NATURAL RESOURCES CONSERVATION SERVICE

VIRGINIA CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, SPRINKLER

(No. and Ac.)

CODE 442

DEFINITION

An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure.

PURPOSE

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

- Efficiently and uniformly apply irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment.
- Climate control and/or modification.
- Applying chemicals, nutrients, and/or waste water.
- Leaching for control or reclamation of saline or sodic soils.
- Reduction in particulate matter emissions to improve air quality.

CONDITIONS WHERE PRACTICE APPLIES

The sprinkler method of water application is suited to most crops, irrigable lands, and climatic conditions where irrigated agriculture is feasible. Areas must be suitable for irrigation or sprinkler water application and have an adequate supply of suitable quality water available for the intended purpose(s).

This standard applies to the planning and design of the overall water application through sprinkler discharge systems. This standard pertains to the planning and functional design of all sprinkler components except for special structures, such as permanently installed main and lateral pipelines or pumping plants. Other components shall meet appropriate Virginia Conservation Practice Standards.

This standard does not include criteria for mini- or micro-sprinkler systems, which are covered by Virginia Conservation Practice Standard *Irrigation System, Microirrigation (Code 441)*.

CRITERIA

<u>General Criteria Applicable to All Purposes</u>

Comply with all federal, state and local laws, rules and regulations for the installation and operation of sprinkler irrigation systems.

The criteria for the design of components not addressed in NRCS Conservation Practice Standards shall be consistent with sound engineering principles.

Design each sprinkler discharge system as an integral part of an overall plan of conservation land use and treatment for the intended purpose(s) based on the capabilities of the land and the needs of the operator. Base the selected system on a site evaluation, expected operating conditions and verification that soils and topography are suitable for the intended purpose(s).

Depth of Application

Design the net depth of application for the intended purpose, not exceeding the available soil water holding capacity and meeting the land user's management plan for the intended purpose.

Capacity

Design the sprinkler irrigation system with adequate capacity to accomplish the primary purpose(s) of the system.

Design Application Rate

Select rates such that runoff, translocation, and unplanned deep percolation are minimized.

Apply additional conservation measures, such as furrow diking, dammer diking, in-furrow chiseling, conservation tillage or residue management as needed and appropriate.

Distribution Patterns, Nozzle Spacing and Height

Select a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution.

Use Coefficient of Uniformity (CU) data or distribution uniformity (DU) in selecting sprinkler spacing, nozzle size, and operating pressure. Definitions of each of these uniformity values can be found in the NRCS National Engineering Handbook, - Part 652, Irrigation Guide.

Pipelines

Ensure that required water quantities can be conveyed to all operating lateral lines at required pressures when designing main lines, submains, and supply lines. For detailed criteria, see Virginia Conservation Practice Standard *Irrigation Pipeline (Code 430)*.

Pump and Power Unit

Where required, size pump and power units to efficiently operate the sprinkler system at design capacity and total dynamic head. For detailed criteria, see Virginia Conservation Practice Standard *Pumping Plant (Code 533)*.

Management Plan

Develop an Irrigation Water Management plan, in accordance with Virginia Conservation Practice Standard *Irrigation Water Management (Code 449),* for this practice, unless the purpose of the practice is waste water application. Where implemented for waste application, as a component of a Comprehensive Nutrient Management Plan (CNMP), a waste utilization plan and/or nutrient management plan shall be developed that meets the requirements of Virginia Conservation Practice Standard *Waste Utilization (Code 633)* and/or *Nutrient Management (Code 590)*), as appropriate.

Additional Criteria Applicable to Center Pivot or Linear-Move Sprinkler Systems

Design Capacity

For the purpose of crop irrigation, design sprinkler irrigation systems to have either (1) a design capacity adequate to meet peak water demands of all irrigated crops in the design area, or (2) adequate capacity to meet requirements of selected irrigations during critical crop growth periods when less than full irrigation is planned.

Allow for reasonable application water losses in computing capacity requirements.

Distribution Patterns, Nozzle Spacing and Height

Pivot system (Heermann-Hein) or Linear (Christensen) CU shall not be less than 85% (76% DU), except as noted in the criteria for a Low Energy Precision Application (LEPA) system. In lieu of the manufacturer's CU information, use Agricultural Research Service model Center Pivot Evaluation and Design (CPED) or similar modeling software for simulation modeling. Manufacturer's information on nozzle packaging, allowing exclusion of the end gun and the first 12% of pivot length, not to exceed 250 feet, shall be considered acceptable documentation of system CU.

