CHAPTER 13

NON-WATER QUALITY IMPACTS

13.0 INTRODUCTION

Eliminating or reducing one form of pollution may create or aggravate other environmental problems. Sections 304(b) and 306 of the Clean Water Act (CWA) require that the U.S. Environmental Protection Agency (EPA) consider the non-water quality environmental impacts (NWQI) of effluent limitations guidelines and standards. This chapter presents the methodology and estimates from EPA's NWQI analysis of seven primary regulatory options that were considered for concentrated animal feeding operations (CAFOs), including beef (includes heifer) operations, dairies, veal, swine, broiler, layer, and turkey operations. These impacts include:

- Air emissions from the animal production area, including animal housing and manure storage and treatment areas;
- Air emissions from application of manure to land;
- Air emissions from vehicles, including those involved in off-site transport of manure and in on-site composting operations; and
- Energy impacts from land application activities, the use of digesters, and the transportation of manure.

Typically, NWQI also include estimates of the generation of solid waste. Because manure is considered a by-product of animal feeding operations and is not regulated directly, the solid waste NWQI of the manure are not considered. In addition, although the chemical content of the manure may change, the amount of manure generated is not expected to change under any of the regulatory options being considered; therefore, this chapter does not discuss solid waste NWQI.

The remainder of this chapter contains the following information:

- Section 13.1 presents an overview of the analysis and pollutants;
- Section 13.2 discusses the methodology for estimating air emissions from animal feeding operations;
- Section 13.3 discusses the methodology for estimating air emissions from land application activities;
- Section 13.4 discusses the methodology for estimating air emissions from vehicles;
- Section 13.5 discusses the methodology for estimating energy impacts;

- Section 13.6 summarizes the industry-level non-water quality impacts for Large and Medium CAFOs; and
- Section 13.7 lists the references used in this section.

EPA's Office of Air Quality Planning and Standards also conducted an in-depth study of air emissions from animal feeding operations and prepared a draft report in August 2001. The National Academy of Sciences subsequently reviewed this report, and since that time, EPA has updated the available data used to develop air emission factors. This chapter presents results based on available data and methodologies developed as of September 2002. A more detailed description of the analysis is provided in the report *Non-Water Quality Impact Estimates for Animal Feeding Operations* (ERG, 2002a).

13.1 Overview of Analysis and Pollutants

A number of factors affect the energy use at and the pollutant emissions from CAFOs. Most of the substances emitted are the products of microbial processes that decompose the complex organic constituents in manure. The microbial environment determines which substances are generated and at what rate. This section describes the chemical and biological mechanisms that affect the formation and release of emissions.

The pollutants included in this analysis are:

- Ammonia. Ammonia is a by-product of the microbial decomposition of the organic nitrogen compounds in manure. Nitrogen occurs as both unabsorbed nutrients in manure and as either urea (mammals) or uric acid (poultry) in urine. Urea and uric acid hydrolyze rapidly to form ammonia and are emitted soon after excretion. Urea plus ammonia nitrogen from urine usually accounts for 40 to 50 percent of the total nitrogen excreted in manure (Van Horn et al., 1994).

  Ammonia continues to form during the microbial breakdown of manure under both aerobic and anaerobic conditions. Because it is highly soluble in water, ammonia accumulates in manure handled as liquids and semisolids or slurries, but volatilizes rapidly with drying from manure handled as solids. In aqueous solution, ammonia reacts with acid to form ammonium, which is not gaseous. The chemical equilibrium in an acid environment promotes rapid conversion of ammonia to ammonium with little release of ammonia to the atmosphere. Because most animal manure, lagoons, and feedlot surfaces have a pH greater than 7.0 (i.e., a nonacidic environment), ammonia is rapidly lost to the atmosphere. Consequently, ammonia losses from animal manure can easily exceed 50 percent (Van Horn et al., 1994).

- Nitrous oxide. Nitrous oxide can also be produced from the microbial decomposition of organic nitrogen compounds in manure. Unlike ammonia, however, nitrous oxide is emitted only under certain conditions. Nitrous oxide is emitted only if nitrification occurs and is followed by denitrification. Nitrification is the microbial oxidation of ammonia to nitrites and nitrates, and the process requires an aerobic environment. Denitrification is most commonly a microbially mediated process where nitrites and nitrates are reduced under anaerobic conditions. The principal end product of denitrification is dinitrogen gas (N_2). However, small amounts of nitrous oxide as well as nitric oxide also can be generated under certain conditions. Therefore, for nitrous oxide emissions to occur, the manure must first be handled aerobically and then anaerobically.

Research indicates that aerobic manure storage, such as composting, produces more nitrous oxide than anaerobic storage, such as lagoons (AAF Canada, 2000). In general, manure that is handled as a liquid tends to produce less nitrous oxide than manure that is handled as a solid. The quantity of nitrous oxide generated is typically small and varies significantly depending on environmental conditions such as pH, drainage, and plant uptake.

- Methane. With respect to livestock emissions, methane is produced in the normal digestive processes of animals and during the decomposition of animal manure. This analysis assesses only the amount of methane produced in manure decomposition. Livestock manure is principally composed of organic material. When this organic material decomposes in an anaerobic environment, methanogenic bacteria, as part of an interrelated population of microorganisms, produce methane. Methane is insoluble in water. Thus, methane volatilizes from solution as rapidly as it is generated. Concurrent with the generation of methane is the microbially mediated production of carbon dioxide, which is only sparingly soluble in water. The mixture of these two gases is commonly referred to as biogas.

The principal factors affecting methane emission from animal manure are the methane-producing potential of the waste and the portion of the manure that decomposes anaerobically. The second factor depends on the biodegradability of the organic fraction and how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, pits), it tends to decompose anaerobically and produce a significant quantity of methane. When manure is handled as a solid (e.g., in stacks or pits) or when it is deposited on pastures and rangelands, it tends to decompose aerobically, producing little or no methane (IPCC, 2000).

- Hydrogen sulfide. Hydrogen sulfide is produced and subsequently emitted from animal manure only under anaerobic conditions and results from the mineralization of organic sulfur compounds and the reduction of the more oxidized inorganic forms of sulfur, including sulfites and sulfates. In animal manure, the principal organic sulfur compounds are the sulfur amino acids, and the principal sources of inorganic sulfur are minerals, such as copper and zinc, which are added to diets to correct nutritional deficiencies or to serve as growth stimulants. High concentrations of hydrogen sulfide can be released by agitation and pumping of liquid wastes. Although only small amounts of hydrogen sulfide are produced in a manure tank compared with the other major gases, this gas is heavier than air and becomes more concentrated in the tank over time. Research has determined that hydrogen sulfide production from animal feeding operations depends on the average outside air temperature, the size of the housing or waste management areas, the air retention time in the housing areas, and the daily sulfur intake of the animals.

- Criteria air pollutants. Criteria air pollutants are those pollutants for which a national ambient air quality standard has been set. Animal feeding operations that transport their manure off site and/or compost their manure on site use equipment (e.g., trucks, tractors) that release criteria air pollutants when operated. These pollutants are also released when biogas, generated from energy recovery systems for anaerobic digesters, is used for fuel (e.g., in an engine or flared). The criteria air pollutants included in this analysis are volatile organic compounds, nitrogen oxides, particulate matter, sulfur dioxide, and carbon monoxide.

- Energy usage. CAFOs also use energy when transporting manure off site, applying manure to land, and performing on-site operations such as composting. In some cases, the CAFO may generate energy from capturing and using biogas. Energy usage included in this analysis is expressed in kilowatt hours (kW-hr) and in consumed fuel (gallons). Energy use also includes production of fertilizer. Though CAFOs do not generate commercial fertilizer, the manure is used as a fertilizer replacement. Since the criteria air pollutants analysis reflects NWQI due to increased hauling distances and spreading of manure, an energy usage NWQI estimate is used to reflect national reductions in fertilizer consumption. This analysis of reductions in commercial fertilizer use are included in the memorandum entitled “Commercial Fertilizer Analysis” (ERG, 2002).

Where possible, the NWQI estimates for each regulatory option are presented in relation to the baseline conditions under which animal feeding operations generate air emissions and use energy (i.e., prior to implementation of a regulatory option). In some cases, however, there were insufficient data to quantify baseline NWQI. In these cases, the impacts presented in this chapter reflect only the change in impacts expected to result from implementation of the regulatory options from baseline.

