III. Summary of Operations, Impacts, and Pollution Prevention Opportunities for the Agricultural Livestock Production Industry

This section provides an overview of commonly employed operations and maintenance activities in the agricultural livestock production industry. This discussion is not exhaustive; the operations and maintenance activities discussed are intended to represent the material inputs, major pollution outputs, and associated environmental impacts from agricultural livestock production practices. General pollution prevention and waste minimization opportunities are also discussed in the context of each of the operations and maintenance activities.

The choice of practices or operations influences the material used and the resulting pollution outputs and environmental impacts. Keep in mind that environmental impacts are relative, as some kinds of pollution outputs have far greater impacts than others.

Impact of Agriculture on the Environment

> The Clean Water Act Plan of 1998 called for the development of the EPA/USDA *Unified National Strategy for Animal Feeding Operations* (AFOs) to minimize the water quality and public health impacts of AFOs.

According to the *EPA/USDA Unified National Strategy for Animal Feeding Operations* (March 9, 1999), despite progress in improving water quality, 40 percent of the Nation's waterways assessed by States do not meet goals for fishing, swimming, or both. While pollution from factories and sewage treatment plants has been dramatically reduced, the runoff from city streets, agricultural activities, including AFOs, and other sources continues to degrade the environment and puts environmental resources (i.e., surface water, drinking water) at risk. According to EPA's 1996 305(b) water quality report, the top two pollutants from agriculture were identified as sediment and nutrients, respectively. Additional agricultural pollutants, such as animal wastes, salts, and pesticides, were identified by EPA[1]. The following presents a brief discussion of the environmental impacts or effects of agricultural pollutants.

(1) ***Nutrients***. Excess nutrients in water (i.e., phosphorus and nitrogen) can result in or contribute to low levels of dissolved oxygen (anoxia),

[1] *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters,* U.S. Environmental Protection Agency, January 1993.

eutrophication, and toxic algal blooms. These conditions may be harmful to human health; may adversely affect the suitability of the water for other uses; and, in combination with other circumstances, have been associated with outbreaks of microbes such as *Pfiesteria piscicida*.

- Phosphorus. Phosphorus determines the amount of algae growth and aging that occurs in freshwater bodies. Runoff and erosion can carry some of the applied phosphorus to nearby water bodies.

- Nitrogen. In addition to eutrophication, excessive nitrogen causes other water quality problems. Dissolved ammonia at concentrations above 0.2 mg/L may be toxic to fish. Biologically important inorganic forms of nitrogen are ammonium, nitrate, and nitrite. Ammonium becomes adsorbed to the soil and is lost primarily with eroding sediment. Even if nitrogen is not in a readily available form as it leaves the field, it can be converted to an available form either during transport or after delivery to waterbodies. Nitrogen in the form of nitrate, can contaminate drinking water supplies drawn from groundwater. Nitrates above 10 ppm in drinking water are potentially dangerous, especially to newborn infants.

(2) ***Sediment.*** Sediment affects the use of water in many ways. Suspended solids reduce the amount of sunlight available to aquatic plants, cover fish spawning areas and food supplies, clog the filtering capacity of filter feeders, and clog and harm the gills of fish. Turbidity interferes with the feeding habits of fish. These effects combine to reduce fish and plant populations and decrease the overall productivity of waters. In addition, recreation is limited because of the decreased fish population and the water's unappealing, turbid appearance. Turbidity also reduces visibility, making swimming less safe.

(3) ***Animal Wastes***. Animal waste includes the fecal and urinary wastes of livestock and poultry; process water (such as from a milking parlor); and the feed, bedding, litter, and soil with which fecal and urinary matter and process water become intermixed. Manure and wastewater from AFOs have the potential to contribute pollutants such as nutrients (e.g., nitrogen and phosphorus), organic matter, sediments, pathogens, heavy metals, hormones, antibiotics, and ammonia to the environment. Decomposing organic matter (i.e., animal waste) can reduce oxygen levels and cause fish kills. Solids deposited in waterbodies can

accelerate eutrophication through the release of nutrients over extended periods of time.

Contamination of groundwater can be a problem if runoff results from the misapplication or over application of manure to land or if storage structures are not built to minimize seepage. Because animal feed sometimes contains heavy metals (e.g., arsenic, copper, zinc), the possibility for harmful accumulations of metals on land where manure is improperly or over applied is possible.

Pathogens in manure. Pathogens in manure can cause diseases in humans if people come in contact with the manure. Pathogens in manure also create a food safety concern if manure is applied directly to crops at inappropriate times or if manure contaminates a product (e.g., food, milk). In addition, pathogens are responsible for some shellfish bed closures. Runoff from fields receiving manure may contain extremely high numbers of bacteria (though all of these bacteria may not be harmful) if the manure has not been properly incorporated. Pathogens, such as *Cryptosporidium*, have been linked to impairments in drinking water supplies and threats to human health.

Air pollution is also a concern in relation to animal wastes. Farms on which animals are raised often concentrate odors associated with the microbial degradation of manure and other by-products of the production of meat, milk and eggs. Odors can be a nuisance to neighbors of animal operations, and there is increasing concern about the potential health effects from emissions of odorous compounds.

(4) ***Salts***. Salts are a product of the natural weathering process of soil and geologic material. In soils that have poor subsurface drainage, high salt concentrations are created within the root zone where most water extraction occurs. The accumulation of soluble and exchangeable salts leads to soil dispersion, structure breakdown, decreased infiltration, and possible toxicity; thus, salts often become a serious problem on irrigated land, both for continued agricultural production and for water quality considerations. High salt concentrations in streams can harm freshwater aquatic plants just as excess soil salinity damages agricultural crops.

(5) ***Pesticides.*** The primary pollutants from pesticides are the active and inert ingredients, diluents, and any persistent degradation products. Pesticides and their degradation products may enter groundwater and surface water in solution, in emulsion, or bound to soils. Pesticides may, in some instances, cause impairments to the uses of surface

waters and groundwater. Both the degradation and sorption characteristics of pesticides are highly variable. Some types of pesticides are resistant to degradation and may persist and/or accumulate in aquatic ecosystems. Pesticides may harm the environment by eliminating or reducing populations of desirable organisms, including endangered species.

Within a livestock production establishment, pesticides may be applied directly to livestock or to structures (e.g., barns, housing units) to control pests, including parasites, vectors, and predators.

Pesticides are both suspected and known for causing immediate and delayed-onset health hazards for humans. If exposed to pesticides, humans may experience adverse effects, such as nausea, respiratory distress, or more severe symptoms up to and including death. Animals and birds impacted by pesticides can experience similar illnesses or develop other types of physical distress.

Pollution Prevention/Waste Minimization Opportunities in the Agricultural Livestock Production Industry

The best way to reduce pollution is to prevent it in the first place. Industries have creatively implemented pollution prevention techniques that improve operations and increase profits while minimizing environmental impacts. This can be done in many ways such as reducing material inputs, reusing byproducts, improving management practices, and employing substitute toxic chemicals.

To encourage these approaches, this section provides general descriptions of some pollution prevention advances that have been implemented within the agricultural livestock production industry. While the list is not exhaustive, it does provide core information that can be used as the starting point for establishments interested in beginning their own pollution prevention projects. This section provides information from real activities that may be or are being implemented by this sector. When possible, information is provided that gives the context in which the technique can be effectively used. Please note that the activities described in this section do not necessarily apply to all facilities that fall within this sector. Facility-specific conditions must be carefully considered when pollution prevention options are evaluated, and the full impacts of the change must examine how each option affects air, land, and water pollutant releases.

The use of pollution prevention technologies and environmental controls can substantially reduce the volume and concentration of the contaminants released/discharged into the surrounding environment. In some cases, these pollution prevention approaches may be economically beneficial to the agricultural production industries because they decrease the amount of chemicals needed, and therefore the cost of maintaining operations.

Waste minimization generally encompasses any source reduction or recycling that results in either the reduction of total volume or the toxicity of hazardous waste. Source reduction is a reduction of waste generation at the source, usually within a process. Source reduction can include process modifications, feedstock (raw material) substitution, housekeeping and management processes, and increases in efficiency of machinery and equipment. Source reduction includes any activity that reduces the amount of waste that exits a process. Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product or as an ingredient or feedstock in an industrial process.

It should be noted that as individual practices, these pollution prevention and waste minimization practices can significantly reduce the environmental impacts of agricultural operations. However, to get the full effect of the practices and maximize pollution prevention potential, an agricultural operation must consider its individual practices in the context of a system. The practices combine to form an integrated system in which each practice interacts with the others and is affected by the others. That is, outputs from one practice may be inputs into one of the other practices, in effect creating a closed-loop system that both maximizes profits and minimizes environmental impacts. By considering their establishments as systems, operators will be better able to evaluate and implement pollution prevention or waste minimization opportunities.

