Irrigation Scheduling in a Severe Drought
Scheduling for Survival
Turf Irrigation Performance and Scheduling
Webinar Session 4

Presented by
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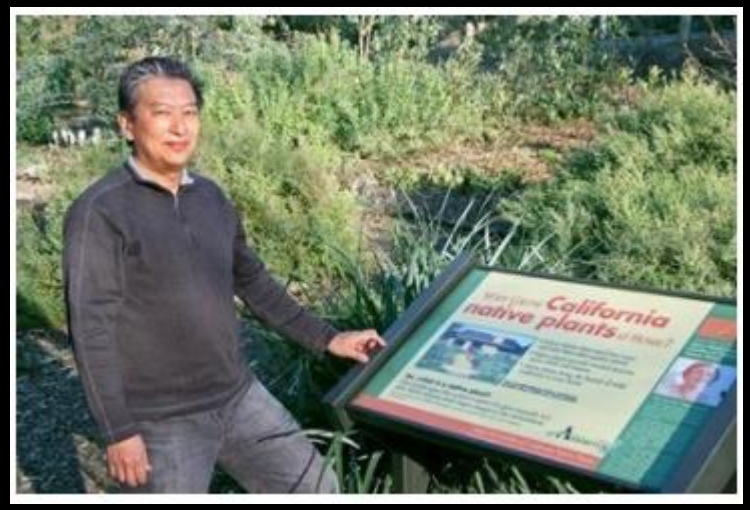
EWING
Irrigation & Landscape Supply



Dave Fujino - Ph. D. – Director
California Center for Urban Horticulture at U.C. Davis

UCDAVIS
California Center for
Urban Horticulture

The Situation – The primary purpose for irrigating turf in this severe drought is to mitigate the losses in landscape material that will occur. Irrigation runoff, and poor sprinkler performance related to common maintenance problems must be a priority.

Designated Watering Day by City for Overhead Irrigation

Monday	Tuesday	Wednesday	Thursday	Friday
• Ross • Tiburon • Belvedere • San Geronimo • Forest Knolls • Lagunitas	• San Rafael • All other unincorporated areas in Marin County	• San Quentin • Sausalito • Corte Madera • San Anselmo	• Mill Valley	• Woodacre • Larkspur • Fairfax • Greenbrae • Kentfield

No overhead irrigation is allowed on Saturdays and Sundays and no watering between the hours of 9:00 a.m. and 7:00 p.m.!

We should be grateful…It could be a lot worse!!!

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CITY OF HEALDSBURG
CALIFORNIA SINCE 1867

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GOVERNMENT DEPARTMENTS & SERVICES RESIDENTS BUSINESS

month).

- **Commercial Customers are required to reduce water usage by 40%.**
- **Automated irrigation -- sprinklers or drip -- is prohibited for all residential, commercial and industrial custor**

- **Residential Customers are assigned a water budget of 74 gallons per person per day (cumulative 2,244 gallons per month).**
- **Commercial Customers are required to reduce water usage by 40%.**
- **Automated irrigation -- sprinklers or drip -- is prohibited for all residential, commercial and industrial customers.**
- Hosing driveways, hardscapes areas power washing, and washing personal vehicles are prohibited.
- Planting new plants or grass is prohibited.
- Hand-watering is allowed so long as it's within water allowance.
- Restaurants and food establishments to provide water upon request only.
- Emptying existing pools is prohibited. New pools must source water from outside the City's water system.

The One Thing -

Overhead irrigation, sprays, rotators, and single stream rotors apply water at rates that exceed soil infiltration rates. They have great variability in rates of application so this must be evaluated by the irrigation manager.

The manager must then maximize controller programming flexibility to apply water to replace evapotranspirative losses with site specific precipitation rates.

Three elements for today's webinar!

Sprinkler performance tests to achieve maximum irrigation efficiency.

Evapotranspiration and WUCOLS – Water required when watering turf for maximum stress.

Programming an irrigation schedule for turf survival.

Three learning Objectives Today!

Learning Objective 1

At the completion of this webinar, the participant will understand how to quickly field evaluate sprinkler performance for scheduling purposes by learning the steps of a precipitation rate audit.

Learning Objective 2

At the completion of this learning objective, the participants will learn how to factor reference evapotranspiration from CIMIS station 157 – Pt. San Pedro with WUCOLS coefficients to develop a turf watering target in inches per week.

Learning Objective 3

Effective landscape irrigation scheduling is based on matching the turf water requirement in inches (or fractions of an inch per week) with the application rate of the sprinklers that is site specific.
At the completion of this objective the participant will understand how to develop a program for an irrigation controller for a one day per week watering schedule with no runoff.

Precipitation rate calculations require a comparison of flow rate of the irrigation system to the area under irrigation so it is important to accurately measure both!

The water, sprinklers discharge in gallons per minute (GPM), is available from the sprinkler manufacturers on their websites and in their catalogs.

15' Series with 27° Trajectory

Pattern	Desc.	psi	GPM	Radius	Prec. Rate* △	Prec. Rate* ∟
180°	15-H	20	1.37	13	1.79	1.55
		30	**1.65**	**15**	**1.66**	**1.44**
		40	2.02	16	1.77	1.53
		50	2.14	16	1.87	1.62
	15-H-PC	30-40	1.50	15	1.49	1.29
		40-75	1.65	15	1.64	1.42

15 Series MPR

30° Trajectory

Nozzle	Pressure psi	Radius ft.	Flow gpm	Prec In/h ■	Prec In/h ▲
15F	15	11	2.60	2.07	
	20	12	3.00	2.01	
	25	14	3.30	1.62	1.87
	30	15	3.70	1.58	1.83
15H	15	11	1.30	2.07	2.39
	20	12	1.50	2.01	2.32
	25	14	1.65	1.62	1.87
	30	15	1.85	1.58	1.83
15Q	15	11	0.65	2.07	2.39
	20	12	0.75	2.01	2.32
	25	14	0.82	1.62	1.87
	30	15	0.92	1.58	1.83

Note: *All MPR nozzles tested on 4" (10.2 cm) pop-*

■ *Square spacing based on 50% diameter of throw*

▲ *Triangular spacing based on 50% diameter of throw*

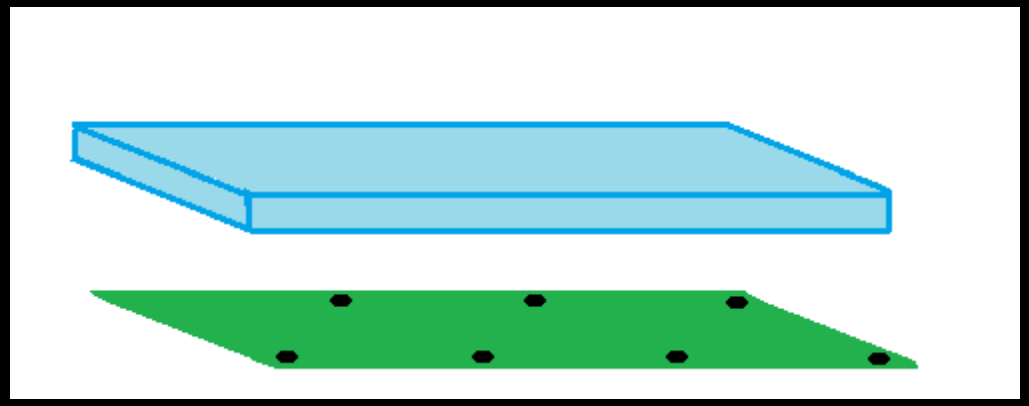
Whenever the sprinkler spacing is changed or the water pressure changes, it will change the rate of application known as the precipitation rate which is expressed in inches per hour!

Sprinkler spacing and precipitation rates of the Toro 570 *(low pressure closer spacing)*

The precipitation rate of the 15H nozzle at 20 psi and 13 ft equilateral triangular spacing is 1.79 inches/hr.

15' Series with 27° Trajectory

Pattern	Desc.	psi	GPM	Radius	Prec. Rate* △	Prec. Rate* ∟
180°	15-H	20	1.37	13	1.79	1.55
		30	**1.65**	**15**	**1.66**	**1.44**
		40	2.02	16	1.77	1.53
		50	2.14	16	1.87	1.62
	15-H-PC	30-40	1.50	15	1.49	1.29
		40-75	1.65	15	1.64	1.42

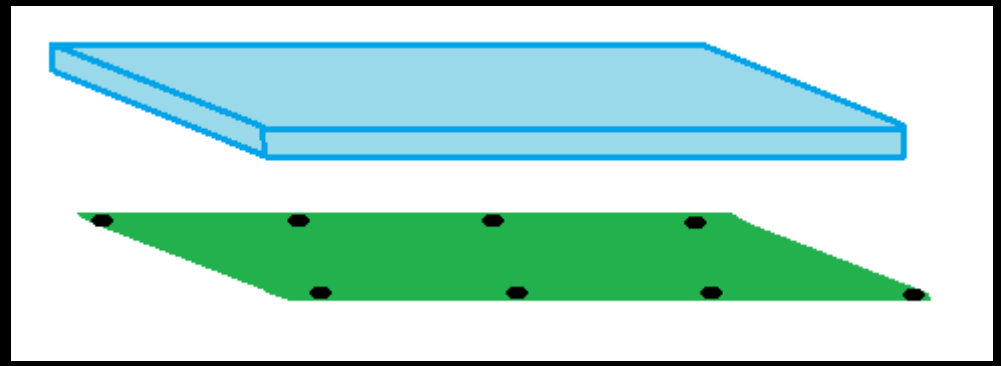


Sprinkler spacing and precipitation rates of the Toro 570 – square spacing *(low pressure closer spacing)*

The precipitation rate of the 15H nozzle at 20 psi and 13 ft square spacing is 1.55 inches/hr.

15' Series with 27° Trajectory

Pattern	Desc.	psi	GPM	Radius	Prec. Rate* △	Prec. Rate* ∟
180°	15-H	20	1.37	13	1.79	1.55
		30	**1.65**	**15**	**1.66**	**1.44**
		40	2.02	16	1.77	1.53
		50	2.14	16	1.87	1.62
	15-H-PC	30-40	1.50	15	1.49	1.29
		40-75	1.65	15	1.64	1.42



The performance charts should always be used as “fallback” to obtain precipitation rates, but they will change with spacing and pressure.

RAIN BIRD

12 Series MPR

30° Trajectory

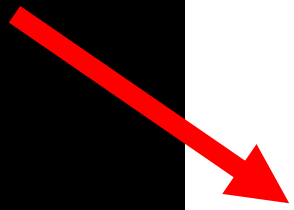
Nozzle	Pressure psi	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
12F 	15	9	1.80	2.14	2.47
	20	10	2.10	2.02	2.34
	25	11	2.40	1.91	2.21
	30	12	2.60	1.74	2.01
12H 	15	9	0.90	2.14	2.47
	20	10	1.05	2.02	2.34
	25	11	1.20	1.91	2.21
	30	12	1.30	1.74	2.01
12Q 	15	9	0.45	2.14	2.47
	20	10	0.53	2.02	2.34
	25	11	0.60	1.91	2.21
	30	12	0.65	1.74	2.01

10 Series MPR

15° Trajectory

Nozzle	Pressure psi	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
10F 	15	7	1.16	2.28	2.63
	20	8	1.30	1.96	2.26
	25	9	1.44	1.71	1.98
	30	10	1.58	1.52	1.75
10H 	15	7	0.58	2.28	2.63
	20	8	0.65	1.96	2.26
	25	9	0.72	1.71	1.98
	30	10	0.79	1.52	1.75
10Q 	15	7	0.29	2.28	2.63
	20	8	0.33	1.96	2.26
	25	9	0.36	1.71	1.98
	30	10	0.39	1.52	1.75

Despite what the manufacturer's say, be careful about mixing 10, 12, and 15 ft nozzles on the same valve!



Spray Nozzles

MPR Nozzles

www

Plastic MPR Nozzles

Matched Precipitation Rate Nozzles

Features

- Matched precipitation rates across sets and patterns in 5 Series, 8 Series, 10 Series, 12 Series, and 15 Series for even water distribution and design flexibility

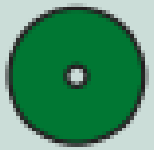
Models

- 5 Series: Quarter, Half, Full Nozzles
- 5 Series: Bubbler Nozzles
- 8 Series: Quarter, Half, Full Nozzles
- 8 FLT Series: Designed for lower traje windy areas
- 10 Series Nozzles

Be careful when using old style van nozzles intermingled with fixed arc MPR's. The precipitation rate is more than double that of the fixed arc nozzles.

8 Series MPR

10° Trajectory

Nozzle	Pressure psi	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
8F 	15	5	0.74	2.85	3.29
	20	6	0.86	2.30	2.66
	25	7	0.96	1.89	2.18
	30	8	1.05	1.58	1.82
8H 	15	5	0.37	2.85	3.29
	20	6	0.42	2.25	2.59
	25	7	0.47	[illegible]	2.13
	30	8	0.52	1.56	1.81
8Q 	15	5	0.18	[illegible]	3.20
	20	6	0.21	2.25	2.59
	25	7	0.24	1.89	2.18
	30	8	0.26	1.56	1.81

8 Series VAN

5° Trajectory

Nozzle	Pressure psi	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
330° Arc 	15	6	1.21	3.53	4.07
	20	7	1.36	2.91	3.36
	25	7	1.55	3.32	3.83
	30	8	1.70	2.79	3.22
270° Arc 	15	6	1.11	3.95	4.55
	20	7	1.24	3.24	3.74
	25	7	1.41	3.69	4.25
	30	8	1.55	3.10	3.58
180° Arc 	15	6	0.84	4.49	5.18
	20	7	0.97	3.81	4.40
	25	7	1.09	[illegible]	4.94
	30	8	1.19	3.58	4.13
90° Arc 	15	6	0.51	[illegible]	6.29
	20	7	0.59	4.64	5.35
	25	7	0.66	5.19	5.98
	30	8	0.72	4.33	5.00

Rotating stream nozzles have very different precipitation rates based on the manufacturer
The Rain Bird R-VAN is 50% higher than the Hunter MP-2000!

