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Virginia Farm*A*Syst

Virginia Farmstead Assessment System

Fact Sheet/Worksheet No. 14

Management of Irrigation Systems

NOAA

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INTRODUCTION TO THE VIRGINIA FARMSTEAD ASSESSMENT SYSTEM

Water wells and springs are the most common sources of private household water for rural homesites and farmsteads in Virginia. However, activities related to these environments may contribute to contamination of the groundwater which so many rural residents depend upon for household water. For example, farm facilities such as chemical and fuel storage tanks, livestock and poultry holding areas, irrigation systems, and septic systems are sometimes located near the farmstead well or spring. Retail agribusinesses and enterprises such as nurseries, greenhouses and direct farm markets are unique operations that may have production, storage, and sales areas close to a water well which may be also exposed to the general public. Inadequate maintenance of well-head and farmstead facilities and/or poor farmstead management practices can contribute to contamination of groundwater and drinking water supplies. Rural residents need to be aware of threats to water quality and of measures that will reduce or eliminate contamination of household water supplies.

To meet these challenges, as a part of a nationwide effort, the Virginia Farmstead Assessment System (Virginia Farm *A* Syst) was developed. This voluntary, educational/technical program is mainly a preventive program designed to: (1) provide safe, drinking water and thereby protect the health of Virginia's rural residents; (2) reduce potential land owner liability due to groundwater contamination which may result from farmstead or retail agribusiness activities; and (3) maintain or enhance farm property values throughout Virginia.

The Farm *A* Syst program is designed to guide an individual through a step-by-step evaluation of factors such as soils and geologic properties of the site, well-head or spring condition, and farmstead management practices that may impact the quality of his/her groundwater/drinking water supply. The program participant can identify potential pollution sources, and make an assessment of pollution risks to existing water supplies. Based on identified risks, corrective measures and/or management practices can be selected to reduce the likelihood of contamination.

This assessment is conducted by using a series of fact sheets and worksheets. A fact sheet /worksheet set deals with a specific pollution factor or source such as household wastewater, chemical storage, etc. Fact sheets are explanatory materials that contain background information on factors that affect groundwater quality, and legal requirements which address water quality and environmental protection. Worksheets are provided to determine ranking of potential pollution risks for each problem described in the fact sheets.

Each worksheet consists of a series of questions related to a specific farmstead feature or management practice such as well-head condition, fertilizer/chemical use, soils and geology of the site, etc. Based on the response to each question, a numerical ranking which indicates relative groundwater pollution risks is calculated. These rankings can then be used as a guideline to identify and prioritize corrective measures that will reduce or eliminate the potential for groundwater/drinking water pollution.

Users of this package need only to select those fact sheets/worksheets which are applicable to his/her activities or specific situations. For example, those evaluating rural, non-farm, homesite water supplies may select Fact Sheets/ Worksheets No. I -No. 5. Fact sheets/worksheets that will be important to many agribusinesses are No. 1 - No. 7. Some farming operations may relate to all worksheets. It is strongly recommended that the fact sheet corresponding to each worksheet be reviewed before using the worksheet itself. After developing a good understanding of each fact sheet, it will take about 15-30 minutes to complete each worksheet except for Worksheet No. 1 (Soils and Geology). To accomplish the task one needs only a pencil and a simple calculator. Each worksheet provides directions for completing the task. In addition, all users will need Worksheet No. 13 (Overall Risk Assessment). Fact Sheet/Worksheet No. 14 (Management of Irrigation Systems) was developed as an addendum chapter to the original Virginia Farm *A* Syst package and can be used in a stand alone manner or incorporated into the Overall Risk Assessment (Worksheet No. 13) as part of a complete farm assessment.

The Virginia Farm * A * Syst package contains the following Fact Sheets and Worksheets:

Fact Sheet/Worksheet No. 1 - Site Evaluation: Groundwater, Soils & Geology

Fact Sheet/Worksheet No. 2 - Well and Spring Management

Fact Sheet/Worksheet No. 3 - Household Wastewater Treatment and Septic Systems

Fact Sheet/Worksheet No. 4 - Hazardous Waste Management

Fact Sheet/Worksheet No. 5 - Petroleum Products Storage

Fact Sheet/Worksheet No. 6 - Fertilizer Storage, Handling, and Management

Fact Sheet/Worksheet No. 7 - Pesticide Storage, Handling, and Management

Fact Sheet/Worksheet No. 8 - Livestock and Poultry Yard Management

Fact Sheet/Worksheet No. 9 - Livestock Manure Storage and Treatment Facilities

Fact Sheet/Worksheet No. 10 - Poultry Litter Management and Carcass Disposal

Fact Sheet/Worksheet No.11- Milking Center Wastewater Treatment and Management

Fact Sheet/Worksheet No. 12 - Silage Storage and Management

Worksheet No. 13 - Overall Risk Assessment

Fact Sheet/Worksheet No. 14 - Management of Irrigation Systems

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MANAGEMENT OF IRRIGATION SYSTEMS

