Management Allowed Depletion Irrigation Scheduling

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The Intelligent Use of Water.™

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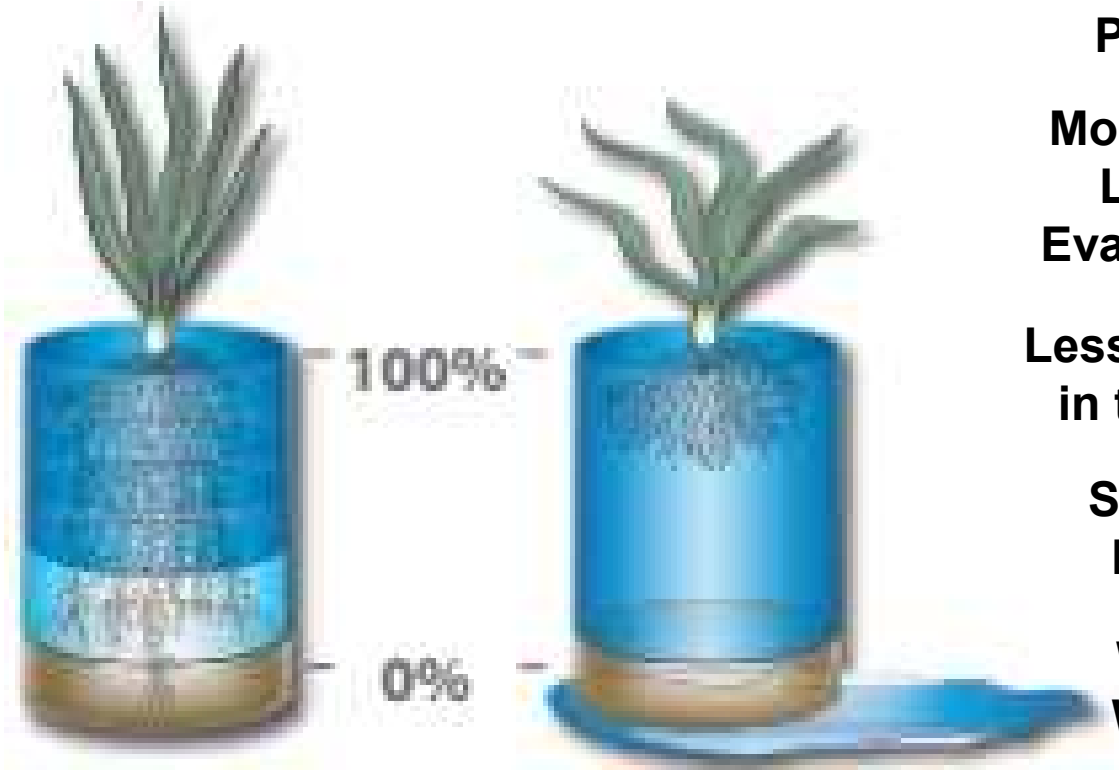
Question?

- **What irrigation controller program day cycle setting should I use?**
  - Custom, Odd, Odd31, Even, or Cyclical options
  - Water every day
  - Water every day with the day before mowing off
  - Water on select days of the week (Mon, Wed, Fri, Sun)
  - Water every other day (cyclical)
  - Water every third day (cyclical)
  - Water only on Odd calendar dates
  - Water only on Even calendar dates
- **Does it matter which option I choose?**

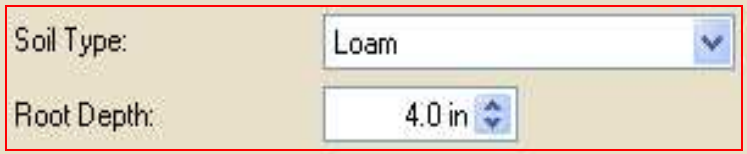
Management Allowed Depletion (MAD)

1. MAD is the maximum amount of Plant Available Water (PAW) allowed to be removed from the soil before irrigation refill occurs
2. Increased surface evaporation of water and usually higher rates of transpiration are associated with high frequency irrigation; It is best to irrigate only when the root zone has reached MAD
3. For most landscape purposes, 50% MAD represents a reasonable overall value; For sensitive, shallow rooted plants, or heavy compacted soils, a smaller depletion should be considered (30-50% MAD)
4. For stress-tolerant plants, deep root zones or lighter soils, a larger depletion can be used (50-70% MAD)

Irrigation Frequency

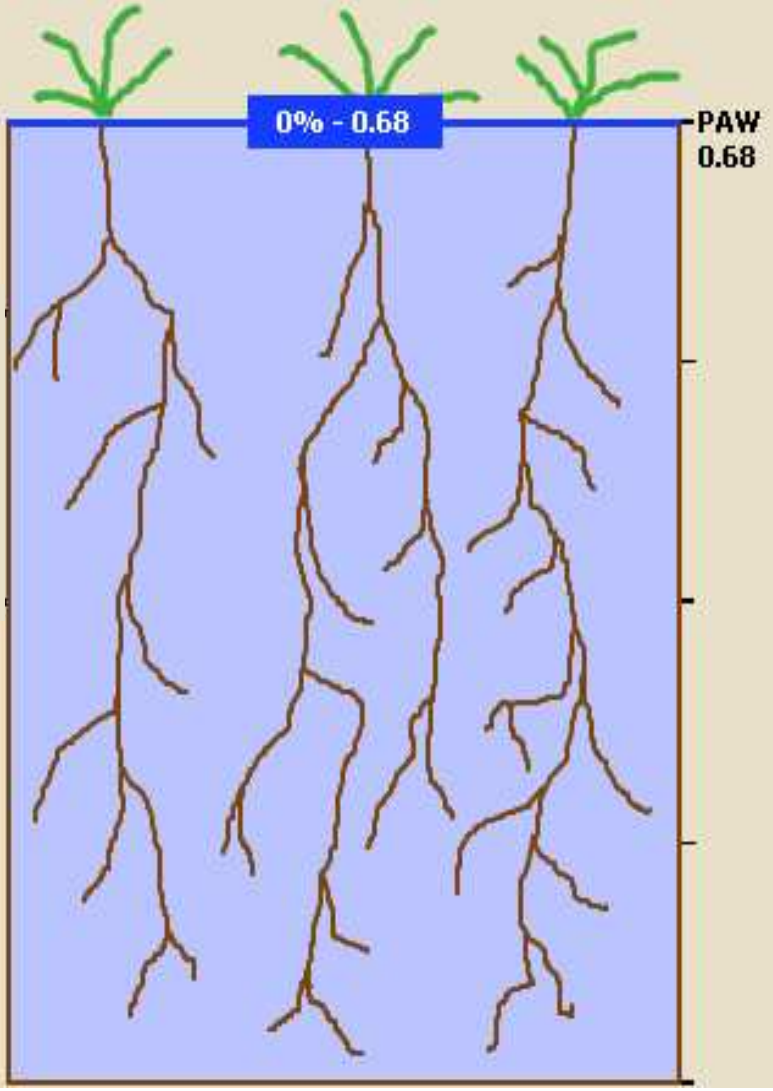
	Less Frequent Deep Watering	Frequent Light Watering	
Healthier Plants			Weaker Plants
Less Water Lost to Evaporation			More Water Lost to Evaporation
Water/Oxygen Mixture in Soil			Less Oxygen in the Soil
Deeper Roots			Shallow Roots
Water Savings			Water Waste

Plant Available Water

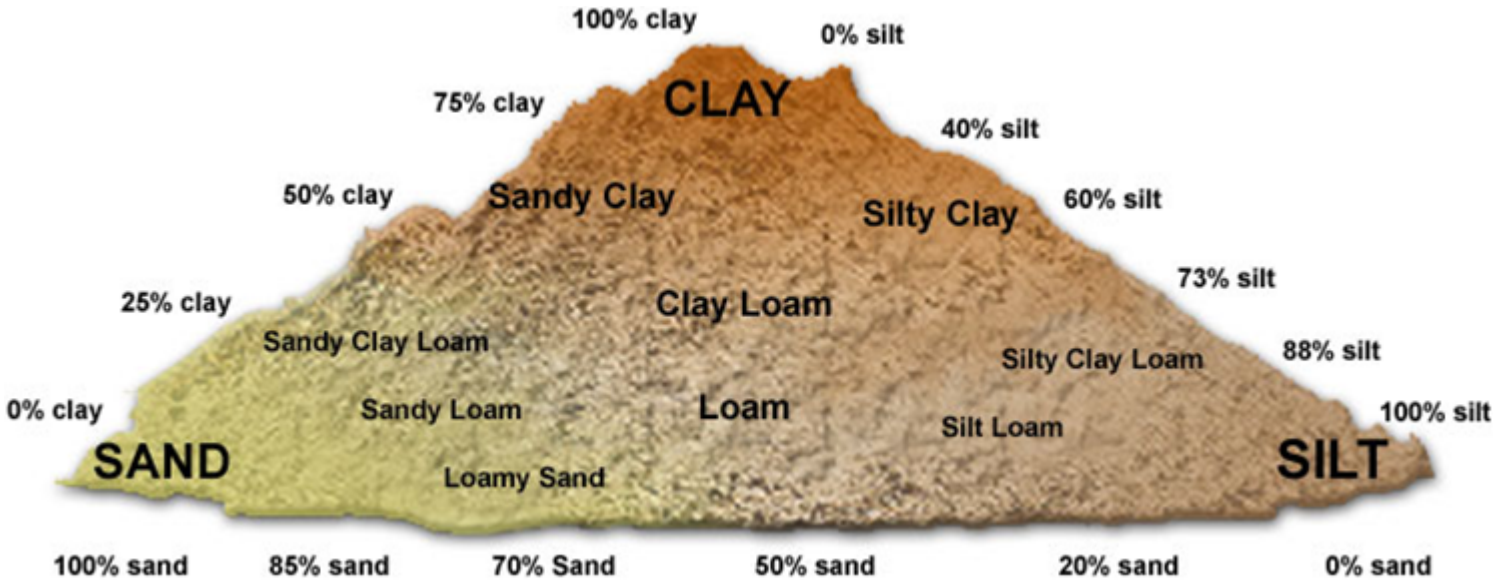


Plant Available Water (PAW):
The total amount of water held in the plant root zone based on:

