IWM – 1. - Planning for Irrigation Water Management

The Natural Resources Conservation Service provides technical assistance in planning and designing irrigation systems with landowners. This planning process includes the following steps:

- 1. Identify resources of concern, 2. Determine irrigator objectives, 3. Inventory resources, 4. Analyze resource data,

  5. Formulate irrigation alternatives, 6. Evaluate alternatives, 7. Document decisions, 8. Water user implements irrigation plan, 9. Follow-up.

CONSIDERATIONS FOR PLANNING AN IRRIGATION SYSTEM

Some of the major items to consider in planning an on-farm irrigation system are:

- Water Quantity Available – How much water is available for irrigation and when is it available?
- Water Quantity Needed – Is there adequate water available to meet the demand of the crops to be grown while considering the irrigation efficiency?
- Water Quality – Is the salinity, pH and mineral content of the water compatible with the planned crops and irrigation method?
- Irrigation Method – Is the proposed irrigation method compatible for the crop to be grown?
- Soil Type – Is the proposed irrigation method compatible with the soil type, in terms of infiltration rate, water holding capacity, and stratification that may exist in the soil profile?

On lands used primarily for field and forage crop production, orchards, and ornamental crops, the producer's inputs and management practices may have a significant impact on the current and future conditions of Soil, Water, Air, Plant, Animal and Human (SWAPA + H). As well as soils, rainfall and other natural resource information, cropland inventory needs to include a description of current crops, crop rotations, tillage operations, nutrient and pest management inputs, livestock numbers and class, available equipment, and the timing and management of other important activities. The best source for this information is the client and is best collected when the client and the planner work together on-site in the planning area (field, tract or farm). A successful inventory process will "set the stage" for planning steps 4. Analyze Resource Data, 5. Formulate Alternatives, 6. Evaluate Alternatives, and 7. Make Decisions. The overall Cropland Inventory Worksheets (Agronomy Tech Note 70, http://www.nm.nrcs.usda.gov/technical/tech-notes/agro/ag70.doc) and the IWM Inventory (in the following section) can be used.

(IWM – 2) IWM Resource Inventory

Producer: ____________________________
Crop: _______________________________
Variety: _____________________________
Crop Rotations: _______________________
Predominant Soil(s): _________________
Soil Texture: _________________________
Acres: _______________________________
Field width (ft.) x Field length (ft.) ÷ 43,560 =
_____________________Acres
Irrigation System Type and Delivery System (concrete ditch, pipe, surface, sprinkler, drip, etc.):
____
Irrigation Application Efficiency: ______ %

Field #: ______________________________
Planting Date: ________________________
Seeding Rate: _________________________
Row Spacing: __________________________
Soil Structure (e.g., granular, blocky, platy, etc.)
____
Soil Intake Family: ____________________
Soil Moisture Monitoring (Type):_______________________________
Source of irrigation water (canal, well, spring, other): _______________________
Water Quality (ECiw & SAR):
____

IWM Evaluation Date: ________________
Harvest date(s): _______________________
Yield: ___________________________________
Quality: _________________________________
Soil Drainage (Rapid, Moderate and Slow):
____
Number of Irrigations/yr.: _____________
Average time (hrs)/irrigation: __________
Net application depth (in.): ____________
Total Water Applied to Crop: __________
When is irrigation water available (e.g., on demand, fixed schedule, rotation, pumped etc.):
____

Sprinkler System Description:

Mainline Size (in)		**Revolution/ Set Time / Speed of Gun (hr)**	
Lateral Spacing (ft)		**Operating Pressure of Line (psi)**	
Sprinkler Head Spacing (ft)		**Pressure Regulator Rating (Y or N)**	
Nozzle Size (in)		**Nozzle output (gpm)**	

Surface System:

Length of field(s) (ft)		**Grade at end of field (Circle one)**	**Flat Moderate Steep**
Furrow/Border Spacing		**System Type**	**Siphon tubes Gated pipe High flow turnouts**
% slope of land		**Delivery System (type and condition)**	
Turnout (cfs)			

Subsurface Drip:

Depth of Tubing (in)		**Inch per day application rate (in/day)**	
Emitter Size (gal/hr)		**Design Efficiency (%)**	
Emitter Spacing (in)		**Type of filtration (explain)**	

Record Field Observations such as runoff, water-induced soil erosion, deep percolation, shallow water table, soil stratification, clay lenses, shallow soils over coarse sand/cobbles/rocks, tail water, ponding, crusting, surface sealing, steep slopes, compaction, salt crust, etc.: ____

(IWM – 3) Soils Data Interpretation Table for IWM Planning

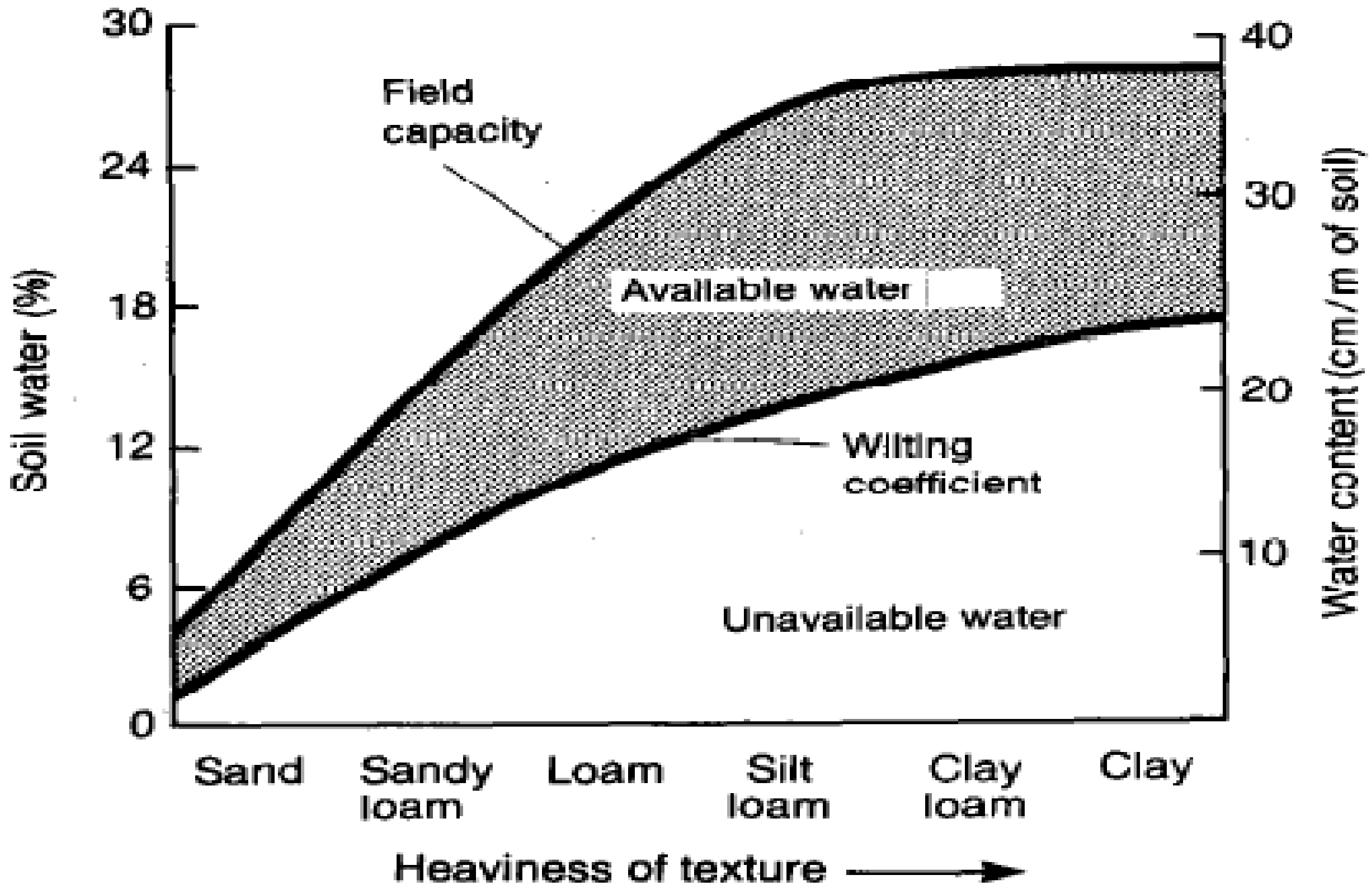
Soil Texture	% Sand	% Silt	% Clay	CEC Range (meq/100g)	Bulk Density (g/cm^3)	Soil weight (Million lbs. per ac-ft)	Soil Solids		Unavail-able Water		Available Water		Soil Porosity at FC	
							% Vol.	in/ft	% Vol.	in/ft	% Vol.	in/ft	% Vol.	in/ft
Sands	86 - 98	2 - 14	2 - 8	2 – 6	1.65	4.48	62.3	7.47	2.5	0.3	4.17	0.5	31.1	3.73
Loamy Sands	72 - 88	2 - 28	2 - 14		1.6	4.35	60.4	7.25	7.0	0.84	8.33	1.0	24.3	2.91
Fine Sands	86 - 98	2 - 14	2 - 8		1.65	4.48	61.5	7.38	10.2	1.22	10.4	1.25	17.9	2.15
V. F. Sands	86 - 98	2 - 14	2 - 8		1.65	4.48								
Loamy F. Sands	72 - 88	2 - 28	2 - 14		1.6	4.35								
Loamy V. F. Sands	72 - 88	2 - 28	2 - 14		1.6	4.35								
Sandy Loam	46 - 84	2 - 48	2- 18	3 – 8	1.56	4.24	58.8	7.06	12.3	1.48	12.5	1.5	16.3	1.96
Fine Sandy Loam	46 - 84	2 - 48	2 - 18		1.56	4.24								
V. F. Sandy Loam	46 - 84	2 - 48	2 - 18		1.53	4.16	55.4	6.65	16.2	1.94	16.7	2.0	11.8	1.41
Loam	26 - 50	30 - 48	10 - 26	7 – 15	1.42	3.86								
Silt Loam	2 - 48	52 - 78	2 - 26	10 –19	1.46	3.97								
Silt	2 - 18	82 - 98	2 - 10		1.47	3.99								
Sandy Clay Loam	46 - 78	2 - 26	22 - 36		1.4	3.8	50.2	6.02	20.0	2.4	18.3	2.2	11.5	1.38
Silty Clay Loam	2 - 18	42 - 70	28 - 38		1.27	3.45								
Clay Loam	22- 44	18 - 50	28 - 38		1.32	3.59								
Sandy Clay	46 - 62	2 - 16	38 - 54		1.33	3.61	47.9	5.75	21.5	2.58	16.7	2.0	13.9	1.67
Silty Clay	2 - 18	42 - 58	42 - 58		1.23	3.34								
Clay	2 - 44	2 - 38	42 - 98	15 - 30	1.25	3.4								

