Executive Summary

I. Purpose of the Feedlots Study

While many diverse sources contribute to water pollution, States report that agriculture is the most widespread source of pollution in the nation's surveyed rivers and lakes. In the 22 States that categorized impacts from specific types of agriculture, animal operations impact about 35,000 river miles of those miles assessed.

Animal Feeding Operations (AFOs) can pose a number of risks to water quality and public health, mainly because of the amount of animal manure and wastewater they generate. Manure and wastewater from AFOs have the potential to contribute pollutants such as oxygen-demanding substances, ammonia, nutrients (e.g., nitrogen, phosphorus), sediment, pathogens, heavy metals, hormones, and antibiotics to the environment. Excess nutrients in water can result in or contribute to eutrophication, hypoxia (i.e., low levels of dissolved oxygen), and, in combination with other circumstances, have been associated with toxic outbreaks of microbes such as *Pfiesteria piscicida*.

Pathogens, such as *Cryptosporidium parvum*, have been linked to impairments in drinking water supplies and threats to human health. Pathogens in manure can create a food safety concern if manure is applied directly to crops at inappropriate times. In addition, pathogens are responsible for some shellfish bed closures. Nitrogen, in the form of nitrate, can contaminate drinking water supplies, particularly ground water sources. Nutrients can also contribute to toxic algal blooms which may be harmful to human health.

These risks persist in spite of regulatory controls (effluent limitations guidelines) that have been in place for Concentrated Animal FeedingOperations (CAFOs), or Feedlots, since 1974. These regulations prohibit the release of wastewaters to surface waters unless extreme storms (at least as large as those with a 25-year, 24-hour probability) cause overflows from containment systems designed to hold wastewaters and a minimum amount of runoff. The regulations do not specifically address discharges that may occur as these wastewaters or solid manure mixtures are applied to soil.

In addition, much of the industry has changed dramatically since the development of the existing regulation. A trend toward consolidation in which fewer and larger operations replace smaller operations has resulted in more nutrients being concentrated over smaller geographic areas. Much of this consolidation trend has shifted production to states with fewer statutory controls and more lenient interpretations of the federal regulations, causing concerns about equitable permit and enforcement requirements. Some production methods have changed as well to support the development of larger operations. With respect to poultry, some parties maintain that EPA misunderstood the methods in place and evolving at the time EPA was developing the effluent limitations guidelines.

Because of the various concerns outlined above, EPA decided to gather preliminary information on the waste the industry produces, the technologies and practices used to manage these wastes, the industry's size structure, geographic distribution, and economic status, and some water quality impacts and other environmental problems that may be attributed to animal feeding operations. The report is not intended to be a comprehensive summary of all research done in this area, nor does it identify all of the practices and pollutant releases associated with all of the nation's animal feeding operations. This Preliminary Data Summary summarizes the data EPA collected.

II. Existing Regulatory Programs (Appendix Introduction unless otherwise specified)

The current Feedlots Effluent Limitations Guidelines (ELG) were published in 1974 at 40 CFR 412. The existing regulation does not cover all stages or all types of animal production. It applies to large operations that raise beef and dairy cattle, poultry (chickens, turkeys, and ducks), swine, sheep, and horses. The rule essentially prohibits the direct discharge of pollutants to surface waters. Operations with containment systems designed to hold wastewater and runoff for a 25-year, 24-hour storm are allowed an exception when a storm event exceeds the containment capacity.

The ELG are implemented through National Pollutant Discharge Elimination System (NPDES) permits. The regulation at 40 CFR 122.23 defines which animal feeding operations are point sources and subject to the NPDES program. This rule applies to the same animal types as does the ELG, but it divides the industry up into three groups based on the number of animals raised. An operation in the largest group (with a capacity for over 1,000 animal units, see next paragraph) can be defined as a point source without the additional criteria applied to the other two groups. An operation in the smallest group (with a capacity of up to 300 animal units) can only be defined as a point source if it is designated a concentrated animal feeding operation (CAFO) by EPA or a state to which this authority has been delegated. The definition for the middle group (with a capacity from 300 up to 1,000 animal units) is dependent on pollutant discharge (or potential to discharge).

EPA and USDA have both used animal units (AUs) for regulations. Animal units are intended to normalize numbers of animals across animal types. USDA's animal units are more detailed and updated than the ones used by EPA to define size thresholds for applicability in the existing regulations. Animal units are typically based on an average liveweight for each animal species. Other approaches are possible as discussed in the Appendix Introduction, but results will probably correlate closely with the results from a liveweight basis.

USDA estimated that there were about 510,000 "confined" animal production facilities among all beef and dairy cattle, swine and poultry farms in 1992 (Economics Appendix: Preliminary Study of the Livestock and Poultry Industry). This estimate was obtained under the assumption that each of the sectors raise or house all animals in confinement -- except beef cattle to exclude grazing and pasture-based cattle. Compared to the 1.2 million commercial livestock and poultry operations during the same year, confined operations comprise less than 50 percent of all farms. From the 1992 Census data, USDA estimated the number of confined animal facilities with more than 1,000 animal units (AUs)[1] at 6,700 livestock and poultry operations. As a share of all confined operations, facilities with more than 1,000 AU that may be considered "concentrated animal feeding operations" or "CAFOs" comprised little more than 1 percent of all confined operations in 1992.

EPA also estimated (from Census of Agriculture data) the likely number of operations that might meet the current definition of a CAFO and to how many of those operations the existing effluent guideline might apply. The number of potential CAFOs ranged from 5,800 with at least 1,000 animal units (excluding chicken operations and some horse and sheep grazing operations) to 55,000 operations with at least 300 animal units (including chicken operations). The effluent guidelines might apply to between 5,800 operations with chicken and grazing operations excluded to 20,000 operations under the most inclusive criteria. More information on this analysis and the results are presented in the Appendix in section 1.0 of the Feedlot Industry Sector Profile.

In addition to control under the NPDES program, there are state-level regulatory programs covering Feedlots. A preliminary analysis reveals that most State permits have effluent limits based on the same 25-year, 24-hour containment standard identified in the existing federal regulations. Various operation and maintenance and land application requirements also appear to be rather common. Nutrient management plans, monitoring, record keeping, and reporting are required less consistently. Dead animal disposal and siting requirements are relatively rare.

Operations that are not defined as a point source may still face restrictions under the Total Maximum Daily Load (TMDL) program (see 40 CFR 130.7). There are also a number of voluntary programs that provide funding or guidance to operations and states, both through EPA and USDA.

III. Size and Geographic Profile (Economic Appendix: Preliminary Study of the Livestock and Poultry Industry, except where noted)

According to the 1992 Census of Agriculture, 1.2 million operations raise livestock in the U.S. For the most part, our analysis was limited to those operations that raised swine, chickens, turkeys, beef and dairy cattle, sheep, horses, goats, and ducks. These sectors make up the vast majority of the industry. Little information was available for operations raising other animal types. (Technology Section, chapter 1.0)

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[1]One animal unit is equivalent to one slaughter or feeder cattle; 0.7 mature dairy cattle; 2.5 swine (over 55 pounds); 0.5 horses; 10 sheep or lambs; 55 turkeys; 100 laying hens or; or 5 ducks.

A. Confined Production Facilities as a Share of Total Farms

In 1992, there were a total 1.2 million commercial livestock and poultry operations in the United States. However, there is wide variability in both the mode and scale of production, with individual farms spanning small scale production facilities with few animals to large, intensive production facilities.

