Vineyard Irrigation Management

"Advanced" Tools for efficient irrigation

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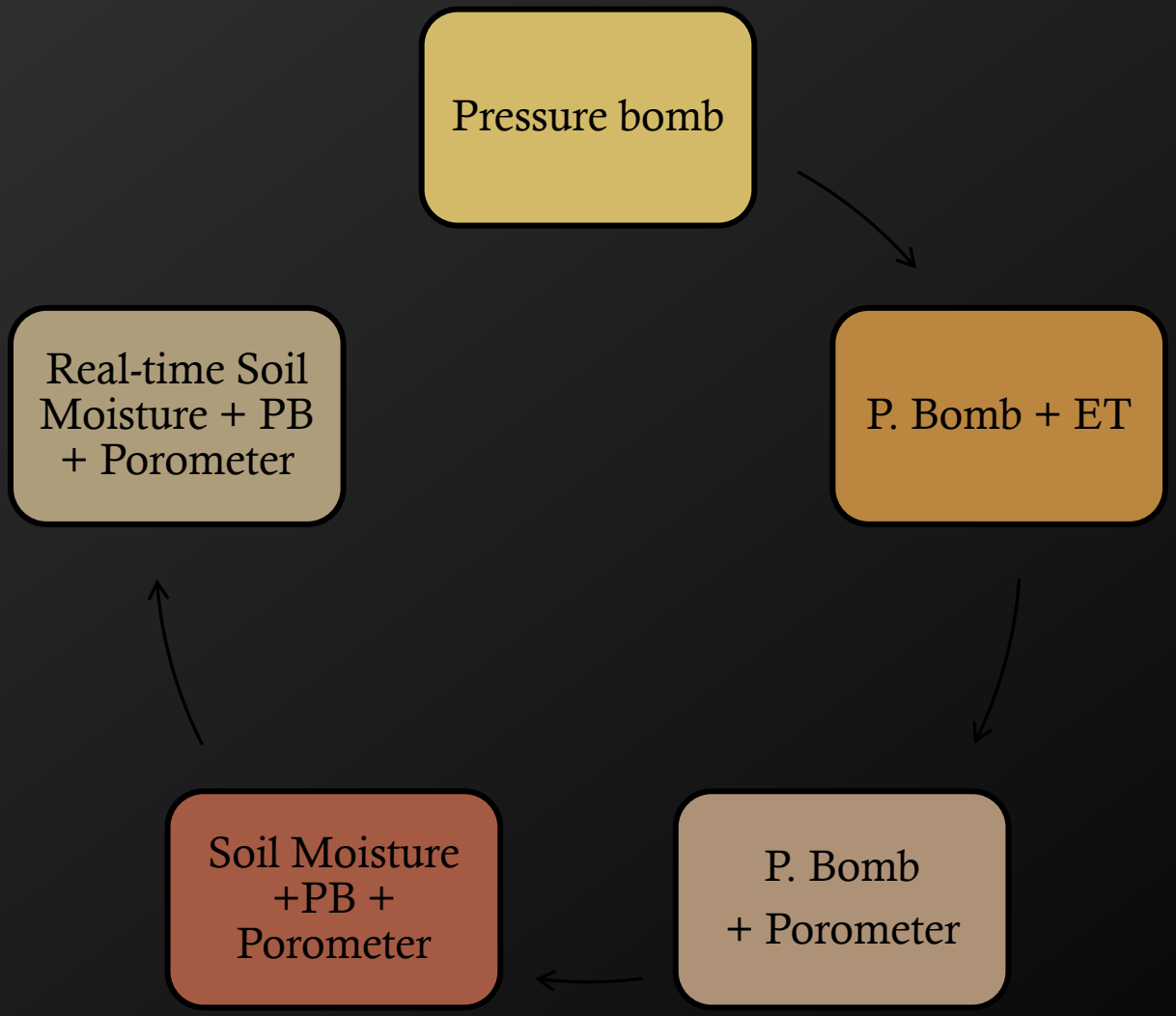
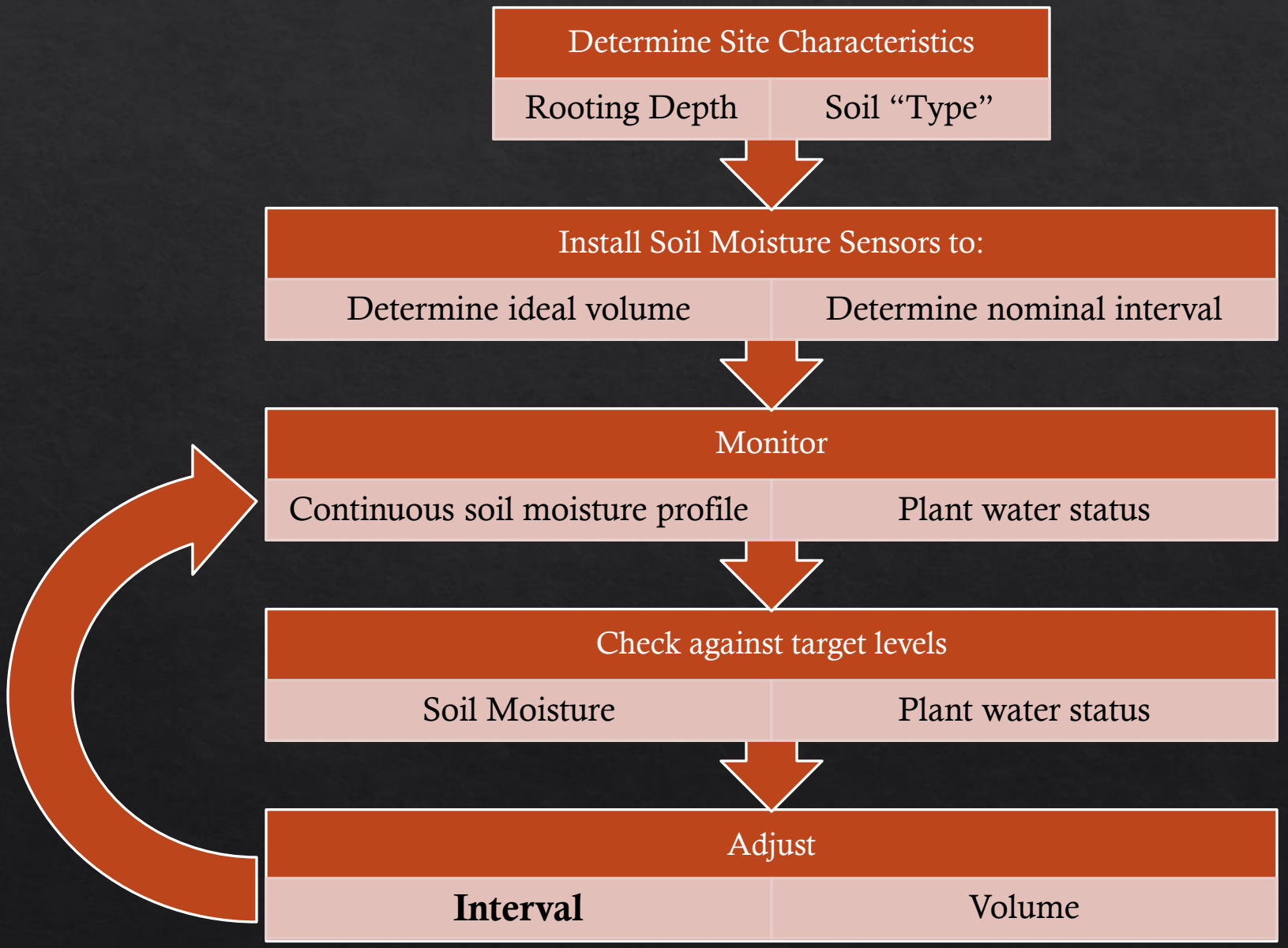


Objectives

- To discuss a simplified irrigation management scheme based on continuous soil moisture measurements and supported with plant water status measurements
- Focus on soil moisture dynamics
- Benefits of real-time
- Some case studies

Irrigation Flowchart



Irrigation Scheduling

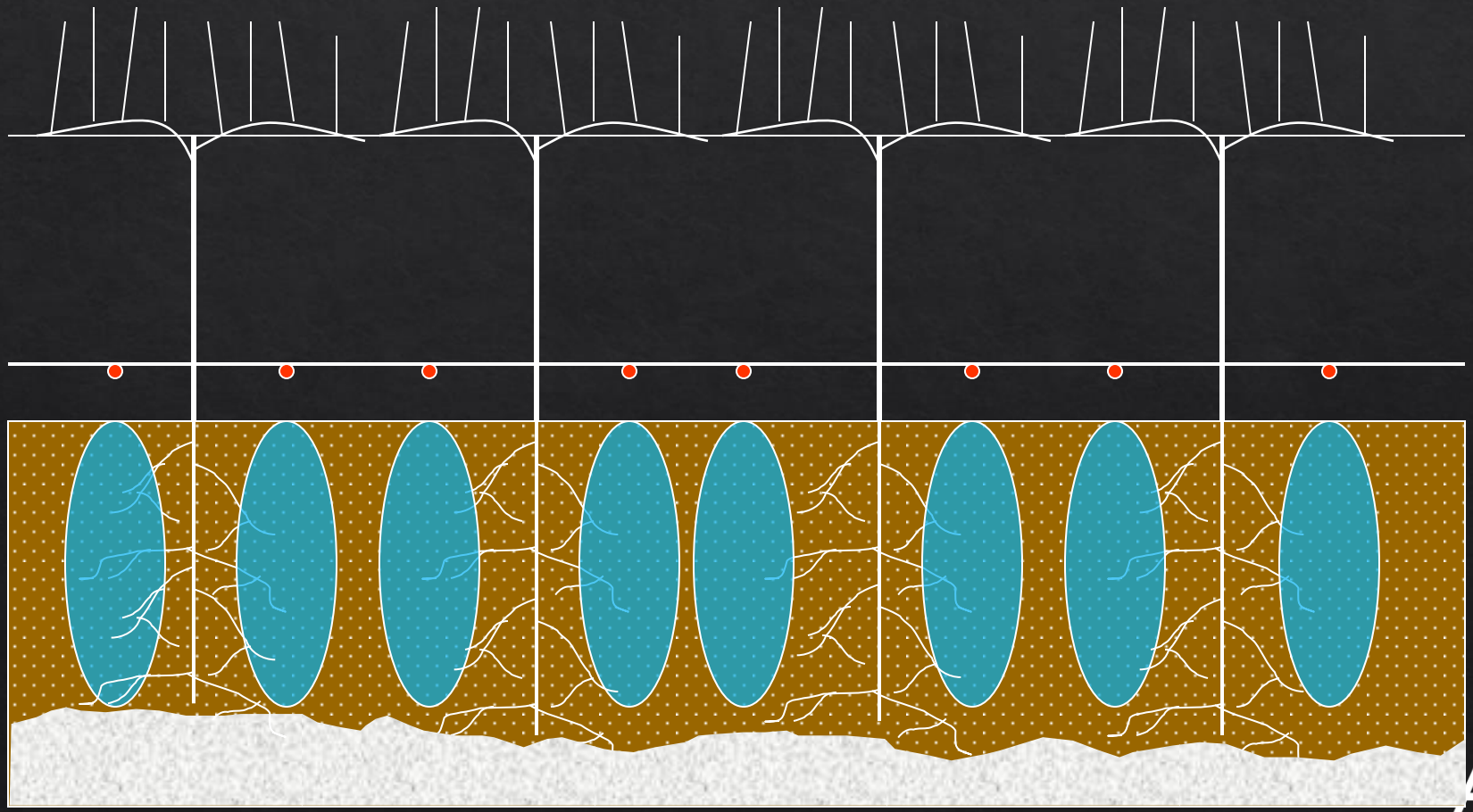
- Volume and Interval
- Need to learn about your soils and your root systems

	Shallow (< 24”)	Deep (>36”)
Light Textured and/or gravelly	Very Low Vol. & Very Frequent	Moderate Vol. & Frequent
Heavy Textured	Low Vol. & Frequent	High Volume & Infrequent