13.2 Air Emissions from Animal Feeding Operations

Animal feeding operations generate various types of animal wastes, including manure (feces and urine), waste feed, water, bedding, dust, and wastewater. Air emissions are generated from the decomposition of the wastes from the point of generation through the management and treatment of these wastes on site. The rate at which emissions are generated varies as a result of a number of operational variables (e.g., animal species, type of housing, waste management system) and weather conditions (e.g., temperature, humidity, wind, time of release).

EPA evaluated air releases from animal confinement areas and manure management systems under baseline conditions and seven regulatory options considered by the Agency. Little data exist to allow for a complete analysis of all possible compounds; therefore, this analysis focused on the release of ammonia, hydrogen sulfide, and greenhouse gases (methane and nitrous oxide) from animal confinement areas and manure management systems and certain criteria air pollutants (carbon monoxide, nitrogen oxides, and volatile organic compounds) from energy recovery systems.

This section summarizes the methodology used for the following air emission calculations from the animal feeding operation:

- Section 13.2.1 - Ammonia and hydrogen sulfide from animal confinement areas and manure management systems;
- Section 13.2.2 - Greenhouse gases from animal confinement areas and manure management systems; and
- Section 13.2.3 - Criteria air pollutants from energy recovery systems.

A detailed description of the data inputs and equations used to calculate these air emissions is provided in the report *Non-Water Quality Impact Estimates for Animal Feeding Operations* (ERG, 2002a).

13.2.1 Ammonia and Hydrogen Sulfide Emissions From Animal Confinement Areas and Manure Management Systems

Animal housing and manure management systems produce ammonia and hydrogen sulfide emissions. Nitrogen is the primary component of animal waste most likely to generate air emissions. Total nitrogen comprises organic nitrogen, ammonia, nitrite, and nitrate. The primary form of nitrogen emissions from animal feeding operations to the atmosphere occurs as ammonia. For this analysis, EPA calculated emissions of ammonia for drylots, confinement houses, ponds and lagoons, and composted manure.

Hydrogen sulfide is produced by anaerobic decomposition of organic wastes such as animal manure. High concentrations can be released by agitation and pumping of liquid wastes. Research has determined that hydrogen sulfide production from animal feeding operations depends on the average outside air temperature, the size of the housing or waste management areas, the air retention time in the housing areas, and the daily sulfur intake of the animals. EPA estimated hydrogen sulfide emissions for confinement houses operating deep-pit systems, as these are production areas with anaerobic conditions.

The Agency based emission rates of ammonia and hydrogen sulfide on the emission factor and the amount of nitrogen or sulfur in the excreted manure. Emission factors depend upon the animal species as well as the type of animal confinement and manure management area. Because only swine emission factors for hydrogen sulfide have been published in the literature, EPA transferred these data to other animal types.

Livestock may be confined in a number of different ways that impact the type and amount of ammonia emissions. Some animals are housed in traditional confined housing (e.g., tie stall barns, freestall barns), while others are confined in outdoor areas (e.g., drylots, paddocks). Studies have shown that the method of confinement directly affects the emission of ammonia (Jacobson et al., 2000). Management of waste within the confinement area (e.g., litter system, deep-pit, freestall) also influences emissions of both ammonia and hydrogen sulfide. For instance, deep-pit systems are associated with a higher nitrogen emission factor because waste remains in the pit for a longer period of time, increasing ammonia volatilization.

Anaerobic lagoons and waste storage ponds are major components of the waste management systems at many animal feeding operations. These systems rely on microbes that biodegrade organic nitrogen to ammonium and ammonia. The ammonia continuously volatilizes from the surface of lagoons and ponds. The high sulfur content of swine, dairy, veal, and layer waste also results in hydrogen sulfide emissions from lagoons. Settling basins, used as a technology basis for several regulatory options, are estimated to remove 50 percent of manure solids at an operation. The remaining 50 percent reach the pond or lagoon. It is assumed that these basins remove approximately 12 percent of nitrogen and 50 percent of sulfur; therefore, 88 percent of the nitrogen and 50 percent of the sulfur excreted in manure enters the storage pond or lagoon.

The seven regulatory options, based on the implementation of different types of waste management systems, influence whether emissions of ammonia and/or hydrogen sulfide will increase or decrease when compared to baseline.

13.2.2 Greenhouse Gas Emissions from Animal Confinement Areas and Manure Management Systems

Manure management systems, including animal confinement areas, produce methane (CH_4) and nitrous oxide (N_2O) emissions. Data used to estimate greenhouse gas emissions include: animal weight, volatile solids excretion rate, nitrogen excretion rate, maximum methane-producing potential, runoff solids generation, and manure composted. The maximum methane-producing potential is the maximum volume of methane that can be produced per kilogram of volatile solids and is based on the type of animal and its diet. The methane and nitrous oxide emissions were estimated based on the guidance developed for international reporting of greenhouse gas emissions (IPCC, 2000) and used by EPA's Office of Air and Radiation.

Methane production is directly related to the quantity and quality of waste, the type of waste management system used, and the temperature and moisture of the waste (EPA, 1992). In general, manure that is handled anaerobically will produce more methane, while manure that is handled aerobically produces little methane. For example, liquid and slurry systems result in higher methane production because they promote anaerobic conditions. Certain animal populations, such as beef cattle on feedlots, may produce more methane if they are fed higher energy diets. Methane is also produced from the digestive processes of ruminant livestock as a result of enteric fermentation. However, because the regulatory options do not establish requirements dictating specific feeding strategies that affect diet, the effect on enteric fermentation methane emissions is difficult to predict and is not discussed further.

Nitrous oxide is produced as part of the nitrogen cycle through the nitrification and denitrification of the organic nitrogen in livestock manure and urine. The emission of nitrous oxide from manure management systems is a function of the nitrogen content of the manure, as well as the length of time the manure is stored and the specific type of system used. In general, the amount of nitrous oxide emitted from manure management systems tends to be small because conditions are often not suitable for nitrification to occur; however, when nitrous oxide is generated, manure that is handled as a liquid tends to produce less nitrous oxide than manure handled as a solid. The amount of emitted nitrous oxide depends upon the nitrogen excreted by the animal, and emission factors are assumed not to vary regionally.

13.2.3 Criteria Air Emissions From Energy Recovery Systems

Criteria air pollutants are those pollutants for which a national ambient air quality standard has been set. The criteria pollutants evaluated as non-water quality impacts from energy recovery systems include oxides of nitrogen (NOx), which are precursors to ozone, as well as carbon monoxide (CO) and sulfur dioxide (SO_2). These criteria pollutants are formed from the flaring and combustion of biogas.

NOx emissions result from the oxidation of nitrogen compounds in biogas and from thermal formation during the flaring and combustion processes. No emission factors incorporate both situations; therefore, EPA estimated emissions using an emission factor for each situation and a subsequent calculation estimating the amount of volatilized ammonia oxidized to NOx. EPA calculated sulfur dioxide emissions under the assumption that the sulfur compounds in biogas are completely oxidized in both the flare and gas turbines and estimated carbon monoxide emissions associated with the incomplete combustion of methane and other organic compounds.

Criteria pollutant air emissions from flaring and energy recovery systems are expected under Options 5 and 6. Under Option 5, anaerobic lagoons at all swine, chicken, and veal operations are modeled as covered, and the biogas is vented to a flare. Option 6 is based on the implementation of anaerobic digestion systems with energy recovery for Large swine operations and dairies. Options 5 and 6 greatly reduce the emissions of methane through the capture of biogas; however, flaring the biogas or using it in an energy recovery system will increase emissions of the criteria pollutants NOx, SO_2, and CO. These pollutants are generated from oxidation of nitrogen (from NH_3), sulfur (from H_2S), and carbon compounds (from organics and methane).

13.3 <u>Air Emissions from Land Application Activities</u>

Applying animal manure from animal feeding operations to cropland generates air emissions. These emissions result primarily from the volatilization of ammonia at the point the material is applied to land (Anderson, 1994). Additional emissions of nitrous oxide are released from cropland when nitrogen applied to the soil undergoes nitrification and denitrification. Loss through denitrification depends upon the oxygen levels of the soil to which manure is applied. Low oxygen levels, resulting from wet, compacted, or warm soil, increase the amount of nitrate-nitrogen released into the air as nitrogen gas or nitrous oxide (OSUE, 2000). However, a study by Sharpe and Harper (1997), which compared losses of ammonia and nitrous oxide from the sprinkler irrigation of swine effluent, concluded that ammonia emissions contributed more to airborne nitrogen losses. This analysis of air emissions from land application activities focuses on the volatilization of nitrogen as both ammonia and nitrous oxide and quantified both on- and off-site emissions.