Hunter®

MP2000
Radius: 13' to 21'
Adjustable Arc and Full-Circle
- Black: 90° to 210°
- Green: 210° to 270°
- Red: 360°

Arc	Pressure PSI	Radius ft.	Flow GPM	Flow GPH	Precip in/hr ■	Precip in/hr ▲
90°	25	17	0.34	20.4	0.45	0.52
	30	18	0.38	22.8	0.45	0.52
	35	19	0.40	24.0	0.43	0.49
	40	**20**	**0.43**	**25.8**	**0.41**	**0.48**
	45	21	0.46	27.6	0.40	0.46
	50	21	0.47	28.2	0.41	0.47
	55	21	0.48	28.8	0.42	0.48
180°	25	16	0.6	36.0	0.45	0.52
	30	17	0.64	38.4	0.43	0.49
	35	18	0.71	42.6		0.49
	40	**19**	**0.77**	**46.2**	**0.41**	**0.47**
	45	20	0.85	51.0	0.41	0.47
	50	21	0.91	54.6	0.40	0.46
	55	21	0.95	57.0	0.41	0.48
210°	25	16	0.72	43.2	0.46	0.54
	30	17	0.75	45.0	0.43	0.49
	35	18	0.81	48.6	0.41	0.48
	40	**19**	**0.86**	**51.6**	**0.39**	**0.45**

R-VAN24 17' - 24' (5.2 to 7.3m)

Arc	Pressure psi	Radius ft.	Flow gpm	Precip. (in/h) ■	Precip. (in/h) ▲
270°	30	19	1.80	0.64	0.74
	35	20	1.95	0.63	0.72
	40	22	2.31	0.61	0.71
	45	**23**	**2.52**	**0.61**	**0.71**
	50	24	2.82	0.63	0.73
	55	24	2.88	0.64	0.74
210°	30	19	1.40	0.64	0.74
	35	20	1.52	0.63	0.72
	40	22	1.80	0.61	0.71
	45	**23**	**1.96**	**0.61**	**0.71**
	50	24	2.19	0.63	0.73
	55	24	2.24	0.64	0.74
180°	30	19	1.20	0.64	0.74
	35	20	1.30	0.63	0.72
	40	22	1.54	0.61	0.71
	45	**23**	**1.68**	**0.61**	**0.71**
	50	24	1.88		0.73
	55	24	1.92	0.64	0.74
90°	30	19	0.60	0.64	0.74
	35	20	0.65	0.63	0.72
	40	22	0.77	0.61	0.71
	45	**23**	**0.84**	**0.61**	**0.71**
	50	24	0.94	0.63	0.73
	55	24	0.96	0.64	0.74

RAIN BIRD

So how about gear driven single and dual stream rotor sprinklers?

Be careful with these charts!!! When rotors are set for FC arc, It cuts the Precipitation rate in half.

BLUE/GREY NOZZLES P/N 782900

PGP® ULTRA / I-20 BLUE STANDARD NOZZLE PERFORMANCE DATA

Nozzle	Pressure PSI	Radius ft.	Flow GPM	Precip in/hr ■	Precip in/hr ▲
1.5 Blue	25	29	1.2	0.27	0.32
	35	31	1.4	0.28	0.32
	45	**31**	**1.5**	**0.30**	**0.35**
	55	32	1.8	0.34	0.39
	65	32	1.9	0.36	0.41
2.0 Blue	25	33	1.4	0.25	0.29
	35	33	1.7	0.30	0.35
	45	**34**	**2.0**	**0.33**	**0.38**
	55	34	2.1	0.35	0.40
	65	32	2.3	0.43	0.50
2.5 Blue	25	33	1.7	0.30	0.35
	35	35	2.1	0.33	0.38
	45	**35**	**2.5**	**0.39**	**0.45**
	55	35	2.6	0.41	0.47
	65	35	2.9	0.46	0.53
3.0 Blue	25	35	2.2	0.35	0.40
	35	36	2.7	0.40	0.46
	45	**38**	**3.0**	**0.40**	**0.46**
	55	39	3.4	0.43	0.50
	65	39	3.7	0.47	0.54

PGP® ULTRA / I-20 BLUE STANDARD NOZZLE PERFORMANCE DATA

Nozzle	Pressure PSI	Radius ft.	Flow GPM	Precip in/hr ■	Precip in/hr ▲
4.0 Blue	25	37	3.0	0.42	0.49
	35	39	3.5	0.44	0.51
	45	**40**	**4.0**	**0.48**	**0.56**
	55	41	4.5	0.52	0.60
	65	41	4.8	0.55	0.63
5.0 Blue	25	37	3.7	0.52	0.60
	35	39	4.5	0.57	0.66
	45	**42**	**5.0**	**0.55**	**0.63**
	55	42	5.7	0.62	0.72
	65	42	6.2	0.68	0.78

8.0 ● Blue		
	45	44
	55	46
	65	46

Notes:

Bold = Recommended pressure.

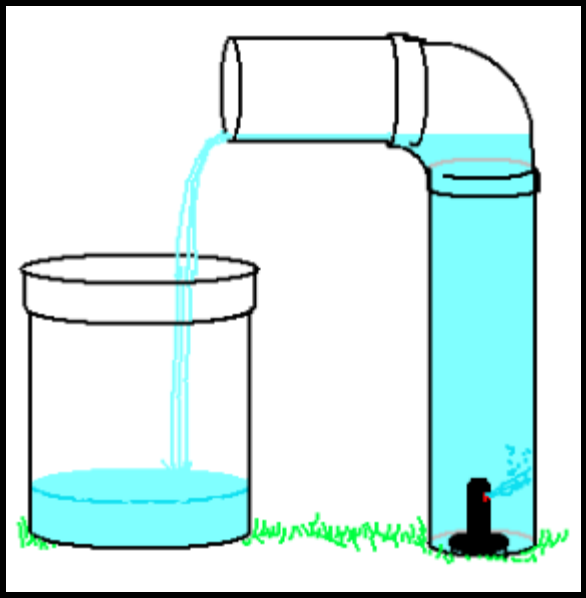
All precipitation rates calculated for 180 degree operation. For the precipitation rate for a 360 degree sprinkler, divide

5000 Series Std. Angle Rain Curtain™ Nozzle Performance

Pressure psi	Nozzle	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
25	1.5	33	1.12	0.20	0.23
	2.0	35	1.50	0.24	0.27
	2.5	35	1.81	0.28	0.33
	3.0	36	2.26	0.34	0.39
	4.0	36	2.91	0.43	0.49
	5.0	37	3.72	0.52	0.60
	6.0	37	4.25	0.60	0.69
	8.0	33	5.90	1.26	1.50
35	1.5	34	1.35	0.22	0.26
	2.0	36	1.81	0.27	0.31
	2.5	37	2.17	0.31	0.35
	3.0	38	2.71	0.36	0.42
	4.0	40	3.50	0.42	0.49
	5.0	41	4.47	0.51	0.59
	6.0	43	5.23	0.54	0.63
	8.0	41	7.06	0.94	1.10
45	1.5	35	1.54	0.24	0.28
	2.0	37	2.07	0.29	0.34
	2.5	37	2.51	0.35	0.41
	3.0	39	3.09	0.37	0.43
	4.0	42	4.01	0.44	0.51
	5.0	43	5.09	0.48	0.56
	6.0	44	6.01	0.59	0.69
	8.0	44	8.03	0.92	1.06
55	1.5	35	1.71	0.27	0.31
	2.0	37	2.30	0.32	0.37
	2.5	37	2.76	0.39	0.45
	3.0	40	3.47	0.42	0.48
	4.0	42	4.44	0.48	0.56
	5.0	45	5.66	0.54	0.62
	6.0	50	6.63	0.51	0.59

An alternative method for measuring precipitation rates in the field! Once again you will need area and flow.

Here is a novel way to measure rotor flow!



Irrigation & Landscape Supply

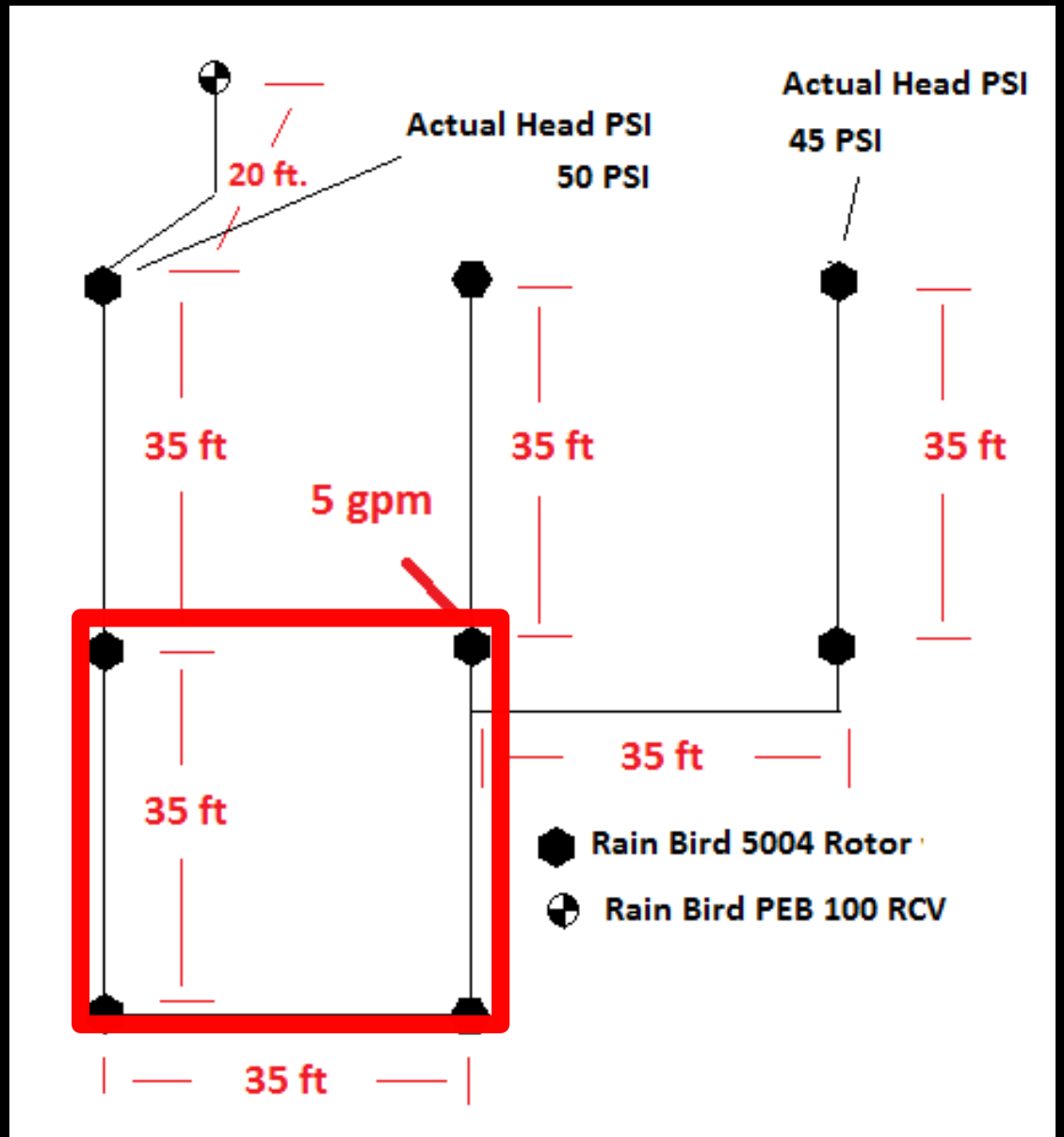
Mark your bucket because it is not 5 gallons

Gallons	Distance from bottom
6.2	Full
6	13 5/8"
5.5	12 5/8"
5	11 5/8"
4.5	10 7/8"
4	9 7/8"
3.5	8 1/2"
3	7 3/8"
2.5	6 3/8"
2	5 1/2"
1.5	4"
1	2 5/8"

"5 Gallon" Bucket

EWING Irrigation & Landscape Supply

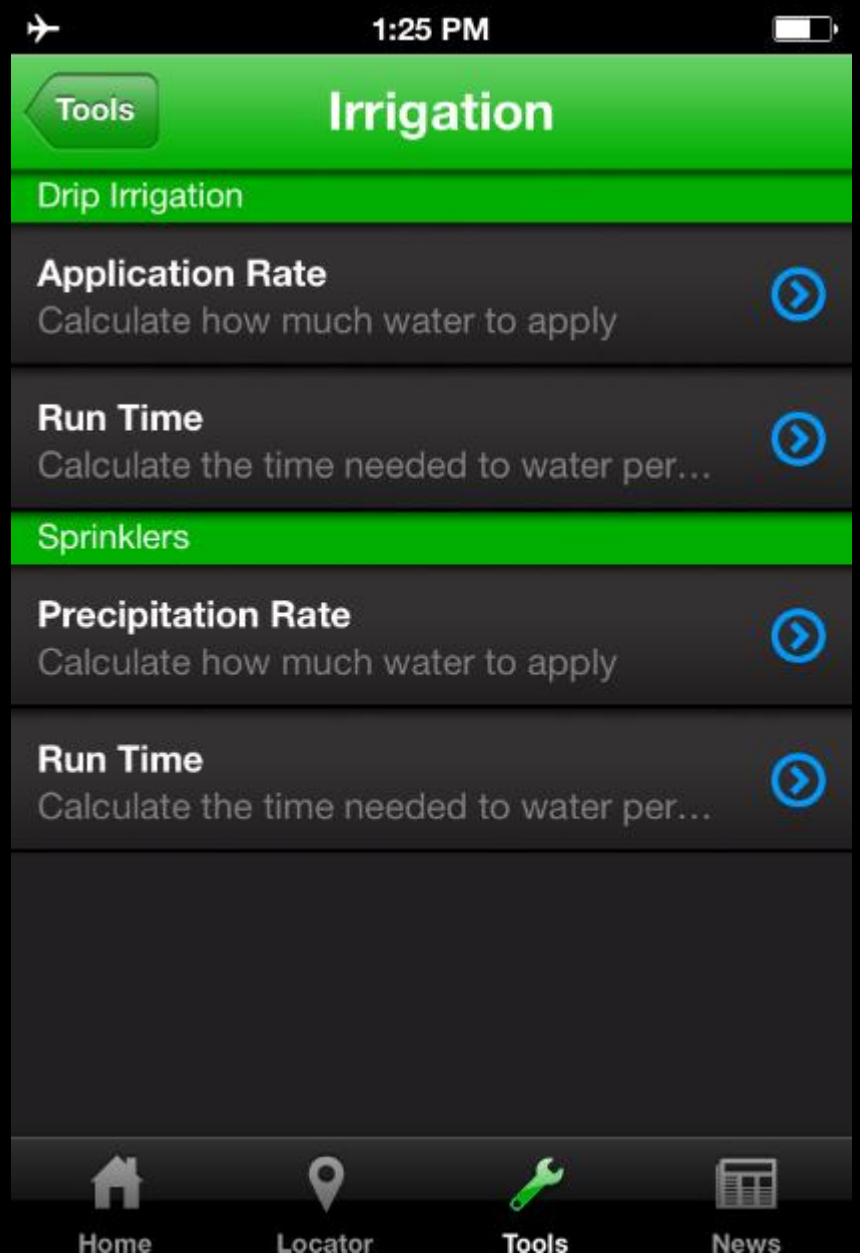
Next measure the typical sprinkler to sprinkler spacing and row spacing to determine the Area In square feet.

