Attachment 6

Monthly Agricultural Water Allocation (AWA) Formula and Methodology for the WA-12 Agricultural Service Rate Schedule

AWA Formula

To establish a monthly AWA, the following formula was developed using the following elements: ETo, Kc, IA and the conversion factor of 36.3. Similar elements are used by other public agencies who also allocate agricultural water budgets in similar formulas (City of Santa Barbara and Rancho California Water District). The result of the formula provides the agricultural water allocation (AWA) value in CCF/month. The various elements within the formula are described below.

$$AWA\left(\frac{CCF}{month}\right) = ETo(inches/month)\ x\ Kc\ x\ IA\ (acres)\ x\ 36.3(CCF/inch/acre)$$

Reference Evapotranspiration (ETo)

The ETo is the number of inches of irrigation required per month of the year for a particular geographic area to support a crop of cool season grass that is four to seven inches tall (known as the grass reference crop). Riverside is located in Zone 6 of the California Irrigation Management Information System (CIMIS) Reference Evapotranspiration Map. The monthly ETo used in the AWA formula will be established using a 15 year rolling average of Zone 6 ETo data from CIMIS Station #44 located at the University of California Riverside, with the values being updated in January of each year. The initial 15 year rolling average ETo data used in the WA-12 Monthly CCF Water Allocation Calculator was derived by averaging the monthly Zone 6 CIMIS Station #44 ETo values from 2004 – 2018. This data is included as part of this methodology package and will be available on the Riverside Public Utilities (RPU) website.

Crop Factor (Kc) Values

Kc values are the factors that are multiplied by the ETo value to produce the evapotranspiration rate for a particular crop (known as the ETc, or ET(crop), value). Kc values are specific and different for each crop, micro-climate, CIMIS zone, geographical location, irrigation technique, soil type, and time of year. Kc values for specific crops typically land in ranges of values that fluctuate across the year, instead of fixed values. While reviewing a number of the available published resources on crop factor data staff observed Kc values as low as 0.15 and as high as 1.25 for all the different crops referenced. The grass reference Kc factor is set at 1.0, which means cool season grass of four to seven inches in height would require the same amount of inches of irrigation as the ETo for that month and region, or ETo x 1.0 = ETo. Since the Kc value is multiplied against the ETo value, as the Kc increases above 1.0 the ETc value increases above the reference ETo, and as the Kc decreases below 1.0 the ETc value is reduced below the grass reference ETo. For example, if the ETo was two inches/month and the Kc for the crop was 0.50 then the required irrigation would become 2.0 inches/month x 0.50 = 1.0 inch/month. This relationship between the ETo and Kc in the AWA formula illustrates the importance of the initial Kc values being reasonable and fair so appropriate agricultural water allocations are made.

Remember, as a Kc increases, so would the ETc, and ultimately the water allocation under the WA-12 AWA formula.

Irrigated Area Allocation (IA)

The IA component of the AWA formula is the area in acres that is planted with Qualifying Agriculture and requiring irrigation. The planted area(s) will be indicated by the customer on the required WA-12 Agricultural Service Application Form. Staff will confirm and measure the planted area by conducting onsite visits and in some cases by utilizing available Geographic Information System (GIS) tools for remote verification. Grouped plantings such as tree orchards, row crops, nursery stock, and pasture are simply measured by length x width calculations of the planted area. When using remote GIS measurement tools, a polygon can be drawn around the planted area with the area within the polygon automatically calculated by the GIS tool. If qualifying agriculture, such as trees or vines, are individually planted across a property then the fixed area assignments of 400 square feet per tree or 100 square feet per grape vine are used. Staff identified two potential situations, described below, where a fixed area assignment could over allocate IA to a property or where certain properties could potentially receive a double allocation of agricultural water. Staff has proposed language within the WA-12 rate schedule to address these two situations.

Situation 1: Staff analyzed several potential allocation scenarios and found that if only the fixed area approach was used there could be significant over allocation of IA in certain circumstances. An example of this was a 20 acre orchard parcel planted with 2,730 qualifying citrus trees. Using only the fixed area allocation of 400 square feet per tree the IA became 25 acres, therefore the 20 acre parcel would receive an additional five acres of IA over and above the total parcel size. In another allocation scenario a residential property had approximately 75 dwarf citrus trees (trimmed into shrub sizes) tightly planted in the frontage parkway area of the property. Using only the fixed area allocation of 400 square feet per tree the IA would be 0.69 acres, when these 75 trees were actually only occupying a total measured planted area of about 0.20 acres. In order to resolve these potential over allocation scenarios staff recommends that the IA cannot exceed the measured planted area, or parcel size, whichever is smaller. This ensures area allocations are fair and adequate while avoiding allocation to non-planted areas, areas without qualifying agriculture, or areas outside the parcel.