In the absence of CU data, use sprinkler performance tables provided by the manufacturer in selecting nozzle size, operating pressure, and wetted diameter for the required sprinkler discharge. To the extent possible, design low pressure spray nozzles to be at uniform heights along the length of the lateral, with the exception of height adjustment to increase wetted diameter for runoff control. From a point midway between the first and second tower to the distal end of a center pivot, do not exceed 25% of the effective wetted diameter for the spray nozzle spacing along lateral lines or 50% of the effective wetted diameter of the impact sprinkler spacing. Determine the effective wetted diameter from the manufacturer's information for the nozzle height.

Lower elevation nozzle application systems, typically less than 7 feet from ground surface, that discharge water in the crop canopy for a considerable length of time during the growing season shall also meet the criteria of a Low Pressure in Canopy (LPIC) system as defined in this standard.

Additional Criteria Applicable to LEPA and Low Elevation Spray Application (LESA) Center Pivot or Linear-Move Sprinkler Systems

Distribution Patterns

For center pivot systems, use the nozzle discharge CU using the Heermann-Hein weighted area method in selecting sprinkler spacing, nozzle size, and operating pressure. Nozzle discharge CU shall not be less than 94% of the calculated design flow rate needed at the discharge point. For linear systems, base discharge on equivalent unit areas.

Nozzle Spacing

Nozzle spacing shall not be greater than two times the row spacing of the crop, not to exceed 80 inches.

Specific Additional Criteria for LEPA

Discharge Height

Discharge water through a drag sock or hose on the ground surface, or through a nozzle equipped with a bubble shield or pad at a uniform height not to exceed 18 inches.

Row Arrangement and Storage

LEPA systems are only applicable on crops planted with furrows or beds. Row patterns that match the lateral line movement (i.e., circular for center pivots) are required for LEPA systems. Do not apply water in the tower wheel track of a LEPA system. Eliminate runoff and translocation under LEPA systems by providing surface basin storage such as furrow dikes, dammer dikes, or implanted reservoirs.

Slope

The slope for a LEPA system shall not exceed 1.0 % for the slope on more than 50 percent of the field.

Meet the LESA criteria for systems that utilize bubble pads or shields, or drag hoses for a portion of the crop year and then spray nozzles at uniform height not exceeding 18 inches for a portion of the crop year.

Specific Additional Criteria for LESA

Discharge Height

LESA Systems shall discharge water through a spray nozzle at uniform heights not to exceed 18 inches.

Row Arrangement and Storage

LESA Systems are applicable on crops flat planted, drilled, or planted with furrows or beds. Employ some method of providing surface basin storage such as furrow dikes, dammer dikes, or implanted reservoirs, or farming practices such as conservation tillage, in-furrow chiseling, and/or residue management to prevent runoff.

Slope

The slope for LESA systems shall not exceed 3.0% for the slope on more than 50% of the field.

Additional Criteria Applicable to LPIC and Mid Elevation Spray Application (MESA) Center Pivot or Linear-Move Sprinkler Systems

Meet LPIC criteria for systems that utilize bubble pads or shields or drag hoses for a portion of the crop year and spray nozzles for a portion of the crop year not meeting all of the LEPA or LESA criteria.

Distribution Patterns, Nozzle Spacing and Height

For row crops, when nozzles operate in canopy for 50 percent or more of the growing season, do not exceed every other crop row for nozzle spacing. Avoid areas of high leaf concentration (i.e., corn near the ear height (approximately 4 feet)) in canopy heights. Local research and Extension Service information with applicable crops may serve as a guide for establishing appropriate nozzle spacing, height, and row arrangement.

CU (Heermann–Hein CU for center pivots) shall not be less than 90% for all LPIC and MESA Systems with nozzle heights less than 7 feet.

CU shall not be less than 85% (76% DU) for MESA Systems with nozzle heights 7 feet or greater.

Slope

The slope for LPIC and MESA systems shall not exceed 3% for the slope on more than 50% of the field for fine textured soils or 5% on more than 50% of the field on coarse textured soils.

