

# Using capacitance sensors to monitor soil moisture

## Interpreting the numbers



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# MEASURES OF SOIL WATER STATUS

- There are two ways to describe the soil moisture:
- Volumetric Water content (% , in/ft)
  - Quantitative
- Soil Water Potential. (Centibars suction)
  - Qualitative

# Volume Units

- Rainfall inches/depth
- Crop Water Use inches/depth
- Soil moisture inches/depth

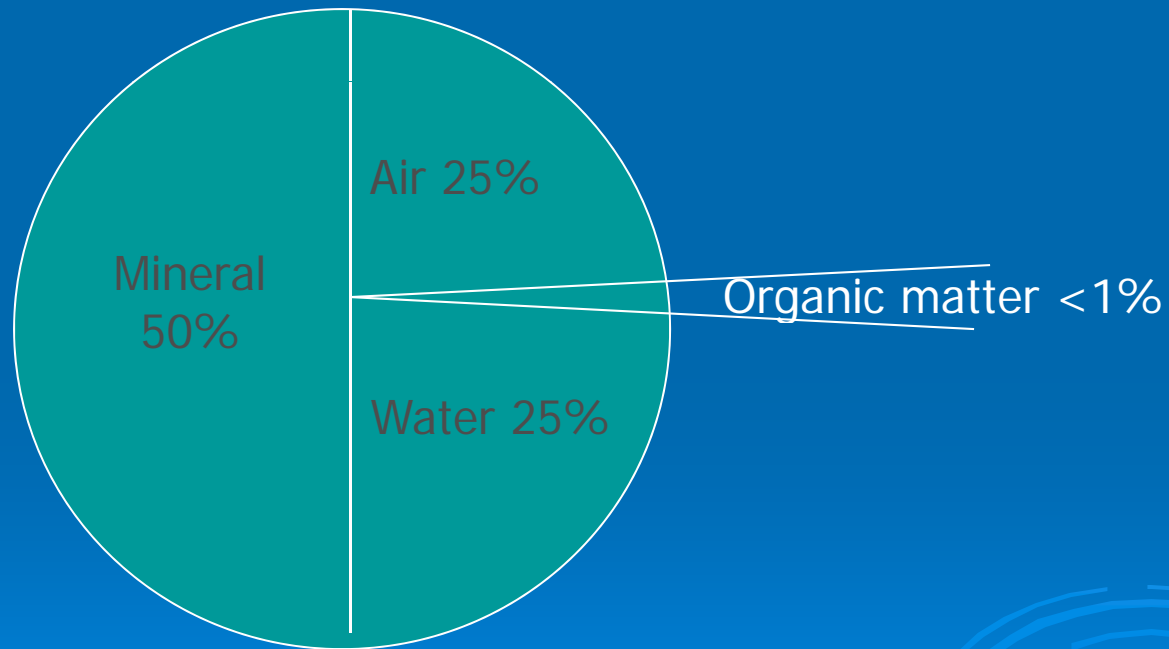
$\% = \text{in} / \text{in}$

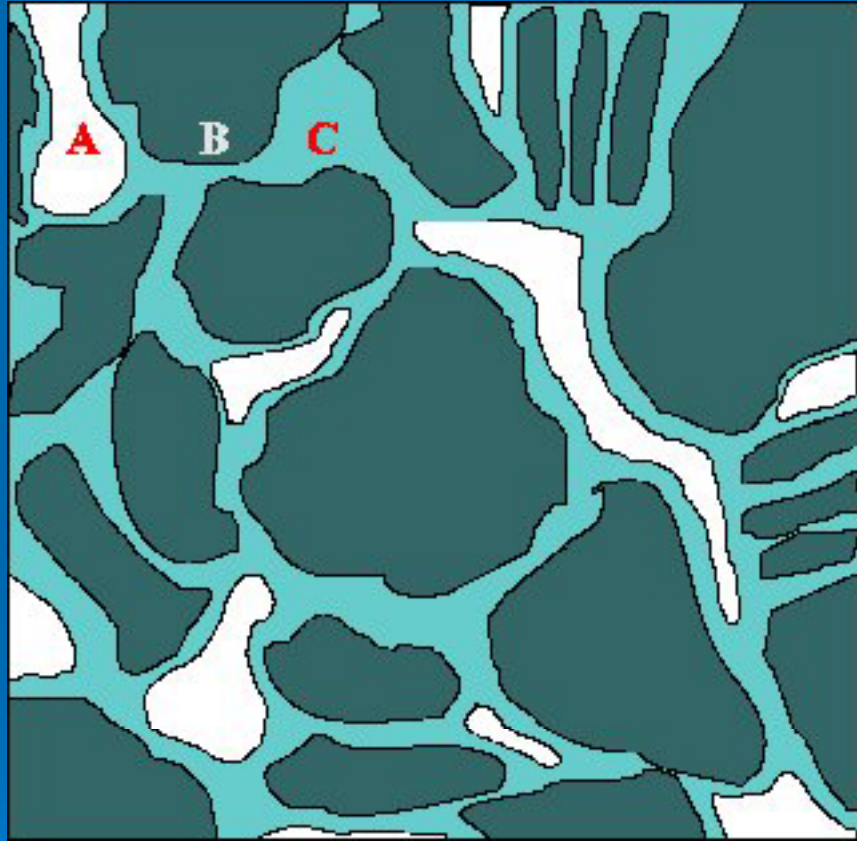
$\% \times 12 \text{ inches} = \text{inches} / \text{foot soil}$

