Irrigation Lessons Learned at the Fair Oaks Horticulture Center

Master Gardener Monthly Meeting
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Sacramento

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The First Irrigation

Orchard, Feb. 1998

2nd Irrigation and Cover Crop

Fall 1999

Cover Crop

Spring 2000

The Orchard

1998

Garden in Orchard

1998

Orchard

Drip, then Microsprinklers

Microsprinklers in Orchard

Wetting Pattern of Microsprinklers

One emitter broken

Citrus Row

Too many emitters? Same number on all trees?

Citrus Row

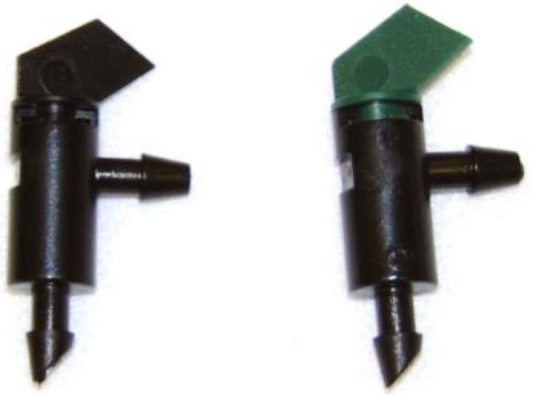
Too many emitters? Same number on all trees?

Vineyard

4 1-gph emitters/vine

Punch-In Emitters

Flag Emitter

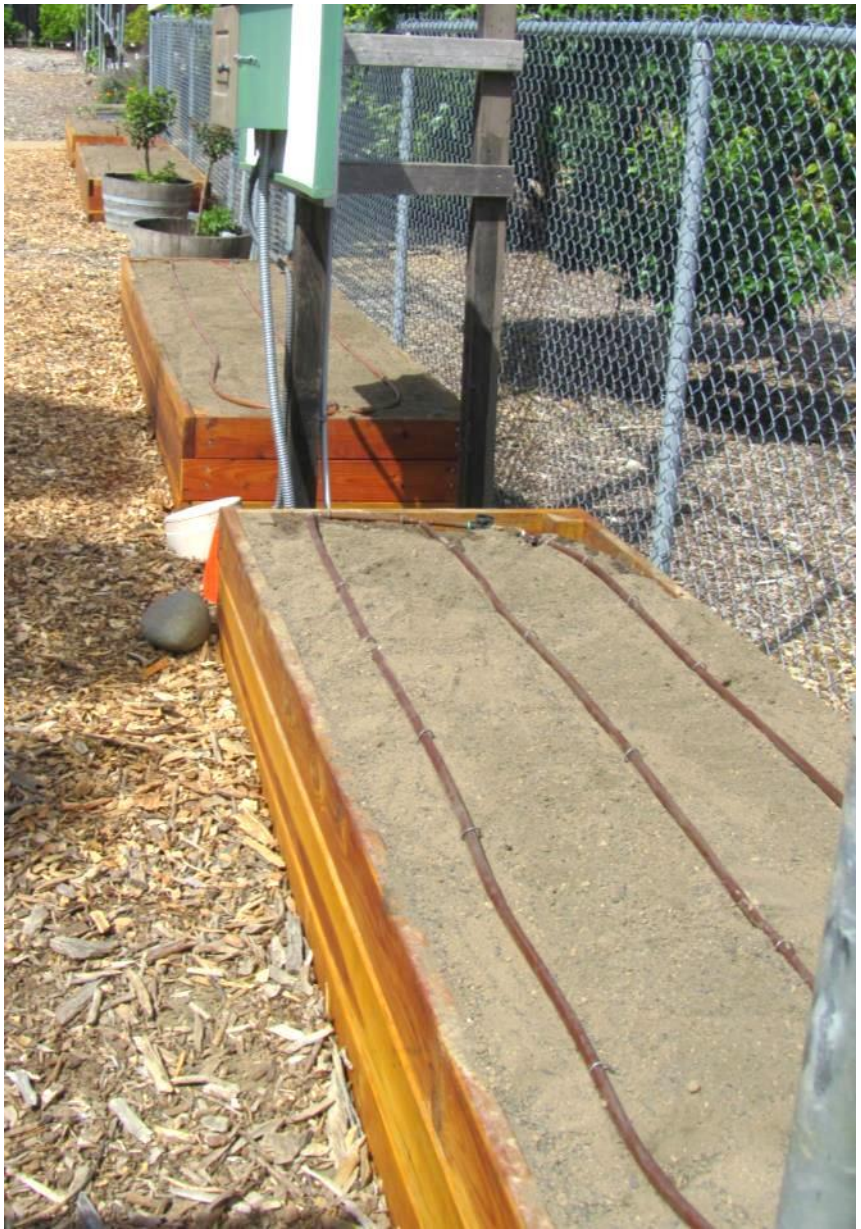


- Not pressure-compensating
- Remove flag to unclog

Over Time, Flow Can Be Variable

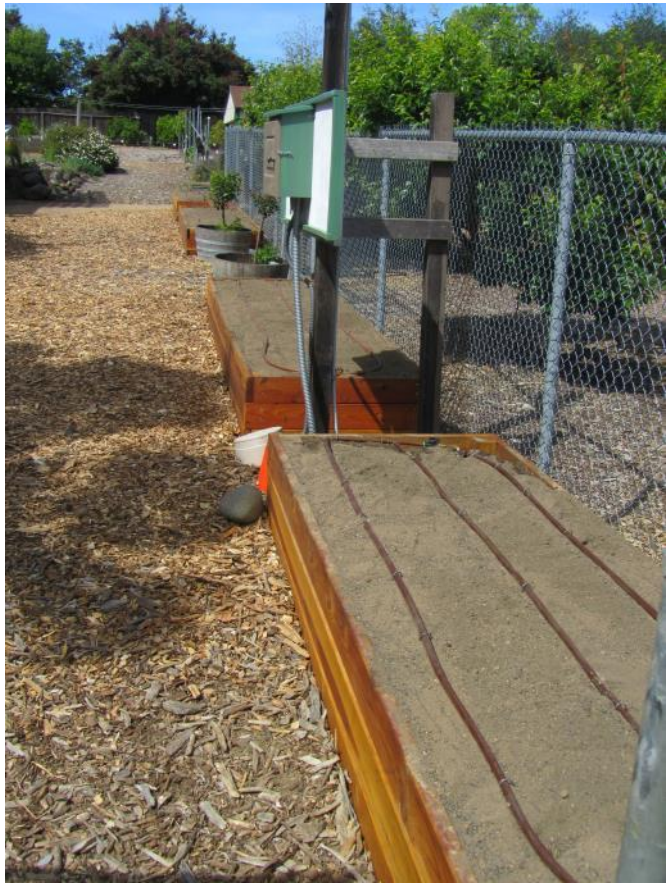
Grape Pots

Herb Beds



Herb Beds

One side more shaded - Effects on soil moisture?



Tubing and Emitters

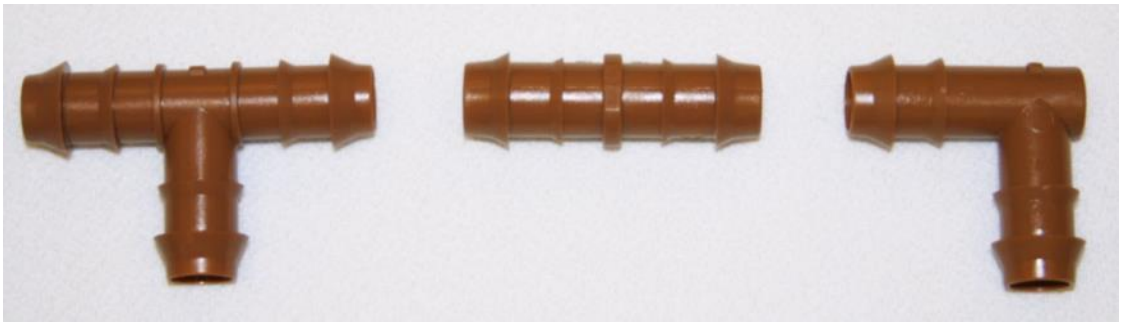
Standard black tubing
18 mm (0.700”)

In-line emitter tubing
17 mm (0.670”)

Maintenance issues!