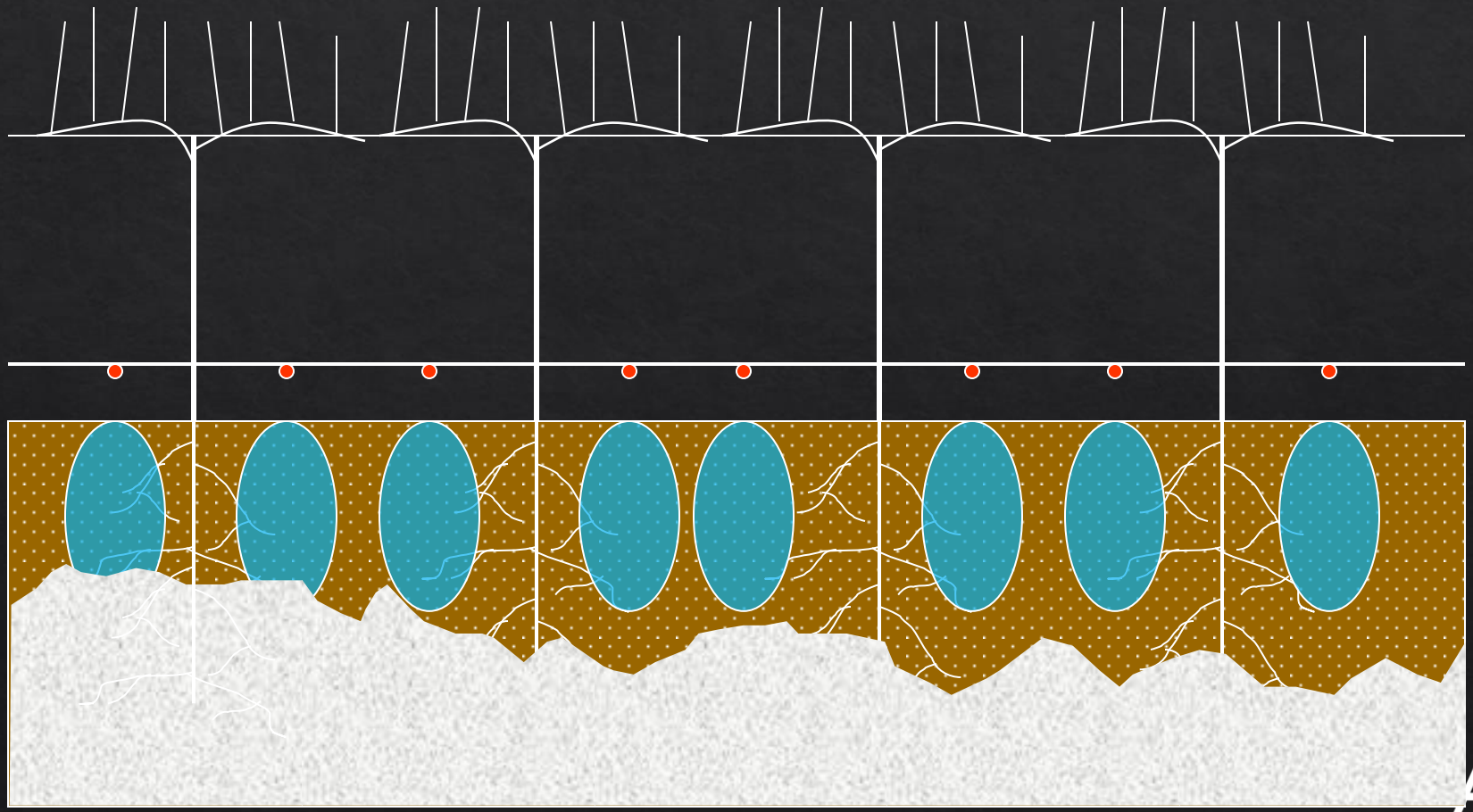
Hillsides

Valley Floor

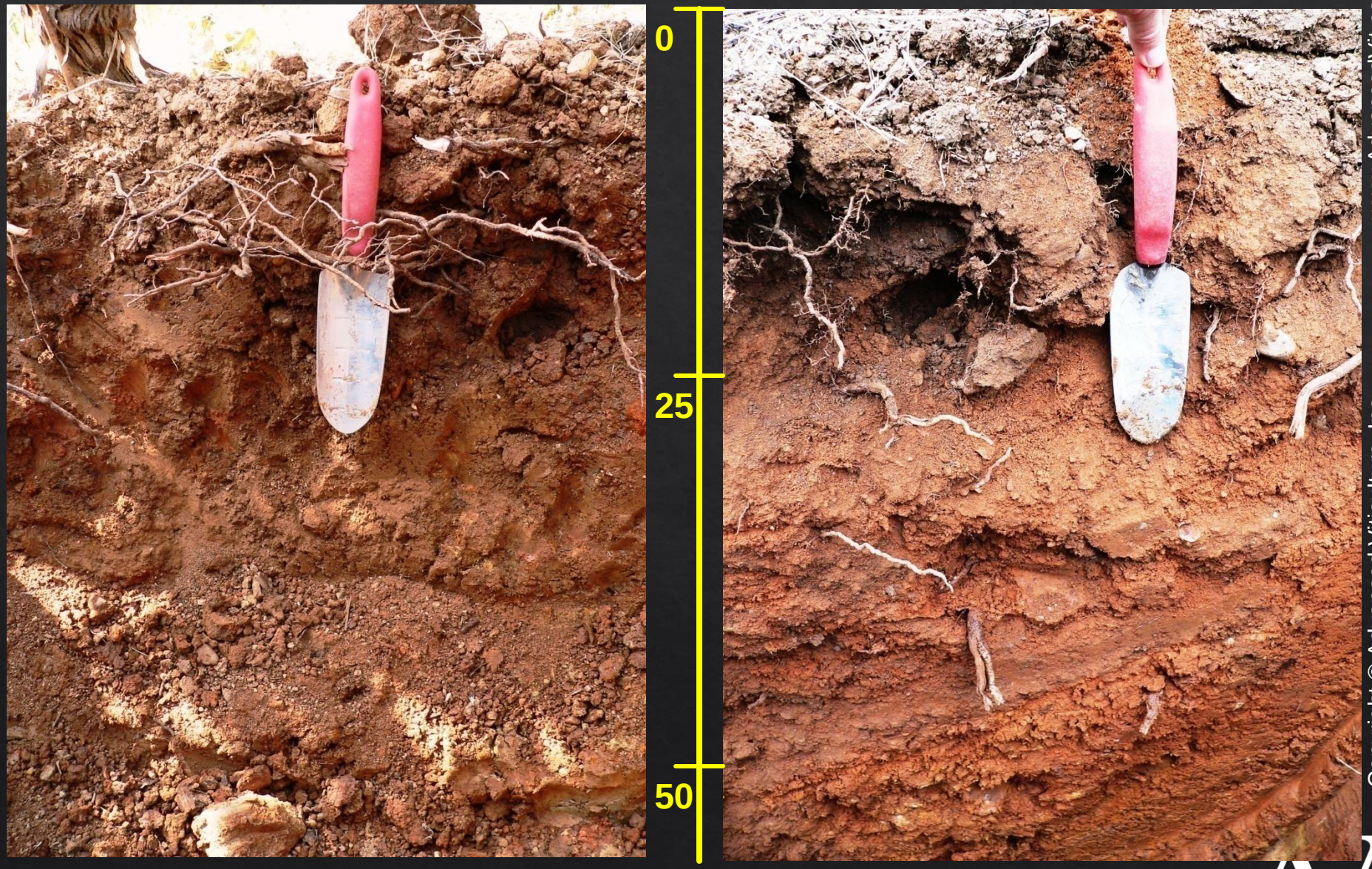
Proper volume and interval



Proper volume and interval

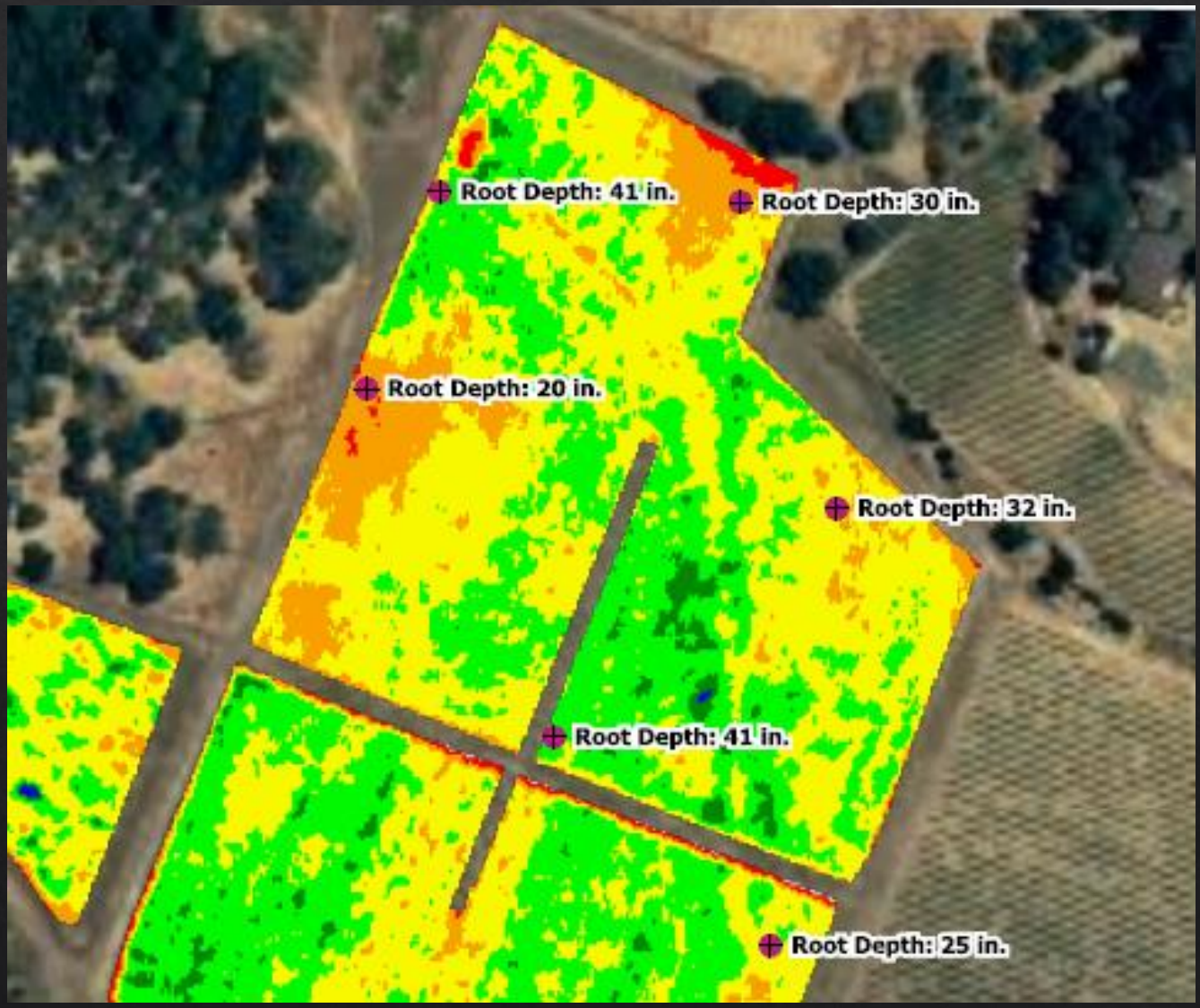


Identify rooting depth



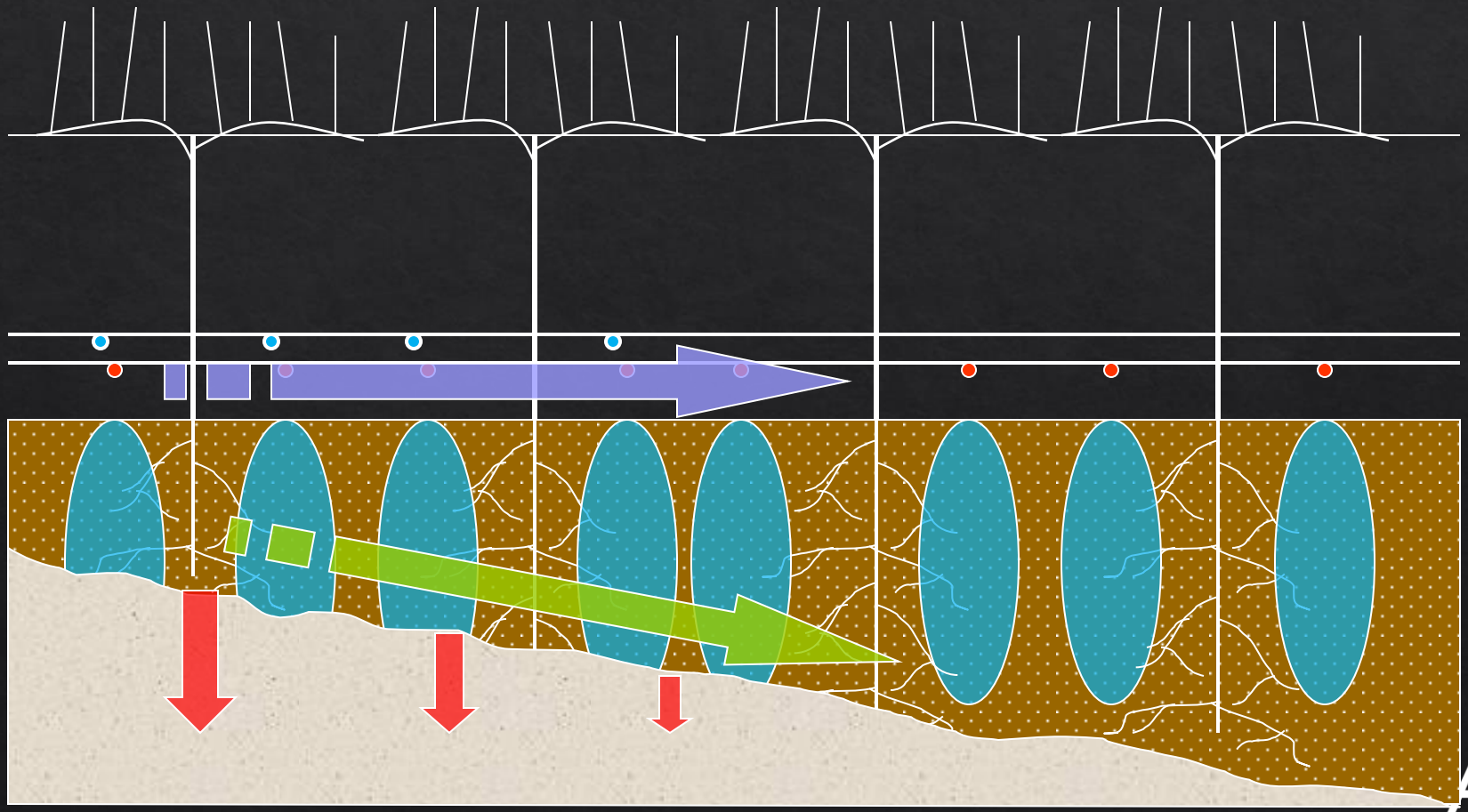
Depths are approximate (cm)

