Irrigation Scheduling Using *Stress Threshold RDI Irrigation Method*

1. Determine Production Goals
2. Stress Threshold: Select a threshold to begin irrigation (leaf water potential, shoot tip observations, etc.)
3. Assess vineyard canopy coverage (to find your Kc)
4. RDI%: Select the percent of full vine water use to apply
5. Calculate full potential vineyard water use
6. Calculate the irrigation volume to apply (predicted volume) using the RDI %

The master plan

- From the web, get ***historical*** ETo for a selected period of time
- In your vineyard, determine the crop coefficient
- Multiply ETo by the crop coefficient to turn it into Etc which is full potential water use for your grapevines
- Decide on your RDI%
- Take into consideration
  - soil water contribution and effective in-season rainfall
- In a perfect world, determine your emission uniformity
- When you consider your vine spacing, you are now able to calculate hours to run your system for that time period

The following Monday, log onto CIMIS and get ***actual*** ETo for that time period and re-calculate the hours that you should have applied. NO WORRIES! Just adjust the amount of time you apply during the next period.

Vineyard Site Conditions (mature vineyard)

- Variety/rootstock Cabernet Sauvignon/Freedom
- Site ---- Lodi, CA
- CIMIS Station ---- # 166
- Vine spacing ---- 7 × 11 feet
- Canopy (trellis) ---- Bilateral cordon with T top
- Irrigation system ---- single emitter per vine,
  flow rate = 1.0 gal/hour

Soil Resource

- Soil Sandy loam
- Root zone 8 feet depth
- Root zone total soil moisture at bud break --- 16.0 inches
- Root zone soil moisture at the threshold --- 12.4 inches
- Root zone soil moisture at harvest (previous year) --- 10.0 inches

Calculated values based on Site Conditions and Soil Resource:

- Vines per acre 566
- Sq ft per vine 77
- Gross application rate 0.021 in/hr (0.96 gal/hr)
- Soil available water (between bud break and harvest)
  6.0 in.
- Soil available water (between the threshold and harvest)
  2.4 in.

1. Determine Production Goals

Irrigation Scheduling Decisions

- Stress Threshold = -13 bars
- Regulated deficit (RDI %) = 50%
- Threshold date = July 8th
- Harvest Date (est.) = October 1st

- Post harvest irrigation = All of October (at full potential water use ???)

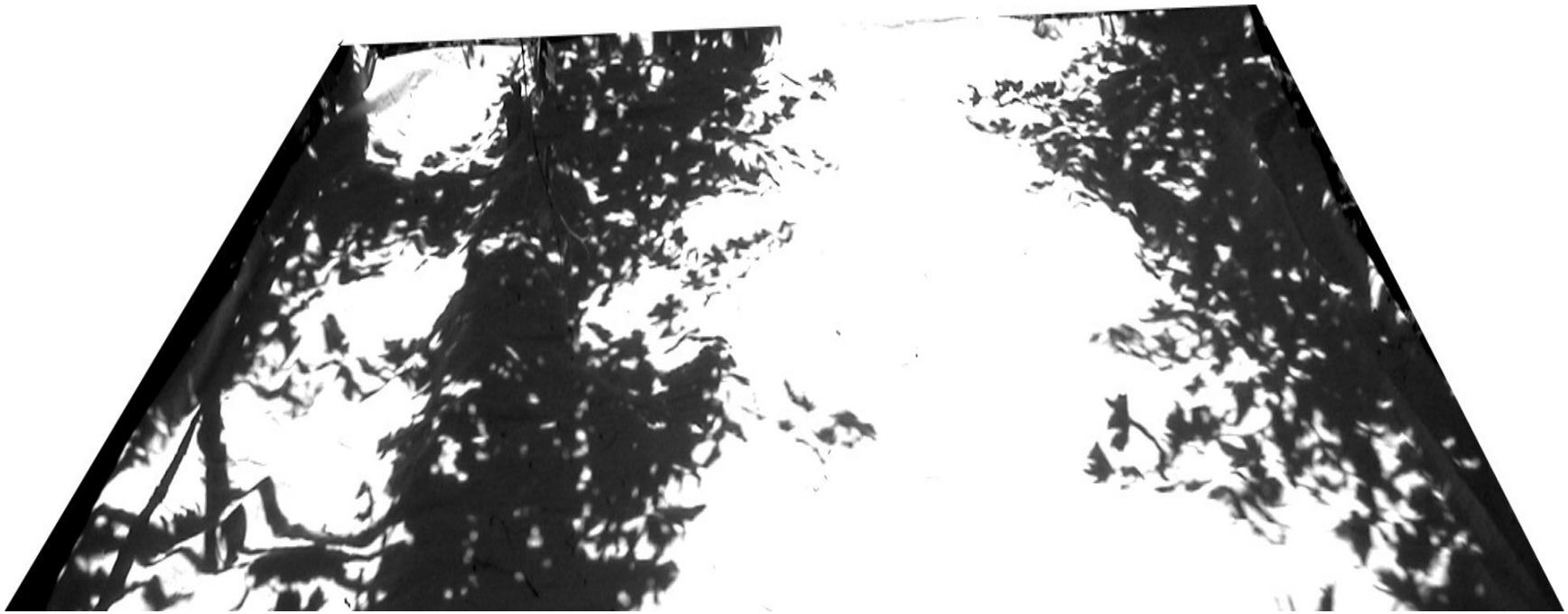
2. Stress Threshold: Select a threshold to begin irrigation (leaf water potential, shoot tip observations, etc.)

Stress Threshold

-13 bars

3. Assess vineyard canopy coverage (to find your Kc)

Shaded Area = 40%

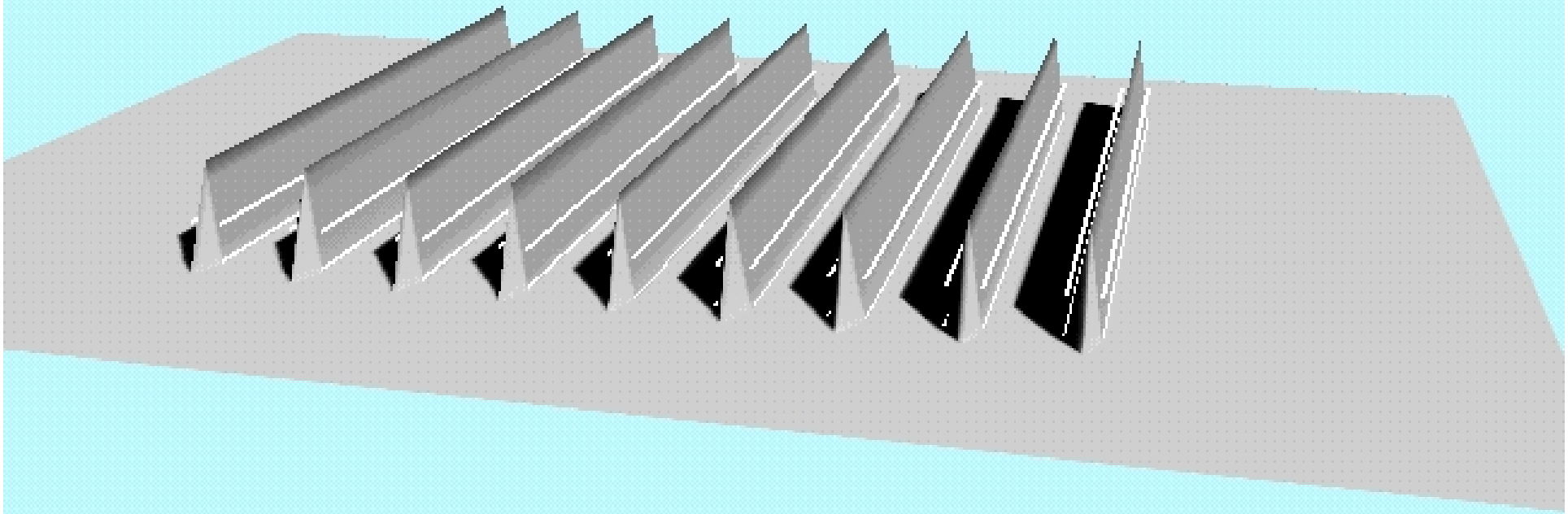


Relationship between vineyard floor shaded and crop coefficient
determined by Larry Williams, Department of Viticulture and Enology, UCD

Kc = Percent of vineyard floor shaded x 0.017

Kc = 40 x 0.017 = 0.68

Row Direction (and aspect) affects the amount of vineyard floor shade at solar noon



Mike Bobbitt & Associates
http://www.mikebobbitt.com/

4. RDI%: Select the percent of full vine water use to apply

Regulated Deficit Irrigation percentage selected = 50%

This means that after the threshold has been reach, you will supply half of full vine water use.