Operations of Livestock Production

Livestock production generally includes the following activities:

- Feed storage, loading, and unloading
- Housing
- Feeding and watering
- Managing animal waste
- Applying pesticides and pest control
- Maintaining and repairing agricultural machinery and vehicles
- Fuel use and fueling activities

The additional activities of planning and management are required for all of the above processes to occur. Exhibit 17 presents the material inputs and pollution outputs from each of these processes.

Exhibit 17. Livestock Production Activities and Potential Pollution Outputs

Activity	Potential Pollution Outputs
Feed storage, loading, and unloading	S Dust emissions S Unusable or spilled feed S Leachate from silage S Nutrient-contaminated runoff
Housing	S Animal waste S Waste bedding S Air emissions (e.g., odors, methane, ammonia) S Washwater from flushing and washdown of housing areas
Feeding	S Animal waste S Air emissions (e.g., dust, methane) S Moldy feed discard S Spilled feed S Nutrient-contaminated runoff
Watering	S Animal waste S Water contaminated with animal waste S Destruction of stream bank, riparian zone (from animals in streams)

Typically, most of the above activities include the generation of *animal waste.* Animal waste must be managed appropriately because of its potential environmental impacts.

Managing animal waste, includes collecting and transporting; storing and treating; and utilizing animal waste	S Discharges and leaching of wastewater S Manure and urine S Bedding S Air emissions (e.g., ammonia, methane, other gases, odor, dust) S Hair and/or feathers S Carcasses S Pathogens S Heavy metals S Wasted products (e.g., milk, eggs)

Exhibit 17. Livestock Production Activities and Potential Pollution Outputs

Activity	Potential Pollution Outputs
Additional activities that occur at agricultural establishments and their potential pollution outputs include:	
Pest control	S Discharges and leaching of pesticides S Chemical air emissions
Maintaining and repairing agricultural machinery and vehicles	S Used oil S Spent fluids and organic solvents S Used tires S Spent batteries S Metal machining wastes S Scrap metal
Fuel use and fueling activities	S Fuel spills or leaks

III.A. Feed Storage, Loading, and Unloading

Feed storage, loading, unloading, and transport are major activities in livestock production. Livestock feed may include hay, grain (sometimes supplemented with protein, vitamins, mineral supplements and antibiotics), and silage -- with grain and hay being the most common feeds. Livestock operations may produce all, a portion, or none of the animal feed. Purchased feed is transported to the livestock operation by truck or, at very large animal operations, by rail. Stored feed must be loaded, transported to the animals' normal feed location, and unloaded.

S Hay that has been cut and partially dried is collected from fields and compacted into small rectangular bales or rolled into large round bales. Hay may be stored in covered and enclosed buildings, in fields, and in outside storage areas where it may or may not be covered. Small rectangular hay bales may be placed in a barn by conveyor.

Feed hay is often transported on tractor-drawn wagons to feed bunkers, feed rings, and mangers. Small rectangular hay bales may be mechanically or manually placed in bunkers and mangers. Front-end loaders are used to unload round bales and place them in the feed rings.

- Harvested grain is sometimes milled (ground) on site or more commonly sent offsite to a milling facility for grinding prior to being returned to the facility for use. Depending on the livestock species, protein, vitamins, mineral supplements, and antibiotics are often added at the time of milling or mixing. Grain is typically stored in aerated grain bins and handled with augers. High moisture corn is stored in silos. Grain, which is typically placed in feed bunkers, troughs, or feeder units, can be transported using a front-end loader, tractor front bucket, grain wagon, or manually for smaller volumes.

- Silage is usually produced onsite and may consist of chopped green corn or hay. Silage is allowed to ferment in vertical or horizontal silos or storage bunkers prior to use as feed. Silage is removed from silos and then distributed along the feed bunks.

Potential Pollution Outputs and Environmental Impacts

The primary pollution outputs include unusable feed; dust emissions from loading, unloading, and grinding activities; air emissions from transportation to and from sites; and leachate from silage. A minor pollution output is contamination of storm water from spilled feed. Dust emissions pollute the air that agricultural workers and animals breathe and can cause respiratory problems in instances of prolonged exposure. Research indicates that silage materials stored at 65 percent moisture content or higher can produce leachate.

Pollution Prevention/Waste Minimization Opportunities

One potential pollution prevention practice focuses on minimizing unusable feed and consequently maximizing the amount of feed that is consumed by the animal. One way to maximize animal consumption is by grinding the feed in either a grinder-mixer or a tub grinder. Grinding increases the ability of the animal to digest the feed. Where possible, grinders should be used with a dust collector to reduce dust emissions. Silage leachate can be reduced by allowing the material to wilt in the field for 24 hours, varying cutting and harvesting times, cutting or crimping the material, or adding moisture-absorbent material to the silage as it is stored[2].

[2] *Farm-A-Syst, Fact Sheet #9, Reducing the Risk of Groundwater Contamination by Improving Silage Storage*, University of Wisconsin, Extension/Cooperative Extension, College of Agricultural and Live Sciences.

III.B. Housing

Livestock housing may consist of feed lots, barns, stables or stalls, corrals, covered loafing areas, pens, poultry houses, and other similar structures that confine the animals in an area and manner best suited to the overall livestock production process. There are three general ways to house livestock:

(1) Enclosed housing (i.e., a roofed and walled structure)
(2) Partially enclosed (i.e., usually roofed with walls on some structure sides)
(3) Open or no structures

The type of housing used for a particular animal type/livestock production is related to animal size, feeding, animal health and biosecurity, climate, and the goal of achieving the optimum weight gain or commodity produced at the lowest cost.

- Dairy cattle. Most dairy operations provide separate housing for different animal groups based on age or milking status (lactating versus dry). Calves may be housed in barns, individual pens within a barn, open fields, and hutches. Heifers may be housed in freestall barns and bedded pack housing. Bedded pack housing is often used with an open feeding area. Dry cows (<3 months to calving) are usually housed on pasture or in freestall barns. Lactating cows are housed in freestall and other types of barns such as stanchion, corrals, structures, and open lots that provide shade[3].

- Beef cattle. Beef cattle are mainly housed in pastures and open feedlots. Calving facilities may consist of an open pasture, a shed with stalls, or an open, wind-protected pen. Bulls are either penned separately or in groups of up to 10. They may be contained in a barn or in an open pen with shade. Cattle feedlots are usually open areas that may have windbreaks and shade. Very few beef cattle are housed in freestall barns with slotted floors for manure collection.

- Sheep. Sheep are maintained primarily on open grazing land, but some are kept in open lots with shelters, facilities with slotted floors for manure collection, and in bedded pens.

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[3] *Preliminary Data Summary: Feedlots Point Source Category Study*, U.S. Environmental Protection Agency, Office of Water, Washington, DC, December 1998.

- Horses. Most horses maintained in concentrated numbers are housed in stalls within an enclosed barn. Approximately 70 percent of the horse operations that use stalls have one animal per stall. Horses may also be housed in partially enclosed housing or on pasture.

- Poultry. Poultry including turkeys and ducks are maintained in an enclosed house. Chicken broilers, roasters, and pullets, which may be caged, are usually maintained in houses on a solid floor with bedding. Breeders are usually maintained in houses with a slatted floor generally covering one-third of each side of the house along the length of the side-wall of the house. Most layers are maintained in houses inside of cages with mesh floors, and a few in houses with a litter or slat/litter floor. Turkey poults are reared in enclosed brooder houses, then generally are moved to grower houses and sometimes to range. Turkeys are normally raised on a dirt or clay floor with a bedding cover. Duck housing is normally an enclosed house that has a wire-mesh floor, a solid floor, or a combination of the two.

- Goats. Goats are housed in loose housing common areas that may contain bedded and exercise areas, individual stalls, pens, and corrals. Pregnant does are usually housed in bedded pens.

- Swine. While some swine are raised outdoors with a shelter (e.g., hoop housing), most are housed in an enclosed barn or house. Breed sows may be kept in small group pens and then during farrowing, a sow is usually placed in an individual pen. Young pigs are placed together in larger nursery pens. Finishing operations keep several pigs in the same pen.

The floors of some livestock housing for cattle, swine, and sheep, may be of slotted construction. The floors for some poultry housing may be of wire-mesh or slat construction. The slotted, wire-mesh, and slatted housing floor systems allow the manure to drop into a long-term or temporary storage/collection/transfer area.

Bedding is mostly used in the housing of dairy cattle, poultry, and horses but may be used for the housing of any of the livestock types presented above. Manure and bedding needs to be removed at regular intervals. Methods of removal vary depending on the type of housing. Manure is primarily removed from housing by scraping, scooping, and flushing (see Section III.D. Managing Animal Wastes).

Potential Pollution Outputs and Environmental Impacts

The primary pollution outputs include animal wastes, bedding, wastewater from flushing and washdown of housing areas, and air emissions (e.g., methane, ammonia, and odors). The main impacts of these outputs are soil and water contamination stemming from waste spills, improper storage, and runoff.