Situation 2: During the process of creating the financial impact analysis staff realized another potential situation where a property could receive a double water allocation. This situation involves a property that has a residence and receives non-potable water from the Gage Canal Company (Company), either by owning shares in the Company or through the Utilities' WA-8 Greenbelt Irrigation Service rate. When a property with a residence receives water from the Company there is a potential for the property to receive irrigation water from both the Company and the WA-12 rate. In this instance the residence could utilize the potable AWA for non-agricultural purposes while the qualifying agriculture is irrigated by non-potable water received from the Company. Staff identified about seventeen properties within the existing WA-3 and WA-9 customer group that have residences and receive Company water. In order to resolve this potential double allocation scenario staff suggests a property with a residence and capability to receive non-potable water from the Company is subject to having its AWA reduced proportionally to the amount of water received by the Company.

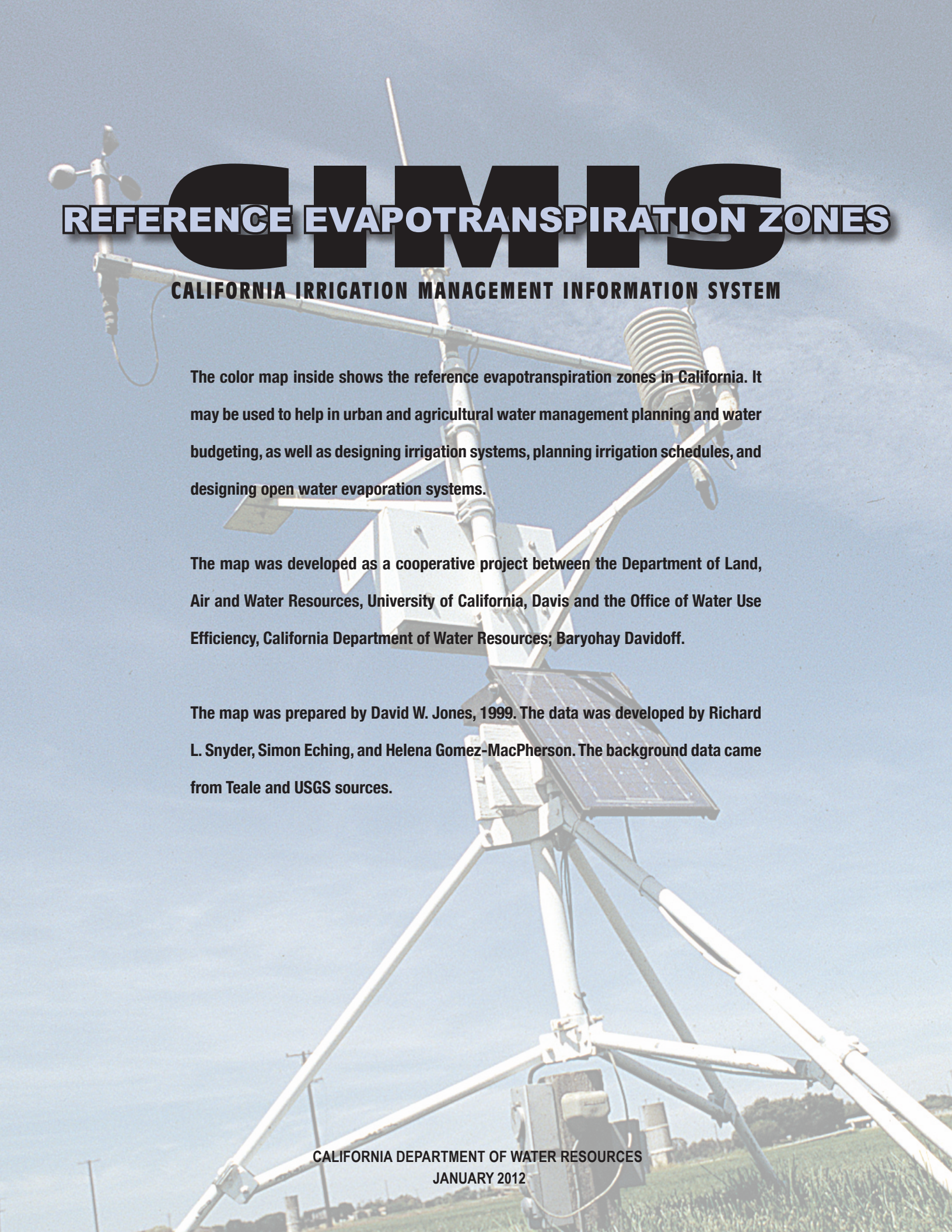
36.3 Conversion Factor

The CIMIS Zone 6 ETo values are provided in inches/month and these units ultimately need to be converted to CCF/month. This is accomplished by using the conversion factor of 36.3 CCF/inch/acre as derived from the equation below.