Rooting depth map



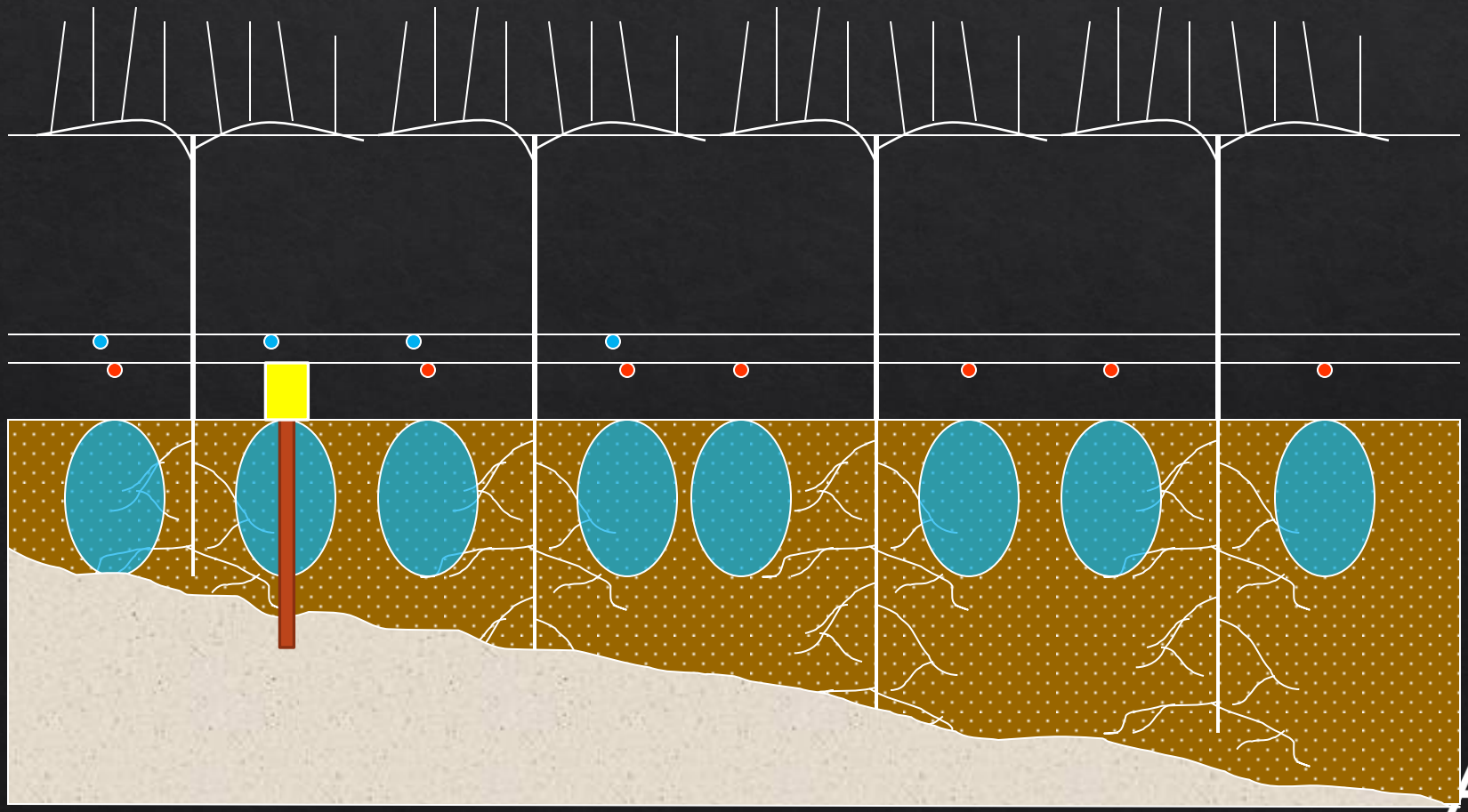
Irregular root zone and/or soil

Determining proper volume



Irregular root zone and/or soil

Irrigation volume to weakest portion of block



Monitoring

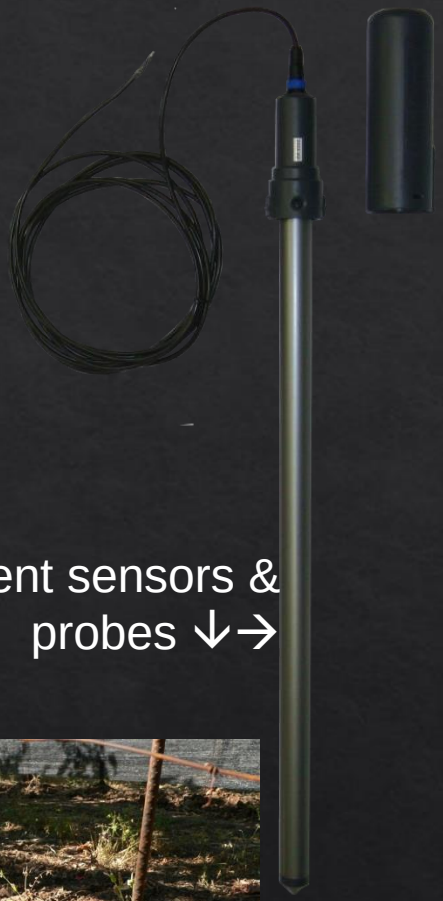
- Monitoring is “feedback” used to adjust irrigation schedule
- Methods include:
  - Soil Moisture: Discrete; Profile; Portable; continuous-logging
  - Visual Indicators – shoot elongation rates, shoot tips, droopy tendrils, leaf sun-avoidance
  - Plant water status instruments:
    - Pressure Chamber
    - Porometer
    - Sap Flow

Soil Moisture Measurement

- Measure at multiple levels to determine depth of irrigation
- Measure continuously (electronic sensing)!
- For drip irrigation, measure close to the dripper (4in)
- Use to determine nominal irrigation volume per application
- Use to determine nominal irrigation interval between applications
- Use in conjunction with plant moisture status measurements to precisely adjust intervals

Electronic Soil Moisture measurement

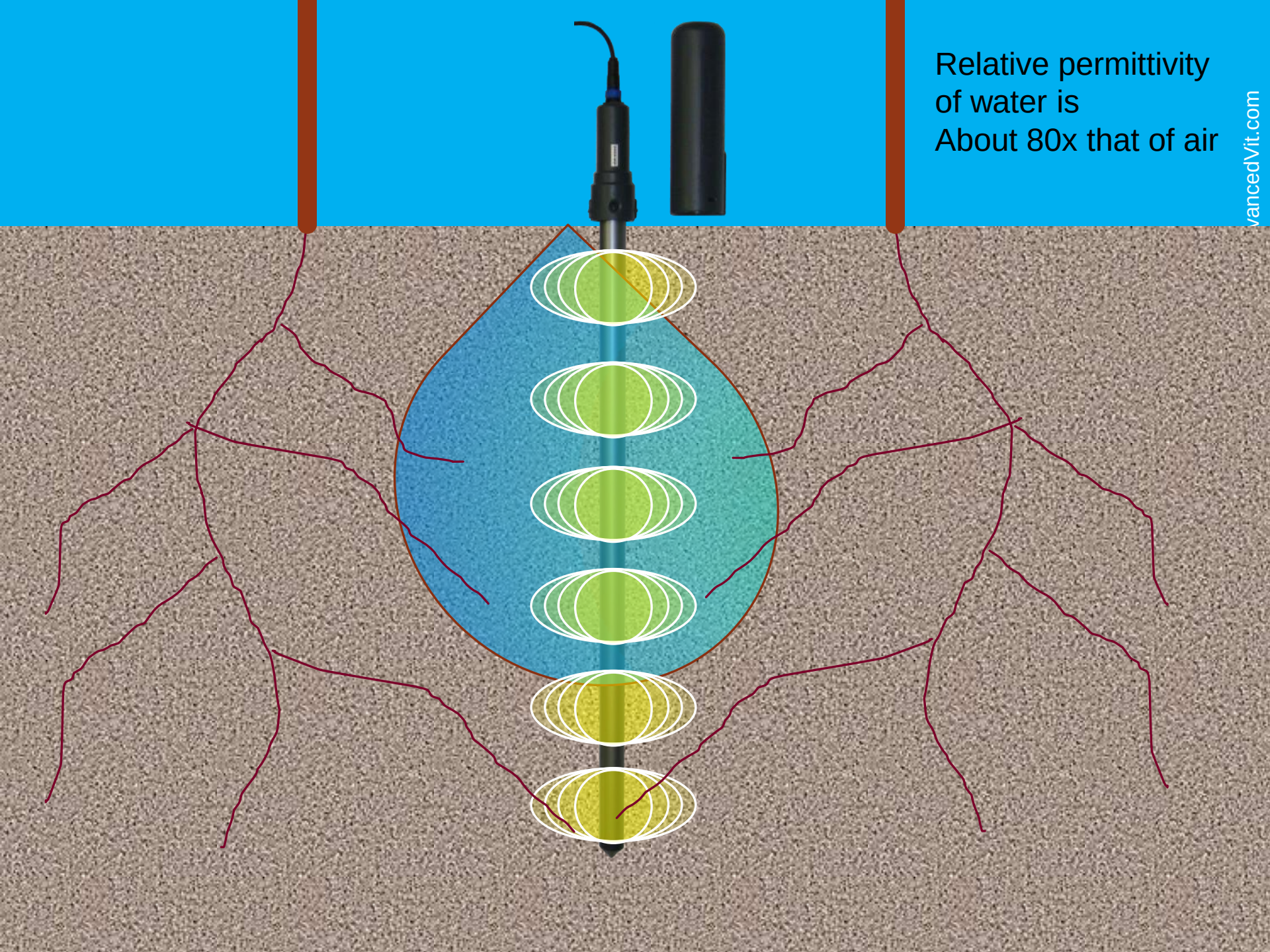
← Soil matric potential sensors



Soil water content sensors & probes ↓→

Aquacheck Probes

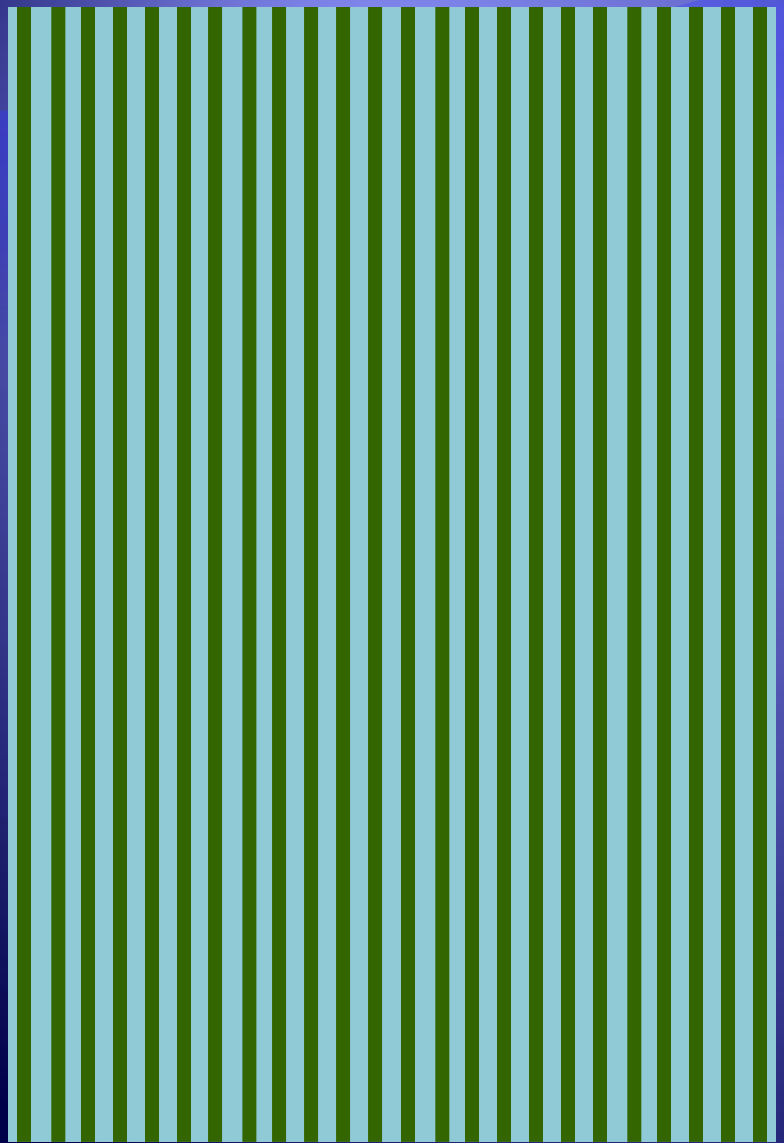
- Based on the Sentek / C-probe
- Water content based on capacitance sensors
- 6 sensors per probe
- 4” to 8” depth intervals depending upon length
- Available in 32 to 60” lengths
- Advantages over predecessors:
  - Thinner diameter – easier to install
  - Epoxy-filled for durability and less thermal noise
  - Very clean signal

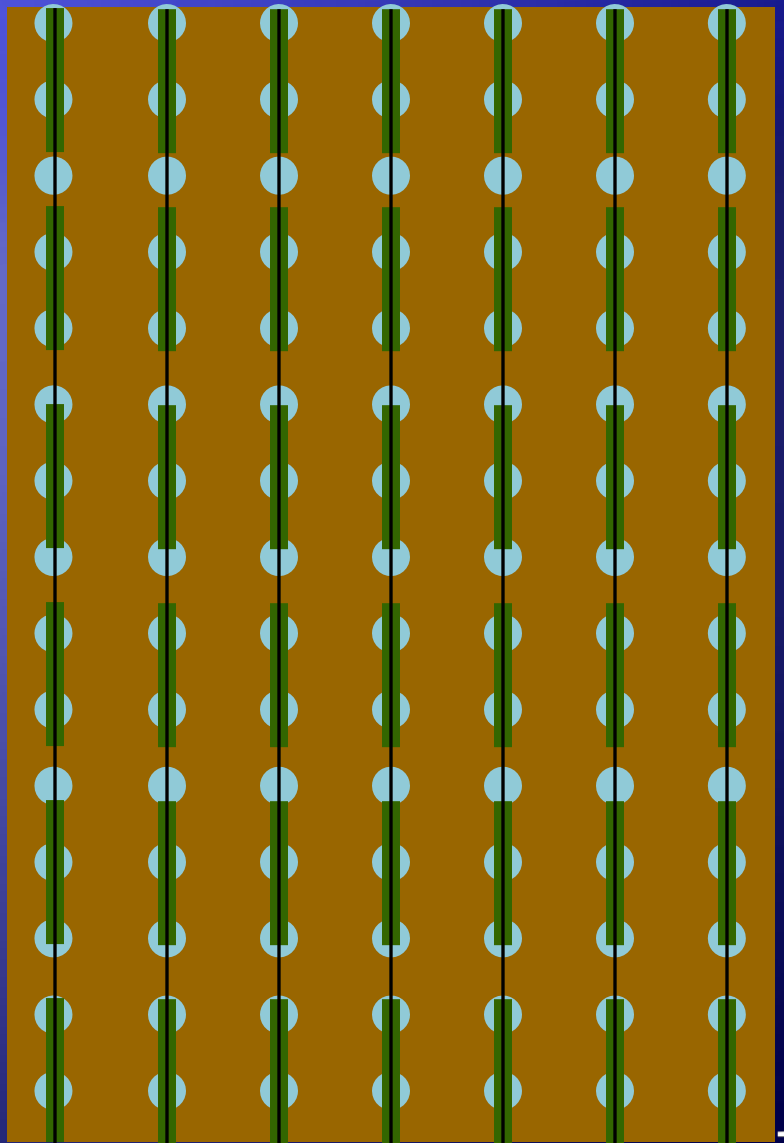

Relative permittivity
of water is
About 80x that of air
vancedVit.com

Comparison of electronic soil moisture sensor types

	Advantages	Disadvantages
Volumetric	•Available in multi-level •Easy to interpret patterns •Can sum or average over soil profile	•Very difficult to calibrate •Therefore, not a physical measurement
Matric Potential	•True physical measurement •Does not require calibration	•Discrete sensors not available in multi-level •Measures only the wetter portion of SM •Cannot sum over soil profile

Flood/furrow vs. drip irrigation





Water balance computations

- Volumetric water content (Θ_v) = volume of water per volume of soil/water/air (vol/vol)
- Can be expressed as inches of water per foot
- Θ_{v2}-Θ_{v1}times depth of root zone = irrigation for replacement
- But, this is meaningless when working with drip irrigation because we have variable and unknown soil volume

