Salt Concentration

In The Soil

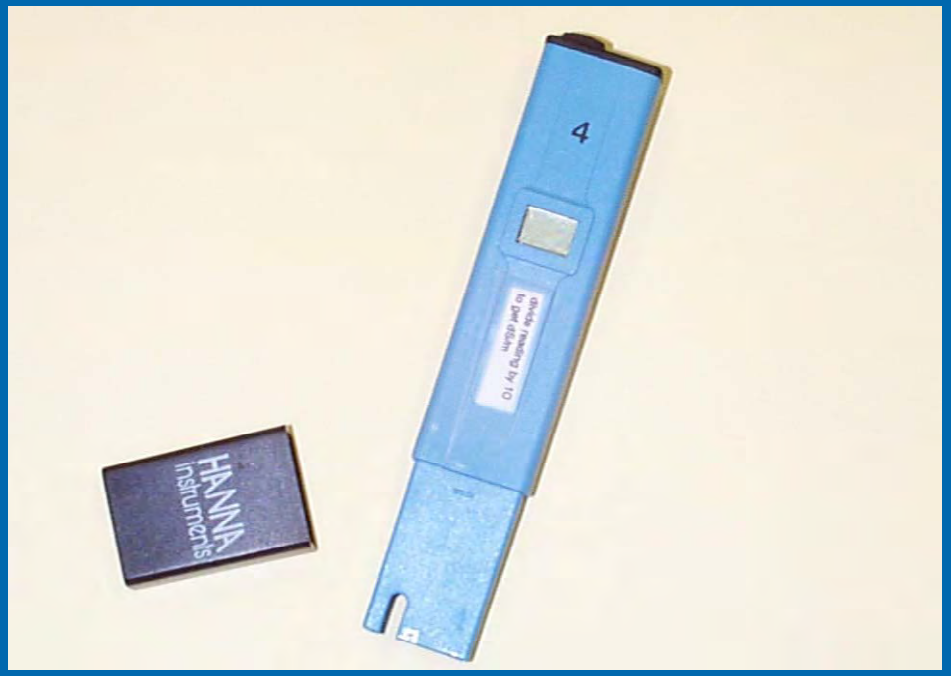
By Clarence Chavez

USDA NRCS

EC Meter detects Salt Concentration

EC - Demo

Others minimal types of salts at very low concentrations are: Boron, Arsenic, Cadmium, Silicates, etc…



Irrigation Salinity (pg. 80)	EC	TDS
Classification - Table 11	(dS/m)	(mg/l)
No effects usually noticed	0.75	500
Can have detrimental	0.75 – 1.50	500 – 1,000
effects on sensitive crops		
Can have adverse	1.50 – 3.00	1,000 – 2,000
effects on many crops		
Can be used for tolerant	3.00 – 7.50	2,000 – 5,000
plants (on permeable soils)		

Salts in the soil	EC range for 1:1 soil:water suspension for which yield reductions occur
Rating	
(Table 6. pg. 61)	
S = Sensitive	> 0.90 dS/m
MS = Mod. Sensitive	> 1.40 dS/m
MT = Mod. Tolerant	> 2.50 dS/m
T = Tolerant	> 4.0 dS/m

Electrical Conductivity

Indicates the amount of salts present in the soil. (K^+, Ca^+, Mg^+, Na^+ , Cl^-, HCO_3^-
Excess salts will hinder plant growth and/or can affect infiltration.

SOLUBLE SALTS

(Irrigation Water Quality example)

Dominant Cations (Ions with a positive charge)			Dominant Anions (Ions with a negative charge)		
Calcium	Ca^{++}	80 ppm	Sulfate	SO_4^{--}	192 ppm
Sodium	Na^{+}	115 ppm	Chloride	Cl^{-}	92 ppm
Magnesium	Mg^{++}	14 ppm	Bicarbonate	HCO_3^{-}	183 ppm
Potassium	K^{+}	8 ppm	Carbonate	CO_3^{--}	6 ppm

Total ppm: 217 ppm (cations) + 473 ppm (anions) = 690 ppm = 690 mg/l (Soluble Salts)

TDS (ppm) = EC (dS/m) x 640, for EC between 0.1 and 5.0 dS/m
TDS (ppm) = EC (dS/m) x 800, for EC > 5.0 dS/m

- TDS = Total Dissolved Solids
- ppm = parts per million; mg/l = milligrams/liter (ppm = mg/l)
- EC = Electrical Conductivity

690 ÷ 640 ≈ 1.08 dS/m (EC)
(dS/m = mmhos/cm = mS/cm)
dS/m = deciSiemens/meter
mmhos/cm =milliMhos/centimeter
mS/cm = milliSiemens/centimeter
2.72 x ppm = lbs. of salts/ac-ft
(2.72 x 690 ppm = 1,877 lbs/ac-ft)

Section 2J – Irrigation Water Salinity and Sodium Adsorption Ratio (SAR) Assessment Guide)

Section 2 of 22 (2j - Irrigation Water Salinity & Sodium Adsorption Ratio (SAR) Assessment Guide)

Irrigation Water Lab Analysis for Soluble Salts and SAR (mg/l = milligrams/liter; meq/l = milliequivalents/liter)