- V = Very & F = Fine
- Particle diameter (mm) for Sand, Silt & Clay: Very Coarse Sand (2.0 - 1.0), Coarse Sand (1.0 - 0.5), Med. Sand (0.5 - 0.25), Fine Sand (0.25 - 0.1), Very Fine Sand (0.1 - 0.05), Silt (0.05 - 0.002) and Clay (< 0.002)
- Cation Exchange Capacity (CEC) taken from the Western Fertilizer Handbook, 2nd ED., 1995
- Bulk Density (Ref. bulk density calculator @ Pedosphere.com)
- Unavailable Water (Ref. Figure 1-9 of the National Engineering Handbook; Section 15 – Irrigation)
- Available Water (Ref. NRCS Salinity Management for Soil & Water; Table 5.1, page 5.10)
- FC = Field Capacity.

NOTE: Soil structure is evaluated for its effect on downward movement of water: Single grain (rapid), Granular (rapid), Blocky (moderate), Prismatic (moderate), Platy (slow) and Massive (slow). The Soil Intake Family (typically 0.1 thru 2.0) is used in IWM field evaluations and irrigation system design. Irrigation Water Quality (i.e., Electrical Conductivity of irrigation water (ECiw) in dS/m & Sodium Adsorption Ratio (SAR)) is evaluated for its potential detrimental effects on plant moisture availability and water infiltration. rudy garcia 2008

Figure 1-9. (IWM – 5)

General Relationship Between Soil Water Characteristics and Texture



(IWM – 6) *IRRIGATION Water Requirement Guide (calculated at 50% Maximum Allowable Depletion (MAD) in the upper root zone)

Soil Textural Class		AWC (in./ft.)	0 – 12 inch depth (Shallow Roots)			0 – 24 inch depth (Medium Roots)			0 – 36 inch depth (Deep Roots)		
			% Leaching Fraction (LF)								
			10	20	30	10	20	30	10	20	
			Inches of Water needed at the time of Irrigation								
Coarse Texture	Sands	0.5	0.17	0.19	0.2	0.34	0.38	0.41	0.52	0.56	0.61
	Loamy Sands	1.0	0.34	0.38	0.41	0.69	0.75	0.81	1.03	1.13	1.22
	Fine Sands V. F. Sands Loamy F. Sands Loamy V. F. Sands	1.25	0.43	0.47	0.51	0.86	0.94	1.02	1.29	1.41	1.52
Mod. Coarse Texture	Sandy Loam Fine Sandy Loam	1.5	0.52	0.56	0.61	1.03	1.13	1.22	1.55	1.69	1.83
Medium Texture	V. F. Sandy Loam Loam Silt Loam Silt	2.0	0.69	0.75	0.81	**1.38**	1.5	1.63	2.06	2.25	2.44
Mod. Fine Texture	Sandy Clay Loam Silty Clay Loam Clay Loam	2.2	0.76	0.83	0.90	1.51	1.65	1.79	2.27	2.48	2.68
Fine Texture	Sandy Clay Silty Clay Clay	2.0	0.69	0.75	0.81	1.38	1.5	1.63	2.06	2.25	2.44

Example Calculation of Irrigation Water Requirement:

- Soil: Silt Loam
- AWC = 2.0 in./ft.
- Root Zone: 0 – 24"
- LF = 10%
- MAD = 50% at 0 – 6" depth

Root Zone Depth:	% of Total Soil Moisture Used:	Inches Used:
0 – 6"	40	0.5
6 – 12"	30	0.375
12 – 18"	20	0.25
18 – 24"	10	0.125

Total Soil Moisture depleted at irrigation = 1.25 in.

1.25" x 0.10 = 0.125" (LF)
Total Irrigation needed:
1.25" + 0.125" = **1.38"**

*Calculated values were based on the following Crop Root soil moisture extraction patterns (i.e., % of total soil moisture extracted at given depths) for the following root zones:

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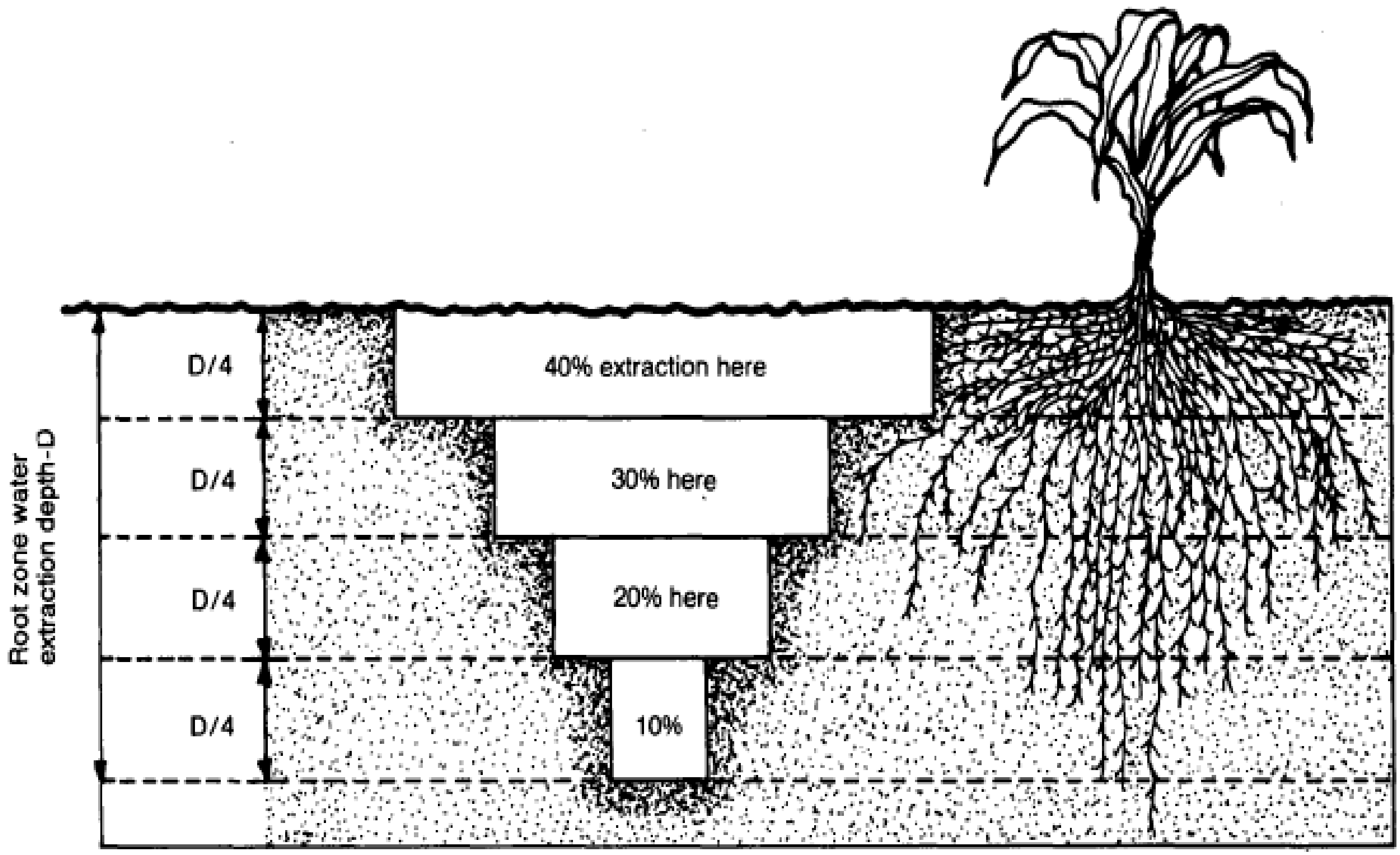
1 ft. depth	2 ft. depth	3 ft. depth
40% at 0 - 3" 30% at 3 - 6" 20% at 6 - 9" 10% at 9 - 12"	40% at 0 - 6" 30% at 6 - 12" 20% at 12 - 18" 10% at 18 - 24"	40% at 0 - 9" 30% at 9 - 18" 20% at 18 - 27" 10% at 27 - 36"

NOTE: Site-specific data is needed to estimate actual irrigation water requirements; therefore, this TABLE should be used as a GUIDE.

