IRRIGATION WATER MANAGEMENT (Code 449)

Irrigation Water Management (IWM) is the practice of monitoring and managing the rate, volume, and timing of water application according to the seasonal crop needs, giving consideration to the soil intake and water holding capacities. Soil moisture should be managed to obtain optimum yields, without deep percolation losses or runoff.

Irrigation water management will help irrigators determine the effectiveness of irrigation practices, make good water management decisions, and justify making irrigation adjustment in existing systems.

Tools are available to assist the irrigator with irrigation water management:

- Flow meters to record instantaneous flow rates and total volume usage.
- Sensors or tensiometers to monitor soil moisture.
- Data loggers (used with sensors) to record soil moisture history throughout the growing season.
- “Checkbook” method to record and monitor soil moisture during the irrigation season.

Checkbook Method

The Checkbook Method is an excel computer program used to track available soil moisture, based on plant evapotranspiration rate, precipitation and irrigation. The program helps producers properly schedule irrigation by computing available soil moisture on a daily basis.

Daily temperatures, which drive evapotranspiration, can be obtained for different locations in Montana at: [http://www.accuweather.com/us-city-list.asp?zipcode=&state=MT](http://www.accuweather.com/us-city-list.asp?zipcode=&state=MT)

The checkbook balance is used to determine if soil moisture is properly managed between Field Capacity and the Management Allowed Depletion (MAD) level (see Figures 1-3). The MAD level is defined as the percentage of available soil water that can be depleted between irrigations without causing plant stress.
Producers input data into the checkbook program themselves or send the data to a contractor on a weekly basis. If a contractor is utilized to track the daily balance of soil moisture in the field, the contractor will notify the producer of potential MAD level shortfalls and recommend irrigation adjustments.

The producer will participate in a year-end feedback session with NRCS staff and contractor to review the effective management of soil moisture through the growing season, and discuss the potential for water and energy savings. The producer or NRCS will print out the soil moisture balance sheet, recommended irrigation schedule, graphed presentation of water use, potential energy savings, and technical certification sheet and review these documents during the feedback session.

The technical certification sheet must be signed by the landowner, contractor (if used), and NRCS prior to the release of program payments.

**Irrigation Water Management Levels**

The producer can contract one of three IWM levels.

**Basic Level** – The producer determines the initial soil moisture in the field by the Feel and Appearance Method. Irrigation application amounts are collected with a flow meter or other measurement device. Data is organized and tracked by the checkbook method. The checkbook is kept current throughout the irrigation season so adjustment can be made to irrigation amounts or set times to keep soil moisture between Field Capacity and the MAD level.

**Intermediate Level** – The producer determines soil moisture in the field using soil moisture sensors or tensiometers. The producer installs one set of sensors or tensiometers per field. A set includes three sensors or three tensiometers installed at three different depths. Sensors are read with an electronic meter. Tensiometers are manually read from a vacuum gauge. Irrigation application amounts are collected with a flow meter or other measurement device. Data is organized and tracked by the checkbook method. The checkbook is kept current throughout the irrigation season so adjustment can be made to irrigation amounts or set times to keep soil moisture between Field Capacity and the Management Allowable Depletion (MAD) level.

**Advanced Level** – The producer determines soil moisture in the field using sensors. Sensors data is transmitted to a data logger by hard wire or telemetry. Logged data is transmitted to a web service and viewed by smart phone or computer. Irrigation application amounts are collected with a flow meter or other measurement device. Data is organized and tracked by the checkbook method. The checkbook is kept current throughout the irrigation season, so adjustment can be made to irrigation amounts or set times. The producer actively manages soil moisture between Field Capacity and the Management Allowable Depletion (MAD) level for their specific soils and crops.
Tensiometers

A tensiometer should be placed at 3 different depths to accommodate changes in rooting depth during the growing season. Tensiometers should be read frequently to monitor how hard the crop is working to extract moisture. Following irrigation, the reading on the tensiometer will decrease.

Soil Moisture Sensors
Soil moisture sensors are similar to tensiometers, but they use an indirect method of measuring soil moisture. Sensors are used with the Intermediate and Advanced levels of IWM. An electronic meter is used to read the amount of moisture absorbed through the sensor. The resistance across a pair of electrodes imbedded within the sensor varies with moisture content. This varied resistance is calibrated against known values and reported as centibars or percent volumetric moisture. Sensors shall be designed to compensate for the effects of salinity.