From an environmental standpoint, each type of livestock housing (enclosed, partially enclosed or open) has advantages and disadvantages. The move from outdoor housing to confinement housing has removed the weather factor and runoff, which is a substantial problem for outdoor housing, and provided producers the opportunity to manage manure as a resource and not a waste. However, concentrated amounts of manure can be viewed as a disadvantage. While concentrating the animals (and therefore the animal manure) may lead to easier manure management, concentrated amounts of manure have a greater potential to significantly impact the environment in the event of a spill, release, or improper management.

Wastes, including manure and fouled bedding, that are not properly transported from housing could spill and potentially contaminate storm water runoff. Open housing such as feedlots, corrals, and pens, if not scraped as necessary, may also contaminate storm water runoff. Wastes carried in storm water runoff may be discharged to surface waters causing pollution, or may be deposited in low areas and potentially leach to the groundwater.

Animals contained in pasture areas (technically not housing but used for livestock containment) can wear away soil from feeding sites, destroy streambanks at natural watering sites, and, if allowed access, defecate and urinate in surface waters. This results in increased runoff, soil erosion as well as sediments, manure, and urine in the water.

With enclosed or partially enclosed housing areas, odors and other gases (e.g., methane, ammonia, and hydrogen sulfide gases) from animal waste can be concentrated, potentially harming the health of the animals and workers. When the gases are released outside, the odor can affect the surrounding areas and create nuisance problems for neighbors.

Pollution Prevention/Waste Minimization Opportunities

While the majority of the wastes discussed above for housing cannot be prevented, both the wastes and their impacts can be reduced by implementing best management practices.

- *Minimize water use during cleaning*. By cleaning livestock (except poultry) housing on a regular and frequent basis and using minimal amounts of water during cleaning, operations may reduce the volume of wastes to be handled and used. Keeping the waste dry also facilitates its management, reduces runoff potential, and minimizes odors from decomposition.

- *Minimize runoff by cleaning open areas*. Cleaning open areas reduces the potential for the runoff of wastes to surface waters.

- *Reduce odor by preventing ammonia generation*. Ammonia is created by the rapid conversion of urinary nitrogen (urea) to ammonia by microorganisms. By applying various chemicals (e.g., urease inhibitors) on a weekly basis, the conversion of nitrogen to ammonia can be reduced, thus minimizing ammonia emissions and odors, and conserving valuable fertilizer[4].

- *Use tools to minimize odor impacts on the surrounding community.* When considering the installation of a new livestock operation or the expansion of an existing operation, facilities should consider maximizing the distance to neighboring dwellings, the existence of "reverse" setback rules, the potential for new neighbors, and the potential impact neighbors may have on limiting the expansion of the animal housing. Additional methods for reducing odors in other aspects of livestock operations are discussed below.

III.C. Animal Nutrition and Health

There are many activities and considerations when managing animal nutrition and health, including feeding, watering, and biosecurity issues. Animal nutrition is an important consideration for livestock operators for various reasons, including the health of the animals, as well as the nutrient

[4] *Use of Urease Inhibitors to Control Nitrogen Loss From Livestock Waste,* U.S. Department of Agriculture, 1997.

composition of the manure. The nutrient composition of manure (nitrogen and phosphorus) is directly related to the composition of the animal feed, feed supplements, and ability of the animal to digest the feed.

Feeding

Corn, soybean, grasses, hay, silage, and other grains are some of the common food sources for livestock. Most livestock operations adjust the composition of the animals' feed to meet the animals' current protein needs. As an example, dry cows are typically fed a lower protein diet when compared to cattle being milked or nursing calves. Likewise, swine operations often use phase feeding and separation of sexes to best meet the animals' protein needs, lower feed costs, and reduce nutrient levels of the manure. Generally, swine operations feed varying protein diets in relationship to the growth phase and/or need of the animal. As an example, operations provide higher protein feed to farrowing sows, less protein to gilts, and even less to barrows (made possible through separate confinement of sexes). Some livestock operations place swine in confinements recently used for cattle. The swine will receive a portion of its nutrient requirement by feeding on the cattle manure. This provides an overall reduction in the nutrients excreted at the livestock operation.

Feed supplements may include amino acids and enzymes. The supplement of synthetic lysine in swine feed assists in lowering the nitrogen level in the manure. The addition of this amino acid allows feeding of a lower protein diet. Normally, the phosphate in the phytic acid passes through the digestive tract of swine and poultry and is excreted. The addition of phytase, an enzyme to swine and poultry feed, will allow the animal to digest phytic acid from cereal grains and soybean meal and convert it to phosphate for use by the animal. This reduces the need for supplemental phosphorus in the diet of swine and poultry. Currently, the use of phytase is not feasible due to economic and production concerns.

The ability of the animal to digest the feed can be increased by fine grinding and pelletizing feed. Fine grinding increases the surface area of the feed and thereby increases the portion digested.

Feeding can take place in the housing facility, at a separate feeding facility or feeder unit(s), and from pastureland. Other than grazing, where the animal (e.g., sheep, horses, cattle) goes to the feed, the feed is brought to the animals and placed in a feeding device. The feeding process begins with the feed being transported, by various means, from the storage areas to feeding area or unit. The method of feeding is usually related to the type of animal and the housing structure.

- Most dairy operations feed the animals between milking events and may feed the animals from feed bunks that may be covered or uncovered. Small dairy cattle operations may feed the animals during milking and place them on pasture for grazing between milkings.

- Beef (feeder) cattle operations generally feed the animals from feed bunks that may be covered or uncovered. These operations may also use feed rings for large bales of hay.

- Horses, if maintained inside, are fed from a manger and/or other feed device.

- Housed poultry and swine are generally fed continuously from feeding devices. The two major types of feeding devices for poultry and swine are self feeders, which provide the animal with a constant supply of food, and mechanical feeders, which distribute the feed to the animals at predetermined intervals.

Watering

Watering involves the operation and maintenance of animal drinking systems or access to naturally-occurring surface waters or man-made watering structures (e.g., ponds, reservoirs). It is essential that a constant or on-demand supply of water be provided for livestock.

For those housed or in other types of confined areas, there are many different types of man-made watering devices, each of which can be modified depending on the animal using the system. Some of the most commonly used systems include the following:

- *Animal-operated pumps or drinkers*. Large livestock kept in enclosed and partially enclosed housing can use animal-operated pumps or valves (nose pumps/valves). Livestock-operated on-demand watering devices allow the animal to use its nose to actuate a valve or push a pendulum unit that dispenses water. Small livestock kept in enclosed housing generally have on-demand drinkers that are actuated by the mouth or beak of the livestock.

- *Trough systems*. Large livestock kept in enclosed and partially enclosed housing can also use trough systems. In trough systems, animals drink directly from troughs or tanks. The discharge of water to the trough/tank may be float-controlled or continuous.

Many partially enclosed, open, and pasture/grazing livestock operations perform water hauling or provide access to watering sources to meet livestock watering needs.

- *Water hauling*. Water may also be provided to animals in open pastures and grazing operations through water hauling. By using a truck with a main storage tank and an easily-moved stock tank, the watering point can be relocated as necessary throughout the operation.

- *Access to privately-owned ponds or reservoirs using restricted access ramps*. For grazed cattle and pastured dairies, natural streams and other surface waters provide a source of drinking water. Many partially enclosed, open, and pasture/grazing livestock operations allow animals access to watering sources, such as privately-owned ponds or reservoirs, via restricted access ramps. Access ramps allow the animals to use the water source while minimizing erosion of the banks. While some reservoirs are supplied by natural precipitation, many use water pumping systems. Powered by gas, solar energy, and wind, these systems transport water from the water source to the reservoir or pond.

Biosecurity
Biosecurity consists of the procedures used to prevent the spread of animal diseases from one facility to another. Animal diseases can enter a facility with new animals, on equipment, and on people. Animals, equipment, and people that have recently been at another facility may pose the greatest biosecurity risk. Biosecurity procedures include such general categories as use of protective clothing, waiting periods for new animals and visitors, and cleaning.

Biosecurity is important to livestock owners because some diseases can weaken or kill large numbers of animals at an infected facility. In some cases, the only remedy available to an operation is to sacrifice an entire group of animals in order to prevent the spread of the disease to other parts of the facility or to other facilities. In other words, a failure to conduct biosecurity procedures can cause serious financial and productivity losses for a livestock operation.

The types of biosecurity procedures necessary will depend on the type of animal at a facility, the way the diseases of concern spread to and infect animals, and vulnerability of the animals to each specific disease. For example, if a group of swine has little immunity to a serious virus, and that virus can enter the facility on the skin or clothing of visitors, a facility may need to require visitors to observe a waiting period, take a shower, and change into clean clothing provided by the facility before entering. A different group of swine may have better immunity to the virus, and such biosecurity measures would be unnecessary.

Some of the general types of biosecurity procedures include:

- Controls on the introduction of new animals to a group or facility (such as quarantine periods).
- Controls on equipment entering the farm (such as washing and disinfecting crates).
- Controls on personnel entering the farm (such as requiring service personnel to stay out of animal buildings, or providing protective clothing and footwear).
- Controls on wild or domestic animal access (such as closing holes in buildings to keep undesirable animals out).
- Sanitation in animal housing areas (such as cleaning pens).
- Identification and segregation of sick animals (including adequate removal and disposal of dead animals).

