Welcome and introductions

Monet, *Haystacks*

Intro me.

My website.

Who is here?

How many commercial farmers?

How many gardeners?

Others?

Vegetables?

Fruits and berries?

Pasture?

Other?

Organic?

Slides, etc. available here

https://www.deanmoberg.com/

Click on References.

The "here" link in this picture of the slide is not active, but the link IS active in the website.

Goals

1. Estimate how much water your crops need.

2. Know how much water your system provides.

3. Determine when to turn system on and how long to run it.

Goal is NOT

Teach how to design an irrigation system.

Usually farmers get help from vendors for this.

Irrigation as a system

Plants.

Hardware.

Soil.

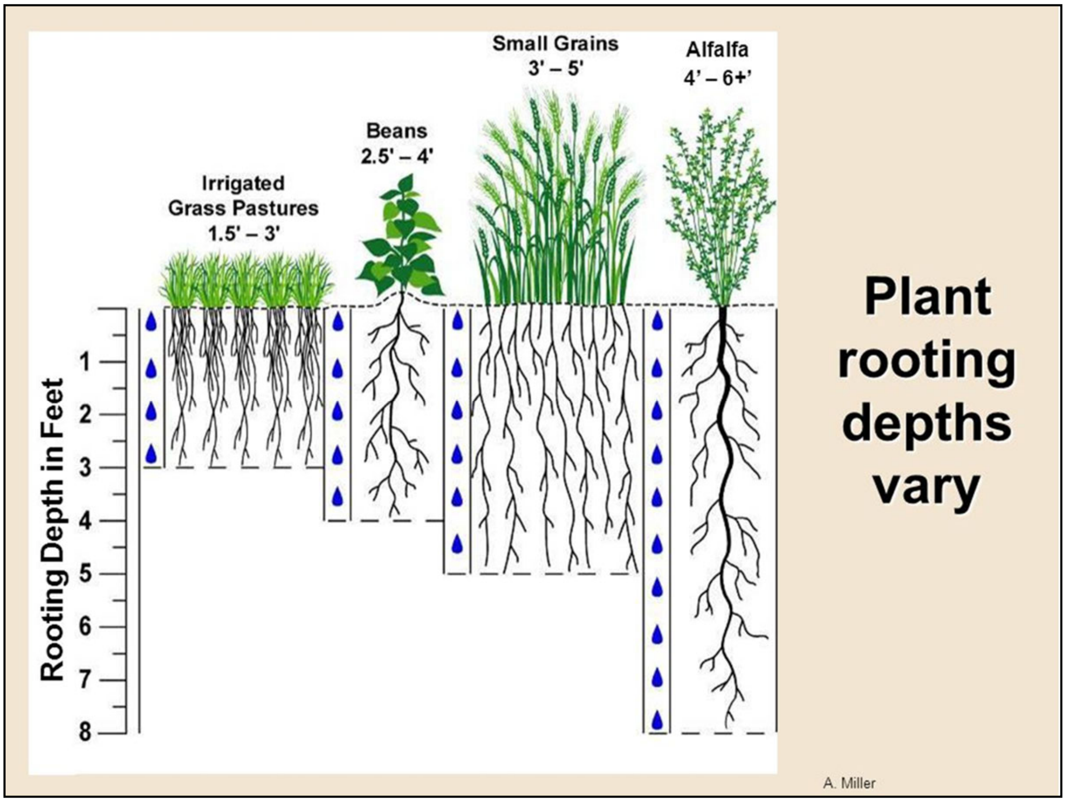
Escher, *Waterfall*

Irrigation as a system

Plants.

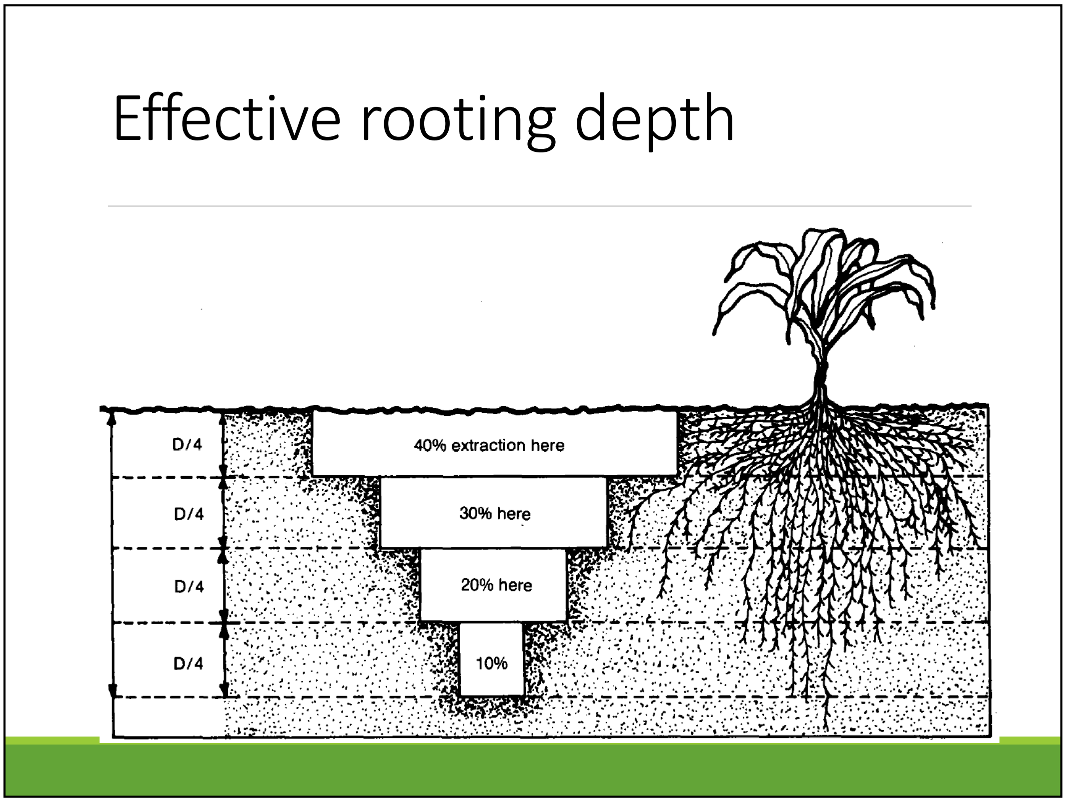
Hardware.

Soil.



Caveats:

- rooting depth for annuals increases as the plants grow.
- published rooting depths are usually high estimates.



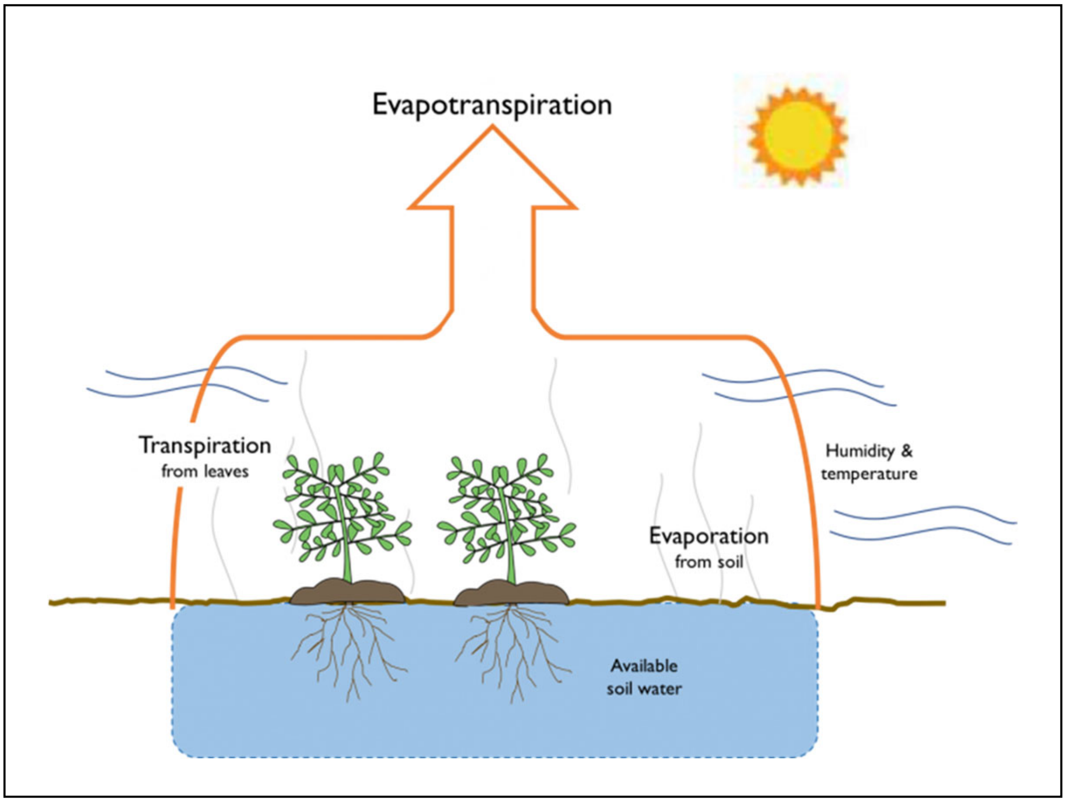
Maximum root depths can be quite high:

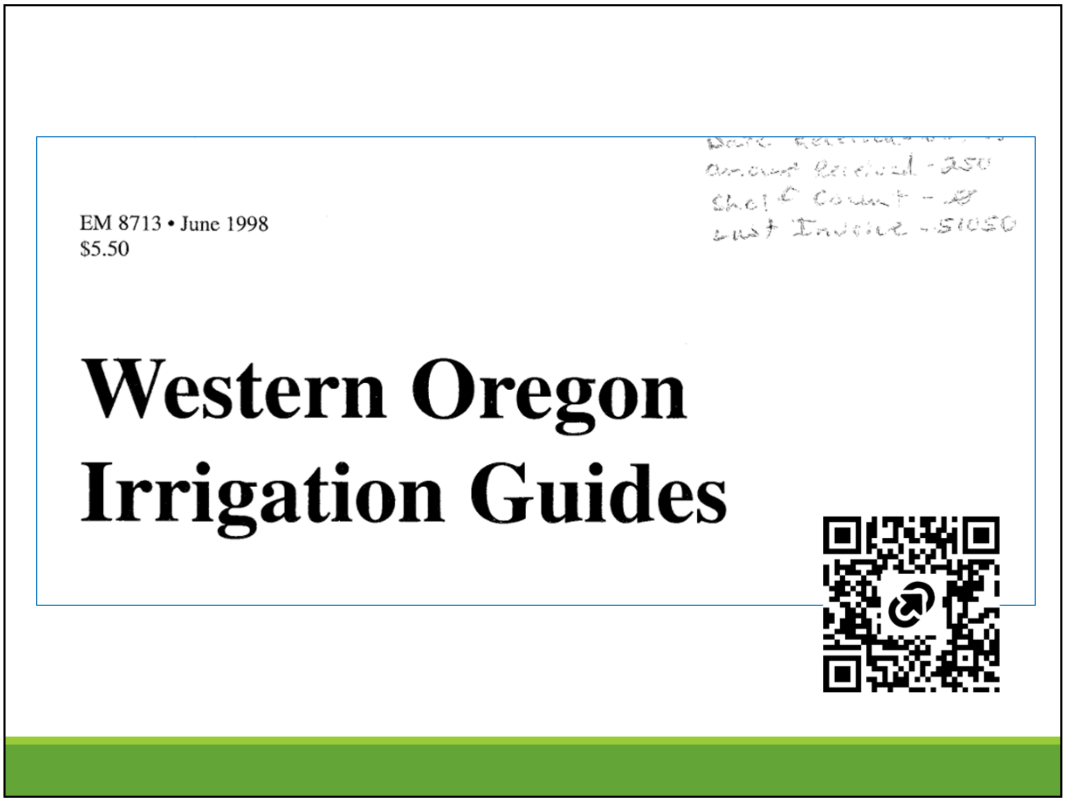
E.g., tomato = 5-8 feet deep

So, use ¼ or ½ of maximum root depth to estimate root zone that is really suitable for AW calculations.

NRCS, National Engineering Handbook Section 15: Irrigation.

https://irrigationtoolbox.com/WebPages/NEH.html

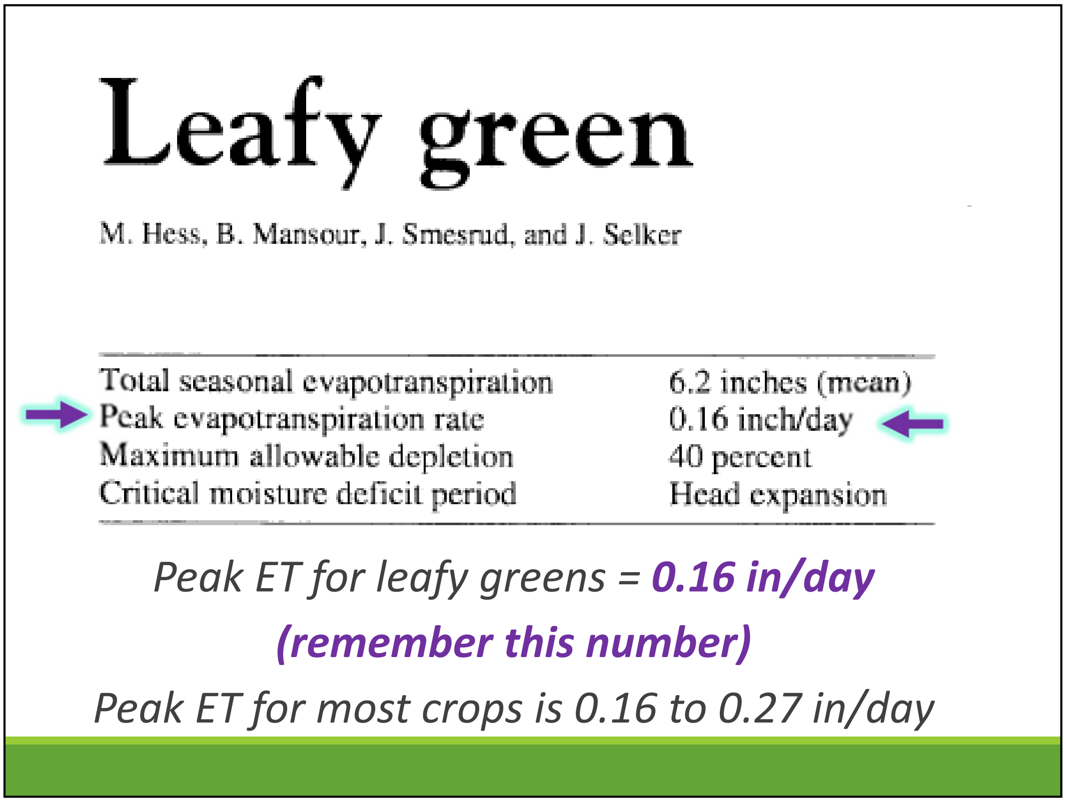

Evapotranspiration
Transpiration
from leaves
Humidity &
temperature
Evaporation
from soil
Available
soil water



This website has concise two-page guides to irrigating many crops commonly grown in the Willamette Valley.

Probably not available via the OSU catalog or in Extension offices, but link in this slide works for what looks like a scanned version of the guides.

https://extension.oregonstate.edu/sites/extd8/files/documents/em8713.pdf



Peak ET is usually reached in July for most crops.

ET values shown in guide are generally conservative (most days in July will be lower ET), but:

- Some days will be higher.
- The changing climate is making these values less conservative than they used to be.

