Agriculture Stationary Gun Irrigation Scheduling Calculator Users Guide

Prepared and Published by

Irrigation Industry Association of British Columbia (IIABC)

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www.irrigationbc.com

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Agricultural Stationary Gun Irrigation Scheduling Calculator User's Guide

Information from the B.C. Irrigation Management Guide produced by the **Irrigation Industry Association of British Columbia** has been used as a guide in the preparation of this document. The Irrigation Scheduling Calculator was developed solely by the Ministry of Agriculture and Lands and the Irrigation Industry Association of British Columbia with funding from the Canada British Columbia Water Supply Expansion Program.

INTRODUCTION

The Irrigation Scheduling Calculator found at **www.irrigationbc.com** has been developed specifically for use in British Columbia although other regions can use the calculator by entering their own Reference Evapotranspiration (ETo) data. This guide provides background information on the parameters and calculations used for sprinkler systems in the Agricultural Irrigation Scheduling Calculator. While there is on line help available on the calculator, often not enough detail is provided to make a good determination on which value to use.

Irrigation systems should be designed and operated to supply the crop water requirement while minimizing runoff and leaching. To ensure peak irrigation system performance the system design should take into account evapotranspiration, crop coefficients, soil type and irrigation system efficiencies. High frequency irrigation leads to increased surface evaporation and usually a higher rate of transpiration by the crop. The Agricultural Irrigation Scheduling Calculator minimizes the frequency of irrigation but maximizes duration of application that is allowed by the soil and crop. It is better to have an irrigation schedule where irrigation occurs less frequently but fully utilizes water stored in the crops' root zone.

The Agricultural Irrigation Scheduling Calculator assumes that the irrigation system has been properly designed to match the location, soil type and crop water requirements and maintained in good operating condition. It is recommended that a Certified Irrigation Designer be used to design an irrigation system.

The calculator takes the following information into account in the development of an irrigation schedule:

- How much water the crop requires.
- How much water can be stored in the soil that is readily available to the plant.
- The amount of effective rainfall that is useable by the plant.
- How much water the irrigation system needs to apply to make up the moisture deficit that has occurred.

This User's Guide provides direction on the calculations that are made by the calculator and how to select the information that populates the entry boxes in the calculator. There are four sections in the calculator that must be completed in order for a schedule to be developed. These are:

- Crop Type
- Soil Cross-section
- Irrigation System Design
- Irrigation Scheduling

To navigate from step to step click the next button on the lower right side of the screen.

To begin using the irrigation calculator, open the website **www.irrigationbc.com** Scroll down to the irrigation calculators. Click on the Agricultural Calculator icon.

Figure 1- Irrigation Calculators

The sign-in page will appear. Follow the instructions on the page if creating a new account. See Figure 2.

Enter your username and password, then click **Login!**

Figure 2 - Login

The opening page will appear. See Figure 3. You will need to select a field you have already entered or create a new one by clicking on **New Field**.

Figure 3 - New Field
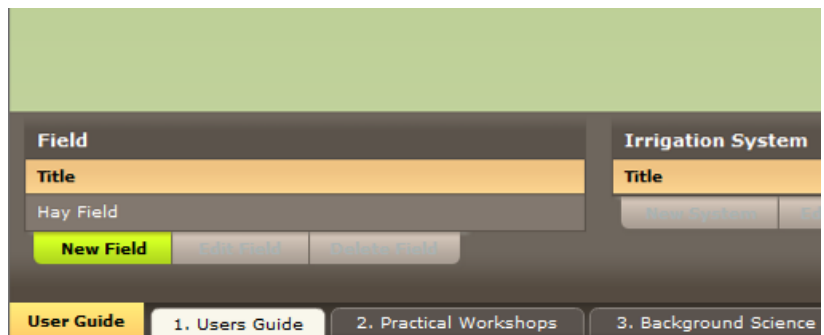
Now select the irrigation system you entered earlier. See Figure 4. Then click complete worksheets. You can create another system by clicking on **New System**

Figure 4 - New System
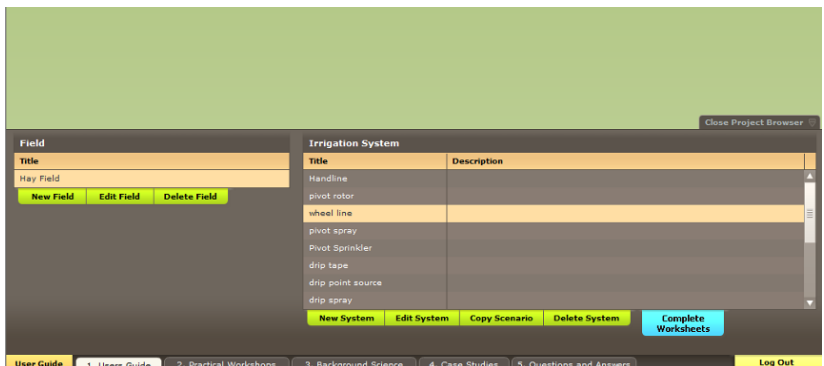
1.1 CROP TYPE

The crop tab allows the type of crop that is to be grown to be selected. Once this is done a number of default values will be displayed.

Figure 5 - Crop Type Tab

Effective Rooting Depth of Mature Crops

The crop's active **rooting depth (RD)** is the soil depth from which the crop extracts most of its water needs. It is determined by digging a soil pit to observe the actual rooting depth or using plant rooting depth information from other sources. A deeper rooting depth creates a larger reservoir of water for the plant to draw upon between irrigation. The calculator provides an estimate of the crop rooting depth automatically. The depth selected by the calculator can be altered if the plant is not mature or if there is a soil depth restriction that limits the crop rooting depth by clicking on the override defaults tab.
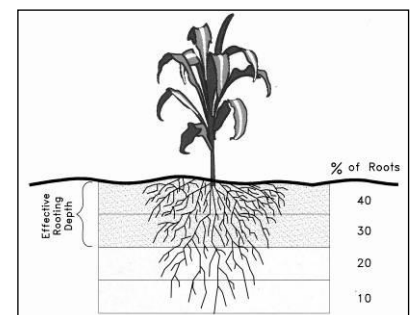
Figure 6 - Rooting Depth

Availability Coefficient   (AC)

Plants can only extract a portion of the water stored in the soil without being stressed. The **availability coefficient (AC)** is used to determine the portion of water stored in the soil that is readily available to the plant. The availability coefficient is expressed as a percentage and is used to calculate the Maximum Soil Water Deficit (MSWD) in the soil cross – section tab. The MSWD is the maximum amount of water that may be removed from the soil before irrigation is again required. The calculator selects a default AC automatically as shown in Table 1. This value can be changed by clicking on the override defaults tab.

