University of California

Nitrogen Management Training

for Certified Crop Advisers

MODULE 6

Nitrogen Management and Irrigation

Part 1- Irrigation Management

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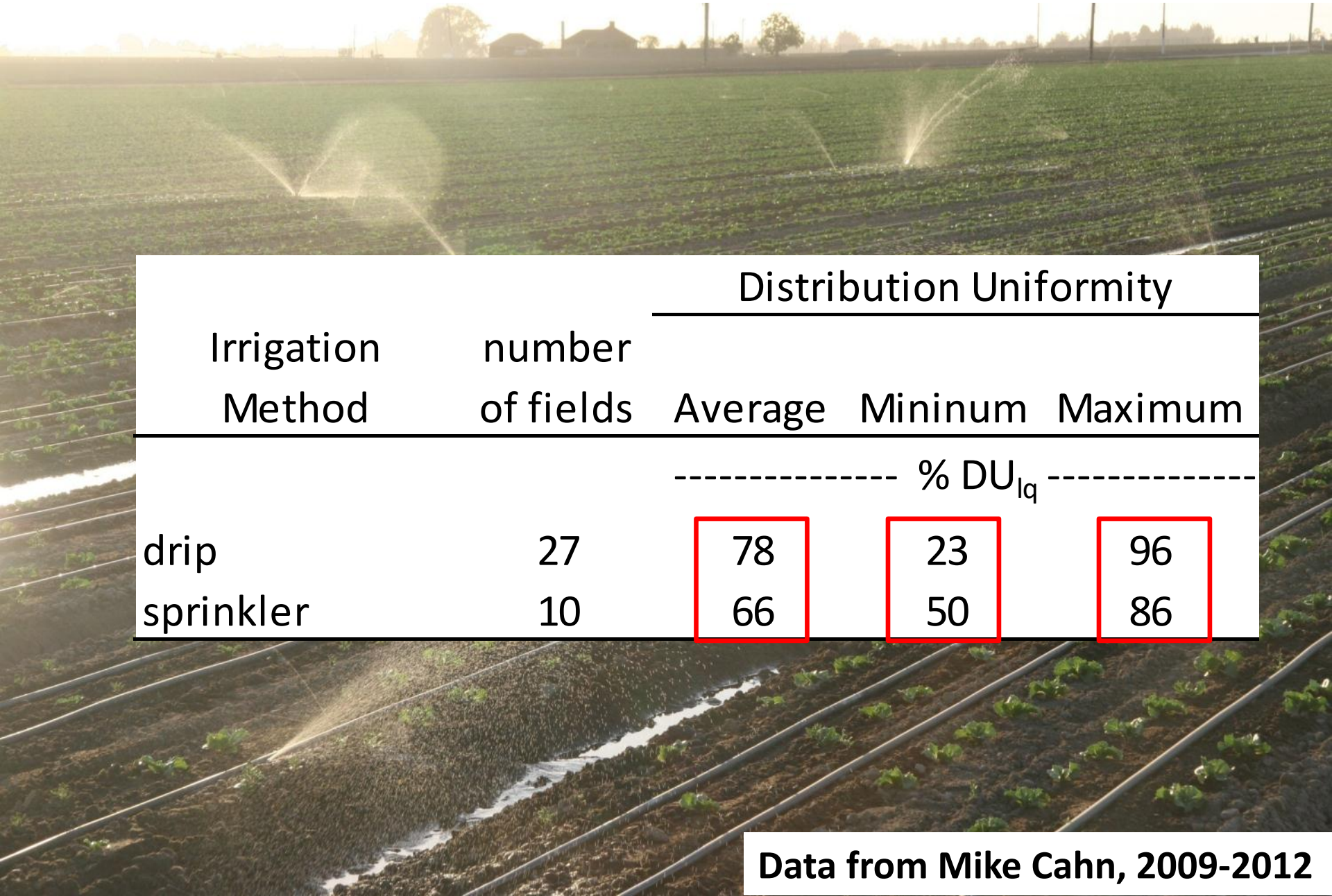
Irrigation management can make or break N use efficiency

Irrigation and Nitrogen Management

Successful nitrogen management depends on efficient irrigation water management:

- Nitrate is mobile and moves with water.
- You can apply the right amount of N in the root zone, but N can leach past the root zone unless the correct amount of water is applied at the correct time.
- Inefficient irrigation may result in N-deficient crops and potentially add nitrates to groundwater.

