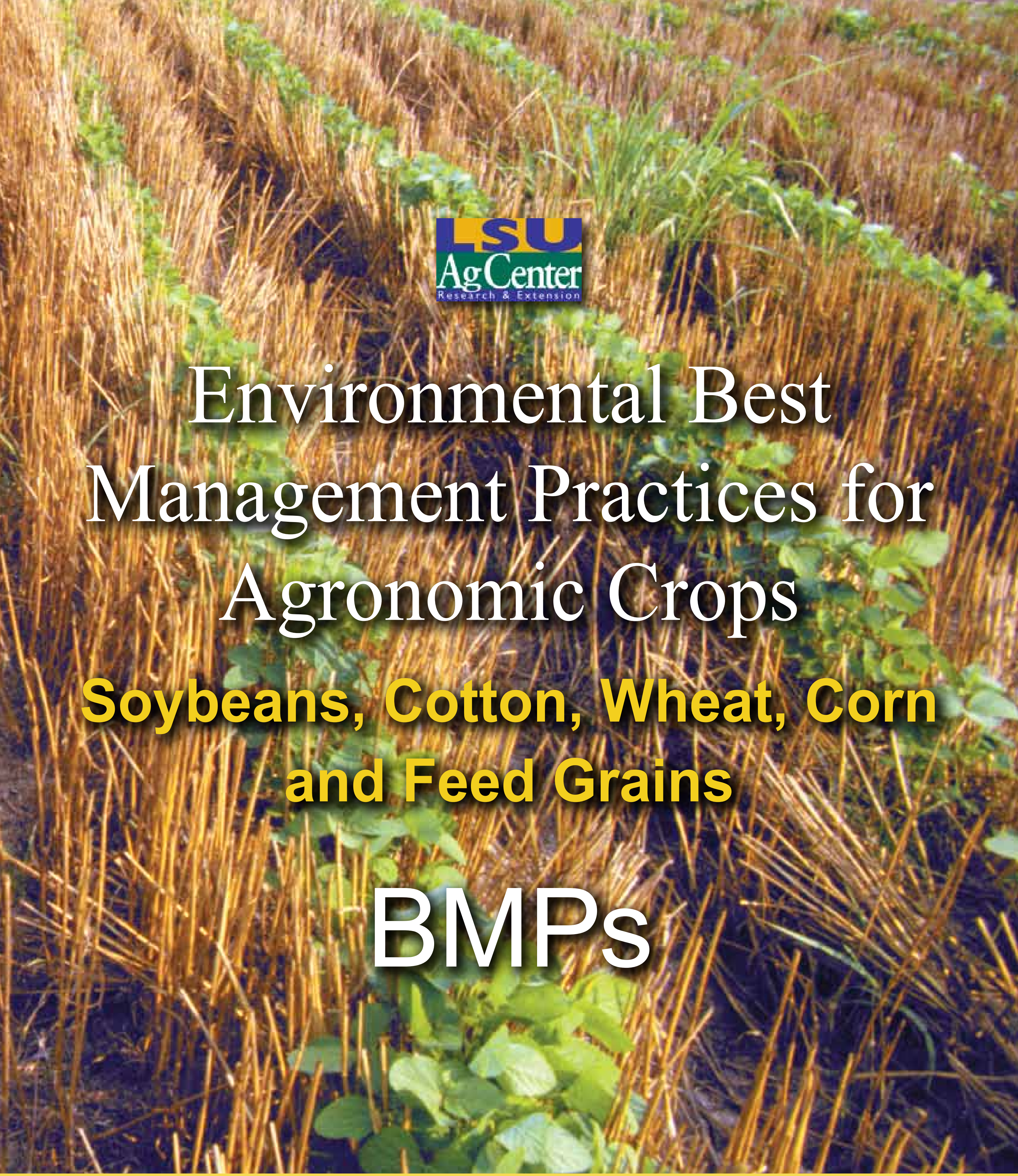

LSU AgCenter
Research & Extension

Environmental Best Management Practices for Agronomic Crops

Soybeans, Cotton, Wheat, Corn and Feed Grains

BMPs

NRCS

FARM BUREAU LOUISIANA

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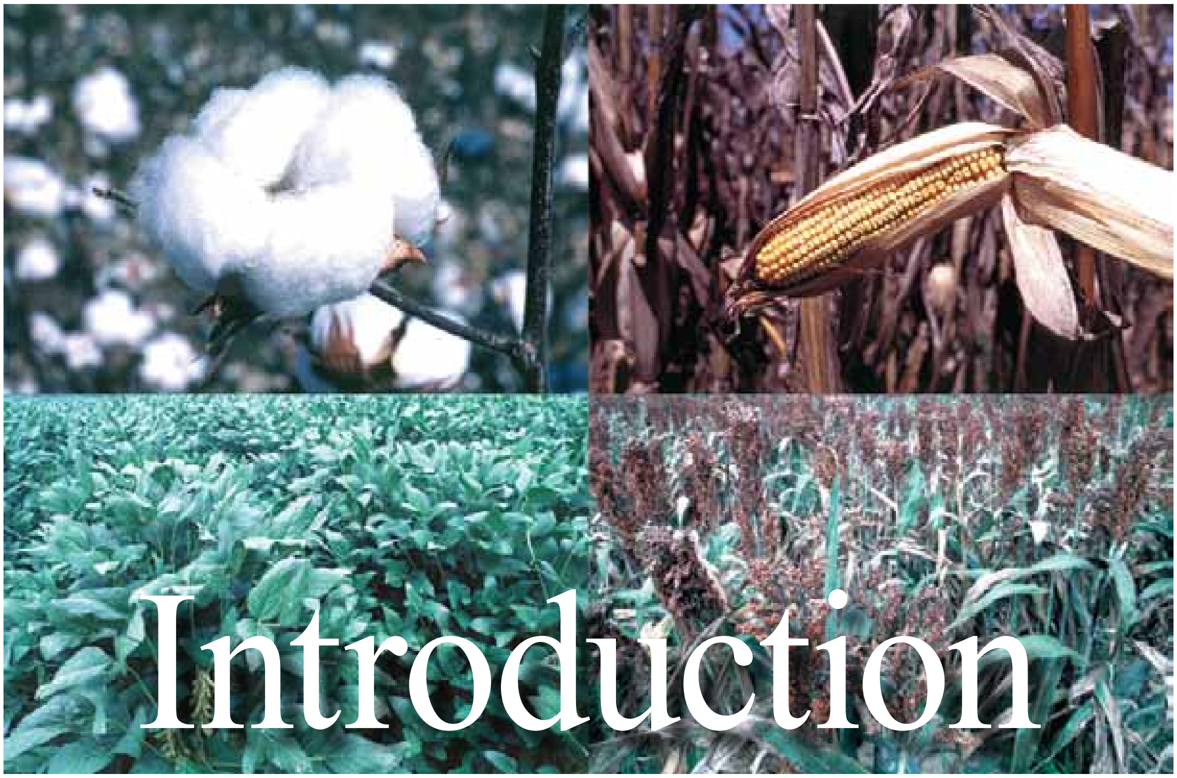
Why BMPs Are Important to Louisiana

In Louisiana, we are blessed with beautiful and abundant waters to enjoy fishing, hunting, boating or just relaxing on the shore of a lake, river or bayou. Most of the water in Louisiana's rivers and lakes comes from rainfall runoff. As this runoff travels across the soil surface, it carries with it soil particles, organic matter and nutrients, such as nitrogen and phosphorus. Many agricultural activities also can contribute to the amount of these materials entering streams, lakes, estuaries and groundwater. In addition to ensuring an abundant, affordable food supply, Louisiana agricultural producers must strive to protect the environment.

Research and educational programs on environmental issues related to the use and management of natural resources have always been an important part of the LSU AgCenter's mission. Working with representatives from agricultural commodity groups, the Natural Resources Conservation Service, the Louisiana Department of Environmental Quality, the Louisiana Farm Bureau Federation and the Louisiana Department of Agriculture and Forestry, the LSU AgCenter has taken the lead in assembling a group of best management practices, also known as BMPs, for each agricultural commodity in Louisiana.

BMPs are practices used by agricultural producers to control the generation of pollutants from agricultural activities and to thereby reduce the amount of agricultural pollutants entering surface water and groundwater. Each BMP is the result of years of research and demonstrations conducted by agricultural research scientists and soil engineers. A list of BMPs and accompanying standards and specifications are published by the Natural Resources Conservation Service in its Field Office Technical Guide.



Introduction

Agronomic row crops and feed grain crops are important commodities in Louisiana. The total acreage planted for these commodities in the state for 2010 was more than 2 million acres. The gross farm value of Louisiana-grown soybeans, cotton, corn, wheat and grain sorghum in 2010 was more than $820 million. Therefore, the importance of these commodities to the economy of the state cannot be overemphasized.

Because of the acreage involved, the runoff from these crops can have a potentially significant effect on the surface water quality throughout the agricultural regions of the state. The quality of water in the streams, rivers, bayous, lakes and coastal areas of Louisiana is extremely important to all residents.

The intent of best management practices, or BMPs, is to provide the growers of soybeans, cotton, corn, grain sorghum and wheat with some guidelines on practices they can implement to reduce the effects these agricultural practices may have on the environment. If properly implemented, with appropriate incentives, where needed, the practices described in this publication will help to improve water quality without placing unreasonable burdens on the agricultural industry of Louisiana.

References are made to specific Natural Resources Conservation Service (NRCS) production codes, which are explained in the text. More detailed information about these practices can be found in the NRCS Field Office Technical Guide. That guide can be found in all Soil and Water Conservation District offices, in all NRCS field offices or on the NRCS web page. Under voluntary participation by the producer, technical assistance to develop and implement a farm-specific conservation plan is available through the conservation districts, NRCS field offices and LSU AgCenter parish offices.

Importance of BMPs to Reduce Losses

By implementing or using best management practices, Louisiana crop producers are minimizing pollution of water resources of the state as well as saving money in some cases. Sediment runoff reduction is one of the most important practices a producer can adopt – from an economic and environmental perspective. Based on volume, sediment is the largest pollutant of surface water in the nation. Sediment pollution comes from several sources, including all agricultural operations that leave bare soil exposed to rainfall.

From an economic perspective, allowing nutrient-laden soil to run off into rivers and streams is a financial loss to the operation. Soil lost in this manner can never be used by the farmer again for production. Retaining as much soil as possible can reduce the amount of fertilizers and other soil amendments needed to maintain adequate production acreage.

Negative environmental effects that are increasingly noticed and can cause much concern to the public and environmental regulatory agencies include increasing the turbidity of water, reducing light penetration, impairing photosynthesis and altering oxygen relationships (which can reduce the available food supply for certain aquatic organisms). Excessive runoff can adversely affect fish populations in areas where sediment deposits cover spawning beds and, in some situations, given a long enough period of time, partially fill in ponds, lakes and reservoirs.

In addition, sediment is often rich in organic matter. Nutrients such as nitrogen and phosphorus and certain pesticides may enter streams with sediment. The potentially harmful effects may include rapid algae growth, oxygen depletion as organic matter and algae decompose, fish kills from oxygen depletion, toxic effects of pesticides on aquatic life and unsafe drinking water caused by high nitrate or pesticide content.

Manure runoff reduction is of paramount importance to any operation that uses manure or other organic fertilizers such as poultry litter. Producers should practice all cost-effective methods to ensure wastes are handled and treated properly. One of the greatest concerns of the regulatory agencies and the public is the escape of manure runoff and the accompanying bacteria and nutrients that can enter the streams and tributaries of Louisiana's surface waters. Many of the water bodies in Louisiana that are listed as impaired and require attention by the U.S. Environmental Protection Agency and the Louisiana Department of Environmental Quality are polluted with fecal coliform bacteria and do not meet their designated use for swimming, water contact or fishing. Although not all of this pollution can be attributed to agricultural operations, in the public's minds, agriculture is always at least part of the source.