Use the following guidelines for soil moisture sensors that read in centibars.

- 0-10 centibars = Saturated soil
- 10-30 centibars = Soil is adequately wet (except coarse sands, which are beginning to lose water)
- 30-60 centibars = Usual range for irrigation (most soils)
- 60-100 centibars = Usual range for irrigation in heavy clay and is the upper limit for a tensiometer.
- 100-200 centibars = Soil is becoming dangerously dry for maximum production. Proceed with caution! **Note:** Tensiometer scales cannot read this high, but soil moisture meters can.

Sensors are calibrated to reflect the same values that would be measured by a tensiometer. Sensors are maintenance free and can be left in the ground permanently. They require very little power and integrate with electronic systems for data transmission and logging.

**Soil Moisture Meter**

The electronic meter is a solid-state, alternating current, resistance bridge. The meter can be calibrated for soil temperature variations. One meter can be used to read an unlimited number of sensors, one at a time. Meter readings can be acquired by connecting two leads to the moisture sensor and selecting the “read” button. The meter reads in centibars and ranges from 0 cb (wet) to 199 cb (very dry).

**Soil Moisture Transmitter and Data Logger**

Transmitters and data loggers are used with the Advanced level of IWM. A Base Station is often used to create a bridge between the soil moisture sensors and the data logger or receiver.

Data loggers record the continuous values of soil moisture which is constantly changing due to irrigation, precipitation and the crop’s consumptive water use. Data can be downloaded and viewed daily with a smart phone or computer. Each manufacturer transmits different output values. A few
examples of transmitters or data logger are presented below.

NRCS recommends systems with wireless data transmission (telemetry) from the data logger to a smart phone or computer. Data loggers that require a hard wire connection to a computer make it difficult to monitor patterns or trends associated with continuous changes in soil moisture.

Special care should be taken in taller crops to ensure that leaves and stems do not obstruct the transmitter or data logger connection. Follow the manufacturer’s recommendation on placement.

A self-tipping rain gauge also should be installed and connected to the data logger.

**Vertical Placement of Sensors or Tensiometers**

One set of sensors or tensiometers is required per field. The set should include three sensors or tensiometers nested together at different depths within the root zone. The shallow sensor is set at 25% of the crop rooting depth; medium sensor is set at 50% of the crop rooting depth; and the deep sensor is set at 75% of the crop rooting depth.
Placement of Sensors or Tensiometers in Furrow Irrigation
Place a set of sensors or tensiometers two-thirds of the way down the furrow, and 3 or 4 rows in from the field edge. Install sensors or tensiometers in the crop row.

Placement of Sensors or Tensiometers in Flood or Border Irrigation
In flood or border method of irrigation, sensors are normally placed two-thirds of the way down the run and midway between the borders. Tensiometers should be of sufficient length to keep the gauges out of the flood water.

Placement of Sensors or Tensiometers in Sprinkler Irrigation
A set of sensors or tensiometers should be located in an area receiving consistent water applications. In pivot irrigation, install a set at one of the following locations: between the first and second tower, between the last two towers, or at the midpoint of the entire machine length. Optional sets can be placed in “hot spots”, lightest soil, quickest to dry, or a point that represents the lowest production area in the field.

Placement of Sensors or Tensiometers in Drip or Trickle Irrigation
In drip (trickle) irrigation, a set of sensors or tensiometers is normally located at the drip line of the crop. The set should be placed within the wet area of the emitter or micro spray. Shallow sensor should be placed in the root ball of the crop regardless of emitter location. In row crops, the set should be placed in the row.

Deficit Irrigation Areas
Deficit irrigation areas are limited by water delivery. The Intermediate level of IWM shall be contracted in these areas. Two sets of tensiometers shall be installed in selected borders or furrows. Document irrigation set times, water infiltration depth, and flow rate (from flow meter). Tensiometers should be moved to different flood borders each year.

One set of tensiometers shall be installed at the head end of a border and the other set at the tail end (approximately 85% down slope) of a border. Information of set times and flow rates can be confirmed or adjusted based on tensiometer readings.

Documentation required for deficit irrigation is recorded on the “Irrigation Water Management Certification Sheet” MT-ENG. 449.pdf. (See Figure 4.)

