





# GUID-1210
# Irrigation Efficiency and Consumptive Use

Daniel R. Haller, P.E., February 2007





# Summary

1. Background / Timeline
2. 2004 Experts Workshop
3. Irrigation 101
   a) Irrigation Water Budget
   b) Evapotranspiration (ET)
   c) Components of Irrigation Efficiency
4. Irrigation Efficiency – What Number Do We Use?
5. Within the Irrigation Efficiency – What is the Consumptive / Non-Consumptive Balance?
6. Using the Guidance Document
   a) Examples, examples, examples

# Background / Timeline



- 1969 → Circular 512 Issued (WSU)
- 1982 → XB0925 Irrigation Bulletin (EB0153)
- 1985, 1990, 1994 → Washington Irrigation Guide
- November 29-30, 2004 → Experts Workshop
- 2005 → Guid-1210 Distributed

# Irrigation Experts Workshop

- Tom Spofford, P.E., USDA National Engineer
- Leigh Nelson, P.E., USDA State Engineer (WA)
- Dr. Robert Stevens, WSU Prosser
- Dr. Allan Thompson, University of Missouri
- Dr. Dennis Kincaid, USDA-ARS Idaho
- Mark Nielson, Franklin County Conservation District
- Robert Montgomery, P.E., Montgomery Water Group
- Paul Wattenburger, P.E., IRZ Consulting
- Dan Haller, P.E., Department of Ecology
- Dr. Darryll Olsen, Benton Co. Water Conservancy Board

*Selected slides adapted from presenters listed above and from WSU Prosser.

# Why do plants need water?

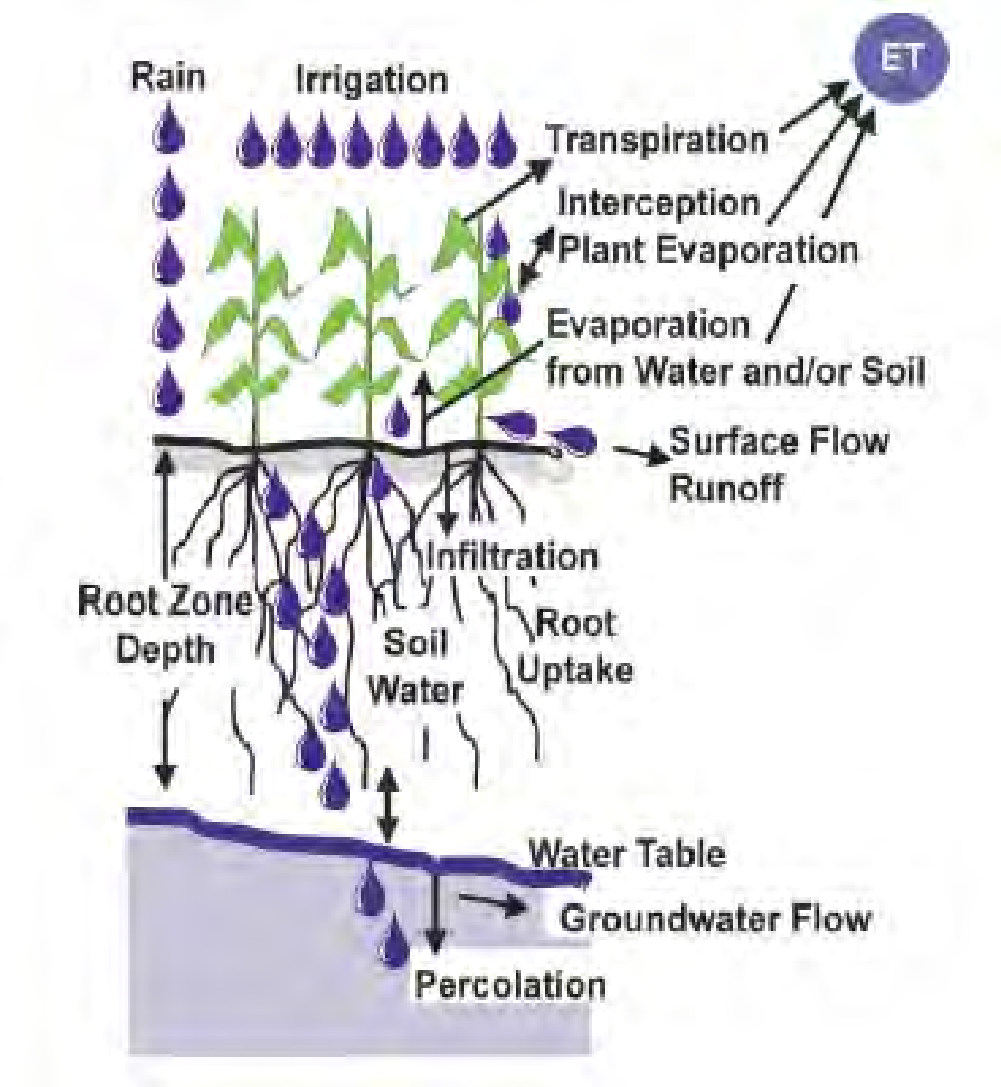


***Water is a . . .***

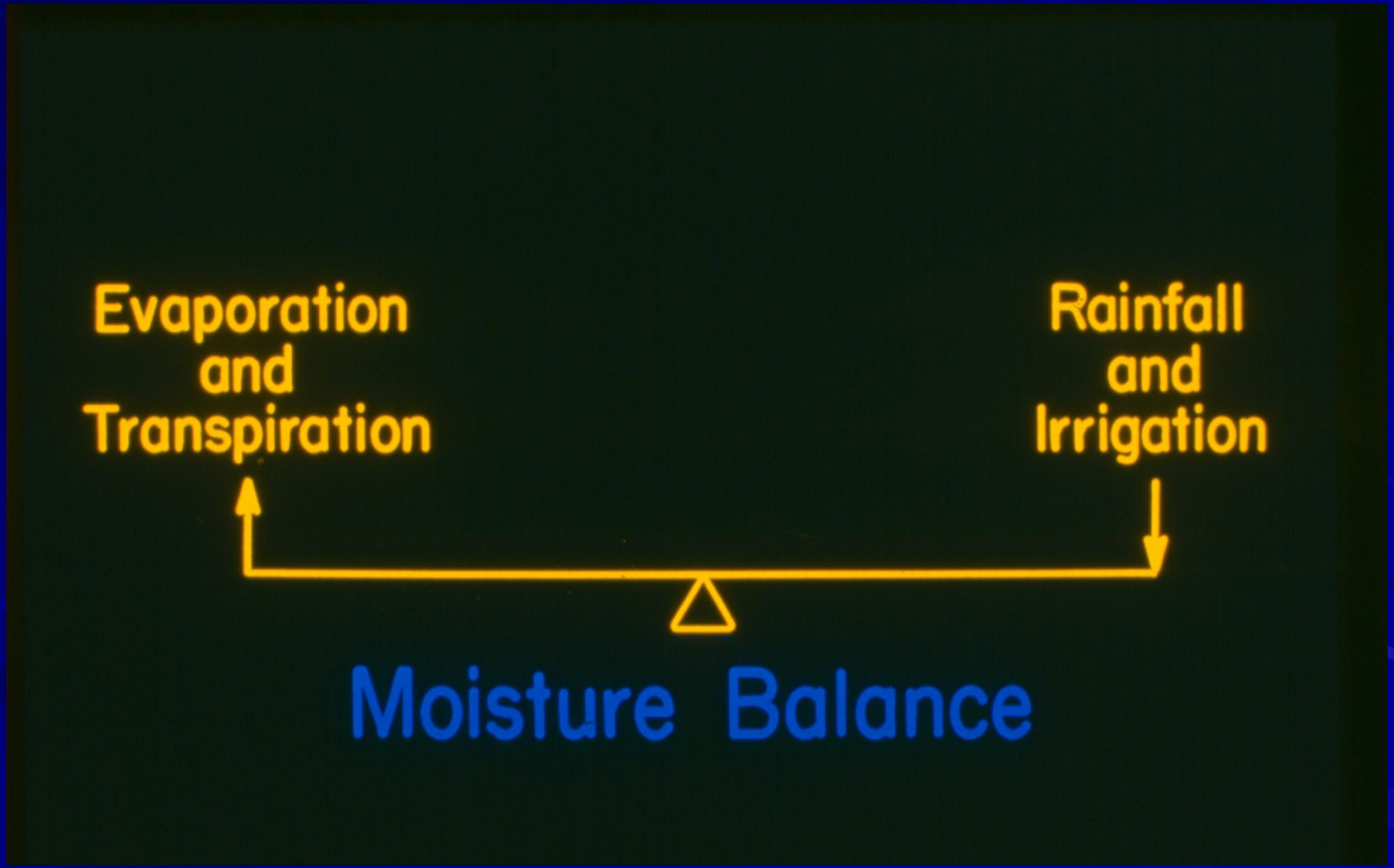
1. Constituent
   - 80-90% fresh weight of fruit, 50% fresh weight of wood
2. Solvent
   - Gases, minerals enter and transported within plant
3. Reactant
   - Key substrate in many processes (e.g. photosynthesis)
4. Maintenance of turgor
   - Essential for cell enlargement, growth, stomatal functions
5. Cool leaves
   - maintain leaf temperature

# Irrigation 101
# The On-Farm Water Budget

- ET
- Rainfall
- Irrigation
- Soil “Reservoir”
- Irrigation Efficiency
  - Canopy Loss
  - Spray Evaporative Loss
  - Wind Drift
  - Deep Percolation
  - Runoff
  - Leaks
  - Non-Uniform Application



# Irrigation 101
# Supply and Demand



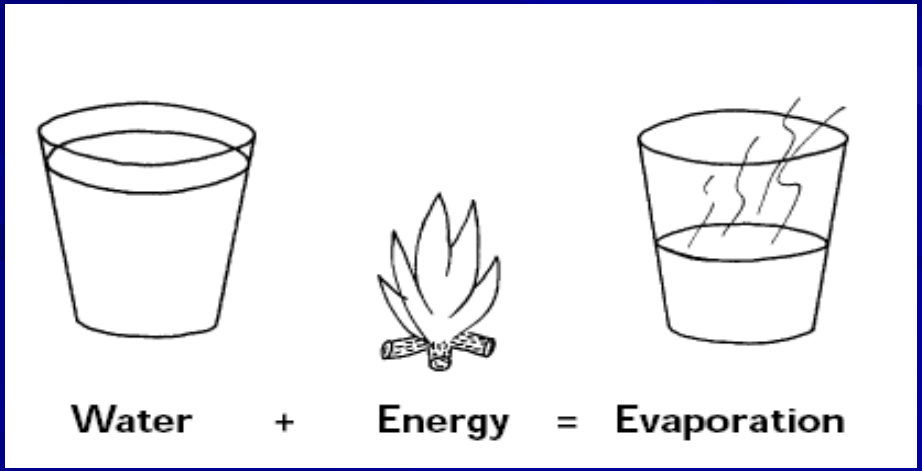


# Evaporation



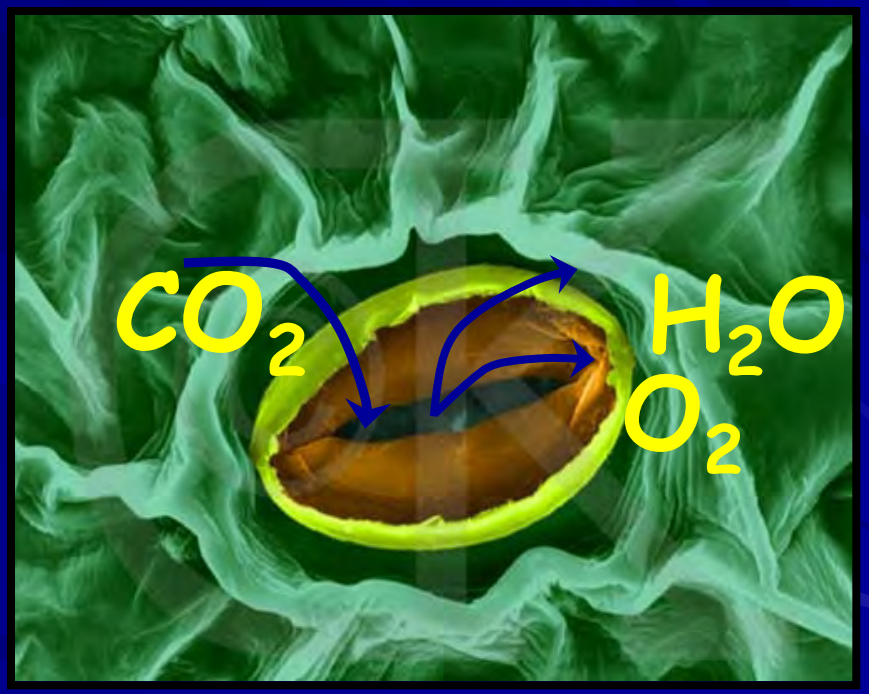
- Evaporation is the process whereby liquid water is converted to water vapor (vaporization) and removed from the evaporating surface (vapor removal).