B. Facility Size Distribution

Historically, livestock production has taken place on a large number of relatively small farms, which were diversified crop-livestock farms that combined animal breeding, raising, and feeding operations. Increasingly, however, the breeding and raising phases of livestock production are occurring in large-scale, high-volume, specialized feeding operations, with few ties to traditional farming. U.S. Census data by farm size and number of animals on those farms highlight the ongoing shift from many small, diversified farms toward fewer large-scale, year-round, intensive breeding and feeding operations. This shift is marked by changes in the proportion of all farms that are small, medium, and large, as well as the proportion of animals housed on these farms.

The trend toward fewer and larger farms is most evident in the hog industry where large farms' share of the farm sector is increasing rapidly and the number of hogs accounted for by large farms is rising. Conversely, the number and share of small hog farms are dropping. Farm level structural changes have also been significant in the broiler sector, where the share of broilers raised by large farms has increased substantially. Among milk producers, small producers account for the bulk of all farms and an increasing share of the nation’s milk cow herd. Large dairy operations with more than 500 cows still account for a small share of all farms and a small share of all animals. Structural change in the turkey, layer and beef sectors have been less stark. Exhibit 1 reflects these changes from 1982 to 1992.

Exhibit 1
Number of Operations and Animals by Representative Farm Size, Total U.S., 1982 and 1992

Animal Group	Small (#animals varies by group [a])				Large (#animals varies by group [a])				All Farms	
	1982	1992	%1982	%1992	1982	1992	%1982	%1992	1982	1992
Beef Cows										
Farms	794,447	643,508	83%	80%	5,063	4,986	1%	1%	957,698	803,241
#Head	13,275,305	10,485,709	39%	32%	5,994,049	4,734,494	18%	15%	34,202,607	32,545,976
Dairy Cows										
Farms	204,747	93,118	74%	60%	1,052	1,694	<1%	1%	277,762	155,339
#Head	1,055,903	1,939,059	10%	20%	921,891	1,692,960	8%	18%	10,849,890	9,491,818
Hogs & Pigs										
Farms	211,493	102,665	64%	54%	9,210	11,869	3%	6%	329,833	191,347
#Head	1,536,783	2,608,659	3%	5%	17,045,000	28,933,549	31%	50%	55,366,205	57,563,118
Layer Hens										
Farms	203,669	80,694	96%	94%	1,328	1,146	1%	1%	212,608	86,245
#Head	9,765	3,128	3%	1%	180,790	226,230	58%	75%	310,535	301,466
Broilers and Meat Chickens										
Farms	2,811	1,000	5%	3%	15,343	16,441	29%	57%	52,834	29,006
#Head	22,398	12,982	<1%	<1%	366,774,568	744,375,854	59%	84%	621,547,081	888,617,180
Turkeys [b]										
Farms	11,899	7,625	63%	55%	2,514	2,609	13%	19%	19,031	13,765
#Head	69,377	51,935	<1%	<1%	55,952,943	68,657,668	76%	78%	73,815,859	87,611,961

Derived from U.S. Department of Commerce, 1995. %All denotes percentage share across all farms/animals per group.
[a] Representative farm sizes vary by group (number head). Beef & Dairy: small (<50); large (>500). Hogs: small (<100); large (>1,000). Layers: small (<3200); large (>50,000). Broilers: small (<2,000); large (>200,000). Turkeys: small (<2,000); large (>60,000). [b] Data shown is for 1987, since 1982 data are not available.

C. Regional Distribution

Following are summaries of the principal producing States in 1992 by animal commodity for beef cattle, swine, dairy cattle, and poultry (broilers, turkeys and laying hens).

- **Beef Cattle.** Ranked by the number of cattle and calves sold, the top ten producing states control 65 percent of U.S. beef production. Texas was the largest producing state, accounting for 16 percent of 1992 sales. Other major states included Kansas, Nebraska, Oklahoma, Colorado, Iowa, California, South Dakota, Missouri, Wisconsin and Montana.

- **Hogs.** The hog farming sector is concentrated among the top five producing states that together supply almost 60 percent of U.S. pork production. Iowa accounted for 24 percent of 1992 hog sales. Other major hog producing states included North Carolina, Illinois, Minnesota, Indiana, and Nebraska.

- **Dairy Cattle.** The top five producing states controlled more than 50 percent of all U.S. milk production in 1992. Wisconsin was the largest dairy producing state with 16 percent of volume milk sales. Other major milk producing states included California, New York, Pennsylvania, and Minnesota.

- **Broilers.** Broiler and chicken meat production is controlled by 10 producing states, which supply about 80 percent of all broilers sold. Arkansas was the largest broiler producer in 1992 with 16 percent of sales. Other states included Georgia, Alabama, North Carolina, Mississippi, Texas, Maryland, California, Delaware, and Virginia.

- **Turkeys.** The top 10 producing states accounted for about 80 percent of turkey production. North Carolina was the largest turkey producing state in 1992 with about 20 percent of sales. Other top producing states included Minnesota, California, Arkansas, Virginia, Missouri, Indiana, Texas, Iowa, and Pennsylvania.

- **Laying Hens.** Egg production is dominated by 10 producing states, which supply almost two-thirds of the eggs sold. California was the largest egg producing state in 1992 with about 12 percent of all egg sales. Other major producers included Indiana, Pennsylvania, Georgia, Ohio, Arkansas, Arkansas, Texas, North Carolina and Alabama.

IV. Industry Economic Profile (Economic Appendix: Preliminary Study of the Livestock and Poultry Industry)

A. Major Commodity Sectors

This report presents a profile of livestock and poultry operations in the United States. Identified by the Standard Industrial Classification (SIC) code and the principal commodity products derived from these sectors, the primary animal commodity groups of the U.S. livestock and poultry sector reviewed in this analysis include:

<table>
<tr><th>SIC Code</th><th>Principal Commodity Products</th></tr>
<tr><td>Beef Cattle Feedlots
(SIC 0211)</td><td rowspan="2">Beef Cattle and Calves and Hog Meat. A typical steer carcass yields about 60 percent higher valued cuts and 40 percent hamburger. Fresh meat cuts from a typical hog carcass constitute nearly 40 percent of carcass weight. The remaining is further processed into sausages and other prepared meats. Other by-products, such as hides, lard, and offal, have value in the manufacture of clothing, foodstuffs, fertilizers, and other industrial products.</td></tr>
<tr><td>Hogs
(SIC 0213)</td></tr>
<tr><td>Dairy Farms
(SIC 0241)</td><td>Dairy Products. Raw farm milk is processed as fluid milk and a wide range of dairy products, including cheese, butter, ice cream and frozen desserts, “soft” manufactured products (yogurt, cottage cheese, sour cream, etc.), processed milk products (dry, evaporated, and condensed milk), and also milk by-products (lactose, whey, casein, etc.).</td></tr>
<tr><td>Broiler, Fryer and Roaster Chickens (SIC 0251)</td><td rowspan="2">Broiler, Chicken and Turkey Meat. Most broilers and turkeys are marketed as eviscerated ice-packed or frozen “ready-to-cook” (RTC) poultry which is available in many forms, including whole birds, cut-up birds, poultry parts, and self-basting poultry. Chicken and turkey products may also be “further-processed,” referring to breaded and pre-cooked parts, ready-made and frozen meals, and other manufactured products.</td></tr>
<tr><td>Turkeys/Turkey Eggs
(SIC 0253)</td></tr>
<tr><td>Chicken Eggs
(SIC 0252)</td><td>Eggs. Almost 70 percent of all egg production is sold in fresh form to retail stores or to institutional buyers. Another 30 percent of total egg output goes to “breakers,” which are firms that process eggs into dried, frozen, and liquid egg products used as ingredients by processors in many food products.</td></tr>
</table>

B. Industry Trends in the U.S. Livestock and Poultry Farm Sectors

Two major trends in the U.S. livestock and poultry sector include: (1) a decrease in the total number of farms and (2) an increase in production efficiency.