5. Calculate full potential vineyard water use

Estimating Full Potential Water Use Using Historical Averages

- ETo *Historical*
  - Use Chart in Appendix
  - Use Monthly averages from a CIMIS station
  - Download all the station data and make your own daily average

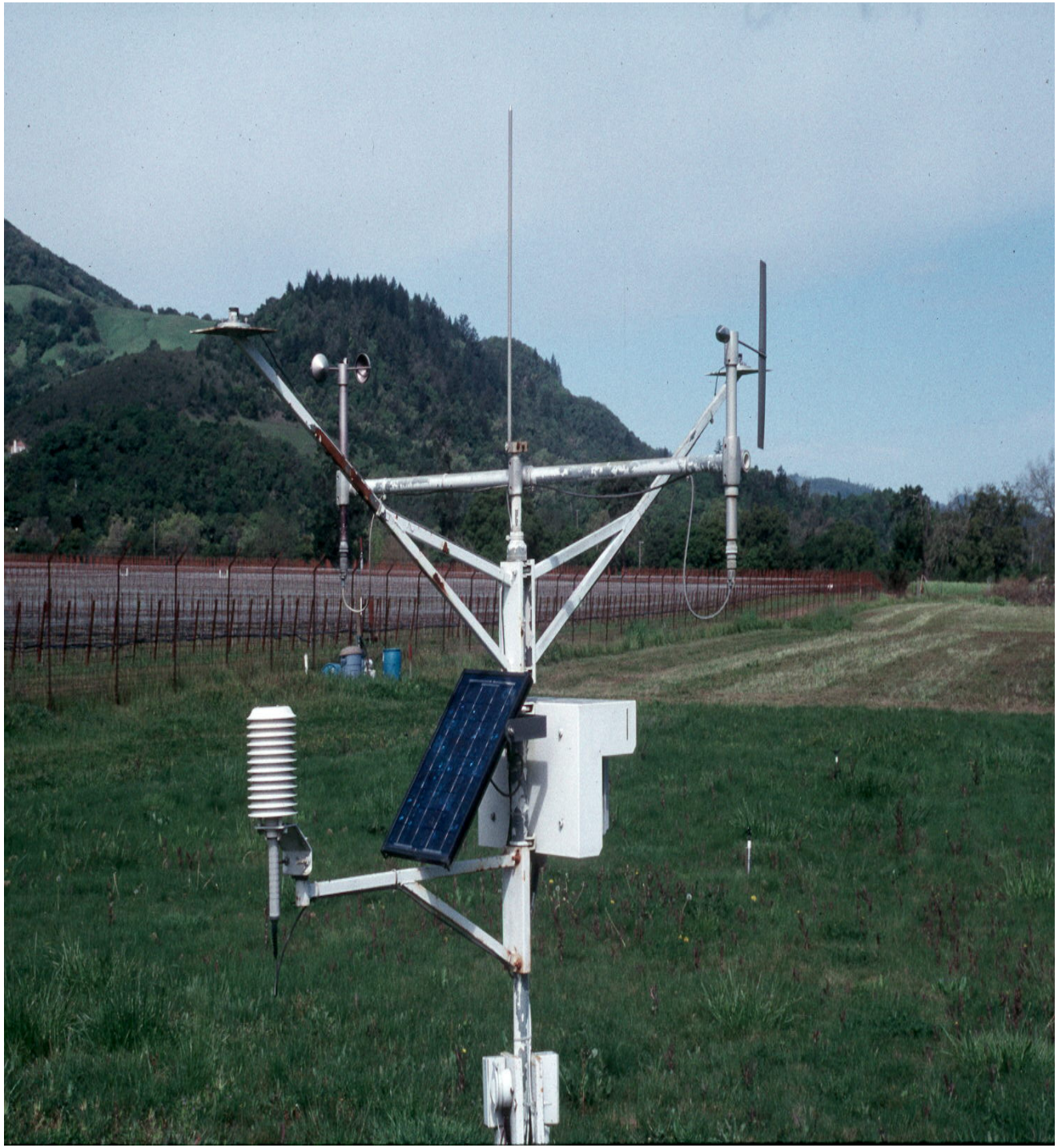
www.cimis.water.ca.gov

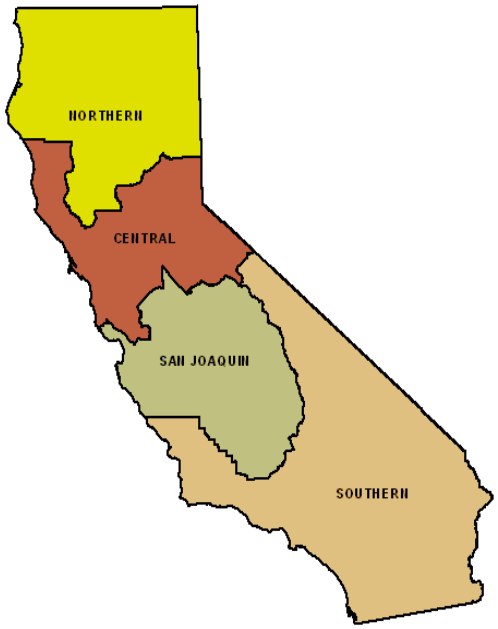
ETo *Historical (~5-20+ years depending on station)*

Lodi, CA CIMIS Stations

42 and # 166

	Inches		Inches
January 1-7	0.19	July 1-7	1.86
January 8-14	0.20	July 8-14	1.82
January 1-21	0.29	July 15-21	1.72
January 22-28	0.30	July 22-28	1.69
January 29-Feburary 4	0.34	July 29 to August 4	1.68
February 5-11	0.40	August 5-11	1.63
February 12-18	0.56	August 12-18	1.56
February 19-25	0.63	August 19-25	1.49
February 26-March 3	0.61	August 26 to September 1	1.45
March 4-10	0.71	September 2-8	1.37
March 11-17	0.80	September 9-15	1.23
March 18-24	0.93	September 16-22	1.17
March 25-31	1.10	September 23-29	1.05
April 1 - 7	1.14	September 30 to October 6	0.97
April 8-14	1.28	October 7-13	0.88
April 15-21	1.24	October 14-20	0.78
April 22-28	1.43	October 21-27	0.66
April 29-May 5	1.57	October 28 to November 3	0.54
May 6-12	1.58	November 4 to 10	0.50
May 13-19	1.59	November 11 to 17	0.40
May 20-26	1.67	November 18-24	0.32
May 21-June 2	1.67	November 25-December 1	0.34
June 3-9	1.74	December 2-8	0.26
June 10-16	1.82	December 9-15	0.24
June 17-23	1.85	December 16-22	0.22
June 24-30	1.80	December 23-29	0.21
		December 30-31(partial week)	0.05

