SIMPLE CRANBERRY IRRIGATION SYSTEM ASSESSMENT

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Introduction:

The intent of this document is to provide guidance to cranberry farmers and other technical specialists who are interested in performing a set of relatively simple assessment procedures for the purposes of informing irrigation water management and identifying potential problems or errors in irrigation system design or operation. Additional assessment, maintenance, or replacement of irrigation infrastructure may be warranted after conducting this preliminary, simple assessment.

Equipment Needed:

- Notepad and pencil
- Measuring tape (ideally one that is at least as long as the spacing between lateral lines)
- Set of high-speed drill bits or individual drill bit(s) of same size as nozzle orifices
- Pressure gauge (0-100 psi) with Pitot tube attachment. [Check with your irrigation system supplier to obtain a gauge and/or Pitot tube.]
- Length of flexible hose having diameter appreciably larger than outside diameter of nozzles (i.e. a 4-foot length of garden hose)
- Large container (at least one gallon) of known volume; calibrated and clearly marked [Note: A full, 5-gallon bucket typically contains more than 5 gallons of water.]
- Stopwatch or watch with a second hand
- Calculator
- Soil probe or soil auger
- Shovel (sharpshooter type preferred)
- Rain gear and boots—you will get wet!

Procedures:

1. Measure lateral and sprinkler spacing and record this information per bed.

2. Record sprinkler makes & models and nozzle sizes & types per bed.

3. Optional: Check for nozzle wear by inserting the shank end of a high speed drill bit into the nozzle opening [while the system is not operating!]. If you are able to wiggle the drill bit 5° to 10° off center, then it may be time to replace nozzles. If a high degree of variability in nozzle wear is observed, consider measuring operating pressure and sprinkler output at nozzles of varying degrees of wear for comparison (see steps 5 and 6).

4. Turn on irrigation system and bring it up to typical operating pressure. Record pressure "at the pump," and operating conditions of the engine (i.e. speed, power demand, etc.).

5. Using the handheld pressure gauge with Pitot tube attachment, check pressure at nozzles by holding the tip of the Pitot tube in the center of the jet stream, approximately ⅛-inch away from the sprinkler nozzle orifice. Record the highest pressure reading shown while the Pitot tube is being held in this position. Check the first 2 or 3 nozzles and last 2 or 3 nozzles on an individual lateral line to determine pressure range along that line. Check beds closest to the pump and furthest from the pump to determine pressure range across the irrigation set. If beds are similar in dimension, with similar spacing and nozzle sizes/types, it probably is not necessary to check every bed in this manner. It may be practical to check every other bed or every third bed in this fashion.

6. Determine flow rates from individual nozzles by directing water discharged from the nozzle into a bucket of known volume, using a length of hose. Record the amount of time it takes to fill the bucket. Use the following equation to calculate the discharge rate:

$$\text{Nozzle discharge rate (gpm)} = \frac{\text{volume (gallons)}}{\text{time (seconds)}} \times 60 \text{ (seconds/minute)}$$

7. Determine the gross average application rate for a given area (i.e. an individual bed) using the following equation:

$$\text{Application rate (in/hr)} = \frac{96.3 \times \text{nozzle discharge rate (gpm)}}{\text{lateral spacing (ft)} \times \text{sprinkler spacing (ft)}}$$

8. Check for variations in depths of water infiltrated into the soil by checking soil moisture at various depths and at various locations within the irrigated area using a soil probe or soil auger. Note: It may be difficult to detect variations in soil moisture if the water table is near the soil surface, <u>or</u> if the soil was at or near field capacity prior to conducting the test (i.e. recent precipitation, irrigation events, or managed floods have maintained soil water at sufficient levels), <u>or</u> if the duration of the test was of a length such that soil moisture was restored to field capacity as a result of the test.

9. Determine effective rooting depth using a shovel or soil auger by removing a small section of the vine mat from an area representative of the bed. For irrigation water management, effective rooting depth is typically defined as the zone within which 70% of the root volume is located.

Interpretation of Results:

<u>Nozzle Wear</u>: Worn nozzles are like leaky pipes—they decrease system efficiency and increase energy demands. Worn nozzles may also reduce Distribution Uniformity (DU) and Application Efficiency (Ea). Even a small amount of nozzle wear (a few thousandths of an inch) may result in costs that exceed those that would be incurred to simply replace the worn nozzles.

<u>Nozzle Pressure</u>: The Wisconsin Natural Resources Conservation Service (NRCS) practice standard for a solid-set sprinkler irrigation system (NRCS practice code 442) requires that pressure variation at any sprinkler should not exceed 20% of the design operating pressure of the sprinklers. For example, if a system is designed to operate at 50 psi at the nozzles, then all sprinklers should be operating within the range of 50 psi ± 10 psi (50 × 20% = 10), or 40 psi to

60 psi. Contact an irrigation system manufacturer or supplier to determine the proper operating pressure for your combination of sprinkler heads, nozzles, and system spacing.

Nozzle Discharge: Compare the actual, measured sprinkler output to the manufacturer's rated performance for the operating pressure measured in the field. NRCS practice code 442 requires that flow variation at any sprinkler should not exceed 10% of the design flow of the sprinklers. If actual output exceeds rated output and nozzle wear was observed, it may be time to replace nozzles.