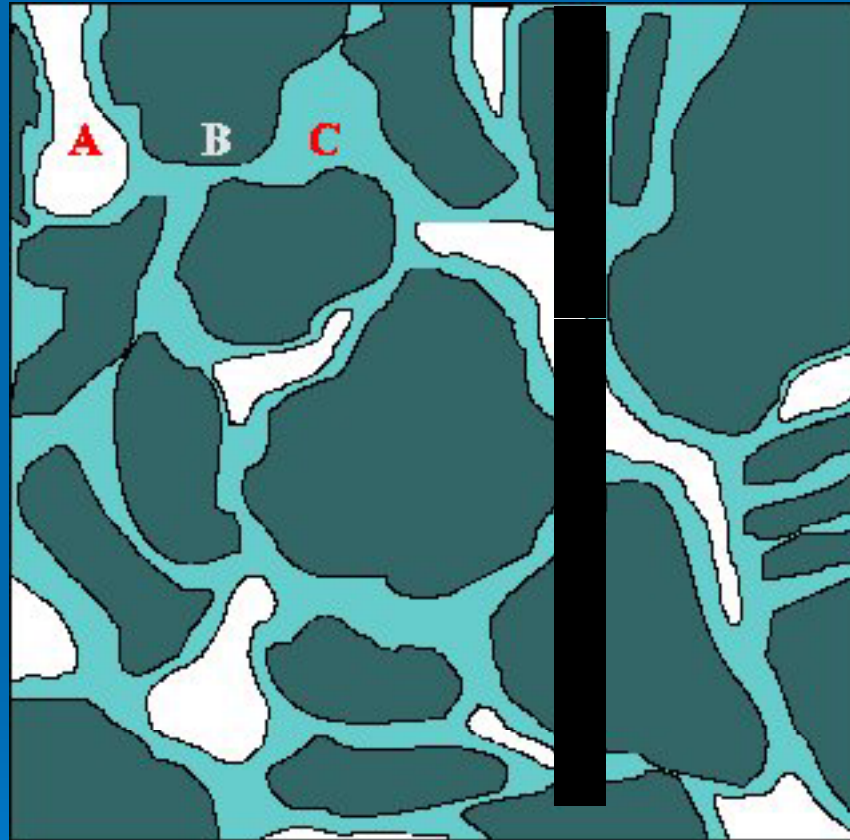
$\% \times \text{rootzone depth} = \text{inches in rootzone}$

# Soil Constituents by Volume

## At field capacity







# Direct / Indirect Methods

## ➤ Direct

- Soil sampling by volume
  - Or--- by weight x soil bulk density

## ➤ Indirect

any method which relates a “reading” to soil sampling moisture content



# Indirect Methods

- Soil Dielectric

Time Domain Reflectometry (TDR)

Ground Penetrating Radar (GPR)

Frequency Domain Reflectometry (FDR  
or capacitance)

- Neutron Scatter

# Soil Dielectric

- The dielectric permittivity is a measure of the capacity of a non-conducting material to transmit electromagnetic waves or pulses.
- Dielectric Permittivity
  - Air = 1
  - soil minerals = 3 to 5  
(denser soils have higher apparent permittivities).
  - Water 81

# Influencing Factors

- Water Content
- Soil Temperature (small in most cases)
- Soil Porosity and Bulk Density
- Minerals (2:1 clays)
- Measurement Frequency
- Air Gaps (installation– swelling soils)

# Frequency Domain/Capacitance

- A couple different methods are used however, they all use:
  - Electronic circuit in which the two plates, rods or rings use the soil between them as dielectric of a capacitor
- The change in the circuit output is related to the dielectric permittivity

Capacitance (C), measured in Farads (F), is defined as:

- the amount of charge (Q) required to increase the voltage (V) by one volt between two plates separated by a known distance containing an insulating material