Barbed Fittings – Generally Best

Rainbird tubing & fittings smaller than others



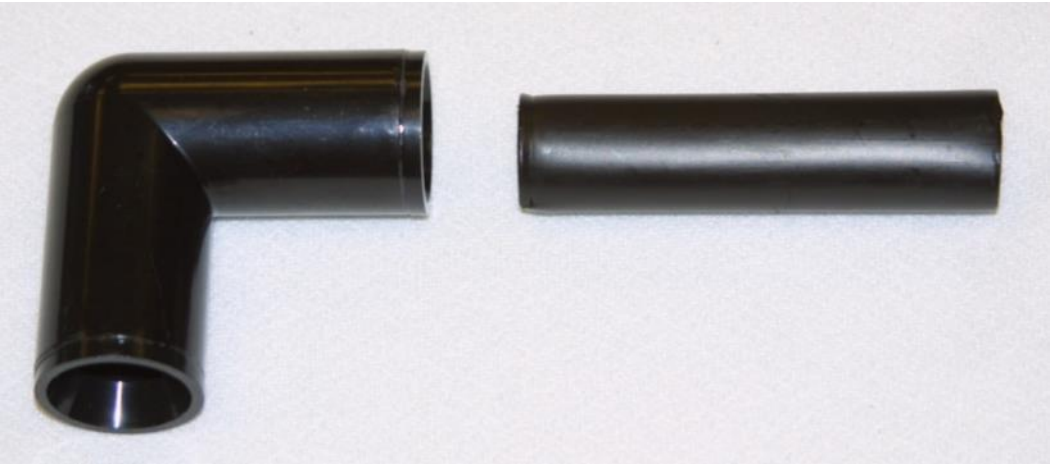
Hot water

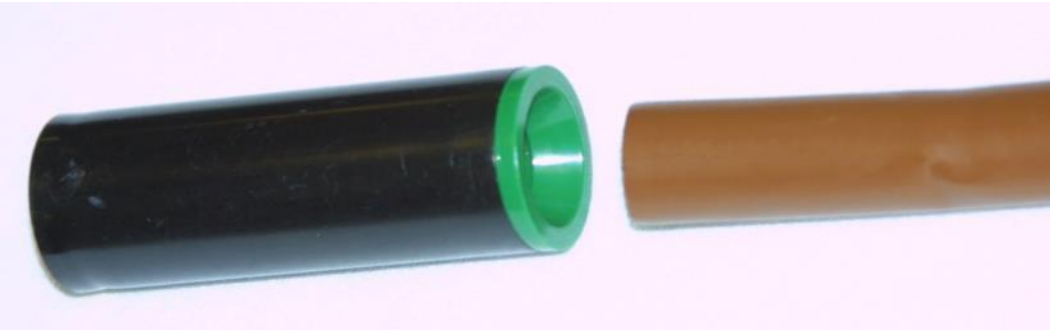
Rain Bird fitting

Rain Bird insertion tool

Compression Fittings

Be Mindful of Size Differences





Old Rainbird tubing → 16 mm = 0.620

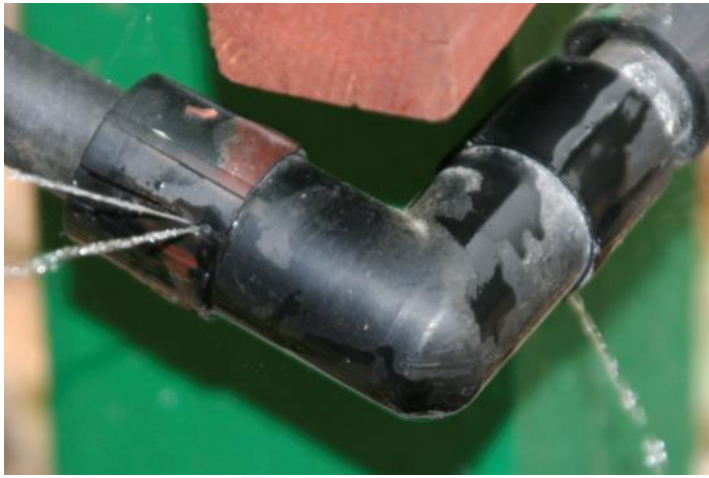
17 mm = 0.670

Universal Compression Fitting (Rainbird)

Fits .620" to .710"
(16-18 mm)

We've had leakage & disconnection issues

Ream out smaller tubing



Universal Compression Fitting (Rainbird)

Fits .620" to .710"
(16-18 mm)

Ream out smaller tubing

- Breakage/disconnection issues over time
- Can avoid using 18 mm for delivery by using blank 17 mm tubing

Veg. Garden

Early 2000s

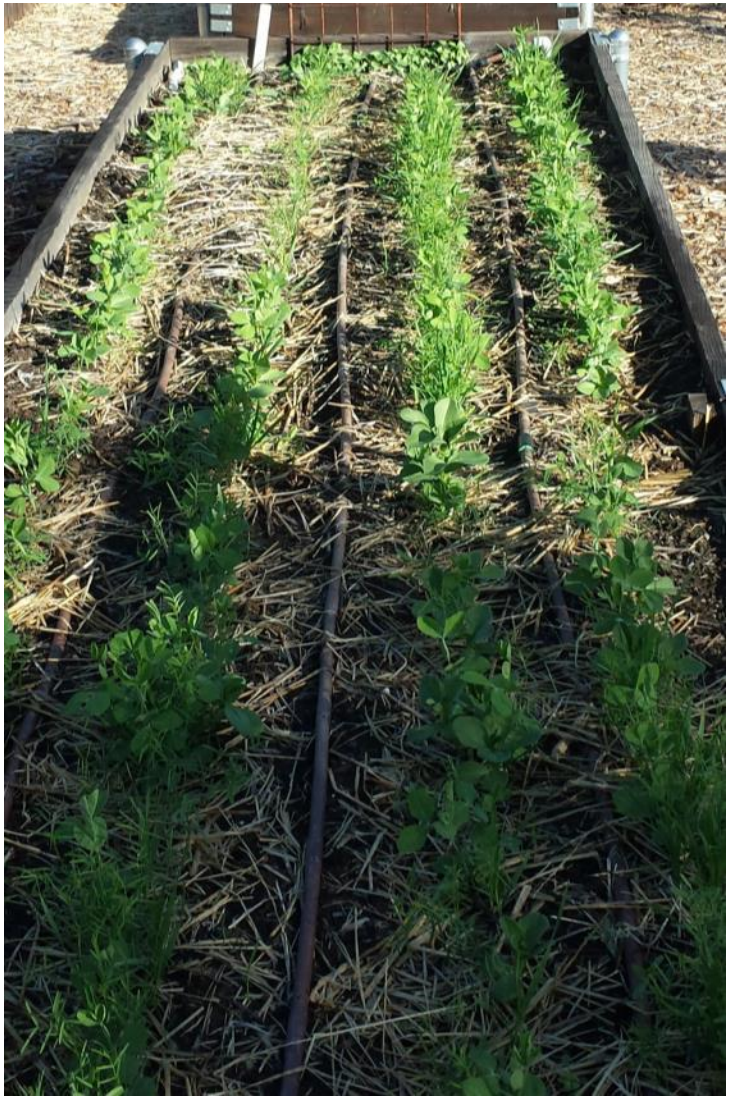
Veg Garden Valves

Veg Garden Irrig. Installation

Jan. 2012

Veg Garden

3 Drip Lines to 4



Water-Efficient Landscape

Sept. 2002

Native Garden Irrig. Retrofit

April 2011

Pipe Installation under Sidewalk to Boost Pressure

May 2016

Tubing snaked to plants, 1 emitter/plant

Inefficient After Year 1

Line Source Drip Irrigation

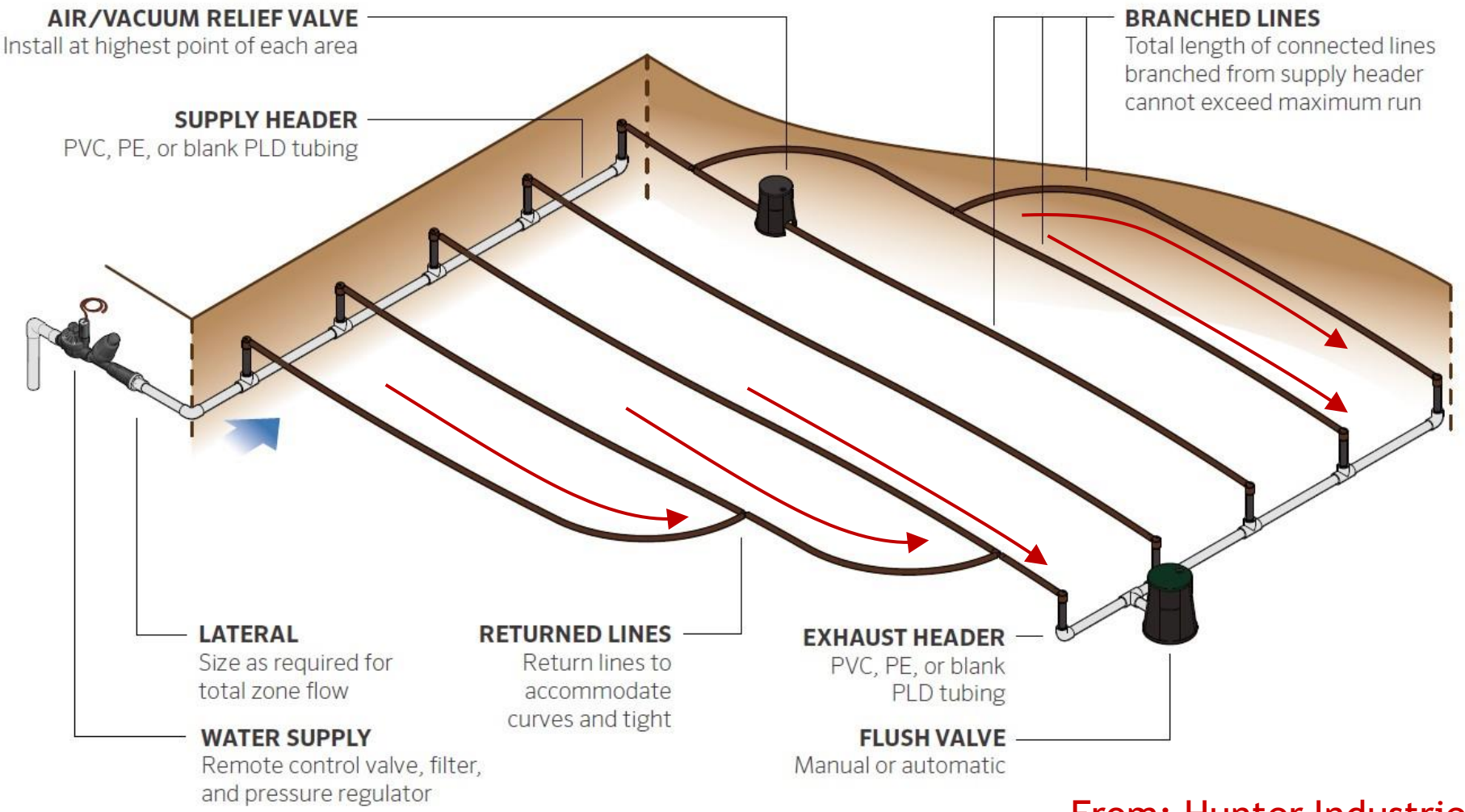
(More plants to come!)

