SECTION 686.2 FURROW EVALUATION

SECTION 686.21 EVALUATIONS BY INFLOW-OUTFLOW METHOD

Inflow and outflow measurements representing an entire irrigation set are most desirable when making an evaluation for the purpose of placing a soil in a furrow intake family. An alternative is to measure inflow and outflow for the first one-fourth to one-half of the total irrigating time. When all irrigations during the season cannot be measured, it is most desirable to make the furrow intake evaluations during the middle of the irrigation season. This time will represent more average conditions as higher intake rates usually occur in the early part of the irrigation season, and lower intake rates occur toward the end of the season.

Site Selection

Furrow tests to determine the intake characteristics must be made on carefully selected sites that are representative of the soil being evaluated. The site should have no recognizable difference in soils throughout the length that is to be evaluated. The furrows should have a uniform cross section and a uniform grade between the inflow and outflow measuring points. Individual wheel rows should not be evaluated; however, they may be included when evaluating a group of furrows. Data should be recorded on Form NE-ENG-69.

Soil Moisture

On-site estimates of soil moisture should be made and are essential when evaluating a specified field. Where feasible, studies should be made when moisture conditions indicate that a normal irrigation application is needed.

Cropping History

The present crop, stage of growth, and previous crop grown should be recorded.

Soil Conditions

The condition of the furrows (freshly cultivated, cloddy, dispersed soil, smoothed by previous irrigation, etc.) has a marked influence on furrow intake rates and should be recorded. The number of times the field has been irrigated since the start of the irrigation season, and since the last furrowing operation, should also be known and recorded.

Flow Measurements

The flow of water in furrows can be measured in several ways. Inflow can be measured volumetrically with a calibrated container and stop-watch, where the flows are small (up to about 20 gpm), or with a number of small measuring devices: e.g., orifice plates, V-notch weirs, trapezoidal flumes, etc. Outflow can be measured with any of the above small measuring devices. See Section 685.23 "Measurement of Flow in Open Ditches," for additional information. Care should be taken in the selection and installation of measuring devices so as not to block the furrow flow. The outflow measuring device should be located at a point where backwater does not affect the flow to the extent that false intake rates are measured.

Flow Control

The inflow rate should be constant throughout the test. If the inflow rate changes, the volume of water in channel storage in the furrow also changes. The inflow rate throughout the test must be described by measured flow rates and the time of measurement.

Installation

At least three adjacent furrows or furrow groups should be measured on each test site. Adjacent furrows on each side of the test area should also be irrigated simultaneously.

Procedure

The furrow length between the inflow and outflow measuring stations should be measured and not estimated. Normally, the full furrow length should be evaluated. The minimum evaluation length should be 200 to 300 feet for high intake rate soils and 500 to 600 feet for low intake rate soils. The average furrow slope and furrow cross section need to be determined. Readings should be taken to determine uniformity of grade. The furrow stream introduced should not cause erosion. It is, however, desirable to use the same flow rate which the farmer normally uses as part of the evaluation, even if the flow rate results in erosion. The minimum flow to be used should be large enough to produce a fairly uniform rate of advance. As shown on Figure 686-13, the example, record the time water starts flowing through each measuring device and adjust streams so that flows into all furrows are approximately equal. Record the time when the water in each furrow reaches each station. Periodically, or when the inflow rate changes, measure the inflow stream and record the rate of flow and the time. Record the time when water starts to flow through the outflow measuring device. Periodically measure and record the outflow. When ending the intake evaluation before completion of the full irrigation, take final inflow-outflow measurements at the same time. The maximum depth of flow should also be measured and recorded.

Although not needed for the intake evaluation, it is desirable to measure the wetted bulb after the completed irrigation for purposes of the field evaluation. For these measurements, a soil moisture probe will readily define the boundary line between the wet soil and the relatively dry soil. The opportunity time to obtain this wetted pattern should be included with the sketch of the bulbs. Another method which can be used is to excavate a trench perpendicular across the furrow and observe the wetted area.

Computation and Evaluation

Compute the inflow and outflow volumes. For each furrow or groups of furrows, determine: the average inflow (0_i), the inflow time (T_i), and the cumulated volumes of inflow (V_i) and outflow (V_o) at the end of tie irrigation and at selected intermediate times. The minimum selected intermediate time should be such that flow has reached the outflow station, the flow is reasonably uniform, and surface storage in the furrow reach is stable. For each furrow, determine a minimum of three points on the cumulated intake vs. time line. Each point is described by the coordinates: (1) cumulated intake for the furrow length (F_f), and (2) the average opportunity time for intake to occur in the furrow length (T_{op}).

The average cumulated intake (F_f) is determined using the following equation:

$$F_f = \frac{1.6041}{L\,(P)}\ (V_{in} - V_{out} - V_s) = \text{inches}$$

where:

V_{in} = volume of inflow, gallons = Q_i x T_i

Q_i = average inflow rate, gpm

T_i = inflow time, minutes

V_{out} = volume of outflow, gallons = Q_2 x T_2

Q_2 = average outflow rate, gpm

T_2 = outflow time, minutes

V_s = surface storage in gallons in evaluation length, L

L = evaluation length, feet (distance between inflow and outflow measuring stations)

P = Width over which intake occurs, equal to wetted perimeter plus a constant

Before it is discussed how these terms can be determined mathematically, it should be understood their values are unique to the different time intervals that are analyzed. The examples will show that it is necessary to analyze more than one time of infiltration.

It should also be understood that the infiltration rate (F_f) that is determined for the selected time interval will be under the cross hatched area in Figure 686-11. The gross application (F_i) will be less than (F_f) as illustrated by Figure 686-12.

The intake width (P) can be determined mathematically using the following:

$$P = 0.2686\left(\frac{Q_i\ n}{S^{0.5}}\right)^{0427} + 0.7462 \text{ - feet}$$

where:

n = Manning coefficient or roughness

S = furrow slope, ft/ft

Surface storage (V_s), in lieu of actual measurements, can be estimated by the following:

$$V_s = L\left[(0.09731)\left(\frac{Q_i\ n}{S^{0.5}}\right)^{0.7527} - 0.00574\right] = \text{gallons}$$

The average opportunity time (T_{op}), in minutes, may be determined as the average of the inflow time (T_i) and the outflow time (T_2) or: $T_{op} = 0.5\ (T_i + T_2)$.

When the advance is curvilinear, a more exact value of average opportunity time can be obtained by averaging the opportunity time at various points along the furrow length or by integration of the advance curve.

Computation of the opportunity time is facilitated by converting the 24 hour clock time used to record the time of measurements, to decimal hours. For example, the 24 hour clock time of 1120 would become 11.33 (11 + 20/60). This is illustrated in the examples. If the set time is over 24 hours, note the date change and continue to accumulate clock hours. For instance, 2 a.m. of the 2nd day could be recorded as 2600 hours.

A plot of cumulated inflow and outflow in gallons vs. clock time since the start of irrigation facilitates determination of the intake volume at any elapsed time, when simultaneous measurements of flow are not made. Subtraction of the cumulated outflow from the cumulated inflow yields the intake and storage. Subtraction of the surface storage yields the volume of intake, in gallons, at any time.

The cumulated intake (F_f) and associated opportunity time (T_{op}) points, when plotted on log-log paper, define the measured intake line. This line is then compared to the Intake Family Lines, Figure 686-15, for determination of the most representative intake family.