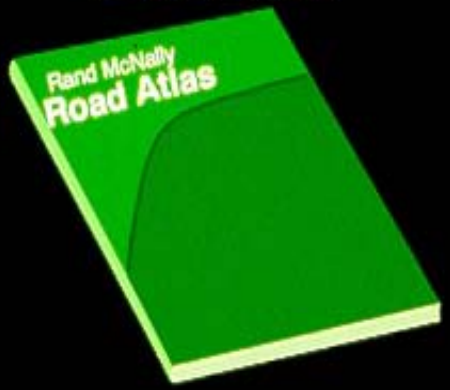
Irrigation Fundamentals

R. Troy Peters, PhD, PE
WSU Extension Irrigation Specialist
Prosser, WA

Water and Fuel Management

Historical Crop Water Use



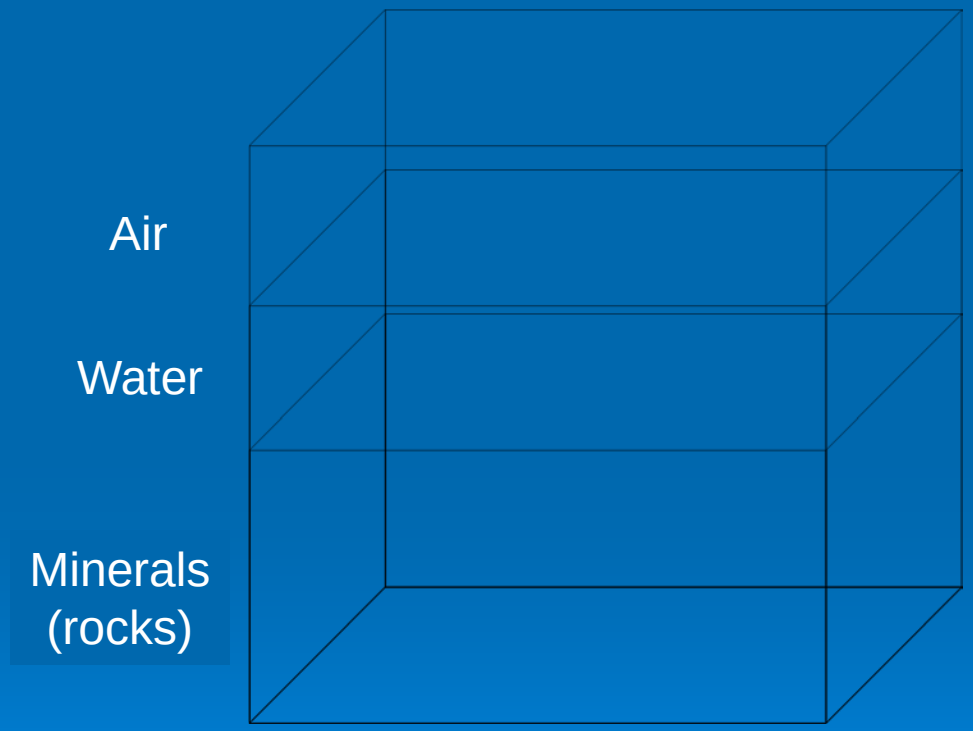
Actual Crop Water Use

Soil Moisture Measurement

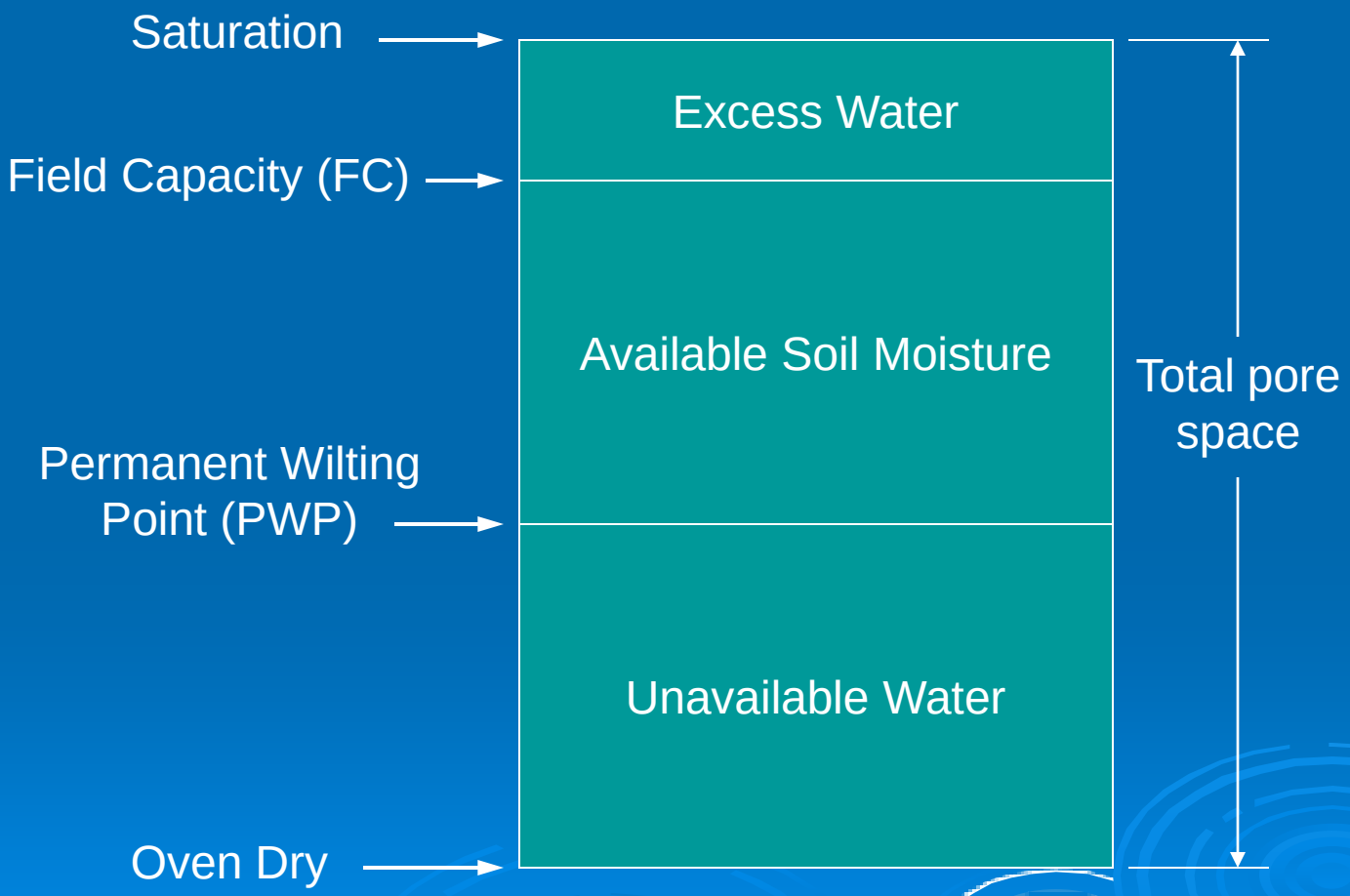
Irrigation System

Soil Water Holding Capacity

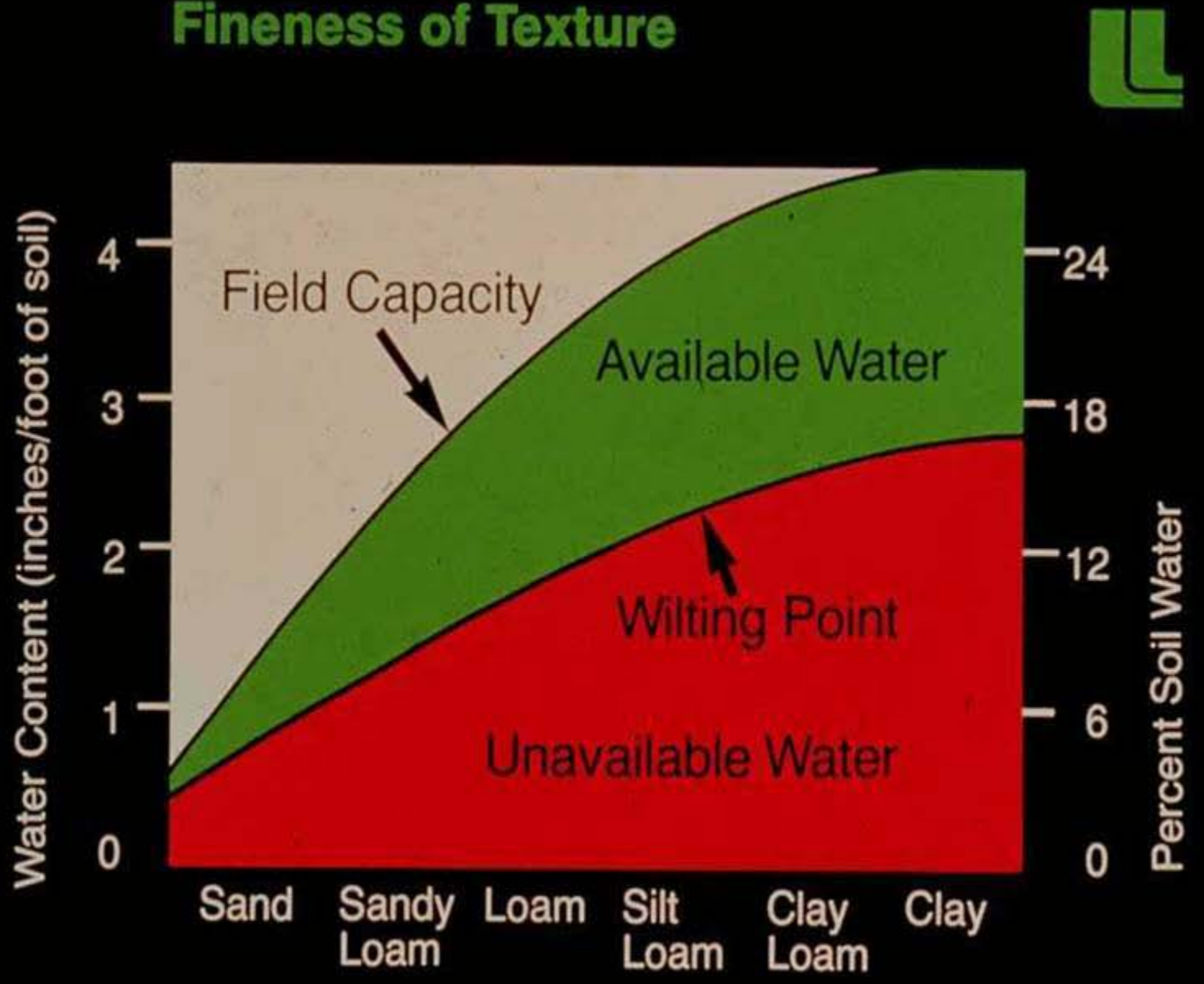
Composition of Soil



Soil Water


Saturation
Field Capacity (FC)
Permanent Wilting Point (PWP)
Oven Dry
Excess Water
Available Soil Moisture
Unavailable Water
Total pore space

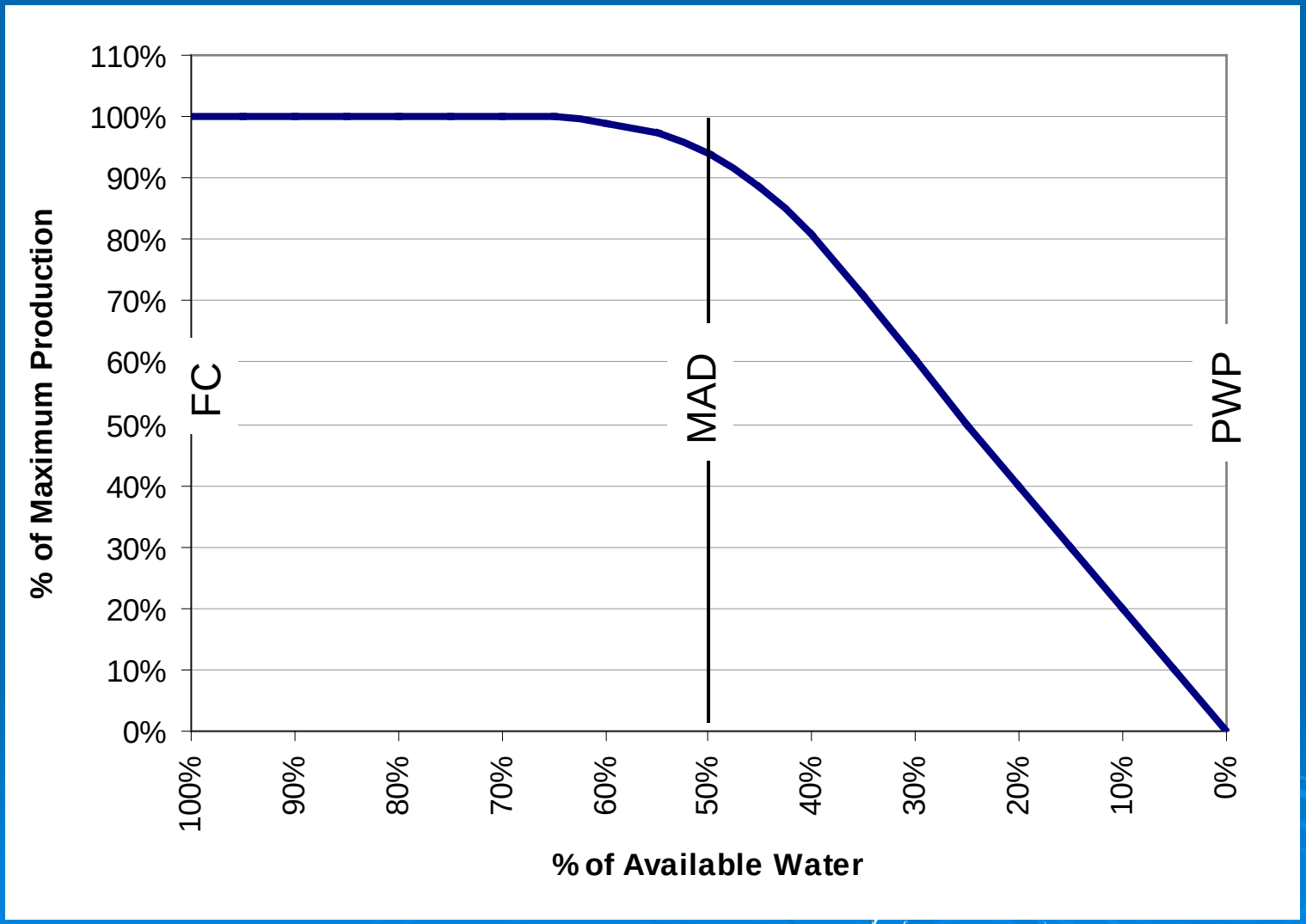
- **Field Capacity (FC)**: Maximum amount of water that a soil can hold indefinitely against gravity (% of volume)
- **Permanent Wilting Point (PWP)**: The amount of water remaining in the soil after plants can no longer pull water from the soil (wilt & die)
- **Available Water (AW)** = FC – PWP
- **Management Allowable Deficit (MAD)**: percent deficit of Available Water (AW) that management will accept


Fineness of Texture
Water Content (inches/foot of soil)
4
3
2
1
0
Field Capacity
Available Water
Wilting Point
Unavailable Water
24
18
12
6
0
Percent Soil Water
Sand
Sandy Loam
Loam
Silt Loam
Clay Loam
Clay