Additional Criteria Applicable to Fixed-Solid-set, Big Gun and Periodic Move Sprinkler Systems

Design Capacity

Design sprinkler irrigation systems to have either (1) a design capacity adequate to meet peak water demands of all crops to be irrigated in the design area, or (2) adequate capacity to meet requirements of selected water applications during critical crop growth periods when less than full irrigation is planned. Allow for reasonable application water losses in computing capacity requirements.

Design Application Rate

Design the application rate to be within a range established by the minimum practical application rate under local climatic conditions, and the maximum application rate consistent with soil intake rate, slope, and conservation practices used on the land. If two or more sets of conditions exist in the design area, use the lowest maximum application rate for areas of significant size.

Lateral Lines

Unless pressure reducers or regulators are installed at each outlet, or other pressure compensating or flow control devices are used, design lateral lines so that the pressure variation or flow variation at any sprinkler, resulting from friction head and elevation differential, does not exceed 20% of the design operating pressure or 10% of the design flow of the sprinklers, respectively.

Distribution Patterns and Spacing

Select a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution.

If available, use CU (or DU) data in selecting sprinkler spacing, nozzle size, and operating pressure. CU shall not be less than the following:

75 % (60% DU) for deep-rooted (4 feet or more) field and forage crops where fertilizers and pesticides are not applied through the system.

85 % (76% DU) for high-value or shallow-rooted crops and for any crop where fertilizer or pesticides are applied through the system.

In the absence of CU data, comply with the following criteria for maximum lateral and nozzle spacing:

1. For low (2-35 pounds/square inch (psi))-, moderate (36-50 psi)-, and medium (51-75 psi)-pressure sprinkler nozzles, do not exceed 50% of the wetted diameter, as given in the manufacturer's performance tables, when the sprinkler is operating at design pressure for the spacing along lateral lines. Do not exceed 65% of the wetted diameter for the spacing of laterals along the main line.

If winds that can affect the distribution pattern are likely during critical crop growth periods, reduce spacing to 60% for average velocities of 1 to 5 miles per hour (mph), to 50% for average velocities of 6 to 10 mph, and to 45% for average velocities greater than 10 mph.

2. For high-pressure and big gun type sprinklers (>75 psi), do not exceed two-thirds of the wetted diameter under favorable operating conditions for the maximum distance (diagonal) between two sprinklers on adjacent lateral lines.

If winds that can affect the distribution pattern are likely during critical crop growth periods, reduce the diagonal spacing to 50% of the wetted diameter for average velocities of 5 to 10 mph and to 30% for average velocities greater than 10 mph. Refer to Table 11-31 in the NRCS National Engineering Handbook – Section 15, Irrigation, Chapter 11, Sprinklers for guidance on towpath spacing of travelers.

3. Sprinkler spacing requirements for orchards, including subtropical fruits:

a) Triangular pattern. Do not exceed 65% of the effective wetted diameter for the spacing along lateral lines. Do not exceed 70% of the effective wetted diameter for the spacing along the main line.

b) Square or rectangular pattern. Do not exceed 65% of the effective wetted diameter at the design operating pressure for the nozzle spacing along the lateral and the lateral spacing along the main line.

c) Reduce spacing between sprinklers and lateral lines by 2.5% for each mph over 3 mph average wind velocity normally occurring during planned hours of operation.

Risers. Design riser pipes used on lateral lines to be high enough to prevent interference with the distribution pattern when the tallest crop is irrigated, except for under tree operations. Riser heights shall not be less than shown below:

Sprinkler discharge *(gallons/minute)*	Riser length *(inches)*
Less than 10	6
10-25	9
25-50	12
50-120	18
More than 120	36

Anchor and stabilize risers over 3 feet in height.

Additional Criteria Applicable to Traveling Sprinkler Irrigation Systems

Follow the recommendations in Table 11-31in the NRCS National Engineering Handbook – Section 15, Irrigation, Chapter 11, Sprinklers for guidance on towpath spacing of travelers.

Additional Criteria Applicable to Climate Control and/or Modification

Design Capacity

For temperature control, design the sprinkler irrigation system to have sufficient capacity to satisfy the evaporative demand on a minute-by-minute basis throughout the peak use period. The NRCS National Engineering Handbook – Section 15, Irrigation, Chapter 2, Irrigation Water Requirements contains guidance on using sprinkler irrigation systems for temperature control.

