THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

Water Quality

GEORGIA FARM*A*SYST

FARM
ASSESSMENT
SYSTEM

# Management of Irrigation Systems

Adam Speir, Public Service Representative
Biological and Agricultural Engineering

## PRE-ASSESSMENT:

### Why Should I Be Concerned?

Water is essential to the production of food and fiber crops. Irrigation to supplement natural rainfall during dry periods is often practiced. Irrigation affects water quality and quantity. Irrigation water that returns to the hydrologic system in the form of *surface runoff* or *deep percolation* can carry pollutants with it. These pollutants may be sediments eroded from the soil surface or agricultural chemicals adsorbed to the soil particles that flow into rivers, lakes and streams. Mobile and soluble materials such as nitrates, salts or naturally-occurring trace elements can also leach or move with water as it percolates below the rooting zone and into the ground water.

Competing demands for water are increasing. Water supplies are completely allocated or even over-allocated in many areas. Water for irrigation will have to be more efficiently used to preserve its quantity and quality. Water conservation is an issue that even Georgia, which receives an abundance of natural rainfall, will have to deal with in the future.

Ground water supplies a large percentage of the drinking water in south Georgia. Poor irrigation practices and irrigation systems that do not apply water uniformly represent a real pollution threat to ground water. Excess *deep percolation* or *surface runoff* poses possible health hazards as well as inefficient use of natural resources.

### How Does This Assessment Help Protect Drinking Water and the Environment?

- This assessment allows you to evaluate the environmental soundness of your farm relating to your irrigation practices.
- You are encouraged to complete the entire document.
- The assessment asks a series of questions about your irrigation practices.
- The assessment evaluation uses your answers (rankings) to identify practices or structures at risk and which should be modified.
- The irrigation facts provide an overview of sound environmental practices to prevent pollution.
- You are encouraged to develop an action plan based on your needs as identified by the assessment.
- Farm *A*Syst is a voluntary program.
- The assessment should be conducted by you for your use. If needed, a professional from the University of Georgia Cooperative Extension or one of the other partnership organizations can provide assistance in completing the assessment or action plan.
- No information from this assessment needs to leave your farm.

** Italicized words are defined in the glossary.*

# *ASSESSMENT:*

## Assessing Your Irrigation Practices

For each category listed on the left, read across to the right and circle the statement that best describes conditions on your farm. If a category does not apply (for example, if it asks about fertigation and you don't do it), then skip the question. Once you have decided on the most appropriate answer, look above that description to find your rank number (4, 3, 2 or 1) and enter that number in the "RANK" column. The entire assessment should take less then 30 minutes.

| IRRIGATION PRACTICES | | | | | |
|---|---|---|---|---|---|
| | **Low Risk (rank 4)** | **Low-Mod Risk (rank 3)** | **Mod-High Risk (rank 2)** | **High Risk (rank 1)** | **Rank** |
| **SITE CHARACTERISTICS (ALL SYSTEMS)** | | | | | |
| **Soils' potential pollution risks to surface water** | Non-erodible soil or slightly erodible soil with erosion control plan, reduced tillage or crop residue management. | Slightly erodible soil or erodible soil with erosion control plan, reduced tillage or crop residue management. | Erodible soil with reduced tillage or crop residue management and vegetated waterways or field buffers to reduce erosion. | Highly erodible soils. | |
| **Soils' potential pollution risks to groundwater** | Low intake rate soils that are deep and uniform; depth to ground water greater than 50 feet. | Low to moderate intake rate soils that are moderately deep; depth to ground water greater than 10 feet. | Moderate to high intake rate soils with shallow soil depth or water table within 10 feet of the soil surface. | High intake rate soils on flat slopes with shallow soil depth or underlain by coarse, fractured materials or water table within five feet of the soil surface. | |
| **Cropping system at time of irrigation** | Perennial forage crops or small grains on flat or low slopes. | Small grains or row crops on slopes less than 3%. | Row crops on steep slopes (greater than 3%) with reduced tillage or appropriate crop residue management plan. | Multiple row crops or extended fallow periods on steep slopes (greater than 3%) with no cultivation or crop residue management plan. | |
| **Irrigation management: When to irrigate and how much** | Irrigation scheduling and amounts based on site-specific crop and soil measurements and weather data. | Aware of crop water use information but do not routinely monitor field conditions. Amount applied is adjusted to fit crop water use. | Irrigation scheduled based on visual crop appearance and water stress indicators. Amount applied is not adjusted to fit crop water use. | No knowledge of crop water requirements or crop water use rates. Soil characteristics not considered in irrigation decision making. | |