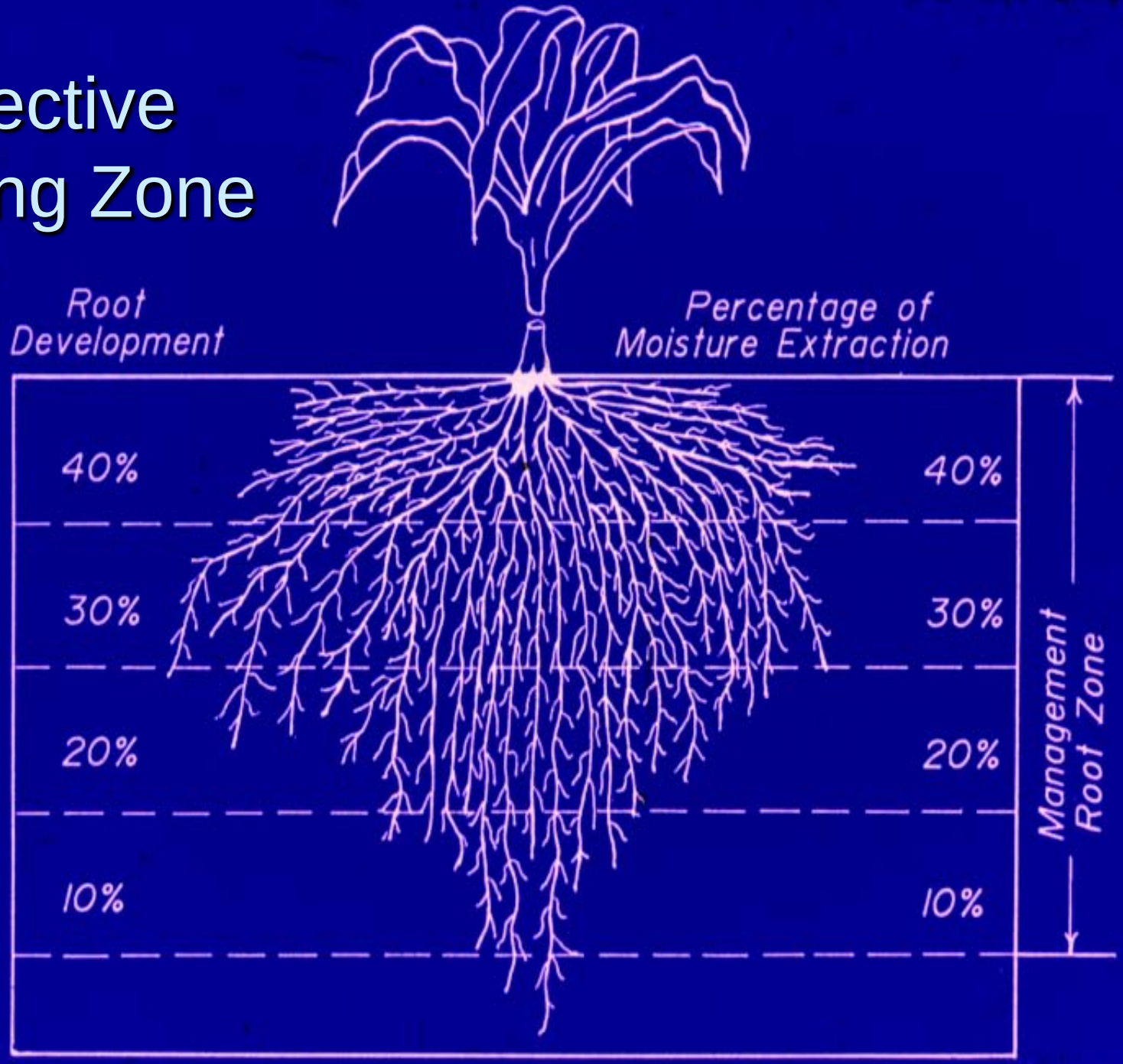
Soil Texture and Available Water

Soil Texture	Available Water (AW) in/ft
Coarse Sand	0.2 - 0.8
Fine Sand	0.7 - 1.0
Loamy Sandy	0.8 - 1.3
Sandy Loam	1.1 - 1.6
Fine Sandy Loam	1.2 - 2.0
Silt Loam	1.8 - 2.8
Silty Clay Loam	1.6 - 1.9
Silty Clay	1.5 - 2.0
Clay	1.3 - 1.8
Peat Mucks	1.9 - 2.9