	Major Cations (ions with a positive charge)	example		Enter Lab Results			Major Anions (ions with a negative charge)	example		Enter Lab Results	
		mg/l	meq/l	mg/l	meq/l			mg/l	meq/l	mg/l	meq/l
Hardness	Calcium (Ca^{++}) 20.04 mg/meq	80	4				Chloride (Cl^{-}) 35.46 mg/meq	92	2.6		
Hardness	Magnesium (Mg^{++}) 12.16 mg/meq	14	1.2				Sulfate ($SO4^{--}$) 48.03 mg/meq	192	4		
	Sodium (Na^{+}) 22.99 mg/meq	115	5			Alkalinity	Bicarbonate (HCO_3^{-}) 61.02 mg/meq	183	3		
	Potassium (K^{+}) 39.10 mg/meq	8	0.2			Alkalinity	Carbonate (CO_3^{--}) 30.01 mg/meq	6	0.2		
	Sum of Total Cations:	**217**	**10.4**				Sum of Total Anions:	**473**	**9.8**		

Total Dissolved Solids (i.e., Soluble Salts) is: 217 mg/l + 473 mg/l = 690 mg/l (or 690 ppm). **0.23 x TDS (ppm) = lbs. of salts/ac-in**
690 mg/l ÷ 640 ≈ ECiw of 1.1 dS/m (i.e., Electrical Conductivity of Irrigation Water in decisiemens/meter)

Irrigation Water Salinity Assessment

Salinity (Soluble Salts): affects crop water availability	Degree of Restriction on Use – ECiw (dS/m)		
	None	Slight to Moderate	Severe
Note: Be sure to compare the Irrigation Salinity (ECiw) with the Soil Test (ECe), in order to evaluate the potential yield reduction of your crop (i.e., Refer to a Crop Threshold Soil Salinity (ECe(ct)) Table)	< 0.7	0.7 – 3.0	> 3.0

Formula: mg/l = Meq/l * atomic weight / valence

Minerals	*Atomic Weight*	*Valence*	*Minerals*	*Atomic Weight*	*Valence*	*Minerals*	*Atomic Weight*	*Valence*
Calcium	40	2	Potassium	39	1	Sulfate	96	2
Chlorine	35.4	1	Sodium	23	1	Zinc	65.4	2
Magnesium	24.3	2	Sulfur	32	2	Phosphorus	31	2

Facts You Must Know

Converting TDS to EC

1 mg/L = 1 mg/kg = 1 ppm (Irrigation Water)

- TDS = Total Dissolved Solids (water)
- ppm = Parts per million,
- mg/L = milligrams/Liter (ppm = mg/L)
- EC = Electrical Conductivity (soil – saturated paste)

TDS (ppm)= EC (dS/m) X 640, for EC between 0.1 and 5.0 dS/m

- 690ppm / 640 = 1.08 dS/m (EC)
- 1.08 dS/m X 640 = 690 ppm or TDS

TDS (ppm) = EC (dS/m) X 800, for EC > 5.0 dS/m

- 690ppm / 800 = 0.86 dS/m (EC)
- 0.86 dS/m X 800 = 690 ppm ot TDS

- 640 and 800 are just conversion factors based on total salt content

****

How Much is That?

dS/m = mmhos/cm = mS/cm (Soil)

- ✓ dS/m = deciSiemens/meter
- ✓ mmhos/cm = milliMhos/centimeter
- ✓ mS/cm = milliSiemens/centimeter

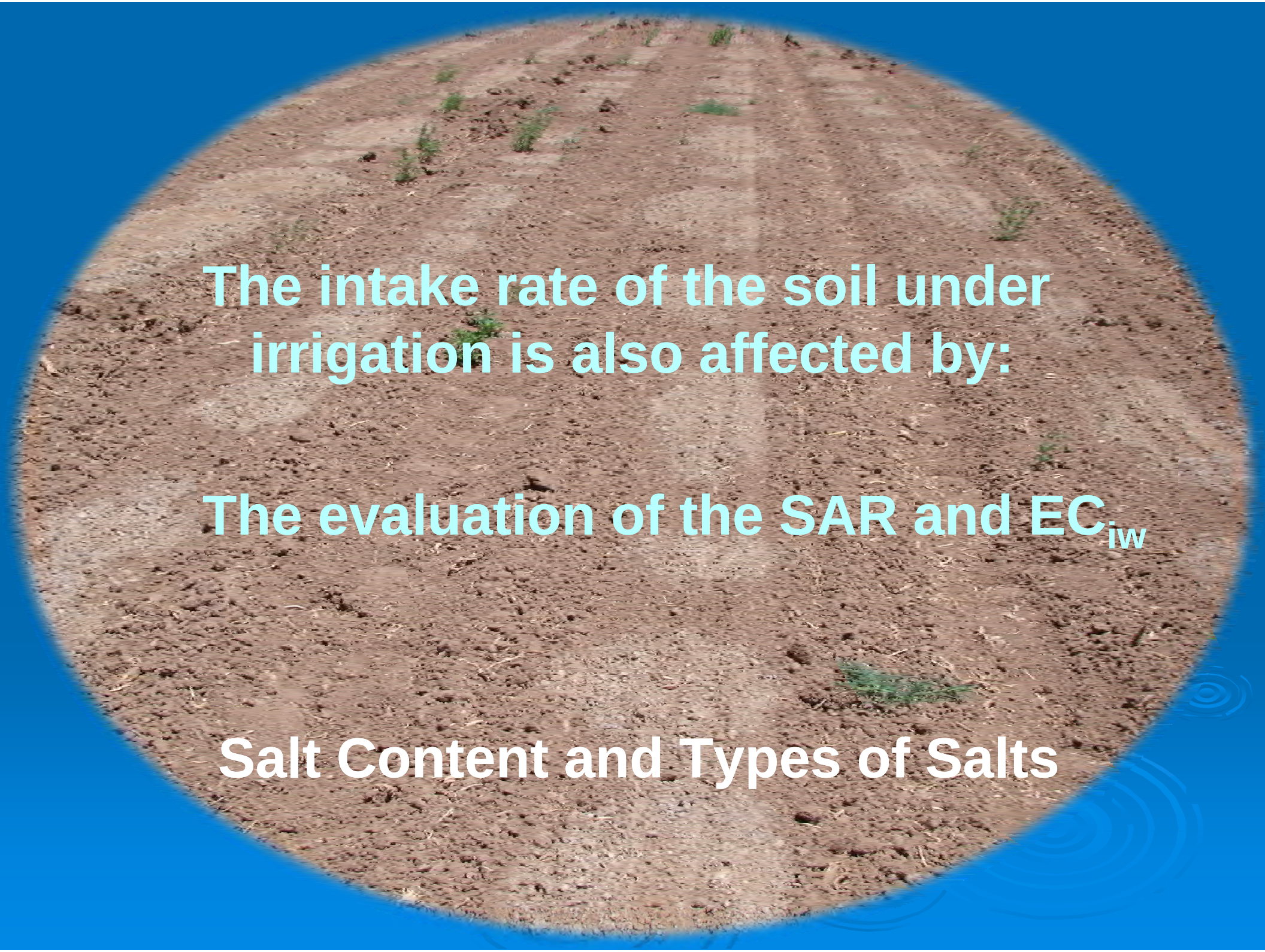
Example: TDS (Total Dissolved Salts)