Downloading Programs
IWM Checkbook program: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/technical/engineering/?cid=nrcs144p2_056931


Or acquire from NRCS office.
Figure 1. Tabulated soil moisture balance sheet (Checkbook).

Figure 2. Graphical presentation of water use.
Figure 3. Certification sheet with potential energy savings and yield improvement.
IRRIGATION WATER MANAGEMENT CERTIFICATION SHEET

Cooperator ____________________________________________________________

Address ____________________________________________________________

County __________ Section ___________ TWP __________ Range ________________

(Attach plan map showing field and border being irrigated with sensors.)

NRCS DESIGN CRITERIA

Border width ______ (ft.) Slope ______________________ (ft./100 ft.) Length ______ (ft.)

Soil Intake family ____ Design flow rate ____________(gpm) Set time _____________(hr.)

Irrigated Borders or Furrow per set __________ Management rooting depth __________(ft.)

Moisture sensor type and depth: Tensiometer __________ (ft.) and ______ (ft.)

Soil Moisture Sensor __________ (ft.) and __________ (ft.)

IWM FIELD DATA

First Irrigation

Flow Measurement Method used ____________________________________________

Flow Meter: Time on __ am __ pm Time off __ am __ pm Date Started, Date finished ________________

Flow Meter reading at time on ______(ac/ft.) at time off ____________________________(ac/ft.)

Total Flow rate from meter or measurement device ______(gpm)

Border start time __ am __ pm Border end time __ am __ pm Border flow rate (gpm) ______

Head end of border: Time shallow sensor reads "0" __ am __ pm Deep sensor reads "0" __ am __ pm

Tail end of Border: Time shallow sensor reads "0" __ am __ pm Deep sensor reads "0" __ am __ pm

Second Irrigation

Flow Meter: Time on __ am __ pm Time off __ am __ pm Date Started, Date finished ________________

Flow Meter reading at time on ______(ac/ft.) at time off ____________________________(ac/ft.)

Total Flow rate from meter or measurement device ______(gpm)

Border start time __ am __ pm Border end time __ am __ pm Border flow rate (gpm) ______

Head end of border: Time shallow sensor reads "0" __ am __ pm Deep sensor reads "0" __ am __ pm

Tail end of Border: Time shallow sensor reads "0" __ am __ pm Deep sensor reads "0" __ am __ pm

Any changes to irrigation flow rate or set time based on soil moisture sensors? Yes, __ No ______

List any changes:

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________________________________________________________________________

________________________________________________________________________

Producer Signature __________________________ Date __________________________

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**Additional irrigations**

**Third Irrigation**

Flow Meter: Time on □ am □ pm  Time off □ am □ pm  Date Started Date finished__________

Flow Meter reading at time on ___(ac/ft.) at time off ___________________________(ac/ft.)

Total Flow rate from meter or measurement device (gpm)

Border start time □ am □ pm  Border end time □ am □ pm  Border flow rate (gpm)________

Head end of border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

Tail end of Border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

**Fourth Irrigation**

Flow Meter: Time on □ am □ pm  Time off □ am □ pm  Date Started Date finished__________

Flow Meter reading at time on ___(ac/ft.) at time off ___________________________(ac/ft.)

Total Flow rate from meter or measurement device (gpm)

Border start time □ am □ pm  Border end time □ am □ pm  Border flow rate (gpm)________

Head end of border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

Tail end of Border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

**Fifth Irrigation**

Flow Meter: Time on □ am □ pm  Time off □ am □ pm  Date Started Date finished__________

Flow Meter reading at time on ___(ac/ft.) at time off ___________________________(ac/ft.)

Total Flow rate from meter or measurement device (gpm)

Border start time □ am □ pm  Border end time □ am □ pm  Border flow rate (gpm)________

Head end of border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

Tail end of Border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

**Sixth Irrigation**

Flow Meter: Time on □ am □ pm  Time off □ am □ pm  Date Started Date finished__________

Flow Meter reading at time on ___(ac/ft.) at time off ___________________________(ac/ft.)

Total Flow rate from meter or measurement device (gpm)

Border start time □ am □ pm  Border end time □ am □ pm  Border flow rate (gpm)________

Head end of border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

Tail end of Border: Time shallow sensor reads “0” □ am □ pm  Deep sensor reads “0” □ am □ pm

Additional Notes:

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Figure 4. Irrigation Water Management Certification Sheet

NRCS-Montana  February 2018