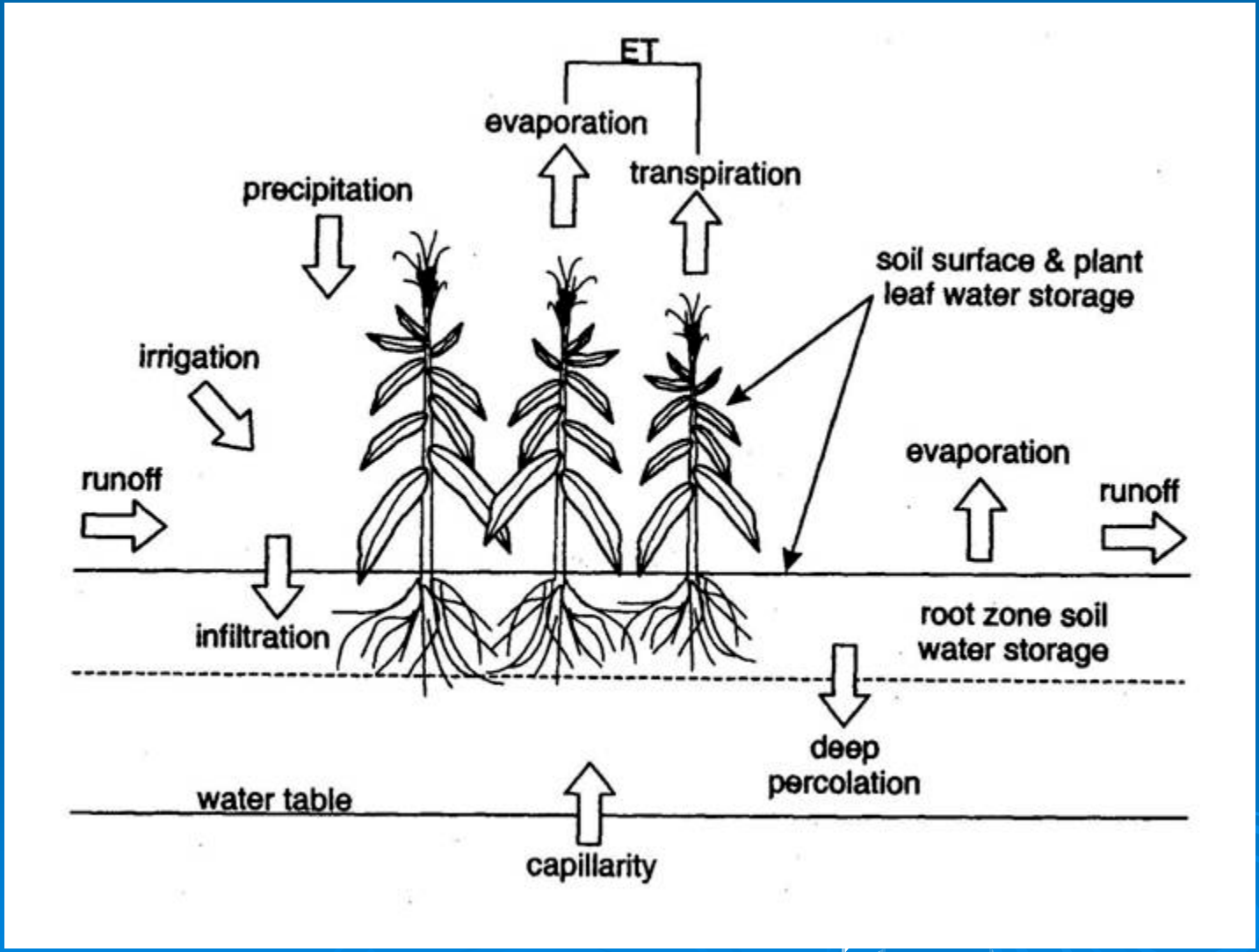
Production Reduction Function



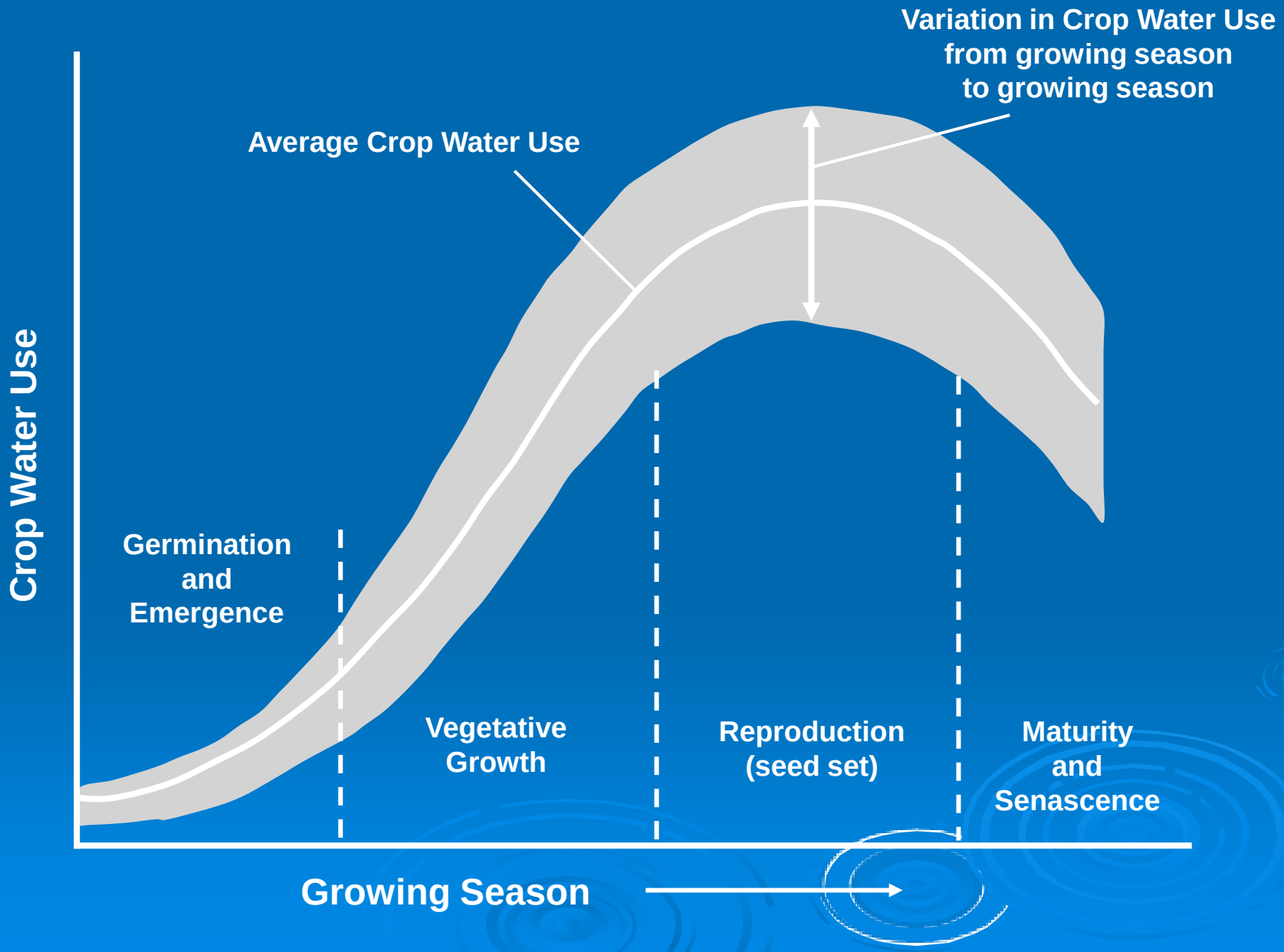
Effective Rooting Zone



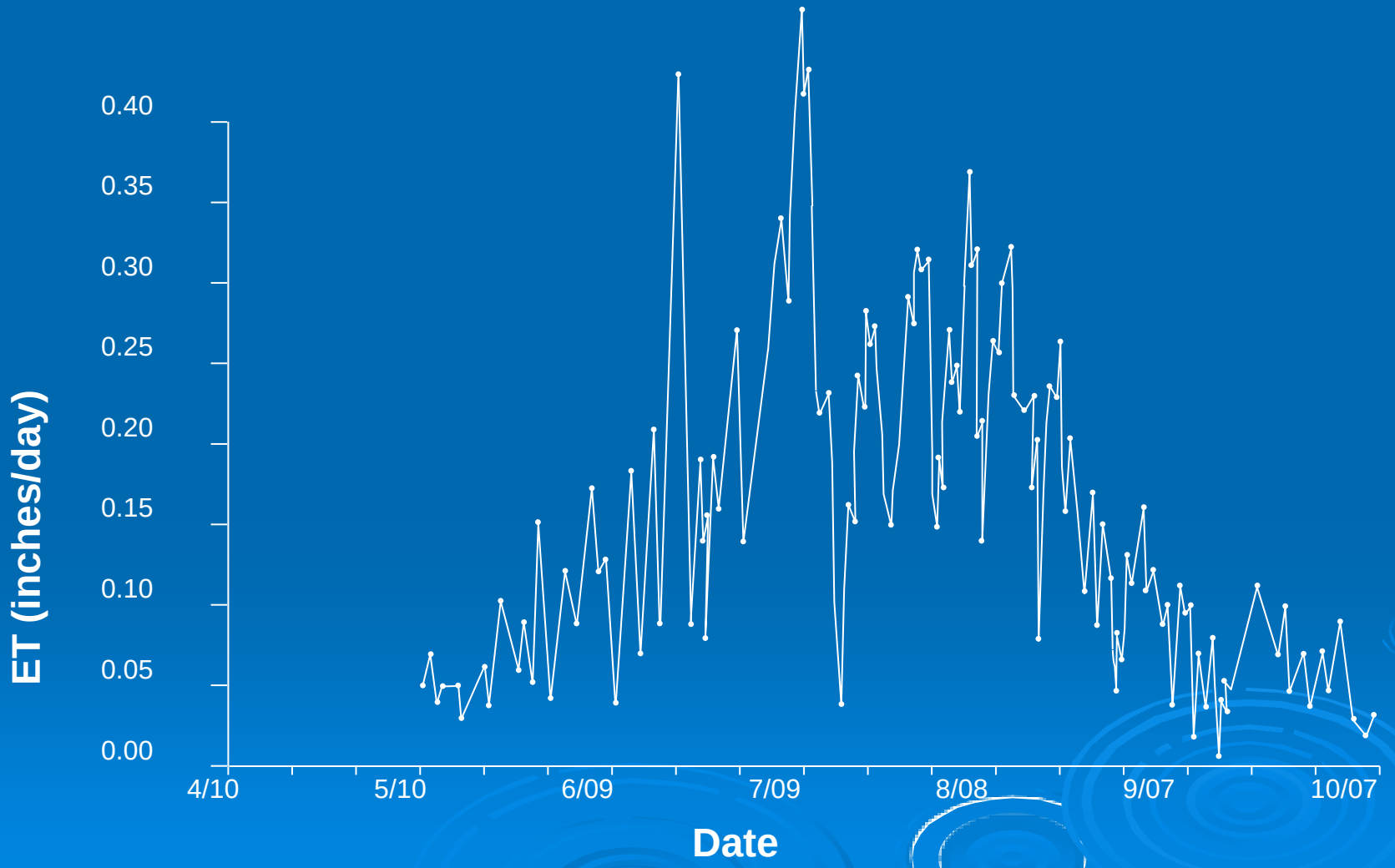
Water Balance



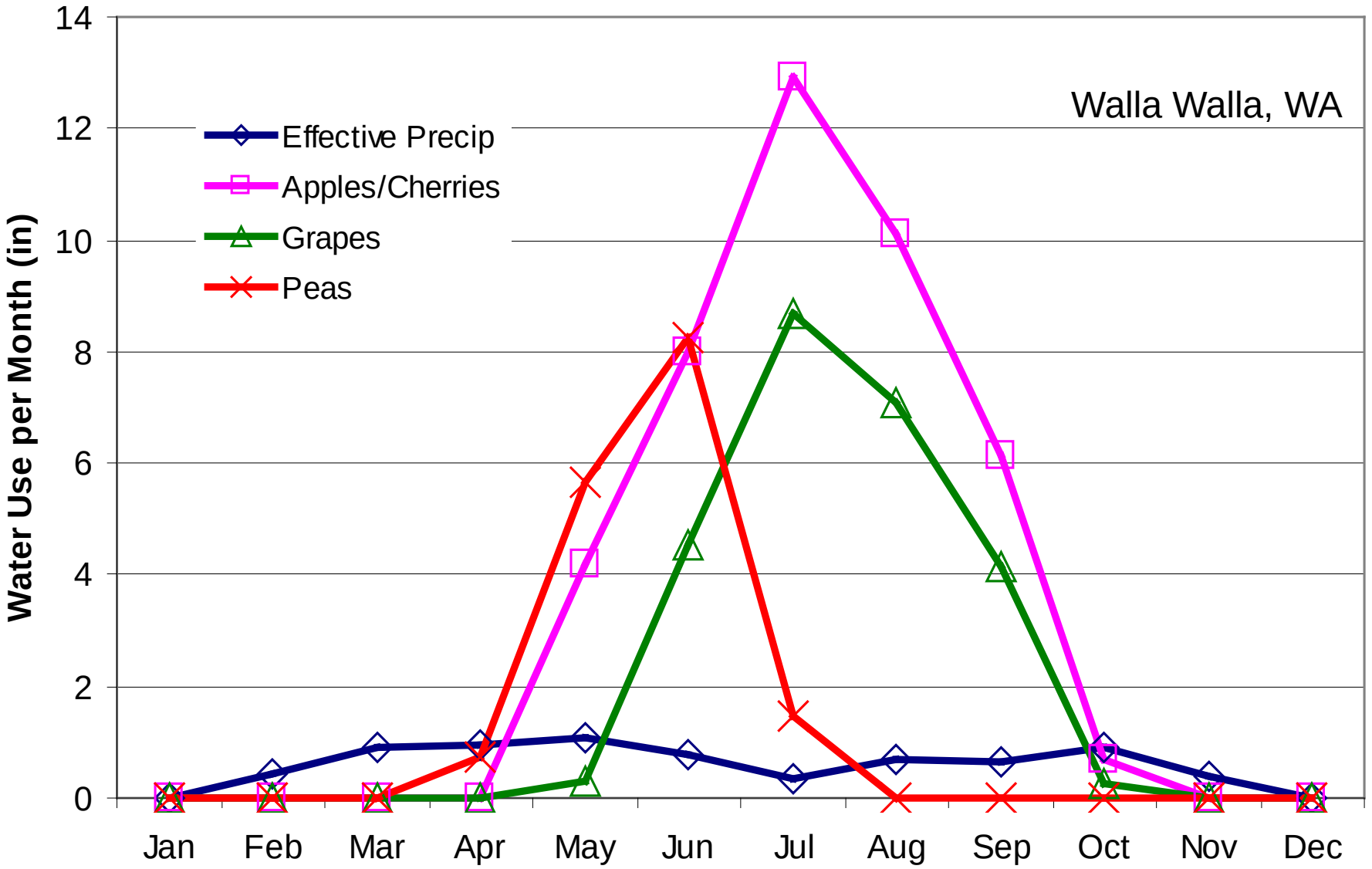
$$SW_2 = SW_1 + Rain + Irrig. + Capillary - ET - DeepPerc - Runoff$$