Application Rates: Calculated gross average application rates do not take into account application efficiency, which is the percentage of water delivered to the field that is actually made available for use by the crop. Application efficiency is difficult to measure in the field and may vary considerably from one cranberry irrigation system to the next or even from one irrigation event to the next. However, a detailed assessment of the performance of a cranberry irrigation system – including the determination of Distribution Uniformity (DU) via a "bucket test" – can help to inform an irrigation manager about the potential application efficiency to the "low-1/4" (E_q) of a field (i.e. the 25% of the field that is receiving the least amount of water). Consult with an irrigation specialist to determine or estimate E_q. The relationships between application rates, E_q, and DU are described by the following equation:

Net Average Application Rate—Low ¼ =
Gross Average Application Rate (from step 7) × Application Efficiency—Low ¼ (E_q),

where E_q = DU * Effective Portion of Water Applied (R_e),
and R_e is either measured or assumed to be 85%

Rooting Depth: The conventional approach to irrigation water management is to maintain plant-available soil water at or above a certain Maximum Allowable Depletion (MAD). For most crops, MAD is assumed to be 50%, but may be lower for high-value, shallow-rooted crops such as cranberries. In other words, at "MAD-50," a manager is willing to allow 50% of plant-available soil water to be depleted before deciding to irrigate to replace that amount of "lost" water. To determine how long a particular system should be run to replace 50% of soil water, a manager needs to know how much total plant-available water can be held in the root zone. This quantity of water is also known as Available Water Capacity (AWC). AWC can be determined by submitting a soil sample to a lab for determination of water holding capacity, or it can be estimated from published data. Consult the appropriate technical specialist for advice on determining water holding capacity. To estimate AWC, calculate the product of the effective rooting depth and water holding capacity of your soil:

Total AWC (inches) = Rooting Depth (inches) × Water Holding Capacity (% by volume or in/in)

Estimates of Water Holding Capacity:
Sands and coarse sands: 2% or 0.02 in/in
Fine sands and loamy sands: 6% or 0.06 in/in

When to Irrigate? A wide variety of instruments and other technology are available to monitor or measure plant available soil water, including tensiometers and several types of soil moisture probes. Consult the appropriate technical specialist for advice on selecting a technology that fits your management style and is appropriate for your growing conditions. Either an appropriate instrument or the feel-and-appearance method (i.e. the "finger test") should be used to help the manager determine when to irrigate. Grower experience is essential when calibrating a new technology, whether that technology includes a ceramic cup, metallic probe, or a finger. The manager establishes the tolerable soil loss, or Maximum Allowable Depletion

(MAD), and the selected technology is used to determine when that threshold has been reached. Ideally, an irrigation application should be made at that point.

How Long to Irrigate? If a manager plans to irrigate when MAD = 50%, and the total AWC is known, then the ideal irrigation duration is however long it takes to apply 50% of the total AWC, accounting for inefficiencies in the system. Here's an example:

MAD = 50%
Rooting Depth = 4 inches
Water Holding Capacity = 2.5%
Total Available Water Capacity (AWC) = 4 inches × 2.5% = 0.1 inches
Soil Water Deficit (SWD) [@ MAD-50] = 50% × 0.1 inches = 0.05 inches

Gross Average Application Rate = 0.15 inches/hour
Distribution Uniformity (DU) = 65%
Effective Portion of Water Applied (R_e) = 85%
Application Efficiency—Low-¼ (E_q) = 65% × 85% = 55%
Net Average Application Rate—Low-¼ = 0.15 inches/hour × 55% = 0.08 inches/hour

Irrigation Runtime = 0.05 inches ÷ 0.08 inches/hour = 0.60 hours ≈ 36 minutes

Of course, it is always a good practice to check soil moisture following an irrigation event to verify that adequate irrigation water has been applied.

Estimating Application Efficiencies: Irrigation systems with 60-75 feet between laterals and 60 feet between sprinklers are probably capable of operating within a range of 50%-70% DU. Systems with 40-50 feet between laterals and 40-50 feet between sprinklers are probably capable of operating within a range of 75%-90% DU. Well-maintained systems may be capable of slightly higher performance, while poorly maintained systems may perform at much lower DU's. In addition, DU is variable, even on a given system, as it is influenced by operating pressure and climatic conditions (especially wind). The effective portion of water applied (R_e) is also variable and is influenced by climatic conditions, including wind, heat, and humidity. Therefore, potential application efficiencies (recall: $E_q = DU \times R_e$) of Wisconsin cranberry systems are highly variable. However, using the ranges of DU for a given system and an assumed rate for the effective portion of water applied (R_e = 85%), it is possible to develop a range of potential application efficiencies:

Lateral × Sprinkler Spacing	Distribution Uniformity	Potential Application Efficiency
60-75 ft × 60 ft	50% < DU < 70%	$42\% < E_q < 60\%$
40-50 ft × 40-50 ft	75% < DU < 90%	$63\% < E_q < 77\%$

Additional Publications:

Detailed Evaluation Procedures for Cranberry Irrigation Systems, NRCS/WSCGA

Irrigation Scheduling Worksheets, NRCS/WSCGA

Estimating Soil Moisture by Feel and Appearance, USDA-NRCS Program Aid No. 1619

References:

Merriam, John L., and Jack Keller, *Farm Irrigation System Evaluation: A Guide for Management*, pp. 22-27, Utah State University, Logan, Utah, 1978.

NRCS National Engineering Handbook, Part 652 – Irrigation Guide, Chapter 9, September 1997.