Rooting Depth (RD) and Availability Coefficient (AC)

Crop	RD [ft]	RD [m]	AC	Crop	RD [ft]	RD [m]	AC
Alfalfa	4	1.2	0.55	Hops	4	1.2	0.50
Almonds	4	1.2	0.40	Kiwifruit	3	0.9	0.35
Asparagus	4	1.2	0.45	Lettuce	1 1/2	0.45	0.30
Beans, green	2	0.6	0.45	Loganberries	4	1.2	0.50
Beets	2	0.6	0.50	Onions, green	1 1/2	0.45	0.30
Blackberries	4	1.2	0.50	Pasture species	1 1/2	0.45	0.50
Blueberries	2	0.6	0.50	Peas	2	0.6	0.35
Broccoli	2	0.6	0.45	Peppers, sweet	3	0.9	0.30
Brussel Sprouts	3	0.9	0.45	Potato	2	0.6	0.35
Cabbage	1 1/2	0.45	0.45	Pumpkin	4	1.2	0.35
Cantaloupe	4	1.2	0.45	Radishes	1 1/2	0.45	0.30
Carrots	2	0.6	0.35	Raspberries	4	1.2	0.50
Cauliflower	1 1/2	0.45	0.45	Spinach	2	0.6	0.20
Celery	2	0.6	0.20	Squash	3	0.9	0.50
Cereals	3	0.9	0.50	Strawberries	2	0.6	0.20
Clover (ladino)	1 1/2	0.45	0.50	Sugar Beets	4	1.2	0.55
Clover (red)	3	0.9	0.50	Tomato	2	0.6	0.40
Corn, field	4	1.2	0.50	Tree fruits (12 ft x 18 ft)	4	1.2	0.40
Corn, sweet	3	0.9	0.50	Tree fruits (3 ft x 10 ft)	2	0.6	0.40
Cucumber	1 1/2	0.45	0.50	Tree fruits (6 ft x 12 ft)	3	0.9	0.40
Eggplant	3	0.9	0.45	Turf	1/2	0.15	0.50
Garlic	1 1/2	0.45	0.30	Turnip	1 1/2	0.45	0.50
Grapes	4	1.2	0.40				

Table 1 - Rooting Depth and Availability Coefficient

Climate Coefficients by Month

Each type of crop selected has a different consumptive rate for water. The crop coefficient adjusts the evaportranspiration rate for the crop type and crop growth stage. The calculator provides a default crop coefficient for each month. Crops with multiple cuts will have consumptive use cycles through the growing season. For use with the calculator these numbers have been averaged for the growing season. The crop coefficients can be altered by the user if better information is available.

Figure 7

Growth cycle for multiple cuttings
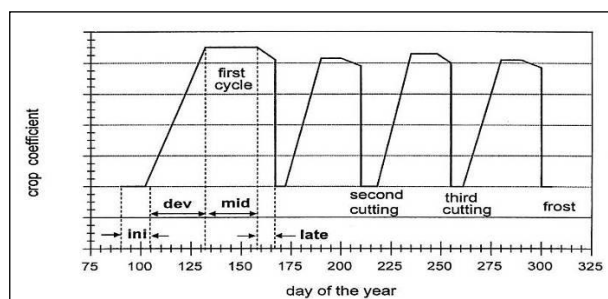
1.2   SOIL CROSS-SECTION

Knowledge about the soil is important to ensure that the correct amount of water is applied when required by the crop. Also the sprinkler application rate and irrigation interval are affected by the soil. The basic soil information required and calculated in the calculator is described below. The Soil Texture by Depth tab is where the soil type and depth is entered. The calculator selects the parameters described below.

Soil Texture and Structure

Soil texture is a term used to describe the size of individual soil particles such as sand, silt, or clay. Soil texture class is a name given to a soil to describe the relative amounts of sand, silt, or clay in that particular soil. The class name may be sandy loam, loamy clay, silty clay loam, etc. See figure 2. Soil texture has a major influence on the amount of water that can be stored in the soil against the pull of gravity. It also has a major influence on soil infiltration rate and the permeability of a soil; these terms are described in more detail later in this section.
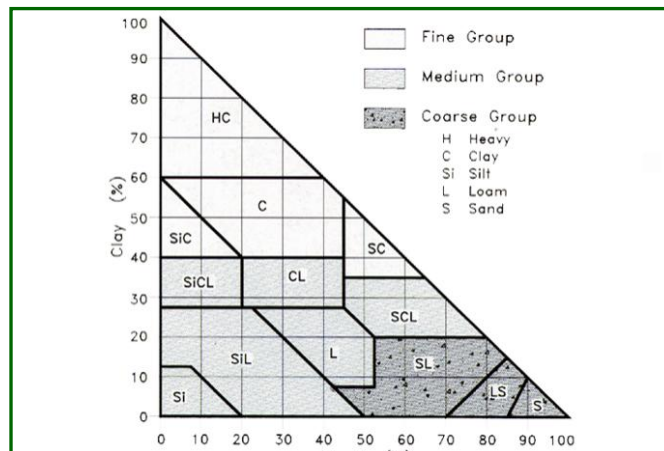
Figure 8 - Soil Textural Triangle

Soil structure is the arrangement of soil particles and soil aggregates into recognizable particles or lumps. Aggregates occur in almost all soils, but their strength, size and shape varies between soil types. Soil structure can be described in many ways such as; granular, blocky, crumb, platy, massive or granular. The structure also influences the amount soil water holding capacity and the infiltration rate. Soil with poor structure at the surface will not allow water to infiltrate easily.