| IRRIGATION PRACTICES | | | | | |
|---|---|---|---|---|---|
| | **Low Risk (rank 4)** | **Low-Mod Risk (rank 3)** | **Mod-High Risk (rank 2)** | **High Risk (rank 1)** | **Rank** |
| **Cropping system: Nutrient and pesticide use excluding those applied through irrigation systems** | Heavy irrigations are avoided immediately following chemical or nutrient application. Nutrient management Plan (NMP) and Integrated Pest Management (IPM) in place. | Heavy irrigations are always avoided immediately following chemical or nutrient application. Crop nutrients are based on soil test or professional recommendations. | Aware of effects of irrigation timing and amounts on chemical or nutrient losses but occasionally irrigate within three days of application. | Irrigation timing and amounts not coordinated with agricultural chemical or nutrient applications. | |
| **System performance evaluation (Irrigation Audit)** | System has been professionally evaluated for irrigation efficiency and uniformity and all recommendations have been implemented. | System has been professionally evaluated for irrigation efficiency and uniformity and some recommendations have been implemented. | Have some knowledge or information on irrigation efficiency or uniformity for designed system. | System has not been evaluated for irrigation efficiency and uniformity. | |
| **Sprinkler application rate and soil intake rate** | Sprinkler application rate is less than the soil intake rate. No ponding occurs. | Sprinkler applicaiton rate is about equal to the soil intake rate; some ponding occurs in low spots but no off-site movement. | Sprinkler application rate exceeds soil intake rate; some water moves off field surface and some ponding in low spots. | Sprinkler application rate greatly exceeds soil intake rate; considerable water movement over field surface. | |
| **SPRINKLER IRRIGATION (SOLID SET OR HAND MOVE SYSTEM)** | | | | | |
| **Irrigation uniformity: Design** | Sprinkler spacing less than or equal to 50% of throw diameter along lateral or number of operating sprinkler heads and operating pressure is carefully matched and maintained versus the design operating conditions of the pump. | Sprinkler spacing about 50% of throw diameter along lateral and less than or equal to 65% of throw diameter from one lateral to the next. | Sprinkler spacing greater than 50% of throw diameter along lateral and greater than 65% of throw diameter from one lateral to the next. | Sprinkler spacing greater than 60% of throw diameter along lateral and greater than 70% of throw diameter from one lateral to the next. Excessive number of sprinkler heads operating, resulting in inadequate sprinkler operating pressures. | |

| IRRIGATION PRACTICES | | | | | |
|---|---|---|---|---|---|
| | **Low Risk (rank 4)** | **Low-Mod Risk (rank 3)** | **Mod-High Risk (rank 2)** | **High Risk (rank 1)** | **Rank** |
| **Irrigation uniformity: Nozzles** | All same size nozzles used. Nozzles routinely checked for wear and replaced as needed. | All same size nozzles used. Nozzle wear not considered. | Mixture of nozzle sizes used. Nozzle wear not considered. | Mixture of nozzle sizes and sprinkler heads. | |
| **Irrigation uniformity: Pressure** | Pressure variation less than 15% of design pressure from highest to lowest operating pressures. | Pressure variation less than 20% of design pressure from highest to lowest operating pressure or pressure compensating nozzles used. | Pressure variation between 20 and 30% of design pressure from highest to lowest sprinkler operating pressures. | Greater than 30% pressure variation. | |
| **SPRINKLER IRRIGATION (CENTER PIVOT AND LINEAR IRRIGATION MOVE SYSTEM)** | | | | | |
| **Irrigation uniformity** | Sprinkler head and nozzle package carefully maintained according to design specifications. Pressure regulators used at each outlet or head. | Sprinkler head and nozzle package design specifications are known and monitored *occasionally*. Pressure regualtors used at each outlet or head. | Sprinkler heads and nozzles are checked annually and worn equipment is replaced according to design specifications. Pressure verification is checked regularly. | Sprinkler heads and nozzles replaced haphazardly with no reference to design specifications. Excessive pressure variation with no pressure controls along length of lateral. | |
| **MICRO-IRRIGATION (DRIP/TRICKLE, SPRAY, SUBSURFACE DRIP)** | | | | | |
| **Irrigation uniformity: Pressure** | Pressure variation less than 7.5% of design pressure from highest to lowest operating pressures or pressure compensating emitters used. | Pressure variation less than 10% of design pressure from highest to lowest operating pressures. | Pressure variation greater than 10% of design pressure from highest to lowest operating pressures. | Pressure variation greater than 15% of design pressure or pressure variation is unknown. | |
| **Irrigation uniformity: Design** | All same size emitters used throughout system. Equal number of emitters per plant; flow from each emitter is periodically checked. | All same size emitters used throughout system; equal number of emitters per plant. | Various size emitters used throughout system or various number of emitters per plant or emission point. | Various size emitters used throughout system and various number of emitters per plant or emission point. | |

| IRRIGATION PRACTICES | | | | | |
|---|---|---|---|---|---|
| | **Low Risk (rank 4)** | **Low-Mod Risk (rank 3)** | **Mod-High Risk (rank 2)** | **High Risk (rank 1)** | **Rank** |
| **Irrigation uniformity: Filtration** | Emitters checked for plugging and cleaned or replaced regularly. Water treatment plan and filtration system in place, well-maintained and systematically followed. | Emitters checked for plugging and cleaned or replaced occasionally. Filtration system in place and periodically back flushed. | Emitters not checked for plugging. Filtration system in place and periodically back flushed. | Many plugged emitters. No filtration system in place. | |
| **CHEMIGATION OR FERTIGATION SYSTEM (IF PRESENT)** | | | | | |
| **Well protection equipment** | Wellhead/water source protection equipment in place and thoroughly maintained. Records of chemical or nutrient usage kept. | Wellhead/water source protection equipment in place and inspected before each application. | Incomplete or partial wellhead/water source protection equipment. | No wellhead/ water source protection equipment in place. | |
| **Chemigation injection system calibration and monitoring** | Chemical injection system monitored for entire injection period and calibrated to deliver proper chemical application rates. | Chemical injection system inspected before each application and calibrated to deliver proper chemical application rates. | Chemical injection system not inspected at application or not calibrated at least annually. | Chemical injection system not inspected or calibrated and leaks are detectable. | |
| **Chemigation injection system and chemical mixing and handling location** | Site is greater than 100 feet from well or surface water and secondary containment is provided for chemical tanks. | Site is greater than 100 feet from well or surface water or secondary containment is provided for chemical tanks. | Site is 50 to 100 feet from well or surface water without secondary containment. | Site is less than 50 feet from well or surface water without secondary containment. | |
| **Chemical storage and handling at site** | No chemical storage or handling at well site. | No chemical storage at the site. Mixing pad with containment is located at site. | Chemical stored offsite but mixing and loading is in uncontained area. | Chemical stored at site and mixing and loading is in a contained area. | |