Water is essential to the production of food and fiber crops. Irrigation to supplement natural rainfall during dry periods of the year is often practiced. The use of water for irrigation affects the quantity available as water for human consumption. Water quality may also be affected as a result of irrigation due to excessive surface runoff that may carry pollutants into rivers, lakes, and streams. These pollutants may be sediments eroded from the soil surface, or agricultural chemicals adsorbed to the soil particles or dissolved in the runoff. 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, even in regions, such as Virginia, that receive an abundance of natural rainfall. Water supplies are completely allocated or even over-allocated in some areas. The use of water for irrigation will have to become more efficient for the preservation of both water quantity and water quality.

Ground water supplies a large percentage of drinking water in Virginia. Poor irrigation practices and irrigation systems that do not apply water uniformly represent a real pollution threat to ground water. Deep percolation and surface runoff each represent a possible environmental and health hazard as well as an inefficient use of natural resources.

In Virginia, increasing demands are being placed 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. The main objective should be to manage the crop production system for profit without compromising the environment. Irrigation uniformity and irrigation application efficiency should be improved to the maximum potential levels for each specific farm, field and irrigation system in use. Irrigation system design, management and maintenance should be thoroughly evaluated to ensure that 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. This portion of the assessment will investigate many of these issues and hopefully supply you with all of the tools necessary to address and explain any of the high risk areas identified in the following section.

I. SITE CHARACTERISTICS AND MANAGEMENT

Irrigation systems supply water to the crop and unused water or "return flow" recharges aquifers, and/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.

A. SOIL PROPERTIES AND TERRAIN FEATURES

The soil type and landscape features both 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 onsite damage and productivity losses as well as sedimentation and pollution for downstream neighbors. Various methods of controlling runoff and erosion (Best Management Practices) such as vegetated waterways, buffer zones, and certain tillage practices can be effective; however, the best strategy is always to prevent the runoff and erosion due to irrigation systems 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 dissolved contaminants 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, it is essential that irrigation amounts, plant nutrients, and pesticide applications be managed to prevent ground water contamination. This is especially important with nitrogen applications as this nutrient is highly soluble and moves readily with percolating water.

B. CROP MANAGEMENT

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 growth status, the soil nutrient storage, and 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 applications and therefore reduce input costs and protect environmental quality. Likewise, by using Integrated Pest Management Strategies, most farm operators can reduce agrichemical use and the chance of having these products move off-site with irrigation return flows.

C. WATER MANAGEMENT

Successful water 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.

One method for scheduling irrigations is based on water balance. The objective is to obtain a balance of available water maintained for the plant. Inputs to this plant available water 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 from the soil. 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 water use curves or pan evaporation data. Computer models based on the water balance principle are available that run on the farm or are kept at central locations with recommendations published daily.

For the most efficient use of water it is desirable to 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 should install either of these types of probes at two or more stations 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 and electrical resistance meters measure soil water levels, they must also be used in a way that accurately reflects conditions the root system is encountering. At each station, one probe should be placed at the midpoint of the root moisture control zone and the other at the bottom. The shallow probe is used to evaluate when to start irrigating while the deeper probe is used to evaluate water penetration into the soil profile plus over-or under-watering. As the readings become higher, the amount of available water decreases, indicating drier conditions and eventually a need to start irrigating.

II. PERFORMANCE OF IRRIGATION SYSTEMS

Agricultural irrigation systems in Virginia fit into one of two broad categories: **sprinkler irrigation** or **micro-irrigation**. Sprinkler irrigation systems include center pivot, linear move, traveling gun, portable pipe, and solid set. Micro-irrigation consists of primarily low pressure, low volume systems that include drip or trickle irrigation and micro-sprinklers.

No one type of system is best for every application. Each has its advantages and disadvantages. Once a type of 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 amounts of water through evaporation, seepage, **surface runoff** and drift. Efficiency is somewhat inherent to the system as shown below.