Fecal coliform is a term used to describe bacteria found in the intestinal tract of warm-blooded animals. Surface waters are monitored for the presence and concentration of fecal coliforms. Not all coliforms are harmful to human health. In fact, some fecal coliforms are normal and essential for human digestion. Without them, our digestive system would not function properly.

If fecal material is present in stream segments in excessive concentrations, the Louisiana Department of Health and Hospitals states there is the potential for other harmful pathogens to also be present. Some forms of coliforms such as a few strains of E. coli can be transmitted from cattle to humans or from person to person and may be harmful to human health. When excessive concentrations of fecal coliforms are found in monitored rivers and streams, the DHH may issue advisories or order closures of the affected surface waters.

In addition, manure runoff also contains nitrogen and phosphorus and can result in nutrient overenrichment of water bodies, which can cause algae blooms and oxygen depletion in surface waters, resulting in fish and other aquatic animal kills.

Nutrient management is another profoundly important aspect of agronomic growing operations, and much attention is given to this aspect of crop production management in this manual. Excessive nutrient runoff can cost the farm significant amounts of money. Often, without a comprehensive nutrient management plan, producers may apply too much of the essential elements. When that occurs, it's just money down the river. Excessive nutrients cost the operation money and ultimately run off the farm and pose environmental problems in nearby surface waters.

Nutrients such as nitrogen and phosphorus can become pollutants. Both are essential for all plant growth and therefore essential for the proper function of ecosystems and necessary for all agricultural operations. But excessive nitrogen and phosphorus concentrations in water can accelerate algae and plant growth in streams and lakes, resulting in oxygen depletion or critically low dissolved oxygen levels. Often referred to as nutrient overenrichment or hypoxia, it is a major concern in many water bodies of Louisiana and the Gulf of Mexico.

Nutrient Management

Introduction

Nutrient levels should optimize crop yields while minimizing movement in surface water and groundwater (NRCS Practice Code 590). A sound soil fertility program is the foundation upon which a profitable farming business must be built.

Agricultural fertilizers are a necessity for producing abundant, high-quality food, feed and fiber crops. Using fertilizer nutrients in the proper amounts and applying them correctly are both economically and environmentally important to the long-term profitability and sustainability of crop production.

The fertilizer nutrients that have potential to become groundwater or surface water pollutants are nitrogen and phosphorus. In general, other commonly used fertilizer nutrients do not cause concern as pollutants.

Because erosion and runoff are the two major ways nonpoint-source pollutants move into surface water resources, practices that reduce erosion or runoff are considered best management practices. Similarly, practices that limit the buildup of nutrients in the soil, which can leach to groundwater or be picked up in runoff, and practices that ensure the safe use of agricultural chemicals also are considered BMPs.

In general, soil conservation and water quality protection are mutually beneficial. Therefore, the BMPs described here are the best means of reducing agricultural nonpoint-source pollution resulting from fertilizer nutrients.

The goal of nutrient management is to apply nutrients in the correct amounts and forms at the correct time to produce optimum crop yields while minimizing the movement of nutrients into surface and groundwater. Research-based recommendations are available through the LSU AgCenter's Extension Service.

Nitrogen

Nitrogen is a part of all plant and animal proteins. Therefore, human survival depends on an abundant supply of nitrogen in nature. Approximately 80 percent of the atmosphere is nitrogen gas, but most plants cannot use this form of gaseous nitrogen.

Fertilizer nitrogen must be applied to the soils to make profitable crop yields. To the degree possible, rely on nitrogen recommendations based on Louisiana research. Nitrogen fertilizer rates for row crops vary, depending on the age of the crop and soil texture. Nitrogen should be applied according to criteria established to prevent excess

runoff and leaching (losses).

Research suggests the optimum time to apply nitrogen fertilizer is April. Nitrogen applied at that time will be available during the peak vegetative growth period, when a plant's root system is extensive enough to use available nitrogen. Injecting nitrogen below the soil surface or incorporating Nitrogen fertilizer with tillage will reduce the possibility of nitrogen runoff. The source of nitrogen is not important if applied in accordance with good agronomic principles. If organic materials are used as nitrogen sources, they should be tested for nitrogen content, the amount of soluble nitrogen and the amount of nitrogen expected to be mineralized from the organic fraction during the growing season. This amount should not exceed the chemical fertilizer nitrogen recommendation for the crop.

High soil organic matter levels also contribute to plant nitrogen. Decomposition of organic matter results in inorganic nitrogen forms such as ammonium (NH_{4+}) and nitrate (NO_{3-}). Ammonium also can be converted into nitrate by a process known as nitrification. Both ammonium and nitrate forms are soluble and readily available for plant uptake. The ammonium form is attracted to soil particles, however, so it does not readily leach through the soil with rainfall or irrigation water. Nitrate, on the other hand, is repelled by soil particles and can leach into groundwater. Both can be lost via surface runoff. Excessive nitrate concentrations in surface water can accelerate aquatic plant growth, which can be detrimental to water quality.

Phosphorus

Naturally occurring phosphorous exists in a phosphate form as soluble inorganic phosphate, soluble phosphate, particulate phosphate or mineral phosphate. The mineral forms of phosphorus (calcium, iron and aluminum phosphate) are low in solubility. Uptake of applied phosphorous fertilizer by the plant will be closely related to soil pH. Soils with low pH will form insoluble iron and aluminum phosphate, and soils with high pH will form insoluble calcium phosphate. Correcting soil pH is an important first step in the management of phosphorous where an optimum range is 5.5-7.0. The amount of these elements (calcium, iron and aluminum) present in reactive forms varies with different soils and soil conditions and will determine the amount of phosphorus that can be fixed in the soil. The immediate source of phosphorus for plants is the portion dissolved in the soil solution. A soil solution containing only a few parts per million of phosphate usually is considered adequate for plant growth. Phosphate is absorbed from the soil solution and used by plants. Available phosphorous is replenished in the soil solution by soil minerals, soil organic matter decomposition or applied fertilizers.

Phosphorus (P) fertilizer rates (expressed as P_2O_5 content) should not exceed the recommended rates suggested by the soil test level for the particular field. Timing of phosphorus fertilizers should be based on soil pH. Application of phosphorus fertilizer during April or May is acceptable at any soil pH. Phosphorus fertilizers may be applied in the fall or winter if the soil pH is between 5.5 and 7.5 and where the soil is not highly erodible.

Injecting phosphorus fertilizers below the soil surface or incorporating phosphorus fertilizer with tillage will reduce the possibility of phosphorus runoff. Reducing erosion also will reduce phosphorus movement since phosphorus binds with the soil particles. If organic materials are used as a phosphorus source, they should be tested for phosphorus content. The organic material should be applied to provide the amount of phosphorus necessary for the crop based on phosphorus levels indicated by a soil test.

Remember that most phosphate is not readily soluble. Most of the ions are either used by living plants or adsorbed to sediment. The potential of it leaching to groundwater is low, and the portion of phosphate bound to sediment particles is virtually unavailable to living organisms. But it becomes more available as it detaches from sediment, such as can occur in runoff into streams. Only a small part of the phosphate moved with sediment into surface water is immediately available to aquatic organisms, but additional phosphate can slowly become available through biochemical reactions. This slow release of large amounts of phosphate from sediment layers in lakes and streams could cause excessive algae blooms and excessive growth of plants, thereby affecting water quality.

Potassium

Potassium is needed to produce adequate row crop yields in Louisiana. Proper soil testing to determine soil potassium levels is important for determining proper application rates. Research-based recommended potash rates are available through the LSU AgCenter's Cooperative Extension Service as are testing for and recommendations on phosphorus and nitrogen.

Nutrient Application Rates

Nutrient application rates should be based on the results of a soil analysis. Select only those materials recommended for use by qualified individuals from the LSU AgCenter (Louisiana Cooperative Extension Service or Louisiana Agricultural Experiment Station), certified crop advisors, certified agricultural consultants and/or published LSU AgCenter data.

Soil Testing

Soil testing is the foundation of a sound nutrient management program. A soil test is a series of chemical analyses on soil that estimate whether levels of essential plant nutrients are sufficient to produce a desired crop and yield.

When not taken up by a crop, some nutrients, particularly nitrogen, can be lost from the soil by leaching, runoff or mineralization. Others, like phosphorus, react with soil minerals over time to form compounds that are not available for uptake by plants.

Soil testing can be used to estimate how much loss has occurred and predict which nutrients and how much of those nutrients should be added to produce a particular crop and yield.

Take soil tests at least every three years or at the beginning of a different crop rotation. Soil testing is particularly important if the field in question has undergone precision leveling.

Generally, a soil test can be taken successfully by keeping the following in mind:

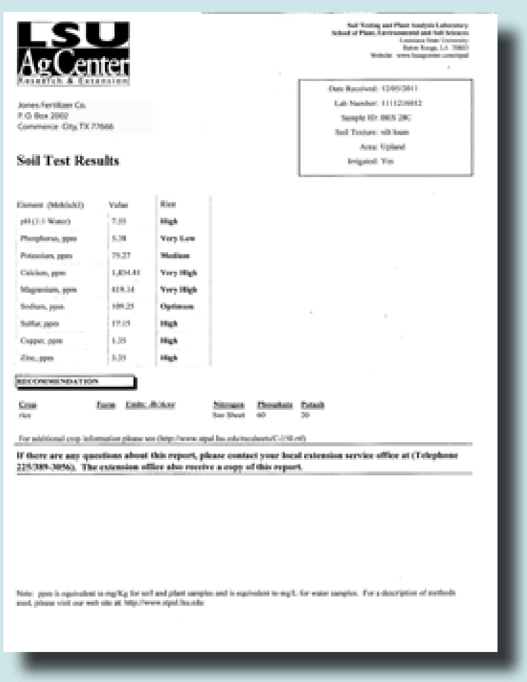
– Soils that differ in appearance, crop growth or past treatment should be sampled separately, provided the area is of such size and nature that it can be fertilized separately. For each sample, collect sub-samples of soil from 10 or more places in each sampling area in a zigzag fashion so as to make a representative sample.

–Mix all random sub-samples from one sampling area thoroughly before filling a sampling carton or container to be mailed to the lab. For each sampling area, the laboratory will need 1 pint of the mixture of all sub-samples.

–One soil sample should represent 10 acres or less. Avoid sampling directly in the fertilized band.

–Proper sampling depth depends on the kind of crop you plan to grow. For pastures and minimum tillage, take the top 2-3 inches of soil. For cultivated crops, collect the upper 5-6 inches of soil.

–If possible, collect and submit samples three to five months before your projected planting date to ensure you have enough time to plan your liming and fertilization program for the upcoming season.



LSU AgCenter Research & Extension

Soil Testing and Plant Analysis Laboratory
School of Plant, Environmental and Soil Sciences
Louisiana State University
Baton Rouge, LA 70803

Jones Fertilizer Co.
P.O. Box 2002
Commerce City, TX 77666

Date Received: 12/05/2011
Sample ID: 0815 28C
Soil Texture: silt loam
Area: Upland
Irrigated: Yes

Soil Test Results

Element (Mehlich3)	Value	Rice
pH (1:1 Water)	7.55	**High**
Phosphorus, ppm	5.38	**Very Low**
Potassium, ppm	75.27	**Medium**
Calcium, ppm	1,834.41	**Very High**
Magnesium, ppm	419.14	**Very High**
Sodium, ppm	109.25	**Optimum**
Sulfur, ppm	17.15	**High**
Copper, ppm	1.25	**High**
Zinc, ppm	3.35	**High**

RECOMMENDATION

Crop	Form	Units: lb/Acre	Nitrogen	Phosphate	Potash
rice			See Sheet	60	30

If there are any questions about this report, please contact your local extension service office at (Telephone 225/389-3056). The extension office also receive a copy of this report.