…It's also not necessary

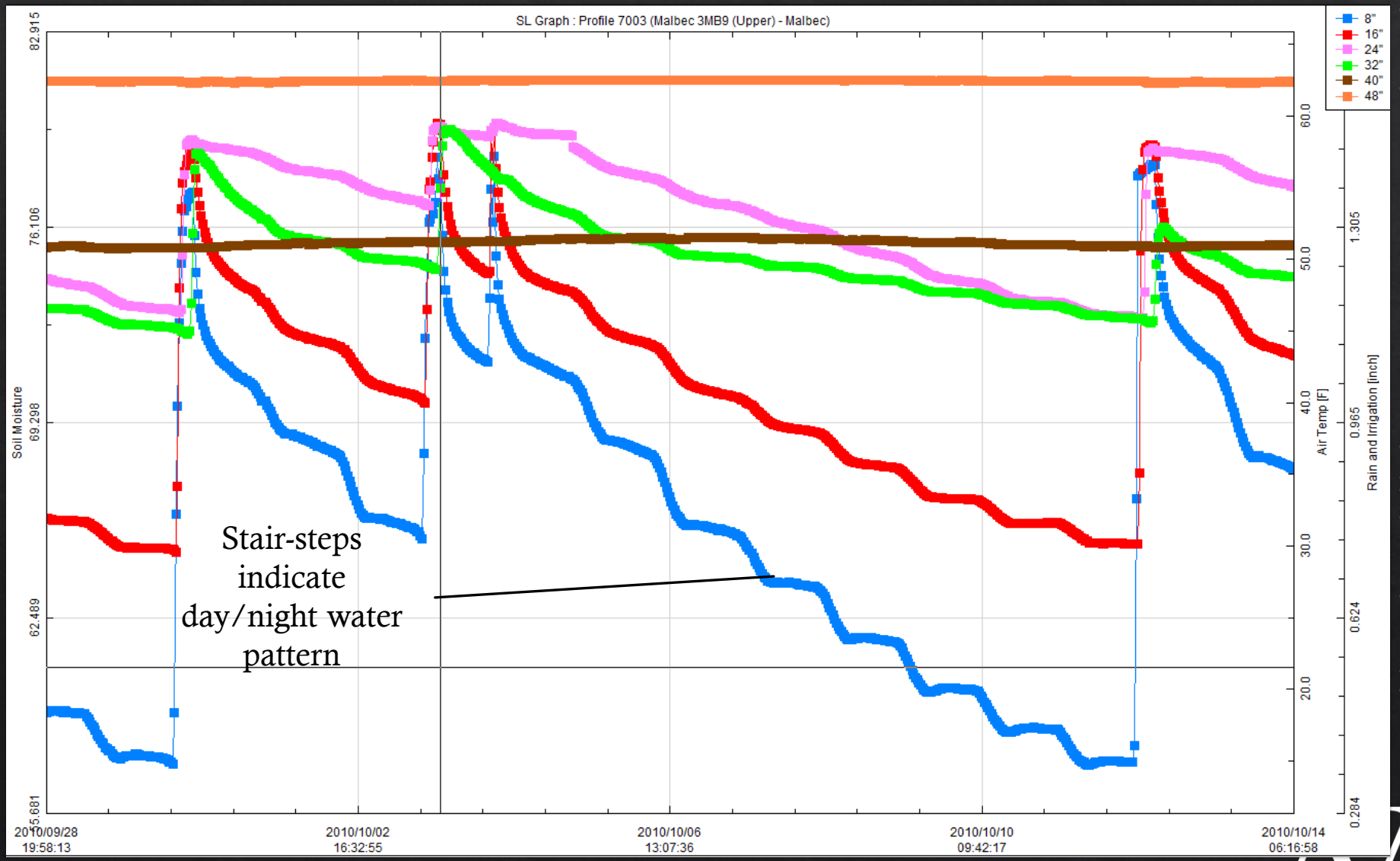
Why use uncalibrated sensors?

- Site-specific calibration of volumetric soil moisture content is difficult and expensive
- Nominal calibrations are available based on texture classes, but are approximations
- Water balance scheduling based on volumetric measurements are meaningless for drip irrigation systems
- All we need are repeatable, precise measurements to accomplish precision irrigation

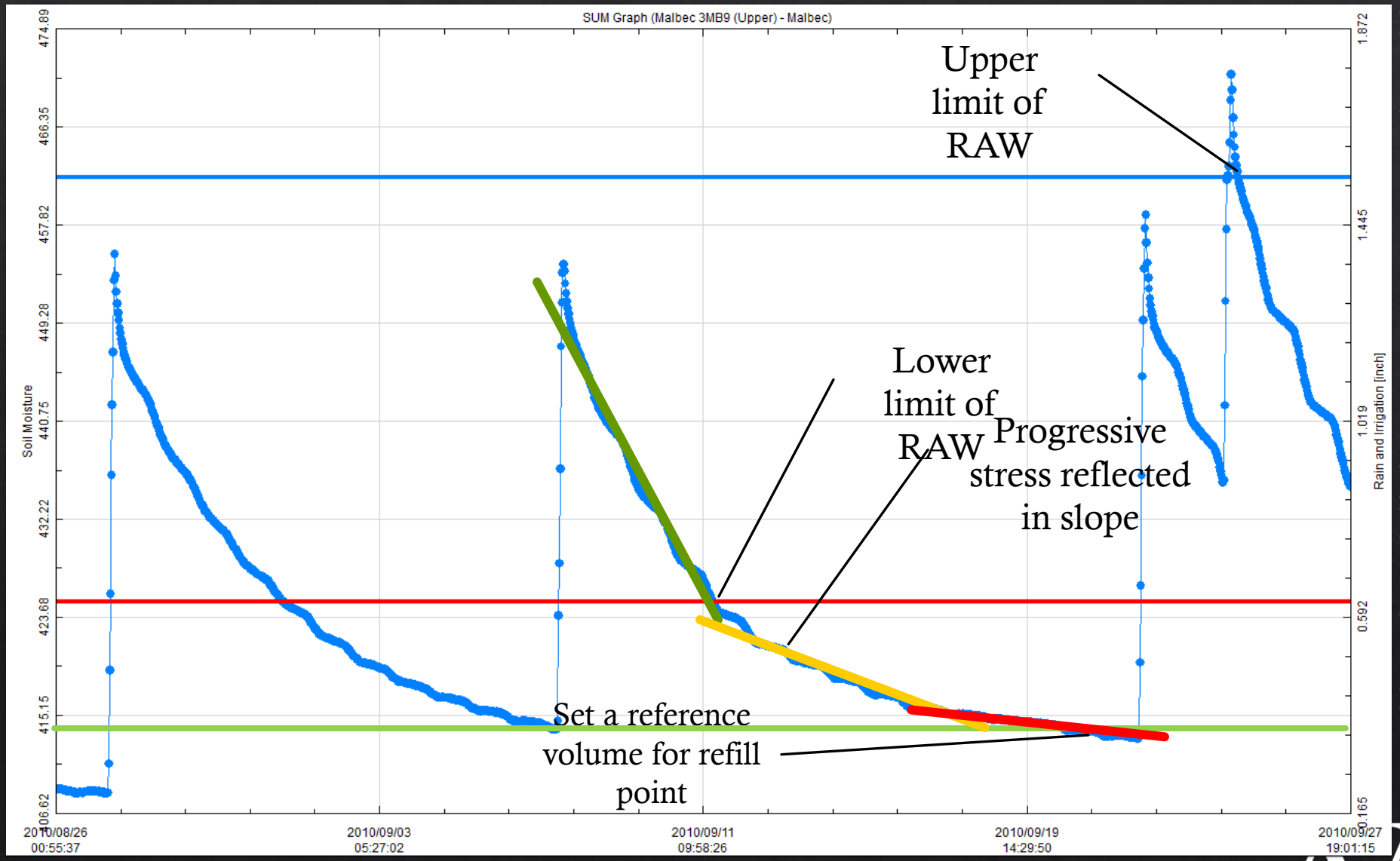
Basic irrigation method

- Use multiple depth water content charts to determine depth of irrigation
  - Identify active root zone
  - Adjust volume by trial-and-error to depth of root zone
  - Use this volume as closely as possible during irrigation season
- Use summation or average WC charts to determine intervals
  - Use slope of depletion curve to identify level of stress
  - Assign full and refill points based on desired stress level
  - Adjust refill point as necessary during growing season