Solar Panel

Cable

Data Logger

Ground Surface

Electrode

Electrode

Access Tube

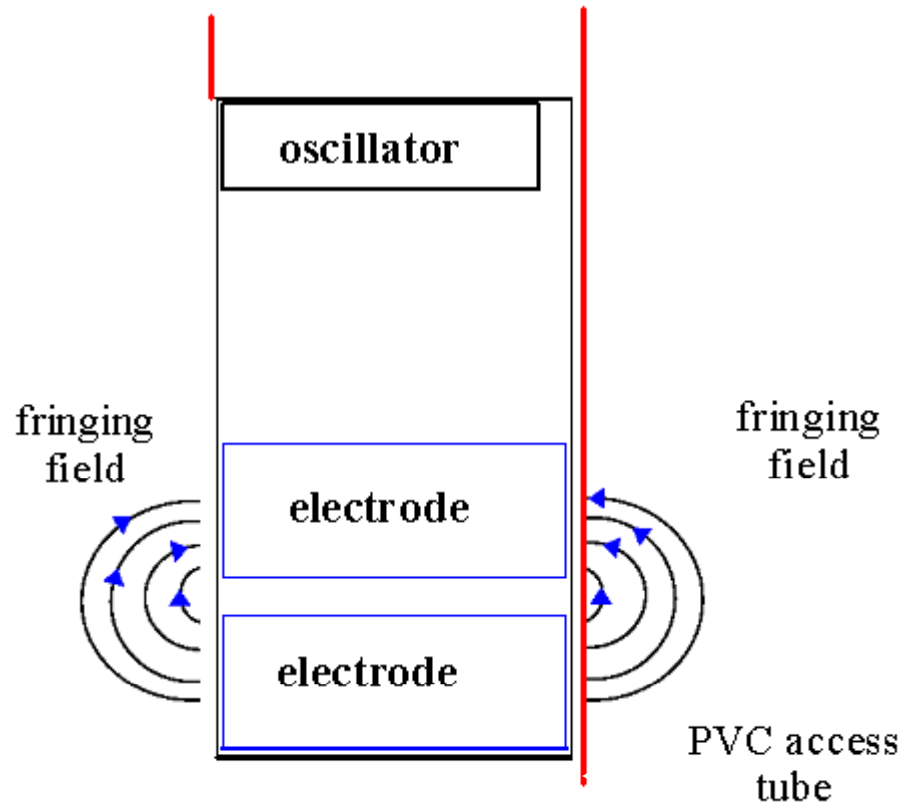


Permanent/logging  
Multi depth

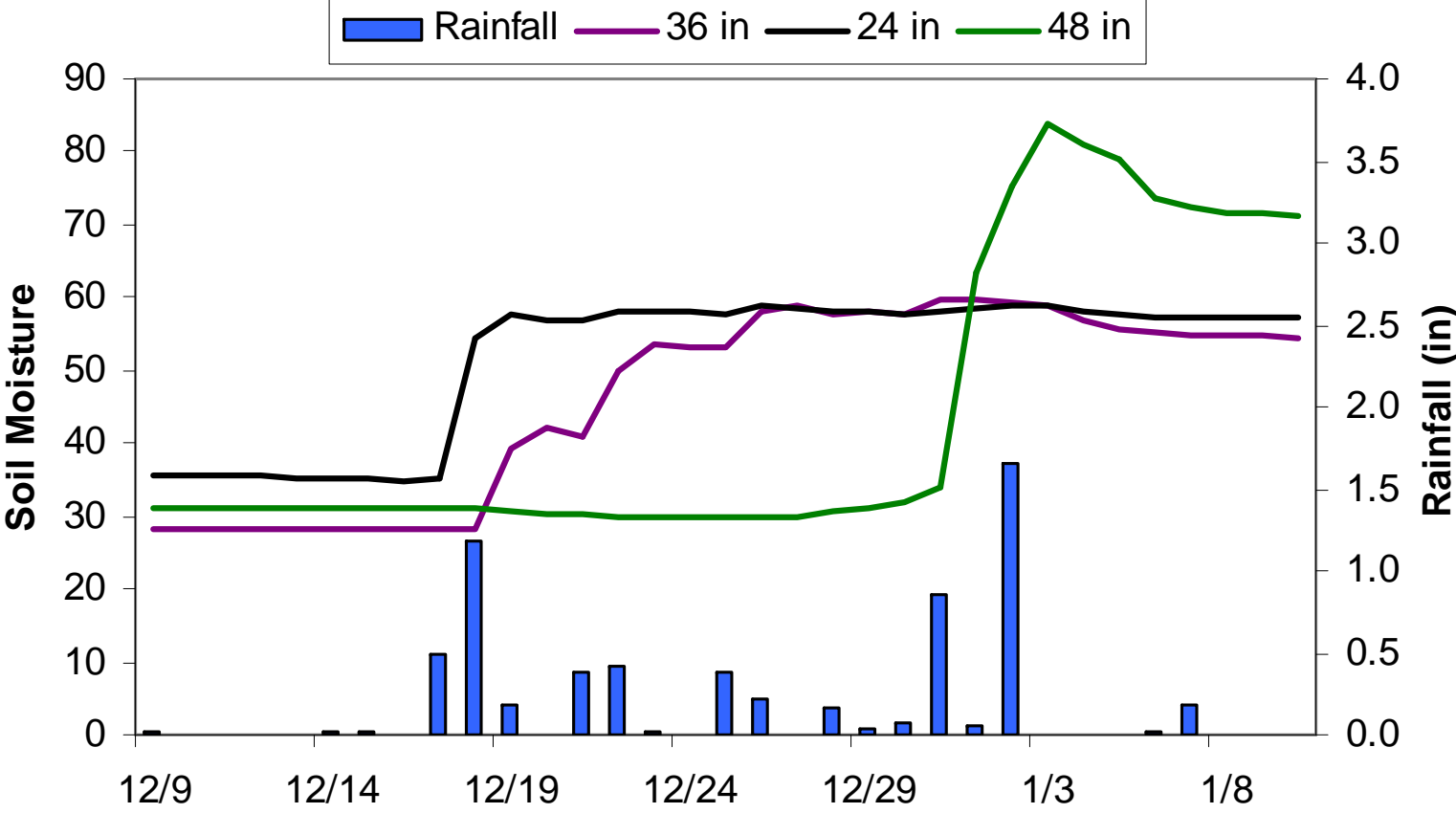
Portable