- **Soil Type**
- **Plant Root Depth**



Water/Soil Relationship



Sandy Soils:

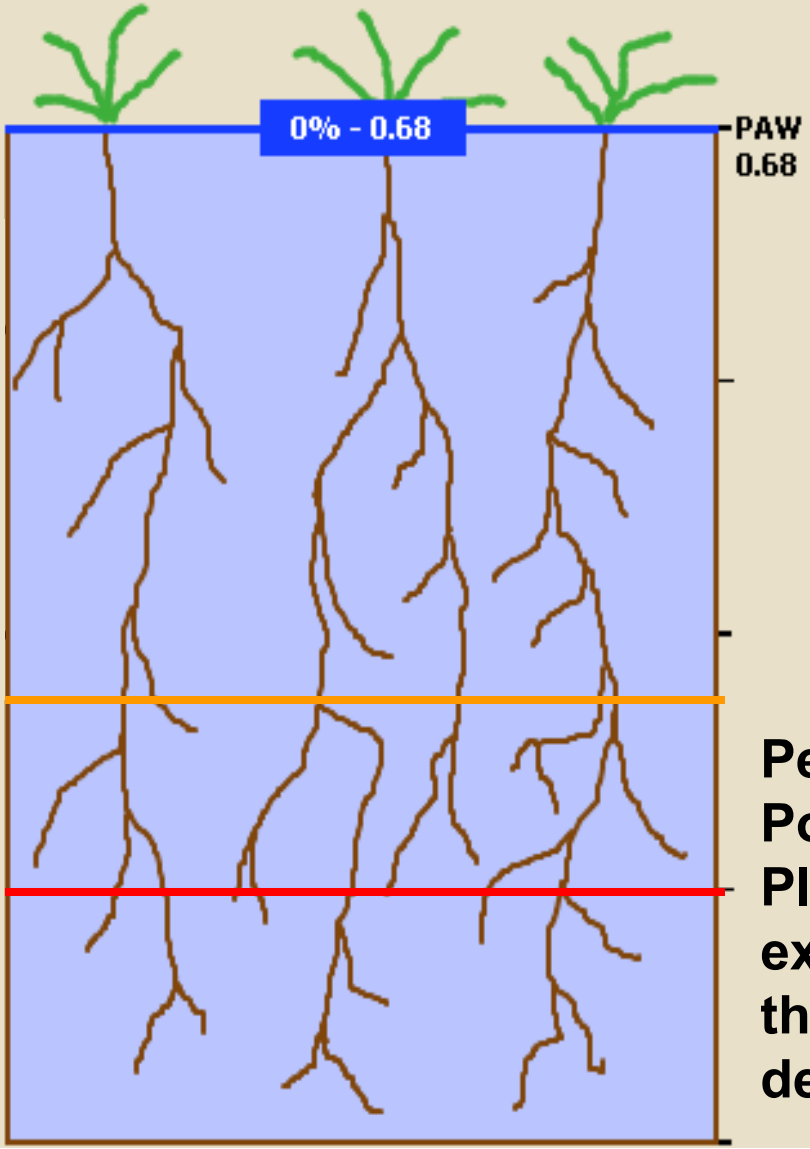
- Large soil particles
- High water infiltration rate
- Low water retention rate

Clay Soils:

- Small soil particles
- Low water infiltration rate
- High water retention rate

Soil Moisture Balance Conditions

Allowable Stress Factor (K_{as}): Minimum soil moisture balance that can still produce acceptable plant quality (40 to 60% depletion)

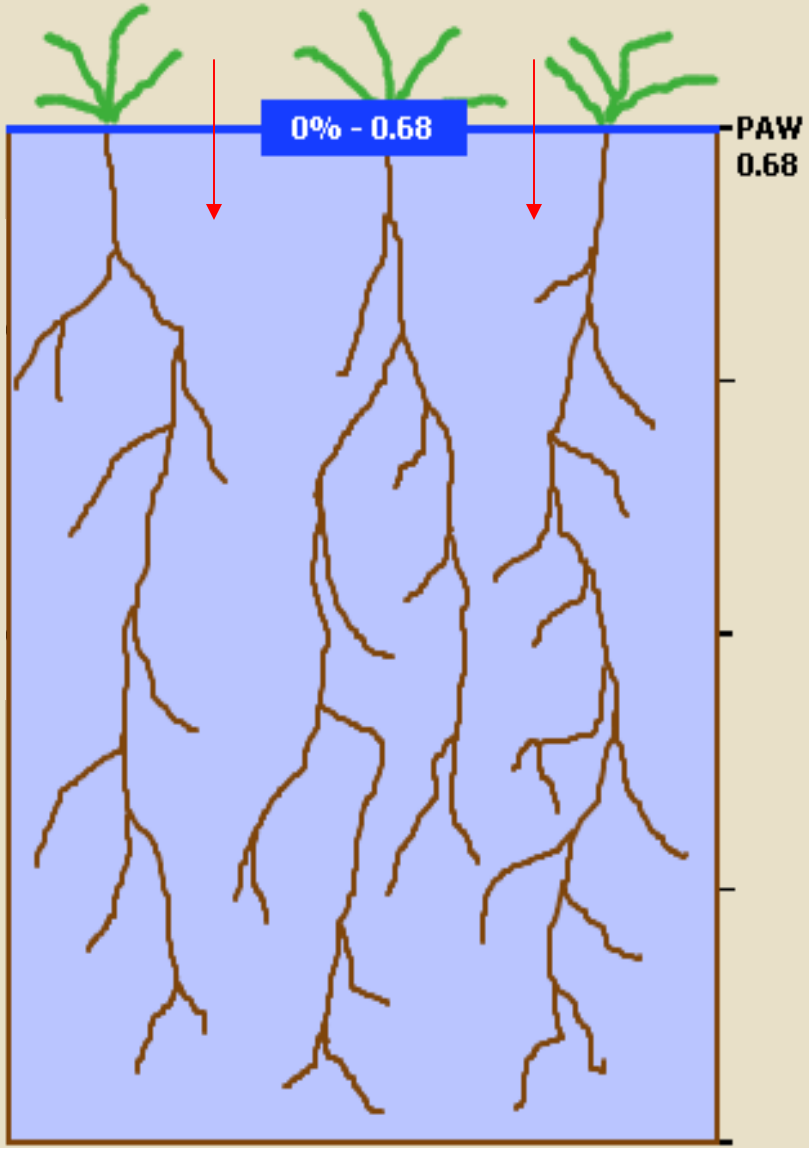


Field Capacity: Thoroughly wetted soil (0% depletion)

Permanent Wilting Point (PWP): Plants can no longer extract moisture from the soil (50 to 70% depletion)