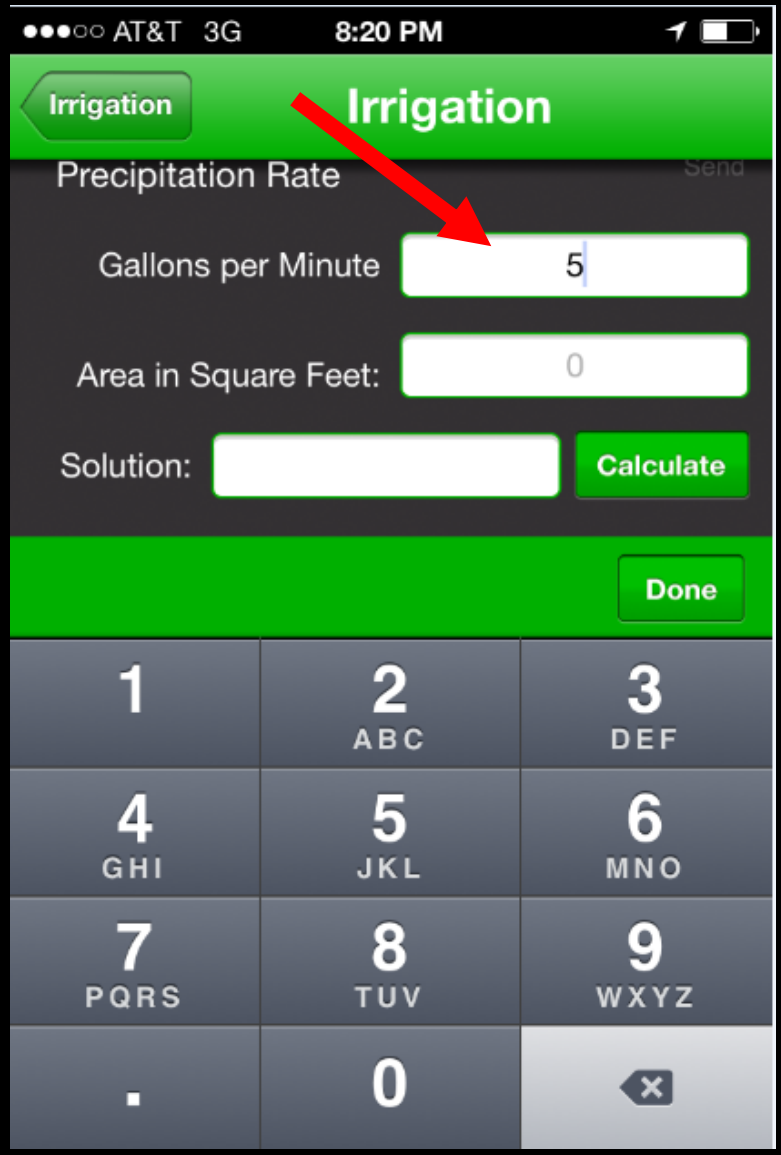


35 ft x 35 ft = 1,225 feet

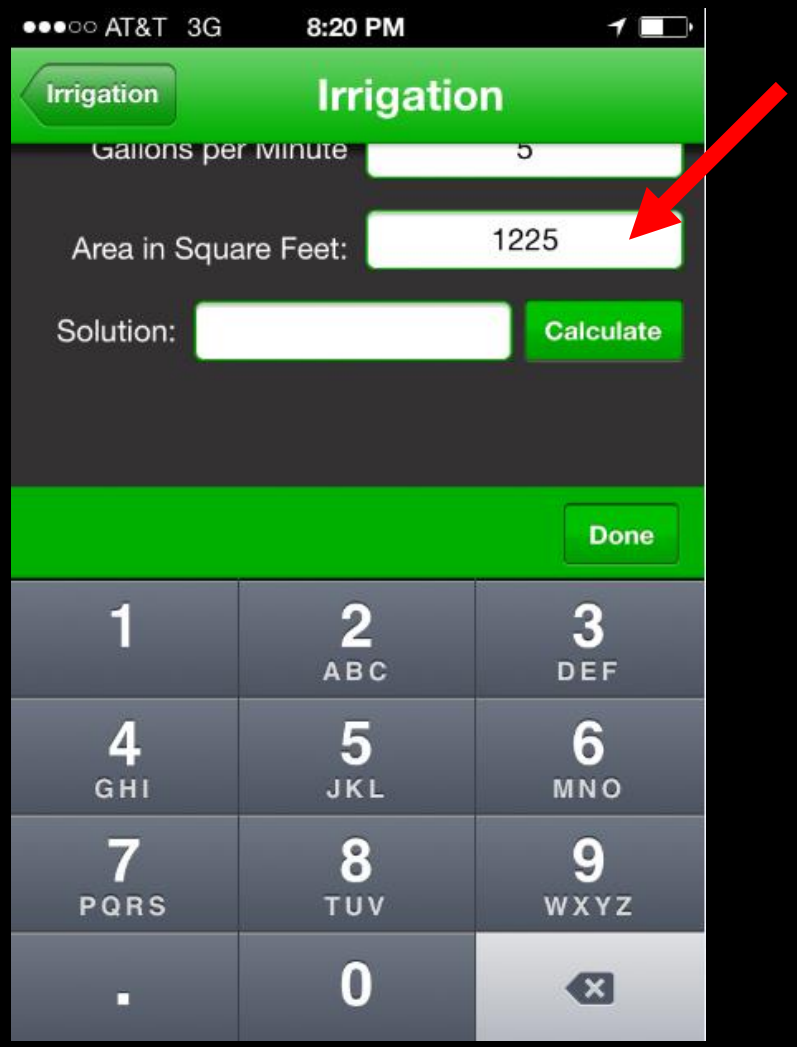
Go to the App store on your phone and load the free Ewing APP.

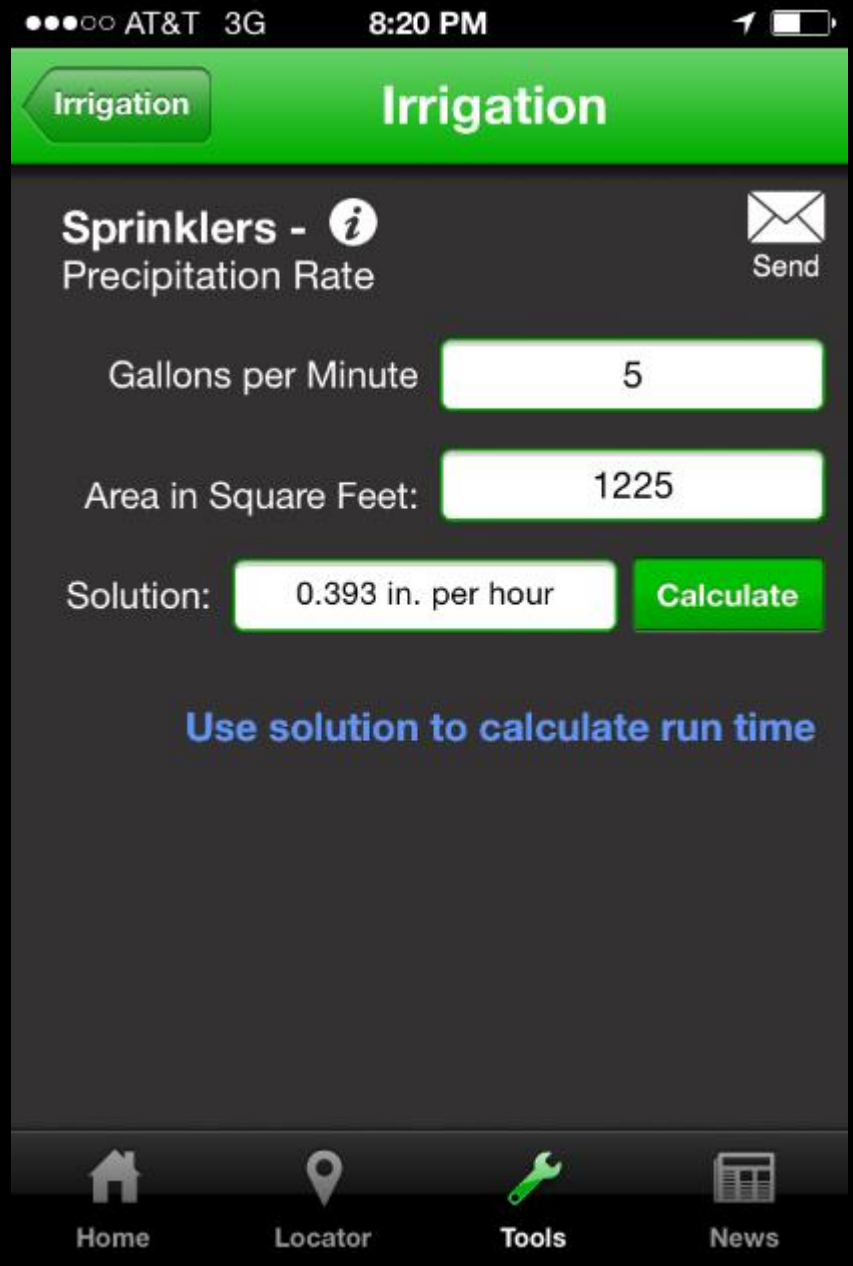
Under “Tools”, select Precipitation Rate and enter the flow of the Full Circle Rotor.





Enter the area in square feet and press calculate for a PR of 0.393” / hr.





So thus far we have explained two methods to determine precipitation rates.

Access the manufacturers performance chart for the sprinkler and nozzle being used to determine the PR rate – (not best)

Measure the FC sprinkler flow with a flow tube to determine GPM. Measure typical row x sprinkler spacing and calculate with free Ewing APP.

Two more methods, we’ll discuss….

Irrigation Audit – Most accurate, but labor intensive. A lot of math involved…..