	Evapotranspiration (inches / day)							
Crop	April	May	June	July	Aug	Sept	Root depth (in)	MAD*
Blueberry	0.09	0.14	0.22	0.25	0.23	0.18	18	50%
Broccoli		0.14	0.24	0.27			18	30%
Bulb onion	0.09	0.12	0.21	0.25	0.20	0.13	18	30%
Caneberry	0.09	0.14	0.23	0.25	0.23	0.18	36	50%
Carrot	0.07	0.09	0.14	0.20	0.17	0.14	18	50%
Cauliflower			0.10	0.26	0.25	0.21	18	40%
Cucumber		0.09	0.14	0.17	0.15	0.10	24	50%
Green bean	0.07	0.10	0.16	0.20	0.16	0.13	18	50%
Leafy greens		0.10	0.16	0.12	0.16		18	40%
Orchard (apple)	0.09	0.10	0.18	0.24	0.25	0.20	36	75%
Peppermint	0.09	0.12	0.20	0.21	0.14		24	35%
Potato	0.09	0.12	0.20	0.17	0.21		18	35%
Squash	0.08	0.12	0.16	0.19	0.15	0.12	24	35%
Strawberry	0.09	0.17	0.22	0.23	0.19	0.11	12	50%
Sweet corn	0.07	0.10	0.18	0.22	0.18	0.14	24	50%
Table beet	0.07	0.09	0.16	0.21	0.17		18	50%

*MAD = maximum allowable depletion

From OSU EM 8713, Western Oregon Irrigation Guides

Evapotranspiration (ET) values above tend to be high estimates (somewhat warmer than average days). On cool days, actual ET will be less. On very hot days, ET may be more.

Notice how squash ET increases as plants grow and weather warms April – July and then starts decreasing as daylength shortens in Aug-Sept.

Leafy greens is odd because the chart assumes two crops (one planted in May and then another in July.

Effective rooting depth is based on healthy crops at full size without soil restrictions. For annual crops, of course, the root depth will be less early in the season.

We will talk about MAD in a minute.

If your crop is not in this list, pick something similar.

Irrigation as a system

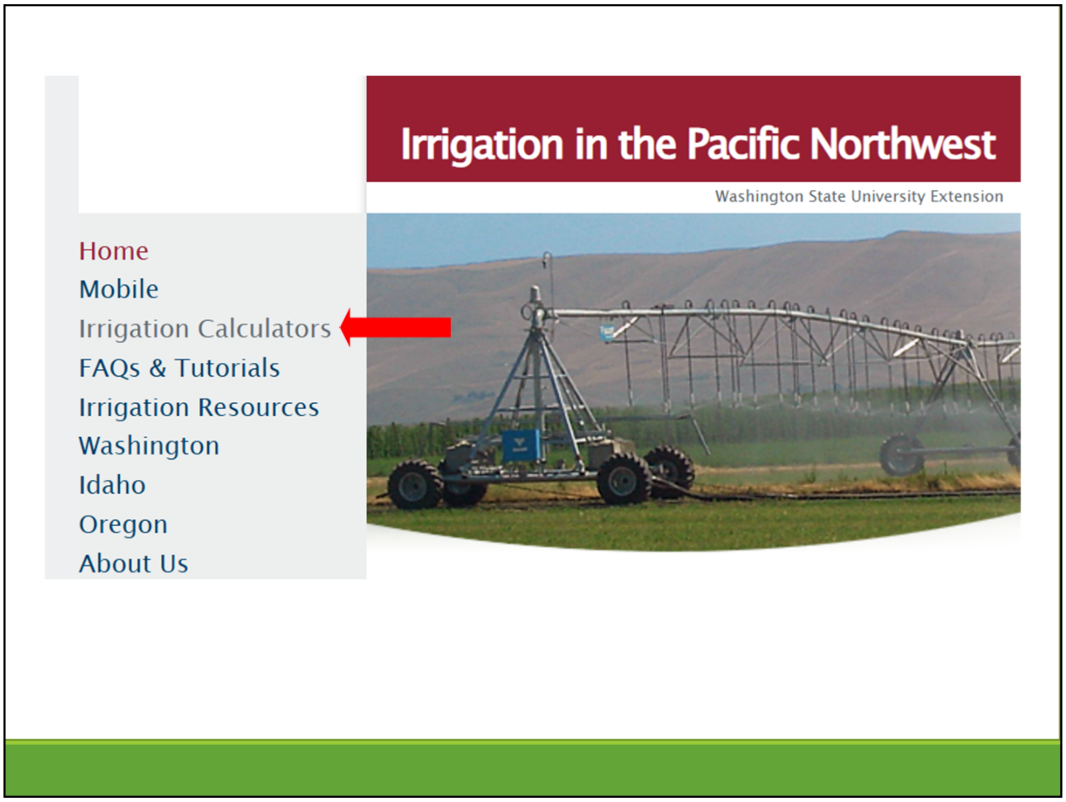
Plants.

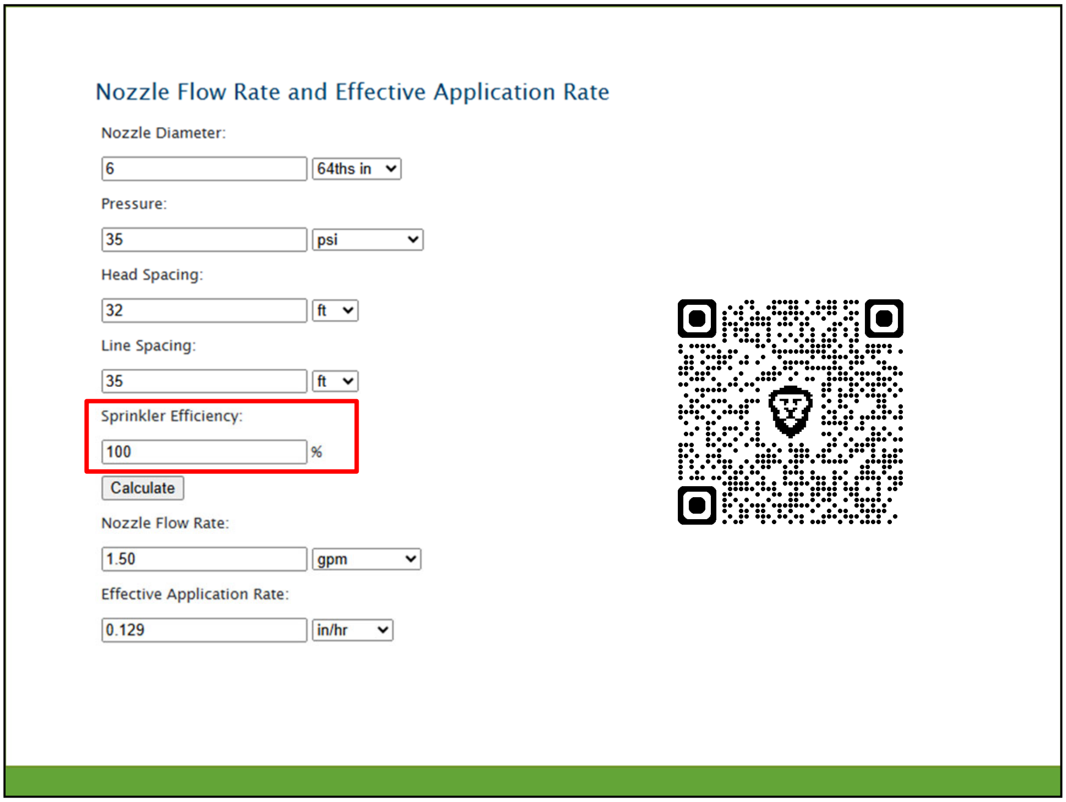
Hardware.

Soil.

This website has tools to help calculate the amount of water your irrigation system supplies per hour.

http://irrigation.wsu.edu/index.php


Irrigation in the Pacific Northwest
Washington State University Extension
Home
Mobile
Irrigation Calculators
FAQs & Tutorials
Irrigation Resources
Washington
Idaho
Oregon
About Us



Does anyone want to calculate their sprinkler application rate?
https://irrigation.wsu.edu/Content/Calculators/Sprinkler/Sprinkler-Application-Rate.php

PARTICIPANTS CALCULATE THEIR SPRINKLER RATE AND WRITE IT DOWN.Nozzle diameter is usually stamped into the brass nozzle (not always easy to see). You can also use drill bits to measure the nozzle diameter.

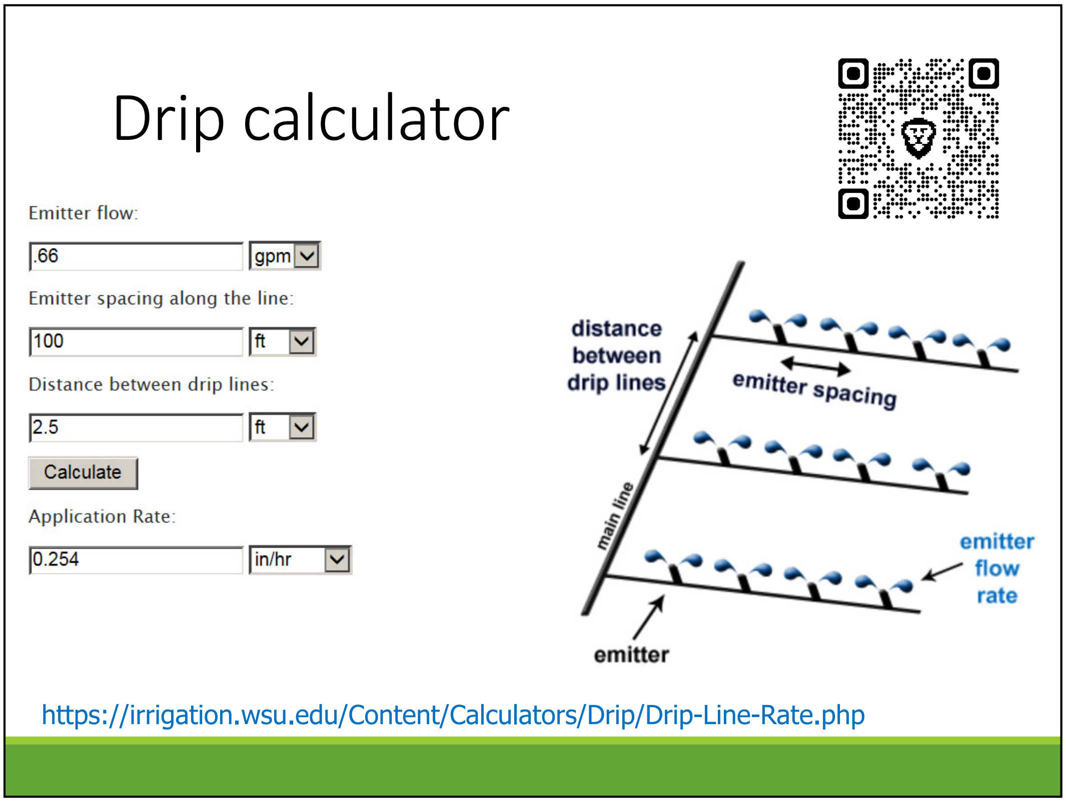
Pressure is best measured with a pressure gauge and pitot tube.
Example pitot tube: https://www.underhillonline.net/product_p/a-phg-160k.htm

Line spacing = distance between irrigation pipes.

Head spacing = distance between sprinklers along the pipe.

Sprinkler efficiency = 70% is a typical value, but for now let’s say 100%.

For sprinkler systems that don’t have standard nozzle diameters, determine flow by measuring output from one sprinkler for one minute. Then experiment with nozzle diameter and pressure in this online tool until you get the nozzle flow rate you want. OR, ask the dealer or visit the manufacturer website. OR, see next page for calculations.



This is based on t-tape being used at Headwaters: 0.66 gallons per minute per 100 feet. Beds are 5 feet in total width with two lines per bed (i.e. 2.5 feet theoretically between lines).

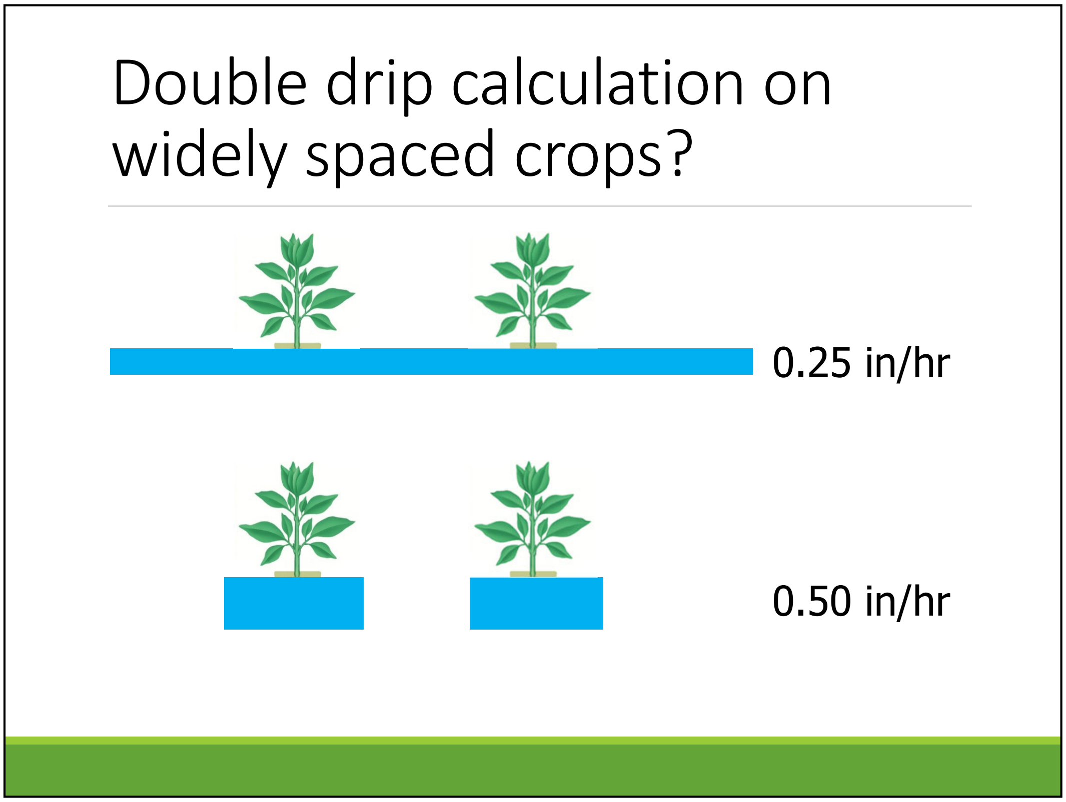
PARTICIPANTS CALCULATE THEIR DRIP RATE AND WRITE IT DOWN.

Other drip lines on the market are classified with a gph per emitter and emitter spacing (e.g., 5 gph, spaced at 1.0 feet).

https://irrigation.wsu.edu/Content/Calculators/Drip/Drip-Line-Rate.php

The diagram on this slide works well for vegetables with relatively narrow rows (e.g., 3 feet). But there is some healthy disagreement on how to measure distance between irrigation lines for widely spaced crops.

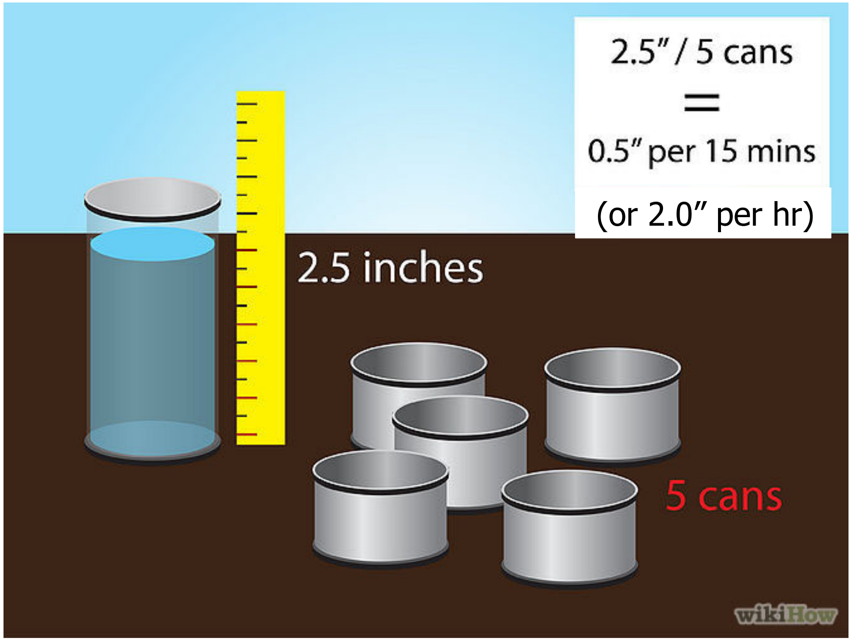
https://irrigation.wsu.edu/Content/Calculators/Drip/Drip-Line-Rate.php



But for blueberries planted in 10 foot wide rows, with one drip line per row, there are two approaches:

1. Just figure 10 foot spacing, which might be 0.25 in/hr.
2. Assume that ET rates are based on sprinkler irrigation and that half of the sprinkler water percolates down between the rows with no benefit to the crop. In this case, you can figure that for DRIP irrigation, the actual blueberry root zone is 5 feet wide and so the effective rate of blueberries is doubled.

