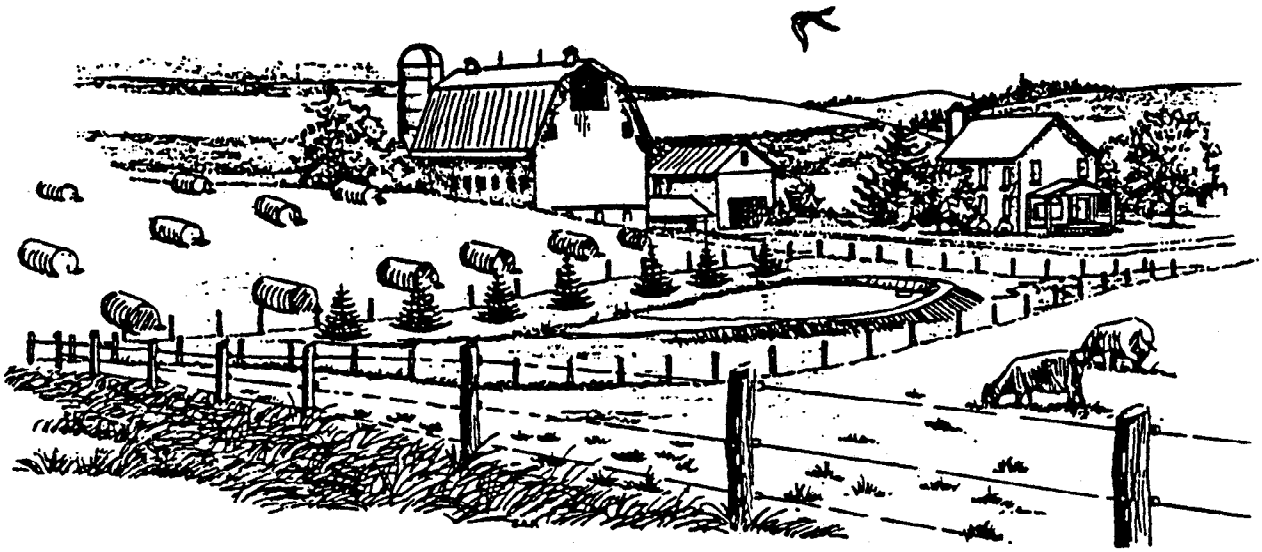
On-Farm Strategies to Protect Water Quality

An Assessment and Planning Tool for Best Management Practices



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Commonwealth of Massachusetts
Argeo Paul Cellucci, Governor
Executive Office of Environmental Affairs
Bob Durand, Secretary
Department of Environmental Management
Peter Webber, Commissioner
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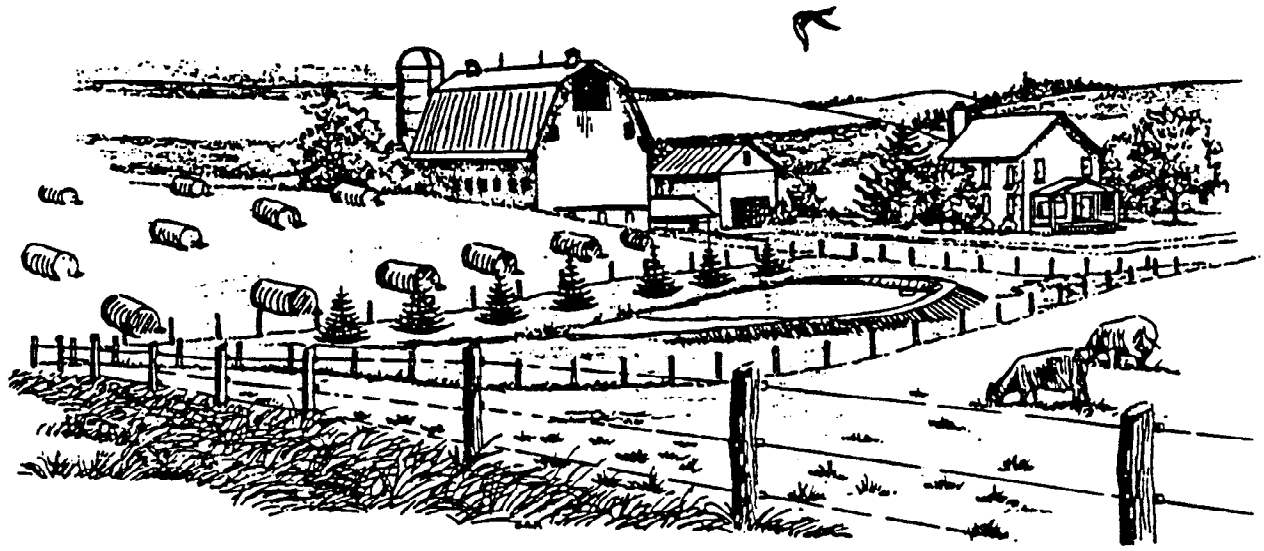

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Acknowledgments

This Guide was produced by the New England Small Farm Institute for the Massachusetts Department of Food and Agriculture (MDFA) and the Massachusetts Coastal Zone Management Office (MCZM). Information was gathered from a wide variety of sources including publications on agricultural best management practices and/or whole farm planning collected from across the country, and from the expertise of Massachusetts agency and agricultural industry representatives.

The Project Coordinator wishes to acknowledge and thank the following people: Guide reviewers Jim Hines and Tara Zadeh (MDFA); Jan Smith, Anne Donovan and Gibbs Ferris (MCZM); Doug Gillespie (MA Farm Bureau); Adam Burt, Warren Shaw and Tim Smith (MA farmers); Craig Hollingsworth, Steve Herbert, Bill Graves, Jay Daliparthy and Scott Jackson (University of Massachusetts Cooperative Extension); Judith Gillan and Warren Hubley (New England Small Farm Institute); Technical Advisor Don Buckloh and Alyssa Aldrich (USDA Natural Resources Conservation Service).

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December 1996

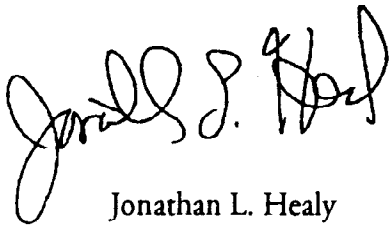
This document was funded through the Massachusetts Coastal Zone Management Office with a grant from the Office of Ocean and Coastal Resources Management, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The views expressed are those of the author(s) and do not necessarily reflect the views of NOAA or any of its sub-agencies. This information is available in alternate formats upon request. Printed on recycled paper.

A Message from Commissioner Jonathan Healy, *Massachusetts Department of Food and Agriculture*

The great majority of our Commonwealth's farmers are outstanding environmental stewards who help preserve nearly 600,000 acres of prime open space. A few of our agriculturalists, however, need to change long established practices in order to remain economically viable and environmentally sound. An example of this progressive change is our farmers' use of Integrated Pest Management (IPM), a technique that has reduced synthetic pesticide use by over fifty per cent in the past few years alone on farms participating in the University of Massachusetts IPM program. Our Department encourages all farmers to assess their current activities and consider what type of farming activities will best provide them with the income they need to continue farming, preserve valuable open space, and minimally effect our natural resources.

This Guide is intended to assist the agricultural community in assessing how their current and future farming practices may be impacting the environment and how those practices may be changed, where necessary, to ensure the continuing health of our soil and water resources. We encourage farmers to use this Guide as part of their overall planning efforts, taking into consideration the economic as well as environmental needs of their farms.

By doing so, we hope that the agricultural community will remain a thriving part of the Massachusetts economy and integrally related to the preservation of the Commonwealth's natural resources.



Jonathan L. Healy

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An Assessment and Planning Tool for Best Management Practices

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PART IV: Directory of Best Management Practices for Water Quality Protection on the Farm

PART V: Resources

On-Farm Strategies to Protect Water Quality

An Assessment and Planning Tool for Best Management Practices

This Guide is designed to help farmers to take an important first step toward comprehensive, "whole farm" planning and management to protect the quality of our water supplies.

PART I: Massachusetts Agriculture and Water Quality

A. Introduction

TODAY, NEARLY EVERYONE IS CONCERNED about water quality. Pollutants from a variety of sources threaten to contaminate public and private drinking water supplies as well as our rivers, coastal waters and lakes. Nationwide, pollutants from industry, urban stormwater, sewage treatment plants, marinas, construction sites and agriculture, for example, can enter surface and ground water in a variety of ways.

In response to federal legislation, the U.S. Environmental Protection Agency (EPA) has developed requirements and guidance for states as they develop nonpoint source pollution control programs. This guidance addresses six categories of pollution sources for which states are required to implement "management measures": agriculture; forestry; urban areas (including urban runoff, construction, roads and septage treatment); marinas and recreational boating; hydromodification; and wetlands and riparian areas. In Massachusetts, the MA Department of Food and Agriculture (MDFA) and the MA Coastal Zone Management Office (MCZM) have collaborated to implement these management measures for agricultural land use. They began by recruiting public involvement. In 1993, representatives from the agricultural and environmental communities and agency personnel were invited to work as a team, or Task Force, to address agricultural nonpoint source pollution in the Commonwealth. Although EPA guidance targets coastal watersheds, the Massachusetts program will be implemented statewide.

The Task Force was asked to identify strategies to reduce negative impacts on water quality from agricultural sources in ways that would meet the requirements of both state and federal mandates for nonpoint pollution control. It met for over two years to design a comprehensive strategy that would a) address statutory mandates, b) encourage voluntary actions on the part of the farming community, c) focus on a farm-comprehensive planning approach and d) provide tools to help farmers address nonpoint pollution. The following collection of information and planning recommendations is one outcome of their work.

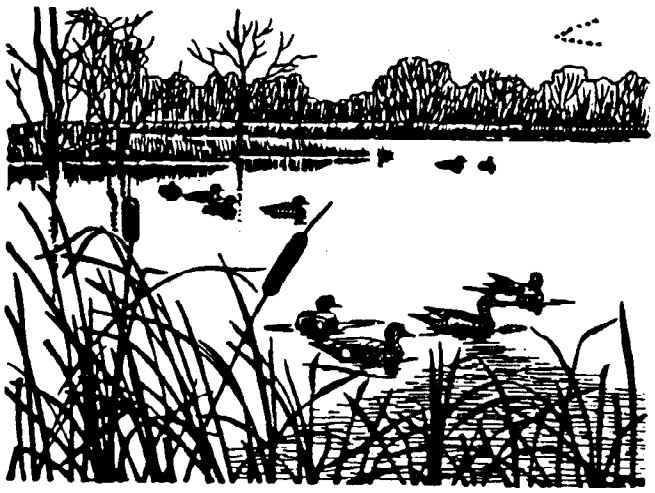
B. Background: Massachusetts Water Quality Issues and Programs

Massachusetts has established a number of state programs and regulations to protect water quality, including its Wetlands Protection Act.

MASSACHUSETTS IS PREDOMINANTLY an urban state, with over 84% of its population living in urban and suburban areas. Although much of the state is forested, its major land use impacts involve residential, commercial and industrial activities and the associated use and disposal of potential water supply contaminants on the land. These include, for example, industrial and household solvents, fuels, septage and sewage, road salt and sand. If not handled properly, these byproducts of everyday life can become pollutants, entering our surface and ground water and posing serious threats to water quality.

In addition, agricultural uses cover over 600,000 acres in Massachusetts. While agriculture's 6,000 farms make significant contributions to the Commonwealth's economy, and provide significant "non-market" amenities such as open space and wildlife habitat, normal farming practices involve activities that can also have unwanted and potentially harmful impacts on surface and ground water. Such activities include the use of pesticides, fertilizers, manure and fuel, and even the mechanical movement of soil.

Like most heavily developed states, Massachusetts has established a number of state programs and regulations to protect the quality of its water, including, for example, its Wetlands Protection Act. Some of these programs address specific agricultural activities, such as pesticide use and handling regulations and regulations limiting agricultural practices near public drinking water supply wells. From some farmers' point of view, this "piecemeal" approach to regulation has resulted in frustration and confusion. This Guide is designed to take an important first step toward comprehensive, "whole farm" planning and management to protect the quality of our water supplies.



C. Massachusetts' "Nonpoint Source Management Plan" for Agriculture: Strategies for Implementation and Use of this Guide

THE PROGRAM DEVELOPED TO meet requirements for Massachusetts' "agricultural management measures" combines two important approaches to farm management: 1.) it promotes the adoption by farmers of appropriate "best management practices" for water quality protection and 2.) it promotes the use of those "BMPs" in the context of developing a Whole Farm planning document. The farm planning model allows farmers to conduct a self-assessment and to determine successful strategies to meet water quality concerns. **This approach provides a framework for a voluntary, comprehensive and practical "hands-on" program** addressing agricultural sources of nonpoint pollution in our state.

The Whole Farm planning model provides a framework for a voluntary, comprehensive and practical "hands-on" program addressing agricultural sources of nonpoint pollution in our state.

The farm planning tools in this Guide may be used to develop a site-specific, realistic Farm Plan for meeting or working toward the following water quality protection goals:

- reduce soil erosion and minimize sedimentation to surface waters;
- limit the discharge(s) from livestock facilities to surface and ground waters;
- maximize nutrient use efficiency, and minimize excessive nutrient loading into surface and ground waters;
- reduce contamination of surface and ground waters from pesticides;
- protect sensitive areas (such as wetlands and stream banks) from negative impacts from livestock grazing and pasture management; and
- minimize the discharge of pollutants to surface and ground waters from irrigation practices.

1. The Purpose of this Guide

This Guide is designed to provide farmers with a structured process to understand and identify on-farm sources of nonpoint pollution, and choose and implement effective strategies to address them, within the context of a comprehensive, whole farm plan. In this way, farmers, along with other Massachusetts residents and businesses, will become active participants in the state's nonpoint pollution control program.

In summary, use of this Guide will:

- increase understanding of on-farm nonpoint pollution;
- provide guidance and tools for farm planning that addresses nonpoint pollution;
- support the selection of practical, do-able agricultural management measures; and
- provide access to help and further information through listed resources and referrals.

2. A Note on Whole Farm Planning

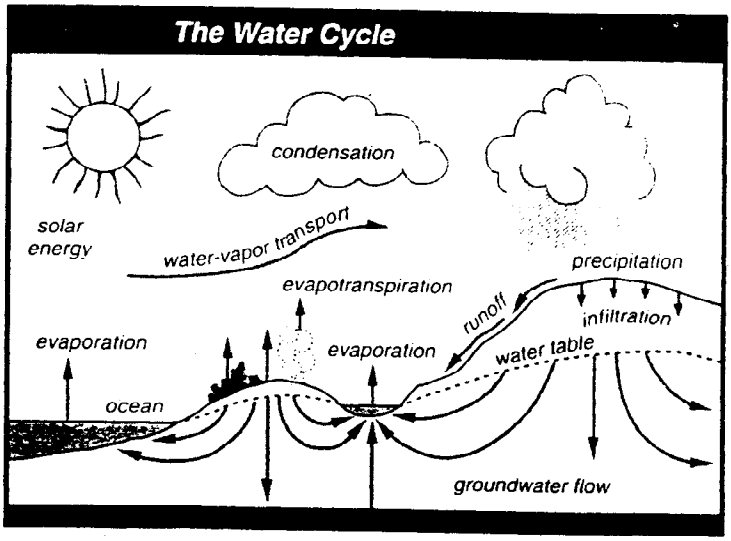
The increasingly popular concept of Whole Farm Planning centers around the notion that the best farm management is the result of careful and comprehensive planning. Terms like "systems" and "holistic" are often used to describe an approach that begins with articulating farm family goals and then evaluates all components of the farm enterprise.

Water is a shared resource. Water used on the farm has been used by others, and will be used by others again.

MDFA strongly encourages the development of such farm plans. Initiatives such as MDFA's Farm Viability Enhancement Program stress the importance of a holistic, systems approach to farm planning and management. There are a variety of farm planning assistance tools available through farm service agencies, MDFA and private consultants. While the tools may vary, they share a systems approach that links all management practices into an integrated whole through careful and comprehensive planning.

Strategies to protect water quality are a central component of Whole Farm Planning efforts. With the help of this Guide and appropriate technical assistance, Massachusetts farmers can design and implement farm plans that, among other goals, work toward successfully meeting standards for controlling nonpoint pollution. Part IV of this Guide includes a directory of "best management practices" that can be built into a plan to address particular on-farm water quality concerns or issues. These "best management practices" are site-appropriate farm activities that control, reduce or avoid nonpoint pollution.

The Worksheets included in this Guide are important tools for comprehensive farm planning. However, they are **not offered as a substitute for detailed inventories and the professional on-site planning and evaluation that can be provided by public or private sector specialists.** Nonetheless, *every farmer who spends time with this Guide is taking positive farm planning action.*



Reprinted from Small Flows, October 1993

PART II: Preparing for Action

A. Step One: Understanding Water Quality Impacts

ADDRESSING AGRICULTURE'S impacts on water quality is an important farm management issue. Becoming informed about water quality impacts, both on-farm and off-farm, is a necessary first step.

1. The Water Cycle

Water is a shared resource. It is in constant motion, continually recycling throughout the environment, and agriculture is but one of

many users that expect a clean supply to meet a variety of needs. Water used on the farm has been used by others, and will be used by others again after it leaves the farm. This "cycle" includes both surface water, such as ponds and lakes, wetlands, streams and rivers, and coastal waters; and ground water, which is the water contained in rock and sand formations below the surface of the ground.

2. Point and Nonpoint Pollution

Water pollutants can come from many sources. The term "point source pollution" refers to pollutants that discharge from a "confined and discrete conveyance" such as a pipe from an industrial or sewage treatment facility. Nationally, there has been considerable success in controlling or eliminating point source pollution. In Massachusetts, it is uncommon to find a point source on a farm.

"Nonpoint pollution" is often more difficult to identify. It usually results from surface runoff, precipitation, drainage or seepage. As water moves over and through the ground, it picks up and carries away both natural pollutants and pollutants resulting from human activity. Contaminants such as soil sediments, nutrients from agricultural and lawn fertilizers, sewage, and chemicals from pesticide use and other sources are picked up as water runs over the ground and through the soil. Contaminated rainwater and snow melt ultimately flow directly into a surface water body such as a pond, river or lake, seep into ground water, or enter a constructed drainage system that eventually carries the contaminants to a surface water body.

Unlike point source pollution from industrial pipe discharges and other direct sources, the sources of nonpoint pollution are extremely diverse and widespread. Virtually every activity that adds something to the environment or takes something away can cause nonpoint pollution. For example, adding fertilizers and pesticides to a field can cause nonpoint pollution when rainwater washes excess nutrients and chemicals into surrounding water bodies. Even cleaning the house, driving to work or walking the dog can contribute to nonpoint pollution. And although each one of these activities alone may have a small impact, the combined impacts of millions of people add up to a water pollution problem of significant size.

3.The Dynamics of Nonpoint Pollution

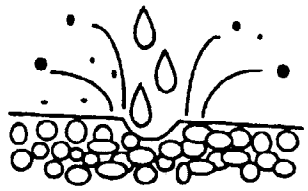
While agriculture's overall contribution to nonpoint pollution is small compared to other sources in Massachusetts, some on-farm practices can and do cause significant localized, negative impacts on water quality. In most cases, Massachusetts' agricultural producers can implement management practices that address nonpoint pollution (and that may also have additional benefits), once the source of the problem has been identified.

To successfully manage agriculture's impact on water quality, it is important to understand and work with the dynamics or "mechanics" of water pollution.

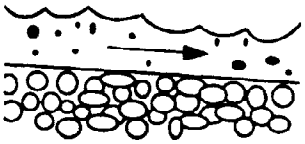
The water cycle includes both "surface water", such as ponds and lakes, wetlands, streams and rivers, and coastal waters; and "ground water", which is the water contained in rock and sand formations below the surface of the ground.

Understanding the "mechanics" of water pollution is important in managing agriculture's impact on water quality.

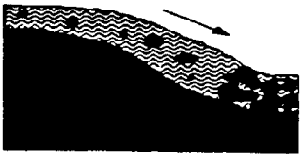
Detachment
Detachment occurs when water splashes onto the soil surface and dislodges soil particles from their original location.



Transport
Transport is the movement of soil particles in moving water across the soil surface.



Deposition
Deposition is when the soil particle is no longer moved by the force of the water.



Water's ability to transport nonpoint pollutants through and/or across the land—and our ability to control it—involves the following:

- availability
- detachment
- transport
- deposition

a. **Availability** of a potential pollutant depends on its location and quantity in or on the soil. Reducing the amount of a potential pollutant available for loss can be accomplished by, for example, reducing pesticide or nutrient application rates and avoiding sensitive areas. **Source control** strategies such as these present the first opportunity in any agricultural pollution control effort. Quite obviously, reduced availability of a potential pollutant means reduced problem potential. As a first line of defense, looking for ways to reduce the use of potential pollutants such as crop nutrients and pesticides makes good sense.

b. **Detachment** is the process in which a soil particle, nutrient or pesticide breaks free from its position in the soil. Soil particles can be separated from the soil mass by wind or rain and deposited in nearby water bodies. Nutrients or pesticides can then move away from the soil material to which they are attached and into the surrounding water. Certain practices can prevent the detachment of a particle or substance, while other practices and naturally occurring events increase the likelihood of detaching soil particles and the nutrients and pesticides that may be attached to them. For example, the impact of rain drops is a major cause of soil particle detachment. Protecting the soil from this impact with crop residues or green covers is one practical response.

c. **Transport** involves the movement of a soil particle, nutrient or pesticide from its original position. Nutrients and pesticides can be attached to soil particles that may become detached or they may become dissolved in water collected on the surface or moving through the soil. Pollution prevention often requires transport or delivery reduction in addition to appropriate source control measures. Strategies that limit or direct the movement of a soil particle or other substance are available. For example, reducing "overland flow" (non-channelized flow of rain or snow melt across the surface of a field) by farming on the contour or increasing crop residues will accomplish this.

d. **Deposition** results in a new, stabilized resting place for a transported soil particle, nutrient or pesticide. A soil particle, possibly with nutrients or pesticides attached, may be deposited in a water body or in a specially designed trap. Properly designed vegetative filter strips, sediment basins and buffers can perform this trapping function successfully.

In summary, management strategies to avoid or reduce nonpoint pollution from farms must attack the problem at its source. Understanding the natural progression of

availability —> detachment —> transport —> deposition

is the key to choosing appropriate actions to avoid or reduce harmful agricultural impacts on water quality.