For frost protection, design the system to be capable of applying the necessary rate, based on the minimum temperature, maximum anticipated wind speed, and relative humidity, in a uniform manner. The capacity shall be sufficient to supply the demand for the entire crop being protected. The NRCS National Engineering Handbook – Section 15, Irrigation, Chapter 2, Irrigation Water Requirements contains guidance on using sprinkler irrigation systems for frost protection.

Additional Criteria Applicable to Chemical, Nutrient and/or Waste Water Application

The installation and operation of a sprinkler irrigation system for the purpose of chemical or nutrient application (chemigation) shall comply with all federal, state and local laws, rules and regulations. This includes backflow and anti-siphon prevention measures. Protect surface waters from direct application.

Locate injectors (chemical, fertilizer or pesticides) and other automatic operating equipment adjacent to the pump and power unit and install in accordance with state regulations, and in accordance with the manufacturer's recommendation. Size the chemical injection device to be within 1 percent of maximum injection rates and so that it's easily calibrated and adjustable for all chemicals at the required injection rate.

Design sprinkler irrigation systems used to apply waste with sprinkler nozzles of sufficient size to prevent clogging. Treatment of the wastewater using solid separators, two stage lagoons, two-stage waste holding ponds, etc., may be needed to reduce percent solids.

Design Application Rate and Timing

Timing of chemical applications shall be the minimum length of time it takes to deliver the chemicals and flush the pipelines at rates specified by the label.

Coefficient of Uniformity

If available, use CU (or DU) data in selecting sprinkler spacing, nozzle size, and operating pressure. The CU shall not be less than 70% for wastewater and not less than 85% (76% DU) for chemigation or fertigation. If CU data is not available, follow the appropriate specific criteria of this standard for distribution patterns and spacing requirements.

Nutrient and Pest Management

Apply chemicals, fertilizers and liquid manure in accordance with appropriate Virginia Conservation Practice Standards: *Nutrient Management (Code 590)*, *Pest Management (Code 595)*, *Waste Utilization (Code 633)*, and *Waste Transfer (Code 634)*. Chemical or nutrient application amounts shall not exceed these standards.

The NRCS National Engineering Handbook – Section 15, Irrigation, Chapter 11, Sprinkler Irrigation contains guidance on using sprinkler irrigation systems for chemigation.

Additional Criteria Applicable to Reduction in Particulate Matter Emissions to Improve Air Quality

These criteria pertains to sprinkler systems used to improve air quality by controlling dust emissions from confined animal pen areas and other critical areas such as unpaved roads, staging areas, and equipment storage yards.

Conform to the criteria in previous sections of this standard, unless described by criteria in this section for the installation of fixed solid set sprinklers or periodic move sprinkler systems for dust control. For the installation and operation of sprinkler systems for dust control on confined animal pen areas, provide application coverage on the majority of pen areas occupied by livestock, except for feed bunk aprons. The quality of discharge water shall be pathogen free and fit for animal consumption.

Capacity and Application Rate

For dust control, design the sprinkler irrigation system to have sufficient capacity and operational flexibility to apply the design application depth every three days or less. When determining capacity requirements, allow for reasonable water losses during application.

Meet the maximum total daily wet soil evaporation rate, with allowances for moisture input to pen areas from animal manure and urine for the minimum design application rate.

Apply open-lot management practices that include scraping and removal of manure in pens between occupations, and shape the holding areas to prevent water ponding and chronic wet areas.

Avoid over-application and excessive sprinkler overlap to minimize runoff and reduce odor and fly problems.

Water Amendments

Appropriately labeled chemicals for pest control or dust suppression may be applied through the sprinkler system when designed, installed and operated with appropriate backflow prevention and anti-siphon devices. When chemicals are applied through the sprinkler system, protect surface waters and livestock watering facilities from direct application unless chemical labels indicate that direct application will not negatively impact animal health or water quality.

Distribution Patterns and Spacing

Select a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution pattern.

Maximum spacing of sprinklers along laterals shall not be greater than 75%, and no closer than 50% of the wetted diameter listed in the manufacturer's performance tables. For spacing between laterals, comply with the following criteria:

1. For medium (51-75 psi)-pressure sprinkler nozzles, space laterals along the main line no further apart than 90%, and no closer than 70% of the wetted diameter.

2. For high-pressure sprinklers (>75 psi), do not exceed 100% of wetted diameter for the maximum distance between two sprinklers on adjacent lateral lines.