But be careful with this: it can make you believe you are applying more water than is actually needed. Altho drip in vegetables with 30 inch row spacing may not provide water to the soil in the aisles, the ET rate for vegetables is based on the whole field (crop row and aisles combined), so it's best to only consider using this adjustments on widely spaced crops (e.g., 10 foot rows or more).



If your irrigation system does not fit one of the calculators, you can use the tuna can approach. Collect water in 5 or more cans for 15 minutes. Pour all water into one can and measure the depth collected. Multiple that by four (because you only collected for 15 minutes) to get inches per hour. All cans need to be the same diameter.

Or measure flow from a sprinkler head with a hose, bucket and watch.,

Irrigation duration - sprinkler

Leafy greens in June:

ET = 0.16 inches/day

Sprinkler rate = 0.09 inches/hour

(0.16 inches/day) / (0.09 inches/hour)

= 1.8 hours /day for sprinklers

(1 hour and 50 minutes)

IF NOBODY IS USING SPRINKLERS, SKIP THIS SLIDE.

The 0.16 inches/day ET is from the Western OR Irrigation Guide, and the 0.09 inches/hour rate is from the online calculator, where we said the efficiency was 70%.

Remember that cool days will be less and very hot days may be more. Some crops will be 0.25 inches per day ET.

This assumes you run the sprinklers every day.

Irrigation duration - drip

Leafy greens in June:

Average ET = 0.16 inches/day

Drip rate = 0.25 inches/hour

(0.16 inches/day) / (0.25 inches/hour)

= 0.6 hours /day for drip example

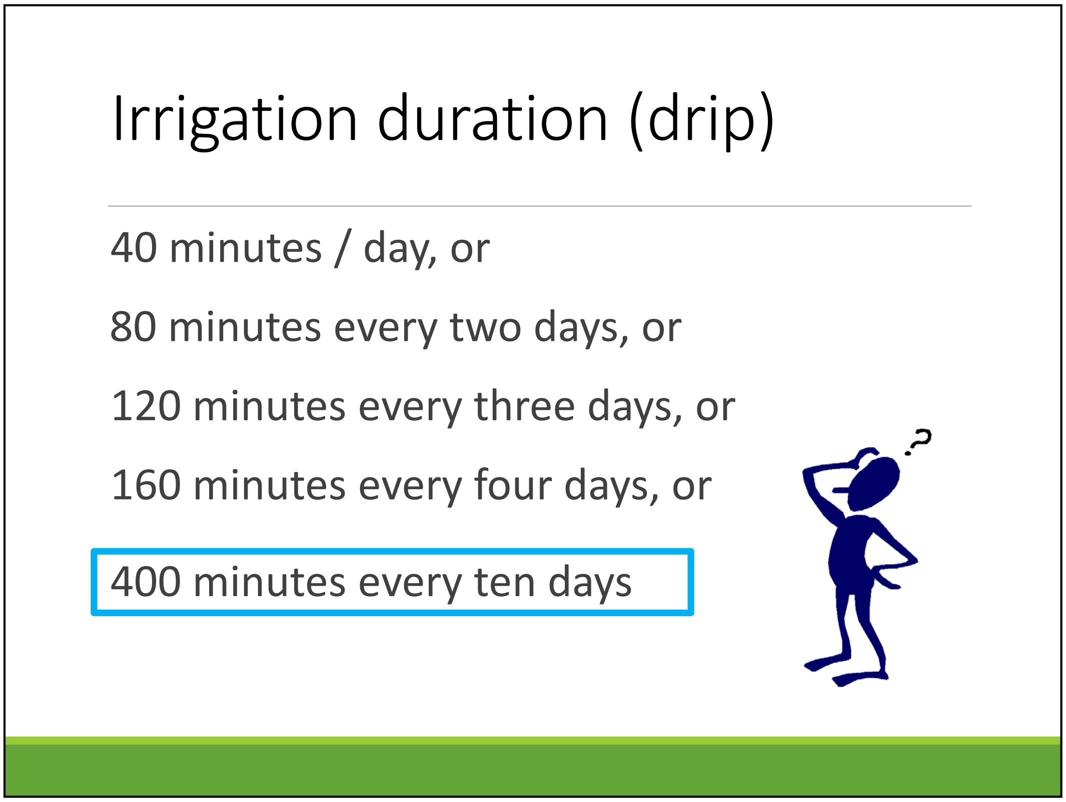
(35-40 minutes)

This assumes efficiency is 100%, which is probably an OK assumption.

But on an average day for leafy greens in June, you need to run this drip system about 40 minutes.

On cool days, this might be a bit more water than you need, and on hot days this will be somewhat less water than you really need.

This assumes you run the sprinklers every day.

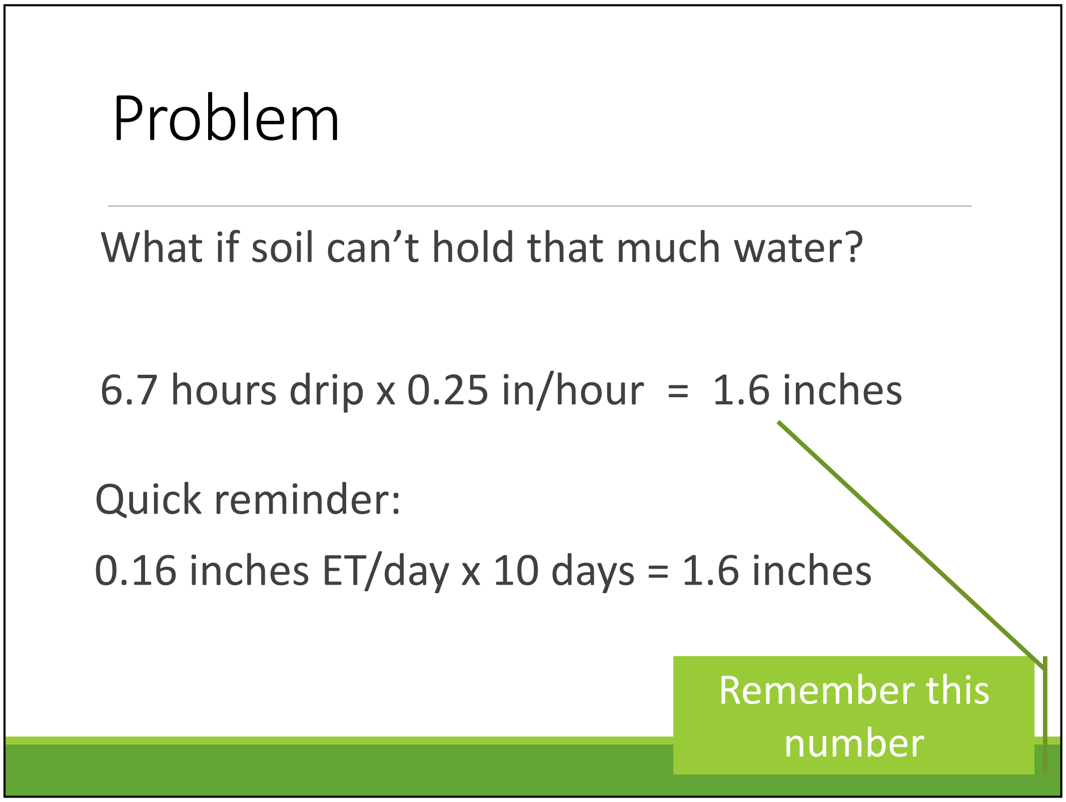


But you don’t necessarily need (or want) to irrigate every day. So, you can run the system for 80 minutes every other day for the same result. The idea here is that the soil can store enough water that will last for more than one day of ET.

It’s sort of like how we spend money every day but only need to deposit a pay check every two weeks.

But the pay check analogy isn’t perfect because a bank account can hold limitless amounts of money, but the soil in the root zone can only hold so much.

Just to make a point, let’s pretend like we plan to provide for our leafy green vegetables by irrigating 400 minutes (6.7 hours) every ten days.



400 minutes is about 6.7 hours.

6.7 hours at 0.25 inches per hour is a total of 1.6 inches of water.

This makes sense because the total ET is 0.16 inches/day x 10 days = 1.6 inches

Irrigation as a system

Plants.

Hardware.

Soil.

Soil / water, simplified

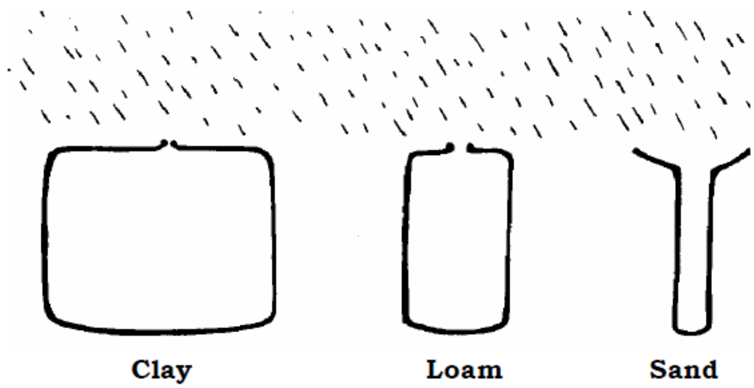


Figure 1. Soil-Bottle Analogy.

Smesrud et al., 1997

Clay holds more water, but sand has higher infiltration rate (can apply irrigation water faster).

But it would be helpful to quantify how much water a soil can hold.

Web Soil Survey

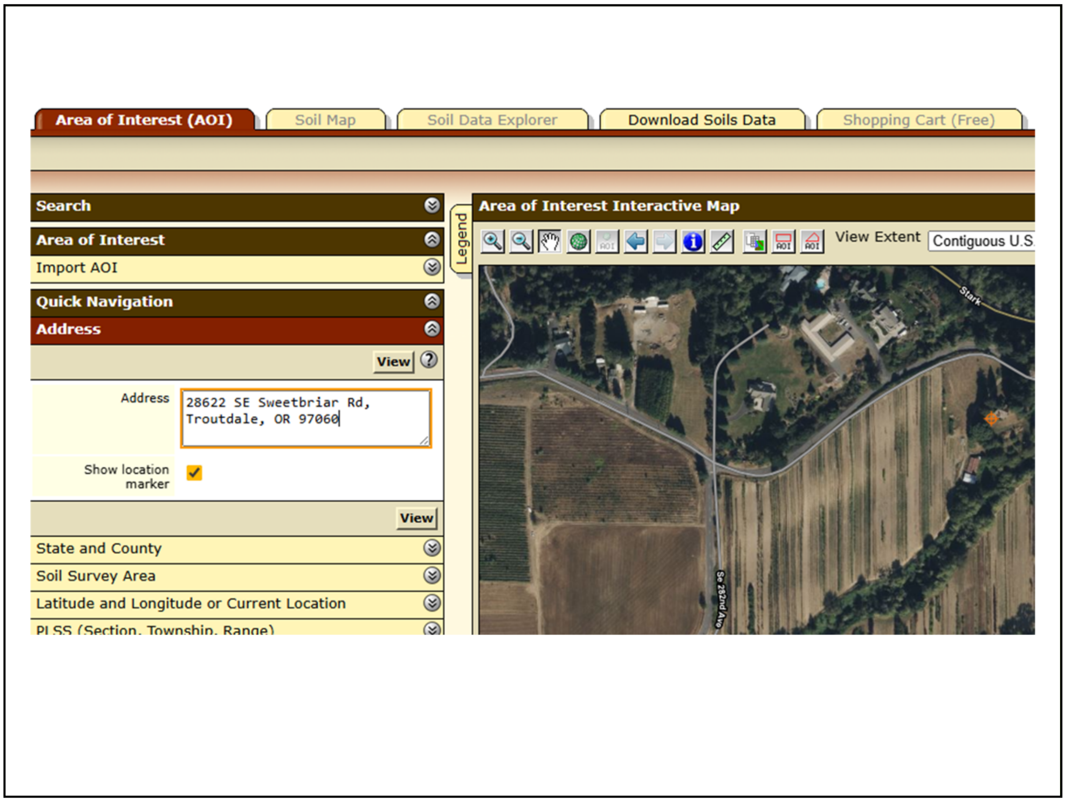
Free, fun, easy

Skip hands on Web Soil Survey if most participants are in Multnomah, Clackamas, Washington counties and know their soil map unit.

Instead, use soil data viewer to look up AWC for each participant.

https://websoilsurvey.nrcs.usda.gov/app/

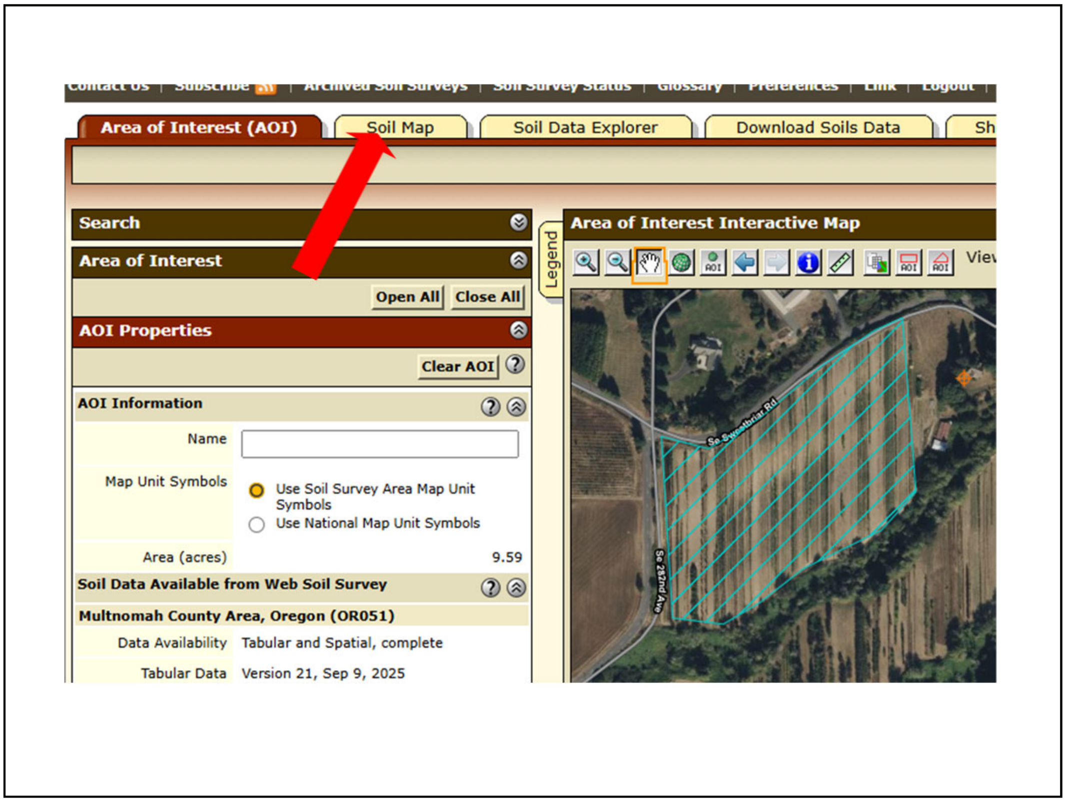
Green Start WSS button



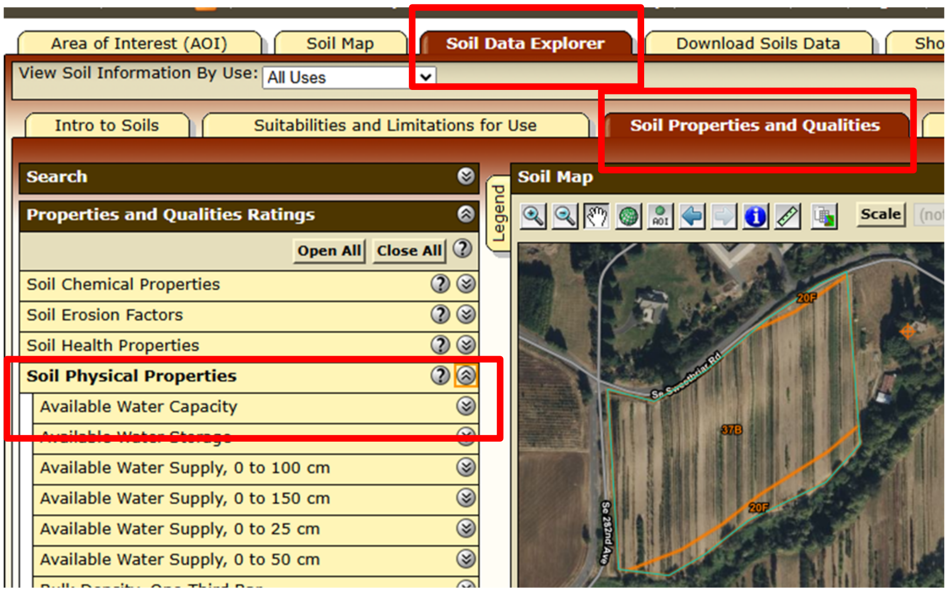
Navigate to property

Use magnifying glass icon to zoom in or out

On phones, it's easiest to use the polygon AOI to outline the property.
Double click on last point.