Note: ppm is equivalent to mg/Kg for soil and plant samples and is equivalent to mg/L for water samples.

Grid Sampling and Variable Rate Applications

Variable rate applications of nutrients and lime to adjust soil pH are feasible if fields are properly grid sampled. Applying nutrients and lime on parts of the field only where needed will improve crop yield, reduce costs to the grower and lower runoff from excess applications.

Another application of variable rate technology is soil electrical conductivity. Sensors have been developed to determine electrical conductivity that can be used to map nutrient and crop management zones that rely on the properties of soils. Crops can then be managed according to soil texture.

Cover Crops

Cover crops can provide positive benefits to growers and have an effect on reducing nitrogen and phosphorus movement off-field and into surface water. A winter cover crop, such as wheat, may take up excess nitrogen and phosphorous and thus reduce potential for leaching or runoff. Legume cover crops, such as crimson clover, add nitrogen to the soil, but limited research has not been able to quantify the amount of nitrogen to be credited for legume cover crops.

Cover crops also provide soil erosion control, which limits runoff-associated losses of nitrogen and phosphorous. Cover crops also can improve soil health by increasing organic matter inputs. In addition, some cover crops can provide an economic incentive if commodity prices remain stable, especially with soybeans.

Fertilizer Application Equipment

Injecting fertilizers below the soil surface and/or incorporating with tillage will reduce runoff losses. Fertilizer application equipment should be calibrated at least annually to ensure uniformity and accuracy of fertilizer application. Fertilizer equipment or storage vessels should not be cleaned out near bodies of surface water. Fertilizer should not be stored in areas where the possibility of contaminating groundwater or surface water could occur.

Generally Recommended Practices

1. Soil test for nutrient status and pH to determine the amounts of additional nutrients needed to reach designated yield goals and the amount of lime needed to correct soil acidity problems, determine the organic matter concentration to decide how much of these nutrients the particular soil is capable of holding, optimize farm income by avoiding excessive fertilization and reducing nutrient losses from leaching and runoff, and identify other yield-limiting factors such as high levels of salts or sodium that may affect soil structure, infiltration rates, surface runoff and, ultimately, groundwater quality.
2. Base fertilizer applications on soil test results, realistic yield goals, moisture prospects, crop nutrient requirements, past fertilization practices and previous cropping history.
3. Manage low soil pH by applying lime according to the soil test to reduce soil acidity and improve fertilizer efficiency, improve decomposition of crop residues and enhance the effectiveness of certain soil-applied herbicides.
4. Time nitrogen applications to correspond closely with crop uptake patterns that will increase nutrient use/efficiency and minimize leaching and runoff losses from fields.
5. Inject fertilizers or incorporate surface applications in conventionally tilled systems when possible to increase accessibility of fertilizer nutrients to plant roots, reduce volatilization losses of ammonia nitrogen sources and reduce nutrient losses from erosion and runoff.
6. Use animal manures and organic materials when available and economically feasible to improve soil tilth, water-holding capacity and soil structure and to recycle nutrients and reduce the need for commercial inorganic fertilizers.
7. Rotate crops when feasible to improve total nutrient recovery with different crop rooting patterns, reduce erosion and runoff and reduce diseases, insects and weeds.
8. Use legumes, where adapted, to replace part or all of crop needs for commercial nitrogen fertilizer, reduce erosion and nutrient losses and maintain residue cover on the soil surface.
9. Control nutrient losses in erosion and runoff by using appropriate structural controls, adopting conservation tillage practices (where appropriate), properly managing crop residues, leveling land, using filter strips (where possible) and implementing other soil and water conservation practices.
10. Skillfully handle and apply fertilizer by properly calibrating and maintaining application equipment, properly cleaning equipment and disposing of excess fertilizers containers and wash water, and storing fertilizers in a safe place.

Nutrient Management Plans

Both the U.S. Environmental Protection Agency and the U.S. Department of Agriculture are encouraging a voluntary approach to managing nonpoint-source issues related to agriculture. With the implementation of nutrient management plans all agricultural producers will ensure that fertilizers are managed responsibly.

Developing a Nutrient Management Plan

A nutrient management plan is a strategy for making wise use of plant nutrients to enhance farm profits while protecting water resources. It is a plan that examines your entire farming operation by making the best use of fertilizers and other nutrient sources. Successful nutrient management requires thorough planning and recognizes that every farm is different. The type of farming and the specifics of your operation will affect your nutrient management plan. The best plan is one that is matched to the farming operation and the needs of the person implementing the plan.

The Parts of a Nutrient Management Plan

Nutrients are brought to the farm through fertilizers and other off-farm soil amendments. These inputs are used, and some are recycled, by the row crop operation. Nutrients leave the farm in the harvested crop/product, runoff water and eroded soil. These are nutrient removals. Ideally, nutrient inputs and removals should be approximately the same.

When nutrient inputs to the farm greatly exceed nutrient removals from the farm, the risks of nutrient losses to groundwater and surface water are greater. When you check nutrient inputs against nutrient removals, you are creating a mass balance. This nutrient mass balance is an important part of a nutrient management plan and is important to understand for your farming operation.

Another important part of a successful nutrient management plan is soil testing, which helps you select the proper nutrient rate so crops can use nutrients efficiently. This not only reduces nutrient losses and protects the environment but can also increase farm profitability. Other best management practices may include managing the farm to reduce soil erosion, improving soil tilth through conservation tillage (reduced tillage and residue management), planting cover crops, or using filter strips and buffers to protect water quality.

The Basic Steps

Nutrient management plans (NRCS Code 590) consist of four major parts:

1.Evaluation of Nutrient Needs

a.Maps and Field Information

You will need a detailed map of your farm. The map should include farm property lines; field identification; locations of all surface waters such as ditches, canals, bayous, rivers, ponds or lakes and direction of surface flows with arrows indicating the direction of flow from the farm; and a soils map. This map will serve as the basis for the nutrient management plan, so each field should have a unique identification. In addition to the map, prepare a list of the crops to be grown in each field with a realistic yield goal for each crop. Most of this information is available at your local USDA Farm Service Agency office.

b.Locate Critical Areas

Certain areas on your farm such as canals, bayous, rivers, lakes or ponds are sensitive to nutrient overload. You should create buffer zones around these areas where nutrient use will be reduced or eliminated and indicate those on your map. Slowing water flow from ditches allows sediment to settle before being emptied into larger bodies of water. This can be achieved by shallower ditches and smaller diameter culverts. By buffering these water areas, water quality problems can be decreased.

c.Soil Testing (See previous section for details.)

d.Determine Nutrients Needed for Each Field

Based on soil test results, you can determine the nutrient needs of the crop. At a minimum, the amounts of lime, nitrogen, phosphorus and potassium should be listed in the plan for each field. Soil testing laboratories will provide recommended application rates based on soil test results. Your LSU AgCenter county agent can help you with this.

2.Inventory of Nutrient Supply

Many of the nutrients needed to grow your crops are already present on your farm in the soil or in crop residues. Knowing the amounts of nutrients already present in these sources is important so that you do not apply more nutrients than needed. A soil test is necessary to obtain a nutrient inventory.

3.Determining Nutrient Balance – Balance Between Supply and Need

Once you have determined both the supply and need of nutrients for each of your fields, a critical aspect of a nutrient management plan is balancing the two. This can be done in several ways. Most nutrient management plans are developed based on nitrogen, but other factors such as phosphorus and potassium could control how much you can use under certain conditions.

4. Preventive Maintenance and Inspections

Keeping good, detailed records that help you monitor your progress is essential to know if your NMP is to accomplish your goals. Examine how nutrients change over time based on your management practices. Records should be kept on crop yields and nutrient application rates, timing and methods. Keep detailed schedules and records on calibration of spraying and spreading equipment. When you have a major change in production, update your plan to reflect these changes.

Record Keeping

Keeping good, detailed records that help you monitor your progress are important to determine if your goals have been accomplished. Always keep records of:

- Nutrient management plan documents.
- Soil and plant tissue tests. Observe the response to management practices over time.
- Purchased fertilizers.
- Crop yields. Update your management plan as production changes.
- Nutrient application rates, timing and application methods.
- Detailed schedules and records on calibration of application equipment.
- Emergency action plan documents.

Where Can You Obtain Information Needed for Your Nutrient Management Plan?

The LSU AgCenter, the USDA's Natural Resources Conservation Service, the Louisiana Department of Agriculture and Forestry, certified crop advisers or other private consultants will be able to assist you in developing parts of a nutrient management plan.

A nutrient management plan is a good tool to help you use your on-farm and off-farm resources more efficiently and to prevent future problems. A successful plan will help you obtain the maximum profit while protecting the environment.

Irrigation and Land Management

Proper irrigation water management (NRCS Code 449) means timing and regulating water applications in a way that will satisfy the needs of a crop and efficiently distribute the water without applying excessive amounts of water or causing erosion, runoff or percolation losses.

Good irrigation water management can reduce moisture extremes. Crop producers should have a good understanding of the factors influencing proper irrigation scheduling and water management. The timing of irrigation and the total amount applied per irrigation should be based on both the crop's water use and the moisture content of the soil, as well as on expected rainfall.

Crop residue cover and tillage practices play important roles in the way crops use water and also affect the ability of irrigation systems to replace that water. Tillage practices (NRCS Codes 329, 345 and 346) and crop residue management (NRCS Code 344) play important roles in the way irrigation systems perform and are managed. Tillage practices affect the way water moves into and off of the soil (infiltration and runoff). Decreasing tillage also can result in increasing organic matter, which plays a big part in increasing the water-holding capacity of the soil.

Managing Furrow Irrigation Systems (NRCS Practice 443, Irrigation System, Surface and Subsurface)

Many factors affect the performance of furrow irrigation systems. Physical conditions, such as soil texture, soil structure, field slope, field length, furrow shape and the amount of crop residue cover, all have some effect on the performance of the irrigation system. The way the system is managed, including the furrow flow rate, length of application time and irrigation frequency, also affects system performance.

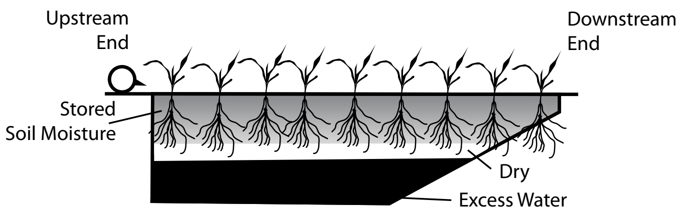
Irrigation system performance often is measured in terms of the percentage of the water applied that remains in the active root zone after the irrigation (application efficiency). Thus, deep percolation (water passing through the root zone) and runoff (tailwater) should be held to a minimum while supplying adequate water to the crop along the length of the furrow.

Tillage practices affect furrow irrigation systems by altering the infiltration characteristics of the soil and by altering crop residue in the furrow. Both factors affect the ability of the furrow to convey water down the field. As tillage practices become less intensive, infiltration rates often increase.