| IRRIGATION PRACTICES | | | | | |
|---|---|---|---|---|---|
| | **Low Risk (rank 4)** | **Low-Mod Risk (rank 3)** | **Mod-High Risk (rank 2)** | **High Risk (rank 1)** | **Rank** |
| **IRRIGATION WATER SOURCE (EXCLUDING ANIMAL WASTE LAGOONS)** | | | | | |
| **Source location** | Water source is up slope from all pollution sources and located well outside of cropped area. | Water source is at grade with pollution sources and located adjacent to cropped area with a chemical- and nutrient-free buffer zone. | Water source is at grade with or slightly down slope from pollution sources and located adjacent to cropped area. | Water source is down slope from pollution sources and within cropped area. | |
| **On-farm conveyance and distribution structures** | Water distributed from water source to fields using closed and well-maintained pipelines. Pipelines and fittings routinely inspected for leaks and repairs immediately made. | Water distributed from water source to fields using open concrete or synthetic membrane lined ditch or pipelines with small leaks. | Water distributed from water source to fields in ditches that are well-maintained and cleaned annually. | Water distributed from water source to fields in ditches that are weedy, infrequently cleaned and have excessive seepage losses or pipelines, fittings and valves have considerable number of leaks. | |
| **Well type** | Drilled well less than 10 years ago. | Drilled well 10 to 30 years ago. | Driven well less than 30 years old or drilled well greater than 30 years old. | Dug well or driven well greater than 30 years old. | |
| **Well construction** | Reinforced concrete platform around casing extends at least 1 foot beyond bore hole diameter, no cracking in platform, complete casing with sealed joints. | Concrete platform around casing extends at least 1 foot beyond bore hole diameter but has visible cracking and complete casing with sealed joints. | Large cracks in well platform or platform does not extend beneath soil surface; casing does not have sealed joints. | No casing or well-head platform. | |

| IRRIGATION PRACTICES | | | | | |
|---|---|---|---|---|---|
| | **Low Risk (rank 4)** | **Low-Mod Risk (rank 3)** | **Mod-High Risk (rank 2)** | **High Risk (rank 1)** | **Rank** |
| **Power Unit and Pump** | | | | | |
| **Energy type and fuel storage** | Electric pump. | LP-propane, natural gas or diesel *or* gasoline with well-maintained *secondary containment system* for fuel tanks and regular inspection for leaks. | Gas or diesel without *secondary containment* for fuel tanks but regular inspection of piping and consistent inventory control. | Gas or diesel without *secondary containment.* Obvious leaks and spills. | |
| **Fuel tank location** | More than 100 feet from well or surface water. | 50 to100 feet from well or surface water. | 10 to 50 feet from well or surface water. | Less than 10 feet from well or surface water. | |
| **Lubrication for turbine pumps** | Water lubricaton. | Oil lubrication; used oil recycled and filters properly disposed. | Oil lubrication; used oil taken to landfill. | Oil lubrication with used oil disposed on farm. | |

**Number of Areas Ranked** _______
**(Number of questions answered. there are a total of 25 questions.)**

**Ranking Total** ______
**(Sum of all numbers in the “RANK” column)**

## *NOTES:*

## *ASSESSMENT EVALUATION:*
**What Do I Do with These Rankings?**

### STEP 1: Identify Areas Determined to be at Risk
Low risk practices (4s) are ideal and should be your goal. Low to moderate risk practices (3s) provide reasonable protection. Moderate to high risk practices (2s) provide inadequate protection in many circumstances. High risk practices (1s) are inadequate and pose a high risk for causing environmental, health, economic or regulatory problems.

**High risk practices (rankings of "1") require immediate attention.** Some practices may require little effort to correct, while others could be major time commitments or costly to modify and these may require planning or prioritizing before you take action. All activities identified as "high risk" or "1s" should be listed in the action plan. Rankings of "2s" should be examined in greater detail to determine the exact level of risk and attention given accordingly.

### STEP 2: Determine Your Irrigation Risk Ranking
The Irrigation Risk Ranking provides a general idea of how your irrigation practices might be affecting your ground and surface water, contaminating your soil and affecting your air quality.

Use the Ranking Total and the Total Number of Areas Ranked on page 7 to determine the Irrigation Risk Ranking.

| RANKINGS TOTAL | ÷ | TOTAL NUMBER OF AREAS RANKED | = | IRRIGATION RISK RANKING |
|---|---|---|---|---|
| ____________ | ÷ | __________________ | = | ___________ |

| IRRIGATION RISK RANKING | LEVEL OF RISK |
|---|---|
| 3.6 to 4 | Low Risk |
| 2.6 to 3.5 | Low to Moderate Risk |
| 1.6 to 2.5 | Moderate Risk |
| 1.0 to 1.5 | High Risk |

This ranking gives you an idea of how your irrigation practices might be affecting your drinking water. This ranking should serve only as a very general guide, and not as a precise diagnosis since it represents the average of many individual rankings.

### STEP 3: Read the Information/Fact Section on Irrigation Practices
While reading, think about how you could modify your practices to address some of your moderate and high risk areas. If you have any questions that are not addressed in the irrigation facts portion of this assessment, consult the references in the back of this publication or contact your county Extension agent for more information.

### STEP 4: Transfer Information to the Total Farm Assessment
If you are completing this assessment as part of a "Total Farm Assessment," you should transfer your Irrigation Risk Ranking and your identified high risk practices to the overall farm assessment.

## *IRRIGATION FACTS:*

Improving the Management of Your Irrigation System

In Georgia, new and expanding water issues are placing increasing demands on agriculture to improve its impact on both water supply and water quality. Irrigation water management involves determining when to irrigate, the proper amount to apply and operating and maintaining the irrigation system.

