Michigan Department of Agriculture

Generally Accepted Agricultural and Management Practices for Manure Management and Utilization

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Michigan Commission of Agriculture
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In the event of an agricultural pollution emergency, such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture and/or Michigan Department of Environmental Quality should be contacted at the following emergency telephone numbers:

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Michigan Department of Agriculture
Right to Farm Program
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PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act (Act 93 of 1981, as amended), which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require necessary revision of the GAAMPs.

The GAAMPs that have been developed are as follows:

1) 1988-Manure Management and Utilization
2) 1991-Pesticide Utilization and Pest Control
3) 1993-Nutrient Utilization
4) 1995-Care of Farm Animals
5) 1996-Cranberry Production
6) 2000-Site Selection and Odor Control for New and Expanding Livestock Production Facilities
7) 2003-Irrigation Water Use

These GAAMPs were developed with industry, university, and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

The MDA website for the GAAMPs is http://www.michigan.gov/gaamps .

I. INTRODUCTION

Like all other segments of our economy, agriculture has changed significantly during the past 50 years and will continue to change in the future. The trend toward larger facilities (the overwhelming majority being family owned and operated) has resulted in farm operations being more capital intensive and less labor intensive. Larger farm size offers marketing advantages and generally lower unit cost of production compared to smaller sized operations. However, increased farm size brings new management challenges for environmental protection, animal welfare, and human welfare.

Animal agriculture in Michigan must have the flexibility and opportunity to change agricultural enterprises and adopt new technology to remain economically viable and competitive in the market place while being protective of the environment. If a healthy, growing livestock industry in Michigan is to be assured, efforts must continue to address concerns of livestock producers and their neighbors, particularly in two areas: (1) producers who use GAAMPs in the livestock operations should be protected from harassment and nuisance complaints and (2) persons living near livestock operations, who do not follow GAAMPs, need to have concerns addressed when odor nuisance or water quality problems occur.

No two livestock operations in Michigan can be expected to be the same, due to the large number of variables, which together determine the nature of a particular operation. The GAAMPs presented in this document provide options to assist with the development of environmental practices for a particular farm that prevents surface water and groundwater pollution.

These GAAMPs are referenced in Michigan's Natural Resources and Environmental Protection Act (NREPA), Act 451 of 1994, as amended. NREPA protects the waters of the state from the release of pollutants in quantities and/or concentrations that violate established water quality standards. In addition, the GAAMPs utilize the nationally recognized construction and management standard to provide runoff control for a 25-year, 24-hour rainfall event. Air quality issues related to production agriculture are addressed in the Odor Management Section.

About This Document

For quick reference, management practices are first presented as a numbered list. This list is not meant to convey all the information regarding GAAMPs. Rather, it is intended to be a useful tool to assist individuals in determining what management practices exist and in what section of this document further information can be found. The remainder of the document provides additional information on each of these management practices and is categorized in four areas: 1) runoff control and wastewater management, 2) odor management, 3) construction design and management for manure storage and treatment facilities, and 4) manure application to land. Throughout this document you will find some text that is bolded and other text that is not. Section headings and recommended management practices in the GAAMPs for Manure Management and Utilization are in **bold text**. The un-bolded text provides supplemental information to help clarify the intent of the recommended management practices.

Appendix A provides essential data for manure management system planning.

Appendix B discusses the difference between Manure Management System Plans (MMSP) and Comprehensive Nutrient Management Plans (CNMP) and explains who needs a CNMP. Appendix C shows a sample MMSP to help the reader become more familiar with the type of information that is typically included in a MMSP.

The final portion of this document is a list of references that can provide detailed information not supplied in this document.

II. Runoff Control and Wastewater Management

1. Facilities may be paved, partially paved around waterers and feed bunks, or unpaved.

2. Runoff control is required for any facility if runoff from the lot leaves the owner's own property or adversely impacts surface and/or groundwater quality. Examples include runoff to a neighbor's land, a roadside ditch, a drain ditch, stream, lake, or wetland.

3. Milk parlor and milk house wastewater shall be managed in a manner to prevent pollution to waters of the state.

4. Provisions should be made to control and/or treat leachate and runoff from stored manure, silage, food processing by-products, or other stored livestock feeds to protect groundwater and surface waters.

5. Runoff storage basins should be designed to contain normally occurring direct precipitation and resulting runoff and manure that accumulate during the storage times projected in the Manure Management System Plan. In addition, storage volume should be provided that will contain the direct rainfall and runoff that occur as a result of the average 25-year, 24-hour rainfall event for the area. Storage basins must be constructed to reduce seepage loss to acceptable levels.

6. Application rates should be determined based upon the ability of the soil to accept and store the water and the ability of plants growing in the application area to utilize nutrients. Land application should be done when the water can be used beneficially by a growing crop.

7. An alternative to a storage pond is a structure for settling solids and an infiltration area wastewater treatment strip (FOTG 635) for handling lot runoff, and/or silage leachate wastewater. The vegetative area may be either, a long, grassed, slightly sloping channel, or a broad, flat area with little or no slope, surrounded by a berm or dike. All outside surface water should be excluded from the infiltration area so that the only water applied is lot runoff and/or silage leachate and direct precipitation. Vegetation should be maintained and harvested at least once per year to prevent excessive nutrient build up in the soil of the infiltration area.

8. Stocking densities and management systems should be employed which ensure that desirable forage species are present with an intensity of stand sufficient to slow the movement of runoff water and control soil erosion and movement of manure nutrients from the pasture land. See the NRCS-FOTG for criteria.

9. Livestock should be excluded from actual contact with streams or water courses except for controlled crossings and accesses for water or in accordance with the NRCS Prescribed Grazing Standard (NRCS-FOTG).

10. Runoff from pasture feeding and watering areas should travel through a vegetated filter area to protect surface and groundwater. See the NRCS-FOTG for criteria.

11. Provisions should be made to collect, store, utilize, and/or treat manure accumulations and runoff from outside open lots used for raising livestock.

III. Odor Management

12. Livestock producers should plan, design, construct, and manage their operations in a manner that minimizes odor impacts upon neighbors.

13. The odor of fermented feed materials, such as corn or hay silage, can be minimized by harvesting and storing them at an appropriate dry matter content (generally greater than 33 percent dry matter).

14. Frequent (daily or every few days) removal of manure from animal space, coupled with storage or stacking and followed by application to cropland at agronomic rates, is an acceptable practice throughout Michigan.

15. Solid manure that may contain bedding materials and/or is dried sufficiently, such as that from poultry, cattle, sheep, swine, horse, and fur-bearing animal facilities can be temporarily stacked outside the livestock building.

16. New outside lot systems should not be located in close proximity to residences and other odor-sensitive land uses. They should not be located uphill along a confining valley leading toward residences. New residences or other sensitive land uses should not be located within close proximity to existing outside lot facilities. (For additional guidance, see the GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Production Facilities).

17. Use covered manure storage if technically and economically feasible.

18. Where possible, do not locate manure storage in close proximity to residential areas.

19. Avoid spreading when the wind is blowing toward populated areas.

20. Avoid spreading on weekends/holidays when people are likely to be engaged in nearby outdoor and recreational activities.

21. Spread in the morning when air begins to warm and is rising, rather than in late afternoon.

22. Use available weather information to best advantage. Turbulent breezes will dissipate and dilute odors, while hot and humid weather tends to concentrate and intensify odors, particularly in the absence of breezes.

23. Take advantage of natural vegetation barriers, such as woodlots or windbreaks, to help filter and dissipate odors.

24. Establish vegetated air filters by planting conifers and shrubs as windbreaks and visual screens between cropland and residential developments.

25. Incorporate manure into soil during, or as soon as possible after, application. This can be done by (a) soil injection or (b) incorporation within 48 hours after a surface application when weather conditions permit. However, incorporation may not be feasible where manures are applied to pastures or forage crops, such as alfalfa, wheat stubble, etc., or where no-till practices are used (see Section V).

IV. Construction Design and Management for Manure Storage and Treatment Facilities

26. Construction design for manure storage and treatment facilities should meet specifications and guidelines found in the NRCS-FOTG. Additional publications that can be used are the Concrete Manure Storages Handbook MWPS-36 (MidWest Plan Service, 1994) and Circular Concrete Manure Tanks publication TR-9 (MidWest Plan Service, 1998).

27. To protect groundwater from possible contamination, utilize liners that meet specifications and guidelines in the NRCS-FOTG. Liners include natural existing soil (Barrington and Jutras, 1985; Barrington *et al*., 1987a, 1987b), bentonite or similar high swell clay materials, compacted earthen liners, and flexible membranes.

28. All manure storage structures shall maintain a minimum freeboard of twelve inches (six inches for fabricated structures) plus the additional storage volume necessary to contain the precipitation and runoff from a 25-year, 24-hour storm event.

V. Manure Application to Land

29. All fields used for the production of agricultural crops should have soils sampled and tested on a regular basis to determine where manure nutrients can best be utilized.

30. Use fertilizer recommendations, consistent with those of Michigan State University, to determine the total nutrient needs for crops to be grown on each field that could have manure applied.

31. To determine the nutrient content of manure, analyze it for percent dry matter (solids), ammonium N (NH_4-N), and total N, P, and K.

32. The agronomic (fertilizer) rate of N recommended for crops (consistent with Michigan State University N fertilizer recommendations) should not be exceeded by the amount of available N added, either by manure applied, by manure plus fertilizer N applied, and/or by other N sources. For legume crops, the removal value of N may be used as the maximum N rate for manure applications. The available N per ton or per 1000 gallons of manure should be determined by using a manure analysis and the appropriate mineralization factors (see Manure Management Sheet #2, MSUE Bulletin E-2344 by Jacobs *et al.*, 1992b) for organic N released during the first growing season following application and the three succeeding growing seasons.

33. If the Bray P1 soil test level for P reaches 150 lb/acre (75ppm), manure applications should be reduced to a rate where manure P added does not exceed the P removed by the harvested crop. (If this manure rate is impractical due to manure spreading equipment or crop production management, a quantity of manure P equal to the amount of P removed by up to four crop years can be used for the first crop year, if no additional fertilizer or manure P is applied for the remaining crop years, and this rate does not exceed the N fertilizer recommendations for the first crop grown.) If the Bray P1 soil test reaches 300 lb/acre (150ppm) or higher, manure applications should be discontinued until nutrient harvest by crops reduces P test levels to less than 300 lb/acre (150ppm). To protect surface water quality against discharges of P, adequate soil and water conservation practices should be used to control runoff and erosion from fields where manure is applied.