- The driving force to remove water vapor from the evaporating surface is the difference between the water vapor pressure at the evaporating surface and that of the surrounding atmosphere. Solar radiation, air temperature, air humidity and wind speed are climatological parameters to consider when assessing the evaporation process.



# Transpiration

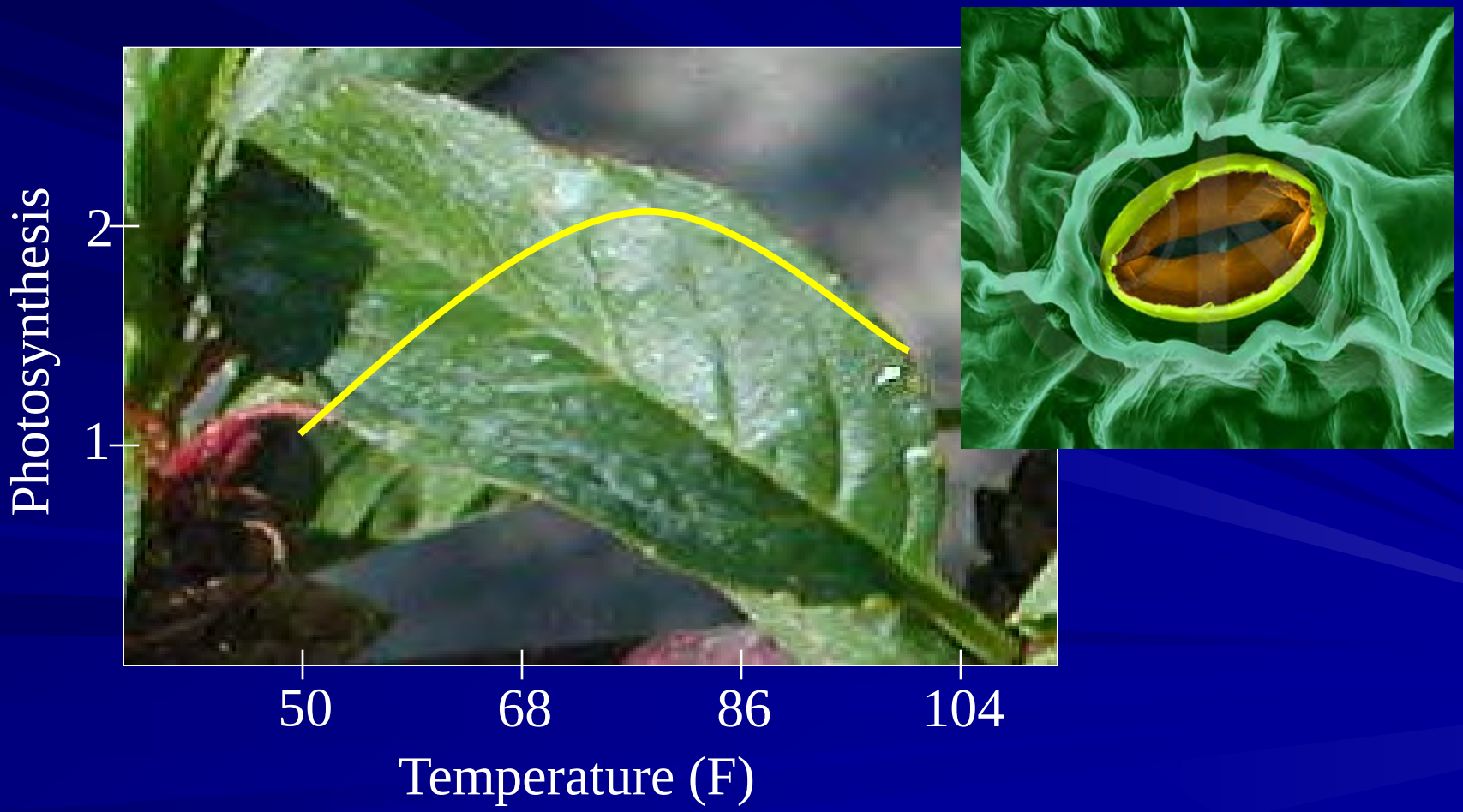
- Transpiration is the evaporation of water from plants. It occurs chiefly at the leaves while their stomata are open for the passage of $CO_2$ and $O_2$ during photosynthesis.
- Transpiration is the "engine" that pulls water up from the roots to:
  - supply photosynthesis (1%-2% of the total)
  - bring minerals from the roots for biosynthesis within the leaf
  - cool the leaf
- Photosynthesis is the synthesis of organic molecules (glucose) using the energy of light.




- **6CO2 + 12H2O -> C6H12O6 + 6H2O + 6O2**

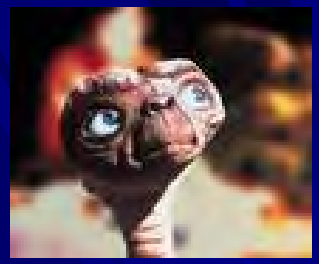
# Temperature & Photosynthesis*

*Dana Faubion, WSU Yakima

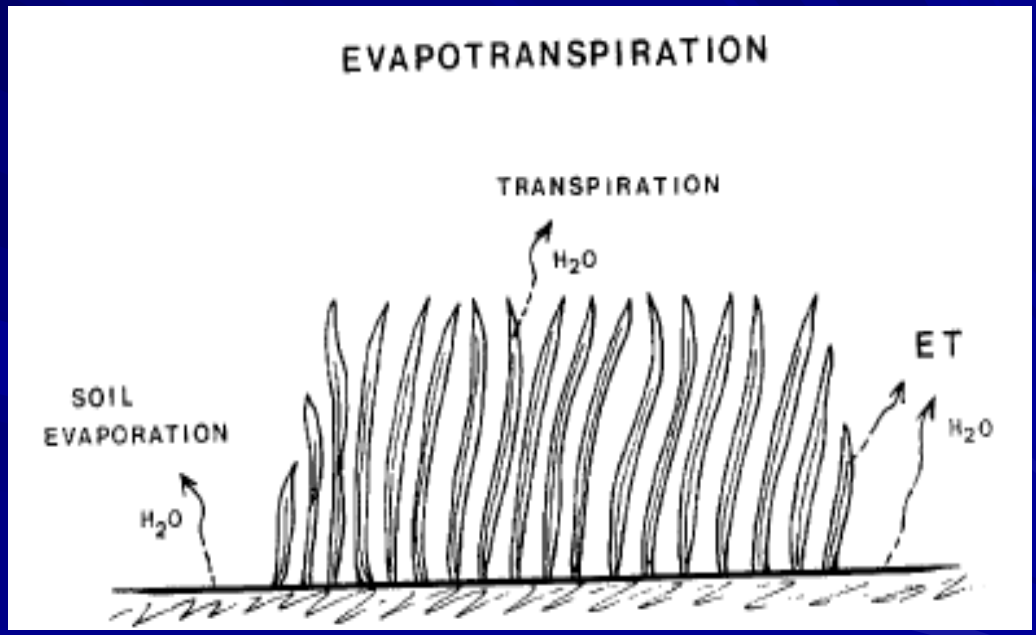




# Evapotranspiration (ET)



- Evapotranspiration (ET) is the loss of water from a vegetated surface through soil evaporation and plant transpiration.
- Sources of ET data
  - Washington Irrigation Guide
    - 60 crops; 1951 – 1980
  - WSU Irrigation Bulletin
    - 39 crops; 1948 – 1973
  - WSU PAWS
    - 42 crops; 1989 – present
  - Derivation Methods
    - Modified Blanney-Criddle (Temperature-Based, WIG)
    - Penman-Montieth (Energy-Based, ASCE, New Standard Adopted by USDA)
    - FAO Radiation (Radiation)
    - Pan Evaporation





# Limitations of ET



- ET is the theoretical maximum uptake of the plants based on the model assumptions
  - WIG and Bulletin data sets increasingly outdated
  - WIG based on “average” conditions
  - Statewide coverage of monitoring locations incomplete
- ET doesn’t tell you what the farmer actually did
- Plants can use < Max ET with no change in yield

# Difference Between Plant Need and Plant Use

## WSU Research: Measuring Whole-Canopy Net Transpiration*

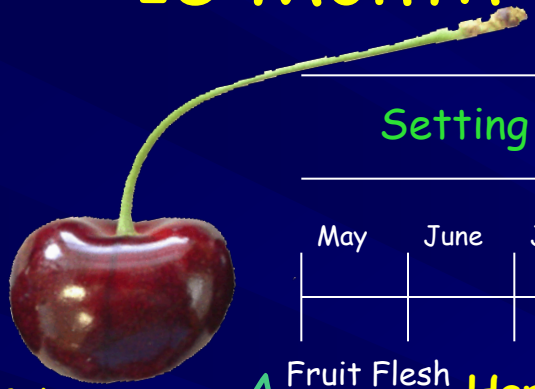
*Dr. Matthew Whiting, WSU Prosser







# 15 Month Sweet Cherry Fruiting Timeline



Setting Up the Future Crop

Actual Fruit Growth

May | June | July | Aug | Sept | Oct | Nov | Dec/Jan/Feb | Mar | Apr | May | June | July

Crop Development Stage:

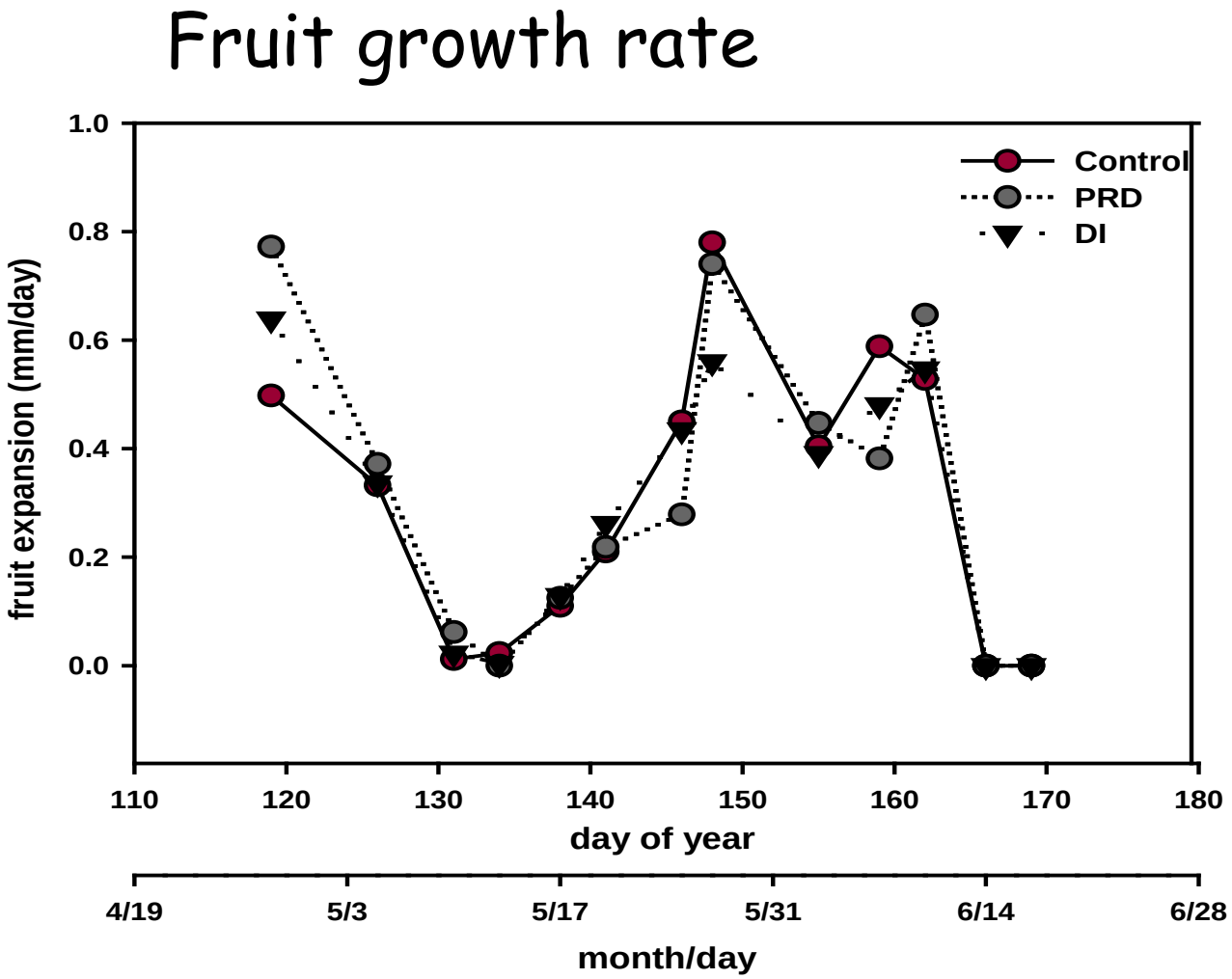
A Fruit Flesh Expansion **Harvest**

B Flower Bud Induction | Flower Organ Differentiation | Bud Growth Stops | Final Flower Development | Bloom | Cell Division | Cell Expansion **Harvest**