The amount of nitrogen released into the environment from the land application of animal waste is affected by the rate and method by which it is applied, the quantity of material applied, and site-specific factors such as air temperature, wind speed, and soil pH. There were insufficient data to quantify the effect of site-specific factors; therefore, they were not addressed in this analysis.

Ammonia emissions depend on the ammonia volatilization rate and the amount of manure applied on and off site. The ammonia volatilization rates used to estimate total ammonia emissions are animal-specific and are based on the application method and the rate of incorporation. Ammonia losses were calculated separately for beef feedlots, dairies, and poultry and swine operations, and total emissions were estimated by summing the volatilization from solid and liquid application. Nitrous oxide emissions were calculated based on the methodology described in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000*, EPA 236-R-02-003 (EPA, 2002). This methodology estimated that 1.25 percent of the nitrogen that is land applied, but does not volatilize to ammonia, will be emitted as nitrous oxide, and that one percent of the nitrogen that volatilizes as ammonia will eventually become nitrous oxide. Like ammonia, the total amount of nitrous oxide emitted on and off site was calculated by summing the emissions resulting from both solid and liquid waste application.

Although ammonia volatilization may be reduced by implementing application techniques aimed at conserving nitrogen, this is not required by any regulatory option. However, Option 5, which mandates total confinement and covered lagoon storage, results in an increased concentration of applied nitrogen and elevated ammonia and nitrous oxide emissions from land application activities. The composting requirement of Option 5A is expected to result in increased emissions of ammonia and nitrous oxide, due to drier manure handling and windrow turning.

13.4 Air Emissions From Vehicles

Animal feeding operations that transport their manure off site and/or compost their manure on site use equipment (e.g., trucks, tractors) that release criteria air pollutants when operated. The NWQI analysis evaluated the increased emissions from off-site transportation and from composting manure on site.

Criteria air emissions from the off-site transportation of animal manure were evaluated for each of the regulatory options considered by EPA, as all options will result in an increase of off-site transportation of manure at some operations. The analysis examined three types of facilities: Category 1 operations have sufficient cropland to apply all manure on site; Category 2 operations do not have enough cropland to apply all waste on site and may or may not currently transport waste; and Category 3 operations have no cropland and currently transport all manure off site. Because Category 1 operations emit no criteria air pollutants from vehicles at baseline, nor will any regulatory option induce them to do so, there are no current or projected emissions in criteria air emissions for this category. Category 2 operations, however, incur costs for transporting more manure off site, leading to an increase in the amount of criteria air pollutants generated by these operations. Although Category 3 facilities currently transport their manure, a regulation that requires phosphorous-based rather than nitrogen-based application may cause facilities to transport their excess manure a further distance; therefore, there may also be an increase in the amount of criteria air pollutants generated by these operations for options that require phosphorus-based application. EPA calculated air emission estimates for the off-site transportation of manure from all Category 2 facilities, as well as from Category 3 facilities that are expected to follow phosphorus-based application.

Two different waste transportation options were also analyzed. One considered the cost of purchasing trucks to transport waste, and the other evaluated the cost of paying a contractor to haul the waste off site. Because of the different methods used to estimate the costs of the two transportation options, two methods were used to calculate air emissions. Criteria pollutant emissions from operations purchasing waste transportation vehicles were based on an estimate of the number of trucks purchased and the annual number of miles traveled. Contract hauling emissions were based on an estimate of the annual amount of waste generated, the annual number of miles traveled, and truck sizes.

Transportation emissions are reported as the incremental increase in criteria air pollutants from baseline for Category 2 and Category 3 operations. Additional criteria air pollutants are released in all cases.

Farm equipment used for on-site composting activities also affects the generation of air emissions. Composting of waste can result in a reduction in transportation air emissions if the volume or weight of material composted is reduced; however, the mere use of composting equipment contributes to criteria air emissions. Option 5A for beef (includes heifer) operations and dairies is based on all operations composting their waste; therefore, criteria air emissions from on-site composting of manure were estimated only for these CAFOs under Option 5A. The amount of waste composted was based on the amount of excreted semisolid waste. Pollutant emissions were determined using vehicle emission factors and miles traveled along the length of the windrow. On-site emissions of criteria air pollutants due to composting activities increase under Option 5A for all for beef (includes heifer) operations and dairies.

13.5 <u>Energy Impacts</u>

Certain regulatory options evaluated for animal feeding operations entail the use of different waste management systems and land application practices that may increase or decrease energy usage. Energy impacts related to land application for animal feeding operations were evaluated under baseline conditions and under the seven regulatory options considered by EPA. Energy impacts related to the use of anaerobic digesters were evaluated for all Large dairies and swine operations under Option 6.

Some beef (includes heifer) operations and dairies do not currently collect and land apply their liquid waste. The regulatory options implementing a no-discharge policy would force these operations to collect and land apply their liquid waste using pivot irrigation systems or traveling guns, depending on the amount of acreage available for application. As a result of the addition of these application systems, the energy requirements of these operations would increase.

Transporting manure off site and composting manure on site requires the use of equipment such as trucks and tractors. The fuel consumption resulting from using these vehicles contributes to the energy impacts associated with land application activities. The estimation of fuel consumption by transportation vehicles used the number of miles traveled per year and the vehicle fuel efficiency as data inputs.

Option 6 includes the use of anaerobic digesters with energy recovery to manage animal waste for the Large dairies and swine operations. Digesters require a continuous input of energy to operate the holding tank mixer and the engine that converts captured methane into energy (Jewell, 1997). The energy required to continuously operate these devices and the amount of energy generated by the system have been determined from EPA's *FarmWare* model. CAFOs using anaerobic digesters with energy recovery systems are expected to have a net decrease in electricity use.

13.6 <u>Industry-Level NWQI Estimates</u>

This section summarizes the industry-level NWQI estimates for each of the regulatory options considered by EPA. To evaluate the impact of the regulation on NWQI, model farm emissions were extrapolated to the population of animal feeding operations covered by the rule. Industry-level impacts for each animal sector (i.e., beef (includes heifer), dairy, veal, swine, and poultry) were estimated for Medium and Large CAFOs throughout the United States. Large facilities are considered CAFOs if they fall within the size range presented in Table 13-1. Medium AFOs are defined as CAFOs only if they fall within the size range presented in Table 13-1 and they meet one of the two specific criteria governing the method of discharge: (1) pollutants are discharged through a man-made ditch, flushing system, or other similar man-made device; or (2) pollutants are discharged directly into waters of the United States that originate outside the facility and pass over, across, or through the facility or otherwise come into direct contact with the confined animals.

Table 13-1. Summary of Size Thresholds for Large and Medium CAFOs.

Sector	Large	Medium[a]
Mature dairy cattle	More than 700	200 - 700
Veal calves	More than 1,000	300 - 1,000
Cattle or cow/calf pairs	More than 1,000	300 - 1,000
Swine (weighing 55 pounds or more)	More than 2,500	750 - 2,500
Swine (weighing less than 55 pounds)	More than 10,000	3,000 - 10,000
Turkeys	More than 55,000	16,500 - 55,000
Chickens (liquid manure handling system)	More than 30,000	9,000 - 30,000
Chickens other than laying hens (other than a liquid manure handling system)	More than 125,000	30,000 - 125,000
Laying hens (other than a liquid manure handling system)	More than 82,000	25,000 - 82,000

[a] Must also meet one of two criteria to be defined as a CAFO.

13.6.1 Summary of Air Emissions for Beef (Includes Heifer) Operations and Dairies

Tables 13-2 and 13-3 present estimates for Large CAFOs, and Tables 13-8 and 13-9 present estimates for Medium CAFOs.

Option 1

Option 1 is expected to result in a change in precursor pollutant (i.e., ammonia and hydrogen sulfide) emissions from CAFOs. Total ammonia emissions from beef (includes heifer) operations and dairies, including both the production area and land application activities, decrease under Option 1. Production area emissions decrease due to the added step of solids separation in waste management. Option 1 also requires agronomic application of manure, litter, and other process wastewater on site, which results in decreased application of manure nitrogen to cropland on site and decreased on-site land application ammonia emissions. However, off-site application of manure nitrogen increases, which also increases the off-site land application ammonia emissions. Hydrogen sulfide emissions from the production area decrease for dairies also because of the practice of solids separation, which allows for increased aerobic decomposition and the inhibition of hydrogen sulfide formation.