34. Manures should be uniformly applied to soils. The amount of manure applied per acre (gallons/acre or tons/acre) should be known, so manure nutrients can be effectively managed.

35. Manures should not be applied to soils within 150 feet of surface waters or to areas subject to flooding unless: (a) manures are injected or surface-applied with immediate incorporation (i.e., within 48 hours after application) and/or (b) conservation practices are used to protect against runoff and erosion losses to surface waters.

36. Liquid manure applications should be managed in a manner to optimize nutrient utilization and not result in ponding, soil erosion losses, or manure runoff to adjacent property, drainage ditches or surface water. An application that results in manure flow in a field tile line is an unacceptable practice.

37. As land slopes increase from zero percent, the risk of runoff and erosion also increases, particularly for liquid manure. Adequate soil and water conservation practices should be used which will control runoff and erosion for a particular site, taking into consideration such factors as type of manure, bedding material used, surface residue or vegetative conditions, soil type, slope, etc.

38. Where application of manure is necessary in the fall rather than spring or summer, using as many of the following practices as possible will help to minimize potential loss of NO_3-N by leaching: (a) apply to medium or fine rather than to coarse textured soils; (b) delay applications until soil temperatures fall below 50°F; and/or (c) establish cover crops before or after manure application to help remove NO_3-N by plant uptake.

39. Application of manure to frozen or snow-covered soils should be avoided, but where necessary, (a) solid manures should only be applied to areas where slopes are six percent or less and (b) liquid manures should only be applied to soils where slopes are three percent or less. In either situation, provisions must be made to control runoff and erosion with soil and water conservation practices, such as vegetative buffer strips between surface waters and soils where manure is applied.

40. Records should be kept of manure analyses, soil test reports, and rates of manure application for individual fields.

II. RUNOFF CONTROL AND WASTEWATER MANAGEMENT

Rainfall and snowfall-induced runoff from uncovered livestock facilities requires control to protect neighboring land areas and prevent direct discharge to surface or groundwaters. Livestock facilities, which require runoff control, include all holding areas where livestock density precludes sustaining vegetative growth on the soil surface.

1. **Facilities may be paved, partially paved around waterers and feed bunks, or unpaved.**
2. **Runoff control is required for any facility if runoff from the lot leaves the owner's own property or adversely impacts surface and/or groundwater quality. Examples include runoff to a neighbor's land, a roadside ditch, a drain ditch, stream, lake, or wetland.**
3. **Milk parlor and milk house wastewater shall be managed in a manner to prevent pollution to waters of the state.**
4. **Provisions should be made to control and/or treat leachate and runoff from stored manure, silage, food processing by-products, or other stored livestock feeds to protect groundwater and surface waters.**

The NRCS-FOTG, Chapter 6 of MWPS-18 (MidWest Plan Service, 1993), Guideline for Milking Center Wastewater, Natural Resource, Agriculture, and Engineering Service (NRAES-115 by Wright and Graves, 1998).

<u>Storage Facilities for Runoff Control</u>

Runoff control can be achieved by providing facilities to collect and store the runoff for later application to cropland.

5. **Runoff storage facilities should be designed to contain normally occurring direct precipitation and resulting runoff and manure that accumulate during the storage times projected in the Manure Management System Plan. In addition, storage volume should be provided that will contain the direct rainfall and runoff that occur as a result of the average 25 year, 24 hour rainfall event for the area. Storage facilities must be constructed to reduce seepage loss to acceptable levels.**

<u>Land Application of Runoff</u>

Equipment must be available for land application of stored runoff wastewater. Land application should be done when the soil is dry enough to accept the water.

6. **Application rates should be determined based upon the ability of the soil to accept and store the runoff and wastewater and the ability of plants growing in the application area to utilize nutrients. Land application should be done when the wastewater can be used beneficially by a growing crop. On fields testing over 150 ppm P (300 lb P/acre) soil test Bray P1, there may be instances where on-farm generated wastewater, $\leq$1 percent solids, can be utilized if applied at rates that supply 75 percent or less of the annual phosphorus removal for the current crop or next crop to be harvested.**

In these instances, the following conditions must be met:

- **a) annual sampling of the applied wastewater to determine its P content, so P_2O5 loadings can be calculated;**
- **b) soil P test levels must show a progressive decline over time;**
- **c) no other phosphorus can be applied to the crop field from other sources;**
- **d) when using irrigation as an application method, the GAAMPs for Irrigation Water Use must be followed to ensure that irrigation scheduling is used to meet and not exceed evapotranspiration needs of the crop/soil system to avoid excess wastewater disposal that would flush soluble phosphorus past the depth of crop rooting; and**
- **e) tile drained fields must be monitored in accordance with GAAMP 36;**

Sprinkler irrigation methods will provide uniform application of liquid with minimum labor requirements. Directing lot runoff through a structure for settling solids can reduce odor from the liquid storage and application to the land (refer to NRCS-FOTG & MWPS-18). For additional guidance, refer to Section III. - Odor Management Practices.

<u>Infiltration Areas</u>

7. **An alternative to a storage pond is a structure for settling solids and an infiltration area wastewater treatment strip for handling lot runoff, and/or silage leachate wastewater. The vegetative area may be either a long, grassed, slightly sloping channel or a broad, flat area with little or no slope, surrounded by a berm or dike. All outside surface water should be excluded from the infiltration area so that the only water applied is lot runoff and/or silage leachate and direct precipitation. Vegetation should be maintained and harvested at least once per year to prevent excessive nutrient build up in the soil of the infiltration area.**

Design information about infiltration areas, such as sizing, establishment, and maintenance, is available in the NRCS-FOTG (635 Wastewater Treatment Strip), MWPS-18, or the Pork Industry Handbook (MSU Extension Bulletin E-1132 by

Vanderholm and Nye, 1987). These systems are not practical for every situation. Additional information is available in MWPS-18.

Pasture Systems

Pasture land is land that is primarily used for the production of forage upon which livestock graze. Pasture land is characterized by a predominance of vegetation consisting of desirable forage species (see Moline *et al*., 1991; Moline and Plummer, 1991). Sites such as loafing areas, confinement areas, or feedlots which have livestock densities that preclude a predominance of desirable forage species are not considered pasture land.

8. **Stocking densities and management systems should be employed which ensure that desirable forage species are present with an intensity of stand sufficient to slow the movement of runoff water and control soil erosion and movement of manure nutrients from the pasture land. See the NRCS-FOTG for criteria.**
9. **Livestock should be excluded from actual contact with streams or water courses except for controlled crossings and accesses for water or in accordance with the NRCS Prescribed Grazing Standard (NRCS-FOTG).**

As authorized by the Riparian Doctrine, producers are entitled to utilize surface waters traversing their property. However, this use is limited to activities, which do not result in water quality degradation. The goal for controlling livestock access to surface waters is to prevent water quality degradation. Livestock impact water quality by the erosion of sediment and nutrients from stream banks and by the direct deposition of manure nutrients, organic matter, and pathogens.

Direct deposition is effectively prevented by restricting livestock to controlled access locations. Banks are effectively stabilized by maintaining vegetation or, as in the case of controlled watering accesses and crossings, stream banks and beds may be stabilized with appropriate protective cover, such as concrete, rocks, crushed rock, gravel, or other suitable cover. In addition to addressing environmental and public health aspects, controlling livestock access to surface water and providing alternate drinking water sources may improve herd health by reducing exposure to water and soil-borne pathogens.

10. **Runoff from pasture feeding and watering areas should travel through a vegetated filter area to protect surface and groundwater. See the NRCS-FOTG for criteria.**

Outside Lots

11. **Provisions should be made to collect, store, utilize, and/or treat manure accumulations and runoff from outside open lots used for raising livestock.**

Outside open lots used for raising livestock are areas of animal manure accumulation. Maintenance of open lot systems requires manure handling methods to periodically remove accumulated solid or semisolid manure and control lot runoff. Solid manure is typically transferred from the lot to storage facilities or equipment for application to cropland. The frequency of removal of accumulated manure will depend on the animal density (square feet of lot area per animal), the amount of time the animals spend on the lot, the animal size, and the type of feed system. Clean runoff should be diverted away from the livestock lot area. While paved lots generally result in more runoff than unpaved lots, a paved surface improves manure collection and runoff control and minimizes the potential for groundwater contamination.

III. ODOR MANAGEMENT

The goal for effective odor management is to reduce the frequency, intensity, duration and offensiveness of odors, and to manage the operation in a way that tends to create a positive attitude toward the operation. Because of the subjective nature of human responses to certain odors, recommendations for appropriate technology and management practices are not an exact science. The recommendations in this section represent the best professional judgment available.

Odor perception is a subjective response to what people detect, through their sense of smell, in the air they breathe. While there is no scientific evidence that odorous gases that escape from livestock operations are toxic at the concentrations experienced by neighbors, they can become an annoyance or a nuisance.

The following 14 management practices (#12-25) provide guidance on how to minimize potential odors from livestock operations. Producers should select those practices which are applicable to their livestock operations and develop an Odor Control Plan as part of their Manure Management System Plan (MMSP). See Appendix C for a sample MMSP that contains an example Odor Control Plan (section IX).

12. **Livestock producers should plan, design, construct, and manage their operations in a manner that minimizes odor impacts upon neighbors.**

The proximity of livestock operations to neighbors and populated areas is usually the most critical factor in determining the level of technology and management needed to minimize odor impacts upon neighbors. Therefore, site selection is an important factor in minimizing odor impacts for and upon neighbors. The more remote the livestock operation, the better the likelihood that odors will not become an annoyance for neighbors; and, therefore, a lower level of technology and management will adequately manage odors at the livestock facility. However, the distance which a livestock operation should be located from neighboring land uses to effectively control odors is not easily established. Additional information and recommendations can be found in the GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Operations.

The principles upon which the most common and effective techniques for odor control are based include (a) reducing the formation of odor-causing gases and (b) reducing the release of odorous gases into the atmosphere. The degree to which these principles can be applied to the various odor sources found in livestock operations depends on the level of technology and management that can be utilized. Feed materials and manure are the most common and predominant sources of odor and are discussed in the following subsections.

Feed Materials

Using fermented feeds, such as corn or hay silage, is an acceptable animal husbandry practice throughout Michigan for dairy and beef cattle, horses, sheep, and goats. Some odors associated with the storage and feeding of these materials are normal for these livestock operations.

13. The odor of fermented feed materials, such as corn or hay silage, can be minimized by harvesting and storing them at an appropriate dry matter content (generally greater than 33 percent dry matter).

