User’s Guide to the SISC Simple Irrigation Efficiency (SIE) Metric Calculator

November 2018
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I. Introduction

This is a detailed guide on how to use the SISC Simple Irrigation Efficiency (SIE) metric excel spreadsheet calculator. If you have any questions while reading this guide or while using the calculator, please contact the Stewardship Index for Specialty Crops (SISC) administrator, Alison Edwards, at aedwards@stewardshipindex.org. For more information on SISC, visit https://www.stewardshipindex.org/.

The SIE metric measures the amount of water applied to a crop relative to the crop’s actual water demand. The SIE metric takes into account the crop’s water need based on crop and site-specific evapotranspiration and considers a potential leaching requirement and effective rainfall contribution.

\[ \text{Simple Irrigation Efficiency} = \frac{\text{Water applied}}{\text{Crop’s water demand}} \]

Difference between SIE and the other SISC water metric, Applied Water Use Efficiency Metric

SISC has already developed one water use metric, the Applied Water Use Efficiency metric, which measures the total amount of applied water used to produce the crop. The Applied Water Use Efficiency metric is the total acre-inches of applied water divided by tons of product harvested. In comparison, the Simple Irrigation Efficiency metric is the total amount of applied water divided by the crop’s water demand. “Crop’s water demand,” the denominator in the Simple Irrigation Efficiency metric, accounts for evapotranspiration of the crop and includes a leaching requirement and effective rainfall as optional variables. Unlike the Applied Water Use Efficiency metric, the SIE metric allows comparison across regions and year-to-year.

SIE is an end-of-season performance metric

This metric is an end-of-season performance metric and not an irrigation management tool – there is the optional inclusion of environmental factors (e.g. leaching requirement and rainfall contribution), but it does not include other grower-specific management factors like irrigation method and Distribution Uniformity. These elements are not included because they can be managed to increase a grower’s efficiency and therefore improve a grower’s SIE ratio. Because these and other management variables are not included, the tool should not be used for irrigation scheduling. The tool should only be used as a performance metric at the end of the growing season.

Please note that the excel spreadsheet file will not work for Excel versions earlier than Excel 2013.
II. Data Inputs

Variables included in the spreadsheet as references

- Kc values
- Soil salinity tolerated by crop (ECe* for optional leaching requirement)
- Length of crop growth stages

Variables that the user must look up externally

- Reference ETo data from local weather station; select alfalfa or grass reference

Required User Input Variables

- Number of crops (of interest) annually rotated on management area (select from drop-down: 1 crop, 2 crops, or 3 crops – populates data input cells for crops 2 and 3 if more than one crop was rotated; for perennial crops, select 1 crop)
- Type of crop (select from drop-down list)
- Plant and end of harvest dates
- Best fit for growth stage and best fit for Kc values (select from drop-down)
- Wind speed (select from drop-down: light, light to moderate, moderate to strong, strong)
- Daily minimum relative humidity (select from drop-down: arid, semi-arid, sub-humid, humid, very humid)
- Amount of water applied (inches per day)

Optional User Input Variables

- User Management Area Name
- Effective rainfall (inches per day)
- User-specified growth stages (override of normalized growth stages if user has data)
- Local Kc values (override of adjusted Kc values if user has local data)
- Height of mature crop (override of crop height if user has data)
- Salinity of applied irrigation water (ECw for leaching requirement)
III. Using the Excel Spreadsheet Calculator

Color Key

- **Blue Field: Required User Input** – if using the SIE metric, you *must* fill out these data inputs
- **Gold Field: Optional User Input** – you are not required to fill out these data input fields*
- **Grey Field: Calculated, No User Input** – do not edit these fields, the calculator will populate

*Some of these data inputs are more relevant to certain regions (e.g. rainfall) while others might be helpful in improving your SIE metric score (e.g. salinity of water applied for leaching requirement calculation). It is up to the discretion of the user when deciding which optional data inputs, indicated with the gold color, are significant.