In addition, Option 1 is expected to result in a change in greenhouse gas emissions. For Large beef (includes heifer) and dairy CAFOs, methane emissions decrease due to the added step of solids separation in the waste management system. The separated solids are stockpiled rather than held in waste storage ponds or anaerobic lagoons. This drier method of manure handling reduces anaerobic conditions and the potential for volatile solids to convert to methane. This approach also results in greater conversion of nitrogen to nitrous oxide; thus, nitrous oxide emissions from dairies increase. For Medium beef (includes heifer) CAFOs, methane emissions increase due to increased liquid storage from baseline.

Due to the requirement under Option 1 to apply manure, litter, and other process wastewater at nitrogen-based agronomic rates, CAFOs with insufficient land on which to apply their waste at these rates will transport the excess manure off site. Due to this increase in transportation, emissions of criteria air pollutants increase from baseline for beef (includes heifer) and dairy CAFOs.

Options 2-4 and 7

Options 2-4 and 7 also result in changes to precursor and greenhouse gas emissions as discussed for Option 1. However, these options require manure, litter, and other process wastewater to be applied at agronomic rates for phosphorus for some operations.

Therefore, criteria air emissions increase compared to baseline and Option 1 due to an increase in the amount of manure nutrients transported off site.

Option 5A

Option 5A requires the implementation of composting at beef (includes heifer) and dairy CAFOs. Under Option 5A, ammonia emissions increase for these operations. Ammonia volatilizes rapidly from drying manure, resulting in an increase in emissions as more manure is handled as a solid rather than a liquid or slurry. In addition, composting practices release more emissions than stockpiles because the windrows are turned regularly, exposing more manure to the air. Stockpiles tend to form outer crusts that reduce the potential for volatilization.

Under a composting option, production area methane emissions increase as a result of the addition of organic material to the waste prior to composting. This material decomposes and contributes to increased methane emissions compared to other options and baseline. Nitrous oxide emissions also increase for these operations, as aerobic storage enhanced by windrow turning promotes the release of this gas.

Option 5A also results in an increase in criteria air emissions. The practice of composting requires turning equipment, which consumes fuel and generates additional air emissions. However, this increase is not as large as the increase under Options 2-4, 6, and 7. The additional criteria pollutants emitted by composting equipment is partially offset by reductions in transportation emissions, resulting from a decrease in the weight and/or volume of the composted material.

Option 6

Under Option 6, emissions of pollutants do not differ from Option 2 for all beef (includes heifer) CAFOs, and for Medium dairy CAFOs. However, for Large dairy CAFOs, this option results in changes to greenhouse gas and criteria air emissions. Methane and nitrous oxide emissions from the production area of Large dairy CAFOs decrease substantially, due to the addition of an anaerobic digester with energy recovery. Generated methane is collected as biogas and converted to energy, and nitrous oxide is oxidized during the combustion process. Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide increase due to combustion of the biogas.

13.6.2 Summary of Air Emissions for Swine, Poultry, and Veal Operations

Tables 13-4 through 13-7 present estimates for Large swine, poultry, and veal CAFOs, and Tables 13-10 through 13-13 present estimates for Medium swine, poultry, and veal CAFOs.

Option 1

Emissions of precursor pollutants and greenhouse gases do not change for veal, swine, and poultry operations under Option 1, as this option does not result in changes to the production area waste management procedures. However, criteria air pollution increases for swine and poultry operations due to the nitrogen-based application requirements and the associated increases in transportation of manure nutrients off site. Emissions for veal operations do not change from baseline because it is assumed that they have adequate cropland to apply all waste on site and consequently do not transport any manure.

Options 2-4 and 7

Under these options, emissions of precursor pollutants and greenhouse gases do not change from baseline for all veal, swine, and poultry operations, as waste handling practices are not expected to change.

As in Option 1, there is no increase in criteria air pollutant emissions for veal operations because they are not expected to transport manure off site. However, there is an increase in these pollutant emissions for swine and poultry operations when compared to baseline and Option 1 because of the increased transport of waste necessitated by the phosphorus-based application requirement.

Option 5

Option 5 requires zero discharge, with no allowance for overflow. It is expected that operations will implement total confinement and covered storage, in addition to the requirements of Option 2, for all swine, poultry, and veal operations. Under this option, ammonia emissions decrease for veal, swine, and chicken operations. Usually, ammonia in the effluent from the covered lagoon is released upon exposure to air. Option 5, however, is based on covered storage at all times; thus, depending on the application methods (e.g., if the waste is incorporated into the soil), ammonia emissions could substantially decrease. The use of a covered lagoon lowers the production area ammonia emissions. It should be noted, however, that ammonia emissions increase from material applied to land both on site and off site. Ammonia emissions from turkey operations do not change compared to baseline. Emissions of hydrogen sulfide decrease for veal and swine and drop to zero for wet-layer operations due to the practice of covered storage.

Methane and nitrous oxide emissions from the production area decrease for all veal, chicken, and swine operations as a result of total confinement and covered storage. However, nitrous oxide emissions increase from material applied to land both on site and off site.

Veal operations emit a larger quantity of nitrogen oxides, carbon monoxide, and sulfur dioxide compared with baseline and all other options due to flaring. Wet layer and swine operations also emit additional criteria air pollutants compared to baseline because of this practice. However, compared to Options 2-4 and 7, these operations emit a smaller amount of VOCs, nitrogen oxides, particulate matter, and carbon monoxide but a larger amount of sulfur dioxide. For turkey operations, criteria air emissions increase from baseline to the same level that results from Options 2-4, 6 and 7.

Option 6

Under Option 6, emissions of precursor pollutants do not differ from Option 2 for all veal and poultry CAFOs and for Medium swine CAFOs. However, for Large swine CAFOs, this option results in changes to greenhouse gas and criteria air emissions. Methane and nitrous oxide emissions from the production area of Large swine CAFOs decrease substantially, due to the addition of an anaerobic digester with energy recovery. Generated methane is collected as biogas and converted to energy, and nitrous oxide is oxidized during the combustion process. Emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide increase due to combustion of the biogas.

13.6.3 Energy Impacts

The regulatory options evaluated for CAFOs are based on the use of certain waste management systems and land application practices that may impact electricity and fuel usage. Both energy usage indicators were estimated in relation to baseline, with electricity usage in units of megawatt-hours per year (MW-hr/yr) and fuel usage in gallons.

Increased electricity usage occurs at beef (includes heifer) and dairy CAFOs under all options. Surface runoff from the feedlot must be collected and stored before it can be land applied. These additional measures require an increase in electricity expenditures. Because veal, poultry, and swine are confined in houses, these operations do not experience elevated electricity demands, as there are no additional runoff controls expected. In addition, the land application of waste consumes electricity during the operation of the irrigation system. It is assumed that swine and poultry operations already land apply their waste and therefore do not experience additional electricity needs. However, some beef (includes heifer) operations and dairies do not currently collect and land apply their liquid waste, and a zero discharge policy would likely result in these operations collecting and land applying this waste using new irrigation systems. As a result, the energy requirements of these operations are expected to increase.

Under Option 1, all operations except veal operations experience an increase in fuel usage due to the requirement that manure be land applied according to agronomic rates for nitrogen. This requirement is expected to result in excess manure nutrients being transported to off-site land application sites. This fuel usage grows under Options 2-4, 6 and 7 because of the more stringent phosphorus-based requirement and the resultant increase in the amount of manure to be transported. Veal operations are assumed to apply all waste on site no matter the option and thus do not incur additional energy costs.

Under Option 5, swine and chicken operations use less fuel as a result of the total confinement and covered storage requirements. Fuel consumption at veal and turkey operations does not change from baseline under any option.

Under Option 5A, which requires composting at beef (includes heifer) and dairy CAFOs, fuel usage by transportation vehicles decreases due to a decrease in the weight and/or volume of the waste. Nevertheless, because of the fuel demands of the composting equipment, total fuel usage at beef and heifer operations increases compared to other options. Because all beef (includes heifer) waste is deposited on the drylot, a large amount of waste is available for composting. The additional fuel usage of composting equipment at these operations offsets the decrease from lower transportation fuel requirements. At dairies, however, much of the manure is in liquid and slurry form and less solid waste can be composted. Consequently, the energy demands of the composting equipment do not outweigh the energy saved from a reduction in transportation, and the overall fuel usage for dairies decreases under Option 5A.