The practice of feeding food processing by-products; (e.g., cull potatoes, dairy whey, pastry by-products, sugar beet pulp, and sweet cornhusks) to livestock is a generally accepted practice. This is especially common where livestock operations exist within close proximity to food processing facilities. Using these materials for livestock feed diverts useful by-products (that can pose a substantial load on local sewage treatment plants and a major problem for food processing plants) from the waste stream and converts them into a valuable resource. Properly handled in a livestock operation, these feeds pose no threat to the environment. These products may require special feed handling systems and may substantially increase or change the manure generated by the animals to which they are fed. Some of these by-products, and the manure produced from their consumption by livestock, can generate unusual and rather offensive and intense odors. In these situations, feed handling and manure management practices should be used to control and minimize the frequency and duration of such odors. Human garbage can only be fed under a permit in Michigan. (See PA 173 of 953, as amended).

Manure

Fresh manure is usually considered to be less odorous than anaerobically decomposing manure. Fresh manure emits ammonia but in general is not accompanied by other products of decomposition, which contribute to odors.

14. **Frequent (daily or every few days) removal of manure from animal space, coupled with storage or stacking and followed by application to crop land at agronomic rates, is an acceptable practice throughout Michigan.**

Manure odors are generally those associated with the anaerobic (in the absence of oxygen) decomposition of organic material by microorganisms. The intensity of odors depends upon the biological reactions that take place within the material, the nature of the excreted material (which is dependent upon the species of animal and its diet), the type of bedding material used, and the surface area of the odor source. Sources of decomposing manure can include stacked solid manure, outside lots when manure is allowed to accumulate, uncovered manure storages, manure treatment systems, and land application areas.

Stacked Solid Manure

15. **Solid manure that may contain bedding materials and/or is dried sufficiently, such as that from poultry, cattle, sheep, swine, horse, and fur-bearing animal facilities, can be temporarily stacked outside the livestock building.**

Further review may be needed regarding environmental precautions needed with temporary storage practices.

Temporary stockpiling of manure at field application sites may be necessary when crop production and field conditions preclude immediate application to cropland. Timely application of stockpiled manure to land at agronomic rates and soil incorporation within 48 hours after application will help to control odors and may have nutrient management crop production benefits. Leachate from solid stacked manure is subject to control as described in Section II, Runoff Control and Wastewater Management, Practice No. 4. Odors from such manure storages are minimal, except when disturbed such as during removal for application to land.

Livestock operations may utilize a variety of bedding materials as part of their manure management system. The use of straw, hay, sand, sawdust, wood shavings, waste paper, or other suitable materials, either individually or in combination as livestock or poultry bedding, is a common generally accepted practice. Bedding materials should be of an appropriate size to maximize absorptive properties and to prevent blowing and dispersion when subsequently applied to cropland. Waxed paper, aluminum foil, and plastics should not be present in bedding material.

Outside Lots

Outside open lots with or without shelters are acceptable for raising livestock in Michigan. In these systems, manure is deposited over a relatively large surface area per animal (compared to a roofed confinement system for example) and begins to decompose in place. Odor impacts can be mitigated by keeping the lot surface as dry as possible, thus limiting the microbiological activity that generates odors. Providing adequate slopes, orientation that takes advantage of sunlight, diverting up-slope runoff water away from the lot, and using recommended stocking densities will enhance drying of the lot surface. The MWPS-18, National Pork Industry Handbook, and Michigan Beef Production Notebook provide details and alternatives to accomplish this. Most feed additives and odor control chemicals applied to feedlot surfaces have not been demonstrated to be effective in reducing odors from feedlots in humid areas, such as Michigan.

In spite of good facilities design and management, odors may be generated from outside livestock lot systems. The intensity of these odors is somewhat proportional to the surface area of the odor producing sources. The frequency of impact and offensiveness to neighbors is often related to the distance to neighbors' houses and their location relative to prevailing winds.

16. **New outside lot systems should not be located in close proximity to residences and other odor-sensitive land uses. They should not be located uphill along a confining valley leading toward residences. New residences or other sensitive land uses should not be located within close proximity to existing outside lot facilities. (For additional guidance see the GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Production Facilities).**

Storages and Acceptable Covers

17. **Use covered manure storage if technically and economically feasible.**
18. **Where possible, do not locate manure storage in close proximity to residential areas.**

The primary objective of storage is to temporarily store the manure before application to land. However, some biological activity occurs in these storages, and the gases generated can be a source of odors. If storage facilities are left uncovered, the potential for manure odors to be carried away by air movement will increase. Various types of covers can be used to prevent wind driven air from coming into direct contact with a liquid manure surface and incorporating odors.

Acceptable covers that can retard odor escape from manure storages include the following:

a) Natural fibrous mats similar to those which develop on liquid manure storages receiving manure from beef and dairy cattle fed a high roughage diet.
b) Slotted flooring or other underbuilding tanks. Ventilation must be provided in the building to prevent accumulation of noxious and flammable gases.
c) A flexible plastic or similar material that covers the liquid surface and is of such strength, anchorage and design that the covering will not tear or pull loose when subjected to normal winds that have an average recurrence interval of 25 years. Gas escape ports should be provided which allow any gas that may evolve to escape.
d) A solid covering such as concrete, wood, plastic or similar materials that covers the entire liquid surface and is of such strength, anchorage, and design that it will withstand winds and expected vertical loads. Adequate air exchange should be provided which will prevent the occurrence of explosive concentrations of flammable gases.

Treatment Systems

A biological treatment system is designed to convert organic matter (feed, bedding, animal manure, and other by-products) to more stable end products. Anaerobic processes (i.e., without free oxygen) can liquefy or degrade high BOD (biochemical oxygen demand) wastes. They can decompose more organic matter per unit volume than aerobic treatment processes. Aerobic processes require free oxygen and are helpful in reducing odor but are generally not considered economical for livestock operations. Extreme environmental changes alter microbial activity. When microorganisms are stressed by their environment, waste treatment processes can malfunction, and odors may become more intense.

Lagoons and Storage Facilities

Anaerobic treatment lagoons are generally basins containing diluted manure and are designed to provide degradation of the organic material. Well-designed and managed anaerobic lagoons can be short-term odor sources. The occurrence of purple sulfur-fixing bacteria can significantly reduce odors from an anaerobic treatment lagoon. The intensity of odors is usually greatest during the early spring and occasionally in the fall.

Aerobic treatment of manure liquids can be accomplished by natural or mechanical aeration. In a naturally-aerated system, such as a facultative oxidation treatment lagoon, an aquatic environment occurs in which photosynthesis from algae and surface aeration from the atmosphere provides an aerobic zone in the upper regions of the treatment lagoon. A transition zone occurs below this aerobic zone that has a limited amount of oxygen. This is the facultative zone where bacteria are present that can live either with or without oxygen. At the bottom, there may be a sludge layer that is anaerobic. The processes that occur in the aerobic zone have a low odor potential, and the odorous compounds that are created in the facultative and anaerobic zones are converted to low odor forms in the aerobic zone. For a naturally aerated system to function properly, design specifications and quantities of manure solids to be treated must be closely followed.

An aerobic treatment lagoon should be loaded at a rate no higher than 44 pounds of ultimate BOD/day/acre. The material in the treatment lagoon should be diluted enough to allow light to penetrate three to four feet into the water. The lagoon should be a minimum of four feet deep (or deeper to allow for accumulation of sludge) to prevent rooted vegetation from growing from the bottom of the lagoon.

Mechanically-aerated systems can be used to treat animal manures to control odors, decompose organic material, remove nitrogen, conserve nitrogen, or a combination of these functions. When adequate oxygen is supplied, a community of aerobic bacteria grows that produce materials with low odor potential. Alternative treatment systems to accomplish mechanical aeration include facultative lagoons, oxidation ditches, or completely mixed lagoons.

Storage facilities are designed for manure storage only with no manure treatment. Treatment lagoons (aerobic and anaerobic) are designed specifically for manure treatment.

Effluent from treatment lagoons and storage basins should be land applied to avoid long-term and extensive ponding and to utilize manure nutrients at agronomic rates (see Section V). Construction design for treatment lagoons and storage basins should conform to the recommendations in Section IV.

Composting

Composting is a self-heating process carried on by bacteria, actinomycetes and fungi that decompose organic material in the presence of oxygen. Composting of organic material, including livestock and poultry manures, can result in a rather stable end product that does not support extensive microbial or insect activity, if the process and systems are properly designed and managed. The potential for odors during the composting process depends upon the moisture content of the organic material, the carbon-nitrogen ratio, the presence of adequate nutrients, the absence of toxic levels of materials that can limit microbial growth, and adequate porosity to allow diffusion of oxygen into the organic material for aerobic decomposition of the organic material. Stability of the end product and its potential to produce nuisance odors, and/or to be a breeding area for flies, depends upon the degree of organic material decomposition and the final moisture content. Additional information and guidance about alternatives for composting manures are available in the "On-Farm Composting Handbook" (Rynk, 1992) and the National Engineering Handbook (USDA, 2000). The occurrence of leachate from the composting material can be minimized by controlling the initial moisture content of the composting mixture to less than 70 percent and controlling water additions to the composting material from rainfall. Either a fleece blanket[1] or a roofed structure can be used as a cover to control rainfall additions or leachate from composting windrows.

Provisions should be made to control and/or treat leachate and runoff to protect groundwater and surface water. If the composting process is conducted without a cover, provisions must be made to collect the surface runoff and it either be temporarily stored (see Section IV) and applied to land (see Section V), added to the composting material for moisture control during the composting process, or applied to grassed infiltration areas (see Section II).

Anaerobic Digesters

Methane can be produced from organic materials, including livestock and poultry manures by anaerobic digestion. This process converts the biodegradable organic portion of animal wastes into biogas (a combination of methane and carbon dioxide). The remaining semi-solid is relatively odor free but still contains all the nitrogen, phosphorus, and potassium originally present in the animal manure, although some of the nitrogen can be lost after storage in a holding pond. Anaerobic digestion is a stable and reliable process, as long as the digester is loaded daily with a uniform quantity of waste, digester temperature does not fluctuate widely, and antibiotics in the waste do not slow biological activity.

Application of Manure to Land

Manure applications can and should be managed to avoid and minimize nuisance odor conditions that may be experienced by neighbors. Livestock and poultry manure applied to cropland at agronomic rates followed by timely soil incorporation, where feasible, helps to control excessive odors. The following list of practices may be used to reduce odor in the application of manure to land. Appropriate implementation will help reduce complaints of odors.