2.72 X ppm = lbs. of salt / ac-ft

2.72 X 690 ppm = 1,877 lbs/ac-ft of TDS or Salt

2.72 is a conversion factor that

= 2,720,000 pounds of water per ac/ft



The intake rate of the soil under irrigation is also affected by:

The evaluation of the SAR and EC_{iw}

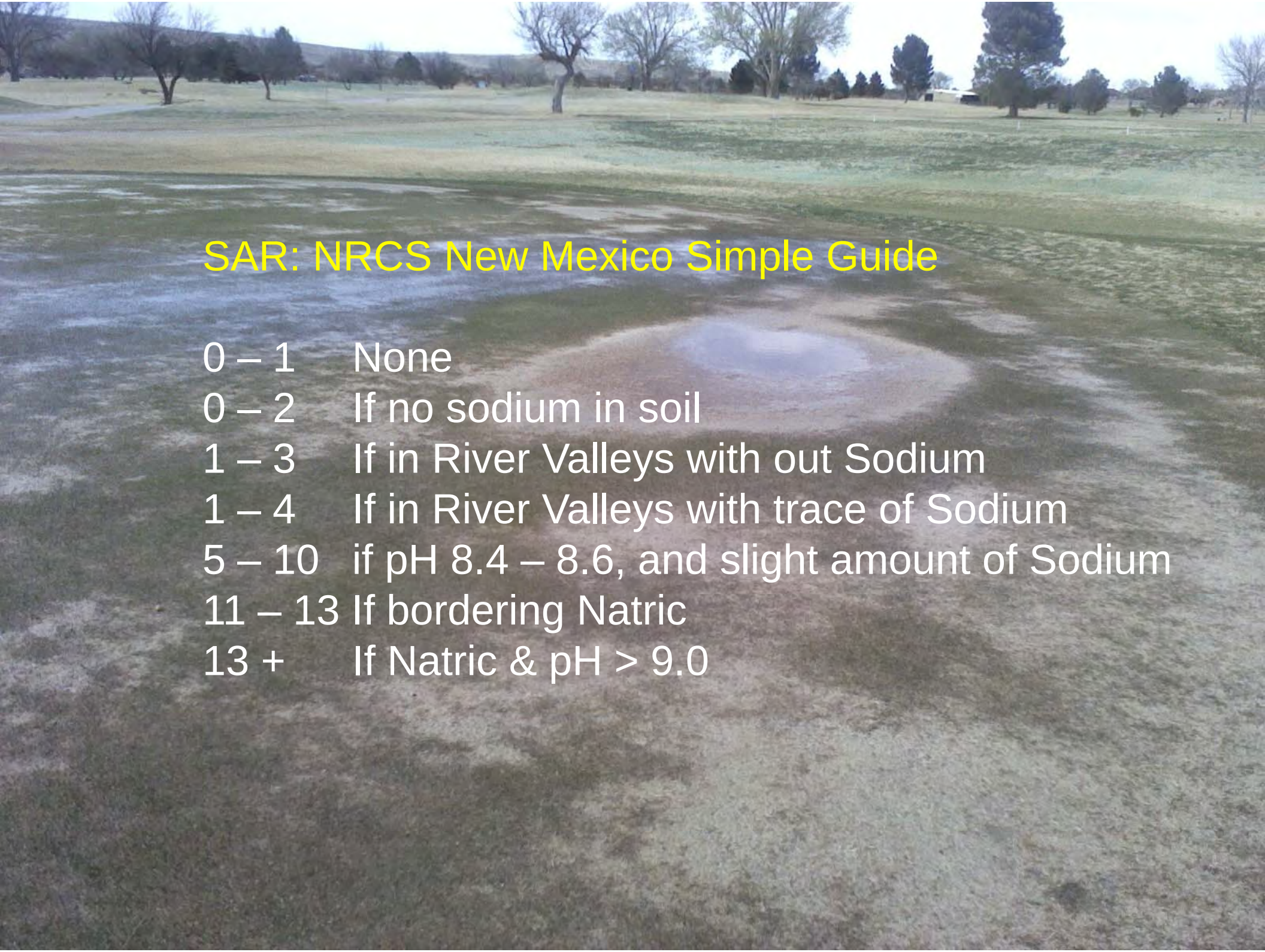
Salt Content and Types of Salts

Sodium Adsorption Ratio

$$SAR = \frac{[Na^+]}{\sqrt{([Ca^{2+}] + [Mg^{2+}])/2}}$$

(concentrations are in meq/L)