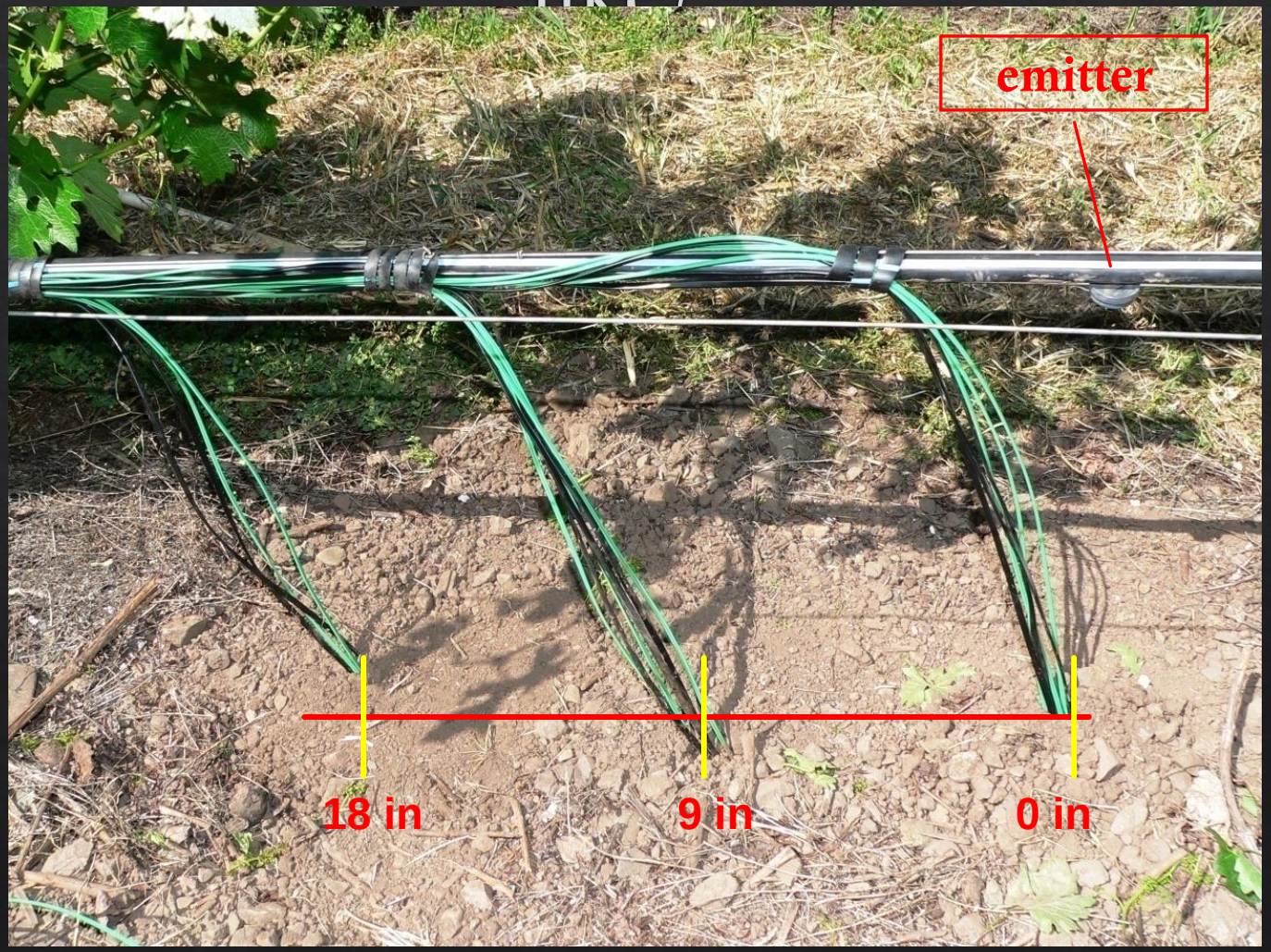
Level Graph

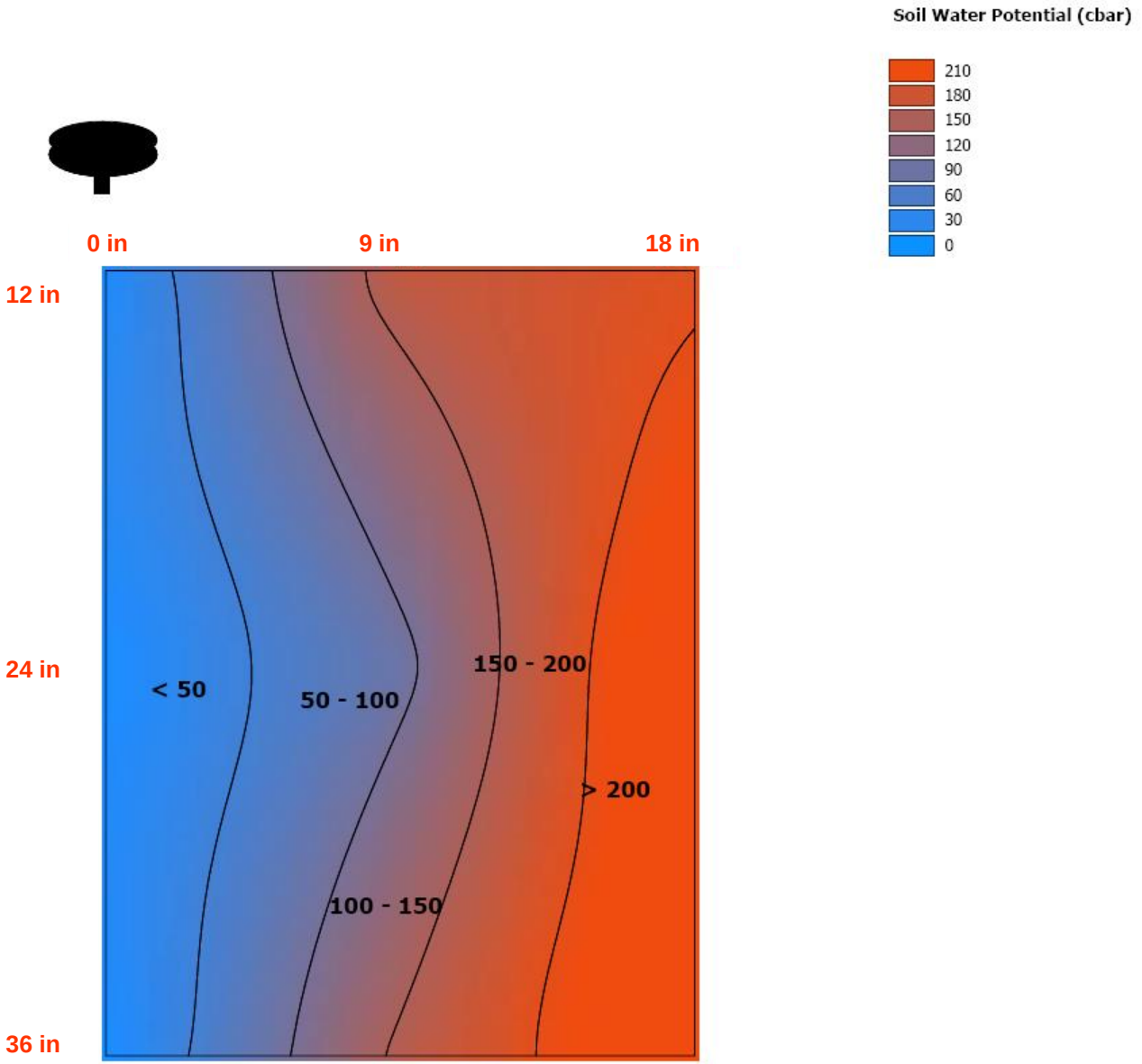


Total soil moisture in profile

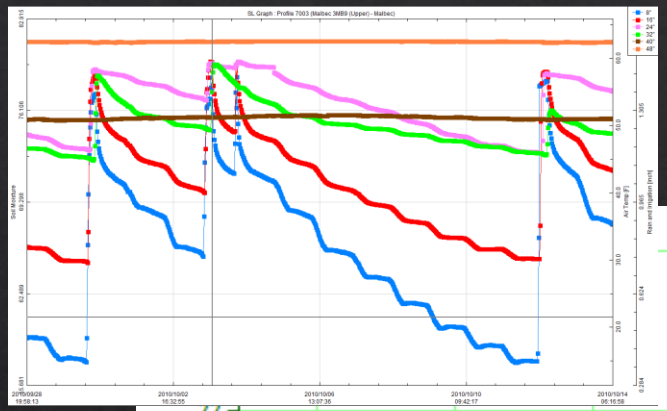


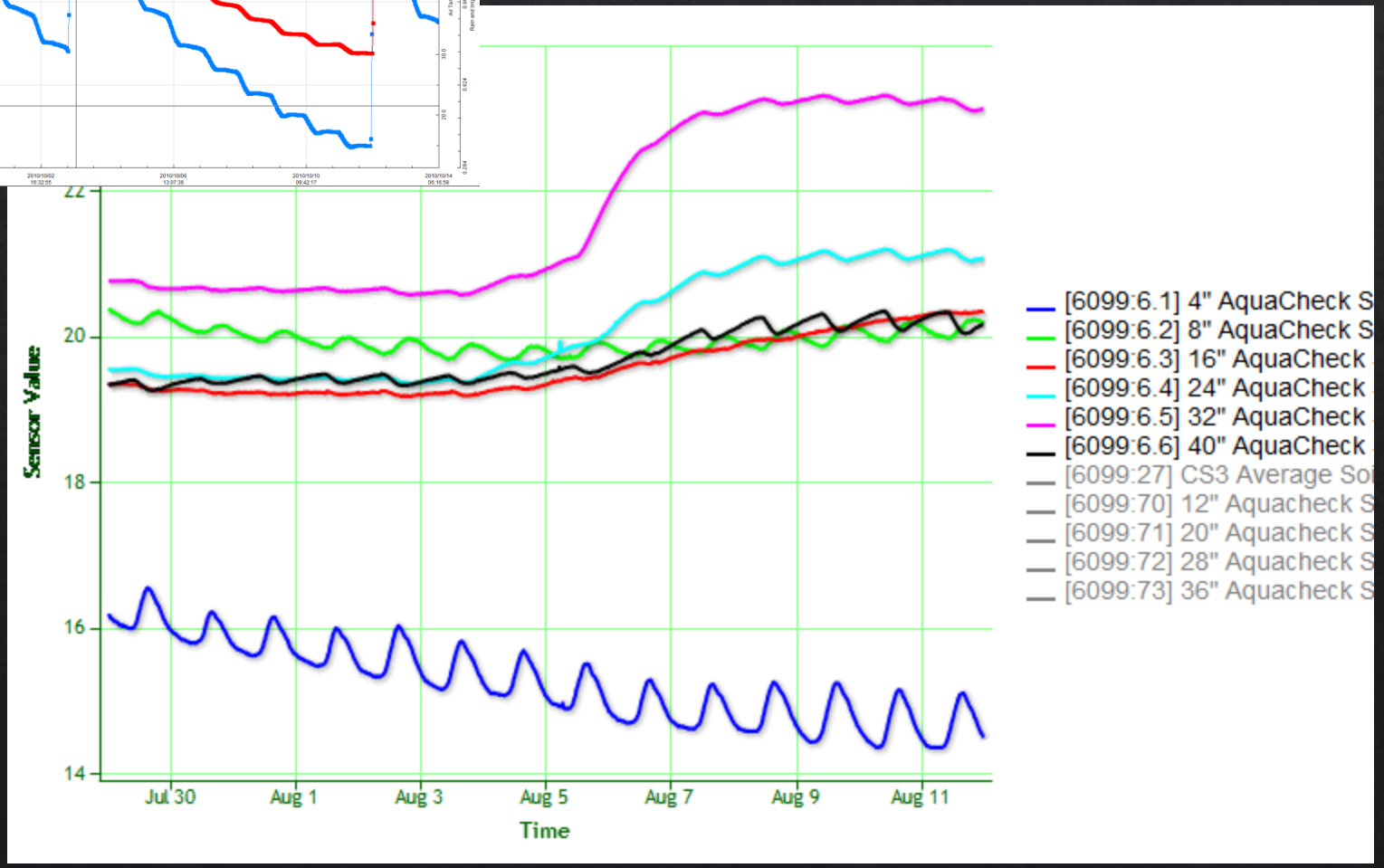
What does the wetting pattern look like?