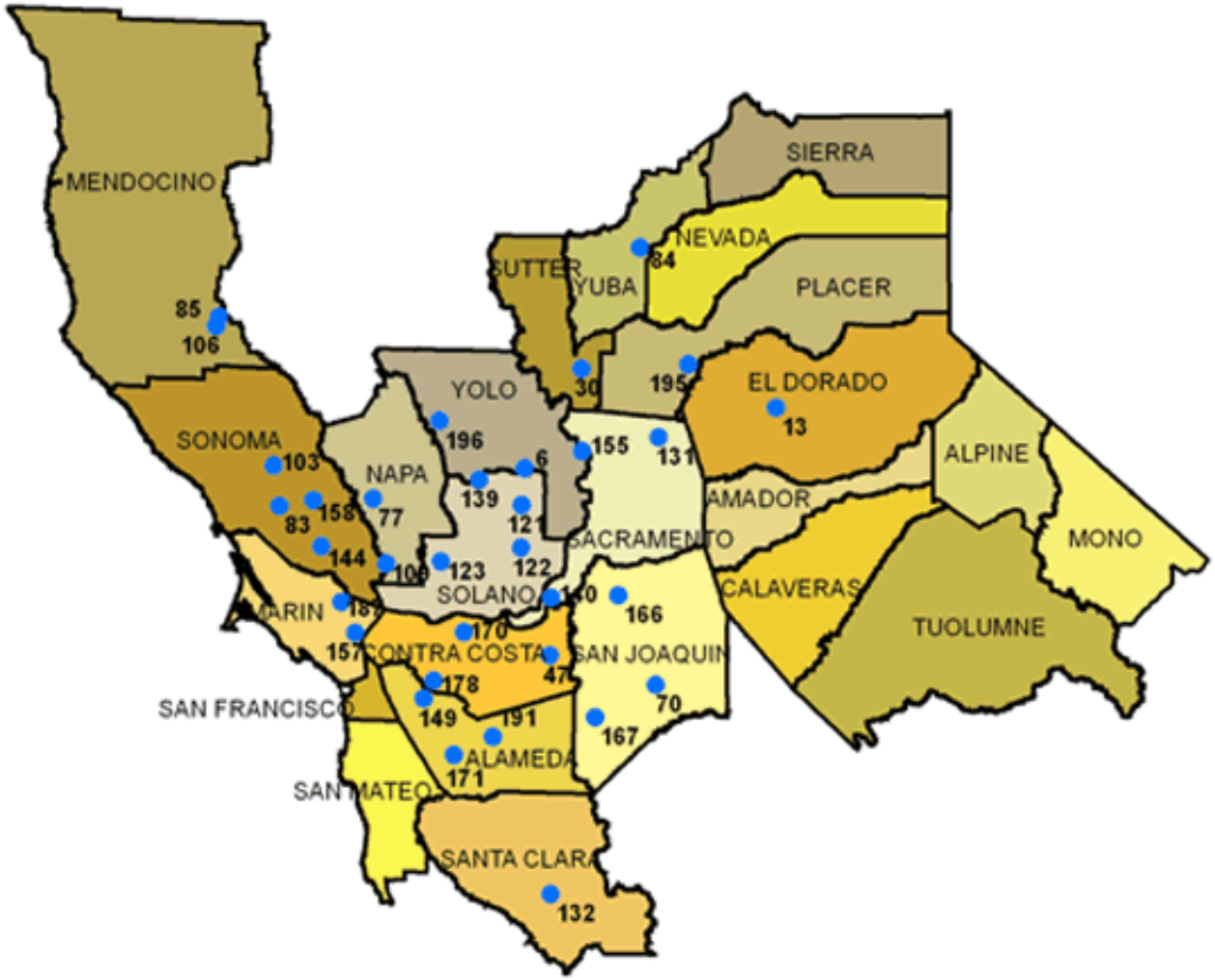




CIMIS Location Maps

CIMIS Central District, 2009

Click on any station to view its detailed station description.