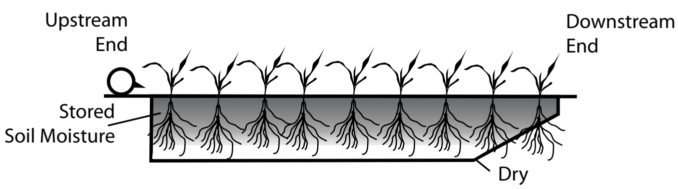
The need to match management factors with the physical conditions present at the time of irrigation is critical. In some cases, a change in tillage practice may cause changes in infiltration rates that are too severe to overcome with management factors alone. In some cases, physical changes to the system may be necessary. The field slope or length of run may need to be changed or furrow packing may be used to help overcome problems associated with extreme increases in infiltration characteristics. (NRCS Code 464, Irrigation Land Leveling).

Proper furrow irrigation practices can minimize water application, irrigation costs and chemical leaching and can result in higher crop yields. Irrigating the entire field as quickly as possible is often the goal of a furrow irrigator. Often irrigators are satisfied just to get the water to the end of the furrows, but consideration should be given to how much water is being applied and how it is distributed.

The number of gates opened or tubes set – the set size – has a significant effect on how fast the water advances across the field and the amount of water being applied. Set size should change during the season and between years to match changing soil intake conditions and crop needs throughout the growing season. Operating too few gates or tubes and using a long set time can result in a large amount of runoff, But operating too many gates or tubes can result in slow water advance, causing poor water distribution and deep percolation losses (Figure 1, !a). These conditions result in reduced irrigation efficiency.



1a. Poor uniformity - adjust stream size and set time



2a. Ideal infiltration pattern

Figure 1. Infiltration profiles under conventional furrow irrigation.

Efficient irrigation is obtained by almost filling the effective crop root zone during each irrigation event, applying water uniformly (Figure 1, 1b) and by either minimizing or using runoff. For furrows, runoff and the uniformity of the water infiltrated along the furrow are related to soil intake rate, flow rate entering the furrow and the irrigator's management practices such as set time, set size, etc.

The correct amount of water to apply during each irrigation event depends on the amount of water used by the plants between irrigations, the water-holding capacity of the soil and the depth of the crop roots. The rate at which water goes into the soil varies from one irrigation event to the next and from season to season. One common problem in furrow irrigation is that too much water is applied, especially during the first irrigation event.

In general, apply water when the crop has used about one-half of the available water capacity in the root zone. When applying water, don't completely fill or overfill the root zone. Overfilling leaches chemicals, such as nitrate-nitrogen; wastes water; and increases costs. Leave room in the soil for storing about 0.5 to 1 inch of rainfall that might occur soon after you irrigate.

The first irrigation often occurs when roots have penetrated about 18 to 24 inches. For the first irrigation, a light application is all that is needed to refill the active root zone. In Louisiana, precipitation usually replenishes the soil profile below this depth. On medium-textured soils, 1.5 to 2 inches of water is all that is necessary to replenish the soil moisture in the top 12 inches of soil.

Return Flows

"Irrigation return flow" is the portion of water that returns to its source after being used to irrigate crops. With increasing environmental concerns, the term "irrigation return flow" has been extended to include irrigation water that makes its way to any body of water after its use on a crop.

Tailwater from furrow irrigation and runoff caused by excessive irrigation or poor system design can make its way into drainage ditches, which eventually lead to bayous, rivers and lakes. Water from irrigated land that is artificially drained must go somewhere – often into the same water body it was taken from.

Irrigation return flow is becoming an important issue because of its potential to be a nonpoint-source of pollution. This is not the only reason producers should use return flow management practices, however. Excessive runoff is a symptom of poor irrigation system design or poor management of irrigation water. It also is water that is wasted. Wasting water not only has immediate financial ramifications but also threatens the long-term availability of water for irrigation. Sound management practices can reduce irrigation return flow while ensuring the most efficient use of water resources.

The major concern is the direct runoff that may occur from irrigated land. Many of the fertilizer nutrients and chemicals used in agriculture are easily adsorbed onto soil particles. When runoff occurs, soil particles containing these adsorbed materials are picked up and transported out of the field. Eroded sediments constitute the major potential for pollution from surface return flows. In addition, soluble chemicals are dissolved by runoff and carried with the water as it flows over the soil.

There are three basic approaches to reducing pollutants in surface return flows:

- Eliminating or reducing surface runoff.
- Eliminating or reducing soil loss.
- Reducing pollutants from irrigation return flow.

The first two approaches are achieved by properly designing, operating and managing irrigation systems, as well as adopting a production system that encourages the accumulation of organic matter.

The third approach involves using grass buffer strips (NRCS Code 386), artificial wetlands (NRCS Code

645), settling basins and ponds (NRCS Code 350) and similar structures to reduce pollutant-bearing sediments. Treating return flow is more costly and troublesome than preventing it.

Managing Sprinkler Systems

Crop residues serve a largely positive role in sprinkler irrigation system management. Selecting a tillage system that is best suited for a particular field situation can be a very important decision. Disregard for the importance of this decision could directly diminish the effectiveness of the water application system and negatively influence other crop production practices, as well.

In general, concerns associated with tillage practice selection and irrigation management are related to the potential for runoff and erosion. The potential for runoff exists whenever the water application rate of the irrigation system exceeds the infiltration rate of the soil.

One option is to reduce the application depth per irrigation. In doing so, the operator reduces the potential for runoff but increases the opportunity for soil evaporation over the course of the growing season. Although crop residues can help reduce the magnitude of soil evaporation losses, repeated wetting of the soil surface will limit the water savings attributed to crop residues.

Runoff also may be generated if the soil infiltration rate is reduced over a period of time. A number of factors, such as soil texture and structure, surface tillage or water application, can reduce infiltration. For example, as the size and number of water droplets increase, fine soil particles are consolidated on the surface to form a thin crust. As the soil crust develops, the water infiltration rate tends to decrease. Soil surface crusts can result in infiltration rate reductions of up to 75 percent.

One way to combat the negative effect of water droplets is to be sure crop residues are distributed evenly over the soil surface. Crop residues spread in this manner protect the soil by absorbing energy carried by falling water droplets. This limits soil crust development, resulting in a more consistent infiltration rate throughout the growing season.

Tillage practices that result in minimal soil disturbance should be used when topography is rolling. On highly erodible land, it is important to check with your local Natural Resources Conservation Service office or Soil and Water Conservation District office regarding compliance with conservation plans while making these decisions.

Crop residues also act like small dams for temporary soil surface storage of excess water. Water applied in excess of the soil infiltration rate will be blocked from running off the field long enough for infiltration to occur. This results in more uniform water application. In the process, soils that would have been transported with the runoff water remain near their point of origin.

Another option is to alter the operating characteristics of the irrigation system. For example, by selecting a sprinkler based on soil type and field topography, you can match more closely the water application rate with the soil infiltration rate. By considering the interaction between sprinkler types and soil, selection of unsuitable sprinklers can be avoided.

The combination of improved water application uniformity resulting from more consistent infiltration rates, less runoff and reduced soil evaporation losses makes crop residues a major factor in the water conservation effort. Residue management (NRCS Code 344) also can be a crucial component to minimizing the effects of irrigation on surface water quality.

Center Pivot Irrigation Systems (NRCS Code 442)

The center pivot is the system of choice for agricultural irrigation because of its low labor and maintenance

requirements, convenience, flexibility, performance and easy operation. When properly designed, operated and equipped with high efficiency water applicators, a center pivot system conserves three precious resources—water, energy and time.

Manufacturers recently have improved center pivot drive mechanisms (motors, gears and shafts), control devices, optional mainline pipe sizes, outlet spacing, span lengths and structural strength. The first pivots produced in the 1950s were propelled by water motors. They operated at high pressures of 80 to 100 psi and were equipped with impact sprinklers and end guns that sprayed water toward the sky, resulting in significant evaporation losses and high energy use.

Today, pivots are driven by electric or oil hydraulic motors located at each tower and guided by a central control panel. Pressures as low as 10 to 15 psi (at the pivot mainline) usually are adequate for properly designed low elevation spray application (LESA) and low energy precision application (LEPA) pivots that are 1/4 mile long and operating on level to moderately sloping fields. Water application efficiency with such systems is 85 to 98 percent. On occasion, sprinkler packages may be improperly matched with the soil infiltration rate. Irrigation system management and tillage practices may be used to control runoff if changes in the irrigation system itself are desirable.

Pivot Design Choices

When purchasing a center pivot system, you must select:

- Mainline size and outlet spacing.
- Length, including the number of towers.
- Drive mechanisms.
- Application rate of the pivot.
- Type of water applicator.

These choices affect investment and operating costs, irrigation efficiency and crop production. Wise decisions will result in responsible water management and conservation, flexibility for future changes and low operating costs.

Switching from furrow to pivot irrigation can save water and money. For example, on the Texas High Plains, field measurements show corn is irrigated an average of 16 to 17 hours per acre per year with furrow irrigation. With center pivot mid-elevation spray (MESA) irrigation (over canopy applicators), similar corn yields are produced with 12 to 13 hours per acre per year. LEPA and LESA applicators further reduce irrigation to an average of 10 to 11 hours per acre per year.

Pivot Costs

A quarter-mile (1,300-foot) system that irrigates about 120 acres typically costs $325 to $375 per acre excluding the cost of groundwater well construction, turbine pumps and power units. Longer systems usually cost less on a per-acre basis. For example, half-mile systems (2,600 feet) that irrigate approximately 500 acres cost about $200 to $250 per acre.

This relatively high cost often is offset by a number of advantages, including reduced labor and tillage, improved water distribution, more efficient pumping, lower water requirements, more timely irrigation and convenience. Programmable control panels and remote control via phone lines or radio can start and stop irrigation, identify location, increase or decrease travel speed and reverse direction.

Fertilizers and certain plant protection chemicals can be applied through the center pivot, which increases the value and use of the system. Programmable injection unit control, monitoring and safety are compatible with center pivot control systems. Towable pivot machines are available so additional tracts of land can be irrigated with the same machine. When considering a towable machine, remember that sufficient water is needed to irrigate all tracts. Plan the irrigated circle and position the pivot so it can be moved to drier soil along a suitable towing path.

Traveling Guns

Traveling gun sprinkler systems are either cable-tow or hard-hose drag travelers. The cable-tow traveler consists of a single gun sprinkler mounted on a trailer with water supplied through a flexible synthetic fabric, rubber-coated or PVC-coated hose. The pressure rating on the hose is normally 160 psi. A steel cable is used to guide the gun cart, a wheel or sled-type cart.

The hose drag traveler consists of a hose drum, a high-density polyethylene hose and a gun-type sprinkler. The hose drum is mounted on a multiwheel trailer or wagon and rotated by a water turbine, water piston, water bellows or internal combustion engine. Regardless of the drive mechanism, travelers should be equipped with speed compensation so the gun cart travels at a uniform speed from the beginning of the pull until the hose is fully wound onto the hose reel.

The hose supplies water to the gun sprinkler and also pulls the gun cart toward the drum. The distance between adjacent pulls is referred to as the lane spacing. To provide proper overlap, the lane spacing is normally between 70 percent and 80 percent of the gun's wetted diameter.

The gun sprinkler is mounted on the gun cart. Normally, only one gun is mounted on the gun cart. A typical layout for a hard-hose drag traveler irrigation system is shown in Figure 2. For uniform distribution, nozzle sizes on gun-type travelers are 1/2 to 2 inches in diameter and require operating pressures of 50 to 100 psi at the gun.

Gun sprinklers have a ring, taper ring or taper bore nozzle. The ring nozzle provides better breakup of the stream, which results in smaller droplets with less impact energy (less soil compaction). But, for the same operating pressure and flow rate, the taper bore nozzle throws water about 5 percent farther than the ring nozzle. That means wetted diameter of a taper bore nozzle is 5 percent wider than the wetted diameter of a ring nozzle. Taper bore nozzles also provide better application uniformity throughout the wetted radius, resulting in about a 10 percent larger wetted area than the ring nozzle. Thus, the precipitation rate of a taper bore nozzle is approximately 10 percent less than that of a ring nozzle.