19. **Avoid spreading when the wind is blowing toward populated areas.**
20. **Avoid spreading on weekends/holidays when people are likely to be engaged in nearby outdoor and recreational activities.**
21. **Spread in the morning when air begins to warm and is rising, rather than in late afternoon.**

[1] A fleece blanket is a non-woven textile material made from synthetic fibers, such as polypropylene. The non-woven texture of a fleece blanket prevents rainfall from penetrating into the composting material, but allows the necessary exchange of carbon dioxide and oxygen.

22. **Use available weather information to best advantage. Turbulent breezes will dissipate and dilute odors, while hot and humid weather tends to concentrate and intensify odors, particularly in the absence of breezes.**
23. **Take advantage of natural vegetation barriers, such as woodlots or windbreaks, to help filter and dissipate odors.**
24. **Establish vegetated air filters by planting conifers and shrubs as windbreaks and visual screens between cropland and residential developments.**
25. **Incorporate manure into soil during, or as soon as possible after, application. This can be done by (a) soil injection or (b) incorporation within 48 hours after a surface application when weather conditions permit. However, incorporation may not be feasible where manures are applied to pastures or forage crops, (see Section V) or where crop residues are retained for erosion control. Incorporation means the physical mixing or movement of surface applied manures and other organic byproducts into the soil so that a significant amount of the material is not present on the soil surface. The physical mixing can be done by using minimal disturbance tillage equipment such as aeration tools. Incorporation also means the soaking of liquid material being applied with irrigation water, barnyard manure runoff, liquid manure, silage leachate, milk house wash water, or liquids from a manure treatment process that separates liquids from solids into the surface soil layer by infiltration, thereby moving surface applied liquid into soils that have void air space not completely filled by soil water.**

Irrigation of manure to land can be an effective land application method for delivering manure to land in a short period of time without the potential damage to soil structure that can occur with other methods. However, the process can be odorous for a short period of time.

Land application of liquid manure through an irrigation system is an acceptable method. Three methods are commonly used: Center pivot spray, center pivot with drop tubes, and volume guns either stationary or movable. Center pivots offer excellent uniformity of application, minimize compaction, and allow for timely application. Except for pivots with drop tubes, all the irrigation systems have potential for odor release.

If liquid manure is applied through an irrigation system, care should be taken to assure that runoff does not occur due to application rates exceeding the soil infiltration rates. On fractured soils or those with preferential flow paths, care must be taken to assure that manure does not flow into subsurface drains. On systems where the manure is diluted with well or surface water, a check valve assembly must be installed to prevent back flow of manure into the well or surface water source.

Spray irrigation produces aerosol sprays that can be detected for long distances. Wind direction and impact on neighbors need to be observed closely. An alternative to traveling big guns that reduces odor is a boom fitted with drop tubes to place the manure below the plant canopy on the soil surface. Research in Europe has shown this method to be effective in minimizing odors.

IV. CONSTRUCTION DESIGN AND MANAGEMENT FOR MANURE STORAGE AND TREATMENT FACILITIES

Construction Design

26. Construction design for manure storage and treatment facilities should meet specifications and guidelines found in the NRCS-FOTG. Additional publications that can be used are the Concrete Manure Storages Handbook MWPS-36 (MidWest Plan Service, 1994) and Circular Concrete Manure Tanks publication TR-9 (MidWest Plan Service 1998).

Seepage Control for Earthen Basins

27. To protect groundwater from possible contamination, utilize liners that meet specifications and guidelines in the NRCS-FOTG (313 Waste Storage Facility). Liners include natural existing soil (Barrington and Jutras, 1985; Barrington *et al.*, 1987a, 1987b), bentonite or similar high swell clay materials, compacted earthen liners, and flexible membranes.

Management

28. All manure storage structures shall maintain a minimum freeboard of twelve inches (six inches for fabricated structures) plus the additional storage volume necessary to contain the precipitation and runoff from a 25-year, 24-hour storm event.

When considering total storage volume, include all bedding, storm runoff water, milk house and parlor wastewater, and silage leachate that enter the storage structure. In addition, manure storage structure integrity should also be maintained by means of periodic inspections. During these inspections, identify any item that would minimize integrity, such as animal burrows, trees and shrubs growing on the berm, and low areas in the structure that may be conducive to leakage.

V. MANURE APPLICATION TO LAND

One of the best uses of animal manure is as a fertilizer for crop production. Recycling plant nutrients from the crop to animals and back to the soil for growth of crops again is an age-old tradition. Depending on the species of animal, 70-80 percent of the nitrogen (N), 60-85 percent of the phosphorus (P), and 80-90 percent of the potassium (K) fed to the animals as feed will be excreted in the manure and potentially available for recycling to soils.

Livestock operations can generate large amounts of manure and increase the challenge of recycling manure nutrients for crop production. Good management is the key to ensure that the emphasis is on manure utilization rather than on waste disposal. Utilizing manure nutrients to supply the needs of crops and avoiding excessive loadings achieves two desirable goals. First, efficient use of manure nutrients for crop production will accrue economic benefits by reducing the amounts of commercial fertilizers needed. Second, water quality concerns for potential contamination of surface waters and groundwater by nutrients, microorganisms and other substances from manure can best be addressed when nutrients are applied at agronomic rates and all GAAMPs for manure applications are followed.

Application of animal manure to fields used for crop production is the predominant form of manure recycling. Three overriding criteria that need to be considered for every manure application are environmental protection, neighbor relations, and nutrient utilization. The manure should be managed in a manner to retain the nutrients in the soil-plant system. The rate and method of application are influenced by soil and weather conditions. For liquid manure, the receiving soil needs to have enough air space for timely infiltration. All manure applications need to be managed to control odors and prevent runoff from the cropland where the manure is applied. Nutrient utilization management includes the use of current soil test results, manure nutrient analysis or book values, and realistic yield goals. Manure applications may provide certain nutrients for multiple years of crop production; and in some cases, the additional carbon supplied as organic matter improves the tilth of mineral soils.

The following management practices are suggested for livestock producers to help them achieve the type of management that will accomplish these two goals. However, adverse weather conditions may, in part, prevent responsible livestock producers from adhering to these practices for a short duration of time. In addition to effective nutrient management and water quality protection, applying manure to land warrants close attention to management practices so potential odor problems can be minimized or avoided. Section III contains odor control measures, which should be implemented as part of the land application program.

Soil Fertility Testing

29. All fields used for the production of agricultural crops should have soils sampled and tested on a regular basis to determine where manure nutrients can best be utilized.

One goal of a well-managed manure application program is to utilize soil testing and fertilizer recommendations as a guide for applying manures. This will allow as much of the manure nutrients as possible to be used for supplying crop nutrient requirements. Any additional nutrients needed can be provided by commercial fertilizers. Soil test results will change over time depending on fertilizer and manure additions, precipitation, runoff, leaching, soil erosion, and nutrient removal by crops. Therefore, soil testing should be done once every one to four years, with the frequency of soil sampling dependent on (a) how closely an individual wants to track soil nutrient changes, (b) the crop(s) grown, (c) cropping rotation, (d) soil texture, and (e) the approach used for sampling fields (see MSUE Bulletin E-498S; Warncke and Gehl, 2006 for more details).

Fertilizer Recommendations

30. Use fertilizer recommendations, consistent with those of Michigan State University, to determine the total nutrient needs for crops to be grown on each field that could have manure applied.

Fertilizer recommendations made by Michigan State University Extension (MSUE) are based on the soil fertility test, soil texture, crop to be grown, a realistic yield goal (average for past 3-5 years), and past crop management. (See Warncke *et al.*, 2004a, 2004b). Fertilizer recommendations can then be utilized by the livestock producer to help identify on which fields manure nutrients will have the greatest value in reducing the amounts of commercial fertilizers needed, thereby returning the greatest economic benefit. (For additional information, see the GAAMPs for Nutrient Utilization).

Manure Analysis

31. To determine the nutrient content of manure, analyze it for percent dry matter (solids), ammonium N (NH_4-N), and total N, P, and K.

Several factors which will determine the nutrient content of manures prior to land application are: (a) type of animal species, (b) composition of the feed ration, (c) amount of feed, bedding, and/or water added to manure, (d) method of manure collection and storage, and (e) climate. Because of the large variation in manure nutrient content due to these factors, it is not advisable to use average nutrient contents provided in publications when determining manure nutrient loadings for crop production. The best way to determine the nutrient content of manure and provide farm-specific information is to obtain a representative sample(s) of that manure and then have a laboratory analyze the sample(s). In order to establish "baseline" information about the nutrient content of each manure type on the farm, sample and test manures for at least a two year period. MSUE can provide information on collecting representative manure samples and where to send samples for analysis.

Manure Nutrient Loadings

32. The agronomic (fertilizer) rate of N recommended for crops (consistent with Michigan State University N fertilizer recommendations) should not be exceeded by the amount of available N added, either by manure applied, or by manure plus fertilizer N applied, and/or by other N sources. For legume crops, the removal value of N may be used as the maximum N rate for manure applications. The available N per ton or per 1000 gallons of manure should be determined by using a manure analysis and the appropriate mineralization factors (see Manure Management Sheet #2, MSUE Bulletin E-2344 by Jacobs *et al*., 1992b) for organic N released during the first growing season following application and the three succeeding growing seasons.

Excessive manure applications to soils can: (a) result in excess nitrate-N (NO_3-N) not being used by plants or the soil biology and increase the risk of NO_3-N being leached down through the soil and into groundwater; (b) cause P to accumulate in the upper soil profile and increase the risk of contaminating surface waters with P where runoff/erosion occurs; and (c) create nutrient imbalances in soils which may cause poor plant growth or animal nutrition disorders for grazing livestock. The greatest water quality concern from excessive manure loadings, where soil erosion and runoff is controlled, is NO_3-N losses to groundwater. Therefore, the agronomic fertilizer N recommendation (removal value for legumes) should never be exceeded.

The availability of N in manure for plant uptake will not be the same as highly soluble, fertilizer N. Therefore, total manure N cannot be substituted for that in fertilizers on a pound-for-pound basis, because a portion of the N is present in manure organic matter which must be decomposed, before mineral (inorganic) forms of N are available for plant uptake.

The rate of decomposition (or mineralization) of manure organic matter will be less than 100% during the first year and will vary depending on the type of manure and the method of manure handling. Therefore, in order to estimate how much of the total manure N in each ton or 1000 gallons of manure will be available for crops (and a credit against the N fertilizer recommendation), some calculations are needed. The total N and NH_4-N content from the manure analysis can be used with the appropriate mineralization factors to calculate this value. Management tools to assist with these calculations include (a) Manure Management Sheet #2, MSUE Bulletin E-2344 (Jacobs *et al*., 1992b), (b) bulletins MM-2 and MM-3 from the Animal Manure Management Resource Notebook (Jacobs, 1995a, 1995b), or (c) the MSU Nutrient Management (MSUNM) computer program (Jacobs and Go, 2001).