4. Nonpoint Source Pollutants

Nonpoint source pollutants that cause agricultural nonpoint pollution can be grouped into three major categories:

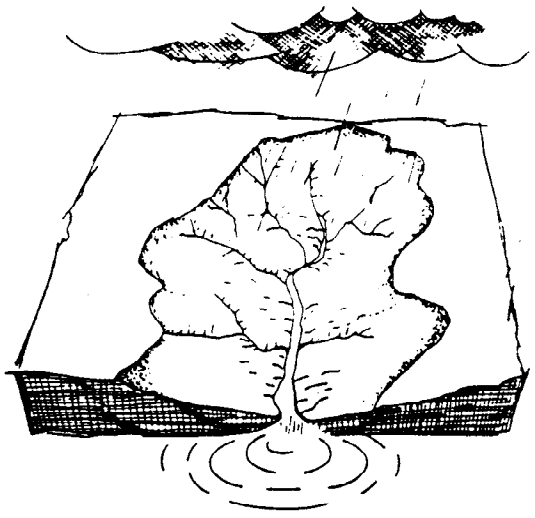
- sediments
- nutrients and pathogens
- toxicants, such as pesticides, fuels and metals

a. Sediments are, quite simply, "materials deposited." In agriculture, this material is typically comprised of soil particles, both organic and inorganic, deposited as a result of water erosion. In Massachusetts, wind erosion, which also carries soil particles, is of less concern. Water erosion is the natural process of soil movement from higher areas to lower areas by the action of precipitation or flowing water. Heavy rain events as well as activities such as cultivation can cause erosion. Factors affecting soil erosion include soil type, slope, intensity and duration of precipitation, soil cover and management practice.

On a bare area, a single storm can remove more soil than ten thousand years of geological erosion.

Sediment affects water quality in several ways. Substances such as phosphorous, ammonium and some pesticides stick to sediment particles. They are then transported and may be released from these particles into a water body or ground water. Eroding sediments generally contain higher concentrations of phosphorous, nitrogen and pesticides than the parent soil because small particles (those that are more easily transported, e.g. clay) have a much greater adsorption capacity than larger particles, such as sand.

Sediment also affects the quality of water as a habitat. Suspended particles affect fish gills, spawning areas, food supplies and feeding habits, and reduce sunlight available to aquatic plants. These effects, in turn, combine to decrease the overall value of lakes, streams, estuaries and coastal waters. Recreational opportunities are reduced: fish populations are reduced and the turbidity (cloudiness) of polluted water makes it less appealing for swimming and other recreational use.



Finally, the movement of sediments also has a negative impact on agricultural land productivity. Topsoil loss from erosion has been a major agricultural problem since the days of the dust bowl. On a bare area, a single

storm can remove more soil than ten thousand years of geologic erosion. Building and maintaining soil health by employing practices that reduce soil migration, such as those recommended in this document, will help prevent both water pollution and soil loss.

b. **Nutrients and Pathogens.** Major sources of nutrients and pathogens in agriculture are fertilizers, silage juices, sludges, crop residues, irrigation water, and manures and animal bedding. Runoff and leachate (liquids percolating through the soil into the ground water) from agricultural land may transport pollutants such as the following:

- excess crop nutrients: both bound to organic soil particles (e.g., phosphorous and organic nitrogen) and soluble (e.g., nitrogen, phosphorous and other major and minor nutrients that dissolve in water); and
- pathogens: harmful bacteria, viruses and other microorganisms.

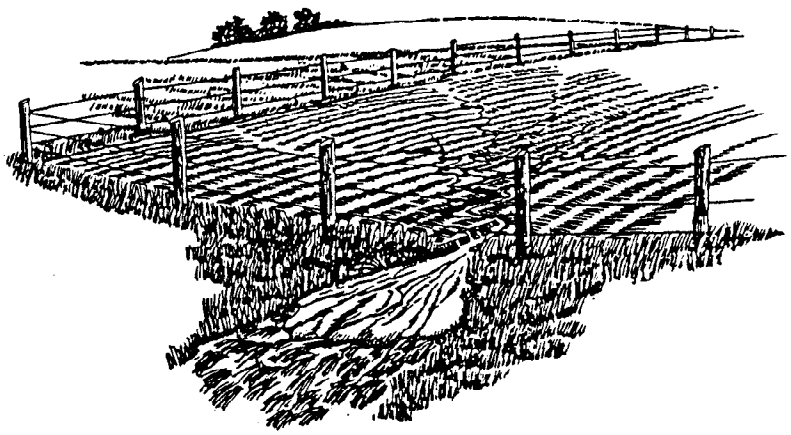
Building and maintaining soil health by employing practices that reduce soil migration will help prevent both water pollution and soil loss.

1) Excess Crop Nutrients. When treating the soil to provide crop nutrition, the goal is to provide no more nitrogen, phosphorous, potassium and/or other nutrients than is necessary. Excess nutrients (those not used by the crop) become readily available for transport to (and pollution of) surface or ground water.

Nutrients in organic form come from manures, bedding and sludges that are applied to cropland, and from decaying crop residues. The nutrient content of such material varies greatly and can be tested to assure that nutrients are not being applied in excess amounts.

The inorganic nutrients available in commercial fertilizer come in many forms. While nutrient content is clearly identified in product literature and labelling, amounts can become "excess" if they are not carefully applied.

Irrigation water can also be an important source of excess nutrients (particularly nitrogen). These may be picked up from the soil as water passes through it. These amounts can be significant. In addition, fertigation (also called chemigation), the process of adding fertilizer to irrigation water, can add potentially excess nutrients to surface or ground water.



While crop nutrients are necessary for crop production, they can have a negative impact on the growth of native aquatic plants. When excess nitrogen or phosphorous enters surface water bodies, aquatic plant productivity may increase dramatically. The physical presence of these "excess" plants can make water unsuitable for swimming or boating, and adversely affect the quality of water as habitat. Further, the decay of

this plant material depletes the water's supply of available oxygen, with negative impacts on aquatic organisms. In addition, runoff, wastewater and/or manure entering surface water can cause toxic conditions resulting in fish kills (the sudden death of large populations of fish) and make surface water unsuitable for drinking, fishing, boating, swimming and other use.

Nitrates in ground water also pose serious public health hazards. Nitrates are potentially dangerous to newborn infants and are a suspected cancer-causing agent. The extent of nitrate contamination of drinking water is only beginning to be documented, but it appears to be widespread in some areas of the country.

2) **Pathogens.** These disease-causing organisms, including bacteria (e.g., E. Coli), viruses and parasites, are found in manures and sludges and can be transported (carried or leached) into surface or ground water. Animal diseases can be transmitted to humans through contact with water contaminated with animal wastes, and high fecal coliform counts have caused the closing of public beaches and shellfish beds.

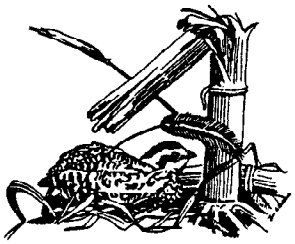
c. **Toxicants.** The storage and use of toxic or hazardous materials on the farm is likely to be subject to state or federal regulation. Planning considerations to protect water quality offers an opportunity to plan for compliance within the context of a practical, economically sensible and comprehensive farm management plan. Major sources of toxicants in surface and ground water include:

- Pesticides
- Fuels and Metals

1) **Pesticides.** Before World War II, commonly used pesticides consisted of a limited number of products made from natural organic sources such as pyrethrum and naturally occurring inorganic substances such as sulfur and copper compounds. Today, over 50,000 manufactured pesticides are registered with the U.S. Environmental Protection Agency (although a smaller number of these are used extensively); for purposes of identification, they are generally grouped according to their intended targets: e.g. insecticides, fungicides and herbicides. Responsible use of these pesticides requires farmers to implement increasingly complex chemical management systems.

These modern agricultural pesticides are generally mixtures of two or more synthetic chemicals—one or, often, several "active" ingredients (those that produce the desired effects) combined with one or more "inert" ingredients added to make the product useable. Although the major pesticide pollutants are these active and inert ingredients, byproducts formed in soil as pesticides degrade can cause problems as well.

Responsible use of pesticides requires farmers to implement increasingly complex chemical management systems.



Farm assessment must take into account the whole farm, and should consider the interrelationship of particular use areas, practices and impacts.

Pesticides and their degradation products may enter surface and ground water dissolved or bound to soil particles. Some pesticide chemicals are resistant to degradation and may persist and accumulate. On the farm, one major source of contamination from pesticide use can be from normal application. For example, a pesticide that may not be toxic by itself can be lethal in combination with other pesticides. Also, an organism may ingest more of a pesticide than it excretes, and when eaten by another animal higher in the food chain, that pesticide is passed along up the food chain to even higher level animals. Normal application, if poorly timed (such as right before a rain) can cause contamination because the pesticide is washed away from its target and made available for transport to surface or ground water. Other pollutant sources include misuse, spray drift, and spills and leaks associated with storage, handling and disposal. When these "stray" pesticides enter drinking water directly, they may have a negative impact on human health. Others may impact a wide range of organisms by destroying food sources, affecting the behavioral and structural aspects of animal life, or causing acute toxicity (such as when pesticide residues have been known to cause fish kills).

While agriculture's pesticide use goals were once almost exclusively tied to production enhancement, farmers now recognize that incautious or wasteful use can threaten not only their own profitability, health and water supplies, but also farmworker health, soil health, on-farm biodiversity, and, potentially, downstream surface water and ground water supplies.

2) Fuels and Metals. On the farm, home heating fuel, and gasoline, kerosene, diesel fuel, and oil (including drain oil) used in farm machinery pose the main threats to water quality. On-farm use and storage of these petroleum products and inputs containing heavy metals (e.g., some sludges and sludge-based composts) must be managed with care. Fuels and many products commonly used in farm shops contain potentially toxic compounds such as solvents; some of these chemicals are considered to be human carcinogens (cancer-causing agents). Even a small leak or spill from an above-ground or underground storage tank, for example, can contaminate a water supply.

B. Step Two: On-Farm Assessment and Planning

TODAY, FARM MANAGERS must deal with an increasingly complex set of issues. Profitability and "quality of life" are key core management goals; production, marketing, and maintenance of infrastructure are only a few of the many factors that must also be addressed. As land managers, farmers are well aware of several increasingly critical natural resource issues. In addition to water quality, these include declining soil health, and the loss of prime farmland and biodiversity. The skillful farm manager must address all these issues when developing a comprehensive farm management plan.

Armed with a basic understanding of water quality impacts, a farm manager's next steps include: assessing the farm for potential or existing threats to water quality; and farm-wide planning to implement appropriate management strategies. Farm assessment must take into account the whole farm, and should consider the interrelationship of particular use areas, practices and impacts.

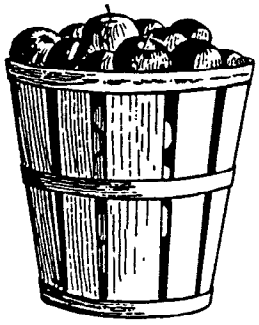
For example, the location of a pesticide mixing area must make practical sense, but certain locations are more risky to water quality than others. Crop selection, such as replacing silage corn only with a mixture of hay, alfalfa and corn, may offer more opportunities for avoiding pollution of surface and ground water. Alternatively, rotational grazing might reduce a pesticide problem, but could cause streambank erosion from unmanaged livestock watering access. Assessment and planning for the whole farm, keeping in mind a "systems perspective", is the best approach to making decisions that are both environmentally and economically sound.

1. A Note about Economics

Quite obviously, implementing some strategies will involve far greater cost than others. However, most best management practices directly increase efficiency and thereby increase farm profits as well. Even if a practice does not pay for itself immediately, it may help to improve soil productivity and sustain yields in the long term. Implementing such strategies can also benefit property and estate values by maintaining a farm without pollution or excessive soil loss.

While protecting water quality should be a high priority, a farmer's efforts to do so must be economically feasible. In fact, the federal guidelines for nonpoint pollution control state that the required management measures must be "economically achievable." The practical limits of resource protection have been based on application of national social, cultural and economic criteria. Some management systems may be too costly; if an entire conservation management system cannot be implemented, an "acceptable management system" that is both less costly and less protective of the resource, may be used instead. In some cases, a "progressive planning approach," the incremental process of building a plan over a period of time, may be used.

While protecting water quality should be a high priority, a farmer's efforts to do so must be economically feasible.



Some best management practices have a high cost-effect ratio; that is, they produce the greatest benefit for the effort or expense required. Farmers may choose to consider these options first. But there will be occasions when a greater level of prevention, correction or reduction of water pollution is necessary. Often, federal cost-sharing funds are available, or grant programs such as the USDA Sustainable Agriculture Research and Education (SARE) Program and MDFA's Agro-Environmental Technology Grant Program provide funds to develop and implement proven as well as experimental management practices.

The purpose of the planning tools in this section is to help you identify and address current and potential water quality concerns on your farm.

2. Using the Guide's Farm Assessment and Planning Tools

Part III of this Guide contains information, guidance and a set of related Worksheets to help farmers plan to include water quality considerations in their current management systems. This material encourages a "hands-on" approach to assessment and planning. Paper, pencil and a good eraser are required. More than that, it requires a close, and sometimes renewed acquaintance with all aspects of a farm's natural and built environments. An important part of assessment will include the farmer's footsteps on the land.

The various sections of Part III are designed to be used in sequence, beginning with a map of current conditions and ending with an Action Plan that is both economically sensible and environmentally sound. These sections include:

- Section A: Mapping Your Farm *(including Worksheets A 1–3)*
- Section B: Farm Assessment *(including Worksheet B)*
- Section C: Best Management Strategies on Your Farm *(including Worksheets C 1–6)*
- Section D: Selecting Management Strategies and BMPs *(including Worksheets D 1–6)*
- Section E: Putting it All Together – Developing an Action Plan *(including Worksheet E)*

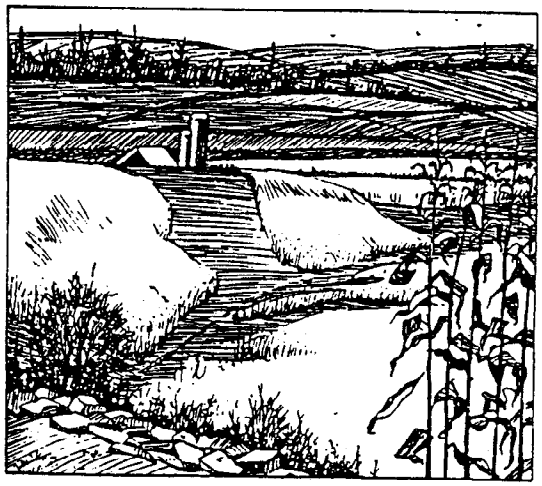
PART III: On-Farm Assessment and Planning Tools

THE PURPOSE OF the planning tools in this section is to help you identify and address current and potential water quali · concerns on your farm. Some problems are obvious, others less so. Some may have partial solutions and would benefit from additional or slightly modified practices.

You already may have taken action to address previously identified water quality concerns. The purpose of these Worksheets is to address those areas and activities of concern that have not been identified or attended to. You will have an opportunity to list and "get credit" for current management practices that protect water quality. (Worksheets C1–6.)

Worksheets appear on yellow paper following page 18, at the end of this section.

A. Mapping Your Farm



AN IMPORTANT FIRST step in assessing potential on-farm water quality impacts is to **generate a Farm Map.** Your completed Farm Map will be an effective tool for starting to identify sensitive natural features and potentially harmful practices. It will help identify 1) areas on the farm that are vulnerable to water contamination ("sensitive" areas), and 2) practices that may contribute to water pollution. This base map of the farm should show all farm fields, the farmstead and barnyard area, related use areas, and "non-productive" areas such as wetlands and forested land. Many farmers already have maps and/or aerial photos of their farms, often as part of a Natural Resources Conservation Service (NRCS, formerly the SCS) Farm Conservation Plan. These documents are helpful if they are detailed and up-to-date. The USDA Farm Services Agency (FSA, formerly the ASCS) will also provide photocopies of aerial photographs that can be helpful in generating a comprehensive Farm Map.

Worksheets A 1–3: Farm Mapping

Worksheets A 1–3 provide space to sketch in your Farm and Farmstead Maps and list existing and potential problems in or near sensitive areas. Please complete them all. Several pages may be required; the quality of the sketches is not important! **See the Sample Farm and Farmstead Maps following this section.**

Your completed Farm Map will be an effective tool for starting to identify sensitive natural features and potentially impactful practices.

Worksheet A1: Farm Map

Directions:

1. Sketch a map view of the farm, including rented lands.
2. Sketch in areas that are "sensitive" with respect to water quality. Sensitive areas include streams, drainage ditches, springs, other flowing surface water bodies. Standing water bodies such as natural or man-made ponds and wetlands are also considered sensitive, as are any wells. Areas subject to flooding are considered sensitive and should be located on the map.

   Use arrows to indicate direction of flow of any moving water. It is important to locate all sensitive areas, including those that may be outside the boundaries of owned or rented property; water pollution is not stopped at property bounds.
3. Sketch in other natural features of the farm, such as sloping topography and low, seasonally wet areas. Use arrows to indicate the direction of the slope; in other words, clearly show how surface water moves across the ground.
4. Sketch in man-made features of the farm, such as the location of any subsurface drainage systems and their outlets, active terraces or waterways, fencing, and irrigation infrastructure. Include areas of livestock concentration, and areas for waste storage, processing, and equipment storage and repair.
5. Based on the information on sources of nonpoint pollution in this Guide, identify by circling and numbering any areas that show signs of erosion,

sedimentation and/or water degradation, and any known or potential areas or activities of concern or "hot spots". These "areas and activities of concern" will typically fall into one or more of the following categories:

1. erosion and sediment control
2. nutrient management
3. pest and pesticide management
4. livestock barnyard, manure and waste management
5. livestock grazing management
6. irrigation management

When completed, your Farm and Farmstead Maps should identify known problems, locations of activities that may negatively impact sensitive areas, and sensitive areas that may need additional protection.

When completed, this Farm Map should identify with numbered circles:

- known problems (e.g., sensitive areas where sediments are collecting)
- locations of activities that may negatively impact sensitive areas
- sensitive areas that may need additional protection

This information will be transferred to Worksheet A3.

Worksheet A2: Farmstead Map

Directions:

1. Sketch a detailed view of the barnyard/farmstead area(s), including sheds, pens and buildings.
2. Sketch in any areas that are sensitive with respect to water quality (for definition of "sensitive", see page 13).
3. Sketch in roof and other drains, storage tanks, mixing, loading and storage areas. Manure and waste storage and processing areas should be marked; indicate any impervious areas (i.e. ground that is paved or otherwise not able to absorb water).
4. Based on the information on sources of nonpoint pollution in this Guide, identify by circling and numbering any areas that show signs of erosion, sedimentation and/or water degradation, and any known or potential areas or activities of concern or "hot spots". These "areas and activities of concern" will typically fall into one or more of the following categories:

    1. erosion and sediment control
    2. nutrient management
    3. pest and pesticide management
    4. livestock barnyard, manure and waste management
    5. livestock grazing management
    6. irrigation management

When completed, this Farmstead Map should identify:

- known problems (e.g. fuel or manure storage near sensitive areas)
- locations of activities that may negatively impact sensitive areas
- sensitive areas that may need additional protection

This information will be transferred to Worksheet A3.

Worksheet A3: Map Summary Sheet – Areas/Activities of Concern
Directions: Using the Farm and Farmstead Maps prepared on Worksheets A1 and A2, list the numbered and circled areas and activities where water quality may be a concern on your farm. In the columns on the right of the Worksheet, mark all categories that apply for each area/activity of concern. (See examples at the top of the Worksheet.) This information, by category, will be used to complete the remaining Worksheets.

B. Farm Assessment

THE FARM ASSESSMENT Questionnaire (Worksheet B) is another tool to help you identify and evaluate specific on-farm water quality issues and/or farm management practices that might have a negative impact on water quality, either now or in the future. **It is not a test to pass or fail!** Rather, your answers to these questions will serve as "indicators" for possible problem areas that can then be constructively assessed and addressed, so as to better protect water resources.

The Farm Assessment Questionnaire is a tool to help you identify and evaluate specific on-farm water quality issues. It is not a test to pass or fail!

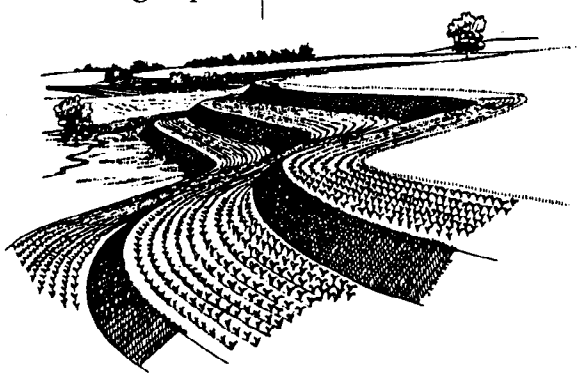
Worksheet B: Farm Assessment Questionnaire
Directions: Answer the questions in all categories relevant to your farm. Use your Farm Map Summary Sheet (Worksheet A3) as a reference. Your answers will be used to complete the remaining Worksheets.

C. Best Management Practices on Your Farm

ONCE AREAS AND ACTIVITIES of concern have been identified, how does a farmer decide what steps to take next? Addressing existing or potential water quality problems requires **information about the range of possible options**, or actions, and, then, **selection from among these options** based on site-specific conditions, cost, timing and other concerns.

The comprehensive Directory in Part IV has been designed to provide such information: it is an extensive collection of strategies, or best management practices (BMPs). Every farmer is encouraged to become well acquainted with sections relevant to his or her farm. The Directory provides information about the purpose, costs and benefits of each listed practice, as well as additional guidance on the need for technical assistance. These best management practices are grouped in the following categories:

1. erosion and sediment control
2. nutrient management
3. pest and pesticide management
4. livestock barnyard, manure and waste management
5. livestock grazing management
6. irrigation management



The Best Management Practices worksheets give you an opportunity to document and "give yourself credit" for your efforts to control water pollution and other problems on your farm.

The Directory lists many Best Management Practices. As you read through each section, some BMPs will be familiar to you — you already may be employing the practice on your farm. **These Worksheets give you an opportunity to document and "give yourself credit" for your efforts to control water pollution and other problems on your farm.** You might realize that a practice employed in one area of the farm, or for one purpose, might serve elsewhere to perform the same or other valuable resource protecting functions.

Worksheets C 1–6: BMP Summary Charts and Checklists
Directions: Worksheets C 1–6 summarize the Best Management Practices in each category. Each Worksheet lists the BMP alphabetically, indicates whether it is a structural intervention, indicates cost and technical assistance requirements, and tells you where to find a description of the BMP in the Directory.

After you have familiarized yourself with the BMPs listed in the Directory, indicate in the last two columns of each Worksheet whether or not the practice is currently employed on your farm. You may take this information into account when preparing your final Action Plan (Worksheet E).

D. Selecting Management Strategies and BMPs

ONCE EXISTING OR POTENTIAL nonpoint pollution problems on the farm have been identified, the next step is to add or modify strategies to eliminate or reduce the problem. The management practices and measures that follow should be considered as a menu; farmers choose one or more from those listed (and there may be others not contained here) that are appropriate and feasible for the particular site and the particular problem.

Worksheets D 1–6 provide the opportunity to group the activities/areas of concern from Worksheets A1–3 and Worksheet B by category, and then to choose and list possible strategies to address these concerns from the following Directory of BMPs. These practices will be those selected in your careful review of the options described in the Directory as having potential value as part of your farm management plan. Each Worksheet (D 1–6) corresponds to the categories identified above.