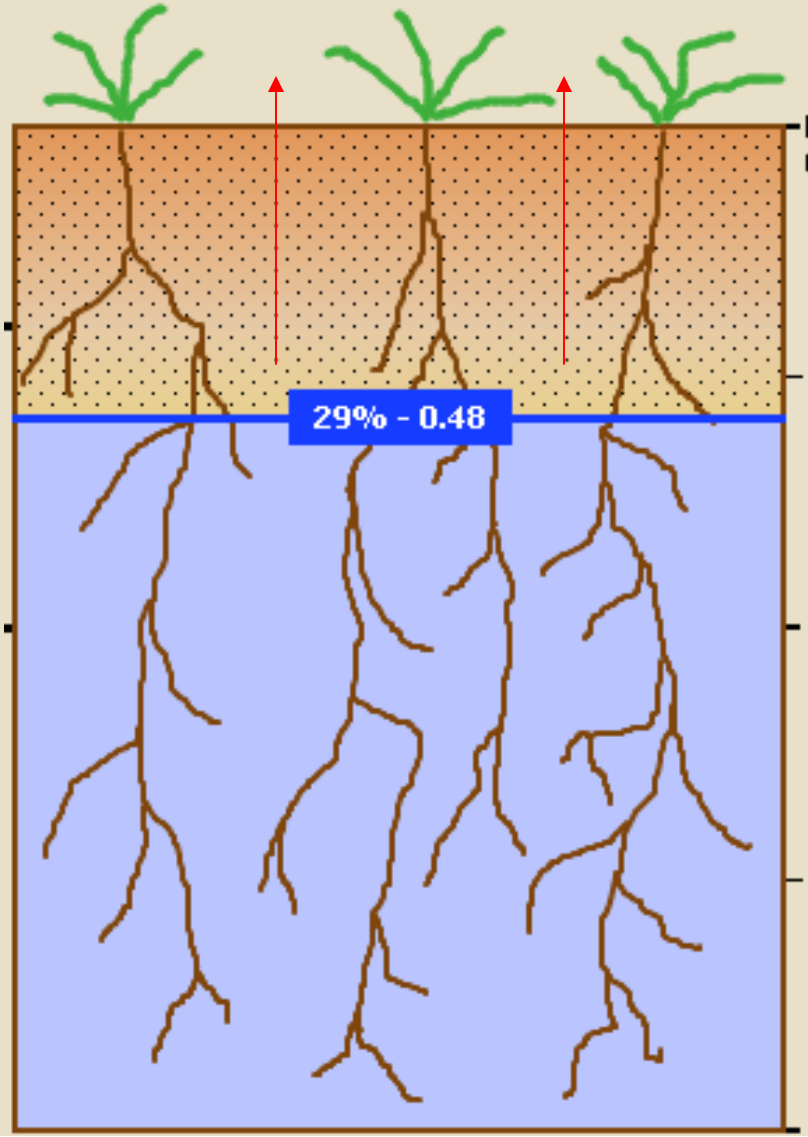
Factors that Increase Soil Moisture

Rainfall and irrigation increase the soil moisture balance



Factors that Decrease Soil Moisture

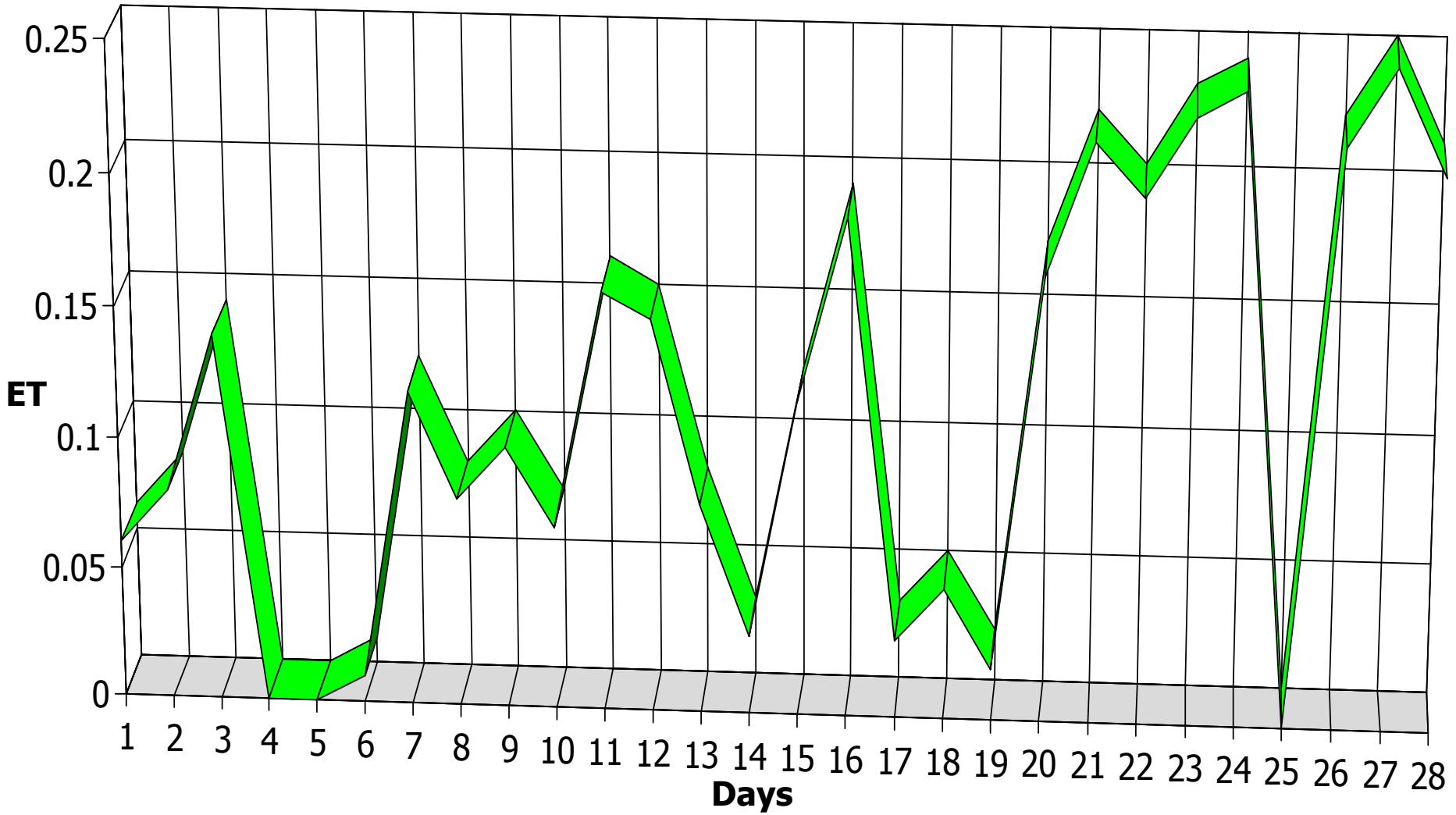
Evapo-transpiration (ET)
The sum of the water lost from the soil surface (evaporation) and the water used by the plants (transpiration)



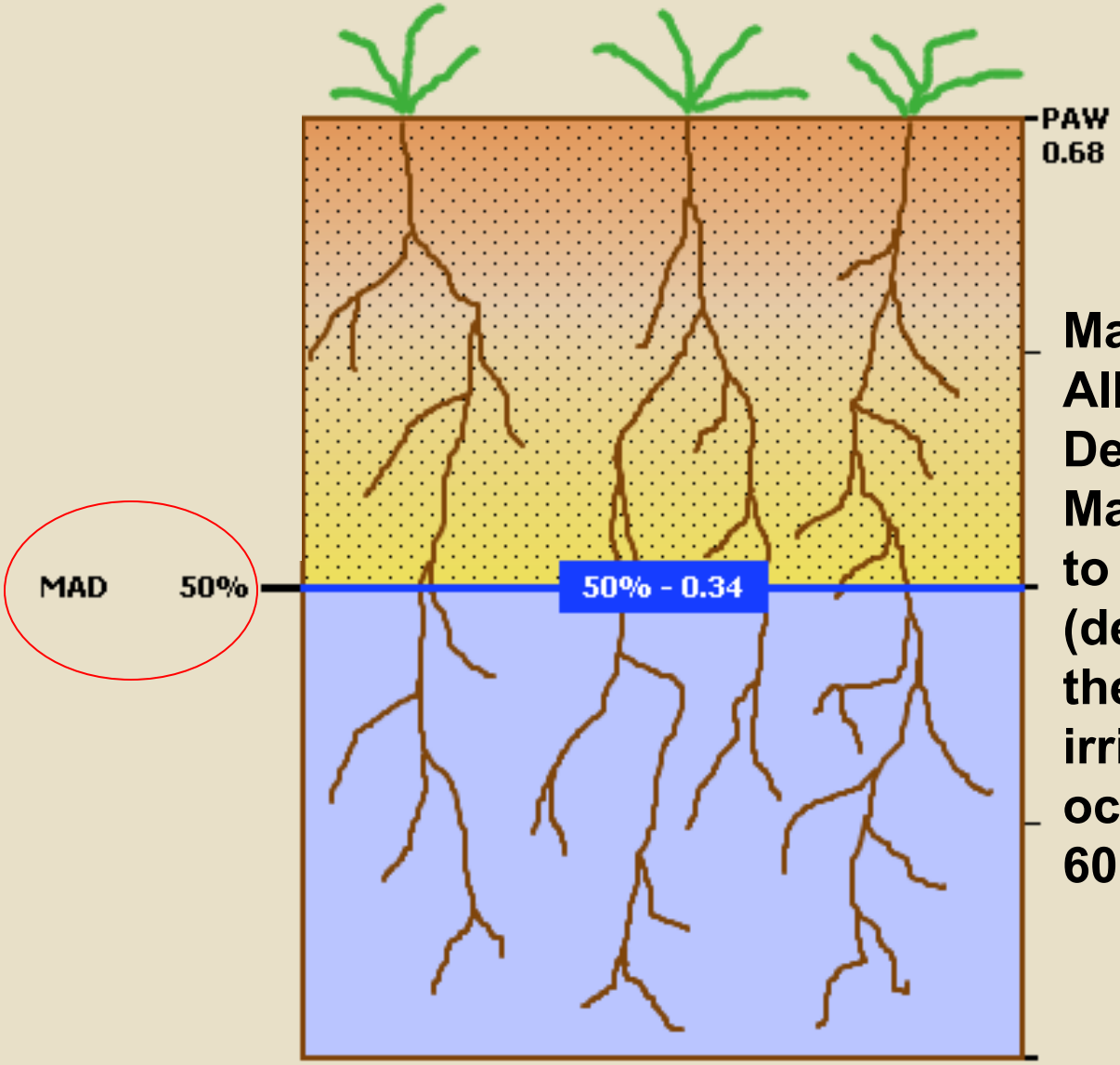
Alfalfa Reference ET (ET_o)
- **Solar Radiation**
- **Relative Humidity**
- **Wind Run**
- **Temperature**
- **Rain**
- **Elevation**
- **Latitude**