This spreadsheet calculator is separated into three different tabs – (1) Calculator, (2) Other Grower Inputs, and (3) Reference. The first tab, **Calculator**, requires data inputs from the user and is where all of the automatic calculations take place. The second tab, **Other Grower Inputs**, requires data inputs from the user that span the growing season. The third tab, **Reference**, does not require any data inputs and contains reference data for the crop coefficients, crop height, and growth stages. While this information is included in the calculator as a helpful default for the grower, input of local values in the **Calculator** tab are strongly recommended. These three tabs, with step-by-step instructions on how to input data, are explained in detail below.

Tab 1: Calculator

**Important: Do **NOT** edit right of the vertical black bar on this tab**

The spreadsheet to the right of the black bar contains calculations and lookup values the calculator automatically computes from user data inputs. The calculator then uses these values to calculate the variables within the metric and the metric itself. It is critical that the cells to the right of this black bar are not altered in any way and thus have been protected.
Management Area Data

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<td>11</td>
<td>Number of crops rotated on this ground in the same season</td>
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<td>13</td>
<td>Crop #1 name and dates</td>
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<td>14</td>
<td>Crop #1 name and dates (if a second crop was rotated)</td>
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<td>Crop #2 name and dates (if a third crop was rotated)</td>
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<td>16</td>
<td>Average mid-season wind speed</td>
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<td>17</td>
<td>Average daily relative humidity</td>
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<tr>
<td>18</td>
<td>Salinity of applied irrigation water (ECw)</td>
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Please provide additional required data in Other Grower Inputs tab

**Management Area Name**: Provide the management area name of your choosing. Keep this name consistent among SISC’s spreadsheet tools if you choose to utilize other SISC metrics.

**Number of crops rotated on this ground in the same season**: Choose from the drop-down how many crops you have rotated on the same ground in the same season. Please note: choosing 2 or 3 will populate the respective data inputs for Crop #2 and Crop #3 section(s) below.

**Crop name and dates**: Select your crop type from the drop-down. The spreadsheet can calculate the metric for up to three crops rotated on the same ground within a year – the dates should not exceed 365 days. Input the start (plant) and end of harvest (termination) dates for Crop #1 and, if you rotated other crops, for Crops #2 and #3. If you did not rotate other crops, ignore Crop #2 and Crop #3 data fields. For an annual crop, the start date is the planting date and the end date is the end of harvest date. For a perennial crop, the start date is the end of harvest from the previous year and the end date is the end of harvest date of this year. If there are multiple harvests or more than one pick for a given crop, do not count this as several crops. In this case, only count the last date of harvest, or termination date, as the end date.

**Average mid-season wind speed**: Select the best estimate from the drop-down. Values are then approximated and converted to m/s. The value for wind speed needs only to be approximate because the equation is not strongly sensitive to this value.

**Average daily relative humidity**: Select the best estimate of average daily relative humidity during the mid-season from the drop-down. The user’s selection of the daily average relative humidity is used to estimate the minimum relative humidity. The value for minimum relative humidity needs only to be approximate because the equation is not strongly sensitive to this value.

**Salinity of applied irrigation water (ECw)**: If you would like the tool to include a leaching requirement within the metric, input the salinity of your applied irrigation water here. If you do not input a value
here, the tool cannot calculate the leaching requirement. This value should be in units of dS/m and come from a recent water analysis report.

**Crop #1 Data**

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<td>26</td>
<td><strong>Crop #1 Data</strong> --</td>
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<td>28</td>
<td>Select best fit for growth stage defaults</td>
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<td>29</td>
<td>Select best fit for Kc values</td>
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<td>Default growth stage date values from selection above</td>
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<td>31</td>
<td>Manual override of growth stage end dates (if user values are available)</td>
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<td>Default data values from selection above -- to be adjusted to climate</td>
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<td>Manual override of Kc values and crop height (if local values are available)</td>
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<td>34</td>
<td>Manual override of avg. soil salinity tolerated by crop for LR (Ece* -- from Crop Selection table, R27)</td>
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<td>35</td>
<td>Total water applied from DATE to DATE (inches)</td>
<td>Manual Override</td>
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<td>36</td>
<td>Total effective rainfall from DATE to DATE (inches)</td>
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<td>37</td>
<td>Leaching requirement (LR)*</td>
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<td>38</td>
<td><em>please note that for the spreadsheet to calculate LR, you must have values for salinity of irrigation water (A20 above) and Ece</em> (either in Crop Selection table, R27, or 137)</td>
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<tr>
<td>39</td>
<td>Crop evapotranspiration (ETc) (inches)</td>
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<td>40</td>
<td>Calculated SIE Metric Value for Crop #1</td>
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</table>