AWC = Available Water-Holding Capacity

Figure 1-20. **(IWM – 7)**

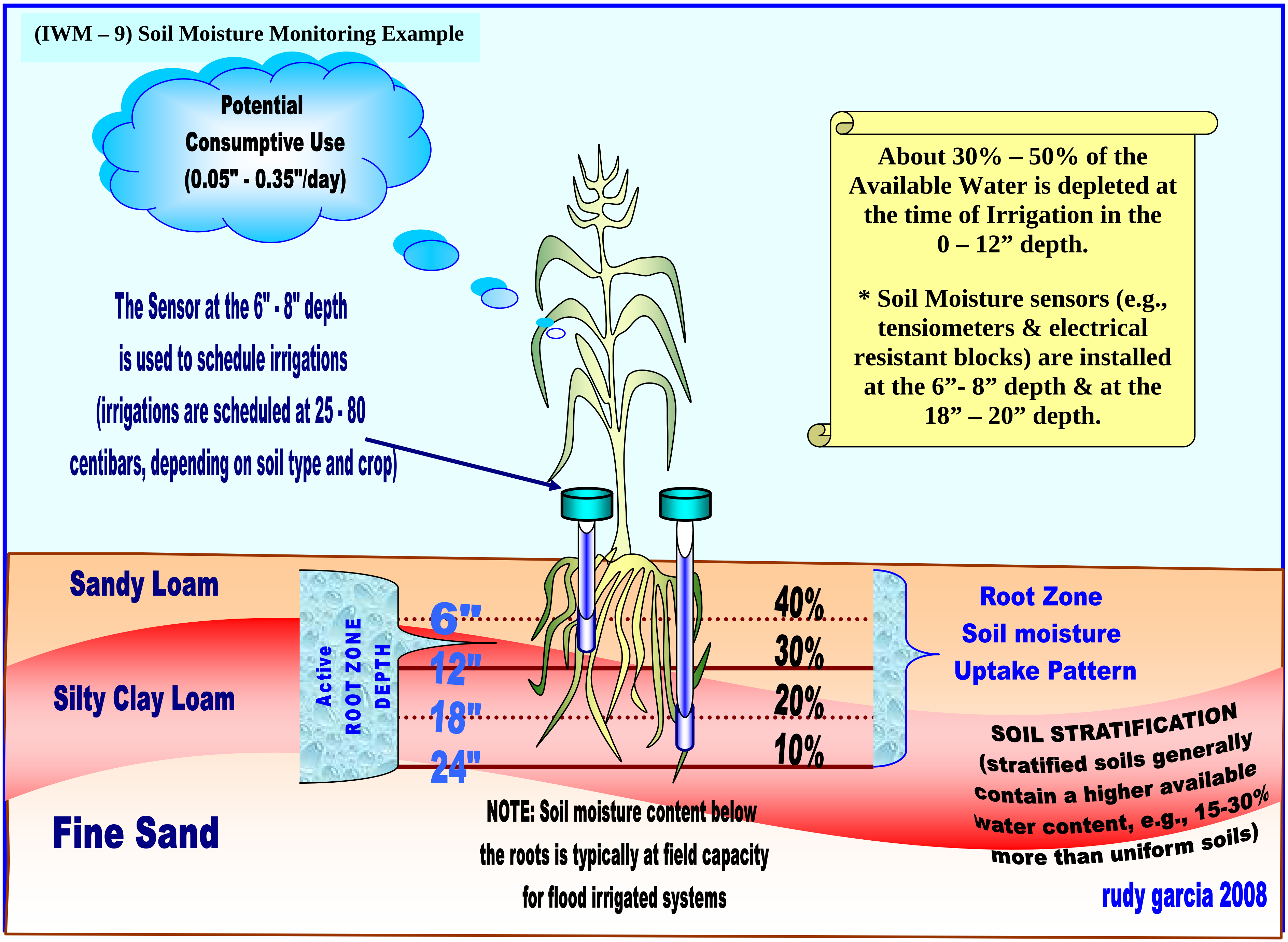
Average Water Extraction Pattern of Plants Growing in a Soil Without Restrictive Layers and With an Adequate Supply of Available Water Throughout the Root Zone



(IWM – 8) Gross Crop Irrigation Water Requirement GUIDE

	Steps to Calculate the Crop Irrigation Water Requirement	Enter Results	Example Calculation (Alfalfa)	Results	NM IWM Manual References & Notes:
STEP 1	Fc = ECe(ct)/ECiw Fc = Ratio of the Crop Threshold Salinity ($ECe_{(ct)}$) to the Electrical Conductivity of irrigation water (ECiw). Units: dS/m		Fc = 2.0/1.0 = Alfalfa ECe(ct) = 2.0 dS/m ECiw = 1.0 dS/m	2.0	➢ Crop Salt Tolerance Table for NM ➢ Irrigation Water Quality Sampling
STEP 2	$LF = 0.3086/Fc^{1.702}$ LF = Leaching Fraction (for conventional irrigation; e.g. surface irrigation).		LF = $LF = 0.3086/2.0^{1.702}$ LF = 0.3086/3.254	0.095	➢ Salinity Assessment GUIDE for Selected Crops
STEP 3	NIR = ETc/(1 – LF) NIR = Net Irrigation Requirement (in.) ETc = Crop Evapotranspiration (in.)		NIR = NIR = 40.01/(1 – 0.095) NIR = 40.01/0.905 ETc = 40.01 inches for Alfalfa	44.21”	➢ NM Crop Consumptive Use Requirements (NRCS FOTG – Section 1: Irrigation Guide for NM)
STEP 4	Ea = Irrigation needed (in.) ÷ Irrigation applied (in.) Ea = Irrigation Application Efficiency		Ea = Ea = 2.06/2.5 2.06” (Irr. needed) ÷ 2.5” (Irr. applied) <u>Irr. applied:</u> 7.5 (cfs) x 2.0 (hrs.) ÷ 6.0 (acres) = 2.5” applied.	0.824 (82.4%)	➢ Irrigation Water Req. Guide (e.g. 3’ root zone & Silt Loam soil @ 10% LF = 2.06” needed) ➢ QT = DA Calculations for Assessing IWM Requirements
STEP 5	Fg = NIR/Ea Fg = Gross Irrigation Application needed		Fg = Fg = 44.21/0.824	53.7”	➢ The calculation of Fg is used in the Planning & Design of Irrigation Systems and the development of IWM Plans
STEP 6	(# Irr. /yr.) x (in. applied/Irr.) = Total in. applied/ac./yr. (Note: in. applied/Irr. is based on an avg.)		13 Irrigations x avg. of 2.5”/Irr. = (e.g., Irrigated field approximately every 2-wks on a fixed schedule (Apr. – Oct.)	32.5”	➢ Amount of Irr. Water applied can differ substantially from the planned Gross Irrigation application needed
STEP 7	Fg – (Total in. applied/ac./yr.) = (Note: evaluate reason(s) for the difference between Fg & Total in. applied/ac./yr.)		53.7” (Fg) – 32.5” (Total in. applied/ac./yr.) =	21.2”	➢ In this example, it is clear that consumptive use is not being met.

ECe(ct) is taken from a soil saturation extract & the ECiw value is taken from a water test (EC units: dS/m = mmhos/cm = mS/cm).	The LF equation used for High Frequency Irrigation is: $LF = 0.1794/Fc^{3.0417}$ (e.g. Drip irrigation) rudy garcia 2008


(IWM – 9) Soil Moisture Monitoring Example
Potential Consumptive Use (0.05" - 0.35"/day)
About 30% – 50% of the Available Water is depleted at the time of Irrigation in the 0 – 12” depth.
* Soil Moisture sensors (e.g., tensiometers & electrical resistant blocks) are installed at the 6”- 8” depth & at the 18” – 20” depth.
The Sensor at the 6" - 8" depth is used to schedule irrigations (irrigations are scheduled at 25 - 80 centibars, depending on soil type and crop)
Sandy Loam
Silty Clay Loam
Fine Sand
Active ROOT ZONE DEPTH
6"
12"
18"
24"
40%
30%
20%
10%
Root Zone Soil moisture Uptake Pattern
SOIL STRATIFICATION (stratified soils generally contain a higher available water content, e.g., 15-30% more than uniform soils)
NOTE: Soil moisture content below the roots is typically at field capacity for flood irrigated systems
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(IWM – 10 a)

Appearance of fine sand and loamy fine sand soils at various soil moisture conditions.

25-50 percent available
0.9-0.3 in./ft. depleted

Slightly moist, forms a very weak ball with well-defined finger mark

50-75 percent available
0.6-0.2 in./ft. depleted

Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.

75-100 percent available
0.3-0.0 in./ft. depleted

Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon

Appearance of sandy loam and fine sandy loam soils at various soil moisture conditions.

25-50 percent available
1.3-0.7 in/ft. depleted

Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers, grains break away.