Landscape Coefficient (K_L)
- **Species Factor**
- **Density Factor**
- **Microclimate Factor**

Daily ET Minus Effective Rainfall

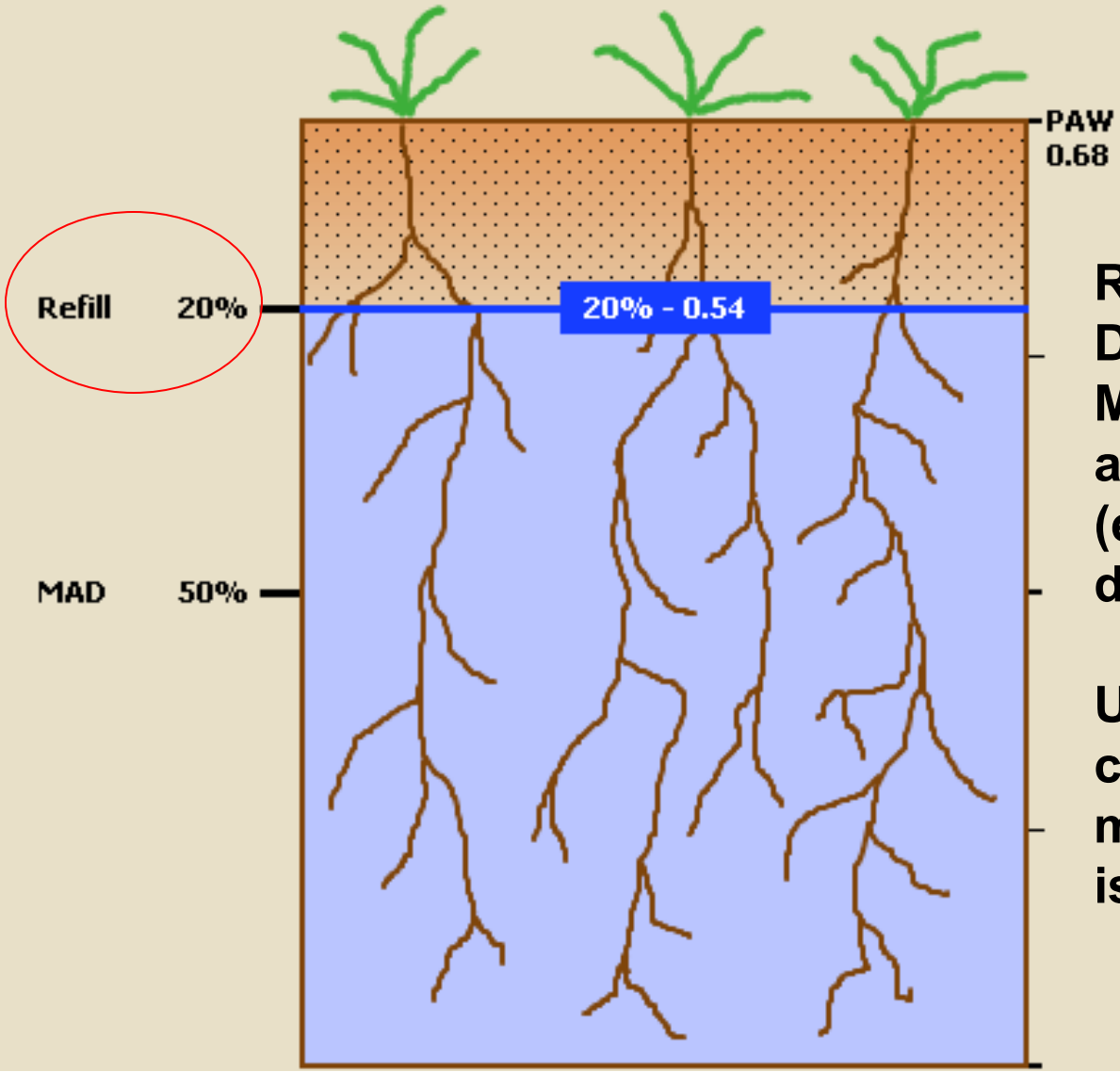


Management Allowed Depletion



Management Allowed Depletion (MAD): Maximum PAW% to be removed (depleted) from the soil before irrigation refill occurs (30 to 60% depletion)

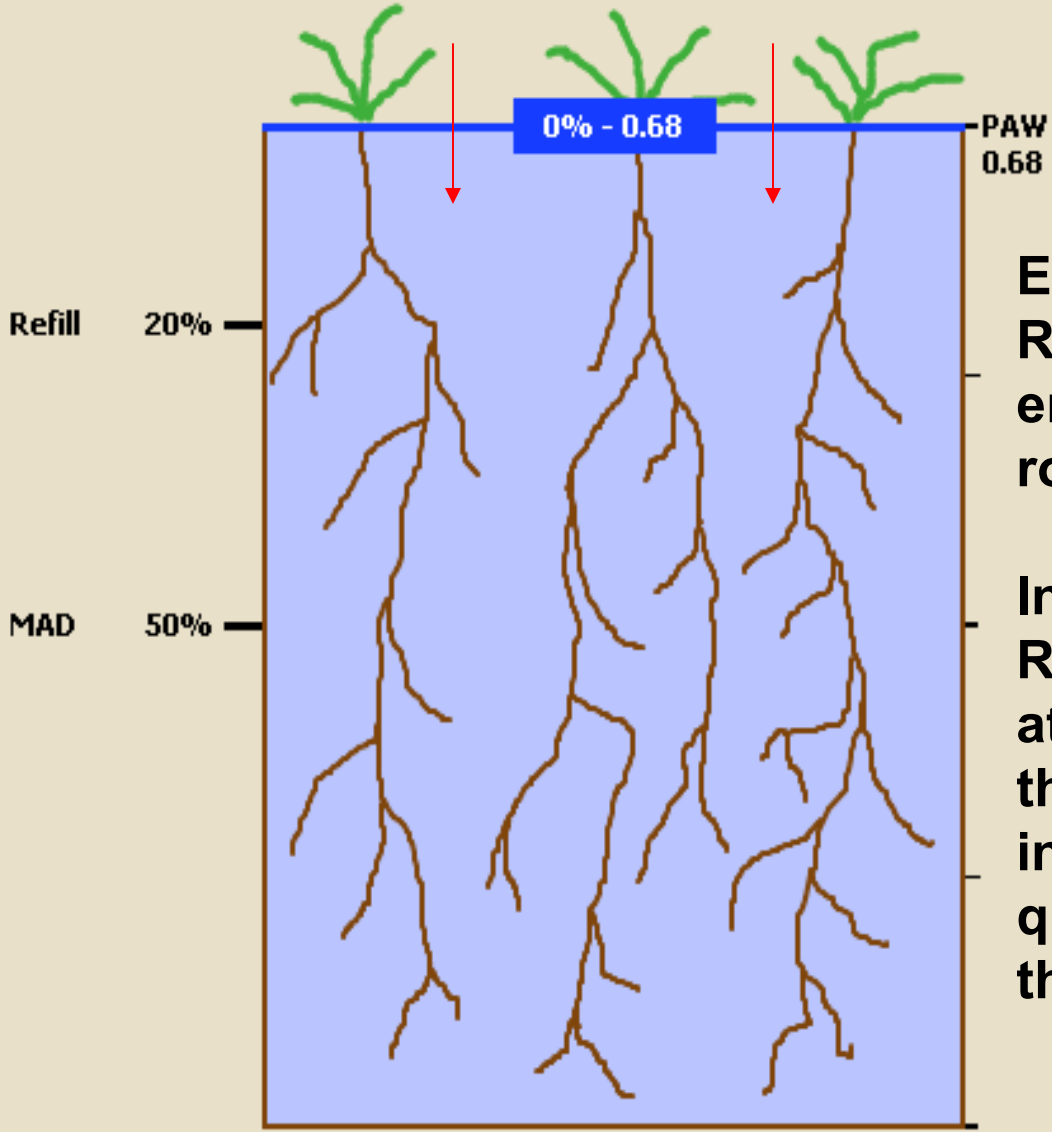
Irrigation Refill %



Refill %: Desired Soil Moisture Balance after irrigation (expressed as a depletion %)