Overall electricity use decreases at those operations that use anaerobic digesters under Option 6. Large swine and dairy CAFOs that digest their waste and recover and use the biogas to operate an engine generate excess energy, which can be sold or used to operate other machinery.

Table 13-2. NWQI for Beef (Includes Heifers) - Large CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	385,256	383,154	383,154	383,154	383,154		505,713	383,154	383,154
Hydrogen Sulfide (H_2S)	NC	NC	NC	NC	NC		NC	NC	NC
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.93	0.86	0.86	0.86	0.86		1.13	0.86	0.86
Nitrous Oxide (N_2O)	7.72	7.72	7.72	7.72	7.72		7.93	7.72	7.72
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	1.4	18.6	18.6	18.6		18.7	18.6	18.6
Nitrogen Oxides (NOx)	Baseline	29.3	387.5	387.5	387.5		389.8	387.5	387.5
Particulate Matter (PM)	Baseline	1.0	12.9	12.9	12.9		13.0	12.9	12.9
Carbon Monoxide (CO)	Baseline	7.6	103.8	103.8	103.8		104.4	103.8	103.8
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC		NC	NC	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	37,986	37,986	37,986		38,257	37,986	37,986
Fuel Usage (gallons/yr)	Baseline	178,069	2,280,586	2,280,586	2,280,586		2,295,467	2,280,586	2,280,586

NC - Not calculated.
[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-3. NWQI for Dairy - Large CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	151,595	147,591	147,591	147,591	147,591		162,576	147,591	147,591
Hydrogen Sulfide (H_2S)	5,986	3,611	3,611	3,611	3,611		3,611	3,611	3,611
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	5.85	3.60	3.60	3.60	3.60		3.68	0.02	3.60
Nitrous Oxide (NOx)	1.46	1.95	1.95	1.95	1.95		2.72	0.56	1.95
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	42.4	90.8	90.8	90.8		88.7	90.8	90.8
Nitrogen Oxides (NOx)	Baseline	850.3	1820.1	1820.1	1820.1		1779.0	1841.3	1820.1
Particulate Matter (PM)	Baseline	26.5	56.8	56.8	56.8		55.5	56.8	56.8
Carbon Monoxide (CO)	Baseline	240.5	514.3	514.3	514.3		502.7	519.7	514.3
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC		NC	20.1	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	14,430	14,430	14,430		14,430	(1,009,331)	14,430
Fuel Usage (gallons/yr)	Baseline	4,682,297	10,031,078	10,031,078	10,031,078		9,805,490	10,031,078	10,031,078

NC - Not calculated.
[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-4. NWQI for Veal - Large CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	149	149	149	149	149	104		149	149
Hydrogen Sulfide (H_2S)	10	10	10	10	10	2		10	10
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.001	0.001	0.001	0.001	0.001	0.00002		0.001	0.001
Nitrous Oxide (N_2O)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0021		0.0017	0.0017
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Nitrogen Oxides (NOx)	Baseline	Baseline	Baseline	Baseline	Baseline	0.41		Baseline	Baseline
Particulate Matter (PM)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Carbon Monoxide (CO)	Baseline	Baseline	Baseline	Baseline	Baseline	0.36		Baseline	Baseline
Sulfur Dioxide (SO_2)	Baseline	Baseline	Baseline	Baseline	Baseline	0.41		Baseline	Baseline
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Fuel Usage (gallons/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline

NC - Not calculated.
[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-5. NWQI for Swine - Large CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	183,732	183,732	183,732	183,732	183,732	109,037		183,732	183,732
Hydrogen Sulfide (H_2S)	13,036	13,036	13,036	13,036	13,036	2,150		13,036	13,036
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	12.46	12.46	12.46	12.46	12.46	2.27		0	12.46
Nitrous Oxide (NOx)	0.29	0.29	0.29	0.29	0.29	0.52		0.20	0.29
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	1.9	32.8	32.8	32.8	16.9		31.5	32.8
Nitrogen Oxides (NOx)	Baseline	38.5	655.4	655.4	655.4	404.7		700.8	655.4
Particulate Matter (PM)	Baseline	1.2	20.4	20.4	20.4	10.5		19.6	20.4
Carbon Monoxide (CO)	Baseline	10.9	185.9	185.9	185.9	154.1		196.8	185.9
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC	66.0		66.0	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		(2,217,565)	Baseline
Fuel Usage (gallons/yr)	Baseline	210,840	3,593,589	3,593,589	3,593,589	1,855,656		3,459,148	3,593,589

NC - Not calculated.
[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-6. NWQI for Chickens - Large CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	205,038	205,038	205,038	205,038	205,038	200,755		205,038	205,038
Hydrogen Sulfide (H_2S)	1,146	1,146	1,146	1,146	1,146	0		1,146	1,146
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	1.19	1.19	1.19	1.19	1.19	0.27		1.19	1.19
Nitrous Oxide (N_2O)	2.30	2.30	2.30	2.30	2.30	2.40		2.30	2.30
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	1.9	7.5	7.5	7.5	6.9		7.5	7.5
Nitrogen Oxides (NOx)	Baseline	41.0	161.7	161.7	161.7	152.7		161.7	161.7
Particulate Matter (PM)	Baseline	1.5	5.8	5.8	5.8	5.4		5.8	5.8
Carbon Monoxide (CO)	Baseline	10.4	40.8	40.8	40.8	39.8		40.8	40.8
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC	2.6		NC	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Fuel Usage (gallons/yr)	Baseline	256,763	1,015,976	1,015,976	1,015,976	952,584		1,015,976	1,015,976

NC - Not calculated.
[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-7. NWQI for Turkeys - Large CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	35,599	35,599	35,599	35,599	35,599	35,599		35,599	35,599
Hydrogen Sulfide (H_2S)	NC	NC	NC	NC	NC	NC		NC	NC
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.09	0.09	0.09	0.09	0.09	0.09		0.09	0.09
Nitrous Oxide (N_2O)	1.05	1.05	1.05	1.05	1.05	1.05		1.05	1.05
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	0.2	1.6	1.6	1.6	1.6		1.6	1.6
Nitrogen Oxides (NOx)	Baseline	4.6	35.3	35.3	35.3	35.3		35.3	35.3
Particulate Matter (PM)	Baseline	0.2	1.3	1.3	1.3	1.3		1.3	1.3
Carbon Monoxide (CO)	Baseline	1.2	8.8	8.8	8.8	8.8		8.8	8.8
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC	NC		NC	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Fuel Usage (gallons/yr)	Baseline	29,706	225,701	225,701	225,701	225,701		225,701	225,701

NC - Not calculated.

[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-8. NWQI for Beef (Includes Heifers) - Medium CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	3990	3964	3964	3964	3964		5386	3964	3964
Hydrogen Sulfide (H_2S)	NC	NC	NC	NC	NC		NC	NC	NC
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.012	0.013	0.013	0.013	0.013		0.016	0.013	0.013
Nitrous Oxide (N_2O)	0.08	0.08	0.08	0.08	0.08		0.10	0.08	0.08
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	0.012	0.067	0.067	0.067		0.070	0.067	0.067
Nitrogen Oxides (NOx)	Baseline	0.3	1.4	1.4	1.4		1.5	1.4	1.4
Particulate Matter (PM)	Baseline	0.009	0.049	0.049	0.049		0.051	0.049	0.049
Carbon Monoxide (CO)	Baseline	0.07	0.37	0.37	0.37		0.39	0.37	0.37
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC		NC	NC	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	1,640	2,821	2,821	2,821		2,822	2,821	2,821
Fuel Usage (gallons/yr)	Baseline	1,613	8,668	8,668	8,668		9,071	8,668	8,668

NC - Not calculated.
[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-9. NWQI for Dairy - Medium CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	39,837	39,185	39,185	39,185	39,185		48,337	39,185	39,185
Hydrogen Sulfide (H_2S)	1,068	598	598	598	598		598	598	598
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.97	0.64	0.64	0.64	0.64		0.67	0.64	0.64
Nitrous Oxide (N_2O)	0.585	0.589	0.589	0.589	0.589		0.818	0.589	0.589
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	0.9	4.3	4.3	4.3		4.0	4.3	4.3
Nitrogen Oxides (NOx)	Baseline	18.4	87.5	87.5	87.5		82.8	87.5	87.5
Particulate Matter (PM)	Baseline	0.6	2.8	2.8	2.8		2.7	2.8	2.8
Carbon Monoxide (CO)	Baseline	5.1	24.1	24.1	24.1		22.7	24.1	24.1
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC		NC	NC	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	970	4,228	4,228	4,228		1,667	4,228	4,228
Fuel Usage (gallons/yr)	Baseline	103,764	498,686	498,686	498,686		473,028	498,686	498,686

NC - Not calculated.