CIMIS

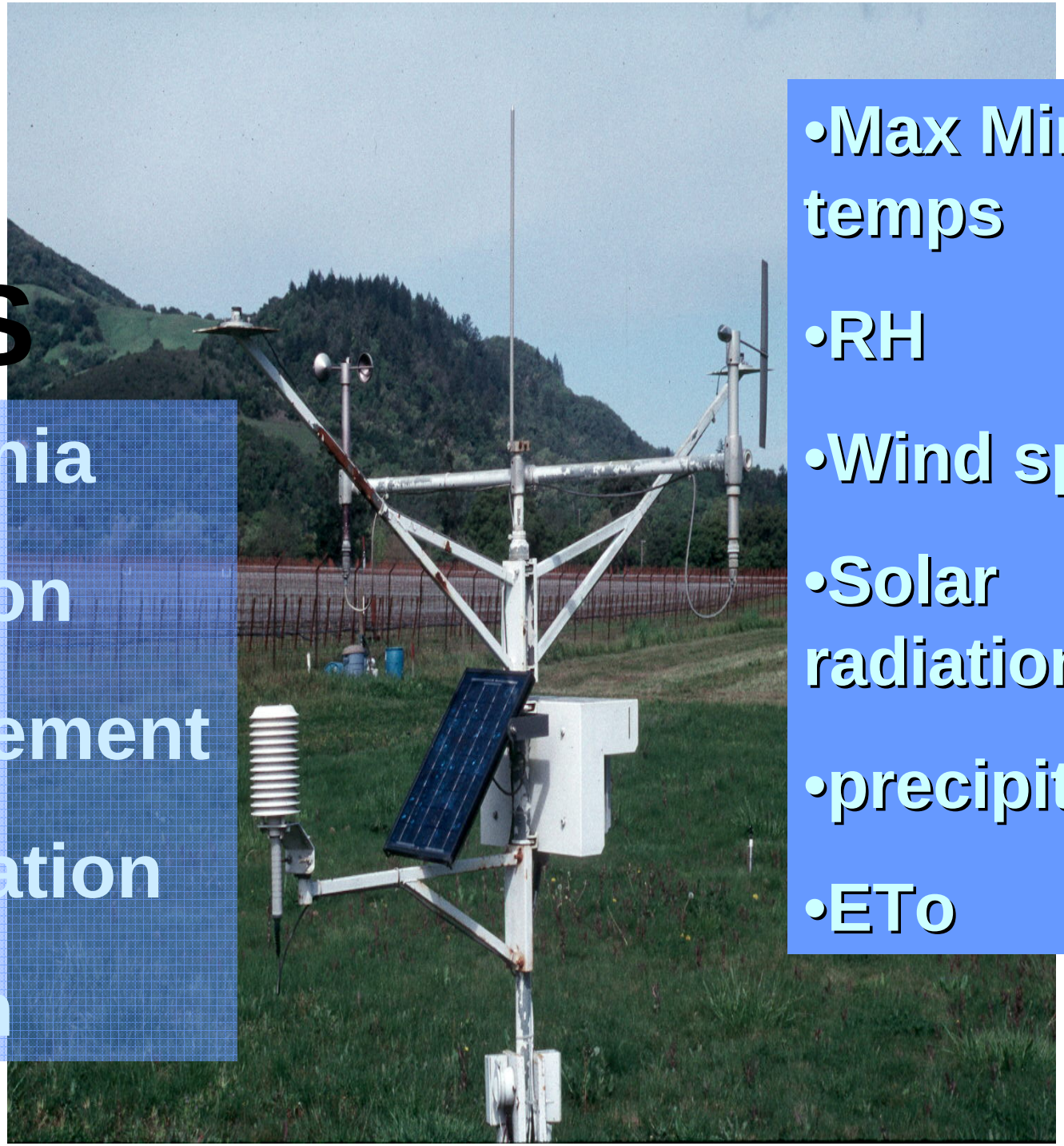
California

Irrigation

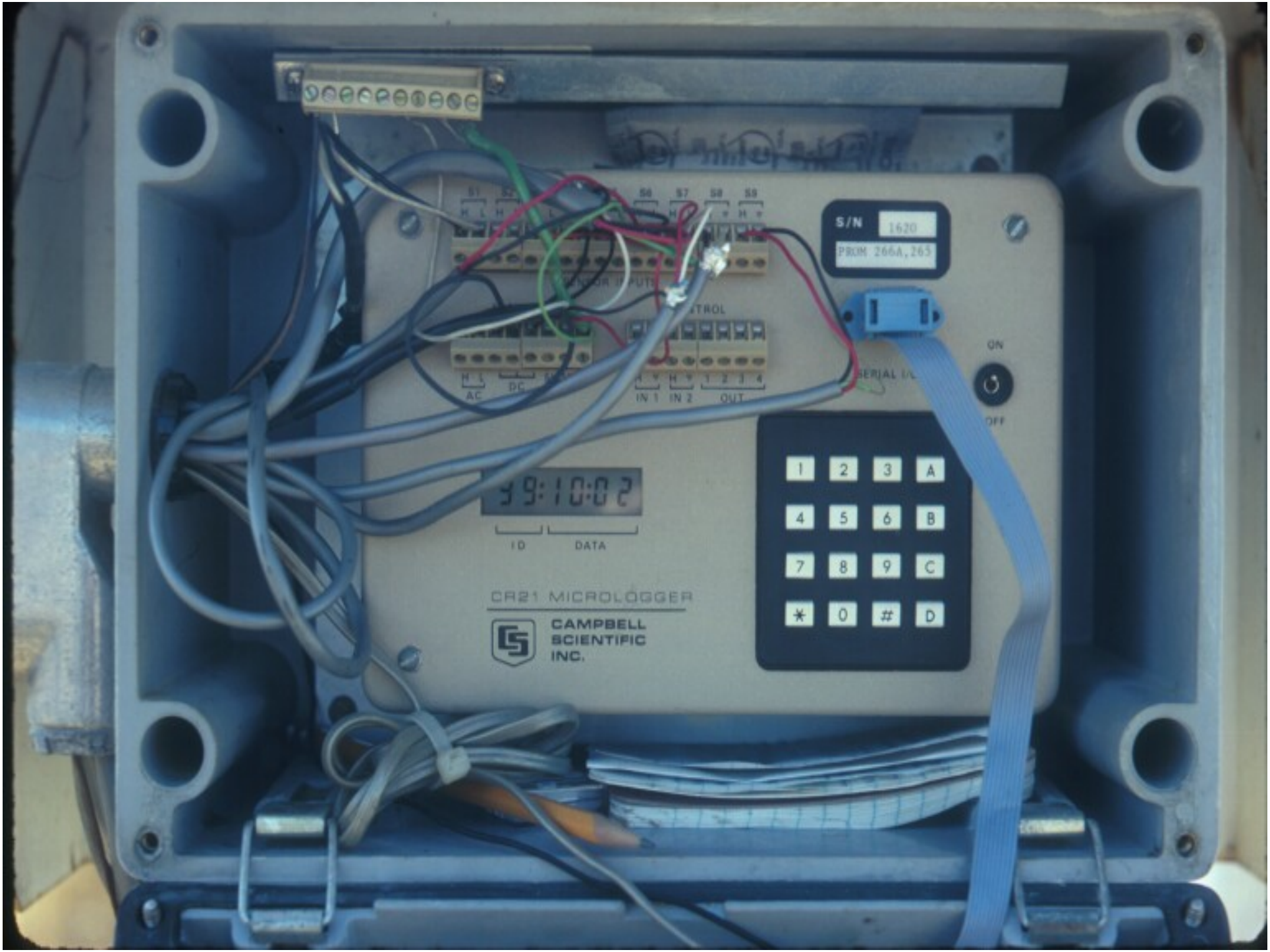
Management

Information

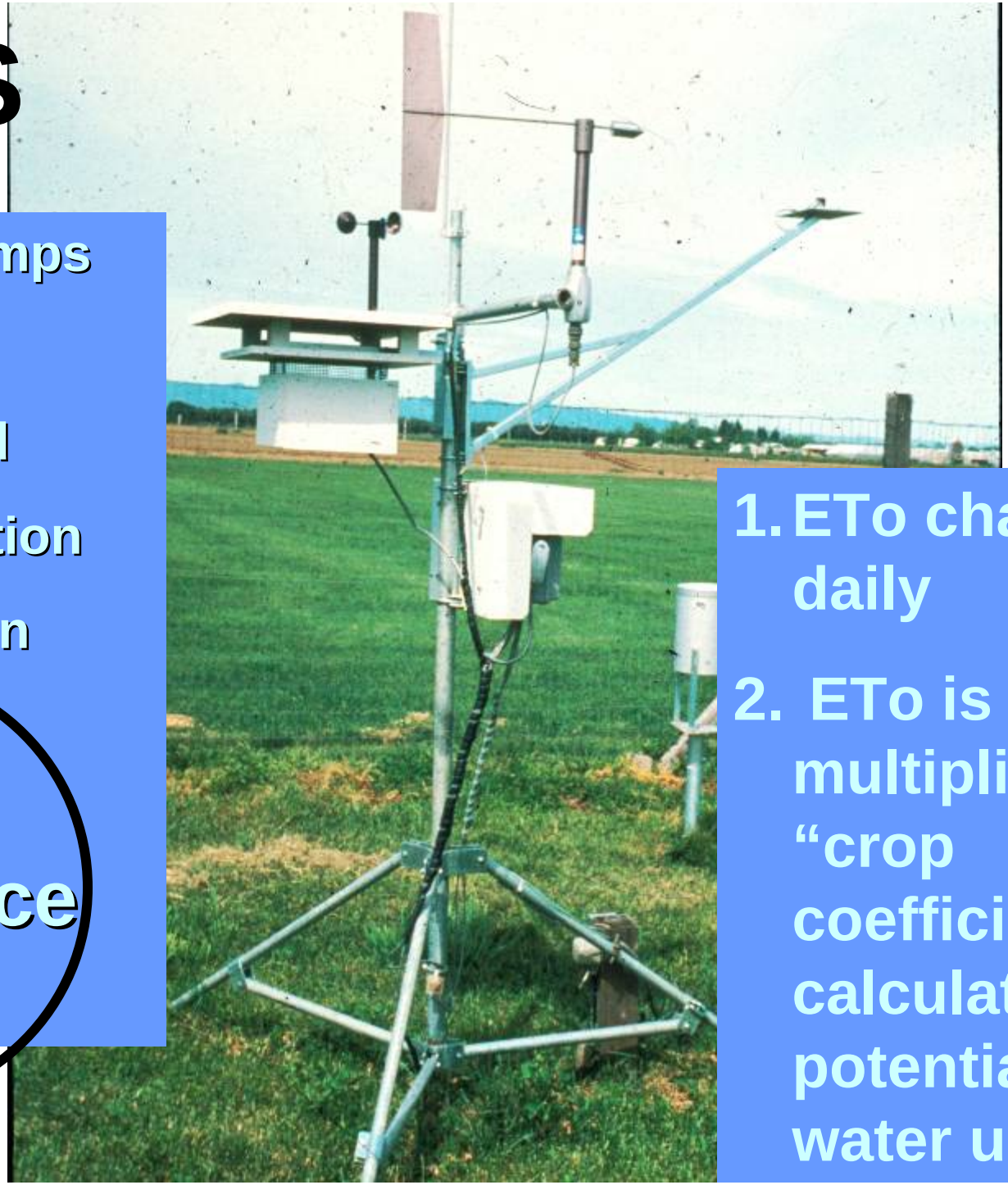
System



- Max Min temps
- RH
- Wind speed
- Solar radiation
- precipitation
- ETo


S/N 1620
PROM 266A,265
ON
OFF
1 2 3 A
4 5 6 B
7 8 9 C
* 0 # D
ID
DATA
CR21 MICROLOGGER
CAMPBELL SCIENTIFIC INC.