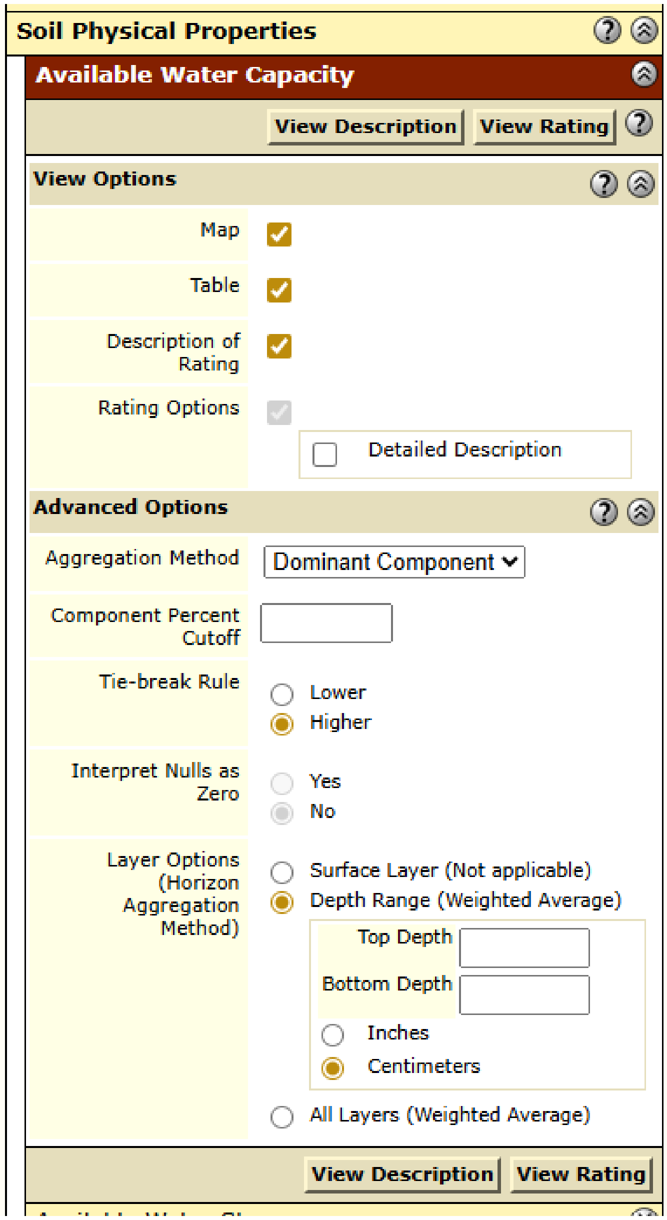
Click the Soil Map tab.



Soil Data Explorer

Soil Properties and Qualities Soil Physical Properties

Available Water Capacity



View option: check map, table, and description.

Aggregation method = dominant component

Component percent cutoff = leave blank

Tie-break rule = higher

Layer Options = depth range

Top Depth = 0

Bottom Depth = you set for depth of active roots (usually 10 - 24 inches)

Select "Inches"

Click "View Rating"

Tables — Available Water Capacity — Summary By Map Unit		
Summary by Map Unit — Multnomah County Area, Oregon (OR051)		
Summary by Map Unit — Multnomah County Area, Oregon (OR051)		
Map unit symbol	Map unit name	Rating (centimeters per centimeter)
34B	Powell silt loam, 3 to 8 percent slopes	0.23

Rating (centimeters per centimeter)
0.23

What the heck does this mean?

This is a rating for Powell silt loam, a soil commonly found in Multnomah County in the farmland between Gresham and Sandy.

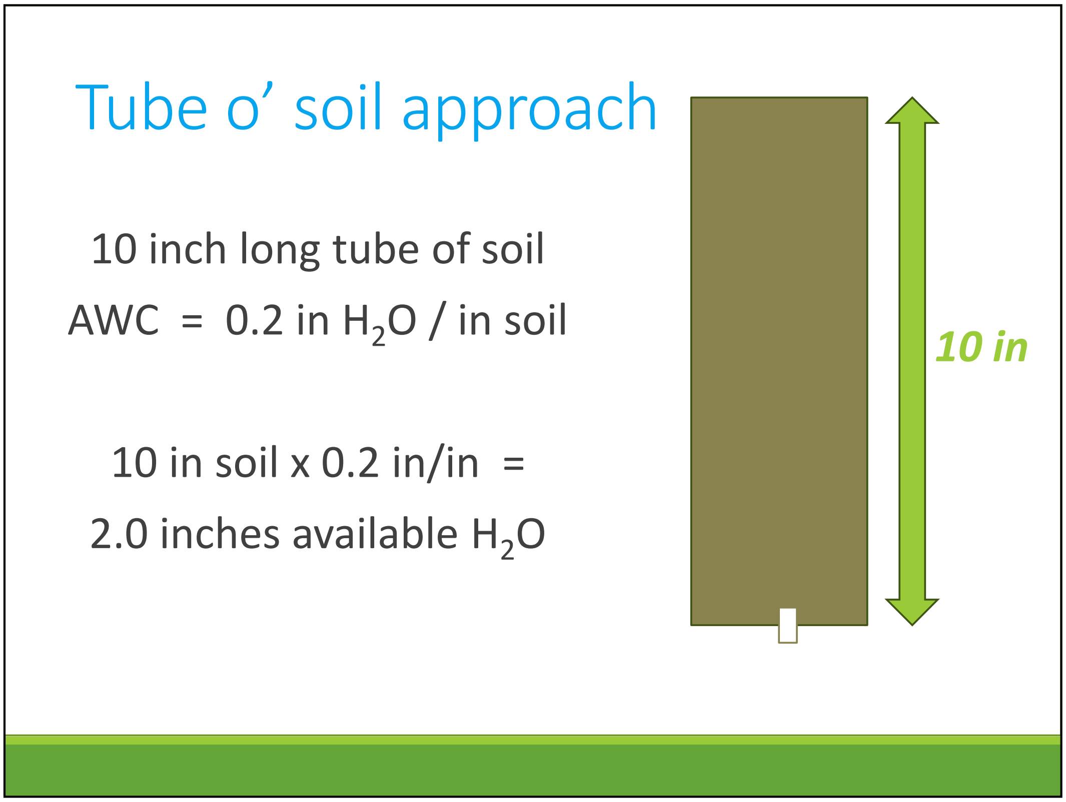
You probably won't manage for hundredths of a cm, so the value for this soil is about 0.2 cm per cm.

But cm per cm is a weird unit. It means cm of water per cm of soil. So one cm of soil has an Available Water Capacity of 0.2 cm of water.

0.2 cm of water per cm of soil is the same thing as 0.2 in of water per in of soil.

AND the same thing as 20%

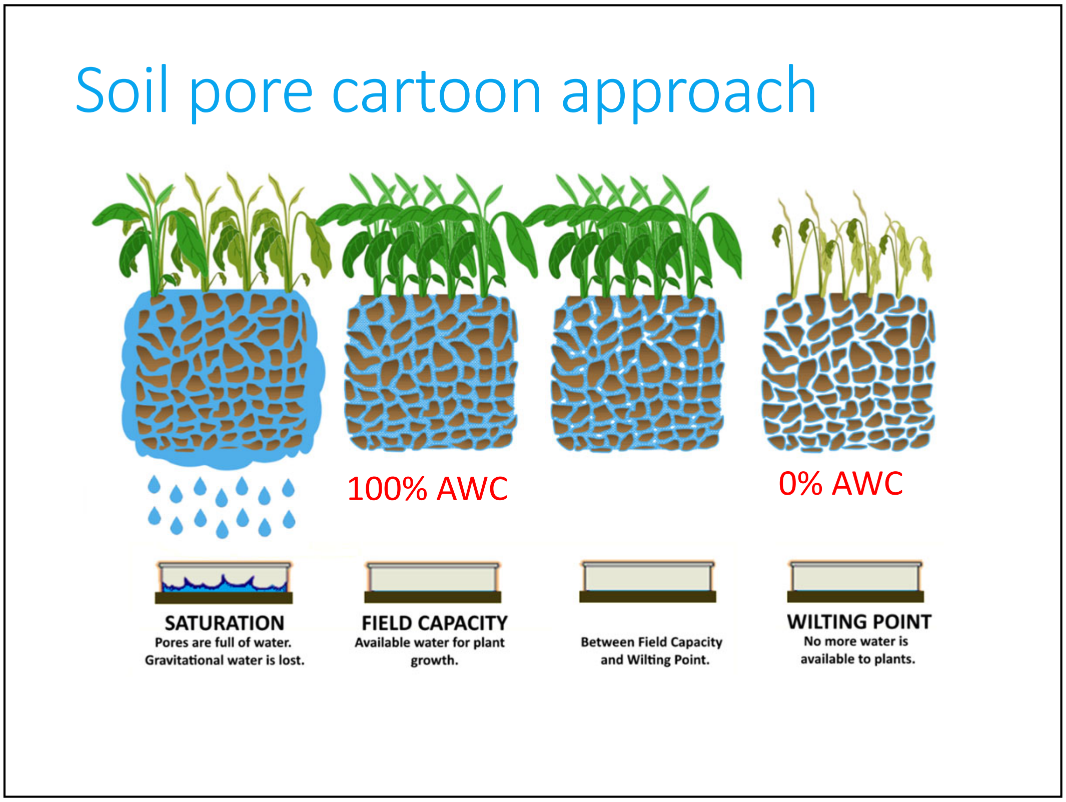
This is not rocket surgery but it requires a new mind set and we will explain with a few approaches.



First, the tube of soil explanation.

[click thru text]

If you added water to this tube of soil to saturate the soil and then waited until water stopped dripping out of the hole at the bottom, the soil would hold 2.0 inches of water available to a plant. Note that 2 inches out of 10 inches is 20%. So 20% of the tube volume is water that's available to a plant.



Next, the same idea illustrated by cartoons of soil pores.

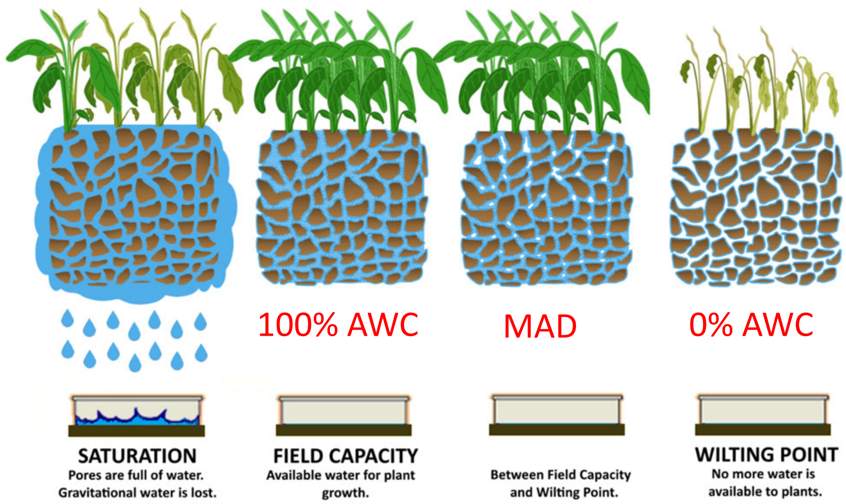
When you add water to the soil until it starts to percolate out the bottom, the soil is "Saturated." All of the soil pores are full and water is moving down thru the soil due to gravity. This drainage comes from really large pores that can't hold water very well.

The water drains down thru the soil (and out of the root zone), is held in the largest pores, is only available to crops for a short time (maybe a day?), and we don't count it in our calculations. Note that soils with a restrictive layer may remain saturated for a longer period.

After the water stops draining down, the largest pores have air in them. The remaining water is held in smaller poreswith a force stronger than the gravity. Right when water stops moving down by gravity, the soil is said to be at "Field Capacity." A lot of this water is available to plants.

Eventually, ET uses up much of the water, leaving only water that is held very tightly in small pores.

This is called "wilting point," when crops will wilt even at night and pretty quickly die.

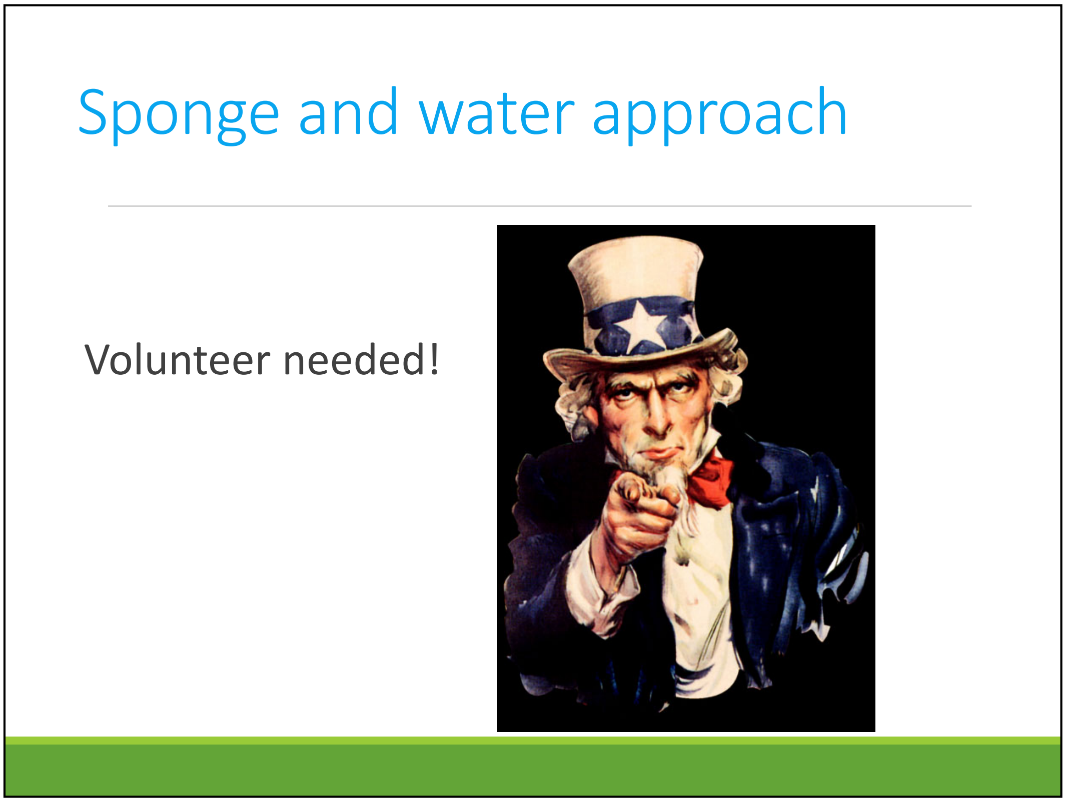


- *Goal #1: Irrigate at or before MAD*
- *Goal #2: Don't irrigate to saturation*

Altho moisture is technically available to crops right up to the wilting point, we need to irrigate well before then. Crops grow well with soil moisture anywhere between FC and MAD, which stands for maximum allowable depletion.

IMPORTANT: MAD is expressed as a % of AWC that is DEPLETED (not the amount remaining). So if MAD is 30% (very sensitive crops), then the AWC at MAD is 70%. Sensitive crops like broccoli have a low MAD (30%); less sensitive crops like field corn or perennial pasture grasses have a higher MAD (over 50%).