Variation in Crop Water Use
from growing season
to growing season
Average Crop Water Use
Crop Water Use
Germination
and
Emergence
Vegetative
Growth
Reproduction
(seed set)
Maturity
and
Senascence
Growing Season

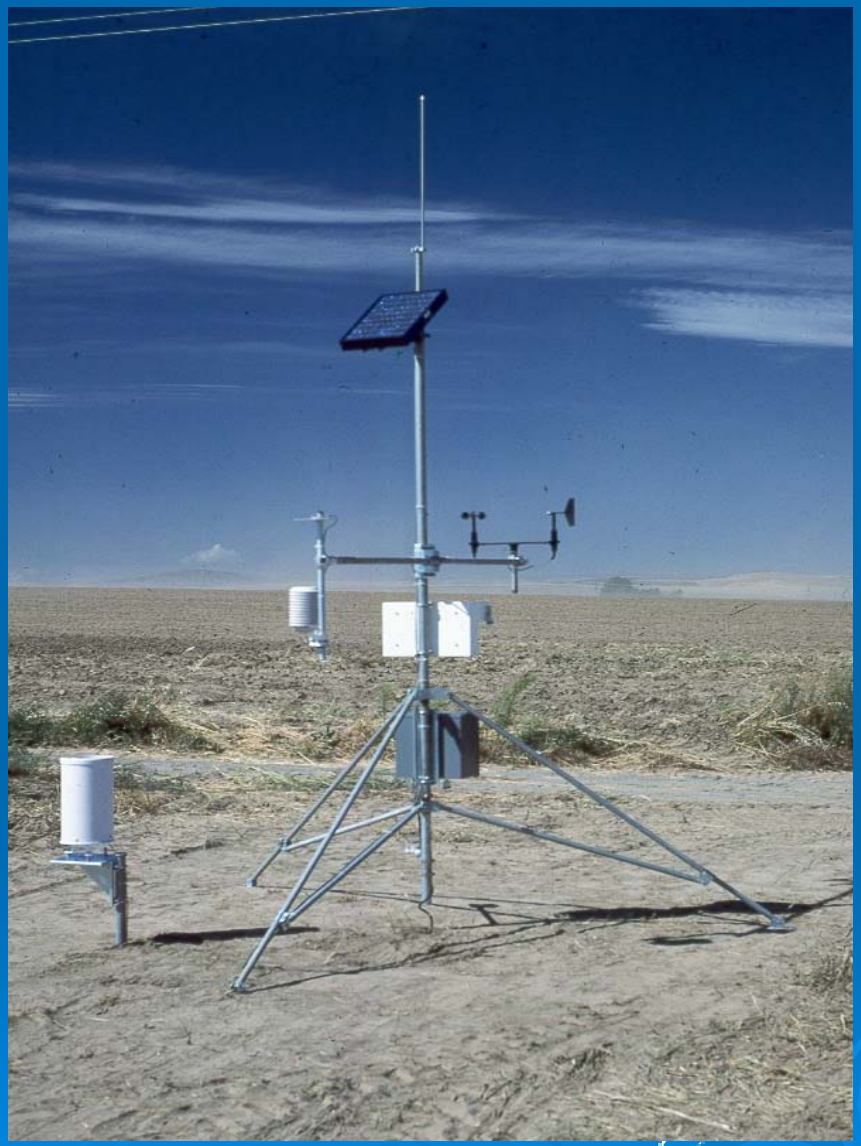
ET and Weather



Avg. Crop Water Needs



Washington Ag Weather Network



http://weather.wsu.edu/

Washington Weather - AgWeatherNet - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://weather.wsu.edu/awn.php

A-Z Index | Campuses | myWSU | WSU Search | WSU Home

Washington State University
World Class. Face to Face.

The Washington Agricultural Weather Network Version 2.0, WSU Prosser

AgWeatherNet

Contact Us | Help | News | AWN Staff | Popular Links | Northwest Forecast | Spokane Forecast | Viticulture & Enology | Tree Fruit IPM DAS

- Home
- Current Observations

- Add Favorites
- Add Low Temp Alert
- Run Favorites/Alerts

- AWN Reports
- AWN Raw Data
- AWN Models
- Tree Fruit IPM Models
- Current Maps
- Yesterday Maps
- Month-To-Date Maps
- Year-To-Date Maps
- Terrain Map
- Google Map

- Regional Current Maps
- Regional Yesterday Maps
- Regional Month-To-Date Maps
- Regional Year-To-Date Maps
- Regional Disease Maps

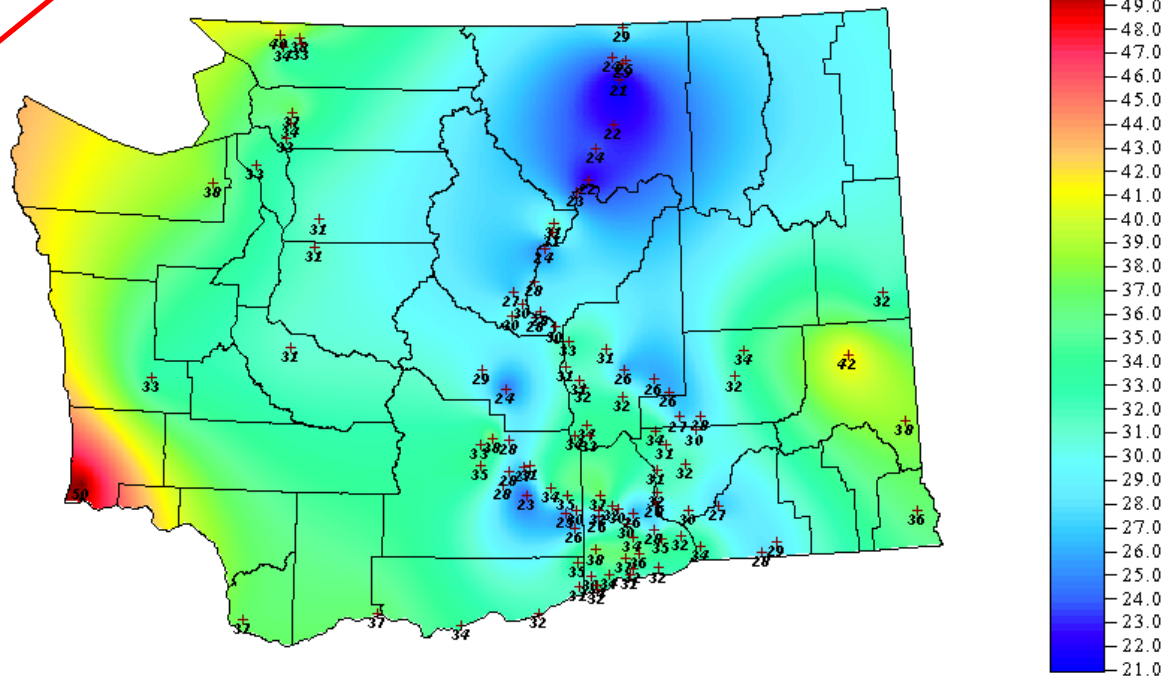
- Account Info
- Edit Account
- Logout

Member Total: 3249
There are 12 members
2 guests viewing the site

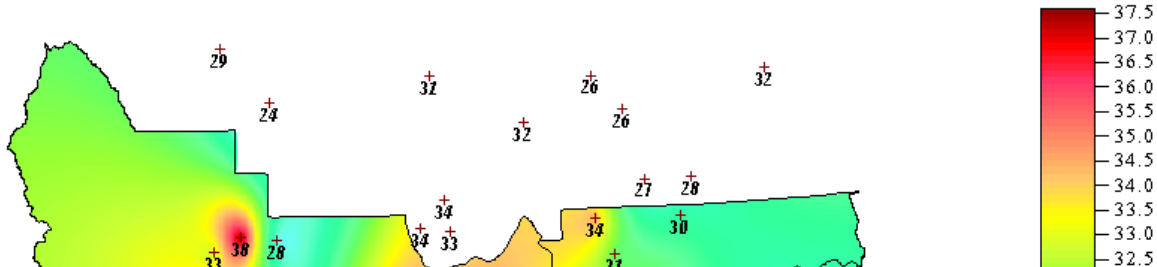
logged in as tpeters

Current

AWN Models



Air Temperature (°F) for Feb-03-2009, 09:00 AM PST



Washington Weather - AgWeatherNet - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://weather.wsu.edu/awn.php?model=selectall

A-Z Index | Campuses | myWSU | WSU Search | WSU Home

Washington State University
World Class. Face to Face.