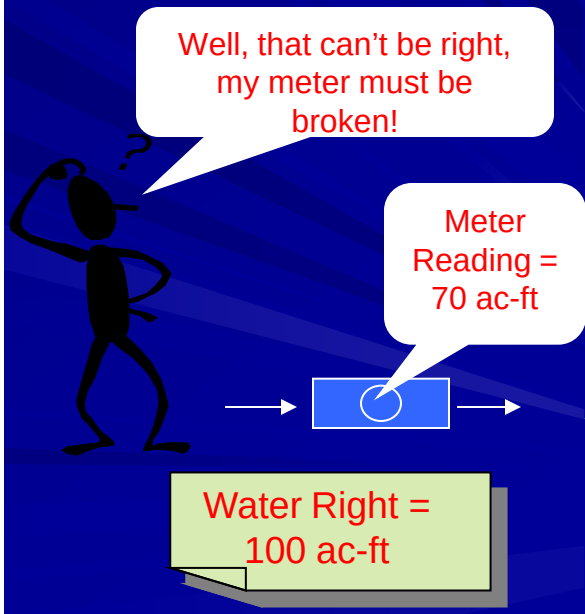




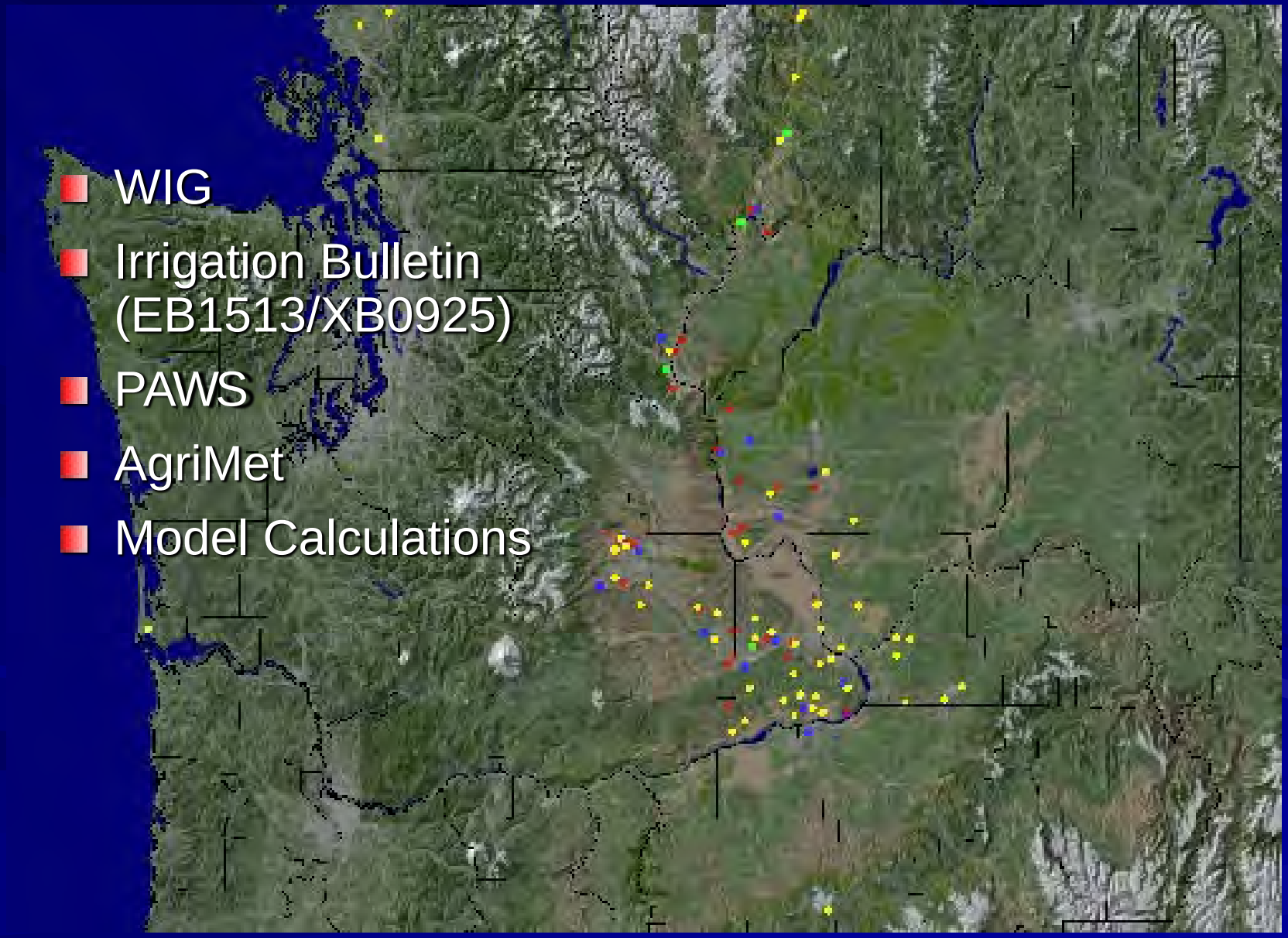
# Cherry Tree Study, 2001-2004




- Control based on full ET, irrigation scheduling
- Experiment gave cherry trees 50% less water
- No effect on yield or quality



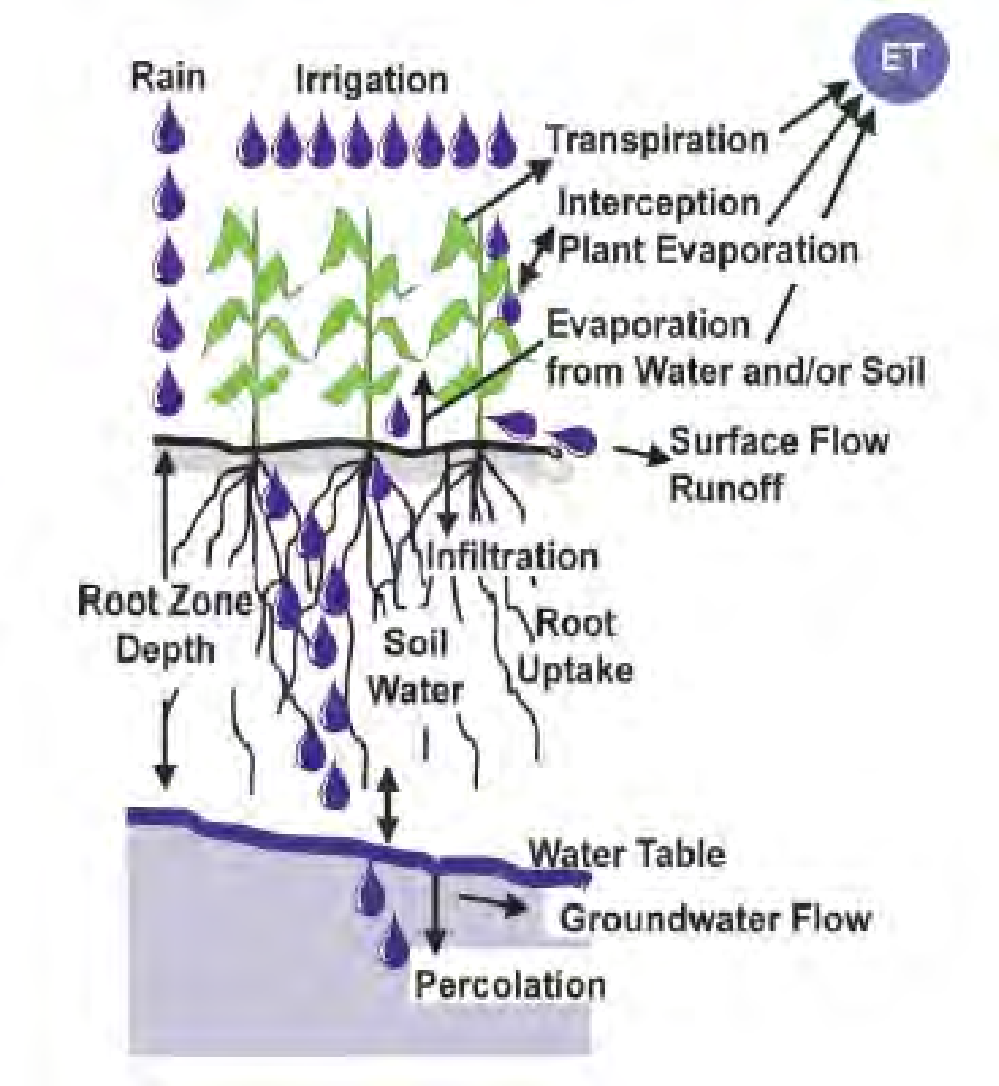
# Sources of ET Data



- WIG
- Irrigation Bulletin (EB1513/XB0925)
- PAWS
- AgriMet
- Model Calculations

# Irrigation 101
# The On-Farm Water Budget

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- Rainfall
- Irrigation
- Soil “Reservoir”
- Irrigation Efficiency
  - Canopy Loss
  - Spray Evaporative Loss
  - Wind Drift
  - Deep Percolation
  - Runoff
  - Leaks
  - Non-Uniform Application



# Crop Irrigation Requirement (CIR) vs. Rainfall



- Living in a desert means rain can't supply all the water to the crop . . .
- CU in the WIG is consumptive use, or ET.
- CIR = ET – Effective Rainfall
- Other demands must also be met:
  - Conveyance loss to the farm
  - Frost Protection
  - Cooling
  - Germination
  - Leaching