Photo: Lori Palmquist

Bradshaw Rd. by 50

Use supply and exhaust header (loop)

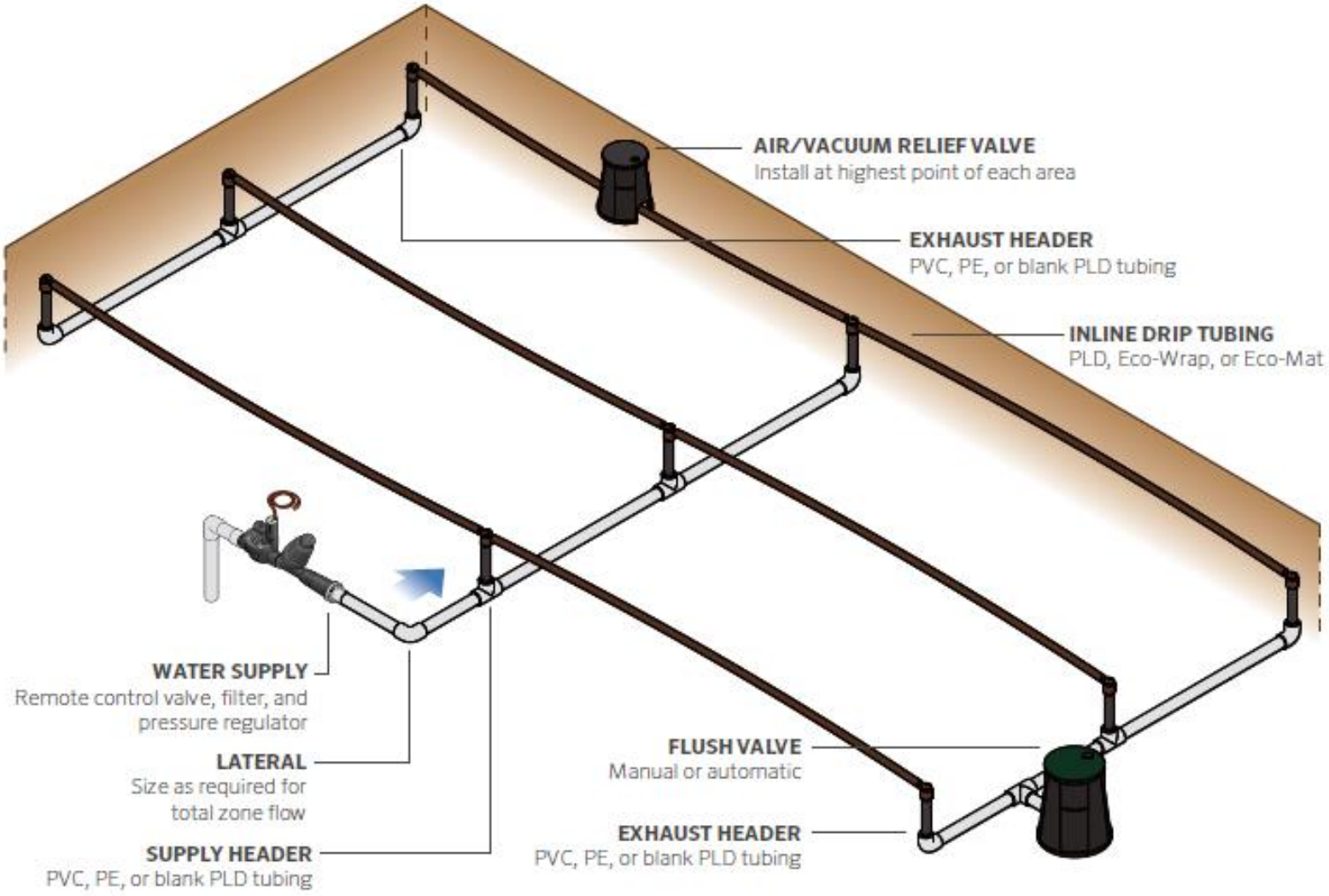
(e.g., PVC pipes, 1/2” or 5/8” tubing)



From: Hunter Industries

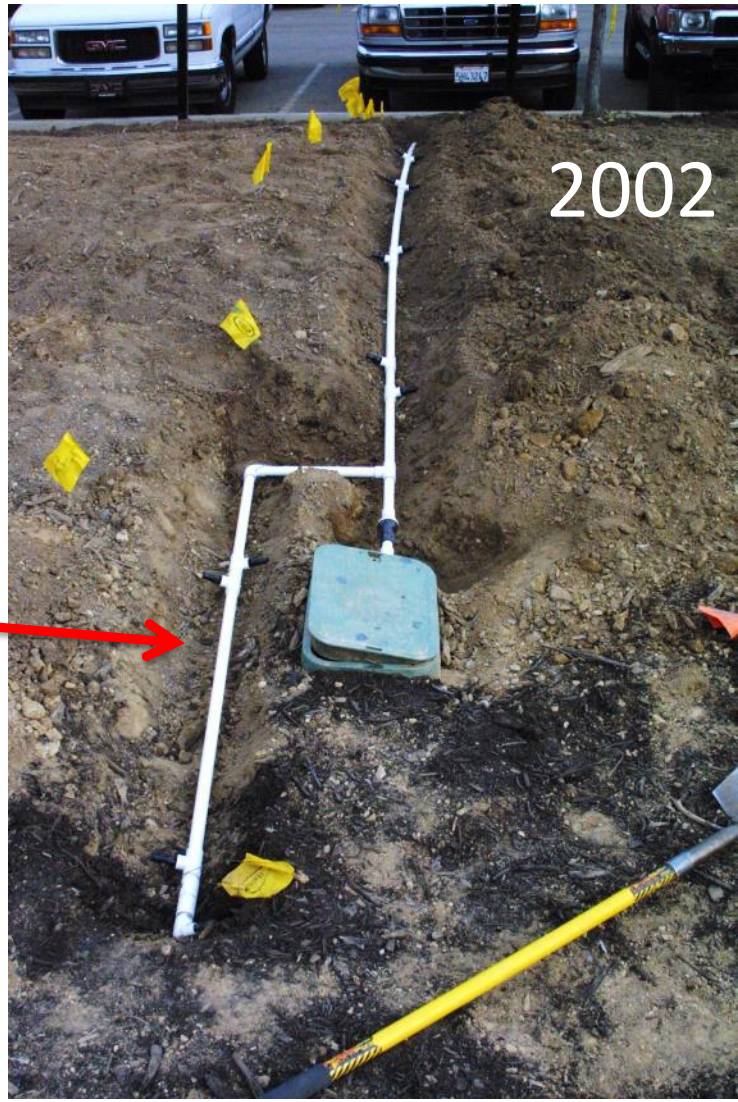
Center Feed Layout

(Hunter)



Header to Ensure Adequate Pressure

Create Map!