The Washington Agricultural Weather Network Version 2.0, WSU Prosser

AgWeatherNet

Contact Us | Help | News | AWN Staff | Popular Links | Northwest Forecast | Spokane Forecast | Viticulture & Enology | Tree Fruit IPM DAS

- Home
- Current Observations

- Add Favorites
- Add Low Temp Alert
- Run Favorites/Alerts

- AWN Reports
- AWN Raw Data
- AWN Models
  - Apple Scab
  - Cherry Powdery Mildew
  - Grape Bunch Rot
  - Grape Powdery Mildew
  - Hop Powdery Mildew
  - Water Use
- Tree Fruit IPM Models
- Current Maps
- Yesterday Maps
- Month-To-Date Maps
- Year-To-Date Maps
- Terrain Map
- Google Map

- Regional Current Maps
- Regional Yesterday Maps
- Regional Month-To-Date Maps
- Regional Year-To-Date Maps
- Regional Disease Maps

- Account Info
- Edit Account
- Logout

Member Total: 3248
There are 8 members

Select time interval, station, and unit

Submit click when finished

1. Please select time interval

- ○ Midnight today to present
- ○ Midnight yesterday to present
- ○ Previous 7 days to present
- ○ Previous 30 days to present
- ◉ Use start and end date

Start Date: February 2 2009 8 : 30

End Date: February 3 2009 8 : 30

Select Station and Dates

2. Please check desired sites (click to show new sites)

Adams
- ☐ Hatton
- ☐ Lind
- ☐ Ritzville
- ☐ WSU Othello

Asotin
- ☐ Anatone

Benton
- ☐ Badger Canyon
- ☐ Benton City
- ☐ Benton City West
- ☐ Canoe Ridge
- ☐ Carlson
- ☐ Coffin
- ☐ Eby
- ☐ Finley
- ☐ Fourmile
- ☐ Gramling
- ☐ Horrigan
- ☐ Wenatchee Heights
- ☐ WSU TFREC

Clallam
- ☐ Sequim

Clark
- ☐ WSU Vancouver RE

Douglas
- ☐ Brays Landing
- ☐ Brewster
- ☐ East Wenatchee
- ☐ Orondo
- ☐ WSU Sunrise

Franklin
- ☐ Basin City
- ☐ CBC Pasco
- ☐ Connell Bench
- ☐ Juniper
- ☐ Mesa SE

Island
- ☐ Whidbey Island

King
- ☐ 21 Acres

Kittitas
- ☐ Broadview
- ☐ Thorp

Klickitat
- ☐ Alderdale
- ☐ Maryhill
- ☐ McKinley Springs
- ☐ Roosevelt

Okanogan
- ☐ Brewster Flat
- ☐ East Oroville
- ☐ Ellisforde
- ☐ Loomis Grade
- ☐ Loomis Valley
- ☐ Stanwood

Spokane
- ☐ Fairfield

Walla Walla
- ☐ College Place
- ☐ FishHook
- ☐ K2H
- ☐ Touchet
- ☐ Walla Walla
- ☐ Wallula
- ☐ Welland

Whatcom
- ☐ Lawrence
- ☐ Lynden
- ☐ Nooksack
- ☐ Ten Mile

Whitman
- ☐ Pullman

Home
Current Observations

Add Favorites
Add Low Temp Alert
Run Favorites/Alerts

AWN Reports
AWN Raw Data
AWN Models
Apple Scab
Cherry Powdery Mildew
Grape Bunch Rot
Grape Powdery Mildew
Hop Powdery Mildew
Water Use
Tree Fruit IPM Models
Current Maps
Yesterday Maps
Month-To-Date Maps
Year-To-Date Maps
Terrain Map
Google Map

Regional Current Maps
Regional Yesterday Maps
Regional Month-To-Date Maps
Regional Year-To-Date Maps
Regional Disease Maps

Account Info
Edit Account
Logout

Member Total: 3248
There are 7 members

Water Use Model

Please enter the following information

(•) Default Emergence and Harvest Dates
OR
( ) Custom Emergence and Harvest Dates

Emergence (mm-dd-yyyy)
Harvest (mm-dd-yyyy)

- [ ] Alfalfa
- [ ] Apples w/o cover crop
- [ ] Apricots w/o cover Crop
- [ ] Bean (dry)
- [ ] Blueberries
- [ ] Cherries w/cover crop
- [ ] Clover
- [ ] Corn (grain)
- [ ] Crucifers
- [ ] Grass (Pasture, Turf)
- [ ] Onions (dry)
- [ ] Peaches w/cover crop
- [ ] Pears, Plums w/cover crop
- [ ] Peas
- [ ] Potatoes
- [ ] Raspberries
- [ ] Sorghum
- [ ] Spearmint
- [ ] Spring grains
- [ ] Sugarbeets
- [ ] Tomato
- [ ] Winter wheat
- [x] Apples w/cover crop
- [ ] Apricots w/cover Crop
- [ ] Asparagus
- [ ] Beans (green)
- [ ] Carrots
- [ ] Cherries w/o cover crop
- [ ] Concord Grapes
- [ ] Corn (sweet)
- [ ] Cucumbers
- [ ] Hops
- [ ] Onions (green)
- [ ] Peaches w/o cover crop
- [ ] Pears, Plums w/o cvr crop
- [ ] Peppermint
- [ ] Radishes
- [ ] Safflower
- [ ] Soybeans
- [ ] Spinach
- [ ] Strawberries
- [ ] Sunflower
- [ ] Wine Grapes

- [ ] All Crops for the last 7 days

Submit

Water Use

Select Crop

Home
Current Observations

Add Favorites
Add Low Temp Alert
Run Favorites/Alerts

AWN Reports
AWN Raw Data
AWN Models
- Apple Scab
- Cherry Powdery Mildew
- Grape Bunch Rot
- Grape Powdery Mildew
- Hop Powdery Mildew
- Water Use

Tree Fruit IPM Models
Current Maps
Yesterday Maps
Month-To-Date Maps
Year-To-Date Maps
Terrain Map
Google Map

Regional Current Maps
Regional Yesterday Maps
Regional Month-To-Date Maps
Regional Year-To-Date Maps
Regional Disease Maps

Account Info
Edit Account
Logout

Member Total: 3248
There are 6 members

Water Use Model

ET Report

Data Extracted: 2009-02-03
Station: **WSU HQ**
Lat: 46.3 Lng: 119.7 Elevation: 868
Date Range from 2009-01-04 to 2009-2-3

Accumlated precip for selected period is: 0.02 Inches.