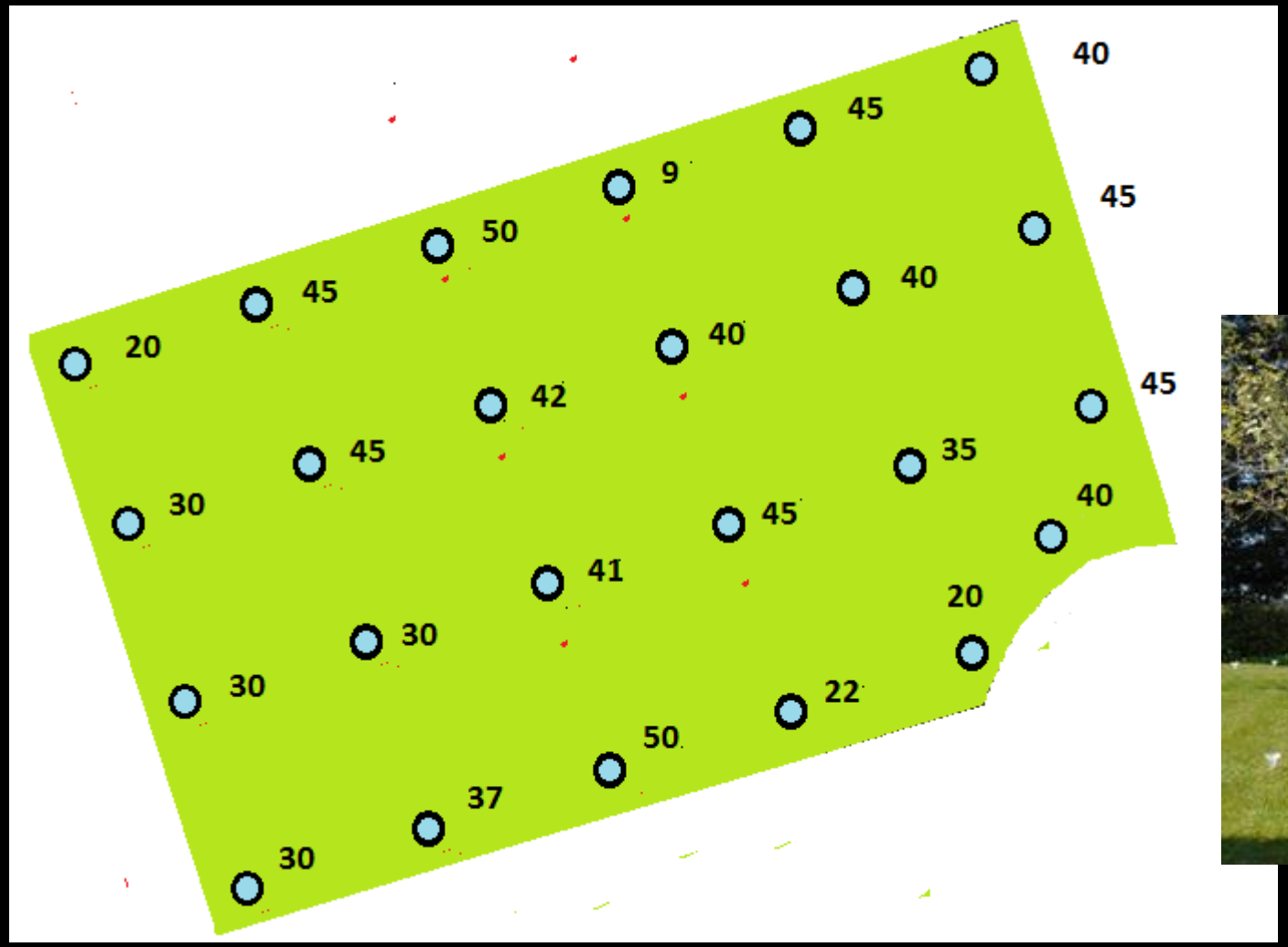
Irrigation Association

QWEL

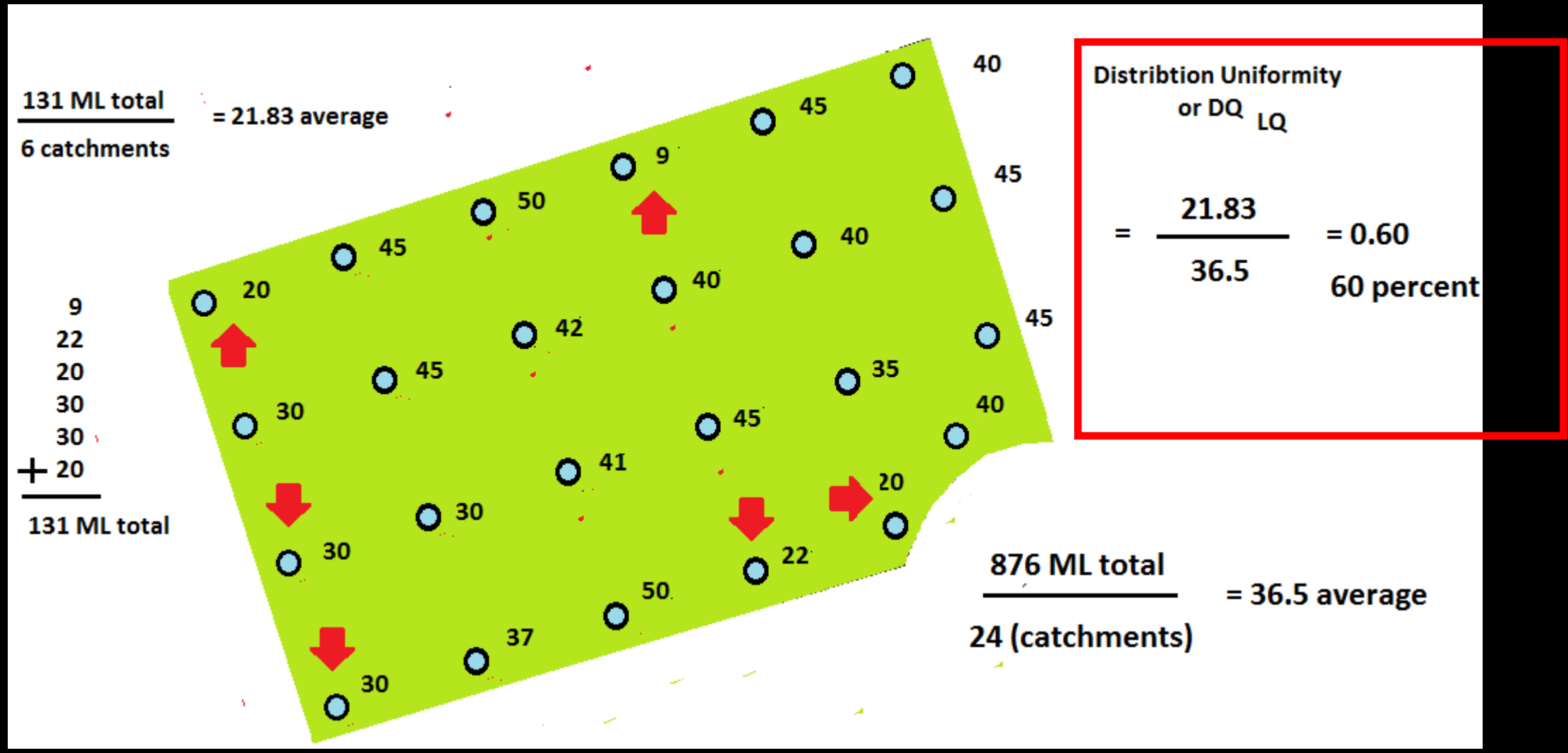
A traditional audit reveals net precipitation rate and uniformity of coverage known as DU (distribution uniformity.)

The test is labor and “math intensive” and involves the use of an expensive auditing kit ($500 – $1,000)

The test time for this zone was 15 minutes. We run the sprinklers with wind less than 5 mph and record values on an “as-built” drawing.



The DU_{LQ} or distribution uniformity is calculated by dividing the average of the catches in the driest ¼- (25%) or 6 cups by the average of all cups.



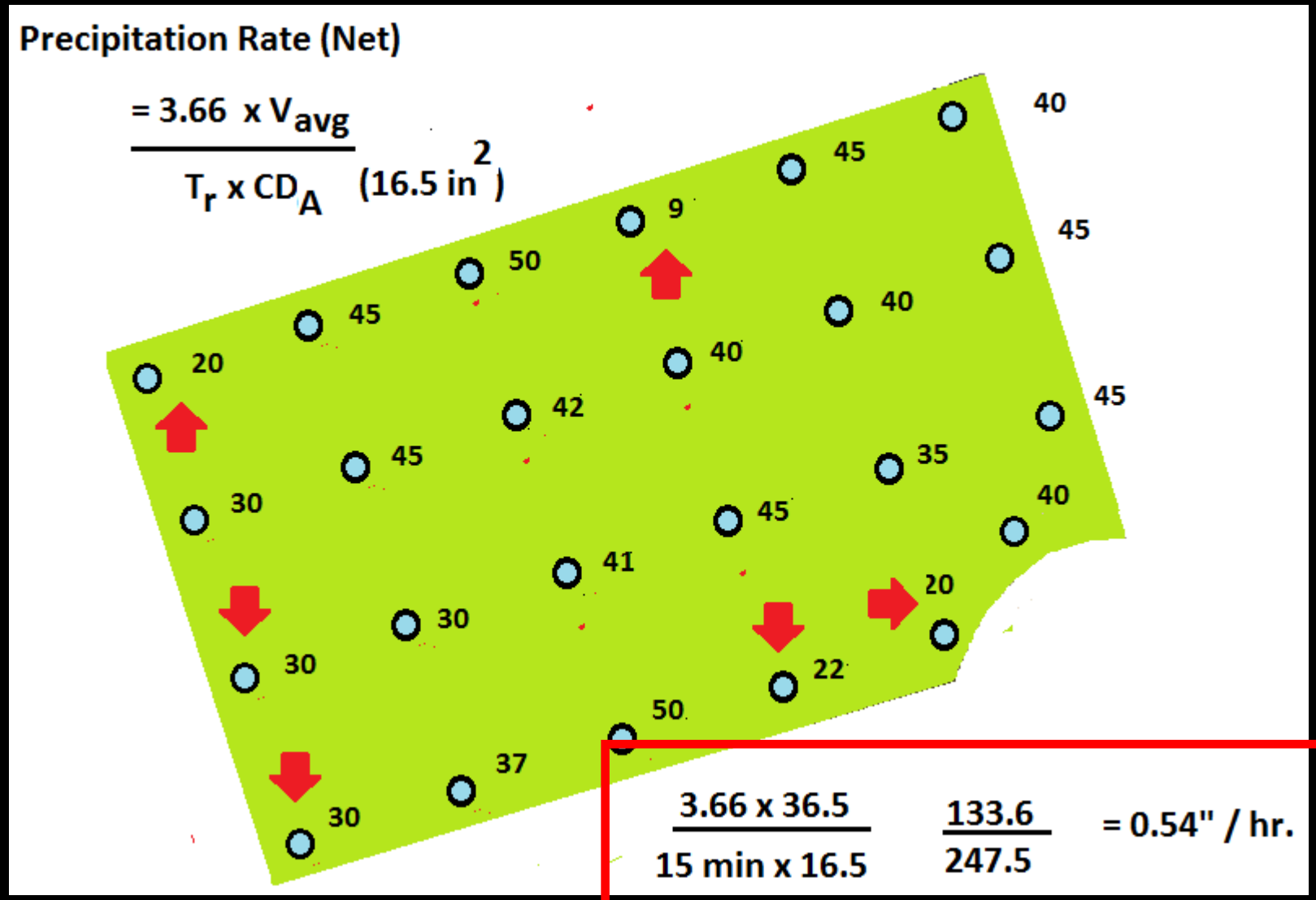
Once you have established distribution uniformity, this table will reveal the scheduling multiplier indicating the increase in irrigation time necessary to compensate for dry areas.

Table 4-2
Conversion table from DU_{lq} to scheduling multiplier

DU_{lq}	SM	DU_{lq}	SM	DU_{lq}	SM
1.00	1.00	0.78	1.15	0.58	1.34
0.98	1.01	0.76	1.17	0.56	1.36
0.96	1.02	0.74	1.18	0.54	1.38
0.94	1.04	0.72	1.20	0.52	1.40
0.92	1.05	0.70	1.22	0.50	1.43
0.90	1.06	0.68	1.24	0.48	1.45
0.88	1.08	0.66	1.26	0.46	1.48
0.86	1.09	0.64	1.28	0.44	1.51
0.84	1.11	0.62	1.30	0.42	1.53
0.82	1.12	0.60	1.32	0.40	1.56
0.80	1.14	Fix the sprinkler problems if below 0.40			

System has a 60% DU with a 1.32 SM. A 10 minute run time would be increased to 13 minutes!

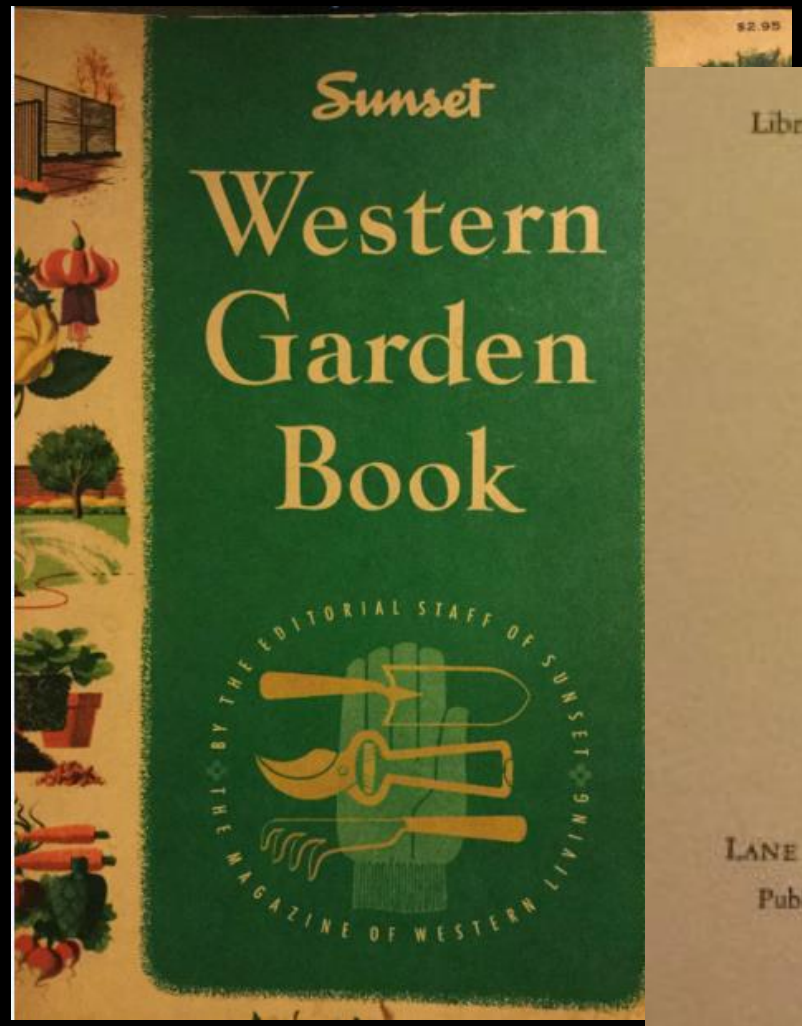
The PR_{NET} or Precipitation Rate Net is calculated by formula and is critical to selecting the right replacement sprinkler. *(very accurate)*



While highly beneficial to the irrigation manager, this testing procedure can take up to 1 hour per zone.

A simplified approach you can utilize to measure sprinkler precipitation rates!

We have developed a hybrid of the audit that incorporates concepts introduced nearly 70 years ago by *Sunset* magazine In their first *Western Garden Guide.*



Library of Congress Catalog Card Number 5-

First Edition

LANE PUBLISHING CO., MENLO PARK, CAL
Publishers of *Sunset*, The Magazine of Western Living
PRINTED IN U. S. A.

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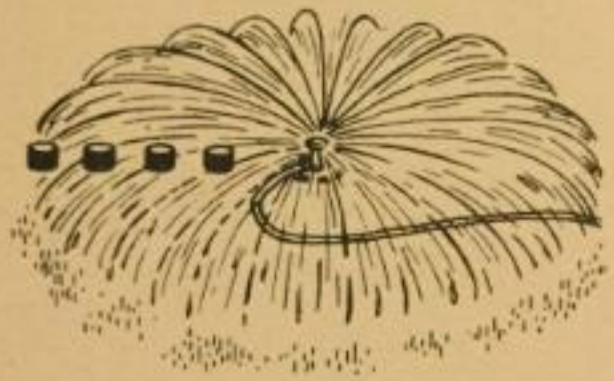


Next question in the formula is how much "rain" your sprinkler produces. This is determined simply with a novel procedure. Place a number of coffee cans spaced at regular intervals in a line running out from the sprinkler. Turn on the spray and note the time it takes to fill the cans to 1 inch. (This experiment may also provide you with revealing information about the efficiency of your sprinkler. Usually, the cans nearest the sprinkler will fill first.)

Our approach uses the same techniques but calculates depth based on total volume in ounces avoiding multiple depth measurements!

Place 3” drain caps with a 3 ¼” diameter in the irrigated area. Utilize a minimum of 24 caps. Run 3 – 5 minutes for sprays and 10 to 15 for rotaries and rotors!

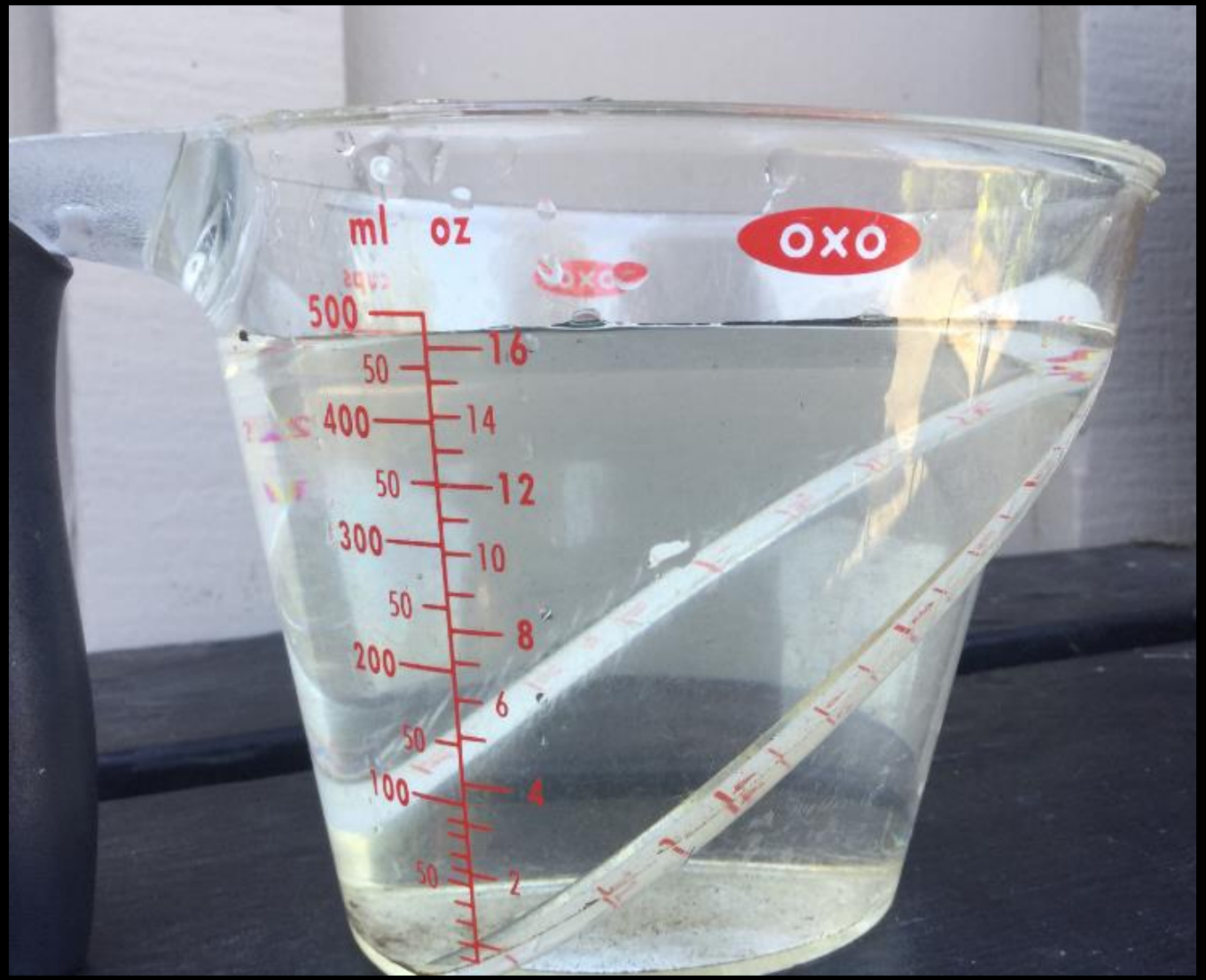
Place caps in a square geometric grid on at 5 to 10 ft spacing

Place caps no closer than 1 to 2 feet from hard edge

Run time – 3 to 5 minutes for sprays, 10 to 15 minutes for rotors and rotary nozzles

Pour contents of caps into a pitcher that measures in ounces

Pour the contents of each cap into a pitcher that measures in ounces.
In our test, the run time was 15 minutes and we collected 16 ounces.