The key to developing adequate biosecurity procedures is to find accurate information about animal diseases and how to prevent them. Potential sources for specific biosecurity information and recommendations include extension services and other agricultural education organizations; veterinarians and veterinary organizations; producer and industry groups; and published information in books, magazines, and World Wide Web sources.

Potential Pollution Outputs and Environmental Impacts

Feeding. When feeding, the potential pollution outputs are soil erosion due to overgrazing, animal wastes (which are partially composed of unabsorbed feed components), spilled feed during feed unloading to feed equipment and by livestock as they feed, mechanical failures with feed equipment (e.g., inoperative cutoff switch), and dust emissions during feed transport. The pollution outputs and potential environmental impacts vary based on the type and location of feed equipment and number of animals.

- *Overgrazing* can contribute to soil losses due to severe erosion, and impoverishment can change the vegetation composition and associated organisms in rangelands.

- *Surface water and groundwater contamination from concentrated wastes*. Totally enclosed feed locations (e.g., barns, poultry houses), when compared to the same livestock types in a partially sheltered or open area, may generate a larger quantity of animal waste per acre of land due to a higher concentration of livestock in a smaller area. Totally enclosed structures are protected from rainfall and should not experience the runoff of livestock wastes and wasted feed that may occur in partially sheltered and open feed locations.

- *Surface water and groundwater contamination from runoff*. Partially sheltered feed locations (e.g., dairy operation free-stall barns and covered loafing areas) and open feed locations (e.g., feeder cattle maintained in a area that has no roofed or walled structures) have a greater pollution potential due to runoff. Areas with no vegetation may experience runoff of livestock waste and spilled feed during rainfall events.

- *Air emissions (e.g., dust).* Areas with no vegetation that are dry may produce dust pollution during the transportation of feed.

Watering. The primary pollution output from watering is excess water, which most likely becomes wastewater that is contaminated with livestock wastes (e.g., manure, urine) and feed. Surface waters and groundwater can become contaminated from wastewater runoff, and surface waters can be directly contaminated with wastes (e.g., manure, urine) from livestock that are allowed access to the water (e.g., during watering).

Properly operated man-made watering systems significantly reduce the environmental impact of livestock. However, continuous watering systems that overflow and cause runoff often cause significant environmental damage. Additionally, livestock with access to creeks, rivers and other natural water sources cause environmental damage by contaminating the water with animal waste, destroying riparian habitat, and eroding the stream banks.

Pollution Prevention/Waste Minimization Techniques
There are many pollution prevention opportunities to reduce or minimize the pollution outputs and impacts from livestock feeding and watering activities. Generation of these wastes can be prevented through management practices, preventive maintenance, appropriate feedlot location, and use of waste minimization technologies.

Feeding. Wastes generated during feeding (e.g., feed spills, unused feed) can be prevented by using troughs or mechanical feeding systems that reduce feed loss and prevent contact with watering areas, weather, and the ground.

- *Use portable and/or covered feeders*. Feeders can be constructed to be portable, eliminating the problem of manure buildup that occurs around stationary feeders. For outdoor or partially enclosed feeding operations, use of covered or protected feeders prevents the feed from being exposed to rain or wind. Examples of such feeders include mineral feeding boxes, and weathervane mineral feeders.
  - A mineral feeding box is simply a trough that is raised off the ground, enclosed on three sides, and covered by a roof.
  - A weathervane mineral feeder consists of a 55-gallon drum with a cut out opening of sufficient size for the animal to reach the feed. The drum pivots on a concrete base that is heavy enough to prevent overturning by cattle or wind. A weathervane is attached to the top of the drum so the feed opening is pushed away from the wind direction, and rain is prevented from reaching the opening.
- *Use specially designed feeders.* For hay feeding operations, using feeders that are specifically designed to accept bales minimizes hay loss and prevents potential nutrient runoff.
- *Use feeders that prevent spills and contact with the ground.* Feeding racks store hay between steel bars, thus minimizing the amount of hay that an animal can pull from the rack and spill on the ground. Totally enclosed racks where the hay is located inside a rectangular or circular enclosure may have diagonally shaped bars containing the hay inside. These bars require the

animal to turn its head in order to reach through and remove its head from the hay, thus significantly reducing the amount of hay the animal can pull from the feeder and spill.

Watering. Pollution prevention techniques to prevent environmental impacts from watering include the following:

- *Prevent access to surface waters*. Livestock operations can use physical barriers (e.g., fencing) to prevent animals access to surface waters (e.g., creeks, streams, rivers). This will minimize contamination of these waters caused by animal defecating directly in the water, and runoff carrying waste reaching the water.

- *Reduce excess water use and spills of water*. Preventing overflows of watering devices and excess water use during watering can prevent water becoming mixed with wastes and potential runoff.

- *Use self-watering devices*. The on-demand, self-watering systems that are used in many types of animal operations are an effective method of reducing waste as long as they are well maintained and checked frequently.

III.D. Managing Animal Wastes

Animal wastes are produced at all stages of the livestock production process, including housing, feeding, and watering. *For the purposes of this document, the term animal waste refers to animal manure, urine, and other materials that come in contact with and/or are managed with manure and urine in a typical livestock operation*. These materials may include, but are not limited to, bedding, wastewater from flushing and washdown of housing areas, lot runoff, disinfectants and cleaners, and spilled feed.

Animal manure has been recognized for centuries as an excellent source of plant nutrients and as a soil "builder" in terms of its positive benefits to soil quality. Animal manure is an excellent source of nutrients for plants because it contains most of the elements required for plant growth. Livestock operators today are managing and using manure as an important and valuable resource. If managed and used properly, manure can provide benefits for the livestock operation, such as reduced commercial fertilizer use and increased soil quality.

Overall, the amount of animal wastes to be managed can be extensive. The challenges of animal waste management have been compounded in recent years due to the growth of animal feeding operations. These types of operations have resulted in the concentration of manure production on an ever smaller land area. The consistency and volume of animal waste to be managed at a livestock operation depends on the types of animals at the facility. Generally, dairy cattle, beef cattle, swine, and sheep produce a comparatively wet waste and broiler poultry litter is dry (22-29 percent water). Laying and breeding operations are often considered to have wet manure because of how the waste is handled. Exhibit 18 provides a comparison of the manure production for various animals.

Animal Type	**Weight of Manure (lbs/day/1000 lbs of animal live weight)**	
Dairy Cow, Lactating	80.0	75-90
Beef, Cow	63.0	20-80
Swine, Grower (40 - 220 lb)	63.4	70-85
Poultry, Broiler	80.0	22-29
Sheep	40.0	70
Horse	50.0	70

Source: *Preliminary Data Summary: Feedlots Point Source Category Study*, Table 11.2, U.S. Environmental Protection Agency, Office of Water, Washington, DC, December 1998.
Composting Manure and Other Organic Residues, Table III, Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, March 1997.

Types of Animal Waste Management Systems. Animal waste management systems involve the collection, transport, storage, treatment, and utilization (rather than disposal) of waste, preferably in a manner that is economically and environmentally sound. The type of system that each operation uses

Additional management activities at livestock operations include controlling or collecting runoff from outdoor lots and waste storage; directing clean water away from lots and storage areas; and disposing of livestock mortalities.

depends on the type of animal(s), manure moisture content, size of the operation, acreage and site, available manure utilization methods, and operator's personal preference. Additional information on animal waste management systems, including collection, storage, treatment, transfer, and utilization, can be found in Chapter 9: Agricultural Waste Management Systems of the *Agricultural Waste Management Field Handbook* (USDA, 1992) which can be accessed at http://www.ftw.nrcs.usda.gov/awmfh.html.

Using Best Management Practices. Livestock operators can implement structural and nonstructural best management practices (BMPs) to reduce the volume of animal wastes that must be managed.

- *Structural BMPs* for an animal waste management system may include roof gutters on buildings to collect and divert clean water; vegetated filter strips and riparian buffers to trap sediment; and surface water diversions to move clean water around the areas containing waste.

- *Non-structural (management) BMPs* for an animal waste management system may include reduced frequency and volume of washdown; implementation of a comprehensive nutrient management plan; relocation of manure stacks; and other site-specific land uses that do not involve construction or land movement.

III.D.1. Collecting & Transporting Animal Wastes

The most significant quantities of animal waste are generated at feeding, watering, and housing locations. Waste collection methods vary based on the type of housing and feeding operations, as well as manpower, available equipment, operator training, pen size, and manure moisture content. Some types of manure collection systems used in livestock productions are:

- *Slotted floor systems*. The slotted floor system allows the manure to drop through the slots to a storage tank or area located beneath the floor.

- *Scraping*. Scraping is the primary method of manure collection for open housing and a common method for partially enclosed housing and enclosed housing. Common scraping equipment includes small tractor operated scrapers, tractor-pulled pan scrapers, and automated alley scraper blades on a cable. The manure may be scraped into storage facilities, to treatment, or to utilization equipment.