Type of System	Efficiency (%)
Micro-Irrigation	90-95
Center Pivot/Linear Move	75-80
Portable/Solid Set	70-75
Traveling Guns	65-70
Flood or Surface Irrigation	50 or less

While this table presents an estimated target 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 is one that 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 the system design; however, improper maintenance and repair of a properly designed irrigation system can reduce system uniformity. You should consider having your irrigation system evaluated by a qualified professional and implement the recommendations for improving irrigation uniformity and efficiency.

Soil type and site characteristics can also impact the design efficiency of a given irrigation system. Irrigation systems must be able to apply water at a low enough rate for it to infiltrate into 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 will result. Under these conditions, systems with lower application rates should be used.

A. SPRINKLER IRRIGATION

Solid set sprinkler systems consist of portable above ground aluminum pipes with sprinklers placed at specific intervals that are hand-moved across the irrigated field. Fixed or permanent sprinkler systems are similar, however are not moved after installation and sufficient lateral pipe and sprinkler heads are required to cover the whole field. These types of systems are typically used on 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. Hand-move portable systems require less investment in irrigation equipment but have higher operating costs due to more labor.

Moving systems such as center pivots, linear move, or traveling guns offer the advantage of adjustable travel speeds to control application amounts and times. The center pivot 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 to 150 feet in corners or other irregular parts of the field. While this is an enormous benefit to the system, care must be taken to insure 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. The main advantage of linear move systems is on large rectangular fields where center pivots would leave major 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 100 psi. 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 insure a uniform and efficient application. If the sprinklers or the operating pressures are changed, then 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 a similar type of sprinkler, and monitor operating pressures to insure 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 can throw water 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. Since the big guns do not clog as easily as smaller sprinklers, the water does not usually require filtration. This makes these systems especially suited for applying low quality water such as liquid lagoon effluent.

In the case of self-propelled systems the travel speed should be checked periodically. For example, the speed of a hose-tow traveling gun should be observed at the beginning, middle, and near the end of the travel lane to assure proper speed compensation as the hose is wound on the drum. Operators of big guns should also be aware that a distribution pattern smaller than a full circle will proportionately increase the rate of water applied. For example, the application rate is doubled when irrigating with a half-circle rather than a full-circle pattern. A partial-circle pattern should, therefore, be used only where necessary.

Since sprinkler systems discharge water into the air above the crop canopy, some losses due to immediate evaporation and drift occur. Under windy conditions, drift losses can be considerable. Although difficult to measure, spray evaporation and drift can range from 5 to 20% 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, less frequent, heavier applications should be used rather than lighter, frequent applications.

B. MICRO-IRRIGATION SYSTEMS

Micro-irrigation includes both drip or trickle irrigation and micro-sprinkler irrigation. These systems distribute water uniformly to 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, 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 insure uniform application.

All micro-irrigation systems require clean water to prevent clogging of the emitters or micro-sprinklers. Filtration systems, such as screen filters on the pump, sand separators, or sand media filters are often used in micro-irrigation systems. 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 growths of algae or bacteria. These growths can be controlled with periodic injections of chlorine. Likewise, injections of acid solutions may be required if you experience a build up of mineral deposits such as calcium or magnesium. Care should be taken 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 no more of the product than required to accomplish your goal.

III. CHEMIGATION

Chemigation means the application of fertilizers 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 fertilizers and pesticides in a more timely and uniform manner, decreased application costs, increased product effectiveness, reduced operator hazards, and often improved 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 crop, soil, and chemical properties 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 when 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 fertilizer 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 applied via chemigation these products will often remain near the soil surface. Some pesticides require foliar applications 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 components should be part of the system:

- **A backflow prevention device (check valve) in water line upstream of fertilizer injection** - this prevents reverse flows from the irrigation system down a well or other water source.

- **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 line** - prevents reverse flows of water or fertilizer into the fertilizer storage tank.

- **Normally closed, solenoid-operated valve** - located on the intake side of the injection pump to prevent fertilizer flow during irrigation system shutdown.

- **Electrical interlock for injection systems using electric-driven fertilizer pumps** - this ensures that the injection pump will shut down if the irrigation pump does.

- **Low pressure drain valve** - to drain water from the pipe between the check valve and the water source, including any leakage past the check valve.