Single-point measure

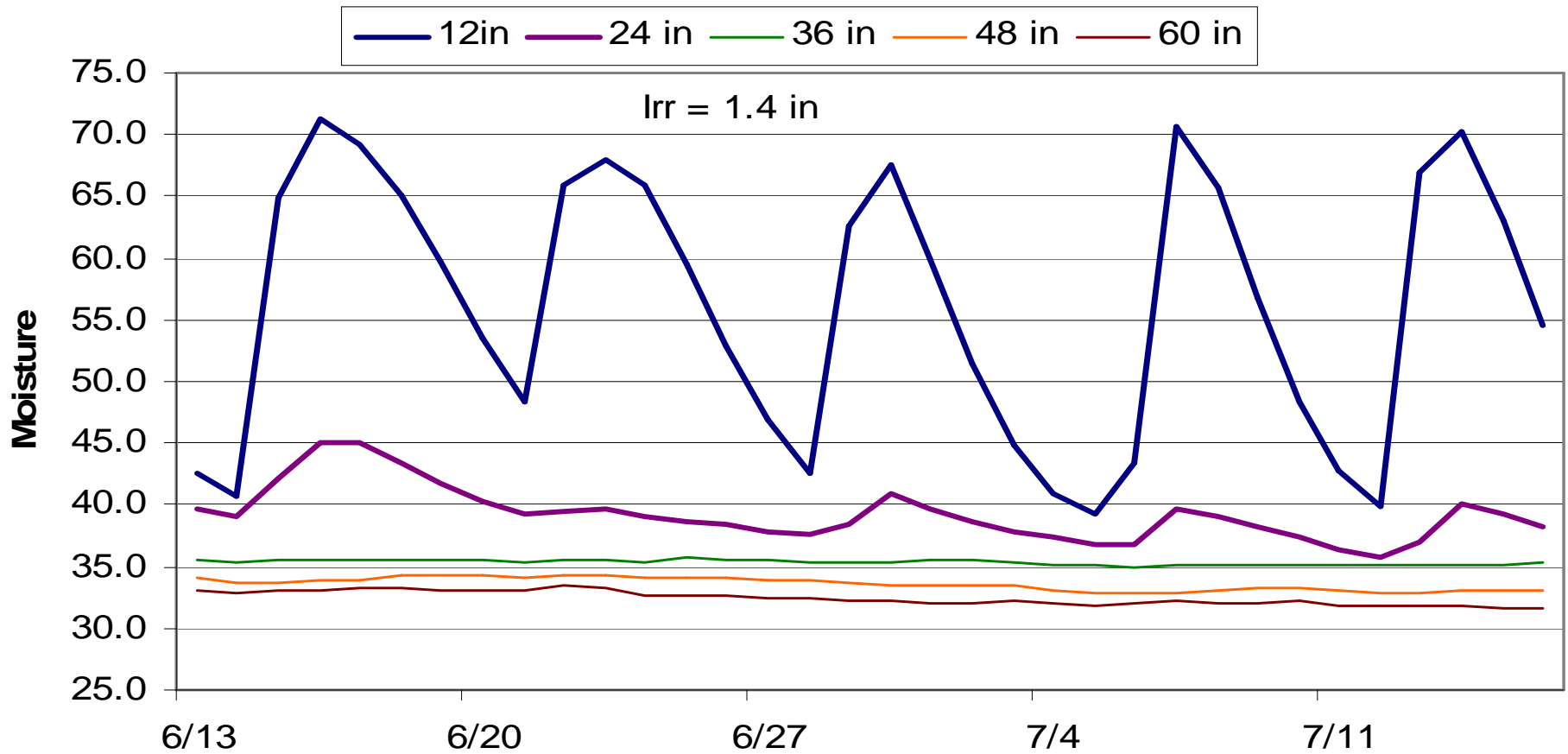
## Capacitance Probe



# C-Probe



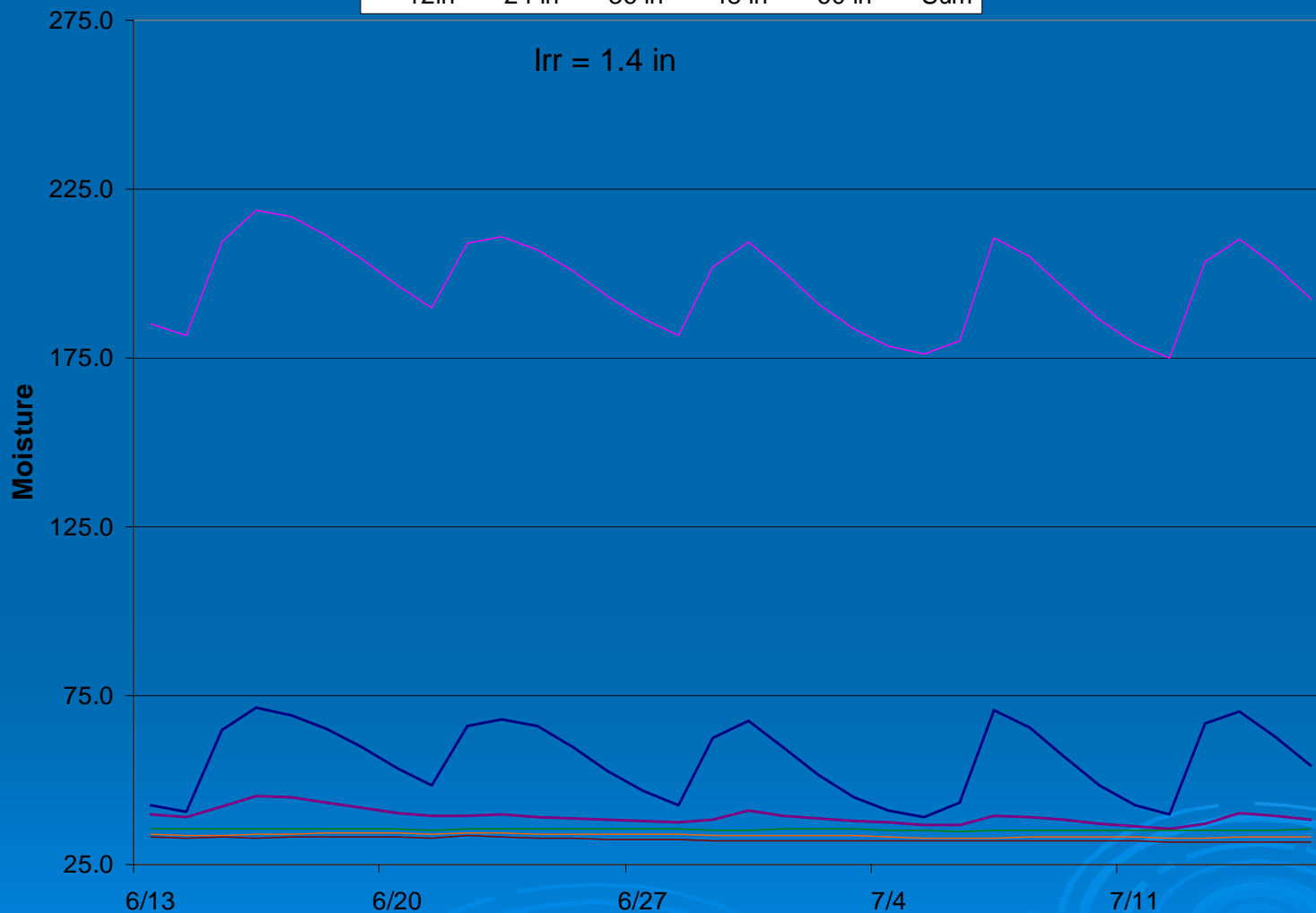
# C-Probe



C-Probe

12in 24 in 36 in 48 in 60 in Sum

Irr = 1.4 in