Worksheet D1–6: Selecting Management Strategies
Directions: With Worksheet A3 (Map Summary: Areas/Activities of Concern) in front of you, copy all the areas/activities of concern for which you placed a mark in the column for "erosion and sediment" onto the left side of Worksheet D1. Next, with Worksheet B in front of you, notice that for each question, the "yes" or "no" answer block has been highlighted. If your answer appears in a highlighted block, this indicates an existing or potential area/activity of concern. Transfer each statement in Category 1 (erosion and sediment control) for which the answer is highlighted onto the left side of Worksheet D1.

You will now have a complete listing of areas/activities of concern in the category of erosion and sediment control.

Next, read through the listing of erosion and sediment control Best Management Practices in the Directory. Choose from this section those BMPs which you think would address EACH identified area/activity of concern. You might list more than one BMP to address the concern. List those choices on the right side of Worksheet D1.

You have already identified practices that are active on your farm on Worksheets C 1–6; you need not list those again, unless they need modification, or would address a concern on another location on the farm.

Repeat this process for each Worksheet D2 –D6.

E. Putting It All Together – Developing an Action Plan

FARMERS WHO HAVE TAKEN the time to complete the Worksheets provided thus far will be well prepared to complete Worksheet E. This Worksheet is a tool for summarizing identified areas/activities of concern and developing actions to address them. This is an opportunity to begin to plan "holistically" by combining selected strategies to address a particular area/activity of concern. You will also begin to see where a particular BMP may address more than one concern.

Now is your opportunity to begin to plan "holistically" by combining selected strategies to address a particular area or activity of concern.

In making your selections, you will be considering the pros and cons of each element of the overall plan, prioritizing the action, identifying barriers to implementation and determining next steps. Technical assistance from the NRCS or other consultants may prove useful at this point, to confirm that a plan includes the most appropriate, effective strategies. Part IV of this Guide lists additional resources to which a farmer may turn for assistance in implementing the Action Plan.

Worksheet E

Directions:

1. From your D 1–6 Worksheets, list selected BMP's in the left hand column. You may group or arrange them in any way that is useful to you in thinking about the whole farm. At this point, you may eliminate from consideration some of the BMPs on your D 1–6 Worksheets. (For example, if the BMP won't "fit" in your barn yard.) Next, identify those areas/activities of concern that are being addressed. Next, assign a priority to implementation. The priority should correspond to your assessment of the severity of the concern as well as the feasibility for implementation.
2. Next, identify and list what you need in order to act. Another way to think about this is in terms of barriers to action. Examples of such needs or barriers are:
    - need technical assistance/ expertise or information not available
    - need to acquire equipment or materials/ materials or services not available

- cost too high
- need to go through permit process/regulations are a barrier
- solution not realistic on this farm
- lack of finances
- lack of time to implement
- lack of necessary equipment

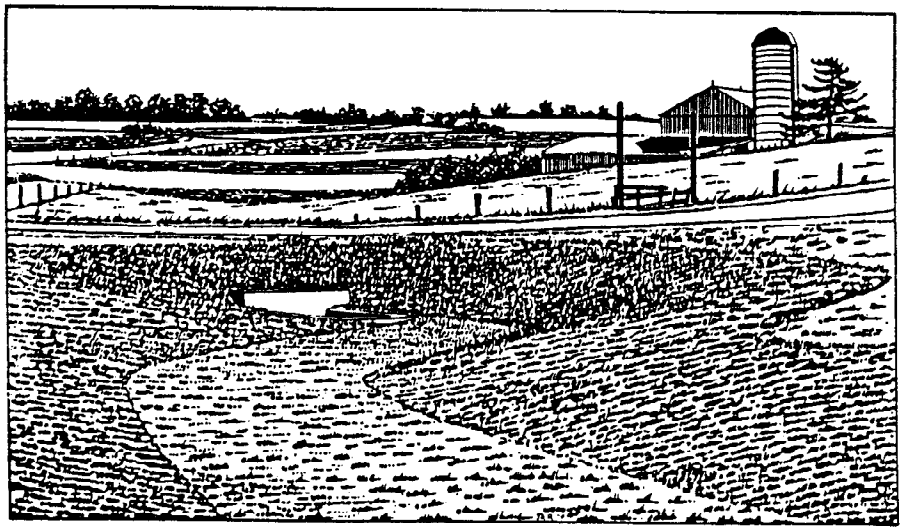
3. Next, consider timing. A chosen strategy may have few barriers to action but be a low priority for immediate attention. Or, a strategy, despite barriers, may be a high priority for immediate attention (for example, making improvements to the pesticide storage facility that is located near a drinking water well). You might think about your timetable for action as follows:

    - immediate *(within next 3 months)*
    - short term *(within next year)*
    - long term *(within next 5 years)*

4. Identifying your next step is critical. Sometimes the biggest barrier to action is simply not identifying and then taking the next step. Next steps are the difference between planning and implementation. This might be a phone call for assistance or information; it might be making repairs on a piece of equipment. You may then refer to the Action Plan to begin the process of implementing components of your management strategy.

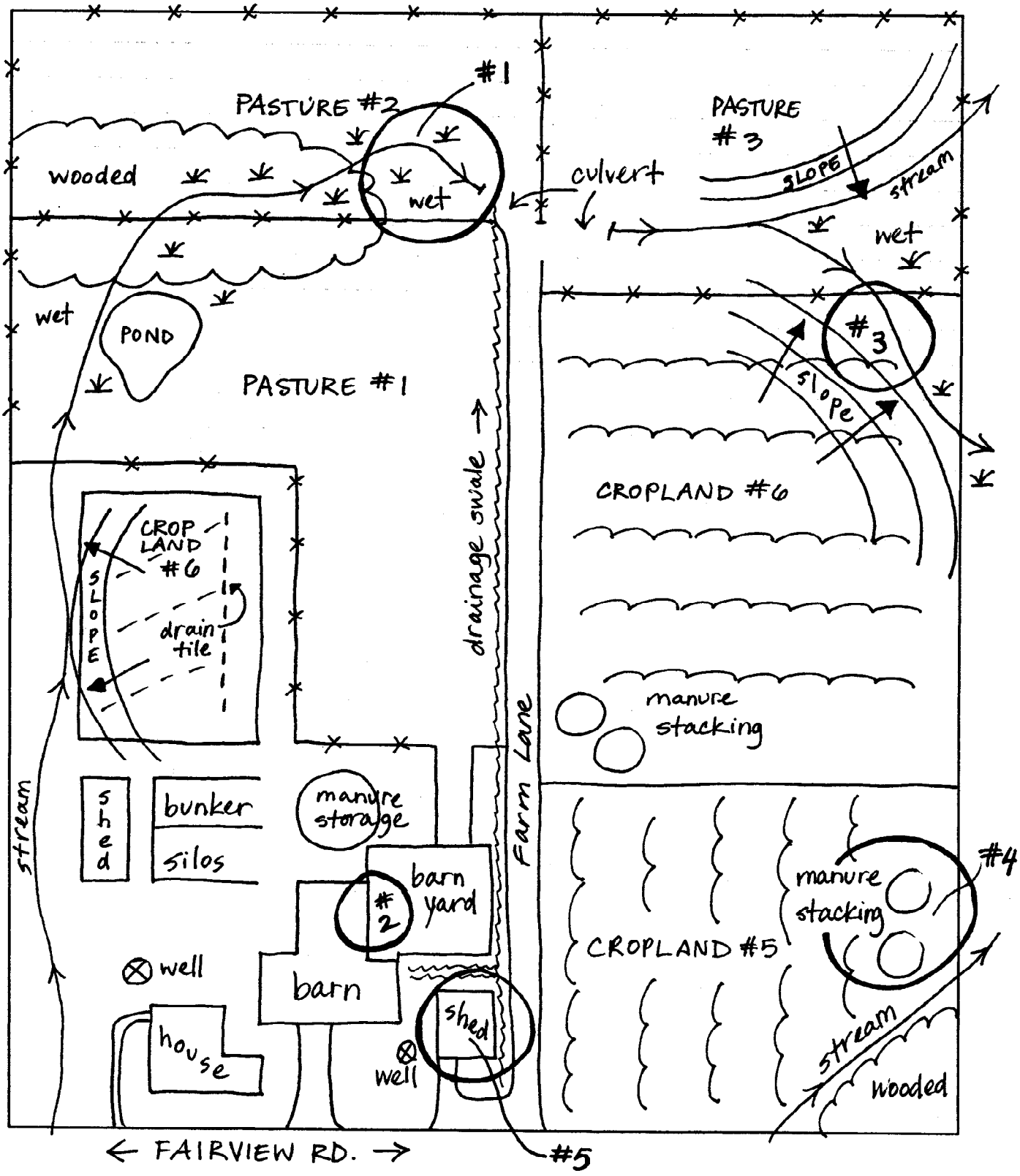
Each step you take will be a significant contribution by the agricultural community toward the enhancement of the Commonwealth's water quality.

The rest is up to you! If you have taken the time to read through this Guide and to complete the Worksheets, you have moved forward to control or eliminate water pollution on your farm. You are armed with both information and a strategy that you developed based on the realities of your farm. There are places to turn for technical and financial assistance. Each step you take will be a significant contribution by the agricultural community toward the enhancement of the Commonwealth's water quality.



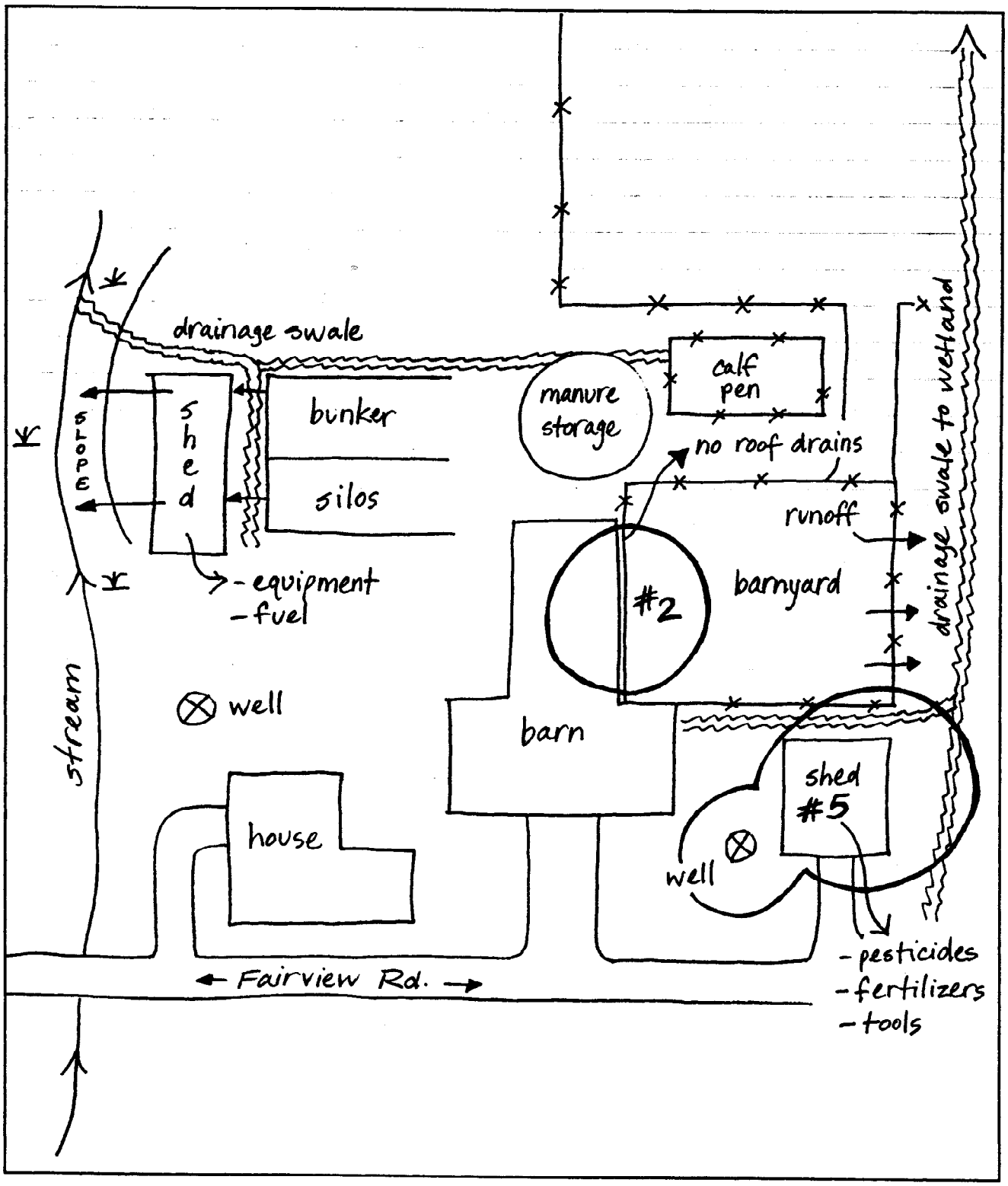
Worksheet A1: Sample Farm Map

NOTE: *Numbered circles are examples of known or potential problems or sensitive areas. The numbered areas correspond to examples on Worksheet A3 and Worksheets D1–D5. Not every known or potential problem and sensitive area on this Sample Farm Map has been circled!*



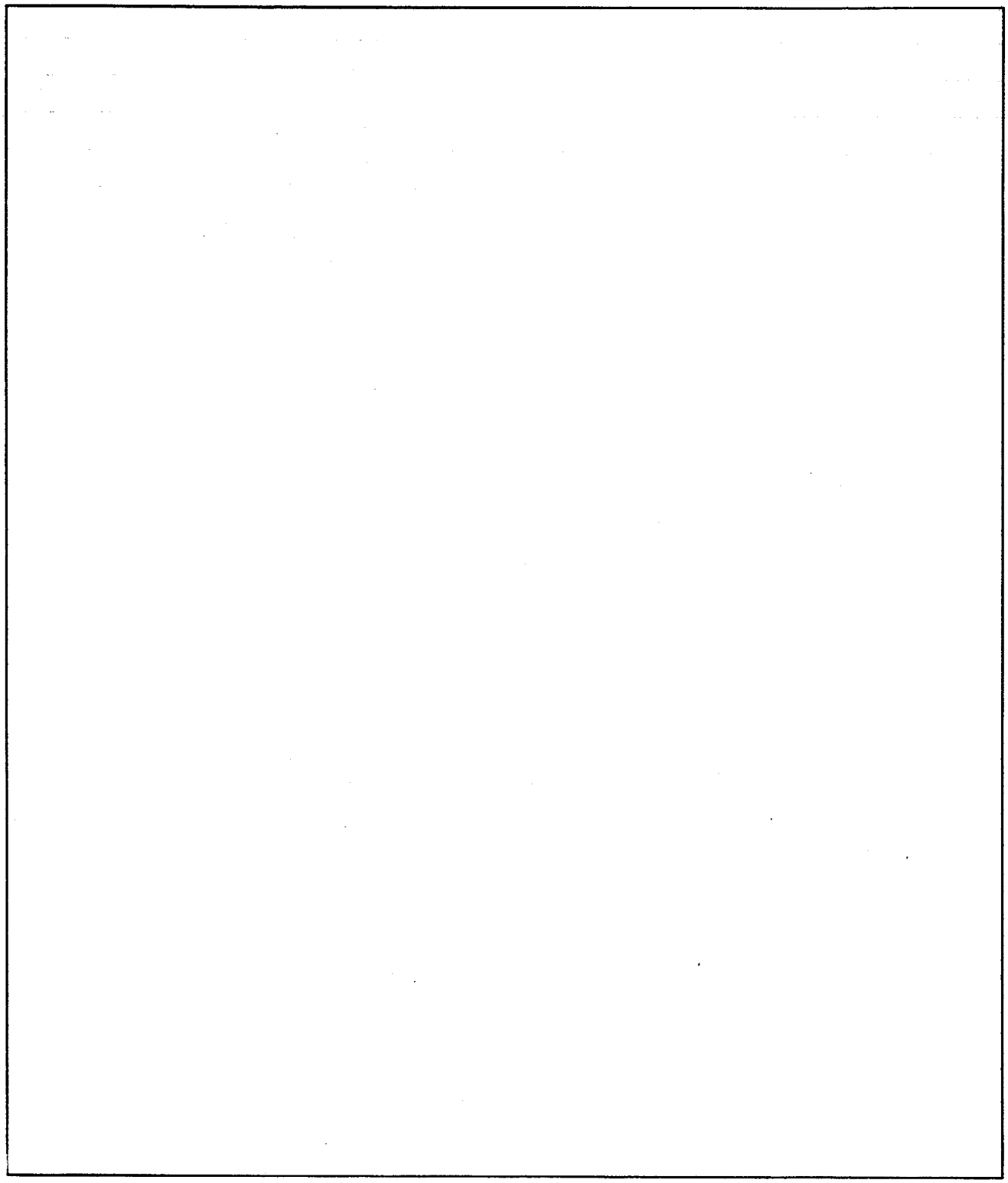
Worksheet A2: Sample Farmstead Map

NOTE: *Numbered circles are examples of known or potential problems or sensitive areas. The numbered areas correspond to examples on Worksheet A3 and Worksheets D1–D5. Not every known or potential problem and sensitive area on this Sample Farm Map has been circled!*