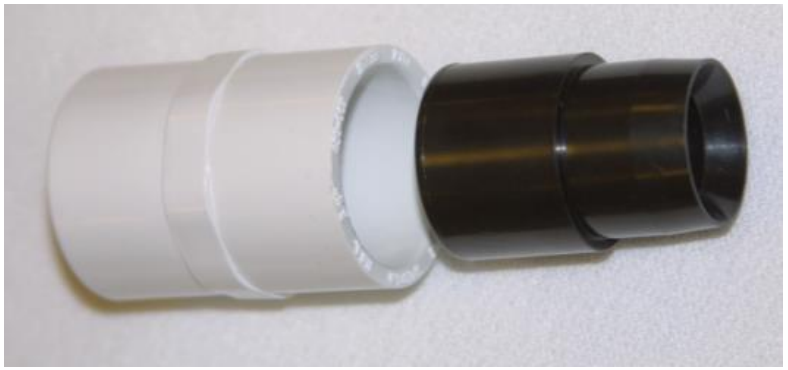
Supply Header

Buried PVC pipe to carry water to drip lines

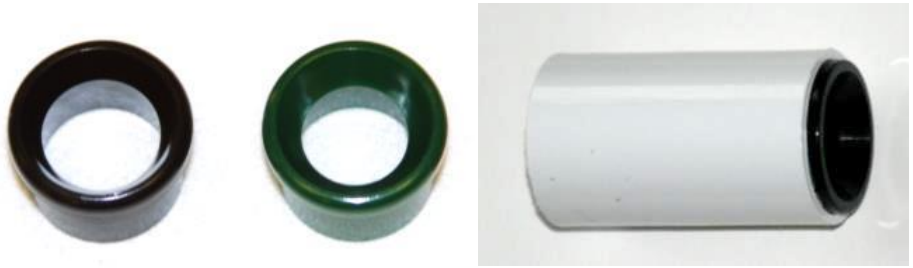
PVC Headers to Ensure Adequate Pressure

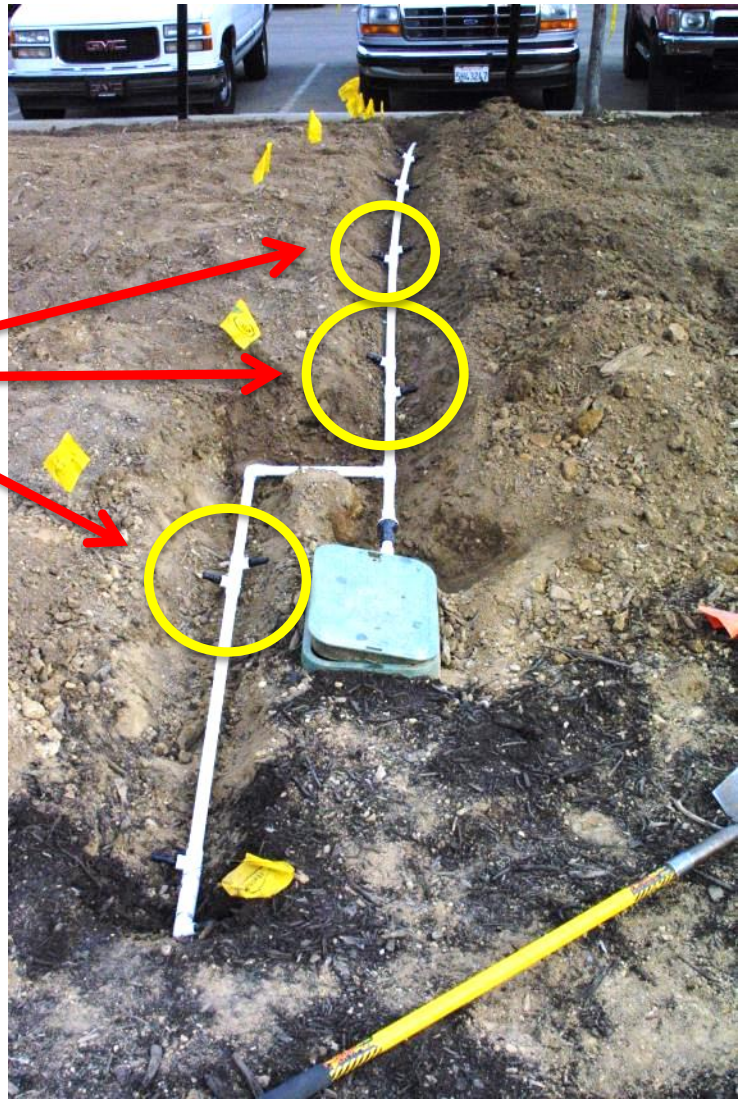
PVC to drip adapters

¾”



½”





18 x 18 in.

Common Garden Irrig. Retrofit - “Line Source”

June 2016

Conversion to Line Source

Common Area Garden

Is the ¾” PVC header big enough?

Line Source, Max. Tubing Length

- Maximum length depends on emitter spacing and flow rate
- "Line source" (in-line emitters) - Generally:
  - Maximum of 200 1-gph emitters from source
  - Drip tubing should be no more than 400 ft. total
- If more needed, consider adding another valve

End Closures

Figure 8 end closure (avoid)

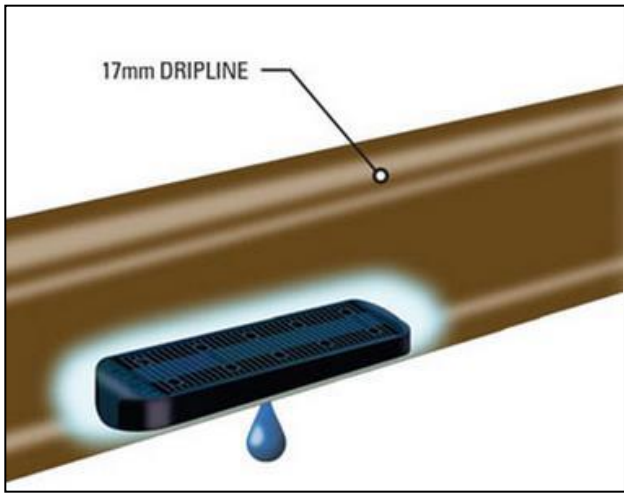
Compression hose end plug with cap

Narrowing Bed and End Cap

Minimum Pressure Required for Drip

(At the most distant emitter)

- Standard tubing = 10 psi
- With check valve:
  - Netafim Techline CV = 15 psi
  - Rain Bird & Hunter = 12 psi



Source: Ewing Irrigation

“Ultra Water-Efficient Landscape”

Categories of Water Needs

A truly ultra WEL is species dependent!

Category	Abbreviation	% of ET_o
High	H	70–90
Moderate/Medium	M	40–60
Low	L	10–30
Very Low	VL	< 10

Ultra water-efficient

Valve Wire Moved to Ultra WEL

Oct. 2015

UC CE | University of California
Agriculture and Natural Resources | Cooperative

Valve Installation in Ultra WEL

Oct. 2015

The Valve Setup (Manifold)

UC CE | University of California
Agriculture and Natural Resources | Co

The Pipeage and Pipers

Be Careful Where You Pound Stakes!

Use photos

Sprinklers Installed

12” pop-up heads

DU only 0.58 (non-uniform spacing)

Streams Blocked by Foliage

UC CE | University of California
Agriculture and Natural Resources | Cooperative

Retrofitting

Sprinkler System to Drip System

- Use existing underground plumbing, ½” risers
- Choose sprinkler heads to convert to drip
- Replace heads with drip retrofit kit
- Cap risers not used, add end caps
- Attach ½” tubing & end caps
- Turn on water to flush lines

Rainbird Spray to Drip Conversion Kit

- Drip adapter (tee or elbow)
- Kit with pressure regulator, screen filter, and cap
- Sprinkler body
  - may come in kit

Retrofit to Line Source Drip Irrigation

Emitters 12”, Tubes 15”, 1.0 gal/hr. (gph)

Rainbird Spray Head Cap

For unused heads

Parallel Lines, Lower Flow in Shaded Area

Emitters 12”, Tubes 15”,
1.0 gal/hr. (gph)

1.0 gph 0.6 gph

End Cap in Box for Flushing

After Installation

Verify Adequate Pressure in Drip Lines

- Insert end cap(s) in drip system
  - Use at far end(s) of zone
  - Also used to flush system

- Attach & read pressure gauge

Determining Flow Rate (per Valve)

Ultra WEL Drip Irrig.

$$\frac{\textit{Irrigated Area (sq. ft.) x 144}}{\textit{(Emitter x Line Spacing [in.])}} \textit{ x Emitter Flow Rate (gph) } \div \textit{ 60}$$

$$\frac{1320 \times 144}{(12 \times 15)} \times 1.0 \div 60 = \textbf{17.6 gpm}$$

(**measured flow = 17.5 gpm**)

Determining Application Rate

Ultra WEL Drip Irrig.

$$\frac{\textit{Emitter flow rate (gph)} \times 231}{\textit{(Emitter x Line Spacing [in.])}}$$

$$\frac{1.0 \times 231}{(12 \times 15)} = \mathbf{1.3\ in./hr.}$$

Precipitation Rate and Flow Rate

Previous Sprinklers vs. Retrofit Drip

- Previous sprinkler applic. rate: 0.9”/hr.
- Retrofit drip applic. rate: 1.3”/hr.

- Previous sprinkler flow rate: 11.5 gal./min.
- Retrofit drip flow rate: 17.6 gal./min.

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- Retrofit drip flow rate: 17.6 gal./min.

High flow problem!

Pressure Loss in Pipe

Speed limit of water (5 ft./sec.)

Size	**1/2"**		**3/4"**		**1"**		**1 1/4"**	
O.D.	**0.840**		**1.050**		**1.315**		**1.660**	
I.D.	**0.622**		**0.824**		**1.049**		**1.380**	
Wall Thk	**0.109**		**0.113**		**0.133**		**0.140**	
Flow gpm	Velocity fps	psi Loss	Velocity fps	psi Loss	Velocity fps	psi Loss	Velocity fps	psi Loss
1	1.06	0.43	0.60	0.11	0.37	0.03	0.21	0.01
2	2.11	1.55	1.20	0.39	0.74	0.12	0.43	0.03
3	3.17	3.28	1.80	0.83	1.11	0.26	0.64	0.07
4	4.22	5.58	2.41	1.42	1.48	0.44	0.86	0.12
5	5.28	8.43	3.01	2.15	1.86	0.66	1.07	0.17
6	6.34	11.81	3.61	3.01	2.23	0.93	1.29	0.24
7	7.39	15.71	4.21	4.00	2.60	1.24	1.50	0.33
8	8.45	20.12	4.81	5.12	2.97	1.58	1.72	0.42
9	9.50	25.01	5.41	6.37	3.34	1.97	1.93	0.52
10	10.56	30.40	6.02	7.74	3.71	2.39	2.15	0.63
11	11.61	36.26	6.62	9.23	4.08	2.85	2.36	0.75
12	12.67	42.59	7.22	10.84	4.45	3.35	2.57	0.88
14	14.78	56.64	8.42	14.42	5.20	4.45	3.00	1.17
16	16.89	72.52	9.63	18.46	5.94	5.70	3.43	1.50
18	19.01	90.17	10.83	22.95	6.68	7.09	3.86	1.87

Source: RainBird

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Source: RainBird

1” Pipe from Valve Changed to 1¼”

Calculating Run Time and Irrigation Frequency

- Run time
  - Wetting depth
  - Soil water holding (Plant Available Water)
  - Application rate
- Irrigation frequency
  - Climate (ET_o)
  - Landscape and plant coefficients (K_L)

Wetting Depth

- How deep to irrigate
  - ➢Depends on plant types
    - Trees, shrubs, ground covers, turf
    - Typically, 36” 24” 18”, and 12”
  - ➢For our example of Ultra WEL (young), we’ll use **18”**

Plant Available Water

- How much water does the soil hold?
- Use chart
  - Need to know soil texture
- For this example: **sandy loam**
  - PAW = 0.11

Soil Texture	Available Water in/in	Infiltration in/hr
Coarse to Moderately Coarse		
Sand/fine sand	0.05	1.50 - 3.00
Loamy sand	0.07	1.00 - 2.00
Sandy loam	0.11	0.80 - 1.20
Medium		
Loam	0.16	0.40 - 0.60
Silty loam/silt	0.20	0.25 - 0.50
Moderately Fine to Fine		
Sandy clay loam	0.15	0.10 - 0.30
Clay loam	0.16	0.07 - 0.25
Silty clay loam	0.18	0.05 - 0.12
Sandy clay	0.12	0.08 - 0.20
Silty clay	0.15	0.05 - 0.15
Clay	0.14	0.05 - 0.10

Calculating Run Time

- **Run time**
  - Wetting depth (18 in.)
  - Plant available water (0.11 in.)
  - Application rate (1.3 in./hr.)
  - Irrigate at 50% field capacity (not fully dry!)

$$Run\ Time = \frac{Depth\ to\ wet \times Plant\ Available\ Water}{Application\ Rate \times 2}$$

$$\frac{18 \times 0.11}{1.3 \times 2} = \mathbf{0.76\ hr.\ (45\ min.)}$$

- This applies **1.0 in.** (1.3 in./hr. x 0.76 hr.)