- *Flushing*. Flushing is often used in enclosed and partially enclosed housing. Manual or automated hydraulic flush equipment uses water to flush the manure to collection/storage pits or lagoons.

The following describes the animal waste collection and transport systems used for different types of animals.

- Dairy cattle. Dairy cattle manure is usually collected and transported from sheds and freestall barn alleys by a manual or automated hydraulic flush in warmer climates and alley scrapers in colder climates. Manure dropped in milking parlors is commonly collected by a manual hydraulic flush. Freestall barns and alleys may also have the manure collected by scraping. Manure in open areas such as corrals is primarily collected by scraping; manure in grazed areas is not collected.

- Beef cattle. Manure is usually collected from beef cattle feedlots by scraping. The feedlot area may be unpaved, partially paved around feed and watering areas, or totally paved. Though rare, if beef cattle are kept in enclosed and partially enclosed housing, manure collection is accomplished by a slotted floor system. The manure drops through the slots to a below-floor tank that provides either short-term or long-term storage. In grazed areas, the manure is not collected.

- Sheep. Sheep are primarily maintained on pasture and the manure is not collected. Manure, from sheep kept in enclosed housing, is usually collected by a slotted floor system.

- Horses. Manure from horses housed in enclosed barn stalls, is most often collected by shoveling. The manure and bedding from stalls is often removed daily and placed in stacks.

- Poultry. Poultry manure collection is generally related to the type of operation. Poultry manure is generally dry (22-29 percent water). Broiler, roaster, pullet, turkey, and some duck houses usually raise the birds on the house floor or in cages on beds of shavings, sawdust, rice hulls, or peanut hulls. The manure is allowed to accumulate on the floor where it is mixed with the bedding.

  Many of the poultry broiler houses are only cleaned out completely once a year. Often, they only remove the top two inches or so between flocks (approximately 5-6 flocks per year in broilers houses). The litter is removed with a cruster machine or a small tractor with a front bucket. In layer and duck operations, the operator commonly collects the manure by allowing it to drop through the wire-mesh cage, house floor or slotted floor to a collection area where it is usually removed by a hydraulic flush or belt scraper to a lagoon. Manure is sometimes composted, but can also be stored in stacking sheds, roofed storage areas, outside and covered or uncovered, or occasionally in ponds until it is ready for transport to a disposal or land application area.

- Goats. Goat manure is collected by manual shoveling from small pens or stalls or scraped from larger containment enclosed, partially enclosed, and open areas.

- Swine. Manure from swine in enclosed housing is often collected by allowing it to drop through a slotted floor to a storage area, or it may be collected by a manual or automated flush system. Manure from swine maintained in partially enclosed or open housing is usually collected by scraping.

In housing where animals are confined, frequent manure collection and transport are critical to livestock health. Frequent removal of wastes reduces the naturally occurring volatilization of nitrogen as ammonia and the anaerobic digestion and the subsequent release of gases in the production buildings. This reduction of pit gases, which can be fatal, and odor improves the in-house environment and employee working conditions.

Collection and transport of wastes by flushing is facilitated by slightly sloped, paved floors, alleys, or gutters. Waste collected through slotted floors and wire-mesh cages is usually transported from the below-floor/below-cage collection area by a hydraulic (water) flush or may be scraped. The flushed manure and/or litter may be transported to a storage area or treatment lagoon. Two advantages of the flush system for collecting and transporting manure are that it is non-labor intensive and it provides a safe means to remove manure from confined spaces. The flush, which can be initiated manually or cycled by timer, dosing system, tip tank, or other means, transports the manure from the collection area. Pumping is used to transport liquid and slurry wastes from collection pits to storage or treatment lagoons. High solid wastes are often collected and transported from the housing or feeding areas using tractors with scraper blades and/or bucket loaders. Manure collected in gutters is often transported by automatic scrapers. Some disadvantages of the flush system include a huge increase in the amount of manure, manure cannot be transported very far because of the high cost versus low value, large use of water, problems with overloading when land-applied, and lagoons increasing the volatilization of nitrogen.

Potential Pollution Outputs and Environmental Impacts

For manure collection and transport, the pollution outputs can include manure, urine, litter, bedding, and water. Additional outputs include ammonia emissions from the waste, odors, hair and/or feathers, pathogens, and heavy metals.

Wastewater that may leak from storage areas or transport processes could result in surface water and groundwater contamination. While waste flushing systems aid in removing manure from underground storage basins, flush systems also generate additional manure wastewater that must be managed. Adding water also increases the risk of a manure spill or runoff reaching groundwater or surface water. Frequent collection and transport of manure and collection of surface runoff assists in reducing the nutrient losses and thereby provides greater nutrient availability during utilization. Between 40 to 60 percent of manure's nitrogen content may be lost through volatilization of ammonia NH_3 while the solid manure remains on an open lot[5]. Other nonvolatile nutrients (e.g., organic nitrogen, phosphorus) may be lost through leaching and surface runoff.

Pollution Prevention/Waste Minimization Opportunities

There are many techniques available to reduce pollution caused by animal waste collection and transport activities.

- *Reduce water used in flushing systems*. Alternative technologies, such as low-flow waste flushing systems or no-flow waste scraping systems, use less water than traditional systems, and decrease the amount of liquid that is sent to be treated in the lagoon.

- *Recycle water for flushing*. To minimize the amount of wastewater generated, some means of recycling clarified wastewater for flushing may be desirable. Separation of solids from flush water can be used to reduce the solids in the recycled flush water.

[5] *Generally Accepted Agricultural and Management Practices for Manure Management and Utilization*, Table 5, Nitrogen Losses During Handling and Storage. Adopted by Michigan Agriculture Commission, Lansing, Michigan, June 1997.

III.D.2. Storing & Treating Animal Wastes

Waste Storage
Storage is the temporary containment of manure and wastes. Following collection, animal waste not immediately used may be stored in dry or wet form by various means and structures. Broiler and beef wastes are stored in dry forms while dairy and swine wastes are stored in wet forms.

- Manure stacks, bunkers, and stacking sheds are commonly used for dry wastes.

- Pits, tanks, ponds, and lagoons for liquid or slurry wastes.

Dry manure or litter is often placed in a covered or roofed area so that it does not come into contact with storm water. Storage may be short-term, usually a few days to a few weeks, or long-term, which is usually less than one year. The purpose of short-term storage is typically the retention of manure at the point of collection until transport to long-term storage or treatment. The purpose of long-term storage is retention of the waste until utilization is possible and/or appropriate as determined by the field condition, crop, weather, and other factors. Storage containment must be designed to hold the total volume of manure generated during the maximum length of time between applications. Additionally, federally regulated CAFO liquid storage units that accept storm water runoff must be sized to contain normal precipitation and runoff (less evaporation) for the storage period plus a 25-year, 24-hour storm event flow and still provide adequate freeboard. Waste storage is not treatment and any treatment that occurs is incidental.

Waste Treatment
Following collection and/or storage, livestock production facilities may treat animal wastes. Treatment may include (1) solids separation by gravity, mechanical, or vegetative methods, and (2) stabilization of the waste by anaerobic lagoons, aerobic lagoons, or composting.

- *Solids Separation.* Solids separation is a physical treatment process whereby a portion of the larger solids and fibers are removed from the manure and can be reused. Solids separation is often used preceding a storage or a treatment lagoon to slow the rate of solids accumulation in the basin. Solids separation may be accomplished by settling basins, mechanical separation, and vegetative filter strips.

- S Settling basin. Solids separation, in a settling basin, is achieved by discharging the wastestream to a basin where the rate of flow is low enough to cause gravity settling of the solids.

- S Mechanical solids separator. A mechanical solids separator unit may be a static screen, vibrating screen, mechanical flat belt (press), or roller press. In solids separation by static or vibrating screen, the flow is generally passed across the screen where the solids are captured and the liquid drops through. The liquid portion from the settling basin and/or mechanical separator is normally sent to storage or treatment or used to irrigate cropland. The collected solids may be used for bedding, feed, soil amendment, or compost.

- *Lagoons (Anaerobic or Aerobic)*. Lagoons can be anaerobic or aerobic (non-mechanical and mechanical), although aerobic lagoons are used less frequently. In contrast to solids separation, lagoons are biological treatment processes used to satisfy the oxygen demand (e.g., BOD, COD) and volatilize nitrogen. Lagoons can convert ammonia nitrogen to nitrate, though this is extremely rare in animal treatment systems.

  Lagoons vary in shape and size, but when properly constructed should have sufficient volume to hold the waste during the treatment period and contain normal precipitation and runoff (less evaporation) for the storage period plus a 25-year, 24-hour storm event flow and still have adequate freeboard. Lagoons should be lined either with clay, naturally occurring high clay content soils, concrete, or a synthetic liner.