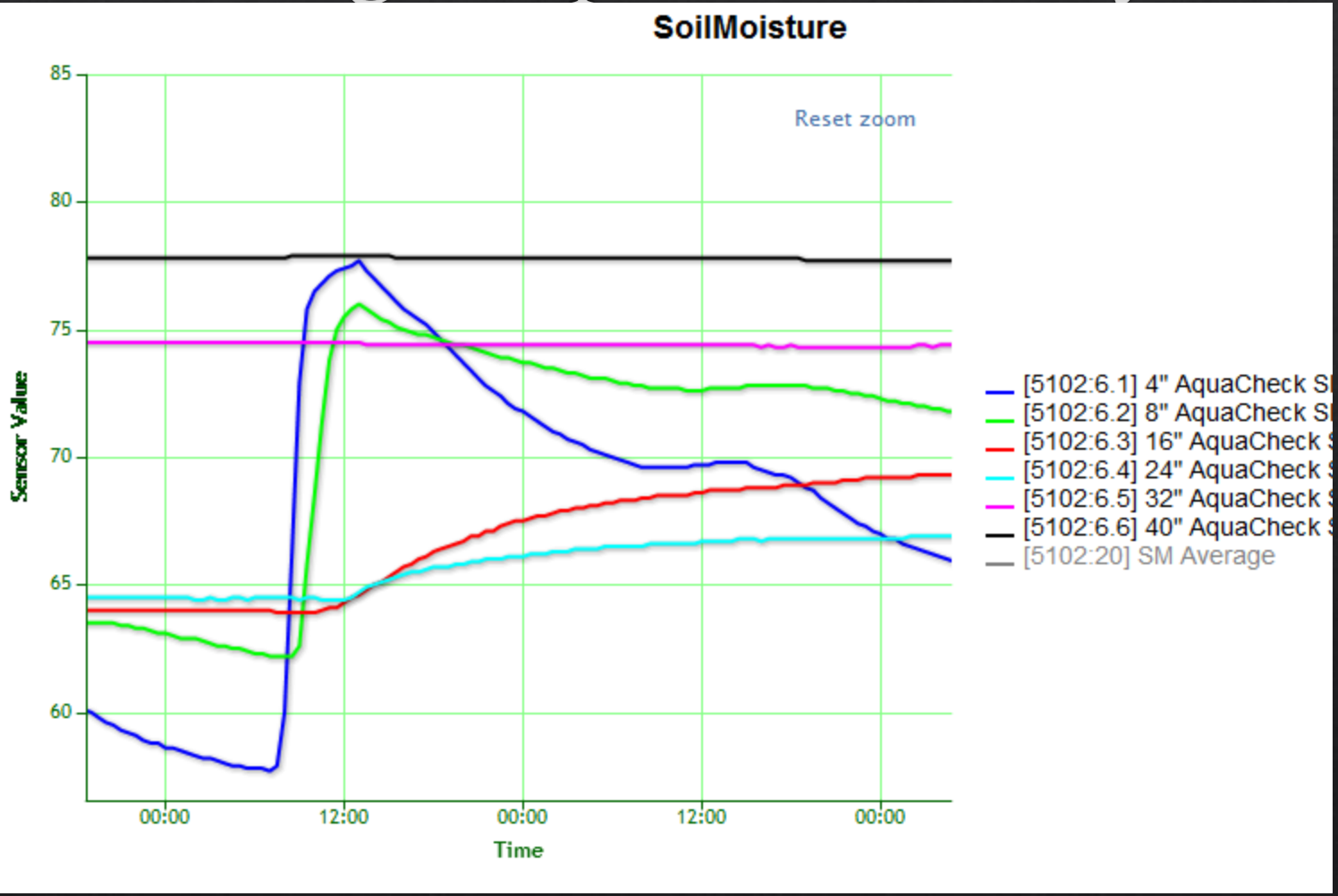


Example of sensor too distant from emitter

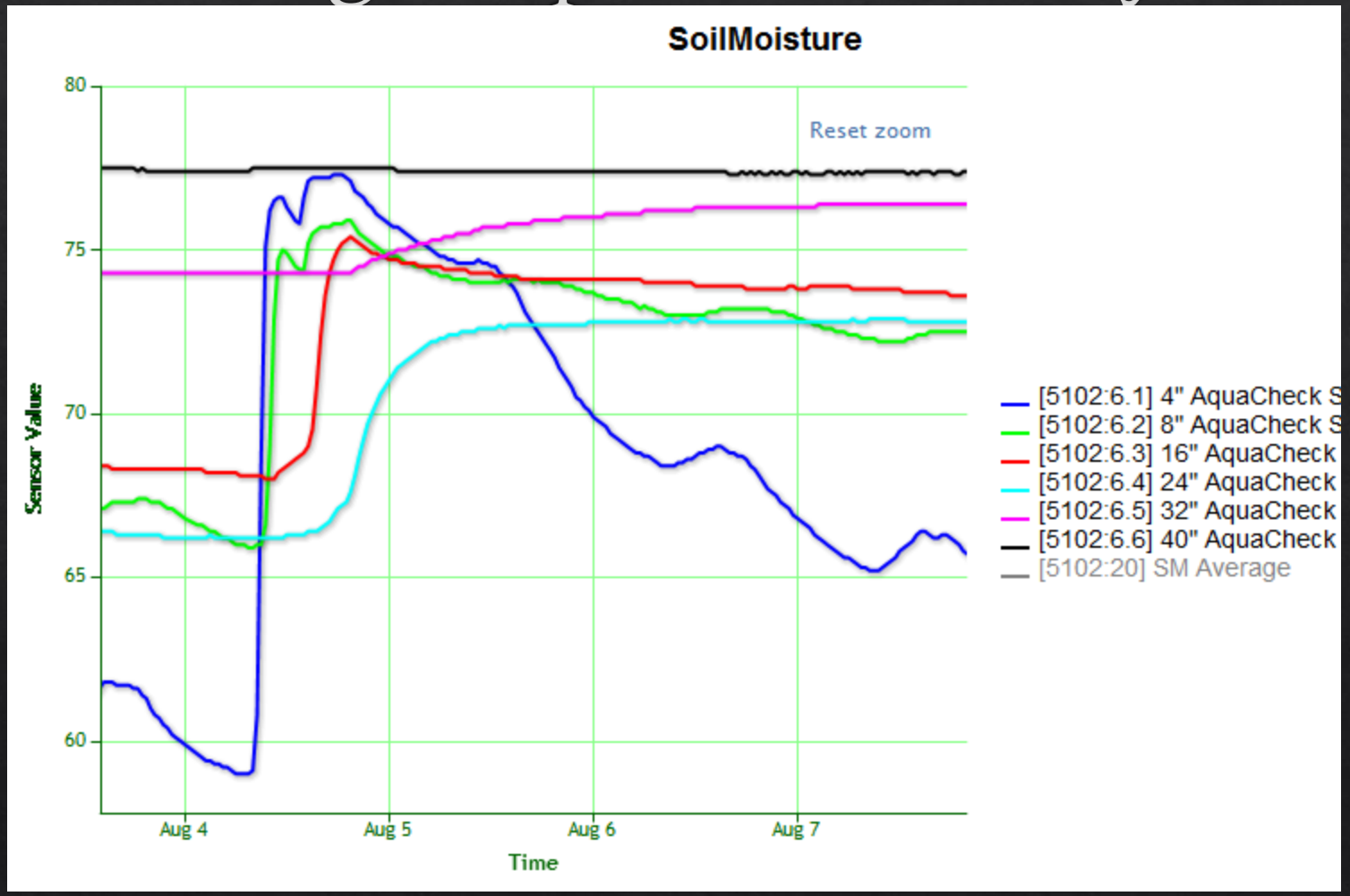




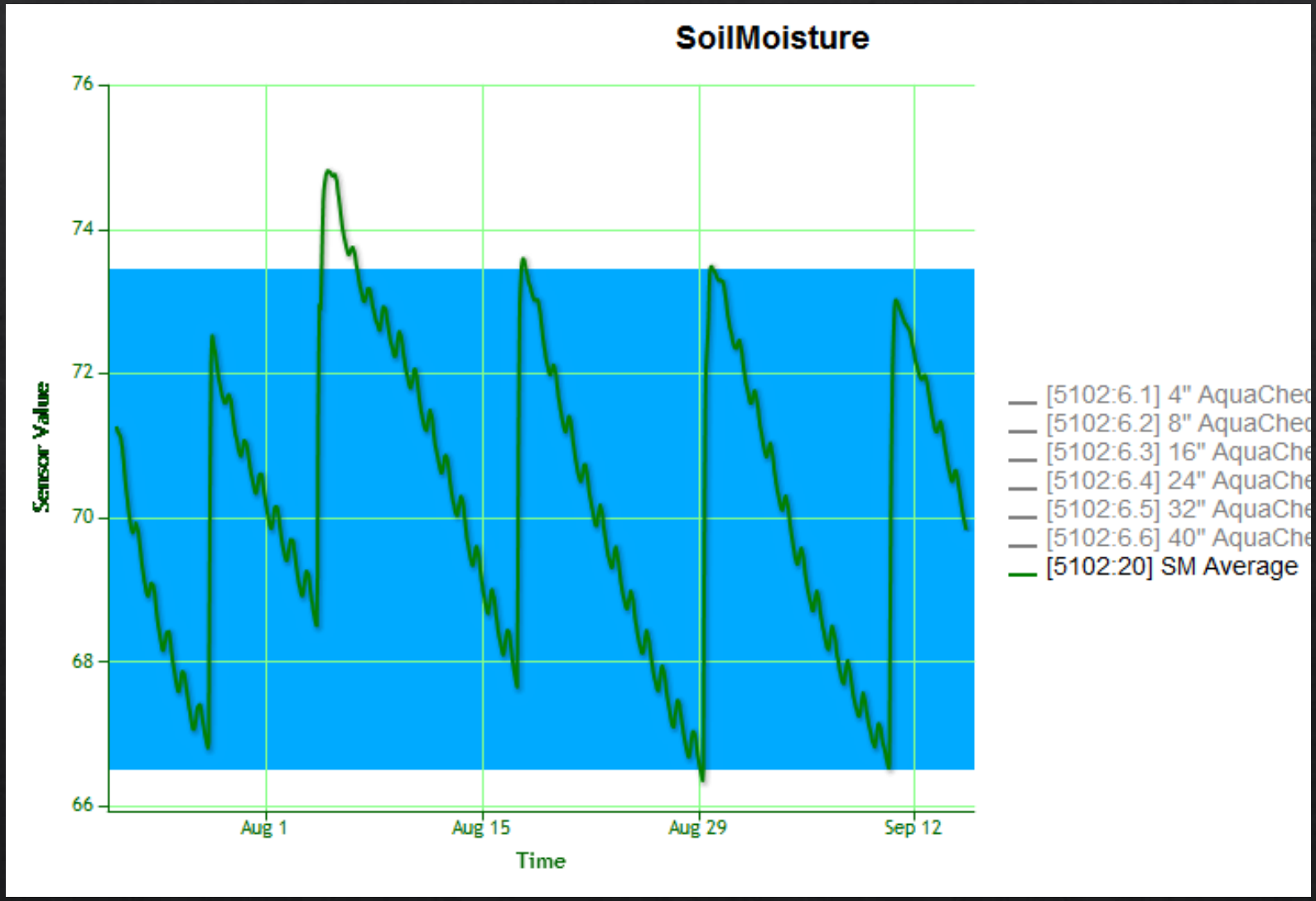
Using the profile – 1st try



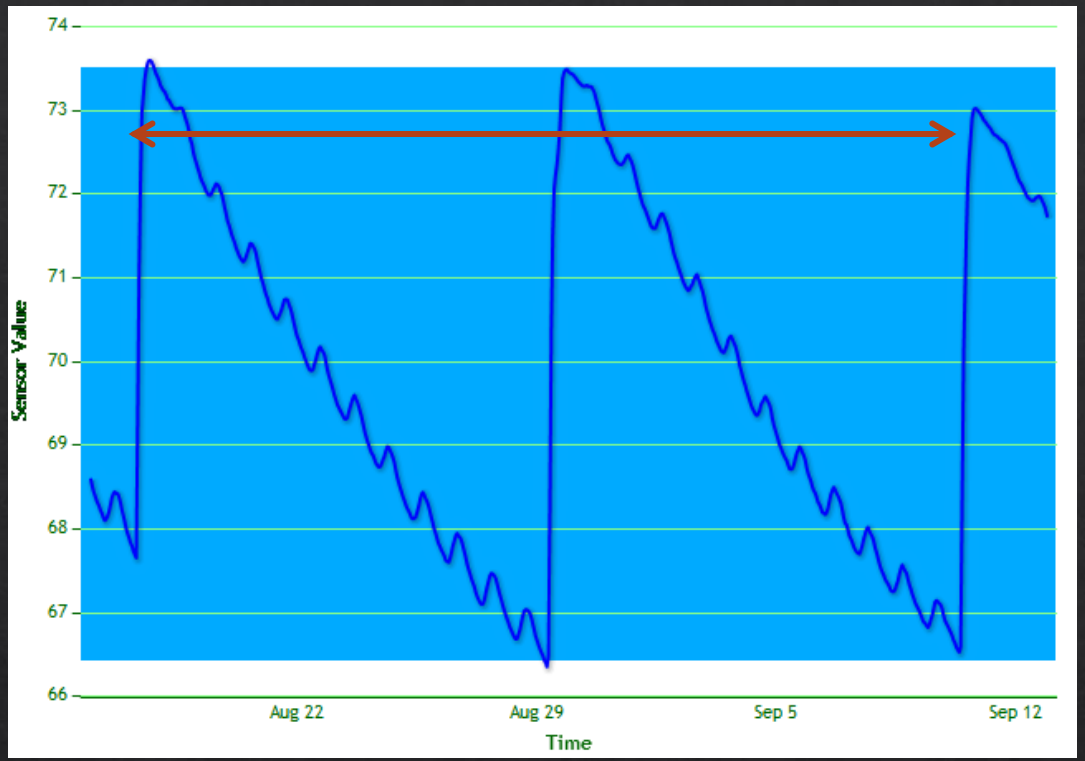
Using the profile – 2nd try



Using total/average soil moisture to schedule



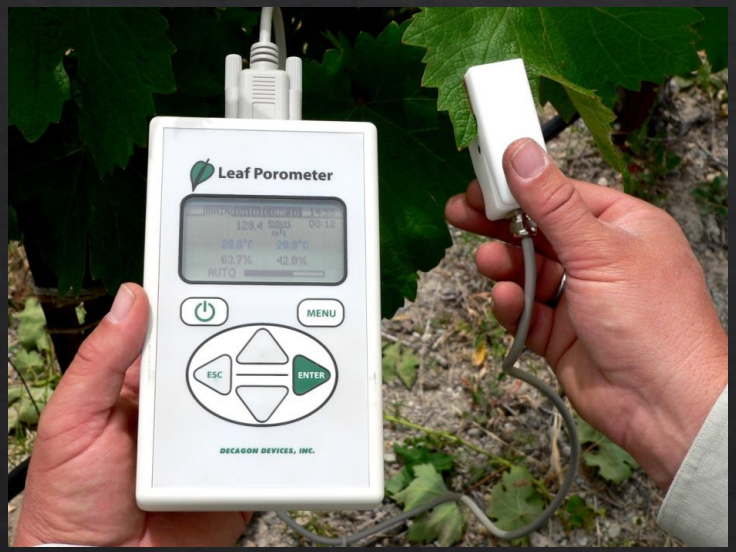
- ETo = 4.42”
- Kc = 0.5
- ETc = 2.21”
  - = 66 gal/vine



- Irrigation: 12 gallons/vine
- → 18% of ETc

	Yolo Silt Loam (deep)	Arbuckle Gravelly Sandy Loam	Pleasanton Gravelly Loam	Zamora Silty Clay Loam	Arbuckle Gravelly Loam	Cortina Very Gravelly Loam	Yolo Sandy Loam	Yolo Sandy Loam w/ gravel
Gallons/Vine	19	40	44	15	21	101	53	118
Inches	**0.7**	**1.6**	**1.8**	**0.6**	**0.8**	**4.1**	**2.1**	**4.7**
ETc Inches	15.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
% ETc	**5%**	**13%**	**15%**	**5%**	**7%**	**34%**	**18%**	**40%**

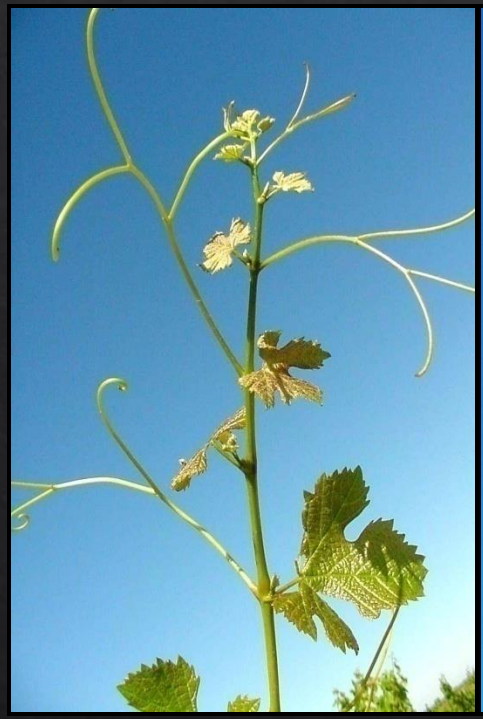
Plant Water status measurement



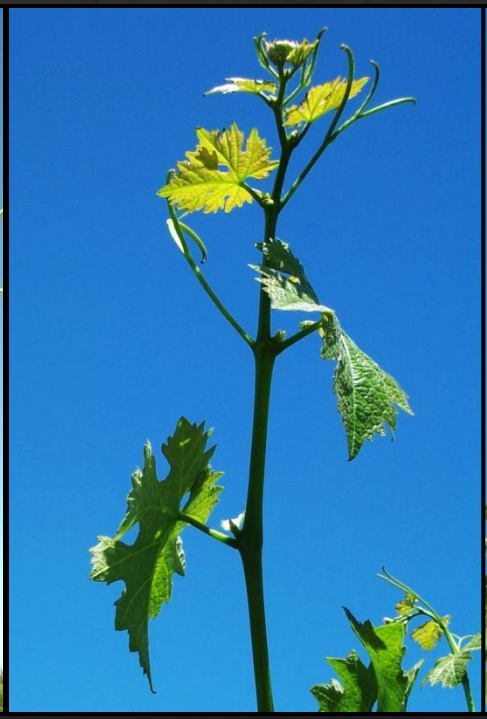
← Porometer

Pressure Chamber →

Visual Indicators



Growing



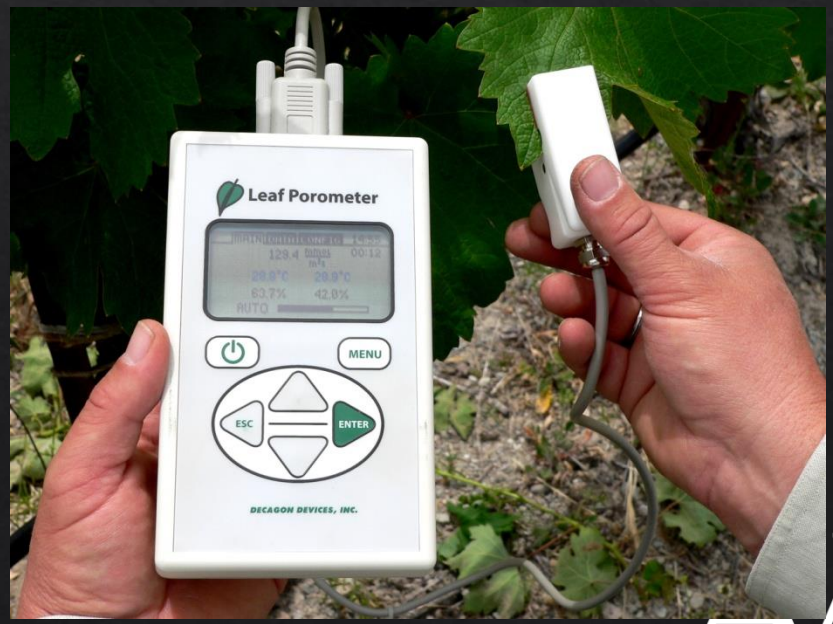
Slowing

Stopped

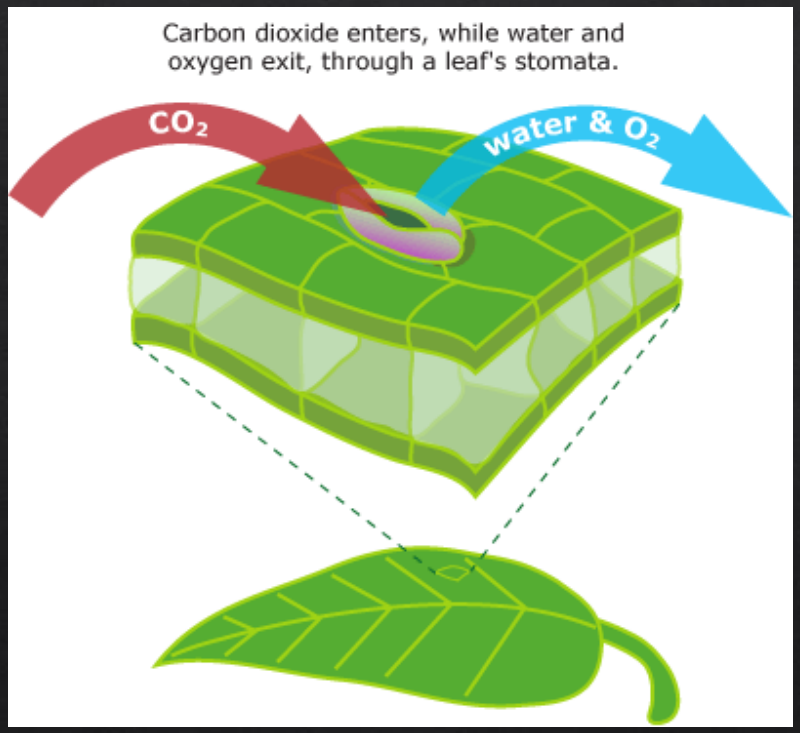
Dead Tip

Porometer

- Measures stomatal conductance (facility of pores to transpire water)
- Advantages: Portability; vine response to water status; indirect indication of photosynthesis
- Disadvantages: Less rugged instrument; sensitive to environmental conditions; more variability than leaf water potential measurements



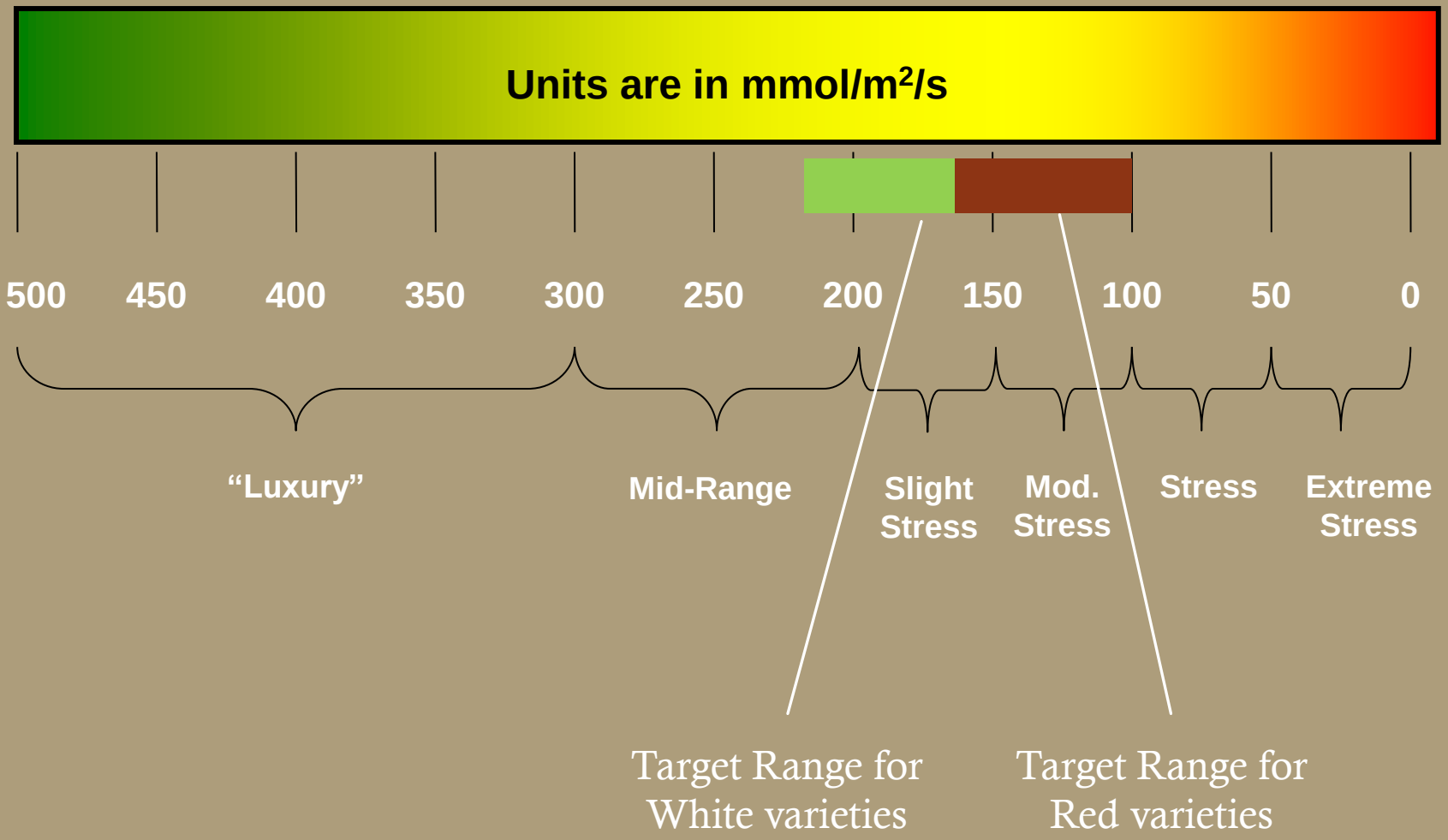
What are stomata?