Recent trends in the U.S. livestock and poultry sectors are marked by a decline in the number of farms attributable to ongoing consolidation in the livestock and poultry industry. Farms are closing, especially small farming operations, due to competitive pressures from highly specialized, often lower cost, large scale producers. This trend toward fewer and larger livestock and poultry operations represents a significant shift in the industry, which has been traditionally composed of a large number of farms with small per-farm herds. Today, the livestock and poultry industry is increasingly dominated by a smaller number of farms that raise and market the majority of animals on U.S. farms.

Another industry trend has been a steady increase in animal production and sales in the United States. This trend has occurred at the same time as there has been a decrease in the number of animals on site. This trend signals continued gains in production efficiency on U.S. farms in the form of higher per-animal yields and quicker turnover of animals prior to marketing.

C. Recent Market Trends

Below is a summary of recent domestic supply and demand trends in the U.S. livestock and poultry sectors, including a review of recent international trade volumes.

- **U.S. Domestic Supply.** In general, meat, poultry, and dairy food production increased since the 1980s. Exhibit 2 shows these trends. The poultry industry experienced the largest gains in production, especially in broiler/chicken meat and turkey production. Turkey production almost doubled from 1982 to 1992. Broiler and chicken meat production increased almost 70 percent over the period. Egg production has remained essentially constant. Pork production rose more than 20 percent from 1982 to 1992, outpacing beef production where increases in production were modest during the period. Milk production rose more than 10 percent from 1982 to 1992.

Exhibit 2
Commodity Production, Livestock and Poultry Industries, Total U.S., Selected Years (1970-1997)

Year	Production					
	Beef	Pork	Chicken	Turkey	Eggs	Milk
	(billion pounds, carcass weight)				(billion dozen)	(billion pounds)
1980	21.6	16.6	11.8	2.4	5.8	128.4
1982	22.5	14.2	12.6	2.5	5.8	135.5
1985	23.7	14.8	14.0	2.8	5.7	143.0
1990	22.7	15.4	19.0	4.4	5.7	147.7
1992	23.1	17.2	21.4	4.8	5.9	150.9
1997	25.5	17.3	27.6	5.4	6.4	156.6

Source: USDA/ERS. Dairy data is from National Milk Producers Federation.

- **Imports and Exports.** Despite the U.S.'s position as one of the single largest agricultural producers in the world, the United States has long been a net importer of red meat and dairy foods. (The U.S. remains a net exporter of poultry meat and egg products and growth in export volumes continues to rise at even faster rates.) In part, the U.S.'s net importer status is attributable to imports from lower-cost net-exporting nations, such as New Zealand, Australia, and Latin America, as well as subsidized exports and/or government supported production from Europe and Canada. A large domestic market for value-added meat, poultry, and dairy products has also limited the U.S.'s need to rely on developing export markets for its products. In recent years, slowing growth and/or saturation in domestic demand has forced the U.S. industries to step up efforts to export products abroad. As a result, U.S. exports of meat and dairy products have grown dramatically. Exhibit 3 shows these trends. However, recent economic crises in the rapidly developing Asian nations-- where imports of meat and dairy food had been growing rapidly-- may dampen export expectations of U.S. producers in the near term.

Exhibit 3
Commodity Trade, Livestock and Poultry Industries, Total U.S., Selected Years (1970-1997)

Year	Imports and Exports								
	Beef		Pork		Chicken	Turkey	Eggs	Milk	
	Imports	Exports	Imports	Exports	Exports [a]			Imports	Exports
	(million pounds, red meat carcass weight)						(mill.doz)	(mill.lbs., ME)	
1980	2,064	220	550	406	781	81	167	3,562	862
1982	1,939	305	612	365	674	56	185	4,184	10,640
1985	2,071	376	1,128	260	581	34	101	4,689	6,503
1990	2,356	1,075	898	351	1,336	66	137	4,292	2,546
1992	2,440	1,400	645	552	1,732	186	175	4,245	7,032
1997	2,343	2,136	633	1,044	5,048	598	220	4,360	5,656

Source: USDA/ERS. Dairy data is from National Milk Producers Federation, expressed in total milk equivalents (ME).
[a] Annual poultry (chicken, turkey, egg) imports are low and are not shown.

C **U.S. Domestic Demand.** The United States is among the highest per capita consumer of poultry, meat, and dairy products in the world. Since the 1980s, per capita U.S. demand for poultry meat, in particular, increased dramatically, outpacing the rate of population growth. Exhibit 4 shows this trend.

Exhibit 4
Per Capita Demand, Livestock and Poultry Industries, Total U.S., Selected Years (1970-1997)

Year	Demand (red meat, carcass weight)					Demand	
	Beef	Veal	Pork	Chicken	Turkey	Eggs	Milk
	(pounds per person, red meat carcass weight)					(eggs/person)	(lbs./person, ME)
1980	103.3	1.8	73.3	48.5	10.2	271.1	523.1
1982	103.9	2.0	62.6	51.5	10.6	264.1	519.4
1985	106.9	2.2	66.0	56.3	11.6	254.7	542.0
1990	95.9	1.3	63.7	70.4	17.5	234.3	570.5
1992	94.7	1.2	67.8	76.9	17.9	235.0	569.6
1997	95.2	1.2	62.5	83.8	17.6	242.4	568.6

Source: USDA/ERS. Dairy data is from National Milk Producers Federation, expressed in total milk equivalents.

D. Farm Revenue

Total farm-gate revenues across each of the livestock and poultry industries examined totaled $86.4 billion in 1992. Measured in real terms (adjusted for price inflation), total farm revenues in the U.S. agricultural sector remained fairly flat from 1982 to 1992. Farm revenues from livestock and poultry sales are generated in each of the United States, ranging in value from more than $8 billion in Texas to as little as $4 million in Alaska.

Farm revenues from cattle farming make up the largest portion of total U.S. farm receipts. In 1992, revenues from farm cattle sales totaled $41.7 billion and accounted for almost one-half of the total value of U.S. livestock and poultry farming. Compared to 1982, cattle farm receipts have risen by 7 percent in real terms. The dairy industry comprises the second largest in terms of the total value of livestock and poultry sales, with revenues of $17.8 billion in 1992, more than 10 percent below adjusted 1982 farm milk revenues. Total farm level sales of broiler, turkeys and eggs totaled $15.4 billion in 1992, with revenues nearly 30 percent above that for 1982. Pork receipts totaled $10.0 billion in 1992, down 17 percent in real terms compared to 1982.