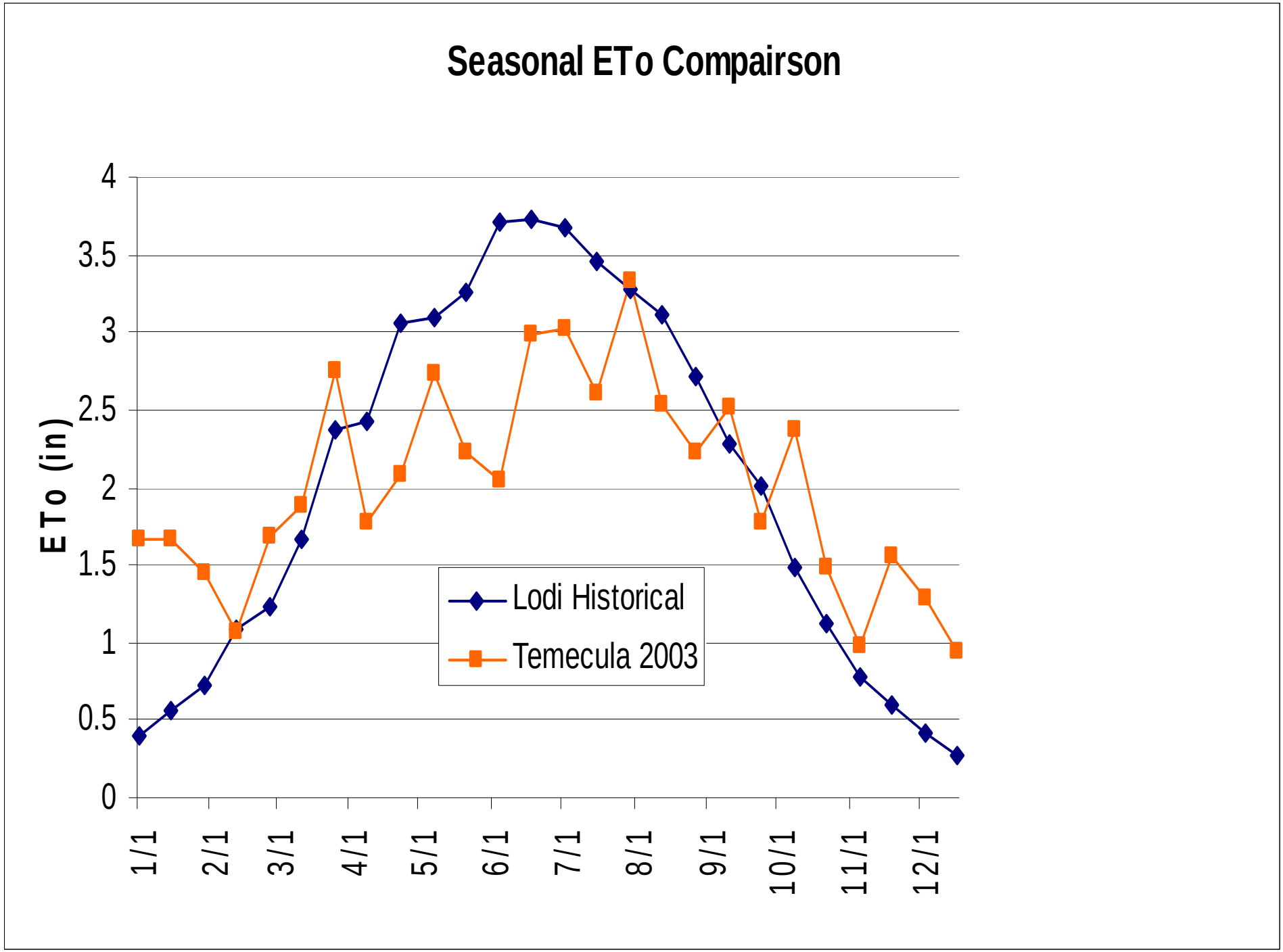
CIMIS



- Max Min temps
- RH
- Wind speed
- Solar radiation
- precipitation

- ETo = Reference ET

1. ETo changes daily
2. ETo is multiplied by a “crop coefficient” to calculate full potential vine water use


Seasonal ETo Compairson
ETo (in)
4
3.5
3
2.5
2
1.5
1
0.5
0
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
12/1
Lodi Historical
Temecula 2003

What you will need to retrieve from CIMIS to schedule your irrigations:

- Reference Evapotranspiration (ETo)
- Precipitation

www.cimis.water.ca.gov

CIMIS “Data” page*enables users to

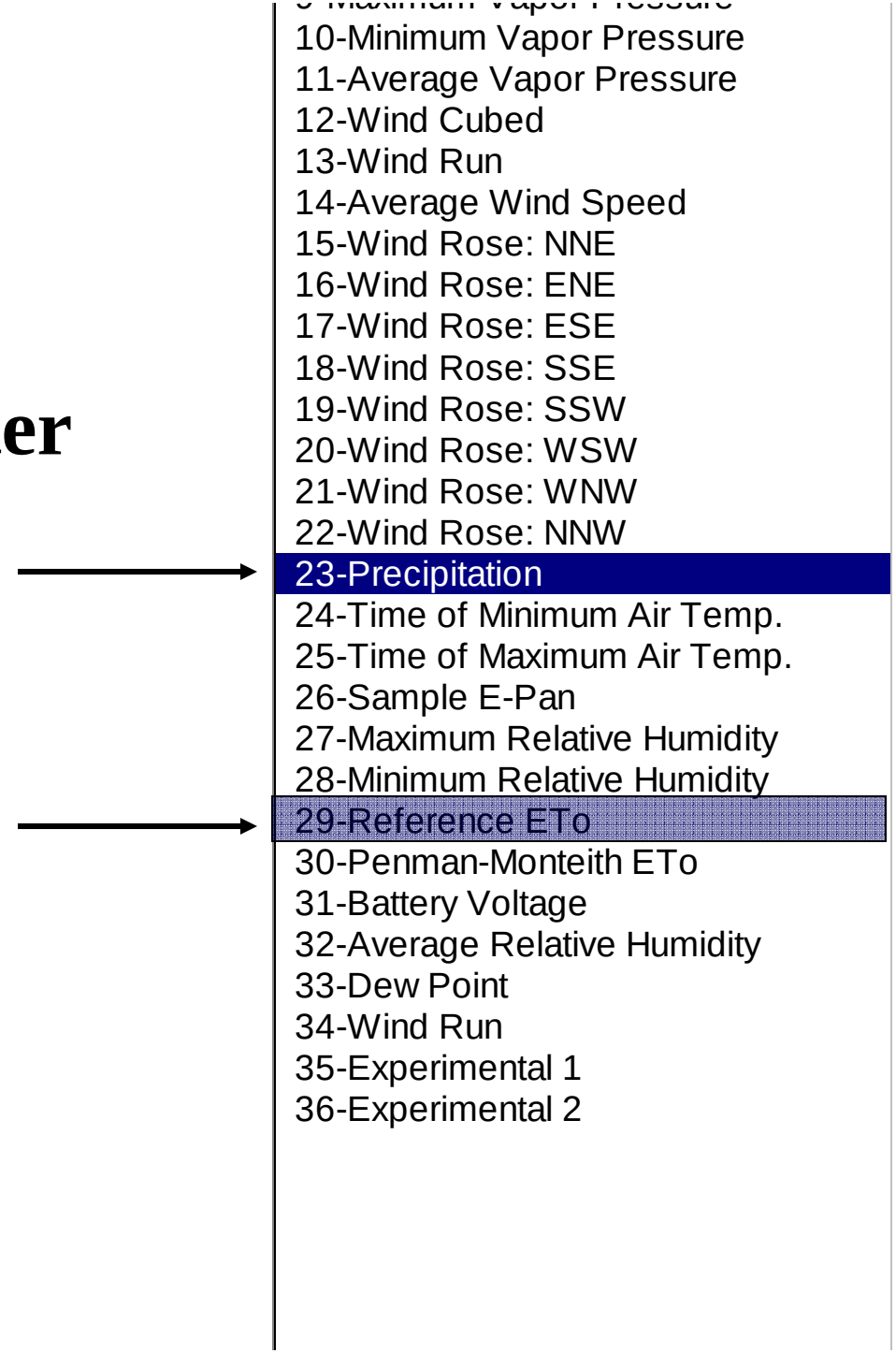
- View daily and monthly sample reports;
- Create and edit a user account;
- Retrieve CIMIS data;
- Read important information on CIMIS quality control;
- Read detailed information on CIMIS data types, formats, and sizes;
- View the weather station list.