50-75 percent available
0.9-0.3 in./ft. depleted

Moist, forms a ball with defined finger marks, very light soil/water staining on fmgers, darkened color, will not slick.

75-100 percent available
0.4-0.0 in./ft. depleted

Wet, forms a ball with wet outline left on hand, light to medium staining on fingers, makes a weak ribbon between the thumb and forefinger.

(IWM – 10 b)

Appearance of sandy clay loam, loam, and silt loam soils at various soil moisture conditions.

25-50 percent available
1.6-0.8 in./ft. depleted

Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.

50-75 percent available
1.1-0.4 in./ft. depleted

Moist, forms a ball, very light staining on fingers, darkened color, pliable, forms a weak ribbon between the thumb and forefinger.

75-100 percent available
0.5-0.0 in/ft. depleted

Wet, forms a ball with well-defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.

Appearance of clay, clay loam, and silt clay loam soils at various soil moisture conditions.

25-50 percent available
1.8-0.8 in/ft. depleted

Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.

50 - 75 percent available
1.2-0.4 in./ft. depleted

Moist, forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger.

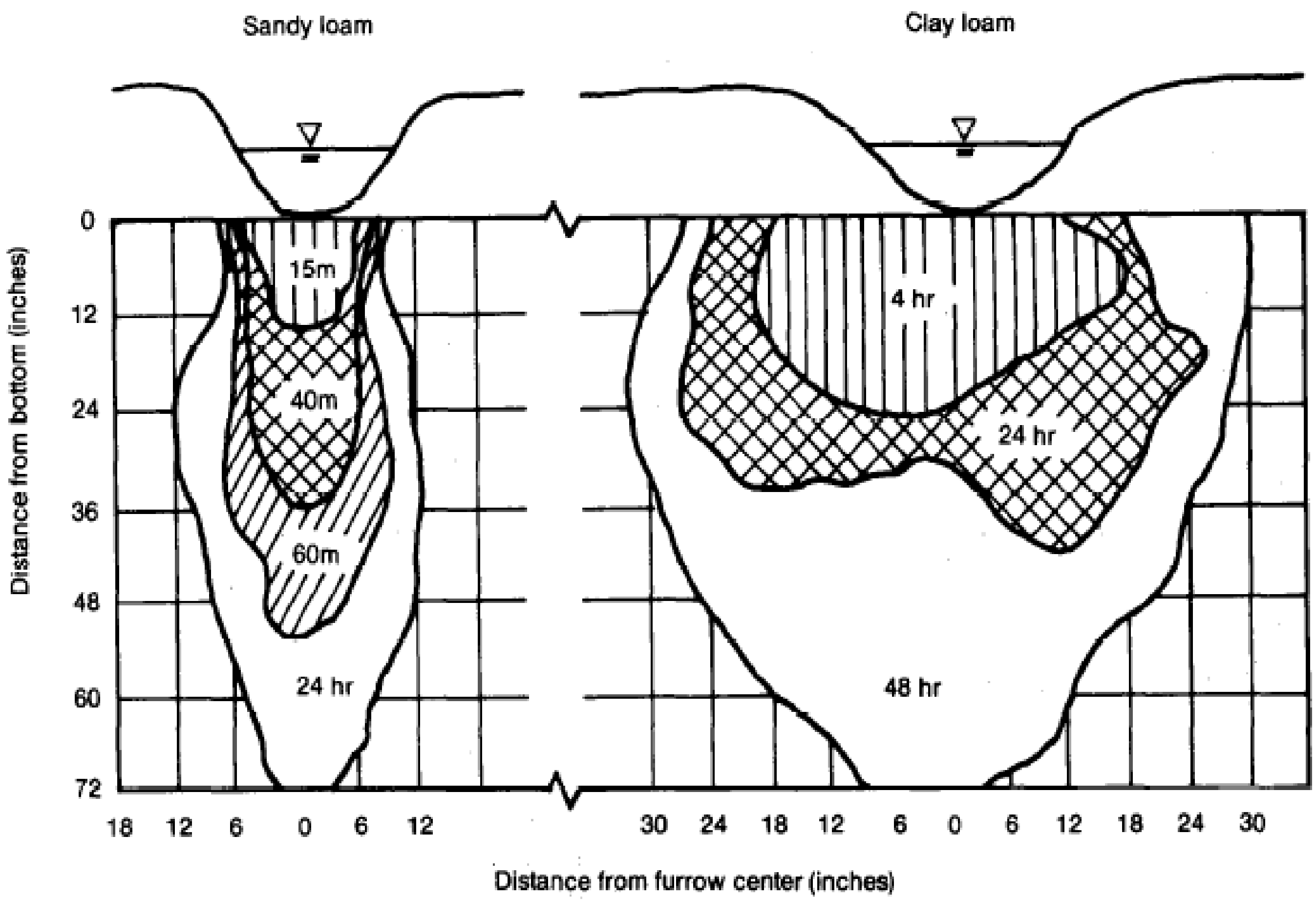
75-100 percent available
0.6-0.0 in./ft. depleted

Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger.

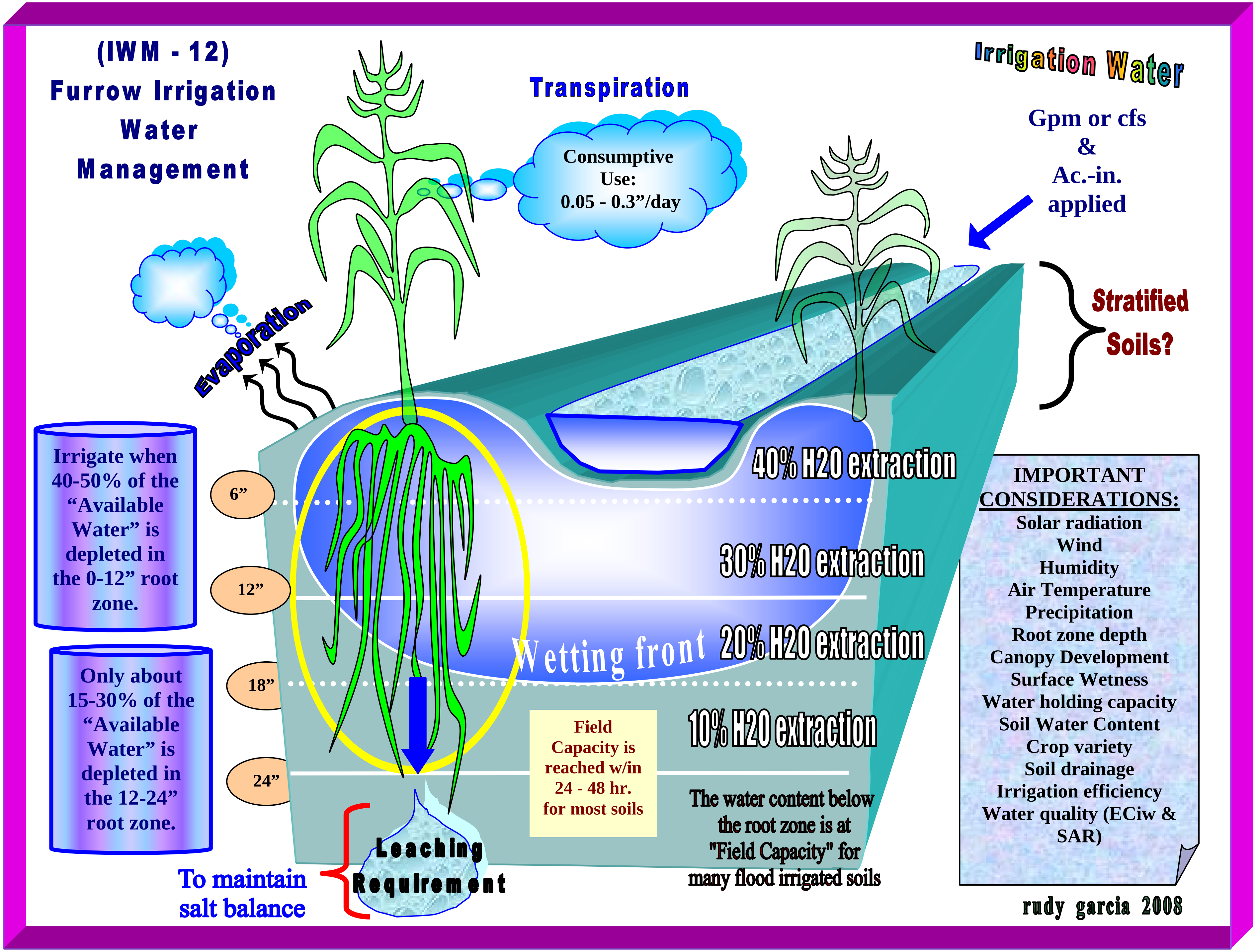
Source: USDA-NRCS, April 1988, Estimating Soil Moisture by Feel and Appearance, ftp://ftp-fc.sc.egov.usda.gov/MT/www/technical/soilmoist.pdf

Figure 1-7. **(IWM -11)**

Water Penetration and Movement in Sandy and Clay Loam Soils; to Achieve Complete Wetting, Furrows Have to be Closer Together on Sandy Soils.