E. Farm-gate Prices.

Prices received by farmers tend to vary seasonally according to production cycles throughout the year and are also prone to wide fluctuations from year-to-year. Farm-gate prices are often subject to periods of high instability according to changing market conditions and/or sharp shifts in supply in response to changing farm prices and/or input costs, among other factors. Even when expressed on an average annual basis and corrected for price inflation, the prices received by farmers in the beef, dairy, pork, and poultry industries show substantial variation between years. Exhibit 5 shows these trends.

Exhibit 5
Prices Received by Farmers, Livestock and Poultry Sales, Total U.S., Selected Years (1982-1997)

Year	Average Annual Prices Received by Farmers (constant dollars, 1990-1992=100)					
	Beef Cattle	Sows	Broilers	Turkeys	Eggs	Milk (fluid)
	($/hundredweight (cwt.))		($/pound)		($/dozen)	($/cwt.)
1982	72.23	62.54	0.362	0.737	0.531	18.31
1992	77.80	35.74	0.347	0.615	0.411	14.35
1994	70.56	32.36	0.371	0.646	0.432	13.80
1996	59.70	42.98	0.388	0.765	0.438	15.05
1997	63.34	42.97	0.374	0.698	0.399	13.41

Source: USDA/NASS. Converted to constant dollars using indexes of prices received by farmers for food/feed (1982=100).

Real farm prices declined significantly during the 10-year period from 1982 and 1992. The most significant decreases were in the pork sector, with farm price decreases more than 40 percent between 1982 and 1992. Stronger prices in 1996 and 1997 spurred significant expansion in the pork sector and caused prices to plummet to under $20 per hundredweight in 1998. Measured in real terms, farm milk prices have dropped most consistently overall from more than $18 per hundredweight in 1982 to around $13 per hundredweight during recent years. These decreases in price have occurred despite strong domestic demand and export growth for dairy foods. Compared to the early 1980s, real beef prices are almost $10 per hundredweight lower and are, in part, attributable to sluggish demand for red meat. Poultry meat prices have not changed dramatically since the 1980s. Farm egg prices declined in real terms.

F. Financial Operating Conditions

Following is a brief summary of the current financial conditions by farm sector for beef cattle, dairy, hog and poultry operations for farms with annual revenues of $50,000 or more. Only limited information is available (1994) to summarize the financial conditions on U.S. livestock and poultry farms at this time.

- **Beef cattle Farms.** Beef farms suffered from poor profitability in the mid 90's due to falling prices and declining receipts, in spite of increasing production. Despite poor profitability, beef farms remained acceptably liquid. USDA reports that net farm income averaged $12,800 and equity averaged $896,800 on U.S. beef farms in 1994. The average beef farm's debt-to-asset ratio of 15.9 percent indicates a healthy debt structure.

- **Dairy Farms.** Dairy farms outperformed all other livestock sectors in this profile analysis, especially in terms of profitability. Net farm income remained relatively stable during the mid-90s. The dairy industry also benefited from the predominance of very profitable large dairy farms. USDA reports net dairy farm income averaged $37,108 and equity averaged $576,200 in 1994. Dairy farms remained acceptably liquid and solvent. In 1994, the average commercial dairy farm earned a return on assets of 1.7 percent. Dairy farms averaged a healthy 17.3 percent debt-to-asset ratio across all farms specializing in dairy production.

- **Hog Farms.** Low profitability and high debt have caused substantial stress among hog producers, though not reaching critical levels. In 1994, net farm income averaged $29,500 and equity averaged $414,200. During that year, 45 percent of commercial farms specializing in hogs earned negative income, along with an average return on assets of -0.4 percent and an average percent profit margin of -1.7. High debt levels also characterized hog farms in 1994. USDA reports that the mean debt-to-asset ratio among all commercial hog farms was 24 percent-- substantially higher than the average for other farms. USDA's farm survey report also identifies hog farms as a particularly "vulnerable" sector because of the prevalence of farms with negative income and debt-to-asset ratios above 40 percent. Debt ratios associated with large hog model farms are estimated at 30 percent and do not indicate insolvency.

- **Poultry Farms.** Poultry producers experienced variable profit performance but maintained a high degree of liquidity and solvency. USDA reports that net poultry farm income averaged $28,300 and equity averaged $496,700 in 1994. The distribution of poultry farms by revenue size is skewed toward large farms, though larger farms had somewhat high debt-to-asset ratios. One-fourth of all poultry farms had debt-to-asset ratios of 34 percent or greater.

G. Industry Marketing Chain

Livestock and poultry operations are part of a production chain that includes supplier, processors and other middlemen, and retailers. The structure of these related sectors and the nature of the commercial relationships between farmers and their customers and suppliers will affect the distribution of costs associated with pollution control. Because of seasonality of production, perishability, and limited resources among farmers to handle farm output, farmers are increasingly reliant upon industry middlemen such as processors, meat packers, and integrators. In general, there are many producers relative to the number of available buyers willing to handle raw farm products, and single farmers generally have little control over the price they receive for their product. This may limit the ability of farmers to recover increased production costs through higher consumer costs.

Another factor that may affect producers' ability to pass on higher costs is the trend toward increased use of contract arrangements. There are two basic types of contracts: *marketing* and *production* contracts. The use of such contractual relationships has been noted to affect the organizational structure of individual industries raising questions about ownership responsibility as well as environmental concerns. This is particularly true when animals are produced under production contracts under which the contractor (processor or integrator) dictates the terms of the contracts and controls the amount produced and the types of production practices used, but the contractee (grower) retains responsibility for increased animal waste management and disease control often without adequate compensation to meet these additional costs.

The use of contractual arrangements in the livestock and poultry industry varies widely by commodity group. In a 1993 study, USDA showed that almost 90 percent of the value of all poultry production is produced under contract, which has played a key role in the influence of integrators in the poultry sector. In the pork industry, farms producing under contract accounted for less than 15 percent of the total value in 1993, but the number of hogs under production contracts has been increasing since the late 1980s in some producing states. Contract production accounts for a much smaller share of beef and milk production.

Following is a summary of the food processing and retailing sector for cattle and hog meat, fluid milk and dairy foods, and poultry meat and egg products.

- **Food Processing Sector.** At the manufacturing level, raw farm commodities undergo further processing and additional value is added prior to sale. The value of shipments of processed meat, dairy, and poultry products was estimated at $148.3 billion in 1992. Of this total, the value of shipments from meat packing plants and processors of sausages and other prepared meats totaled $60.4 billion in 1992. Shipments of poultry meat and related processed products were valued at $23.8 billion. Processed milk and dairy foods were valued at $54.1 billion. Total reported manufacturing sales do not include meat production that is not handled by meat packers but sold directly to retailers. Sales also do not include shipments of shell eggs, which are usually handled directly by retailers.

C **Food Retailing Sector.** Annual total retail sales across the livestock and poultry sectors are estimated at more than $230 billion annually. Estimated retail sales from beef account for the bulk of total annual retail value, estimated at more than $100 billion annually. Dairy product sales were estimated at nearly $65 billion in 1992. Retail sales of pork totaled $25 billion in 1992. Retail poultry sales are estimated at $36 billion. Whole shell egg sales are currently valued at approximately $8 billion annually.