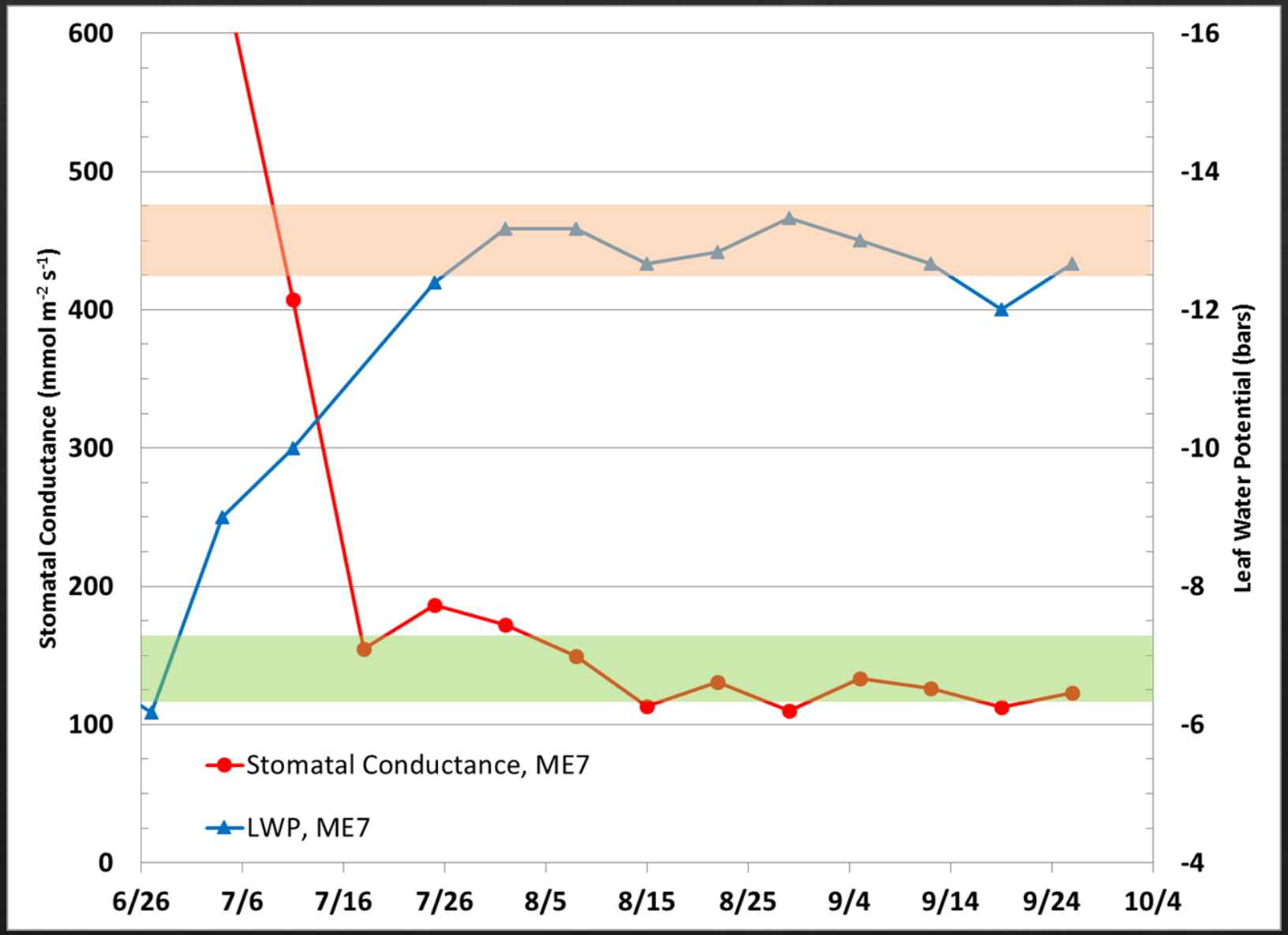
Variety	Stomatal density (mm^{-2})
Cabernet Sauvignon	180.0
Chardonnay	225.5
Flame Seedless	189.3
Merlot	174.5
Pinot Noir	184.0
Riesling	232.6
Sauvignon Blanc	213.4
Semillon	190.1
Shiraz	167.4
Sultana	162.0

Suzy Y. Rogiers*, Dennis H. Greer, Ron J. Hutton and Joe J. Landsberg
Journal of Experimental Botany, Vol. 60, No. 13, pp. 3751–3763, 2009

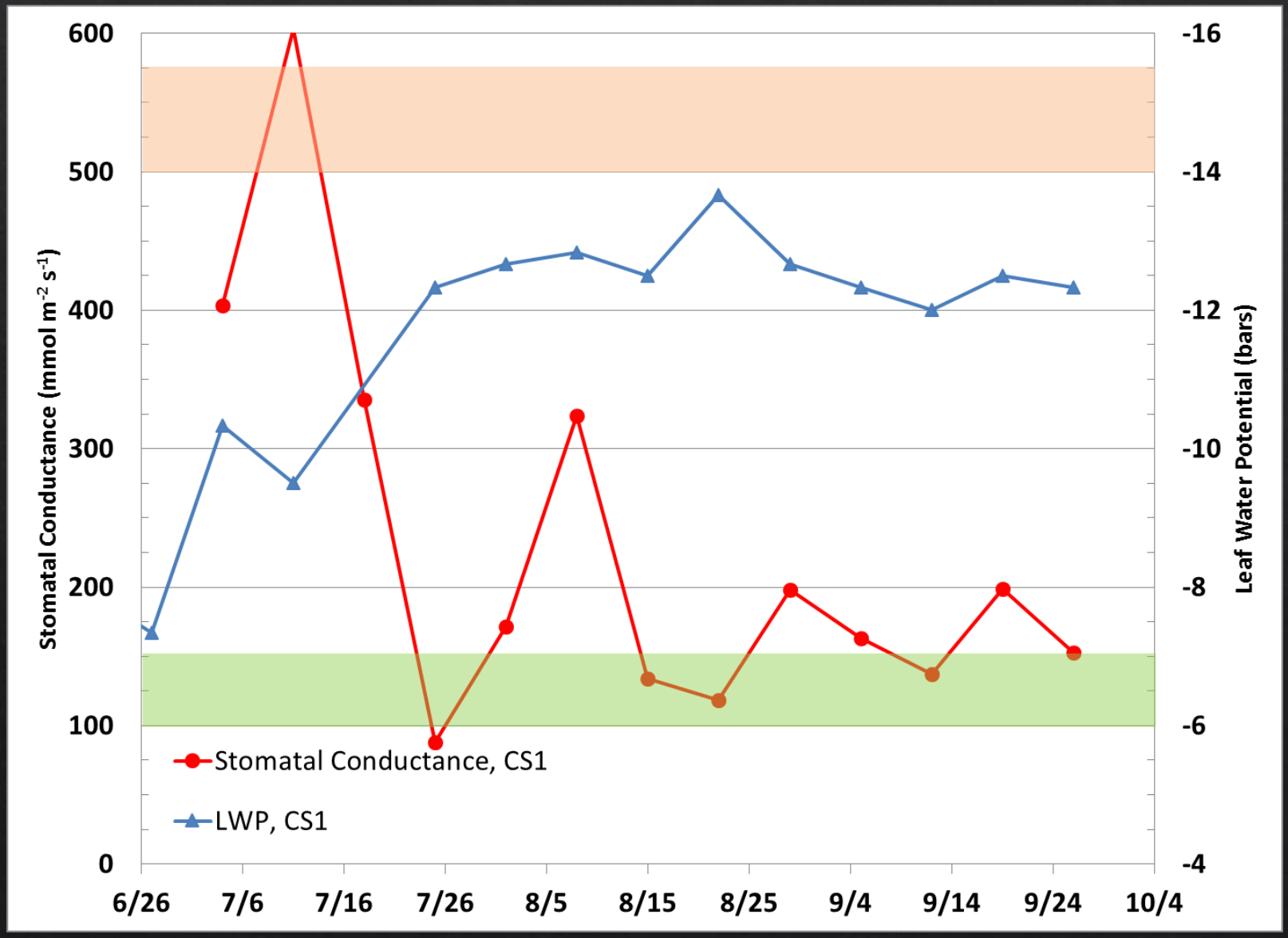
Porometer Ranges



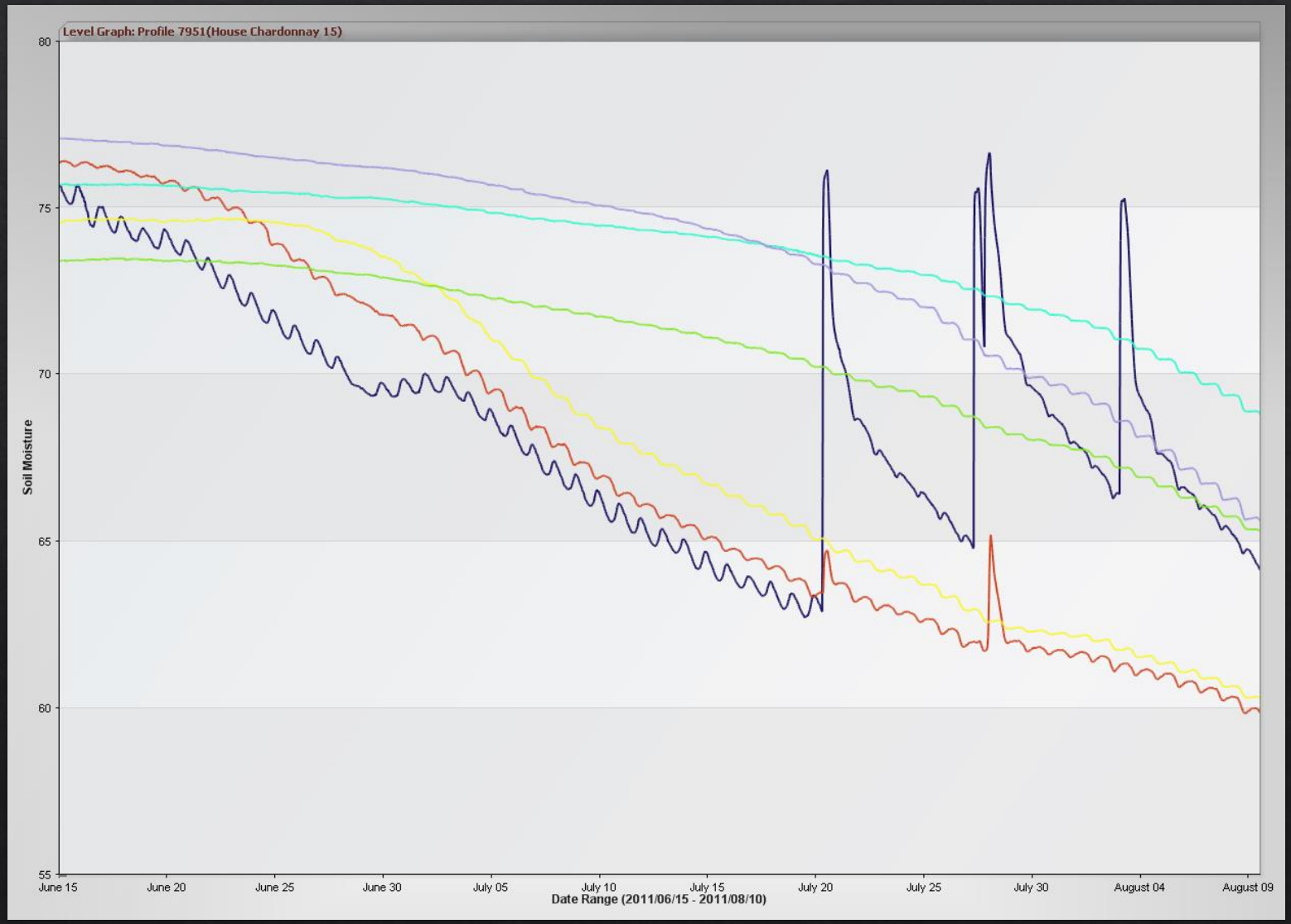
Ideal irrigation – short and frequent



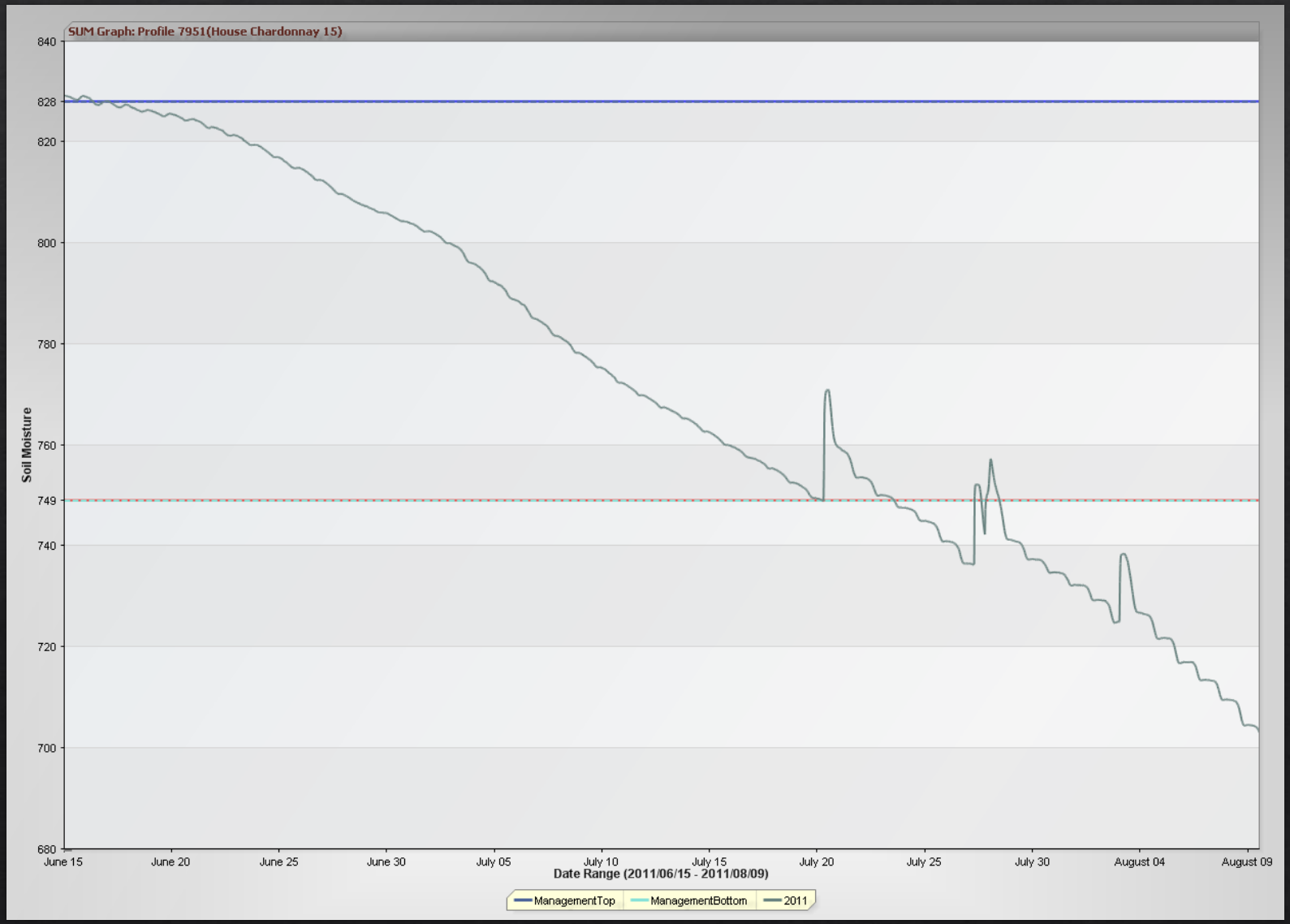
Non-Ideal irrigation – long and infrequent