Soil Layers
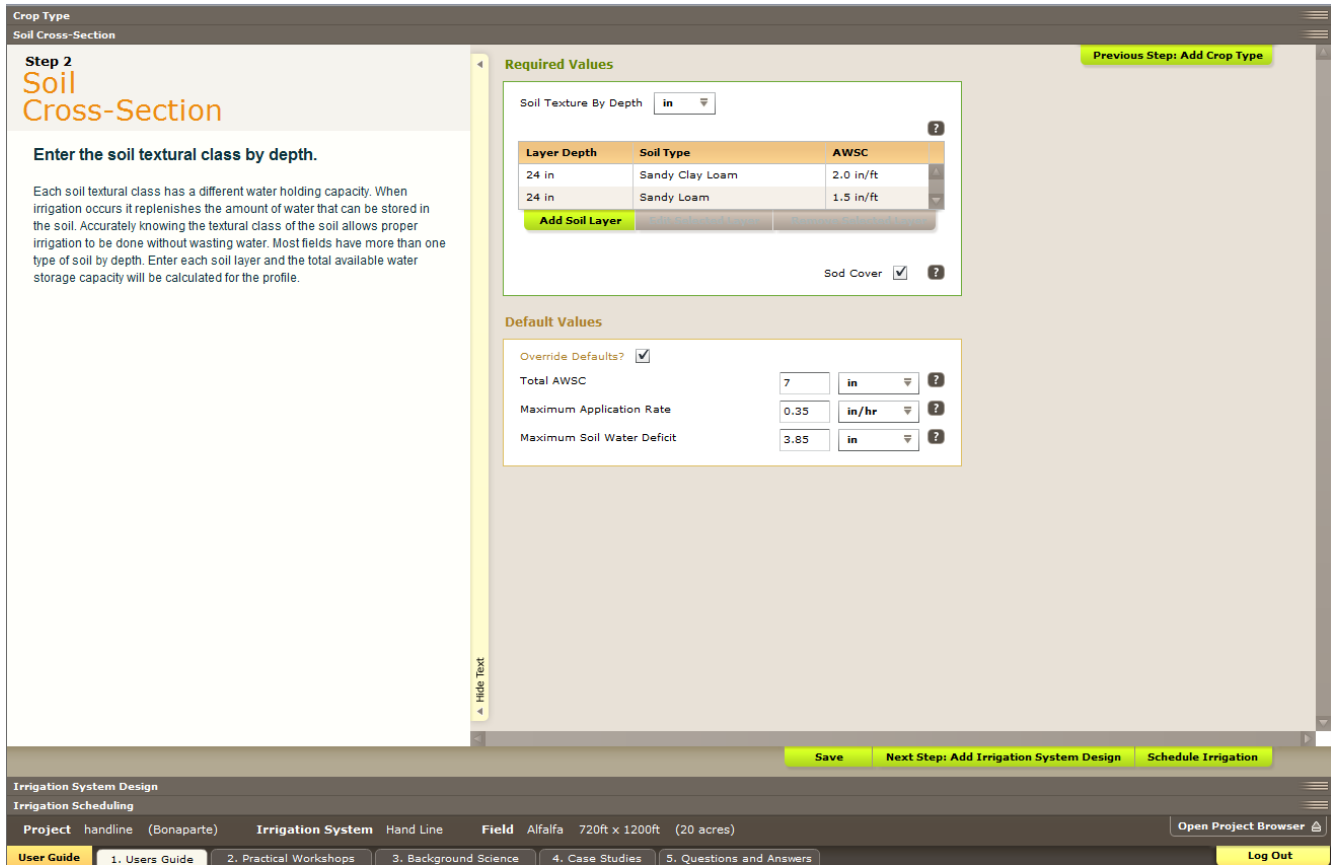
Figure 9 - Soil Cross – Section Tab

The soil cross section tab in the calculator allows a user to add a soil layer by using the drop down table or the soil texture triangle. Once a soil type is selected a soil layer depth must be added in inches. The total depth of the soil must be greater than the rooting depth that was selected in the previous tab. The first soil depth can be less than the rooting depth if a second rooting depth is added. The total depth of the two or more soil types should be greater than the plant rooting depth.
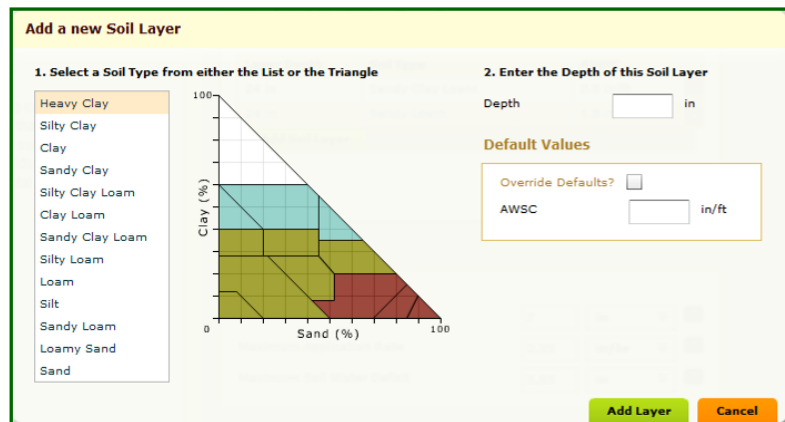
Figure 10 - Soil Triangle Tool

When the soil layer has been added the calculator will select and calculate a number of soil parameters using the information shown in the table below. The terms shown in the calculator are shown below. Although all the values are shown as defaults only the Available Water Storage Capacity should be adjusted by the user if better information is available. .

SOIL PROPERTIES					
SOIL TEXTURE CLASS	AWSC (in. water/ in. soil)	AWSC (in. water/ ft. soil)	AWSC (mm water/ m soil)	INFILTRATION RATE (in/hr)	(mm/hr)
Clay	0.20	2.4	200	0.25	6.3
Silt loam	0.21	2.5	208	0.35	8.9
Clay loam	0.20	2.4	200	0.30	7.6
Loam	0.18	2.1	175	0.35	8.9
Fine sandy loam	0.14	1.7	142	0.40	10.1
Sandy loam	0.12	1.5	125	0.45	11.4
Loamy sand	0.10	1.2	100	0.65	16.5
Sand	0.08	1.0	83	0.75	19

Table 2 - Soil Properties

Total Available Water Storage Capacity   (AWSC)

The soil's A**vailable Water Storage Capacity** (**AWSC**) is the amount of moisture the soil can store between field capacity and the permanent wilting point. The AWSC is related to the soil texture and the soil structure. The above table contains AWSC values for various soil types.