H. Industry Employment Generated

Employment estimates presented in this report represent total direct employment, including employment in supplier industries, farm labor, employment in the processing sector, and employment associated with trade. In 1992, total direct employment generated by the livestock and poultry industries is estimated at over 4.1 million across the United States.[2] This represents approximately 3 percent of the total civilian labor force nationwide. Of the estimated 4 million workers nationwide, more than 1.3 million (33 percent) are farm labor full-time equivalents, approximately 0.6 million (14 percent) are employed in the processing sector, and 0.1 million (2 percent) worked in the commodity export market. The workforce shares not accounted for by on-farm, processing or export employment are associated with employment engaged in the manufacture of agricultural inputs, including feedstuffs and other farm supply sectors. The structure of the labor force varies in each sector, as reflected in Exhibit 6.

Exhibit 6
Estimated Employment Generated, Livestock and Poultry Industries, Total U.S., 1992

Animal Commodity Group	**Total Direct Employment [a]**	**%Civilian Labor Force [b]**	**Farm Labor [c]**	**Processing Labor [d]**	**Export Labor [e]**
	(number employed)	(percent)	(number employed)		
Beef	2,001,200	1.6%	633,900	207,900	38,700
Pork	482,500	0.4%	183,700		5,400
Dairy	855,600	0.7%	466,900	136,400	14,100
Poultry	740,700	0.6%	51,900	193,800	14,900
All Other	na	na	na	na	na
Total	**>4,080,000**	**>3%**	**>1,336,000**	**>528,000**	**>73000**

[a] Estimated using input-output multipliers by Sporleder, Thomas A., and Te-Ru Lin. 1992. The Ohio State University.
[b] Direct employment as a percentage of the civilian labor force in August 1992 (BLS, Unemployment in States, Sept. 1993).
[c] Able, Daft & Early (1993), based on 1990 labor data at the farm level from USDA/ERS, converted to person-year equivalent.
[d] U.S. Department of Commerce, Census of Manufacturers, 1992.
[e] Able, Daft & Early (1993), based on the share of total volume of production exported in 1991.

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[2] *Direct* employment measures the number of jobs related to the production and processing including workers engaged in the manufacture of agricultural inputs and their supplies. This does not include other *indirect* employment, including workers throughout the economy that provide support to the industry.

V. Waste Characterization

Animal waste includes manure and other excreta, dead animals, flush water, bedding, feed wastelage, wash water, and precipitation that contacts these materials. Much of the waste is collected and applied to agricultural land as a soil amendment (Section 11.10). It makes sense to make the maximum use possible of manure as a natural fertilizer. Runoff characteristics of a feedlot vary significantly due to factors such as climate, diet, feedlot surface, animal density, cleaning frequency, and other factors.

Manure is the primary source of pollution from AFOs (Appendix; Environmental Impacts of Animal Feeding Operations). It is much more abundant than human waste. Estimates indicate that U.S. animal waste production in 1992 was 13 times greater (on a dry-weight basis) than human sanitary waste production. Sources of manure pollution include direct discharges, open feedlots, pastures, treatment and storage lagoons, manure stockpiles, and land application fields. Oxygen-demanding substances, ammonia, nutrients (particularly nitrogen and phosphorus), solids, pathogens, and odorous compounds are the pollutants most commonly associated with manure. Manure is also a source of salts and trace metals, and to a lesser extent, antibiotics, pesticides, and hormones. Animal waste can be a valuable fertilizer and soil conditioner, but in many cases it is applied in excess of crop nutrient requirements due to manure nutrient ratios that differ from crop needs, and/or lack of available nearby land. This problem has been magnified as the industry has become more concentrated.

Section 11.4 presents solids, oxygen demand, and nutrient data for supernatant and sludge from anaerobic and aerobic lagoons and beef feedlot runoff ponds. These materials are generally land-applied. Section 11.10 presents nutrients, arsenic, and copper concentrations in runoff from land amended with poultry manure. Section 11.2 presents data for animal manures including volatile solids, oxygen demand (COD and BOD), pH, nutrients, and a variety of metals.

A. Manure and Nutrients Generated (Economics Appendix; Preliminary Study of the Livestock and Poultry Industry except as noted)

In 1992, an estimated 2.07 trillion pounds of manure were generated on U.S. livestock and poultry operations (on a wet weight basis). Compared to 1982, the total amount of manure generated showed a slight decrease from 2.16 trillion pounds, although some categories showed significant shifts over the period. The major nutrients in manure examined in this report include nitrogen and phosphorous. In 1992, the estimated nitrogen content of livestock and poultry manure totaled 11.6 billion pounds, as excreted. Total estimated phosphorous content was 3.5 billion pounds. Exhibit 7 reflects these estimates. The estimates are based on the number of animals produced, and therefore do not reflect changes in feed or breed selection.

Estimates based on the 1992 Census of Agriculture indicate that of all manure excreted from major animal types, beef cattle contribute slightly more than half the total nitrogen and phosphorus. Recoverable beef cattle manure is not the largest source of these nutrients after losses, but contributes around 18% nitrogen and 24% phosphorus. Dairy cattle contribute about 30% of recoverable nitrogen, and chickens and turkeys contribute slightly over one-third of recoverable nitrogen. After phosphorus losses, chickens and turkeys lead in contribution of phosphorus at almost one third of total recoverable phosphorus. Swine contribute slightly less than 10% of nitrogen and excreted phosphorus, and about 16% of recoverable phosphorus after losses. Horses, sheep, goats, and ducks contribute less than 5% of these nutrients. See section 2.0 in the Technical Appendix document Feedlot Industry Sector Profile.

Together, the beef and dairy farm sectors generate 80 percent of all the manure excreted on U.S. farms. Due to the sheer number of beef cattle in the United States, the beef industry is the largest source of manure, accounting for nearly 60 percent of all manure generated. (These estimates do not distinguish between feedlot and grazing beef cattle.) Dairy cattle are the second largest source of manure, accounting for more than 20 percent. Compared to 1982, manure generated from beef and dairy cattle decreased attributable to declining herds on farms.

In 1992, manure from hog operations accounted for 9 percent, while manure from poultry operations accounted for 6 percent. Compared with 1982, manure by hog and poultry facilities has risen. Of the estimates for poultry, approximately one-half of all poultry manure was generated by broilers. Hens and turkeys each generated about 25 percent of all poultry manure.

Although the poultry industry accounts for a relatively small share of the total manure generated among U.S. livestock and poultry farms, its waste has a relatively high nitrogen and phosphorus content by weight. Moreover, the annual mass of these nutrients has increased rapidly with increases in animal production. Between 1982 and 1992, the nutrient contribution from poultry manure increased by almost one-third. Poultry waste accounted for 14 percent of all manure nitrogen in 1992 and 15 percent of all manure phosphorous generated in 1992. Hog manure nutrient mass also rose slightly during the period, accounting for 9 percent of all manure nitrogen and phosphorous in 1992.

Exhibit 7
Estimated Manure and Nutrients Generated, As Excreted[a], Total U.S., 1982 and 1992

Animal Inventory Group	Manure Production			Manure Nitrogen		Manure Phosphorous	
	1982	1992	%1992	1982	1992	1982	1992
	(billion pounds)		(%)	(million pounds)		(million pounds)	
Beef	1,264	1,201	58%	6,217	5,914	2,119	2,015
Dairy	528	464	22%	2,562	2,243	498	437
Pork	170	185	9%	994	1,077	296	320
Poultry[b]	87	116	6%	1,191	1,597	409	543
Other[c]	114	104	5%	873	792	254	223
Total	**2,164**	**2,070**	**100%**	**11,827**	**11,621**	**3,577**	**3,549**

[a] Generated using USDA's methodology. [b] Includes layers, broilers, turkeys and ducks. [c] Includes sheep, goats and horses.