In addition to the amount of plant-available N provided during the first year after a manure application, more N will be released from the residual organic matter not decomposed the first year. This additional decomposition and release of N will occur during the second, third and fourth years and should be estimated and included as an N credit against the fertilizer recommendation to avoid excessive N additions to the soil-plant system. At the present time, organic N released (mineralized) during the second, third and fourth cropping years is estimated to be 50 percent, 25 percent, and 12.5 percent, respectively, of the amount released the first year. To assist with the calculations for estimating this carryover N from previous manure applications, the same management tools listed in the preceding paragraph can be used.

33. If the Bray P1 soil test level for P reaches 150 lb/acre[2] (75 ppm), manure applications should be managed at an agronomic rate where manure P added does not exceed the P removed by the harvested crop. (If this manure rate is impractical due to manure spreading equipment or crop production management, a quantity of manure P equal to the amount of P removed by up to four crop years may be applied during the first crop year. If no additional fertilizer or manure P is applied for the remaining crop years, and the rate does not exceed the N fertilizer recommendations for the first crop grown). If the Bray P1 soil test reaches 300 lb/acre[2] (150 ppm) or higher, manure applications should be discontinued until nutrient harvest by crops reduces P test levels to less than 300 lb/acre. To protect surface water quality against discharges of P, adequate soil and water conservation practices should be used to control runoff, erosion and leaching to drain tiles from fields where manure is applied.

While the availability of N and P in manure may be considerably less than 100 percent, the availability of K in manure is normally considered to be close to 100 percent. Periodic soil testing can be used to monitor the contribution made by P and K to soil fertility levels, but soil tests have not been very effective to determine the amount of N a soil can provide for plant growth.

When manures are applied to supply all the N needs of crops, the P needs of crops will usually be exceeded, and soil test levels for P will increase over time. If Bray P1 soil test P levels reach 300 lb/acre[2] (150 ppm), the risk of losing soluble P and sediment-bound P by runoff and erosion (i.e., nonpoint source pollution) increases. Therefore, adequate soil and water conservation practices to control runoff and erosion should be implemented. For example, conservation tillage can enhance infiltration of water into soils, thereby reducing runoff, soil erosion, and associated P loadings to surface waters. Nevertheless, if Bray P1 soil test P levels reach 300 lb/acre, no more manure (or

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[2] If the Mehlich 3 extractant is utilized for the soil fertility test instead of the Bray P1 extractant, then the following equivalent Mehlich 3 soil test levels can be used for Michigan soils: 150 lb P/acre (Bray P1) = 165 lb P/acre (Mehlich 3) and 300 lb P/acre (Bray P1) = 330 lb P/acre (Mehlich 3).

fertilizer) P should be applied until nutrient harvest by crops reduces P test levels to less than 300 lb/acre.

To avoid reaching the 300 lb/acre Bray P1 soil test level, manure application rates should be managed to provide the P needs of crops rather than providing all of the N needs of crops and adding excess P. Therefore, if the Bray P1 soil test level for P reaches 150 lb/acre[2] (75 ppm), manure applications should be managed at a rate where manure P added does not exceed the P removed by the harvested crop. The quantity of manure P_2O_5[3] that should be added can be estimated from Tables 1 and 2 (Appendix A), using a realistic yield goal for the crop to be grown. For example, if a yield of 120 bu/acre for corn grain is anticipated, the amount of manure P_2O_5 added to this field should be limited to no more than 44 lb/acre (120 bu/acre X 0.37 lb P_2O_5/bu nutrient removal rate).

Up to four crop years of P_2O_5 removal is allowed to be applied as manure P_2O_5 when the Bray P1 soil test is 150-299 lb P/acre. A two to four year crop removal rate of P_2O_5 will accommodate application rates more practical for manure spreading equipment and crop rotations when one crop (e.g., alfalfa) will be grown for two to four years, making manure applications to this crop difficult. An acceptable manure application rate can be calculated using the P_2O_5 content of the manure and the P_2O_5 crop removal (Tables 1 and 2, Appendix A) for the crop(s) to be grown and yields expected for up to four crop years. However, the calculated manure application rate cannot apply more plant-available N (calculated as described above following Practice No. 32) than the amount of the N fertilizer recommendation for the crop to be grown the first year.

Once a suitable manure application rate is calculated, the manure P_2O_5 that is applied becomes a P_2O_5 credit for that field. No additional fertilizer or manure P_2O_5 can be applied to this field until accumulative crop P_2O_5 removal by harvest (Tables 1 and 2, Appendix A) for one or more years has equaled this P_2O_5 credit. Since several fields and different time periods for individual fields may be used for this two to four year P_2O_5 option, a good recordkeeping system tracking these P_2O_5 credits should be used.

Manure Nutrient Loadings on Pasture Land

In pasture systems where the grazed forage is the sole feed source for livestock, nutrients from manure deposited by the grazing livestock will not exceed the nutrient requirement of the pasture forage. These types of pasture systems may actually require supplemental nutrient applications to maintain forage quality and growth. Pasture systems utilizing supplemental feed (e.g., swine farrow/finish) often result in manure nutrient deposition in excess of pasture forage requirements. Therefore, nutrient management with rotation to harvested forage or row crops is necessary. Available nutrient deposition should be quantified based on livestock density and nutrient mineralization factors. Manure nutrient loadings should be based on the

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[3] Fertilizer P recommendations are given in, and fertilizer P is sold as, pounds of phosphate (P_2O_5)

rotational crop nutrient requirement consistent with those recommended by Michigan State University, as noted above.

Method of Manure Application

34. Manures should be uniformly applied to soils. The amount of manure applied per acre (gallons/acre or tons/acre) should be known, so manure nutrients can be effectively managed.

As is true with fertilizers, lime and pesticides, animal manures should be spread uniformly for best results in crop production. Also, in order to know the quantity of manure nutrients applied, the amount of manure applied must be known. Determining the gallons/acre or tons/acre applied by manure spreading equipment can be accomplished in a variety of ways. One method is to measure the area of land covered by one manure spreader load or one tank wagon of manure. A second method is to record the total number of spreader loads of tank wagons applied to a field of known acreage. With either approach, the capacity of the spreader (in tons) or the tank wagon (in gallons) must be known, and some way to vary the rate of application will be needed, such as adjusting the speed of travel or changing the discharge settings on the manure spreading equipment. Guidance is available from MSUE to help determine the rates of manure application that a livestock producer's equipment can deliver.

Incorporating manure immediately (i.e., within 48 hours following surface application) will minimize odors and ammonia (NH_3) loss. When manures are surface applied, available N can be lost by volatilization of NH_3. These losses will increase with time and temperature and will be further increased by higher wind speeds and lower humidities. Therefore, injecting manures directly into the soil or immediately incorporating surface-applied manure will minimize NH_3 volatilization losses and provide the greatest N value for crop production. Table 3 (Appendix A) shows potential volatilization losses when manures are applied to the soil and allowed to dry on the surface before incorporation. When dilute effluents from lagoons that contain low solids (<2 percent) are applied/irrigated at rates that do not cause ponding, most of the NH_4-N will likely be absorbed into the soil and retained (see Jacobs, 1995a, 1995b, or Jacobs *et al*., 1992a for additional information). Surface application of manures via irrigation (or other methods without incorporation) provides alternatives to producers who use a) reduced or no-till soil management, b) supplemental irrigation of crops, or c) application to land with established pasture or other forages, etc.

35. Manures should not be applied to soils within 150 feet of surface waters or to areas subject to flooding unless: (a) manures are injected or surface-applied with immediate incorporation (i.e., within 48 hours after application) and/or (b) conservation practices are used to protect against runoff and erosion losses to surface waters.

36. Liquid manure applications should be managed in a manner to optimize nutrient utilization and not result in ponding, soil erosion

losses, or manure runoff to adjacent property, drainage ditches or surface water. An application that results in manure flow in a field tile line is an unacceptable practice.

To reduce the risk of runoff/erosion losses of manure nutrients, manures should not be applied and left on the soil surface within 150 feet of surface waters. Manures that are injected or surface applied with immediate incorporation can be closer than 150 feet, as long as conservation practices are used to protect against runoff and erosion. A vegetative buffer between the application area and any surface water is a desirable conservation practice. Manure should not be applied to grassed waterways or other areas where there may be a concentration of water flow, unless used to fertilize and/or mulch new seedlings following waterway construction.
Manure should not be applied to areas subject to flooding unless injected or immediately incorporated. Liquid manures should not be applied in a manner that will result in ponding or runoff to adjacent property, drainage ditches, or surface water. Therefore, application to saturated soils, such as during or after a rainfall, should be avoided.

Manure applications to crop land with field drainage tiles should be managed in a manner that keeps manure from reaching tile lines. Liquid manure has the risk of following preferential flow paths through cracks, worm holes, and other soil macropores to field drainage tiles. Liquid manure can also reach field drainage tiles when soils are saturated. This flow can result in a discharge of manure nutrients and contaminants to surface waters. Risks of manure entering field tile can be reduced by analyzing field conditions prior to land application of liquid manure such as tile location and depth, tile inlets, soil type, evidence of soil cracking and soil moisture holding capacity. Recent precipitation and forecasted precipitation should be considered.

Whenever possible, tile outlets should be observed before and after land application. Observations should note the flow rate, color, and odor to confirm that no flow of manure nutrients is occurring. Tile which is flowing prior to land application may be an indication that the soil is saturated. Land application to saturated soils should be avoided. Manure application rates and application methods should be based on field and weather conditions.

Guidance and specific actions can be found in MSU Extension Bulletin WO-1037 (found at www.animalagteam.msu.edu) and in the USDA MI-NRCS Field Office Technical Guide (NRCS-FOTG). These actions are not a substitute for properly evaluating field and weather conditions as described above.

37. **As land slopes increase from zero percent, the risk of runoff and erosion also increases, particularly for liquid manure. Adequate soil and water conservation practices should be used which will control runoff and erosion for a particular site, taking into consideration such**

factors as type of manure, bedding material used, surface residue or vegetative conditions, soil type, slope, etc.

As land slopes increase, the risk of runoff and erosion losses to drainage ways, and eventually to surface waters, also increases. Soil and water conservation practices should be used to control and minimize the risk of nonpoint source pollution to surface waters, particularly where manures are applied. Injection or surface application of manure with immediate incorporation should generally be used when the land slope is greater than 6 percent. However, a number of factors, such as liquid vs. solid or semi-solid manures, rate of application, amount of surface residues, soil texture, drainage, etc. can influence the degree of runoff and erosion that could pollute surface water. Therefore, adequate soil and water conservation practices to control runoff and erosion at any particular site are more critical than the degree of slope itself.