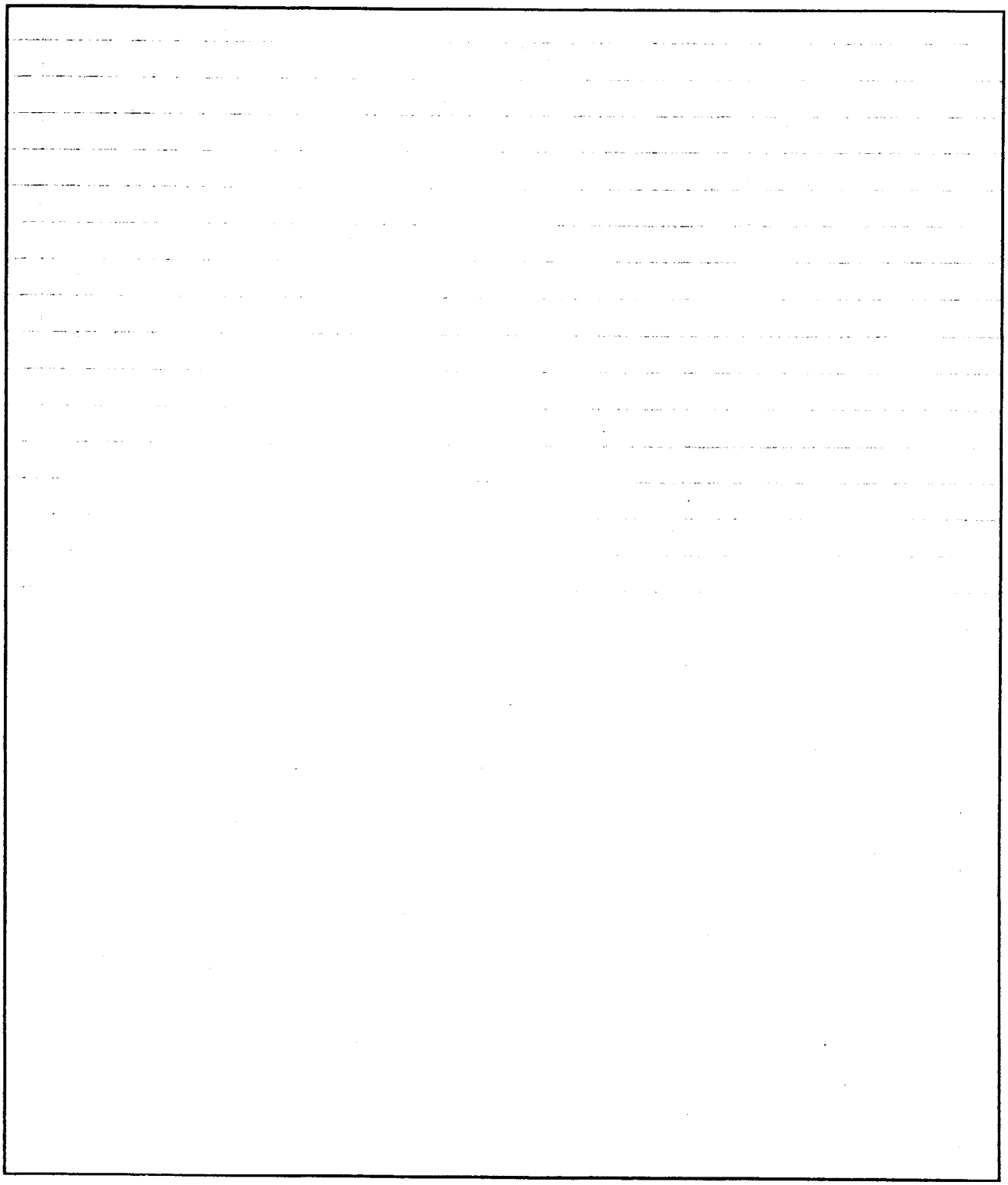
Worksheet A1: Farm Map

Directions: *See page 13 in the Guide.*



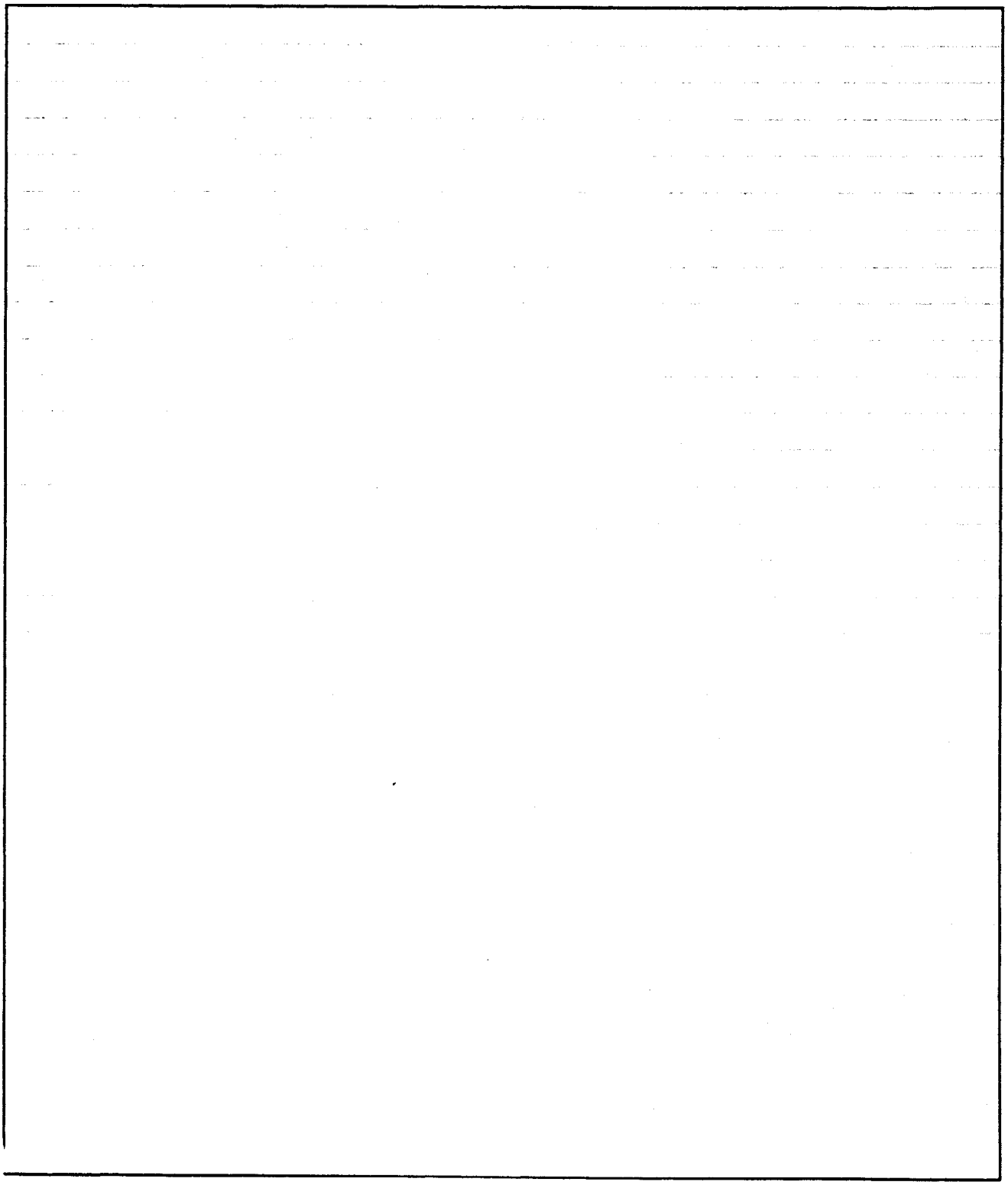
Worksheet A1: Farm Map

Directions: *See page 13 in the Guide.*



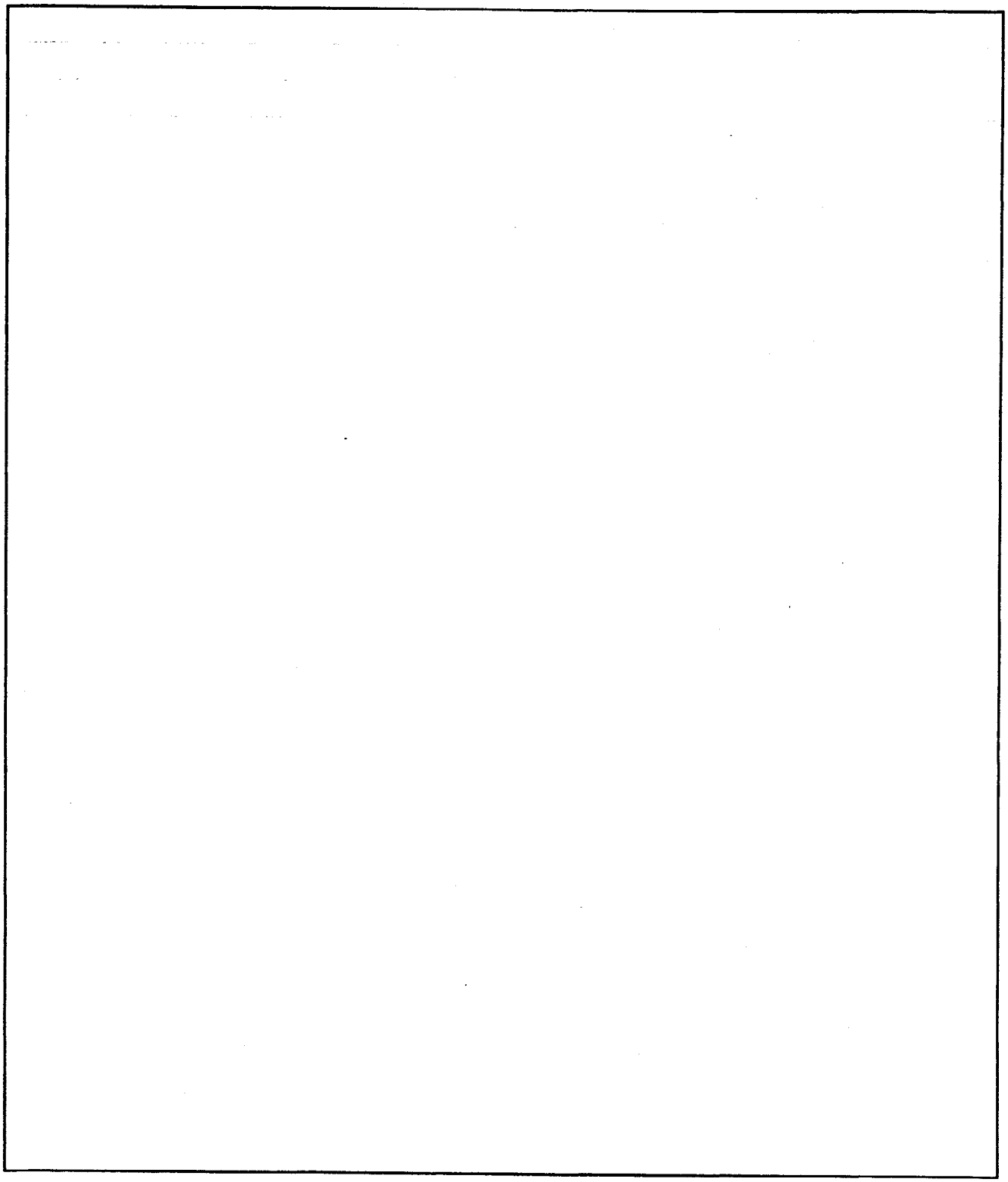
Worksheet A2: Farmstead Map

Directions: *See page 14 in the Guide.*



Worksheet A2: Farmstead Map

Directions: *See page 14 in the Guide.*



Worksheet A3: Map Summary — Areas/Activities of Concern

Directions: *See page 15 in the Guide.*

Example:

Area #	Location	Area/Activity of Concern	1 Erosion & Sediment	2 Nutrient	3 Pest & Pesticide	4 Barnyard, Manure & Waste	5 Grazing	6 Irrigation
1	stream bank in upper pasture	banks eroded by livestock	•				•	
2	barn	roof runoff into barnyard		•		•		
3	field #6	erosion and sediment at toe of slope	•					
4	manure stockpile	too near wetland		•		•		
5	pesticide shed	wash-down water not contained			•			

Area #	Location	Area/Activity of Concern	1	2	3	4	5	6

[continued]

Worksheet A3: Map Summary — Areas/Activities of Concern, *continued*

Directions: *See page 15 in the Guide.*

Area #	Location	Area/Activity of Concern	1 Erosion & Sediment	2 Nutrient	3 Pest & Pesticide	4 Barnyard, Manure & Waste	5 Grazing	6 Irrigation

Worksheet B: Farm Assessment Questionnaire

Directions: *See page 15 in the Guide.*

Category 1: Erosion & Sediment Control	Y	N	N/A
a. Are there visible signs of erosion anywhere on the farm?			
b. Are there visible signs of erosion in sensitive areas (such as into or near water bodies) identified on the Farm or Farmstead Map?			
c. Are any crop or grazing land soils left uncovered?			
d. Are any crops planted up and down the hillside?			
e. Are any conservation tillage practices employed (no-till or minimum-till)?			
f. Does runoff water from fields directly enter water bodies?			
g. Are crops planted up to or past the edge of a wetland or water body?			
h. Are there visible signs of sediment deposits at field edges, on roads, in or near waterways?			
i. Is all highly erodible land identified?			
j. Is soil structure open and crumbly with little sign of crusting or compaction?			
Category 2: Nutrient Management	**Y**	**N**	**N/A**
a. Are fertilizers applied in any sensitive areas? *(See definition, page 13 in the Guide.)*			
b. Are fertilizers stored in a covered, watertight facility, away from sensitive areas?			
c. Are soil tests performed regularly for pH and nutrients?			
d. Are manures and other farm wastes routinely applied to fields?			
e. Are manures and other wastes applied on frozen or saturated ground?			
f. Are manures and other organic wastes tested and credited in nutrient budgeting?			
g. Is equipment used to apply nutrients calibrated regularly?			
h. Are alternatives to chemical fertilizers being used?			
i. Are soil characteristcs considered when applying nutrients?			
j. Are fertilizers mixed and loaded on a properly designed impermeable pad?			

[continued on next page]

Category 3: Pest & Pesticide Management	Y	N	N/A
a. Are pesticides applied within identified sensitive areas?			
b. Is a current pest management plan in use?			
c. Are pesticides stored, mixed or loaded within or near sensitive areas?			
d. Are cultural controls (e.g. cultivation, row covers, crop rotation) used to manage pests?			
e. Are pesticides stored, mixed and loaded in a properly designed structure?			
f. Are crops inspected for pests to determine pest control strategies?			
g. Are records kept for all pesticides used?			
h. Is equipment serviced and calibrated before each crop season and between applications of different pesticides?			
i. Are strategies used to enhance presence/effectiveness of biological agents?			
Category 4: Barnyard, Manure & Waste Management	**Y**	**N**	**N/A**
a. Is manure stored in or within 100 feet of any sensitive area?			
b. Is manure spread in any sensitive area?			
c. Are animal wastes composted?			
d. Is barnyard runoff controlled?			
e. Is manure stored and routinely inspected to prevent "leaking"?			
f. Are records kept on farm applictions of wastes and on wastes leaving the farm?			
g. Does milkhouse waste or silage leachate directly enter sensitive areas?			
Category 5: Grazing Management	**Y**	**N**	**N/A**
a. Are livestock allowed unrestricted access into sensitive areas?			
b. Is shade available to livestock away from sensitive areas?			
c. Are pasture soils exposed due to overgrazing or erosion?			
d. Are pastures routinely managed for brush and weeds?			
Category 6: Irrigation Water Management	**Y**	**N**	**N/A**
a. Is a water measuring device installed in the irrigation system?			
b. Is a backflow prevention device installed in the irrigation system?			
c. Does the irrigation system provide for tailwater recovery?			
d. Are current crop data and water budget figures used in irrigation?			
e. Is irrigation water applied at precise times and in precise amounts?			

Worksheet C1: BMP Summary Chart & Checklist

— *Erosion & Sediment Control* —

Directions: *See pages 15–16 in the Guide.*

Best Management Practice (BMP)	Structural?	Initial Cost?	Maintenance Cost?	Technical Assistance?	Guide Page #	Currently done? YES	NO	N/A
conservation cover		L	L	NR	22			
conservation crop rotation		L	L	D	22			
contour farming		L	L	D	23			
contour strip-cropping		L	L	D	23			
cover cropping		L	L	NR	24			
critical area planting		M	L	D	24			
diversion(s)		M	L	R	24			
field borders		L	L	NR	25			
field strip-cropping		L	L	D	25			
filter strip		M	L	D	26			
grade stabilization structure – water control structure(s)	S	H	L	R	26			
grassed waterway		M	L	R	26			
mulching		L	L	NR	27			
outlet or lined waterway(s)	S	M-H	L	N	27			
pasture and hayland planting		M	L	NR	27			
residue management: no-till, strip till, mulch till, ridge till		L-M	L	D	28			
riparian buffer		L	L	NR	28			
sediment basin(s)	S	H	L	R	29			
stream channel stabilization measures	S	H	M	R	29			
tree planting		L-M	L	NR	30			

LEGEND: **Structural**
S = *structural*

Initial Cost & Maintenance Cost
0 = *zero;* L = *low;* M = *medium;*
H = *high*

Technical Assistance
NR = *not required;* D = *desirable;*
R = *required*

Worksheet D1: Selecting Management Strategies
— *Erosion & Sediment Control* —

Directions: *See pages 16–17 in the Guide.*

Area/Activity of Concern ***(from worksheets A3 and B)***	**Selected BMPs**
example: Farm Map area #3 – stream bank erosion	1. *stream channel control* 2. *critical area planting* 3. *riparian zone management*

Worksheet C2: BMP Summary Chart & Checklist

— *Nutrient Management* —

Directions: *See pages 15–16 in the Guide.*

Best Management Practice (BMP)	Structural?	Initial Cost?	Maintenance Cost?	Technical Assistance?	Guide Page #	Currently done? YES	NO	N/A
agricultural composting		L-H	L-H	D	31			
buffer strips		L	L	D	32			
conservation crop rotation		L	L	D	32			
cover cropping		L	L	NR	33			
equipment calibration		L	L	D	33			
fertilizer storage, handling and containment		L-M	L	NR	33			
green manure cropping		L	L	NR	34			
intercropping		L	L	D	34			
nutrient budgeting		L	L	R	34			
nutrient record keeping		0	NA	NR	35			
plant tissue testing		L	NA	R	35			
proper timing and application methods		0	NA	NR	35			
soil nitrate testing		L	NA	R	36			
soil testing		L	NA	R	36			
yield data		L	NA	NR	37			

LEGEND: **Structural**
S = *structural*

Initial Cost & Maintenance Cost
0 = *zero;* L = *low;* M = *medium;*
H = *high*

Technical Assistance
NR = *not required;* D = *desirable;*
R = *required*

Worksheet D2: Selecting Management Strategies
— *Nutrient Management* —

Directions: *See pages 16–17 in the Guide.*

Area/Activity of Concern ***(from worksheets A3 and B)***	**Selected BMPs**
example: Questionnaire category 2(h) – no alternatives to chemical fertilizers	1. *agricultural composting* 2. *green manure cropping* 3. *intercropping*

Worksheet C3: BMP Summary Chart & Checklist
— *Pest & Pesticide Management* —

Directions: *See pages 15–16 in the Guide.*

Best Management Practice (BMP)	Structural?	Initial Cost?	Maintenance Cost?	Technical Assistance?	Guide Page #	Currently done? YES	NO	N/A
appropriate biological controls		L	L	R	40			
appropriate cultural controls		L	L	NR-D	40			
appropriate physical controls		L-H	L	NR	41			
calibrate and maintain pesticide application equipment		L	L	D	41			
data collection		L	NA	NR	42			
pesticide application plans and records		L	L	D	42			
protect and enhance natural controls		0	NA	D	43			
safe storage, mixing, loading and disposal of pesticides		H	L-M	R	43			
scout for pests		L	L-M	D	44			
special handling of sensitive areas		L	L	NR	45			

LEGEND: **Structural**
S = *structural*

Initial Cost & Maintenance Cost
0 = *zero;* L = *low;* M = *medium;*
H = *high*

Technical Assistance
NR = *not required;* D = *desirable;*
R = *required*

Worksheet D3: Selecting Management Strategies
— *Pest & Pesticide Management* —

Directions: *See pages 16–17 in the Guide.*

Area/Activity of Concern ***(from worksheets A3 and B)***	**Selected BMPs**
example: Farm Map area #5 – pesticide shed *Questionnaire category 3(c) – pesticide mixing*	*1. safe storage, mixing and disposal of pesticides*

Worksheet C4: BMP Summary Chart & Checklist

— *Barnyard, Manure & Waste Management* —

Directions: *See pages 15–16 in the Guide.*

Best Management Practice (BMP)	Structural?	Initial Cost?	Maintenance Cost?	Technical Assistance?	Guide Page #	Currently done? YES	NO	N/A
combined waste facility(s)	S	H	M	R	47			
diversion(s) – grass and other	S	M-H	L	R	47			
filter strip		M-H	M	D	47			
heavy use area protection(s)	S	M-H	L	D	48			
manure composting		M-H	L	R	48			
manure storage facility(s)	S	H	M	R	49			
manure storage field stacking area		L-M	L	D	49			
plan for manure and waste utilization		L	L	D	50			
roof runoff management(s)	S	L-M	L	NR	50			
sediment basin(s)	S	M-H	L	R	50			
silage leachate waste management		H	M-H	R	51			
wastewater treatment system(s)	S	H	M	R	51			

LEGEND: **Structural**
S = *structural*

Initial Cost & Maintenance Cost
0 = *zero;* L = *low;* M = *medium;*
H = *high*

Technical Assistance
NR = *not required;* D = *desirable;*
R = *required*

Worksheet D4: Selecting Management Strategies
— *Barnyard, Manure & Waste Management* —

Directions: *See pages 16–17 in the Guide.*

Area/Activity of Concern *(from worksheets A3 and B)*	**Selected BMPs**
example: Farm Map area #4 – manure stockpile too near wetland *Questionnaire category 4(a) – manure storage*	1. *manure storage field stacking area* 2. *manure composting* 3. *plan for manure utilization*

Worksheet C5: BMP Summary Chart & Checklist

— *Livestock Grazing Management* —

Directions: *See pages 15–16 in the Guide.*

Best Management Practice (BMP)	Structural?	Initial Cost?	Maintenance Cost?	Technical Assistance?	Guide Page #	Currently done? YES	NO	N/A
alternate water supply(s)	S	L-H	L	D	52			
fencing(s)		L-M	L	NR	53			
pasture management		L	L	NR	53			
plan for proper grazing		L	L	D	54			
prescribed grazing (planned grazing system)		L-M	M	D	54			
riparian buffer		L-M	L	D	54			
stream crossing		L-M	L	D	55			
vegetative stabilization		L	L	D	55			

LEGEND: **Structural**
S = *structural*

Initial Cost & Maintenance Cost
0 = *zero;* L = *low;* M = *medium;* H = *high*

Technical Assistance
NR = *not required;* D = *desirable;* R = *required*

Worksheet D5: Selecting Management Strategies
— *Livestock Grazing Management* —

Directions: *See pages 16–17 in the Guide.*

Area/Activity of Concern ***(from worksheets A3 and B)***	**Selected BMPs**
example: Farm Map area #1 & questionnaire category 5(a) – livestock in stream	*1. alternate water supply* *2. fencing*

Worksheet C6: BMP Summary Chart & Checklist

— *Irrigation Management* —

Directions: *See pages 15–16 in the Guide.*

Best Management Practice (BMP)	Structural?	Initial Cost?	Maintenance Cost?	Technical Assistance?	Guide Page #	Currently done? YES	NO	N/A
backflow prevention(s)	S	L-M	L	NR	56			
efficient irrigation system		M-H	M	NR	57			
plan for irrigation water management		L	L	R	57			
tailwater recovery system(s)	S	H	M	NR	58			
water-measuring device(s)	S	L	L	NR	58			

LEGEND: **Structural**
S = *structural*

Initial Cost & Maintenance Cost
0 = *zero;* L = *low;* M = *medium;*
H = *high*

Technical Assistance
NR = *not required;* D = *desirable;*
R = *required*

Worksheet D6: Selecting Management Strategies

— *Irrigation Management* —

Directions: *See pages 16–17 in the Guide.*

Area/Activity of Concern ***(from worksheets A3 and B)***	**Selected BMPs**
example: Questionnaire category 6(b) – no backflow measuring device	*1. backflow prevention*

Worksheet E: Developing the Action Plan

Directions: *See pages 17–18 in the Guide.*

Selected Best Management Practice (BMP)	Area/Activity of Concern being Addressed	Priority (h, m, l)	Needs/Barriers to Action	Timetable for Action	Next Step
example: manure composting	*manure stockpiling alternative fertilizer*	*high*	*need technical assistance*	*w/in 6 months*	*contact NRCS Extension, and Ag. Composting Assoc.*

[continued on next page]

Worksheet E: Developing the Action Plan

Directions: *See pages 17–18 in the Guide.*

Selected Best Management Practice (BMP)	Area/Activity of Concern being Addressed	Priority (h, m, l)	Needs/Barriers to Action	Timetable for Action	Next Step

IV. Directory of Best Management Practices for Water Quality Protection on the Farm

A. Introduction

THIS DIRECTORY OFFERS a "menu" of management options designed to address water quality impacts on farms. These options are called Best Management Practices (BMPs). With respect to water quality, a best management practice is a method, measure or practice applied to prevent or reduce surface and ground water pollution. Another term for "best management practice" is "conservation practice," used for many years by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service, or SCS). In fact, many "conservation practices" have been in common practice since the SCS was created in the dust bowl days.

With respect to water quality, a best management practice is a method, measure or practice applied to prevent or reduce surface and ground water pollution.

Many of the practices and measures listed in the Directory were, in fact, developed by the NRCS. The Massachusetts State Office of the NRCS has assembled those practices most pertinent to Massachusetts from a very wide national inventory of BMPs. These BMPs for Massachusetts have been collected in the NRCS "Field Office Technical Guide" (FOTG). Each practice or measure contained in the FOTG has a detailed and technical description of the BMP, including the definition, purpose, planning considerations and design criteria.

Other BMPs have been developed by farmers and others in the agriculture industry. These BMPs have been tested and proven to be effective in addressing the problem, but currently are not among the list of practices and measures in the FOTG. Such practices may be innovative and extremely effective; some may not have yet withstood the tests of time or quality control that provide additional assurance of their overall effectiveness.

In many cases, the descriptions of BMPs in the Directory do not provide all the information needed to put the measure into practice. Agricultural composting is a good example of a practice that requires far more information than presented here. Some BMPs, such as the installation of a sediment basin or the implementation of an integrated pest management (IPM) program, require substantial technical assistance. Some installations require engineering. The purpose here is to acquaint farmers with the menu of options, and to provide enough information to enable further steps. These further steps may require collecting more data, obtaining technical assistance, or simply securing the proper equipment.

Some of the BMPs may require state or federal permits to implement. Working in or near wetlands or water bodies, composting and use of pesticides are examples of activities that may require a permit. It is best to check with the local conservation commission or Department of Food and Agriculture before such a project is initiated.

NOTE: The "best management practices" included in this Directory have broad application to a wide range of Massachusetts farm enterprises. However, certain commodities, including cranberries, forest products and aquaculture, will have particular concerns and issues that require commodity-specific tools to address them. These are not our focus here; however, Part V of this Guide includes resources and references for these and other more commodity-specific concerns.

B. More on "BMP"s

A BMP may be a practice, such as crop rotation or integrated pest management. Or a BMP may be a structure, such as a manure storage system or a grassed waterway.

A BMP MAY BE A PRACTICE, that is, a non-structural operation such as crop rotation or integrated pest management. Or a BMP may be the installation of a structure, such as a manure storage system or a grassed waterway. A BMP may be used to correct existing problems and/or to prevent future potential degradation of water resources.

Rarely will the use of a single BMP for any land use activity be sufficient to adequately address water quality problems. More often, several BMPs, individually selected to fit the unique characteristics of each site and farming operation, will be required. These practices, when grouped, may be referred to as a "best management system."

Rather than focus on individual practices, a best management system focuses on the sum of the parts. It takes into account the range of effectiveness of any single practice, its cost, and the resulting overall cost and effectiveness. Some individual practices may not be very effective alone, but, in combination with others, may provide a key function in a highly effective system.

A single BMP may address more than one problem. For example, a riparian (streamside) buffer may remove or reduce nutrient, sediment and pesticide contamination, while also enhancing the biological diversity of plant and animal species. It is also possible that a BMP designed to address one problem may actually contribute to another. For example, a farmer who uses conservation tillage, which can reduce erosion and sedimentation, may wind up applying increased amounts of herbicides to control weed pressure, with potentially detrimental impacts to ground water.

One or more "best management practices" may be selected to eliminate, prevent or reduce farm-related water pollution. Professional technical assistance is recommended to provide a more detailed assessment and a set of recommendations for modifications to farm practices. Worksheets C 1–6, provided for use with this Directory, offer farmers the opportunity to make appropriate selections from the "menu" of best management practices included here.