- **High SAR = Unstable Soil (>15)**
- **Low SAR = Stable Soil (<6)**
- **Gypsum or Elemental Sulfur additions usually start at SAR = 6 or greater**
- **Must have calcareous soils to use sulfur**

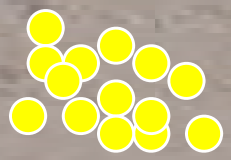


SAR: NRCS New Mexico Simple Guide

0 – 1	None
0 – 2	If no sodium in soil
1 – 3	If in River Valleys with out Sodium
1 – 4	If in River Valleys with trace of Sodium
5 – 10	if pH 8.4 – 8.6, and slight amount of Sodium
11 – 13	If bordering Natric
13 +	If Natric & pH > 9.0

Flocculated vs Dispersed

Flocculated or aggregated clay particles



Dispersed clay particles

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Sodium Promotes Dispersion

No or Reduced Aggregates

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Sodium Promotes Dispersion

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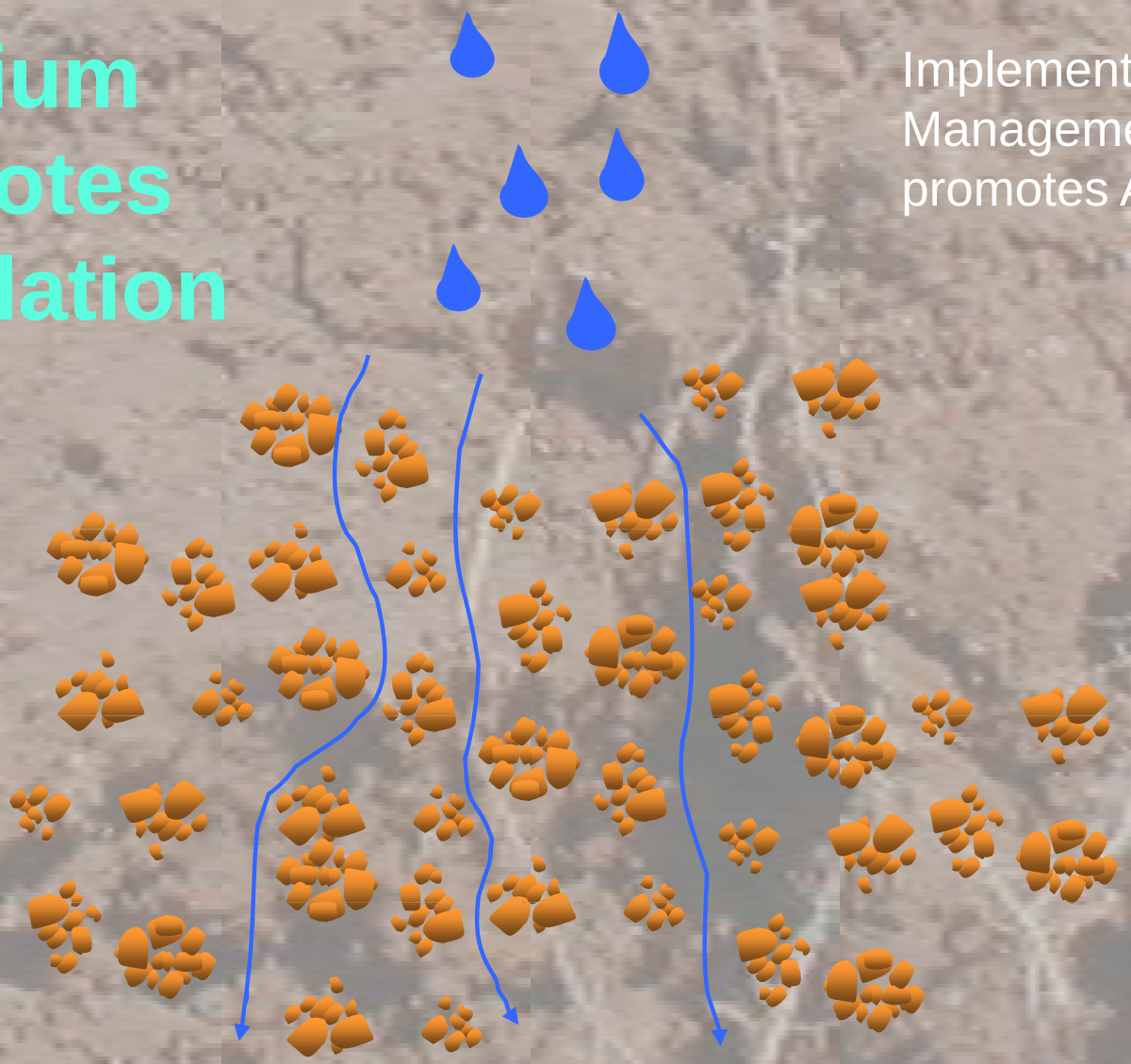
Importance of Aggregates