So we want to irrigate at or sometime before MAD, but fill the soil up to right around field capacity and not up to the saturation point. Note that as we irrigate or it rains, the top layer of the soil is saturated temporarily, but then that water moves downward. We don't want to saturate soil down to the root zone.



So we've looked at a sketch of water in soil pores and done some math. Let's look at this one more way.

Demonstrate FC, MAD, PWP, AW using a sponge and dyed water, putting water into quart mason jars labeled >FC, "easy", "hard".

Note: add dye to mason jars before beginning.

> FC: Water drains by gravity out of large pores in sponge/soil

More water than MAD ("easy"): Gentle squeezing of sponge easily provides water.

Less water than MAD ("hard"): Stronger squeezing of sponge also provides water; crop wilts during day but recovers at night.

PWP: Still water available, but crop no longer recovers at night and eventually dies.

Math approach

	Rating (centimeters per centimeter)
0.21	
0.21	
0.20	

For a 10 inch root zone:

$$10 \text{ in} \times 0.2 \text{ in } H_2O \text{ / in soil} = 2.0 \text{ in } H_2O$$

Remember our question of what the heck this means?

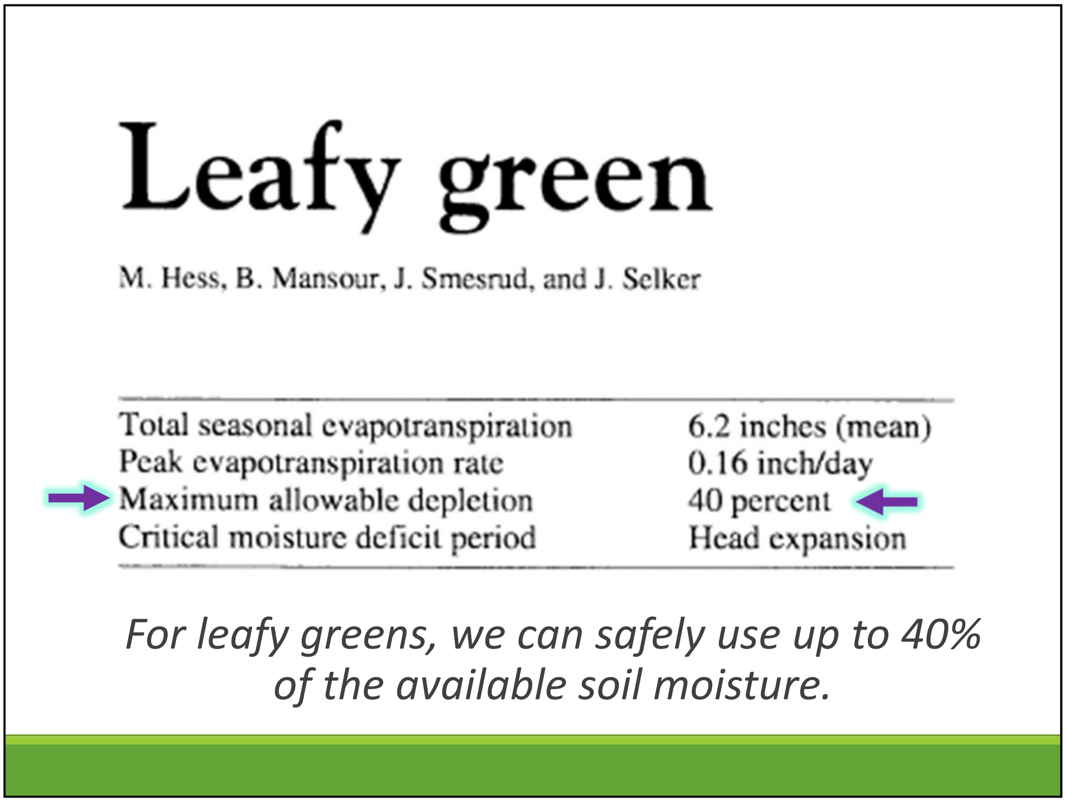
That 0.2 inches of available water per inch of soil is Field Capacity minus Wilting Point.

Let's say you have a 10-inch long tube of this soil.

The most water that soil could provide for a plant is 0.2 inches per inch, or a total of 2.0 inches.

Your crops will be stressed if you try to use up all of that 2.0 inches, so we try to irrigate before we reach the Maximum Allowable Depletion (MAD).

MAD varies from one crop to another. Lettuce is a low MAD. Corn has a higher MAD. Pasture grass has an even higher MAD.



The Western Oregon Irrigation Guides estimate that MAD for lettuce is 40%. So you want to irrigate lettuce before the AWC goes below 60%.

Math approach with MAD

$$AW/inch \ x \ root\ depth \ x \ MAD$$

$$0.20\frac{in}{in} \ x \ 10\ in \ x\ 40\% = \ 0.8\ in\ H_2O$$

Your available water calculation will depend on your ***soil*** *and* ***crop****.*

For a soil with 0.2 in/in AWC and rooting depth of 10 inches.

Some would use a more conservative MAD (e.g., 25%).

But in this situation, the soil can hold 0.8 inches of water that is easily available to the lettuce.

Math approach with MAD

$$AW/inch \ x \ root\ depth \ x \ MAD$$

$$0.20 \frac{in}{in} \ x \ 10\ in \ x \ 40\% = 0.8\ in$$

Can we apply 1.6 inches of water to this crop/soil combination (i.e. irrigate leafy greens every 10 days)?

What if you wanted to wait 8 days between irrigations, with ET = 0.16 in/day? You would need to apply 10 x 0.16 = 1.6 inches of water to make up for the ET.

Waiting for ET to add up to 1.6 inches, depletes the soil water below the maximum allowable depletion (MAD) and the lettuce will suffer.

And if we apply 1.6 inches at or before the soil reaches MAD, the excess (1.6 – 0.8 = 0.8) inches of water will percolate below the root zone.

Multiple crops, one system

Crop	Root depth	MAD	ET peak
Lettuce	10 inches	40%	0.16 inches
Brocolli	18 inches	30%	0.27 inches
Cucumber	24 inches	50%	0.17 inches

Farms with multiple crops all served by one irrigation system can't be irrigated optimally.

These numbers aren't exactly in line with the Western OR Irrig Guide, but I'm using them to make a point.

Multiple crops, one system

Crop	Root depth	MAD	ET peak
Lettuce	**10 inches**	40%	0.16 inches
Brocolli	18 inches	**30%**	**0.27 inches**
Cucumber	24 inches	50%	0.17 inches

Choose the most limiting of the three factors. In a way, this means you are creating a sort of Frankenstein crop that shares characteristics of all of your other crops. In the example above, you will apply more water to the cukes and lettuce than they need (i.e. you will waste water) because you will schedule based on ET from broc. You will irrigate the broccoli and cukes more often than you need to (you will waste time) because you will schedule irrigations based on a shallow root zone and conservative MAD.

Putting it all together

"Well, there it goes again… and here we sit with no opposable thumbs."

Your options

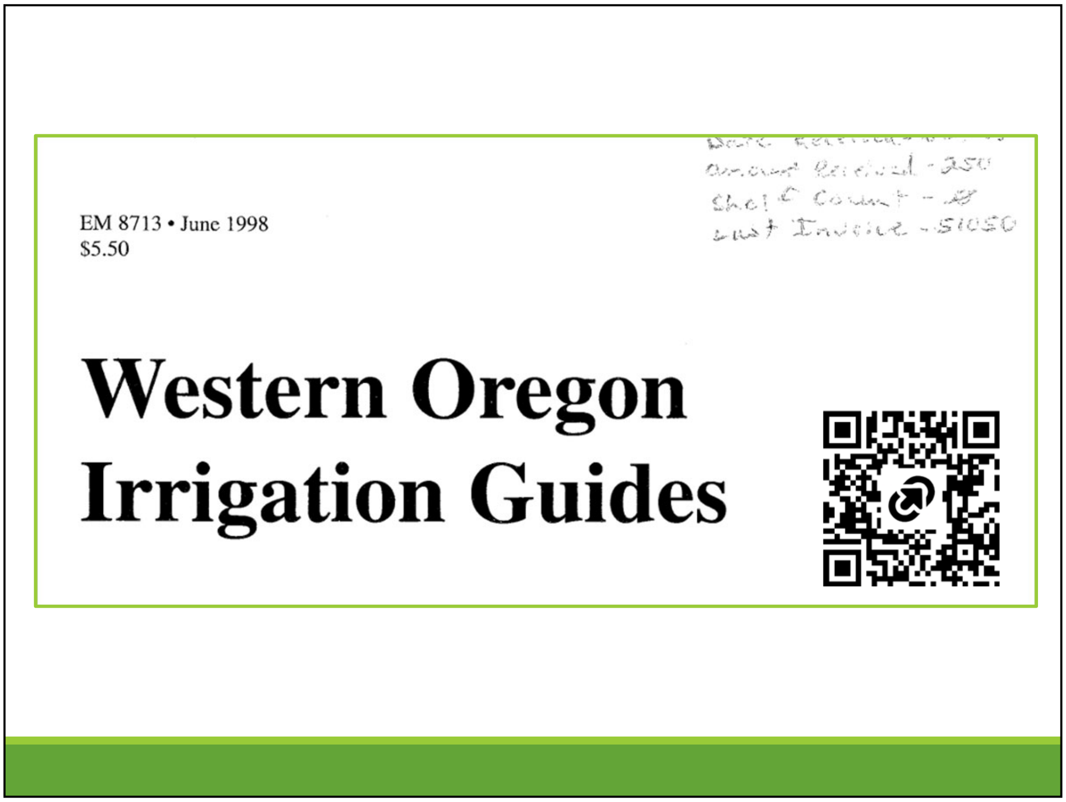
Good: *estimate average irrigation interval and rate for each month, check soil by hand*

Better: *add daily ET or moisture sensors*

Best: *add daily ET* ***AND*** *moisture sensors*

The good (all together now)

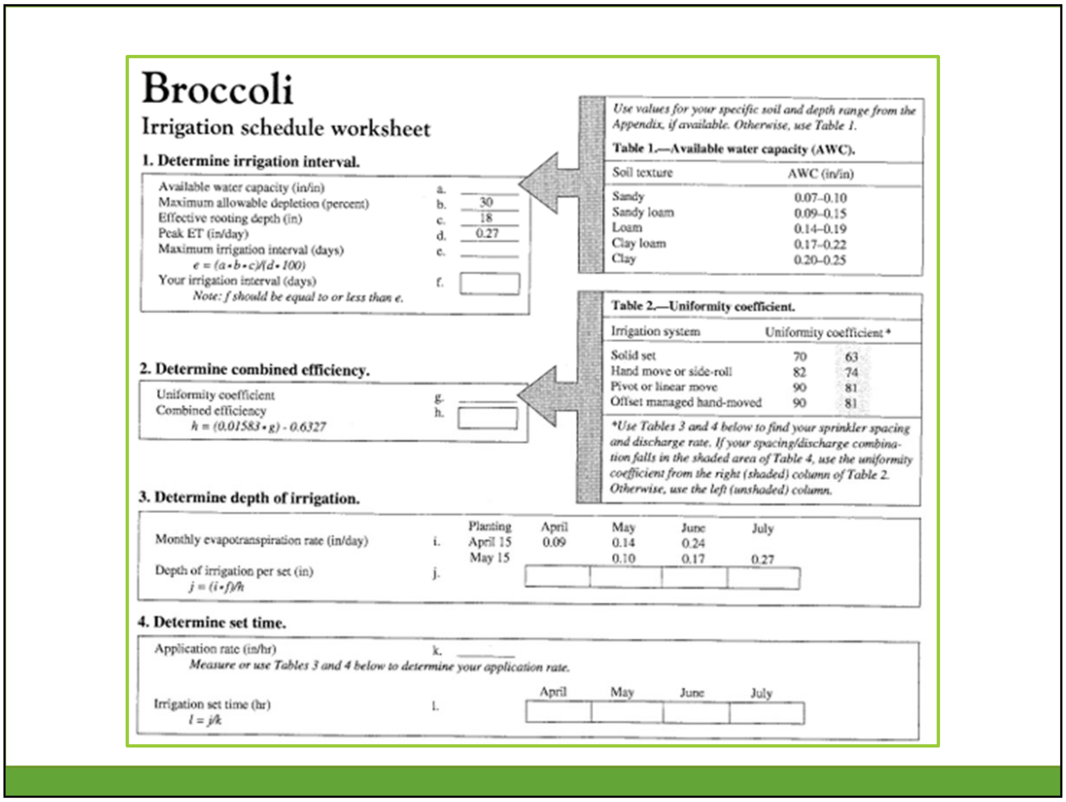
Good: *estimate average irrigation interval and rate for each month, check soil by hand*



PARTICIPANTS COMPLETE A GUIDE WITH INFO FROM:

- system calculations done earlier
- soil info done earlier

https://extension.oregonstate.edu/sites/extd8/files/documents/em8713.pdf



Broccoli

Irrigation schedule worksheet

1. Determine irrigation interval.

Available water capacity (in/in)	a.	
Maximum allowable depletion (percent)	b.	30
Effective rooting depth (in)	c.	18
Peak ET (in/day)	d.	0.27
Maximum irrigation interval (days) $e = (a \cdot b \cdot c)/(d \cdot 100)$	e.	
Your irrigation interval (days) *Note: f should be equal to or less than e.*	f.	

Use values for your specific soil and depth range from the Appendix, if available. Otherwise, use Table 1.

Table 1.—Available water capacity (AWC).

Soil texture	AWC (in/in)
Sandy	0.07–0.10
Sandy loam	0.09–0.15
Loam	0.14–0.19
Clay loam	0.17–0.22
Clay	0.20–0.25

2. Determine combined efficiency.

Uniformity coefficient	g.	
Combined efficiency $h = (0.01583 \cdot g) - 0.6327$	h.	

Table 2.—Uniformity coefficient.

Irrigation system	Uniformity coefficient*	
Solid set	70	63
Hand move or side-roll	82	74
Pivot or linear move	90	81
Offset managed hand-moved	90	81

**Use Tables 3 and 4 below to find your sprinkler spacing and discharge rate. If your spacing/discharge combination falls in the shaded area of Table 4, use the uniformity coefficient from the right (shaded) column of Table 2. Otherwise, use the left (unshaded) column.*

3. Determine depth of irrigation.

		Planting	April	May	June	July
Monthly evapotranspiration rate (in/day)	i.	April 15	0.09	0.14	0.24	
		May 15		0.10	0.17	0.27
Depth of irrigation per set (in) $j = (i \cdot f)/h$	j.					

4. Determine set time.

Application rate (in/hr) k. ______

Measure or use Tables 3 and 4 below to determine your application rate.

		April	May	June	July
Irrigation set time (hr) $l = j/k$	l.				

For example, here's the first page for broccoli.

If you have multiple crops in one bed, a good approach is to pick the crop with the highest ET (e.g., broccoli) and then use the rooting depth and MAD for the most sensitive crop (e.g., lettuce).

Broccoli

Irrigation schedule worksheet

1. Determine irrigation interval.

Available water capacity (in/in)	a.	
Maximum allowable depletion (percent)	b.	30
Effective rooting depth (in)	c.	18
Peak ET (in/day)	d.	0.27
Maximum irrigation interval (days) $e = (a \cdot b \cdot c)/(d \cdot 100)$	e.	
Your irrigation interval (days) *Note: f should be equal to or less than e.*	f.	

Use values for your specific soil and depth range from the Appendix, if available. Otherwise, use Table 1.

Table 1.—Available water capacity (AWC).

Soil texture	AWC (in/in)
Sandy	0.07–0.10
Sandy loam	0.09–0.15
Loam	0.14–0.19
Clay loam	0.17–0.22
Clay	0.20–0.25

Line e should be something like 5 – 15 days.

Line f should be 1 or more days.

2. Determine combined efficiency.

Uniformity coefficient	g.	
Combined efficiency	h.	
*h = (0.01583 * g) - 0.6327*		

Table 2.—Uniformity coefficient.

