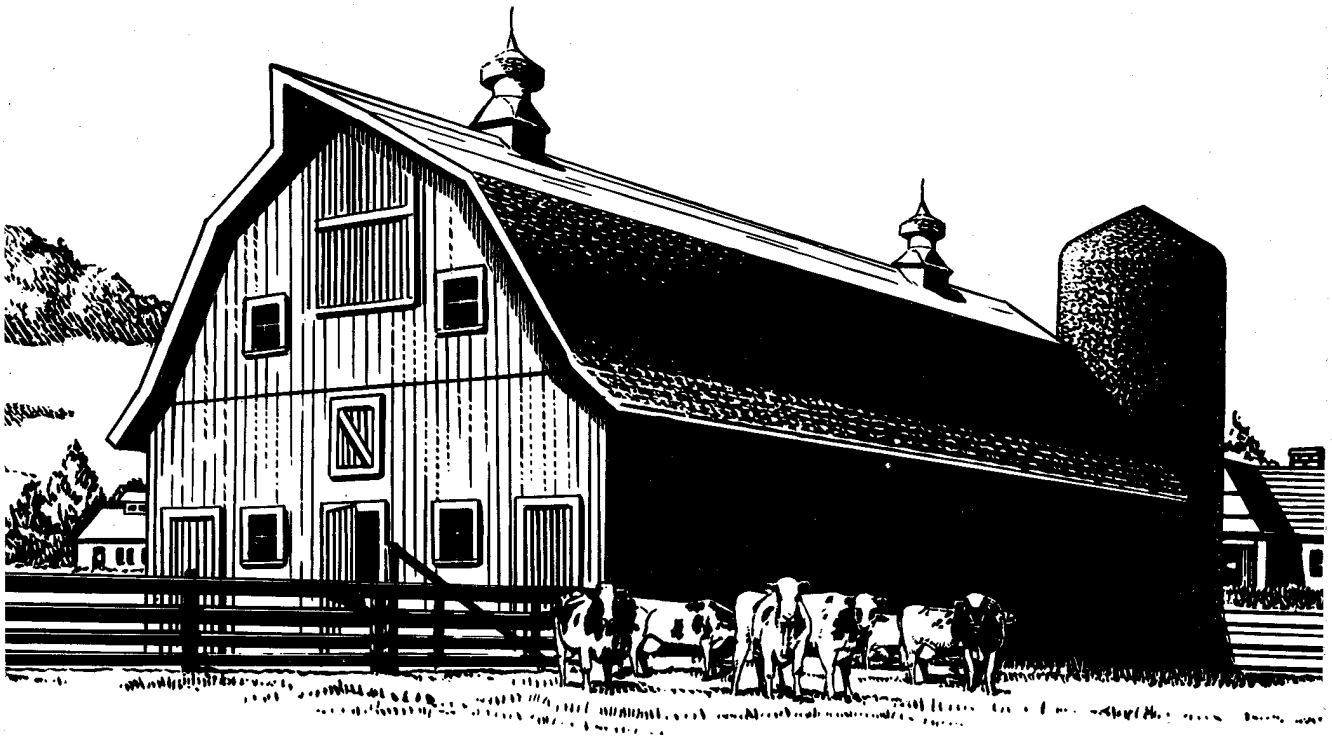
Pennsylvania Department of Environmental Protection

MANURE MANAGEMENT FOR ENVIRONMENTAL PROTECTION



Commonwealth of Pennsylvania, Harrisburg, Pennsylvania
Department of Environmental Protection

361-0300-001 / November 15, 2001

DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT

DOCUMENT NUMBER: 361-0300-001

TITLE: Manure Management for Environmental Protection

EFFECTIVE DATE: November 15, 2001

AUTHORITY: 25 Pa. Code Chapter 91, Section 91.36

PURPOSE: Provides practices for livestock and poultry operations under which DEP approval or a permit is not required. Also, describes related requirements under the Nutrient Management Act and the Pennsylvania Strategy for Concentrated Animal Feeding Operations.

APPLICABILITY: Describes technical practices for all livestock and poultry operations in Pennsylvania.

IMPACT: The revision of this section of the Manure Management Manual updates and clarifies current requirements for livestock and poultry operations and provides a description of DEP approved practices.

DISCLAIMER: The policies and procedures outlined in this guidance document are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements. The policies and procedures herein are not an adjudication or a regulation. There is not intent on the part of DEP to give the rules in these policies that weight or deference. This document establishes the framework, within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

PAGE LENGTH: 27 pages

LOCATION: Vol. 35, Tab 1

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PREFACE

This publication supersedes all previous *Manure Management for Environmental Protection* manuals published by the Commonwealth of Pennsylvania, Department of Environmental Protection (DEP). Due to changes in recommendations and practices, copies of the previous versions of this booklet should be discarded. The current publication consists of a booklet entitled *Manure Management for Environmental Protection,* as well as eight technical supplements. A complete list of titles and where they may be obtained is given at the back of this publication.

This manual was developed in consultation with technical specialists of the USDA Natural Resources Conservation Service and the Cooperative Extension of the Pennsylvania State University. Additional input and review were provided by many individuals including Agricultural Advisory Board to DEP, DEP personnel, members of state farm organizations, and representatives of conservation districts.

The Manure Manual for Environmental Protection and its supplements provide practices that comply with DEP regulations concerning animal manures. Some farmers may have operations that are Concentrated Animal Operations under the Nutrient Management Act Regulations, or Concentrated Animal Feeding Operations under the Pennsylvania strategy for meeting federal requirements. These farmers would follow requirements in addition to those found in this manual. Farmers who do not follow these requirements and the practices in this publication are required to obtain DEP approval or a water quality permit.

Commonwealth of Pennsylvania
Department of Environmental Protection
Office of Water Management
Harrisburg, Pennsylvania
November 15, 2001

MANURE MANAGEMENT
FOR ENVIRONMENTAL PROTECTION

CONTENTS

The Pennsylvania Department of Environmental Protection (DEP) publishes a manual containing guidelines for manure management. The entire collection of eight individual booklets is called the MANURE MANAGEMENT MANUAL. Copies of this manual are available from DEP Regional offices.

Prepared and reviewed with the assistance of agricultural and technical specialists working with the Pennsylvania Department of Environmental Protection. This is a revision to the 1986 version of the manual edited by Robert E. Graves.

Acknowledgments

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LEGAL AND MANAGEMENT ASPECTS OF ANIMAL MANURES

Many Pennsylvania farmers have been practicing good stewardship to conserve the Commonwealth's agricultural resources. The potential for environmental problems resulting from all sources including livestock and poultry operations has increased as the economy has grown and development has occurred. The Department of Environmental Protection (DEP) and others believe it is easier to prevent pollution or other environmental problems than to correct them after they occur.

This manual describes normal farming operations and their relationship to sound environmental protection practices identified by DEP. It illustrates how environmental protection can be integrated into farming operations. It may be used by farmers, DEP personnel, and others interested in agricultural operations and the environment.

Science and careful observation can often determine whether a given farm practice is likely to cause pollution or other environmental problems. Water quality will be adversely affected if manure runs into streams or drainage ditches as a result of land application, spillage, storage overflow, or deliberate dumping. Nutrients in manure applied when there is no growing crop or at rates that greatly exceed crop fertilizer requirements are more likely to leach into ground water or be carried away with runoff water and eroded soil. Excessive manure application may also result in decreased crop yields.

Manure management problems can arise when livestock are added to a farm without increasing the land base. This may result in excessive manure production in relation to the nutrient needs of the land utilized for crops. Farmers who purchase a high percentage of their livestock feed are more likely to have insufficient land to utilize the manure safely and effectively. In some instances, it may be easier or more efficient to reduce inputs. In general, farmers who grow all or most of the feed consumed by their animals probably have sufficient cropland for well-managed manure application.

If manure production exceeds crop requirements, arrangements must be made to move excess manure to other cropland or use it for other beneficial purposes. Each farmer is responsible for providing a sound manure management system that provides adequate protection for the environment. Sound management involves proper design, construction, maintenance and operation of the manure handling system, and lessens the potential costs to the public for addressing pollution problems. When necessary, it may include extra storage, spare parts, backup equipment, or contingency plans for equipment breakdown or for extraordinary weather conditions.

BENEFITS OF SOUND MANURE MANAGEMENT

The reasons for developing a sound manure management program include:

- environmental benefits to Pennsylvania
- economic benefits to the farmer
- compliance with laws and regulations concerning environmental quality
- limited liability protection
- better neighbor relations

Manure management involves setting up an effective system to handle and utilize manure produced by livestock. All situations described in this manual involve returning the manure to cropland as part of a comprehensive crop management program, including regular soil and manure testing. If too much manure is being produced for available land, long-range solutions to solve this problem must be implemented. These involve moving the manure to a nutrient-deficient area, reducing nutrient inputs or using a non-crop utilization system or treatment.

This manual does not attempt to cover specialized systems designed to market manure or utilize it as a fuel, feed, or special fertilizer. Since these systems are usually site specific, interested farmers should seek competent advice to ensure that their methods are environmentally sound. Practices not identified in this manual must be approved by DEP.

Environmental Benefits to Pennsylvania

Livestock manure is extremely beneficial for plant growth, improving soil structure, and increasing soil fertility levels. If improperly handled, however, it can be an environmental problem resulting in contaminated runoff into surface streams and leaching into ground water. Severe cases can increase nitrogen, phosphorus or salt levels in surface or ground water and runoff can cause pathogen contamination, fish kills, and odor and taste problems. Responsible manure management can provide farmers with economic benefits while also protecting the environment.