VI. Treatment Technologies and Management Practices (Technology Appendix: Feedlot Industry Sector Profile unless otherwise noted)

One primary method for source reduction of waste is optimizing the amount of nutrients and other parameters of concern in feed, or increasing the animal assimilation efficiency (Section 11.3). Feeding efficiency has been improved because of extensive research in animal nutrition. Stabilized manure, or plants grown from manure can be fed to animals that can further absorb nutrients not taken up by the original animal (Section 11.11). Actions that restrict the addition of water to the waste, whether as precipitation, spillage from feeding, washwater, or as a part of a manure handling or removal method, both diminish the risks of discharge and decrease the costs of transporting manure (Section 11.12).

Aluminum, calcium, and iron compounds have been added to manure to decrease the water-soluble phosphorus fraction in poultry manure, and to decrease nitrogen loss (Profile Section 11.10). Other chemical amendments have been tested for reduction of odor-causing agents, for binding metals, nutrients, and other compounds, and for promoting waste-degrading bacteria (Sections 11.8 and 11.10).

Manure collection methods vary by animal, size of facility, season, climate, geography, and several other factors (Section 11.4). Manure as excreted ranges from 2% solids for veal excreta (Feedlots Industry Sector Profile, section 11.0) to 39% solids for duck excreta (Feedlots Industry Sector Profile, section 7.0). Solid waste handling systems are appropriate where the solids content is greater than 18 percent. Semisolid manure has a solids content ranging from 10 to 16 percent. A solids content of four to 10 percent allows manure to be treated as a slurry. Manure with a solids content of less than 4 percent is considered liquid (Feedlots Industry Sector Profile, section 3.4). Operations frequently either add water to lower the solids content or add bedding to increase the solids content as needed for their collection or treatment systems. The type of housing system affects the quantity of bedding or dilution water used in a manure management system. This, in turn, influences the manure characteristics and selection of collection, transfer, storage, and transport equipment.

The advantage of solid handling is reduced total volume (Feedlots Industry Sector Profile, section 4.3). Labor requirements may be greater in solid waste handling operations since waste handling cannot be easily automated. Liquid systems are usually associated with the lagoon waste management system (sections 3.4 and 11.4). Liquid systems are favored by large operations because labor costs are minimized and a flushing system can be used to collect and transport waste to the lagoon. However, this approach increases the volume of manure to be handled, treated, and stored and requires a larger capital investment for equipment and storage facilities (Feedlots Industry Sector Profile, section 4.3).

Waste storage volume can be reduced by diverting clean water (precipitation and surface flow) from contact with manure (Feedlots Industry Sector Profile, section 4.3). In high-rainfall regions, roofing on storage can be used to keep precipitation out so that manure can continue to be handled as a solid or semisolid (Feedlots Industry Sector Profile, section 3.4). Separation of liquids and solids reduces the solids entering a storage facility and extends its storage capacity (sections 4.3 and 11.5). Separation of liquids and solids is also advantageous in that the solids from separation are cheaper to transport.

Selection of storage and treatment methods can have broader environmental implications. Open air treatment and storage facilities, including stacked manure and uncovered lagoons, lose a large amount of nitrogen (mostly as ammonia) to the atmosphere (Sections 11.1 and 11.4). Although lagoons can be covered, operations often do not have an economic impetus to do so unless they intend to collect biogas for energy or do so in response to complaints about odor. Earthen storage basins can be lined with clay or a synthetic liner (sometimes both) to prevent leakage to ground water (sections 4.3 and 11.4).

Land application of raw or treated animal wastes can be beneficial if based on a nutrient management plan, which ensures that manure is applied at agronomic rates (Section 11.10). In order to optimize crop uptake while minimizing runoff, volatilization, and groundwater infiltration, manure should be applied (1) as close to the time of crop needs as possible, (2) during low rainfall periods, (3) when the ground surface is not frozen, and (4) when soil moisture is low enough to avoid compaction (Feedlots Industry Sector Profile, section 4.3). The rate of manure application can be determined by balancing crop uptake with existing soil nutrients. Nutrient availability for plant uptake is greater when manure is applied (1) in the spring, (2) when the soil is finely textured, (3) in areas of low precipitation, and (4) when the manure is incorporated or injected rather than just surface applied (Feedlots Industry Sector Profile, section 11.10). To limit nutrient losses, odors, and pollution potential, manure must be applied correctly (Feedlots Industry Sector Profile, section 8.3). Proper timing and application rates can reduce nutrient losses through volatilization, denitrification, leaching, and erosion.

Composting produces an excellent soil conditioner that improves organic matter content, soil quality, and nutrient content and protects against cropland erosion (Feedlots Industry Sector Profile, sections 4.3 and 11.7). Composted manure contains about one-half the nitrogen of fresh manure; moreover, much of the nitrogen is in an organic form that is less susceptible to leaching and volatilization. Properly managed composting has proven an effective method for controlling pathogens. Composting can be labor-intensive and expensive. However, it may reduce transportation costs since composted material is typically one-half the uncomposted volume. Compost can also be used for the disposal of dead animals.

Liquid waste treatment processes include anaerobic digestion in lagoons or tanks, aerobic digestion with mechanical aerators, constructed wetland systems, and scaled-down multistage treatment plants (Feedlots Industry Sector Profile, sections 7.3 and 11.6). Anaerobic digestion decomposes organic material in the absence of air, releasing biogas, a combination of methane and carbon dioxide (Feedlots Industry Sector Profile, section 11.6). Biogas, when collected, can be used as an energy source. However, incomplete anaerobic decomposition of organics can result in offensive by-products, primarily hydrogen sulfide, ammonia, and intermediate organic acids, which may cause disagreeable odors (Feedlots Industry Sector Profile, section 9.3). Aerobic lagoons provide aerobic decomposition of organic matter, which generates less odor (Feedlots Industry Sector Profile, sections 4.3 and 11.4). Oxidation ditches can provide both aerobic and anaerobic treatment in the same unit (section 11.8). Because of the consistency of animal waste, these systems often require large surface areas or high equipment/energy costs to provide sufficient oxygen. Proper construction, operation, and maintenance of a lagoon are critical to prevent leaking, leaching, overflow, and failure (see appendix in Environmental Impacts of Animal Feeding Operations). This includes periodic removal of the nutrient-rich sludge which accumulates in lagoons. This sludge is commonly land applied.

Constructed wetlands and vegetative filter strips use plants to take up nutrients and capture suspended solids from animal waste (Section 11.9). Because sediments can quickly overload the system, some solids removal is general provided before liquids are treated through a vegetative filter area. A vegetative filter is only effective for small quantities of runoff (relatively infrequent or low-intensity runoff events) since continuous application nullifies the ability of the filter strip to take up nutrients (Feedlots Industry Sector Profile, section 4.3). Plant uptake transforms the nutrients into biomass that can be harvested.

A. **Approximate Costs and Effectiveness** (Technology Appendix; Feedlots Industry Sector Profile, Section 11.0)

Performance and cost information presented in the literature examined is often site- or region-specific and is not presented using consistent units or parameters. Cost is also highly dependent on the size of the system needed, among other factors. Technologies for which information was available generally fit into four groups: vegetative, chemical, biological, and physical treatment.