[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-10. NWQI for Veal - Medium CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	12	12	12	12	12	8		12	12
Hydrogen Sulfide (H_2S)	0.7	0.7	0.7	0.7	0.7	0.2		0.7	0.7
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.0001	0.0001	0.0001	0.0001	0.0001	0.000001		0.0001	0.0001
Nitrous Oxide (N_2O)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002		0.0001	0.0001
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Nitrogen Oxides (NOx)	Baseline	Baseline	Baseline	Baseline	Baseline	0.04		Baseline	Baseline
Particulate Matter (PM)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Carbon Monoxide (CO)	Baseline	Baseline	Baseline	Baseline	Baseline	0.04		Baseline	Baseline
Sulfur Dioxide (SO_2)	Baseline	Baseline	Baseline	Baseline	Baseline	0.04		Baseline	Baseline
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Fuel Usage (gallons/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline

NC - Not calculated.

[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-11. NWQI for Swine - Medium CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	10,596	10,596	10,596	10,596	10,596	7,090		10,596	10,596
Hydrogen Sulfide (H_2S)	616	616	616	616	616	183		616	616
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.68	0.68	0.68	0.68	0.68	0.19		0.68	0.68
Nitrous Oxide (N_2O)	0.02	0.02	0.02	0.02	0.02	0.03		0.02	0.02
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	0.0	0.6	0.6	0.6	0.3		0.6	0.6
Nitrogen Oxides (NOx)	Baseline	0.6	11.9	11.9	11.9	7.5		11.9	11.9
Particulate Matter (PM)	Baseline	0.0	0.4	0.4	0.4	0.2		0.4	0.4
Carbon Monoxide (CO)	Baseline	0.2	3.4	3.4	3.4	3.1		3.4	3.4
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC	1.6		NC	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Fuel Usage (gallons/yr)	Baseline	3,266	65,369	65,369	65,369	31,852		65,369	65,369

NC - Not calculated.

[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-12. NWQI for Chickens - Medium CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	6,287	6,287	6,287	6,287	6,287	6,276		6,287	6,287
Hydrogen Sulfide (H_2S)	3.1	3.1	3.1	3.1	3.1	0.0		3.1	3.1
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.040	0.040	0.040	0.040	0.040	0.038		0.040	0.040
Nitrous Oxide (N_2O)	0.1427	0.1427	0.1427	0.1427	0.1427	0.1430		0.1427	0.1427
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	0.07	0.43	0.43	0.43	0.43		0.43	0.43
Nitrogen Oxides (NOx)	Baseline	1.47	9.40	9.40	9.40	9.47		9.40	9.40
Particulate Matter (PM)	Baseline	0.05	0.34	0.34	0.34	0.43		0.34	0.34
Carbon Monoxide (CO)	Baseline	0.37	2.33	2.33	2.33	2.32		2.33	2.33
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC	0.11		NC	NC
Baseline + Energy Usage[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Fuel Usage (gallons/yr)	Baseline	9,404	60,024	60,024	60,024	59,844		60,024	60,024

NC - Not calculated.

[a]Energy estimates reflect the incremental change in usage from baseline.

Table 13-13. NWQI for Turkeys - Medium CAFOs

NWQI	Baseline	Regulatory Option							
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 5A	Option 6	Option 7
AIR EMISSIONS									
Precursor Pollutants (tons per year)									
Ammonia (NH_3)	603	603	603	603	603	603		603	603
Hydrogen Sulfide (H_2S)	NC	NC	NC	NC	NC	NC		NC	NC
Greenhouse Gases (Tg/yr CO_2 - Equiv)									
Methane (CH_4)	0.002	0.002	0.002	0.002	0.002	0.002		0.002	0.002
Nitrous Oxide (N_2O)	0.018	0.018	0.018	0.018	0.018	0.018		0.018	0.018
Criteria Air Pollutants (tons per year)[a]									
Volatile Organic Compounds (VOCs)	Baseline	0.00	0.04	0.04	0.04	0.04		0.04	0.04
Nitrogen Oxides (NOx)	Baseline	0.09	0.82	0.82	0.82	0.82		0.82	0.82
Particulate Matter (PM)	Baseline	0.00	0.03	0.03	0.03	0.03		0.03	0.03
Carbon Monoxide (CO)	Baseline	0.02	0.20	0.20	0.20	0.20		0.20	0.20
Sulfur Dioxide (SO_2)	Baseline	NC	NC	NC	NC	NC		NC	NC
BASELINE + ENERGY USAGE[a]									
Electricity Usage (MW-hr/yr)	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline		Baseline	Baseline
Fuel Usage (gallons/yr)	Baseline	596	5,213	5,213	5,213	5,213		5,213	5,213

NC - Not calculated.

[a]Energy estimates reflect the incremental change in usage from baseline.

13.7 References

AAF Canada. 2000. Estimates of Emissions–Reducing Nitrous Oxide Emissions. In *The Health of Our Air*. Agriculture and Agri-Food Canada. <http://res2.agr.ca/research-recherche/science/Healthy_Air/2d8.html>. October 10.

Anderson, B. 1994. *Animal Manure as a Plant Resource*. <http://www.agcom.purdue.edu/AgCom/Pubs/ID/ID-101.html>. Purdue University. July 5, 2000.

EPA. 1992. Global Methane Emissions From Livestock and Poultry Manure. EPA/400/1-91-048. U.S. Environmental Protection Agency, Washington, DC.

EPA 2002. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000. EPA/236/R-02-003. U.S. Environmental Protection Agency, Washington, DC.

ERG. 2002. Commercial Fertilizer Analysis. Memorandum prepared for U.S. Environmental Protection Agency, Engineering and Analysis Division, Washington, DC. December.

ERG. 2002a. *Non-Water Quality Impact Estimates for Animal Feeding Operations*. Prepared for U.S. Environmental Protection Agency, Engineering and Analysis Division, Washington, DC. December.

IPCC. 2000. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Chapter 4, Agriculture. Intergovernmental Panel on Climate Change, NGGIP..

Jacobson, L. D., R. Moon, J. Bicudo., K. Janni, S. Noll, G. Shurson, J. Zhu, D. Schmidt, P. McGinley, R. Nicolai, C. Clanton, K. Davis, L. Brosseau, J. Bruns, C. Pijoan, T. Blaha, B. Curgan, and K. Draeger. 2000. *Generic Environmental Impact Statement on Animal Agriculture: A Summary of the Literature Related to Air Quality and Odor*. Prepared for Minnesota Department of Agriculture, Environmental Quality Board, St. Paul Minnesota.

Jewell, W.J., P.E. Wright, N.P. Fleszar, G. Green, A. Safinski, and A. Zucker. 1997. *Evaluation of Anaerobic Digestion Options for Groups of Dairy Farmers in Upstate New York*. Department of Agriculture and Biological Engineering, College of Agriculture and Life Sciences. Cornell University, Ithaca, NewYork. June.

OSUE. 2000. *Selecting Forms of Nitrogen Fertilizer*. <http://www2.ag.ohio-state.edu/~ohioline/agf-fact/0205.html>. Ohio State University Extension. July 5.

Sharpe, R.R., and L.A. Harper. 1997. Ammonia and Nitrous Oxide Emissions from Sprinkler Irrigation Applications of Swine Effluent. *Journal of Environmental Quality* 26:1703-1706.

Van Horn, H.H., A.C. Wilkie, W.J. Powers, and R.A. Nordstedt. 1994. Components of Dairy Manure Management Systems. *Journal of Dairy Science* 77:7.