The Total AWSC as shown in the calculator is determined from the Available Water Storage Capacity (AWSC) and the plant's active rooting depth (RD). Knowing the soil water storage allows the calculator to determine how much water to apply at one time and how long to wait between irrigations. For example, the amount of water applied at one time on a sandy soil, which has a low soil AWSC, would be less than for a loam soil, which has a higher AWSC. This is assuming the plant's rooting depth is the same for both soils. Applying more water to the soil than can be stored results in a loss of water to deep percolation and leaching of nutrients beyond the root zone.

Maximum Application Rate

The infiltration rate is a measure of how quickly water enters the soil. The irrigation system application rate cannot exceed the soil's infiltration rate or ponding or runoff will occur. The calculator has built in values that determine an estimated maximum run time based on soil texture. The **Maximum Application Rate** which is equal to the infiltration rate is shown in the default values. Compacted soils and slopes will reduce the infiltration rate of the soil. With the irrigation system running it is useful to physically observe and determine if runoff occurs. These observations can be used to override the calculator values.

Maximum Soil Water Deficit (MSWD)

Maximum soil water deficit (MSWD) is the amount of water that can be stored in the soil that is readily available to the plant. It is the maximum amount of water that should be removed from the soil before irrigation is again required. The MSWD is also the maximum amount of water that can be applied at one time before the risk of deep percolation occurs. It is calculated by multiplying the Total AWSC by the Availability Coefficient.

To encourage deep root growth for plants, a sprinkler irrigation system should be operated as infrequently as possible, irrigating just long enough to fill the soil water storage to full capacity. The maximum amount that can be applied will be equal to the MSWD, providing that the soil moisture level had dropped this amount prior to irrigation.
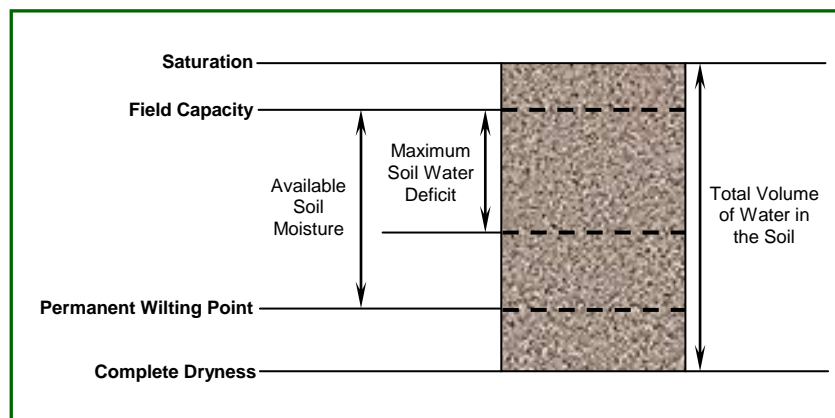
Figure 11 - Soil Water Moisture Terminology

1.3   IRRIGATION SYSTEM DESIGN

The Irrigation System Design tab allows for the entry of irrigation design and operation parameters. The basic information that must be entered is the sprinkler spacing along the lateral, the lateral spacing, the number of sets, the duration of the set, the nozzle size, and the nozzle pressure.

Figure 12 - Irrigation System Design Tab

It is very important that accurate data is entered into the calculator. The entered data will be used to calculate the amount of water that enters the soil. The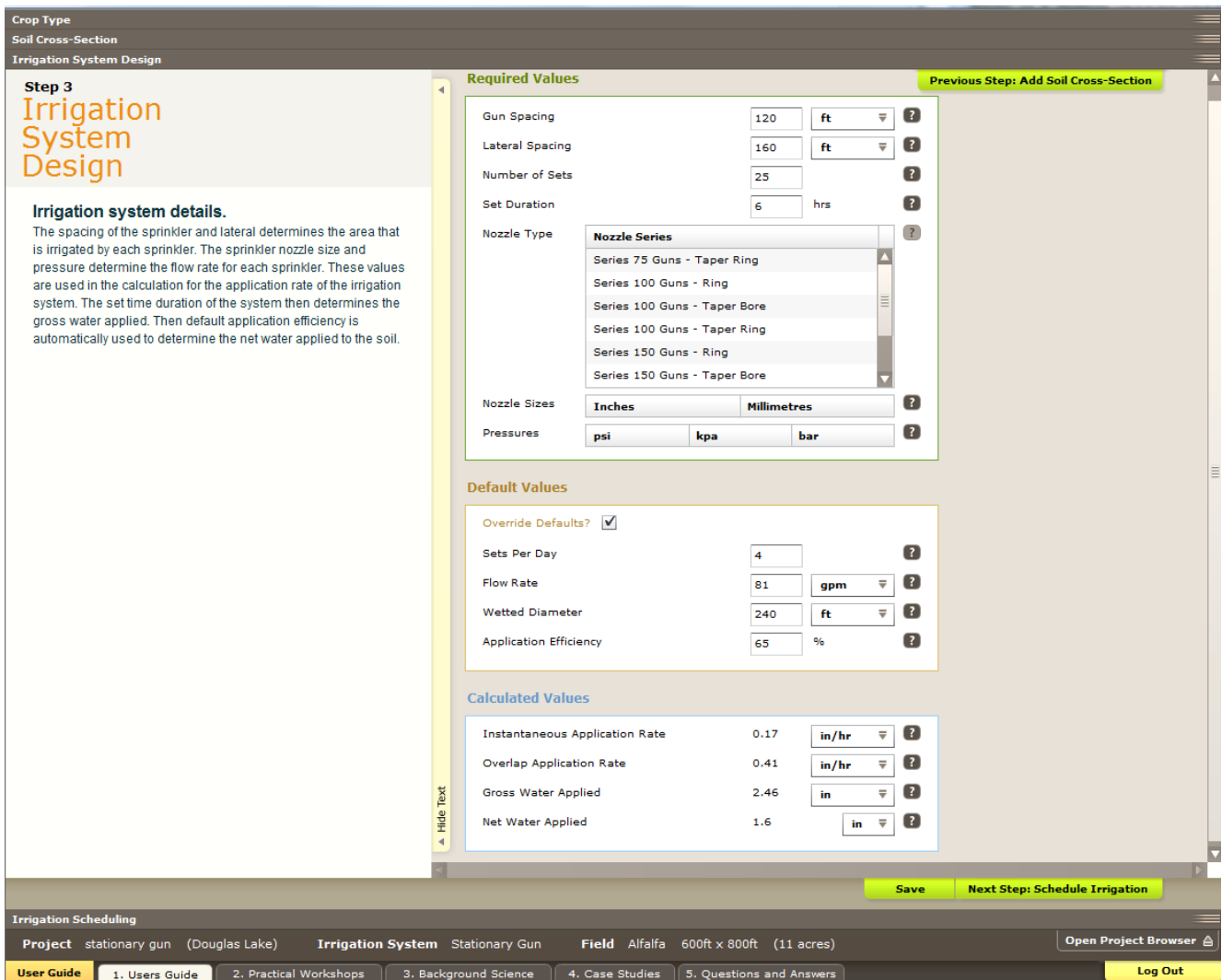 calculator also offers the option of using metric numbers. By clicking the drop down menu beside sprinkler spacing or lateral spacing meters or feet can be selected.