Vegetative treatment can be represented by such technologies as constructed wetlands and vegetative filter strips. Constructed wetlands can remove in the range of 45-60% nitrogen, 54-69% phosphorus, and 51-56% solids, and eliminate 89-95% of fecal coliform bacteria. A wetland costs in the range of $95,000 to construct. Vegetative filter strips can remove approximately 0-84% nitrogen, 27-96% phosphorus, and 56-97% solids, and also reduce bacteria. A vegetative filter strip can cost around $295 per acre.

An example of chemical treatment is flocculation using polyacrylamide (PAM). PAM can remove 80% of the total suspended solids in a wastewater, and costs approximately $2.50 per kilogram.

A typical biological treatment for this industry is the use of anaerobic digestion, usually in a lagoon. However, aerated lagoons, sequencing batch reactors (SBR), composting, and biofilters can all fit into this category. The literature suggests that SBRs are highly effective at removing nitrogen, and aerobic and anaerobic lagoons, biofilters are moderately effective at removing nitrogen. Covered anaerobic digesters retain the nitrogen in the wastewater, and are therefore considered poor at removing nitrogen. All of the technologies just discussed are considered moderate in their ability to remove phosphorus, which partitions to sludge in lagoons and digesters. The treatment lagoons and digesters are all considered excellent at reducing chemical and biochemical oxygen demand. Composting and SBRs are both considered excellent at reducing pathogens, whereas anaerobic digestion is considered moderate. Covered aerobic digesters and SBRs provide excellent odor reduction, whereas composting and biofilters provide moderate odor reduction.

SBRs, biofilters, and aerated lagoons are considered high-cost technologies, as is a covered anaerobic digester. However, an uncovered anaerobic lagoon is considered low-cost. Composting is considered a mid-level cost technology. Some example construction cost ranges are $16,000 to $370,000 for anaerobic digestion and $20,000 to more than $130,000 for on-site composting. A covered anaerobic digester can recover some of the costs by collecting biogas generated (in the range of $9,000 to $160,000 per year).

Examples of physical treatment include mechanical separation and particulate settling, which can occur during storage. Mechanical separation provides moderate removal of nutrients, oxygen demand, pathogens, and odor. It also provides solids reduction anywhere in a range from 16% to 81%. In storage, anywhere from 11% to 84% of nitrogen can be lost to the atmosphere or otherwise removed from wastewater. Phosphorus and potassium partition to sludge, removing anywhere from 9% to 92% of phosphorus and 5% to 85% of potassium. Lagoons are generally more effective at removing nutrients than pits. Settling also removes from 39% to 85% of the solids.

B. Industry Practices (Technology Appendix; Feedlots Industry Sector Profile unless otherwise noted)

Dairy (Feedlots Industry Sector Profile, section 3.0): Since 1991 the proportion of small herds have steadily decreased while the proportion of larger herds (50 or more head) have steadily increased. In 1992, more than one-half of all operations were in the North-Central Region, although more than one-half of the operations with 500 or more animal units were in the West Region. Most dairy cows have access to pasture at least part of the time, so some manure from otherwise confined animals is not collected. Three-fourths of dairy operations have a distance of 500 or more feet between manure storage and the nearest waterway or body of water. More than 80 percent of dairy operations have a distance of 200 or more feet between manure storage and the nearest well. Operations with 200 or more milk cows have a large proportion of operations with anaerobic lagoons without covers (47 percent); 68 percent of all dairy operations do not use storage tanks or lagoons. Most (99 percent) operations apply manure to land owned or rented by the operator. Larger operations have exploited other disposal options including selling, composting, and giving the manure away more than smaller operations. Larger operations also tend to analyze manure for nutrient content more than smaller operations, yet less than one-half of all dairy operations establish manure application rates based on manure nutrients and/or crop needs. For those operations that applied manure to their own land, 56 percent of operations apply manure on a daily or weekly basis during summer months. During winter months, 61 percent of operations dispose of manure on a daily or weekly basis. Broadcast spreaders are the most prevalent equipment used to apply manure regardless of operation size, but they are more common on small operations and can be used for solid or semisolid waste. Larger operations have a higher frequency of irrigation systems for disposing of liquid wastes. Once the solids are removed, grass filter strips can provide surface disposal of effluent. Filter strips can by used by dairy facilities producing less than about 500 gallons per day of milking center wastewater where soil is not too sandy. The dilute wastewater is less likely to overload the filter strip than operations with larger volumes or more concentrated wastewater.

Beef (Feedlots Industry Sector Profile, section 4.0): In 1992, more than one-third of all operations were in the North-Central Region. Most cow-calf operations use pasture for calving. Despite the high proportion of cow-calf operations that use pasture, many operations also provide hay, silage, supplements, or grain depending on the season. About 47% of cow-calf operations haul manure for spreading. In the finishing phase, cattle are generally confined. Unlike grazed land, the runoff from beef feedlots contains high levels of nutrients, salts, bacteria, and organic matter. In 1994, 42 percent of operations with more than 1,000 head began a ground and surface water monitoring program. Nearly 70 percent of these operations also changed their manure management program from 1989. Of operations of this size, 88 percent use their own land to dispose of manure. They also give the manure away (23 percent), sell the manure (9.3 percent), pay someone to take the manure (6.6 percent), or dispose of it by another method (4.1 percent). More than one-third of beef operations with more than 1,000 head test the manure nutrient content, compared with only 7.7 percent of smaller operations. About half of smaller operations and 70 percent of operations with more than 1,000 head test the nutrient content of the soil. However, only one-third of the smaller operations and 63 percent of the operations with more than 1,000 head that test soil use the results to set manure application rates. Forty-five percent of operations with more than 1,000 head and 10 percent of smaller operations test ground water. Nearly 95 percent of dead animals are sent to a renderer for disposal. In some feedlots, a solids separator is used as pretreatment to a retention pond. Dry manure can also be mixed with various bedding materials for loafing barns and resting areas, or it can be recycled as livestock feed.

Sheep (Feedlots Industry Sector Profile, section 5.0): Both the number of operations and the number of sheep raised are slowly decreasing over time. Although only 13% of operations are in the Mountain region, this region has the highest fraction of large operations. Because of sheep manure's density and moisture content (75 percent water), the manure is almost always handled as a solid by scraping and hauling to the field. In fact, handling it as a liquid is difficult because manure solids float to the surface.

Horses (Feedlots Industry Sector Profile, section 6.0): Race tracks account for 53 percent of the operations with 20 or more equids, followed by boarding/training facilities (27 percent) and breeding (23 percent). Horse manure is best handled as a solid. Less than 40 percent of operations say that they compost manure or waste bedding on site at least some of the time. For those operations with more than 20 equids, the most common method of disposal was to apply the waste to fields where no animals graze (31 percent), followed by applying it to fields where livestock graze (30 percent).

Ducks (Feedlots Industry Sector Profile, section 7.0): Both the number of operations and the number of ducks raised have been steadily decreasing. Most commercial ducks are raised in the Midwest. Feed enzymes have been shown to provide 10 percent improvement in nitrogen absorption in ducks. Large-scale operations confine ducks year-round and seldom incorporate outside ranges or swimming The most costly but effective dry litter storage facilities have a permanent roof. Dry litter, duck manure, and carcasses can be treated by composting the materials. Manure collected as a semisolid or liquid is typically stored in tanks or lagoons outside the house.