A gun sprinkler with a taper bore nozzle normally is sold with only one size of nozzle. A ring nozzle, however, often is provided with a set of rings ranging in size from 1/2 to 2 inches in diameter, giving the operator the flexibility to adjust flow rate and throw diameter without sacrificing application uniformity.

A misconception exists, however, that using a smaller ring with a lower flow rate will reduce the precipitation rate. This is not normally the case. Rather, the precipitation rate remains about the same because a smaller nozzle results both in a lower flow and in a smaller wetted radius or diameter. The net effect, therefore, is little or no change in the precipitation rate.

Furthermore, on water drive systems, the speed compensation mechanism is affected by flow rate, and a minimum threshold flow is required for proper operation of the mechanism. If the flow drops below the threshold, the travel speed becomes disproportionately slower, resulting in excessive application even though a smaller nozzle is being used.

Thus, system operators should be knowledgeable of the relationships between ring nozzle size, flow rate, wetted diameter and travel speed before interchanging different nozzle sizes. As a general rule, operators should consult with a technical specialist before changing any nozzle size to a one that is different from what was specified by the system design.

Advantages:

- Moderate labor requirements.
- Few or no plugging problems with the large nozzle.
- Flexible with respect to land area.

Limitations:

- Higher initial cost than systems mentioned earlier.
- High power requirement.
- More mechanical parts than the other systems, especially with an auxiliary engine.
- Limited variability of application rate.

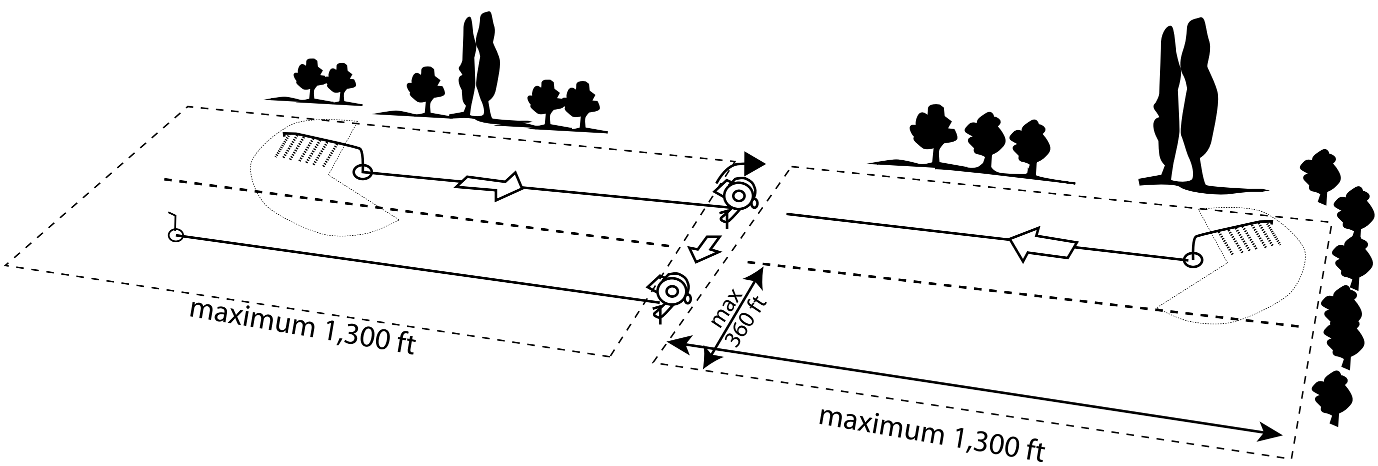


Figure 2. Layout of a hard-hose drag traveler. Travel lanes are 100-360 feet apart, depending on sprinkler capacity and diameter coverage.

Irrigation practices that can reduce or prevent erosion include:

- **Use cover crops on unprotected, easily erodible soils. (NRCS Code 340)**
- **Manage crop residues to reduce surface water contamination. (NRCS Code 344)**
- **Use conservation tillage practices. (NRCS Codes 329, 345 and 346)**
- **Precision level the land to optimize furrow slopes to reduce soil erosion. (NRCS Code 464)**
- **Install tailwater drop structures. (NRCS Code 447)**

Cover Crops (NRCS Code 340)

Cover crops usually are planted when the primary commodity crop is not growing, but such crops may be grown during part of the primary crop growth period.

A cover crop:

- Protects soils from erosion and reduces sedimentation.
- Filters runoff water to reduce pesticide and nutrient losses.
- May uptake residual nutrients, preventing them from being lost to the environment and storing them in biomass for use by the subsequent cash crop.
- May provide supplemental nitrogen if it is a legume.

Agricultural producers should select the combination of tillage and cropping systems that will provide the best protection for soil and water resources. The use of agricultural chemicals should be minimized, especially where the environment is vulnerable. An example of such a situation is the production of crops, such as corn, requiring high levels of nitrogen fertilization on coarse, sandy soils over shallow groundwater. Heavy fertilization on clay-textured soils (with rapid runoff potential) near surface water would pose a similar hazard. Appropriate practices can be determined by the specific soil conditions in each field and by the pollution potential that exists. Producers have many alternatives in voluntarily implementing water protection measures.

Crop Residue Management (NRCS Code 344)

Conservation tillage's greatest effect on surface water quality is reduced runoff. Residues protect the soil surface from the impact of raindrops and act like a dam to slow water movement. Rainfall stays in the crop field, allowing the soil to absorb it.

The decomposition of these residues also increases the soil organic matter. Soils with high organic matter content are less likely to erode than soils with low organic matter content. With conservation tillage, less soil and water leave a field.

The table (Table 1) shows the effects of residue cover on surface runoff and soil loss. An increase in residue cover significantly decreases runoff and sediment loss from a field. Typically, 30 percent residue cover reduces soil erosion rates by 50 percent to 60 percent compared to conventional tillage practices.

Sediment directly damages water quality and reduces the usefulness of streams and lakes in many ways, including:

- Impaired fish spawning areas.
- Reduced light penetration for aquatic life.
- Increased water purification costs.
- Lower recreational value.
- Clogged channels and increased flooding.
- Increased dredging to maintain navigation.
- Reduced storage capacity for reservoirs.

In addition, sediment often is rich in organic matter. Nutrients such as nitrogen and phosphorus and certain pesticides also may enter streams with sediment. The detrimental effects of these substances accompanying the sediment may include:

- Rapid algae growth.
- Oxygen depletion as organic matter and algae decompose.
- Fish kills from oxygen depletion.
- Toxic effects of pesticides on aquatic life.
- Unsafe drinking water because of nitrate or pesticide content.

Table 1. Effects of surface residue cover on runoff and soil loss.

Residue Cover %	Runoff % of Rain	Runoff Velocity ft./minute	Sediment in Runoff % of runoff	Soil Loss tons/acre
0	45	26	3.7	12.4
41	40	14	1.1	3.2
71	26	12	0.8	1.4
93	0.5	7	0.6	0.3

Conservation Tillage Systems/ Practices (NRCS Codes 329, 345 and 346)

In conservation tillage, crops are grown with minimal cultivation of the soil. When the amount of tillage is reduced, the stubble or plant residues are not completely incorporated, and most or all remain on top of the soil rather than being plowed or disked into the soil. The new crop is planted into this stubble or small strips of tilled soil. Weeds are controlled with cover crops or herbicides rather than by cultivation. Fertilizer and lime are either incorporated earlier in the production cycle or placed on top of the soil at planting.

A sequence of changing tillage practices in several watersheds in Oklahoma enabled comparison of surface-water and groundwater effects associated with native grasses, conventionally tilled wheat and no-till wheat. Conversion of native grasses to conventionally tilled wheat increased soil loss dramatically. In areas where no-till cultivation was practiced, however, dramatic reductions in soil loss were minimized. This obvious conclusion was made further relevant by the fact that nutrient runoff was substantially reduced as a consequence of soil retention and soil moisture increased as an added benefit.

Reduced tillage practices in agronomic crops from forages such as corn, wheat and other forage species were introduced more than 50 years ago to conserve soil and water. Fifty years have proven crops grown without tillage use water more efficiently. In addition, the water-holding capacity of the soil increases, and water losses from runoff and evaporation are reduced. For crops grown without irrigation in drought-prone soils, this more-efficient water use can translate into higher yields. In addition, soil organic matter and populations of beneficial insects are maintained, soil and nutrients are less likely to be lost from the field and less time and labor is required to prepare the field for planting. In general, the greatest advantages of reduced tillage are realized on soils prone to erosion and drought.

There also are disadvantages of conservation tillage. Potential problems are compaction, flooding or poor drainage, delays in planting because fields are too wet or too cold and carryover of diseases or pests in crop residue. Another consideration is that as no-till is generally practiced in agronomic crops, the field is prepared for planting by killing the previous crop with herbicidal desiccants such as glyphosate (e.g., Roundup) or gramoxylin (e.g., Paraquat). The no-till seeders available for agronomic crops were designed to plant into these dried residues. Recently, agronomists have been developing no-till systems where cover crops are planted for weed control and then killed with flail or other types of mechanical cutters instead of herbicides. No-till seeders must be modified to work on these tougher residues.

This practice may be applied as part of a conservation management system to supplement one or more of the following:

- Reduce sheet and rill erosion.
- Maintain or improve soil organic matter content and tilth.
- Conserve soil moisture
- Provide food and cover for wildlife.

The table below (Table 2) summarizes the effects of conservation tillage on surface water quality. Conservation tillage significantly reduces surface runoff, decreasing the amount of sediment, nutrients and pesticides in surface waters.

Table 2. Summary of conservation tillage effects on sediment and chemicals in surface runoff (adapted from Sims, et al., 1994)

Item	Effect
Sediment	Surface water runoff decreases with reduced tillage; less soil leaves the field.
Nitrogen	Runoff decreases with reduced tillage, resulting in less nitrogen loss, although runoff concentrations may be higher.
Phosphorus	Phosphorus is mainly associated with sediment. Conservation tillage typically decreases sediment losses, resulting in less phosphorus lost in runoff.
Pesticides	Loss of sediment-associated materials decreases with reduced tillage. Runoff losses of pesticides appear to decrease with use of conservation tillage, although initial runoff concentrations may be higher.

Living vegetation and crop residues left on the soil surface are important in:

- Intercepting rainfall and reducing the impact of raindrops on the soil surface.
- Reducing erosion and sedimentation by decreasing runoff velocity.
- Increasing structural stability of soil aggregates.
- Increasing biological activity in the soil.
- Screening out soil particles from runoff water.

Residue production varies widely from one crop to another. For example, soybean residue breaks down much more quickly than wheat residue. Therefore, particularly on highly erodible soils, it is important to carefully select the type of crop to be grown to enhance the amount of residue left on the soil surface after harvest.

Conservation Tillage

- Requires a 30 percent surface residue cover immediately after planting.
- Requires careful management of residue from previous crops.
- Protects the soil surface from erosion and reduces the amount of sediment and chemicals in runoff water.
- May require greater reliance on pesticides.

The following practices will reduce the potential for nonpoint-source pollution from agricultural production:

Precision Land Forming (NRCS Code 462)

Precision land forming is a practice designed to improve surface drainage, control runoff and reduce erosion by reshaping the surface of the land to planned grades (in situations where it is desired and the land is suitable for this practice). Soils must be of sufficient depth and of suitable textures so an adequate root zone remains to permit the planned use of the land after precision land forming is completed.