Calcium Promotes Flocculation



Implementing Soil Health Management System also promotes Aggregation

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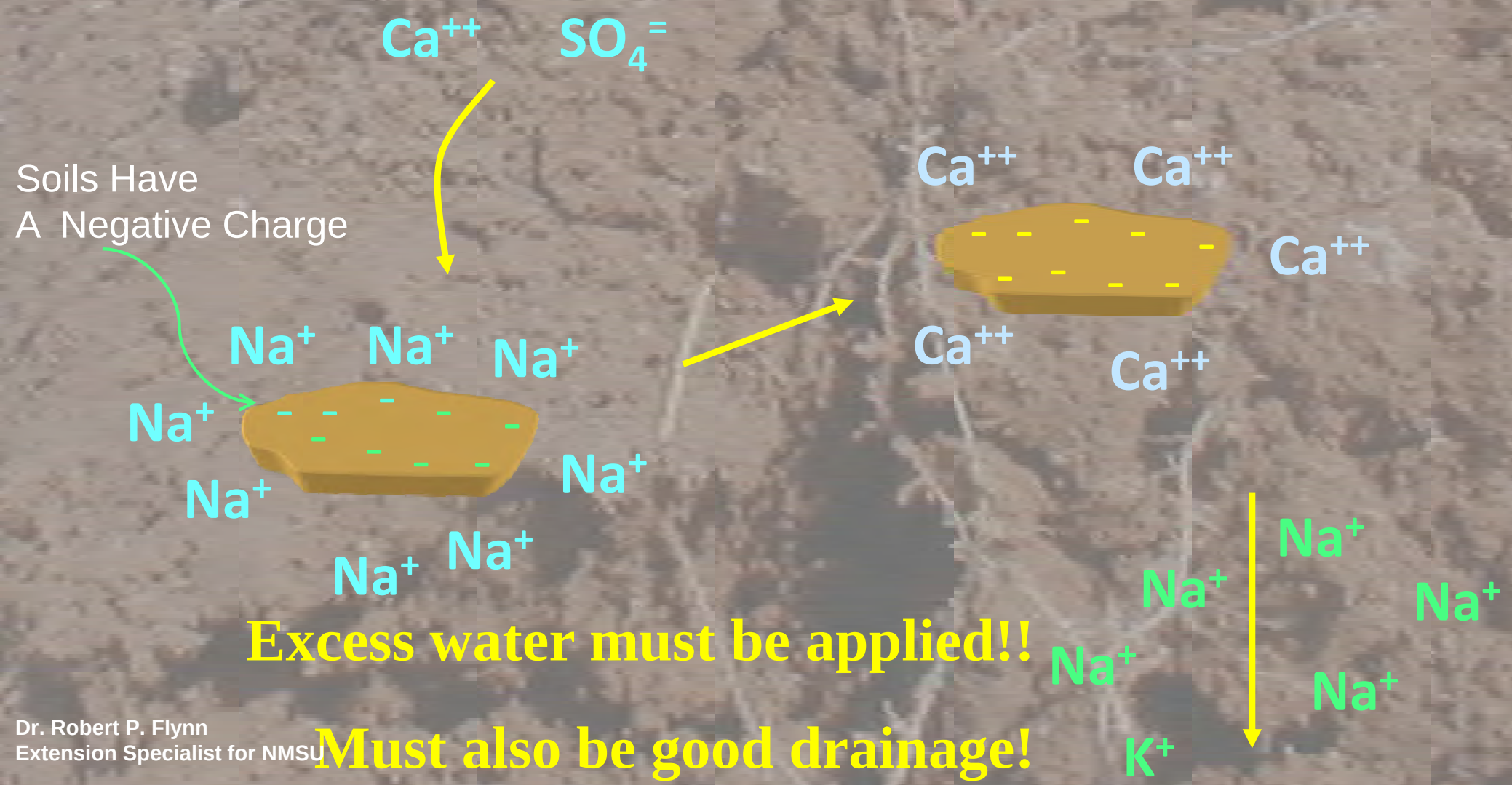
Manage Sodium in Soil with Calcium (Gypsum ($CaSO_4$))



Excess water must be applied!!

Must also be good drainage!

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Example gypsum requirement calculation:

- your soil has a CEC (cation exchange capacity) of 18 milliequivalents per 100 grams and SAR (sodium adsorption ratio) of 26, and you desire an SAR of approximately 10 following treatment. (In these calculations it is correct to assume SAR is roughly equivalent to ESP (exchangeable sodium percent).
- ESP of 26% – desired ESP of 10% = ESP of 16, or 16% exchangeable Na must be replaced with calcium (Ca) to achieve the desired SAR.
- 0.16 x 18 meq CEC /100g = 2.88 meq Na/100 g soil that must be replaced.
- *1.7 tons $CaSO_4$/meq Na x 2.88 meq Na = 4.9 tons of gypsum.
- Thus, about 5 tons of pure gypsum per acre would be required to reclaim the top 12 inches of this soil. Be sure to adjust this calculation for lower grades of gypsum and different soil depths.
- *As a general rule of thumb, 1.7 tons of gypsum is required per meq of sodium.

Section 2 of 22 (2j - Irrigation Water Salinity & Sodium Adsorption Ratio (SAR) Assessment Guide)

Irrigation Water Quality and its potential effects on Infiltration

The amount of **Sodium** and **soluble salts** in the Irrigation Water affects the rate of water infiltration into the soil. This is evaluated using the **SAR** (**Sodium Adsorption Ratio**) and Electrical Conductivity of the Irrigation Water (**ECiw in dS/m**).