C. Using the Directory

THE BMPS LISTED IN this Directory have been organized into sections. These sections address strategies for:

1. erosion and sediment control
2. nutrient management
3. pest and pesticide management
4. livestock barnyard, manure and waste management
5. livestock grazing management
6. irrigation management

Best Management Practices address strategies for managing erosion and sediments, nutrients, pests and pesticides, livestock, barnyard, manure and waste, livestock grazing and irrigation.

In each section, there is a description of specific BMPs that can be incorporated into a management plan to address the problem. Each BMP is described as follows:

- **Name** of the BMP. Those that require structures to be built are designated with an "(s)".
- **Definition** – describes the practice or structural change.
- **Purpose** – describes how the practice protects water quality. Some details about implementation and options are included.
- **Initial Cost** – provides a rough estimate of costs involved in implementing or installing the practice.

  LOW – the cost of implementation or installation is less than $500; it may cost nothing

  MEDIUM – the cost of implementation or installation is between $500 and $3,000

  HIGH – the cost of implementation or installation is above $3,000
- **Maintenance Cost** – provides a rough estimate of the annual cost of maintaining the practice or the installation. For most practices, this is estimated on a per acre basis; for structural measures, the estimate will be further defined by the particular site.
- **Technical Assistance** – indicates whether outside technical assistance is: not required, desirable, or required to implement the practice.
- **Other Benefits** – gives a partial listing of additional benefits that may be derived from implementing the BMP, including other environmental protections, cost savings or efficiencies. These benefits are useful in planning for the whole farm.
- **Other Considerations** – gives a partial listing of possible "side effects" and other implications of implementing the BMP that are useful in thinking about the whole farm system.

1. Strategies for Erosion and Sediment Control

Management systems for controlling soil erosion and sedimentation address two resource issues: water quality and soil loss. The erosion and sediment control management practices in this section may also serve to satisfy other concerns, such as nutrient or pest management.

In addressing pollution issues, the first line of defense is to control the problem at the source, that is, to reduce the availability of the pollutant and the opportunity for it to detach from its surroundings. For sediment control, this means employing methods to keep the soil on the field. The next line of defense is to prevent the pollutant, in this case travelling soil particles, from entering a water source.

The following is a list of BMPs that are recommended to reduce or eliminate water pollution from sediments.

Conservation cover prevents soil erosion by keeping the soil from being disturbed. Typical plantings are grass, shrubs or trees.

Best Management Practices for Erosion and Sediment Control

A. Conservation Cover

Definition: establishment and maintenance of permanent vegetative cover on land retired from production.

Purpose: to prevent soil erosion by keeping the soil from being disturbed. A permanent (perennial) cover is not typically cultivated, and the cover protects the soil from exposure. Typical plantings are grass, shrubs or trees. Such plantings may have productive value, such as walnut trees or blueberry bushes.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: improves soil tilth; decreases pesticide and fertilizer use; may provide economic gain from perennial crops; may enhance wildlife.

Other Considerations: loss of annual cropland acreage if field is planted to a permanent cover.

B. Conservation Crop Rotation

Definition: a planned sequence of growing annual or perennial crops on the same field — the opposite of continuous cropping, where the same crop is grown in the same field year after year.

Purpose: to reduce detachment and transport of sediment by maintaining or improving the physical, chemical and biological conditions of the soil. A sequence of crops is selected to provide a high degree of soil cover and adequate organic residue for maintenance or improvement of soil tilth. Including a legume or grass in a rotation can be very effective for reducing erosion and improving soil structure. Also, rotations decrease loss of dissolved and

sediment-attached nutrients and pesticides. Rotations designed for erosion control may differ from rotations planned as components of pesticide and/or nutrient management.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: may reduce nutrient loss and need for commercial nitrogen; addition of organic matter increases soil fertility; may disrupt build-up of insect populations, disease life cycles and weeds, thereby reducing applications of pesticides; may maximize water use efficiency; may benefit wildlife; may increase yields; may enhance enterprise diversity.

Other Considerations: when legumes are used in a rotation, the nitrogen supplied should be taken into account to prevent over-application of nitrogen on subsequent crops. Soil fertility levels should be monitored and maintained within acceptable ranges for all crops in the rotation. There are economic and management considerations regarding crop selection, as well.

c. Contour Farming

Definition: tilling, planting, cultivating and harvesting crops across the field slope.

Purpose: to reduce surface runoff and transport of sediments. Farming on the contour reduces both velocity and volume of runoff by presence of ridges and furrows that block water movement, allowing soil particles to remain in place. Contour farming may follow the establishment of terraces or diversions.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: see pesticide management; see nutrient management; increased infiltration may promote better crop growth and increased soil tilth.

Other Considerations: slowing surface runoff may increase infiltration of pesticides or nutrients.

The ridges and furrows created by contour farming reduce surface runoff by blocking water movement, allowing soil particles to remain in place.

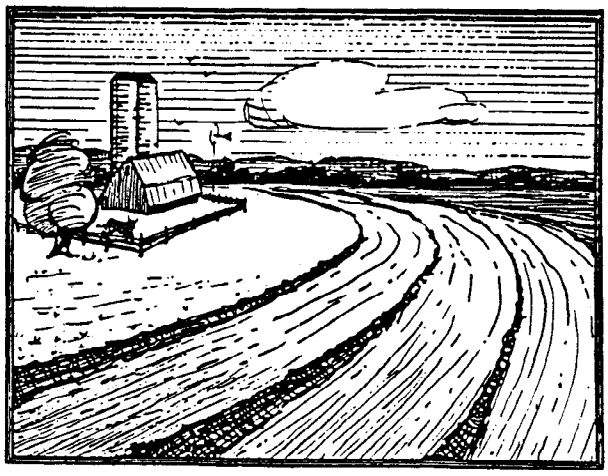
d. Contour Strip-cropping

Definition: the practice of planting strips of crops across the contour (see contour cropping, above) so that those crops that provide limited soil cover (such as annual row crops like corn) are alternated with those that provide protective soil cover (such as hay).

Purpose: to reduce surface runoff and transport of sediments. Strip-cropping may be designed in a rotation.

Initial Cost: low

Maintenance Cost: low



Technical Assistance: desirable

Other Benefits: if in a rotation, legumes can contribute to soil nitrogen.

Other Considerations: may increase or decrease pesticide and/or fertilizer use.

E. Cover Cropping

Definition: a cover of close-growing grasses, legumes or small grains grown primarily for seasonal protection and soil improvement.

Purpose: to control erosion and sedimentation by providing a soil cover, reducing exposure of soil particles; applied when the major crop does not furnish adequate cover, or following harvest; used to cover the soil during winter months; usually planted annually except where used as a permanent cover as in orchards; cover and green manure cropping also serve other important purposes (see below). Sometimes cover crops are seeded by aerial application.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: see pesticide management; see nutrient management; cover and green manure crops add organic material to the soil, improve infiltration, aeration, tilth and wildlife habitat.

Other Considerations: cost of seeds and additional management.

Critical area planting reduces erosion by providing suitable plant cover on areas that are eroding or likely to erode.

F. Critical Area Planting

Definition: planting vegetation such as trees, shrubs, grasses or legumes on highly erodible or critically eroding areas.

Purpose: to reduce erosion and sedimentation by providing a suitable plant cover on areas that are eroding or likely to erode. Typically, plantings are perennial.

Initial Cost: medium

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: see nutrient management; may enhance habitat for wildlife, including "beneficials".

Other Considerations: an increase in erosion may occur during establishment of the planting in these areas; loss of cropland area.

G. Diversion(s)

Definition: a channel or drainageway constructed across a slope.

Purpose: to divert water away from areas where it is excessive to sites where it can be used or disposed of properly and safely. The channel is constructed with a supporting ridge on the downhill side. It intercepts surface runoff water, and reduces runoff volume and velocity by reducing the length of the slope. Diversions are not designed to accommodate a large amount of sedi-

ment in the channel, and are not a substitute for other erosion control measures such as terracing. Diversions may be vegetated or nonvegetated and have an outlet.

Initial Cost: medium

Maintenance Cost: low

Technical Assistance: required

Other Benefits: diverts water carrying pollutants such as barnyard waste from surface waters; may improve wildlife habitat; improves crop health and farmability by diverting excess water.

Other Considerations: may increase delivery of pollutants to surface waters.

Channels or drainageways constructed across a slope divert water away from areas where it is excessive to sites where it can be used or disposed of properly.

H. Field Borders

Definition: a strip of perennial vegetation established at the edge of a field.

Purpose: to reduce transport of sediment by providing "anchoring points" for contour rows, terraces, diversions and contour strip farming.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: may have benefits for wildlife.

Other Considerations:

I. Field Strip-cropping

Definition: systematic arrangement of crops in strips across the general slope (not contour).

Purpose: to reduce delivery of sediments to water bodies by alternating crops that provide limited soil cover with those that provide high soil cover. Since crops are not grown on the contour, there will be areas of concentrated flow. Strip cropping may be done in a rotation.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: see pesticide management; see nutrient management; rotation may increase soil tilth.

Other Considerations: areas of concentrated flow potentially may increase delivery of sediments at a more rapid pace. There are crop selection and management considerations as well.

J. Filter Strip

Definition: an area (typically a strip) of vegetation that is planted and maintained as a permanent cover.

Purpose: with regard to control of erosion and sedimentation, the purpose of a filter strip is to capture sediment transported by runoff. Filter strips trap and remove solids, especially coarser grained and organic materials. Filter strips may be installed at the lower edge of fields, upgradient of terraces or diversions, or on fields next to wetlands, streams or ponds. They vary in their effectiveness and maintenance requirements.

Initial Cost: medium

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: nutrient management; pesticide management; filter strips can also be designed to handle silage juice runoff.

Other Considerations: depending on the function(s) that a filter strip is designed to perform, the degree of efficiency and level of management may vary.

Grade stabilization structures control erosion in channels and prevent the formation or advance of gullies. They may also enhance habitat.

K. Grade Stabilization Structure – Water Control Structure(s)

Definition: a structure used to control the grade and head cutting in natural or artificial channels.

Purpose: to stabilize the grade and control erosion in channels and to prevent the formation or advance of gullies. The structure may be a combination of earth embankment, mechanical spillway, and detention-type structure, and could include an inlet or surface drain component.

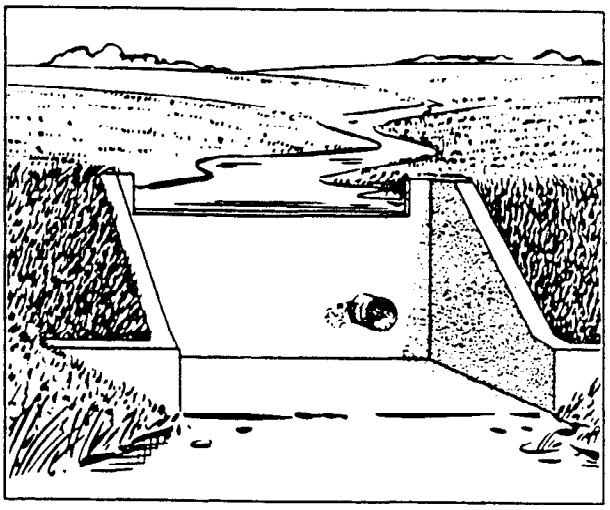
Initial Cost: high

Maintenance Cost: low

Technical Assistance: required

Other Benefits: may enhance habitat.

Other Considerations: attention to fish and wildlife habitat in design and construction; livestock should be fenced out to protect the structure.



L. Grassed Waterway(s)

Definition: a natural or constructed channel or outlet that is shaped or graded to certain dimensions and vegetated.

Purpose: to provide a stable and controlled outlet for the disposal of runoff. Grassed waterways are planted in a suitable grass/legume mix and may have a stone center. The vegetation slows runoff and filters out sediments; usually installed on sites where additional control is required to manage concentrated runoff, as from diversions.

Initial Cost: medium

Maintenance Cost: low

Technical Assistance: required

Other Benefits: see nutrient management; see pesticide management; may provide habitat for beneficials.

Other Considerations: may provide habitat for pests.

M. Mulching

Definition: applying plant residues or other suitable materials to the soil surface.

Purpose: to reduce runoff and transport of sediment by trapping rain drops, especially in areas that are eroding and/or bare; used to allow vegetation to establish itself, to provide cover where vegetation is not possible or desired, or in association with a crop. Plastic mulches perform some of these functions.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: mulching conserves moisture, prevents surface compaction or crusting, controls weeds and helps establish plant cover; may provide nutrients through microbial breakdown.

Other Considerations: may lower soil temperature; may introduce weed seeds; plastic mulches do not degrade and must be removed from the field.

Mulching can reduce runoff and transport of sediment by trapping rain drops, especially in areas that are eroding and/or bare. It may also control weeds and provide nutrients through microbial breakdown.

N. Outlet or Lined Waterway(s)

Definition: a waterway with an erosion-resistant lining of concrete, stone or other permanent material.

Purpose: to reduce erosion in concentrated flow areas, resulting in the reduction of sediment and other substances delivered to receiving waters. This practice may be a component of a waste management system where barnyard runoff is directed away from sensitive areas.

Initial Cost: medium - high

Maintenance Cost: low

Technical Assistance: necessary

Other Benefits:

Other Considerations:

O. Pasture and Hayland Planting

Definition: appropriate treatment and use of pastureland or hayland.

Purpose: regarding erosion and sedimentation, appropriate planting and management of hay or pastureland will reduce erosion and transport of soil particles. Fields covered in permanent vegetation year round are very resistant to erosion.

Initial Cost: medium

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: may enhance plant vigor; may improve forage and haylage quality leading to improved animal health; may decrease pest and/or nutrient management requirements.

Other Considerations:

P. Residue Management: No-till, Strip Till, Mulch Till, Ridge Till

No-till, strip till, mulch till and ridge till systems are known to reduce erosion and sedimentation by as much as 90% in certain circumstances.

Definition: any tillage and planting system that minimizes physical disturbance of the soil and leaves at least 30% of the surface covered by plant residue after planting.

Purpose: to reduce runoff causing detachment and transport of sediments. There are a variety of conservation tillage systems including mulch-till, ridge-till, and strip-till. Conservation tillage is applicable on sloping, highly erodible cropland, where adequate plant residues are produced. It is known to reduce erosion and sedimentation by as much as 90% in certain circumstances. In mulch-tillage the entire soil surface is tilled; at least 30% residue cover is left on the soil surface immediately following planting. In ridge-tillage, ridges are initially established and then planted year after year, with or without subsequent cultivation; at least 30% residue remains. Ridge-till is appropriate primarily for continuous row crops. Strip-till requires tilling of narrow strips for seeding or transplanting, leaving undisturbed surface residues in between; strip-till may be combined with ridge-till, and is appropriate for vegetable and small fruit crops. No-till is a method of planting in prior crop residue, cover crop or perennial sod crop where the surface of the field is left undisturbed. Specialized equipment is needed.

Initial Cost: low, if equipment is rented; medium if equipment is purchased.

Maintenance Cost: low

Technical Assistance: desirable for start-up

Other Benefits: increases soil tilth; increases soil temperature and moisture retention; may break pest and disease cycles; may decrease available weed seeds (no longer brought to the surface by plowing); reduces compaction; reduces fuel and labor costs and saves time.

Other Considerations: may increase ground water contamination by increased fertilizer and pesticide use and by increasing infiltration rates (but application rates may decrease over time); incorporation of fertilizers and pesticides is more difficult; careful nutrient management is advised; may delay germination due to cooler soil temperatures; residues may serve as host site for pests.

Q. Riparian Buffer

Definition: an area of trees and other vegetation located adjacent to and up-gradient from water courses, water bodies and associated wetlands.

Purpose: to protect water quality by preventing streambank erosion, removing sediment, absorbing nutrients and pesticides

and allowing better nutrient uptake. When plantings are carefully selected and maintained, and the practice is used together with other nutrient and sediment control practices, riparian buffers are highly effective and low maintenance.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: may enhance conditions for desirable aquatic plants and animals; may provide commercial timber or forage; may improve wildlife habitat.

Other Considerations:

R. Sediment Basin(s)

Definition: a depression constructed to collect and store debris or sediment.

Purpose: to trap and collect sediments and excess water and to control runoff. The basin may be dug or constructed as an earthen embankment or a combination of ridge and channels. It allows sediments to settle out of runoff water before it discharges into surface water bodies. The basin needs to be maintained by periodically removing collected materials.

Initial Cost: high

Maintenance Cost: low

Technical Assistance: required

Other Benefits: may increase habitat value if permanently seeded.

Other Considerations: may increase infiltration of soluble materials such as some pesticides.

Sediment basins trap and collect sediments and excess water, allowing sediments to settle out of runoff water before it discharges into surface water bodies.

S. Stream Channel Stabilization Measures

Definition: any of a number of constructed measures along or across natural or constructed waterways.

Purpose: to reduce erosion and sedimentation into water bodies. These measures include: spur dikes, which are fingers of stone that extend into a creek; grade control structures, which control the grade and head cutting in channels by creating a series of small "waterfalls"; and riprap bank protection, in which layers of large stones are placed along stream banks or crossings. May also include vegetative "bio-engineered" solutions such as installation of organic rolls and mats and plantings of suitable vegetation.

Initial Cost: medium - high

Maintenance Cost: medium

Technical Assistance: required

Other Benefits: may prevent loss of land or damage of facilities located near banks; may maintain capacity or stability of a channel; may enhance habitat.

Other Considerations: some constructed measures, such as riprap, may negatively impact riparian habitat, especially in stream banks.

T. TREE PLANTING

Definition: planting and maintenance of trees.

Purpose: to reduce erosion and sedimentation by providing stable, perennial cover and root mass.

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: see nutrient management; may attract beneficial insects and birds.

Other Considerations:

A farm nutrient plan is a comprehensive strategy for addressing nutrient input needs on the farm. It includes information on crop requirements, nutrient availability, proper timing and amount of application and environmental considerations.

2. Strategies for Nutrient Management

Plants must receive sufficient and proper nutrients, at the proper times and in the necessary amounts, in order to grow and produce a crop. Farmers use a variety of amendments, including commercial fertilizers, animal and green manures and composts to assure nutrient availability for crops.

Sound nutrient management not only assures optimum production but also reduces input costs and protects water quality. Additionally, soil tilth and organic matter can be improved by correct manure and sludge application. Input costs are reduced by preventing over-application of commercial fertilizers and manures, while also reducing the amount of nutrients lost to receiving waters. It has been proven that over-application of fertilizers serves no beneficial purpose to the crop. In fact, excess nitrogen fertilizer can be harmful to crop yield and quality.

Research has shown that nitrates are a leading ground water contaminant. Commercial fertilizer and manure are significant sources of nitrates in ground water, as well as nitrates and phosphates in surface waters. Careful management of nutrients will reduce the amount of nutrients available for transport from the field because they will be properly taken up by the plant or stored in the soil. Excess nutrients are lost with surface runoff, and by leaching through the soil into ground water. Erosion and sediment control practices are the primary mechanisms to control the transport of nutrients, especially phosphorus, that are attached to soil particles.

Nutrient Management Plans

A farm nutrient management plan is a comprehensive strategy for addressing nutrient input needs on the farm. It includes information on crop requirements, nutrient availability, proper timing and amount of application, and environmental considerations. When the source of the nutrients is not commercial fertilizer, it is important to determine the nutrient value and availability of those contributions. For example, the nitrogen contribution of any legume crop should be calculated and credited, and manures and composts should be tested for nutrient content.

A nutrient management plan contains the following core components:

a. farm and field maps showing acreage, soils, crops and water bodies

b. yield expectations

c. a summary of the nutrient planning resources available to the farmer, including:

   1) soil tests results

   2) nutrient analysis of manures and composts

   3) nitrogen contribution to the soil from legumes (if applicable)

   4) other significant nutrient sources

d. an evaluation of field limitations based on environmental considerations

e. established mix of nutrient sources and requirements

f. timing and application methods

g. equipment operation and calibration

Such a plan requires that farmers have a good understanding of crop requirements, soil types and sensitive areas on and near the farm, such as wetlands and shallow aquifers. A nutrient management plan incorporates this knowledge with a site-specific set of management practices to 1) apply nutrients at rates necessary to achieve realistic crop yields, 2) improve the timing of nutrient application, and 3) use agronomic crop production technology to increase nutrient use efficiency.

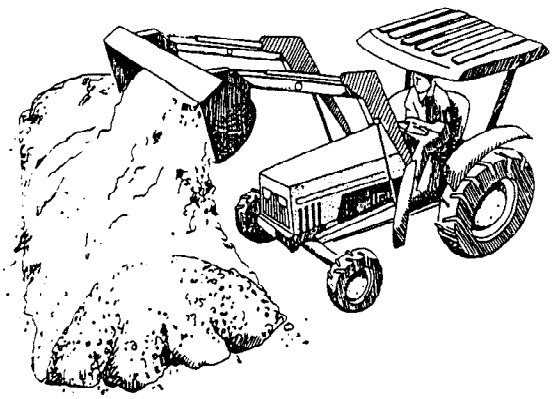
The following is a list of the BMPs that are recommended to reduce or eliminate water pollution from crop nutrients.

The benefits of agricultural composting are many. Compost is an excellent soil conditioner which, when properly managed, is free of weed seeds.

Best Management Practices for Nutrient Management

A. Agricultural Composting

Definition: the aerobic, biological decomposition of organic matter, including manure, leaves, bedding and crop residues. It is a natural process that can be enhanced and accelerated by: selecting organic waste "recipes" with proper carbon/nitrogen balance; mixing to provide proper aeration; and monitoring to insure that ideal moisture levels and temperatures are maintained. These extra steps provide optimal conditions for the microbes that transform "raw" on-farm wastes into a relatively stable soil amendment/crop nutrient.



Purpose: to conserve nutrients produced on the farm; to lower the risk of pollution by stabilizing nitrogen in an organic form, and reducing its loss to ground and surface water.

Initial Cost: low - high

Maintenance Cost: low to high

Technical Assistance: highly desirable for start-up. Massachusetts farmers are advised to contact the MDFA Compost Program.

Other Benefits: The benefits of agricultural composting are many. Compost is an excellent soil conditioner which, when properly managed, is free of weed seeds. Farmers can lower their risk of nuisance complaints about odor and flies. Compost is often easier to handle than manure. Farmers have the opportunity to create a product with significant economic value; many garden centers, suburban neighbors and landscapers are eager to purchase high quality farm compost.

Other Considerations: Most of the nutrients in agricultural compost are in a stable organic form and are released slowly to growing plants. Nutrient availability, timing, and rates of application need to be accounted for in the overall nutrient management plan. The compost "pad," or site where active composting will take place, should be carefully located and designed. A poorly situated pad, like a poorly situated manure stacking area, can contribute to pollution problems.

Buffer strips – strips of close growing vegetation along a water body – can reduce nutrients in runoff entering the water. They may also provide habitat for wildlife.

B. Buffer Strips

Definition: strips of close growing vegetation surrounding or along a water body.

Purpose: to reduce nutrients in runoff entering the water. The width of the vegetative strip will depend on soil characteristics, type of vegetation used, topography and hydrology.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable for initial information

Other Benefits: see pesticide management; may provide wildlife habitat.