Used where field capacity soil moisture balance is not desired

Effective Rainfall



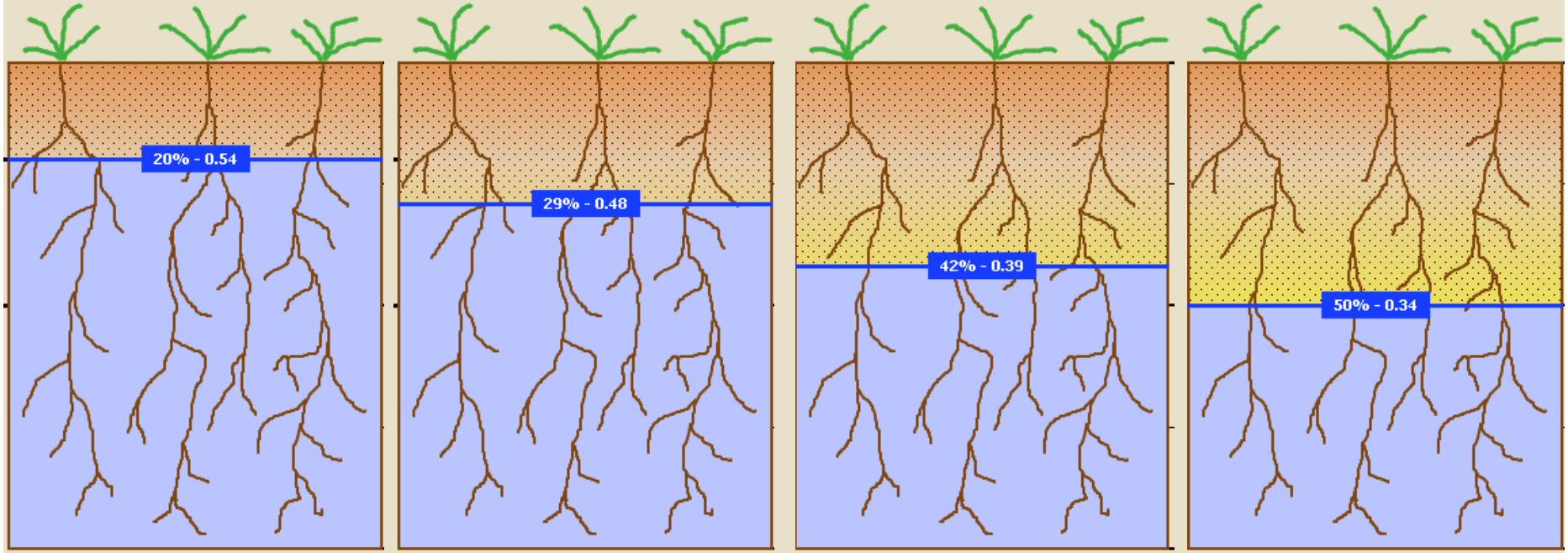
Effective rainfall: Rain water that enters the plant root zone

Ineffective rainfall: Rain water that falls at a faster rate than the maximum soil intake rate and in quantities greater than the PAW

Soil Moisture Balance

Day 1	Day 2	Day 3	Day 4
Irrigation	ET = 0.10”	ET = 0.09”	ET = 0.10”
Refill	Rain = 0.04”	Rain = 0.0”	Rain = 0.05”
0.54”	0.48”	0.39”	0.34”
20%	29%	42%	50%

Balance



Depletion

Watering Frequency Using Management Allowed Depletion Irrigation Scheduling

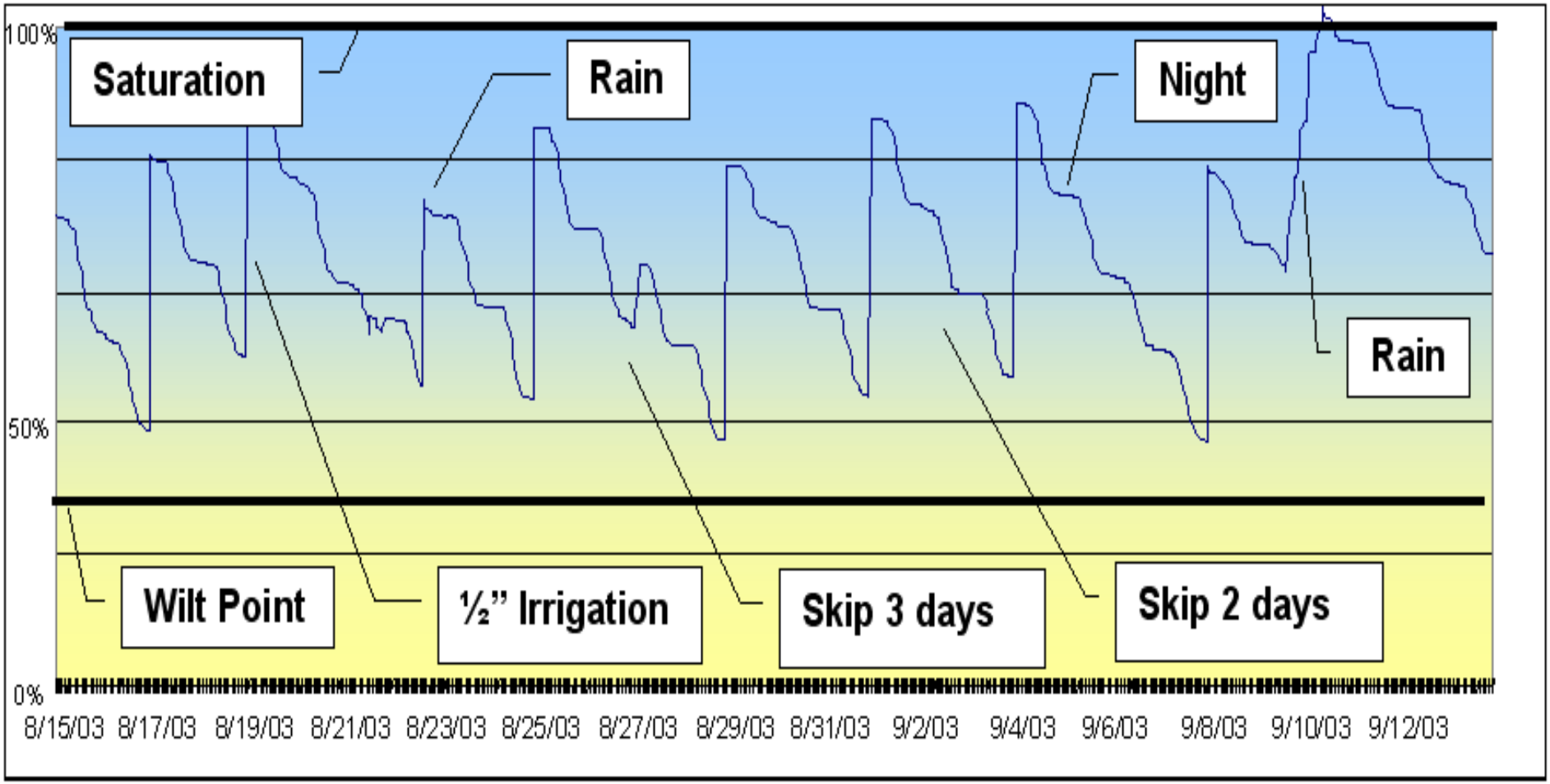
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	TOTALS
Total ETc	0.00	0.00	1.43	3.07	4.78	5.87	7.19	5.75	3.66	2.72	1.11	0.00	35.59
Total Rain	0.89	1.13	1.78	1.82	1.57	0.70	0.21	0.58	0.70	0.77	0.83	0.11	11.09
Watering Days	0	0	0	2	7	11	14	10	6	4	1	0	55.00
Irrigation Amount	0.00	0.00	0.00	1.00	3.50	5.50	7.00	5.00	3.00	2.00	0.50	0.00	27.50

	MAD Scheduling	Every Day Scheduling	Every Other Day Scheduling
Number of Watering Days per year	55	196	98