Gun Spacing   (SS)

Gun spacing is the distance along the lateral between the gun sets. For good design practice the gun sets should be the same distance apart along the lateral and should be spaced at a head to head coverage.

Lateral Spacing   (LS)

Lateral Spacing is the distance between the laterals or the lateral sets. It can be the same as the sprinkler spacing but usually it is greater. The lateral spacing should be no more than 1 1/2 times sprinkler spacing.

Number of Sets   (Sets)

The **Number of Sets** is the number of times the stationary gun is moved to cover the entire field. The calculator will provide a value that is calculated using the field dimensions you have entered and the lateral and sprinkler spacing chosen. If the number is incorrect it can be changed by the user.

Set Duration   (Set Time)

The **Set Duration** is the length time that the stationary gun is operating at one location. It is usually recorded in hours. Stationary guns have high application rates and should not be operated for extended periods or run off and deep percolation will occur. Run times should very rarely exceed 6 hours per set.

Nozzle Type

The **Nozzle Type** is the style of nozzle on the end of the gun. The most common is a taper bore which looks like a cone. The second most common is a ring nozzle which has a large washer plate under a thread on cap at end of the nozzle. The taper ring type is a combination of the two.

Nozzle Size

The **Nozzle Size** is the orifice diameter of the nozzle. The size should be stamped on the side of the nozzle. It is recommended to replace the nozzles if they become worn.

Pressure

Water Flow is determined from the nozzle size and the operating pressure. This information is taken from manufacturer charts. To accurately determine nozzle pressure a gauge should be installed on the side of the gun. A pressure gauge can be purchased from many different irrigation supply companies.

Figure 13 – Pressure Gauge

Sets per Day

This is the number of irrigation sets that the system is actually operating per day. The calculator will determine the number of sets from the set time and a 24 hour day. For example an 8 hour set time will result in 3 sets per day. If this default value is incorrect it can be manually changed. In some instances there may be more than one gun operating at a time. When more than one gun is operating at the same time the users will have to manually adjust the number of S**ets per Day** to allow for the calculator to determine a schedule.

Flow Rate (Q)

The **Flow Rate** is the amount of water that is delivered by the gun nozzle on a per minute basis. The default units are US gallons per minute (gpm). The calculator selects a flow rate based on the nozzle size and the gun operating pressure selected. Gun flow charts are available in the BC Sprinkler Irrigation Manual.

Wetted Diameter (D)

The **Wetted Diameter** is the diameter of throw of the gun. This number is supplied from manufacture charts. It is important in determining the instantaneous application rate.

Application Efficiency (AE)

Not all the water that leaves the gun enters the soil profile. Evaporation, wind and runoff account for a proportion of this water. When taken into account these losses determine the **Application Efficiency (AE)** of the irrigation system. The default application efficiency for the irrigation system type will be automatically entered. This number should only be altered if better information is available or by someone knowledgeable in irrigation design.

Instantaneous Application Rate   (IAR)

Stationary Guns systems should not be operated side by side as the instantaneous application rate by two guns will exceed the soil infiltration rate, which leads to runoff. The **Instantaneous Application Rate (IAR)** calculated by the calculator is based on the diameter of throw of one gun. When operated individually the actual application of water to the ground is over the circular area cover by the gun.

The instantaneous application rate is only used to determine if the soil infiltration rate will be exceeded.

If the system application rate exceeds the soil infiltration rate a red flag will appear notifying the user. The calculator can still provide an irrigation schedule but the irrigation system performance should be improved if at all possible.
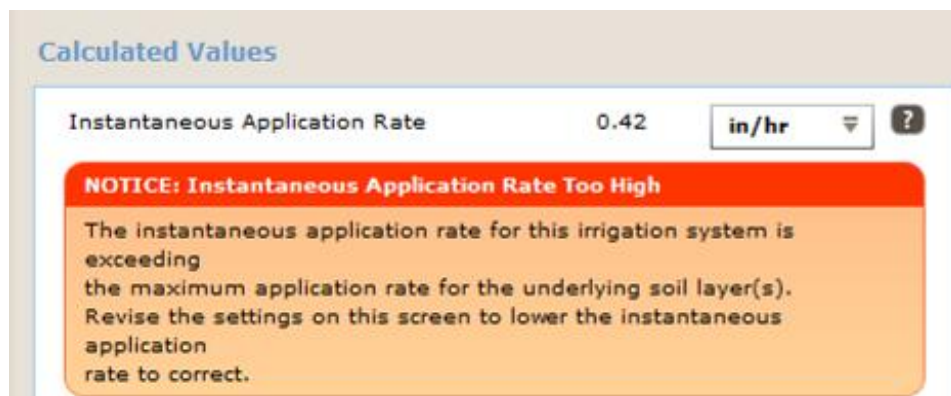

Figure 14 - Red Flag - Application Rate

Overlap Application Rate   (OAR)

Overlap Application rate (OAR) is calculated by using the gun spacing along the lateral and the lateral spacing. The overlap application rate calculated will be higher than the instantaneous application rate but it takes into account the throw from the gun on a number of sets that cover the area. This calculation is required to determine how much water is applied by the system to the crop as it moves around the field. The overlap application rate is multiplied by the set time to determine the Gross Water Applied.