CHAPTER 14

GLOSSARY

aeration	the process of bringing air into contact with a liquid by one or more of the following methods: (1) spraying the liquid in the air, (2) bubbling air through the liquid, and (3) agitating the liquid to promote absorption of oxygen through the air liquid interface
aerobic	having or occurring in the presence of the free oxygen
aerobic lagoon	a holding and/or treatment pond that speeds up the natural process of biological decomposition of organic waste by stimulating the growth and activity of bacteria that degrade organic waste in an oxygen-rich environment
Ag Census	the census of agriculture conducted every 5 years; a major source of information about the structure and activities of agricultural production at the national, state, and county levels
agitation	thorough mixing of liquid or slurry manure at a storage structure to provide a more consistent fertilizer material and allow the producer to empty as much of the storage as possible
agronomic rates	the land application of animal wastes at rates of application that provide the crop or forage growth with needed nutrients for optimum health and growth
air emissions	release of any pollutant into the air
ammonia volatilization	the loss of ammonia gas to the atmosphere
anaerobic	the absence of molecular oxygen, or capable of living and growing in the absence of oxygen, such as anaerobic bacteria
anaerobic lagoon	a holding and/or treatment pond that speeds up the natural process of biological decomposition of organic waste by stimulating the growth and activity of bacteria that degrade organic waste in an oxygen-depleted environment

animal feeding operation (AFO)	a lot or facility (other than an aquatic animal production facility) where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and the animal confinement areas do not sustain crops, vegetation, forage growth, or postharvest residues in the normal growing season. Two or more animal feeding operations under common ownership are a single animal feeding operation if they adjoin each other or if they use a common area or system for the disposal of wastes.
APHIS	Animal and Plant Health Inspection Service, United States Department of Agriculture
baffle	a device (as a plate, wall, or screen) to deflect, check, or regulate flow (fluid, light, or sound)
barrow	a castrated male pig
berm	a narrow shelf, path, or ledge typically at the top or bottom of a slope; a mound or wall of earth
best available technology (BAT)	the best available technology that is economically achievable established under 301(b) and 402 of the Federal Water Pollution Control Act as amended, also known as the Clean Water Act, found at 33 USC 1251 et seq. The criteria and standards for imposing technology-based treatment requirements are listed in 40 CFR 125.3.
best conventional technology (BCT)	the best conventional pollutant control technology that is economically achievable established under 301(b) and 402 of the Federal Water Pollution Control Act as amended, also known as the Clean Water Act, found at 33 USC 1251 et seq. The criteria and standards for imposing technology-based treatment requirements are listed in 40 CFR 125.3.
best management practice (BMP)	a practice or combination of practices found to be the most effective, practicable (including economic and institutional considerations) means of preventing or reducing the amount of pollution generated
bioavailability	the degree and rate at which a substance is absorbed into a living system or is made available at the site of physiological activity
biochemical oxygen demand (BOD)	an indirect measure of the concentration of biodegradable substances present in an aqueous solution. Determined by the amount of dissolved oxygen required for the aerobic degradation of the organic matter at 20 °C. BOD_5 refers to that oxygen demand for the initial 5 days of the degradation process

biogas	a mixture of methane and carbon dioxide produced by the bacterial decomposition of organic wastes and used as a fuel
biosecurity	a defensive health plan and hygiene procedures that can help keep an animal feeding operation disease free
biosolids	solid organic matter recovered from a sewage treatment process and used especially as fertilizer
BPJ	best professional judgement
BPT	best practicable technology
broadcasting	method of application (seed or fertilizer) to the soil surface
broilers	chickens of either sex specifically bred for meat production and marketed at approximately 8 weeks of age
carcass-weight	weight of the dead body of an animal, slaughtered and gutted
certified specialist	someone who has been certified to prepare Comprehensive Nutrient Management Plans (CNMPs) by USDA or a USDA sanctioned organization
compaction	an increase in soil bulk density, limiting both root penetration, and water and nutrient uptake induced by tillage- and vehicular-traffic
composting	a process of aerobic biological decomposition of organic material characterized by elevated temperatures that, when complete, results in a relatively stable product suitable for a variety of agricultural and horticultural uses
concentrated animal feeding operation (CAFO)	an “animal feeding operation” that meets the criteria in 40 CFR Part 122, Appendix B, or an operation designated as a significant contributor of pollution pursuant to 40 CFR 122.23
costing	a systematic method or procedure used to develop the estimated costs of a technology or practice
cover crop	a close-growing crop, whose main purpose is to protect and improve the soil and use excess nutrients or soil moisture during the absence of the regular crop, or in the nonvegetated areas of orchards and vineyards

crop removal rate	the application rate for manure or wastewater which is determined by the amount of phosphorus which will be taken up by the crop during the growing season and subsequently removed from the field through crop harvest. Field residues do not count towards the amount of phosphorus removed at harvest.
crop rotation	a planned sequence of crops
denitrification	the chemical or biological reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen (N_2) or as an oxide of nitrogen (N_2O)
detention pond	a basin whose outlet has been designed to detain the storm water runoff from a design storm (e.g., 25 year/24 hour storm) for some minimum time to allow particles and associated pollutants to settle
digestion	the process whereby organic matter breaks down into simpler and/or more biologically stable products, e.g., ammonia to organic nitrogen
disking	cultivating with an implement that turns and loosens the soil with a series of discs
dry lots	open feedlots sloped or graded from 4 to 6 percent to promote drainage away from the lot to provide consistently dry areas for cattle to rest
effluent	the liquid discharge from a waste treatment process
endogenous	growing or produced by growth from deep tissue (e.g., plant roots)
ephemeral erosion	a shallow, concentrated flow path that develops as a response to a specific storm and disappears as a result of tillage or natural processes
erosion	the wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep
ERS	Economic Research Service, United States Department of Agriculture
evapotranspiration	the loss of water from an area by evaporation from the soil or snow cover and transpiration by plants
farrowing	the act of giving birth to pigs by the sow
farrow-to-finish	contains all three hog production phases: farrow, nursery, finish
fecal coliform	the bacterial count (Parameter 1) at 40 CFR 136.3 in Table 1A, which also cites the approved methods of analysis.

feedlot	a concentrated, confined animal or poultry growing operation for meat, milk, or egg production, or stabling, in pens or houses wherein the animals or poultry are fed at the place of confinement and crop or forage growth or production is not sustained in the area of confinement, and is subject to 40 CFR 412
fertilizer value	the value of noncommercial fertilizer (e.g., manure)
flushing system	a system that collects and transports or moves waste material with the use of water, such as in washing of pens and flushing of confinement livestock facilities
freeboard	the height above the recorded high-water mark of a structure (as a dam) associated with the water
FRN	federal registrar notice
frequency factor	the regional compliance of animal feeding operations with BMPs associated with a nutrient management plan, facility upgrades, or strategies to reduce excess nutrients
FORTRAN	one of the most widely used programming languages for solving problems in science and engineering
gilt	a young or immature female pig
GLEAMS	Groundwater Loading Effects of Agricultural Management Systems
ground water	water filling all the unblocked pores of underlying material below the water table
hen	a mature female chicken
incorporation	mixing manure into the soil, either by tillage or by subsurface injection, to increase manure nutrient availability for use by crops
injection	a tillage implement that cuts into the soil depositing liquid or slurry
integrators	poultry companies, under contract with growers, who supply birds, feed, medicines, transportation, and technical help
irrigation	application of water to lands for agricultural purposes (Soil Conservation Society of America, 1982)

lagoon	an all-inclusive term commonly given to a water impoundment in which organic wastes are stored or stabilized, or both. Lagoons may be described by the predominant biological characteristics (aerobic, anaerobic, or facultative), by location (indoor, outdoor), by position in a series (primary, secondary, or other), and by the organic material accepted (sewage, sludge, manure, or other)
land application	application of manure, sewage sludge, municipal wastewater, and industrial wastes to land for reuse of the nutrients and organic matter for their fertilizer and soil conditioning values
land application area	any land under the control of the CAFO operator, whether it is owned, rented, or leased, to which manure and process wastewater is or may be applied
layer	a mature hen that is producing eggs
leaching	(1) the removal of soluble constituents, such as nitrates or chlorides, from soils or other material by the movement of water; (2) the removal of salts and alkali from soils by irrigation combined with drainage; (3) the removal of a liquid through a non-watertight artificial structure, conduit, or porous material by downward or lateral drainage, or both, into the surrounding permeable soil
load	quantity of substance entering the receiving body
macronutrient	a chemical element required, in relatively large amounts, for proper plant growth
manure	the fecal and urinary excretions of livestock and poultry
micronutrient	a chemical element required, in relatively small amounts, for proper plant growth
mulch	any substance that is spread on the soil surface to decrease the effects of raindrop impact, runoff, and other adverse conditions and to retard evaporation
NAHMS	National Animal Health Monitoring System, United States Department of Agriculture
NASS	National Agricultural Statistics Service, United States Department of Agriculture