Timing of Manure Application

38. Where application of manure is necessary in the fall rather than spring or summer, using as many of the following practices as possible will help to minimize potential loss of NO_3-N by leaching: (a) apply to medium or fine rather than to coarse textured soils; (b) delay applications until soil temperatures fall below 50ºF; and/or (c) establish cover crops before or after manure application to help remove NO_3-N by plant uptake.

Ideally, manure (or fertilizer/other source) nutrients should be applied as close as possible to, or during, periods of maximum crop nutrient uptake to minimize nutrient loss from the soil-plant system. Therefore, spring or early summer application is best for conserving nutrients, whereas fall application generally results in greater losses, particularly for nitrogen as NO_3-N on course textured soils (i.e., sands, loamy sands, sandy loams).

39. Application of manure to frozen or snow-covered soils should be avoided, but where necessary, (a) solid manures should only be applied to areas where slopes are six percent or less and (b) liquid manures should only be applied to soils where slopes are three percent or less. In either situation, provisions must be made to control runoff and erosion with soil and water conservation practices, such as vegetative buffer strips between surface waters and soils where manure is applied.

Winter application of manure is the least desirable in terms of nutrient utilization and prevention of nonpoint source pollution. Frozen soils and snow cover will limit nutrient movement into the soil and greatly increase the risk of manure being lost to surface waters by runoff and erosion during thaws or early spring rains. When winter application is necessary, appropriately-sized buffer strips should be established and maintained between surface waters and frozen soils where manure is applied to minimize any runoff and erosion of manure from reaching surface waters. Particular attention to soil slopes and manure application rates can help prevent runoff and erosion from frozen and/or snow covered soils where manure is applied.

A field-specific assessment, such as the NRCS Manure Application Risk Index (USDA-NRCS, 1999 National Agronomy Manual), will help evaluate the risk for runoff losses. A spreadsheet for using the Manure Application Risk Index can be found at http://www.maeap.org

Management of Manure Applications to Land

40. Records should be kept of manure analyses, soil test reports, and rates of manure application for individual fields.

Good record keeping demonstrates good management and will be beneficial for the producer.

Records should include manure analysis reports and the following information for individual fields:

- **a. soil fertility test reports;**
- **b. date(s) of manure application(s);**
- **c. rate of manure applied (e.g., gallons or wet tons per acre);**
- **d. previous crops grown on the field; and**
- **e. yields of past harvested crops.**

An important ingredient of a successful program for managing the animal manure generated by a livestock operation is "planning ahead". An early step of a manure application plan is to determine whether enough acres of cropland are available for utilizing manure nutrients without resulting in excess nutrient application to soils.

Using Table 4 of these GAAMPs or calculating nutrients excreted based on feed rations (such as worksheet 1. Total manure nutrients excreted by a livestock operation based on using feed rations, MWPs-18, 2000) can help in making preliminary estimates of manure quantities and manure nutrients produced by different types of livestock. Table five can provide further guidance regarding N losses that can occur during handling and storage or manures before they are applied. This information can be used to compare the quantity of available manure nutrients against the quantity of nutrients removed by the crops to be grown in the livestock operation. Manure Management Sheet #1, MSUE Bulletin E-2344 (Jacobs *et al*., 1992b), and the MSUNM computer program (Jacobs and Go, 2001) can assist with this type of inventory. If the quantity of manure nutrients being generated greatly exceeds the annual crop nutrient needs, then alternative methods for manure utilization should be identified. For example, cooperative agreements with neighboring landowners to provide additional land areas to receive and properly utilize all of the manure nutrients may be necessary.

Another consideration is to use good judgment when planning manure applications in conjunction with normal weather patterns, the availability of land at different times during the growing season for different crops, and the availability of manpower and equipment relative to other activities on the farm which compete for these resources. Having adequate storage capacity to temporarily hold manures can add flexibility to a management plan when unanticipated weather occurs, preventing timely applications. Nevertheless, unusual weather conditions do occur and can create problems for the best of management plans.

Finally, good recordkeeping is the foundation of a good management plan. Past manure analysis results will be good predictors of the nutrient content in manures being produced and applied today. Records of past manure application rates for individual fields will be helpful for estimating the amount of residual N that will be available for crops to use this coming growing season. Changes in the P test levels of soils with time, due to manure P additions, can be determined from good records, and that information can be helpful in anticipating where manure rates may need to be reduced and when additional land areas may be needed. Recordkeeping systems, such as that described in MSUE Bulletin E-2340 (Jacobs *et al*., 1992a) or available as a microcomputer program called MSUNM (Jacobs and Go, 2001), may be helpful in accomplishing this goal. The Nutrient Management program can easily calculate manure application rates for individual fields that will follow the nutrient application criteria recommended in these manure management GAAMPs.

VI. APPENDICES

APPENDIX A

Table 1. Approximate nutrient removal (lb/unit of yield) in the harvested portion of several Michigan field crops.[4]

Crop		Unit	N	P_2O_5	K_2O
			- - - - lb per unit - - - -		
Alfalfa	Hay	ton	45[5]	13	50
	Haylage	ton	14	4.2	12
Barley	Grain	bushel	0.88	0.38	0.25
	Straw	ton	13	3.2	52
Beans (dry edible)	Grain	cwt	3.6	1.2	1.6
Bromegrass	Hay	ton	33	13	51
Buckwheat	Grain	bushel	1.7	0.25	0.25
Canola	Grain	bushel	1.9	0.91	0.46
	Straw	ton	15	5.3	25
Clover	Hay	ton	40[2]	10	40
Clover-grass	Hay	ton	41	13	39
Corn	Grain	bushel	0.90	0.37	0.27
	Grain[6]	ton	26	12	6.5
	Stover	ton	22	8.2	32
	Silage	ton	9.4	3.3	8.0
Millet	Grain	bushel	1.1	0.25	0.25
Oats	Grain	bushel	0.62	0.25	0.19
	Straw	ton	13	2.8	57
Orchardgrass	Hay	ton	50	17	62
Potatoes	Tubers	cwt	0.33	0.13	0.63
Rye	Grain	bushel	1.1	0.41	0.31
	Straw	ton	8.6	3.7	21
	Silage	ton	3.5	1.5	5.2
Sorghum	Grain	bushel	1.1	0.39	0.39
Sorghum-Sudangrass	Hay	ton	40	15	58
(Sudax)	Haylage	ton	12	4.6	18
Soybeans	Grain	bushel	3.8	0.80	1.4
Spelts	Grain	bushel	1.2	0.38	0.25
Sugar Beets	Roots	ton	4.0	1.3	3.3
Sunflower	Grain	bushel	2.5	1.2	1.6
Timothy	Hay	ton	45	17	62
Trefoil	Hay	ton	48[2]	12	42
Wheat	Grain	bushel	1.2	0.63	0.37
	Straw	ton	13	3.3	23

[4] Source: Nutrient Recommendations for Field Crops in Michigan. *(Warncke et al., 2004a)*
[5] Legumes get most of their nitrogen from air.
[6] High moisture grain.

Table 2. Approximate nutrient removal (lb/unit of yield) in the harvested portion of several Michigan vegetable crops.[1]

Crop[2]	**N**	**P_2O_5**	**K_2O**
	---- lb/ton[3] ----		
Asparagus crowns, new planting, or established	13.4	4.0	10
Beans, snap	24	2.4	11
Beets, red	3.5	2.2	7.8
Broccoli	4.0	1.1	11
Brussels Sprouts	9.4	3.2	9.4
Cabbage, fresh market, processing, or Chinese	7.0	1.6	6.8
Carrots, fresh market or processing	3.4	1.8	6.8
Cauliflower	6.6	2.6	6.6
Celeriac	4.0	2.6	6.6
Celery, fresh market or processing	5.0	2.0	11.6
Cucumbers, pickling (hand or machine harvested)	2.0	1.2	3.6
Cucumber, slicers	2.0	1.2	3.6
Dill	3.5	1.2	3.6
Eggplant	4.5	1.6	5.3
Endive	4.8	1.2	7.5
Escarole	4.8	1.2	7.5
Garden, home	6.5	2.8	5.6
Garlic	5.0	2.8	5.6
Ginseng	4.6	1.2	4.6
Greens, Leafy	4.8	2.0	6.0
Horseradish	3.4	0.8	6.0
Kohlrabi	6.0	2.6	6.6
Leek	4.0	2.6	4.8
Lettuce, Boston, bib	4.8	2.0	9.0
Lettuce, leaf, head, or Romaine	4.8	2.0	9.0

Crop[2]	N	P_2O_5	K_2O
	---- lb/ton[3] ----		
Market Garden	6.5	2.8	5.6
Muskmelon	8.4	2.0	11
Onions, dry bulb or green	5.0	2.6	4.8
Pak Choi	7.0	1.6	6.8
Parsley	4.8	1.8	12.9
Parsnip	3.4	3.2	9.0
Peas	20	4.6	10
Peppers, bell, banana, or hot	4.0	1.4	5.6
Pumpkins	4.0	1.2	6.8
Radish	3.0	0.8	5.6
Rhubarb	3.5	0.6	6.9
Rutabagas	3.4	2.6	8.1
Spinach	10	2.7	12
Squash, hard Squash, summer	4.0 3.6	2.2 2.2	6.6 6.6
Sweet Corn	8.4	2.8	5.6
Sweet potato	5.3	2.4	12.7
Swiss Chard	3.5	1.2	9.1
Tomatoes, fresh market or processing	4.0	0.8	7.0
Turnip	3.4	1.2	4.6
Watermelon	4.8	0.4	2.4
Zucchini	4.6	1.6	6.6

[1]Source: Nutrient Recommendations for Vegetable Crops in Michigan. (*Warncke, et.al., 2004b*)
[2]Values used for some crops are estimates based on information for similar crops.
[3]1 ton = 20 cwt.