**Select best fit for growth stage defaults**: Choose from the drop-down, select the best fit based on the type of crop, region, and plant date. This selection yields the length of crop development stages — the calculator will automatically compute your normalized growing stages based on these values. You may also override these values (see Growth stage values below).

**Select best fit for crop coefficient (Kc) values**: Choose from the drop-down, select the best fit based on the type of crop. This selection yields the crop values for initial, mid-season and late growth stages ($K_c$ ini, $K_c$ mid, and $K_c$ end) and crop height. You may also override these values (see Kc values and crop height below).

**Growth stage values**: These values are looked up automatically from the Reference tab based on the selection you made in the growth stage default drop-down above. You may override these values if you have the information available simply by inputting the dates of the *end of initial period* (~10% ground cover), *end of developmental period* (effective full cover), and *end of middle period* (start of maturity) into the gold text boxes. Your initial and end period dates are the plant and end of harvest dates that you inputted above.
**Kc values and crop height:** These values are looked up automatically from the Reference tab based on the selection you made in the K value drop-down above. You may override these values if you have local data available by inputting your K values and crop height (in meters) in the respective gold text boxes. *Overriding the default crop values with local data is highly recommended.*

You might find local Kc values from your local university or research and extension institution.

**Average soil salinity tolerated by the crop (ECe*):** The spreadsheet calculates the leaching requirement as long as there is data for 1. the salinity of the applied irrigation water (cell A20) which the user inputs, and 2. the average soil salinity tolerated by the crop which is built in to the calculator for many of the crops (under Crop Selection table, cell R27). However, for a number of crops, there is no ECe* data available or there is only a rough estimate provided. You may add ECe* data to this cell if you have a value available, which will override any value provided in the table for your crop. The average soil salinity tolerated by the crop should be in units of dS/m.

The remaining grey data fields are calculated based on the inputs that you added to the spreadsheet above and in the Other Grower Inputs tab. See the Methodology section below for an outline of formulas and a complete description of how these are calculated.

Data inputs repeated for crops #2 and #3 based on the selection for Number of crops rotated under Management Area Data.

**Tab 2: Other Grower Inputs**

This tab asks the user to input daily values for reference evapotranspiration data, water applied to the user’s management area, and amount of effective rainfall. The dates will auto-populate on this tab after you have inputted the start and end of harvest date of crop #1 in the Calculator tab.
The user has the option to manually override daily water applied and daily effective rainfall by inputting total values for the growing season of each crop under ‘Manual Override’ on the Calculator tab.

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<td>26</td>
<td>Crop #1 Data --</td>
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<td>27</td>
<td>select best fit for growth stage defaults</td>
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<td>select best fit for Kc values</td>
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<td>Default growth stage date values from selection above</td>
<td>End of Initial</td>
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<td>Manual override of growth stage end dates (if user values are available)</td>
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<td>Default data values from selection above -- to be adjusted to climate</td>
<td>Kc ini</td>
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<td>34</td>
<td>Manual override of avg. soil salinity tolerated by crop for LR (ETo* -- from Crop Selection table, R27)</td>
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<td>35</td>
<td>Total water applied from DATE to DATE (inches)</td>
<td>Manual Override</td>
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<td>36</td>
<td>Total effective rainfall from DATE to DATE (inches)</td>
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<td>37</td>
<td>Leaching requirement [LR]*</td>
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<td>Crop evapotranspiration (ETo) (inches)</td>
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<td>Calculated SIE Metric Value for Crop #1</td>
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</table>

Reference Evapotranspiration Data

First, select which type of reference your data is from in the drop-down: grass reference crop or alfalfa reference crop. Typically, the data you find will be from a grass reference crop – if your reference crop is alfalfa, the calculator will automatically use a conversion factor to align with the grass-based Kc values in the Reference tab. Grass reference ET is represented as ETo; alfalfa reference ET is represented as ETr.