$$36.3\ CCF/inch/acre = \frac{7.48\ (gallons/cubic\ foot)\ x\ 43{,}560\ (square\ feet/acre)}{12\ (inches/per\ foot)\ x\ 748\ (gallons/CCF)}$$

WA-12 Monthly CCF Water Allocation Calculator

This is the calculator that will be used to establish the total monthly AWA to each customer for all qualifying agricultural activities and planted areas. All that is required in the calculator is the acreage of qualifying agriculture (IA) for each crop grouping. The IA is multiplied by the ET(crop), which is the product of multiplying the ETo, Kc, and conversion factor of 36.3 together. The ET(crop) value results in units of CCF/acre/month. Once the IA is determined and multiplied by the ET(crop) the resulting CCF/month value is obtained. Each January the 15 year rolling average ETo values will be updated in the calculator. The calculator will be available on the RPU website for customers to estimate their total monthly AWA. Once RPU staff verify and confirm the total IA for a property the total AWA will be calculated and entered into the billing system.



CIMIS

REFERENCE EVAPOTRANSPIRATION ZONES

CALIFORNIA IRRIGATION MANAGEMENT INFORMATION SYSTEM

The color map inside shows the reference evapotranspiration zones in California. It may be used to help in urban and agricultural water management planning and water budgeting, as well as designing irrigation systems, planning irrigation schedules, and designing open water evaporation systems.

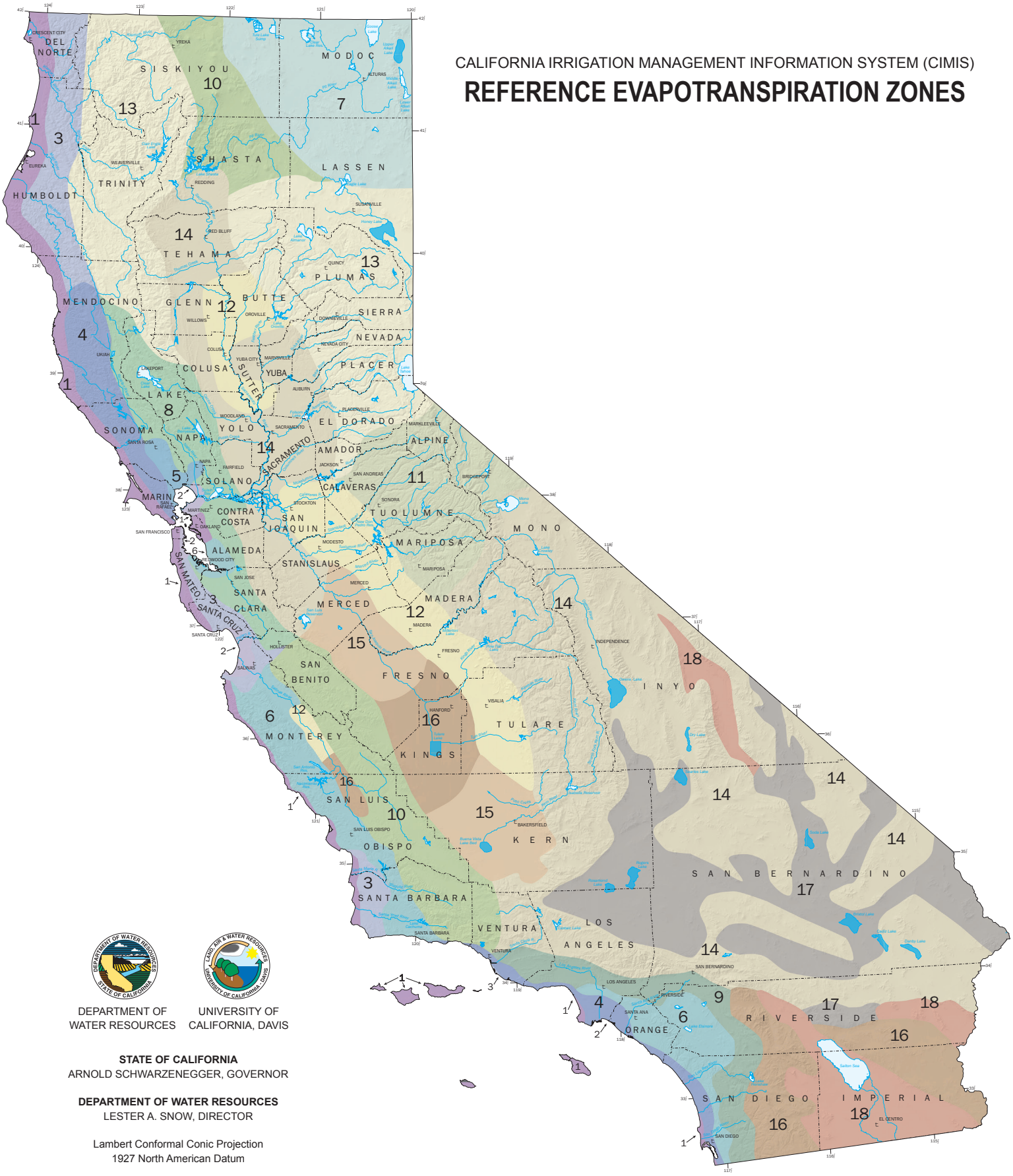
The map was developed as a cooperative project between the Department of Land, Air and Water Resources, University of California, Davis and the Office of Water Use Efficiency, California Department of Water Resources; Baryohay Davidoff.