If winds impact distribution patterns during critical dust emission periods, equip the system with timer overrides that have the flexibility to be operated manually during periods of lesser wind, such as late evening and early morning.

Risers

Design riser pipes used in lateral lines high enough to minimize interference with the distribution pattern. Construct the risers in a manner that provides protection from corrosive soils, equipment damage, and livestock damage. Place the discharge sprinkler not less than 6 feet above ground surface for riser heights. Anchor and stabilize risers.

System Valves and Controllers

Due to high application rates inherent with large sprinkler nozzle diameters, utilize an automatic irrigation control system for all nozzles greater than 0.5 inch diameter. Utilize electro-hydraulic valves facilitating automatic operation for the automatic control system. Size and insure quality of valves with standard engineering practice. Provide the flexibility to change sprinkling duration in one-minute increments and have a minimum of six start times per-day to provide for adjustment for climate conditions.

Equip systems with a rain sensor connected to the control valve network set to prohibit system operation during rainfall events.

Incorporate manual zone isolation valves to isolate laterals allowing partial system operation during periods of maintenance and repair.

In areas of uneven or sloping terrain, incorporate a control valve or low-head drainage device at each sprinkler to ensure that line drainage to the lowest sprinkler is minimized.

CONSIDERATIONS

When planning this practice the following items should be considered, where applicable:

Application rates near the end of a center pivot may exceed soil intake rate. Light, frequent applications can reduce runoff problems, but may increase soil surface evaporation. Nozzle offsets or booms can be used to reduce peak application rates.

For low suspended nozzle application systems, row arrangement, nozzle spacing, discharge nozzle type and configuration, along with height all impact CU. System design and field management should complement each other to yield the highest CU. In general, circular rows for center pivot systems and straight rows for linear move systems provide higher CU's.

Some aspects of non-uniformity tend to average out throughout the irrigation season while others tend to accumulate. Factors that tend to average out during the irrigation season are climatic conditions and uneven travel speed for systems that start and stop. Factors that tend to accumulate during the irrigation season are nozzle discharge variances due to pressure or elevation differences, surface movement of water, and poor water distribution around field boundaries.

Consider the effects of a center pivot end gun operation on CU. A large end gun may reduce the average CU by 1 percent for each 1 percent of the area covered past the main system hardware.

Consider the on and off effects of center pivot corner arm units and end guns on overall sprinkler performance. Discharges reduce flow in the main tower, significantly lowering the CU.

Beneficial effects of conservation practices applied to limit surface redistribution of water and runoff may diminish over the irrigation season.

The velocity of prevailing winds and the timing of occurrence should be considered when planning a sprinkler system. Systems designed to operate in varied time increments aid in balancing the effects of day and night wind patterns.

Consider filtering or screening the irrigation water before it enters the system if it contains particulate matter, algae, or other material that could plug the sprinkler nozzles.

Drop tubes should be installed alternately on both sides of the mainline and when used in-crop they should have a flexible joint between the gooseneck pipes and the application device. Drops should be weighted or secured in windy areas.

Consider different sprinkler application depths and application rates with hand move and center pivot systems. With hand move systems, the application rates more nearly match the soil infiltration rate so that large irrigations can be applied and the number of hand moves reduced. With an automated system, such as a center pivot, hand labor is not a major consideration and small applications at high rates are normal.

Fertilizer and chemical application amounts may vary from prior application methods and rates, due to precise applications possible with some sprinkler irrigation systems.

Management of sprinkler irrigation systems normally include utilizing soil water stored in the root zone, especially during critical crop growth stages.

Deflection of spans on center pivots and linear-move systems is common when the lateral is loaded (filled with water). This should be considered when determining nozzle heights. Wheel track depth will also affect nozzle height.

Water distribution is greatly affected by nozzle spacing and height for LPIC and MESA systems. In general, smaller, more closely spaced nozzles will yield a higher uniformity than larger, more widely spaced nozzles.

On center pivot or linear move systems, nozzles should be diverted away from wheel tracks to avoid rutting.

Low pressure systems (35 psi or less) are sensitive to small changes in nozzle pressure. Consider using pressure regulators on all low pressure systems where elevation differences, pumping depth variations, and end gun or corner arm operation can significantly change nozzle discharge and sprinkler uniformity. Also consider installing a pressure gauge at both ends of the sprinkler system to monitor system pressure.