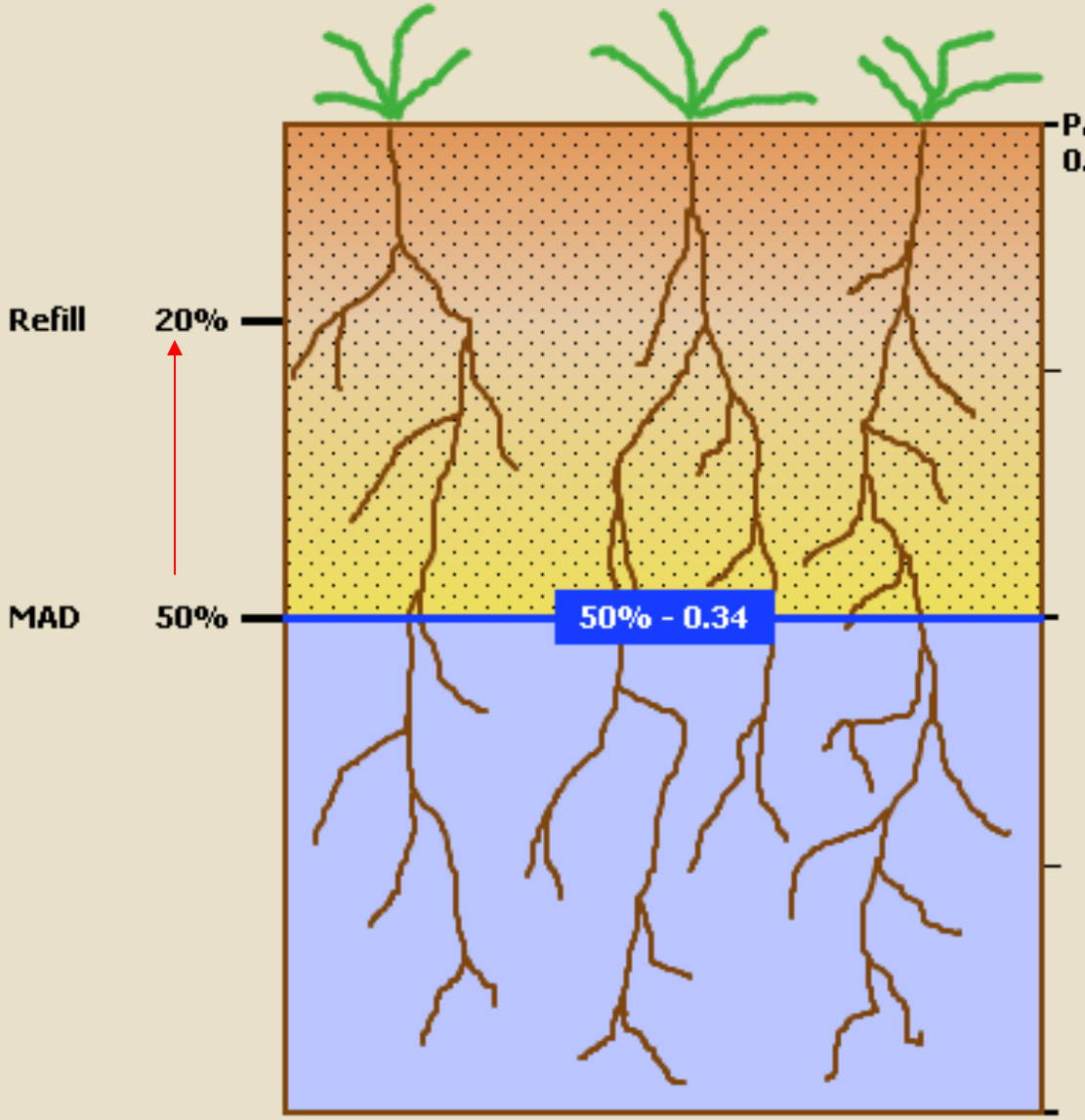
ET Checkbook

Date	ET	Effective Rain	Irrigation	Soil Moisture Level
6/1/2004	0.16	0.00	0.00	0.23
6/2/2004	0.05	0.20	0.00	0.38
6/3/2004	0.09	0.26	0.00	0.55
6/4/2004	0.11	0.14	0.00	0.58
6/5/2004	0.18	0.00	0.00	0.39
6/6/2004	0.14	0.01	0.00	0.26
6/7/2004	0.07	0.12	0.00	0.31
6/8/2004	0.11	0.02	0.00	0.22
6/9/2004	0.18	0.00	0.00	0.03
6/10/2004	0.20	0.39	0.00	0.23
6/11/2004	0.09	0.03	0.00	0.16
6/12/2004	0.18	0.00	0.50	0.48
6/13/2004	0.18	0.00	0.00	0.30
6/14/2004	0.19	0.00	0.00	0.11
6/15/2004	0.08	0.00	0.00	0.03
6/16/2004	0.20	0.00	0.50	0.33
6/17/2004	0.20	0.00	0.00	0.13
6/18/2004	0.08	0.05	0.00	0.09
6/19/2004	0.04	0.44	0.00	0.50
6/20/2004	0.12	0.00	0.00	0.37
6/21/2004	0.19	0.00	0.00	0.18
6/22/2004	0.18	0.00	0.50	0.50
6/23/2004	0.07	0.00	0.00	0.43
6/24/2004	0.21	0.00	0.00	0.22
6/25/2004	0.10	0.00	0.00	0.12
6/26/2004	0.11	0.06	0.00	0.08
6/27/2004	0.06	0.33	0.00	0.35
6/28/2004	0.19	0.00	0.00	0.16
6/29/2004	0.16	0.00	0.50	0.50
6/30/2004	0.10	0.09	0.00	0.49

Real-Time ET-based Irrigation Control



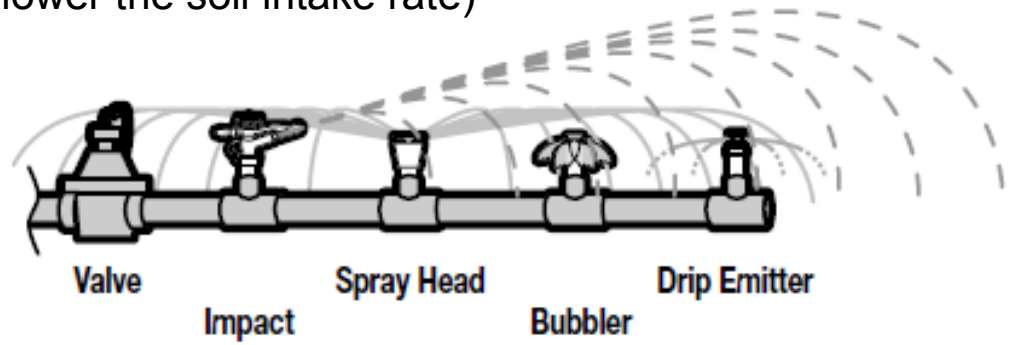
MAD Station Run Time



Station Run Time should be set so that each zone refills the soil moisture balance from MAD to the Refill target

Station Run Times

- **Factors that should be considered:**
  - Precipitation Rate (PR = average amount of water applied per hour)
    - Type of irrigation device (sprays, rotors, drip, etc.)
    - Arc pattern for rotors
  - Distribution Uniformity (DU = factor for delivery uniformly)
    - Sprinkler spacing
    - Sprinkler operating pressure
    - Sprinkler obstructions (wind, alignment, etc.)
  - Soil Intake Rate (rate at which soil can intake water)
    - Slope (the more slope the lower the soil intake rate)
    - Cover vs. bare soil
    - Wetted vs. dry soil



Calculating Precipitation Rates

$$PR = \frac{96.3 \times gpm \text{ (applied to the area)}}{S \times L}$$

- PR = the average precipitation rate in inches per hour
- 96.3 = a constant which incorporates inches per square foot per hour
- gpm = the total gpm applied to the area by the sprinklers
- S = the spacing between sprinklers
- L = the spacing between rows of sprinklers

$$\left(PR = \frac{1000 \times m^3/h \text{ [applied to the area]}}{S \times L} \right)$$

- PR = the average precipitation rate in millimeters per hour
- 1000 = a constant which converts meters to millimeters
- m^3/h = the total m^3/h applied to the area by the sprinklers
- S = the spacing between sprinklers
- L = the spacing between rows of sprinklers

U12 Series

23° Trajectory

Nozzle	Pressure psi	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
U-12F	15	9	1.80	2.14	2.47
	20	10	2.10	2.02	2.34
	25	11	2.40	1.91	2.21
	30	12	2.60	1.74	2.01
U-12TQ	15	9	1.35	2.14	2.47
	20	10	1.58	2.02	2.34
	25	11	1.80	1.91	2.21
	30	12	1.95	1.74	2.01
U-12TT	15	9	1.20	2.14	2.47
	20	10	1.40	2.02	2.34
	25	11	1.60	1.91	2.21
	30	12	1.74	1.74	2.01
U-12H	15	9	0.90	2.14	2.47
	20	10	1.05	2.02	2.34
	25	11	1.20	1.91	2.21
	30	12	1.30	1.74	2.01
U-12T	15	9	0.60	2.14	2.47
	20	10	0.70	2.02	2.34
	25	11	0.80	1.91	2.21
	30	12	0.87	1.74	2.01
U-12Q	15	9	0.45	2.14	2.47
	20	10	0.53	2.02	2.34
	25	11	0.60	1.91	2.21
	30	12	0.65	1.74	2.01

Note: *All U-Series nozzles tested on 4" (10.2 cm) pop-ups*

■ *Square spacing based on 50% diameter of throw*

▲ *Triangular spacing based on 50% diameter of throw*

Performance data taken in zero wind conditions

Radius refers to recommended product spacing. Actual radii along arc may vary

Calculating Station Run Times

$$OT = \frac{I \times 60}{PR \times DA}$$

OT = Circuit operating time in minutes per day
I = System irrigation requirement in inches (millimeters) per week in the "worst case" season
PR = Circuit precipitation rate in inches (millimeters) per hour
DA = Days available for irrigation per week
60 = Constant conversion factor of 60 min/h

- **The higher the PR the lower the run time and conversely, the lower the PR the higher the run time**

Distribution Uniformity (DU)

- Another factor that needs to be considered is how efficient the water is being distributed by the zones sprinklers or drip equipment
- DU is a factor used to adjust the run time to account for non-uniform distribution of irrigation water
- DU is be measured by conducting a catch can audit
- The lower the DU the higher the run time needs to be to deliver enough water to the area with the weakest coverage

Distribution Uniformity (DU)

Sprinkler Type	Excellent	Good	Poor
Rotary Sprinklers	80%	70%	55%
Spray Sprinklers	75%	65%	50%