The map was prepared by David W. Jones, 1999. The data was developed by Richard L. Snyder, Simon Eching, and Helena Gomez-MacPherson. The background data came from Teale and USGS sources.

CALIFORNIA DEPARTMENT OF WATER RESOURCES
JANUARY 2012

CALIFORNIA IRRIGATION MANAGEMENT INFORMATION SYSTEM (CIMIS)

REFERENCE EVAPOTRANSPIRATION ZONES



DEPARTMENT OF WATER RESOURCES

UNIVERSITY OF CALIFORNIA, DAVIS

STATE OF CALIFORNIA
ARNOLD SCHWARZENEGGER, GOVERNOR

DEPARTMENT OF WATER RESOURCES
LESTER A. SNOW, DIRECTOR

Lambert Conformal Conic Projection
1927 North American Datum

Reference EvapoTranspiration (ETo) Zones

1 **COASTAL PLAINS HEAVY FOG BELT** lowest ETo in California, characterized by dense fog

2 **COASTAL MIXED FOG AREA** less fog and higher ETo than zone 1

3 **COASTAL VALLEYS & PLAINS & NORTH COAST MOUNTAINS** more sunlight than zone 2

4 **SOUTH COAST INLAND PLAINS & MOUNTAINS NORTH OF SAN FRANCISCO** more sunlight and higher summer ETo than zone 3

5 **NORTHERN INLAND VALLEYS** valleys north of San Franciaco

6 **UPLAND CENTRAL COAST & LOS ANGELES BASIN** higher elevation coastal areas

7 **NORTHEASTERN PLAINS**

8 **INLAND SAN FRANCISCO BAY AREA** inland area near San Francisco with some marine influence

9 **SOUTH COAST MARINE TO DESERT TRANSITION** inland area between marine & desert climates

10 **NORTH CENTRAL PLATEAU & CENTRAL COAST RANGE** cool, high elevation areas with strong summer sunlight; zone has limited climate data & the zones selection is somewhat subjective

11 **CENTRAL SIERRA NEVADA** mountain valleys east of Sacramento with some influence from delta breeze in summer

12 **EAST SIDE SACRAMENTO-SAN JOAQUIN VALLEY** low winter & high summer ETo with slightly lower ETo than zone 14

13 **NORTHERN SIERRA NEVADA** northern Sierra Nevada mountain valleys with less marine influence than zone 11

14 **MID-CENTRAL VALLEY, SOUTHERN SIERRA NEVADA, TEHACHAPI & HIGH DESERT MOUNTAINS** high summer sunshine and wind in some locations

15 **NORTHERN & SOUTHERN SAN JOAQUIN VALLEY** slightly lower winter ETo due to fog and slightly higher summer ETo than zones 12 & 14

16 **WESTSIDE SAN JOAQUIN VALLEY & MOUNTAINS EAST & WEST OF IMPERIAL VALLEY**

17 **HIGH DESERT VALLEYS** valleys in the high desert near Nevada and Arizona

18 **IMPERIAL VALLEY, DEATH VALLEY & PALO VERDE** low desert areas with high sunlight & considerable heat advection

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	32.9
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.3
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.1
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.4
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variability between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites wihtin a zone for all months is about 0.01 inches per day for the 200 sites used to develop the map.