Economic Benefits to Farmers

When applied in the proper amounts at the appropriate times, livestock manures can provide some, if not all, of the nutrients required for many crops grown on Pennsylvania farms. A manure-handling system also can improve labor and equipment utilization. Manure usually is applied to cropland owned or controlled by the livestock owner. In some situations, the owner may choose to transfer manure to others for use on cropland, gardens, and nurseries. In certain situations, manure may also be recycled as a fuel substitute or additive or as part of a refeeding program.

Manure applied to farmland has the potential for improving crop production and soil productivity. A 50-cow dairy herd and associated young stock produce approximately 1,400 tons of manure annually. Depending on storage and handling methods, this manure contains approximately 15,000 pounds of nitrogen, 6,000 pounds of phosphate, and 12,000 pounds of potash. These nutrients can be effectively used as a fertilizer for growing plants. The organic matter and other trace elements also may improve soil productivity substantially. Farmers who successfully manage this quantity of material to gain maximum crop production save a considerable amount of money on purchased fertilizer. Those who do not manage this nutrient supply efficiently may reduce crop production levels, increase fertilizer bills, and cause pollution. This pollution may effect regional surface and ground water, as well as, the farmer's own water supply. It may also cause odor and air pollution problems.

Compliance with Laws and Regulations

Discharges to surface or ground water are regulated by various federal and state laws so that manure does not pollute surface or ground water. Animal manures or runoff discharged into waterways are a pollutant and are considered under Pennsylvania law to be sewage. Items classified as sewage must be handled and disposed of under the requirements of state water pollution control laws and permitting procedures.

Damage Mitigation

Implementation of an approved plan under the Nutrient Management Act is a mitigating factor in any civil action for penalties or damages resulting from the Clean Streams Law. A civil action for penalties or damages will give appropriate consideration to an operator who is fully and properly implementing a nutrient management plan under the Act.

Better Neighbor Relations

Many problems can be solved or minimized by contacting affected neighbors. This can be done to obtain preferences that will lessen potential conflicts prior to field activities or operation changes. Introducing yourself may help later if problems do arise. When problems do occur, direct contact can increase understanding and help to focus resolution efforts or eliminate confusion.

REQUIRED PERMITS AND PLANS

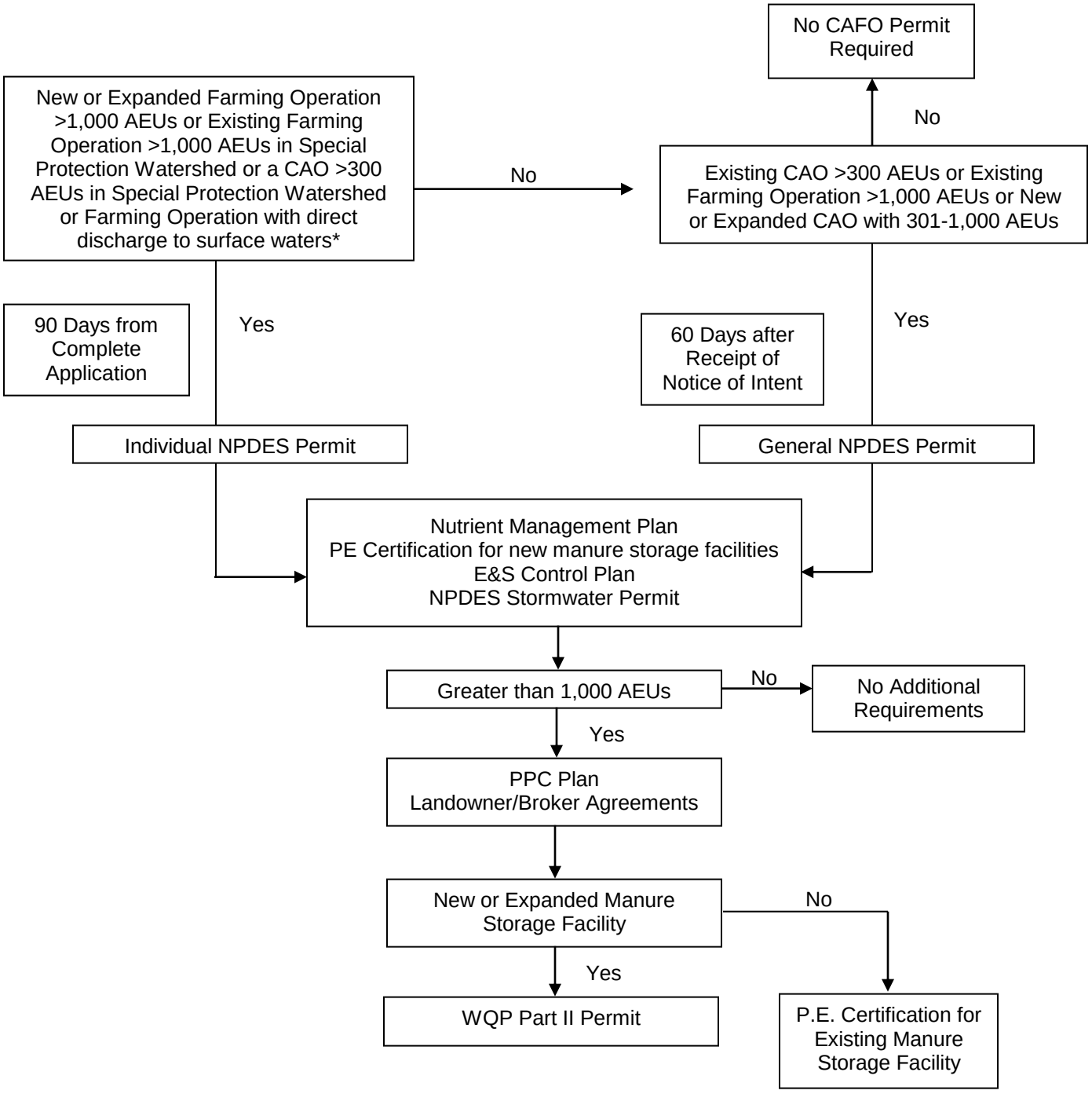
Permits for Concentrated Animal Feeding Operations

Pennsylvania DEP has developed a permitting system to cover all operations that are considered to be Concentrated Animal Feeding Operations (CAFOs). The specific requirements are contained in the *"Final Strategy for Meeting Federal Requirements for Controlling the Water Quality Impacts of Concentrated Animal Feeding Operations".* CAFO is a term that originated from federal regulations. The State CAFO program requires all CAFOs to obtain Individual or General National Pollutant Discharge Elimination System (NPDES) Permits. In Pennsylvania, these broad categories are CAFOs:

- Operations that have greater than 1000 animal equivalent units
- Operations with 301 to 1000 animal equivalent units that are also Concentrated Animal Operations (CAOs) under the Pennsylvania Nutrient Management Regulations
- Any operation with a direct discharge to surface waters during a storm event less than a 25 year, 24 hour storm

An animal equivalent unit (AEU) is one thousand pounds of animal weight as determined by the method used in the Pennsylvania Nutrient Management Regulations. CAOs are operations with greater than 2 AEUs per acre of land suitable for manure application. Exact definitions for AEUs and CAOs are contained in the Pennsylvania Nutrient Management Regulations.

DECISION TREE - CAFO PERMITTING



*Any facility with an actual discharge to surface waters during a storm event less than a 25 year/24 hour storm must obtain an individual permit.

Individual and General Permits

All CAFOs in Pennsylvania must obtain coverage under a NPDES CAFO Permit. There are two types of NPDES Permits – Individual and General. The following operations must operate under an Individual NPDES Permit:

- Existing operations with more than 1,000 AEUs and in a Special Protection Watershed
- New or expanding operations with more than 1000 AEUs
- New, expanding, or existing CAOs with more than 300 AEUs located in a Special Protection Watershed
- Any operation with a direct discharge to surface waters during a storm event less than a 25 year, 24 hour storm

The following operations that are not in Special Protection Watersheds must operate under a General NPDES Permit:

- Existing CAOs with more than 300 AEUs
- Existing operations with more than 1000 AEUs
- New or expanded CAOs with 301 to 1000 AEUs

An operation that existed on or before January 16, 1998 is considered to be an existing operation. Permit deadlines and conditions are located in Chapter 92 of the Pennsylvania Clean Streams Law regulations.

A General NPDES permit is contingent upon approval of the Nutrient Management Plan by the conservation district or the State Conservation Commission. Any CAFO may choose Individual Permit rather than General Permit coverage. Also, the manure storage and handling system must be in compliance with the PA Technical Guide standards.

Required Permit Elements

The following, where applicable, are required for all CAFOs:

- An approved Nutrient Management Plan under the Pennsylvania Nutrient Management Regulations
- Implementation and availability of the Chapter 102 Erosion and Sedimentation Control Plan for earthmoving activities including plowing and tilling where manure is applied
- A NPDES Permit for stormwater discharges for earth disturbance of five acres or more
- Publication in the Pennsylvania Bulletin of permit applications and final actions
- A newspaper notice for all new operations applying for a CAFO permit
- A 30-day public comment period for issuance of an Individual CAFO Permit
- **Self Inspection is required of all CAFOs with more than 1000 AEUs which includes submitting quarterly reports to DEP; others retain reports on-site**
- A public hearing for CAFO permits proposed in Exceptional Value Watersheds

In addition to the above required elements, all CAFOs with more than 1000 AEUs must meet the following permit requirements:

- A Pennsylvania Water Quality Management Part II Permit for a new or expanded manure storage facility prior to construction and operation, which includes storage leak detection and monitoring and design and post-construction certifications by a Pennsylvania registered professional engineer, and prohibits locating in wetlands or the 100-year floodplain
- For existing manure storage facilities, a certification from a professional engineer that the facility is designed and being operated in accordance with the *Pennsylvania Technical Guide*
- In addition to the Contingency Plan for manure which is part of the Nutrient Management Plan, a Preparedness, Prevention and Contingency (PPC) Plan to address the accidental release of all chemicals related to operation of the CAFO
- A signed agreement between the CAFO exporting manure and the importer where the manure is to be applied or the broker to insure that the manure will be applied in an environmentally sound manner. Receiving sites must be covered by a Nutrient Management Plan or a Nutrient Balance Sheet

Obtaining Permit Applications and Information

This is a general description of the type of farming operations in Pennsylvania that are required to obtain CAFO permits and the required permit elements. Issuance of a permit may be appealed within 30 days of the notice in the PA Bulletin. Contact your DEP Regional Office, Water Quality Management Program to obtain a permit application or more specific information.