Irrigation system	Uniformity coefficient*	
Solid set	70	63
Hand move or side-roll	82	74
Pivot or linear move	90	81
Offset managed hand-moved	90	81

**Use Tables 3 and 4 below to find your sprinkler spacing and discharge rate. If your spacing/discharge combination falls in the shaded area of Table 4, use the uniformity coefficient from the right (shaded) column of Table 2. Otherwise, use the left (unshaded) column.*

For most sprinklers on small farms:

g = 70

h = 50

For drip:

95 x 0.01583 – 0.6327 = 87

(say 90%)).

The numbers in “g” and “h” are written as percents (e.g., write 90%, not 90).

3. Determine depth of irrigation.

		Planting	April	May	June	July
Monthly evapotranspiration rate (in/day)	i.	April 15	0.09	0.14	0.24	
		May 15		0.10	0.17	0.27
Depth of irrigation per set (in) $j = (i \cdot f)/h$	j.					

Remember these are average ET values.

This is showing info for two different planting dates. Pick one.

If you grow broccoli into August thru October, use:

August: 0.25

Sept: 0.20

Oct: 0.10

“f“ is the irrigation interval (days) you chose.

“h” is the efficiency (90% for drip, 50% for sprinkler)

4. Determine set time.

Application rate (in/hr) k. ______
Measure or use Tables 3 and 4 below to determine your application rate.

Irrigation set time (hr) l.
$l = j/k$

April	May	June	July

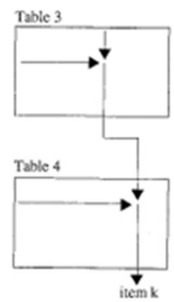
Table 3.—Calculating discharge (gpm).

Pressure (psi)	Standard tapered nozzle diameter (in)							
	3/32	1/8	9/64	5/32	11/64	3/16	13/64	7/32
35	1.5	2.7	3.40	4.16	5.02	5.97	7.08	8.26
40	1.6	2.9	3.63	4.45	5.37	6.41	7.60	8.87
45	1.7	3.2	3.84	4.72	5.70	6.81	8.07	9.41
50	1.8	3.1	4.04	4.98	6.01	7.18	8.49	9.88
55	1.9	3.3	4.22	5.22	6.30	7.51	8.87	10.30

Table 4.—Calculating application rate (in/hr).

Sprinkler spacing (ft)	by (ft)	Discharge per nozzle (gpm) from Table 3						
		2	3	4	5	6	8	10
20	20	0.48	0.72	0.96	1.20	1.44	1.93	2.41
20	40	0.24	0.36	0.48	0.60	0.72	0.96	1.20
30	30	0.21	0.32	0.43	0.54	0.64	0.86	1.07
30	40	0.16	0.24	0.32	0.40	0.48	0.64	0.80
30	50	0.13	0.19	0.26	0.32	0.39	0.51	0.64
40	40	0.12	0.18	0.24	0.30	0.36	0.48	0.60
40	50	0.10	0.14	0.19	0.24	0.29	0.39	0.48
40	60	0.08	0.12	0.16	0.20	0.24	0.32	0.40

How to use these tables



Use the calculations you made earlier for application rate.

Tables 3 and 4 are also an approximate way to estimate application rate.

“j” is the irrigation depth (inches).

So, if you choose to irrigate every X days, the set times in Step 4 will guide you to the amount of water to apply

Moisture sensing by hand

75-100% AWC

50-75% AWC

25-50% AWC

Typical silt loam shown

Upper left photo: 75% AWC is 25% MAD, so this is plenty of moisture for all crops.

Middle photo: this would be sufficient moisture for crops with MAD up to 50%.

But unless you have a crop like pasture grass with MAD > 50%, the soil pictured at lower right is causing crop stress.

Silt loam

50-75%:	ball forms, no crumbs break off
75-100%:	ball forms, moisture is on fingers
25-50%:	ball forms, dry crumbs break off

Photos of moisture in other soil textures:

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wy/soils/?cid=nrcs142p2_026831

The better – you can do it

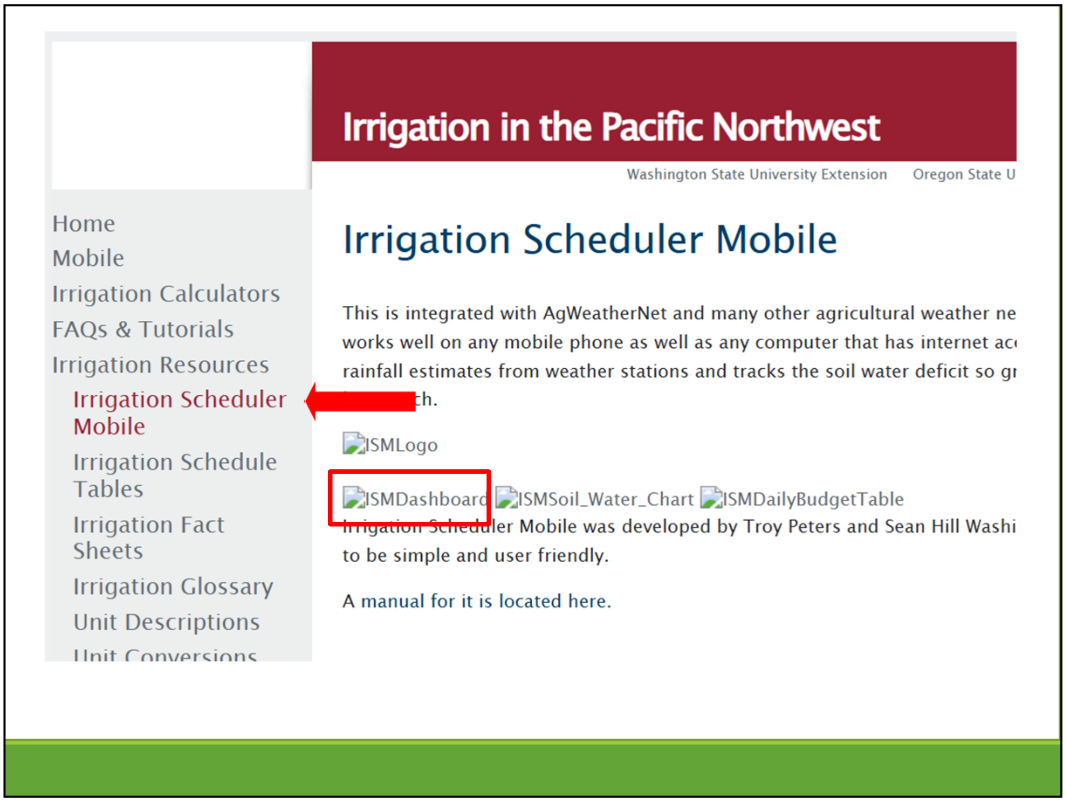
Better: *add daily ET*

Use the Western OR Irrigation Guide, AND use estimates of actual daily ET.

We used the Irrigation Calculators at this site to determine rates of water application for sprinklers and drip.

Click Irrigation Resources and then select ISM Dashboard.

https://irrigation.wsu.edu/index.php



We used the Irrigation Calculators at this site to determine rates of water application for sprinklers and drip.

Click Irrigation Resources and then select ISM Dashboard.

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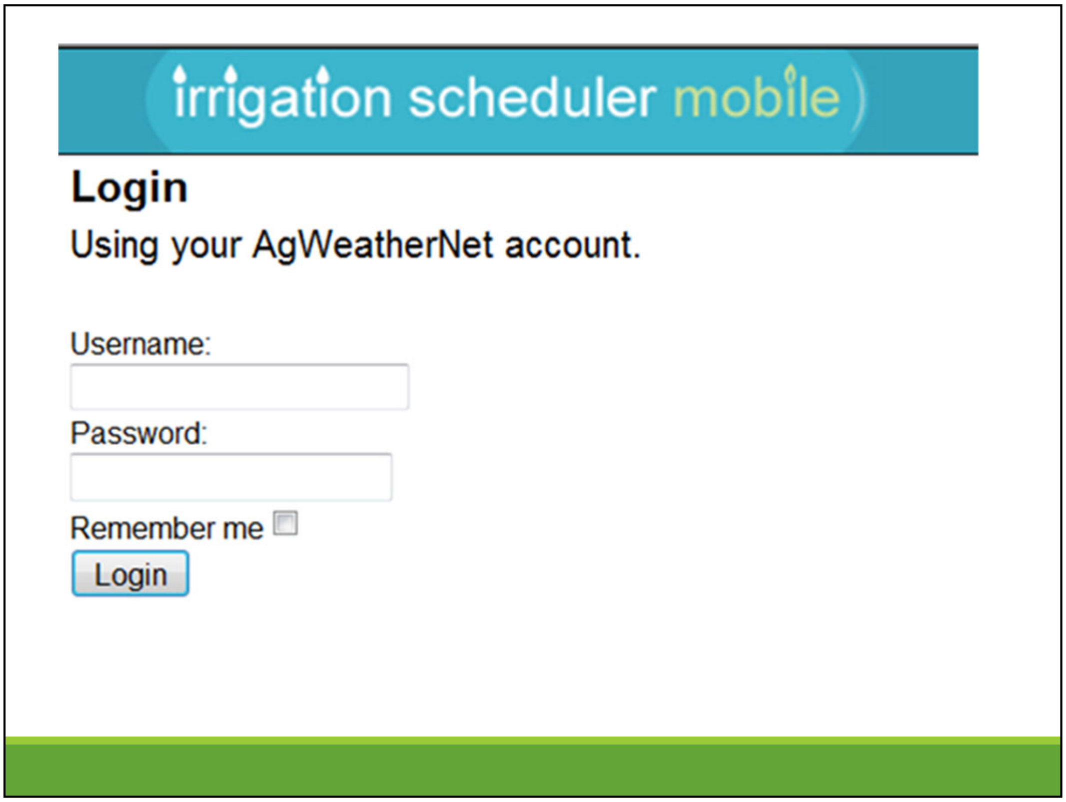
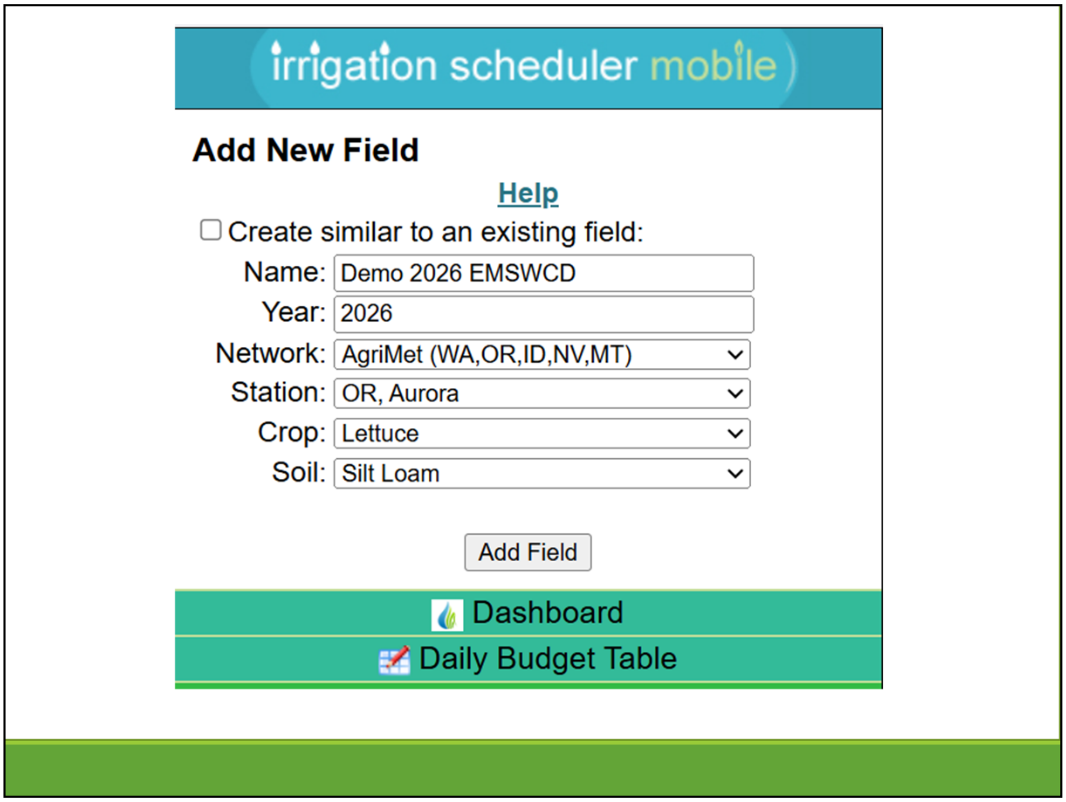
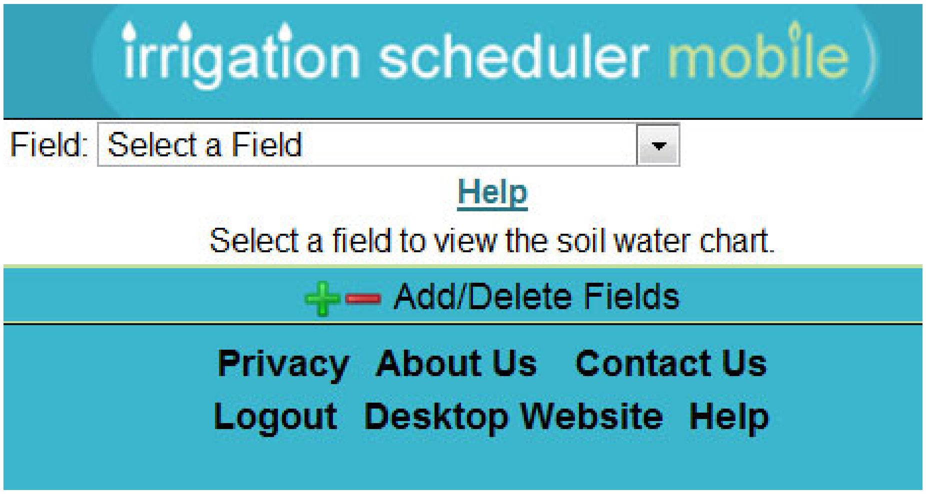


This PNW online system that works on a computer or cell phone.
You will need to register for a AgWeatherNet account (free).



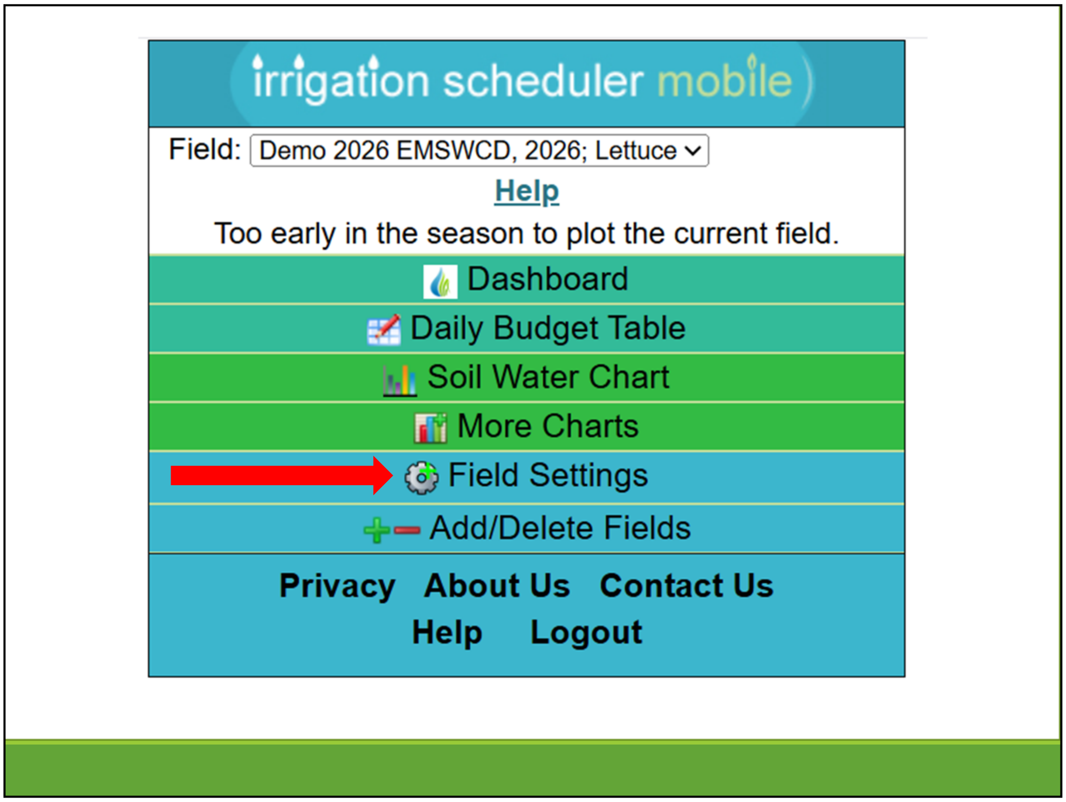
I know Aurora might seem like a long way from your farm. Rainfall might be different, but ET rates will be pretty close. You can search around for other stations on other networks.