Calibration is extremely important in chemi-gation. 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 information you need to calibrate an irrigation system. It is important that you know how to do this rather than relying on

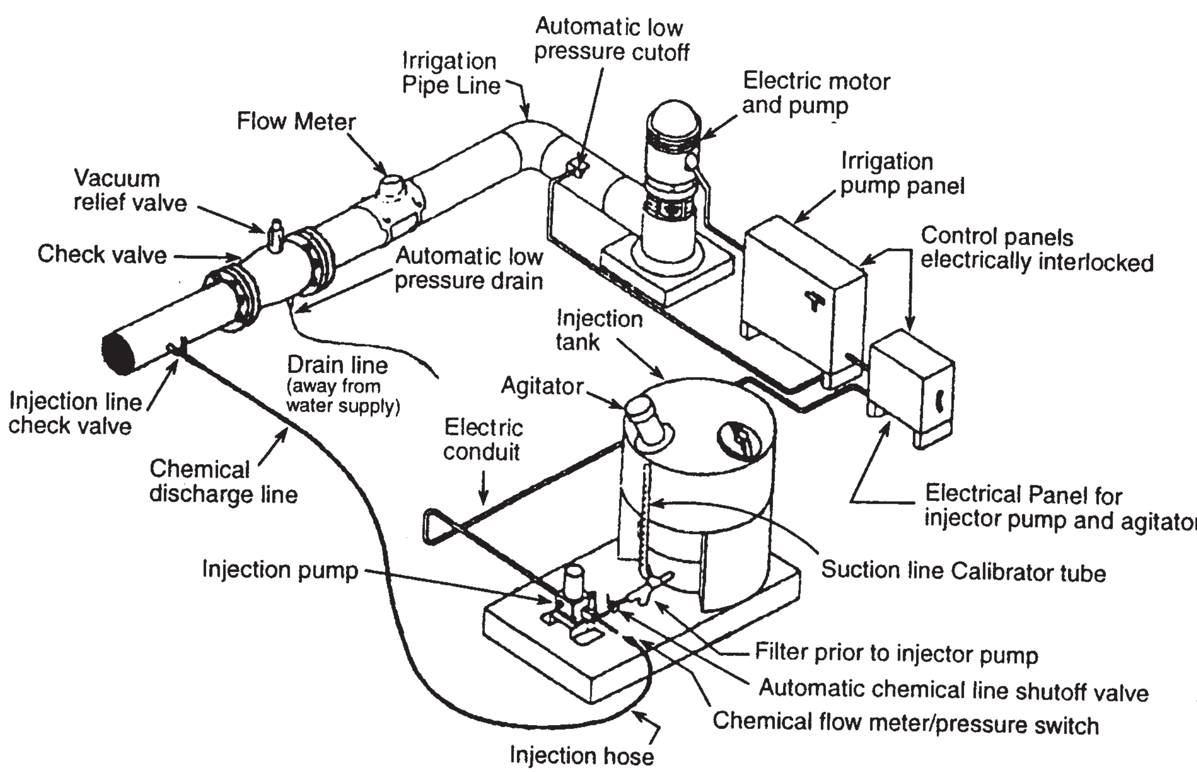

Figure 1: Recommended devices and arrangement of equipment to prevent backflow when applying chemicals through an irrigation system.

manufacturers' recommendations as the conditions at your site are different from the factory. Calibration will insure that you deliver the proper and adequate amount of the chemical and could save you money by avoiding over applications.

Several other important factors need to be considered when chemigating. Uniformity of the irrigation water is critical for uniform distribution of the chemical throughout the field. 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, particularly if 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, while others 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 chemigation. Clean water should be run through the injection meter, discharge hose and check valve. This may take 10 to 15 minutes. Finally, irrigation systems should be monitored much more closely during chemigation, continuously if possible.

It is also important that you use proper chemical storage and handling practices around chemigation systems. All mixing and loading should be done on an impermeable pad at least 100 feet from any well or surface water. Secondary containment should be used so that any spills can be recovered.

IV. WATER SOURCE

Water sources for irrigation in Virginia include both surface and ground water. Surface water supplies include ponds and rivers or streams. Ground water is readily available in the Coastal Plain region of the state from dug ponds and wells that tap into the ground water aquifers. Wells across the remainder of the state generally provide too little water except for the smallest irrigation systems. The most important characteristic of a water source is that it be able to supply adequate quantities of water during dry periods.