Irrigation efficiency is limited by water distribution uniformity



Irrigation Method	number of fields	Distribution Uniformity		
		Average	Mininum	Maximum
		% DU_{lq}		
drip	27	78	23	96
sprinkler	10	66	50	86

Data from Mike Cahn, 2009-2012

Irrigation Efficiency (also called Application Efficiency)

- Measure of how much of the applied water goes to "reasonable and beneficial uses".
  - The major beneficial use is to supply plant water needs and grow productive crops.
  - Other beneficial uses include salt leaching and frost protection, but both of these can lead to N leaching if not carefully done.

- Non-beneficial uses or losses are:
  - Deep percolation below root zone except the amount needed to manage salinity
  - Tailwater runoff that is not reused

Application Efficiency (AE): Calculation

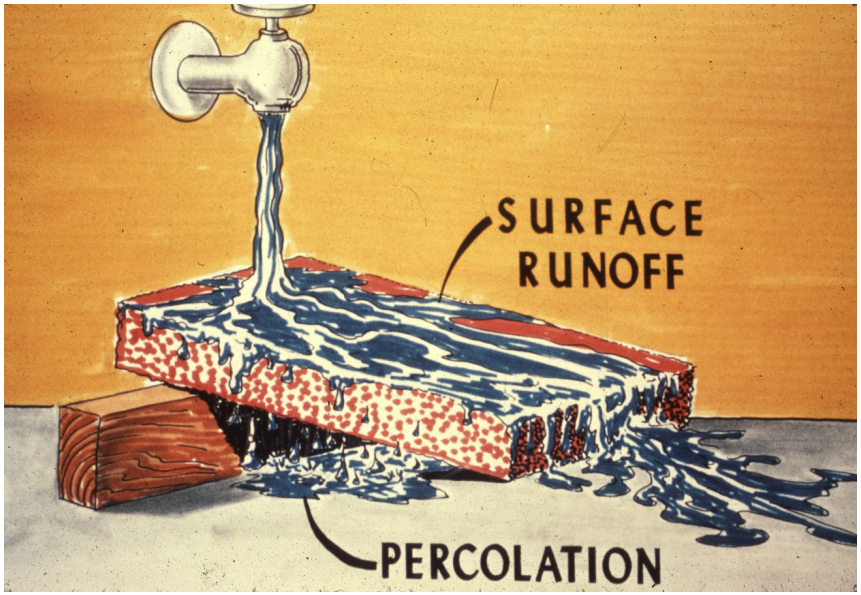
$$\text{Irrigation AE (\%)} = \frac{\text{Beneficially-Used Water}}{\text{Total Water Applied}} \times 100$$

- What is a realistic efficiency?

  70% minimum eventually required by regulations

  85-90% is an impressive efficiency to target

Higher AE= higher N use efficiency
Lower energy and water costs, and lower GHG emissions