Developing an Irrigation Schedule

- So,
  - We know how much to apply (1.0 in)
  - **We want to replace ½ of field capacity**
- Then,
  - We need to estimate when that amount of water is used

Categories of Water Needs

WUCOLS IV

Category	Abbrev.	% of ET_o	K_L
High	H	70–90	0.7 - 0.9
Mod./Medium	M	40–60	0.4 - 0.6
Low	L	10–30	0.1 - 0.3
Very Low	VL	< 10	<0.1

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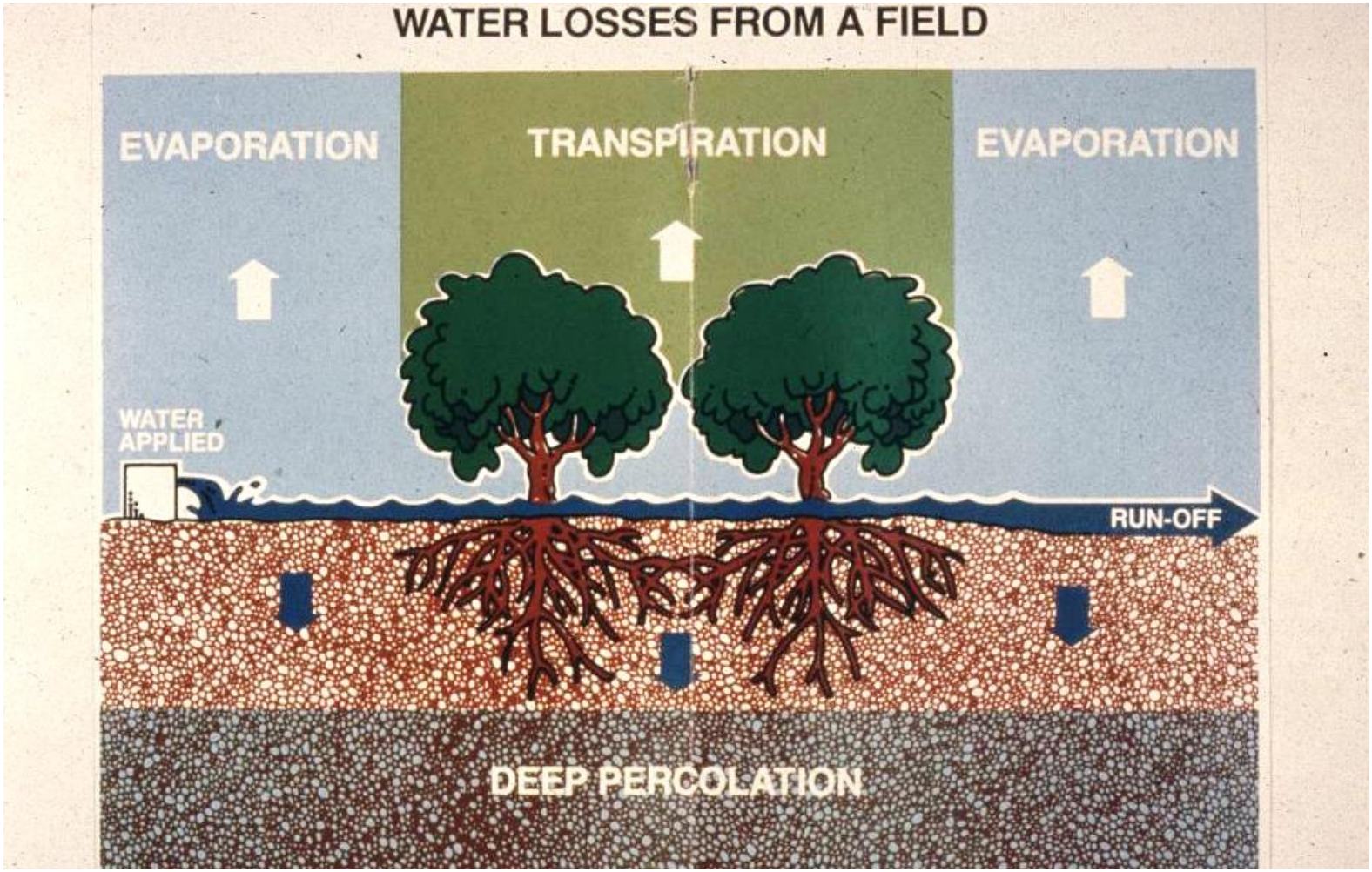
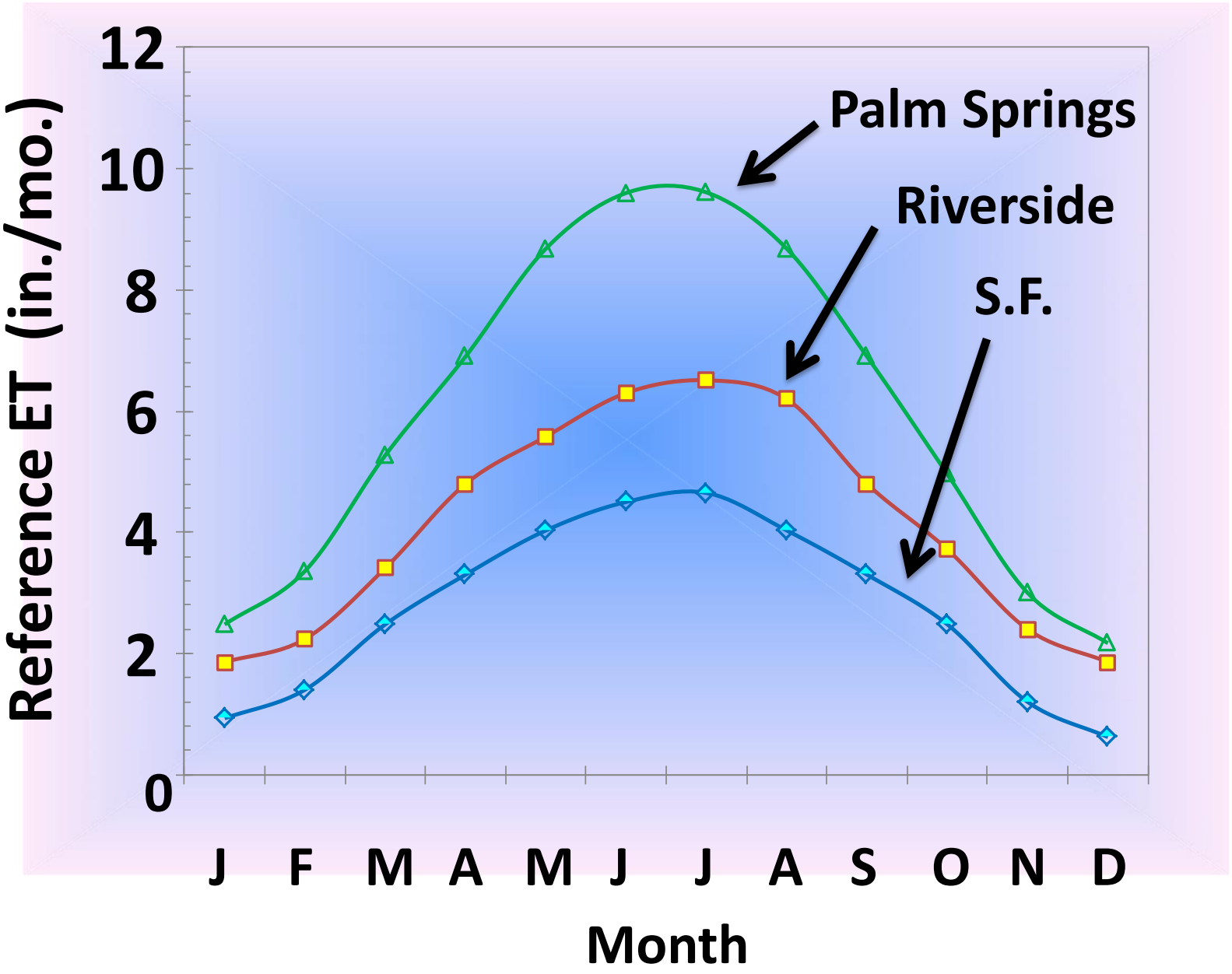
Our example = 0.2

EvapoTranspiration (ET)




Reference ET (in./mo.)
12
10
8
6
4
2
0
Palm Springs
Riverside
S.F.
J
F
M
A
M
J
J
A
S
O
N
D
Month