Your main objective should be to manage the production system for profit without compromising the environment. Improve *irrigation uniformity* and irrigation application efficiency to the maximum potential levels for each specific farm, field and irrigation system. Thoroughly evaluate irrigation system design, management and maintenance to ensure the *surface runoff* and *deep percolation* are kept to a minimum. A site-specific management plan based on irrigation and drainage water quality analyses should be developed and implemented for this purpose.

## SITE CHARACTERISTICS

Effective irrigation systems supply water to the crop. Water not used by the crop (return flow) recharges aquifers, provides wildlife habitat or maintains flow in streams and surface reservoirs. If "return flows" are contaminated with large amounts of sediment, nutrients or agri-chemicals, they can contribute to both surface and ground water pollution. Most systems require little management to prevent environmental contamination; however, certain site conditions can make management of excess irrigation water more difficult.

### Soil Characteristics

Soil and landscape have a major impact on the quality of return flows. Highly erodible soils such as silt loams, clay loams, silty clays, or those with very low intake rates or thick clay subsurfaces produce more runoff and soil erosion. Under these conditions, it is essential that the total application rate of the irrigation system not exceed the *intake rate* of the soil. Otherwise, the resulting runoff and soil erosion will cause on-site damage and productivity losses as well as sedimentation and pollution for downstream neighbors. Other methods of controlling runoff and erosion (Best Management Practices) such as vegetated waterways, buffer zones and certain tillage practices are also effective; however, the best strategy is always to prevent the runoff and erosion from occurring in the first place.

While soils with high intake rates present fewer runoff and erosion problems, they can present a much greater risk for ground water contamination. When irrigation water returns directly to the ground water, the soil removes most of the solid materials and some chemicals; however, some contaminates move with the water. Coarse soils such as sands, sandy loams, and loamy sands and soils that do not have restrictive clay layers can often present greater risk to ground water. Also, poorly-drained soils, those with very shallow *water tables* or those underlain by coarse, fractured materials can provide rapid conduits to ground water aquifers. Under these conditions higher application rates can be used, but it is essential that irrigation amounts, plant nutrients and pesticide applications be managed to prevent ground water contamination. This is especially important with nitrogen application as this nutrient is highly soluble and moves readily with leaching water.

Plant cropping systems can also influence the risk of environmental contamination. Overall, forage crops and small grains pose the least risk as they provide the most vegetative cover to control erosion and runoff and usually require fewer inputs of nutrients and pesticides. Row crops, on the other hand, can require many inputs and do not provide year-round vegetative cover. Optimal fertilizer application based on the current crop status, the soil nutrient storage, and the characteristics and formulation of the fertilizer can reduce these risks. If excess nutrients are available, they could leave the cropped area via leaching, runoff or soil erosion. *Nutrient Management Plans* can be used to determine the appropriate amounts and timing of fertilizer application and therefore reduce input cost and protect environmental quality. Likewise, by using Integrated Pest Management Strategies, most farm operators can reduce agri-chemical use and the chance of having these products move off-site with irrigation return flows.

### Irrigation Scheduling

Successful moisture management calls for applying the right amount of water at the proper time. Frequency and timing of water application have a major impact on yields and operating costs. *Scientific irrigation scheduling* can reduce water and energy use, improve crop yields, and reduce the possibility of environmental degradation.

Although several different methods for scheduling irrigation exist, almost all are based on some form of water balance. The object is to obtain a balance of incoming and outgoing water so that available water is maintained for the plant. Inputs include both rainfall and irrigation. Outputs or water removal are primarily in the form of *evapotranspiration* - water removed by the crop (transpiration) and water loss due to evaporation. Water needed will depend principally on the water-holding capacity of the soil, the soil profile depth and the crop grown. Water removal can be determined using either crop use curves or pan evaporation data. The University of Georgia Cooperative Extension can provide crop use curves and more information on using the water balance method.

For the most efficient use of water, frequently determine the soil moisture conditions throughout the root zone of the crop being grown. Two proven practical field methods for measuring soil moisture are tensiometers and electrical resistance meters. You can install either of the meters at three to five locations in the field. The installation sites should represent the soil types in the field and should be located so that it is convenient to read them on a daily basis. Since tensiometers measure soil water levels, they must be placed in a way that accurately reflects conditions the root system is encountering. Average Georgia conditions dictate that one should be placed 6 inches deep and the other 12 inches deep. The 6-inch depth tensiometer is used to evaluate when to start irrigating while the 12-inch depth tensiometer is used to evaluate water penetration into the soil profile plus over- or under-watering. A tensiometer reading of less than 20 centibars indicates that the amount of available moisture in the plow layer is favorable. As the reading become higher, the amount of available water decreases, indicating drier conditions and a need to start irrigating. Usually irrigations begin when the tensiometers read between 20 and 60 centibars.

Irrigation scheduling based on tensiometers or resistance blocks is more accurate, reliable and possibly automated, while using a tool such as the water balance method is less expensive. Another option is to use computer models. Computer models can be purchased and run on the farm or kept at a central location in the community (such as Extension offices) with recommendations published daily. Regardless of how you conduct irrigation scheduling, it is essential that all management is based on scheduling to avoid either the under- or over-application of irrigation water.

## PERFORMANCE OF IRRIGATION SYSTEMS

Most of the agricultural irrigation systems in Georgia fit into one of two broad categories: sprinkler irrigation or micro-irrigation. Sprinkler irrigation systems include center pivot, linear move, traveling gun, permanent set and solid set. Micro-irrigation consists of primarily low pressure, low volume systems that include drip or trickle irrigation and micro-sprinklers.

### Efficiency and Uniformity

No one type of system is best for every application. Each has its advantages and disadvantages. Once a system has been selected, it should be professionally designed to maximize two parameters: the application efficiency and the *irrigation uniformity*. The application efficiency is a measure of how well the system uses water. Different methods of irrigation waste, varying amount of water through evaporation, seepage, *surface runoff* and drift will affect application efficiency.