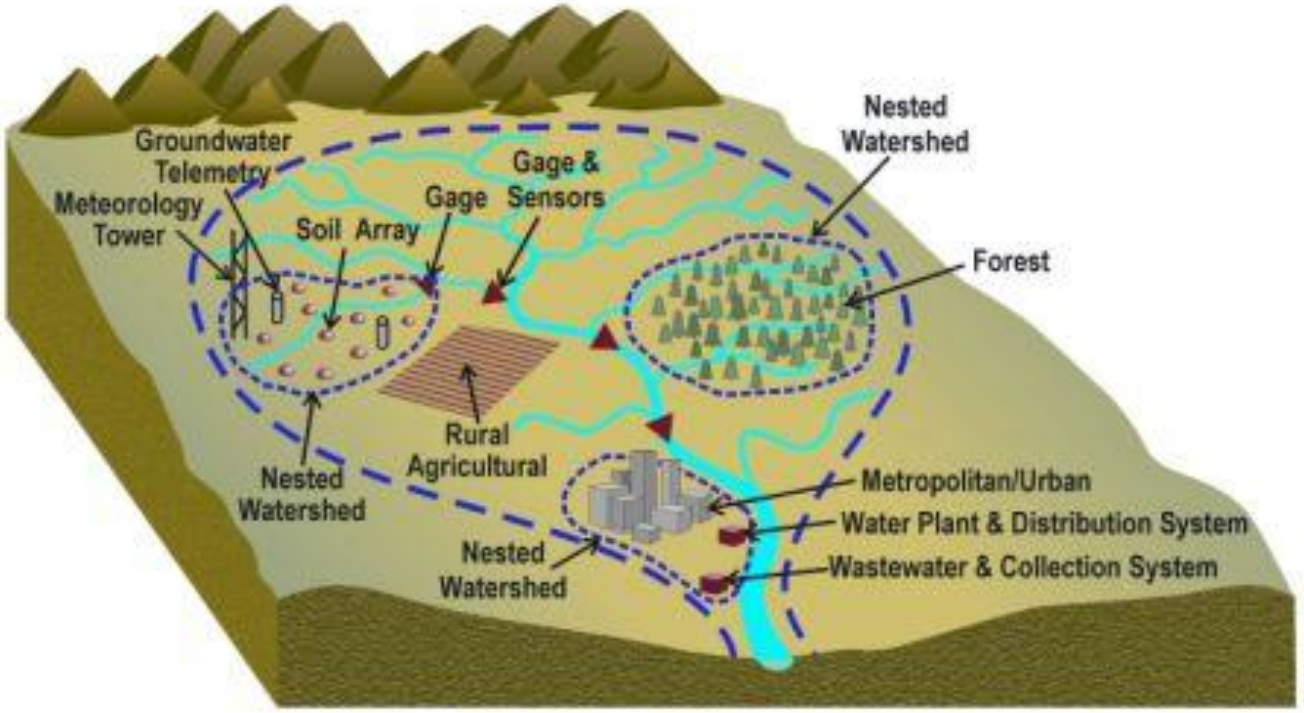


Irrigation Efficiency

Different people arrive at different estimates for Irrigation Efficiency. Why?

Field scale – vs – Watershed or basin scale

Single irrigation – vs – Sum of several irrigations in a season



How Do We Become More Efficient Irrigators?

Know how much water to apply

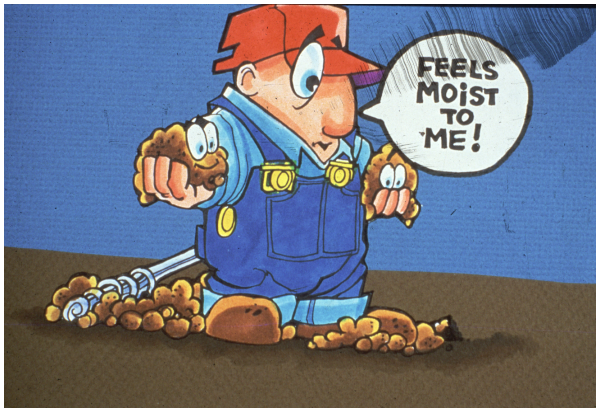
Irrigation Scheduling

- Determining how much water to apply

  - Quantify how much water has been used by the crop since the previous irrigation or rainfall
  - When the correct amount of water is applied at the proper time, potential for deep percolation and leaching of nitrate is minimized.

Irrigation Scheduling: Soil Monitoring Approach

There are numerous soil moisture monitoring techniques, devices, and services available to growers.



"Feel Method," squeeze soil in hand to estimate its moisture level.

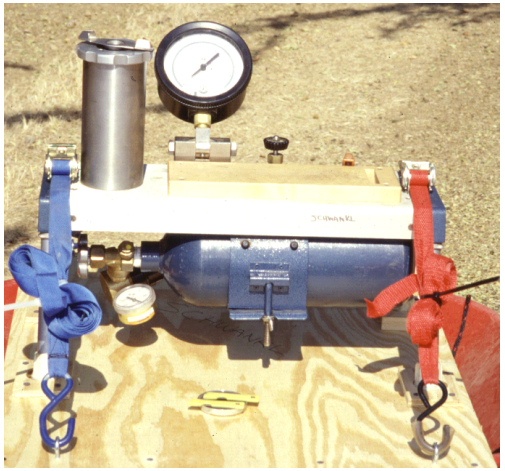
Newer technologies: Sophisticated devices continuously monitor soil moisture and upload data to online databases growers can check.

Irrigation Scheduling: Soil Monitoring Approach: Drawbacks

- Most soil monitoring techniques tell when to irrigate, but not all provide how much to irrigate.
- Effectiveness is subject to representative placement of sensors and good understanding of the crop root zone.