*Please note: choosing the wrong reference crop here will cause errors in the calculator.*
Next, copy and paste the daily evapotranspiration data, in inches, from your local source into the column for ET. Daily reference ET values should be available from a regional weather service or from your local agriculture extension service. You might also obtain this data from the following sources:

- For California, visit the CIMIS (California Irrigation Management Information System) website — click on the Data tab at the top of the page to download a report with ET data from your nearest CIMIS station.
  - CIMIS URL: [https://cimis.water.ca.gov/Default.aspx](https://cimis.water.ca.gov/Default.aspx)

- For Florida, visit the FAWN (Florida Automated Weather Network) website.
  - FAWN URL: [https://fawn.ifas.ufl.edu/tools/](https://fawn.ifas.ufl.edu/tools/)

- For Texas, visit the TexasET Network website.
  - Texas ET Network URL: [http://texaset.tamu.edu/](http://texaset.tamu.edu/)

- For states in the Pacific Northwest (Columbia River Basin in ID, OR, WA, MT, WY), visit the U.S. Department of the Interior’s Bureau of Reclamation – Pacific Northwest Region’s website.
  - USBR URL: [https://www.usbr.gov/pn/agrimet/etsummary.html](https://www.usbr.gov/pn/agrimet/etsummary.html)

- For other resources, visit the Irrigation Association’s (irrigation.org) website — click on ET Resources under “Tools & Calculators” on the Resources tab. Scroll down and click on “ET Connection” to see a list of resources by region.

After you find your local source for ET, you should generate a report that includes the date and reference ET values for each day in inches for your entire growing season. Copy and paste the ET information into the column “Evapotranspiration Data,” ensuring that the dates are aligned.

**Total Water Applied**

See the second section in the Appendix below, Approved Methods for Measuring Water Applied, for a list of approved methods for calculating applied water based on irrigation conveyance type. These instructions were taken directly from SISC’s other water metric, the [Applied Water Use Efficiency](https://irrigation.org/IA/Resources/Tools-Calculators/ET-Resources/IA/Resources/ET-Resources.aspx?hkey=576c5d0f-fee5-415f-b325-2ea2a95083fb) metric.

Total Water Applied is the sum of the daily water applied data, in inches, provided by the calculator user. For annual crops, total water applied should include all applied water from start (planting) date to end of harvest date in inches. For perennial crops, total water applied should include all applied water from the end of harvest through the following harvest the year after. It can be measured as the total volume of water applied in acre-inches divided by the number of acres.
**Effective Rainfall**

This is the sum of the daily effective rainfall data, in inches, provided by the calculator user. For annual crops, the total amount of rainfall is the sum of all rain events between planting and end of harvest dates. For perennial crops, the total amount of rainfall is the sum of all rain events, starting at the end of harvest through the following harvest the year after.

The user should only include effective rainfall in excess of .10 inches. The user must account for how much rainfall is actually effective – rainfall exceeding cumulative ETc since the last irrigation or rain event should not be included. Only include rainfall up to the amount of cumulative ETc since the last irrigation or rain event. The calculator will not allow the user to input a number less than .10 inches.

If full-bed plastic mulch, hoop houses, or any other method that blocks access of the root zone to rainfall is used, rainfall should not be counted.

**Tab 3: Reference**

Reference values for Kc values, average height of crop, and growth stages are provided in this tab from FAO 56. Do **not** edit the information provided in this tab. There are places in the Calculator tab for you to override these reference values if you have local data – see guidance above for how to override the provided reference data [Tab 1: Calculator].