Date yyyy-mm-dd	Penman ETr Alfalfa (in)	Accum Alfalfa ET (in)	Apples w/cover crop ET (in)	Apples w/cover crop Accum ET (in)
2009-01-04	0.01	0.01	0.00	0.00
2009-01-05	0.02	0.03	0.00	0.00
2009-01-06	0.07	0.10	0.00	0.00
2009-01-07	0.17	0.27	0.00	0.00
2009-01-08	0.11	0.38	0.00	0.00
2009-01-09	0.04	0.42	0.00	0.00
2009-01-10	0.02	0.44	0.00	0.00
2009-01-11	0.03	0.47	0.00	0.00
2009-01-12	0.05	0.52	0.00	0.00
2009-01-13	0.01	0.53	0.00	0.00
2009-01-14	0.01	0.54	0.00	0.00
2009-01-15	0.00	0.54	0.00	0.00
2009-01-16	0.00	0.54	0.00	0.00
2009-01-17	0.00	0.54	0.00	0.00
2009-01-18	0.01	0.55	0.00	0.00
2009-01-19	0.01	0.56	0.00	0.00
2009-01-20	0.01	0.57	0.00	0.00
2009-01-21	0.01	0.58	0.00	0.00
2009-01-22	0.01	0.59	0.00	0.00
2009-01-23	0.02	0.61	0.00	0.00
2009-01-24	0.02	0.63	0.00	0.00
2009-01-25	0.04	0.67	0.00	0.00
2009-01-26	0.05	0.72	0.00	0.00
2009-01-27	0.04	0.76	0.00	0.00
2009-01-28	0.07	0.83	0.00	0.00

Example Soil Water Budget

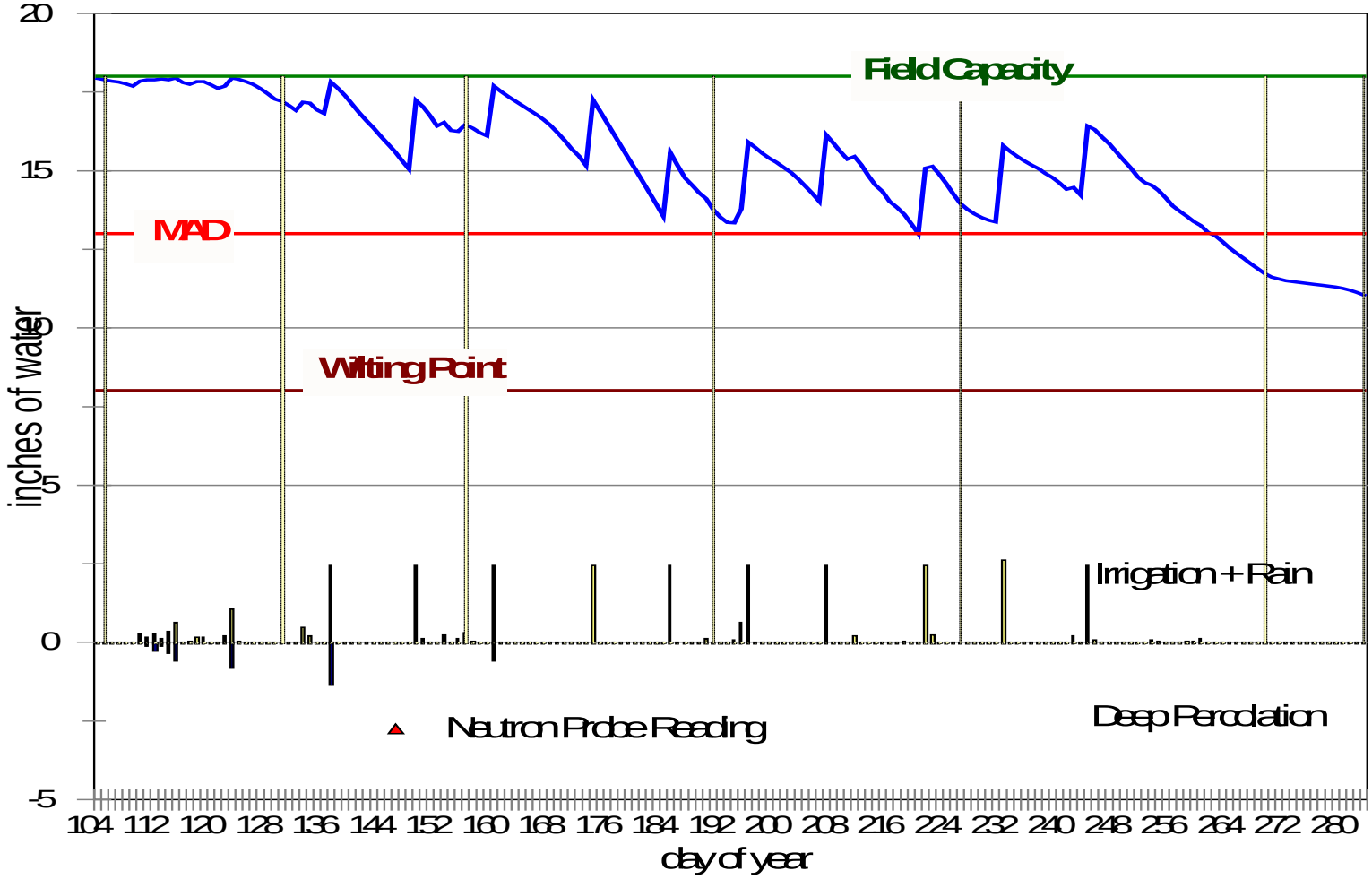
- Sand: AW = 1 in/ft
- Effective rooting depth: 2.5 ft
- Total water holding capacity: $2^{in}/_{ft}$ x 2.5ft=5in
- MAD: 30%
- Irrigation Efficiency: 75%
- Soil water deficit at MAD: 5 in * 30% = 1.5 in

Example Soil Water Budget cont..

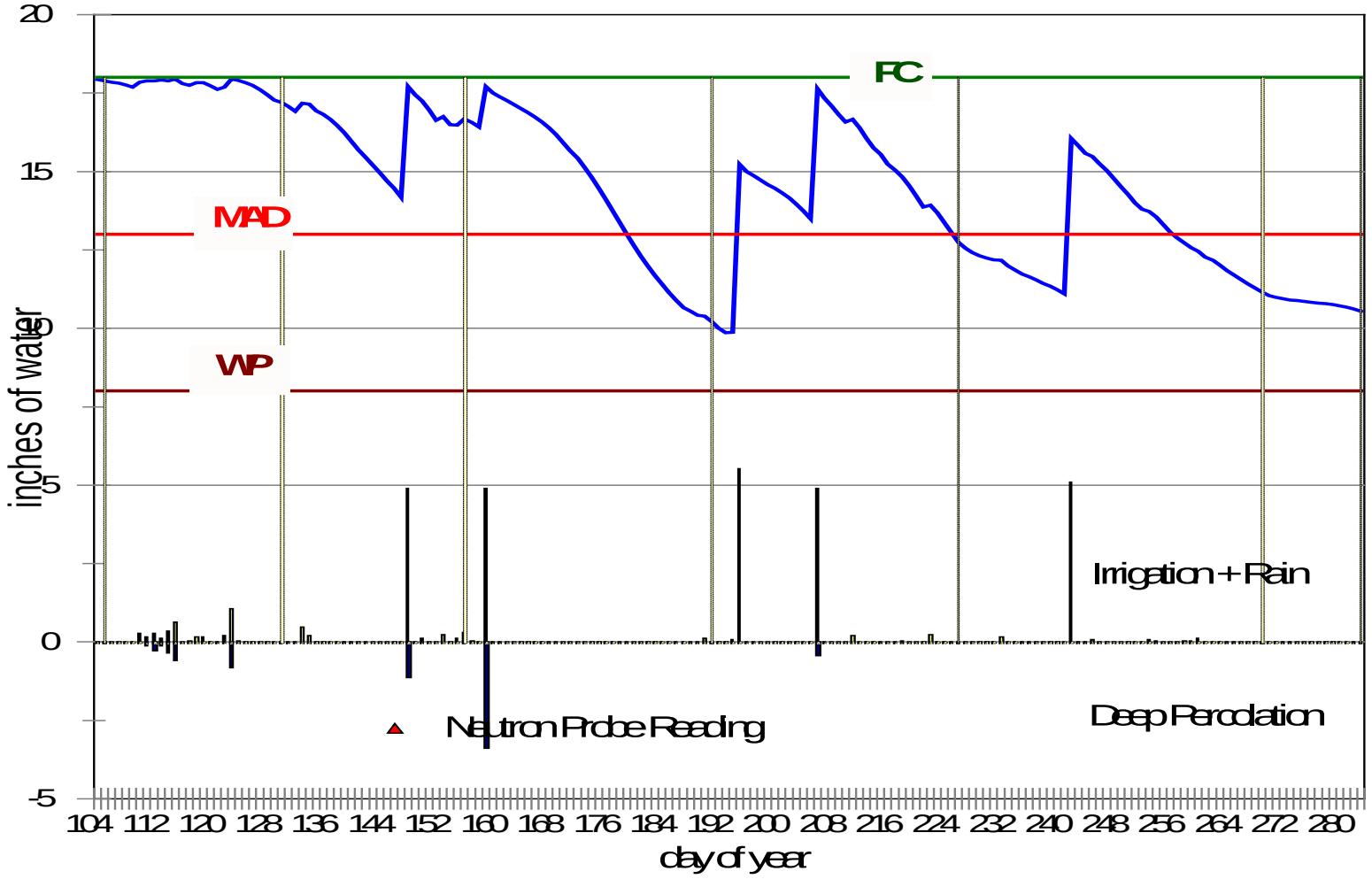
- Daily ET rate: 0.25 in/day (or use actuals from web site)
- Time to dewater full profile to MAD:

  1.5 in / 0.25 in/day = 6 days
- Irrigation Efficiency: 75%
- Irrigation Amount: 1.5 in / 75% = 2 in
- How long does it take to put on 2 in?