Determine Precipitation Rate from the table provided…

(Precipitation Rate Test with 3" Drain Caps)
(24 cap test)
(Minutes of Run Time)

ML (Total)	Ounces (Total)	3	4	5	6	7	8	9	10	11	12	13	14	15
29.57	1	0.18	0.14	0.11	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.04	0.04	0.04
59.14	2	0.36	0.27	0.22	0.18	0.16	0.14	0.12	0.11	0.10	0.09	0.08	0.08	0.07
88.71	3	0.54	0.41	0.33	0.27	0.23	0.20	0.18	0.16	0.15	0.14	0.13	0.12	0.11
118.28	4	0.73	0.54	0.44	0.36	0.31	0.27	0.24	0.22	0.20	0.18	0.17	0.16	0.15
147.85	5	0.91	0.68	0.54	0.45	0.39	0.34	0.30	0.27	0.25	0.23	0.21	0.19	0.18
177.42	6	1.09	0.82	0.65	0.54	0.47	0.41	0.36	0.33	0.30	0.27	0.25	0.23	0.22
206.99	7	1.27	0.95	0.76	0.63	0.54	0.48	0.42	0.38	0.35	0.32	0.29	0.27	0.25
236.56	8	1.45	1.09	0.87	0.73	0.62	0.54	0.48	0.44	0.40	0.36	0.33	0.31	0.29
266.13	9	1.63	1.22	0.98	0.82	0.70	0.61	0.54	0.49	0.45	0.41	0.38	0.35	0.33
295.7	10	1.81	1.36	1.09	0.91	0.78	0.68	0.60	0.54	0.49	0.45	0.42	0.39	0.36
325.27	11	1.99	1.50	1.20	1.00	0.85	0.75	0.66	0.60	0.54	0.50	0.46	0.43	0.40
354.84	12	2.18	1.63	1.31	1.09	0.93	0.82	0.73	0.65	0.59	0.54	0.50	0.47	0.44
384.41	13	2.36	1.77	1.41	1.18	1.01	0.88	0.79	0.71	0.64	0.59	0.54	0.51	0.47
413.98	14	2.54	1.90	1.52	1.27	1.09	0.95	0.85	0.76	0.69	0.63	0.59	0.54	0.51
443.55	15	2.72	2.04	1.63	1.36	1.17	1.02	0.91	0.82	0.74	0.68	0.63	0.58	0.54
473.12	16	2.90	2.18	1.74	1.45	1.24	1.09	0.97	0.87	0.79	0.73	0.67	0.62	0.58
502.69	17	3.08	2.31	1.85	1.54	1.32	1.16	1.03	0.92	0.84	0.77	0.71	0.66	0.62
532.26	18	3.26	2.45	1.96	1.63	1.40	1.22	1.09	0.98	0.89	0.82	0.75	0.70	0.65
561.83	19	3.45	2.58	2.07	1.72	1.48	1.29	1.15	1.03	0.94	0.86	0.80	0.74	0.69
591.4	20	3.63	2.72	2.18	1.81	1.55	1.36	1.21	1.09	0.99	0.91	0.84	0.78	0.73
620.97	21	3.81	2.86	2.28	1.90	1.63	1.43	1.27	1.14	1.04	0.95	0.88	0.82	0.76
650.54	22	3.99	2.99	2.39	1.99	1.71	1.50	1.33	1.20	1.09	1.00	0.92	0.85	0.80
680.11	23	4.17	3.13	2.50	2.09	1.79	1.56	1.39	1.25	1.14	1.04	0.96	0.89	0.83
709.68	24	4.35	3.26	2.61	2.18	1.87	1.63	1.45	1.31	1.19	1.09	1.00	0.93	0.87

Suggested test times - Spray Type 3 - 5 minutes - Rotors (including Rotary 10 - 15

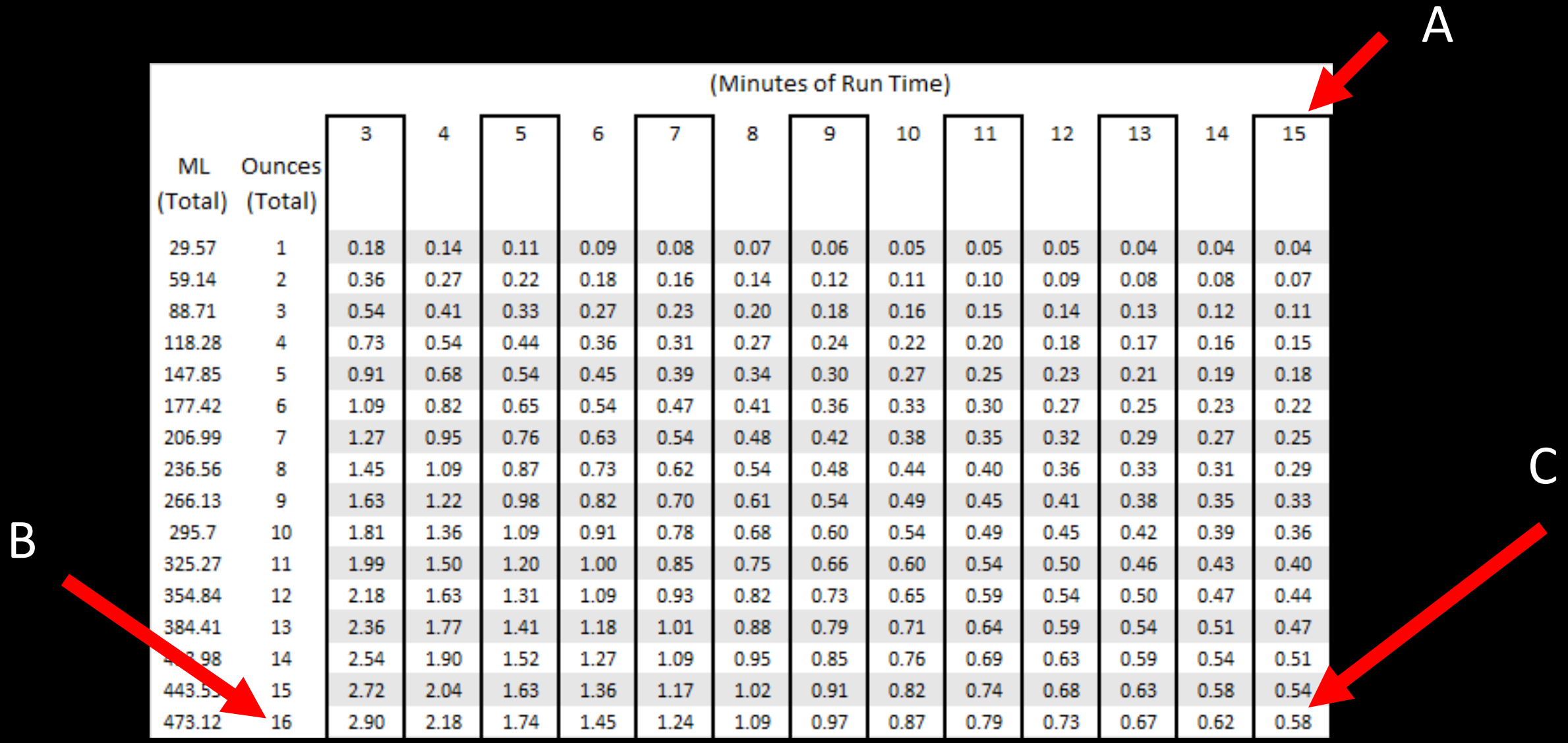
Adjust run times on Part circle rotor zones so they apply 1/2 the water in gallons as the FC zones.

Use the time set for the FC rotors as the test time

Suggested spacing 5 - 7 feet square grid - locate caps 1-2 feet from edges

EWING Irrigation & Landscape Supply

Locate test run time (A) and then locate total ounces (B). The point Of intersection at (C) is the PR rate which is 0.58 inches per hour



		(Minutes of Run Time)												
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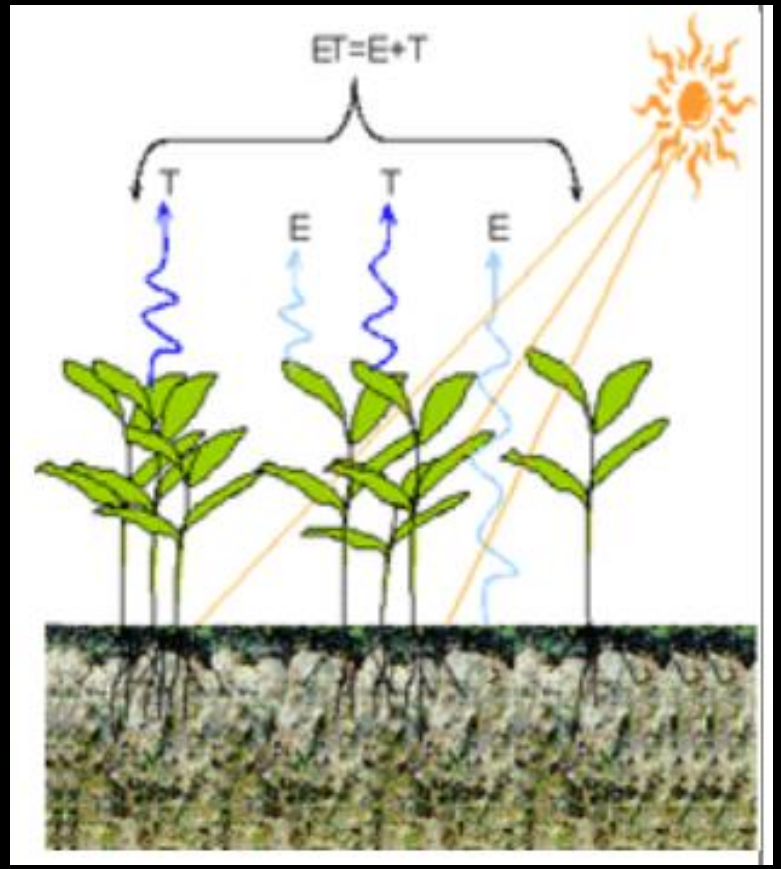
384.41	13	2.36	1.77	1.41	1.18	1.01	0.88	0.79	0.71	0.64	0.59	0.54	0.51	0.47
[illegible]	14	2.54	1.90	1.52	1.27	1.09	0.95	0.85	0.76	0.69	0.63	0.59	0.54	0.51
443.5[illegible]	15	2.72	2.04	1.63	1.36	1.17	1.02	0.91	0.82	0.74	0.68	0.63	0.58	0.54
473.12	16	2.90	2.18	1.74	1.45	1.24	1.09	0.97	0.87	0.79	0.73	0.67	0.62	0.58

Learning Objective 2

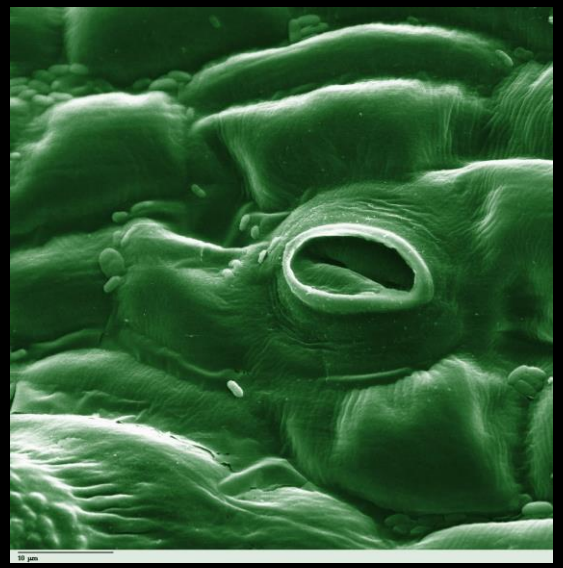
At the completion of this learning objective, the participants will learn how to factor reference evapotranspiration from CIMIS station 157 – Pt. San Pedro with WUCOLS coefficients to develop a turf watering target in inches per week.