Use meq/l for calculating the SAR

$$SAR = Na/\sqrt{(Ca + Mg)/2}$$

SAR	Degree of Restriction on Use – ECiw (dS/m)		
	None	Slight to Moderate	Severe
0 – 3	> 0.7	0.7 – 0.2	< 0.2
3 – 6	> 1.2	1.2 – 0.3	< 0.3
6 – 12	> 1.9	1.9 – 0.5	< 0.5
12 – 20	> 2.9	2.9 – 1.3	< 1.3
20 - 40	> 5.0	5.0 – 2.9	< 2.9

Steps to Calculate the Crop Irrigation Water Requirement

Step 1

$$Fc = ECe(ct)/EC_{iw}$$

Fc = Ratio of the Crop Threshold Salinity (ECe(ct)) to the Electrical Conductivity of irrigation water (ECiw). Units: dS/m

Crop Salt Tolerances section 2b to select your Ec_e

Ec_{iw} = is from a water lab test.

Section 2 of 22 (2b – Crop Salt Tolerances)

Crop (name)	Yield loss 0%		Yield loss 10%		Yield loss 25%		Yield loss 50%		Maximum
	ECe[1]	ECw[2]	ECe[1]	ECw[2]	ECe[1]	ECw[2]	ECe[1]	ECw[2]	ECe[3]
Alfalfa	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	15.5
Almond	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.7	7.0
Apple	1.7	1.0	2.3	1.6	3.3	2.2	4.8	3.2	8.0
Apricot	1.6	1.1	2.0	1.3	2.6	1.8	3.7	2.5	6.0
Barley	8.0	5.3	10.0	6.7	13.0	8.7	18.0	12.0	28.0
Beans	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.5
Beets	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15.0
Bermuda Grass	6.9	4.6	8.5	5.7	10.8	7.2	14.7	9.8	22.5
Blackberry	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0
Boysenberry	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0
Broccoli	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	13.5
Cabbage	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12.0
Cantaloupe	2.2	1.5	3.6	2.4	5.7	3.8	9.1	6.1	16.0
Carrot	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.1	8.0
Clover	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	10.0
Corn, Grain & Silage	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Corn Silage	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	15.5
Corn, Sweet	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Cotton	7.7	5.1	9.6	6.4	13.0	8.4	17.0	12.0	27.0
Cucumber	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10.0
Fescue, Tall	3.9	2.6	5.8	3.9	8.6	5.7	13.3	8.9	23.0
Grape	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12.0
Lettuce	1.3	0.9	2.1	1.4	3.2	2.1	5.2	3.4	9.0
Love Grass	2.0	1.3	3.2	2.1	5.0	3.3	8.0	5.3	14.0
Meadow Foxtail	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.6	12.0
Onion	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.5
Orchard Grass	1.5	1.0	3.1	2.1	5.5	3.7	9.6	6.4	17.5
Peach	1.7	1.0	2.2	1.4	2.9	1.9	4.1	2.7	6.5
Pear	1.7	1.0	2.3	1.6	3.3	2.2	4.8	3.2	8.0
Pecan[4]	1.9	1.3**	2.4*	1.6**	3.2*	2.4**	4.6	3.0**	8.0*
Pepper	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.5
Potato, Irish	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Potato, Sweet	1.5	1.0	2.4	1.6	3.8	2.5	6.0	4.0	10.5
Radish	1.2	0.8	2.0	1.3	3.1	2.1	5.0	3.4	9.0
Raspberry	1.0	0.7	1.4	1.0	2.1	1.4	3.2	2.1	5.5
Ryegrass, Perennial	5.6	3.7	6.9	4.6	8.9	5.9	12.2	8.1	19.0
Safflower	5.3	3.5	6.2	4.1	7.6	5.0	9.9	6.6	14.5
Soybean	5.0	3.3	5.5	3.7	6.2	4.2	7.5	5.0	10.0
Spinach	2.0	1.3	3.3	2.2	5.3	3.5	8.6	5.7	15.0
Strawberry	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4.0
Sudan Grass	2.8	1.9	5.1	3.4	8.6	5.7	14.4	9.6	26.0
Sugar Beet	7.0	4.7	8.7	5.8	11.0	7.5	15.0	10.0	24.0
Tomato	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	12.5
Trefoil, Big	2.3	1.5	2.8	1.9	3.6	2.4	4.9	3.3	7.5
Trefoil, Birdsfoot	5.0	3.3	6.0	4.0	7.5	5.0	10.0	6.7	15.0
Vetch	3.0	2.0	3.9	2.6	5.3	3.5	7.6	5.0	12.0
Wheat	6.0	4.0	7.4	4.9	9.5	6.4	13.0	8.7	20.0
Wheatgrass, Crested	3.5	2.3	6.0	4.0	9.8	6.5	16.0	11.0	28.5
Wheatgrass, Fairway	7.5	5.0	9.0	6.0	11.0	7.4	15.0	9.8	22.0
Wheatgrass, Tall	7.5	5.0	9.9	6.6	13.3	9.0	19.4	13.0	31.5
Wild Rye, beardless	2.7	1.8	4.4	2.9	6.9	4.6	11.0	7.4	19.5

[1] ECe is the electrical conductivity of saturated soil extract, reported in millimhos per centimeter at 25°C.

[2] ECw is the electrical conductivity of the irrigation water, reported in millimhos per centimeter at 25°C.

[3] Maximum ECe is the conductivity of saturated soil extract, reported in millimhos per centimeter at 25°C, at which the plant dies.