NUTRIENT MANAGEMENT PLANS

Appropriate nutrient management techniques are described in the "Field Application of Manure" supplement to this manual. Certain large and/or densely populated animal operations are required under the regulations to have detailed nutrient management plans as described below.

In 1993, the Pennsylvania Nutrient Management Act became law and created a legal framework for addressing

nutrient management for certain operations in Pennsylvania. On October 1, 1997, the Nutrient Management Regulations (Title 25, Chapter 83.201 *et seq*.) became effective. These regulations provide the details and requirements for the development and implementation of Nutrient Management Plans under the Nutrient Management Act. The plans cover the following:

- Farm identification
- Plan summary
- Best management practices schedule
- Nutrient application
- Excess manure utilization
- Manure management including barnyard areas
- Stormwater runoff control and
- Manure storage facilities

All plans required for CAFOs or under the Nutrient Management Regulations must be developed by Nutrient Management Specialists certified by the Pennsylvania Department of Agriculture and approved by a delegated conservation district or the State Conservation Commission. Nutrient Management Plans are required for all CAFO permits in Pennsylvania.

Required CAO Plans

The Pennsylvania Nutrient Management Regulations require an operation classified as a Concentrated Animal Operation (CAO) to submit a complete Nutrient Management Plan for approval to a delegated County Conservation District or the State Conservation Commission. A CAO plan must be implemented according to the schedule in the approved plan. The plan submission requirements for different categories of CAOs are:

- CAOs in existence on or before October 1, 1997 must have nutrient management plans
- CAOs that came into existence after October 1, 1997 must submit plans prior to commencement of manure operations
- Operations that become CAOs because of expansion of animal units or loss of suitable land for manure application must submit plans within three months of the operation change

CAOs are defined by the regulations as operations with greater than 2 Animal Equivalent Units (AEUs) per acre of land suitable for manure application. An AEU is one thousand pounds of animal weight as determined by the Nutrient Management Regulations.

Compliance Plans

An operation found to be in violation of the Pennsylvania Clean Streams Law may be required to submit and implement a Nutrient Management Plan that meets the requirements for CAO plans. Additional information may be required by the DEP to address specific concerns related to the Clean Streams Law.

Voluntary Plans

Any operation that is not a CAO may voluntarily submit a Nutrient Management Plan for approval to a delegated County Conservation District or the State Conservation Commission. Operations with voluntary plans will only receive the benefits of the plan to the extent that the plan is implemented. Benefits may include limited liability protection, operational efficiency, pollution prevention, and financial and technical assistance.

Preemption of Local Ordinances

Section 17 of the Nutrient Management Act contains provisions pre-empting certain local ordinances.

OBTAINING ADDITIONAL INFORMATION ON NUTRIENT MANAGEMENT PLANS

Additional information on nutrient management planning may be obtained from delegated County Conservation Districts. Also, state agencies that are assigned to assist the program can provide specific program information. Responsibility for implementing the Nutrient Management Regulations rests with the State Conservation Commission. The Commission staff including assigned Departments of Environmental Protection (DEP) and Pennsylvania Department of Agriculture (PDA) staff assists with program implementation. DEP Bureau of Water Quality Protection staff assists with program monitoring and delegation to County Conservation Districts. PDA Bureau of Plant Industry staff administers the Nutrient Management Specialist certification program, and assists with program outreach and implementation. A guidance manual titled *Pennsylvania's Nutrient Management Act Technical Manual* provides details to explain and implement the technical requirements in the Nutrient Management Regulations. The technical guidance manual can be obtained from the PDA Bureau of Plant Industry.

LEGAL REQUIREMENTS FOR ALL ANIMAL OPERATIONS

The manure management system must follow the practices in this manual or obtain DEP approval or permit. If applicable, the approved practices must work in conjunction with the approved and implemented plan under the Nutrient Management Regulations, Title 25, Chapter 83. The regulations under Pennsylvania Clean Streams Law, Title 25, Chapter 91, Sections 91.33 through 91.36 cover the following:

- Freeboard requirements (i.e., additional storage volume above the maximum design capacity) for manure storage facilities
- The authority for DEP to require reports or plans on the location, size, construction and contents of manure storage facilities, or for water polluting activities
- Obtaining permits for certain wastewater impoundments and manure storage facilities
- Design, construction and operation requirements for all manure storage facilities
- Registered professional engineer certification for the design and construction of existing manure storage facilities at existing animal operations with over 1,000 AEUs
- CAFOs with over 1,000 AEUs and operators with plans under the Nutrient Management Act must obtain registered professional engineer certification that the design and construction of new or expanded liquid and semi-solid manure storage facilities comply with the standards of the PA Technical Guide
- DEP approval or permits for manure storage facilities that do not follow the *Manure Management Manual for Environmental Protection* and the *Pennsylvania Technical Guide*
- DEP approval or permits for land application of manure that does not follow the *Manure Management Manual for Environmental Protection*
- The requirement to prevent, address and report water pollution incidents

When necessary, refer to the appropriate requirements in the Chapter 91 regulations or the supporting guidance documents. In addition, Chapter 102 requires operations with earthmoving activities to have an Erosion and Sedimentation Control Plan, and an NPDES permit for earth disturbance of five acres or more. You may also obtain information from the DEP Regional Office, Water Quality Management Program.

Manure Storage Freeboard Requirements

- All agricultural operations with more than 1,000 AEUs must provide at least a 2-foot freeboard for new or expanded waste storage facilities at all times
- An agricultural operation with 1,000 AEUs or less must provide at least a 12-inch freeboard for waste storage ponds and at least a 6-inch freeboard for waste storage structures
- Agricultural operations with more than 1,000 AEUs must provide at least 12 inches of freeboard on existing waste storage ponds and 6 inches on existing waste storage structures (as described in the PA Technical Guide) and these facilities must be certified by a Pennsylvania registered Professional Engineer to be adequate

Conditions That Require Permits or DEP Approval

- Agricultural operations classified as CAFOs must obtain Individual or General NPDES Permits
- Existing, new or expanded CAOs with 301-1,000 AEUs and not in special protection watersheds must apply for a General NPDES Permit by February 28, 2002
- CAOs with greater that 300 AEUs and in Special Protection Watersheds must obtain Individual NPDES Permits
- New or expanded agricultural operations with more than 1,000 AEUs must obtain an Individual NPDES Permit
- Agricultural operations with more than 1,000 AEUs that install new or expanded manure storage facilities must obtain Water Quality Management Part 2 Permits
- Existing operations with more than 1,000 AEUs must obtain General NPDES Permits
- Design, construction and operation of manure storage facilities not consistent with the *Manure Management Manual for Environmental Protection* and the *Pennsylvania Technical Guide*
- Land application of manure not consistent with the *Manure Management Manual for Environmental Protection*

Other Requirements

Some farmers may have operations that are Concentrated Animal Operations under the Nutrient Management Act Regulations, or Concentrated Animal Feeding Operations under the Pennsylvania strategy for meeting federal requirements. These farmers would follow requirements previously mentioned in this manual (Contact the nearest DEP regional office for additional information). Regardless of whether a permit is required, farmers are

always responsible for any pollution of surface or ground water caused by their farming operations.

In addition to the Clean Streams Law and Nutrient Management Act, various local, state, and federal laws also may apply to manure handling, including:

- Federal Clean Water Act
- Pennsylvania Dam Safety and Encroachments Act
- Pennsylvania Solid Waste Management Act
- Pennsylvania Safe Drinking Water Act
- Pennsylvania Sewage Facilities Act
- Pennsylvania Air Pollution Control Act
- 1956 Pennsylvania Fertilizer Law
- Right to Farm Act
- Pennsylvania Local ordinances

MANURE MANAGEMENT SYSTEM

Various liquid and non-liquid systems can be used successfully to handle, store, and utilize or dispose of manure. These are affected by type of animal, housing system, amount and location of available land, housing system location, manure utilization method, and personal preference.

Pasturing livestock is one of the simpler forms of manure management. The livestock spread manure, with little effort required by the farmer. Stream access ramps and fencing systems can be used to lessen stream degradation.

A poultry producer with a cage layer house has a much different situation. Manure may fall directly from the birds to a storage area underneath the cages, or it may accumulate on scraping boards under cages, which are regularly scraped to a cross conveyor which carries manure to a storage area or to spreaders. If there is no bedding or other material to soak up liquid portions of the manure, storage and handling systems must be planned and managed accordingly. In a high-rise house, the ventilation and watering systems are managed to promote maximum drying so material can be handled with conventional front-end loaders. A scraper-board system, on the other hand, is more efficient when handling wet manure or for a liquid system outside the house.