Table 3. Ammonium nitrogen volatilization losses for surface application of solid and semi-solid manures.[1]

Days Before Incorporation	Retention Factor (RF)	Loss Factor (LF)
0-1 day	0.70	0.30
2-3 days	0.40	0.60
4-7 days	0.20	0.80
>7 days	0.10	0.90

[1]Source: Recordkeeping System for Crop Production. *(Jacobs et al., 1992a)*

Table 4. Manure and manure nutrients produced by different livestock species.[1]

Animal Species	Type and Average Size[2] (lb)		Production (per day)[3] Manure(ft^3)	Nutrients (lb) N	P_2O_5	K_2O
Dairy Cattle		150	0.2	0.05	0.01	0.04
		250	0.32	0.08	0.02	0.07
	Heifer	750	1.0	0.23	0.07	0.22
	Lactating Cow	1,000	1.7	0.58	0.30	0.31
		1,400	2.4	0.82	0.42	0.48
	Dry Cow	1,000	1.30	0.36	0.11	0.28
		1,400	1.82	0.50	0.20	0.40
	Veal	250	0.14	0.04	0.03	0.06
Beef Cattle	Calf	450	0.42	0.14	0.10	0.11
	High Forage	750	1.0	0.41	0.14	0.25
	High Forage	1,100	1.4	0.61	0.21	0.36
	High Energy	750	0.87	0.38	0.14	0.22
	High Energy	1,100	1.26	0.54	0.21	0.32
	Cow	1,000	1.00	0.31	0.19	0.26
Swine	Nursery Pig	25	0.04	0.02	0.01	0.01
	Grow-Finish	150	0.15	0.08	0.05	0.04
	Gestating	275	0.12	0.05	0.04	0.04
	Lactating	375	0.36	0.18	0.13	0.14
	Boar	350	0.12	0.05	0.04	0.04
Sheep		100	0.06	0.04	0.02	0.04
Horse		1,000	0.80	0.28	0.11	0.23
Poultry (per 100 birds)	Chicken Layers	4	.004	0.35	0.27	0.16
	Chicken Broilers	2	.003	0.23	0.14	0.11
	Turkey[2]	20	.014	1.26	1.08	0.54
	Duck	6	.005	0.46	0.38	0.28

[1]Source: Manure Characteristics, MWPS-18, Table 6 (*MidWest Plan Service, 2000*).
[2]Weights represent the average size of the animal during the stage of production.
[3]Note: Values are as-produced estimations and do not reflect any treatment. Values do not include bedding. The actual characteristics of manure can vary +/- 30 percent from the table values. Increase solids and nutrients by 4 percent for each 1 percent feed wasted above 5 percent.

Table 5. Nitrogen losses during handling and storage.[1]

Manure Type	Handling System	Nitrogen Lost (percent)
Solid	Daily scrape & haul	20-35
	Manure pack	20-40
	Open lot	40-55
	Deep pit (poultry)	25-50
	Litter	25-50
Liquid	Anaerobic pit	15-30
	Above-ground	10-30
	Earth Storage	20-40
	Lagoon	70-85

[1]Source: Livestock Waste Facilities Handbook. (*MidWest Plan Service, 1993*).

Table 6. Michigan 25-Year, 24-Hour Precipitation by County[1]

County	Precipitation (inches)	County	Precipitation (inches)
Alcona	3.60	Lake	4.48
Alger	3.87	Lapeer	3.60
Allegan	4.45	Leelanau	3.89
Alpena	3.60	Lenawee	3.60
Antrim	3.89	Livingston	3.60
Arenac	3.56	Luce	3.87
Baraga	4.17	Mackinac	3.87
Barry	4.09	Macomb	3.60
Bay	3.56	Manistee	3.89
Benzie	3.89	Marquette	4.17
Berrien	4.45	Mason	4.48
Branch	4.09	Mecosta	4.15
Calhoun	4.09	Menominee	4.17
Cass	4.45	Midland	4.15
Charlevoix	3.89	Missaukee	3.89
Cheboygan	3.60	Monroe	3.60
Chippewa	3.87	Montcalm	4.15
Clare	4.15	Montmorency	3.60
Clinton	4.09	Muskegon	4.48
Crawford	3.60	Newaygo	4.48
Delta	3.87	Oakland	3.60
Dickinson	4.17	Oceana	4.48
Eaton	4.09	Ogemaw	3.60
Emmet	3.89	Ontonagon	4.17
Genesee	3.60	Osceola	4.15
Gladwin	4.15	Oscoda	3.60
Gogebic	4.17	Otsego	3.60
Grand Traverse	3.89	Ottawa	4.45
Gratiot	4.15	Presque Isle	3.60
Hillsdale	4.09	Roscommon	3.60
Houghton	4.17	Saginaw	3.56
Huron	3.56	Sanilac	3.56
Ingham	4.09	Schoolcraft	3.87
Ionia	4.09	Shiawassee	4.09
Iosco	3.60	St Clair	3.60
Iron	4.17	St Joseph	4.09
Isabella	4.15	Tuscola	3.56
Jackson	4.09	Van Buren	4.45
Kalamazoo	4.45	Washtenaw	3.60
Kalkaska	3.89	Wayne	3.60
Kent	4.45	Wexford	3.89
Keweenaw	4.17		

[1]Source: Rainfall Frequency atlas of the MidWest (Huff and Angel, 1992).

APPENDIX B

Manure and Nutrient Management Plans

Manure and nutrient management plans are management tools that provide detailed information about your farm and any operations dealing with the farm regarding the GAAMPs previously discussed. Every farm should have a plan, and one may be needed to determine conformance to the GAAMPs, especially if a complaint is registered with the MDA's complaint response program.

Manure Management System Plan

A manure management system plan (MMSP) focuses on two subject areas: (1) management of manure nutrients and (2) the management of manure and odor. The most critical aspect of a MMSP to ensure that a livestock operation remains environmentally sustainable is to determine the quantity of manure nutrients (nitrogen, phosphate, and potash) that is being generated by the operation. Then you must determine how these nutrients can be utilized in accordance with the aforementioned GAAMPs either on the livestock farm or transported off the farm for utilization elsewhere. If manure nutrients are not utilized properly, accumulation of too many nutrients may result in loss of nutrients into surface and groundwater resources.

A MMSP will include most, but probably not all, of the following components:

1. Production refers to the amount of volume of manure and any other agricultural by-products produced and the associated nutrient content. Examples include total manure produced, silage leachate, milk house wastewater, and/or rainwater that flow through the barnyard.
2. Collection refers to how manure and any other by-products will be gathered for management. This includes collection points, method and scheduling of collection, and structural facilities needed. Examples include: solid stacking, a scraping system, a flushing system, slotted floors, etc.
3. Transfer occurs throughout the system and may take different forms at different steps in the system. Transfer includes movement between production and collection points, storage facilities, treatment facilities, and land application. The plan may specify the method, distance, frequency, and equipment needs for transfer.
4. If storage facilities are part of the system, the type of storage device should be described (e.g., underground concrete tank, solid manure stack, earthen basin). The plan should include the intended storage time, storage volume, shape and dimensions, and site location.
5. Treatment of manure and any other by-products may occur either before or after storage, depending on the system, and can be physical, biological, and/or chemical. Common forms of treatment include solids separation, anaerobic and aerobic lagoons, composting and methane digesters. Treatment usually involves more

intensive management and may require specialized equipment, but it is not a necessary component for all systems.

6. Utilization refers to the end-use of the manure and other livestock operation by-products. A use needs to be identified for the full quantity of manure and other by-products, as described in the “production” section. For most livestock operations, manure and other by-products are used as a nutrient source for crops. Soil test information, manure and by-product nutrient content, crops to be grown, realistic yield goals, and availability of crop fields are key elements in scheduling land applications and utilizing manure and other by-products for nutrients. Other end-uses may include, but are not limited to, use as a feed supplement and use of composted manure as a mulch, soil amendment, or as bedding material.
7. Recordkeeping plays a critical role in helping make decisions that lead to effective environmental protection and beneficial use of manure related materials. Records also play a critical role in documenting, communicating, and assessing sound manure management practices that can help assure the general public that the environment is being protected.
8. Odor management practices that reduce the frequency, intensity, duration, and offensiveness of odors may be included in any of the above steps. Air quality is an important factor when considering neighbor relations and environmental impacts.

A MMSP that accurately and completely describes the current physical system and the associated management practices, along with records that document implementation of the plan, demonstrate responsible management. For additional assistance on developing a MMSP, contact Michigan State University Extension, USDA Natural Resources Conservation Service, Conservation Districts, or a private consultant.

Comprehensive Nutrient Management Plan

A comprehensive nutrient management plan (CNMP) is the next step beyond a MMSP. All efforts put towards a MMSP may be utilized in the development of a CNMP, as it is founded on the same eight components as the MMSP, with a few significant differences. Some of the "optional" sub-components of a MMSP are required in a CNMP. Examples include veterinary waste disposal and mortality management. In addition, the "production" component is more detailed regarding items such as rainwater, plate cooler water, and milk house wastewater. More thorough calculations are also needed to document animal manure and by-product production.

Another difference between a MMSP and a CNMP is in the "utilization" component. With a MMSP, nutrients need to be applied at agronomic rates and according to realistic yield goals. However, with a CNMP, a more extensive analysis of field application is conducted. This analysis includes the use of the Manure Application Risk Index (MARI) to determine suitability for winter spreading, and the Revised Universal Soil Loss Equation (RUSLE) to determine potential nutrient loss from erosive forces, and other farm specific conservation practices. More detail regarding the timing and method of manure applications and long term cropping system/plans must be documented in a CNMP.

Additional information on potential adverse impacts to surface and groundwater and preventative measures to protect these resources are identified in a CNMP. Although the CNMP provides the framework for consistent documentation of a number of practices, the CNMP is a planning tool not a documentation package.

Odor management is included in both the MMSP and CNMP.

Implementation of a MMSP is ongoing. A CNMP Implementation Schedule typically includes long-term change. These often include installation of new structures and/or changes in farm management practices that are usually phased in over a longer period of time. Such changes are outlined in the CNMP Implementation Schedule, providing a reference to the producer for planning to implement changes within their own constraints.

As is described above, a producer with a sound MMSP is well on his/her way to developing a CNMP. Time spent developing and using a MMSP will help position the producer to ultimately develop a CNMP on their farm, if they decide to proceed to that level or when they are required to do so.

WHO NEEDS A CNMP?

1. A livestock production facility that requests MDA's Michigan Agriculture Environmental Assurance Program (MAEAP) Livestock System verification.
2. Some livestock production facilities receiving technical and/or financial assistance through USDA-NRCS Farm Bill program contracts.
3. A livestock production facility that a) applies for coverage with the MDEQ's National Pollutant Discharge Elimination System (NPDES) permit, or b) is directed by MDEQ on a case by case basis.

For additional information regarding MAEAP, go to: www.maeap.org or telephone 517-373-9797.

For additional information regarding the permit, go to: www.michigan.gov/deq.