The overlap application rate is used to determine how long the irrigation system should run to replace the moisture removed from the soil by the plant between irrigations.

Gross Water Applied   (GWA)

The **Gross Water Applied (GWA)** per irrigation is calculated from the gun application rate and the set time that the system operates on that location. The gross water applied per irrigation would be the number that is divided into the annual irrigation duty to determine the allowable number of irrigations per year.

Net Water Applied   (NWA)

The **Net Water Applied (NWA)** per irrigation is calculated from the gross water applied and the application efficiency of the system. The net water applied per irrigation is the amount of water that enters the soil.

If the amount of water applied exceeds the soils capacity to store the water a red flag will appear notifying the user. You can still proceed to determine the irrigation schedule but modifications to system operation should be made to improve performance. Two options would be to reduce nozzle size or reduce set time.

Figure 15 - Red Flag - Net Applied

1.4   IRRIGATION SCHEDULING

When the crop, soil and irrigation system information has been entered into the calculator, an irrigation schedule can now be determined. The calculator will retrieve Evapotranspiration data from a weather station of your choice. The calculator operates in real time so the climate date generated by the calculator will be the current date with an estimated forecast of the next five days. Climate data for the calculator is obtained from **www.Farmwest.com**

Evapotranspiration (ET) is the term used to describe plant water use and is a measurement of the total amount of water evaporated from the soil and plant surfaces plus the amount of water transpired by the plant. Factors such as temperature, wind, solar radiation and latitude all determine the ET rate. ET can be obtained from various sources. The data is collected daily but can be summarized for any time period.

Note: If accessing the calculator in the morning the climate data for the current date may not have been posted to the Farmwest web site yet. Climate data gets posted in the early afternoon of each day. For best results the calculator should be used in the evening to determine a schedule for the next few days.

To obtain irrigation scheduling information: select the **Closest Weather Station** to be used, and select the **Field Irrigation Started On** date from the calendar.

The calculator can also go back in time if desired to previous weeks, months or years if desired. By entering a date in the **Explore Historical Weather Data** calendar the calculator will determine an irrigation schedule from the past.
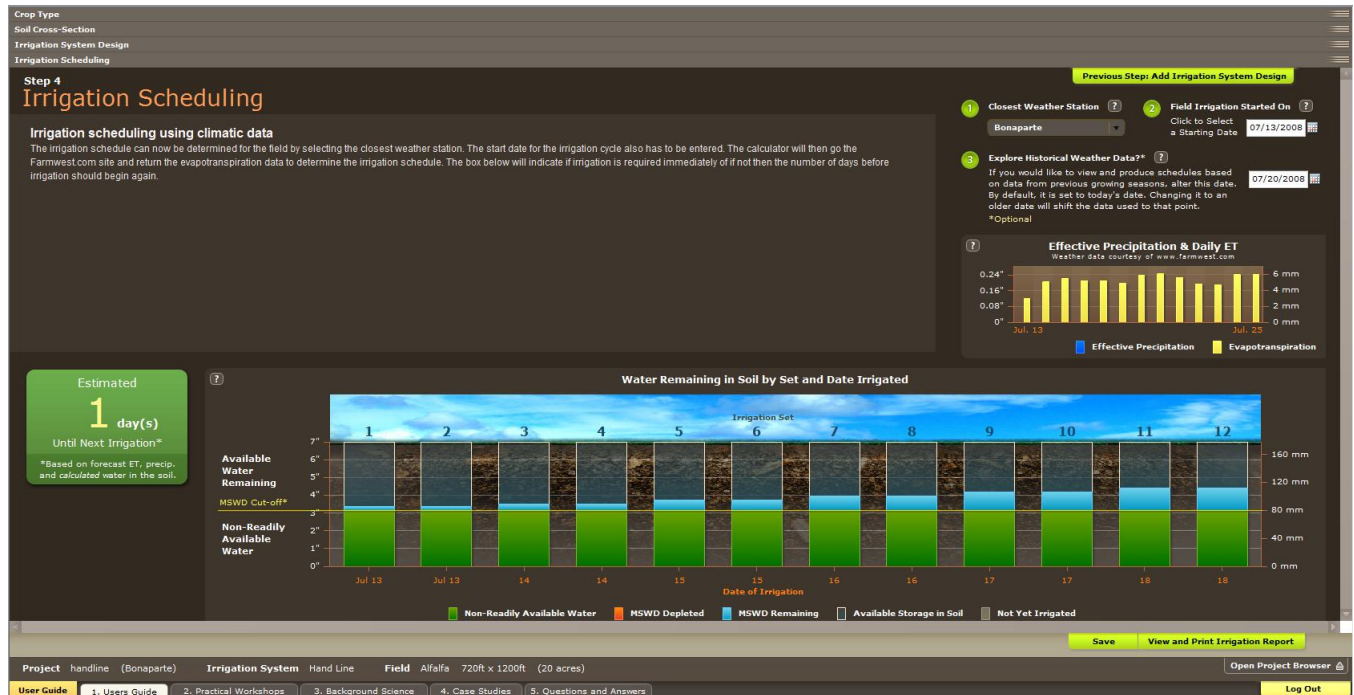

Figure 16 - Irrigation System Scheduling Tab Inputs
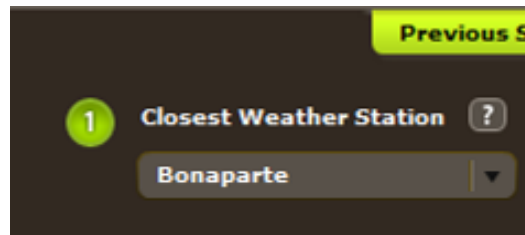
Closest Weather Station

Figure 17 - Closest Weather Station

The **Closest Weather Station** will default to the station selected when the field was entered in the calculator. This can be changed if the station data is missing or another station better represents the climatic conditions at the field.