The practice is used as an integral part of an overall system to facilitate the conservative use of soil and water resources. It can be used in combination with other conservation practices such as grassed waterways, drainage field ditches and filter strips to accomplish specific goals.

Tailwater Recovery (NRCS Code 447)

Tailwater recovery is a practice implemented to conserve irrigation water supplies and improve offsite water quality. It may include facilities for the collection, storage and transportation of irrigation tailwater – including pickup ditches, sumps, collecting basins, pumping plants and pipelines.

Practices that address treatment of sediment-laden water include:

- Install vegetative field boarders and strips (NRCS codes 386 and 393).
- Collect and reuse surface runoff (NRCS Code 570).
- Install sedimentation basins (NRCS Code 350).

Stormwater Treatment

Field Borders and Filter Strips (NRCS Codes 386 and 393)

Field borders and filter strips are strips of grass or other close-growing vegetation planted around fields and along drainage ways, streams and other bodies of water. They are designed to reduce sediment, organic material, nutrients and chemicals carried in runoff, as well as provide habitat.

In a properly designed filter strip, water flows evenly through the strip, slowing the runoff velocity and allowing contaminants to settle from the water. In addition, where filter strips are seeded, fertilizers and herbicides no longer need to be applied next to susceptible water sources.

Soil particles (sediment) settle from runoff water when flow is slowed by passing through a filter strip. The largest particles (sand and silt) settle within the shortest distance. Finer particles (clay) are carried the farthest before settling from runoff water and they may remain suspended when runoff velocity is high. Farming practices upslope from filter strips affect the ability of strips to filter sediment. Fields with steep slopes or little crop residue will deliver more sediment to filter strips than more gently sloping fields and those with good residue cover. Large amounts of sediment entering the filter strip may overload the filtering capacity of the vegetation, and some may pass through.

Filter strip effectiveness depends on five factors:

1. The amount of sediment reaching the filter strip. This is influenced by:

- Type and frequency of tillage in cropland above the filter strip. The more aggressive and frequent tillage is above filter strips the more likely soil is to erode.
- Time between tillage and rain. The sooner it rains after a tillage operation the more likely soil is to erode.
- Rain intensity and duration. The longer it rains, and thus the more sediment deposited, the less effective filter strips become as they fill with soil.
- Steepness and length above the filter strip. Water flows faster down steeper slopes. Filter strips below steep slopes need to be wider in relation to the cropland that is being drained to slow water and sediment movement adequately.

In general, a wider, uniformly shaped strip is more effective at stopping or slowing pollutants than a narrow strip. As a field's slope or watershed size increases,

wider strips are required for effective filtering. Table 3 gives the suggested filter strip width based on slope. For a more accurate determination of the size of filter strip you will need for your individual fields, consult your local Natural Resources Conservation Service or Soil and Water Conservation District office.

Table 3. Suggested Vegetated Filter Strip Widths Based on Land Slope Percentage.

Land Slope, %	Strip Width, Feet
0-5	20
5-6	30
6-9	40
9-13	50
13-18	60

*Widths are for grass and legume species only and are not intended for shrub and tree species. Adapted from the NRCS Field Office Technical Guide, 1990.

Where the majority of sediment and sediment-associated pollutants, such as phosphorus and pesticides, are controlled by no-till cultivation and the buffer is in an upland position or the stream next to the buffer is incised (Figure B), a 50-foot buffer is needed – either 50 feet of tree buffer or 25 feet of trees next to the stream plus 25 feet of grass buffer. If the stream or ditch is in a lower position in a landscape with hydric soils (very wet soils), a 25-foot vegetated (trees, grass or shrubs) buffer is considered sufficient to reduce nitrogen, assuming that erosion is minimal either because conservation tillage is used or the topography is very flat (Figure C).

Where the pollutant of concern is nitrogen, a fenced, 25-foot buffer is considered sufficient (Figure D). Grass buffers can be used if the stream bank is stable; otherwise, a tree buffer should be used. If livestock are permanently or occasionally present, it is necessary to fence them out of streams to reduce stream-bank degradation and nutrient deposition. A buffer of 25 feet is considered sufficient to reduce the low levels of nitrate moving into the stream.

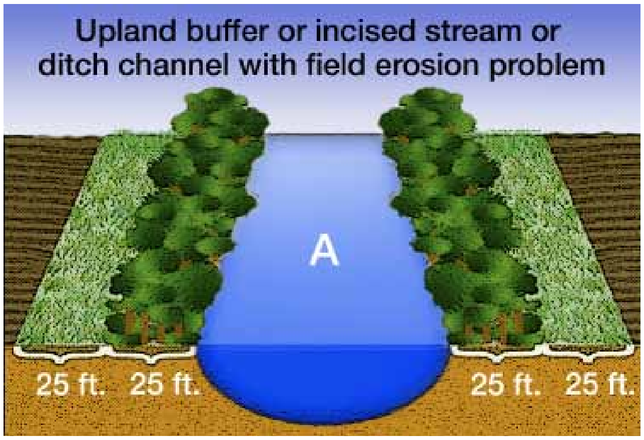


Figure A. Ideal buffer: 25 ft. forested on side of channel and 25 ft. grassed bottom next to field.

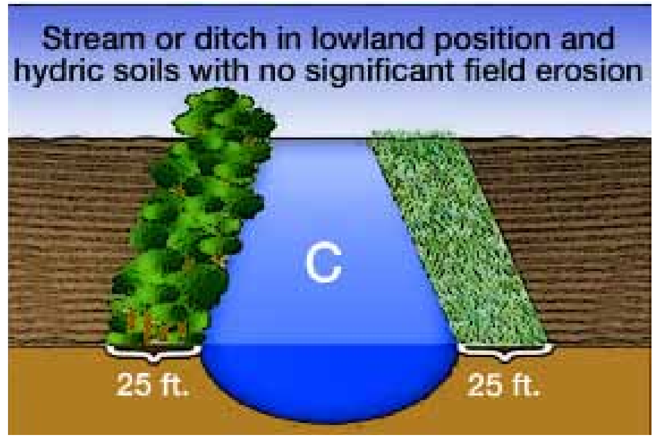


Figure C. Stream or ditch in lowland position and hydric soils with no significant field erosion.

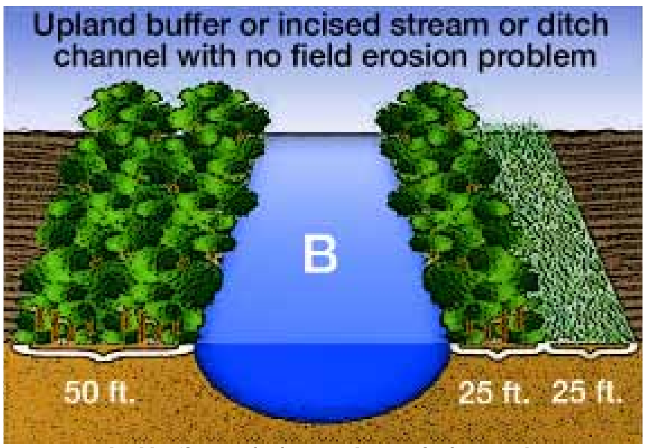


Figure B. Ideal buffer: 50 ft. forested or 25 ft. forested next to stream with no field erosion problem.

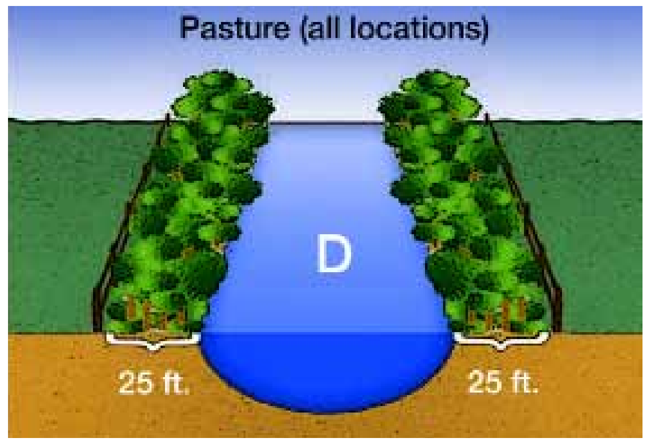


Figure D. Adequate buffer: 25 ft. forested each side of stream.

2. The amount of time water is retained in the filter strip. This is influenced by:

- Width of the filter area. Filter strips will vary in width, depending on the percentage of slope, length of slope and total drainage area above the strip.
- Type of vegetation and quality of stand. Tall, erect grass can trap more sediment than short, flexible grass. The best species for filter strips are tall, perennial grasses. Filter strips may include more than one type of plant and may include parallel strips of trees and shrubs, as well as perennial grasses. In addition to potential for improving water quality, these strips increase diversity of wildlife habitat.

3. Infiltration rate of the soil

Soils with higher infiltration rates will absorb water and the accompanying dissolved nutrients and pesticides faster than soils with low infiltration rates. Soil survey reports for Louisiana parishes include a table listing the infiltration rate group for the soils identified in each parish.

4. Uniformity of water flow through the filter strip

Shallow depressions or rills need to be graded to allow uniform flow of water into the filter strip and along its length. Water concentrated in low points or rills will flow at high volume, so little filtering will take place.

5. Maintenance of the filter strip

When heavy sediment loads are deposited, soil tends to build up across the strip, forming a miniature terrace. If this becomes large enough to impound water, water eventually will break over the top and the flow will become concentrated in that area. Strips should be inspected regularly for damage. Maintenance may include minor grading or re-seeding to keep filter strips effective.

Grassed Waterways (NRCS Code 412) are natural or constructed channels that are shaped or graded to required dimensions and planted in suitable vegetation to carry water runoff. They are designed to carry this runoff without causing erosion or flooding and to improve water quality by filtering out some of the suspended sediment.

Riparian Buffers (NRCS Code 391) are areas of trees, shrubs and other vegetation located adjacent to and uphill from water bodies. This practice may be applied in a conservation management system to supplement one or more of the following:

- To create shade to lower water temperature, which improves habitat for aquatic organisms.
- To remove, reduce or buffer the effects of nutrients, sediment, organic material and other pollutants before entry into surface water and groundwater recharge systems.

This practice applies on crop hay, range, forest and pasture areas adjacent to permanent or intermittent streams, lakes, rivers, ponds, wetlands and areas with groundwater recharge where water quality is impaired or where there is a high potential of water quality impairment.

In summary:

- Vegetative filter strips can reduce sediment effectively if water flow is even and shallow.
- Filter strips must be properly designed and constructed to be effective.
- Filter strips become less effective as sediment accumulates. With slow accumulation, grass regrowth between rains often restores the filtering capacity.
- Filter strips remove larger sediment particles of sand and silt first. Smaller clay-size particles settle most slowly and may be only partially removed, depending on the strip width and water flow rate.
- Because soil-bound nutrients and pesticides are largely bound to clay particles, filter strips may be only partially effective in removing them.
- Fewer dissolved nutrients and pesticides will be removed than those bound to soil particles.
- Filter strips are a complementary conservation practice that should be used with in-field conservation practices such as conservation tillage, contour buffer strips, strip cropping and waterways.

Other Important Conservation Practices for Agronomic Crops

Land Smoothing (NRCS Code 466)

Land smoothing of fields is closely related to precision land forming (NRCS Code 462) and involves precision grading to reduce land slope. In some cases, rows can be lengthened and ditches can be eliminated, which reduce runoff and afford an opportunity to use the headland as a filter strip. Precision grading improves surface drainage, provides for more effective use of precipitation, obtains more uniform planting depths, provides for more uniform cultivation and improves equipment operation.