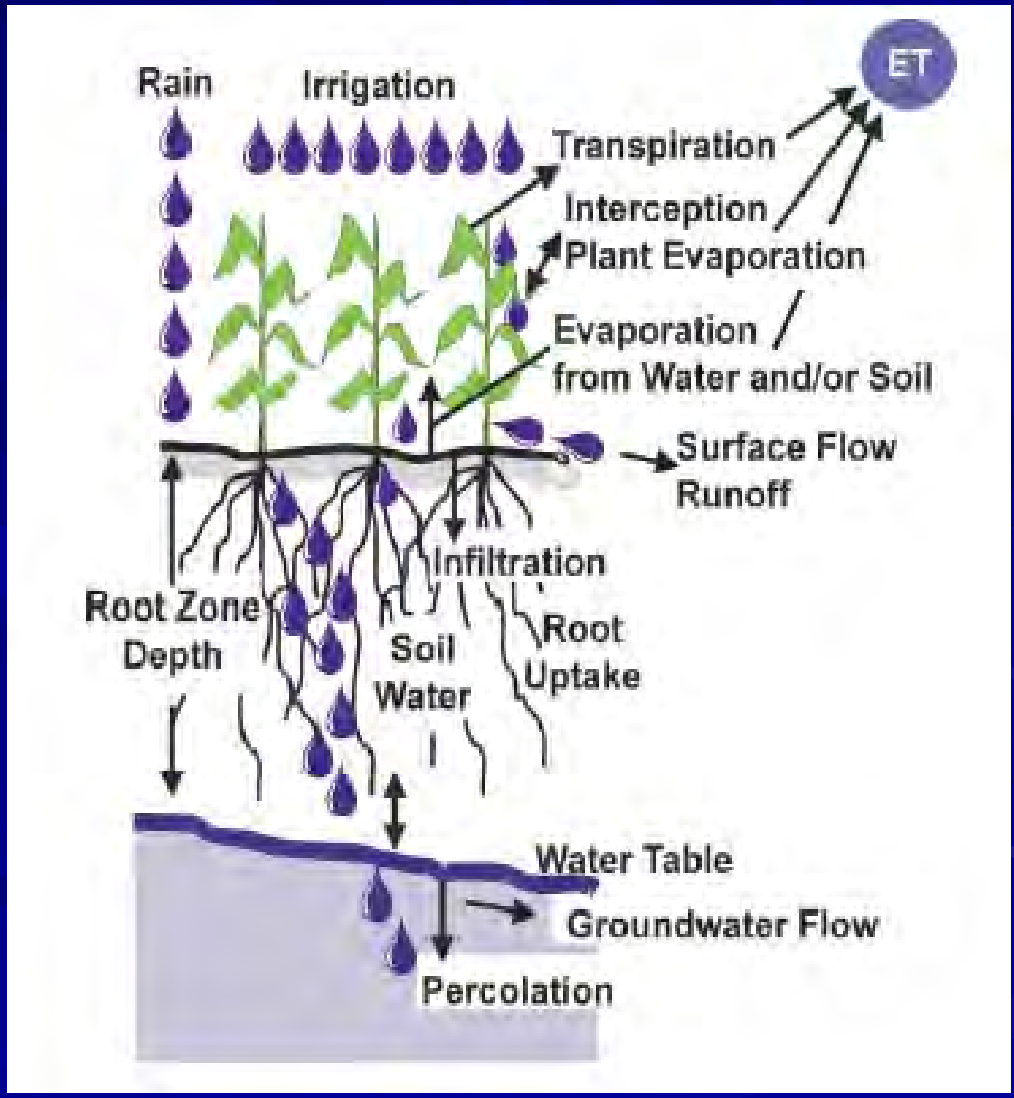
# What's so tough about irrigation?

- How much water do I need?
- How often do I water?
- How long should I water?
- What type of soils do I have?
- Is my water applied uniformly?



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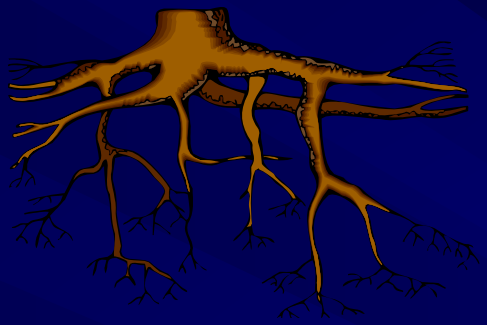


# Irrigation Scheduling Starts With The Soil Reservoir.

## How Big is our Bucket?!



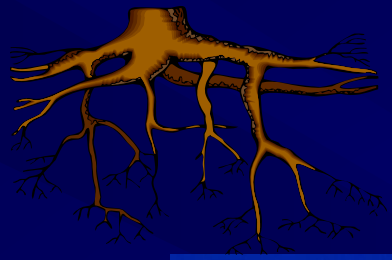
= ?



# How Big is Your Bucket?
or
# Why Does Soil Type Matter?

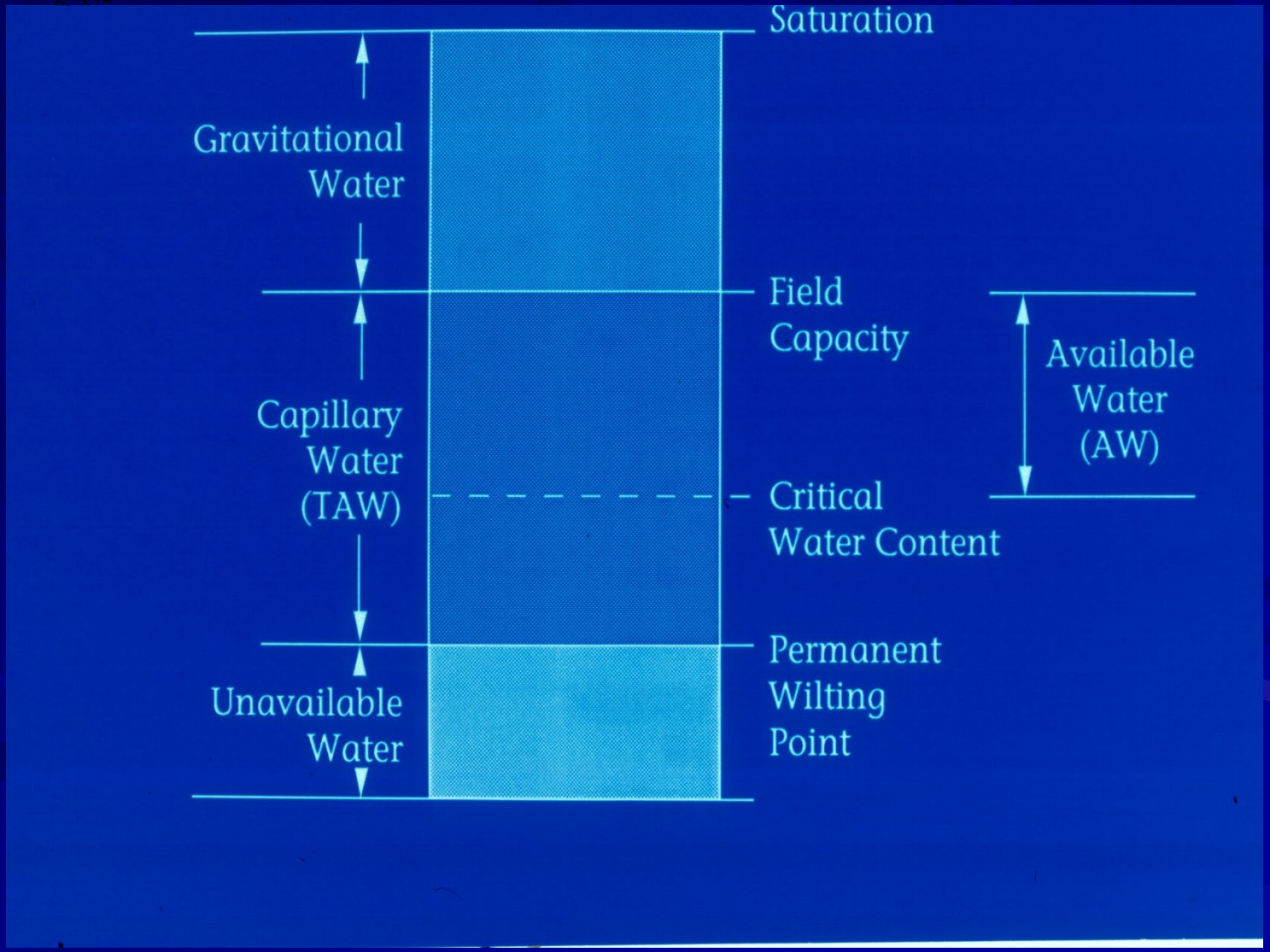


- Plants obtain the water they need from their roots.
- Knowing the Root Zone Depth for your crops determines how much soil storage is available during irrigation. 80 to 90 percent of a plant feeder roots contained in the upper 60-75 percent of the root zone.
- The Root Zone Depth and the Type of Soil determine the Available Water Capacity (AWC). AWC = the amount of water available to the plant typically expressed in inches/foot or inches/inch.
- Don’t let your bucket go completely dry before refilling it! Management Allowed Deficiency, expressed in percent, is the portion of water in the root zone that plants can utilize before experiencing stress. Plants under stress will shift from growth to reproduction cycles. Yield declines.



# The Soil Reservoir

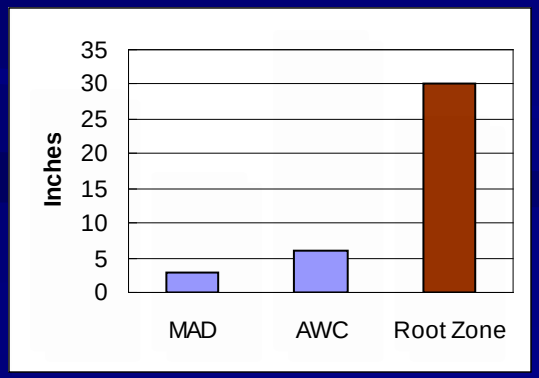




# The “How Big is My Bucket” Example 1

## Wenas Silt with High AWC

- Crop = Pasture/Turf
- Root Zone = 2.5 feet = 30 inches
- Soil Type = Wenas Silt
- AWC = 0.20 in/in x 30 in = 6 inches
- MAD = 50% = 3 inches

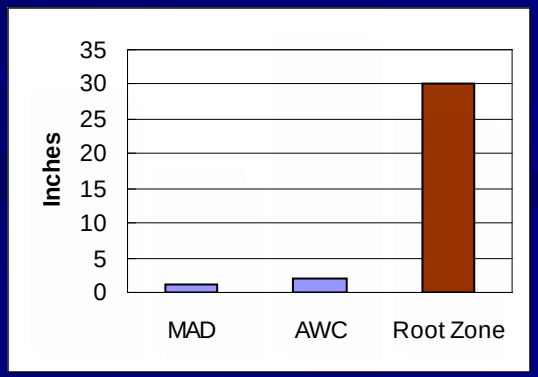





# The “How Big is My Bucket” Example 2

## Quincy Fine Sand with Low AWC

- Crop = Pasture/Turf
- Root Zone = 2.5 feet = 30 inches
- Soil Type = Quincy Fine Sand
- AWC = 0.07 in/in x 30 in = 2.1 inches
- MAD = 50% = 1.05 inches






# Why Does Irrigation Scheduling Matter?

## Irrigation Scheduling Dictates Return Flows

- Irrigation Scheduling for Pasture
  - 7 acres
  - Handline sprinklers
  - 24 hour sets, 7 day rotation
  - 1 acre / set
  - 45 gpm (0.1 cfs/ac)
  - 45 gpm is 0.2 ac-ft / day
- Snapshot of Applied Water (Soil Issues – 1 Day)
  - 0.2 ac-ft = 2.4 inches applied
  - Wenas, assume bucket @ MAD = 3 inches
    - Return Flow = 0
  - Quincy MAD? = 1.05 inches
    - Return Flow = 1.35 inches
  - What if Empty Bucket?
- How Fast Does the Bucket Empty?
  - WIG, Yakima Station
  - May = 0.19 in/day = 1.4 in/week
  - June = 0.24 in/day = 1.7 in/week
  - July = 0.30 in/day = 2.2 in/week
- Let's Go Deeper in the Bucket!



# Let's Go Deeper in the Bucket!



## Irrigation Scheduling Over Several Months (Wenas Soil in May)

Assume Uniform Application for Now

| Day | Starting Bucket Level | Applied Water (+) | Demand (-) | Ending Bucket Level | Return Flow |
|---|---|---|---|---|---|
| 5/1 | 3 in | 2.4 in | 0.19 in | 5.21 in | 0 |
| 5/6 | 5.21 in | 0 | 1.14 in | 4.07 in | 0 |
| 5/7 | 4.07 in | 2.4 in | 0.19 in | 6.00 in | 0.28 in |
| 5/13 | 6.00 in | 0 | 1.14 in | 4.86 in | 0 |
| 5/14 | 4.86 in | 2.4 in | 0.19 in | 6 in | 1.07 in |
| 5/20 | 6.00 in | 0 | 1.14 in | 4.86 in | 0 |
| 5/21 | 4.86 in | 2.4 in | 0.19 in | 6 in | 1.07 in |
| 5/27 | 6.00 in | 0 | 1.14 in | 4.86 in | 0 |
| 5/28 | 4.86 in | 2.4 in | 0.19 in | 6 in | 1.07 in |

- Total Return Flows in May = 3.49 inches over 7 acres, or 2 ac-ft
- May Efficiency = 1 – (Return Flows / Applied Water) = 3.5 / 12 = 71%
- What would this look like for other months?
  - Crop demand increases in June and July, which would reduce return flows and increase efficiency

# How Could Efficiency Be Improved & Return Flows Be Reduced?

- Do a better job of matching applied water to crop demand
  - Reduce set times (can be tough given labor constraints)
  - Reduce sprinkler discharge (still need to accommodate max demand)
  - Reduce rotation (go 12 days in May, 10 days in June, 7 days in July)





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  - Deep Percolation
  - Runoff
  - Leaks
  - Non-Uniform Application

“Application Efficiency (Ea)”. The ratio of the average depth of water infiltrated and stored in the root zone to the average depth of water applied, expressed as a percentage.