Other Considerations:

C. Conservation Crop Rotation

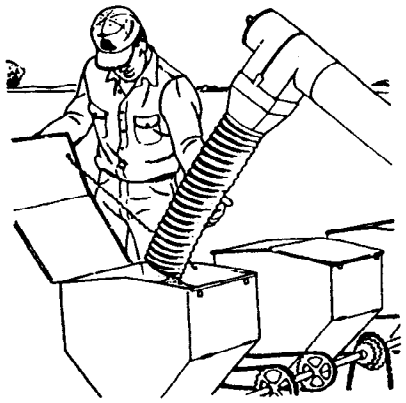
Definition: the successive planting of different crops in the same field — the opposite of continuous cropping.

Purpose: one purpose of crop rotation is to reduce the need for nitrogen fertilizer by planting a legume. Also, continuous applications of manure can result in the build-up of excessive levels of phosphorus; crops in anunmanured part of the rotation may take up phosphorus, thereby reducing the potential for loss by run-off of excess phosphorus. Rotation is valuable for controlling soil erosion, building soil tilth, increasing yields and eliminating or reducing certain diseases or pests.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable for start-up



Other Benefits: see erosion and sediment management; see pesticide management; may improve soil fertility.

Other Considerations:

D. Cover Cropping

Definition: the practice of planting a crop primarily for protecting and improving the soil between periods of regular crop production.

Purpose: regarding nutrient management, to provide nutrients for subsequent crops, thus reducing the total amount of additional nutrients necessary; to take up all the excess nutrients left in the field after the harvest of the main crop (called a "catch crop"); also, to utilize excess nutrients from the field, thus reducing the amount of nutrients that may leach to ground water. Annual cover crops are either harvested, plowed under, grazed or killed with herbicides before the primary crop is planted. Perennial cover crops, between trees and vines in orchards, for example, are left in place and managed by mowing.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: see erosion and sediment management; weed pest control.

Other Considerations:

Proper and timely adjustment of equipment used to apply nutrients can minimize the chance of over-application of fertilizer and manure.

E. Equipment Calibration

Definition: proper and timely adjustment of equipment used to apply nutrients.

Purpose: to minimize the chance of over-application of fertilizer and manure. Calibration insures that recommended rates are being applied.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable for start-up

Other Benefits: this practice also applies to calibration of pesticide application equipment.

Other Considerations: should be done annually, and whenever fertilizer or pesticide is changed.

F. Fertilizer Storage, Handling and Containment

Definition: the management of fertilizer substances on the farm.

Purpose: to assure safety and prevent spills and leaks in which uncontrolled amounts of fertilizer might leach or run off into surface or ground water. Fertilizer storage areas, valves and containers should be secured when not in use. Dry fertilizer should be stored inside a structure or device capable of preventing it from getting wet. Liquid fertilizer should be stored in containers approved for and compatible with the fertilizer being stored. Fertilizer storage areas should be located away from wells, areas that are very porous, and any surface water bodies.

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: may improve health and safety.

Other Considerations: storage areas should be inspected annually to ensure safety.

G. Green Manure Cropping

Definition: the practice of planting a grass or legume crop primarily to be plowed down for its contribution to soil fertility.

Purpose: to provide nutrient value to the subsequent crop.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: moisture retention; enhances soil tilth and organic matter; reduces soil salinity; may reduce need for purchased fertilizer.

Other Considerations: may increase costs (seed and labor); plowdown may provide excess nitrogen.

Intercropping – the growing of two or more crops simultaneously on the same field – adds nitrogen and other nutrients to the soil. Inter-cropping of certain crops is also intended to improve yields per acre and provide "crop insurance".

H. Intercropping

Definition: the growing of two or more crops simultaneously in a specific pattern or fashion on the same field.

Purpose: regarding nutrient management, the purpose of intercropping is to add nitrogen and other plant nutrients to the soil. Legumes and grass crops are often used. Seeding in of the second crop may be done at various stages of the main crop's development.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable for start-up

Other Benefits: may reduce weeds.

Other Considerations: intercropping of certain crops is also intended to improve yields per acre and to provide "crop insurance" in case of a crop failure.

I. Nutrient Budgeting

Definition: evaluation of the contributions of all sources of nutrients to the needs of a particular crop.

Purpose: to encourage the use of manure and other agricultural wastes, and other nutrient-contributing practices (e.g., cover cropping, planting legumes) and to avoid application of excess nutrients. Nutrient budgeting accounts for the contributions of all sources of nutrients, so that additional commercial fertilizers and/or animal manures are only applied to make up a lack. Testing of manures, composts, effluents as well as green manure and legume contributions can be performed using specialized worksheets available from University of Massachusetts Extension for manure and cover crops. Information

should be noted on record keeping forms. Management that focuses on providing fertility through enriching the soil with naturally occurring amendments "feeds the soil, then the soil feeds the plant".

Initial Cost: low

Maintenance Cost: low

Technical Assistance: required for start-up

Other Benefits: may reduce costs of purchased inputs; may promote recycling of on-farm wastes.

Other Considerations:

J. Nutrient Record Keeping

Definition: a system of documenting field, crop and nutrient application data.

Purpose: to provide historical and planning data in order to make informed decisions about nutrient applications that are resource-protecting and efficient. Record keeping is an important part of a nutrient management plan. Useful forms are available from technical assistance providers.

Initial Cost: none

Maintenance Cost: not applicable

Technical Assistance: not required

Other Benefits: helps to make efficient use of both manures and purchased inputs.

Other Considerations:

K. Plant Tissue Testing

Definition: a test that determines the nutritional status of plant tissues.

Purpose: to determine existing or potential nutrient problems. Plant tissue testing is an excellent tool for determining exact plant nutrient needs for many essential nutrients including nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc, manganese, copper, boron, molybdenum, chlorine, sulphur and others. Though not routinely done on all crops, testing may help diagnose nutrient deficiences.

Initial Cost: low

Maintenance Cost: not applicable

Technical Assistance: required

Other Benefits:

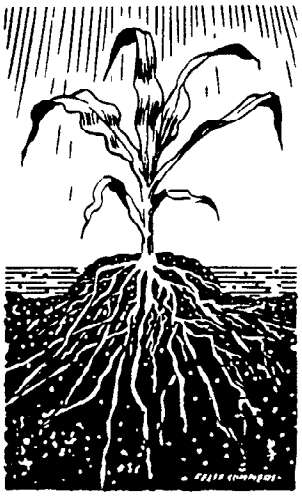
Other Considerations:

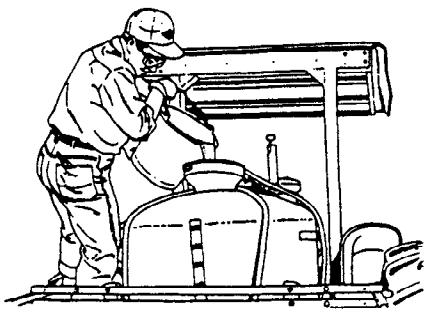
L. Proper Timing and Application Methods

Definition: a set of practices that addresses the application of nutrients in environmentally sensitive ways.

Purpose: to protect water resources by selecting the best fertilizer, properly timing and locating applications to avoid runoff and maximize plant uptake.

Providing fertility through enriching the soil with naturally occurring amendments "feeds the soil, then the soil feeds the plant."





Manure and fertilizer should not be applied on frozen ground; they should be incorporated immediately. Fertilizer nitrogen is best applied just before the period of maximum uptake by crops, and in amounts matching the ability of the crop to take it up. Application under rainy conditions or when soil is saturated should be avoided. Application to very shallow soils or to exposed bedrock also should be avoided. Sometimes split applications are effective. In selecting fertilizers, less leachable forms and slow release varieties are advantageous both for water protection and effectiveness. Banding, which is the application of fertilizer along the row, close to the plant, rather than broadcasting, is an effective method of crop fertilization that can reduce nutrient loss.

Initial Cost: none

Maintenance Cost: not applicable

Technical Assistance: not required

Other Benefits: may enhance efficient use of fertilizers.

Other Considerations:

Proper timing and application of fertilizers in environmentally sensitive ways can avoid runoff and maximize plant uptake.

M. Soil Nitrate Testing

Definition: a test that determines the soil nitrate-nitrogen concentrations immediately prior to side- or top-dressing with nitrogen fertilizer.

Purpose: to avoid the application of excess nitrogen fertilizer by determining crop nitrogen needs.

Initial Cost: low

Maintenance Cost: not applicable

Technical Assistance: required (soil testing lab)

Other Benefits:

Other Considerations: may reduce farm fertilizer and labor costs.

N. Soil Testing

Definition: determination of nutrient content of a soil sample by a laboratory.

Purpose: to avoid excessive use of nutrients while ensuring that the right amounts are applied for desired crop yield. At least one soil sample for each field and crop type should be tested for phosphorus, potassium, calcium, magnesium and soil pH, and any other nutrients of concern for the planned crop. Nitrogen application should not be based on a routine soil test prior to planting a crop; a special nitrogen soil test is needed during the growth of the crop. Soil tests should be updated on a regular basis, and before fertilizers are applied; results will change over time, depending on fertilizer and other additions, precipitation, runoff, leaching, erosion and crop uptake. Soil samples may be sent to University of Massachusetts or other commercial labs.

Initial Cost: low

Maintenance Cost: not applicable

Technical Assistance: required

Other Benefits: may yield economic savings from reduced purchased fertilizer.

Other Considerations:

o. YIELD DATA

Definition: information about crop yields to determine realistic expectations.

Purpose: to manage nutrient applications to match realistic yield expectations. Yield data is based on yield history and other relevant information provided by the grower. For example, a farmer might average the three highest yields in five consecutive crop years. Information from the University of Massachusetts Extension can be used when field data is not available. Increased yield expectations due to new and improved varieties and hybrids should be considered. Yield data will also depend on climatic conditions, available moisture and soil type.

Initial Cost: low

Maintenance Cost: not applicable

Technical Assistance: not required

Other Benefits:

Other Considerations:

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3. Strategies for Pest and Pesticide Management

The management of agricultural pests is a major concern to nearly every Massachusetts farmer. Pests include insects, weeds, diseases, fungi and vertebrates (e.g., rodents) that can reduce if not destroy crop production. Agriculture has always been faced with the need to limit crop damage due to pests. Since the 1950s, petrochemically-based pesticides have become an important tool for farmers. Of course, pesticides are applied in non-agricultural settings as well, for example on home lawns, golf courses, roadsides and utility rights-of-way.

The management of agricultural pests is a major concern to nearly every Massachusetts farmer.

Wherever pesticides are used, there are concerns about potential impacts to water quality. Negative impacts to surface water bodies have been documented since the 1940's. More recently, studies have shown public and private water supply contamination from pesticides. Because of these and other concerns (e.g., the health and safety of the pesticide handler), pesticides and their application have become increasingly regulated, resulting in higher costs to the grower.

Yellow trefoil
(Medicago lupilina)

Remembering that pollution reduction focuses on the principles of availability, detachment, transport and deposition, the potential for pesticide contamination to surface and ground water depends on the following factors:

- pesticide application: including the rate, formulation, timing and mode of application (e.g., foliar, injection, surface incorporation)
- pesticide properties: including solubility, mobility, stability, and degradation

- climate: including precipitation, temperature and wind
- soil properties: including composition (% sand, clay and silt; soil organic matter), porosity, moisture content and pore size
- site characteristics: including topography, slope, proximity to water resources
- agricultural management practices: including tillage choices, mixing, loading and storage practices, cover cropping, irrigation/chemigation

Clearly, a goal of any pest management strategy is to reduce risks of contaminating surface and ground water. The basic concept of pest management in this regard is to encourage effective and safe use of pesticides, only when necessary, without causing environmental harm. The most effective approach is, first, to limit the amounts and types of pesticides (availability), and second, to use practices that minimize the movement (detachment, transport and deposition) of pesticides to surface and ground water.

A good pest management plan will emphasize natural controls and non-chemical tactics wherever possible, while maintaining a healthy crop with high yield and quality.

Pest Management Plan

As with nutrient management (see page 30), the most effective approach for environmentally sensitive pest control is to develop and implement a pest management plan. The goal of a pest management plan is to reduce the impact of pests to tolerable levels. The plan focuses on the assessment of options based on site- and crop-specific data. Developing a plan that includes sound agricultural management practices for how, what, where and when to apply pesticides will help minimize the problems associated with pesticide use. Natural controls and non-chemical tactics should be emphasized wherever possible. A good plan will maintain a healthy crop with high yield and quality, while protecting water quality and other environmental interests.

At minimum, a pest management plan includes:

- an evaluation of past and current pest problems and cropping history
- an evaluation of the physical and biological characteristics of the site
- evaluation, selection and implementation of appropriate alternative pest management strategies
- proper selection, application and timing of pesticide(s)
- proper mixing, loading, and storage of pesticides

An integral component of many pest management plans is the practice of integrated pest management (IPM). IPM is an approach aimed at reducing pesticide use to the minimum quantity while ensuring high quality crops and protecting human health and environmental quality. IPM includes the selection, integration and implementation of pest control methods based on predicted economic, ecological and sociological consequences. IPM includes the use of pesticides only when pest populations exceed economic thresholds (when making a decent return on the crop is threatened) and only when alternative control tactics are not appropriate or available. An IPM program strives to minimize

crop losses by optimizing the use of cultural management techniques and biological pest controls.

Typically, there are four components of an IPM system:

- **pest identification:** all potential pests as well as all beneficial insects are inventoried; particular species or varieties may require special treatment
- **monitoring:** also known as scouting, the aim is to accurately sample and record pest populations and to identify the location and time where a pest problem may become intolerable
- **action thresholds:** action thresholds and injury levels are established for each individual pest species. The action threshold is the level at which a control action must be taken in order to prevent damage
- **methods of prevention and suppression:** include some combination of controls described below to manage pest populations

There are many options for supressing pests, usually used in combination. These tactics may be grouped in the following categories:

- biological controls
- cultural controls (including host resistance)
- physical and mechanical controls
- chemical controls

IPM guidelines have been established for a number of crops in Massachusetts. These include sweet corn, peppers, tomatoes, strawberries, cranberries, potatoes, apples, cole crops, winter squash and pumpkin. New guidelines for other crops are continually being developed. Nonetheless, certain integrated pest management strategies can be successfully employed in a wide variety of situations, even without a certified program in place. Plans may be developed by the producer or by a private crop consultant who may be employed to help develop and implement the plan.

In Massachusetts, IPM programs have reduced pesticide use on apples, strawberries, cranberries, corn and potatoes by as much as 40-60%. The "Partners with Nature" program in Massachusetts recognizes farmers who practice IPM by certifying their produce. The program raises the visibility of farmers who practice IPM, increasing the marketability of their products, leading to economic benefits for those farmers.

Once a pest management plan has been developed, a variety of best management practices can be employed to implement aspects of the plan. Some plans may include particular IPM strategies that are included in the best management practices that follow. Best management practices that comprise elements of an IPM Program are included below.

The following is a list of the BMPs that are recommended to reduce water pollution from pesticide storage and use.

In Massachusetts, IPM programs have reduced pesticide use on apples, strawberries, cranberries, corn and potatoes by as much as 40–60%.

Best Management Practices for Pest and Pesticide Management

A. Appropriate Biological Controls

Appropriate biological controls include the use of natural predators to help keep pest populations in check.

Definition: use of natural enemies, including predators, parasites and diseases to help keep pest populations in check.

Purpose: to reduce or eliminate pests by introducing biological control agents that may not be native to the area, or not present in sufficient quantities, into the environment. For example, beneficial mites are commercially available and can be released in the field. These must be introduced before pest numbers are out of control, and periodic re-releases are usually needed. These agents include parasites, predators or disease pathogens such as bacteria, fungi and viruses.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: required for initial information and start-up

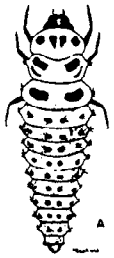
Other Benefits:

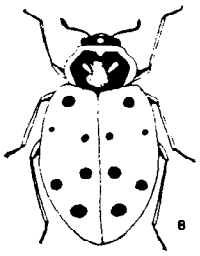
Other Considerations:

B. Appropriate Cultural Controls

Definition: use of various farming practices that impact pest populations.

Purpose: to destroy or remove a pest's habitat by such practices as plowing, crop rotation, manipulation of planting and harvest dates, animal housing sanitation and manure management, and tillage. For example, alfalfa fields with significant numbers of alfalfa weevils may be harvested early to avoid further losses and reduce weevil populations. Crop rotation can be extremely effective in breaking up pest life cycles (e.g. the Colorado potato beetle). Various methods can be employed to destroy breeding refuges and over-wintering sites, including escaped apple trees for apple maggot. Included in this category are all practices that provide optimum growing conditions for the crop, thereby enhancing plant health and resistance and reducing plant stress. There is a wide range of cultural controls. Not all of them are appropriate on all farms, and farmers need to select carefully.



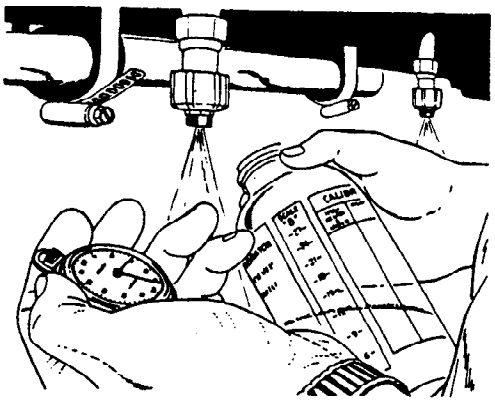


Convergent Lady Beetle
A. Larva B. Adult

Examples of cultural controls include the following:

- site selection: choosing sites that are less favorable to pests
- cultivar selection: choosing varieties that are resistant to pests
- crop rotation: rotating away from crops of the same family can prevent weed growth and break up pest cycles
- intercropping: planting a mixture of crops may reduce insect damage, e.g., underseeding broccoli with clover
- cover cropping: can provide shelter for beneficials
- trap cropping: planting crops to attract the pest away from the main crop; for example in tomatoes, trap crops of potatoes and eggplant can be used for Colorado potato beetle

- tillage: provides weed control and may kill some insects and pathogens
- timing and method of planting: may help to avoid a generation of the pest
- sanitation: removal of pest habitat such as cull piles or dropped fruit; for example, potato cull piles provide a place for potato late blight and other diseases to overwinter
- pruning: removes a food source or point for infection and increases circulation
- healthy seed and transplants: avoids introducing pests; use of seed that has been certified disease-free



Initial Costs: low

Maintenance Cost: low

Technical Assistance: not required - desirable

Other Benefits: certain cultural control practices may also improve soil tilth and fertility.

Other Considerations:

c. Appropriate Physical Controls

Definition: use of physical structures or mechanisms to exclude pests from crops.

Purpose: to prevent or reduce crop losses from pest damage by providing physical barriers such as netting over small fruits and screening in greenhouses or milkhouses. Row covers and fencing are also examples.

Initial Cost: low - high

Maintenance Cost: low

Technical Assistance: not required

Other Benefits:

Other Considerations:

d. Calibrate and Maintain Pesticide Application Equipment

Definition: adjustment of application equipment by properly calibrating applicator nozzles; general maintenance of equipment parts.

Purpose: to assure proper pesticide application rates throughout the season. Such calibration should occur minimally at the beginning and middle of each season; ideally, each time pesticides or application rates are changed. Improper calibration of application equipment can result in application rates that are significantly different from the intended rate. Low applications can result in poor pest control, yield losses and costly repeat applications. Rates which are too high waste pesticide, reduce profitability and pose a greater risk of environmental contamination than necessary. Higher than recommended application rates also promote the development of pest resistance to the pesticide, do not achieve better pest control and may result in poor pest control. Since nozzle wear can increase application rates and change spray patterns, calibration rates should be checked during the spray season. Even

Properly calibrating pesticide application equipment assures proper application rates throughout the season, reducing both pesticide waste and the risk of environmental contamination.

small, hand operated applicators, such as hand-pump sprayers, should be calibrated each season. Sprayer equipment should be maintained regularly.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable for initial information

Other Benefits: lowered costs due to less pesticide use.

Other Considerations:

Data collection allows farmers to make informed pest management decisions based on knowledge of cropping patterns, current and historical pest problems, pesticide use and soil and physical characteristics of the site.

E. Data Collection

Definition: inventory of field, crop and pest information.

Purpose: to make informed pest management decisions based on knowledge of cropping patterns, current and historical pest problems, pesticide use and soil and physical characteristics of the site. Attention should be paid to the history of crop production, information on soils types, exact acreages of each field, and information about past pest problems, pesticide use and other information for each field. Additionally, particular attention should be directed to areas where mixing, loading and storage activities take place, and physical limitations such as proximity to well heads and surface water, runoff potential, highly permeable or poorly drained soils, and shallow aquifers.

Initial Cost: none

Maintenance Cost: not applicable

Technical Assistance: not required

Other Benefits: may enhance efficiency and reduce cost.

Other Considerations:

F. Pesticide Application Plans and Records

Definition: a procedure for planning and documenting pesticide use that includes specific pesticide selection, application and handling.

Purpose: to assure the proper selection, timing and rates of application to maximize effective and judicious use of pesticides while minimizing unnecessary, excessive or inappropriate uses. Pesticides that are least likely to cause contamination to surface or ground water should be selected. Available models such as NPURG can assist in determining relative risk from a pesticide given crop, soil, water and topographic conditions. If an evaluation indicates a high risk, consideration of slope, foliar coverage and other risk reducing site factors or management practices such as spot spraying or banding will help. Such plans should also account for proper timing of applications. Replace calendar date scheduled applications with crop, pest and weather specific timing to increase effectiveness and reduce risk as well as waste (from, for example, application before a heavy rain or during windy conditions). Record keeping is an important component of any pesticide use, as well as a legal requirement. Knowing what went on what field and how successful it was in obtaining desired results is useful planning data. Forms can be obtained from the University of Massachusetts Extension.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable for start-up

Other Benefits: may enhance wildlife habitat; may contribute to farmer health and safety.

Other Considerations:

G. Protect and Enhance Natural Controls

Definition: The encouragemant of naturally-occurring populations of biological control agents such as beneficial mites and certain fungi, worms and wasps.

Purpose: to allow natural controls to contribute to pest management by fostering and not destroying their habitat. Natural enemies can be encouraged by providing shelters or food sources. For example, a sod or weedy cover in an apple orchard provides an overwintering site for predatory mites, which control European red mite and two-spotted spider mite. Selecting pesticides that have minimal effect on beneficials is an important consideration; applying only when needed, and carefully scheduling to have the least effect on beneficials, will also encourage native populations of many biological control organisms.