* Will be demonstrated

Weather Stations

139 - Winters
140 - Twitchell Island
141 - Mecca
142 - Orange Cove
143 - San Juan Valley
144 - Petaluma East
145 - Madera
146 - Belridge
147 - Otay Lake
148 - Merced
149 - Oakland Foothills
150 - Miramar
151 - Ripley
152 - Camarillo
153 - Escondido SPV
154 - Salton Sea North
155 - Bryte
156 - Oxnard
158 - Bennett Valley
159 - Monrovia
160 - San Luis Obispo West
161 - Patterson
162 - Indio
163 - Atascadero
165 - Sisquoc
166 - Lodi West
167 - Tracy
169 - Porterville
170 - Concord
171 - Union City

Select Parameter



Enter the beginning and ending date for your report

Specify date range: The default setting for date range is the previous 7 days.

Start Date: July 8 2006

End Date: July 14 2006

Select reporting method.
Click here for details.

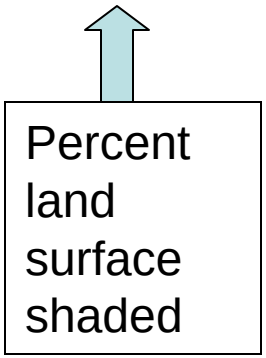
Web Report
PDF
CSV with Headers
CSV without Headers
(non-report format)
XML

CIMIS CSV with headers output

Stn Id	Station	Region	Date	Jul	qc	Precip (in)	qc	CIMIS ETo (in)
166	Lodi West	San Joaquin Valley	7/8/2006	189	*	0	*	0.28
166	Lodi West	San Joaquin Valley	7/9/2006	190	*	0	*	0.27
166	Lodi West	San Joaquin Valley	7/10/2006	191	*	0	*	0.25
166	Lodi West	San Joaquin Valley	7/11/2006	192	*	0	*	0.26
166	Lodi West	San Joaquin Valley	7/12/2006	193	*	0	*	0.26
166	Lodi West	San Joaquin Valley	7/13/2006	194	*	0	*	0.24
166	Lodi West	San Joaquin Valley	7/14/2006	195	*	0	*	0.26
					Sum	0		1.82

Crop Coefficient (Kc)

Kc = 0.40 x 1.7 = 0.68

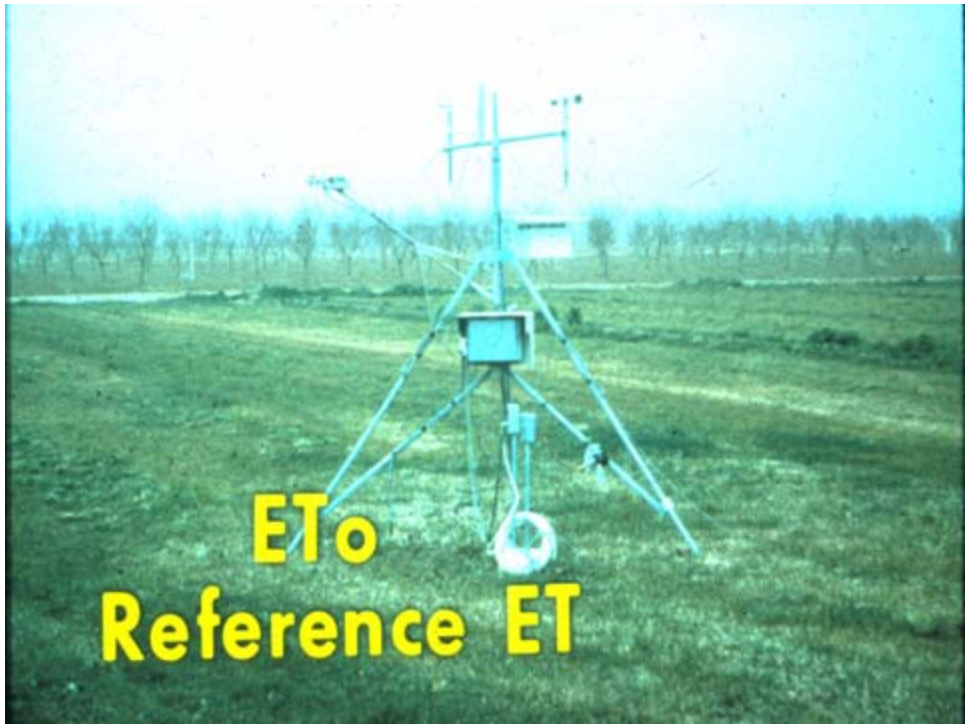


Same as

Kc = 40 x 0.017 = 0.68

To calculate Full Potential Water Use, get historical average ETo data from CIMIS then use your Kc

- ETo x Kc = Full Potential Water Use
- Use weekly summed data



Date	A = Historical Eto[a]	B = Crop Coefficient[b]	C = A x B: Potential Water Use
Period	Inches/Period	Kc	(in)
Jly 8-14	1.82	0.68	1.24
Jly 15-21	1.720	0.68	1.17
Jly 22-28	1.692	0.68	1.15
Jly 29 to Aug 4	1.676	0.68	1.14
Aug 5-11	1.626	0.68	1.11
Aug 12-18	1.556	0.68	1.06
Aug 19-25	1.494	0.68	1.02
Aug 26 to Sept 1	1.448	0.68	0.98
Sept 2-8	1.368	0.68	0.93
Sept 9-15	1.225	0.68	0.83
Sept 16-22	1.171	0.68	0.80
Sept 23-29	1.054	0.68	0.72
Sept 30 to Oct 6	0.974	0.68	0.66
Oct 7-13	0.883	0.68	0.60
Oct 14-20	0.779	0.68	0.53
Oct 21-27	0.660	0.68	0.45
Oct 28 to Nov 3	0.540	0.68	0.37

Total		14.75

6. Calculate the irrigation volume to apply (predicted volume) using the RDI %

Calculating the Volume of Water to Apply using the Regulated Deficit Irrigation %