new source	a source that is subject to subparts C or D of 40 CFR 412 and, not withstanding the criteria codified at 40 CFR 122.29(b)(1): (i) is constructed at a site at which no other source is located; or (ii) replaces the housing including animal holding areas, exercise yards, and feedlot, waste handling system, production process, or production equipment that causes the discharge or potential to discharge pollutants at an existing source; or (iii) constructs a production area that is substantially independent of an existing source at the same site. Whether processes are substantially independent of an existing source, depends on factors such as the extent to which the new facility is integrated with the existing facility; and the extent to which the new facility is engaged in the same general type of activity as the existing source.
nitrification	the biochemical transformation by oxidation of ammonium (NH_4^+) to nitrite (NO_2^-) or nitrate (NO_3^-)
nitrogen	a chemical element, commonly used in fertilizer as a nutrient, that is also a component of animal wastes. Plant available nitrogen forms include nitrate (NO_3^-) and ammonium (NH_4^+).
no-till	a planting procedure that requires no tillage except that done in the immediate area of the crop row
NRCS	Natural Resource Conservation Service, United States Department of Agriculture
NSPS	New Source Performance Standards are uniform national EPA air emission and water effluent standards that limit the amount of pollution allowed from new sources or from modified existing sources
nutrient management	a planning tool used to control the amount, source, placement, form, and timing of the application of nutrients and soil amendments (USDA, 1999)
nutrient management plan	an approach for managing the form, rate, timing, and method of application of nutrients, including nutrients from biosolids, being applied to the soil in a manner that provides adequate plant nutrition but minimizes the environmental impact of these nutrients
nutrient removal rate	the removal of nutrients in harvested material on a per acre basis
NWPCAM	National Water Pollution Control Assessment Model
organic matter	the organic fraction of the soil exclusive of undecayed plant and animal residue

overflow	the process wastewater discharge resulting from the filling of wastewater or liquid manure storage structures to the point at which no more liquid can be contained by the structure
permit nutrient plan (PNP)	a plan developed in accordance with 40 CFR 412.33 (b) and §412.37. This plan shall define the appropriate rate for applying manure or wastewater to crop or pasture land. The plan accounts for soil conditions, concentration of nutrients in manure, crop requirements and realistic crop yields when determining the appropriate application rate.
phosphorus	one of the primary nutrients required for the growth of plants. Phosphorus is often the limiting nutrient for the growth of aquatic plants and algae.
phosphorus level	a system of weighing a number of measures that relate the potential for phosphorus loss due to site and transport characteristics. The phosphorus index must at a minimum include the following factors when evaluating the risk for phosphorus runoff from a given field or site: (1) Soil erosion. (2) Irrigation erosion. (3) Run-off class. (4) Soil phosphorus test. (5) Phosphorus fertilizer application rate. (6) Phosphorus fertilizer application method. (7) Organic phosphorus application rate. (8) Method of applying organic phosphorus.
phosphorus threshold (TH level)	a specific soil test concentration of phosphorus established by states. The concentration defines the point at which soluble phosphorus may pose a surface runoff risk.
photoperiod	the time between sunrise and sunset
phytase	an enzyme effective at increasing the breakdown of phytase phosphorus in the digestive tract and reducing the phosphorous excretion in the feces
point source	the release of a contaminant or pollutant, often in concentrated form, from a conveyance system, such as a pipe, into a waterbody
porous dam	a runoff control structure that reduces the rate of runoff so that solids settle out in the settling terrace or basin. The structure may be constructed of rock, expanded metal, or timber arranged with narrow slots.

potassium	one of the primary nutrients required for the growth of plants
poult	a young, immature turkey
precipitation	a deposit on the earth of hail, mist, rain, sleet, or snow; *also* **:** the quantity of water deposited
pretreatment	a process used to reduce, eliminate, or alter the nature of wastewater pollutants from nondomestic sources before they are discharged into publicly owned treatment works
process wastewater	water directly or indirectly used in the operation of the CAFO for any or all of the following: spillage or overflow from animal or poultry watering systems; washing, cleaning, or flushing pens, barns, manure pits, or other CAFO facilities; direct contact swimming, washing or spray cooling of animals; litter or bedding; dust control; and stormwater which comes into contact with any raw materials, products or by-products of the operation.
production area	that part of the CAFO that includes the animal confinement area, the manure storage area, the raw materials storage area, and the waste containment areas. The animal confinement area includes but is not limited to open lots, housed lots, feedlots, confinement houses, stall barns, free stall barns, milkrooms, milking centers, cowyards, barnyard, exercise yards, animal walkways, and stables. The manure storage area includes but is not limited to lagoons, sheds, under house or pit storage, liquid impoundments, static piles, and composting piles. The raw materials storage area includes but is not limited to feed silos, silage bunkers, and bedding materials. The waste containment area includes but is not limited to settling basins, and areas within berms, and diversions which separate uncontaminated stormwater . Also included in the definition of production area is any egg washing or egg processing facility.
production phase	the animal life cycles grouped into discreet categories based on age and maturity
protease	any of numerous enzymes that hydrolyze proteins and are classified according to the most prominent functional group (as serine or cysteine) at the active site
PSES	Pretreatment Standards for Existing Sources
PSNS	Pretreatment Standards for New Sources
pullet	an immature female chicken

reduced-till	a management practice whereby the use of secondary tillage operations is significantly reduced
residue cover	unharvested material left on the soil surface designed to reduce water and wind erosion, maintain or increase soil organic matter, conserve soil moisture, stabilize temperatures, and provide food and escape cover for wildlife
RFA	Regulatory Flexibility Analysis
rill erosion	an erosion process in which numerous small channels of only several centimeters in depth are formed; occurs mainly on recently cultivated soils
runoff	the part of precipitation or irrigation water that appears in surface streams of waterbodies; expressed as volume (acre-inches) or rate of flow (gallons per minute, cubic feet per second)
SBA	Small Business Administration
SBREFA	Small Business Regulatory Enforcement Fairness Act
setback	a specified distance from surface waters or potential conduits to surface waters where manure and wastewater may not be land applied. Examples of conduits to surface waters include, but are not limited to, tile line intake structures, sinkholes, and agricultural well heads.
sheet erosion	soil erosion occurring from a thin, relatively uniform layer of soil particles on the soil surface; also called interrill erosion
side-dressing	the application of fertilizer alongside row crop plants, usually on the soil surface. Nitrogen materials are most commonly side-dressed.
sludge	settled sewage solids combined with varying amounts of water and dissolved materials that are removed from sewage by screening, sedimentation, chemical precipitation, or bacterial digestion
slurry	a thin mixture of a liquid and finely divided particles
soil test phosphorus	the measure of the phosphorus content in soil as reported by approved soil testing laboratories using a specified analytical method
sow	a mature female hog
spreader	a farm implement used to scatter fertilizer
supernatant	the liquid fraction in a lagoon

surface runoff	the portion of precipitation on an area that is discharged from the area through stream channels
surface water	all water whose surface is exposed to the atmosphere (Soil Conservation Society of America, 1982)
suspended solids	(1) undissolved solids that are in water, wastewater, or other liquids and are largely removable by filtering or centrifuging; (2) the quantity of material filtered from wastewater in a laboratory test, as prescribed in APHA Standard Methods for the Examination of Water and Wastewater or similar reference
tanker	a vehicle constructed to transport bulk liquids
tom	a male turkey
total suspended solids (TSS)	the weight of particles that are suspended in water. Suspended solids in water reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles. Differentiated from total dissolved solids by a standardized filtration process whereby the dissolved portion passes through the filter.
USDA	United States Department of Agriculture
volatilization	the loss of gaseous components, such as ammonium nitrogen, from animal manure
waste management system	a combination of conservation practices formulated to appropriately manage a waste product that, when implemented, will recycle waste constituents to the fullest extent possible and protect the resource base in a nonpolluting manner
wastewater	the spent or used water from a home, a community, a farm, or an industry that contains dissolved or suspended matter
water quality	the excellence of water in comparison with its intended use or uses