Initial Cost: none

Maintenance Cost: not applicable

Technical Assistance: desirable for initial information

Other Benefits:

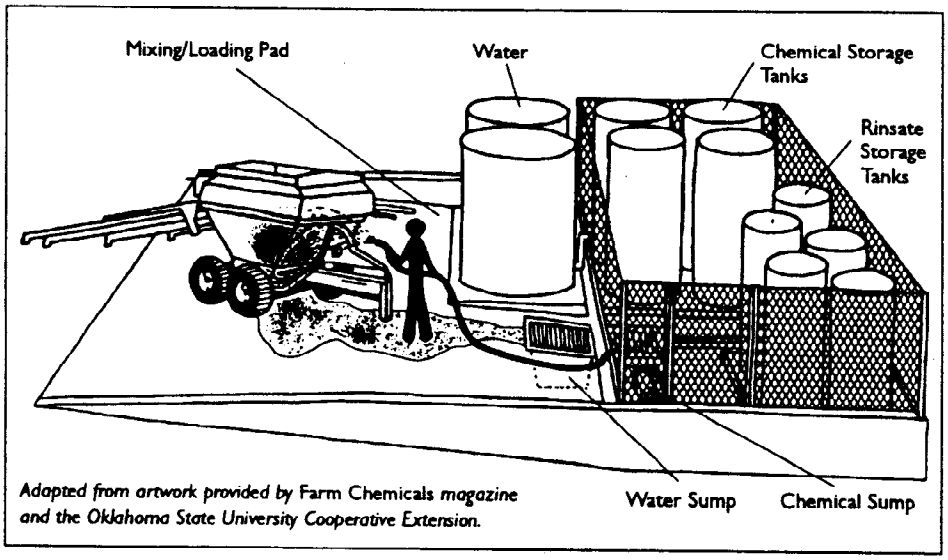
Other Considerations: other management practices, such as burning or mowing of field edges, may diminish beneficial populations.

Proper storage and handling of pesticides avoids contamination risks associated with accidental spills and misuse of pesticides.

H. Safe Storage, Mixing, Loading and Disposal of Pesticides

Definition: specific management activities for the proper storage and handling of all pesticides.

Purpose: to avoid contamination risks associated with accidental spills and misuse of pesticides. Surface water, ground water and soil can be contaminated in areas where pesticides are stored under inappropriate conditions, or improperly mixed and loaded into application tanks, where equipment is washed and rinsed after application, and where containers are dis-



Adapted from artwork provided by Farm Chemicals *magazine and the Oklahoma State University Cooperative Extension.*

posed of improperly. Pesticides should be stored in the original containers with the label intact, in a closed and locked building. Such containers should be recycled where possible. The building should be located at least 200 feet down-gradient from any surface water body and 150 feet down-gradient from any wellhead. A secondary containment area, such as a curbed, impermeable pad, is recommended to contain any accidental spills or leaks.

Chemical mixing and storing and equipment rinsing stations should be located at least 300 feet away from aquifer and wellhead areas and open water. Backflow prevention devices should be installed and operating properly. Proper warning signs must be posted, and use of an impervious pad to contain spills and facilitate clean-up is desirable. Of course, such materials should be locked and out of reach of children and animals. Mixing and loading areas should be located to minimize the impact of spills. All transfer of pesticides between containers should be conducted over a spill containment surface designed to intercept, retain and recover spills, leaks and wash water. This can be a specially constructed pad or alternate system such as a portable basin.

Initial Cost: medium - high

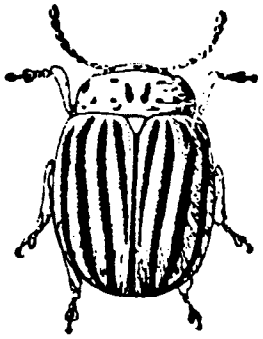
Maintenance Cost: low - medium

Technical Assistance: required

Other Benefits: may reduce human health and safety risks, may reduce future liability risks.

Other Considerations:

Scouting for pests provides an early detection system that locates and identifies potentially serious pest situations before economic losses occur.



Colorado potato beetle

1. Scout for Pests

Definition: crop monitoring for presence of pests.

Purpose: to accurately sample and record pest populations and to recommend and track control actions based on scouting data. Determining how many pests are present on a crop at a point in time requires that the crop be monitored on a regular schedule. Scouting usually involves visual plant or animal inspections and/or environmental monitoring. Scouting provides an early detection system that locates and identifies potentially serious pest situations before economic losses occur. Used with pest action thresholds, it also helps to avoid unnecessary pesticide applications. Samples are collected according to certain protocols. Often, scouting is done by agribusinesses or private consultants.

Initial Cost: low

Maintenance Cost: low - medium

Technical Assistance: desirable for initial information

Other Benefits: may result in higher quality crop

Other Considerations: a consultant may be hired to perform this function and provide pest management advice.

J. Special Handling of Sensitive Areas

Definition: with respect to pesticide application, particular attention to and appropriate management of areas such as wet spots, stream sides and areas near well heads; may include avoiding application entirely.

Purpose: to reduce risk of contamination by identifying sensitive areas and reducing or eliminating pesticide applications there. Use of a map locating such areas is helpful, making sure that the applicator is aware of such locations and any specific requirements. MDFA has useful fact sheets about applying high risk pesticides in high risk areas.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits:

Other Considerations: these sensitive areas should be treated with special handling when applying nutrients also, to avoid leaching of nutrients, especially nitrates, into ground water.

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4. Strategies for Livestock Barnyard, Manure and Waste Management

Concerns about potential contamination of surface and ground water from livestock focus on two components of farm animal management. The first is on areas or structures where animals are stabled or held and fed or maintained, plus areas used for processing and storage of product (such as feed), manure, facility wastewater (e.g., milkhouse waste, barn and pen cleaning water, animal washing) and other related runoff. These areas are typically centered around the barnyard and are sometimes referred to as "confined animal facilities". The second is on animal grazing areas, particularly riparian, or stream-side zones (see Section 5, below).

Special handling of sensitive areas involves reducing or eliminating pesticide applications to wet spots, stream sides and areas near well heads.

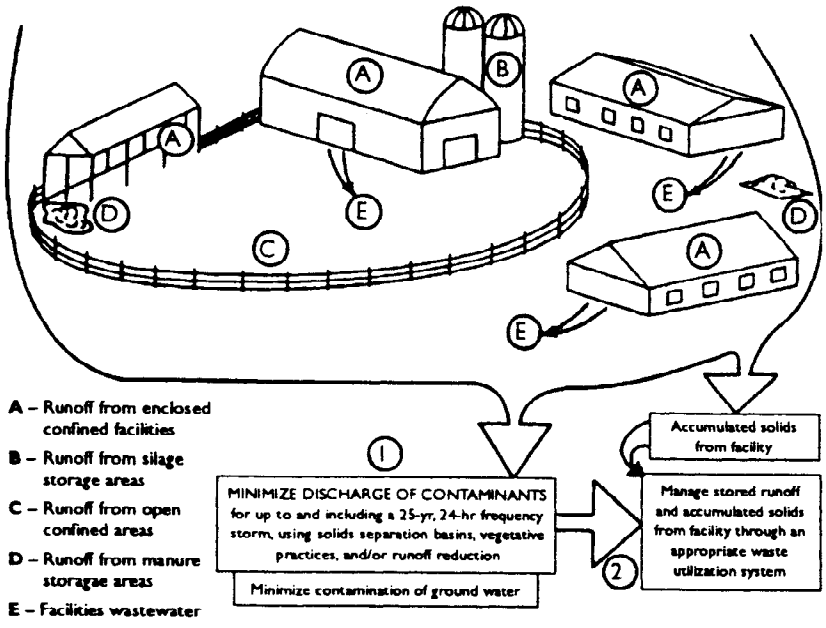
Pollutants from confined animal facilities include nutrients, salts, pathogens and organic solids from manure and bedding. Phosphorus is a concern from milkhouse cleaning. Milk itself, if it gets into a stream and decomposes, uses up oxygen, and bacteria growing in milk transmit diseases downstream. Surface waters can be seriously impacted, causing fish kills, anaerobic conditions, eutrophication and unsuitability for drinking, fishing or swimming. Ground water can be contaminated by nutrients and salts from manure storage areas and related runoff seeping into the ground. Silage wastes are extremely concentrated and can be toxic to plant and animal life if discharged directly. Water running from up-slope through a confined animal facility, as well as rain and snow from roofs, increases the volume of facility runoff.

While most livestock manures are applied to cropland, improperly stored or handled manure can pose a direct threat to water resources. Direct runoff from manure stockpiles, leaking or overflowing storage units and barnyards can contribute nutrients (and pathogens; see below) directly into sensitive areas.

A good waste management plan will include management practices for storage, handling, treatment and disposal of agricultural wastes.

It has become commonplace to think of manure as a "waste". **Regarding manures as valuable and cost-saving resources that contribute to farm fertility, rather than as a waste, may lead to improved handling and utilization.** As a resource, manures applied to cropland add nutrients and organic matter to soils. But overapplication of manures can contribute to water pollution because excess nutrients that are not taken up by the crop leach or runoff. So a "waste management plan" and a "nutrient management plan" are companions in a comprehensive management system.

As with pest management and nutrient management above, developing a waste management plan is the recommended first step. Such a plan will address limiting discharges from confined animal facilities by identifying appropriate systems that collect solids, reduce contaminant concentration and reduce runoff. The plan will also address management of stored runoff and accumulated solids by identifying an appropriate waste utilization system. Utilizing wastes to the fullest extent possible is a prudent waste management strategy as well as a potentially effective and cost-efficient nutrient management strategy. A good waste management plan will include management practices for storage, handling, treatment and disposal of manure and other agricultural wastes. The aim is to minimize the potential impact of the manure-associated pollutants in both ground and surface waters. A waste management system may consist of one or more components, appropriately suited to the particular operation.



Management Measure for Facility Wastewater and Runoff from Confined Animal Facilities (Small Units) *from "Management Measures for Agricultural Sources," EPA-840-B-92-002, January 1993*

Cost effectiveness is a major concern when choosing appropriate waste management practices for a farm. Livestock operations of all sizes may need to or choose to install storage structures, which can be a costly component of a livestock enterprise. There are numerous manure storage systems available; the choice of the system will depend on the location, type and size of the farm operation, available sites and equipment, and economics.

The following is a list of the BMPs that are recommended to reduce or eliminate water pollution from barnyards, manures and wastes.

Best Management Practices for Barnyard, Manure and Waste Management

A. Combined Waste Facility(s)

Definition: a structure or system for handling more than one type of waste.

Purpose: to meet environmental protection needs by maximizing efficient waste facility design. For example, milkhouse waste may be added to liquid manure or manure run-off storages that already exist. If a facility is being constructed to handle multiple storages, it must be designed to handle the total volume. Milkhouse wash water will dilute manure which makes it easier to pump. Silage leachate also may be combined with other wastes and manures.

Initial Cost: high

Maintenance Cost: medium

Technical Assistance: required

Other Benefits:

Other Considerations: federal cost share may be available.

B. Diversion(s) – grass or other

Definition: a drainageway constructed across a slope to divert surface runoff.

Purpose: to divert water away from barnyard, bunker silage storage areas and other heavy use areas, preventing excessive runoff from carrying organic wastes, sediments and other pollutants to surface water bodies.

Initial Cost: medium - high

Maintenance Cost: low

Technical Assistance: required

Other Benefits: may facilitate barnyard maintenance by reducing surface water.

Other Considerations: will require periodic maintenance to remove debris and assure stability.

C. Filter Strip

Definition: a strip or area of vegetation for removing sediment, organic matter and other contaminants from runoff and wastewater.

Purpose: to trap organic materials from concentrated livestock areas by trapping them in the vegetative material of the filter strip. Properly located filter strips may also filter pollutants from controlled overland flow treatment of liquid wastes. Filter strips must be managed and maintained. Saturated filter strips will not function properly.

Initial Cost: medium - high

Maintenance Cost: medium

Technical Assistance: desirable

Other Benefits: may provide wildlife and/or beneficials habitat.

Other Considerations: will require maintenance.

Filter strips are areas of vegetation for removing sediment, organic matter and other contaminants from runoff and wastewater.

D. Heavy Use Area Protection(s)

Definition: installation of semi-impervious or hard impervious surfaces in heavily used areas.

Purpose: to prevent degradation and to stabilize areas intensely used by livestock, and to allow for collection, management, and utilization of animal wastes, thereby reducing migration of contaminants to surface water bodies. Grading and surfacing of heavily used areas helps protect them from erosion, trampling, rutting or other deterioration, and helps prevent the collection of pollutants. Concrete or asphalt paving will be necessary if runoff is to be collected for treatment. Compacted gravel or other earth materials may otherwise be sufficient to stabilize the ground surface. Drainage and runoff control devices and filter strips may be components of heavy use area protection.

Initial Cost: medium - high

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits:

Other Considerations:

Manure composting prevents water contamination by biologically treating organic wastes. The by-product of this process is a safe-to-use soil amendment.

E. Manure Composting

Definition: the process of controlled and accelerated aerobic biodegradation and stabilization of livestock manures. (See also, Agricultural Composting, under Nutrient Management, page 31.)

Purpose: to prevent water contamination by biologically treating organic wastes. The by-product of this process is a safe-to-use soil amendment. Composting stabilizes nutrients and reduces pathogens, making them less likely to leach into surface or ground water. Active composting usually takes place in windrows, static aerated piles or in-vessel structures. Passive "composting", with no active effort to manage or monitor the process, is not an effective or acceptable technique for managing organic wastes high in nitrogen. Successful composting requires careful attention to: site selection and design, selection and carbon:nitrogen ratio of ingredients, moisture, temperature, timing, proper equipment and management.

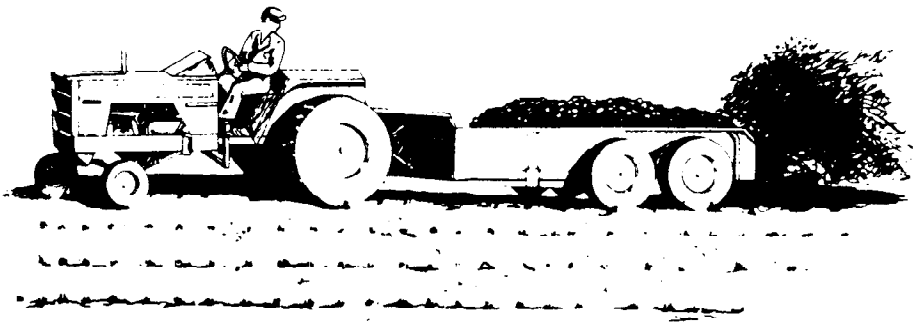
Initial Cost: medium - high

Maintenance Cost: low

Technical Assistance: required

Other Benefits: compost may be used on farm as a soil amendment/crop nutrient or sold commercially.

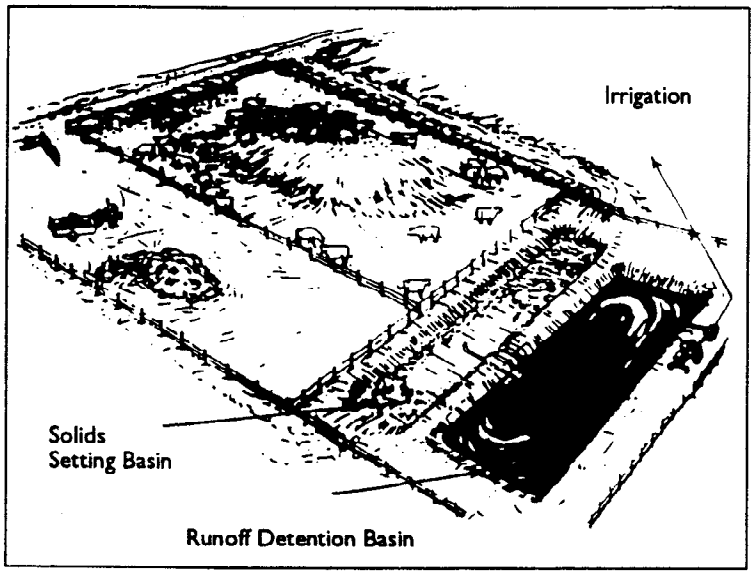
Other Considerations: needs careful management; there may be odor concerns; there may be regulatory considerations.



F. Manure Storage Facility(s)

Definition: a permanent, constructed structure for temporary storage of animal manures or other organic agricultural by-products.

Purpose: to reduce contaminant loading to surface waters by intercepting and storing polluted runoff from manure stacking areas, barnyards and feedlots. Such structures may be earthen empoundments (ponds), tanks or other facilities constructed of concrete, wood, steel, plastic or other materials. Tanks are used for liquid and slurry wastes and can be open or covered, inside or outside or beneath slotted floors. Stacking facilities are used for solids and may be open or roofed.



Example of manure and runoff storage system (Sutton, 1990). *From Management Measures for Agricultural Sources, EPA-840-B-92-002, January 1993*

Initial Cost: high

Maintenance Cost: medium

Technical Assistance: required

Other Benefits:

Other Considerations: federal cost share may be available.

G. Manure Storage Field Stacking Area

Definition: a temporary stacking area for solid manures located in a field.

Purpose: to temporarily stockpile manure for at most six months in a location where ground and surface water will be least threatened by contamination. As a component of a waste management plan, such an area is not a substitute for a manure storage structure, but may supplement the storage volume of such a structure. A stacking area allows temporary storage, when weather or field conditions may prevent daily field application, or when waiting to spread until after crop harvest. A well designed, located and managed stacking area may help in the timely application of stored manures, thereby reducing water quality impacts; a poorly designed, sited or maintained area may cause increased water quality problems.

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: desirable; may be necessary for establishment

Other Benefits:

Other Considerations: site must be carefully selected to avoid negative impacts to wetlands and other sensitive areas, and to avoid odor problems with neighbors.

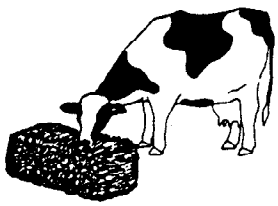
Manure storage facilities reduce contaminant loading to surface water by intercepting and storing polluted runoff from manure stacking areas, barnyards and feedlots.

H. Plan for Manure and Waste Utilization

Definition: using animal manures or other appropriate by-products on land in an environmentally acceptable manner while maintaining or improving soil and plant resources.

Purpose: to reduce transport of sediment and other pollutants to surface waters by applying wastes to fields where they may be incorporated, allowing crops to use nutrients that might otherwise contaminate ground water. As an essential part of a manure management plan, a waste utilization plan needs to be coordinated with a nutrient management plan that determines the amount, form, placement and timing of waste applications to meet agronomic needs. Technical assistance is useful to evaluate field and other conditions to maximize utilization without compromising water quality.

Using animal manures or other appropriate by-products on land in an environmentally acceptable manner maintains and improves soil and plant resources.



Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits:

Other Considerations:

I. Roof Runoff Management(s)

Definition: a facility for collecting, controlling and disposing of runoff water from roofs.

Purpose: to prevent roof runoff water from flowing into or across concentrated waste areas, barnyards, livestock or equipment laneways or other areas where clean roof runoff could wash contaminants into surface or ground waters. Such facilities include erosion-resistant channels or subsurface drains installed along building foundations below eaves, and roof gutters and downspouts.

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: may contribute to animal health and safety.

Other Considerations:

J. Sediment Basin(s)

Definition: a depression constructed to collect and store polluted runoff.

Purpose: to slow runoff that may contain animal manures. The basin may be dug or constructed as an earthen embankment. It allows solids to settle before runoff is discharged.

Initial Cost: medium - high

Maintenance Cost: low

Technical Assistance: required

Other Benefits: may control erosion and sediment; may enhance nutrient management.

Other Considerations: basin will need periodic cleaning or dredging.

K. Silage Leachate Waste Management

Definition: a planned system for collection, storage and disposal of silage wastes in an environmentally acceptable manner.

Purpose: to collect, store and dispose of silage leachate in a manner that minimizes threats to water resources. Silage leachate is an extremely strong organic waste, using up tremendous amounts of oxygen if released into water bodies or into the soil. The best strategy is to prevent or minimize the formation of silage leachate and to safely store and dispose of any generated. Proper siting and sizing of silage facilities is the first step. Practices such as harvesting the silage at a moisture content that will not result in excessive silage leachate production, covering the silage pile to eliminate rain infiltration, and installing drains and/or diversions to separate ground water and surface water runoff from the ensiled forage are also important. A properly designed waste collection and storage system may combine silage leachate with other agricultural wastes. Leachate may be land applied, alone in diluted form, or mixed with manure or other wastes according to a waste utilization plan and a nutrient management plan, paying particular attention to application rates.

Initial Cost: high

Maintenance Cost: medium - high

Technical Assistance: required

Other Benefits: may have nutrient value as soil amendment.

Other Considerations: federal cost share may be available; consider directing waste to municipal sewer.

Silage leachate may be land applied, alone in diluted form or mixed with manure or other wastes according to a waste utilization plan and a nutrient management plan, paying particular attention to application rates.

L. Wastewater Treatment System(s)

Definition: a planned system for biological treatment of wastewater generated in milkhouses, typically consisting of a settling tank, distribution system and treatment system.

Purpose: to reduce threats to water quality by biologically treating organic milkhouse waste. In situations where milkhouse waste is not combined with liquid manures, biological systems for treatment will reduce the amount of suspended solids, biological oxygen demand and dissolved nitrogen that may enter the water table. Such systems are not designed to include waste milk or sewage. An underground treatment system is similar to a traditional septic system, and in fact must follow Massachusetts Title V requirements. In suitable soils, organic matter treatment beds function like leach fields, using organic matter to absorb the waste.

Initial Cost: high

Maintenance Cost: medium

Technical Assistance: required

Other Benefits:

Other Considerations: regular maintenance is required; discharging milkhouse wastes into a municipal sewer should be considered; this practice may not be effective in treating the cleaning agents used to disinfect the milking system; availability and disposal of organic bedding material must be considered.

5. Strategies for Livestock Grazing Management

Across Massachusetts, farms are nestled in the hills, valleys, floodplains and coastal reaches characteristic of our varied topography. Both upland and lowland areas are used for animal grazing, and each area has its advantages and disadvantages for livestock management. Water quality concerns related to livestock grazing focus on potential impacts to sensitive areas such as streambanks, wetlands, estuaries, ponds and lake shores. Sensitive areas also include the riparian zone, an extremely diverse and vital vegetated ecosystem along a water body.

Water quality concerns related to livestock grazing focus on potential impacts to sensitive areas such as streambanks, wetlands, estuaries, ponds, and lake shores.

Impacts to ground water, surface water bodies and the riparian zone include sedimentation, and the introduction of nutrients, pathogens and organic solids. Healthy riparian and wetland ecosystems rely, in part, on good management of the immediate areas as well as upland areas. Careful selection of grazing management systems, controlled access and vegetative stabilization practices all should be considered in the development of a grazing and pasture management plan.

A grazing management system needs to accommodate the demands of vegetation, terrain and type of livestock operation. A well-designed system supplies and improves grazing lands and facilities, develops appropriate water sources, and protects stream sides and other sensitive water resources. Well-managed pastures are stable, with suitable plantings and minimal erosion. Uncontrolled access to streams and ponds for watering may seem economical and convenient, but cost-efficient alternatives that avoid negative water quality impacts are available. Pasturing systems (for example, rotational grazing) can be designed to maximize forage opportunities while minimizing stresses on land and water systems.

The following is a list of the BMPs that are recommended to reduce or eliminate water pollution from livestock grazing.

Best Management Practices for Livestock Grazing Management

A. Alternate Water Supply(s)

Definition: several options for livestock watering that keep animals away from streambanks and riparian zones.