Full Potential Water Use x RDI %

Date	C = A x B: Potential Water Use	D = RDI coefficient[c]	G = C x D : Net Irrigation Application
Period	(in)	RDI %	(in)
Jly 8-14	1.24	0.5	0.62
Jly 15-21	1.17	0.5	0.58
Jly 22-28	1.15	0.5	0.58
Jly 29 to Aug 4	1.14	0.5	0.57
Aug 5-11	1.11	0.5	0.55
Aug 12-18	1.06	0.5	0.53
Aug 19-25	1.02	0.5	0.51
Aug 26 to Sept 1	0.98	0.5	0.49
Sept 2-8	0.93	0.5	0.47
Sept 9-15	0.83	0.5	0.42
Sept 16-22	0.80	0.5	0.40
Sept 23-29	0.72	0.5	0.36
Sept 30 to Oct 6	0.66	1	0.66
Oct 7-13	0.60	1	0.60
Oct 14-20	0.53	1	0.53
Oct 21-27	0.45	1	0.45
Oct 28 to Nov 3	0.37	1	0.37
Total	14.75		8.68

Adjusting the Schedule for the "Current Season's" Soil Water Storage and Climate

- Add soil water extraction from the threshold
- Account for effective rainfall *after the threshold*
- Account for irrigation uniformity in the irrigation block, irrigation system application rate and finally, vine density

Reality Check:

Replace Historical ETo with **current year values**

When threshold is reached, ADD soil water extraction

Soil Water Reservoir

- Texture
- Depth
- Winter Rain Quantity
- Alternative Sources
  - Water Table
  - Spring Rains
- Root Extensiveness

By irrigation start these factor are minimized

When threshold is reached, ADD soil water extraction

Soil Moisture Measurement

- Quantitative (quantity)
- Qualitative (status)

Quantitative Moisture Measurement Methods

- Gravimetric / Volumetric Soil Sampling
- Neutron Moisture Meter
- Dielectric Moisture Sensors
  - Capacitance Probes
  - Frequency Domain Reflectometry (FDR)

Add soil water extraction from the threshold

Soil Moisture

TableH-1. Water content typical of a 7 ft depth sandy loam soil in Lodi, California		
	inches	inches
Total Moisture		
A – Bud Break	16.0	
B – Irrigation start	12.4	
C – Harvest	10.0	
Available Water		
Bud Break	A – C	6.0
Irrigation Start	B – C	2.4

Date	C = A x B: Potential Water Use	D = RDI Coefficient[c]	E = Soil Contribution	F = Effective Rainfall[d]	G = [(C x D) - E - F]: Net Irrigation Amount
Period	(in)	RDI	(in)	(in)	(in)
Jly 8-14	1.24	0.5	0.2	0	0.42
Jly 15-21	1.17	0.5	0.2	0	0.38
Jly 22-28	1.15	0.5	0.2	0	0.38
Jly 29 to Aug 4	1.14	0.5	0.2	0	0.37
Aug 5-11	1.11	0.5	0.2	0	0.35
Aug 12-18	1.06	0.5	0.2	0	0.33
Aug 19-25	1.02	0.5	0.2	0	0.31
Aug 26 to Sept 1	0.98	0.5	0.2	0	0.29
Sept 2-8	0.93	0.5	0.2	0	0.27
Sept 9-15	0.83	0.5	0.2	0	0.22
Sept 16-22	0.80	0.5	0.2	0	0.20
Sept 23-29	0.72	0.5	0.2	0	0.16
Sept 30 to Oct 6	0.66	1		0	0.66
Oct 7-13	0.60	1		0	0.60
Oct 14-20	0.53	1		0	0.53
Oct 21-27	0.45	1		0	0.45
Oct 28 to Nov 3	0.37	1		0.32	0.05
Total	14.75		2.40		5.96

Account for effective rainfall after the threshold

Effective Rainfall

- More than 3x daily ETo

- Rainfall = 0.65 in
- Effective Rainfall =

$$[0.65 - 0.25] \times 0.8 = 0.32 \text{ in}$$

Date	C = A x B: Potential Water Use	D = RDI Coefficient[c]	E = Soil Contribution	F = Effective Rainfall[d]	G = [(C x D) - E - F]: Net Irrigation Amount
Period	(in)	RDI	(in)	(in)	(in)
Jly 8-14	1.24	0.5	0.2	0	0.42
Jly 15-21	1.17	0.5	0.2	0	0.38
Jly 22-28	1.15	0.5	0.2	0	0.38
Jly 29 to Aug 4	1.14	0.5	0.2	0	0.37
Aug 5-11	1.11	0.5	0.2	0	0.35
Aug 12-18	1.06	0.5	0.2	0	0.33
Aug 19-25	1.02	0.5	0.2	0	0.31
Aug 26 to Sept 1	0.98	0.5	0.2	0	0.29
Sept 2-8	0.93	0.5	0.2	0	0.27
Sept 9-15	0.83	0.5	0.2	0	0.22
Sept 16-22	0.80	0.5	0.2	0	0.20
Sept 23-29	0.72	0.5	0.2	0	0.16
Sept 30 to Oct 6	0.66	1		0	0.66
Oct 7-13	0.60	1		0	0.60
Oct 14-20	0.53	1		0	0.53
Oct 21-27	0.45	1		0	0.45
Oct 28 to Nov 3	0.37	1		0.32	0.05
Total	14.75		2.40		5.96

Account for YOUR drip system

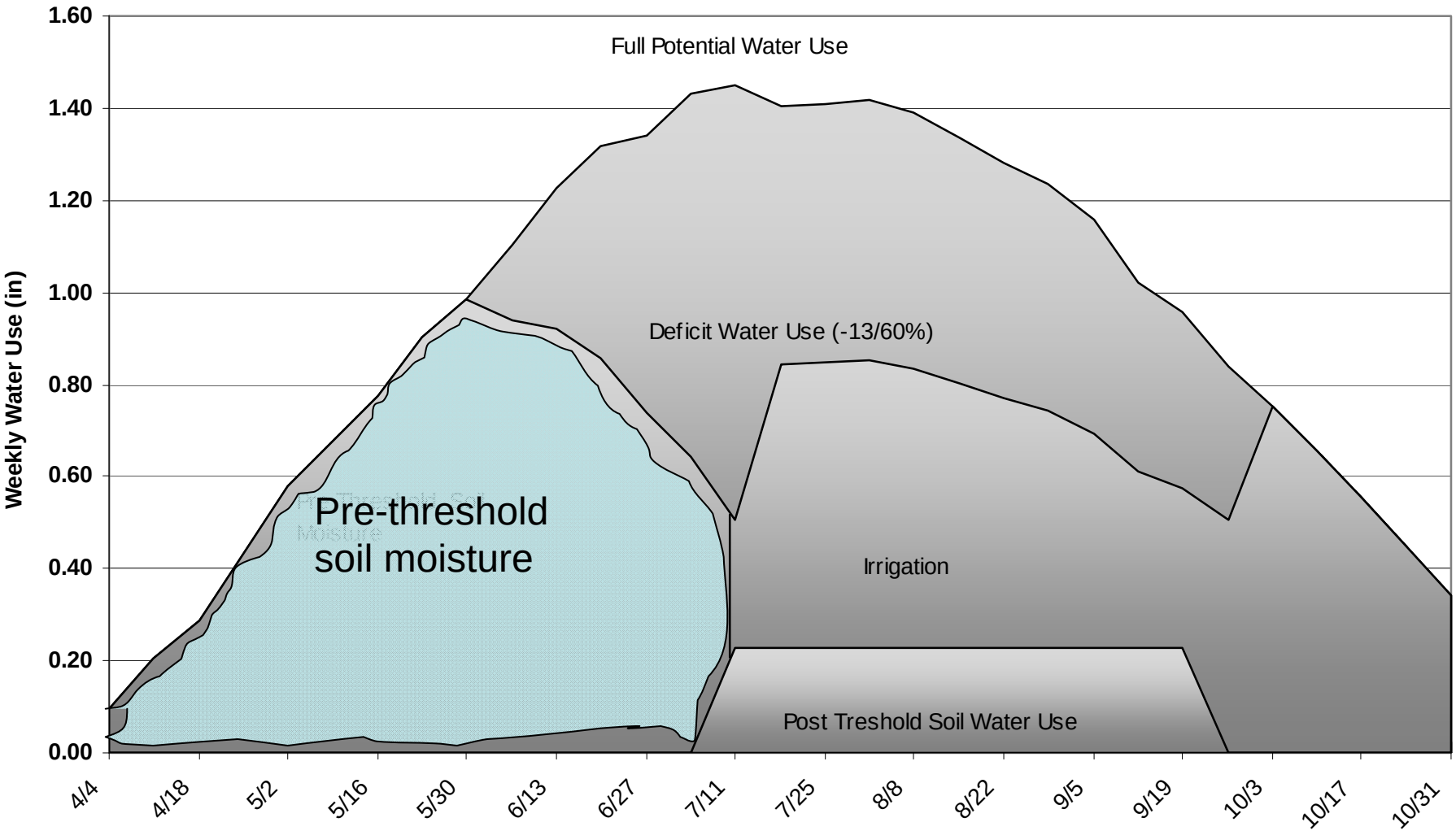
Determining the Net Weekly Vine Irrigation Volume