Source: USDA-NRCS National Engineering Handbook, 15-1, Dec. 1991, http://www.info.usda.gov/CED/ftp/CED/neh15-01.pdf


(IWM - 12)
Furrow Irrigation
Water
Management
Transpiration
Consumptive Use: 0.05 - 0.3"/day
Irrigation Water
Gpm or cfs
&
Ac.-in.
applied
Evaporation
Stratified Soils?
Irrigate when 40-50% of the "Available Water" is depleted in the 0-12" root zone.
Only about 15-30% of the "Available Water" is depleted in the 12-24" root zone.
6"
12"
18"
24"
40% H20 extraction
30% H20 extraction
20% H20 extraction
10% H20 extraction
Wetting front
Field Capacity is reached w/in 24 - 48 hr. for most soils
The water content below the root zone is at "Field Capacity" for many flood irrigated soils
Leaching Requirement
To maintain salt balance
IMPORTANT CONSIDERATIONS:
Solar radiation
Wind
Humidity
Air Temperature
Precipitation
Root zone depth
Canopy Development
Surface Wetness
Water holding capacity
Soil Water Content
Crop variety
Soil drainage
Irrigation efficiency
Water quality (ECiw & SAR)
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Tensiometers and Electrical Resistance Blocks

Background. **Electrical Resistance Blocks (ERB) and Tensiometers haves stood the test of time for accuracy, simplicity, and reliability as real-time methods to determine soil moisture.**

The first generation ERB is perhaps better known as the gypsum block. This device, while able to measure soil tension up to about 200 centibars (cb), tends to dissolve in the soil and thus lose accuracy. A more recent ERB, also know as a granular matrix sensor, is also calibrated to give soil moisture meter readings in cb's. It has proven itself to maintain calibration for extended periods of time. The ERB is set at the depth in the soil where the moisture level is to be measured.

Tensiometers from the various manufacturers' measure soil moisture tension with a vacuum gauge. A ceramic-tipped probe is set at the depth where the moisture measurement is desired.

Installation. **As with the ERB, tensiometers are generally placed at several depths within the root zone in order to get a more accurate understanding of irrigation requirements. Each manufacturer has specific guidelines to prepare the moisture measuring devices for installation, the actual installation process, and sensor maintenance. Once the devices are prepared for installation, the location and depth of the sensor needs to be determined.** **(See example on next page.)**

1. **Location of the sensors in the field mainly depends upon the type of irrigation, the size of the field, the variability of the soil, and the depth of the soil. They should be placed so as to represent the crop and soil in the locale in which they are located. They should also be located where they are accessible for reading and out of harms way, particularly from farm equipment.**
2. **Sensors should be placed at different depths at a location to reflect the root zone of the crop being grown. Usually two and sometimes three sensors are needed to properly monitor soil moisture in the root zone.**
3. **A hole for the sensor can be prepared with a rod the same diameter as the sensor, driven into the ground. A preferred method is to extract a soil core of approximately the same diameter as the sensor. This method precludes-compaction of the soil immediately surrounding the probe and thus provides a more representative reading.**
4. **The sensors must be "seated" in the profile. This is accomplished with a slurry made from the soil removed from the hole, and placed in the hole with the probe.**

Soil moisture measurement is the key to Irrigation Water Management.

Figure 1-12.

Tensiometers Are Used to Measure Soil Water

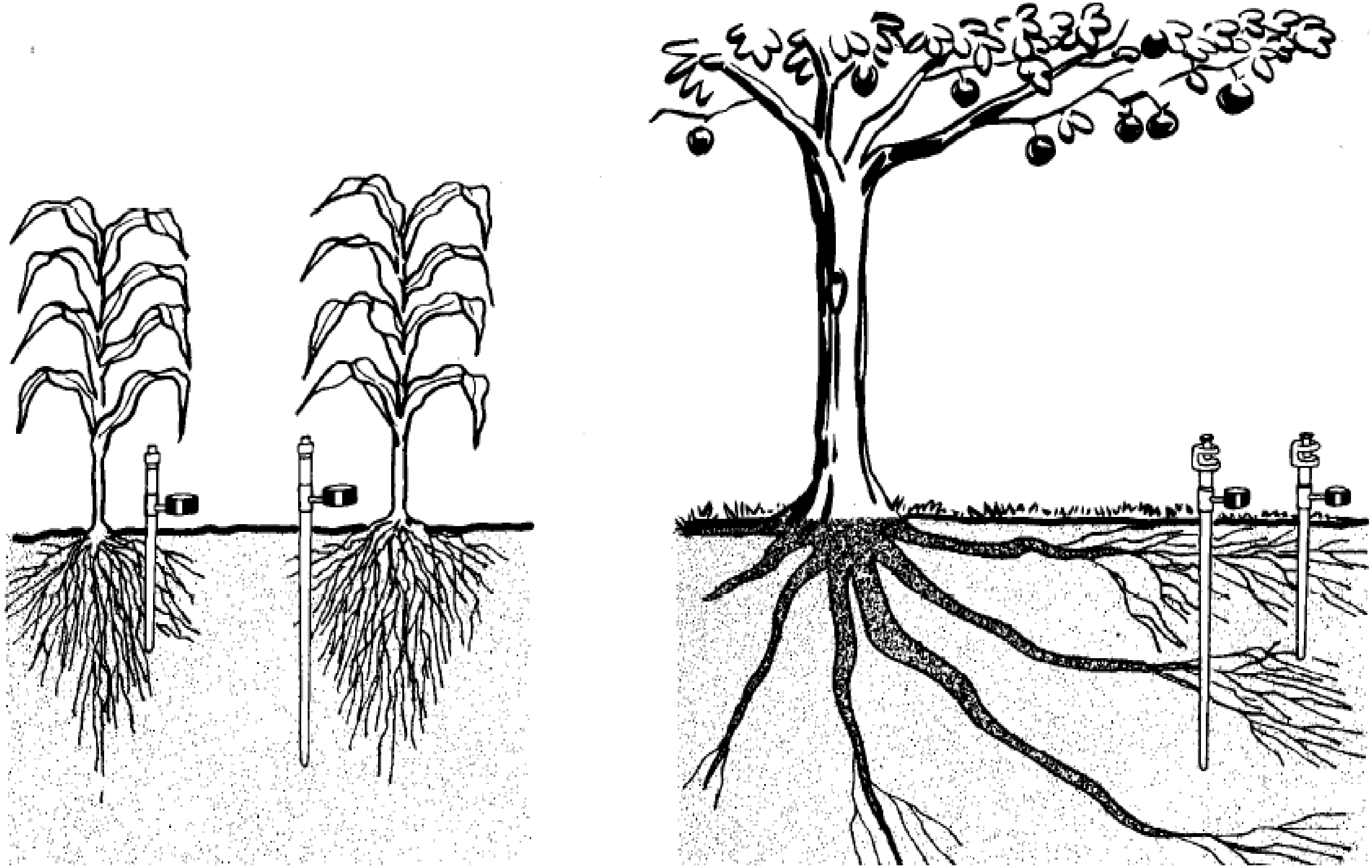
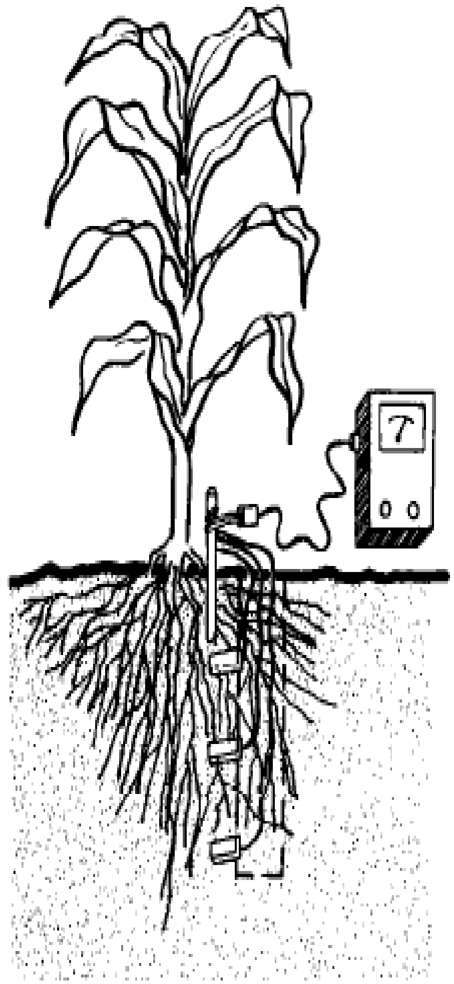
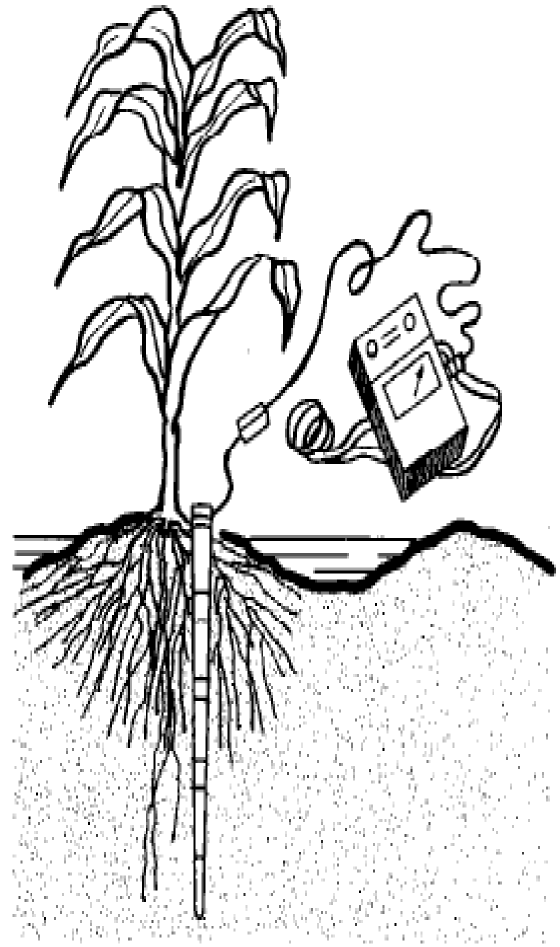


Figure 1-13.

