Well Water Quality and Elements of Interpreting Lab Results

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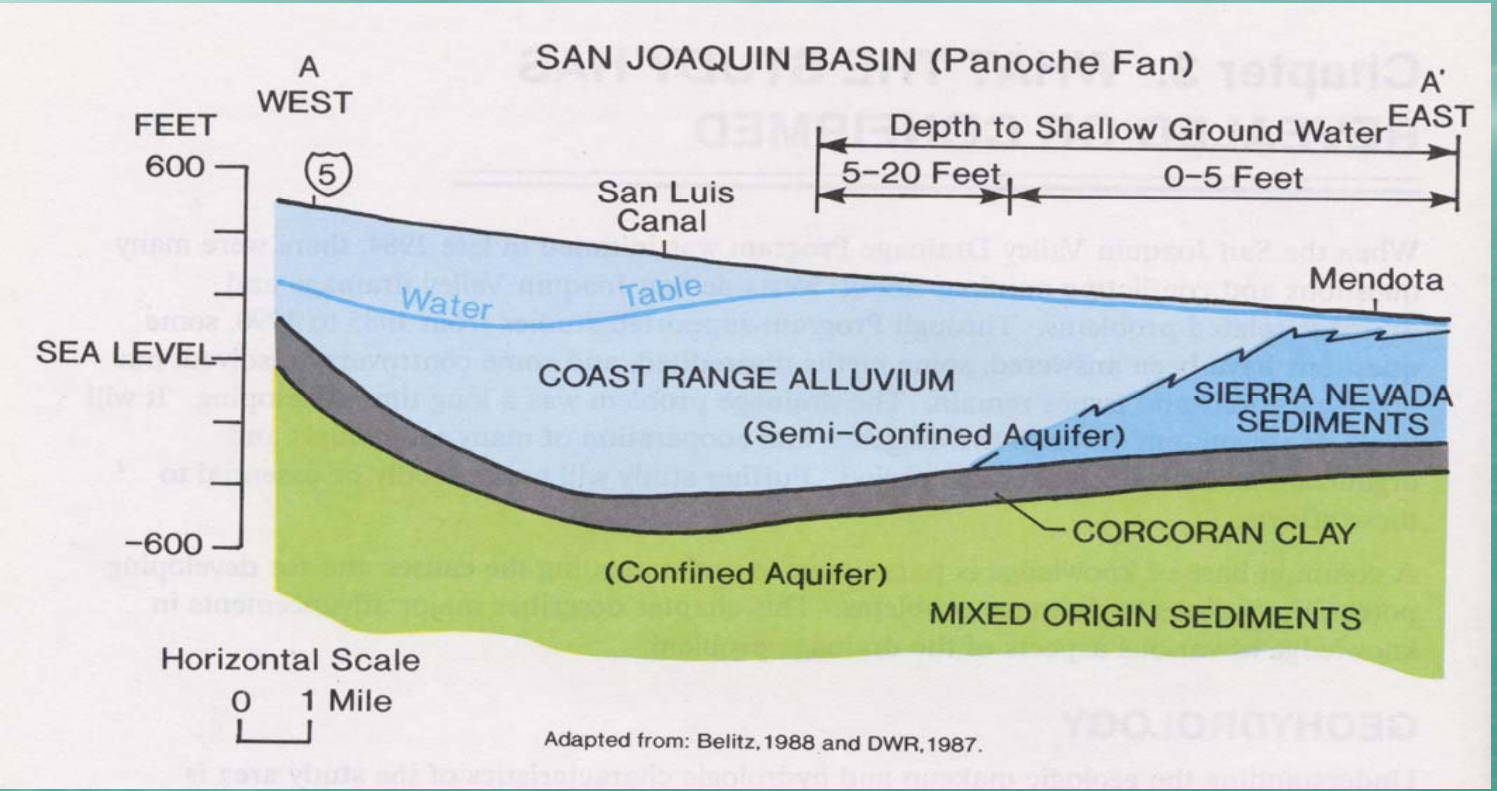
Information on West Side Groundwater Quality