Various forms of manure can be produced on dairy farms. Bedded/loafing sheds used for dry cows and heifers may require handling only a few times a year. The waste produced is usually hard-packed combination of bedding and dried manure. From a free-stall housing system or paved feeding area, the produced manure may range from a semisolid to a liquid. With semisolid or liquid manure, scraping and handling equipment must be designed to contain the more free-flowing manure and, in some cases, treat it as a pumpable liquid. Feeding and resting yards also must be able to handle runoff without washing manure into streams or lakes. In a tie-stall or stanchion barn, bedding is usually added to the manure. This produces a more solid, stackable material.

Most modern hog and veal confinement facilities have a liquid manure that can be stored either under the facility or adjacent to it. Housing and management considerations dictate the manure-handling system.

One of the first decisions facing a livestock farmer when considering a handling system is whether or not to provide for manure storage. This decision must be based on a nutrient management plan. Hauling and spreading manure when it is removed from the animal area appears to be the simplest and easiest handling method. In a tie-stall dairy barn, where daily cleaning is required for sanitation, daily removal of manure is required. If land is available, daily spreading may be the best choice. For a bedded-pack barn cleaned twice a year, semiannual spreading is carried out. In outside feed yards, scraping-board poultry houses, or hog confinement units, some other schedule would be applied, based on a nutrient management plan.

Although immediate spreading appears to be the easiest and most economical method, this may not be the case. A farmer who must spread manure every day must find a suitable location. This often results in placing manure on fields or crops which may not immediately utilize the nutrient value. It also may result in rutting and soil compaction in wet fields. Spreading every day may lead to excess wear and tear of equipment. Spreading manure on the soil surface when crops are not growing increases the chance for nutrient loss and can result in pollution of nearby streams, lakes, or ground water due to leaching or runoff. Nutrient loss usually means purchasing more commercial fertilizer to maintain crop yields. Cover crops can be used to retain nutrients on the farm and to provide additional feed.

An improperly designed or sized storage system also can be an economic and environmental hazard. A storage that is too small may have to be cleaned out during adverse weather, and the manure may have to be spread when field conditions are poor, resulting in problems associated with daily spreading. An improperly designed, constructed or operated storage that leaks, overflows, or fails to contain manure can cause environmental and safety hazards in the immediate area.

A manure-handling and storage system can be an economic liability to the farmer. All costs and benefits must be carefully considered along with the management advantages and efficiencies when contemplating an investment in storage systems.

In situations where livestock or poultry producers have more manure than should be applied to available cropland, an alternate utilization method is needed. Possibilities include burning broiler litter to produce heat, processing layer manure as a fertilizer or feed additive, or separating and drying solids from dairy manure for bedding.

In general, alternative treatment and handling schemes are very site specific. A farmer considering their use should make a detailed study of the situation and take advantage of available opportunities, such as marketing manure as a soil conditioner, composting material or other commercial uses. A farmer with the right motivation and proper plan can develop economical alternative uses of manure. Recycling manure through crops is the most common alternative for farmers with adequate cropland to utilize nutrients produced by animals. Manure should be applied to land at rates that will maximize crop growth, never at rates that will cause environmental degradation.

INFORMATION AND PROFESSIONAL ASSISTANCE

Because manure disposal systems are complex and may pose both human safety and environmental hazards, they should be designed, constructed, operated, and maintained in a manner that protects workers and others. Fencing around manure storages, signs to warn of possible hazards from noxious gases, and proper machinery installation and guarding are a few examples of special requirements.

The Pennsylvania farmer should seek assistance in developing and coordinating a manure management system. *Manure Management for Environmental Protection* and its supplements apply to most livestock systems typical to Pennsylvania. A separate supplement covers agricultural composting. Land application including spray irrigation is covered by the *Field Application* supplement. Treatment is covered in this booklet and in the swine supplement. Copies of these supplements are available from DEP regional offices. The farmer is also encouraged to seek information from local equipment distributors, sales personnel, consultants, agency personnel and contractors. Specific sources of information are:

- **General information:** Conservation Districts, Certified Nutrient Management Specialists
- **Education and technical advice:** Cooperative Extension Office
- **Technical planning and design assistance:** USDA Natural Resources Conservation Service
- **Financial assistance:** USDA Farm Services Agency, Conservation Districts
- **Laws and regulations:** Departments of Environmental Protection and Agriculture, Conservation Districts

MANURE MANAGEMENT MANUAL

Below is a table of contents for *Manure Management for Environmental Protection* and its supplements. The complete collection is referred to as the Manure Management Manual. Each section is followed by the abbreviation used in pagination.

Treatment Basins for Swine Manure Treatment - SM3

Swine Manure Runoff Control - SM4

Methane Gas From Swine Manure - SM5

Beef Manure Management - Supplement BM a supplement to Manure Management for Environmental Protection

Veal Calf Manure Management - Supplement VM a supplement to Manure Management for Environmental Protection

Horse, Sheep, Goat, and Small-Animal Manure Management - Supplement HS a supplement to Manure Management for Environmental Protection

Manure Management for Horses- HS1

Managing Sheep and Goat Manure - HS2

Managing Manure and Wastes from Small Animals - HS3

Agricultural Composting of Manures

Copies of *Manure Management for Environmental Protection* and its supplements are available from the Water Quality Management office in the Department of Environmental Protection regional offices listed below:

Southeast Regional Office
2 E. Main St.
Norristown, PA 19401-4915
Telephone: 24 hours (484) 250-5900

Bucks	Montgomery	
Chester	Philadelphia	
Delaware		

Northeast Regional Office
Two Public Square
Wilkes-Barre, PA 18701-1915
Telephone: 24 hours (570) 826-2511

Carbon	Monroe	Susquehanna
Lackawanna	Northampton	Wayne
Lehigh	Pike	Wyoming
Luzerne	Schuylkill	

South-central Regional Office
909 Elmerton Avenue
Harrisburg, PA 17110
Telephone: 24 hours (866) 825-0208

Adams	Franklin	Lebanon
Bedford	Fulton	Mifflin
Berks	Huntingdon	Perry
Blair	Juniata	York
Cumberland	Lancaster	
Dauphin		

North-central Regional Office
208 West Third Street
Williamsport, PA 17701
Telephone: 24 hours (570) 327-3636

Bradford	Columbia	Snyder
Cameron	Lycoming	Sullivan
Centre	Montour	Tioga
Clearfield	Northumberland	Union
Clinton	Potter	

Southwest Regional Office
400 Waterfront Drive
Pittsburgh, PA 15222-4745
Telephone: 24 hours (412) 442-4000

Allegheny	Fayette	Washington
Beaver	Green	Westmoreland
Cambria	Somerset	

Northwest Regional Office
230 Chestnut Street
Meadville, PA 16335-3481
Telephone: 24 hours (800) 373-3398

Armstrong	Erie	Mercer
Butler	Forest	Venango
Clarion	Indiana	Warren
Crawford	Lawrence	
Elk	McKean	

Revised from material originally prepared by Robert E. Graves, Extension Agricultural Engineer, The Pennsylvania State University.

SAFETY AND EMERGENCY RESPONSE FOR MANURE MANAGEMENT SYSTEMS

On-farm storage of animal manure is becoming more common in Pennsylvania. Many dairy, beef, veal, swine, and poultry operations are installing manure storage systems with the potential, under certain circumstances, for safety risks. Experience in several states indicates that when an accident does occur, it is likely to involve two or three fatalities. Large numbers of livestock may also perish.

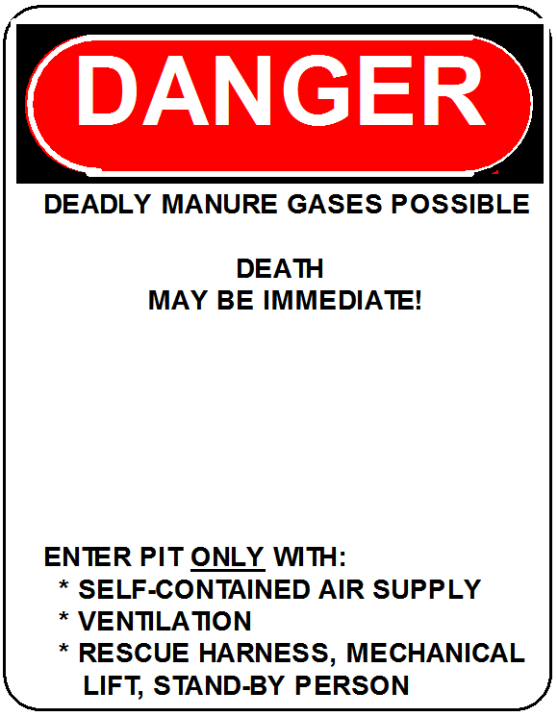
Some manure storage systems are more hazardous than others. Below-ground storages, or pits, are more hazardous than above-ground ones. Systems that are covered by lids, caps, or slotted floors are more hazardous than uncovered systems. Thus the most dangerous storages are pits within buildings or directly beneath livestock. Pump-out pits with lids or caps can also be very hazardous.

SAFETY HAZARDS

Under certain circumstances, manure storage hazards include gases that are toxic (hydrogen sulfide), asphyxiant (carbon dioxide), corrosive (ammonia), and explosive (methane), and may include an atmosphere that contains insufficient oxygen to sustain life. Drowning is also a possibility. With covered pit storages, the danger from gases is most severe when manure is being agitated or pumped out, and after emptying. At other times, little gas is produced, and natural air movement or ventilation from fans usually prevents hazardous gas buildup and oxygen levels from becoming dangerously low. With open storages and above-ground tanks, oxygen depletion and toxic and explosive gas buildup are less likely, so the major potential hazard normally associated with such systems is drowning.