[4] Complete data is not currently available for pecans. The * is an interpolation between the 0% and 50% range. The ** for ECw is calculated as ECe x 0.67, which is a general rule of thumb for these ratios under average conditions. RDFischer 2/09

Steps to Calculate the Crop Irrigation Water Requirement

- **Step 1**
- **$Fc = ECe(ct)/EC_{iw}$**

  (Fc = Ratio of the Crop Threshold Salinity)

Example:

- **Fc = 2.0** dS/m **/ 1.0** ds/m **= 2.0** dS/m
- Alfalfa $EC_{e(ct)}$ = 2.0 dS/m (from Crop Salt Tolerance Table)

  EC_{iw} = 1.0 dS/m

From: Section 8 of 22 (8b Gross Crop Irrigation Water Requirement Guide) On our web site.

- **ECiw = Electrical Conductivity of irrigation water / ECe = Electrical Conductivity of the soil saturation extract (units: decisiemens/meter (dS/m), which is equal to millimhos/centimeter (mmhos/cm),**

Steps to Calculate the Crop Irrigation Water Requirement

- **Step 2 if Surface Flood Irrigated (soil EC is about 1.5 times Water EC)**

  $LF = 0.3086/Fc^{1.702}$

  $LF = 0.3086 / 2.0^{1.702}$

  $LF = 0.3086 / 3.254$

  $LF = 0.095$

  Or

- **Step 2 if Drip (soil EC is about 3 times Water EC)**

  $LF = 0.1794/Fc^{3.0417}$

  $LF = 0.1794/2.0^{3.0417}$

  $LF = 0.1794/8.2346$

  $LF = 1.47729$

Updated Calculations for water requirements

Referenced; **Section 8b of 22 - Gross Crop Irrigation Water Requirement Guide**

- **LF = 0.3086/Fc3.0417 Leaching Fraction (for conventional irrigation; e.g. surface irrigation)**
- **LF = 0.1794/Fc3.0417 (e.g. Drip irrigation)**

Irrigation Water Requirements - Consumptive Use / Evapotransporation

Irrigation Water Requirements
Crop Data Summary

Job: Albuquerque
Location: Albuquerque
By: Rhett
Weather Station: ALBUQUERQUE WSFO AIRPOR
Latitude: 3503 Longitude: 10637
Computation Method: Blaney Criddle (TR21)
Crop Curve: Blaney Criddle Perennial Crop
Begin Growth: 4/16 End Growth: 10/30

Crop: Alfalfa, hay, northern
County: Bernalillo, NM
Date: 01/26/05
Sta No: NM0234
Elevation: 6310 feet above sea level

Net irrigation application: 2 inches
Estimated carryover moisture used at season:
Begin: 0.6 inches End: 0.6 inches

Month	Total Monthly ET (3) inches	Dry Year 80% Chance (1)		Normal Year 50% Chance (1)		Average Daily ETc inches	Peak Daily ETPk inches
		Effective Precipitation inches	Net Irrigation Requirements inches (2)	Effective Precipitation inches	Net Irrigation Requirements inches (2)		
January	0.00	0.00	0.00	0.00	0.00	0.00	
February	0.00	0.00	0.00	0.00	0.00	0.00	
March	0.00	0.00	0.00	0.00	0.00	0.00	
April	1.98	0.10	1.38	0.15	1.33	0.12	
May	6.39	0.29	6.10	0.42	5.97	0.21	0.23
June	9.35	0.38	8.97	0.54	8.81	0.31	0.34
July	10.47	0.79	9.68	1.13	9.34	0.34	0.37
August	8.80	0.96	7.84	1.38	7.42	0.28	0.31
September	5.85	0.52	5.33	0.74	5.11	0.19	0.21
October	3.11	0.41	2.20	0.58	2.03	0.10	
November	0.00	0.00	0.00	0.00	0.00	0.00	
December	0.00	0.00	0.00	0.00	0.00	0.00	
TOTAL	45.85	3.46	41.60	4.84	40.01		

(1) For 80 percent occurrence, growing season effective precipitation will be equaled or exceeded 8 out of 10 years. For 50 percent chance occurrence, effective precipitation will be equaled or exceeded 1 out of 2 years.

(2) Net irrigation requirements is adjusted for carryover moisture used at the beginning of the season and carryover moisture used at the end of the growing season.

(3) ET Evapotranspiration) is adjusted upwards 10% per 1000 meters above sea level.

Date: 7/21/2005

ETc = Crop Evapotranspiration (in.)

FOTG Section 1:
http://www.nm.nrcs.usda.gov/technical/fotg/section-1/consumptive-use/consumptive-use.html

- **Etc = 40.01(in) Crop Evapotranspiration for alfalfa**

Net Irrigation Requirement (NIR) (in.) Used to plan and design irrigation systems & IWM.

- **NIR = Etc/(1-LF)**

- **NIR = 40.01 / (1-0.095)**
- **NIR = 40.01 / 0.905**
- **NIR = 44.21 inches**

Section 8 (8d Irrigation Water Requirement Guide
(Calculated at 50% Max., Allowable Depletion (MAD)

Section 8 of 22 (8d – 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	30
			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

Irr. Needed

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: rudy.garcia.2008

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

Irrigation Application Efficiency – Calculates the irrigation application efficiency.

- Ea = irr. needed / irr applied
- Irrigation Needed = 2.06
- Irrigation Applied = 2.5in

  7.5 (cfs) X 2.0 (hrs) / 6.0 (ac) = 2.5 irr. Applied

  Q = DA/T Calculation for Irrigation Applied

- Ea = 2.06 / 2.5
- Ea = 0.824 or 82.4% Application Efficiency

Section 2 of 22 (2g - 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.)	X	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.)	X	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)	X	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)	X	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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Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

Gross Irrigation Application needed

- Fg = NIR/Ea
- Fg = 44.21 / 0.824
- Fg = 53.7 inches

NIR = 44.21 inches

Ea = 0.824 or 82.4%

- Fg = Gross Irrigation Application needed
- Ea = Irrigation Application Efficiency
- NIR = Net Irrigation Requirements

Total Inches of water Applied / Acre / Year

Total inches applied/ac/yr = Irrigations X Irr. App.