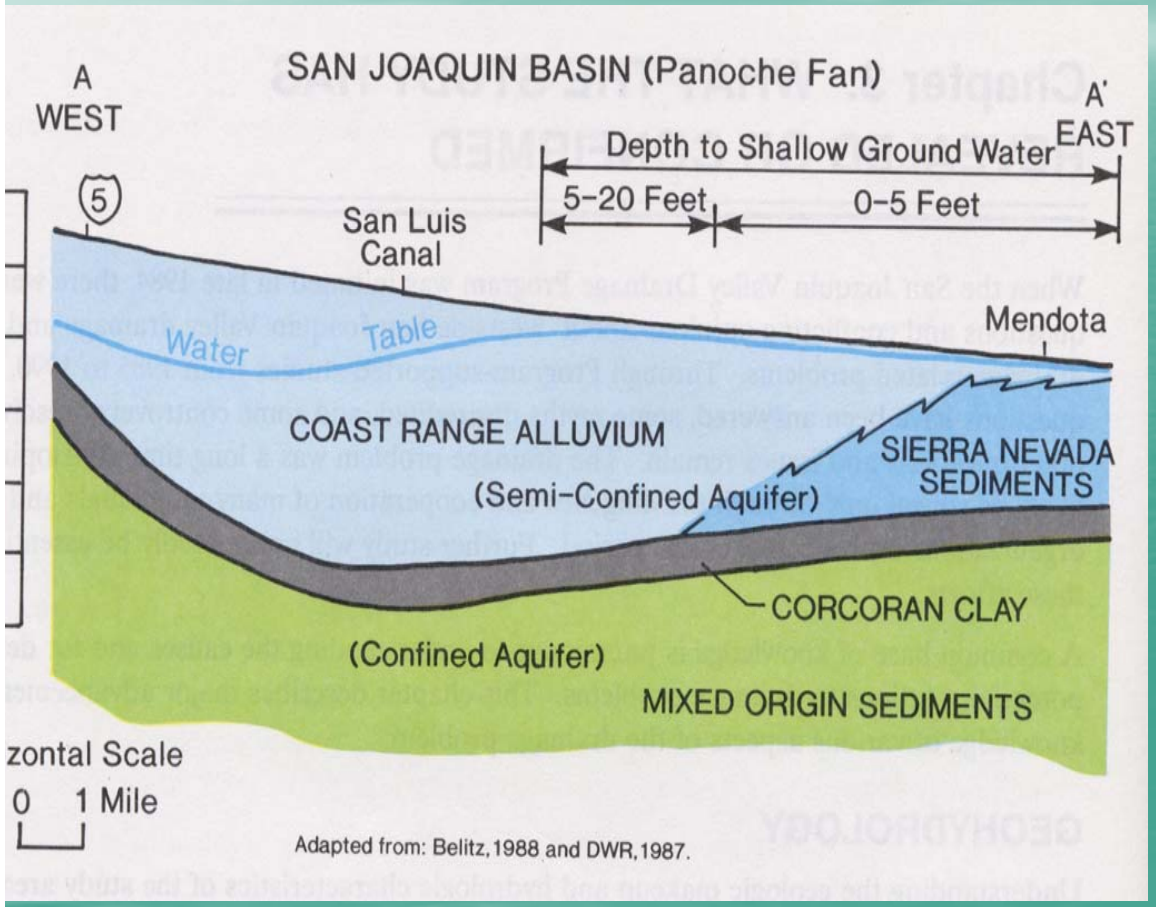
- USGS 1959, 1968 (data intensive)
- Recent study Westlands WD
- No comprehensive review of GW quality in the area
- Connate waters (I-5), deep WQ?