**Table 1: Efficiency is somewhat inherent to the system, as shown below.**

| **Type of System** | **Efficiency (%)** |
|---|---|
| Micro-Irrigation | 90 |
| Center Pivots | 60 |
| Traveling Guns | 60 |
| Flood or Surface Irrigation | 50 or less |

While this table presents an estimated efficiency, often there is substantial variability for each type of system. Improved management and proper design and maintenance can increase the efficiency through improved water usage.

*Irrigation uniformity* refers to the "evenness" that the system applies water to the crop. A desirable irrigation system supplies the same amount of water at each point or to each plant within the field. Farmers that have irrigation systems with poor uniformity characteristics must balance over irrigating parts of the field with under irrigating other parts. System uniformity depends on system design; however, improper maintenance and repair of a properly designed irrigation system can reduce system uniformity. You should have professional advisement and implement the recommendations for improving *irrigation uniformity* and efficiency.

### Application Rates

Soil type and site characteristics can also influence the type of irrigation system selected. Irrigation systems must apply water at a low enough rate so that water can infiltrate the soil profile. If the application rate is too high for a soil with a low *intake rate* or on a steeper slope, runoff and soil erosion result. Under these conditions, use systems with lower application rates.

## SPRINKLER IRRIGATION

Solid set sprinkler systems consist of portable above ground aluminum pipes with sprinklers placed at specific intervals. Fixed or permanent sprinkler systems are not moved after installation. Sufficient lateral pipe and sprinkler heads are required to cover the whole field. These types of systems are typically used for small acreage and/or crops with high cash values. They are best suited for conditions where light, frequent irrigations are required. Permanent set systems require very little labor but are one of the most expensive in terms of initial cost per acre.

### Pivots and Moving Systems

Moving systems such as center pivots, linear move or traveling guns generally apply water more uniformly than fixed systems and offer the advantage of adjustable travel speeds to control application amounts and times. The center pivot is the most widely used irrigation system on Georgia farms. It is a self propelled system that rotates around a central pivot point. Since center pivots cover a circular area, they are best adapted to fields that are round or square. Most center pivots have end guns that are turned on or off as the system moves around the field enabling the system to water an additional 100 to150 feet in corners or other irregular parts of the field. While this is an enormous benefit to the system, care must be taken to ensure that the end gun is always functioning properly. Not only do improperly functioning end guns waste energy and water, but they can also create environmental hazards and do not usually provide uniform applications.

Linear move systems are similar to center pivots except, rather than moving around a pivot point, they move laterally across the field. While most center pivots use a centrally-located well as the water source, lateral move systems are usually supplied with water from a ditch or hose that runs the length of the field. The main advantage of linear move systems is on large rectangular fields where center pivots would leave large areas unirrigated. They usually require more labor and maintenance than center pivot systems.

Both linear move and center pivot systems require many sprinklers, and many choices are available. Sprinklers are designed to distribute water uniformly in droplet form. To cover a large area, a sprinkler must throw the water considerable distances and this requires pressure. As pressure increases, the area covered increases and application rates decrease. Sprinkler packages are available with a variety of operating pressures ranging from 1 pound per square inch (psi) to 100psi. The lower pressure sprinklers require less energy to operate, but also supply higher application rates that may exceed the *intake rate* of the soil, resulting in runoff and erosion. When irrigation systems are designed, they are equipped with certain sprinkler packages that operate at a given pressure to ensure a uniform and efficient application. If the sprinklers or the operating pressures are changed, the system does not perform as designed. This usually results in decreased uniformity that will affect crop yields. The solution is to check the sprinklers regularly, always replace worn sprinklers with the same type of sprinkler and monitor operating pressures to ensure that they meet the design specifications.

A final type of sprinkler system is the traveling gun system. These systems consist of a large sprinkler (big gun) mounted on a wheeled cart that is mechanically moved across the field. Big guns typically discharge between 100 and 600 gallons per minute and will irrigate a radius of 80 to 250 feet. Traveling systems usually operate at high pressures and have high energy requirements. This makes them more expensive to operate than center pivot systems. They also require more labor to operate. The advantage they offer is that they are moveable and do not require high water quality such as liquid lagoon effluent.

Since sprinkler systems discharge water into the air above the crop canopy, some evaporation and drift occurs in the air. Under windy conditions drift can be considerable. Although difficult to measure, spray evaporation and drift can range from 5 to 20 percent of the water discharged. Avoiding windy days and irrigating on cooler days or in the evening or night can reduce losses. Evaporation also occurs at the soil surface and from the crop canopy. To reduce these losses, use less frequent, heavier applications rather than lighter, more frequent applications.

## MICRO-IRRIGATION SYSTEMS

Micro-irrigation includes drip or trickle irrigation and micro-sprinkler irrigation. These systems distribute water uniformly to the crop via low pressure output devices such as drip emitters, drip tape or micro-sprinklers. The advantages of micro-irrigation include less water use, less energy use, more precise water placement, ease to adapt to fertigation, easy automation and reduced labor. Since most micro-irrigation systems are permanent, they are ideally suited for small acreage enterprises such as orchards, nurseries and vegetable crops. Most systems use 1/2 inch to 3/4 inch polyethylene tubing with point source emitters that deliver from 1/2 to 2 gallons per hour. The number of emitters per plant will often vary depending on the crop and its water requirements. Micro-sprinklers or drip tape can be used for water delivery instead of emitters. Drip tape is commonly used in plasticulture systems while micro-sprinklers are used to cover larger areas in many orchard crops. The systems are often designed to operate daily in dry conditions and may even be installed beneath the soil surface.