Soil Intake Rate

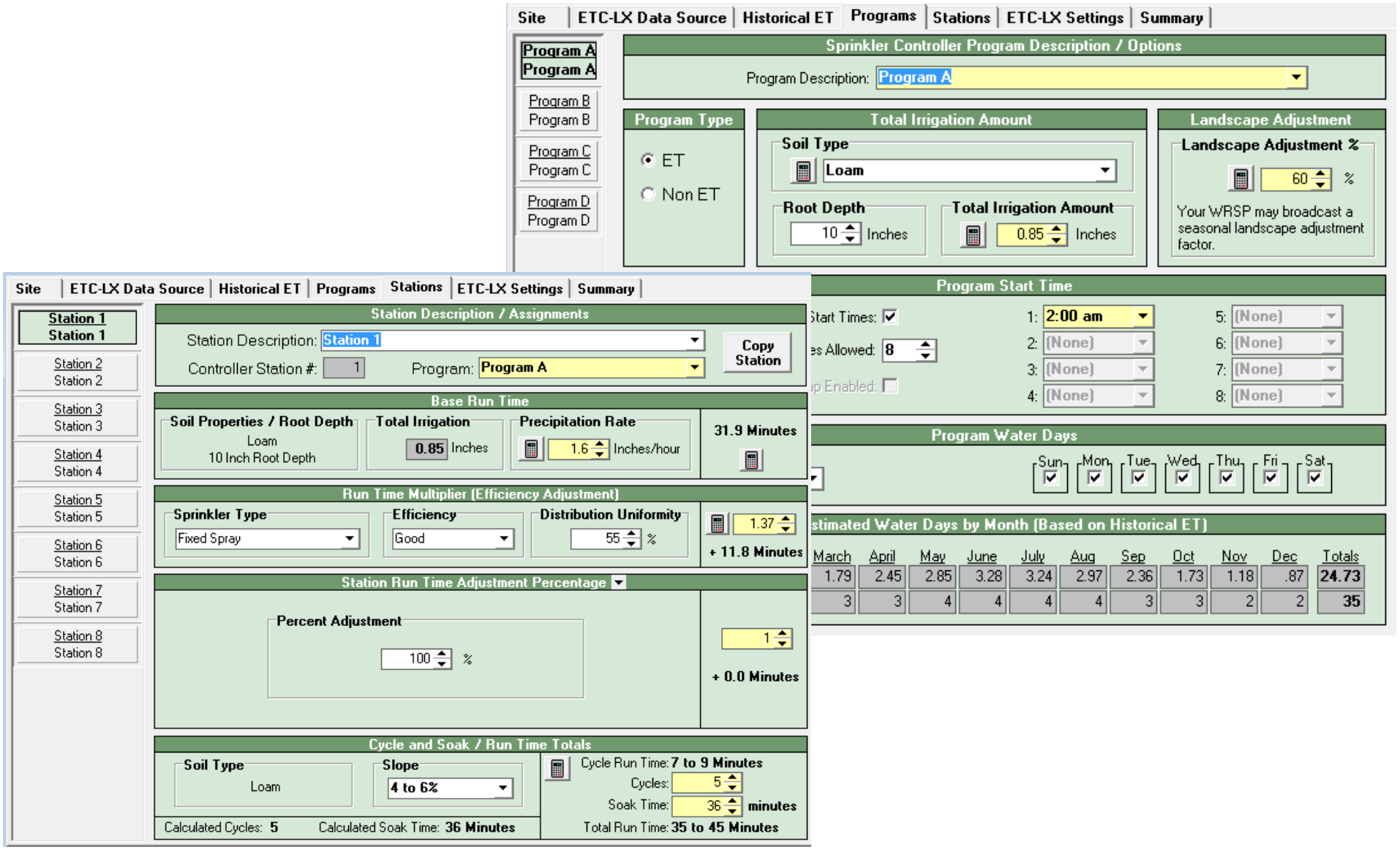
Soil Type	AW (in/in)	Intake Rate (in/hr)	MAD%
Clay	0.17”	0.10”	30%
Silty Clay	0.17”	0.15”	40%
Clay Loam	0.18”	0.20”	40%
Loam	0.17”	0.35”	50%
Sandy Loam	0.12”	0.40”	50%
Loamy Sand	0.08”	0.50”	50%
Sand	0.06”	0.60”	60%

Free MAD Calculator Tools

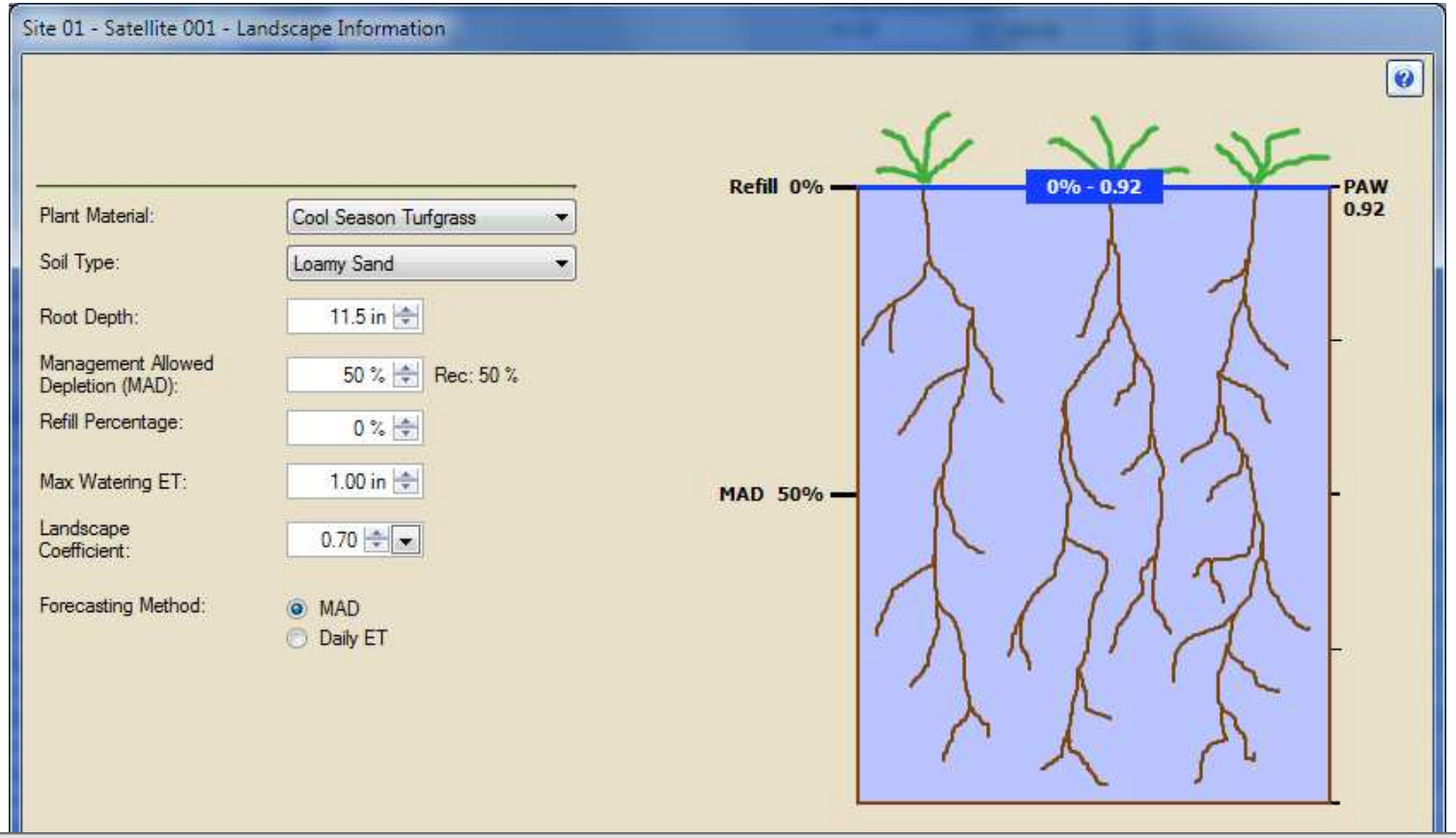
- **ET Manager Scheduler Software**
  - Download for free from the Rain Bird website
  - Calculates PAW, MAD, program frequency, station run times, Cycle+Soak times or multiple program start times
  - Printed report

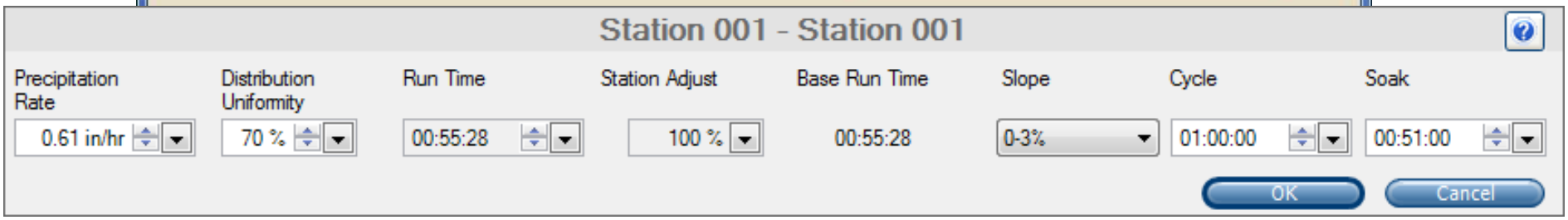
- **IQ Demo Central Control Software**
  - Ask your Rain Bird Salesman for a free copy
  - Calculates PAW, MAD, station run times, Cycle+Soak times
  - Calculates program frequency based on user entered ET (ET Checkbook)
  - Printed reports