Maximum safe gas concentrations, or threshold limit values (TLV), have been established for an 8-hour exposure for humans by the American Conference of Government Industrial Hygienists. TLV are expressed in parts per million (ppm). Safe gas levels for animals have not been established, but animal responses to gases are known to be similar to human responses. Animals, however, suffer more continuous exposure and may be adversely affected over time by a lower level of gas than affects humans. This is of particular concern with small or lightweight animals, such as newborn pigs.

The concentrations of gases in manure storages can be measured with special instruments, but such instruments



are reliable only if they are carefully maintained, stored, calibrated, and operated by trained personnel. Many instruments cost as much as a few thousand dollars. Although using sophisticated gas detection instruments is the best way to monitor a hazardous environment, using the equipment may be impractical for most farmers. However, some local emergency services may have such instruments and can use them effectively.

An inexpensive alternative to expensive gas detection instruments would be the use of detector tubes or direct reading colorimetric tubes. The tubes are made specifically for one type of gas and for one instantaneous measurement. The cost of the tubes is around $3 to $4 each. Along with a tube, a pump and extension hose is necessary. When correctly calibrated the pump will pull the correct amount of air through the tube, giving an accurate reading of the concentration of gas present. The cost of the pump is approximately two hundred dollars. This type of instrumentation is easy to use and requires minimal training. One drawback is that the tube only gives an initial reading of the gas concentration and is for the specified gas. You would have to take readings for all suspected gases that are present. After determining the gas concentration(s), you should continue to monitor and ventilate the space.

Hydrogen sulfide (H_2S), the most hazardous manure gas, is associated with most fatalities in manure storages. H_2S can cause death within seconds at high concentrations. The TLV is 10 ppm. It is colorless and heavier than air, accumulating near the bottom of the storage. Though very low concentrations (100 to 150 ppm) can be identified by a rotten-egg odor, hydrogen sulfide deadens one's sense of smell and its odor is often masked by other smells common to livestock facilities. Lethal concentrations of 500 to 600 ppm are thus difficult to detect. The amount of the gas can increase a thousand fold during agitation and emptying of a manure facility.

Carbon dioxide (CO_2), while a nontoxic gas itself, displaces oxygen and therefore can asphyxiate humans and animals. The TLV is 5000 ppm. Being both colorless and odorless, carbon dioxide is impossible to detect without gas detection equipment. Because it is heavier than air, it accumulates near the bottom of the storage.

Ammonia (NH_3) can severely damage the eyes, throat, and lungs. It combines with moisture in the eyes and respiratory tract to form an alkaline solution that causes severe burns. Its TLV is 25 ppm. NH3 is lighter than air and has a strong bleach-like odor. Because of its irritating nature, people usually leave a contaminated area quickly. Therefore it is not suspected to have caused any human deaths. Constant low-level exposure to ammonia, however, can have a discomforting effect on humans and livestock.

Methane (CH_4) is a highly flammable and explosive gas. The TLV for methane is 1000 ppm. Like carbon dioxide, it is odorless, colorless, asphyxiating, and impossible to detect without gas detection instruments. Methane is lighter than air and readily rises out of storage areas to collect under hoods, roof ridges, and corners. It is most likely to accumulate during hot weather, especially if ventilation is poor. Methane explosions have resulted from someone lighting a torch or from short circuits in electrical systems.

Oxygen (O_2) deficient atmosphere occurs when oxygen is displaced by another gas to less than 19.5 % by volume of the total air. Normally, oxygen in air is 20.8 % by volume. When oxygen is at 16.0 % by volume of the air, a person becomes disorientated and has impaired judgement. At 14.0 % by volume of the air, a person has rapid fatigue and faulty judgement. At 6.0 % by volume of air, a person can have difficulty in breathing and death will occur within minutes. The oxygen percent should be measured at all levels of a manure storage to insure that there is no oxygen deficiency.

DESIGN AND CONSTRUCTION RECOMMENDATIONS

Many safety hazards can be minimized by proper design and construction of a manure storage facility. Several recommendations to consider when building a storage are listed below. Many of the recommendations should also be incorporated into existing storages.

- Keep in-barn pits for liquid manure to a minimum volume and divide pits into small compartments to reduce or eliminate the need for agitation.
- Locate pump-out openings for manure pits outside of buildings. Use heavy covers or grates for pit access points and keep them in place.
- Equip ventilation systems with an alarm to indicate power failure, and provide a backup ventilation system.
- Build railings for all walkways on piers or walls along open manure storage structures. Push-off platforms or piers should have a barrier strong enough to stop a slow moving tractor. If animals are to be on a pier, install a low guardrail to keep them from rolling into the pit if they slip.
- If the manure storage is outdoors, provide a gas trap or other device in pipes running to the storage to prevent gases in the storage structure from reentering the building, especially during pit agitation.
- Install a fence around open storages, ponds, treatment basins, and lagoons. The fence should be tight enough to keep out small children. Warning signs should be placed near open storages and above-ground tanks, and a rescue pole and rope should be located conspicuously in the area.

OPERATING RECOMMENDATIONS

Manure storage hazards can be further reduced by consistently following recommended operating procedures. You should adopt all of the following practices that apply to your operation.

- Become familiar with and follow the Occupational Safety and Health Administration (OSHA) regulations and recommended practices for confined spaces (OSHA 1910.146). While production agriculture was excluded from these regulations, any farmer with an employee could be cited for a violation under the General Duty Clause of the OSHA Act, Public Law 91-596. The General Duty Clause states that each employer “shall furnish each of his

employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees". A confined space, such as a manure storage, may fit this clause.

- Test the pit atmosphere for toxic gases and levels of oxygen.

- Never enter a pit without proper ventilation. When going in, wear an air-supplied respirator or a self-contained breathing apparatus (SCBA), as well as a safety harness attached to a rope attended by two people at the entrance to the pit. Any person utilizing this equipment must be trained in advance. Attaching the safety rope to a winch or hoist is also recommended. *Cartridge-type masks are not safe.*

- Keep people and animals out of any building where manure is being agitated or emptied. Provide strong mechanical ventilation during agitation and pumping, and for a few hours after pumping has stopped. If an animal collapses during pit agitation, do not try to rescue it immediately. Turn off the pump and ventilate the building until the gases have had a chance to escape.

- Never fill a manure pit completely, but allow 1 to 2 feet of air space to accommodate concentrations of gas. Lower the level of liquid manure in a storage facility before starting agitation to reduce the possibility of gas being forced above floor level.

- Keep the agitator below the liquid surface because gas is released in greater volumes with vigorous surface agitation.

- Forbid smoking, open flames, or spark-producing operations in the immediate vicinity of the storage area. Keep all guards and safety shields in place on pumps, pump hoppers, tank wagons, and power units, and maintain electrical motors, fixtures, and wiring in good condition.

- Do not leave temporary access ladders leaning against above-ground tanks. Permanent ladders on the outside of above-ground tanks should terminate above the reach of people or should have locked entry guards.

- Do not walk, ride, or allow animals on the crust-like surface of open-air storages. Like ice, the crust is not uniformly solid and can break through suddenly.

- Warn visitors and guests of the hazards of manure storages. You are legally responsible for their safety while they are on your property.

EMERGENCY PROCEDURE

Emergencies result from ignoring or not knowing the hazards of manure storages and the recommended safety practices. Generally, someone enters a pit without a self-contained breathing apparatus (or is not properly trained in its use) and passes out almost immediately from toxic gases or oxygen deficiency. The tragedy can be compounded when would-be rescuers, family, coworkers, emergency personnel—panic and follow the first victim into the pit.

When someone collapses in a pit, gases are so concentrated that it is extremely dangerous for anyone else to enter without a self-contained breathing apparatus and proper training. The only reasonable immediate action is to ventilate the storage area and notify rescue personnel who can bring the proper equipment. Barn fans and silo blowers may be activated to provide ventilation, but do not lower fans into the pit because of the possibility of a methane explosion.

In any rescue attempt, the rescuer should have a self-contained breathing apparatus, proper training and a safety harness with a lifeline. The lifeline should be attended by at least two people outside the storage unit. Rescuers should never place their own masks on a victim or remove their own lifelines. Ropes, carriers, and oxygen for victims can be lowered into the pit if necessary. Victims should be brought out as quickly as

possible, administered to by emergency services personnel, and transported to an emergency room.

Prepared by Dennis J Murphy, Extension Safety Specialist, and William Lloyd, Graduate Assistant, The Pennsylvania State University.

PLANNING, DESIGN & CONSTRUCTION OF MANURE MANAGEMENT SYSTEMS

PLANNING

Livestock and poultry farms need manure management systems, usually including manure storage facilities, to properly handle their manure. A manure management system must be linked to a nutrient management plan that determines how long manure must be stored or that verifies that the available storage capacity is adequate for the longest period between scheduled field applications.

Depending on the type of farm operation and the nutrient management plan, the manure management system may need other components in addition to a storage facility. These might include barnyard runoff control, roof runoff management, and field erosion and runoff control practices. The mix of components that will be suitable must be determined on a case-by-case basis by qualified professional conservationists who work with the farmer.

At the planning stage, the farmer must consult with appropriate specialists, such as a nutrient management specialist, a soil scientist, and an engineer. A complete plan is needed prior to design preparation to assure that the farmer's needs and legal obligations can be met. The plan must identify the type, number or size, and location(s) of all the components of the manure management system. To the fullest extent possible, the components must be identified as named conservation practices from the PA Technical Guide. A list of the practices is included in Section IV of the PA Technical Guide.