“The values presented here have been discounted for evaporation, wind drift, deep percolation, runoff and component uniformity”. WIG, WA 684.20.4.

# Canopy Loss

- Irrigation Efficiency
  - Canopy Loss
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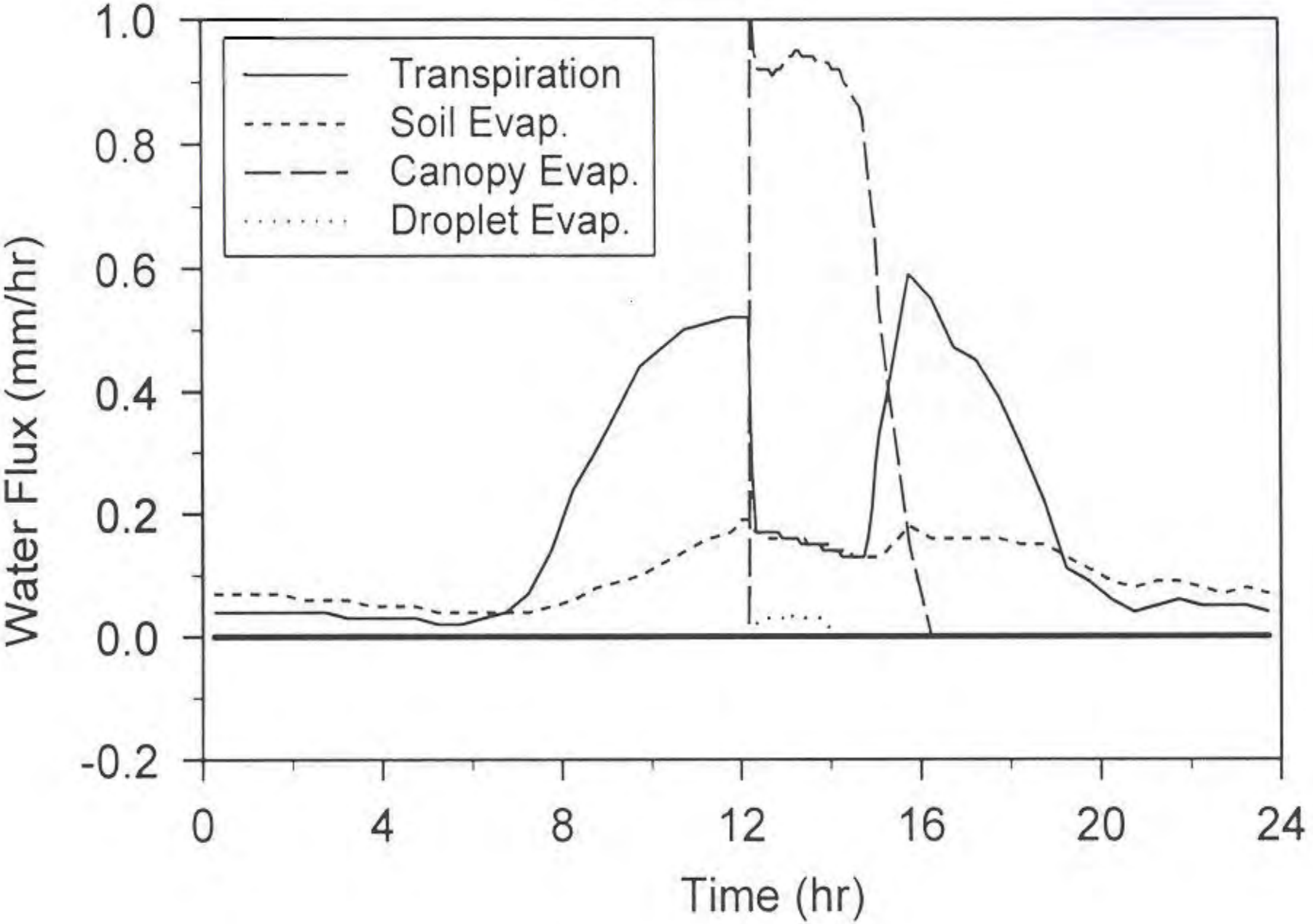
- During irrigation, some water lands on the plant canopy and is retained there, rather than falling to the soil below.
- While this water is not available for uptake by the plant, evaporation of this water cools the plant, which reduces plant uptake from the roots.
- During actual sprinkler irrigation, canopy evaporation typically > pre-irrigation transpiration loss, because there is less resistance to direct evaporation than through stomata.




ZIMMATIC






Transpiration
Soil Evap.
Canopy Evap.
Droplet Evap.
Water Flux (mm/hr)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0
4
8
12
16
20
24
Time (hr)

# Spray Evaporative Loss

- Irrigation Efficiency
  - Canopy Loss
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- During irrigation, some water evaporates as it travels through the air.
- While this water is not available for uptake by the plant, evaporation of this water cools the plant, which reduces plant uptake from the roots.
- For moderate wind conditions (e.g. 5 mph or less), spray losses averaged 0.5% to 1% per foot of elevation.

# Spray Evaporative Loss

## High and Low Elevation Sprays on a Center-Pivot



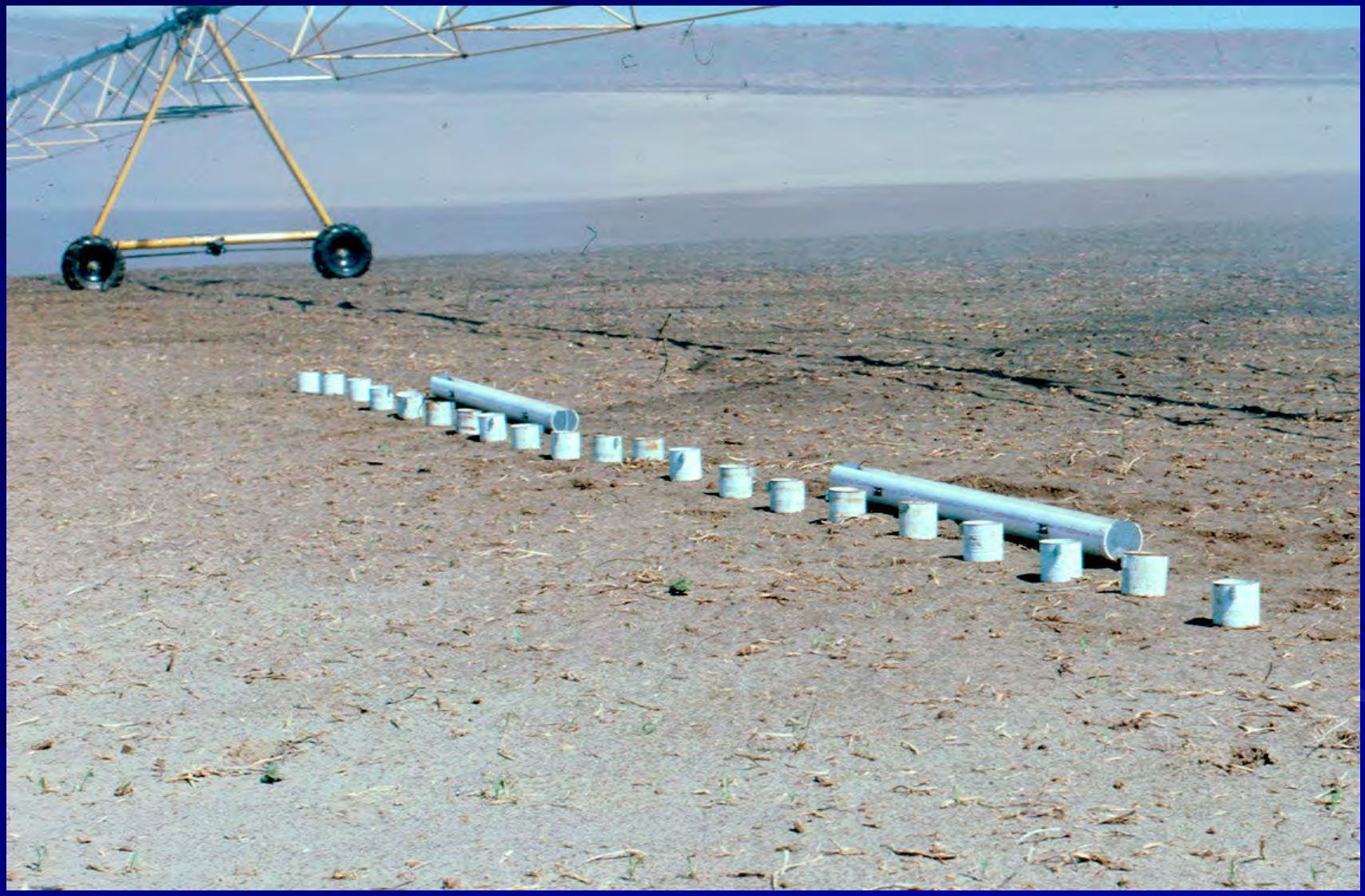
# Wind Drift

- Irrigation Efficiency
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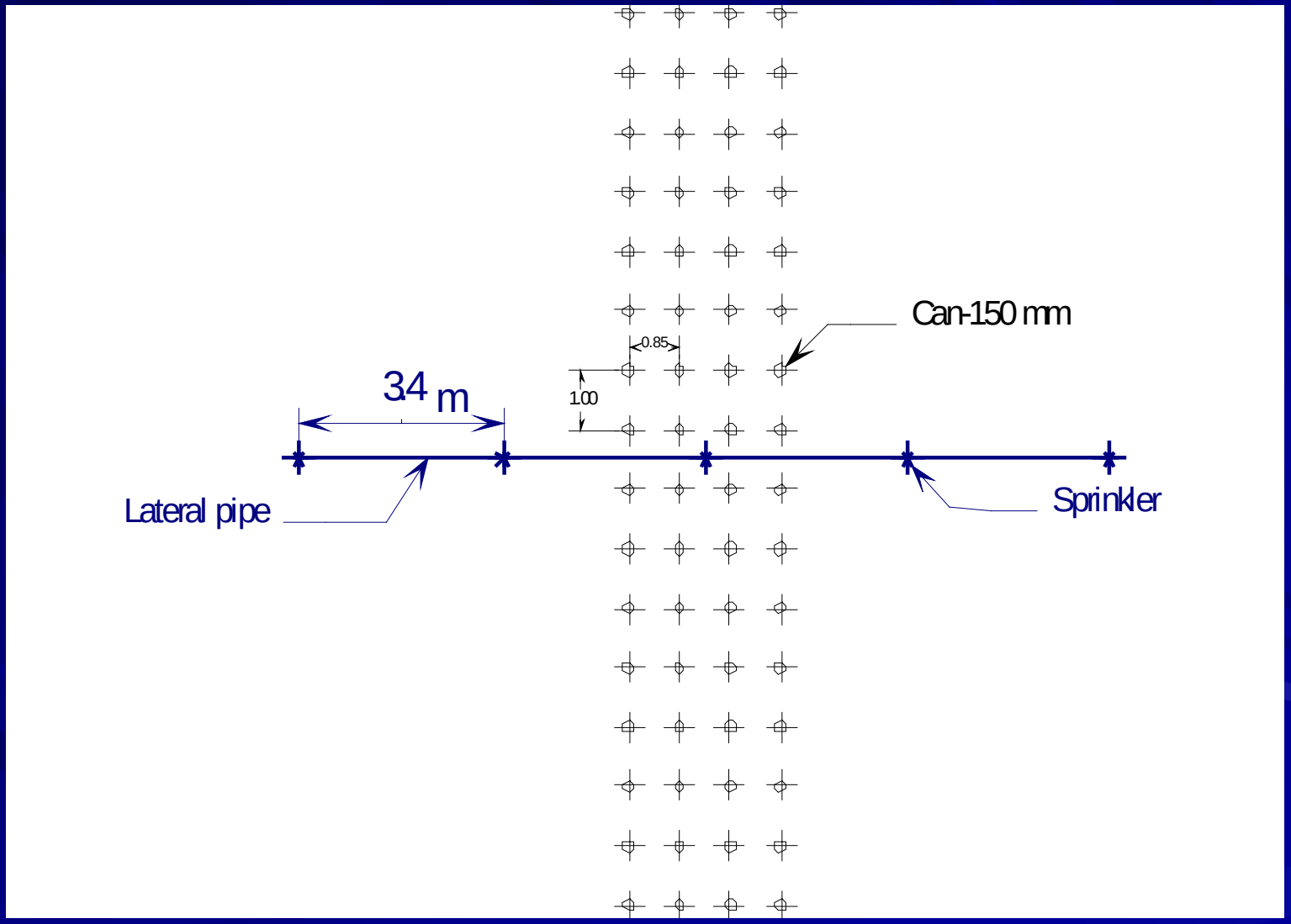



- Wind can cause sprinkled water to drift out of the application area.
- Smaller droplets (<1 mm in size) are most susceptible to wind drift.
- Wind decreases sprinkler uniformity.
- Water that drifts off the field is generally considered consumed, while water that drifts within the field helps to cool the crop, reducing uptake from roots.
- For wind conditions >10 mph, spray losses can increase dramatically.