Surface Drainage – Field Ditch (NRCS Code 607)

A graded ditch for collecting excess water in a field or for irrigation water drainage. This practice intercepts or collects surface water and carries it to an outlet.

Irrigation Canal or Lateral (NRCS Code 320)

A permanent irrigation canal or lateral constructed to move water from the source of supply to one or more farms. The conservation objectives are to prevent erosion or degradation of water quality or damage to land, to make proper water use possible and to move water efficiently.

Open Channel (NRCS Code 582)

The constructing or improving of a channel, either natural or artificial, in which water flows with a free surface. It provides discharge capacity required for flood prevention, drainage or a combination of these purposes.

Grassed Waterways (NRCS Code 412)

These are natural or constructed channels that are shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff. They are designed to convey runoff without causing erosion or flooding and to improve water quality.

Upland Wildlife Habitat Management (NRCS Code 645)

Any combination of grasses, legumes, shrubs and trees used to create habitat or link separate wildlife habitats and provide cover for wildlife to travel between habitats. Corridors, like vegetated filter strips, may provide some filtering of pollutants from nearby croplands but they primarily provide benefits for wildlife and divert wildlife from adjacent fields.

Riparian Zones (Forested Buffers, NRCS Code 391, and Herbaceous Cover, NRCS Code 390)

A riparian zone consists of the land adjacent to and including a stream, river or other area that is at least periodically influenced by flooding in a natural state. Similar to vegetated filter strips, plants in riparian areas effectively prevent sediment, chemicals and organic matter from entering bodies of water. Unlike filter strips, riparian zones use plants that are of a higher order, such as trees or shrubs, as well as grasses or legumes. Vegetated filter strips often are used in riparian areas as initial filtering components next to crop field borders.

Lined Waterway or Outlet (NRCS Code 468):

A waterway or outlet having an erosion-resistant lining of concrete, stone or other permanent material. The lined section extends up the side slopes of the outlet. It provides for efficient flow of runoff without damage from erosion.

Crop Rotation (NRCS Code 328)

Systems in which crops are alternated from one year to the next; commonly a low residue crop is followed by a high residue crop, or a legume is rotated with a nonlegume crop. This practice reduces the need for pesticides and perhaps fertilizers. Where legumes are included in the rotation, it decreases the need for manufactured nitrogen. Where erosion is a problem, high residue crops are included in the rotation to reduce soil loss.

For more information on these practices and how to implement them, contact your local Natural Resources Conservation Service off, Soil and Water Conservation District Office or LSU AgCenter Extension Service office.

General Farmstead Management

Farmstead management is a generic term to describe several best management practices that might be necessary on your farm. Consult with your local Natural Resources Conservation Service office or LSU AgCenter Extension Service county agent to determine which, if any, of these practices might benefit your situation.

Heavy-Use Area Protection (NRCS Code 561)

Open, unpaved, bare areas are common on Louisiana dairies. Examples are feeding or watering areas, pathways to the barns, pre-milking staging areas, shaded animal areas and transition areas from pavement to dirt. These areas may be considered to need runoff controls in most cases, and improvements to these areas will minimize the effects of runoff into streams.

Some unpaved areas of bare dirt that receive moderate traffic with not too heavy a weight may be underlaid with suitable surface materials to reduce muddy conditions. One option might be geotextile fabric or filter cloth. If used, the surface on which the nonwoven geotextile is placed should be graded smooth and free of loose rocks, depressions, projections and standing or flowing water. The geotextile is unrolled and placed loosely on the graded soil surface, overlapping at the seams by 18 inches. Approximately 4 to 6 inches of crusher-run gravel is placed on top of the geotextile. This installation allows surface liquids to drain through and provides a firm footing for the animals, thereby preventing miring of their hooves.

When possible, bare ground areas should be located at least 100 feet away from perennial streams and 25 feet from intermittent streams and drainage ways and should have a permanently vegetated buffer between them and the drainage area. Sloping areas should have cross terraces to reduce erosion and to collect eroded sediment and solids. At the lowest point of the bare area edge, earthen or concrete settling basins can help trap solids that may otherwise leave in rainfall runoff. Areas with very light traffic can sometimes be seeded with grass, thus eliminating the need for geotextile fabric and gravel or rock.

Critical Area Planting (NRCS Code 342)

Examples of applicable areas are levees, cuts, fills and denuded or gullied areas where vegetation is difficult to establish by usual planting methods. The easiest and most effective way to protect these areas is to maintain perennial plants in these locations. These plants provide soil stabilization, help control erosion, provide water quality protection and supply wildlife habitat.

The roots of native grasses, low shrubs and aquatic plants bind to the soil and provide the necessary benefits. Proper treatment of a critical area involves the planting of vegetation, such as trees, shrubs, vines, grasses or legumes, on highly erodible or critically eroding areas. This practice does not include planting trees for wood products.

Although any rooted plants growing in these areas are helpful, some plants give better protection than others. Low grasses and shrubs that provide deep, strong, fibrous root systems are the best and grow faster than trees. One group of native tree that grows relatively fast and provides the necessary root system are the willows (Salix). Unlike trees, these are woody shrubs that love water and develop deep, strong root systems in wet soil. Plants that are suitable for planting in theses areas can be found in most nurseries or can be transplanted from existing stands. For advice on the proper plants for your situation, contact the local NRCS office or LSU AgCenter Extension Service agent.

Fuel storage tanks

Aboveground fuel storage tanks in Louisiana are regulated by the State Fire Marshal's Office and by the U.S. Environmental Protection Agency if surface water is at risk. Aboveground tanks containing 660 gallons or more require secondary containment, but the state fire marshal recommends that some sort of secondary containment be used with all fuel storage tanks. This could include the use of double-walled tanks, diking around the tank for impoundment or remote impoundment facilities.

These practices must be followed:

- Any existing aboveground fuel storage tank of 660 gallons or more (or 1,320 gallons total, if you have more than one tank) must have a containment wall surrounding the tank that is capable of holding 100 percent of the tank's capacity (or the largest tank's capacity, if more than one) in case of spillage. Additional secondary containment measures are required for operations that store more than 1,320 gallons of fuel. It is required that all facilities with aboveground storage capacity of 1,320 gallons have a spill prevention, control and countermeasure plan, and if the total storage exceeds 10,000 gallons, in some cases the plan must be certified by a certified engineer. See link to LSU AgCenter website for more information:

  http://www.lsuagcenter.com/en/environment/conservation/fuel_oil/

  (NRCS Code 710 has financial assistance only for the development of approved SPCC plans.) Additional information can be obtained from your local NRCS office in consultation with the local LSU AgCenter agent.
- The tank and storage area should be located at least 40 feet from any building. Fuel storage tanks should be placed at least 150 feet away and downslope from surface water and water wells.
- It is recommended that the storage tank be on a concrete slab to prevent any spillage from entering surface water and/or groundwater.
- The storage area should be kept free of weeds and other combustible materials.
- The tank should be conspicuously marked with the name of the product that it contains and "FLAMMABLE:-KEEP FIRE AND FLAME AWAY."
- The bottom of the tank should be supported by concrete blocks approximately 6 inches above the ground surface to protect the bottom of the tank from corrosion.
- If a pumping device is used, it should be tightly and permanently attached and meet NFPA approval. Gravity discharge tanks are acceptable, but they must be equipped with a valve that will automatically close in the event of a fire.
- Plans for the installation of all storage tanks that will contain more than 60 gallons of liquid must be submitted to the State Fire Marshal's Office for approval.
- All tanks that catch on fire must be reported to the State Fire Marshal's Office within 72 hours of the fire.
- Underground storage tanks are defined as containing more than 10 percent of their total volume beneath the soil surface. Underground tanks represent more of a problem than aboveground tanks, because leaks often can go for long periods without being detected. This poses a serious threat to groundwater sources in the vicinity of the tank. If you have an underground fuel storage tank, you need to contact the State Fire Marshal's Office for regulations affecting these storage tanks.

Roof Runoff Management (NRCS CODE 558)

This practice can be used if rainfall runoff from barns or other structures is flowing across bare ground areas where significant erosion is occurring. Management of this runoff ensures sediments are not transported into drainage branches or small creeks that ultimately can carry pollutants into surface water off the farm. The practice also can sometimes have the added benefit of protecting the foundation of the building from water inundation and weakening. In some cases, if desired, roof runoff can be collected, stored and used for other purposes.

Gutters and downspouts commonly are used, and care should be taken to ensure water from downspouts is directed away from the building foundation and areas of concern. Water from downspouts emptied onto the ground surface should have velocity dissipation systems such as rock pads, rock-filled trenches or concrete to prevent erosion and to ensure ground infiltration.

Irrigation Water Quality

Irrigation water (surface and/or well) should be tested during the spring to determine the salinity (salt) level before irrigating a field or pasture. Take samples to an approved laboratory for analysis.

Responding to Complaints

More and more families are moving into rural areas of Louisiana. These families typically come from non-farm backgrounds and do not understand contemporary agricultural practices. Balancing the expectations of rural landowners and the needs of row crop producers to provide a safe and economical supply of food and fiber will become more and more challenging in the future.

There are some things that can be done, however, to be a good steward of the land and a good neighbor. Being friendly and courteous to people who neighbor your farm can go a long way to help foster good working relationships. The appearance of the farming operation also helps. The way a producer or farm manager handles complaints and concerns also is a vital part in keeping good relations with neighbors.

Be considerate of neighbors. Give advance notice when you are planning to burn and or conducting any farming practice that may affect areas outside of your operation. Let your neighbors know you are willing to talk about the issue and that you care.

A system of communication also may need to be set up. This will help solve problems before they get out of hand. Some people feel more comfortable talking to someone other than the person with the problem. Give concerned members of the community a person to contact. This third-party can be separated from the issue, can be less emotionally involved and can likely identify simple and mutual solutions.

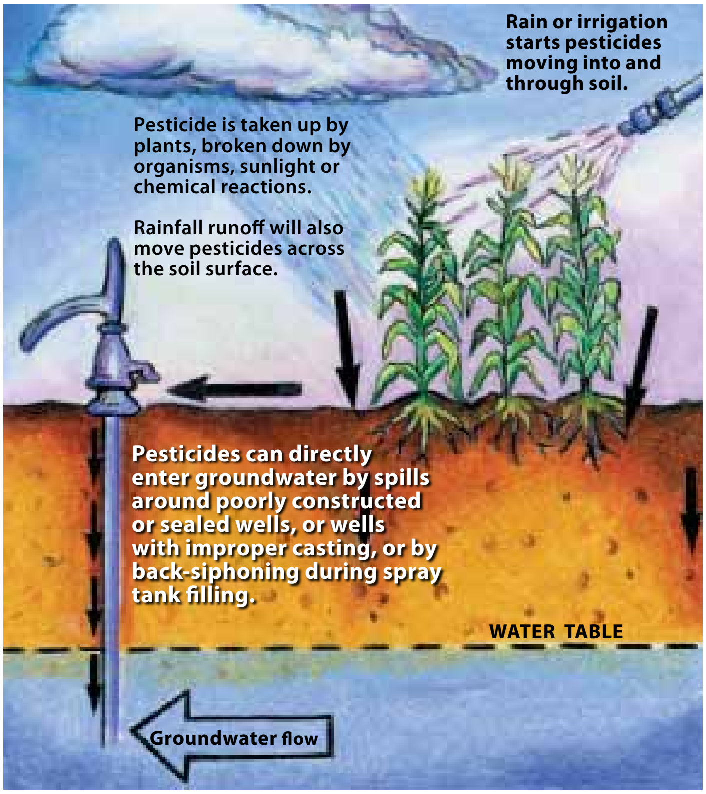
Finally, producers need to work with community leaders and regulatory agencies when a complaint arises. By working with community leaders, producers may reduce the demands for unnecessary regulations.