How plants use water

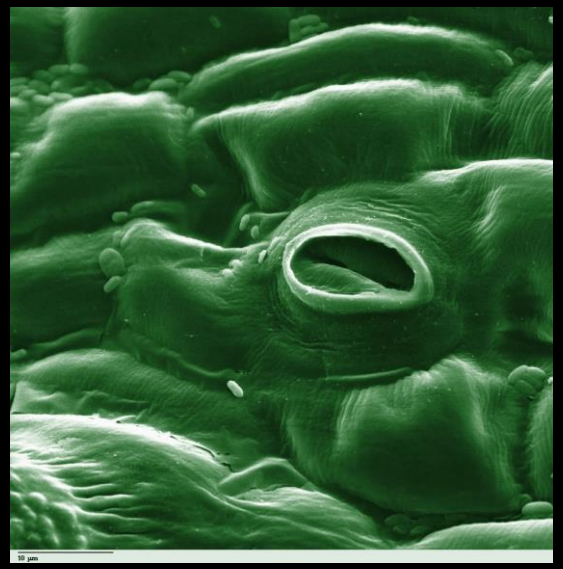
Evaporatranspiration (ET) is a measure of plant water use

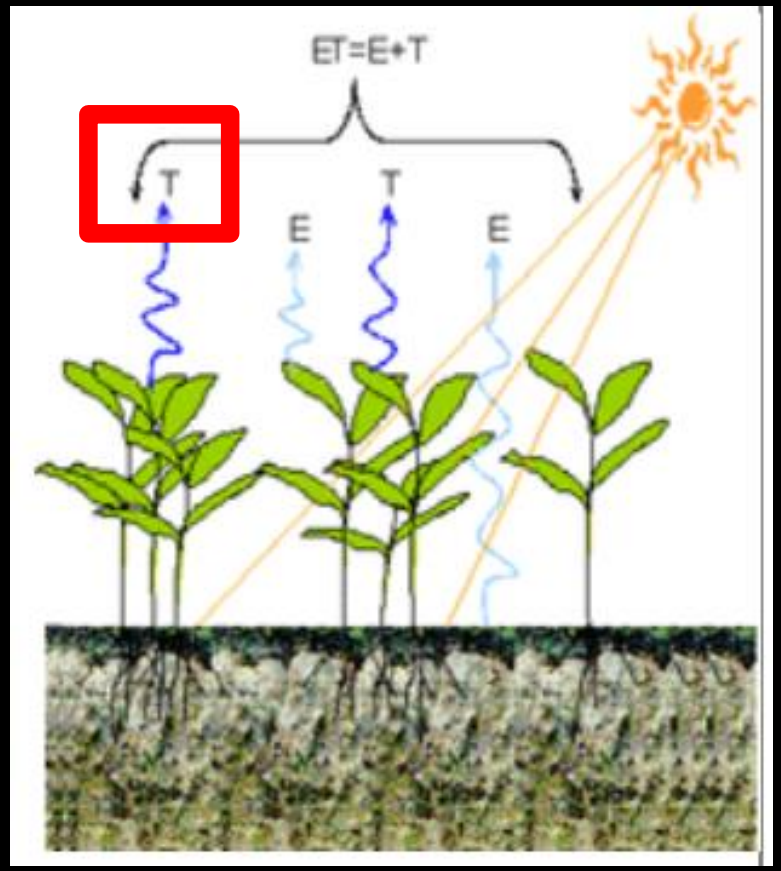


Plants take in water through their roots, Plants take in CO2 through tiny openings in their leaves known as stomata and release oxygen. As this occurs water is released through the stomata.

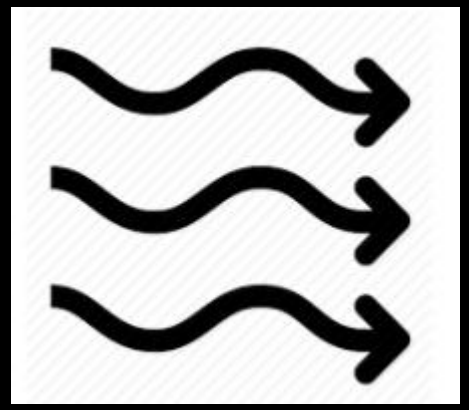


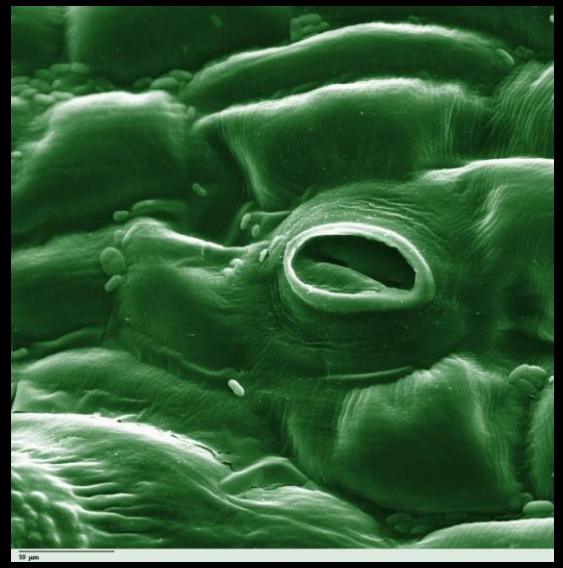
As temperatures rises with higher levels of solar radiation, the water on the leaf surface is turned to vapor in a process known as **transpiration.**

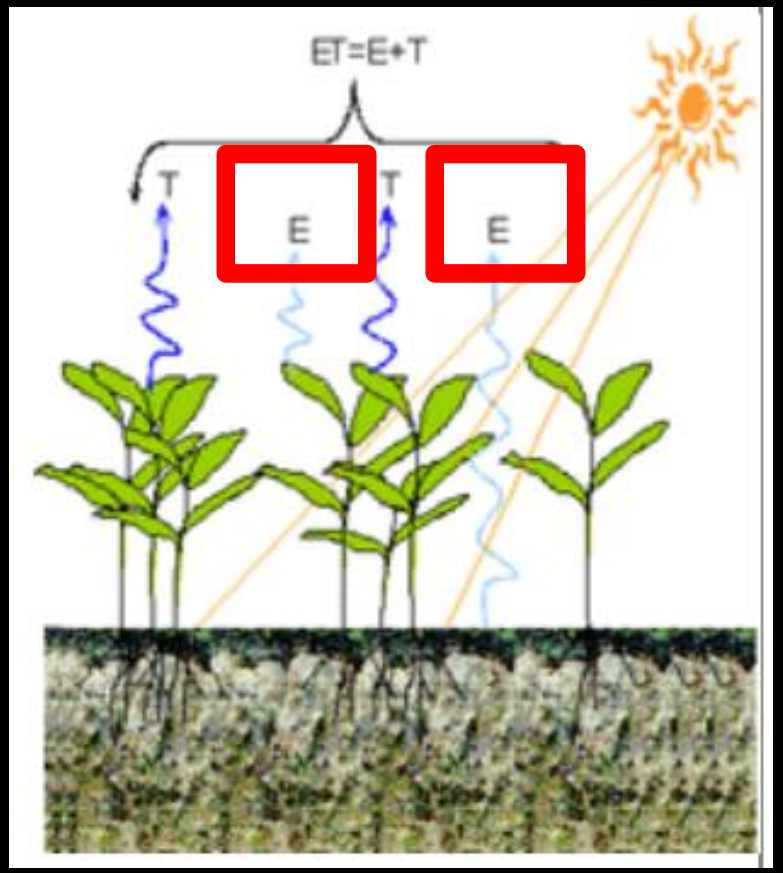




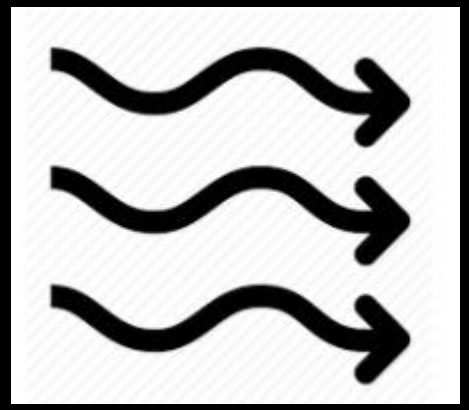
As wind passes over the leaf surface, it removes the vapor from the leaf surface and surrounding soil in a process known as <u>evaporation.</u>

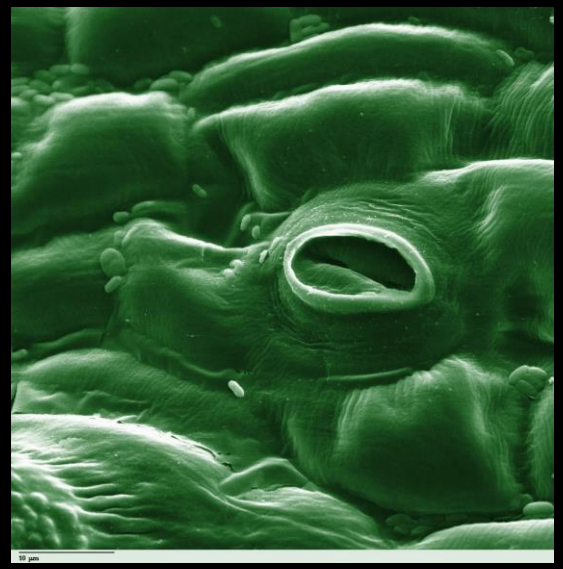


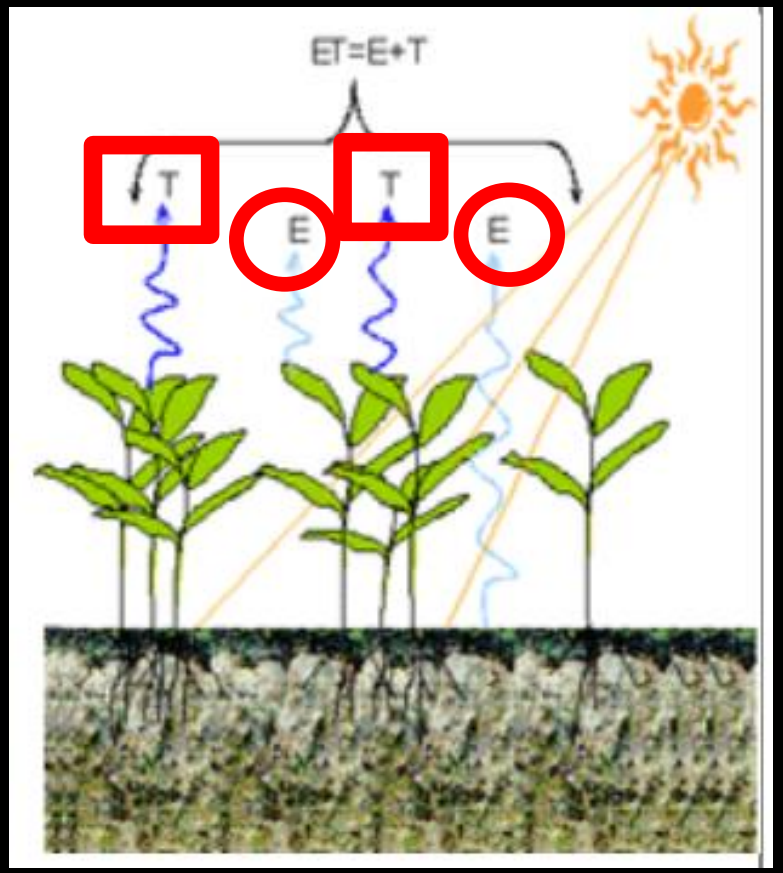




Evapotranspiration is the sum of water used by the plant due to evaporation and transpiration measured in inches of water.



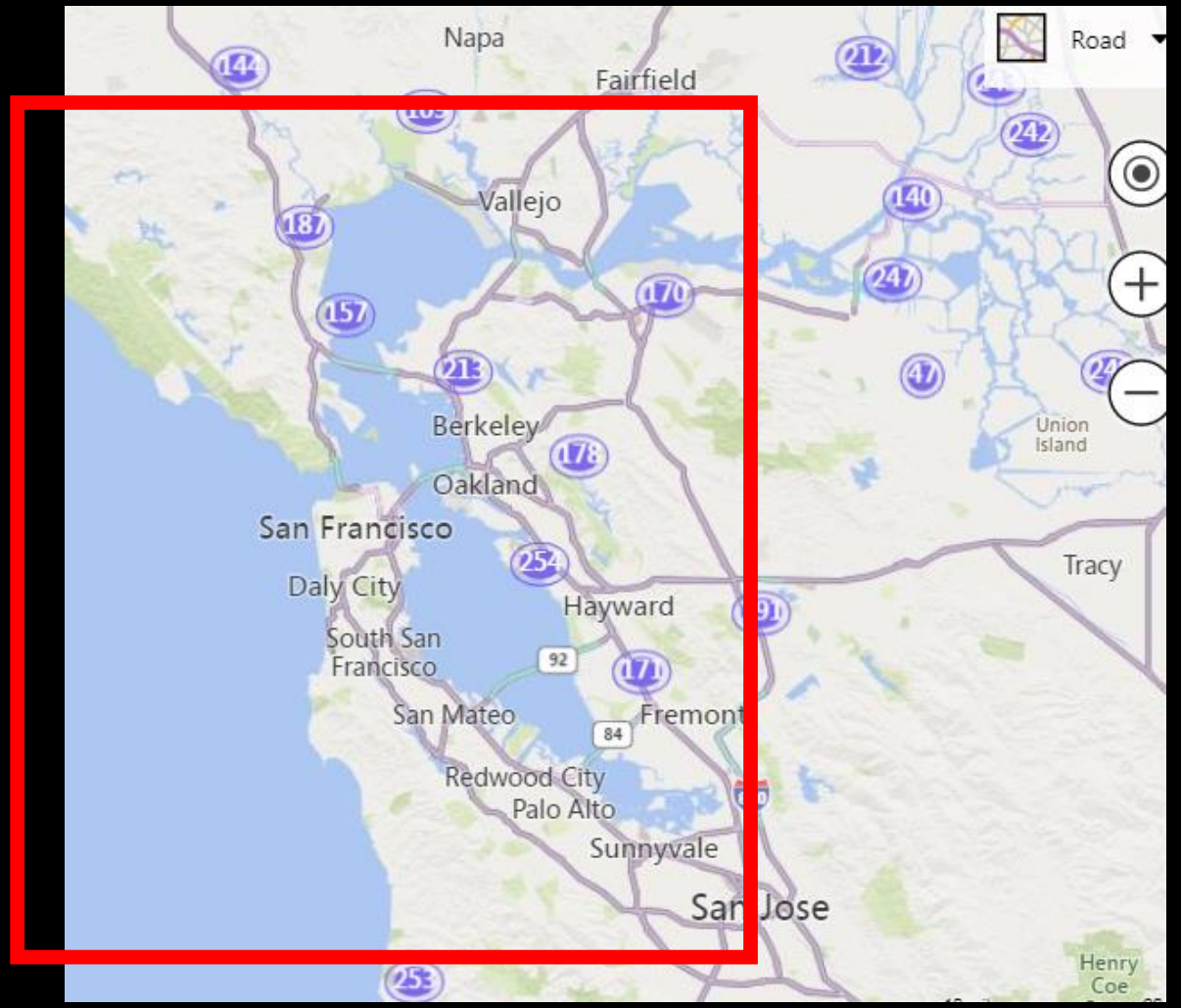




In the 1980's California developed a network of computerized weather stations known as CIMIS (California Irrigation Management Information System) that records levels of ET at nearly 200 locations in California.