Electrical Resistance Soil Water Meters





(IWM – 14) Soil Moisture Monitoring and Irrigation Record keeping Form

Important: Monitoring the rate of change of the soil moisture tension, is just as important as the actual reading used to schedule the irrigation.	**Coarse:** Sands, f. sands, very f. sands, Loamy sands, Loamy f. sands & Loamy very fine sands	**Moderately Coarse:** Sandy loam fine Sandy loam	**Medium:** v. f. Sandy loam Loam Silt loam Silt	**Moderately Fine:** Sandy clay loam Silty clay loam Clay loam	**Fine:** Sandy clay Silty clay Clay
	***Approximate** Soil Moisture Sensor readings at the time of Irrigation (Units: centibars - cb) (NOTE: Irrigation scheduling is typically based on sensor readings in the 6” – 9” root zone depth)				
	30 – 40 cb	**40 – 50 cb**	**50 – 60 cb**	**60 – 70 cb**	**70 – 80 cb**
	Enter the date of Irrigation and the sensor reading (read at least once a week)				
April					
May					
June					
July					
August					
September					
October					

*** i.e., For Tensiometers & Electrical Resistance Blocks or other type of soil moisture sensors.**

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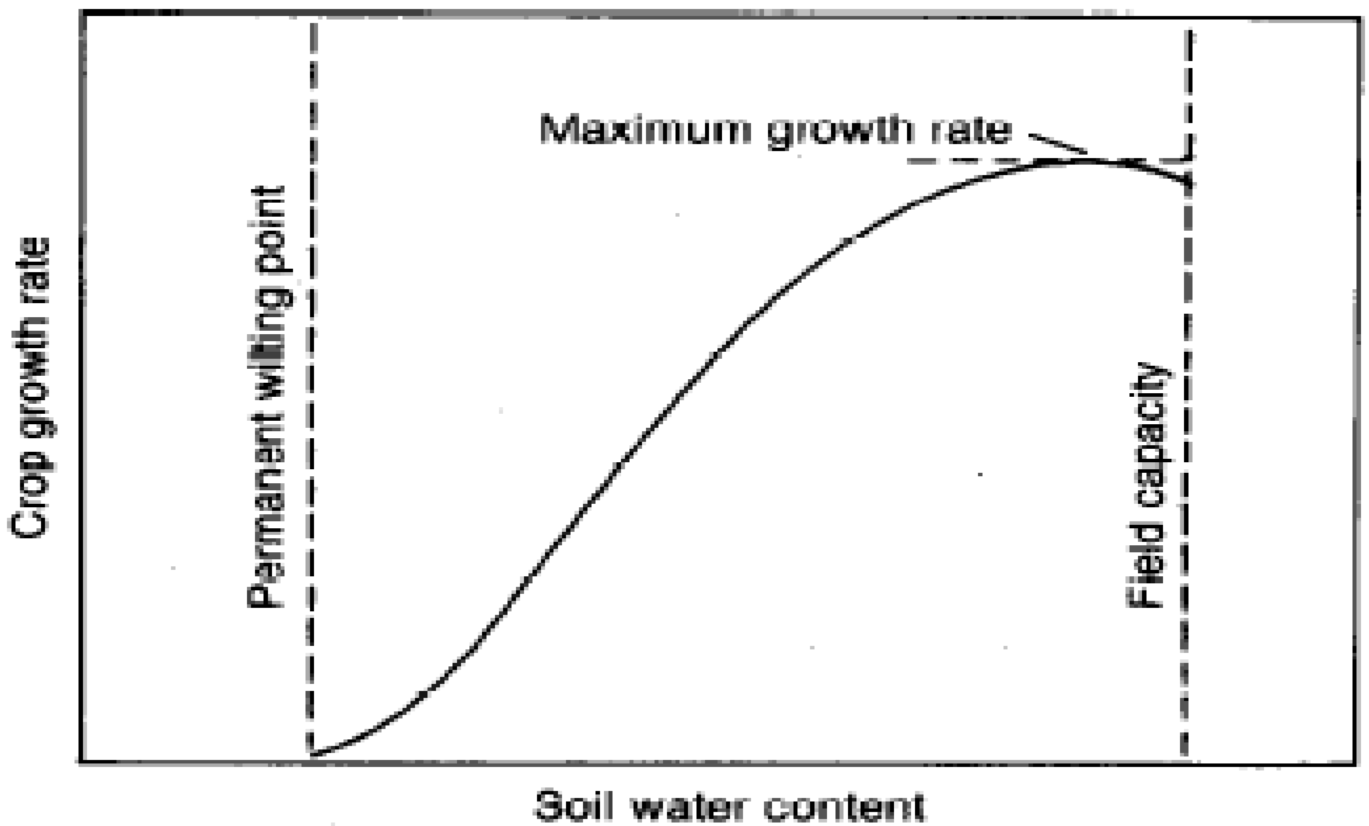
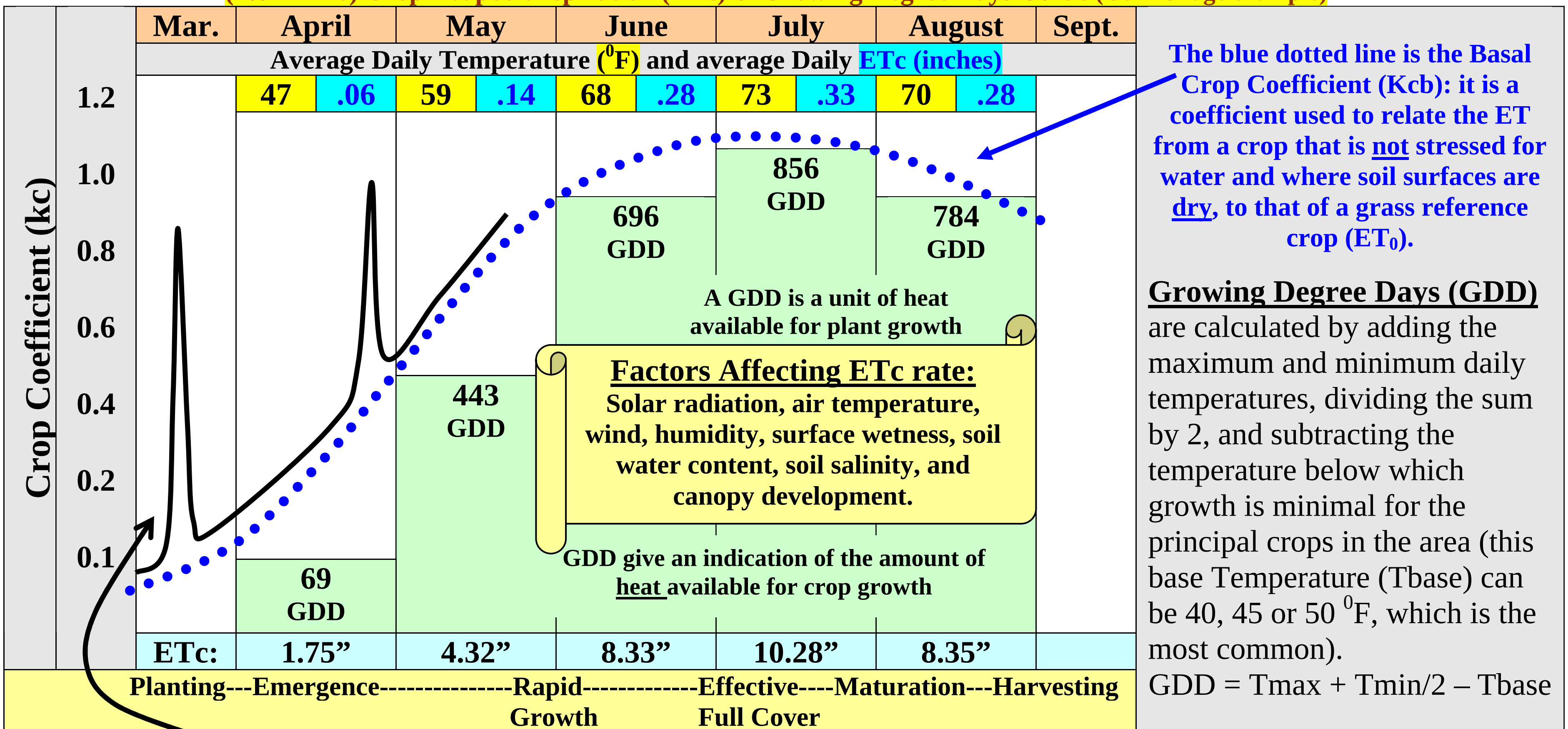
Figure 1-31. **(IWM – 15)**

Generalized Relationship Between Soil-Water Retention and Crop Growth



Source: USDA-NRCS National Engineering Handbook 15-1, Dec. 1991, http:/;www.info.usda.gov/CED/ftp/CED/neh15-01.pdf

(IWM – 16) Crop Evapotranspiration (ETc) & Growing Degree Days Guide (Corn Silage example)



The **solid black line** represent a temporary increases in the kc due to irrigations causing surface wetness (high evaporation)

- **Kc is the ratio of the actual Crop ET to a reference Crop (e.g. grass) ET_0 at a specific time.**
- **Kc for harvested grass and forage legumes drop at harvest and then increase as regrowth occurs.**
- **When crops are stressed because of lack of water and/or elevated soil salinity, the ETc rate decreases.**
- **When the crop completely shades the soil surface, the Kc may exceed 1.0 (i.e. the crop has a higher ET rate than grass reference crop; e.g., alfalfa would have a higher ET rate than grass prior to harvest).**

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Growing Degree Days (GDD) are calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (this base Temperature (Tbase) can be 40, 45 or 50 °F, which is the most common).