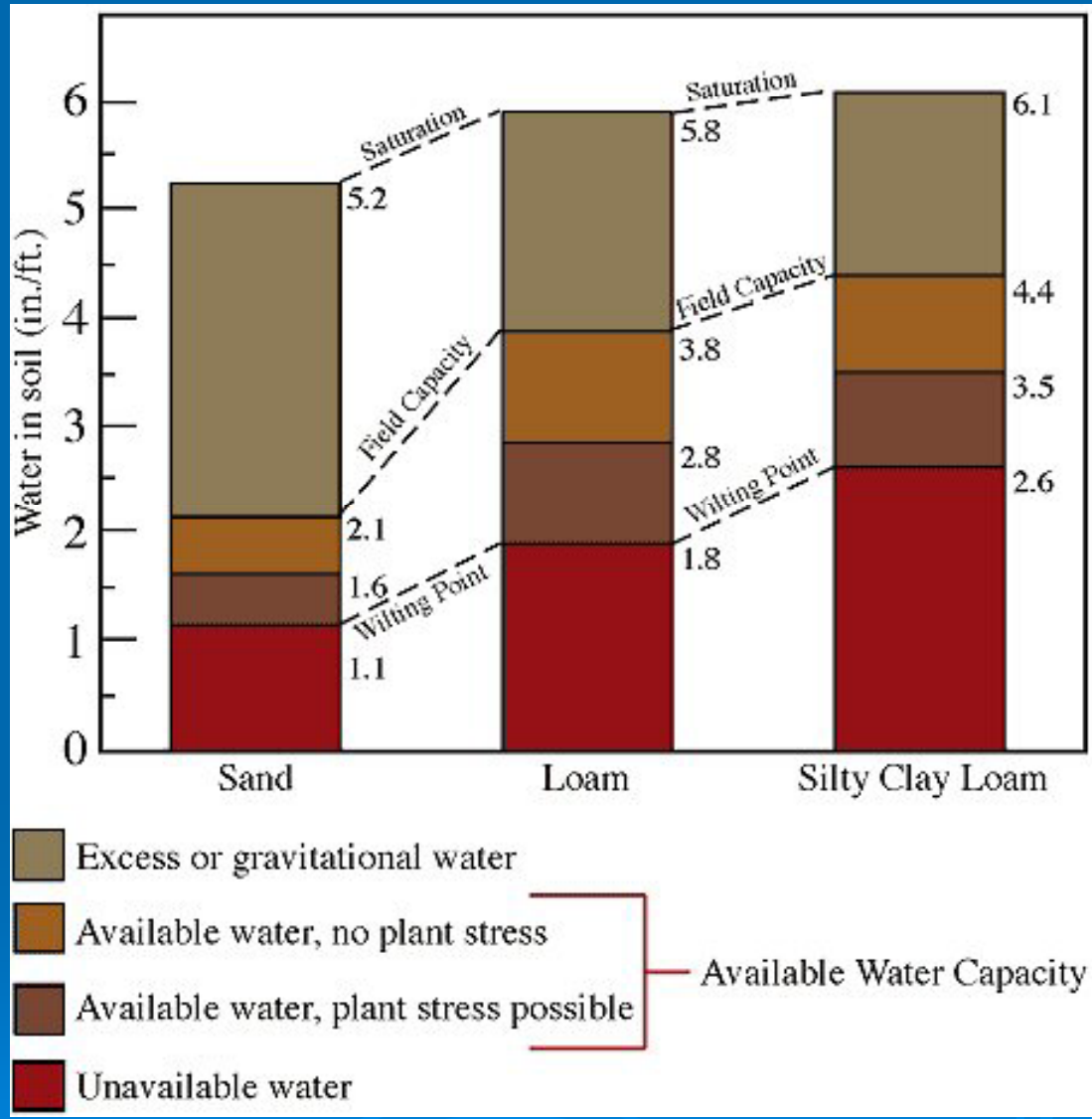


# *FDR Advantages*

- Relatively inexpensive
  - low frequency standard circuitry
- No radiation hazard / hassles
- Fast response time
- Logging capable
- Portable