- Irrigation Uniformity
  - Under deficit irrigation, Irrigation Uniformity = Emission Uniformity (i.e. there are no deep percolation losses)

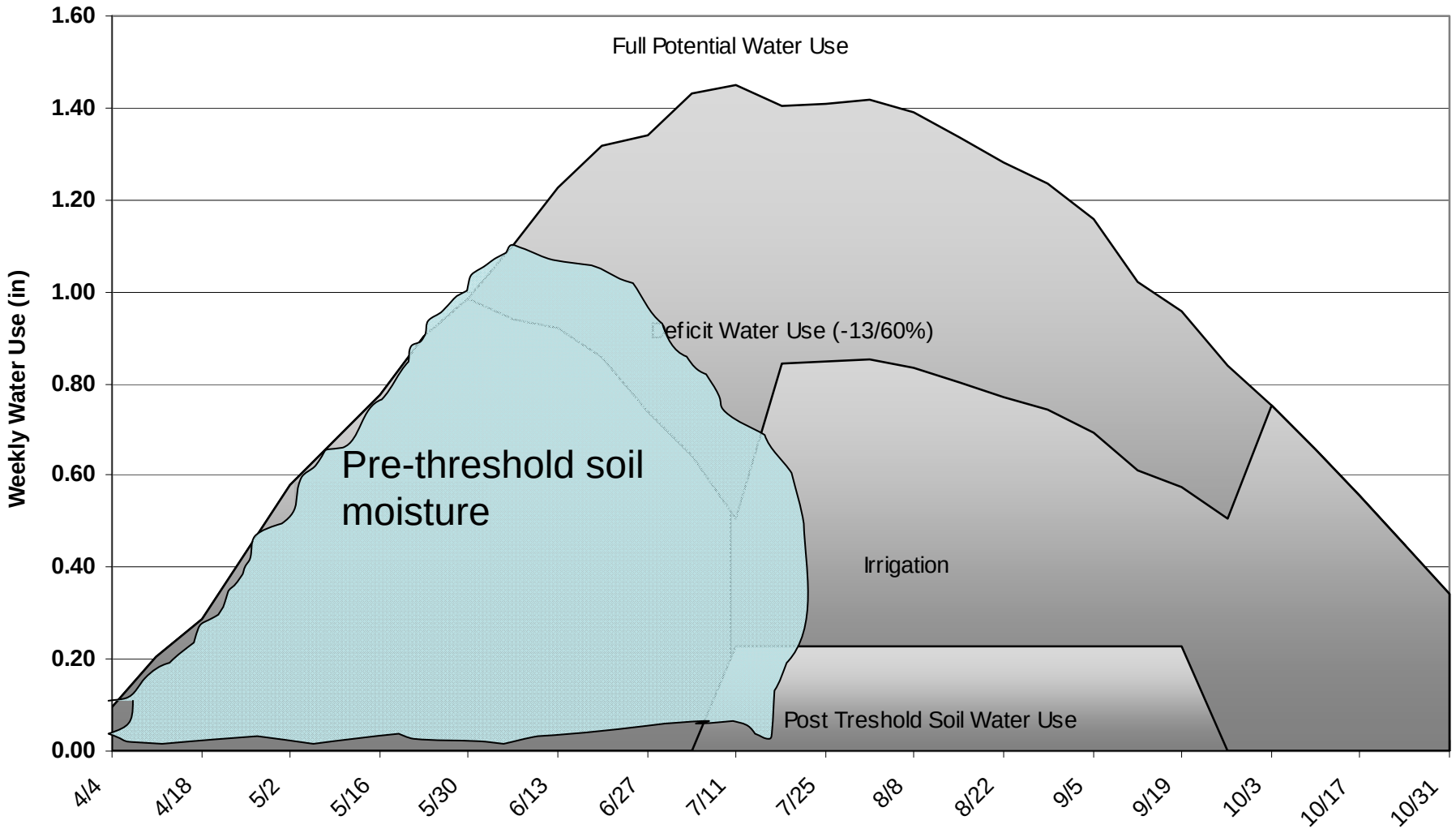


- Irrigation system application rate
- Vine spacing

Date	G = [(C x D) - E - F]: Net Irrigation Amount	H = Emission Uniformity[e]	I = G/H: Gross Irrigation Amount	J = Vine Spacing[f]	K = (I x J x .623): Gallons per Vine/ Period	L = Average Application Rate	M = (K/L): Hours of PREDICTED Irrigation Time
Period	(in)	(%)	(in)	(sq feet)	(gal/week)	(gph/vine)	(hours)
Jly 8-14	0.42	92	0.45	77	21.8	0.96	22.7
Jly 15-21	0.38	92	0.42	77	20.1	0.96	20.9
Jly 22-28	0.38	92	0.41	77	19.6	0.96	20.4
Jly 29 to Aug 4	0.37	92	0.40	77	19.3	0.96	20.1
Aug 5-11	0.35	92	0.38	77	18.4	0.96	19.2
Aug 12-18	0.33	92	0.36	77	17.2	0.96	17.9
Aug 19-25	0.31	92	0.33	77	16.1	0.96	16.7
Aug 26 to Sept 1	0.29	92	0.32	77	15.2	0.96	15.9
Sept 2-8	0.27	92	0.29	77	13.8	0.96	14.4
Sept 9-15	0.22	92	0.24	77	11.3	0.96	11.8
Sept 16-22	0.20	92	0.22	77	10.3	0.96	10.8
Sept 23-29	0.16	92	0.17	77	8.3	0.96	8.6
Sept 30 to Oct 6	0.66	92	0.72	77	34.5	0.96	36.0
Oct 7-13	0.60	92	0.65	77	31.3	0.96	32.6
Oct 14-20	0.53	92	0.58	77	27.6	0.96	28.8
Oct 21-27	0.45	92	0.49	77	23.4	0.96	24.4
Oct 28 to Nov 3	0.05	92	0.05	77	2.4	0.96	2.5
Total	5.96		6.47				
	Gallons per vine applied though harvest =				191.3		
			Hours of irrigation time through harvest =				199.3


Full Potential and Deficit Water Use and sources
Weekly Water Use (in)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Full Potential Water Use
Deficit Water Use (-13/60%)
Pre-threshold soil moisture
Irrigation
Post Treshold Soil Water Use
4/4
4/18
5/2
5/16
5/30
6/13
6/27
7/11
7/25
8/8
8/22
9/5
9/19
10/3
10/17
10/31

Full Potential and Deficit Water Use and sources



Reality Check:

Replace Historical ETo with **current year values**