Pesticide Management and Pesticides

Introduction

To preserve the availability of clean and environmentally safe water in Louisiana, contamination of surface water and groundwater by all agricultural and industrial chemicals must be reduced. Some sources of contamination are easily recognizable from a single, specific location. Other sources are more difficult to pinpoint. Nonpoint-source pollution of water with pesticides is caused by rainfall runoff, particle drift or percolation of water through the soil.

These pest management practices are based on current research and extension recommendations. By using these recommendations, pesticide use will follow environmentally sound guidelines.



Soil-incorporated systemic pesticide

Pesticide is carried into and through soil. Movement through soil is affected by soil and pesticide properties and amount and timing of water. Pesticide residue and byproducts not absorbed are broken down into the groundwater.

Movement with groundwater – additional breakdown generally slowed, but depends on chemical nature and groundwater.

Pest Management Procedures

Pesticides should be applied only when they are necessary to protect the crop or to control vermin or parasites. The pesticide should be chosen carefully to ensure that the one you pick will give the most effective pest control with the least potential adverse effects on the environment.

Water quality, both surface water and groundwater, will be protected by following all label recommendations and guidelines dealing with water quality. Therefore:

- All label statements and use directions designed specifically to protect groundwater must be followed closely.
- Specific best management practices designed to protect surface water should be followed closely.
- Erosion control practices (such as pipe drops, etc.) should be used to minimize runoff that could carry soil particles with adsorbed pesticides and/or dissolved pesticides into surface waters.

Pesticide Application

Management practices such as the pesticide selected, the application method, the pesticide rate used and the application timing influence pesticide movement. Pesticides should be applied only when needed to prevent economic loss of a crop.

In pesticide application, "the label is the law." Using chemicals at rates higher than specified by the label is ILLEGAL as well as an environmental hazard because more pesticide can potentially run off or leach. Poor timing of a pesticide application (application just before rain falls) can result in pesticide movement into water sources, as well as give little control of the targeted pest.

Certain areas on your land, such as streams and rivers, wellheads and lakes or ponds, are sensitive to pesticides. You should create buffer zones around these areas where pesticide use will be reduced or eliminated. By buffering these areas, you may reduce water quality problems. Areas such as roads, off-site dwellings and areas of public gatherings should be identified. You may want to limit the use of pesticides near these types of areas, too.

These practices should be followed:

- Select the pesticide to give the best results with the least potential environmental effect outside the spray area.
- Select application equipment with care and maintain it carefully.
- Carefully calibrate application equipment at the beginning of the spray season and periodically thereafter. Spray according to recommendations.
- Minimize spray drift by following the label instructions and all rules and regulations developed to minimize spray drift (the physical movement of spray particles at the time of or shortly after application).
- Before applying a pesticide, make an assessment of all of the environmental factors involved in all of the areas surrounding the application site.
- Carefully maintain all applications of pesticides, not just restricted use pesticides.

Pesticide Selection

When selecting pesticides, consider chemical solubility, adsorption, volatility and degradation characteristics. Chemicals that dissolve in water readily can leach through soil to groundwater or be carried to surface waters in rainfall or irrigation runoff. Some chemicals hold tightly to, or are adsorbed on, soil particles, and these chemicals do not leach as much. But even these chemicals can move with sediment when soil erodes during heavy rainfall. Runoff entering surface waters may ultimately recharge groundwater reserves. Chemicals bound to soil particles and organic matter are subject to the forces of leaching, erosion or runoff for a longer period, thus increasing the potential for water pollution.

These practices should be followed:

- Pesticide selection should be based on recommendations by qualified consultants and crop advisers and the published recommendations of the LSU AgCenter.
- The selection of the pesticide to be used must be based on its registered uses and its ability to give the quality of pest control required.
- The selection also must be based on a pesticide's effects on beneficial insects, other nontarget organisms and the general environment.

Pesticide Storage and Safety

Farmers and commercial pesticide applicators are subject to penalties if they fail to store or dispose of pesticides and pesticide containers properly. Each registered pesticide product, whether general or restricted use, contains instructions for storage and disposal in its labeling. Louisiana's pesticide laws address specific requirements for storage and disposal. The applicator must follow these requirements carefully and ensure that employees follow them as well.

The recommended procedures do not apply to the disposal of single containers of pesticides registered for use in the home and garden. These containers may be disposed of during municipal waste collection if wrapped according to recommendations.

Storage sites should be chosen to minimize the chance of pesticides escaping into the environment. Pesticides should not be stored in an area susceptible to flooding or where the characteristics of the soil at the site would allow escaped chemicals to percolate into groundwater. Storage facilities should be dry, well ventilated and provided with fire protection equipment. All stored pesticides should be carefully labeled and segregated and stored off the ground. Do not store pesticides in the same area as animal feed. The facility should be kept locked when not in use. Further precautions include appropriate warning signs and regular inspection of containers for corrosion or leakage. Protective clothing should be stored close by but not in the same room as the pesticides to avoid contamination of the clothing. Decontamination equipment should be present where highly toxic pesticides are stored.

Exceptions for Farmers

Farmers disposing of used pesticide containers from their own use are not required to comply with the requirements of the hazardous waste regulations provided they triple rinse or pressure wash each container and dispose of the residues on their own farms in a manner consistent with the disposal instructions on the pesticide label. Note that disposal of pesticide residues into water or where they are likely to reach surface water or groundwater may be considered a source of pollution under the Clean Water Act or the Safe Drinking Water Act and therefore is illegal.

After the triple-rinse procedure, the containers are then "empty," and the farmer can discard them in a sanitary waste site without further regard to the hazardous waste regulations. The empty containers are still subject to any disposal instructions contained in the labeling of the product, however. Disposal in a manner "inconsistent with the labeling instructions" is a violation of EPA guidelines and could lead to contamination of water, soil or people, as well as legal liability.

Agricultural Chemicals and Worker Safety

The EPA has general authority to regulate pesticide use to minimize risks to human health and to the environment. This authority extends to the protection of farm workers exposed to pesticides. All employers must comply with all instructions of the Worker Protection Standard concerning worker safety or the employers may be subject to penalties. Labels may include, for example, instructions requiring the wearing of protective clothing, handling instructions and instructions setting a period of time before workers are allowed to re-enter fields after the application of pesticides (restricted entry interval).

Employers should read the Worker Protection Standard regulations governing the use of and exposure to pesticides. The regulations set forth minimum standards that must be followed to protect farm workers and pesticide handlers. The regulations include standards requiring oral warnings and posting of areas where pesticides have been used, training for all handlers and early re-entry workers, personal protective equipment, emergency transportation and decontamination equipment.

The EPA regulations hold the producer of the agricultural product on a farm, forest, nursery or greenhouse ultimately responsible for compliance with the worker safety standards. This means the landowner or farmer must ensure compliance by all employees and by all independent contractors working on the property. Contractors and employees also may be held responsible for failure to follow the regulations.

The Occupational Safety and Health Act (OSHA)

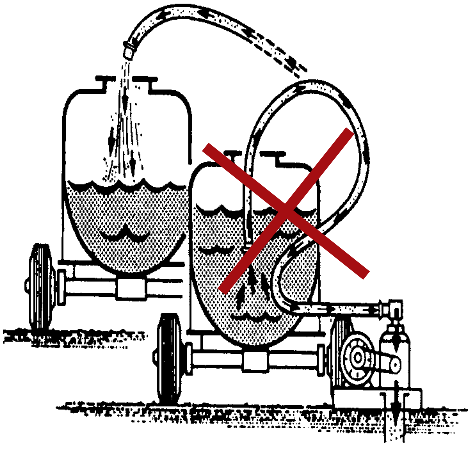
The federal government also regulates farm employee safety under the Occupational Safety and Health Act (OSHA). OSHA applies to all people (employers) engaged in business affecting interstate commerce. The federal courts have decided that all farming and ranching operations, regardless of where goods produced are actually sold or consumed, affect interstate commerce in some respect and thus are subject to OSHA's requirements. In general, every employer has a duty to provide employees with an environment free from hazards that are causing or are likely to cause death or serious injury.

Pesticide summary:

- All label directions must be read, understood and followed.
- The Louisiana Department of Agriculture and Forestry is responsible for the certification of pesticide applicators in the state. All commercial and private pesticide applicators who apply restricted-use pesticides must successfully complete a certification test administered by the state Department of Agriculture and Forestry. The LSU AgCenter conducts training sessions and publishes study guides in various categories covered by the test. Contact your LSU AgCenter county agent for dates and times of these sessions.
- All requirements of the Worker Protection Standard must be followed, including, but not limited, to:
  - Notifying workers of a pesticide application (either oral or posting of the field) and abiding by the restricted entry interval.
  - Maintaining a central notification area containing the safety poster; the name, address and telephone number of the nearest emergency medical facility; and a list of the pesticide applications made within the past 30 days that have a restricted entry interval.
  - Maintaining a decontamination site for workers and handlers.
  - Furnishing the appropriate personal protective equipment to all handlers and early entry workers and ensuring that they understand how and why they should use it.
  - Ensuring that all employees required to be trained under the Worker Protection Standard have undergone the required training.
- Pesticides should be stored in a secure, locked enclosure and in a container free of leaks, abiding by any specific recommendations on the label. The storage area must be maintained in good condition, without unnecessary debris. This enclosure should be at least 150 feet away and downslope from any water wells.

Wash pad with collection pond

- All uncontained pesticide spills of more than 1 gallon liquid or 4 pounds dry weight must be reported to the director of Pesticide and Environmental Programs with the Louisiana Department of Agriculture and Forestry within 24 hours by telephone (225-925-3763) and by written notice within three days. Spills on public roadways must be reported to the Louisiana Department of Transportation and Development. Spills into navigable waters must be reported to the Louisiana Department of Environmental Quality, U.S. Coast Guard and U.S. Environmental Protection Agency.
- Empty metal, glass or plastic pesticide containers must be either triple rinsed or pressure washed, and the rinse water should be added to the spray solution to dilute the solution at that time or stored according to Louisiana Department of Agriculture and Forestry rules to be used later. Rinsed pesticide containers must be punctured, crushed or otherwise rendered unusable and disposed of in a sanitary landfill. (Plastic containers may be taken to specific pesticide container recycling events. Contact your LSU AgCenter county agent for dates and locations in your area.)
- All pesticides must be removed from paper and plastic bags to the fullest extent possible. The sides of the container should be cut and opened fully, without folds or crevices, on a flat surface. Any pesticides remaining in the opened container should be transferred into the spray mix. After this procedure, the containers can be disposed of in a sanitary landfill.
- Application equipment should be triple rinsed and the rinse water applied to the original application site or stored for later use to dilute a spray solution.
- Mix/load or wash pads (NRCS production code Interim) should be located at least 150 feet away and downslope from any water wells and away from surface water sources such as ponds, streams, etc. The pads should be constructed of an impervious material, and there should be a system for collecting and storing the runoff.
- Empty containers should not be kept for more than 90 days after the end of the spray season.
- Air gaps should be maintained while filling the spray tank to prevent back-siphoning.



The complex nature of nonpoint pollution means programs designed to reduce its impact on the environment will not be easy to establish or maintain. Controlling these contaminants will require solutions as diverse as the pollutants themselves. Through a multi-agency effort, led by the LSU AgCenter, these BMP manuals are targeted at reducing the impact of agricultural production on Louisiana's environment. Agricultural producers in Louisiana, through voluntary implementation of these BMPs, are taking the lead in efforts to protect the waters of Louisiana. The quality of Louisiana's environment depends on each of us.

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