Kc values and average height (in meters) are from Table 12 in FAO 56. Growth stages are from Table 11 in FAO 56. Several references have been added for crops that are not listed in FAO 56 – these are indicated by light grey shading within the tables on this tab. If there is no data available for a given crop but there is a qualified equivalent, the equivalent crop’s data was used – this is also indicated by a light grey shading.
IV. Appendix

Methodology

The equations listed here are built into the SIE calculator. There are some variables a grower will be required to look up from their local weather station or local crop extension website (see Section II. Data Inputs above on page 3).

Outline of Formulas/Data Points

1 – ETc
1a - Adjusted Kc values
1b - Normalized growth stages
1c - Kc as a variable of growth stage
1d – Kratio (alfalfa reference data)
2 – Water Applied
3 – Rainfall
4 – LR

Simple Irrigation Efficiency Metric

\[
SIE = \frac{\text{Water Applied}}{\frac{ETc}{(1 - LR)} - \text{Rainfall}}
\]

ETc, or Evapotranspiration of the Crop

Units = [inches]

ETc is calculated by multiplying the grass reference evapotranspiration (ETo) by the crop coefficient (Kc):

\[ ETc = ETo \times Kc \]

Kc is calculated [1a below] and adjusted to climate OR can be a direct data input from local universities or research and extension institutions and is unitless.

ETo is the grass reference evapotranspiration values and is in units of inches/day.

Adjusting Kc values to the climate of the growing region when local Kc values are unavailable

[unitless]

Terminology in the following equations. Reference K values (from Table 12, FAO 56):

- \( Kc_{\text{ini \ TABLE}} \) = crop coefficient during initial stage
- \( Kc_{\text{mid \ TABLE}} \) = crop coefficient during mid-season stage
- \( Kc_{\text{end \ TABLE}} \) = crop coefficient at the end of the late season stage
Adjusted Kc values:
Source: Equation 62, FAO 56

\[ Kc_{ini} = Kc_{ini \_ TABLE} + [0.04(u_2 - 2) - 0.004(RH_{min} - 45)] \left( \frac{h}{3} \right)^{0.3} \]

\[ Kc_{mid} = Kc_{mid \_ TABLE} + [0.04(u_2 - 2) - 0.004(RH_{min} - 45)] \left( \frac{h}{3} \right)^{0.3} \]

\[ Kc_{end} = Kc_{end \_ TABLE} + [0.04(u_2 - 2) - 0.004(RH_{min} - 45)] \left( \frac{h}{3} \right)^{0.3} \]

where

\( u_2 \) = average daily wind speed at 2m above ground surface [meters/second]

\( RH_{min} \) = average daily minimum Relative Humidity (%) – from Table 16, FAO 56

\( h \) = height of crop [meters]

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**Determining crop growth stages**

Terminology in the following equations, Reference Growth Stages (from Table 11, FAO 56):

- \( L_{ini \_ TABLE} \) = length of initial growth stage
- \( L_{dev \_ TABLE} \) = length of developmental growth stage
- \( L_{mid \_ TABLE} \) = length of mid-season growth stage
- \( L_{end \_ TABLE} \) = length of late season growth stage

\[ L_{ini \_ TABLE} + L_{dev \_ TABLE} + L_{mid \_ TABLE} + L_{end \_ TABLE} = L_{TOTAL} \]

Normalized growth stages:

\[ L_{ini} = \left[ start \ date + \left( \frac{L_{ini \_ TABLE}}{L_{TOTAL}} \ast growth \ season \right) \right] - start \ date \]

\[ \text{[End of initial period]} \]

\[ L_{dev} = \left[ end \ of \ initial \ period + \left( \frac{L_{dev \_ TABLE}}{L_{TOTAL}} \ast growth \ season \right) \right] - end \ of \ initial \ period \]

\[ \text{[End of developmental period]} \]
\[ L_{\text{mid}} = \left[ \text{end of dev period} + \left( \frac{L_{\text{mid \ TABLE}}}{L_{\text{TOTAL}}} \times \text{growth season} \right) \right] - \text{end of dev period} \]

\[ L_{\text{late}} = \text{harvest date} - \text{end of mid season period} \]