  - S *Anaerobic lagoons* are commonly used to treat animal waste -- particularly swine, but also cattle and layers. Because anaerobic lagoons do not require free oxygen for treatment, they are usually six to ten feet deep. Anaerobic systems are sometimes operated with two lagoons in series allowing the first lagoon to overflow via pipe or spillway to the second lagoon.

  - S *Non-mechanical aerobic lagoons* are shallow, usually two to five feet deep and have a large surface area. This allows more sunlight to reach the algae, which in turn produce oxygen needed for treatment to occur. Non-mechanical aerobic lagoons are rarely used in livestock applications because they require large amounts of land.

- *Mechanical aerobic lagoons* have higher construction costs due to the aeration equipment. The aeration process is expensive to operate; however, digestion occurs at a faster rate and fewer odors are produced. Due to the additional construction and operating costs, mechanical aerobic lagoons are uncommon. Mechanically aerated lagoons are sometimes used to control odors in odor-sensitive areas. Aerobic lagoons will produce more sludge than anaerobic lagoons and thus require additional solids handling.

• *Composting.* Composting is an aerobic biological process that converts organic waste into a stable organic product that can be used onsite or transported offsite for use. Composting reduces the volume of waste and kills pathogens while preserving more of the nutrients for use by crops. The composted material improves soil fertility, tilth (tilled earth), and water holding capacity. Composting is optimized by proper ratios of carbon to nitrogen and carbon to phosphorus; moisture content; temperature; pH; and time.

In the composting process, a bulking agent (e.g., wood chips, peanut husks, animal bedding, or other materials) is mixed with the manure to provide the proper carbon ratios. Because of its high nutrient to volume ratio, composted animal waste, or compost, is a beneficial agricultural product. Compost can be spread on paddocks, cropland, and nursery stock, or used for landscaping and home gardens. Note: Many poultry and some swine operations also use composting for carcasses.

There are four general composting methods -- static pile, aerated static, windrow, and in-vessel.

- Static pile method is the simplest composting operation and requires the least labor, but take the longest time to complete the process. The static pile operation is not mixed or aerated.

- Aerated static pile method is not mixed but usually has piping to allow air to reach the interior of the pile.

- Windrow method involves a long narrow pile that is regularly mixed and aerated.

S In-vessel method is an enclosed operation that allows accurate control of moisture and other parameters, while containing the odors.

Potential Pollution Outputs and Environmental Impacts

During waste storage, livestock production operations may produce stack seepage and storm water runoff which should be directed to the liquid storage ponds and lagoons.

During waste treatment, the pollution outputs and impacts include releases of ammonia and other gases to the air, contaminated runoff to surface waters, leaching resulting in groundwater contamination, and odors. For lagoons, the major pollution output is wastewater that is leached to groundwater through improperly lined lagoons; discharges to surface waters due to overfilling and breakthroughs; or improper transfer of wastes between facilities resulting in surface water contamination.

Pollution Prevention/Waste Minimization Opportunities

There are pollution prevention techniques that can be used during animal waste storage and treatment activities. These include:

- *Proper location*. The location of manure storage systems should consider proximity to water bodies, floodplains, and other environmentally sensitive areas.

- *Cover wastes*. During storage, place dry manure or litter in a covered or roofed area so that it does not come into contact with storm water. When composting, impacts can be significantly reduced by maintaining the compost operation under a roof or in an enclosed area.

- *Prevent spills by regular inspections and maintenance*. Spills and overflows can be prevented by regular inspections and preventive maintenance of lagoons; never filling lagoons beyond treatment capacity; and removing sludge as needed.

- *Use vegetative filters.* Vegetative filters are often used to prevent runoff from lagoon or settling basin liquid overflow from reaching a waterbody. As the water flows across the vegetative strip, the solids drop out of the water, thus reducing the amount of solids that can impact the environment. Vegetative filters are effective when located near the lagoon.

- *Build a reserve lagoon*. While the installation of a reserve lagoon may not be economically viable in all situations, the potential release of lagoon contents to the environment can be reduced by maintaining a spillway to a reserve lagoon. Spillways provide for limited release of overflow, which reduces the tendency for stress-related structural failure. A reserve lagoon is an integral component of a spillway system that prevents contamination of surface water and groundwater.

- *Prevent overtopping*. In preparation of rain events or to prevent exceeding lagoon capacity, livestock operations may hire a contractor to remove liquids from lagoons that are in danger of overtopping.

III.D.3. Utilizing Animal Wastes

Animal wastes (e.g., manure and urine) can be used as sources of plant nutrients. Land application is the most common, and usually most desirable, method of utilizing manure and wastewater because of the value of the nutrients and organic matter. Land application should be planned to ensure that the proper amount of nutrients are applied in a manner that does not adversely impact the environment or endanger public health.

> **Benefits of Land Application of Animal Wastes.** The benefits of proper application include improvement of the physical, chemical, and biological properties of the soil, as well as significant economic returns from the use of manure as a plant nutrient.

Considerations for appropriate land application should include:

Nutrient Management Plans[6]. The primary purpose of nutrient management is to achieve the level of nutrients (e.g., nitrogen and phosphorus) required to grow the planned crop by balancing the nutrients that are already in the soil with those from other sources (e.g., manure, biosolids, commercial fertilizers) that will be applied. At a minimum, nutrient management can help prevent the application of nutrients at rates that will exceed the capacity of the soil and the planned crops to assimilate nutrients and prevent pollution.

- S Comprehensive Nutrient Management Plans (CNMPs). As discussed in the *USDA-EPA Unified National Strategy for Animal Feeding Operations*, all animal feeding operations should develop and implement technically sound, economically feasible, and site-specific CNMPs to minimize impacts to water quality and public health. In general, a CNMP identifies actions or priorities that will be followed to meet clearly defined nutrient management goals at an agricultural operation. CNMPs should address, as necessary, manure and wastewater handling and storage, land application of manure and other nutrient sources, site management, record keeping, and feed management. CNMPs should also address other utilization options for manure where the potential for environmentally sound land application of manure is limited at the point where it is generated.

- *Timing and Methods of Application:* The timing and methods of application should minimize the loss of nutrients to groundwater or surface water and the loss of nitrogen to the atmosphere. Manure and wastewater application equipment should be calibrated to ensure that the quantity of material being applied is what is planned. Care must be taken when land-applying manure and wastewater to prevent it from

[6] On May 24, 1999, USDA-NRCS released the Policy for Nutrient Management and the revision to the conservation practice standard for Nutrient Management (Code 590). NRCS' directive and supporting technical guide establishes policy for nutrient management, sets forth guidance to NRCS personnel who provide nutrient management technical assistance, and for the revision of the NRCS nutrient management conservation practice standard. These two documents will provide the framework for all nutrient management plans developed by NRCS for the agricultural community, which will be tailored by State Conservationists within a two-year period. Of particular importance is the new policy as it relates to producers that may not have sufficient land available to spread manure at rates that utilize nitrogen and phosphorus and will, as a result, need to pursue off-farm utilization options.

entering streams, other water bodies, or environmentally sensitive areas.

Manure can be land applied as solids, slurries, and liquids. The type of application equipment used depends on the manure moisture content. Box spreaders are typically used for dry manure, flail spreaders and injection for slurries, and irrigation and injection for liquids. Manure application may be by the livestock operation personnel or a custom applicator.

- *Surface application*. Box and flail spreaders apply the manure to the soil surface as the spreader is pulled or driven across the field. If surface applied, the manure may then be incorporated into the soil. Incorporation within 24 hours greatly reduces ammonia volatilization thus retaining nitrogen.

- *Injection*. Injected manure is incorporated into the soil as the equipment is driven or pulled across the field.

- *Irrigation.* Many livestock operations with storage ponds or treatment lagoons use irrigation systems, portable irrigation equipment, or hire custom irrigators. Those establishments with field crops or silviculture often use portable irrigation systems such as traveling guns or center pivots. Operations with several different fields or large acreage on which to apply the waste typically use travelers. Small acreage establishments often use small-nozzle, moderate-pressure, permanent irrigation systems, because they provide low labor costs and more uniform distribution of lagoon liquids.

Potential Pollution Outputs and Environmental Impacts

While properly applied animal wastes provide nutrients and have little negative environmental consequence, improper management and use of animal wastes, such as overapplication, excessive spraying, or application during rain events or on frozen ground, may result in serious impacts to the environment.

The potential pollution outputs of land application include nutrient runoff and leaching, which may cause surface water and groundwater contamination, respectively. Pollutants of concern include (1) nitrates and nitrites that originate from oxidation of nitrogen contributed by the manure, and (2) phosphorus. Groundwater contamination is caused by the nitrates leaching from the crop root zone into the groundwater aquifer. The amount of contaminated runoff depends on factors such as what type of manure is used, how it is handled, type of crop being grown, stage of growth, weather conditions, method of application, and the amount of existing nutrients in the soil.