Regardless of whether your water source is ground water or surface water, it is essential that you take adequate measures to protect it. All pollution sources, such as fuel tanks, chemical injection systems, and areas that receive nutrient and pesticide applications should be downstream and more than 100 feet from any well or inlet for surface water. When water is transported from its source to an irrigation system, 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, efforts should insure that leaching losses are kept to a minimum and that weeds and other obstructions are removed regularly.

If ground water is being used then efforts need to be made to protect the wellhead area.

The six principles of wellhead protection include:

- Proper well siting: distance from pollution sources
- Proper well construction: age, platform, and casing
- Keeping contaminants away from well
- Backflow prevention
- Sealing abandoned wells
- Testing well water

V. POWER UNIT AND PUMP

Most Virginia 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 safer 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, you need to insure 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 upmost importance. Generally, you should try to place your storage tanks at least 500 feet from any wells, springs, rivers, lakes or other water resources.

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, monitoring tanks containing petroleum products is important.

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. Oil filters should always be punctured and drained before being disposed of in a certified landfill.

GLOSSARY

Irrigation System Management

Crop Water Requirement:	The amount of water needed by a crop to satisfy evapotranspiration and leaching 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 which moves below the rooting zone of the crop, becoming unavailable for crop use and possibly recharging the ground water supply.
Effective Precipitation:	The portion of total precipitation which is available for plant use.
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 its surface.
Inventory measurement:	Measuring the volume of tank contents regularly and comparing 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 which is used by the crop to the total amount applied by the irrigation system. 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.
Logged:	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 insure proper operation.
Nutrient Management Plan (NMP):	A specific plan for managing animal wastes for the highest economic benefit and environmental protection. 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 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 ability of 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, such as sand, have coarse-textured materials that permit rapid water movement.
Surface Runoff:	Water which leaves an irrigated field, farm or basin as surface flow.
Water Table:	The upper surface of the saturated zone below the soil surface where the water is at atmospheric pressure.

MANAGEMENT OF IRRIGATION SYSTEMS

Read Fact Sheet No. 14, "Management of Irrigation Systems" before completing this worksheet.

How will this work sheet help you to protect your drinking water and the environment?

- It will take you step by step through your irrigation system.
- It will rank your activities according to how they might affect the groundwater that provides your drinking water.
- It will provide you with easy-to-understand rankings that will help you analyze the "relative risk level" of your irrigation system.
- It will help you determine which of your practices are reasonably safe and effective and which practices might require modification to better protect your drinking water and the environment.

Follow the directions at the top of the chart.

Irrigation Worksheet: Management of Irrigation Systems

1. Use a pencil. You may want to make changes.
2. For each category listed on the left that is appropriate to your farmstead, read across to the right and circle the statement that best describes conditions on your farmstead. (Skip and leave blank any categories that don't apply.)
3. Then look above the description you circled to find your "rank number" (4, 3, 2, or 1) and enter that number in the blank under "your rank."
4. Directions on overall scoring appear at the end of the worksheet.
5. Allow about 15-30 minutes to complete the worksheet and figure out your risk rank.

SITE CHARACTERISTICS AND MANAGEMENT [All Systems] (See Fact Sheet No. 14, Section I)

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
Field 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. Bare soil surface.	____
Soil potential pollution risks to ground water	Low intake rate soils that are deep and uniform and depth to ground water greater than 50 feet.	Low to moderate intake rate soils that are moderately deep and 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.	____

SITE CHARACTERISTICS [All Systems] cont'd

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
Cropping system: Chemical use excluding those applied through irrigation system	Irrigations are avoided immediately following chemical application; Nutrient Management Plan (NMP) and Integrated Pest Management (IPM) in place.	Irrigations are always avoided immediately following chemical 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.	____
Irrigation Management: When to irrigate and how much to apply	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.	Irrigations 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.	____
System performance evaluation	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/soil intake rate	Sprinkler application rate less than the soil intake rate.	Sprinkler application rate 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 Moved System] (See Fact Sheet No. 14, Section IIA)

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
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 resulting in inadequate sprinkler operating pressures	_____
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 head types, i.e., some single nozzle heads, some double nozzle 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 20-30% of design pressure from highest to lowest sprinkler operating pressures.	Greater than 30% pressure variation.	_____

SPRINKLER IRRIGATION [Center Pivot/Linear Move or Traveling Gun System] (See Fact Sheet No.14, Section IIA)