# *FDR Disadvantages*

- Small measurement volume sensitive to small-scale soil variations (most in 5cm)
- Sensitivity to installation
- Site specific calibration is necessary for accurate soil volumetric water content
- Tends to have larger sensitivity to salinity, temperature, bulk density, clay content and air gaps than TDR



# Looking Ahead

- Increased use of devices which can log transmit and allow automatic data processing. --- Dielectric methods

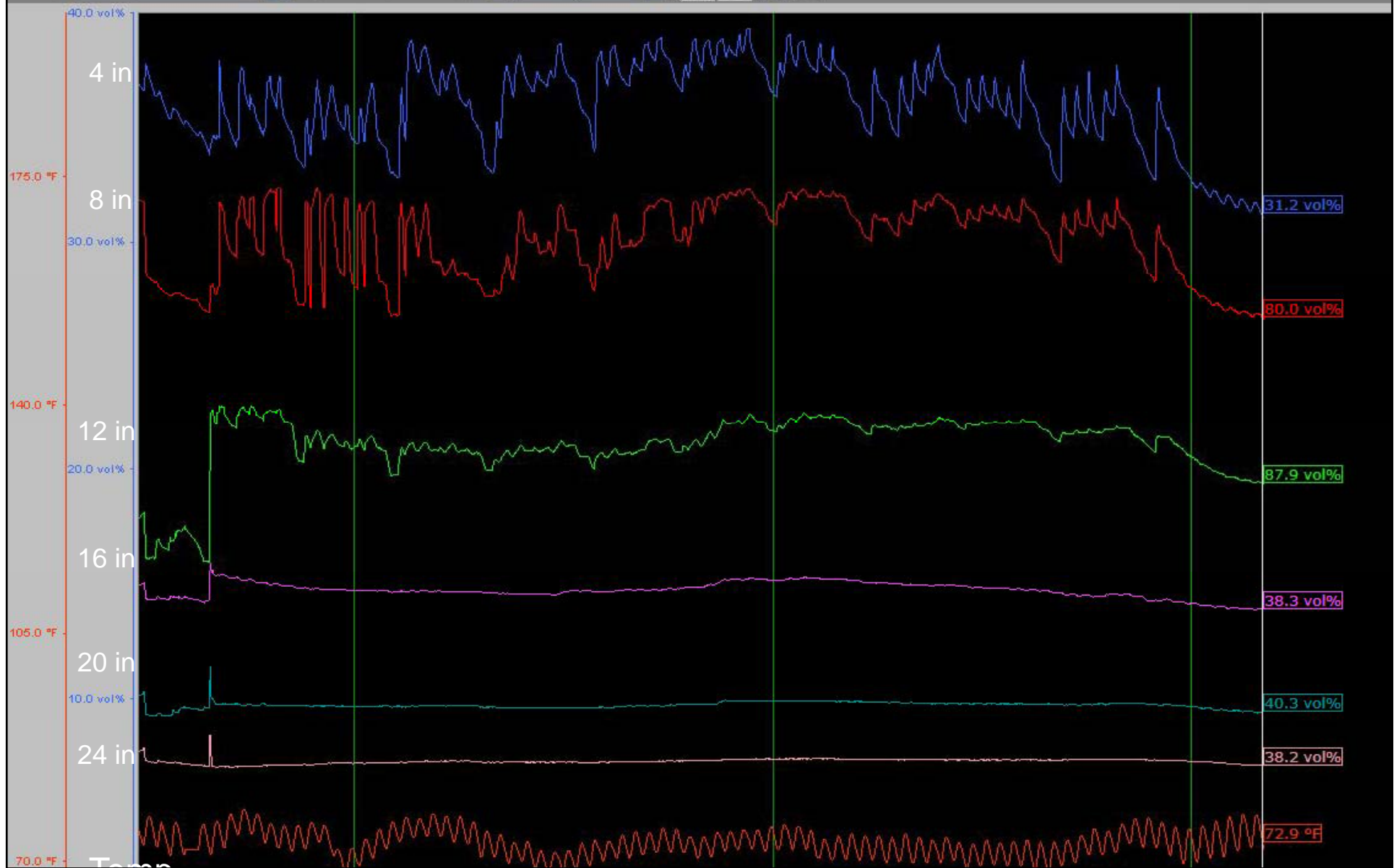


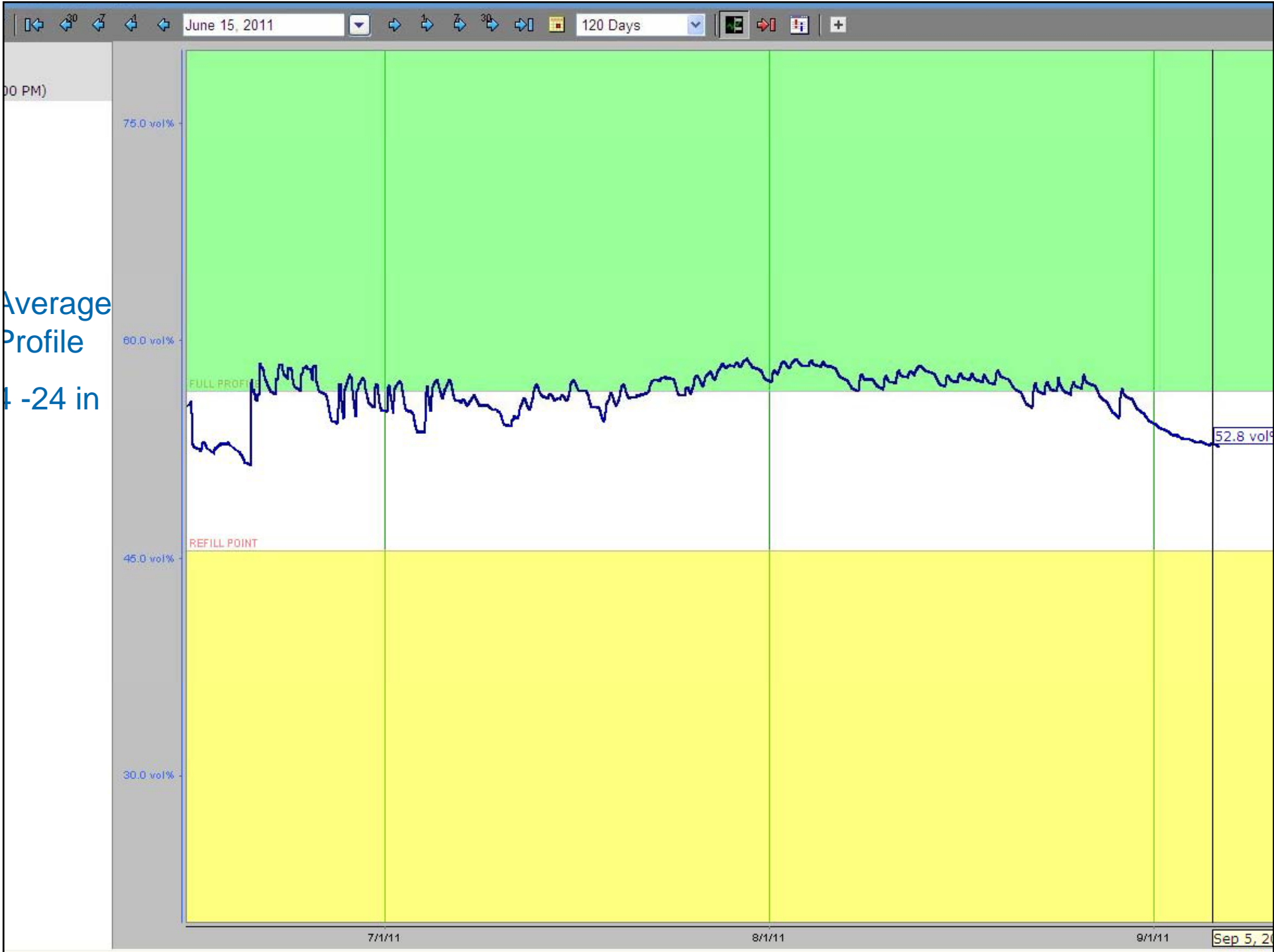


el=29648

out

June 15, 2011 120 Days