ET Manager Scheduler Software



IQ Central Control Demo Software

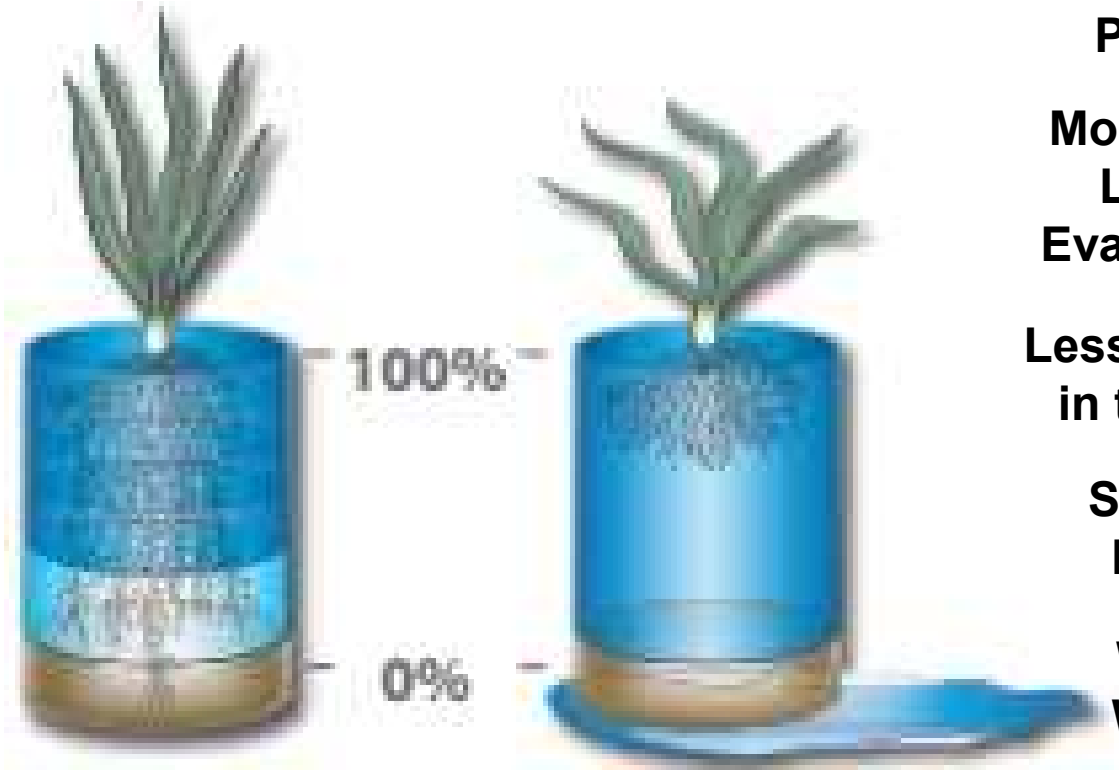




Advantages of MAD Irrigation Scheduling

- Irrigation amount (station run times) remains the same year-round; The number of days between irrigation applications changes with the ET/rainfall
- Irrigate less often; Irrigation equipment lasts longer
- Deeper watering promotes deeper plant root depth; Less root intrusion issues
- Less surface water; Less evaporation
- Deeper rooting depth increases PAW
- Increasing PAW promotes healthier, more drought tolerant plants

Irrigation Frequency

	Less Frequent Deep Watering	Frequent Light Watering	
Healthier Plants			Weaker Plants
Less Water Lost to Evaporation			More Water Lost to Evaporation
Water/Oxygen Mixture in Soil			Less Oxygen in the Soil
Deeper Roots			Shallow Roots
Water Savings			Water Waste

MAD Products & Features

- **Smart Controllers**
  - Automates the irrigation frequency and station run times based either on historical weather data, data from local sensors or a weather service
- **Central Control**
  - Automates the irrigation frequency and station run times based data from a weather service or weather station
- **Control Runoff**
  - Cycle+Soak controls irrigation runoff on tight soils and slopes
- **Control Watering Time Window**
  - Water Windows prevent irrigating during hours when the site is in use
- **Measure/Track Water Use**
  - Add flow sensing to monitor and log irrigation water use and automatically react to flow issues (broken pipes, failed valves, etc.)

Rain Bird MAD Control Products

Product	Type	ET Source	Connection
ESP-SMT	Smart Controller	Historical Weather & Local Sensors	Wired
ESP-LXME with ETC-LX	Smart Controller	Weather Service	Wireless
ESP-LXMEF with ETC-LX	Smart Controller	Weather Service	Wireless
ESP-LXD with ETC-LX	Smart Controller	Weather Service	Wireless
IQ	Central Control System	Weather Service or Station	Wired or Wireless
SiteControl	Central Control System	Weather Station	Wired or Wireless
Maxicom	Central Control System	Weather Station	Wired or Wireless

Rain Bird MAD Control Products

Product	Cycle +Soak	Flow Sensing	Water Windows	Valve Wiring	Max. Stations
ESP-SMT	Yes	No	Yes	Traditional	13 per Controller
ESP-LXME with ETC-LX	Yes	Optional	Yes	Traditional	48 per Controller
ESP-LXMEF with ETC-LX	Yes	Yes	Yes	Traditional	48 per Controller
ESP-LXD with ETC-LX	Yes	Yes	Yes	2-Wire	200 per Controller
IQ	Yes	Yes	Yes	Traditional & 2-Wire	Up to 30,000 per Site
SiteControl	Yes	Yes	Yes	Traditional & 2-Wire	Up to 21,504 per Site
Maxicom	Yes	Yes	Yes	Traditional	Up to 672 per Site

ESP-SMT Smart Controller

- **Residential/Light Commercial**
- **4 to 13 traditionally-wired stations**
- **Automatic MAD Adjustments**
- **Historical weather data & local temperature and tipping rain weather sensors**

* Available in North America only

ET Manager Smart Controller

- **Commercial**
- **ESP-LXME Traditionally-Wired 8 to 48 Stations**
- **ESP-LXD 2-Wire Decoder 50 to 200 stations**
- **Automated MAD Adjustments**
- **ET Manager Weather Reach Signal (wireless weather data from local weather station)**
- **Optional local tipping rain sensor**

* Available in North America only

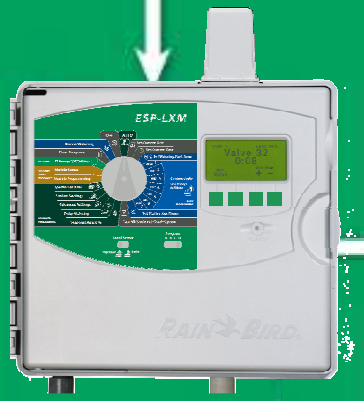
Weather Reach Signal Provider

Weather Station

Server/Software

Paging Service

Your Irrigation System



ESP-LXME or -LXD with ETC-LX

Any Irrigation System

IQ Central Control System

- **Commercial, Multi-Site**
- **ESP-LX Series Controllers & IQ-NCC Communication Cartridges**
  - GPRS/Cellular, Phone, Ethernet, Wi-Fi, Radio, & Cable Communication
- **Automated MAD Adjustments with IQ Advanced ET Feature Pack**
- **Weather Source Options:**
  - CIMIS2 (California), ETMi ET Manager (North America), WSPROLT & WSPRO2 Weather Stations

Maxicom^2 Central Control System

- **Commercial, Multi-Site**
- **CCU Cluster Control Units & ESP-SAT/-SITE Satellites**
  - Cellular, Phone, Ethernet, Wi-Fi, Radio, & Cable Communication
- **Automated MAD Adjustments using MIN-ET Feature**
- **WSPRO2 Weather Station**

SiteControl Central Control System

- **Commercial, Single-Site**
- **TWI/SDI/LDI Interfaces & ESP-SAT/-SITE Satellites**
  - Traditionally-Wired Satellite Controllers or 2-Wire Decoders
  - Radio & Cable Communication
- **Automated MAD Adjustments with Automatic ET Software Module and MIN-ET Feature**
- **WSPROLT & WSPRO2 Weather Stations**

Want Additional Training on MAD?

- **Irrigation Association Classes**
  - Advanced Irrigation Design for Water Conservation
  - Alternative Water for Landscape Irrigation
  - Irrigation System Installation & Maintenance
  - Landscape Drip Design, Maintenance & Scheduling
  - Predicting & Estimating Landscape Water Use
  - Principles of Irrigation: Landscape
  - Smart Technologies for Irrigation Management
  - Sprinkler System Scheduling
- **Irrigation Association Certifications**
  - Certified Irrigation Contractor (CIC)
  - Certified Irrigation Designer (CID)
  - Certified Landscape Irrigation Auditor (CLIA)
  - Certified Landscape Water Manager (CLWM)

Questions?

The Intelligent Use of Water.™

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