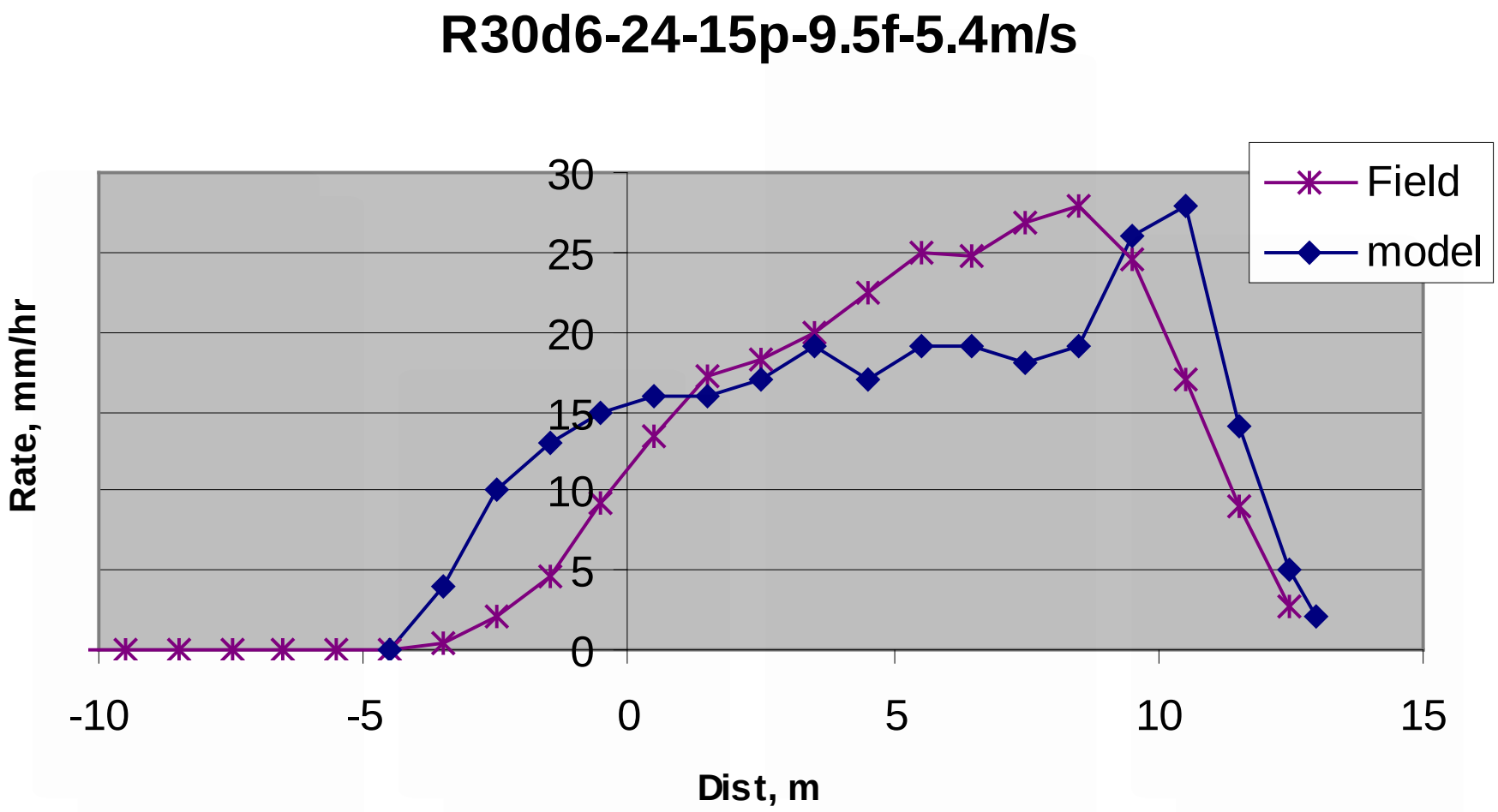
# Measuring Wind Drift



# Field test layout for drift measurement



# Wind drift test #7232 (Kincaid)
# AV=6.1 m, Max=74 m Ev=1.9%  Drift=4.0%



# Deep Percolation, Runoff & Leaks

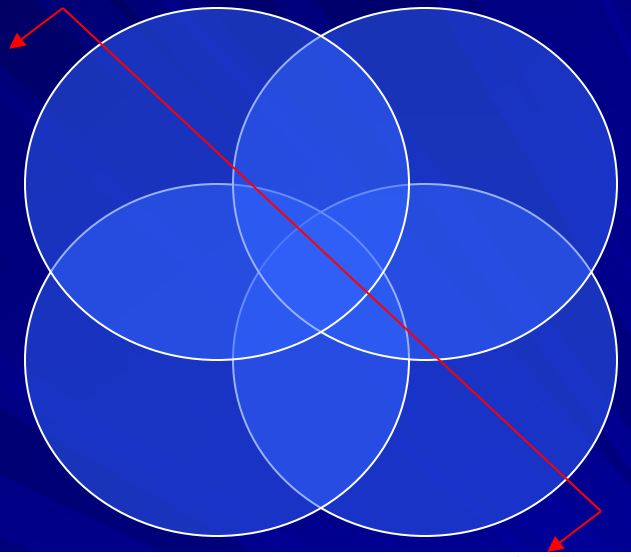
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- Leaks, over-application and non-uniform application can all lead to Deep Percolation. Leaks are influenced by system installation and O&M.
- When water is applied at a rate greater than the soil can infiltrate, it can lead to Runoff.
- Deep Percolation and Runoff are heavily influenced by irrigation scheduling and soil type. Deep percolation occurs when water passes below the root zone.
- If Deep Percolation or Runoff returns to waters of the State, or is intercepted but would otherwise return to waters of the State, it is considered return flow.

# Non-Uniform Application

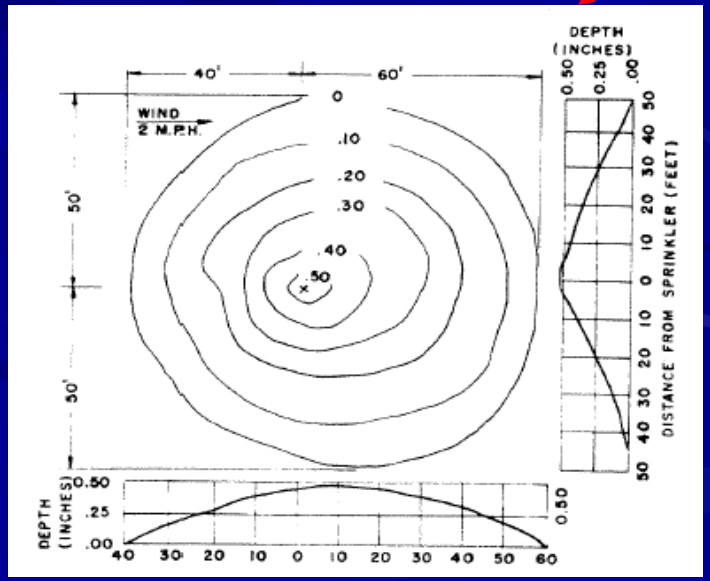
## How Does Application Uniformity Affect Irrigation Efficiency?



- Perfect Uniformity = Rain



- Sprinklers are designed to maximize yield
- Some overlap is necessary to ensure the entire field receives enough water
- Design degree of overlap depends on crop type, chemical addition
- Distribution Uniformity (DU) is a percent value indicating degree of overlap
- DU is the ratio of the average low-quarter depth to the average depth of water applied
- DU values in the range 65% - 85% common