Goats (Feedlots Industry Sector Profile, section 8.0): Goat manure is normally handled as a solid because it does not liquefy well and is unsuitable for liquid manure handling and treatment systems. Milking parlor waste is either handled as a solid or washed as a semi-solid into an outside storage tank or lagoon. Goat manure is typically not treated before being disposed of on land.

Swine (Feedlots Industry Sector Profile, section 9.0): While many farms still raise relatively small numbers of pigs outdoors, the trend in the swine industry is toward larger confinement farms where pigs are raised indoors. Confined, three-site operations predominate in the Southeast, South-Central, and West Regions, but the Midwest continues to be the nation's leading hog producer. Several nutritional strategies have been developed for use with hogs. Fine grinding and pelleting improve feed utilization and decrease nitrogen and phosphorus excretion. Supplementing the diet with synthetic lysine to meet part of the dietary lysine requirement reduces nitrogen excretion. Dividing the growth period into more phases with less spread in weight allows producers to more closely meet the pig's protein requirements. Supplementing the diet with the enzyme phytase reduces phosphorus excretion. Nearly all operations dispose of their waste on their farm; the largest size group does so mostly by irrigation. Only four percent of the nation's hog operations separate the solid and liquid portions of waste. Treatment of manure to separate nutrients can be economical when the cost of storing and hauling manure slurry exceeds its potential value as a fertilizer. Anaerobic lagoons without covers are used most frequently by operations that market more than 10,000 hogs. Producers disposed of animal carcasses most often by burying them.

Chickens and Turkeys (Feedlots Industry Sector Profile, section 10.0): Broiler, layer, and turkey production in the United States has increased over the last decade. The number of broiler operations is highest in the Southeast. The highest numbers of turkey and layer operations are in the North Central region. Manure from scrape-out and belt systems usually has a moisture content of between 70 and 85 percent. Therefore, the manure must be handled as a slurry and is either injected or land applied with a spreader that can handle the high-moisture manure. The high nutrient content of poultry manure presents alternative management strategies. Composting and bagging a pelleted poultry manure fertilizer produces a marketable product for the commercial horticulture industry. Ease of handling, lack of objectionable odor, and freedom from pathogens makes composted poultry manure an attractive soil amendment. The high concentration of phosphorus and protein in poultry manure has been capitalized upon as a dietary supplement for cattle in poultry-producing areas since the 1950s.

VII. Environmental Impacts (Appendix; Environmental Impacts of Animal Feeding Operations

According to EPA's 1996 *National Water Quality Inventory*, agricultural operations, including animal feeding operations (AFOs), are a significant source of water pollution in the U.S. States estimate that agriculture contributes to the impairment of at least 173,629 river miles, 3,183,159 lake acres, and 2,971 estuary square miles. Twenty-two states reported on the impacts of specific types of agriculture on rivers and streams, attributing 20 percent of the agricultural impairment to intensive animal operations. In addition, NOAA reports that feedlots were a contributing factor in 110 of the 3,404 impaired shellfish areas in 1995. These findings, as well as incidents of waste spills, excessive runoff, leaking storage lagoons, and odor problems, have heightened public awareness of environmental impacts from AFOs. Grazing and range animal operations also present a significant environmental concern, although many of the associated impacts are not addressed in this study. Such impacts include physical damage to stream channels and riparian vegetation, compaction and reduced infiltration of soils, and imbalance in terrestrial plant communities due to selective grazing.

AFO pollutants can impact surface water, groundwater, air, and soil. In surface water, the waste's oxygen demand and ammonia content can result in fish kills and reduced biodiversity. Solids can increase turbidity and smother benthic organisms. Nitrogen and phosphorus can contribute to eutrophication and associated algae blooms. These blooms can produce negative aesthetic impacts and increase drinking water treatment costs. Turbidity from the blooms can reduce penetration of sunlight in the water column and thereby limit growth of seagrass beds and other submerged aquatic vegetation, which serve as critical habitat for fish, crabs, and other aquatic organisms. Decay of the algae (as well as night-time algal respiration) can lead to depressed oxygen levels, which can result in fish kills and reduced biodiversity. Eutrophication is also a factor in blooms of toxic algae and other toxic estuarine microorganisms, such as *Pfiesteria piscicida*. These organisms can impact human health as well as animal health. Human and animal health can also be impacted by pathogens and nitrogen in animal waste. Nitrogen in manure is easily transformed into nitrate form; transport to drinking water sources can result in potentially fatal health risks to infants. Trace elements in manure may also present human and ecological risks. Salts can contribute to salinization and disruption of the ecosystem. Antibiotics, pesticides, and hormones may have low-level, long-term ecosystem effects.

In groundwater, pathogens and nitrates from manure can impact human health via drinking water. Additionally, leaching salts may cause groundwaters to become unsuitable for human consumption. Nitrate contamination is more prevalent in groundwaters than surface waters. EPA found that nitrate is the most widespread agricultural contaminant in drinking water wells, and estimates that 4.5 million people are exposed to elevated nitrate levels from drinking water wells.

In soils, trace elements and salts from land-applied manure can accumulate and become toxic to plants. Salts can deteriorate soil quality by leading to reduced permeability and poor tilth. Crop uptake may provide a human and animal exposure pathway for trace elements and pathogens.

Air emissions from AFOs also produce environmental impacts. Odors from anaerobic waste decomposition are particularly offensive. Odors can produce mental health impacts, and many odor-causing substances (e.g., ammonia, hydrogen sulfide, and organic dusts) can also cause physical impacts. Furthermore, volatilized ammonia can be redeposited on the earth and contribute to eutrophication of surface waters. Methane emissions from anaerobic waste lagoons are a concern because they contribute to global warming.

Nutrients are a major source of impairment of U.S. waters. Several studies have focused on nutrient contribution from animal waste and other sources (e.g., point sources, commercial fertilizers, atmospheric deposition, and urban runoff). In many watersheds, animal waste represents a significant portion of the total nutrients added. In several counties, nutrients from confined animals exceed the uptake potential of non-legume harvested cropland and hayland, according to a USDA analysis of 1992 conditions. USDA found that recoverable manure nitrogen exceeds crop system needs in 266 of 3,141 counties, and that recoverable manure phosphorus exceeds crop system needs in 485 counties. The USDA analysis is not intended to represent actual manure management practices or transport of applied nutrients, and cannot be used to indicate the presence or absence of water quality problems. However, it is useful as a general indicator of excess nutrients on a broad-scale basis.

Transport factors were considered in a national modeling effort by the USGS. Modeling of 1987 conditions indicates that animal manure (from all livestock, not just confined animals) is a significant contributor to in-stream nutrient concentrations in watershed outlets. Per the estimates, manure is a greater contributor than point sources to in-stream total nitrogen in 1,802 (88%) of the 2,056 watershed outlets in the U.S. Additionally, manure is the single largest contributor to total nitrogen in 113 watersheds. USGS also found that manure is a significant contributor to in-stream total phosphorus concentrations, noting that livestock waste is a greater contributor than commercial fertilizer.

It is important to note that waste quantity is not the only risk factor with respect to potential environmental impacts. For example, other factors that can influence environmental risk include waste handling methods, availability of sufficient land for agronomic application of the waste, proximity to populated areas and water bodies, depth to groundwater, climate, and soil type.