Overapplication or improper application of animal waste can also lead to aesthetic problems, including odors and vectors. It can also result in polluted runoff resulting in contamination of surface waters. The presence of ammonia, phosphates and organic matter in surface waters can result in increased biochemical oxygen demand and low levels of oxygen. This can cause the death of fish and other aquatic life forms. (Ohio State University, *Ohio Livestock Manure and Wastewater Guide*)

> Vectors are defined as organisms that carry pathogens from one host to another, such as insects or rats/mice.

Pollution Prevention/Waste Minimization Opportunities
In addition to land application, other manure use practices include:

- Processing and recycling through ruminant feeding programs.
- Biogas production as an energy source using anaerobic digester technologies.
- Pyrolysis processes to produce electricity, chars (materials scorched, burned, or reduced to charcoal), and industrial petrochemicals.
- Microbial and algae production as an animal feed source.
- Aerobic degradation to produce composted products.

III.E. Other Management Issues

Odor Control

Odors are typically generated throughout the livestock production process. The odor from manure can vary depending on the type and consistency of the manure, how it is stored, and how and where it is applied.

Potential Pollution Outputs and Environmental Impacts
With enclosed or partially enclosed housing areas, odors and other gases (e.g., methane, ammonia, and hydrogen sulfide gases) from animal waste can be concentrated, potentially harming the health of the

animals and workers. When the gases are released outside, the odor can affect the surrounding areas and create nuisance problems for neighbors.

Pollution Prevention/Waste Minimization Techniques
There are several ways livestock facilities can reduce odors resulting from their operations and waste management practices. These include:

7 *Reduce methane emissions*. One method of reducing methane emissions from livestock is to supplement the animal's diet. Scientists have found that supplementing a cow's diet with substances such as urea increases the animal's ability to digest food. With improved digestion, less fermentation takes place during digestion, and methane emissions per unit of forage have been reduced 25-75 percent. In addition, as digestion improves, productivity also improves, as dairy cows produce more milk and beef cattle fatten faster (*Information Unit on Climate Change, 1993*).

7 *Follow BMPs for land application*. Odors from land application of manure can be minimized by following BMPs that are designed to maximize the nutrients available to the soil and crops. Many of these BMPs may be required by state or local ordinance. These practices include the following:

S Spreading manure within agronomic rates.

S When possible incorporating surface-applied manure within 24 hours.

S Spreading early in the day as the air is warming and rising; this allows the applied waste to dry which reduces odor.

S Avoiding spreading manure on windy days (i.e., blowing towards the neighbor).

S Avoiding spreading manure during holidays and weekends.

S Avoiding spreading waste near heavily traveled roads.

Managing Animal Carcasses

Dead animals should be disposed of in a way that does not adversely affect ground or surface water or create public health concerns. Composting, rendering, and other practices are common methods used to dispose of dead animals.

As with rendering plants, dead animals may be processed for use as pet food, composted, buried, or incinerated. USDA and FDA regulations prohibit the use of mortalities as feed for animals that are to be consumed by humans. *Note: State law or self-imposed industry standards may limit some of these options.* Because rendering must generally occur within 24 hours of an animal's death, it is helpful for the livestock production facility to establish rendering contacts in advance. Where this may not be possible, freezer storage could be used until such time as the rendering facility can collect the animals for processing. Some centrally located rendering facilities may provide pickup services to local livestock operations.

Animal carcass composting is another common method of handling poultry and small animal mortalities. Carcass composting typically takes more time than manure or yard waste composting, but has been shown to be an effective waste management approach. Many poultry and some swine operations use composting for carcasses. Livestock operations may use poultry compost sheds to dispose of their dead birds by mixing the dead birds with bedding and other materials.

As with manure composting, the compost process requires a carbon source to provide the proper carbon/nitrogen ratio for the necessary bacterial processes. Sawdust and straw are typically used as a carbon source due to their small particle size, ease of handling, absorbency, and high carbon content. Sawdust in excess of that required for the ideal carbon/nitrogen ratio is used in the initial stages of composting to provide adequate coverage of the carcasses. Sawdust also helps reduce odors from the composting process.

Potential Pollution Outputs and Environmental Impacts

Animal carcasses must be properly and quickly managed because they are a source of disease and can attract many vectors. Environmental impacts of carcasses depend on the management method used.

- Burial and/or pit disposal of carcasses in coarse textured soils and in areas of a high water table may contribute nutrients to groundwater.

- Animal carcasses that are disposed of above ground or insufficiently covered can cause aesthetic and potential human health impacts including odor generation and vector attraction, such as flies and mice.

- Specifically, poultry compost houses can be a potential source of pollution if not managed properly (e.g., kept at the right temperature, moisture content, etc.) because a leachate can form and leak from the compost house.

- The rendering process generates wastewater that must be managed according to the rendering facility's NPDES permit or pretreatment permit.

Pollution Prevention/Waste Utilization Techniques

There are several techniques that can be used to minimize wastes resulting from animal mortalities. As described above, rendering or composting are considered disposal methods that prevent pollution. If these are not available, burying carcasses can be another option. The impact of burying carcasses can be minimized by burying them deep below the surface of the ground, well away and downgrade from any source of drinking water, and covered with a generous supply of quicklime to reduce soil pH before fill dirt is added. If the carcasses must be disposed of onsite, it is preferable to have:

- A burial area at least 100 meters away from houses and watercourses
- The pit base at least 38 inches above the level of the watertable
- Heavy soil of low permeability and good stability
- Good access to the site for earthmoving machinery and stock transport unless the stock are to be walked in for slaughter

It is important to avoid sites sloping toward watercourses and areas that are likely to drain to surface water. Many states may have more strict statutes regulating the burial of dead animals. For example, Oregon requires that the animal carcasses be buried to such a depth that no part of them are nearer than four feet to the natural surface of the ground and they are covered with quicklime and at least four feet of soil.

> The burial of dead animals is being phased out. In fact, some states prohibit the practice, except under the most extreme circumstances.

III.F. Pest Control

Within a livestock production establishment, pesticides may be used for a variety of purposes. They may be applied directly to livestock or to structures, such as barns and housing units, to control pests (e.g., parasites, vectors). Pesticides can also be used to control predators. Vectors are defined as organisms that carry pathogens from one host to another, such as insects or rats/mice.

Livestock. Commonly, pesticides are applied directly to livestock using high-pressure and low-pressure sprayers, mist application equipment (i.e., fumigation and foggers), and dipping vats. In addition, pesticides may be added to ear tags and to gates through which animals commonly pass (i.e., gate wipes/brushes). Spraying or fogging animals, especially high-pressure spraying, allows penetration into fur and wool to control lice, mange, wool maggots, and other parasites and vectors. Portable dipping vats are used for treating external parasites, especially of sheep and swine.

Structures. Pesticides may also be applied directly to or used in and around structures, such as barns or other types of housing units. Sprayers and foggers are the most commonly used methods to apply insecticides, rodenticides, and disinfectants, although other methods may be used, such as injected termite treatments, rat/mouse traps, or other types of insect traps. Such applications are used to control flies, beetles, and manure larvicides, among others.

Predators. Some livestock operations, especially sheep and goat operations, experience problems with predators. Historically, these problems have been addressed by operators through various methods to scare away potential predators. Such methods included scarecrows or bells. Recently, another method, livestock protection collars, have been developed to help combat predators. Livestock protection collars are placed around the necks of the livestock and contain a rubber bladder filled with a pesticide. When predators, primarily coyotes, attack livestock they go for the throat, puncture the bladder on the collar, and ingest the pesticide. The livestock are unhurt, but the coyotes ultimately die from the ingested pesticide.

Potential Pollution Outputs and Environmental Impacts

The potential environmental impacts from pesticide application are runoff or leaching to surface water or groundwater, spills to surface waters, potential human and animal exposure, overtolerance levels on animals and products, and soil contamination that could leave land unproductive. These environmental impacts may all occur if pesticides are not applied in accordance with the label directions. The degree of environmental impact depends on the application method.

- The application of pesticides using spray or fogger systems is more likely to involve releases to air, which may result in human and excessive animal exposure.

- If not disposed of properly, liquids from dipping vats may contaminate both surface water and groundwater.

- If not protected with backflow prevention devices, pesticides applied through spray systems that are connected to water supplies can siphon back to the water source and potentially contaminate drinking water systems.

- In addition to runoff and leaching, spills of pesticides may also negatively impact the environment. The impacts are the same as for runoff and leaching, but may be more significant since the spilled materials will be concentrated in one specific area. Also, improperly cleaned and disposed pesticide containers may cause releases to the soil and/or surface waters.

Pesticides are both suspected and known for causing immediate and delayed-onset health hazards for humans. If exposed to pesticides, humans may experience adverse effects, such as nausea, respiratory distress, or more severe symptoms up to and including death. To help reduce this potential exposure, tolerance levels have been established for residues on agricultural products. Animals and birds impacted by pesticides can experience similar illnesses or develop other types of physical distress. Following label directions for application, protective gear, and disposal will help ensure such environmental impacts do not occur.

