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NF94-179 Surge Irrigation Management

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Surge Irrigation Management

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Surge irrigation is the intermittent application of water in furrows. A butterfly valve with a computer controller is used to direct the flow to either side of the valve. By alternating flow on each side, an intermittent wetting and soaking cycle is created in the furrow. This wetting and soaking action settles soil particles in the bottom of the furrow and may reduce the intake rate of the soil. If the intake rate is reduced, water will advance down the furrow faster. Faster advance can result in a more uniform application, reducing the amount of water needed to effectively irrigate the field.

Proper use of a surge irrigation system can help achieve the following furrow irrigation management goals:

1. reduce excess infiltration,
2. reduce the gross application,
3. manage or reduce runoff,
4. increase infiltration on steep slopes or clay soils by keeping water on the field for a longer time,
5. manage time and labor more effectively.

This NebFact deals primarily with goals 1 and 2. Goals 3, 4, and 5 will likely evolve at each site as the irrigator gains experience with the surge system.

Terminology

Proper installation and management of a surge irrigation system requires a familiarity with the terminology used to describe the process of surge irrigation.

> **Set** — The total number of furrows with gates open at any time. Note that this is gates open, not flowing. Thus the total is for both sides of the valve.
>
> **Set Time** — The total time that water runs between gate changes.

On-Time — The total amount of time that water is actually applied (flowing into) a given furrow.

Advance Time — The on-time required to advance water from the upstream to the downstream end of the furrow.

Cycle — One on-off sequence for one side of the valve. During this time, both sides of the valve receive water. One side is on-off, the other side is off-on.

Advance Cycles — Cycles that result in water passing over dry soil. The number of advance cycles is usually from two to eight depending on field conditions. Each successive advance cycle is longer than the previous one.

Advance Phase — The time during which the advance cycles occur.

Soak or Cutback Cycles — Cycles that occur after the last advance cycle. If the advance cycles were properly timed, water should reach the downstream end during the final advance cycle. Cutback cycles are usually of constant duration, and are continued until the desired application amount is applied. These cycles should be just long enough to produce the runoff required to properly irrigate the downstream reaches of the field. Cutback cycles that just advance water to the downstream end with no runoff (on open-end systems) will likely result in crop water stress over the downstream reaches of the field.

Change Time — The on-time required to advance water to the portion of the field where wetting is desired during the first cycle time. This is one-half of the first advance cycle using the measured advance method.

First Time Controller Settings

First time surge system users may need to experiment to find the correct surge valve settings and number of gates to open. Remember that any change in the number of gates opened, which changes the flow rate in each furrow, will affect the surge valve controller settings.

Start off by opening about 30 percent more total gates than would be opened with a conventional system, with half of these open on each side of the valve. For example, if you would have opened 100 gates per set with a continuous flow system, open 130 gates, 65 on each side of the surge valve. A less desirable option is necessary if this strategy results in erosive flow rates — open more gates and increase the set time proportionately. Socks or flakes of a straw bale placed under the gates may be necessary to reduce erosion since the furrow flow rate will be increased. Remember that one goal of surge irrigation is to advance water across the field as quickly as possible. Soak cycles will be used later to reduce the runoff component.

Using one of the factory installed programs may be the easiest way to get started. Begin with program 1, 2, or 3 in the Waterman controller. A good place to start with the P&R controller is to estimate the advance time for a continuous flow system and multiply that time by 1.33. Use this number as the "out time" in the P&R controller.

The Measured Advance Method

The factory installed programs (1, 2, or 3 for the Waterman, 1.33 times continuous flow advance time for the P&R) are a good starting place, but the valve can be user programmed for maximum effectiveness at each individual field. The best way to customize controller settings is to use the measured advance method. The measured advance method uses actual field conditions and furrow flow rates to determine controller settings with the following steps:

Waterman Valves

Step 1. Open the desired number of gates on each side of the valve.

Step 2. Start the well and note the start time. Turn the controller on, select program 4, and press enter. The display should read "TIMING."

Step 3. Wait until about 90 percent of the rows complete the first advance cycle on the first side of the valve. For example, if four advance cycles are used, this would be the time required for 90 percent of the furrows on the first side of the valve to reach the quarter point of the field.

Step 4. Note the change time and press the RUN button. This automatically sets the rest of the cycles. This method is described in Waterman product literature.

P&R Valves

Step 1. Open the desired number of gates on each side of the valve.

Step 2. Start the well and note the start time. Turn the controller on and set the total advance time to 24 hours.

Step 3. Wait until about 90 percent of the rows complete the first advance cycle on the first side of the valve. For example, if four advance cycles are used, this would be the time required for 90 percent of the furrows on the first side of the valve to reach the quarter point of the field. Note this time as the "change time."