Here I added a new field for our demo.



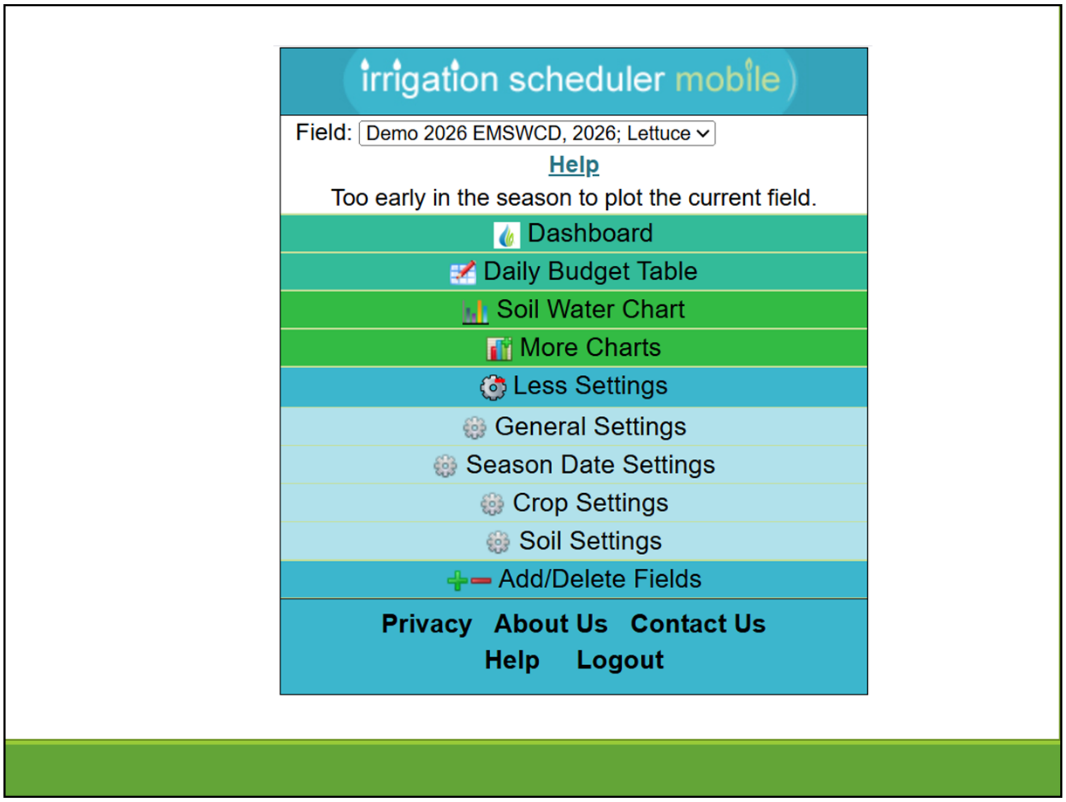
http://irrigation.wsu.edu/

http://www.irrigation.wsu.edu/mobileirr/



Select your field or fields.

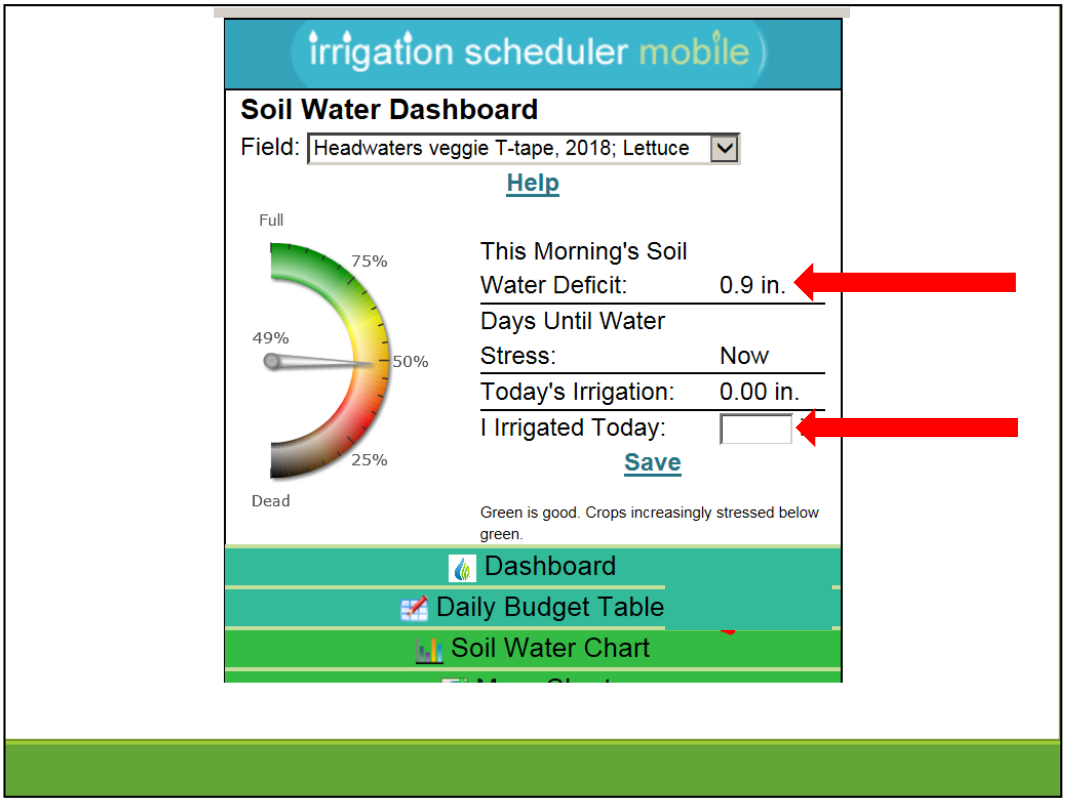
Click through all of the field settings.



Adjusting settings is intuitive.

There's a lot of flexibility for you to enter your own info, including:

- Rooting depth
- Available water capacity
- Crop season
- MAD

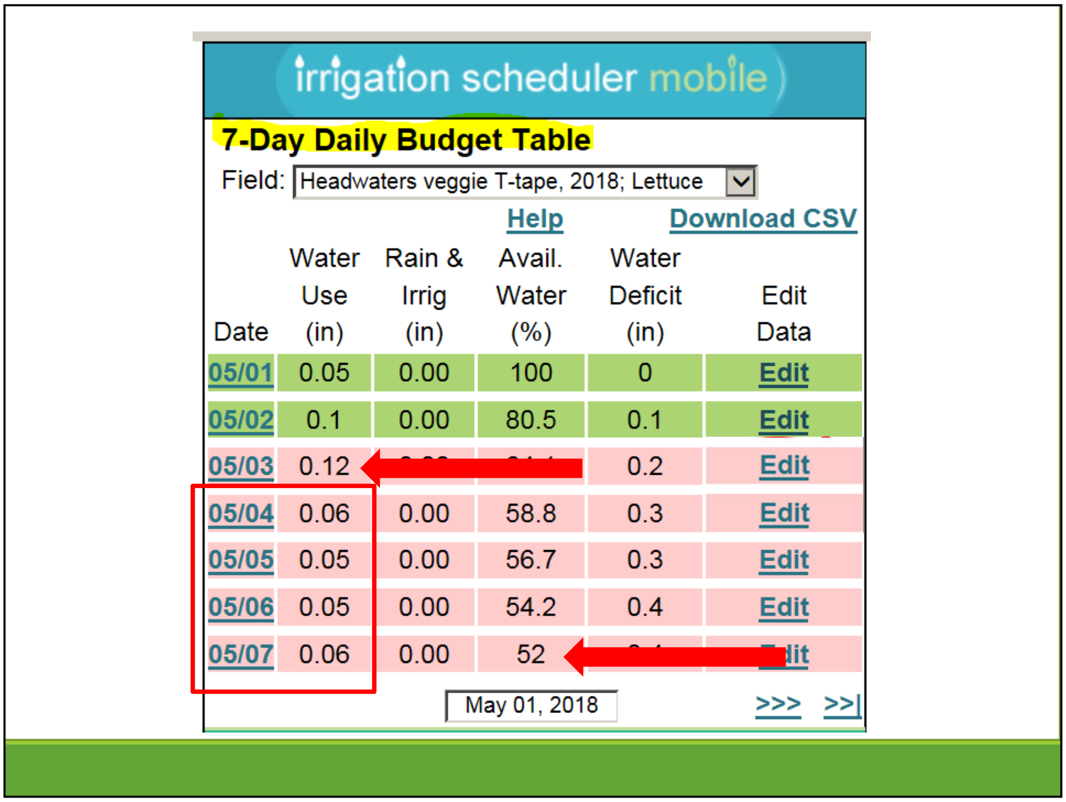


This screen is only available during the growing season.

The soil water dashboard provides a fuel gauge type reading of estimated soil moisture based on your soil and crop, ET from the weather station you select, rainfall, and irrigation.

This is where you enter your irrigation amount.

You should not apply water in excess of the deficit. But you don't want the gauge to get into the red zone.



irrigation scheduler mobile

7-Day Daily Budget Table

Field: Headwaters veggie T-tape, 2018; Lettuce

Help   Download CSV

Date	Water Use (in)	Rain & Irrig (in)	Avail. Water (%)	Water Deficit (in)	Edit Data
05/01	0.05	0.00	100	0	Edit
05/02	0.1	0.00	80.5	0.1	Edit
05/03	0.12	[illegible]	[illegible]	0.2	Edit
05/04	0.06	0.00	58.8	0.3	Edit
05/05	0.05	0.00	56.7	0.3	Edit
05/06	0.05	0.00	54.2	0.4	Edit
05/07	0.06	0.00	52	[illegible]	[illegible]

May 01, 2018   >>> >>|

The tool forecasts precip and ET into the future based on weather predictions. These are shown as pink cells.

In this example, May 3 is predicted to have a higher ET (first column, labeled "Water Use") and then the weather forecast is for cooler weather for May 4-7. But if no irrigation is applied, the available soil water is predicted to be down to 52% by May 7, which means lettuce crops will have been stressed. Remember that MAD for lettuce is 40% AWC .

A little tricky: if MAD is 40%, you want to irrigate before the AWC reaches 60%.

I.e., subtract 100% - MAD to find the AWC that indicates you are getting close to danger zone.

(use the water in the mason jars to illustrate that 100% - MAD ("easy" water) = %AWC that holds the "hard" water)

You can edit daily values too.

Data from Headwaters Farm

Weather Conditions for EMHWF

Current Time: 02/04/2026 15:55 PST

Most Recent Weather Conditions at: 02/04/2026 14:45 PST

Graphical Links	14:45	Max Since 0:00 (PST)	Min Since 0:00 (PST)	24 Hour Maximum	24 Hour Minimum
Temperature	58.6° F	60.1 at 14:25	44.6 at 8:20	60.1 at 14:25	44.6 at 8:20
Dew Point	42.0° F	43.6 at 13:10	39.2 at 8:20	43.6 at 13:10	39.2 at 8:20
Wet bulb temperature	49.8° F	51.1 at 14:20	42.1 at 8:20	51.1 at 14:20	42.1 at 8:20
Relative Humidity	54%	81 at 8:45	53 at 14:25	81 at 8:45	53 at 14:25
Wind Speed	5.4 mph	13.5 at 14:35	3.1 at 4:45	13.5 at 14:35	3.1 at 4:45
Wind Gust	13.5 mph	13.5 at 14:45	8.2 at 9:15	28.5 at 21:10	8.2 at 9:15
Wind Direction	ESE	-	-	-	-
Solar Radiation	286.0 W/m*m	467.0 at 12:45	0.0 at 7:10	467.0 at 12:45	0.0 at 7:10
Evapotranspiration	0.0000 in	0.0100 at 14:00	0.0000 at 14:45	0.0100 at 14:00	0.0000 at 14:45
Battery Voltage	13.66 Volt	13.90 at 9:15	12.09 at 7:25	13.90 at 9:15	12.09 at 7:25

If you are farming at or near Headwaters Farm, you could get ET data from its weather station, which is not part of the network used by Irrigation Scheduler.

For weather, including ET, at the East Multnomah Headwaters Farm (EMHWF), see Mesowest.

You could average the ET max and ET min and then overwrite the data in the Irrigation Scheduler.

You might try comparing the EMHWF and Aurora ET values for a few dates. If the values are pretty close, you might choose to just use the Aurora values (or choose another station from the Irrigation Scheduler), which are updated daily in Irrigation Scheduler.

Reference is Mesowest:

https://mesowest.utah.edu/cgi-bin/droman/meso_base_dyn.cgi?stn=EMHWF

7-Day Daily Budget Table

Field: Headwaters veggie T-tape, 2018; Lettuce

Help Download CSV

Date	Water Use (in)	Rain & Irrig (in)	Avail. Water (%)	Water Deficit (in)	Edit Data
05/13	0.14	0.24	94	0.1	Edit
05/14	0.14	0.00	84.6	0.2	Edit
05/15	0.09	0.00	79.3	0.3	Edit
05/16	0.1	0.24	89.3	0.2	Edit
05/17	0.1	0.00	84.1	0.3	Edit
05/18	0.1	0.00	79.3	0.4	Edit
05/19	0.1	0.24	87.9	0.2	Cancel

Irrigation: 0.24 in

☑ Reset/Correct % Available Water Content

Set To: 75 %

☐ Add Notes

Save

You can also look back in time and make entries you may have skipped on really busy days.

The tool allows you to reset Available Water content, but this is a little tricky, especially for the common soil moisture meters like Watermarks. This is tricky, tho, because Watermarks read in cb and this tool uses % AWC.

Your options

***Best:** use daily ET **and** moisture sensors*

Use the Western OR Irrigation Guide, the irrigation scheduler, AND soil moisture measurements.

Moisture sensing gadgetry

- *Tensiometer*
- *Gypsum block (Watermark)*
- *Time domain reflectometery (Acclima)*
- *Pressure chamber for leaf petioles*
- *Systems that log data or even automate irrigation*

There are a variety of automated systems that turn irrigation on and off based on soil moisture and/or ET.

Demo Watermark.

This hand held device reads soil moisture tension in centibars (cb), which is the same thing as kilopascals (kPa).

Moisture tension is how hard a plant works to extract moisture: higher numbers are drier soil and the plant is working harder.

The reader goes up to 200 cb, which is really dry.

Sensors are about $50

Meter is around $175

Data logger (optional) is $500 to $1,000.

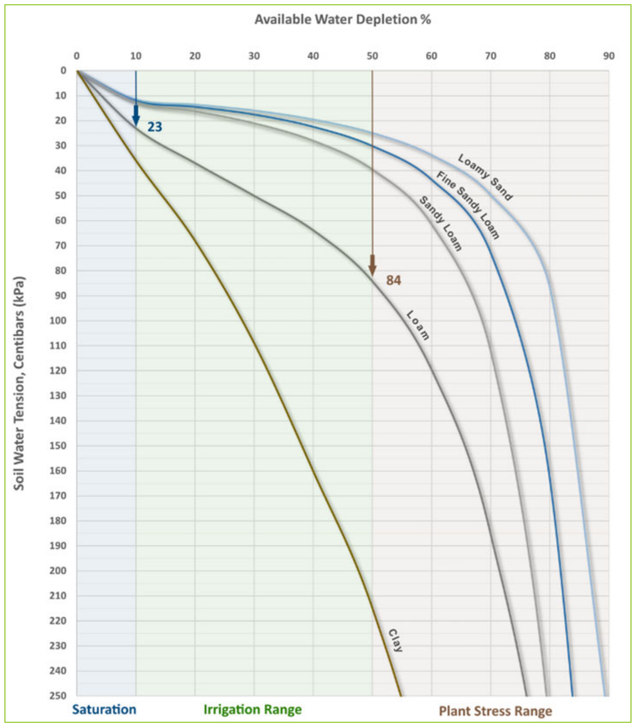
BUT, the sensor is actually measuring electrical resistance, acting like an ohm meter, and then the device converts that resistance to soil moisture tension. The measurement indicates how difficult it is for a plant to extract water.