DESIGN

Careful design, materials selection, and construction are required to build a sturdy, safe and environmentally sound manure management system. Designs of all practices must be done in accordance with the PA Technical Guide standards and this manual, and must prevent or eliminate the discharge of manure or contaminated water under all weather conditions up to the 25-year, 24-hour storm. A farm operation with facilities built to a lesser standard may be required to obtain a NPDES permit. A manure storage facility built to a lesser standard may be required to obtain a Water Quality Part II permit.

For manure storage facilities where the manure is of semi-solid or liquid consistency, there is a potential hazard to public health and safety. Because of this potential hazard, these types of manure storage facilities must be designed, construction overseen and completion certified by a Pennsylvania registered Professional Engineer. In many cases, storage components are "pre-engineered" or based on standard detail drawings. Even though these components may have been prepared or approved by an engineer, their appropriate use must be based on a site investigation and a site-specific design, prepared or approved by a Professional Engineer, which includes the "pre-engineered" component.

All manure storage ponds shall be designed in accordance with Standard PA-313. A key element in the design of manure storage ponds is the provision for watertight containment of the waste. The ponds shall be lined with a compacted clay soil, a soil with clay or chemical additives, a geosynthetic liner, a concrete liner, or a combination of these features. Soil liners shall be designed and built in accordance with Appendix 10D of the Agricultural Waste Management Field Handbook.

All manure storage structures shall be designed in accordance with Standard PA-313. Manure storage structures for semi-solid or liquid manure shall be watertight. They shall be designed and built of concrete, steel, durable plastic, or a combination of these materials. All manure storage facilities shall be designed and built to prevent leaching or runoff of contaminated water into surface or ground water.

All manure transfer systems shall be designed and built to be watertight under all normal operating conditions and in accordance with standard PA-634, "Manure Transfer". Pipes shall be adequate to handle all internal and external design loads, and be equipped with watertight joints that exceed the expected operating pressure.

The designer of any component of a manure management system must provide the farmer with a copy of the design, including any as-built design changes, and a written operation and maintenance plan that explains the proper operation and care of all the components of the designed facility. All designs must include specifications that describe the quality of the materials and the method or performance requirements that the farmer or contractor must meet to properly install the designed practice. The specifications must be tailored to the specific design, and shall be in conformance with the PA Technical Guide specifications for the particular practice.

CONSTRUCTION

The farmer is responsible for having the component practices installed according to the design and for requiring the contractor(s) to provide quality control during construction and to certify that they have followed the design and specifications. Independent quality assurance, including inspections by qualified individuals, will protect the investment of the farmer and minimize liability. All field design changes must be approved by the designer and recorded on as-built drawings.

[1]A manure storage facility is defined as a permanent structure or facility, or portion of a structure or facility, utilized for the primary purpose of containing manure. Examples include liquid manure structures, manure storage ponds, component reception pits and transfer pipes, containment structures built under confinement buildings, permanent stacking and composting facilities and manure treatment facilities. The term does not include the animal confinement areas or poultry houses, horse stalls, freestall barns or bedded pack animal housing systems.

Prepared by Timothy J. Murphy, Conservation Engineer, USDA Natural Resources Conservation Service

OPERATION AND MAINTENANCE OF MANURE MANAGEMENT SYSTEM

The goals of manure management are to efficiently utilize manure nutrients, to protect the public's health and safety, to minimize degradation of the air and soil, and to prevent pollution of surface water and ground water. A well-designed manure management system provides for storage of manure and its utilization on cropland or for other purposes. Some systems also use manure treatment lagoons (not to be confused with storage ponds) which use microbial action to break down wastes to reduce the nutrient content of wastewater.

This document provides guidelines for effective operation and maintenance of manure management systems. Procedures necessary for both storage and treatment systems are listed, followed by measures specific to treatment systems. Important safety considerations are listed for both storage and treatment.

COMPONENTS OF AN OPERATION AND MAINTENANCE PLAN

Operating and maintaining a manure management system is the owner/operator's responsibility. He or she should use a site-specific plan to manage the manure and other wastes in an environmentally acceptable manner. Such a plan should also provide specific details concerning the system's various components, including the following items:

- Minimum and maximum operating depths for storage and treatment facilities.
- Operations specific to a given system, such as manure nutrient analysis, salinity and pH checks, methods of loading, or the approximate frequency of solids removal.
- Safety warnings, particularly where there is danger of drowning or exposure to poisonous or explosive gases.
- Operating instructions and maintenance requirements for pumps, valves and other mechanical equipment.
- Operating instructions for all BMPs, including frequency of barnyard scraping, cleaning of settling and screening devices and vegetative filter area dosing intervals.

PRACTICES FOR STORAGE AND TREATMENT SYSTEMS

The following list of procedures for operation and maintenance applies to both manure storage and manure treatment systems.

- Design your manure facility to fit the nutrient management plan.
- Develop and implement a nutrient management plan that meets the requirements in the manure manual.
- In storage ponds and treatment lagoons, install and maintain a gauge post that clearly marks the one-half-full and full operating volumes.
- At least twice a year, when a storage facility is unloaded, check the walls and floor for cracks or separations. Check the backfill areas around structures for excessive settling, and determine the cause. Make the necessary repairs.
- On earthen facilities, check the berms and embankments twice a year for sloughing, erosion, or settling. Make repairs to maintain the impervious lining, the slope stability and the top height and width.
- The outlets of foundation drains and subdrains should be kept open and checked frequently, and must drain to a satisfactory outlet. Repairs should be made to correct any leaking of manure into the drains. To check for leaks, the drain's outflow should be observed when the facility is being used. Leaking may be detected by the color and smell of the outflowing liquid; by lush, dark green vegetation around the outlet; by the algae growth in the surface outlet; or by the vegetation dying near the outflowing liquid.
- To prevent erosion, good vegetative cover should be established and maintained on berms and embankments. Plantings should be clipped three times each year to encourage their growth and to kill weeds. If the vegetative cover is damaged, berms and embankments should be replanted as soon as possible.
- Channels and berms of clean-water diversions around the barnyards, buildings, and manure facilities should be inspected frequently. The channels should be protected from erosion. Berms must be high enough for the channels to have adequate capacity. The channels and berms should be mowed periodically

and should not be used as haul roads unless they were designed and constructed for that purpose.

- Buildings, structures, berms, and embankments should be checked frequently for burrowing animals. The animals should be removed and any damage repaired.
- Haul roads and other approaches to manure facilities should be inspected frequently and the need for stone, gravel, or other stabilizing material determined.
- Runoff or spills from loading areas should not be allowed to flow into streams or roadside ditches.
- Fences should be inspected and maintained to keep livestock and unauthorized people away from manure facilities. All warning and hazard signs should be examined and repaired when necessary.

PRACTICES FOR TREATMENT LAGOONS

Several additional guidelines apply to the safe and effective operation of manure treatment lagoon. Unless otherwise stated, these apply to both aerobic and anaerobic lagoons.

- Before using an anaerobic lagoon, fill it to half its designed volume (4 to 5 feet deep for most lagoons).
- If possible, begin loading a lagoon in the spring or summer.
- Add manure to a lagoon regularly, frequently, and in increasing amounts until each day's production is added daily.
- Maintain an anaerobic lagoon at or near the designed depth (6 to 9 feet for most lagoons).
- Except for naturally aerated lagoons, never empty a lagoon below the 5-foot to 6-foot level. If salt builds up in a lagoon, restart the lagoon from the 5-foot depth. To control odor, maintain the lagoon's pH above 6.7. Hydrated lime can be added daily at the rate of 1 pound per 1000 square feet until the pH becomes neutral (7.0).
- Check the sludge buildup in a lagoon annually. When sludge fills the designed storage volume, test its nutrient content and spread it on cropland accordingly.

IMPORTANT SAFETY CONSIDERATIONS

Manure storage and treatment facilities, especially covered tanks or pits, are high hazard areas. The biodegradation of manure forms gases, such as methane (CH_4), hydrogen sulfide (H_2S), ammonia (NH_3), and carbon dioxide (CO_2), which can be fatal to both animals and humans. In the proper mixture with air, some of the gases can also explode. For these and other reasons, manure facilities require strict safety precautions, including the following:

- When someone is working near a manure facility, the area should be well ventilated. Welding near storage or using open flames or electric motors that spark (e.g., saws, drills, shop-vacs) is extremely hazardous and should be avoided.
- Care must be taken to provide mechanical ventilation during agitation and emptying of indoor manure facilities because agitated liquid manure can release large volumes of dangerous gases. Humans should always stay out of the building during agitation and emptying. If the adequacy of ventilation is uncertain, animals should be evacuated. No one should work alone when agitating or emptying a manure facility.
- A tank, pit, or other closed storage structure that has been emptied of manure still contains dangerous gases. No one should enter the structure except to make repairs, and then only with special precautions, including a safety harness, mechanical ventilation of the structure, and an air-supplied respirator or self-contained breathing apparatus (NOT A CARTRIDGE-TYPE MASK) including proper training. Two people should remain outside to take appropriate action in the event of an emergency.
- All lids, gates, hatch covers, and safety grills to prevent unauthorized entry must be secured when tanks and pits are left unattended. Heavy slide-in-place covers can be moved by livestock.
- Manure storage and treatment facilities should be posted with signs bearing appropriate warnings. (See example on Page 1, MM2)
- Open, ground-level facilities, such as storage facilities, should have an additional warning. (See example on Page 3, MM2)

Prepared by William J. Bower, State Conservation Engineer and Timothy J. Murphy, Conservation Engineer., USDA Natural Resources Conservation Service.