Step 4. Calculate the advance time to be entered into the controller:

Advance Time (hours) = Change Time (minutes) x F *divided by 30*

where: F = 5.5 for three advance cycles (change time measured at 1/3 field length),
F = 8.6 for four advance cycles (change time measured at 1/4 field length),
F = 12 for five advance cycles (change time measured at 1/5 field length),
F = 15.8 for six advance cycles (change time measured at 1/6 field length),
F = 20 for seven advance cycles (change time measured at 1/7 field length).

Step 5. Enter the advance time calculated in step 4 into the controller. The valve will switch to the opposite side, calculate the new cycle times, and continue to run. Press "CUSTOM." If the number of advance cycles shown is different than that used in step 4, press the + or - button to adjust to the correct number of advance cycles.

A final step that is critical, regardless of the type of controller used, is to return to the field at the end of the advance phase. Check the downstream end of the field to see if and how much water has reached the end. See Table I for recommendations to modify either the advance time, number of gates open, or both. Remember that if water has not reached the end after the final advance cycle, soak cycles may not advance water to the end either (they are shorter than the final advance cycle). When this occurs you may need to change something during the current set as well as in later sets. If there is too much water at the downstream end, make your adjustments on the next set by reducing the advance time, opening more gates, or both. The same principals apply for adjusting the soak cycles. Once the advance cycles are set correctly, too much runoff will require shorter soak cycles. Too little runoff will require longer soak cycles.

Table I. Modifications based on downstream end observations.

Water at the Downstream End	*Advance Time*	*Number of Gates Opened*
Yes	OK	OK
No	Too Short	Too Many
Too Much	Too Long	Too Few

Reducing the Total Water Application

University of Nebraska researchers tested and evaluated surge irrigation from 1983 to 1989 on many soils throughout irrigated regions of the state. This research showed that surge flow reduced advance times when compared to continuous flow in 50 percent of the tests. In those cases where water did reach the end of the field faster using surge irrigation, the average difference was 30 percent. The average was approximately 17 percent when all cases were considered. Thus, if surged flow were effective at a site, we would expect water to advance in seven hours using surge flow if it would have taken 10 hours using continuous flow. These research trials compared only advance times under similar flow rates (a soil phenomena) and not the total amount of water pumped (depends on how long the sets are allowed to run). The total amount of water applied depends on the total time that water is applied during and after the advance phase.

In general, fields that are difficult to get water through will show the most benefit from surge irrigation. Sandy soils and silt loam soils with high infiltration rates have a greater chance of reducing advance times due to the wetting and soaking action of surge irrigation. Fields with long runs and flat slopes that are difficult to furrow irrigate also have a better chance of showing faster advance times with surge flow. Soils with high clay contents or compaction problems already have a low infiltration rate, and are thus less likely to show dramatic advance time decreases when surge flow is used.

A reduction in advance time due to surge irrigation makes it possible to reduce the total water application. A reduction in water application will occur only if a change in set time, set size, or both is made. The example in Table II shows that surge setting 1 did not reduce the total water application because the relative increase in number of gates (100/50 = 2) equaled the relative increase in the set time (24/12 = 2). Thus the same area was covered in the same time period when switching from conventional to surge flow. Surge setting 2 results in a savings in applied water because the relative increase in number of gates (72/50 = 1.44) was greater than the relative increase in the set time (16/12 = 1.33). This reduced the time to irrigate the 40 acre field from 4.5 to 4 days, where the surge system would result in a 10 percent savings in applied water.

Table II. An example 40 acre field with 1/4 mile runs, 36 inch row spacing, irrigating 440 (every) furrows.

	Continuous Flow	*Surge Setting 1*	*Surge Setting 2*
Set Time (hours)	12	24 (12/side)	16 (8/side)
Gates Opened		100	72

per Set	50	(50/side)	(36/side)
Days to Irrigate Field	4.5	4.5	4
Water Saved vs. Continuous Flow		0	10% Less Water

Fine Tuning the System

After a set is irrigated use a soil probe to check the upstream and downstream ends of the field for the depth of infiltration. Probe on the side of the ridge at an angle to determine the moisture content beneath the plant. If very little infiltration has occurred at the downstream end, lengthen the soak cycles to get more runoff or close some gates to get a higher stream size.

In many cases surge irrigation will reduce the amount of water stored in the root zone. Thus, irrigations will need to be scheduled more frequently to reduce the chance of water stress. Use the flow meter on your well to calculate the amount of water applied with each irrigation and use a soil probe to determine the soil moisture status of the root zone.

Field conditions will change for each irrigation and the controller settings should change accordingly. Usually it is much easier to get water through the field on the second irrigation — the controller needs to know this. After the third or fourth irrigation the furrows are usually fairly stable and controller changes, if necessary, will be slight. After the third irrigation the effects of surge irrigation will probably be less dramatic than with the first irrigation.

Note: The mention of trade names herein does not constitute endorsement by the University of Nebraska, Institute of Agriculture and Natural Resources, Cooperative Extension.

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