As with sprinklers, micro-irrigation systems are designed to operate with little pressure variation. Pressure compensating emitters are available that will deliver uniform rates despite pressure. These are especially useful in sloping areas. Where pressure compensating emitters are not used, it is important to monitor the pressure or check flow rates regularly to ensure uniform application.

All micro-irrigation systems require clean water to prevent clogging of the emitters or micro-sprinklers. Filtration systems such as screen filters are often used. These filtration systems will require maintenance. Additionally, all emitters need to be checked regularly and clogged emitters should be replaced with the same size emitter. Detection of malfunctioning emitters is essential for maintaining system uniformity and maximizing crop yield. Many systems, particularly those that use surface water, may experience organic growths of algae or periodic injections of chlorine. Likewise, injections or acid solutions may be required if you experience build-up of mineral deposits such as calcium or magnesium. Be careful whenever any chemical is injected through the irrigation system. It is important that you know the effect the chemical can have on plants, soil quality and human health and that you use as little of the product as possible to accomplish your goal.

## CHEMIGATION

*Chemigation* means the application of fertilizer or pesticides by introducing the product into water flowing through an irrigation system. *Chemigation* has increased dramatically in the past 15 years, particularly for sprinkler and drip systems, because it offers many advantages over conventional chemical application. These include the ability to apply nutrients and pesticides in a more timely and uniform manner, decrease application costs, increase product effectiveness, reduce operator hazards, and usually improve crop yields. If proper safety devices are installed and the chemical injection system is properly and accurately calibrated, the risk of environmental contamination is also reduced.

When applying chemicals through an irrigation system, you must be aware of the soil and chemical characteristics as well as the characteristics of the irrigation system. For the most part, chemicals applied through an irrigation system behave similarly to conventionally applied chemicals followed by rainfall or irrigation. Soluble nutrients and pesticides will move with the irrigation water. This means it is critical that you monitor irrigation amounts to prevent runoff or leaching. For example, nitrogen is highly mobile. If you apply it through an irrigation system and use more water than the plant root zone can hold, then the nitrogen could flow through the plant root zone, resulting in ineffective nutrient use and possible ground water contamination. In contrast, phosphorus fertilizer and some pesticides move very little in the soil. Therefore, when application is via *chemigation,* these products will often remain near the soil surface. Some insecticides require foliar application and would not be effective if *chemigation* through a drip system were used. Therefore, it is important that you understand the characteristics and operating mechanisms of any pesticide before applying it through your irrigation system.

Agri-chemicals have the potential to get into the irrigation water source if proper operating procedures and safety devices are not installed or maintained by the operator. **Figure 1** shows a recommended layout for direct injection of chemicals into irrigation pipelines.

**The following are part of the system:**

- A backflow prevention device (check valve) in water lines upstream of fertilizer injection prevents reverse flows from the irrigation system down a well or other water source.
- A vacuum relief valve prevents a vacuum from forming upstream of the check valve.
- A backflow prevention device (automatic quick closing check valve) in fertilizer feed lines prevents reverse flows of water or fertilizer into the fertilizer storage tank.
- Normally closed, a solenoid-operated valve located on the intake side of the injection pump will prevent fertilizer flow during irrigation system shutdown.
- An electrical interlock for injection systems using electric-driven fertilizer pumps ensures that the injection pump will shut down if the irrigation pump does.
- A low pressure drain valve drains water from the pipe between the check valve and water source, including any leakage past the check valve.

Reputable fertilizer and chemical dealers can probably provide any of this equipment.

Calibration is extremely important in *chemigation*. Not only must you know the precise amount of water your system is delivering to a known acreage, but you must also know the precise amount of chemical being delivered by the injection pump. Extension personnel or most irrigation dealers can give you all the informa-