CIMIS

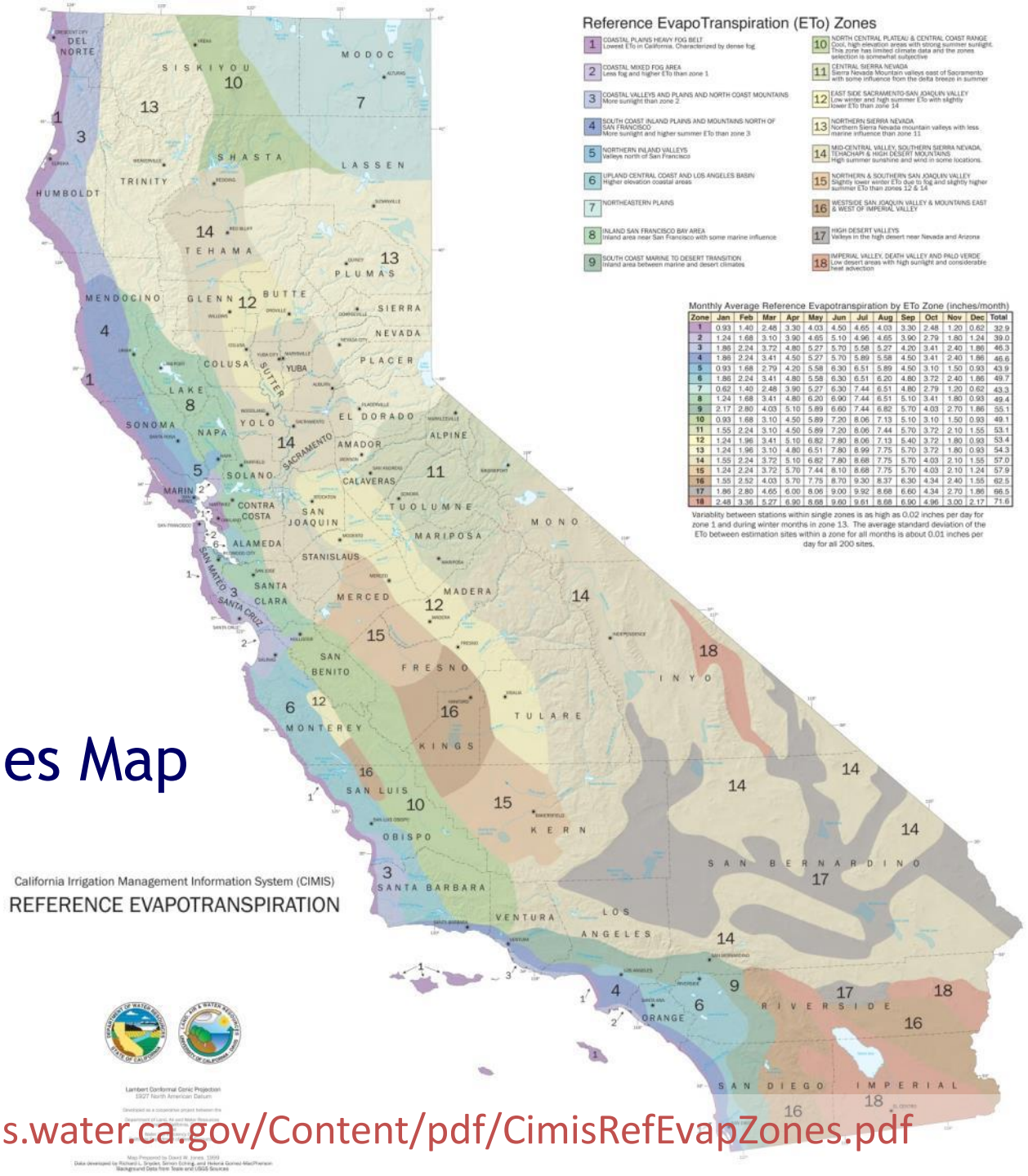
C alifornia
I rrigation
M anagement
I nformation
S ystem

- Collects weather info
- Estimates plant water use
- Cool-season turf
- More than 120 stations

Water use data (ET_o) are used with a crop or landscape coefficient (K_L) to estimate site water use

http://wwwcimis.water.ca.gov/cimis/

ETo Zones Map



http://wwwcimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf

Monthly Average ETo by Zones (in/mo)

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

http://wwwcimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf

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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
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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
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13	1.24	1.96	3.			0	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.			0	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

Our example

http://wwwcimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf

Developing An Irrigation Schedule

- Climate (Water Use Rates)

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

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
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

  - Example: July = 8.68 in/month
  - ET_o = 8.68 in ÷ 31 days = **0.28 in/day**

Developing An Irrigation Schedule

- How fast is our landscape using water?
  - $ET_L = ET_{day} \times K_L$
  - $ET_{day} = 0.28$ in/day
  - $K_L = 0.2$

$ET_L = 0.28 \times 0.2 =$ **0.06 in/day**

Developing An Irrigation Schedule

- Determine when to irrigate
  - Irrigation application = 1.0 in
  - ET_L = 0.06 in/day
- Accumulate ET_L daily
- When accumulated total reaches 1.0 in
- Irrigate!

Developing An Irrigation Schedule

ET_{day} = 0.28
K_L = 0.2
ET_L = 0.06
Irrig = 1.0

July	Day	Total ET_L	Day	Total ET_L
	1	0.06	11	0.66
	2	0.12	12	0.72
	3	0.18	13	0.78
	4	0.24	14	0.84
	5	0.30	15	0.90
	6	0.36	16	0.96
	7	0.42	17	0.06
	8	0.48	18	0.12
	9	0.54	19	0.18
	10	0.60	20	0.24

← Irrigate

← Start over

More Things to Consider

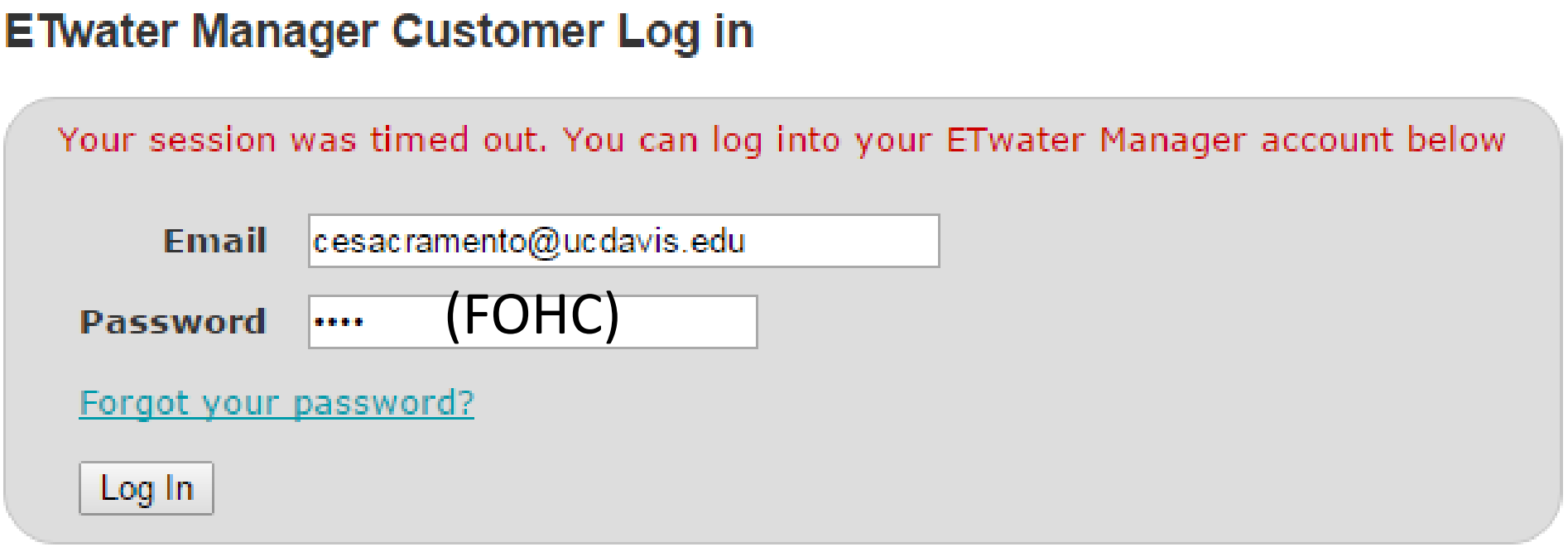
- Interval vs. duration
  - DO NOT reduce run times
    - Affects wetting depth
  - If increase interval between irrigations
    - May need to replace >half of soil's field capacity
    - Slightly longer run time

Our “Smart” Controller

ET Water

(Google: ET Water Manager)