Pollution Prevention/Waste Minimization Opportunities

Environmental impacts from pesticides can be minimized by following the label directions and preventing or minimizing their use wherever possible. Pesticide use accounts for a substantial portion of farm production costs. By reducing their use, agricultural establishments can not only reduce production costs, but also reduce environmental impacts of their operations. Pesticide use and impact can be minimized by using general good housekeeping practices, integrated pest management, and good management practices. Examples of these are presented below.

7 **Integrated Pest Management**. Integrated pest management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment. Examples of IPM in the livestock production industry could include maintaining structures (e.g., plug holes, place stripping around doors and windows), good housekeeping in barns and other structures, rodent and insect traps, and use of predators (e.g., certain insects, snakes). IPM can involve the use of pesticides. In such cases, the IPM plan should indicate when a pesticide is needed, and its selection is based on persistence, toxicity, and leaching and runoff potential such that the most environmentally friendly pesticide is used.

7 **Good Management Practices**. In addition to use consistent with the label, there are other general management practices associated with pesticides that can help reduce their environmental impact. Such practices include:

S Buy only the amount needed for a year or a growing season.

S Minimize the amount of product kept in storage.

S Calculate how much diluted pesticide will be needed for a job and mix only that amount.

S Apply pesticides with properly-calibrated equipment.

S Purchase pesticide products packaged in such a way as to minimize disposal problems.

S Work with the state to locate a pesticide handler who can use the excess pesticide.

S Return unused product to the dealer, formulator, or manufacturer.

- Implement setbacks from wellheads for application and storage.

- If possible, choose nonleachable pesticides labeled for the pest.

III.G. Maintaining and Repairing Agricultural Machinery and Vehicles

Day-to-day maintenance and repair activities keep agricultural machinery and vehicles safe and reliable. Maintenance activities include oil and filter changes, battery replacement, and repairs, including metal machining.

Potential Pollution Outputs and Environmental Impacts
The wastes from maintenance and repair activities can include used oil, spent fluids, spent batteries, metal machining wastes, spent organic solvents, and tires. These wastes have the potential to be released to the environment if not handled properly, stored in secure areas with secondary containment, protected from exposure to weather, and properly disposed of. If released to the environment, the impact of these releases can be contamination of surface waters, groundwater, and soils, as well as toxic releases to the atmosphere. Groundwater pollution can also result from discharges of wastes to Class V wells.

Pollution Prevention/Waste Minimization Opportunities
Preventive maintenance programs can minimize waste generation, increase equipment life, and minimize the probability of significant impacts and accidents. Where the wastes cannot be eliminated, safe handling and recycling can minimize environmental impacts. The following presents pollution prevention/waste minimization opportunities for each type of waste.

Used Oil. The impact of oil changes can be minimized by preventing releases of used oil to the environment, and recycling or reusing used oil whenever possible. Spills can be prevented by using containment around used oil containers, keeping floor drains closed when oil is being drained, and by training employees on spill prevention techniques. Oil that is contained rather than released can be recycled, thus saving money, and protecting the environment.

Recycling used oil requires equipment like a drip table with a used oil collection bucket to collect oil dripping from parts. Drip pans can be placed under machinery and vehicles awaiting repairs to capture any leaking fluids. By using catch pans or buckets, rather than absorbent materials to contain leaks or spills of used oil, the used oil can be more easily recycled. To encourage recycling, the publication "How To Set Up A Local Program To Recycle Used Oil" is available at no cost from the RCRA/Superfund Hotline at 1-800-424-9346 or 1-703-412-9810.

Proper Disposal of Oil-Based Fluids. Spent petroleum-based fluids and solids should be sent to a recycling center whenever possible. Solvents that are hazardous waste must not be mixed with used oil or, under RCRA regulations, the entire mixture may be considered hazardous waste. Non-listed hazardous wastes can be mixed with waste oil, and as long as the resulting mixture is not hazardous, can be handled as waste oil. All used drip pans and containers should be properly labeled.

Spent Fluids. Farm machinery and vehicles require regular changing of fluids, including oil, coolant, and others. To minimize releases to the environment, these fluids should be drained and replaced in areas where there are no connections to storm drains or municipal sewers. Minor spills should be cleaned up prior to reaching drains. Used fluid should be collected and stored in separate containers. Fluids can often be recycled. For example, brake fluid, transmission fluid, and gear oil are recyclable. Some liquids are able to be legally mixed with used motor oil which, in turn, can be reclaimed.

During the process of engine maintenance, spills of fluids are likely to occur. The "dry shop" principle encourages spills to be cleaned immediately so that spilled fluid will not evaporate to air, be transported to soil, or be discharged to waterways or sewers. The following techniques help prevent and minimize the impact of spills:

- Collect leaking or dripping fluids in designated drip pans or containers. Keep all fluids separated so they may be properly recycled.

- Keep a designated drip pan under the vehicle while unclipping hoses, unscrewing filters, or removing other parts. The drip pan prevents splattering of fluids and keeps chemicals from penetrating the shop floor or outside area where the maintenance is occurring.

- Immediately transfer used fluids to proper containers. Never leave drip pans or other open containers unattended.

Radiator fluids are often acceptable to antifreeze recyclers. This includes fluids used to flush out radiators during cleaning. Reusing the flushing fluid minimizes waste discharges. If a licensed recycler does not accept the spent flushing fluids, consider changing to another brand of fluid that can be recycled.

Batteries. Farm operators have three options for managing used batteries: recycling through a supplier, recycling directly though a battery reclamation facility, or direct disposal. Most suppliers now accept spent batteries at the time of new battery purchase. While some waste batteries must be handled as hazardous waste, lead acid batteries are not considered hazardous waste as long as they are recycled. In general, recycling batteries may reduce the amount of hazardous waste stored at a farm, and thus reduce the farm's responsibilities under RCRA.

The following best management practices are recommended to prevent used batteries from impacting the environment prior to disposal:

7 Place on pallets and label by battery type (e.g., lead-acid, nickel, and cadmium).

7 Protect them from the weather with a tarp, roof, or other means.

7 Store them on an open rack or in a watertight secondary containment unit to prevent leaks.

7 Inspect them for cracks and leaks as they come to the farm. If a battery is dropped, treat it as if it is cracked. Acid residue from cracked or leaking batteries is likely to be hazardous waste under RCRA because it is likely to demonstrate the characteristic of corrosivity, and may contain lead and other metals.

7 Neutralize acid spills and dispose of the resulting waste as hazardous if it still exhibits a characteristic of a hazardous waste.

7 Avoid skin contact with leaking or damaged batteries.

Machine Shop Wastes. The major hazardous wastes from metal machining are waste cutting oils, spent machine coolant, and degreasing solvents. Scrap metal can also be a component of hazardous waste produced at a machine shop. Material substitution and recycling are the two best means to reduce the volume of these wastes.

The preferred method of reducing the amount of waste cutting oils and degreasing solvents is to substitute with water-soluble cutting oils. If non-water-soluble oils must be used, recycling waste cutting oil reduces the potential environmental impact. Machine coolant can be recycled, either by an outside recycler, or through a number of in-house systems. Coolant recycling is most easily implemented when a standardized type of coolant is used throughout the shop. Reuse and recycling of solvents also is easily achieved, although it is generally done by a permitted recycler. Most shops collect scrap metals from machining operations and sell these to metal recyclers. Metal chips which have been removed from the coolant by filtration can be included in the scrap metal collection. Wastes should be carefully segregated to facilitate reuse and recycling.

III.H. Fuel Use and Fueling Activities

Fuel is used to operate agricultural machinery, equipment, and vehicles that are used throughout the livestock operation. Agricultural machinery and vehicles are typically fueled using an above ground fueling dispenser that is connected to an above ground or underground fuel tank.

Potential Pollution Outputs and Environmental Impacts
Agricultural machinery and vehicles that use fuel most likely emit pollutants to the atmosphere. The activity of fueling itself can emit air pollutants, and spills of fuel can cause water, soil and groundwater contamination. Underground fueling systems that are not monitored or maintained properly can leak into the surrounding soils and eventually contaminate groundwater.

Pollution Prevention/Waste Minimization Opportunities
Properly maintaining fuel tanks, lines, and fueling systems can substantially reduce the probability of accidental fuel spills or leaks. All leaking pipe joints, nozzle connections, and any damage to the fueling hose (e.g., kinks, crushing, breaks in the carcass, bulges, blistering, soft spots at the coupling, deep cracks or cuts, spots wet with fuel, or excessive wear) should be fixed immediately to reduce the amount of pollution to the environment. Spill and overflow protection devices can be installed to prevent fuel spills and secondary

containment can be used to contain spills or leaks. Additional pollution prevention techniques for fueling include the following:

- Inspect fueling equipment daily to ensure that all components are in satisfactory condition. While refueling, check for leaks.

- If refueling occurs at night, make sure it is carried out in a well-lighted area.

- Never refuel during maintenance as it might provide a source of ignition to fuel vapors.

- Do not leave a fuel nozzle unattended during fueling or wedge or tie the nozzle trigger in the open position.

- Discourage topping off of fuel tanks.

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