Consider system effects on the water budget, especially the volume and rate of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

Consider system effects on erosion and movement of sediment, and soluble and sediment-attached substances carried by runoff.

Consider system effects on soil salinity, soil water or downstream water quality including subsurface drains. Crops may be more sensitive to salts applied to plant foliage during sprinkling than to similar water salinities applied by surface irrigation, subirrigation, and microirrigation. Information on foliar injury from saline water applied by sprinkler irrigation is contained in NEH, Part 623, Chapter 2. If the salt content of the irrigation water is high, other irrigation methods should be considered.

Where wastewater is used for irrigation, timing of irrigation based on prevailing winds should be considered to reduce odor. In areas of high visibility, irrigating at night should be considered. The use of wastewater may reduce the life of the system due to corrosion or abrasion.

When utilized for particulate matter reduction, check to assure adequate animal feeding operation water supplies are available to meet other operating needs, during sprinkler system operation.

Irregularly shaped pen areas that are impractical to treat with a sprinkler system and where potential dust sources may occur should be treated for dust control with tanker water trucks equipped with hoses, or nozzles designed to apply water at rates similar to an equivalent sprinkler system.

Open-feedlot management practices that minimize thickness of loose manure will reduce water demands for dust control, as well as, reduce wet areas and ponding that could increase ammonia emissions.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing irrigation sprinkler systems shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

Record all required information in an engineer field book, on a plan sheet or design computation sheet, or in another appropriate location.

DESIGN DATA

1. Completed Environmental Evaluation and subsequent requirements.
2. Soils investigation.
3. Survey and plot data: profile, cross-sections, topography, as needed.

4. Design computations, including purpose of practice and references used.
   a. All design data required by other Virginia Conservation Practice Standards, such as *Pumping Plant (Code 533)* or *Irrigation Pipeline (Code 430)*, as applicable.
   b. Application depth and rate calculations.
   c. System design capacity calculations.
   d. Sprinkler size, and nozzle spacing and height calculations.
   e. Irrigation Water Management Plan (Virginia Conservation Practice Standard *Irrigation Water Management (Code 449)*).
5. Plan view of site with existing and planned features, including dimensions, distances, etc.
6. Standard Cover Sheet (VA-SO-100A).
7. Materials and quantities needed. Identify borrow material and/or spoil area, as needed.
8. Vegetation and/or ground cover requirements.
9. Identification of needed Erosion & Sediment Control measures.
10. Supplemental practices required.
11. Virginia Conservation Practice Specifications (700 Series).
12. Operation and Maintenance Plan.

CHECK DATA

1. As-built survey.
2. As-built plans including dimensions, types and quantities of materials installed, and variations from design. Include justification for variations.
3. Locations of appurtenant practices.
4. Adequacy of vegetation and/or ground cover.
5. Complete as-built section of Cover Sheet.

OPERATION AND MAINTENANCE

Provide specific instructions for operating and maintaining the system to insure that it functions properly. Also provide information regarding periodic inspections and prompt repair or replacement of damaged components. At minimum, include provisions to address the following:

- Periodic checks and removal of debris and sediment as necessary from nozzles to assure proper operation.
- Inspection or testing of all pipeline and pumping plant components and appurtenances, as applicable.
- Regular testing of pressures and flow rates to assure proper operation.
- Periodic checks of all nozzles and spray heads for proper operation and wear.
- Routine maintenance of all mechanical components in accordance with the manufacturer's recommendations.
- Prior to retrofitting any electrically powered irrigation equipment, electrical service must be disconnected and the absence of stray electrical current verified.

REFERENCES

1. USDA-Natural Resources Conservation Service. Electronic Field Office Technical Guide (eFOTG), Section IV [Online]. Available at http://www.nrcs.usda.gov/technical/eFOTG
2. USDA-Natural Resources Conservation Service. National Engineering Handbook, Section 15.
3. USDA-Natural Resources Conservation Service. National Engineering Handbook – Part 650, Engineering Field Handbook.
4. USDA-Natural Resources Conservation Service. National Engineering Handbook – Part 652, Irrigation Guide.
5. USDA-Natural Resources Conservation Service. National Engineering Handbook – Part 651, Agricultural Waste Management Field Handbook, amendments VA-1 and VA-2.