Irrigation Scheduling: Plant Monitoring Approach

- Monitoring the plant itself for signs of water stress
- Relatively new approach, equipment and knowledge still developing



Irrigation Scheduling: Plant Monitoring Approach: Drawbacks

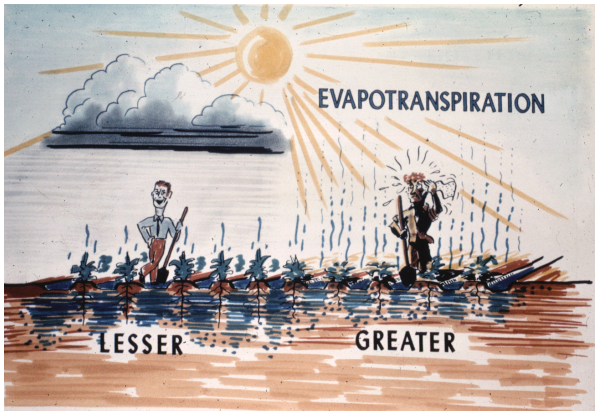
- **Limited information**, available for some crops & not for others
  - Interpreting pressure bomb readings and crop stress levels for most CA crops is unexplored

- Methods tend to be **labor intensive** – working toward automation

- Crop stress and readings tell you **when** to irrigate (plant is stressed) but not **how much**
  - How much water is needed can be learned with experience or by coupling plant monitoring with other approaches (i.e. ET)

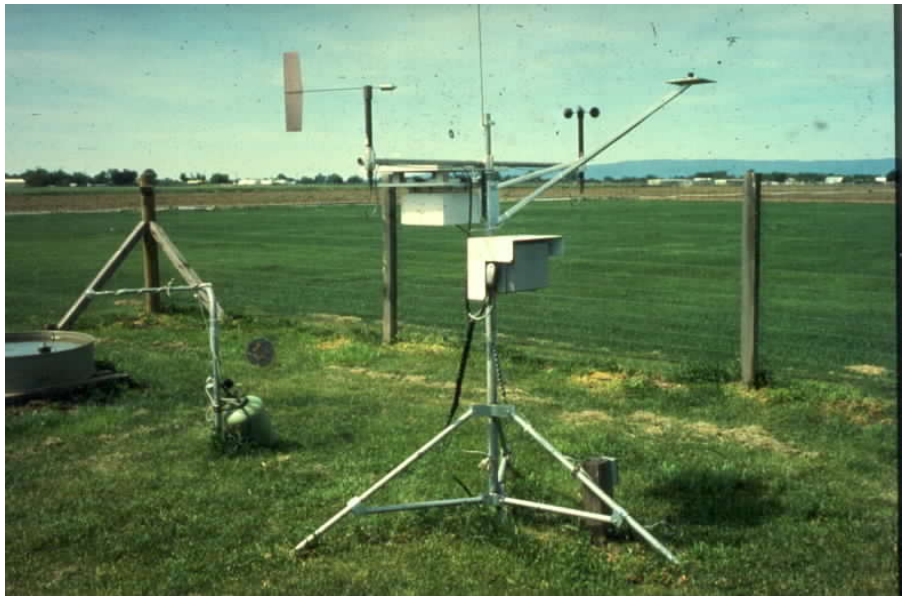
Irrigation Scheduling: Weather Monitoring Approach

- Climatic conditions (solar radiation, temperature, humidity, and wind) drive the water use of plants.
- Monitor the weather and use it to estimate crop water use (evapotranspiration, ET).



Irrigation Scheduling: Weather Monitoring Approach

California has the CIMIS network to provide weather information and estimates of **Reference Crop ET** (ET of unstressed cool-season grass).



Irrigation Scheduling: Weather Monitoring Approach

- Relates estimate to irrigation system design and performance (Need ETo and crop specific coefficients, called crop coefficient or Kc)
- Tells us both **when** and **how much** to irrigate