http://manager.etwater.com/Customer/api_dashboard.cfm?site_id=0



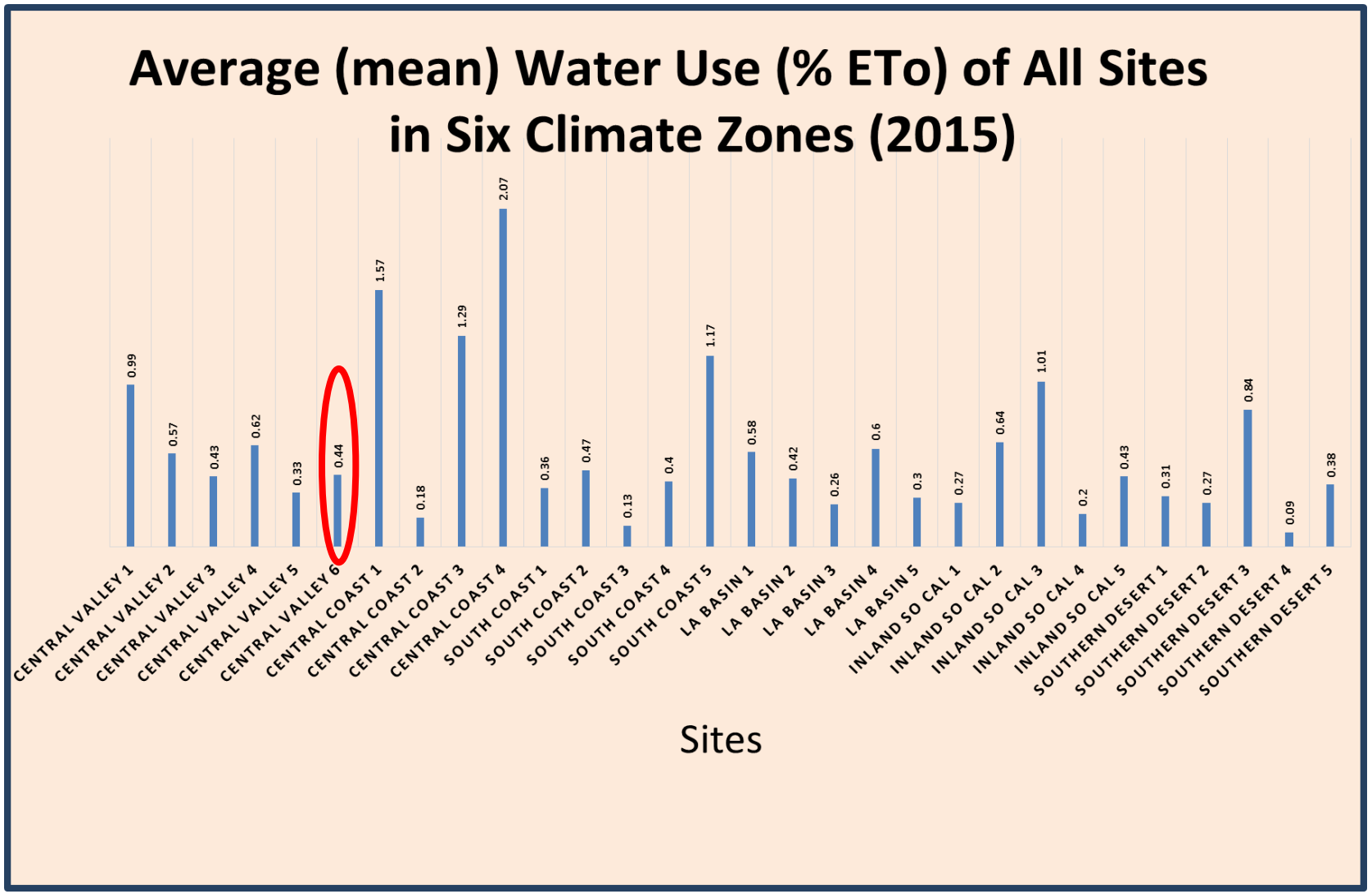
FOHC Controller Programs - late July 2016

#	Station	Program	Run Time	Schedule	Next 7 Days						
					S	S	M	T	W	T	F
1	Orch W	60 min, 1x	60 min	3 days/wk	⊘	💧	⊘	💧	⊘	⊘	💧
2	Orch M	60 min, 1x	60 min	3 days/wk	⊘	💧	⊘	💧	⊘	⊘	💧
3	Orch E	60 min, 1x	60 min	3 days/wk	⊘	💧	⊘	💧	⊘	⊘	💧
4	Herbs	30 min, 1x	30 min	3 days/wk	💧	⊘	💧	⊘	⊘	💧	⊘
5	Berries	45 min, 1x	45 min	4 days/wk	💧	⊘	💧	⊘	💧	💧	⊘
6	Veg N drip	40 min, 1x	40 min	3 days/wk	⊘	⊘	💧	⊘	💧	⊘	💧
7	Veg S drip	40 min, 1x	40 min	3 days/wk	⊘	⊘	💧	⊘	💧	⊘	💧
8	Veg Barrel	5 min, 1x	5 min	7 days/wk	💧	💧	💧	💧	💧	💧	💧
9	Veg Spray	10 min, 1x	10 min		⊘	⊘	⊘	⊘	⊘	⊘	⊘

FOHC Controller Programs - late July 2016

10	Vineyard	180 min, 1x	180 min	3 days/wk	💧	⊘	💧	⊘	⊘	💧	⊘
11	Grape pots	3 min, 1x	3 min	7 days/wk	💧	💧	💧	💧	💧	💧	💧
12	Citrus	45 min, 1x	45 min	3 days/wk	💧	⊘	💧	⊘	⊘	💧	⊘
13	WEL pk lot	180 min, 1x	180 min	3 days/wk	💧	⊘	⊘	💧	⊘	💧	⊘
14	WEL Low	180 min, 1x	180 min	3 days/wk	⊘	💧	⊘	⊘	💧	⊘	💧
15	UWEL grass	92 min, 1x	92 min	Ev. 5 days		💧					💧
16	WEL Med	180 min, 1x	180 min	3 days/wk	⊘	💧	⊘	⊘	💧	⊘	💧
17	WEL Comm	132 min, 1x	132 min	Ev. 5 days		💧					💧
18	WEL Native	180 min, 1x	180 min	3 days/wk	⊘	💧	⊘	💧	⊘	⊘	💧
19	UWEL main				⊘	⊘	⊘	⊘	⊘	⊘	⊘