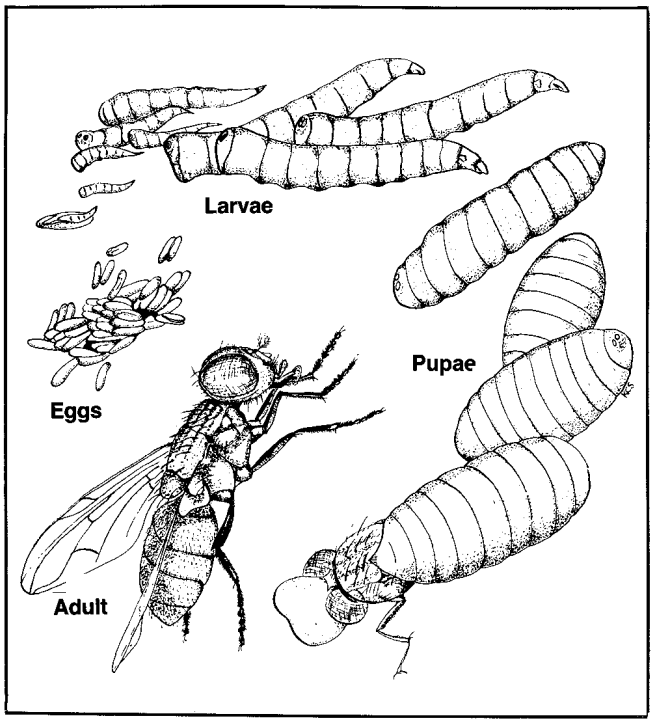
MANURE MANAGEMENT STRATEGIES TO CONTROL FLIES

Numerous species of manure-breeding flies can become a serious problem on the farm and within the community if manure-handling systems are not managed properly. With the movement of people and housing into prime agricultural areas, flies dispersing from livestock and poultry operations can become a significant public nuisance and health problem, even leading to poor community relations and threats of litigation.

FLY DEVELOPMENT

Flies have four stages of development: egg, larva (maggot), pupa, and adult. The rate of development, which varies with species and environmental conditions, is affected by temperature and moisture levels within the breeding area. Moist manure attracts adult flies and provides ideal breeding conditions.

Figure 1. House fly life cycle.



FLY SPECIES

Species most prevalent around livestock housing are the house fly (Musca domestica), stable fly (Stomoxys calcitrans), little house fly (Fannia canicularis), black garbage fly (Hydrotaea aenescens), and drone fly (Eristalis tenax).

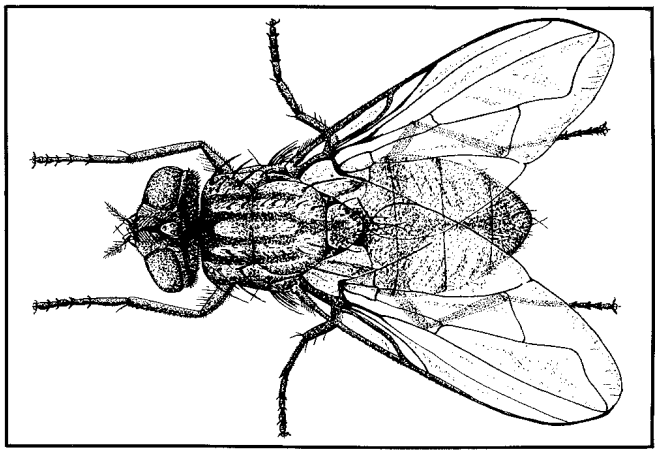
House flies usually are the predominant species present in livestock and poultry operations. House flies are nonbiting flies that breed in fresh manure, decaying silage, spilled feed, bedding, and other decaying organic matter. Adults feed on manure and animal secretions with their sponging mouth parts. Under ideal conditions, they can complete their life cycle in as little as 7 days. On the farm, most generations of flies require about 2 weeks to develop in summer. Each female can produce 120 to 150 eggs, which are laid in at least six batches at 3- to 4-day intervals. Eggs hatch in 8 to 24 hours and maggots feed for 4 to 7 days. Mature maggots usually crawl away from their breeding site, seeking a drier environment for pupation. Adult flies emerge in 3 to 4 days and typically live about 3 to 4 weeks.

Moisture levels of 75 to 80 percent are optimal for house fly oviposition (egg laying), larval development, growth, longevity, and survival. Fresh cattle manure is approximately 83 percent moisture and fresh poultry manure is 75 percent moisture. Larvae developing in organic substrates with less than 60 percent moisture usually fail to pupate. Optimal moisture levels for pupation range from 40 to 60 percent.

House fly populations in Pennsylvania increase rapidly in June, peak in September, and decline with cold weather in early October. From seven to nine generations occur during the fly season. Within environmentally controlled livestock housing (i.e., high-rise or deep-pit poultry houses), suitable breeding conditions may be present year round. Broken eggs, failure to control leaky waterers, and an occasional dead bird in the manure storage add to the problem.

High-rise houses normally are cleaned only once or twice a year. House flies often disperse in large numbers as far as 3.7 miles from their breeding site; and distances of 10 to 20 miles have been reported. While house flies are only a minor direct annoyance to livestock, their potential for transmission of diseases and causing a public nuisance are of major concern.

Figure 2. House fly.



Stable flies are vicious biters commonly associated with dairy and equine operations. Male and female stable flies feed several times each day, ingesting one or two drops of blood at each meal. When not feeding, adult flies rest in the shade on posts, trees, and buildings. Breeding takes place in wet straw, spilled feeds, silage, and decaying vegetation. The stable fly's life cycle is longer than that of the house fly, requiring about 3 weeks to complete under optimal conditions. Eggs hatch in 1 to 3 days, and the maggots feed for 11 to 30 days before reaching maturity, depending on the weather. When fully grown, they pupate and within 6 to 20 days, emerge as adults which live for 20 to 30 days. Each female lays 200 to 400 eggs during her lifetime. Stable flies have two primary generations per season, peaking in early July and again in early September. They over-winter as larvae or pupae. Stable flies can travel many miles from the breeding site.

Little house flies usually are most abundant in early spring and late fall, when fly control practices normally are considered unnecessary. Eggs are deposited chiefly on decaying vegetable matter and chicken, hog, horse, and cattle manure. Life cycles may vary from 3 weeks to 2 months, depending on environmental conditions. The larvae are flattened, about 6 mm long when fully grown, and conspicuously fringed with spine like projections. The pupae resemble the larvae in appearance. Adult flies prefer a sheltered habitat, inside or on the shaded sides of buildings.

Figure 3. Stable fly.

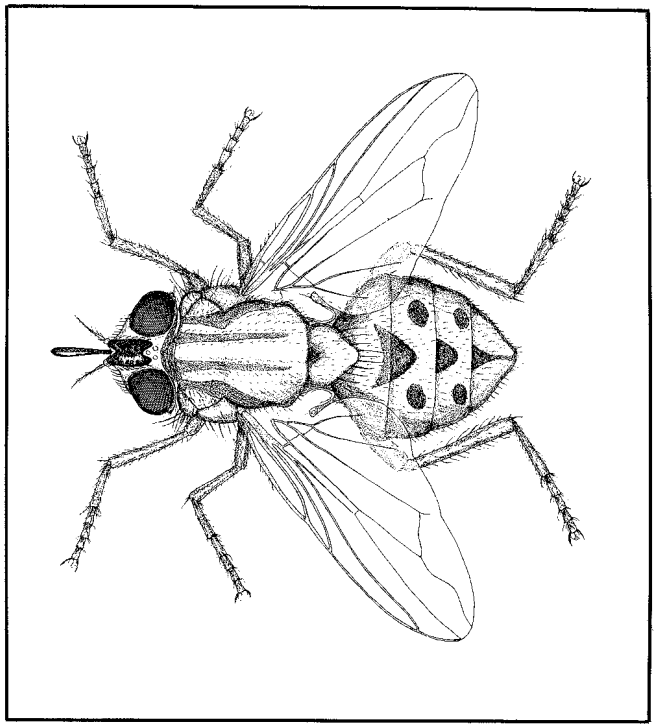
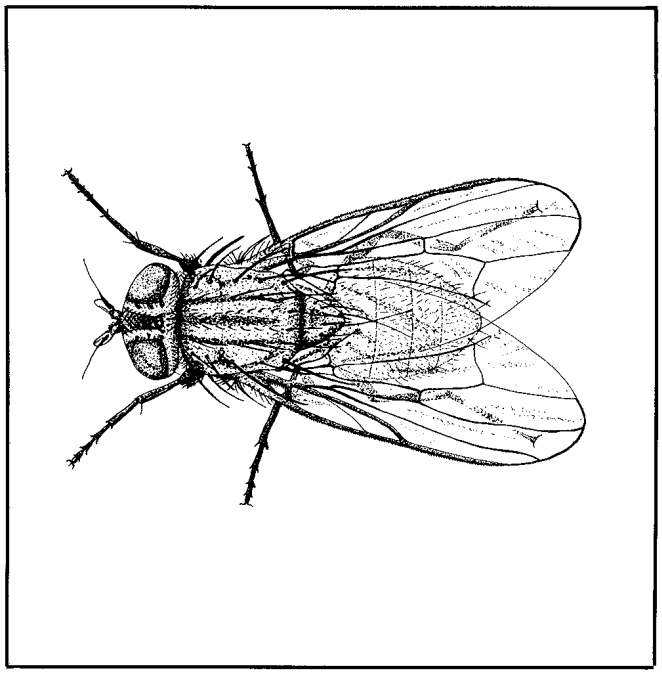
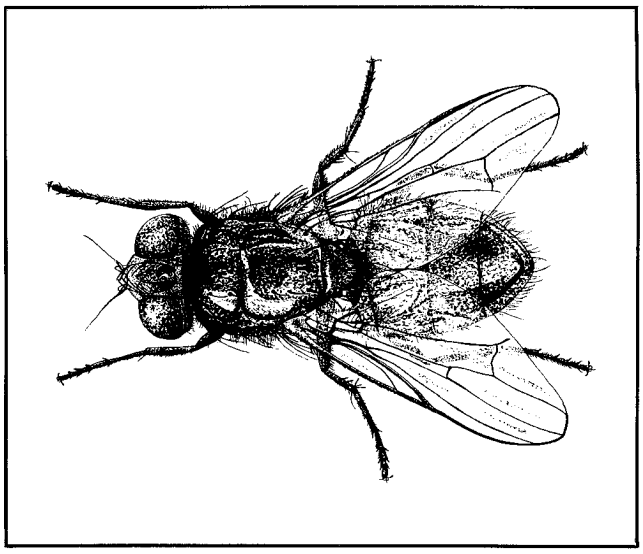


Figure 4. Little house fly.