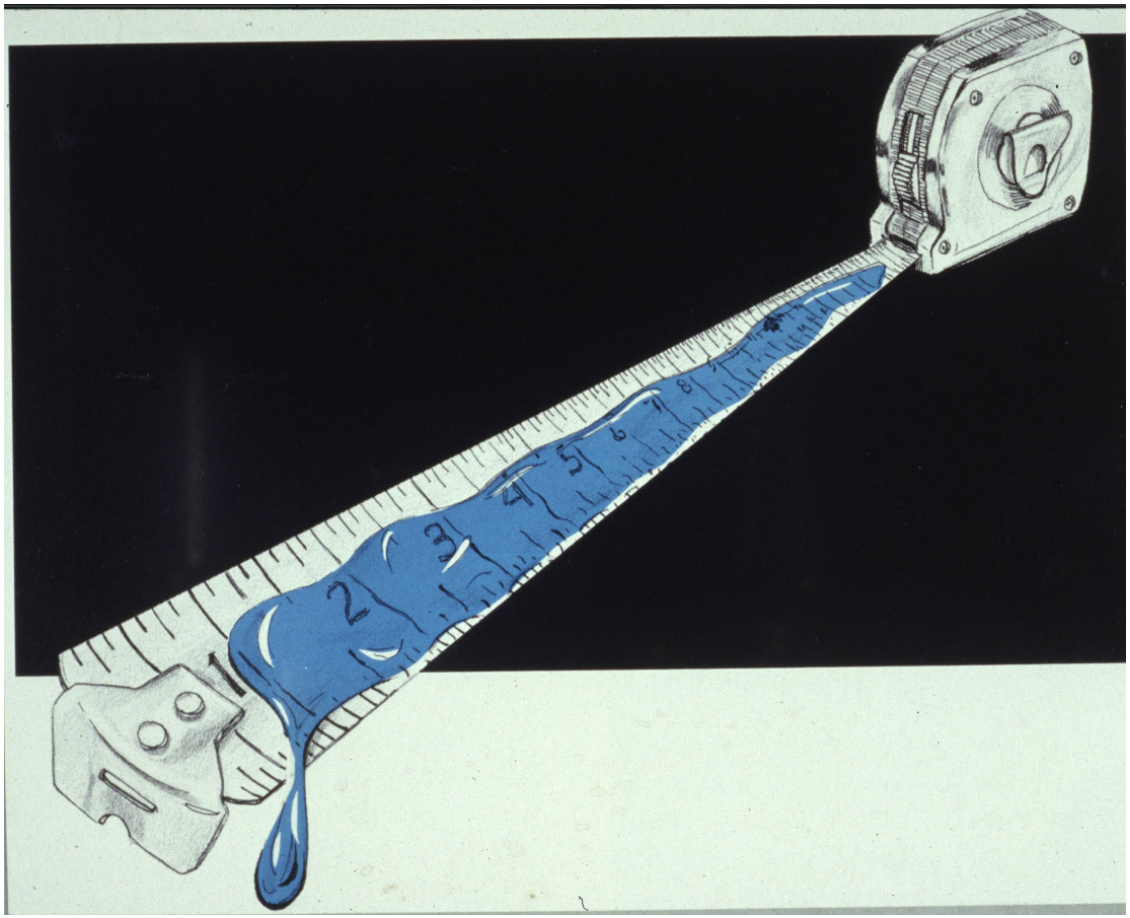
How Do We Become More Efficient Irrigators?

Apply the correct amount of water with a good irrigation system at the right interval

Sound Irrigation System Design Concepts

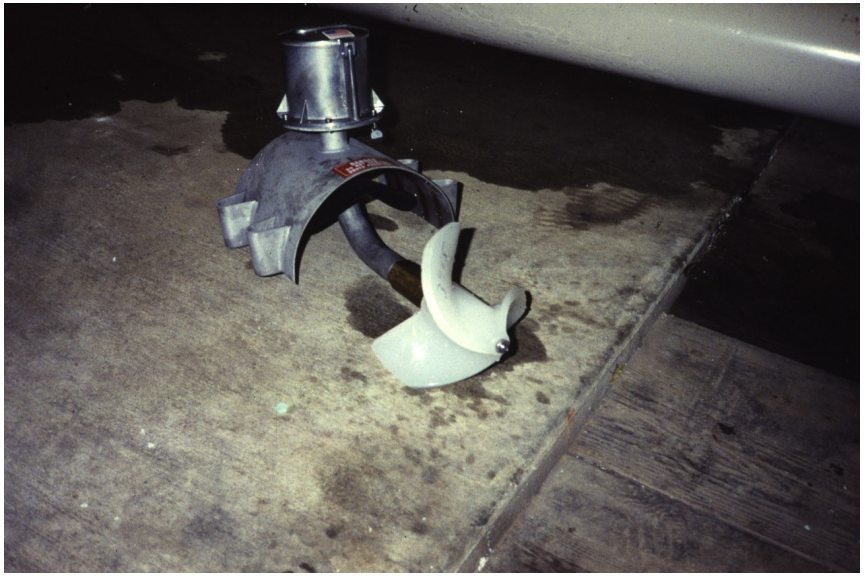
- Ability to measure applied water and thus control leaching

Our ability to manage water improves if we have the ability to measure it.