Most Smart Irrigation Controllers measure ET_O or reference ET and make automatic adjustments to irrigation run times. Data from these stations may be used to validate the performance of smart controllers.

Parts of the Bay Area are somewhat underserved by stations.



In these cases, Reference ET may be derived from Spatial CIMIS by zip code! ET is expressed in inches of water / month for years 2015 thru 2019.

CIMIS STATION			Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
SPATIAL	Atherton	94027	2.77	3.89	4.26	5.46	5.37	5.21	4.3	3.34
170	Concord	94529	3.34	4.69	6.3	7.23	7.5	6.66	5	3.34
131	Fair Oaks		3.24	4.52	6.35	7.44	7.91	7.03	5.14	3.36
171	Fremont	94536	3.31	4.44	5.39	6.04	6.23	5.39	4.38	3.08
254	Oakland	94577	3.31	4.44	5.39	6.04	6.23	5.39	4.38	3.08
191	Pleasanton	94588	3.63	4.94	6.16	7.1	7.53	6.61	4.98	3.5
SPATIAL	San Mateo	94401	2.74	3.87	4.14	5.44	5.35	5.21	4.28	3.28
SPATIAL	San Jose	95118	2.84	4.16	4.57	5.92	5.79	5.56	4.58	3.59

The amount of water that plants need relative to ET_O is expressed by their unique coefficient available from the WUCOLS IV website (water use classification of landscape species)

WUCOLS IV is a system of categorizing plant water use relative to ET_O in six growing regions of California. Planners, Architects, Contractors and landscape maintenance personnel use this information to plan and manage landscapes.

The amount of water that plants need relative to ET_O is defined by their water use category or K_L known as a species factor

lassification of Landscape Species

Categories of Water Needs

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

Species were evaluated as needing high (H), moderate/medium (M), low (L), and very low (VL) amounts of irrigation water. Expressed as a percentage of reference evapotranspiration (ET_o)[1], these categories were quantitatively defined as follows.

Fig. 2. Five-finger fern was assigned to the "high" water needs category in four regions.

Fig. 3. Cone flower was

Water needs categories were assigned for each species in each of the six regions. The category High contains species requiring the greatest amount of water during the summer months to maintain acceptable health, appearance, and growth, such as white alder (*Alnus rhombifolia*) and five-finger fern (*Adiantum aleuticum*) (Fig. 2). Species in the category Moderate/Medium need lesser amounts of water, such as ivy geranium (*Pelargonium peltatum*) and cone flower (*Echinacea* spp.) (Fig. 3). Species in the category Low are considered to

Over a nearly, thirty-year period, teams of the state's leading horticulturalists have been meetingto develop these WUCOLS water use coefficients for 6 regions in the state.

Regions

Since substantially different climate zones exist in California, species were evaluated for regions that represent six different climatic conditions. These are not the only climate zones that exist in California, but they include much of the state where irrigated landscapes occur. For locations outside of the six regions, it is best to use species evaluations from a region that is most similar climatically to the location of interest.

Number	WUCOLS Region	Sunset climate zones*	CIMIS ET_0 zones**	Representative Cities
1	North-Central Coastal	14, 15, 16, 17	1, 2, 3, 4, 6, 8	Healdsburg, Napa, San Jose, Salinas, San Francisco, San Luis Obispo
2	Central Valley	8, 9, 14	12, 14, 15, 16	Auburn, Bakersfield, Chico, Fresno, Modesto, Sacramento
3	South Coastal	22, 23, 24	1, 2, 4, 6	Irvine, Los Angeles, Santa Barbara, Ventura, Vista
4	South Inland	18, 19, 20, 21	9	Corona, Escondido, Pasadena, Riverside, San Bernardino, Santa Paula
5	High and Intermediate Desert	11	14, 17	Apple Valley, Barstow, Bishop, Lancaster, Lone Pine, Tehachapi
6	Low Desert	13	18	Borrego Springs, Blythe, Death Valley, El Centro, Needles, Palm Springs

*See Brenzel, K. N., ed., *Sunset Western Garden Book* (2012).

REGIONAL COMMITTEE MEMBERS: 1992 - 2013

The plant database has over 3,700 listings available in downloadable format in either XLS or PDF format

Ba	Bu	G	Gc	P	Pm	S	Su	T	V	N	Botanical Name	Common Name	1	2	3	4	5	6
						S					Abelia chinensis	Chinese abelia	M	?	?	M	/	/
						S					Abelia floribunda	Mexican abelia	M	?	M	M	/	/
						S					Abelia mosanensis 'Fragrant Abelia'	fragrant abelia	?	?	?	?	?	?
						S					Abelia parvifolia (A. longituba)	Schuman abelia	?	?	?	M	?	?
			Gc			S					Abelia x grandiflora and cvs.	glossy abelia	M	M	M	M	M	/
						S					Abeliophyllum distichum	forsythia	M	M	?	?	?	?
						S					Abelmoschus manihot (Hibiscus manihot)	sunset muskmallow	?	?	?	L	?	?
								T			Abies pinsapo	Spanish fir	L	L	L	/	/	/
								T		N	Abies spp. (CA native and non-native)	fir	M	M	M	M	/	/
				P						N	Abronia latifolia	yellow sand verbena	VL	VL	VL	/	?	?

This basic equation factors the unique plant coeefficients against the variable ET_O to derive the plant water requirement in inches of water.

Plant Water Requirement - ET_L $= ET_O \times K_L$

English Laurels in July in San Jose, CA. Plant Water Requirement in inches

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ET_O = 5.79 inches of water

Regions

Since substantially different climate zones exist in California, species were evaluated for regions that represent six different climatic conditions. These are not the only climate zones that exist in California, but they include much of the state where irrigated landscapes occur. For locations outside of the six regions, it is best to use species evaluations from a region that is most similar climatically to the location of interest.

Number	WUCOLS Region	Sunset climate zones*	CIMIS ET_o zones**	Representative Cities
1	North-Central Coastal	14, 15, 16, 17	1, 2, 3, 4, 6, 8	Healdsburg, Napa, San Jose, Salinas, San Francisco, San Luis Obispo

Categories of Water Needs

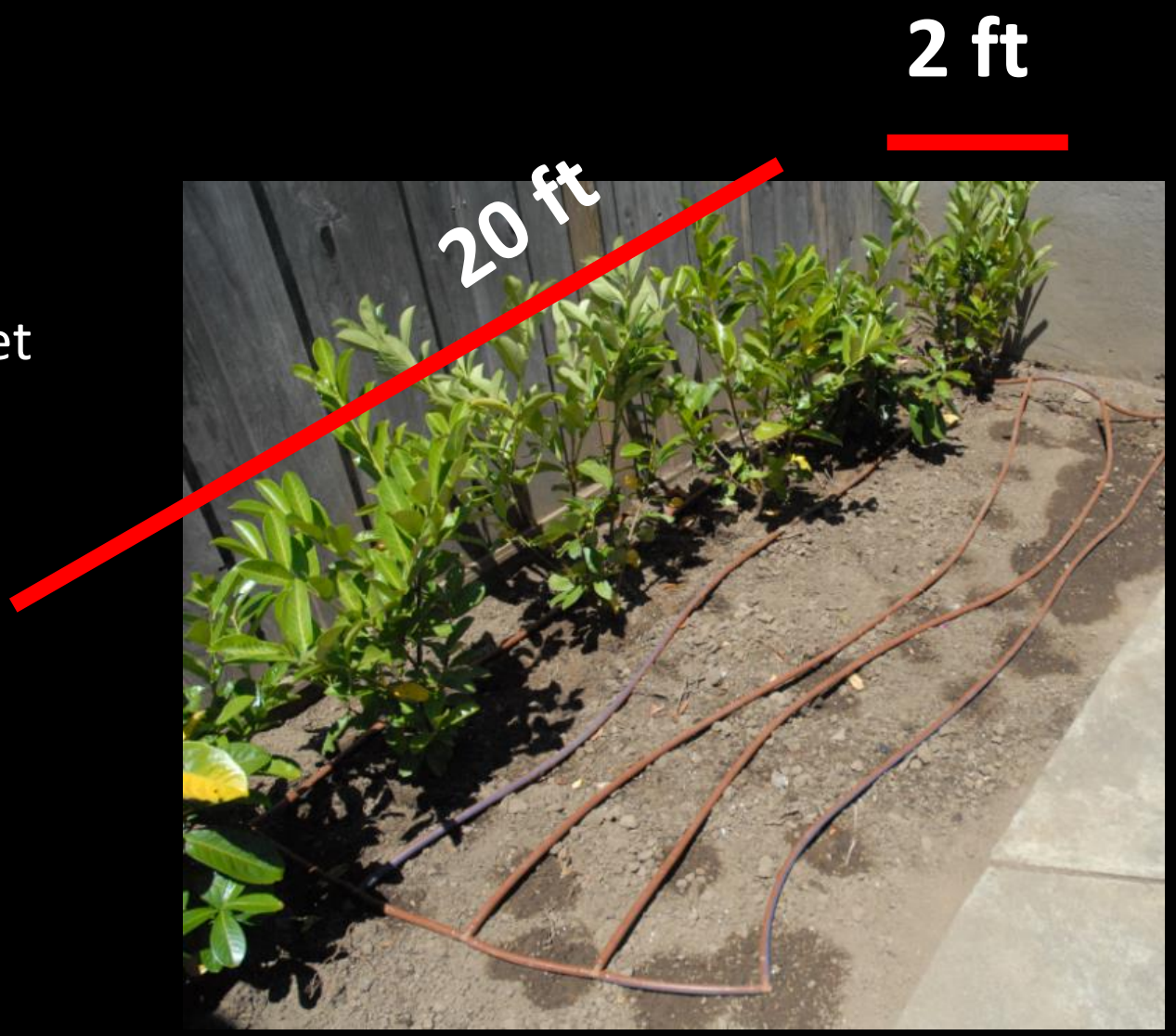
Category	Abbreviation	Percentage of ET_o
High	H	70–90
Moderate/Medium	M	40–60
Low	L	10–30
Very Low	VL	< 10

Plant Water Requirement = 5.79” x 0.50 = 2.90” in July

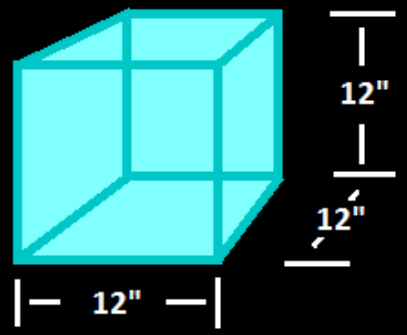
E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
P	Pm	S	Su	T	V	N	Botanical Name	Common Name	1	2	3	4	5	6
		S		T			Prunus laurocerasus	English laurel	M	M	M	H	/	/
				T			Quercus robur	English oak	M	M	M	M	?	/

But, we are often asked, how man gallons would that be for the group of laurels for a week in July?

The area of the canopy is 40 square feet



We'll need a water "constant"- # of gallons in a square foot inch

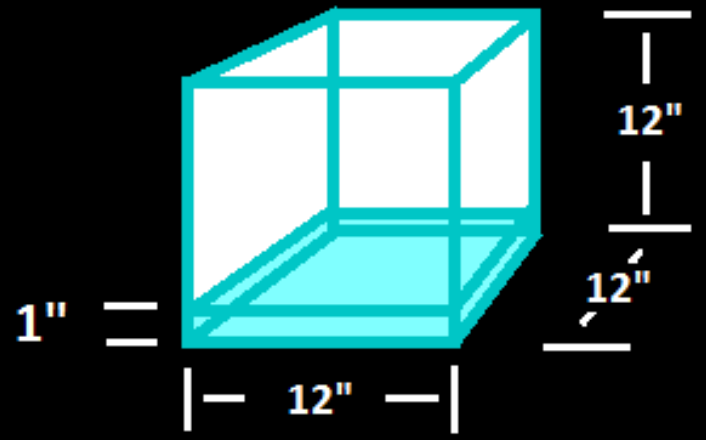


(divided by)

Gallons in a cubic foot = 7.4805

12 inches

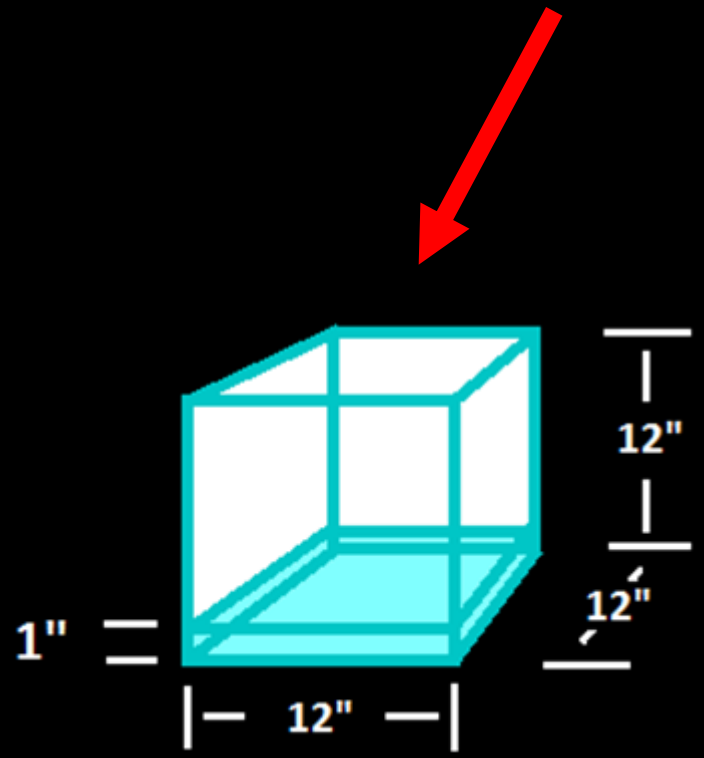
= 0.623 gallons



(proof – 0.623 x 12" = 7.4805 gal)