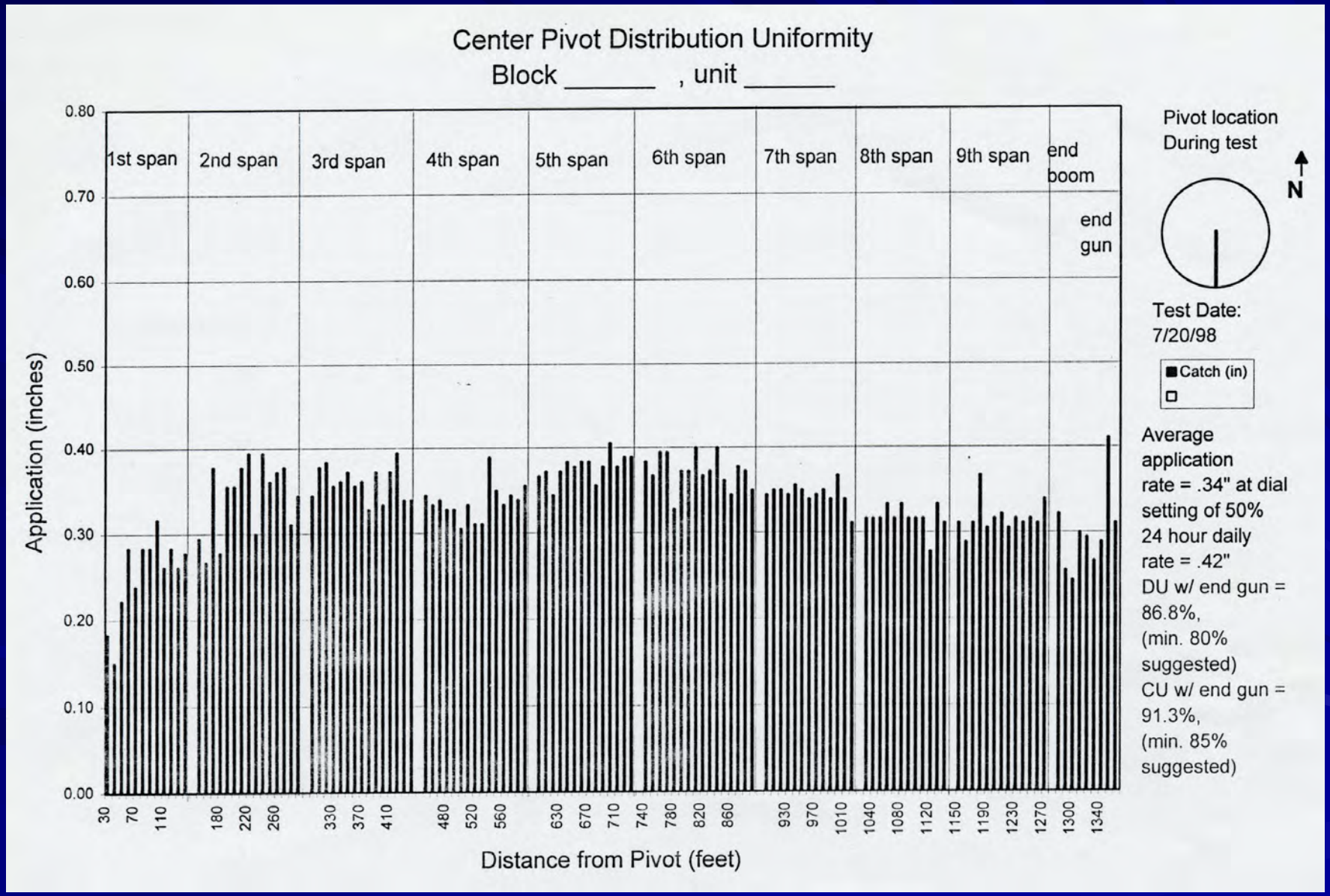


# Non-Uniform Application

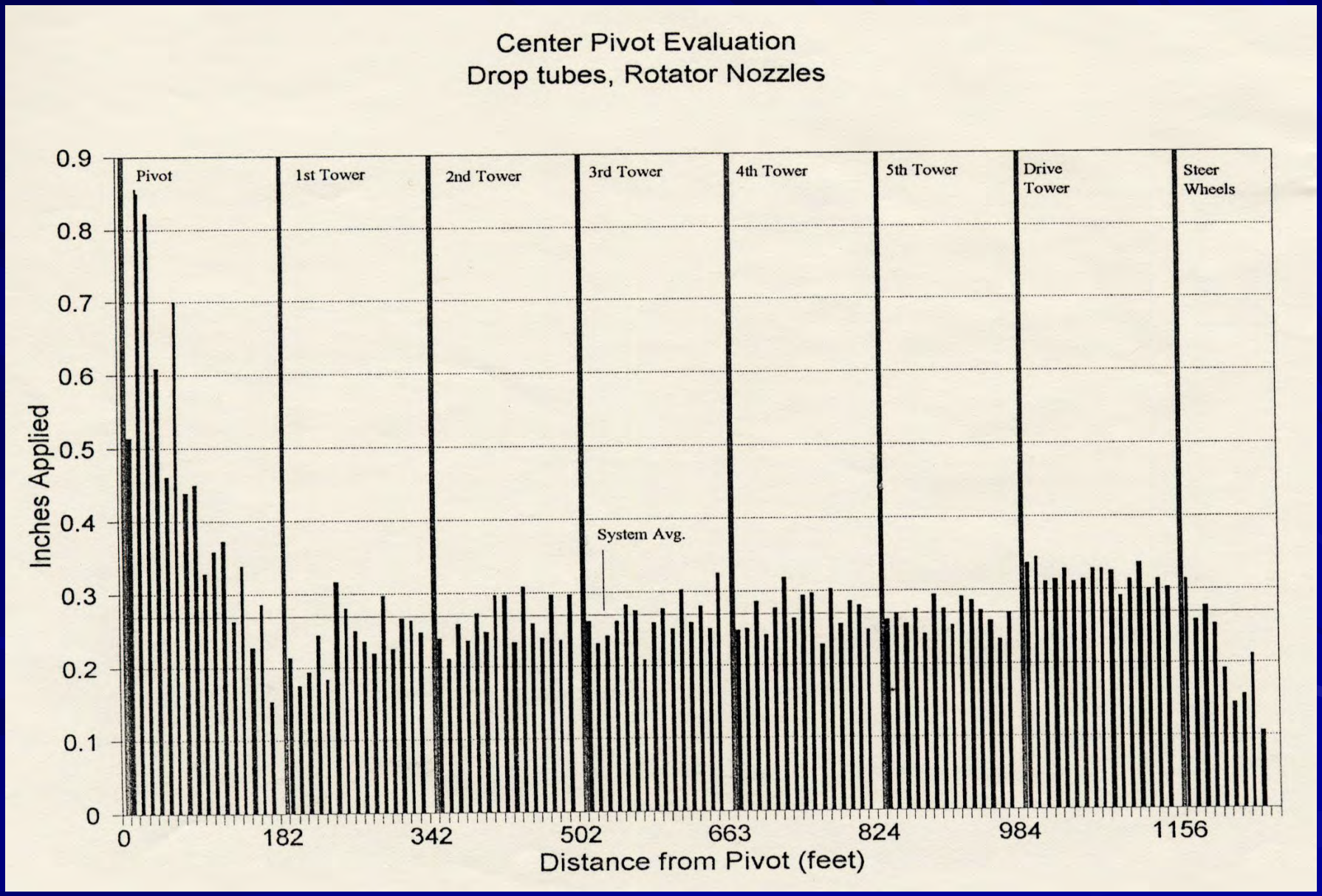
Catch Can Testing, Mark Nielson, Franklin County Conservation District



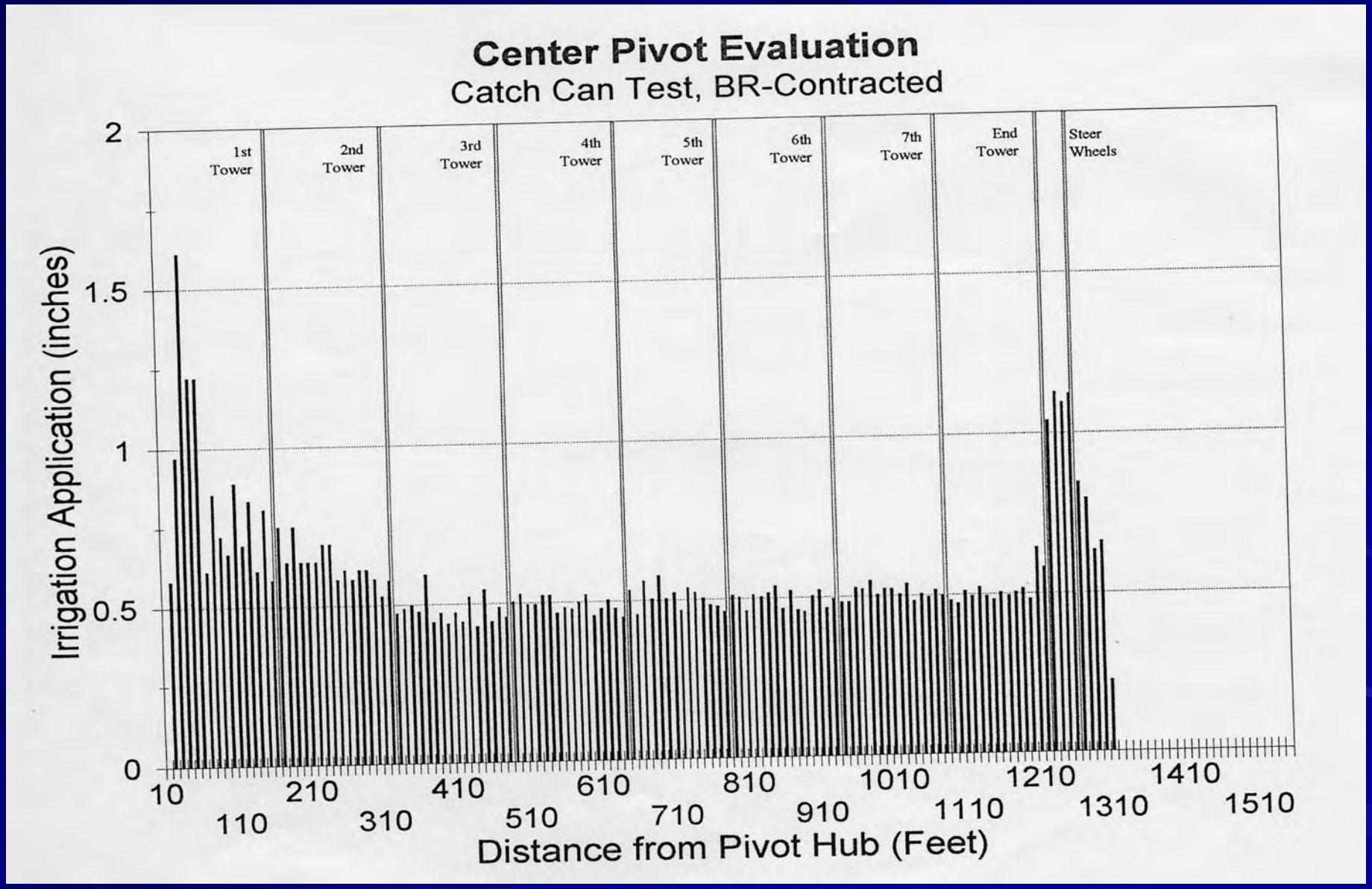
# Catch Can Test Results



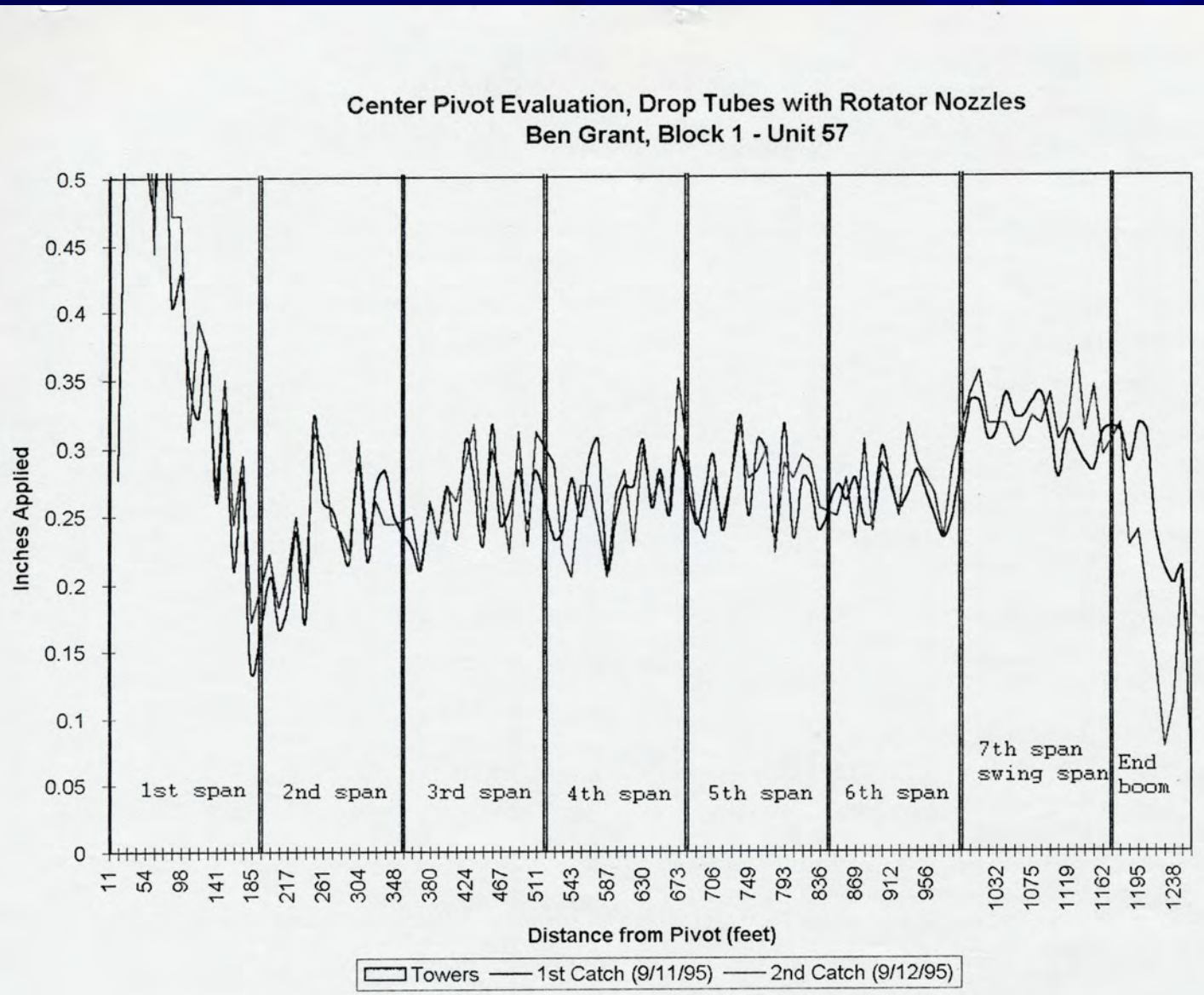
# Catch Can Test Results



# Catch Can Test Results



# Catch Can Test Results




1st Catch
DU = 81.2%
CU = 88.1%
WINDS 10 mph with gusts > 15 mph

2nd Catch
DU = 72.5%
CU = 84.0%
WINDS calm ≤ 5 mph

BETTER uniformity with windy conditions.