**Which crop coefficient to use depending on time (growth stage period) in season**

Source: Equation 66, FAO 56

If date < start date of initial period, 0

If date < end date of initial period, \( Kc_{\text{ini}} \)

If date < end date of developmental period, \( Kc_{\text{ini}} + \left[ \frac{\text{date-end of initial period}}{L_{\text{dev}}} \right] \times (Kc_{\text{mid}} - Kc_{\text{ini}}) \)

If date < end date of mid-season period, \( Kc_{\text{mid}} \)

If date < harvest date, \( Kc_{\text{mid}} + \left[ \frac{\text{date-end of mid period}}{L_{\text{late}}} \right] \times (Kc_{\text{end}} - Kc_{\text{mid}}) \)

\( K_{\text{ratio}}, \) for use if alfalfa is the reference crop

[unitless]

Grass Reference
\( \text{ETc} = \text{ETo} \times Kc \)

Alfalfa Reference
\( \text{ETc} = \text{ETR} \times Kc \times K_{\text{ratio}} \)

Depending on ET\( \text{O/R} \) data type (grass reference vs alfalfa), the Kc based on alfalfa reference needs to be converted for compatibility with grass reference data. A Kc based on alfalfa reference can be converted for use with grass reference data through a K\( _{\text{ratio}} \). If the user selects alfalfa as the reference ET data, the calculator will automatically implement the K\( _{\text{ratio}} \).
If grass reference is selected, $K_{ratio} = 1$

If alfalfa is selected, $K_{ratio}$ will be calculated based on equation 62 and local climate data:

$K_{ratio}$ depends on the climate and is based entirely on equation 62, as stated in 1a but with variables accounting for alfalfa data [use $K_c$ mid = 1.2, listed for alfalfa in FAO 56 Table 12, and $h = 0.5$ m, average height of alfalfa]

$$K_c_{mid} = K_c_{mid \, TABLE} + [0.04(u_2 - 2) - 0.004(RH_{min} - 45)](h^{0.3})$$

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**Total water applied during the growing season**

Units = [inches]

This is the sum of the daily water applied data throughout the entire crop cycle provided by the calculator user. Total water applied should include all applied water from start (planting) date to end of harvest date in inches. It can be measured as the volume of water applied in acre-inches divided by the number of acres.

The amount of water applied should be estimated by using one of the approved methods, outlined below or in the document “SISC Metric: Applied Water Use Efficiency” available on the metrics page at www.stewardshipindex.org.

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**Rainfall (optional)**

Units = [inches]

This is the sum of the daily effective rainfall data, in inches, provided by the calculator user. The user should only include effective rainfall in excess of .10 inches. The user must account for how much rainfall is actually effective – rainfall exceeding cumulative ETc since the last irrigation or rain event should not be included. If full-bed plastic mulch, hoop houses, or any other method that blocks access of the root zone to rainfall is used, rainfall should not be counted.
LR, or Minimum Leaching Requirement (optional)  
[unitless]\[LR = \frac{EC_w}{5 \times EC_e - EC_w}\]  
[Rhoades equation, Equation 9 from FAO 29]  
where  
\(EC_w\) = salinity of applied irrigation water [dS/m]  
\(EC_e^*\) = average soil salinity tolerated by the crop, from FAO 29, Table 4

The amount of water needed to meet both crop demand and LR (Equation 7 from FAO 29):  
\[AW = \frac{ET}{1 - LR}\]  
where  
\(AW\) = depth of water demanded by crop (inches)  
\(ET\) = evapotranspiration (inches)  
\(LR\) = leaching requirement expressed as a fraction, using the Rhodes equation above (unitless)
Approved Methods for Measuring Water Applied

From SISC’s Applied Water Use Efficiency Metric Guidance

In order to maintain sufficient accuracy and precision, growers may select from one of the following water conveyance methods, based on irrigation conveyance type, that have been pre-approved for calculating applied water. Determination of “applied water” must be measured at the field (SISC Management Area) level. Method 4 provides a way to estimate field-level usage if actual measurement has not been performed.

Approved methods for measuring applied water are listed here, with detail on each provided below.