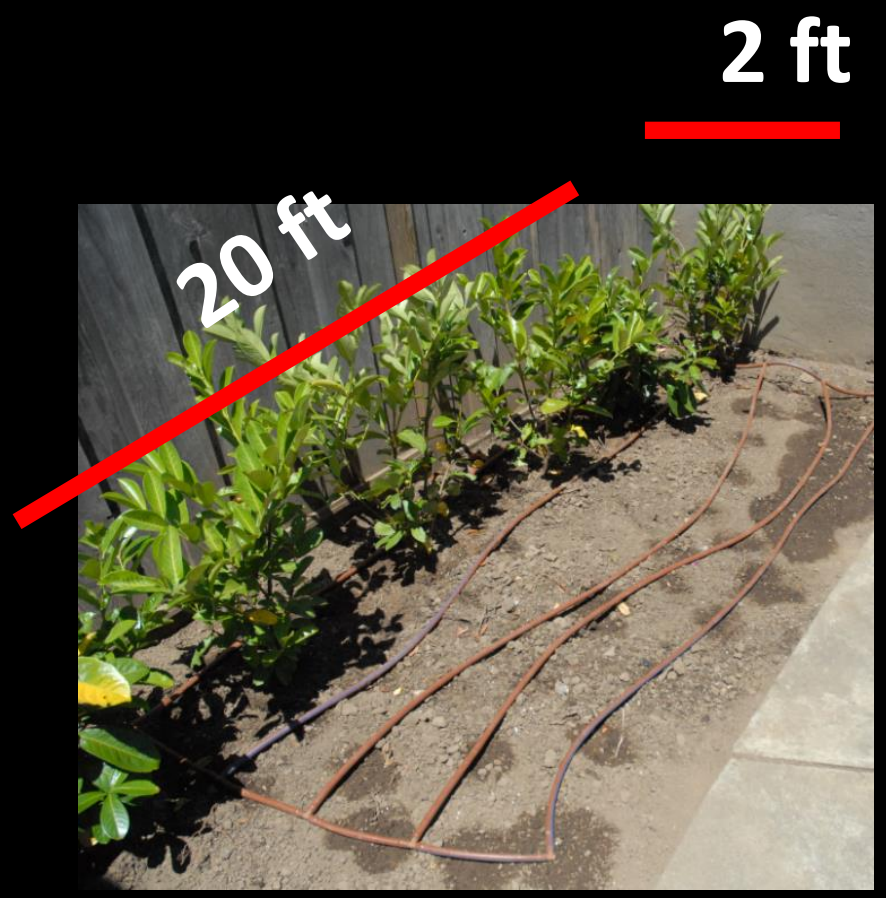
The area of the canopy is 40 square feet

gallons / month = 2.90 x 0.623 x 40 ft^2



2.90 x 0.623 x 40 = 72 gal/mo

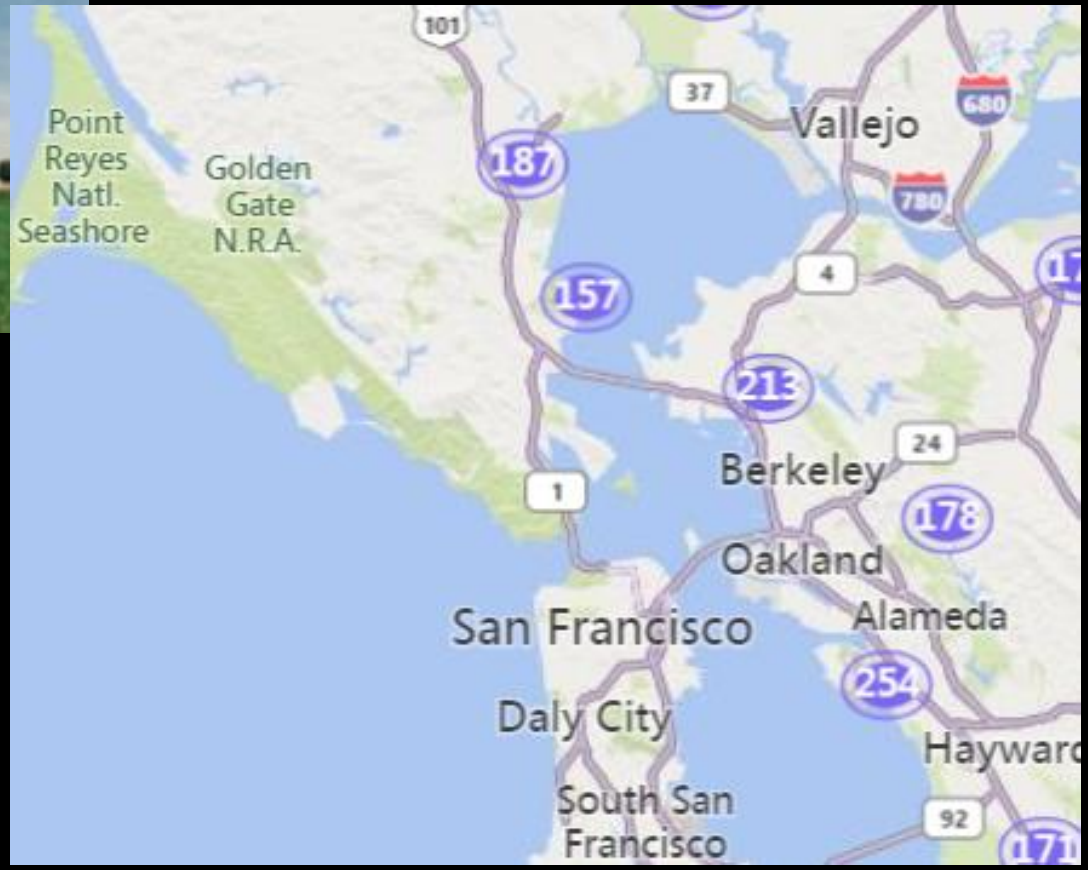
(72.0 / 31) x 7 = <u>16 gallons / week</u>



Let’s do a similar calculation for weekly water requirement in inches for cool season turf for August referenced to CIMIS Sta. 157 – Pt. San Pedro.

ET_O – Reference ET – 18 year average - CIMIS Station 157 – Pt. San Pedro

Sta. 157 Pt. San Pedro	2003-2020 18 year Average
Jan	1.39
Feb	2.01
Mar	3.20
Apr	4.52
May	5.51
Jun	6.20
Jul	6.27
Aug	5.53
Sep	4.48
Oct	3.26
Nov	1.81
Dec	1.28



APPENDIX

Appendix 1. Water requirements for warm-season and cool-season turfgrasses. Data taken from *Managing Turfgrasses during Drought* (Harivandi et al, 2009). To access this publication, see "Resources".

Type	Common name	Optimal Irrigation* (% ET_0)	Deficit Irrigation** (% ET_0)
Warm season	Common bermudagrass	60	40
	Hybrid bermudagrass	60	40
	St. Augustinegrass	60	40
	Seashore paspalum	60	40
	Zoysiagrass	60	40
	Buffalograss	60	40
	Kikuyugrass	60	40
Cool Season	Tall fescue	80	60
	Perennial ryegrass	80	60
	Kentucky bluegrass	80	60
	Fineleaf fescues	80	60
	Creeping bentgrass	80	60
	Rough bluegrass	80	60

* Optimum irrigation is the amount of water needed for most efficient growth, maximum quality, and best appearance.

** Deficit irrigation provides sufficient water to maintain adequate appearance with less growth (relative to optimum irrigation).

The water use coefficient for cool season turf ranges from as low as 60% deficit to 80% optimal Irrigation*

We are using a watering coefficient of 70% for Cool Season Turf!

* Traditionally, irrigation run times are adjusted upwards out of consideration for sprinkler uniformity of coverage issues. The approach here is to make no such adjustment but to select a plant coefficient of 70%.

	ET_O- Aug.	K_L (cs Turf)	
Turf Water Requirement	= 5.53” x	0.70 =	3.87” in Aug.

Turf Water Requirement (Weekly) = (3.87” / 31) X 7= <u>0.87” in Aug. / week</u>

ET_O will change from month to month, but the coefficient will not

The turf water requirement is expressed in inches per week per week.
Sprinkler precipitation rates are in inches per hour.

Developing a run time in minutes brings us to our third learning objective…

Learning Objective 3

Effective landscape irrigation scheduling is based on matching the turf water requirement in inches (or fractions of an inch per week) with the application rate of the sprinklers that is site specific.
At the completion of this objective the participant will understand how to develop a program for an irrigation controller for a one day per week watering schedule with no runoff.

There is just one equation needed to develop a weekly irrigation run time…

0.87”

Run Time (minutes) = $\frac{\text{Turf Water Requirement (inches per week)}}{\text{Sprinkler Precipitation Rate (inches per hour)}}$ X 60 (constant)

divided by

3.58”

8 Series VAN					
5° Trajectory				■	▲
Nozzle	Pressure psi	Radius ft.	Flow gpm	Precip In/h	Precip In/h
180° Arc	15	6	0.84	4.49	5.18
	20	7	0.97	3.81	4.40
	25	7	1.09	[illegible]	4.94
	30	8	1.19	3.58	4.13

There is just one equation needed to develop a weekly irrigation run time…

$$15 \text{ min.} = \frac{0.87”}{3.58”} \text{ divided by } X \; 60 \text{ (constant)}$$

The biggest concern we have with sprays is with runoff on clay soils!!!

The intake rate on flat clay soils before runoff is 0.10” / hr

GENERAL SOIL CHARACTERISTICS					
			AD		
	AW	PAW	allowable		
	Available	Plant Avail Water	depletion	IR	IR
	water	with 6" RZ	between irrigation	Infiltration	avg
Soil Texture	in/in	inches	days	in/hr	in/hr
Coarse					
Sand/Fine Sand	0.05	0.30	0.15	1.50 - 3.00	2.25
Loamy Sand	0.07	0.42	0.21	1.00 - 2.00	1.5
Moderately Coarse					
Sandy Loam	0.11	0.66	0.33	0.80 - 1.20	1
Medium					
Loam	0.16	0.96	0.48	0.40 - 0.60	0.5
Silty Loam	0.20	1.2	0.6	0.25 - 0.40	0.375
Silt	0.20	1.2	0.6	0.30 - 0.50	0.4
Moderately Fine					
Sandy clay loam	0.15	0.9	0.45	0.10 - 0.30	0.2
Clay loam	0.16	0.96	0.48	0.07 - 0.25	0.16
Silty clay loam	0.18	1.08	0.54	0.05 - 0.12	0.8
Fine					
Sandy clay	0.12	0.72	0.36	0.08 - 0.20	0.14
Silty clay	0.15	0.9	0.45	0.05 - 0.15	0.1
Clay	0.14	0.84	0.42	0.05 - 0.10	0.075

It is necessary to calculate the maximum cycle length before runoff…

Infiltration/intake rate of clay

$$1.7 \text{ min.} = \frac{0.10”}{3.58”} \quad \text{divided by} \quad X \; 60 \text{ (constant)}$$

Maximum cycle length is 2 minutes. This would require seven (7) two-minute cycles!!!!

Tuesday (morning)

Program A

Sprays, rotors, rotators on lawns and Drip

Start 1 - 12:00 (2 min.)

Start 2 - 1:30 (2 min.)

Start 3 - 3:00 (2 min.)

Start 4 - 4:30 (2 min.)

Tuesday (morning - evening)

Program B

Sprays, rotors, rotators on lawns and Drip

Start 1 - 6:00 a.m. (2 min.)

Start 2 - 9:00 p.m. (2 min.)

Start 3 - 10:30 p.m. (2 min.)

Friday (morning)

Program C

Drip Only

Start 1 - 12:00

Start 2 - 2:00

Start 3 - 4:00

Start 4 - 6:00

(San Rafael and unincorporated Marin County)

Now, let’s do a calculation for the MP Rotators from our drain cap audit!

$$90 \text{ min.} = \frac{0.87”}{0.58”} \text{ divided by } X \; 60 \text{ (constant)}$$

It is necessary to calculate the maximum cycle length before runoff…

Infiltration/intake rate of clay

$$10 \text{ min.} = \frac{0.10”}{0.58”} \quad \text{divided by} \quad X \; 60 \text{ (constant)}$$

Maximum cycle length is 10 minutes. This would require nine (9) 10 minute cycles

WE ARE NOW PUSHING THE LIMITS OF THE CONTROLLER CAPABILITY)!!! (8 X 11 MIN = 88 MIN.)

Tuesday (morning)

Program A

Sprays, rotors, rotators on lawns and Drip

Start 1 - 12:00 (11 min.)

Start 2 - 1:30 (11 min.)

Start 3 - 3:00 (11 min.)

Start 4 - 4:30 (11 min.)

Tuesday (morning - evening)

Program B

Sprays, rotors, rotators on lawns and Drip

Start 1 - 6:00 a.m. (11 min.)

Start 2 - 9:00 p.m. (11 min.)

Start 3 - 10:00 p.m. (11 min.)

Start 4 - 11:00 (11 min.)

Friday (morning)

Program C

Drip Only

Start 1 - 12:00

Start 2 - 2:00

Start 3 - 4:00

Start 4 - 6:00

(San Rafael and unincorporated Marin County)

(Let’s do a quick review!!!)

Learning Objective 1

At the completion of this webinar, the participant will understand how to quickly field evaluate sprinkler performance for scheduling purposes by learning the steps of a precipitation rate audit.

Learning Objective 2

At the completion of this learning objective, the participants will learn how to factor reference evapotranspiration from CIMIS station 157 – Pt. San Pedro with WUCOLS coefficients to develop a turf watering target in inches per week.

Learning Objective 3

Effective landscape irrigation scheduling is based on matching the turf water requirement in inches (or fractions of an inch per week) with the application rate of the sprinklers that is site specific.
At the completion of this objective the participant will understand how to develop a program for an irrigation controller for a one day per week watering schedule with no runoff.

Tomorrow’s Topics

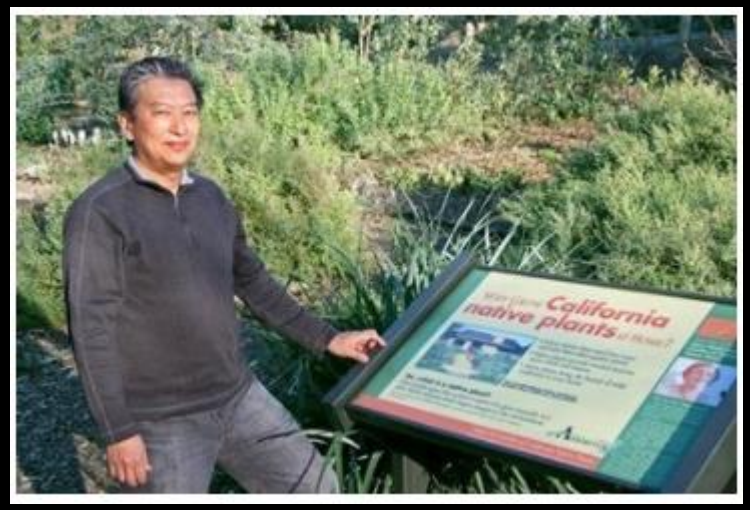
Additional technical challenges presented by the compressed watering schedule with solutions.

Alternative temporary drip system for turf

Open “mic” Q & A for Dave, Jim, and Carrie

Presented by
Jim Borneman - Ewing Irrigation and Landscape Supply
(retired) jborneman@ewingirrigation.com

EWING
Irrigation & Landscape Supply



Dave Fujino - Ph. D. – Director
California Center for Urban Horticulture at U.C. Davis

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Urban Horticulture