Statewide ETAF Study Results

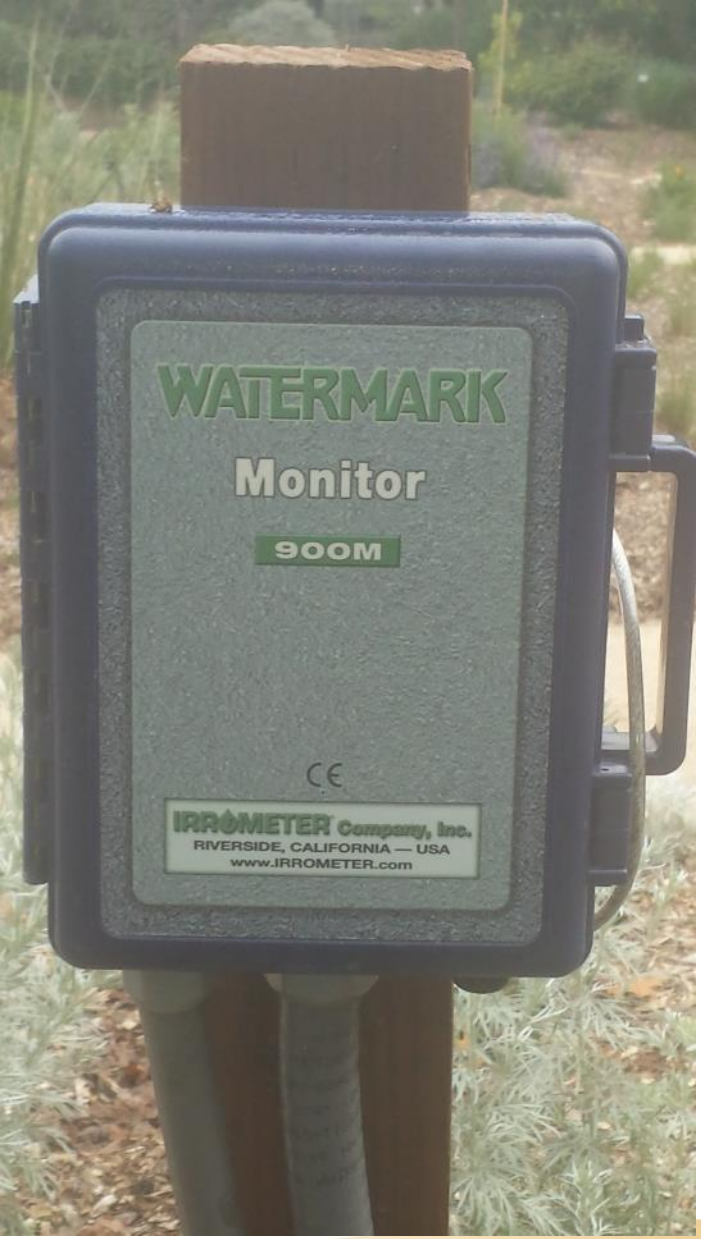


Avg. ET for FOHC

UC ETAF Study

	Upper Perennial Walk	Native Garden
2014	0.67	0.47
2015	0.38	0.25

Watermark Sensors



Sensors & Wiring in Ultra WEL

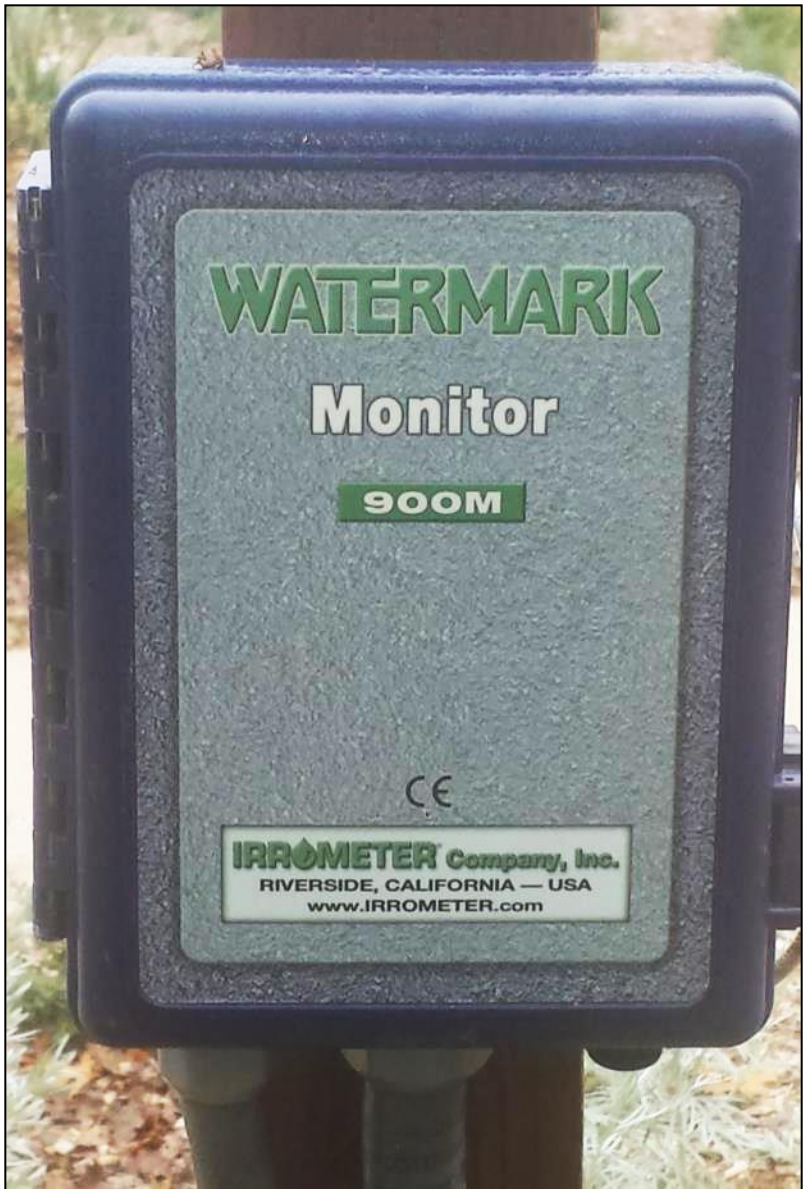
Sensors & Wiring under Grape Arbor

Sensors & Wiring in Vineyard

Sensors & Wiring in Orchard

Watermark Monitor

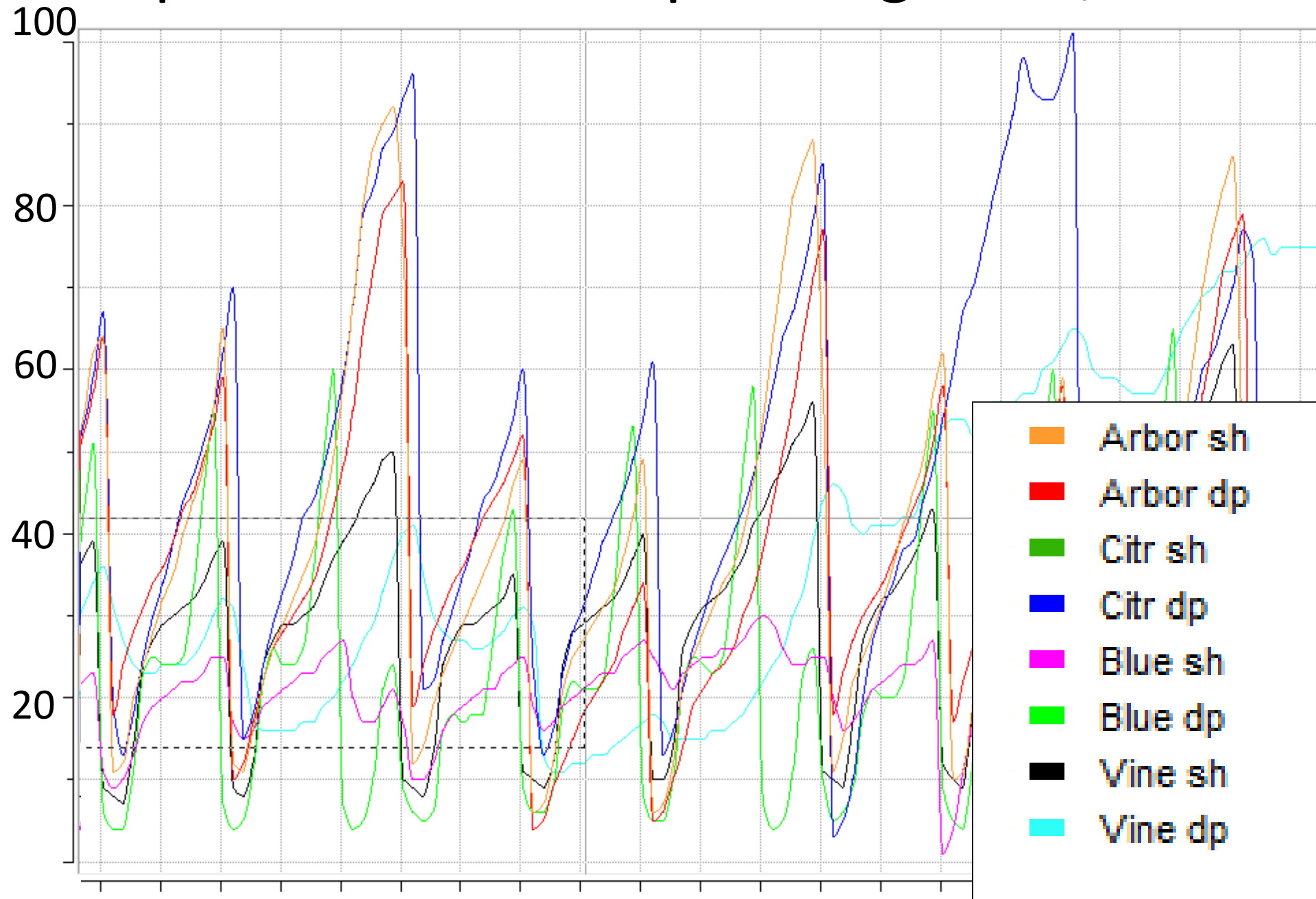
3 at FOHC (UWEL, Orchard, Grape Arbor)



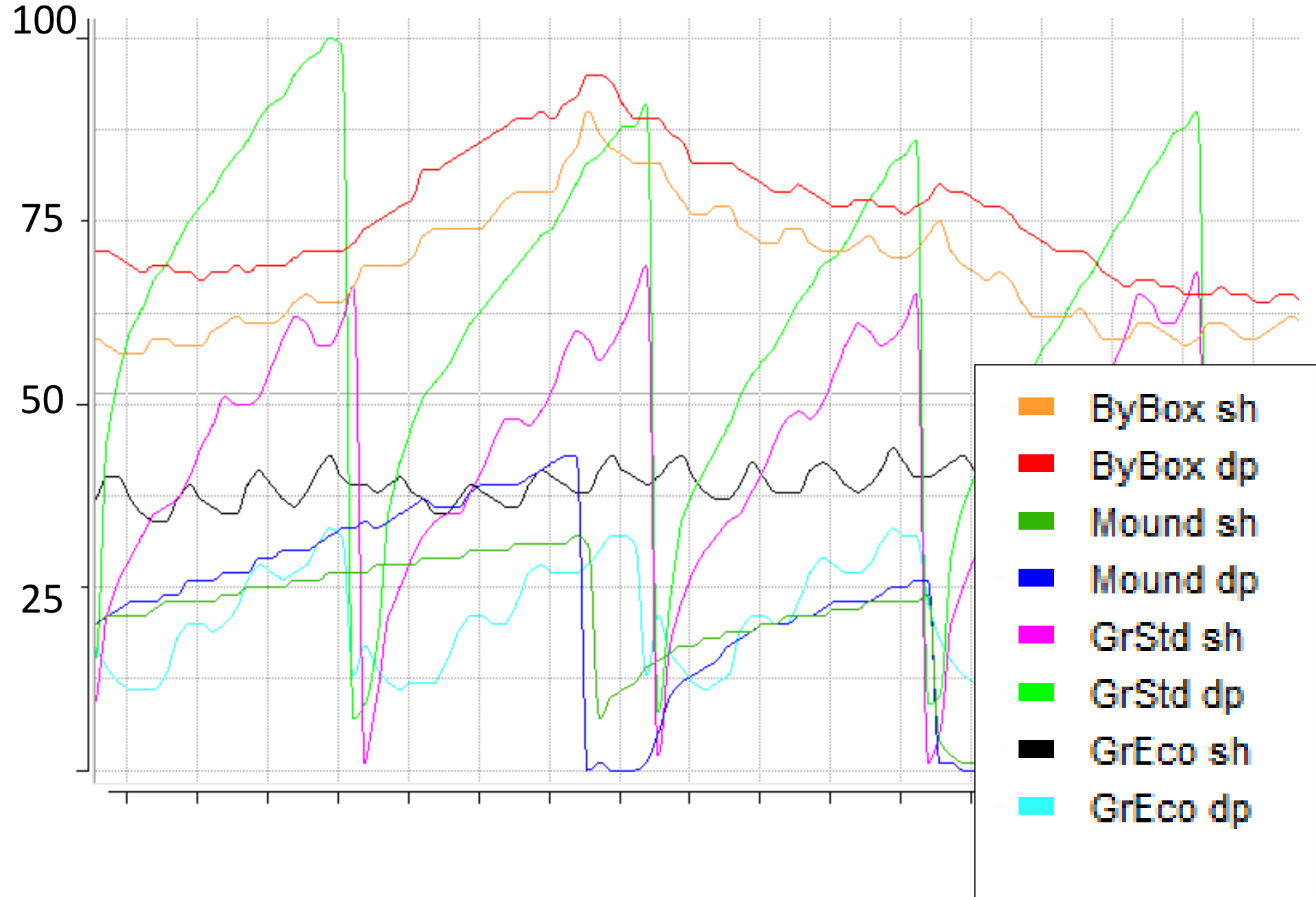
Watermark Sensor Values

- **0-10** Saturated soil
- **10-30** Adeq. wet (coarse sands losing water)
- **30-60** Usual range for irrigation (most soils)
- **60-100** Usual range for irrigation in heavy clay
- **100-200** Dangerously dry for max production

Crop Watermark Graph - Aug. 1-17, 2016



UWEL Watermark Graph - Aug. 1-17, 2016



Thank you!
Questions?

http://ccag-eh.ucanr.edu