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
Irrigation uniformity: Center pivot/linear move system	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 regulators used at each outlet or head.	Sprinkler heads and nozzles are checked annually and worn equipment is replaced according to design specifications. Pressure variation 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.	_____
Irrigation uniformity: Traveling gun system	Lane spacing, nozzle selection, and big gun pressure all meet original design specifications. Full circle sprinkler pattern only used.	Lane spacing nozzle selection, and big gun pressure all meet original design specifications. Part-circle sprinkler pattern used but travel speed adjusted.	Pressure at big gun varies by more than 10% at different locations in the field. Part-circle sprinkler pattern used but travel speed adjusted.	Design lane spacing not used. Different nozzle sizes used. Pressure at big gun is variable. No adjustments made for part-circle patterns.	_____

MICRO-IRRIGATION [Drip/Trickle, Spray, Subsurface Drip] (See Fact Sheet No. 14, Section IIB)

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
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 uniformity: Filtration	Emitters checked for plugging and cleaned or replaced regularly. Water treatment and filtration system based on irrigation water quality, 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/FERTIGATION [If Present] (See Fact Sheet No. 14, Section III)

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
Water source protection	Wellhead/water source protection measures in place and thoroughly maintained. Records of chemical or nutrient usage kept.	Wellhead/water source protection measures in place and inspected before each application.	Incomplete or partial wellhead/water source protection measures.	No wellhead/water source protection measures in place.	_____
Chemigation 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/FERTIGATION [If Present] cont'd

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
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 well site	No chemical storage or handling at well site.	No chemical storage at the site; mixing pad with containment is located at the site.	Chemical stored offsite but mixing and loading is in uncontained area.	Chemical stored at site and mixing and loading is in uncontained area.	____

IRRIGATION WATER SOURCE [Excluding Animal Waste Lagoons] (See Fact Sheet No. 14, Section IV)

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
Water source location	Water source is up slope from all pollution sources and located 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 or slightly down slope with 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 old.	Drilled well 10 to 30 years old.	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 one foot beyond bore hole diameter, no cracking in platform, complete casing with sealed joints.	Concrete platform around casing extends at least one foot beyond bore hole diameter but has visible cracking, 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 wellhead platform.	____

POWER UNIT AND PUMP (See Fact Sheet No. 14, Section V)

	LOW RISK (rank 4)	LOW-MOD RISK (rank 3)	MOD-HIGH RISK (rank 2)	HIGH RISK (rank 1)	Your Rank
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 a 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.	50-100 feet from well or surface water.	10-50 feet from well or surface water.	Less than 10 feet from well or surface water.	_____
Lubrication for turbine pumps	Water lubrication.	Oil lubrication, used oil recycled and filters properly disposed.	Oil lubrication, used oil taken to landfill.	Oil lubrication with used oil disposed on-farm.	_____

Total _____
Use this total to calculate risk rank (see next page).

Calculate Risk Rank

Step 1:

Sum up the rankings for the categories you completed and divide by the total number of categories ranked. Carry your answer out to one decimal point.

Rank Number Total _______ ÷ No. of categories ranked _______ = Risk Rank _______

Risk Categories
3.6-4.0 = low risk
2.6-3.5 = low to moderate risk
1.6-2.5 = moderate to high risk
1.0-1.5 = high risk

This ranking gives you an idea of how your well or spring management practices as a whole might be affecting your drinking water. Later you will combine this risk ranking with other farmstead management rankings in Worksheet No. 13, "Overall Risk Assessment." This ranking should serve only as a very general guide, not a definitive indicator of contamination. Because it represents an averaging of many individual rankings, it can mask any individual rankings (such as 1's or 2's) that should be of concern (see Step 2.).

Step 2:

Look over your ranking for each category:

- Low-risk practices (4's): ideal; should be your goal despite cost and effort.
- Low-to-moderate risk practices (3's): provide reasonable groundwater protection.
- Moderate-to-high-risk practices (2's): inadequate protection in many circumstances.
- High-risk practices (1's): inadequate; pose a high risk of polluting groundwater.

Any individual rankings of "1" require immediate attention. Some concerns you can take care of right away; others could be a major-or costly-project, requiring planning and prioritizing before you take action. Note the activities that you identified as 1's to be listed later under "High-Risk Activities" in Worksheet No. 13.

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 feel the need for detail or additional areas not included.

Area of Concern	Risk Ranking	Planned Action to Address Concern	Time Frame	Estimated Cost