Sound Irrigation System Design Concepts

How much water is being applied? Measure with a flow meter



Saddle Propeller Meter, the most common type of flow meter, attached by cutting through the pipe. It is sufficiently accurate for agricultural purposes.

Saddle propeller meter attached to pipe

Sound Irrigation System Design Concepts

How much water is being applied? Measure with a flow meter

Electronic flow meter, known as a MagMeter. It is a very accurate type of meter, but locating it near elbows and forks can alter pressure and decrease accuracy. Follow the manufacturer's specification for installation.

Debris in water can hinder propeller meters; installations with weeds and trash in the water need special flow meter devices.

Sound Irrigation System Design Concepts

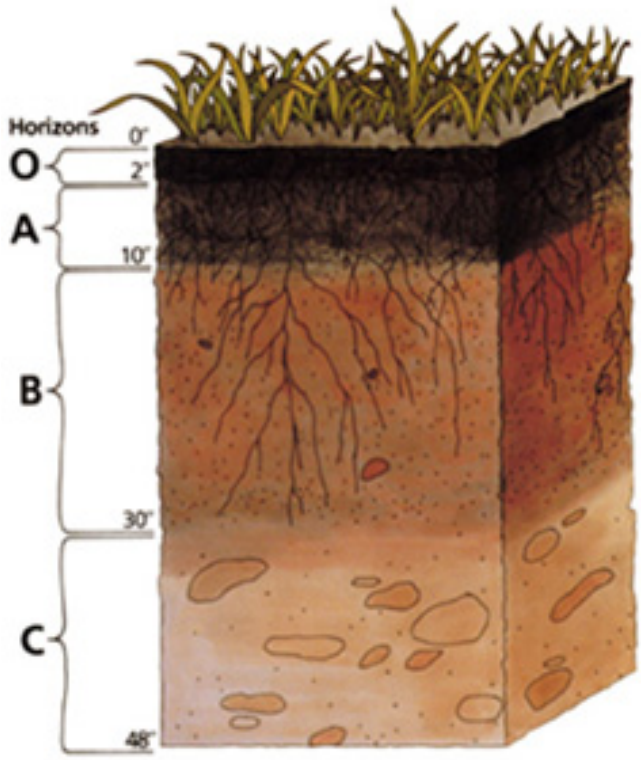
How much water is being applied? Irrigation system evaluation

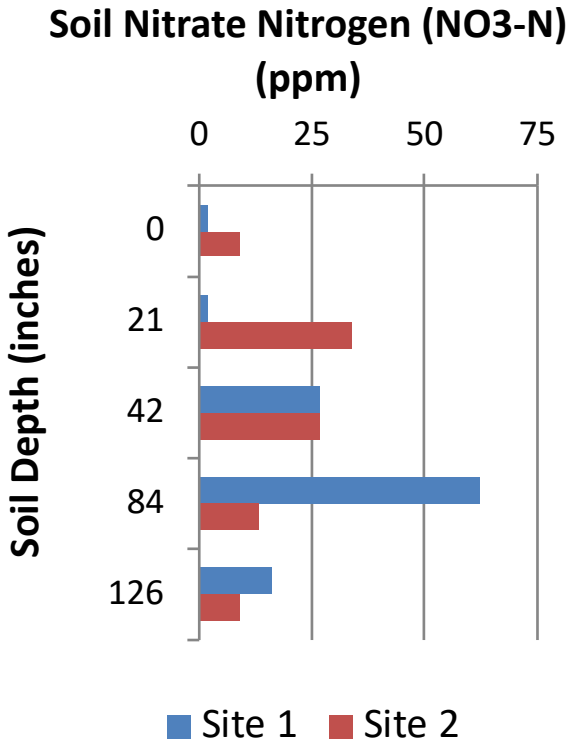
Water application rate and uniformity

Irrigation System Evaluation: Application Rate

A measure of the field-wide water application rate

- Most easily measured in pressurized irrigation systems
- Relates to how deep water (and nitrogen) will penetrate the crop root zone depending on the irrigation set time





Rapid Assessment

Step 1

Determine soil moisture depletion since last irrigation (ET)

Table CWU-8. Corn (Planted May 1) ET (in/day)