Origins of Groundwater



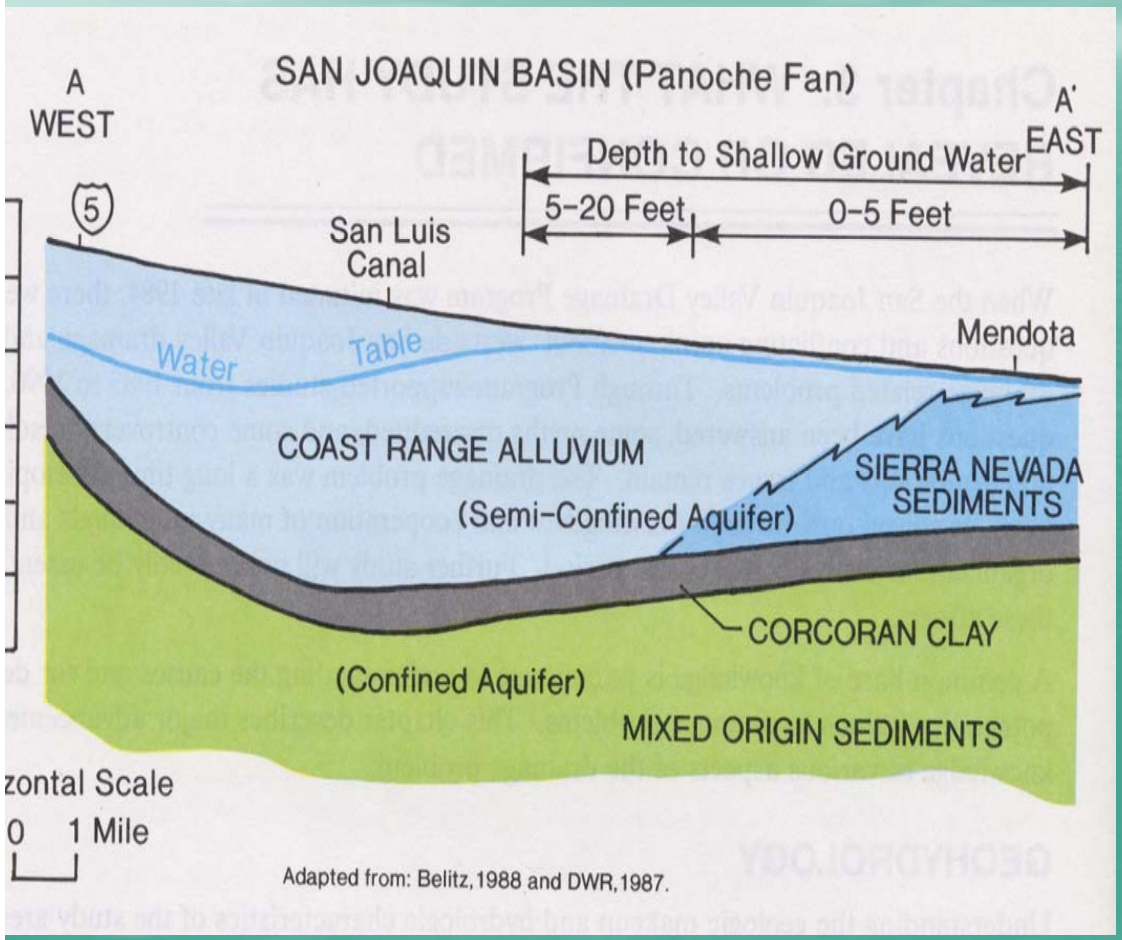
- Source sediments
- Residence time
- Exposure/Mixing effects

Groundwater Quality Issues



- Drainage from marine rocks and surface sediments (Se, B)
- HS- corrosive
- Methane
- Wells accidentally perforated SW of Mendota

Groundwater Quality Issues



- Complex interconnections
- East meets west …origins
- Inches to 1,000's of feet/yr
- $NaSO_4$ dominated w/ Cl "pockets"