Purpose: to protect streambanks, wetlands and riparian zones from adverse impacts from livestock trampling and waste. For example, a pipeline may be installed to convey water to an upland area. A livestock pond can be excavated or constructed with a dam or embankment. A trough or tank, with devices for water control and waste water disposal may be installed. This practice may encourage better distribution of livestock over the pasture and grazing may be better controlled. In some cases, the development of a well or spring is a positive alternative.

Initial Cost: low - high

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits:

Other Considerations:

B. Fencing(s)

Definition: enclosing or dividing an area of land with a suitable structure that acts as a barrier to livestock.

Purpose: to keep animals from riparian zones and other sensitive water resources, to prevent wastes from entering water bodies, streambank degradation, compaction of soils and loss of vegetation in riparian zones. As part of a grazing management plan, location of fencing should take into account the fact that fencing can have the effect of concentrating animals in particular areas, such as along the fence line, where paths may become channels that concentrate and accelerate runoff. Some fencing, when installed across the slope, can serve to slow down runoff. Exclusion fencing may be accompanied by installation of properly designed and located livestock accessways and crossings. Fencing may be permanent or may be designed to be temporary and moveable.

Fencing keeps animals from riparian zones and other sensitive water resources, preventing wastes from entering water bodies.

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: not required

Other Benefits:

Other Considerations:

C. Pasture Management

Definition: proper treatment and use of pastureland.

Purpose: to minimize adverse impacts to ground and surface water by maintaining or improving the quality and quantity of forage, protecting the soil, conserving water and optimizing the use of fertilizers and pesticides on pasture. Practices include postponing grazing or resting grazing land for a prescribed period, which protects pasture areas with bare ground or little ground cover from eroding. Proper pastureland management will minimize movement of sediments from exposed soils and nutrients from manures to ground and nearby surface waters. As vegetative cover increases, the filtering processes are enhanced, trapping more silt and nutrients. Early spring grazing on wet and soft soils should be avoided. Soil testing and proper application of lime, manures and other nutrients are key to healthy pasture management.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: may enhance crop health and vigor.

Other Considerations:

D. Plan for Proper Grazing

Definition: A plan for grazing at an intensity that will maintain enough cover to protect the soil and maintain or improve the quantity and quality of desirable vegetation.

Purpose: to reduce transport of sediments and other pollutants from grazed areas by assuring a healthy and stable vegetative cover. Overgrazed pastures result in poor plant cover and plant health, and exposed soils. Deferred grazing and rotational grazing are two practices that encourage proper grazing intensity. Pasturing animals in woodlands should be limited to areas that produce a significant amount of forage that can be harvested without damaging other forest values or creating negative impacts to ground or surface water quality. Wooded areas should be grazed at a rate that maintains adequate cover for soil protection and maintains or enhances the quantity and quality of trees and forage vegetation.

A plan for proper grazing reduces transport of sediments and other pollutants from grazed areas by assuring a healthy and stable vegetative cover.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: optimum livestock health; improved forage production and quality.

Other Considerations: grazing areas may be restricted by eliminating wooded and/or wet areas.

E. Prescribed Grazing (Planned Grazing System)

Definition: a practice in which two or more grazing units are alternately rested and grazed in a planned sequence.

Purpose: to decrease movement of sediments, nutrients and other substances into downstream waters by increasing the quality and quantity of vegetation in grazed areas. With a planned grazing system (e.g., the "Voisin" method, or intensive rotational grazing) livestock spend less time in each pasture or section of pasture. The vegetation helps trap manure.

Initial Cost: low - medium

Maintenance Cost: medium (for management time)

Technical Assistance: desirable

Other Benefits: may yield economic savings; may increase grazing efficiency; may increase and improve quality and production of forage (including season extension); may improve flexibility in a grazing program; grass-based livestock management may decrease manure handling, decrease fertilizer use, require less machinery; may enhance wildlife habitat.

Other Considerations: increases required management; requires supplying livestock water.

F. Riparian Buffer

Definition: an established area of vegetation located next to and upgradient of water courses, water bodies and associated wetlands.

Purpose: to maintain or improve surface water quality by removing or buffering the effects of sediment, nutrients, organic matter and some pesticides. As a grazing practice, it is most applicable in areas downslope from pastures. Management practices include protecting or establishing vegetation, installing an upgradient filter strip, installing livestock exclusion fencing, excluding heavy equipment, and designing and installing proper livestock access and crossings. Buffer width varies depending on soil type, slope and vegetative cover; 50 feet is considered minimum. If possible, native species should be planted/encouraged and fertilizers and pesticides should not be used.

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: may enhance streambank stabilization; may improve wildlife and aquatic habitat (see also, nutrient management, pest management and erosion and sediment control).

Other Considerations: may reduce amount of active grazing land; may limit livestock access to water or shade.

Vegetative stabilization practices which improve or reestablish vegetative cover on pastures reduce erosion into water bodies.

G. Stream Crossing

Definition: a stabilized area to provide access across a stream for livestock; may be used for farm machinery.

Purpose: to avoid degradation of streams and streambanks from animal trampling and wastes. Properly designed and installed stream crossings minimize bank and streambed erosion, reduce sediment and enhance water quality. A crossing might be graded and stoned or might consist of a constructed bridge or a culvert.

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: some stream crossings may enhance wildlife habitat.

Other Considerations: may require wetlands permit.

H. Vegetative Stabilization

Definition: practices designed to improve or reestablish vegetative cover on pastures.

Purpose: to reduce erosion into water bodies. Such practices include seeding or reseeding stands of adapted forage species, planting vegetation such as grasses, shrubs or trees on highly erodible or critically eroding areas, brush and weed management and prescribed burning.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: desirable

Other Benefits: may enhance habitat.

Other Considerations:

6. Strategies for Irrigation Management

While cranberry producers are the most significant users of irrigation water in Massachusetts, other growers irrigate vegetable, fruit, nursery, greenhouse and other specialty crops. While Massachusetts typically is blessed with abundant rainfall, irrigation is occasionally necessary. Chemigation, the practice of applying fertilizers and/or pesticides to crops through irrigation systems, is also used by some farmers. The concern associated with irrigation is the potential movement of pollutants such as sediments, organic solids, pesticides, metals, microbial organisms, salts and nutrients from the land into ground and surface waters. Ground water is particularly vulnerable where coarse textured soils allow high infiltration.

A backflow prevention system prevents chemical backflow to the water source during chemigation.

Proper irrigation management will help minimize discharge of pollutants while also reducing water waste and improving water use efficiency. An irrigation management plan will include components that address irrigation scheduling practices, efficient application, proper utilization of tailwater, drainage and runoff, and backflow prevention. The first step in such a plan is the development of a water budget and water balance for the crop to be irrigated. Technical assistance may be required for these calculations.

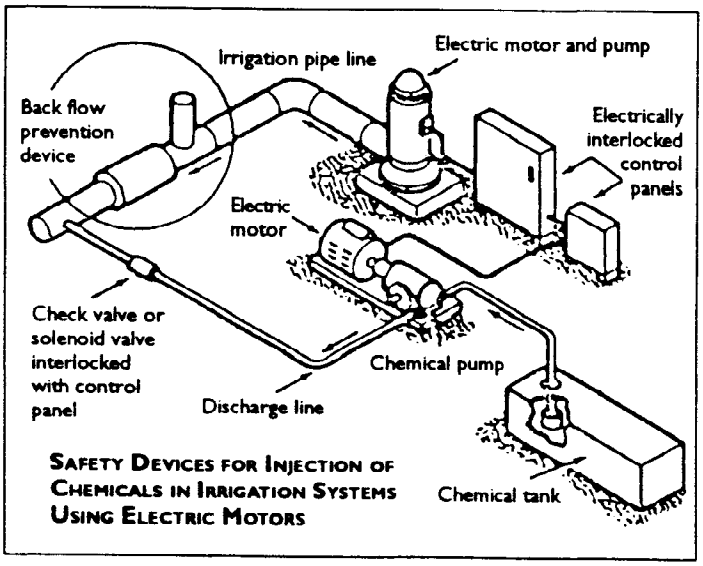
The following is a list of the BMPs that are recommended to reduce or eliminate water pollution from crop irrigation.

Best Management Practices for Irrigation

A. Backflow Prevention(s)

Definition: a system to prevent chemical backflow to the water source during chemigation.

Purpose: to prevent contamination of a water source by installing devices that prevent chemicals from entering the irrigation water source in cases when the irrigation pump shuts down. There are several different systems used as backflow preventers such as an air gap, a check valve with vacuum relief and low pressure drain, a double check valve, a reduced pressure principle backflow preventer and an atmospheric vacuum breaker. Factors to consider when selecting a backflow prevention system are the characteristics of the chemical that can backflow, the water source and the geometry of the irrigation system.



Safety Devices for Injection of Chemicals in Irrigation Systems Using Electric Motors

Initial Cost: low - medium

Maintenance Cost: low

Technical Assistance: not required

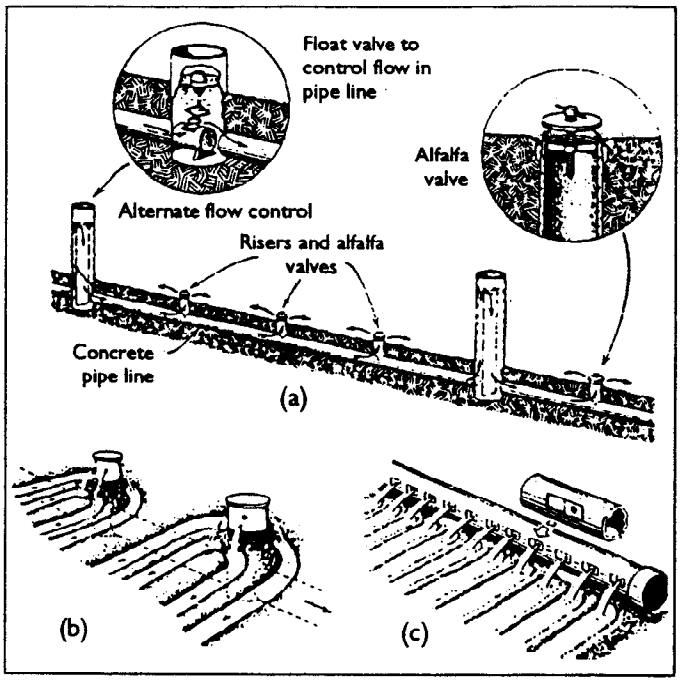
Other Benefits:

Other Considerations:

B. Efficient Irrigation System

Definition: a planned system of crop irrigation that has as one goal the efficient use of water resources. Systems will vary with the type of crop grown, the soils and the topography.

Purpose: to ensure efficient use and distribution, minimize runoff or deep percolation and eliminate soil erosion. Several kinds of systems, properly designed and operated, can be used. Drip or trickle irrigation is a system in which all necessary facilities are installed for efficiently applying water directly to the root zone of plants by means of applicators (e.g. porous tubing or perforated pipe) operated under low pressure. A typical trickle system has a mainline with a control head, leading to laterals placed in the field. Runoff is reduced in this system, but potential hazards to shallow ground water exist if chemigation is used.



Methods of distribution of irrigation water from (a) low-pressure underground pipe, (b) multiple-outlet risers, and (c) portable gated pipe. (Schwab et. al., 1981) *From Management Measures for Agricultural Sources, EPA-840-B-92-002, January 1993.*

A sprinkler irrigation system applies water by means of perforated pipes or nozzles operated above ground, under pressure. Proper management of such a system controls runoff and prevents negative impacts to downstream surface waters. Chemigation with this system allows management of nutrients, wastewater and pesticides, but poor management may cause pollution of surface and ground water. Surface and subsurface irrigation systems deliver water by surface means, such as furrows, borders, contour levees or ditches, or by subsurface means. Proper management of such systems will prevent downstream pollution associated with runoff and percolation, including elevated temperatures of receiving waters.

Initial Cost: medium - high

Maintenance Cost: medium

Technical Assistance: not required

Other Benefits: conserves water; enhances efficient delivery of fertilizer and/or pesticides (known as "fertigation").

Other Considerations:

A planned system of crop irrigation has as its goal the efficient use of water resources. Systems will vary with the type of crop grown, the soils and the topography.

C. Plan for Irrigation Water Management

Definition: determining and controlling the rate, amount and timing of irrigation water in a planned and efficient manner.

Purpose: to minimize the loss of dissolved substances and sediments from the irrigation system to surface or ground water. Effective use of available irrigation water will promote the desired crop response, control water loss and protect water quality. An irrigation management plan will take into account the various and complex factors that need to be considered. The grower must know how to determine when irrigation water should be applied and

how to measure or estimate the amount of water required for each irrigation. Proper scheduling requires consideration of factors such as soil properties, type of crop, its drought sensitivity and status of crop stress, stage of crop development, availability of a water supply and climatic factors such as rainfall and temperature. Proper irrigation also requires the ability to make necessary adjustments to the water stream, rate and time, and management of irrigation runoff.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: required

Other Benefits: conserves water.

Other Considerations:

A tailwater recovery system collects, stores and transports irrigation tailwater for reuse in the farm irrigation distribution system.

D. Tailwater Recovery System(s)

Definition: a facility to collect, store and transport irrigation tailwater for reuse in the farm irrigation distribution system.

Purpose: to increase water efficiency and reduce potential for contamination by recovering irrigation water for reuse in irrigation or for proper disposal. Using runoff water to provide additional irrigation or to reduce the amount of water diverted increases the efficiency of irrigation water use. In a tailwater recovery facility, sediments and substances attached to them (e.g. salts, metals, soluble nutrients and pesticides) are trapped, thereby decreasing downstream impacts to water quality. Recovered water with high salt or metal content will have to be disposed of in an environmentally safe manner and location.

Initial Cost: high

Maintenance Cost: medium

Technical Assistance: not required

Other Benefits:

Other Considerations:

E. Water-measuring Device(s)

Definition: an irrigation water meter, flume, weir or other water-measuring device installed in a pipeline or ditch.

Purpose: to measure the rate of flow and/or application of water and the total amount of water applied to the field with each irrigation. Such information can assist the grower in maximizing the efficiency and effectiveness of irrigation scheduling and equipment and provide data with which to consider modifications.

Initial Cost: low

Maintenance Cost: low

Technical Assistance: not required

Other Benefits: conserves water.

Other Considerations:

Summary of BMP Contributions to Farm Management Systems

Best Management Practice (BMP)	Erosion & Sediment	Nutrient	Pest & Pesticide	Barnyard, Manure & Waste	Grazing	Irrigation
agricultural composting		●		●		
alternate water supply					●	
appropriate cultural controls		○	●			
appropriate biological controls			●			
appropriate physical controls			●			
backflow prevention						●
buffer strips	○	●		○		
calibrate and maintain pesticide application equipment			●			
combined waste facility		○		●		
conservation cover	●	○				
conservation crop rotation	●	●	○			
contour farming	●					
contour strip-cropping	●	○				
cover cropping	●	●	○			
critical area planting	●					
data collection			●			
diversion (grass and other)	●			●		

Best Management Practice (BMP)	Erosion & Sediment	Nutrient	Pest & Pesticide	Barnyard, Manure & Waste	Grazing	Irrigation
efficient irrigation system						●
equipment calibration		●				
fencing	○				●	
fert. storage, handling and containment		●				
field borders	●					
field strip-cropping	●	○				
filter strip	●	○		●		
grade stabilization structure (water control structure)	●					
grassed waterway	●	○				
green manure cropping	○	●				
heavy use area protection	○			●		
intercropping		●	○			
manure storage facility		○		●		
manure composting		●		●		
manure storage field stacking area		○		●		
mulching	●					○
nutrient budgeting	●			●		
nutrient record keeping		●				

● = primary benefit ○ = additional benefit

Summary of BMP Contributions to Farm Management Systems

Best Management Practice (BMP)	Erosion & Sediment	Nutrient	Pest & Pesticide	Barnyard, Manure & Waste	Grazing	Irrigation
outlet or lined waterway	●			○		
pasture management	○	○		○	●	
pasture and hayland planting	●				○	
pesticide application plans and records			●			
plan for irrigation water management						●
plan for proper grazing	○				●	
plan for waste utilization		○		●		
plant tissue testing		●				
prescribed grazing (planned grazing system)	○			○	●	
proper timing and application methods		●				
protect and enhance natural controls		●				
residue management: no-till, strip till, mulch till, ridge till	●	○	○			
riparian buffer	●		○		●	
roof runoff management	○			●		

Best Management Practice (BMP)	Erosion & Sediment	Nutrient	Pest & Pesticide	Barnyard, Manure & Waste	Grazing	Irrigation
safe storage, mixing, loading and disposal of pesticides			●			
scout for pests			●			
sediment basin	●			●		
silage leachate waste management				●		
soil nitrate testing		●				
soil testing		●				
special handling of sensitive areas		○	●			
stream channel stabilization measures	●					
stream crossing	○				●	
tailwater recovery system		○	○			●
tree planting	●					
vegetative stabilization	○				●	
wastewater treatment system				●		
water-measuring device						●
yield data		●				

● = primary benefit ○ = additional benefit

PART V: Resources

THE FOLLOWING AGENCIES and organizations can provide information, technical assistance, financial assistance and/or referrals to Massachusetts farmers about best management practices and on-farm water quality concerns.

Agriculture Composting Association
P.O. Box 608
Belchertown, MA 01007
(413) 323-9294

Conservation Districts:

Berkshire Conservation District
78 Center Street
Pittsfield, MA 01201
(413) 443-1776

Bristol Conservation District
P.O. Box 475, 84 Center St.
Dighton, MA 02715
(508) 669-6558

Cape Cod Conservation District
P.O. Box 296
West Barnstable, MA 02668
(508) 362-6327

Dukes Conservation District
P.O. Box 1010
Edgartown, MA 02539
(508) 627-9088

Essex Conservation District
562 Maple Street
Hathorne, MA 01937
(508) 774-5578

Franklin Conservation District
P.O. Box 783
Greenfield, MA 01302
(413) 773-9576

Hampden Conservation District
243 King Street, Room 39
Northampton, MA 01060
(413) 584-1464

Hampshire Conservation District
243 King Street, Room 39
Northampton, MA 01060
(413) 584-1464

Middlesex Conservation District
319 Littleton Road, Suite 205
Westford, MA 01886
(508) 692-9395

Nantucket Conservation District
P.O. Box 1285, Candle House Rd.
Nantucket, MA 02554
(508) 228-0714

Norfolk Conservation District
460 Main Street
Walpole, MA 02081
(508) 668-0995

Plymouth Conservation District
15 Cranberry Highway
West Wareham, MA 02576
(508) 295-5495

Worcester Conservation District
52 Boyden Road
Holden, MA 01520
(508) 829-0168

Suffolk Conservation District
P.O. Box 248
Boston, MA 02021

Massachusetts Department of Food and Agriculture

Main Office
100 Cambridge Street
Boston, MA 02202
(617) 727-3000
FAX (617) 727-7235

Division of Agricultural Development
(617) 727-3018 x 188

Bureau of Land Use
(508) 792-7712

Bureau of Markets
(617) 727-3018 x 173

Bureau of Education and Outreach
(617) 727-3018 x 178

Bureau of Fairs and Equine Activities
(617) 727-3018 x 166

Division of Dairy Services
(617) 727-3018 x 180

Division of Regulatory Services
(617) 727-3020 x 120

Bureau of Animal Health
(617) 727-3018 x 121

Bureau of Farm Products
(617) 727-3018 x 141

Pesticide Bureau
(617) 727-3000 x 127

Bureau of Plant Pest Control
(617) 727-3000 x 123

Compost Program
(617) 727-3000 x 188

Central Massachusetts Office
142 Old Common Road
Lancaster, MA 01523
(508) 792-7712

Western Massachusetts Office
University of Massachusetts
Draper Hall, Room 117
Amherst, MA 01003
(413) 545-5731

Massachusetts Farm Bureau Federation
466 Chestnut St.
Ashland, MA 01721
(508) 881-4766
(Please contact this office for county chapter information)

Resources, *continued*

New England Small Farm Institute
P.O. Box 937
Belchertown, MA 01007
(413) 323-4531
FAX (413) 323- 9594

Northeast Organic Farming Association/Massachusetts
411 Sheldon Road, RFD 2
Barre, MA 01005
(508) 355-2853

University of Massachusetts Cooperative Extension
212 Stockbridge Hall
University of Massachusetts
Amherst, MA 01003-0099
(413) 545-4800
(Please call this number for all agent and department referrals)

USDA Farm Service Agency
(formerly ASCS)
Massachusetts State FSA Office
445 West Street
Amherst, MA 01002-2994
(413) 256-0232

County Offices:

Berkshire County FSA Office
78 Center Street, Arterial
Pittsfield, MA 01201
(413) 443-9227

Bristol County FSA Office
84 Center Street
Dighton, MA 02715
(508) 669-6621

Franklin County FSA Office
55 Federal Street
Greenfield, MA 01301
(413) 772-6810

Hampden County FSA Office
171 Park Avenue
West Springfield, MA 01089
(413) 732-5215

Hampshire County FSA Office
243 King Street
Northampton, MA 01060
(413) 586-6570

Middlesex/Essex County FSA Office
319 Littleton Rd., Suite 203
Westford, MA 01886
(508) 692-5163

Norfolk County FSA Office
Norfolk County Agricultural High School
400 Main Street
Walpole, MA 02081
(508) 668-0245

Southeastern MA County FSA Office
(Plymouth, Barnstable, Dukes and Nantucket Counties)
15 Cranberry Highway
West Wareham, MA 02576
(508) 295-6860

Worcester County FSA Office
52 Boyden Rd., Suite 103
Holden, MA 01520
(508) 829-5721

USDA Natural Resources Conservation Service
(formerly the Soil Conservation Service)

Barnstable Field Office
(serving the Cape Cod, Dukes and Nantucket Conservation Districts)
P.O. Box 709, Flintrock Road
Barnstable, MA 02630
(508) 362-9332
District Conservationist:
Donald W. Liptack

Greenfield Field Office
(serving the Franklin Conservation District)
55 Federal Street
Hayburne Building, Room 270
Greenfield, MA 01301
(413) 772-0384
District Conservationist:
Diane Leone

Holden Field Office
(serving the Northeastern, Northwestern, and Southern Worcester Conservation Districts)
The Medical Arts Center Building
52 Boyden Road
Holden, MA 01520-2587
(508) 829-6628
District Conservationist:
Ronald E. Thompson

Northampton Field Office
(serving the Hampden and Hampshire Conservation Districts)
Potpourri Mall
243 King Street, Room 39
Northampton, MA 01060
(413) 586-5440
District Conservationist:
Deb Johnson

Pittsfield Field Office
(serving the Berkshire Conservation District)
78 Center Street (Arterial)
Pittsfield, MA 01201
(413) 443-6867
District Conservationist:
Mark W. Grennan

West Wareham Field Office
(serving the Bristol, Norfolk, and Plymouth Conservation Districts)
15 Cranberry Highwy
West Wareham, MA 02576
District Conservationist:
Leonard R. Reno, Jr.

Westford Field Office
(serving the Essex, Middlesex and Suffolk Conservation Districts)
319 Littleton Road
Westford, MA 01886
(508) 692-1904
District Conservationist:
Daniel J. Lenthall