If you have your own data that is not connected through Farmwest.com then **Custom Values** can be entered. This is explained in greater detail at the end of the user's guide.
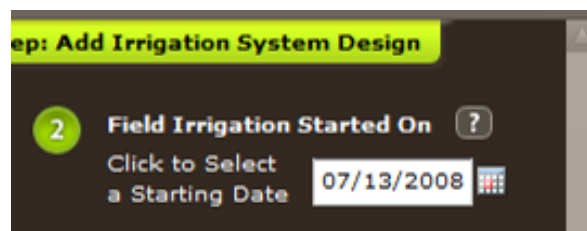
Field Irrigation Started On

Figure 18 - **Field Irrigation Started On**

The **Field Irrigation Started On** date refers to the start date for the irrigation cycle that is currently in progress or recently completed, not the beginning of the season. When the irrigation system was designed it should have had an irrigation schedule supplied. The irrigation system design will have been based on a Peak ET rate for the hottest time of the year. The calculator determines an irrigation schedule for times of the year when ET conditions are not at the peak time. The start date should be the day when the irrigation system started irrigation at the first set in the field.

Explore Historical Weather Data

Figure 19 - Explore Historical Weather Data

The **Explore Historical Weather Data** calendar allows the user to look at past climatic records and determine if the actual irrigation practice matched the climate records. When using the Explore Historical Data feature, make sure that the field irrigation started on date is also altered to an earlier date.
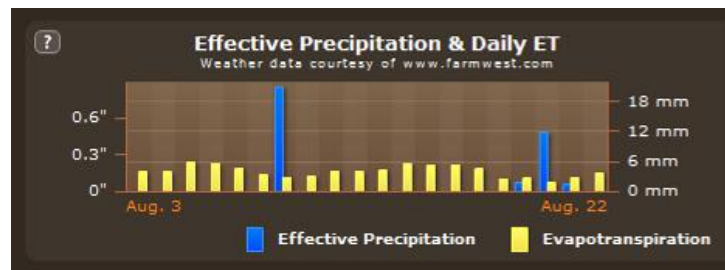
Effective Precipitation & Daily ET

Figure 20 - Effective Precipitation & Daily ET

The Effective Precipitation & Daily ET box has the downloaded data from Farmwest.com. By putting the computer mouse on top of a graph bar for the ET or Effective Precipitation the amount for that date will be shown.
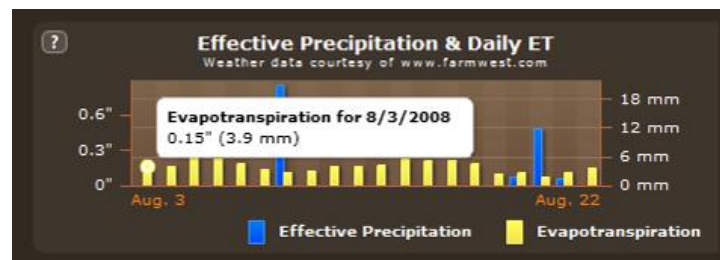

Figure 21 - Evapotranspiration by date

Effective precipitation is the amount of rainfall that occurs above 5 mm. It is then multiplied by 75 percent to cover application efficiency losses. If the rainfall event is less than 5 mm then no rainfall amount is entered since very little or none of the rainfall will enter the soil reservoir.

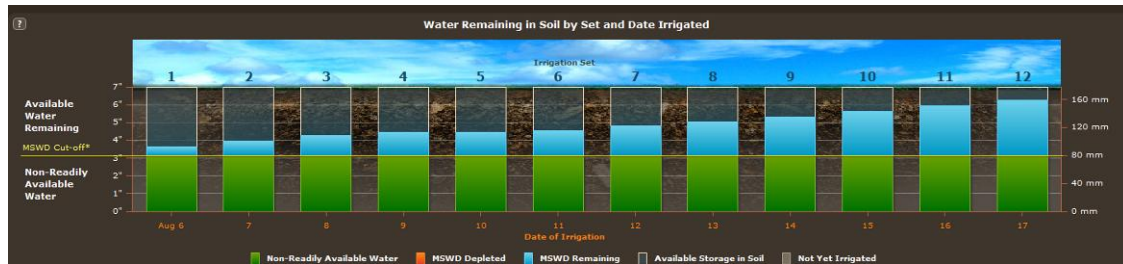## Water Remaining in the Soil by Set and Date Irrigated

Figure 22 - Water Remaining

The water remaining in the soil is indicated by the blue graph bar. The irrigation set on the last day will show the amount of water that is applied by the irrigation system. Set 1 would be the first set that the current irrigation cycle started on. It is also the oldest date in the chart. If an effective precipitation occurred it is added to the water storage of all the sets. The Evapotranspiration received from Farmwest.com which has been adjusted by crop coefficients is removed daily from each set. As the graph shows the available water remaining in each set chronologically reduces.
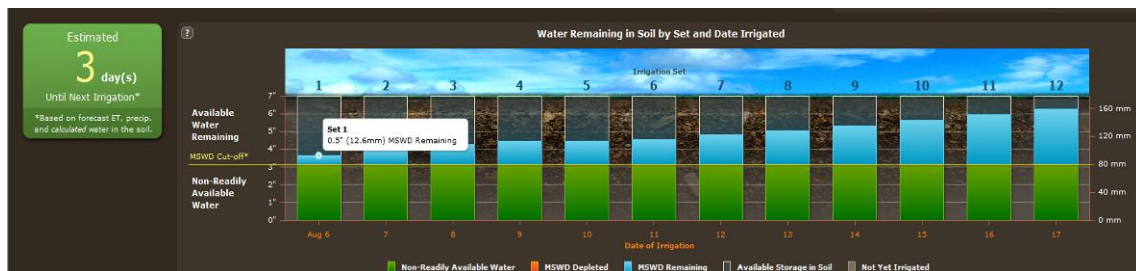
Figure 23 - Green Box

The box on the left will provide information on an estimated time until the next irrigation. If there is adequate water in the soil the calculator will recommend a length of time before irrigation needs to occur again. If the box indicates a 5+ days value the calculator should be run again in 4 or 5 days to determine an irrigation date.

Figure 24 - Orange Box

When the remaining water reaches the MSWD Cut-off (maximum soil water deficit) the indicator box turns orange warning that the field is dry.