1. Irrigation District Reporting (with approved measurement devices)
2. Closed Conduit Measuring Devices (aka pressurized pipe)
3. Standard Open Channel Measuring Devices for Surface Irrigation
5. Alternative to Direct Measurement: Estimating for Subsurface Drip Irrigation Systems

*The standard for precision is +/- 6%.

* The standard is based on the 1998 California Department of Water Resources guidelines. However, new water measurement regulations that took effect in California July, 2012 require +/-12% accuracy for existing systems and +/-10% field accuracy for new systems. (California CCR Title 23, Div. 2, Ch. 5.1, sec. 597.3) SISC still supports a +/-6% accuracy goal.

1. Irrigation District Reporting

If water is delivered by an irrigation district, district measurements may be used if each of the following conditions applies:

- Water is measured directly by an approved measurement device (see below).
- Water is measured at the field/block level.
- The field being measured is the same as where the crop is grown

2. Closed Conduit Measuring Devices (aka Pressurized Pipe)

If water is delivered through pressurized pipe, whether groundwater or surface water, to irrigation devices such as drip or center-pivot irrigation, then the following technologies are acceptable. Note that the pipeline must be flowing full to work properly and the water user must demonstrate a reliable method of recording total flows with a display unit.

- Mechanical in-line propeller meter
- Insertion type electromagnetic meter
- Full profile magnetic type flow meters, such as acoustic transit-time or Doppler flow meter.

3. Standard Open Channel Measuring Devices for Surface Irrigation

If water is delivered via gravity-fed surface irrigation, such as flood or furrow irrigation, then the following methods are acceptable:

- Flow gates or control structures with an accurate rating curve and level sensors in an adjacent stilling well. Approved devices include:
  - Sharp-crested weir
  - Undershot or Waterman gate (with up- and downstream water levels)
4. Alternative to Direct Measurement: Using Power Records*

If none of the direct measurement methods is appropriate, then a grower may use extrapolation from power records to estimate the annual diversion from a pump as an alternative measurement method. The following conditions apply in order to qualify to use this method.

Derivation of the Power Consumption Coefficient (PCC) is required, which is the ratio of the number of kilowatt-hours needed to pump an acre-foot of water. This number is unique to each well or pumping plant due to physical aspects of the system and can be applied to the year-end power records to determine the total acre-feet pumped.

To determine the rate of flow, a portable measuring device, such as a non-invasive ultrasonic flow meter can be used. Simultaneous with the flow measurement, power is measured using the utility’s kilowatt hour meter. A qualified individual with the necessary equipment will be required to perform these measurements. Because systems wear and water levels change, the flow-to-power ratio may change over time. Therefore, the power consumption coefficient must be re-calibrated at least once every three years.

Pumps must be single speed, not variable rate or variable frequency.

CONSTRAINTS: If any of the following are true, a different method must be utilized as then power records are unlikely to yield acceptable results:

- If the well flows (artesian) so that water can be diverted when the pump is off.
- The electrical meter also records power used by other devices not integral to the irrigation system.
- The electrical meter records power used by more than one pump.
- Variable frequency drives operate the pump, resulting in variable flow rates.
- The energy supplied to the pump cannot be accurately and reliably measured. For example, most diesel and propane driven pumps do not have provisions to measure the fuel used by the engine.
- The flow rate from the pump varies significantly due to changes in demand or operation. For example, pumps that discharge into a pressurized system sometimes and then open discharge at other times, or pumps that supply multiple pivots and/or other discharge points, would likely have flow rates that change considerably. These changes generally alter the flow to power ratio, causing inaccurate estimates of diversions.


5. Alternative to Direct Measurement: Estimating for Subsurface Drip Irrigation Systems

Growers using subsurface drip irrigation systems may estimate applied water inputs based on pressure, emitter size and spacing, and length of drip line. The University of Arizona Cooperative Extension provides instruction and simple calculator for this estimation approach at http://ag.arizona.edu/crops/irrigation/azsched/drip.html
References


Additional references provided in the References tab of the excel calculator.

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