APPENDIX C

SAMPLE MANURE MANAGEMENT SYSTEM PLAN (MMSP)

I. General Overview

Dairy farm is currently a partnership between a farmer and his two sons. The dairy currently has 245 animal units (one animal unit equals 1,000 pounds), which includes lactating and dry cows, replacement heifers and calves. The land base of the operation is approximately 1,275 acres. Crops grown on the farm are corn grain, corn silage, wheat, and alfalfa. The purpose of this plan is to indicate how manure produced on the farm is managed to meet the current Michigan Right-To-Farm management practices, while utilizing the nutrients for crop production, without causing any adverse environmental impacts. Currently, there are no plans of any future expansion of the operation.

Soil testing is being done on the crop fields to have current soil tests on hand. Soil testing will be done on any field, which does not have a current soil test (no more than three years old). Manure testing is planned for the spring of 2003 to obtain nutrient levels of the manure. Manure tests will be done at least three times during the first year to establish a base line and then at least once a year thereafter, or more often if feed rations or bedding types and quantities are changed.

II. Volume and Nutrient Production From All Sources

Table 1. Estimated Annual Volume and Nutrient Production From All Sources

Name of Manure Storage	Numbers of Animals (Size)	Consistency/ Contents	**Estimated Annual Manure and Nutrient Production** (values rounded)			
			Volume* (cu.ft)	**Total N (lbs)**	**P_2O_5**	**K_2O (lbs)**
Free Stall Barn	150 (1,400 lb)	Liquid/Sand	131,000	44,900	23,000	26,300
Loafing Barn	50 (250 lb)	Solid/Straw	5,840	1,460	360	1,280
Calf Barn	25 (150 lb)	Solid/Straw	1820	460	90	360
Open Heifers	25 (750 lb)	Solid/Straw	9,120	2,100	640	2,010
Totals			148,000	48,900	24,100	30,000

*These volumes do not include bedding. (If manure storage facilities are to be built, the volume of bedding that will be included with the stored manure will need to be determined in order to size the storage appropriately.)

The manure produced is currently scraped daily and hauled from the free stall barn and parlor. The heifer barns, calf barn, and loafing barn are dry packed for up to one month and sometimes two, if needed, due to weather conditions. See the attachments for the locations of manure storage and animal numbers per barn.

Straw bedding in the additional barns is also hauled to the fields with the manure when the barns are cleaned. Any spoiled feed is hauled and spread on crop fields.

III. Manure Collection

The free stall barn is scraped and hauled daily. This manure is scraped to a ramp where the manure spreader is parked below for loading. The milkhouse wastewater and parlor washwater are collected in a storage pond south of the parlor. Any manure in the parlor is scraped away prior to flushing with clean water. The flush water is also collected in the storage pond.

The manure from the young stock is dry packed in the corresponding barns (see attachment). All manure is under cover of the barns so polluted runoff is not a concern from the housed animals. The feed lot could be a potential source of polluted runoff, but any runoff will be contained on the farm and not allowed to move off site.

IV. Manure Storage

The heifer barn is 30 ft. x 50 ft., the calf barn is 28 ft. x 48 ft., and the loafing barn is 62 ft. x 100 ft. The dry pack will vary from one to two feet in depth, depending on the spreading schedule. This allows for at least two months storage of manure.

There currently are no plans for additional storage facilities or expansion within the near future.

V. Manure Treatment

There currently is no additional treatment of manure.

VI. Manure Transfer and Application

The manure spreader used is a John Deere 785 Hydra Push Back. The box capacity is 243 cu. ft. or 1,818 gallons. This spreader is used for both liquid and solid manure.

The manure from the free stall barn is scraped from the barn down a ramp. The manure spreader is parked below the ramp, and the manure is scraped directly into the box. A front-end loader is used to load the spreader with the dry packed manure from the young stock barns.

Manure is typically applied during the summer after wheat, in the fall after corn harvest, through the winter as needed, and in the spring just before planting. Manure, which is spread during the winter, is applied only to fields with slopes no greater than 6%. A 150 feet setback from surface water will be followed when spreading manure. Manure is incorporated within 48 hours after application in the summer. The Manure Application Risk Index (MARI) will be done on all fields which will be subject to winter spreading, in order to assess the potential for polluted runoff. Manure is transported from 1/4 to 1 1/2 miles from the headquarters. Most fields are located directly adjacent to the headquarters.

The manure spreader has not been calibrated in the past, but it has been planned for the summer of 2002. The Groundwater Stewardship Technician from MSU Extension is available to assist in calibrating the manure spreader.

VII. Manure Utilization

Table 2. Estimated Annual Farm Nutrient Balance for Fields Receiving Manure

Crop Grown	Yield Goal	Acres (Typical Year)	Nitrogen (lbs)	Estimated Crop Nutrient Removal	
				P_2O_5 (lbs)	K_2O (lbs)
Corn	125 bu.	580	62,200	26,800	19,600
Corn Silage	20 tons	70	13,200	4,620	11,200
Alfalfa Haylage	20 tons	150	42,000	12,600	36,000
Alfalfa Hay	10 tons	150	67,500	19,500	75,000
Wheat	50 bu.	100	6,000	3,150	1,850
Totals		1050	191,000	66,700	144,000
Annual nutrient production from Table 1			48,900	24,100	30,000
Nutrients needed to balance cropping system			-142,000	-42,600	-114,000

The manure nutrients will be utilized as fertilizer in the production of the field crops. The manure will provide approximately 48,900 lbs. of nitrogen, 24,100 lbs. of P_2O_5 and 30,000 lbs. of K_2O annually. The manure will be land applied after the harvesting of the crops and in the spring before planting, with daily spreading throughout the year.
The crop rotation will be a corn, hay, and wheat rotation. Refer to Table 2 for realistic crop goals and acres planted during a typical year. The soils on this farm are loamy

sands and sandy loams with clay loam inclusions. The slopes on these fields run from 2% to 10%.

To help determine rates of manure that can be applied to individual fields, a list of fields is included showing the average Bray P1 soil test levels in Table 3. The fields have been grouped by those fields having Bray P1 lest levels <150 lb P/ac, 150-299 lb P/ac, and ≥300 lb P/ac. Fields having <150 lb P/ac will usually have manure applied to provide all of the N recommended for the crop and yield to be grown. To be in compliance with the Right To Farm GAAMPs, fields having soil test levels of 150-299 lb P/ac will receive manure P2O5 loadings equal to the P2O5 expected to be removed by the harvested crop, and fields with soil tests ≥300 lb P/ac will not receive any manure (currently, 225 of 1,275 acres will not be receiving manure applications; only 115 of the 225 acres are depicted in Table 3).

Table 3. Field Identification Bray P1 Soil Test Results and Crops Grown*

Field Number	Acres	Bray P1 (lbs./ac.)	2003 Crop	2002 Crop
Fields with Bray P1 soil test levels <150 lb P/ac				
7	40	114	Corn	Corn
8	80	102	Corn	Corn
Fields with Bray P1 soil test levels 150-299 lb P/ac				
2	60	192	Corn	Corn
9	80	246	Corn	Hay
Fields with Bray P1 soil test levels ≥300 lb P/ac				
1	75	354	Corn	Hay
3	40	456	Corn	Hay

*For this example MMSP, only a partial listing of fields is included.

VIII. Manure Recordkeeping System

Yearly records will be kept on the following:

- □ Soil test results (three years old or less) on all fields where manure will be applied;
- □ Manure analysis (most recent);
- □ Manure and fertilizer spreading by field (where, when, how much, weather conditions, etc.);
- □ Crops grown and yield data;
- □ Date of spreader calibration; and
- □ Cropping plan.

These records will be kept in a three-ring binder located at the farm headquarters.

IX. Odor Control Plan

Odors from manure applications will be controlled by using the following practices:

- □ Spreading during times when neighbors may be spending time outside, such as on holidays or weekends will be avoided.
- □ Spreading during hot humid days when the air is heavy and still will be avoided as much as possible.
- □ Manure will be incorporated immediately or at least within 48 hours of application, unless unexpected weather prevents this.

Odors from the facility will be controlled by using the following practices:

- □ Install visual screen via tree lines or fence rows to contain odors and reduce complaints from neighbors.
- □ Clean water will be diverted to help keep the facility dry.
- □ A cover will be kept on the silage or it will be kept in “Ag Bags”.

THE FOLLOWING ITEMS ARE OPTIONAL, BUT ARE STILL GOOD IDEAS TO INCLUDE IN YOUR PLAN:

X. Community Relations

To develop and maintain a positive relationship with the entire community, one or more of the following should be considered:

- □ Keeping the farmstead area esthetically pleasing should be a high priority.
- □ Each spring, a farm newsletter could be sent to all appropriate community members describing farm activities, personnel, and management.
- □ A community picnic and farm tour could be held once a year for all in the immediate community and manure application areas.
- □ Your farm could be made available to local schools for farm visits as field trips or school projects.
- □ Participate in local community such as a local town festival, parade, etc., where there is an opportunity to do so.

XI. Emergency Manure Spill Plan

Points that should be covered:

- □ Detailed procedure to be used in the event of a spill, e.g., listing contact people and notification phone numbers;
- □ Include the Michigan Department of Agriculture Ag Pollution Hotline (800) 405 0101;

- □ Plan for spills that might happen at various places including a breach of the storage structure, at loading, during transport, and in the field;
- □ A large part of the Manure Spill Plan should have to do with prevention and monitoring, e.g., maintaining a minimum freeboard in your manure storage to prevent overflows, mowing manure storage berms and inspecting for burrowing animal activity periodically to prevent manure releases; and
- □ Include a farm map showing all structures at the farmstead.

XII. Veterinary Waste Disposal

Explain how veterinary waste will be disposed of by the attending veterinarian, e.g.,

- □ Any veterinary waste generated from farm medicating will be disposed of by having it picked up by a sanitary waste disposal company (residential trash removal).
- □ Any sharps (e.g. needles) will be placed in a closed container (such as an empty plastic bleach bottle, water bottle, juice bottle, etc.) to prevent needle pricks from occurring to any potential handler of the waste.

XIII. Mortality Disposal

Explain how dead animals will be handled, e.g.,

- □ Dead animals will be picked up by a rendering service within 24 hours.
- □ If animals are going to be buried, the Michigan Bodies of Dead Animals Act will be consulted for proper burial procedures.

XIV. Conservation Plan

Points that should be covered:

- □ Farm field soil conservation measures being used, such as conservation tillage, no till, and grass filter strips;
- □ Storm water runoff control measures, such as berms, retention basins, and infiltration strips;
- □ Runoff from driveways, silo aprons, and open feed lots; and
- □ Measures used to keep clean roof runoff out of manure.

This Manure Management System Plan was prepared by:

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REFERENCES

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