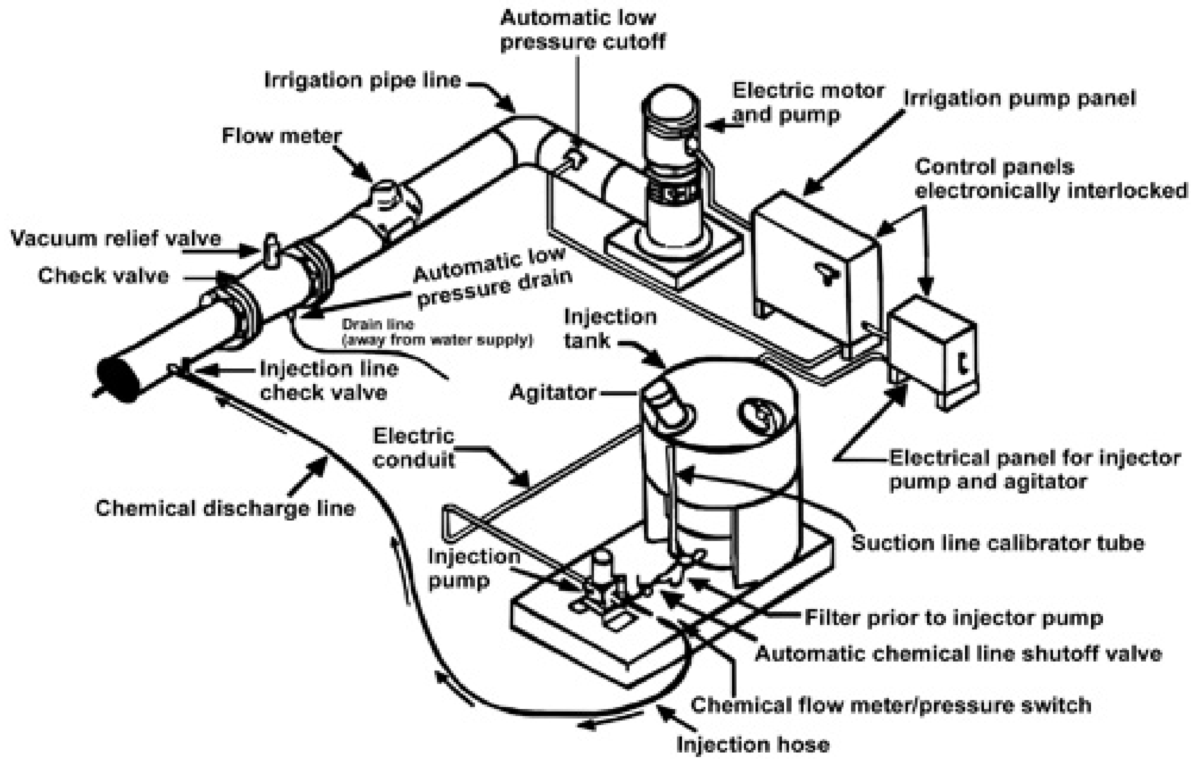


**Figure 1: Recommended devices and arrangement of equipment to prevent backflow when applying chemicals or nutrients through an irrigation system.**

tion you need to calibrate irrigation systems. It is important that you know how to do this rather than relying on manufacturers' recommendations because the conditions at your site are different from the factory. Calibration will ensure that you deliver the proper and adequate amount of products and could save you money by avoiding over-applications.

Consider several other important factors when chemigating. Distribution uniformity of the irrigation water is critical for uniform application of the fertilizer. If the irrigation system does not supply water uniformly then *chemigation* should not be used. Some products applied through irrigation systems increase the likelihood of clogging. Make sure the combination of fertilizers and water will not produce clogging in using a micro-irrigation system. The type of injection device is critical depending on the type of irrigation system being used. Some devices will inject at a relatively uniform rate throughout the irrigation, and some will not. Be aware of which type is being used and which type is required by the situation. Also, be aware of the requirements for flushing the irrigation system after fertigation. This may take 10 to 15 minutes. Run clean water through the injection meter, discharge hose and check valve. Finally, monitor irrigation systems much more closely during *chemigation*, continuously if possible.

It is also important that you use proper chemical storage and handling practices around *chemigation* systems. Do not store chemicals near the site. If possible, all mixing and loading should be done on an impermeable pad at least 100 feet from any well or surface water. Use *secondary containment* so that any spills can be recovered. For more information, request the Pesticide or Fertilizer Storage and Handling Practices Farm *A*Syst Assessment from your local Extension office.

## WATER SOURCE

Water sources for irrigation in Georgia include surface and ground water. Surface water supplies include ponds and rivers or streams. Ground water is readily available in most of the southern half of the state and most of the irrigation systems in South Georgia use wells that tap into these ground water aquifers. The most important characteristic of a water source is that it can supply adequate quantities of water during dry periods. Since 1988, the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources has required that all large (more than 100,000 gallons per day in any month) agricultural water users obtain permits for either surface or ground water. If your water source is not permitted, then you need to contact the EPD about obtaining a permit.

Regardless of whether your water source is ground water or surface water, it is essential that you take adequate measures to protect it. Distance is often the best method of protection. All pollution sources such as fuel tanks, chemical injection systems and areas that receive nutrient and pesticide application should be downstream and more than 100 feet from any well or inlet for surface water. If water from the source is transported to an irrigation system, then the conveyance mechanism should protect the water and prevent losses. Pipelines that are regularly inspected and repaired are the best method for moving large quantities of water. If ditches or channels are used, be sure that leaching losses are kept to a minimum and weeds and other obstructions are removed regularly. If ground water is used, efforts to protect the wellhead should be made.

**The six principles of wellhead protection are:**

- Proper well siting: distance and location.
- Keeping contaminants away from the well.
- Sealing abandoned wells.
- Proper well construction: age, platform and casting.
- Backflow prevention.
- Testing well water.

Your local Extension office has many publications dealing with wellhead protection if you would like more details on any of these components.

## POWER UNIT AND PUMP

Most Georgia farmers use either electricity or diesel engines to supply power for irrigation, but propane, natural gas or gasoline may also be used. Environmentally, electrical power is better than any of the fuels as it does not present any contamination risk. However, electrical power may not always be available, can cost more and does present some human safety concerns. If electrical power is used, be sure that all of your equipment and wiring meet National Electric Code Standards. Remember: Water and metal pipes are both excellent conductors of electricity.

If liquid fuels are used, the location of the storage tank is of utmost importance. Generally, try to place your storage tanks at least 500 feet from any wells, springs, reservoirs, lakes or other water resources to provide adequate assurance that subsurface flow or seepage of contaminated water will not reach your water.

Leak detection and inventory control practices are also important. This is something you can do by simply keeping a close eye on how much fuel is in the tank and the tank's condition. Since cleanup of a diesel or gasoline leak is always costly and often not totally effective, on-site monitoring of tanks containing petroleum products is important. If you find a leak or spill from any tank, state law requires that you notify the Georgia Environmental Protection Division at **404-362-2687**. Take whatever actions are necessary to remedy the problem, according to recommendations you receive when you report the spill or leak. You are also required to notify the State Fire Marshal at **404-656-2298** within 72 hours of any fires or explosions involving fuel storage tanks. **If fuel storage is a concern in your operation, you should also contact your local Extension office to obtain a copy of the Farm *A*Syst Petroleum Storage and Handling Assessment.**

One final note on turbine pumps concerns the type of lubrication used. Most pumps are lubricated with either water or oil. While water does not pose any environmental threat, oil does present risks to both surface and ground water. Used oil and oil filters should always be recycled or disposed of properly. Used oil may be stored in small amounts and taken to a local recycling center. Consult the Yellow pages or your waste disposal service for information on local recycling centers. Always puncture and drain oil filters before disposal in a certified landfill.