	Location					
	Madera	**Merced**	**Stockton**	**Modesto**	**Parlier**	**Visalia**
Apr 1-15						
Apr 16-30						
May 1-15	0.04	0.04	0.04	0.04	0.04	0.04
May 16-31	0.05	0.05	0.04	0.05	0.05	0.05
Jun 1-15	0.14	0.14	0.13	0.14	0.14	0.14
Jun 16-30	0.24	0.24	0.23	0.23	0.24	0.24
July 1-15	0.30	0.30	0.28	0.28	0.29	0.29
July 16-31	0.30	0.30	0.28	0.28	0.27	0.29
Aug 1-15	0.28	0.27	0.25	0.25	0.25	0.27
Aug 16-31	0.20	0.19	0.19	0.18	0.20	0.20
Sept 1-15	0.13	0.13	0.07	0.13	0.13	0.14
Sept 16-30						
Oct 1-15						
Total	**24.88**	**24.59**	**22.52**	**23.51**	**24.03**	**24.64**

Rapid Assessment

Step 2

Measure Flow and Determine how much water has been applied (flow rate)

- Flow meters the best way - on all pumps
- Irrigation District information
- Pump test - discharge will change (often a lot) if groundwater level changes.

Rapid Assessment

Step 2

Measure Flow and Determine how much water has been applied (inches)

$$D = \frac{(Q \div 449) \times T}{A}$$

D = inches of water applied

Q = gpm (gallons per minute) flow rate

T = hours irrigation set time

A = acres in irrigation set

***If flow is measured in cfs, no need to divide by 449 in equation**

Rapid Assessment

Step 3 Is the risk of deep percolation high?

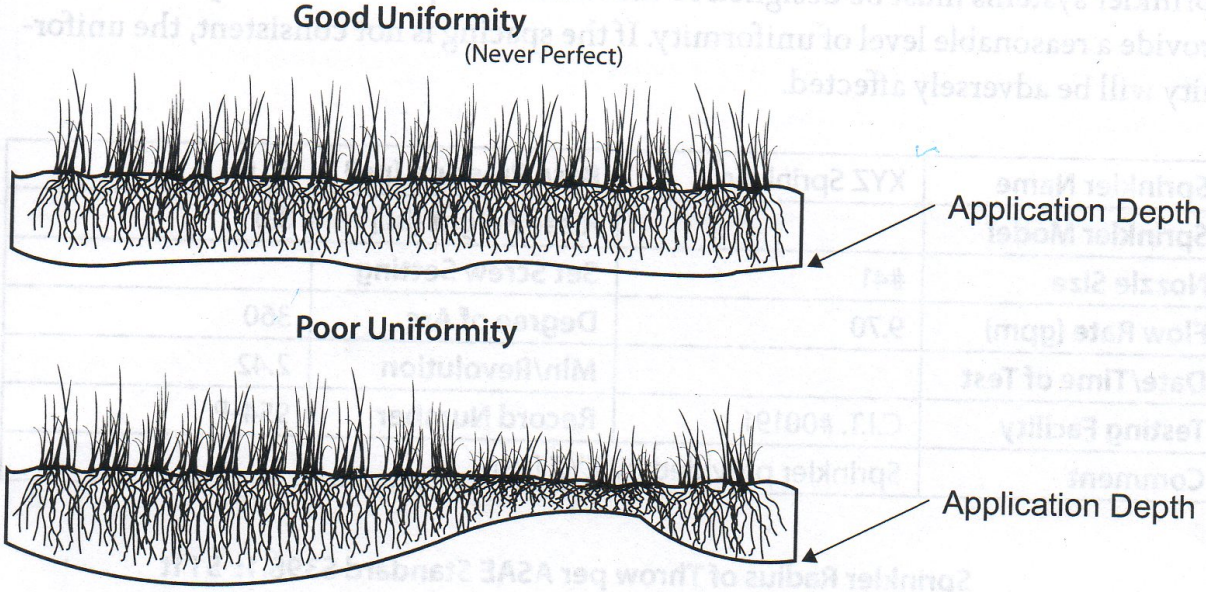
Compare the amount applied water to the amount used since last irrigation.

- Leaching is likely to occur when runoff is minimal and applied water is “much” greater than crop use.