GDD = Tmax + Tmin/2 – Tbase

Example GDD for July

GDD = 83.7 + 61.4/2 = 72.6

GDD = 72.6 – 45 = 27.6 GDD/day

27.6 x 31 days = **856 GDD/month of July**

Total GDD to reach Crop maturity = 2,848

(IWM – 17) Graded Border Irrigation Application Efficiency Analysis – Example

Example analysis is for an alfalfa field irrigated with a Hi-Flow Turn Out (flow rate is 7.5 cubic feet/second (cfs))

Parameters Analyzed by NRCS Irrigation Program								*Irrigation Program Analysis Results				
Border Width	Border Length	Area Irrigated	Slope (ft./100 ft.)	Soil Intake Family	Roughness Coefficient	Flow per Border	Net Application	Inflow Time	Deep Percolation	Runoff	Gross Application	Application Efficiency
ft.	ft.	acres	%	number	n value	cfs	inches	hour(s)	inches	inches	inches	%
436	600	6.0	0.1	0.6	0.15	7.5	2.0	2.0	0.36	0.11	2.48	81
Enter producer's Site-Specific field parameters								Irrigation Program Analysis Results				

NOTE: It is highly recommended that at least one or two field Irrigation Water Management (IWM) evaluations be conducted. IWM evaluations is crucial baseline information that is needed, in order to properly assess, plan, and implement changes for obtaining increased IWM levels, crop yields, and quality. The following variables are part of the IWM evaluation:

- Crop quality & yield
- Soils (texture & structure)
- Type of irrigation system/efficiency
- Irrigation Water Mgmt. skill
- Water supply & source
- Water Quality
- Irrigation scheduling & constraints
- System Operation & Maintenance
- Labor, Costs, etc.

Irrigation field notes (e.g., acres irrigated, crops, yield, water supply/quality, soils, system O&M, drainage, runoff, ponding, etc.):

(*USDA-NRCS Surface Irrigation System Program was used for the above analysis)

(IWM – 18) QT = DA Calculations for assessing IWM Requirements

Q is the flow to the border in cubic feet per second (cfs)
T is the inflow time (hours), i.e. the Irrigation Time set
D is the irrigation application depth (inches)
A is the area irrigated (acres)

Example: Alfalfa irrigated with a Hi-flow Turn Out

- available flow per border is 7.5 cfs (Q)
- field took 2.0 hours (T) to irrigate
- 2.5 inches (D) of irrigation water was applied per acre

Continued: i.e., 2.0" was needed ÷ 2.5" applied = 0.80 (irrigation has an 80% application efficiency)

- area irrigated was 6-acres (A); (436 ft. x 600 ft.) ÷ 43,560 = 6.0 acres)

To solve for Q: Q = DA/T

Flow to Border		Application Depth (in.)		Area (acres)		Inflow Time (hours)		
cfs	=	2.5 inches	X	6.0 acres	÷	2.0 hours	=	7.5 cfs

To solve for T: T = DA/Q

Inflow Time		Application Depth (in.)		Area (acres)		Flow to Border (Q)		
hrs.	=	2.5 inches	X	6.0 acres	÷	7.5 cfs	=	2.0 hrs.

To solve for D: D = QT/A

Application Depth		Flow to Border (Q)		Inflow Time (hours)		Area (acres)		
inches	=	7.5 cfs	X	2.0 hours	÷	6.0 acres	=	2.5 inches

To solve for A: A = QT/D

Area		Flow to Border (Q)		Inflow Time (hours)		Application Depth (in.)		
acres	=	7.5 cfs	X	2.0 hours	÷	2.5 inches	=	6.0 acres

NOTE: Refer to the **Field Irrigation Evaluation Guide**. This guide is used to assess the actual irrigation application efficiency (Ea), IWM skill & understanding, etc., in order to plan and implement irrigation system and Irrigation Water Management (IWM) improvements.

Irrigation Application Efficiency (Ea): is the ratio of the average depth of irrigation water infiltrated & stored in the root zone to the average depth of irrigation water applied.

USDA-NRCS Surface Irrigation System – Graded Border Program gave the following analysis for irrigated field evaluated:

Inputs:

- cfs = 7.5
- Net application depth = 2"
- Field Slope = 0.001ft/ft
- Soil Intake = 0.6
- Roughness Coefficient = 0.15
- Field width = 436 ft
- Field Length = 600 ft

Results:

- Application Efficiency = 81%
- Gross Application = 2.48"
- Inflow time = 2.0 hrs.
- Runoff = 0.11"
- Deep Percolation = 0.36"

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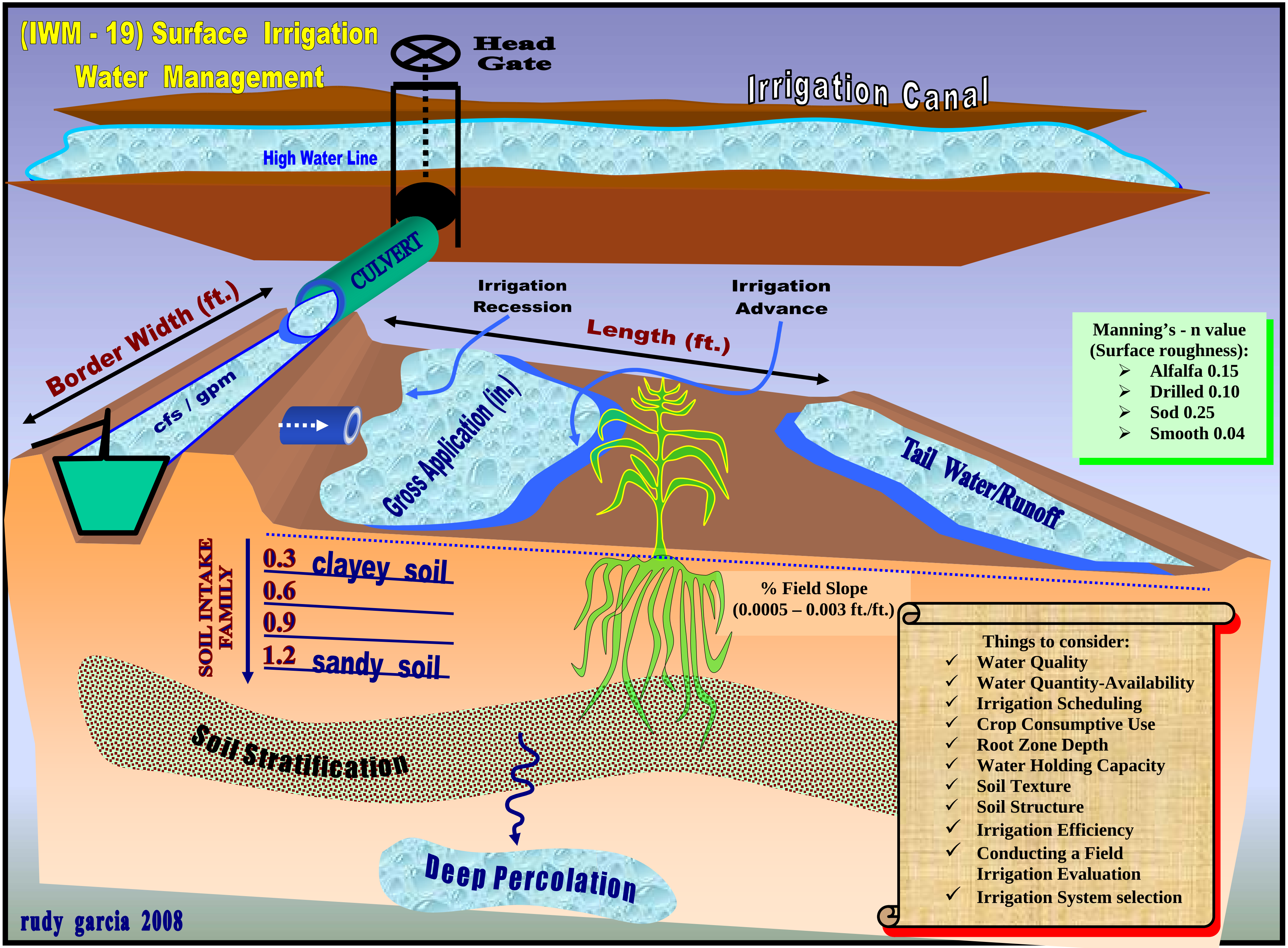

