Another recommendation is that the Act be changed to reflect the difference in the amount of wastes which exists between the wastes from hogs, sheep, and beef cattle. The cost data also showed that the hog feeders pay more cost per pound of gain than the beef feed yards. Another change which should be instituted in the Act is to bring other animals such as dairy cattle under the Act. The general trend in the dairy industry is to larger and larger herds.

Limitations of Current Study and Need for Further Research

The study does have limitations. Most of the limitations center around the problem of data variation. Interview data has more variation than does technical design data developed by the researcher for economic engineering. The variation in costs from the computed averages was quite significant and was not necessarily correlated with the size of the operation considered.

The material relating to large beef feed yards must be used with caution due to the few interviews and lack of experience with new waste handling techniques by the operators. Several large beef feed yards were so new that they did not have a waste handling plan worked out yet.

The Feed Yards Act applies to beef, hogs, sheep and horses. At the present time sheep and horse feeding operations are few in number in Oklahoma. The lack of sufficient numbers of sheep and horse feeding operations prevented inclusion of these types of operations in the study.

A number of aspects related to waste handling and water pollution from wastes appear to require further study for solution of problems. The value of animal wastes as fertilizer is contingent on the preservation of the waste quality. Research is needed to determine economical methods of preservation of fertilizer value of wastes until the wastes can be spread.

Animal wastes may have value for uses other than fertilizer. Some preliminary work has been done on feeding wastes as a hay-waste feed called wastelage. More research is needed to perfect methods of using wastes for animal feed.

The downstream effects of feed yard runoff on fish and wildlife is still only imperfectly understood. Research related to the effect of animal waste runoff on aquatic life, stream quality and on reservoirs should be increased.

Because the problems of animal waste pollution are interdisciplinary in nature, it is suggested that more interdisciplinary projects, under the leadership of an individual not connected with any of the regular departments of the university, be established. Graduate research could be developed from various aspects where the time required for the graduate students program would not hinder the main ongoing project to which the various departmental personnel would be assigned.

Another recommendation, which results from the frustrations met doing the review of literature, is that all researchers doing work involving the quality or other parameters of wastes use certain standards which would be listed in a standard handbook, in addition to the

unique measures which the researcher might be establishing. This would allow other researchers to compare results from different studies.

This study recommends using land for spreading wastes. More research should be conducted to determine the practical limits to which wastes can be applied to land. Extremely heavy applications of wastes may cause other problems such as pollution of ground water.

These recommendations are not to be construed as a complete listing but rather as some of the more immediate, intense problems which need solutions in the near future.

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