Total Inches Applied = 13 X 2.5

Total Inches Applied = 32.5

13 = Average of Irrigations per year.

2.5 in = Irrigation water Applied

(Las Cruces)

The difference between total inches irrigation water applied and gross irrigation water needed.

- Fg – Total In Applied/ac/yr
- 53.7 – 32.5
- Deficit irrigation = 21.2 in/ac/yr

$$$

- Fg = **53.7 inches**
- Total Applied = 32.5
- E.g., instead of growing 8 tons, might produce 6.5 tons

- **Fg = Gross Irrigation Application needed**
- **Ea = Irrigation Application Efficiency**
- **NIR = Net Irrigation Requirements**

Section 8b – Step by Step

Section 8 of 22 (8b - 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) Irr. applied: 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)

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Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

Section 7 of 22 (7a - 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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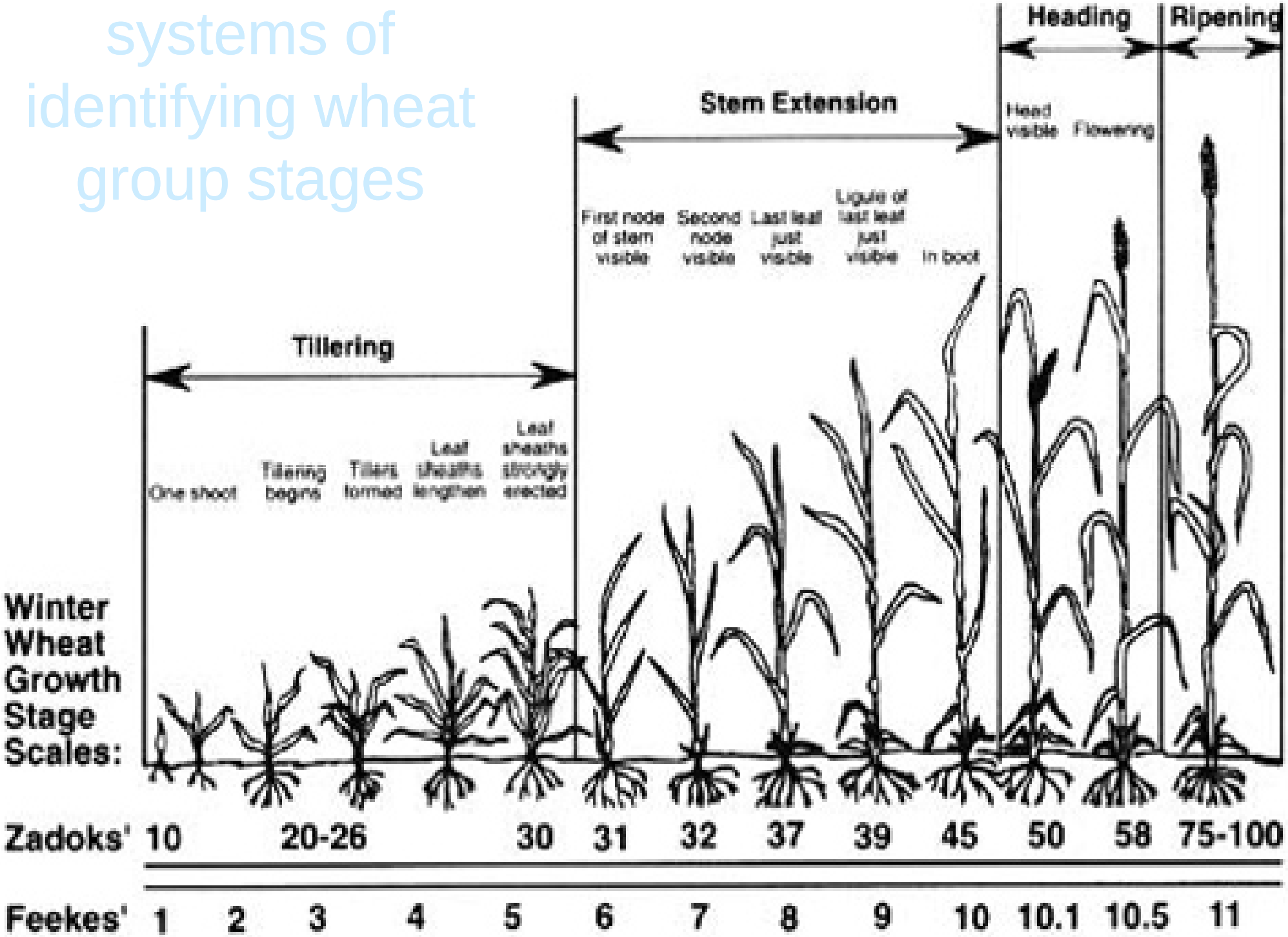
Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

systems of identifying wheat group stages



Zadoks decimal growth scale is based on ten cereal growth stages.

Soil and Water EC

The bottom line

Timing and amount of watering will help in the management of salts in any soil.

Soil Health Management system.

Salt: IWM

(Irrigation Water Management)

Soil Health is very important –

Infiltration

Leaching –

Structure

Reactive Carbon

Nutrient Cycling

Soil Biota

Roots

Etc….

Low Equipment Cost
&
Good Return on Investment

For more information Please Contact Your Local Office of the:

Natural Resources Conservation Service

or

Soil and Water Conservation District

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