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6. Using the Guidance Document
   a) Examples, examples, examples

# Irrigation Efficiency – What Number Do We Use?

- The literature (e.g. WIG) provides average efficiency values.
- Actual efficiencies vary significantly according to local conditions and management (e.g. irrigation scheduling) by the farmer.
- Dr. Blaine Hansen, University of California, Davis, 1995 measured efficiencies of nearly 1000 different irrigation systems (below).
- Dr. Terry Howell, USDA-ARS Texas, 2002, collected and summarized existing irrigation efficiency research.
- Experts Workshop recommendation was to use this data and include ranges to allow adjustment for site-specific conditions.

| Irrigation Method | Sample Size | Average DU (%) | Standard Deviation (%) |
|---|---|---|---|
| Sprinklers | | | |
| Continuous-move | 57 | 75a | 10 |
| Portable Solid-set | 56 | 64b | 11 |
| Periodic-move | 109 | 61b | 17 |
| Under-tree | 28 | 79ade | 16 |
| Micro-irrigation | | | |
| Microsprinklers | 276 | 71c | 14 |
| Drip emitters | 163 | 77ae | 14 |
| Surface | | | |
| Furrow | 157 | 81d | 15 |
| Border | 72 | 84d | 14 |

| DU Range | CM | SS | PM | MS | D | F | B |
|---|---|---|---|---|---|---|---|
| 0-10 | 0 | 0 | 1.8 | 0 | 0 | 0 | 0 |
| 11-20 | 0 | 0 | 0.9 | 0 | 0 | 0 | 0 |
| 21-30 | 0 | 0 | 2.8 | 1.4 | 1.2 | 0 | 0 |
| 31-40 | 1.8 | 0 | 7.3 | 2.5 | 1.8 | 2.0 | 2.9 |
| 41-50 | 1.8 | 12.5 | 14.6 | 4.3 | 2.4 | 2.6 | 1.4 |
| 51-60 | 1.8 | 21.4 | 13.8 | 14.5 | 6.1 | 9.2 | 1.4 |
| 61-70 | 22.8 | 39.2 | 29.3 | 21.3 | 14.7 | 5.9 | 12.9 |
| 71-80 | 38.6 | 21.4 | 20.2 | 27.2 | 27.0 | 20.4 | 10.0 |
| 81-90 | 33.3 | 5.4 | 8.2 | 25 | 35.0 | 27.3 | 35.7 |
| 91-100 | 0 | 0 | 0.9 | 3.6 | 11.6 | 32.9 | 35.7 |

CM = continuous-move sprinklers, SS = solid-set sprinklers, PM = periodic-move sprinklers, MS = microsprinklers, D = drip emitters, F = furrow, B = border.

# Irrigation Efficiency: What Numbers Do We Use?

| Method | | Application Efficiency, Ea (%) | | %Total Evaporated | % Total Use Consumed | Return Flow |
|---|---|---|---|---|---|---|
| | | Range | Average, $Ea_{avg}$ | %Evap | %CU, Average | %RF, Average |
| Surface: | Graded Furrow | 50 – 80 | 65 | 5 | 70 | 30 |
| | Flood | 35 – 60 | 50 | 5 | 55 | 45 |
| Sprinkler: | Periodic Move (Handline) | 60 – 85 | 75 | 10 | 85 | 15 |
| | Moving Big Gun | 55 – 75 | 65 | 10 | 75 | 25 |
| | Solid-Set—Overtree | 55 – 80 | 70 | 15 | 85 | 15 |
| Center-Pivot | Spray heads w/o end gun | 75 – 95 | 90 | 10 | 100 | 0 |
| Microirrigation: | Trickle/Drip | 70 – 95 | 88 | 5 | 93 | 7 |
| | Microspray | 70 – 95 | 85 | 10 | 95 | 5 |

Waste? ⟷ Deficit Irrigation?

# Using the Guidance Document to Determine Efficiency



- Determine Actual Use, then Calculate Efficiency
  - Metering Data
  - Power Data
  - Flow x Time

➢Ea = CIR / Total Water Use

CIR from WIG
Total Water Use from Actual Data

- Assume Efficiency, then Estimate Use
  - WIG / Eff
  - Status Quo for Permit Writers

# Summary

1. Background / Timeline
2. 2004 Experts Workshop
3. Irrigation 101
   a) Irrigation Water Budget
   b) Evapotranspiration (ET)
   c) Components of Irrigation Efficiency
4. Irrigation Efficiency – What Number Do We Use?
5. Within the Irrigation Efficiency – What is the Consumptive / Non-Consumptive Balance?
6. Using the Guidance Document
   a) Examples, examples, examples

# Within Irrigation Efficiency—

## What is the Consumptive / Non-Consumptive Balance?

- Experts recommendations:
  - System complexity does not reward quantification of individual components of Ea
  - Some non-target evaporation occurs in every above-ground irrigation system (5% is reasonable)
  - As elevation increases, opportunities for evaporation increases (e.g. canopy, spray and wind losses)
  - Allow for site-specific conditions, inform yourself about irrigation scheduling

# Irrigation Efficiency: What Numbers Do We Use?

| Method | | Application Efficiency, Ea (%) | | %Total Evaporated | % Total Use Consumed | Return Flow |
|---|---|---|---|---|---|---|
| | | Range | Average, $Ea_{avg}$ | %Evap | %CU, Average | %RF, Average |
| Surface: | Graded Furrow | 50 – 80 | 65 | 5 | 70 | 30 |
| | Flood | 35 – 60 | 50 | 5 | 55 | 45 |
| Sprinkler: | Periodic Move (Handline) | 60 – 85 | 75 | 10 | 85 | 15 |
| | Moving Big Gun | 55 – 75 | 65 | 10 | 75 | 25 |
| | Solid-Set—Overtree | 55 – 80 | 70 | 15 | 85 | 15 |
| Center-Pivot | Spray heads w/o end gun | 75 – 95 | 90 | 10 | 100 | 0 |
| Microirrigation: | Trickle/Drip | 70 – 95 | 88 | 5 | 93 | 7 |
| | Microspray | 70 – 95 | 85 | 10 | 95 | 5 |

# What is the Con / Non-Con Balance?

- Step 0: Calculate (or estimate) Total Use
- Step 1: Calculate (or assume) reasonable Ea
- Step 2: %CU = Ea + %Evap
- Step 3: %RF = 100 - %CU
- Step 4: CU = %CU x Total Use
- Step 5: RF = %RF x Total Use

# Example 1: Typical Farmer With No Data

- Background: 10 acres of pasture, handline irrigation, CIR from WIG = 3 ac-ft/ac, water right Qa = 40 ac-ft based on 75% Ea, no power or meter data available.

- Step 0: Calculate (or estimate) Total Use, Total Use = 3 / 0.75 = 4 ac-ft / ac. 4 ac-ft / ac x 10 acres = 40 ac-ft.

- Step 1: Calculate (or assume) Ea, Ea = 75%.

- Step 2: %CU = 75 + 10, %CU = 85%.

- Step 3: %RF = 100 - 85, %RF = 15%.

- Step 4: CU = 85% x 40 ac-ft, CU = 34 ac-ft.

- Step 5: RF = 15% x 40 ac-ft, RF = 6 ac-ft.

# Example 2: Atypical Farmer With Metering Data

- Background: 10 acres of pasture, handline irrigation, CIR from WIG = 3 ac-ft/ac, no water right Qa specified, meter data available (51.7 ac-ft).

- Step 0: Calculate Total Use, Total Use = 51.7 ac-ft.
- Step 1: Calculate Ea, Ea = (3 ac-ft/ac) x (10 ac) / 51.7 ac-ft = 58%.
  Reasonable? (waste, local custom, labor constraints, type of system)
- Step 2: %CU = 58 + 10, %CU = 68%.
- Step 3: %RF = 100 - 68, %RF = 32%.
- Step 4: CU = 68% x 51.7 ac-ft, CU = 35.16 ac-ft.
- Step 5: RF = 32% x 51.7 ac-ft, RF = 16.54 ac-ft.

# Example 3: Farmer With Power Data & PAWS

- Background: 10 acres of pasture, wheelline irrigation, ET from PAWS = 3.4 ac-ft/ac, irrigation scheduling, water right Qa = 52 ac-ft based on 65% Ea, power data available (13,000 kW-hr), site visit yielded TDH (200 feet), Peff (70%), and Meff (90%).

- Step 0: Calculate Total Use, WAC 173-173-160, Metering Rule, V = 318,600 x kW-hr x Peff x Meff / TDH = 13 MG = 40 ac-ft. Assuming no sufficient causes, 12 ac-ft relinquished.

- Step 1: Calculate Ea, Ea = (3.4 ac-ft/ac) x (10 ac) / 40 ac-ft = 85%. Reasonable? (irrigation scheduling, AgriMet, set-times, soils, site-inspection)

- Step 2: %CU = 85 + 10, %CU = 95%.

- Step 3: %RF = 100 - 95, %RF = 5%.

- Step 4: CU = 95% x 40 ac-ft, CU = 38 ac-ft.

- Step 5: RF = 5% x 40 ac-ft, RF = 2 ac-ft.

# Example 4: Farmer With Pump Run-Times

- Background: 10 acres of pasture, solid-set irrigation, CIR from WIG = 3 ac-ft/ac, water right Qa = 46 ac-ft based on 65% Ea, pump capacity 100 gpm, 184 day season (4/1 to 10/1), 14 day harvest—no water, otherwise runs continuously.

- Step 0: Calculate Total Use, 100 gpm x 1440 x (184 – 14 days) / 325851 = 75 ac-ft, which exceeds authorized Qa. Perform calculations based on authorized use of 46 ac-ft.

- Step 1: Assume Ea, Ea = 65%.

- Step 2: %CU = 65 + 10, %CU = 75%.

- Step 3: %RF = 100 - 75, %RF = 25%.

- Step 4: CU = 75% x 46 ac-ft, CU = 34.5 ac-ft.

- Step 5: RF = 25% x 46 ac-ft, RF = 11.5 ac-ft.

# Example 5: 2005 Conservancy Board Decision

- Background: In 2004 Ecology completed a proof exam and issued a certificate to a farmer for 80 ac-ft for irrigation of 20 acres. The farmer then filed a change to spread this quantity to additional acres. Ecology AFFIRMED the Board's decision with clarification.

- Ecology evaluated the Board's ACQ analysis consistent with its consumptive use policy, procedure and guidance document (POL-1210, PRO-1210, and GUID-1210 (draft)) and concluded that the ACQ was 74 ac-ft, which is within 1% of the Board's calculation. Ecology AFFIRMS the Board's determination that the ACQ is 73.2 ac-ft.

- Given the Board's calculations, 6.8 ac-ft of the applicant's valid water right is return flow (e.g. 80 – 73.2 ac-ft). Although this still represents a portion of the applicant's valid water right, Ecology AFFIRMS the Board's determination that only the ACQ of 73.2 ac-ft may be transferred in this instance, because the proposed uses (e.g. deficit irrigation of grapes with drip irrigation) are expected to be entirely consumptive.

# Example 6: What About Deficit Irrigation?

- Background: Irrigation present in site inspection and in aerial photos, but not a lush crop. Dry spots evident and interview suggests full irrigation duty not applied. What do you do?

- WIG CU is based on “use of an extensive surface of 3 in. to 6 in. tall green grass cover of uniform height, actively growing, completely shading the ground and not short of water”.
- WIG estimates generally reflect intensive farming practices where the goal is to maximize crop yield.
- What constraints exists that prevent the use of a full WIG CIR?
  - Labor Constraints
  - Site Constraints
  - Infrastructure Constraints
  - Operational Constraints
- Reductions in the CIR are a matter of best professional judgment.

# Conclusions



- How big is your bucket?



- WIG is still the champ,
  but getting soft in the belly.



- Empower yourself to use your best professional judgment.
- Return flows are no longer the “Where’s Waldo” of the water rights world.







Questions?

Other Examples?