Irrigation System Evaluation: Irrigation Uniformity

A measure of how evenly water is applied to the field

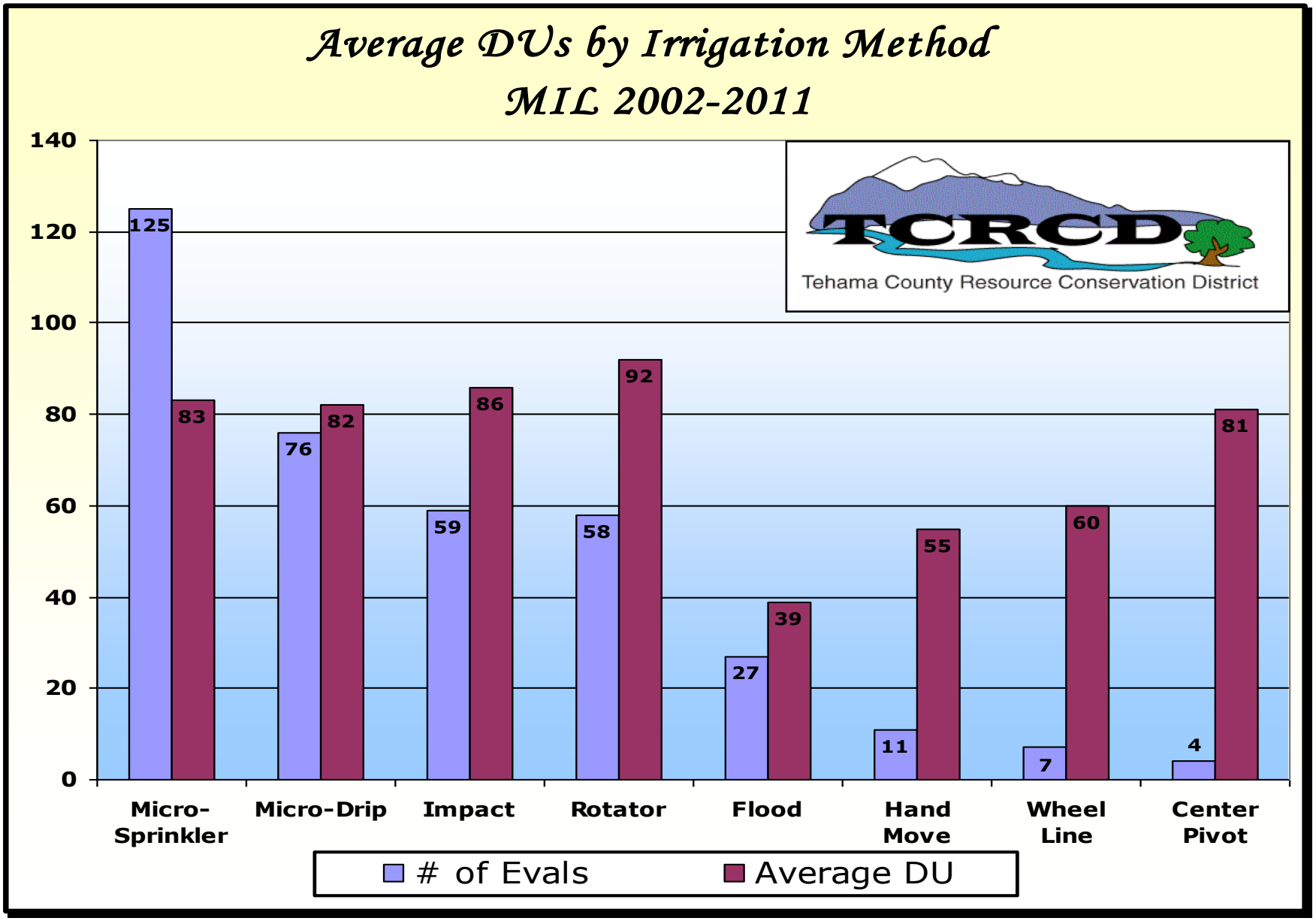
- Given as percentage with 100 % being perfect
- Various measures including Distribution Uniformity (DU), Coefficient of Uniformity (CU), and Emission Uniformity (EU).
- Knowing the general concept is more important than the details about the different measurement methods of irrigation uniformity.



Importance of Irrigation Uniformity

- Poor irrigation uniformity means that portions of the field are getting less water than others.
- Most growers do not want to under-irrigate even a portion of the crop, so they irrigate to make sure the area receiving the least water gets enough.
- Some portions of the field receive too much water. Too much water leads to deep percolation losses (leaching of water). If nitrate is in the soil profile, it can be leached with the water.
- Poor irrigation uniformity makes N leaching more likely.

Importance of Irrigation Uniformity



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Summary

- Irrigation management is the key to reduce N losses and leaching

- Higher irrigation efficiency= lower N losses, water and energy savings, and reduction in GHG emissions

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