# *GLOSSARY:*

## Irrigation System Management

**Crop Water Requirement**: The amount of water needed by a crop to satisfy *evapotranspiration* and leeching requirements, exclusive of *effective precipitation*.

**Chemigation/Fertigation**: The process of introducing agricultural chemicals that are appropriately labeled or fertilizers into the irrigation system for application with the irrigation water.

**Deep Percolation**: Water that moves below the rooting zone of the crop and becomes unavailable for the crop to use.

**Effective Precipitation**: The portion of total precipitation that becomes available for plant growth.

**Soil Erodibility**: The inherent susceptibility of a soil to erode. Soils that are low in organic matter, have little aggregation and have medium textures tend to erode more and have higher erodibilities.

**Evapotranspiration (ET)**: The combined processes of evaporation of water from the soil and plant surfaces and transpiration of water by the crop.

**Intake Rate**: The rate at which water enters into the soil at the surface.

**Inventory Measurement**: Measuring and comparing the volume of tank contents regularly with product delivery and withdrawal records to help detect leaks before major problems develop.

**Irrigation System Application Efficiency**: The ratio of the amount of water that is beneficially used by the crop to the total amount applied by the irrigation system. Beneficial uses include meeting the soil water deficit and any leaching requirement to remove salts from the root zone.

**Irrigation Uniformity**: The evenness with which water is applied to the land surface by an irrigation system.

**Log**: A written record(s) of water measurements, water usage, chemical applications, etc.

**Metered**: Measured with a device such as a flow meter.

**Monitored**: Observation of a system or process to ensure proper operation.

**Nutrient Management Plan (NMP)**: A specific plan for managing animal wastes for the highest economic benefit and environmental protection. The Natural Resources Conservation Service, Cooperative Extension, a professional engineer registered in Georgia or an agricultural consultant should prepare the plan. It should detail the management and disposal of wastes generated on the farm and include maps of the waste-management facilities and land-application sites.

**Scientific Irrigation Scheduling**: A systematic and routine process for determining when to irrigate and how much to apply at each irrigation based on soil and crop characteristics. Weather-based *evapotranspiration* estimates are often employed as well as routine soil water monitoring and a soil water budget.

**Secondary Containment**: A system such as a sealed basin and dike or doubled-walled system that will catch and hold the contents of a tank or pipe if it leaks or ruptures.

**Soil Permeability**: The quality that enables soil to transmit water or air. Slightly permeable soils have fine-textured materials like clays that permit only slow water movement. Moderately or highly permeable soils have coarse-textured materials like sand that permit rapid water movement.

**Surface Runoff**: Water that leaves an irrigated field, farm or basin as a surface flow.

**Water Table**: The upper surface of a saturated zone below the soil surface where the water is at atmospheric pressure.

## ACTION PLAN:

An action plan is a tool that allows you to take the needed steps to modify the areas of concern as identified by your assessment. The outline provided below is a basic guide for developing an action plan. Feel free to expand your plan if you need detail or additional areas. Consult the list of references on the next page if you need additional assistance to develop a detailed action plan.

| Area of Concern | Risk Ranking | Planned Action to Address Concern | Time Frame | Estimated Cost |
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## *REFERENCES:*

| CONTACTS AND REFERENCES | | | |
|---|---|---|---|
| **Organization** | **Responsibilities** | **Address** | **Phone Number** |
| Georgia Environmental Protection Division | Questions regarding installation of new irrigation wells. | 205 Butler Street, SE<br>Floyd Towers East,<br>Suite 1152<br>Atlanta, GA 30334 | 404-656-3214 |
| National Response Center (NRC) | Spills that could drain into waters of Georgia. | S.P.C.C. Department<br>U.S. EPA<br>345 Courtland Street, NE<br>Atlanta, GA 30565 | 1-800-424-8802<br>*Notification required within 24 hours |
| Biological & Agri-cultural Engineering Department<br>University of Georgia | Questions concerning all aspects of irriga-tion. | Extension Unit<br>Rural Development Center<br>P.O. Box 1209<br>Tifton, GA 31793 | 229-386-3377 |
| Pollution Prevention Assistance Division (P2AD) | Pollution prevention references. | P2AD<br>7 Martin Luther King Jr. Dr.,<br>Atlanta,GA 30334 | 404-542-2154<br>or<br>1-800-685-2443 |
| Georgia Department of Community Affairs | Recycling Markets Directory listing of Used Oil Collectors. | State Recycling Coordinators<br>100 Peachtree St., NE<br>Atlanta, GA 30303 | 404-657-8831 |

# *PUBLICATIONS:*

**University of Georgia Cooperative Extension**
**Athens, Georgia 30602**

- Evaluating and Interpreting Application Uniformity of Center Pivot Irrigation Systems, Bulletin MP-391
- Factors to Consider in Selecting a Farm Irrigation System, Bulletin 882
- Regulations for On-Farm Storage Tanks in Georgia, Bulletin 1136
- Wellhead Protection for Farm Wells, Circular 819-13
- Drip Chemigation: Injecting Fertilizer, Acid and Chlorine, Bulletin 1130

**Georgia Soil and Water Conservation Commission**
**P.O. Box 8024, Athens, Georgia 30603**

- Best Management Practices for Agriculture

*The Georgia Farm Assessment System is a cooperative project of the Pollution Prevention Assistance Division, Georgia Department of Natural Resources, the University of Georgia, College of Agricultural and Environmental Sciences, Cooperative Extension, the State Soil and Water Conservation Commission and the USDA, Natural Resources Conservation Service.*

**This bulletin is a revision of "Management of Irrigation Systems" developed by Drs. Kerry Harrison and Mark Risse.**



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