Soil moisture tension is the same as soil moisture potential but opposite sign. E.g., for tension = 50 cb, potential = -50 cb.

There are charts that convert soil moisture tension.“soil moisture potential”). Those charts vary by soil texture and organic matter content. In Dean’s opinion, those charts are not useful in using Watermarks.

But for a loam, real rough conversions are:

- Field capacity 10 - 20 cb
- Irrigate at 30 - 50 cb
- Very dry > 80 cb
- PWP > 200 cb (the sensors only read up to 200 cb)

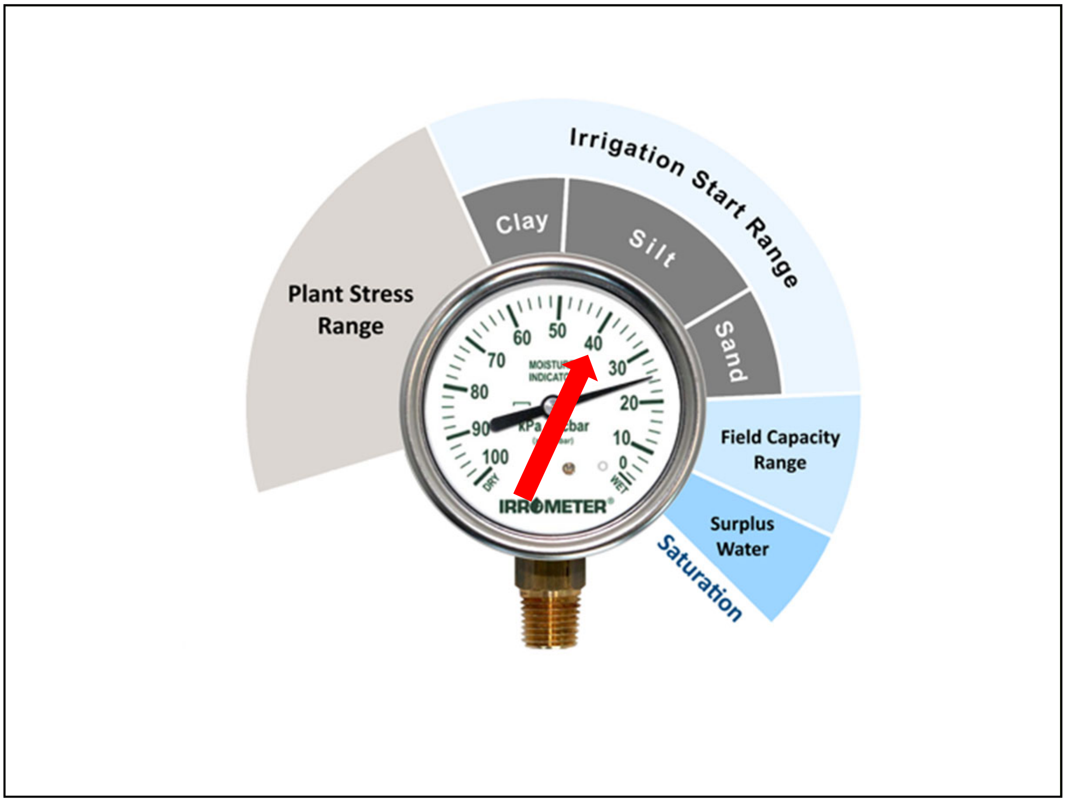


Here's an example of % available water capacity vs. tension (cb).

- curves are different depending on texture (and organic matter)

- curves are not linear

- curves tend to show a lot of available water at fairly high tension. E.g. for loam, this curve shows AWC = 50% at 84 cb. But, Dean's experience is that 84 cb on a Watermark sensor is really dry.



So Watermarks are useful to:

- Tell you when to irrigate.
- But not how much water to apply.

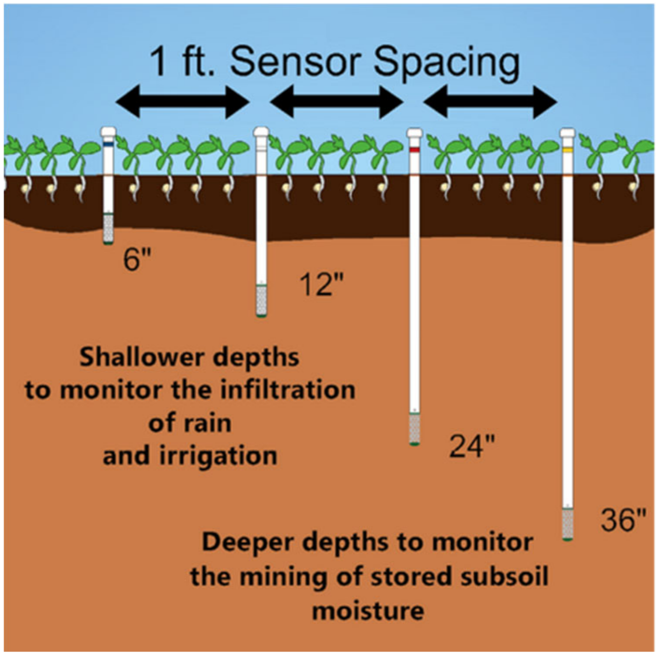


Diagram by Mississippi State Univ.

Inserting the sensors into plastic pipe makes the operation efficient.

Some instructions call for using ½ inch Class 315 PVC (aka SDR 13.5), but ¾ inch SDR 11 CPVC also works and might be easier to find.

Drill 3/16” hole ¼ “ above bottom of pipe and then align this hole with the slot in the sensor when gluing them together.

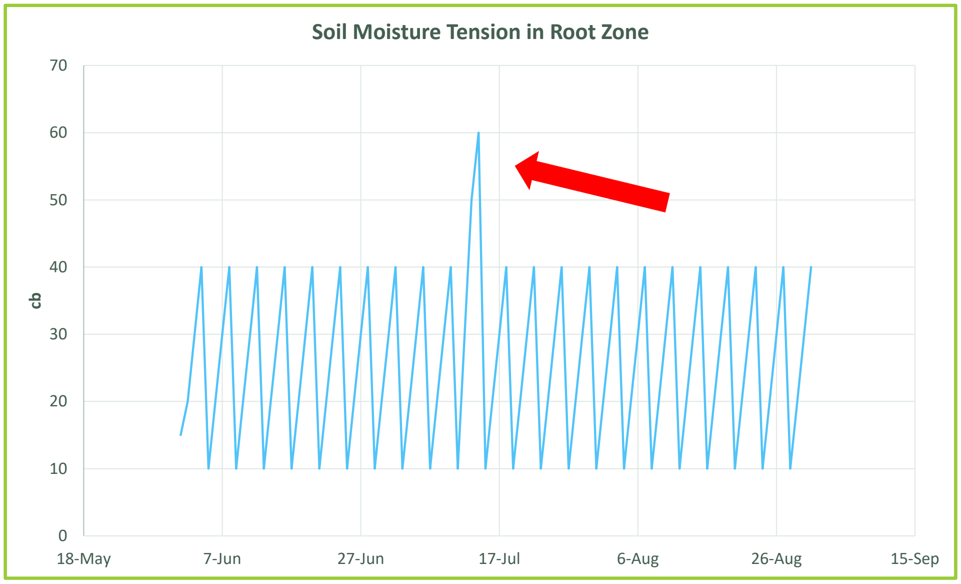
Measure depth from a point 0.8 inches above the bottom of the sensor (this is the point where most water infiltrates the sensor.

Place sensors at different depths, including one below the “root zone” you plan to irrigate.

Then experiment with application amount to avoid watering to the deep sensor.

QR codes from Mississippi State Univ sites:

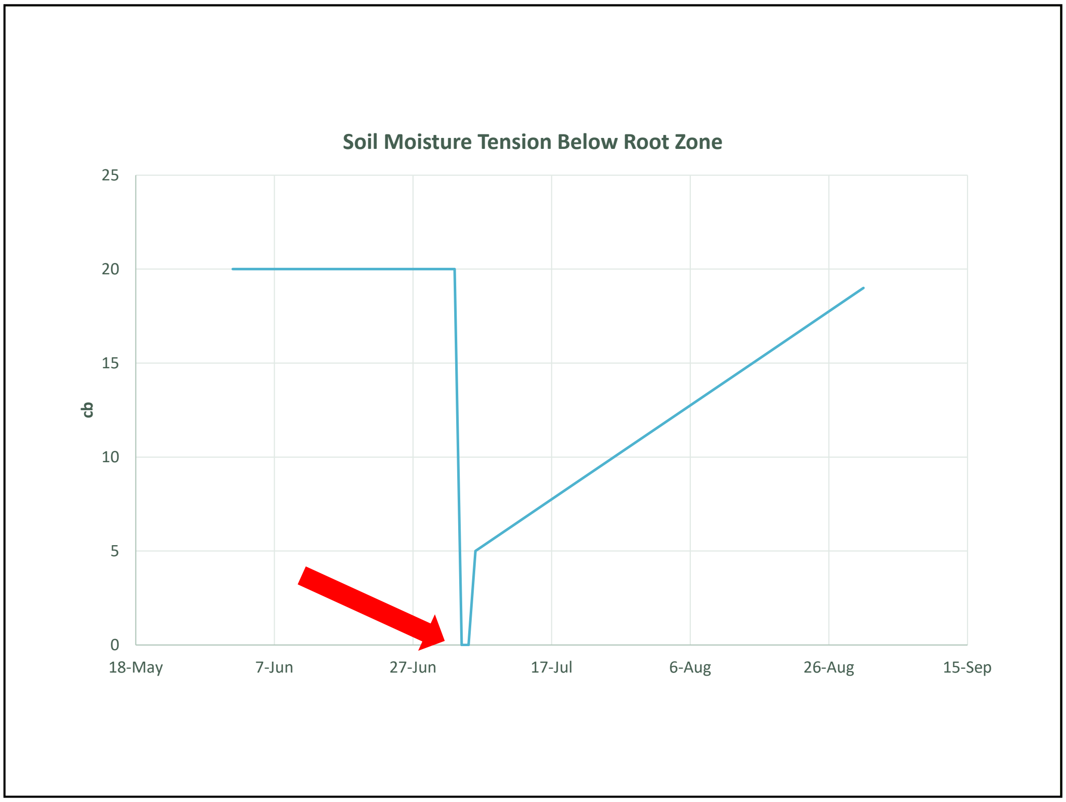
- Construction of sensors in PVC: https://www.irrometer.com/pdf/ext/P3538_Web.pdf
- Installation of sensors in field: https://www.irrometer.com/pdf/ext/MSU%20EXT%20Watermark%20Installation%20Procedures.pdf



Remember, higher tension means drier soil.

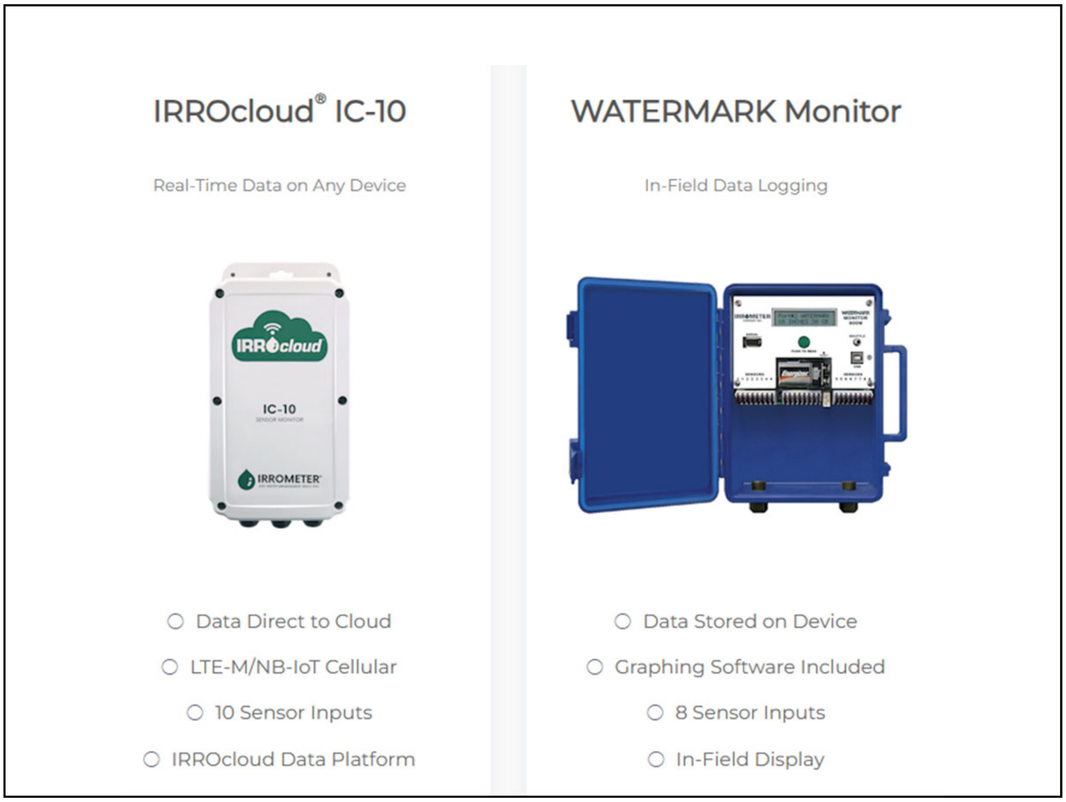
In this example, they probably waited too long to irrigate if moisture hit 60 cb.

Dean made this chart with simplified pretend readings in order to illustrate how the readings work. Real life readings are “noisier.”



In late June, irrigation water reached the deep sensor.
This indicates too much water applied and it percolated down below root zone.

These are also simplified pretend data made up by Dean.



The company (Irrometer) also sells data loggers and data loggers that upload to the cloud.

There are other companies that sell gadgets like this.

Last note: Watermarks should be replaced about every 5 years.

Goals we set in the beginning

1. Estimate how much water your crops need.

2. Know how much water your system provides.

3. Determine when to turn system on and how long to run it.

1. Veg crops in Willamette Valley have peak ET of 0.16 to 0.27 inches per day.

2. You now have access to online tools that calculate application rates in inches per hour for sprinklers and drip.

3. The Western Oregon Irrigation Guides tell how often to irrigate and how long to run the system based on average ET values.

The WSU Irrigation Scheduler and tools like Watermark sensors add more accuracy because they work on actual ET or actual soil moisture data.

One last thing: staying legal

- *Water rights specify how you may irrigate:*
  - *Rate (gallons per minute)*
  - *Total amount (inches per year)*
  - *Dates*
- *See watermaster for help:*
  amy.j.landvoigt@water.oregon.gov
  10722 SE Highway 212
  Clackamas, OR 97015
  503-312-1743

Goya, *the Third of May 1808*

And justice for all

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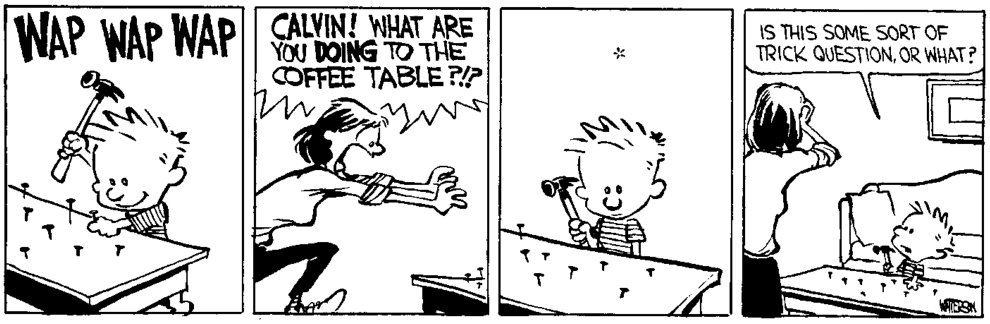
Questions?


WAP WAP WAP
CALVIN! WHAT ARE YOU DOING TO THE COFFEE TABLE ?!?
IS THIS SOME SORT OF TRICK QUESTION, OR WHAT ?
WATERSON

Vonnoh, *Coquelicots*