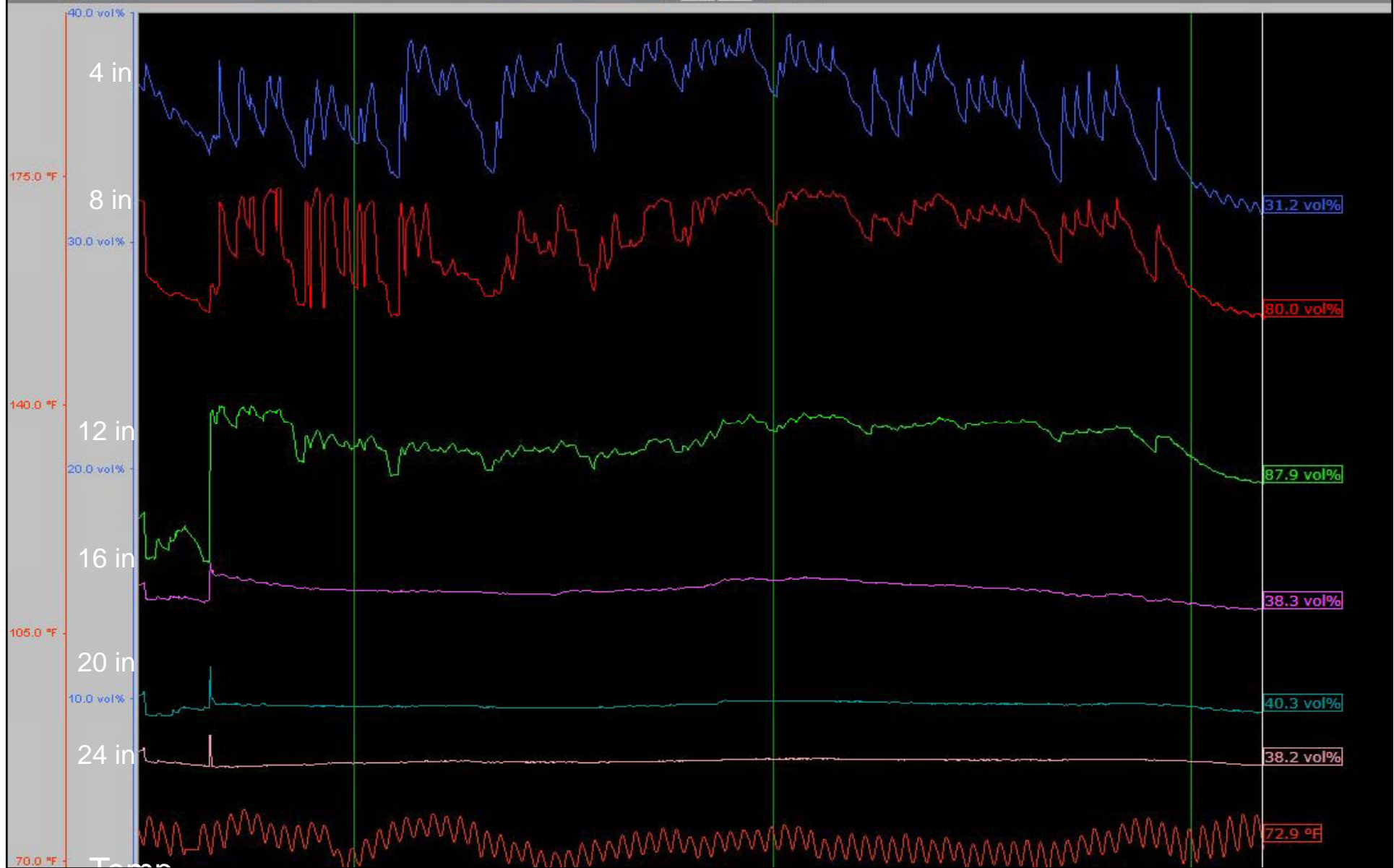




el=29648

out

June 15, 2011 120 Days





# Surface Irrigation



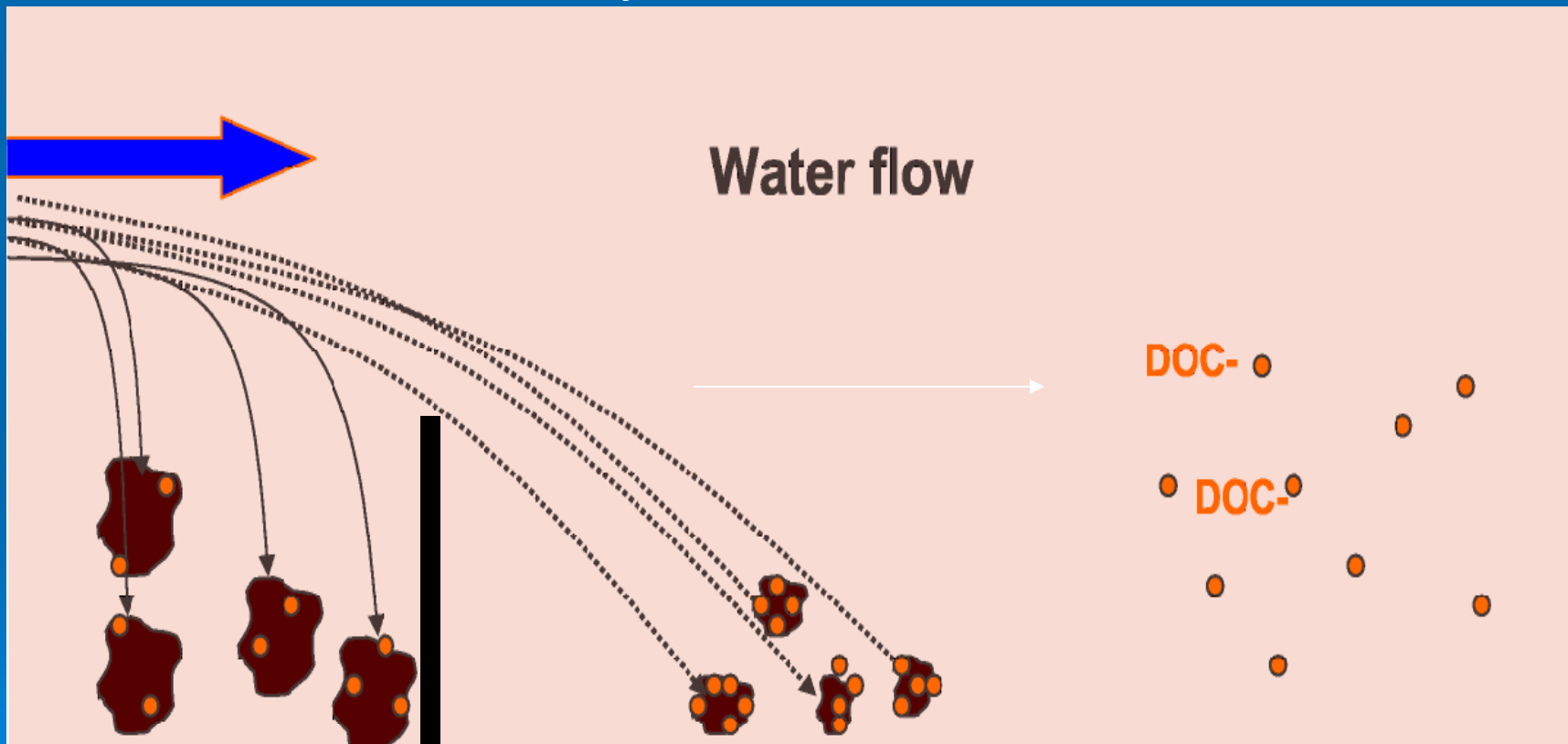
Runoff = 15% of onflow volume





# Settling Basin

Pyrethroids attached to:  
Fine silt, clay and dissolved carbon



# Water Diversion Limits