Custom Evapotranspiration Values

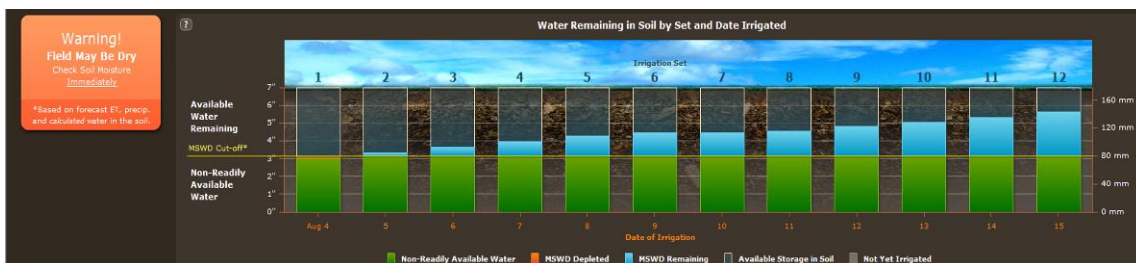The **Custom Values** option is at the bottom of the weather station drop down menu. When this is selected the Enter Custom ET Values button appears. By clicking this button the process for entering custom ET begins.

Figure 25 - Custom Values

The **Enter Custom Evapotranspiration Data** pane appears first. The Start date and then the end date are requested. After they are entered the daily ET and Effective Precipitation data can be entered. Each box requires data for the schedule to be determined. The Fill ET and Fill Precip box will populate all the boxes with the same data then edits can be done. After entering the data click the Use Entered Data button.

Figure 26 - Enter Custom Evapotranspiration Data

View and Print Irrigation Report

At the bottom right hand corner of the irrigation scheduling tab is an icon for printing a report on the irrigation system. Click the ==View and Print Irrigation Report== to do this.

Agricultural Irrigation
SCHEDULING CALCULATOR

Report for
stationary gun in Hay Field
Alfalfa. Field Size: 600 x 800 ft. Irrigation Method: Stationary Gun. Climate Station: Douglas Lake

Crop Alfalfa

Soil Properties (includes sod)		
Soil Type	Soil Depth	Soil AWSC
Silty Loam	48 in	2.3 in/ft
Plant Rooting Depth		4 ft
Availability Coefficient		0.55
Max Soil Water Deficit		5.06 in
Max Application Rate		0.35 in/hr

Stationary Gun System Design	
Gun Spacing	120 ft
Lateral Spacing	160 ft
Number of Sets	25
Set Duration	6 hrs
Sets Per Day	4
Flow Rate	120 gpm
Wetted Diameter	275 ft
Application Efficiency	65
Instantaneous Application Rate	0.19 in/hr
Overlap Application Rate	0.6 in/hr
Gross Applied	3.6 in
Net Applied	2.34 in

Monthly Climate Modifier	
May	0.5
June	1
July	1.1
August	1.1
September	0.9
Off Season	0.5

Size	in | mm
Flow Rate	psi | gpm

Simulation Results for the selected period of **Wed Apr 29 2009** to **Fri May 8 2009**
Field will not require irrigation for 5+ day(s).

Print this Report
File #300-323

Figure 27 – View and Print Irrigation Report

1.5   FORMULAS USED

The following formulas are used in the calculator to generate a schedule.

EQUATION 1 - TOTAL AVAILABLE WATER STORAGE CAPACITY

$$\text{Total AWSC} = (AWSC_1 \times RD_1) + (AWSC_2 \times RD_2) + ...$$

Where:

Total AWSC   = Total available water storage capacity, in or mm
$ASWC_{1,2,...}$ = Available water storage capacity of that soil layer
$RD_{1,2,...}$ = Rooting depth of that soil layer

EQUATION 2 - MAXIMUM SOIL WATER DEFICIT

$$\text{MSWD} = \text{Total AWSC} \times AC$$

Where:

MSWD   = Maximum soil water deficit, inch or mm
Total AWSC   = Total available water storage capacity, in or mm
AC   = Availability coefficient of the soil, %

EQUATION 3 - SETS PER DAY

$$\text{Sets per day} = \text{round} (24 / \text{runtime})$$

Where:

Sets per day   = Number of irrigation sets per day
24   = Number of hours per day
Runtime   = Length of time the system operates in one location

EQUATION 4 - INSTANTANEOUS APPLICATION RATE

$$IAR = \frac{96.3 \times Q}{Pi \times r^2}$$

Where:

     AR   = Application rate, in/hr
     Q   = Sprinkler flow rate, USgpm
     Pi   = 3.14159 (ratio of circle to its diameter)
     LS   = Lateral spacing, ft
     96.3 = factor used to convert gpm and spacing in ft to application in in/hr

EQUATION 5 - OVERLAP APPLICATION RATE

$$AR = \frac{96.3 \times Q}{SS \times LS}$$

Where:

     AR   = Application rate, in/hr
     Q   = Sprinkler flow rate, USgpm
     SS   = Sprinkler spacing along lateral, ft
     LS   = Lateral spacing, ft
     96.3 = factor used to convert gpm and spacing in ft to application in in/hr

EQUATION 6 - GROSS WATER APPLIED

GWA = AR x Set time

Where:

     GWA   = Gross water applied, in or mm
     AR   = Application rate, in/hr or mm/hr
     Set time   = Length of time lateral operated, hrs

EQUATION 7 - NET WATER APPLIED

NWA = GWA x AE

Where:

NWA   = Net water applied, in or mm
GWA   = Gross water applied, in or mm
AE   = Application efficiency, %

EQUATION 8 - CROP EVAPOTRANSPIRATION

The crop **water use (ET_C)** can be calculated for a specific plant by using a reference evapotranspiration rate (ET_O), and applying a **crop coefficient (K_C)** to convert the reported ETo to ET_C.

$ET_C = K_C \times ET_O$

Where:

ET_C = Evapotranspiration Crop, inch or mm
K_C = Crop coefficient
ET_O = Reference evapotranspiration for a grass reference crop, mm

EQUATION 9 - WATER REMAINING IN SOIL BY SET AND DATE IRRIGATED

The remaining water each day is determined by removing the daily ET and adding the effective precipitation.

$MSWD_R$ = Previous day $MSWD_R$ – daily (ETc + PPTe)

Where:

$MSWD_R$ = Remaining available water for plant growth, in or mm
Previous day MSWD = Previous days maximum soul water deficit, in or mm
ET_C = daily Evapotranspiration, in or mm

PPTe   = daily effective precipitation, in or mm

PPTe   = (PPT – 5) x 0.75