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CIMIS Information
wwwcimis.water.ca.gov

Zone 6 - CIMIS Station #44 Total ETo (inches/month)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	**15 Year Avg. Eto**
Jan	2.49	2.02	2.92	3.28	1.69	3.32	2.35	2.91	3.02	2.72	3.27	2.84	2.09	1.81	2.41	**2.61**
Feb	2.76	2.21	3.35	2.91	2.31	2.41	2.44	2.91	3.41	3.18	3.03	3.32	4.29	2.08	3.17	**2.92**
Mar	4.81	3.93	3.42	5.02	5.30	4.62	4.67	4.22	4.51	4.80	4.95	5.85	4.92	5.01	3.81	**4.66**
Apr	5.90	5.41	4.26	5.04	6.04	5.58	5.11	5.57	5.85	5.71	6.52	6.28	6.04	6.13	5.69	**5.68**
May	7.10	6.47	6.02	6.47	6.28	6.32	6.18	6.67	7.00	7.01	7.65	5.37	6.21	5.95	5.57	**6.42**
June	6.50	6.49	7.16	7.16	7.59	5.37	6.25	6.95	7.62	7.36	7.61	7.46	7.21	6.98	7.61	**7.02**
July	7.55	7.28	7.73	7.57	7.53	7.60	6.57	7.76	7.93	7.13	7.77	6.75	7.74	7.11	8.04	**7.47**
Aug	6.81	6.68	7.20	7.09	7.23	6.68	6.99	7.65	7.84	7.37	7.29	7.66	6.88	6.40	7.35	**7.14**
Sept	5.83	5.32	5.70	5.44	5.79	5.89	5.45	5.47	6.44	6.14	6.19	5.81	5.30	4.92	5.86	**5.70**
Oct	3.39	3.65	3.95	4.34	5.02	4.40	2.10	4.03	4.38	4.27	4.52	4.22	3.87	4.54	4.30	**4.07**
Nov	2.44	2.84	3.14	2.81	3.14	3.18	3.22	2.45	2.72	2.76	3.21	2.77	3.18	2.35	3.13	**2.89**
Dec	2.30	2.15	2.94	2.24	1.89	2.08	1.78	2.82	1.70	2.80	2.01	2.35	1.99	3.09	2.24	**2.29**

The data in this table was downloaded from Station #44 of the California Irrigation Management Information System (CIMIS) located at the University of California Riverside (https://cimis.water.ca.gov/Default.aspx). CIMIS Station #44 is located in CIMIS Zone 6 and the table above uses the Station #44 monthly Reference Evapotranspiration (Eto) rates in inches/month for 2004 - 2018 to establish the 15 year average monthly ETo values (**in bold**) that are used in the WA-12 Agricultural Service monthly agricultural water allocation (AWA) formula. This 15 year average will be updated annually to ensure a continual 15 year rolling average of ETo values.

WA-12 Monthly CCF Water Allocation Calculator

	CIMIS Station #44 Reference 15 year average ET_0 (2004-2018) in inches / month [1]											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
	2.61	2.92	4.66	5.68	6.42	7.02	7.47	7.17	5.7	4.07	2.89	2.29
[2] K_c for citrus, avocado, fruit and nut trees, and nursery stock	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
ET_{crop} (CCF/acre/mo)	65.37	73.14	116.72	142.27	160.80	175.83	187.10	179.59	142.77	101.94	72.39	57.36
Irrigated Area in acres (IA)												
Monthly CCF allocation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
[2] K_c for grape vines and row crops	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
ET_{crop} (CCF/acre/mo)	50.21	56.18	89.65	109.28	123.51	135.06	143.72	137.94	109.66	78.30	55.60	44.06
Irrigated Area in acres (IA)												
Monthly CCF allocation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
[2] K_c for pasture with livestock	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
ET_{crop} (CCF/acre/mo)	84.32	94.34	150.55	183.50	207.41	226.80	241.33	231.64	184.15	131.49	93.37	73.98
Irrigated Area in acres (IA)												
Monthly CCF allocation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
[2] K_c for immature trees	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
ET_{crop} (CCF/acre/mo)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irrigated Area in acres (IA)												
Monthly CCF allocation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Monthly AWA	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

[1] *The rolling 15 year average will be updated annually*

[2] *Kc factors were derived from the Irrigation Training & Research Center (ITRC) California Evapotranspiration Database developed by California Polytechnic State University San Luis Obispo for CIMIS Zone 6, average values from irrigation design and water balance conditions for drip, spray and surface irrigation techniques.*

WA-12 Monthly CCF Allocation Formula

AWA= ET(o) x Kc x IA x 36.3

AWA = Agricultural Water Allocation in CCF per month, per customer