(IWM - 19) Surface Irrigation
Water Management
Head Gate
Irrigation Canal
High Water Line
CULVERT
Border Width (ft.)
cfs / gpm
Irrigation Recession
Irrigation Advance
Length (ft.)
Gross Application (in.)
Tail Water/Runoff
Manning's - n value (Surface roughness):
Alfalfa 0.15
Drilled 0.10
Sod 0.25
Smooth 0.04
SOIL INTAKE FAMILY
0.3 clayey soil
0.6
0.9
1.2 sandy soil
% Field Slope (0.0005 – 0.003 ft./ft.)
Soil Stratification
Deep Percolation
Things to consider:
Water Quality
Water Quantity-Availability
Irrigation Scheduling
Crop Consumptive Use
Root Zone Depth
Water Holding Capacity
Soil Texture
Soil Structure
Irrigation Efficiency
Conducting a Field Irrigation Evaluation
Irrigation System selection
rudy garcia 2008

(IWM 20) Field Irrigation Evaluation Example Guide - Form

Producer: **Date:** **Crop:** **Plant Height:**	**Border width:** **Border Length:** **Total acres:** **Soil type:**	**% Slope:** **Soil Intake Family:** **Flow per Border:** **Irrigation System:**

- **Irrigation Date: 7/15/2007; Irrigated with a High Flow Turn Out (flow rate/border = 7.5 cfs)**
- **Irrigation Started at 9:15 am & Ended at 11:15 am (Irrigation Time = 2.0 hrs.)**
- **Field has been laser leveled**

- **Crop: Alfalfa; Soil Intake Family: 0.6**
- **Border width = 436 ft. & length = 600 ft. (6-acres)**
- **Soil: Silt Loam; % Slope: 0.1ft./100 ft.**

Total depth applied (using *QT = DA): 2.5 inches applied(2.0" was needed)

Important:

Compare Opportunity Time with Infiltration Time (i.e., to get ≈ inches applied)

Soil Texture	Avail. Water (in./ft.)	Irrigation Range(cb)
Sands	0.5	
Loamy Sands	1.0	
F. Sands V. F. Sands Loamy F. Sands Loamy V. F. Sands	1.25	30 - 40
Sandy Loam F. Sandy Loam	1.5	40 - 50
V. F. Sandy Loam Loam Silt Loam Silt	2.0	50 - 60
Sandy Clay Loam Silty Clay Loam Clay Loam	2.2	60 - 70
Sandy Clay Silty Clay Clay	2.0	70 - 80

Field Evaluation Zone	Border Length measurement (ft.)	Border Length measurement (ft.)	Irrigation Water Advance	Irrigation Water Advance	Irrigation Water Recession	Irrigation Water Recession	Opportunity Time (Hrs.)	Opportunity Time (Hrs.)
¼	150		9:35 am		12:20 pm		2.75	
½	300		10:15 am		12:55 pm		2.67	
¾	450		10:50 am		1:23 pm		2.55	
End of Field	600		11:25 am		2:00 pm		2.58	

Soils Intake Family	Inches Applied 1.0	Inches Applied 2.0	Inches Applied 3.0
	Infiltration Time (Hrs.)		
0.1	2.8	10.5	22.3
0.3	1.0	3.5	6.8
0.5	0.63	2.0	3.8
0.75	0.48	1.5	2.8
1.0	0.33	1.0	1.8
1.25	0.28	0.8	1.5
1.5	0.23	0.7	1.3
1.75	0.20	0.6	1.1

NRCS Surface Irrigation Program calculated an 81% application efficiency, Gross application of 2.48" and Runoff of 0.11" **rudy Garcia 2008**

*** QT = DA (Q = flow rate (cfs); T = Irrigation Time (hrs.); D = Application Depth (inches); A = Area (Acres))**

(IWM – 21) Soils INTAKE Guide									
Acre-Inches applied	Soils Intake Family								
	0.1	0.3	0.5	0.75	1.0	1.25	1.5	1.75	2.0
	Approximate time for the applied depth to infiltrate *(Hours)*								
1	2.8	1.0	0.63	0.48	0.33	0.28	0.23	0.2	0.18
2	10.5	3.5	2.0	1.5	1.0	0.8	0.7	0.6	0.52
3	22.3	6.8	3.8	2.8	1.8	1.5	1.2	1.1	0.9
4	34.0	10.0	5.5	4.1	2.6	2.2	1.8	1.6	1.33
5	49.0	14.0	7.6	5.6	3.6	3.0	2.4	2.2	1.78

Acre-Inches applied: By knowing the:

- Irrigation flow rate (Q = cfs) (cubic feet per second)
- Irrigation time set (T = hours)
- And area irrigated (A = acres)

You can calculate the acre-inches applied (D = QT/A). Where D is equal to the depth of application in inches.

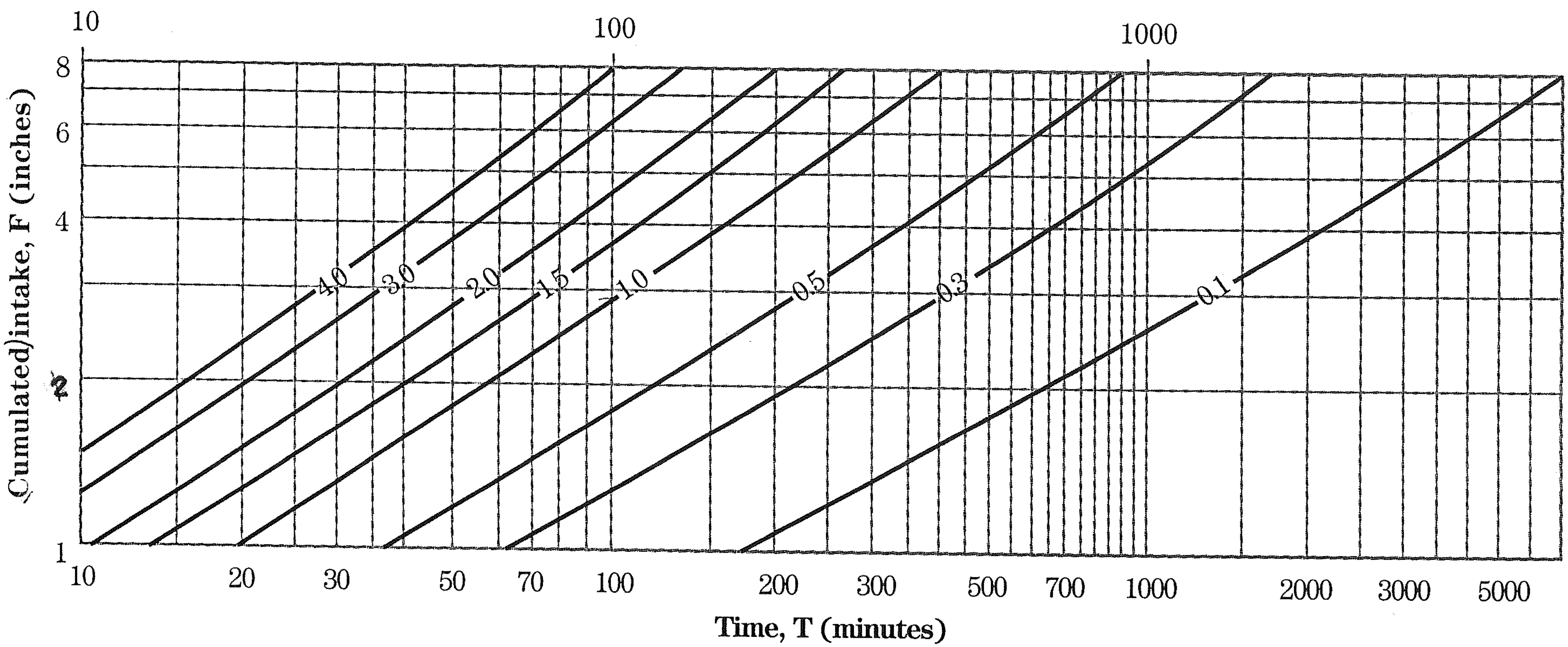
Soils Intake Family: The intake family number of a soil relates the time required to infiltrate a given quantity of water in a specific soil type. Since the intake rate of the soil decreases as more water is applied, the family designation (e.g., 0.1, 05, 1.0, 1.5,…) reflect the final intake rate of the soil.

Time (Hours): This is the total hours required (i.e., Opportunity Time) for the given Irrigation application amount to infiltrate into the soil for a specific Intake Family. The times shown in the table do not reflect the total time of the irrigation set.

NOTE: The intake rate of the soil under irrigation is affected by many factors such as: Soil Texture, Soil Structure, Compaction, Organic Matter, Stratified Soils, Salts in the soil, Water Quality, Sediments in the irrigation water, etc. Therefore, the above times can vary for a given application depth and intake family number.

IWM-22

Intake families for border and basin irrigation design



$F = aT_o^b + c$

F = cumulative intake for an opportunity time T period (inches)
a = intercept along the cumulative intake axis
T_o = opportunity time (minutes)
b = slope of cumulative intake vs. time curve
c = constant (commonly 0.275)