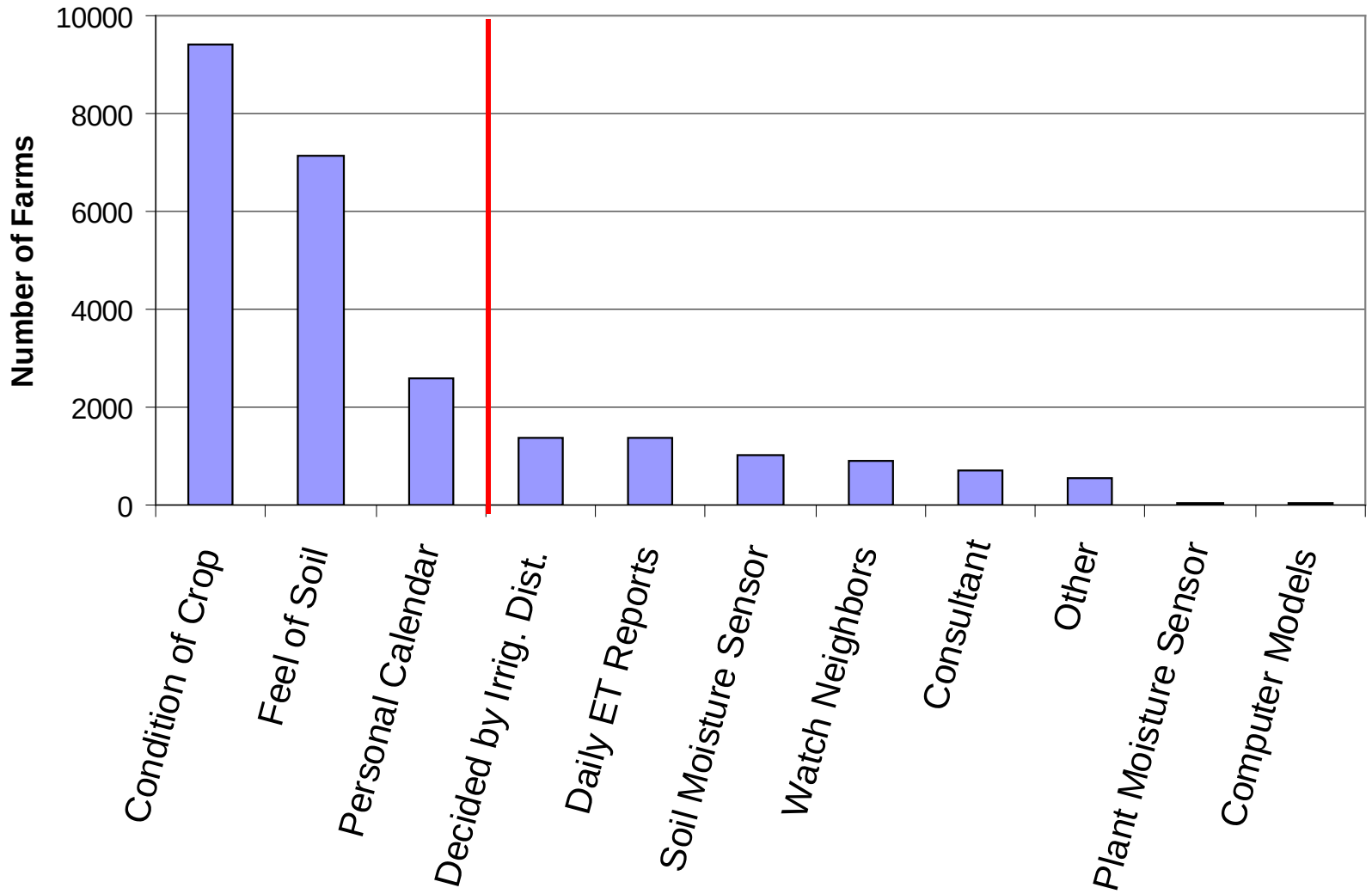
Good Irrigation Management



Poor Irrigation Management



Methods Used in Washington to Determine When to Irrigate



Levels of Irrigation Scheduling

Worst

- Same schedule all season / Guessing
- Kicking the dirt / Looking at the plants

Less Profitable

- Look and feel method using shovel or soil probe
- Checkbook method / ET (AgWeatherNet)
- Soil moisture monitoring
- Neutron probe + checkbook

More Profitable Growers

Best

Soil Moisture Sensors

Soil Moisture Sensors
Tensiometers

- Strengths
  - Soil water tension (same as plant sees)
  - Less expensive
  - Widely used, studied and accepted
  - Not affected by salinity
- Weaknesses
  - Small sample area
  - Indicates “when” to irrigate, not “how much”

Soil Moisture Sensors
Resistance type

- Strengths
  - Inexpensive
  - Usable trends
  - Give soil water potential (same as plant sees)
  - Easy to log data
- Weaknesses
  - Affected by salinity
  - Imperfect accuracy
  - Samples small area

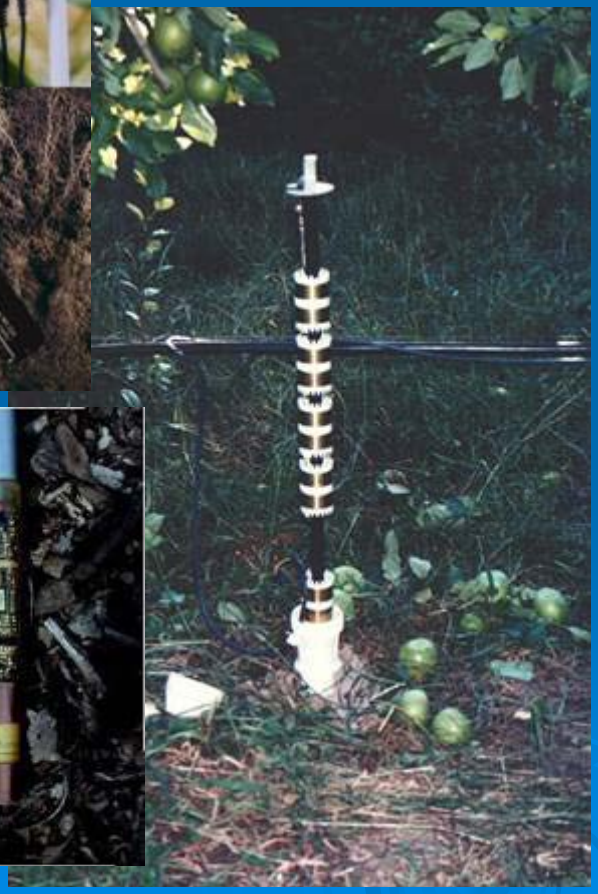
RESISTANCE


WATERMARK
25

Soil Moisture Sensors
Neutron Probe

- Strengths
  - Accurate
  - Gives soil water content
  - Large soil sample area
  - Unaffected by salinity or temperature
  - Repeatable
  - Easy to sample at different depths
- Weaknesses
  - Highly regulated (nuclear device)
  - Can’t leave in the field
  - Expensive

Soil Moisture Sensors
Dielectric constant/Capacitance



- Strengths
  - Usable trends
  - Gives soil water content
  - Easy to log data (real-time)
- Weaknesses
  - Imperfect accuracy
  - Inconsistent (high variability)
  - Small sample area
  - Can be expensive
  - Proper installation is critical, and difficult to do
  - Affected by salinity and temperature

Soil Moisture Sensors
The “Look and Feel Method”

- Advantages
  - Cheap
  - Easy
  - Forces you to get out in the field
- Weaknesses
  - Subjective

Soil Moisture Sensors
Summary

- Neutron Probe is still the best.
- All others are not as accurate, and are not as repeatable to varying degrees
- Most sensors will give a trend that is usable for irrigation scheduling.
- Proper installation of sensors is critical and must be done right or data is worthless
- Not all sensors are suitable to all soil types

Washington Irrigation Guide

- http://www.wa.nrcs.usda.gov/technical/ENG/irrigation_guide/index.html

Extension Irrigation Publications

- http://pubs.wsu.edu/cgi-bin/pubs/index.html

Web Soil Survey

- http://websoilsurvey.nrcs.usda.gov