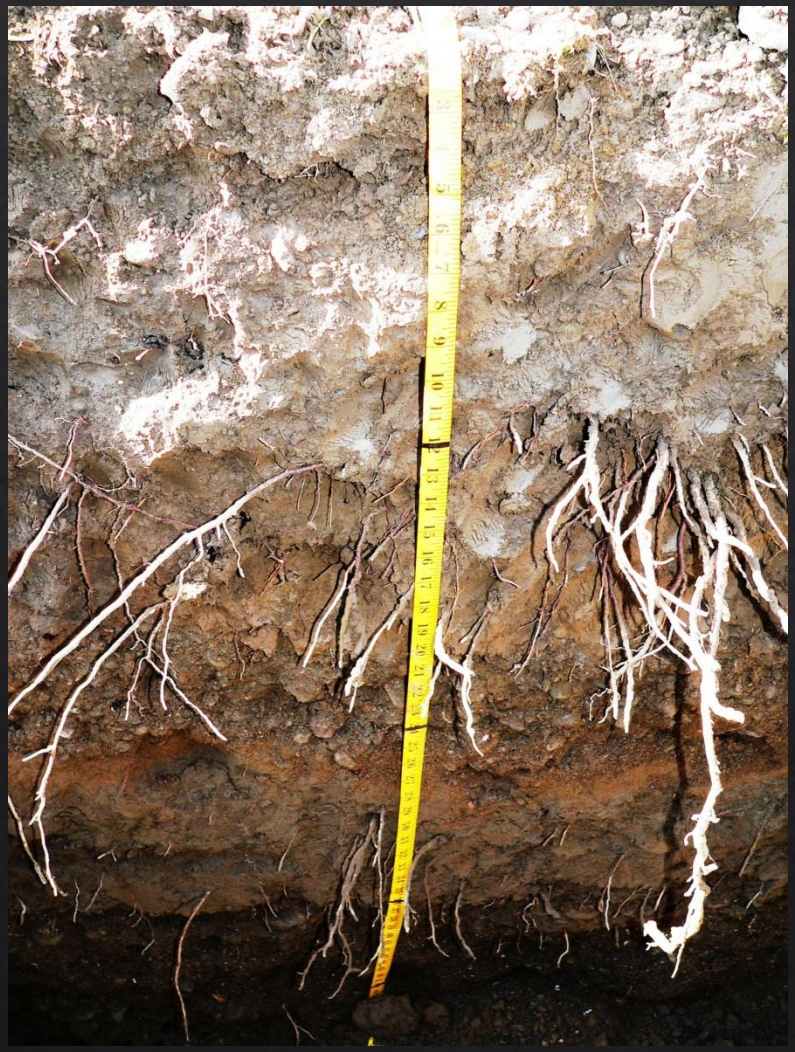
Problem irrigation

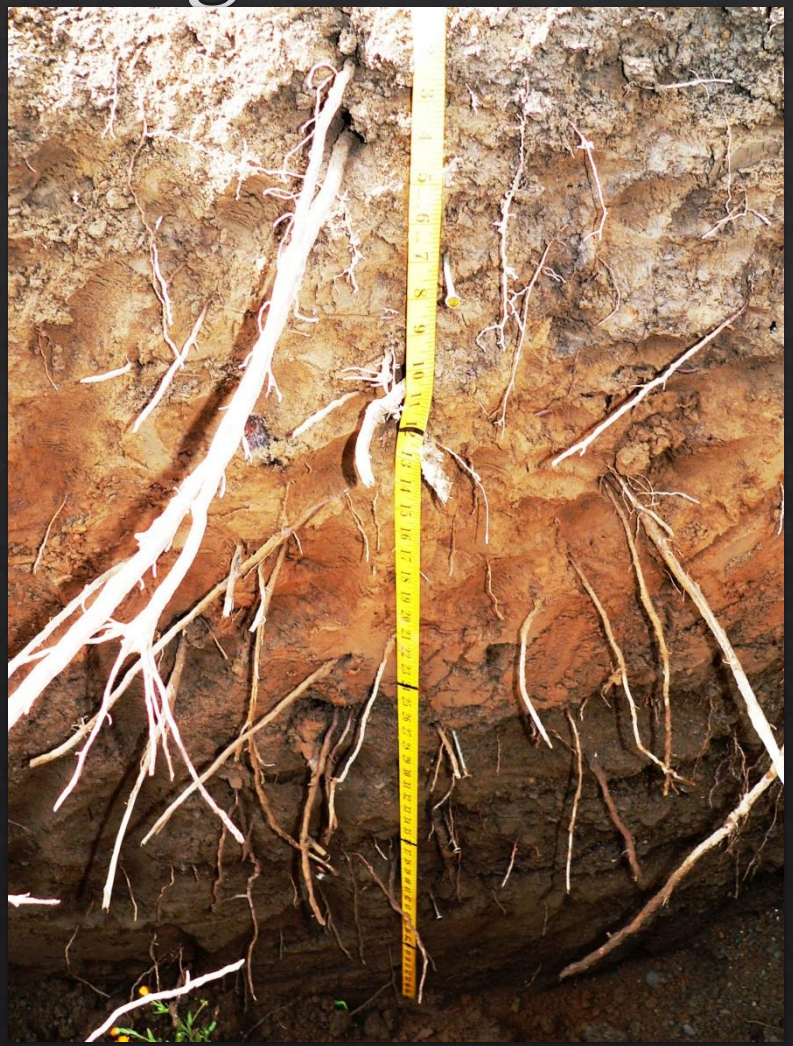


Problem irrigation

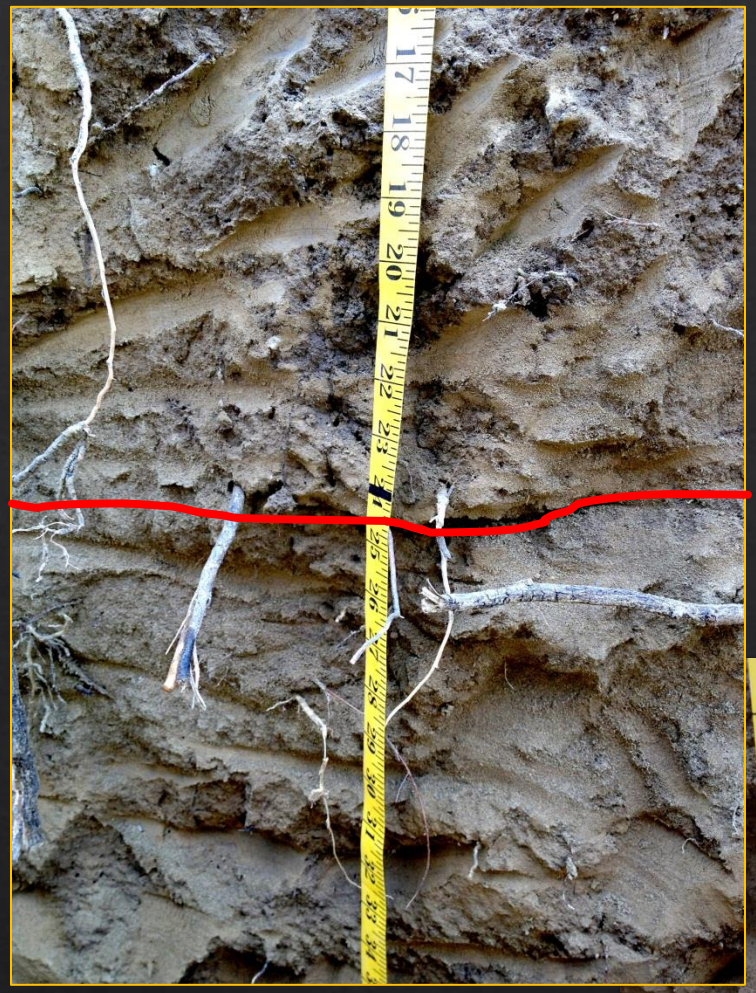


Problem irrigation





Cortina Very Gravelly Loam



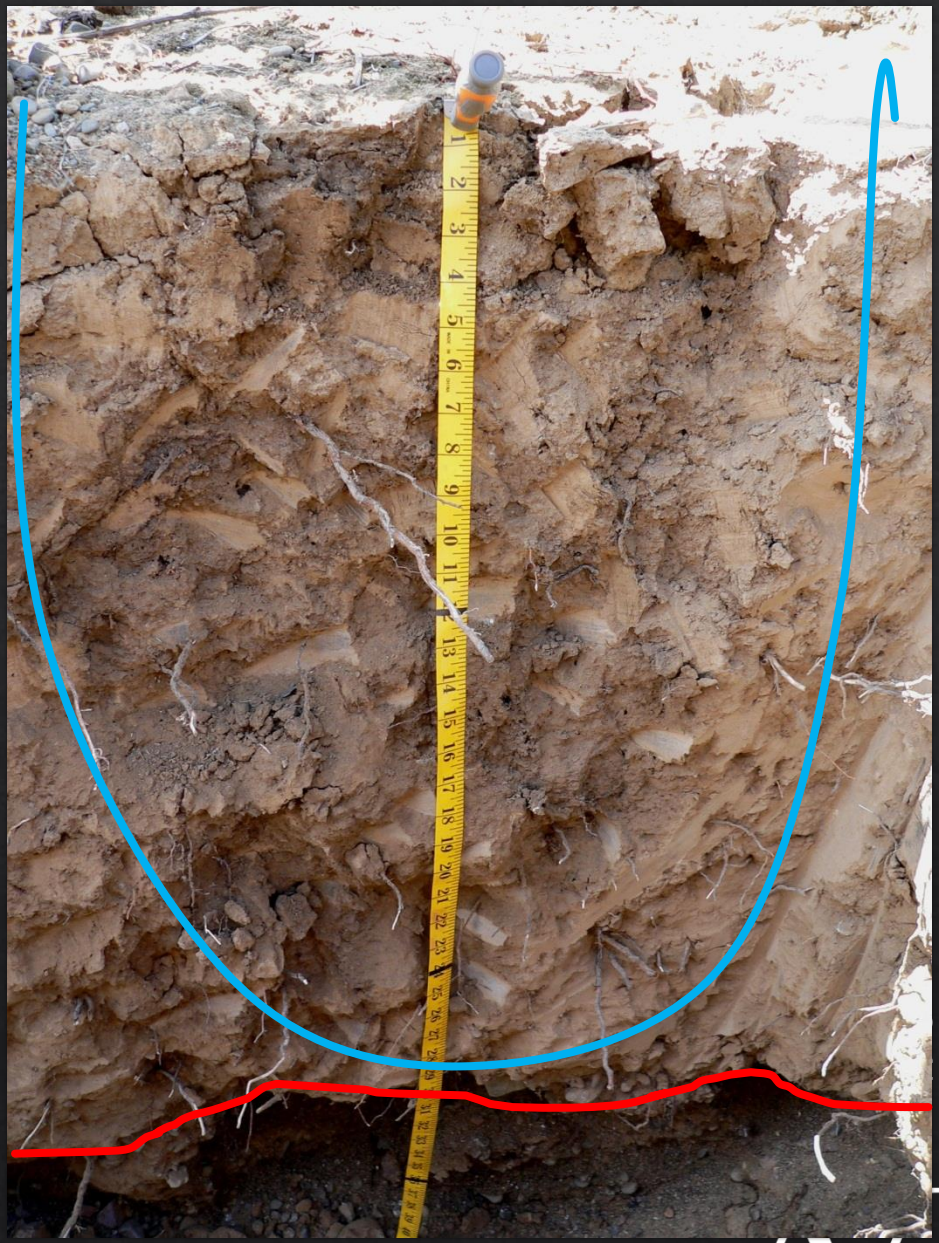
Sandy loam to 21" over abrupt boundary change to sand to 41" over abrupt coarser unconsolidated sand and gravel.

Wetting zone is not well-defined, but width of wetting zone is 26" deep observed 12" from dripper. Roots to 40".

Pleasanton Gravelly Loam

Very gravelly. Loosely consolidated loam with large pores. Strong stratification to coarse gravel at 23". Wetted bulb down to 23" deep and 21" wide at 10" from emitter drop. Gravel to at least 48". Prolific rooting in mid row to 34".

Yolo Silt Loam (non-gravelly)



Extremely uniform silt loam throughout profile. Roots to 36". Wetting from irrigation is widespread to at least 36" deep and 22" away from emitter (radius not diam).

Summary

- Soil Moisture
  - Measure continuously, and at several depths
  - Use multi-level to determine proper volume, THEN
  - Use to sum/average graph to determine intervals as season progresses
- Plant moisture status
  - Measure to track stress and adjust refill point
- Small Drink versus Big Drink?
  - Uniform soils allow deep percolation; stratified soils prevent percolation
  - Short and frequent seems better in any case

- Forget about “regulated deficit irrigation”
- “Controlled Stress Irrigation”

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THANK YOU

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