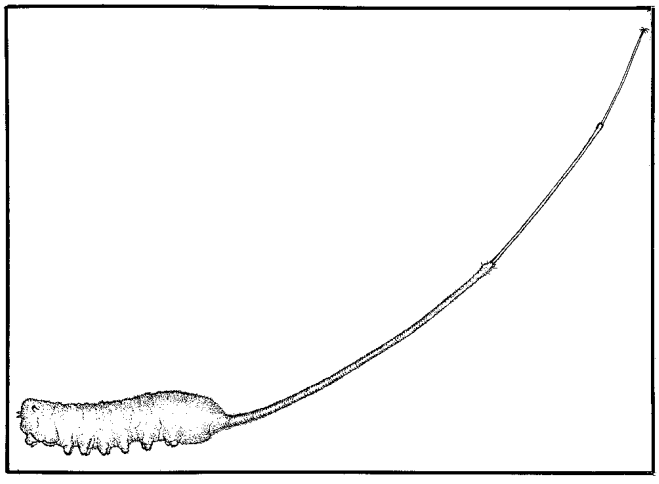
Black garbage flies often are found in large numbers in poultry houses. Their life cycle is 14 to 17 days. The larvae develop readily in poultry manure and may prey on house fly maggots. The black fly larvae are not considered to be practical biological control agents for house flies, since the black fly adults are also pests.

Figure 5. Black garbage fly.



Drone or flower flies (rat-tailed maggots) are common inhabitors of liquid manure tanks, storage basins, and anaerobic treatment basins. Where livestock are housed on slatted floors over liquid manure tanks, rat-tailed maggots may be found breeding in large numbers during the summer. There are usually several broods a year. The maggots are an inch long and have a long tail. When fully developed, they move from liquid waste to drier areas to pupate and change into adult flies. During this period, the maggots become nuisance pests, crawling by the thousands onto walkways, feed bunks, and elsewhere. Piles of sawdust, sand, and other dry material near the manure pits provide a pupation site and reduce the number of crawling maggots within the barn and milkhouse. Other than being a nuisance, this insect causes no harm.

Figure 6. Drone or flower fly (rat-tailed maggot).



CONTROL STRATEGIES

Sanitation, moisture control, and manure management are critical to a successful fly-control program, which must break the fly reproduction cycle. The number of suitable fly breeding sites must be kept to a minimum and conditions favorable to the development of natural fly predator populations must be maintained. Appropriate insecticides may be used when necessary, but chemical control works best in conjunction with good sanitation practices. It is easier and less expensive to prevent a heavy fly buildup than to control large fly populations after buildup has occurred. If pesticides are applied directly to manure or fed through animals for fly control, label restrictions must be followed.

Fly control requires more than just manure removal because hauling of animal manures and organic debris controls only the immature insects. Spreading the manure thinly in the fields kills eggs and larvae through drying. Failure to spread the manure evenly leaves large clumps where adult flies can develop and even produce a second field generation in wet weather. *Incorporation of manure into the soil soon after it is spread aids in breaking the fly development cycle*.

While manure and organic debris removal controls maggots and pupae, adult fly populations within the barns and poultry houses must also be killed. This can be accomplished through the use of residual insecticide sprays, space sprays, and baiting. All pesticide label instructions and safety measures should be followed. Failure to control adult flies prior to manure removal may release many flies into the community.

In dairy cattle operations, three potential fly breeding spots are calf pens or hutches and box stalls used for freshening and for sick animals, and spilled or wasted feed. Pens should be cleaned as frequently as possible and outdoor calf hutches moved regularly. Wet hay or straw, other organic matter, and silage seepage should be removed. Barnyards should have proper drainage, with gravel and other fill used to eliminate low spots. Alteration of breeding sites to moisture levels below 60 percent should significantly reduce fly populations. Since both stable and houseflies breed in wet grain, silage, haylage, and fermenting green-chopped materials, areas around and under feed bunks can also be fly breeding sites when water drains from the bunks and mixes with manure and spilled feed. Adult flies observed on or around manure may have come from other breeding sites, such as wet silage or spilled feed. Improved silage and feed management can control what may be perceived as a manure related problem.

Manure storage systems that are not completely liquid can also be a major source of flies, especially during dry weather. As maggots leave the manure to pupate, they seek dry areas. Liquid material completely surrounding solid or semisolid material prevents successful pupation. During dry weather, water may need to be added to a liquid tank or basin to maintain the solid-liquid interface along the storage edges. Also, manure containing large amounts of straw, hay, and sawdust may furnish adequate pupation sites. Seepage from the manure storage areas can also furnish suitable fly breeding sites outside of the storage area. If moisture levels remain above 85 percent, liquid manure systems will not be a breeding site for flies other than rat-tailed maggots.

Within shallow or deep-pit poultry houses, moisture levels are affected by several different factors. Leaks in the poultry watering system are the major source of excess moisture in the manure. Producers should check for leaks on a regular basis. Some manure pits also remain wet due to seepage from the exterior, which can be avoided by proper site selection, grading, and drainage. Houses equipped with scrapper boards usually have lower moisture levels since the scrapper boards aid in manure drying. A few poultry producers use a series of fans or mechanical rakes to dry the manure further. Keeping the pit dry, so that the manure cones up under the cages, reduces the amount of manure suitable for fly breeding and enhances populations of naturally occurring predators and parasites.

Accumulations of manure which have the proper moisture and physical conditions often contain large numbers of mites, parasitic wasps, and beetles, which prey on fly eggs or larvae. In an attempt to enhance natural predator/prey populations, stored semisolid or stacked manure should be maintained in as dry a condition as possible. This provides a desirable habitat for the predator and parasite reproduction and reduces the suitability of the manure for fly oviposition and larval development.

Populations of predators and parasites are affected by the manure removal schedule. In livestock housing designed for manure removal every few days, there is no buildup of the beneficial agents. In situations where manure is stored over long periods of time and natural predators and parasite populations have built up, only part of the manure should be removed at a time. A thick base of old manure should be left to perpetuate the beneficial insects as well as to assist in absorbing excess moisture as new manure is added.

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Unit 8 *Measurement of Agricultural Dust and Gases*
Unit 9 *Personal Protection Equipment*

American Society of Agricultural Engineers
2950 Niles Road, St. Joseph, MI 49085
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D384 *Manure Production and Characteristics*
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112 Agricultural Administration Building
University Park, PA 16802
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Minnesota Cooperative Extension
Agricultural Engineering Building
University of Minnesota, St. Paul, MN 55108
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National Safety Council
444 North Michigan Avenue, Chicago, IL 60611
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254 - *Excavation, Trench*

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250 Agricultural Engineering Building
University Park, PA 16802
NRAES-1 *Pole Frame Buildings* ($12.00)

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112 Agricultural Administration Building
University Park, PA 16802
S230 *Controlling Insects and Mites on Dairy and Beef Cattle*
S240 *Controlling External Parasites on Poultry*
S338 *Poultry Management for Pennsylvania and the Northeast*

Penn State Department of Agricultural & Biological Engineering
246 Agricultural Engineering Building
University Park, PA 16802
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Safety-2 *Personal Protective Devices*
Safety-12 *Agricultural Respiratory Hazards and Protective Devices*
Safety-26 *Farm Respiratory Hazards*
Safety-28 *Manure Storage Hazards*
SW-18 *Where to Have Your Water Tested*
Plans:
770-6282 *Manure Storage and Settling Basin*
770-6363 *Water Weighted Valve Opener*
G-79 Odor Control for Animal Production Operations

Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077
Circular Concrete Tanks Without Prestressing

Natural Resources Conservation Service
Available for inspection at county NRCS offices; distributed by National Technical Information Service,
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 605-6000
email: orders@ntis.fedworld.gov.
EFM-1, 1A-1I-*Engineering Field Manual for Conservation Practices* ($70.00)
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This and related environmental information are available electronically via Internet. For more information, visit us through the PA PowerPort at http://www.state.pa.us or visit DEP directly at http://www.dep.state.pa.us (choose directLINK “Manure Management”).

www.GreenWorks.tv - A web space dedicated to helping you learn how to protect and improve the environment. The site features the largest collection of environmental videos available on the Internet and is produced by the nonprofit Environmental Fund for Pennsylvania, with financial support from the Pennsylvania Department of Environmental Protection, 877-PA-GREEN.