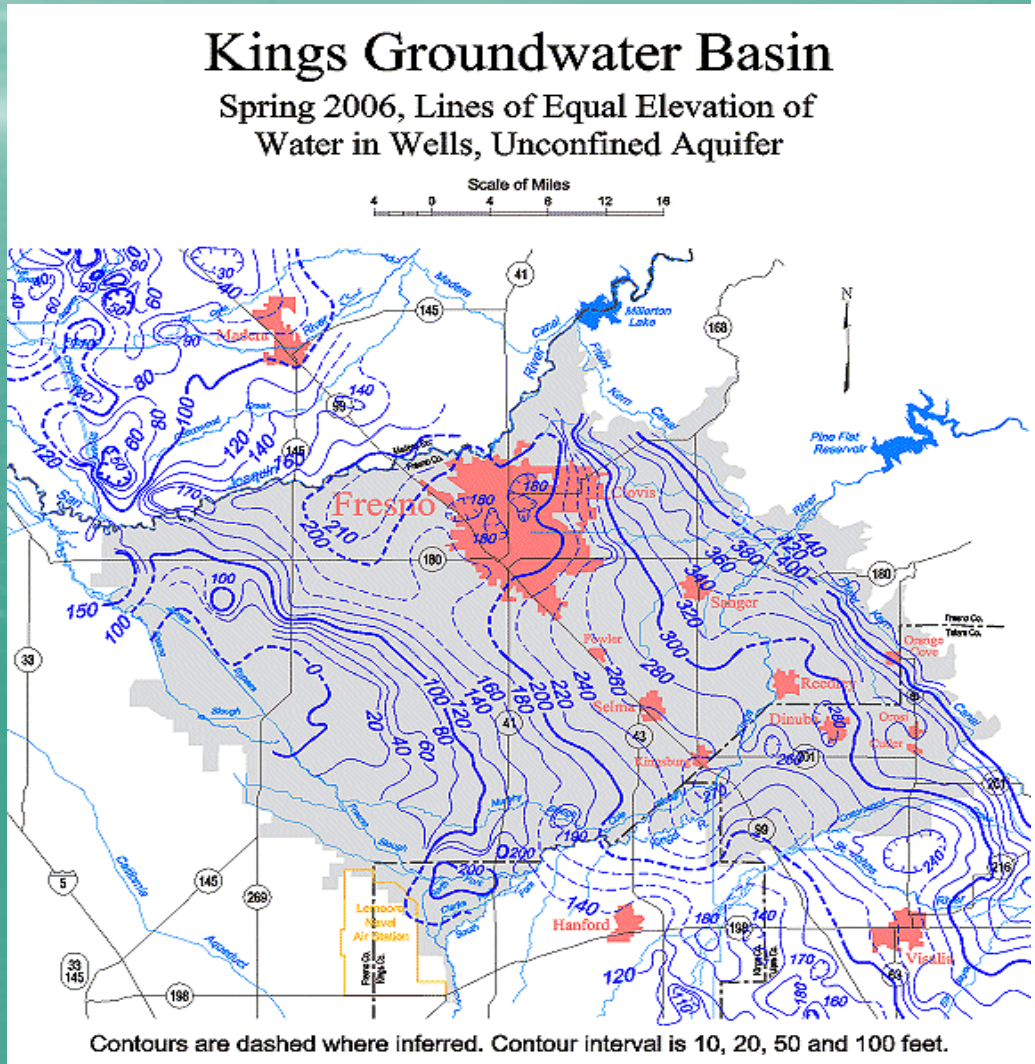
Source Issues

Reliability of Source:

- Mechanical problems
- Groundwater wells can produce a wide range of water qualities

Access to groundwater

- Well yield
- Depth
- Sediment type
- Interconnected "branches"
- Changes w/ time- overdraft



Groundwater: In the dark

- To predict impact on crops and soils we need better info on:
  - geographical distribution of sediments (interconnections)
  - Water quality
- Recharge sources and rates

GW Issues Going Forward

- **Better inventory of SJV basin resources**
- **How does recharge balance pumping today?**
- **How will water quality be impacted over time with anticipated pumping?**
- **Will we have a resurgence in subsidence?**

Assessment:

What water quality issues merit concern?

- Water infiltration problems?
- Premature crop water stress
- Crop physiology- Leaf symptoms
- Variability appears to be increasing

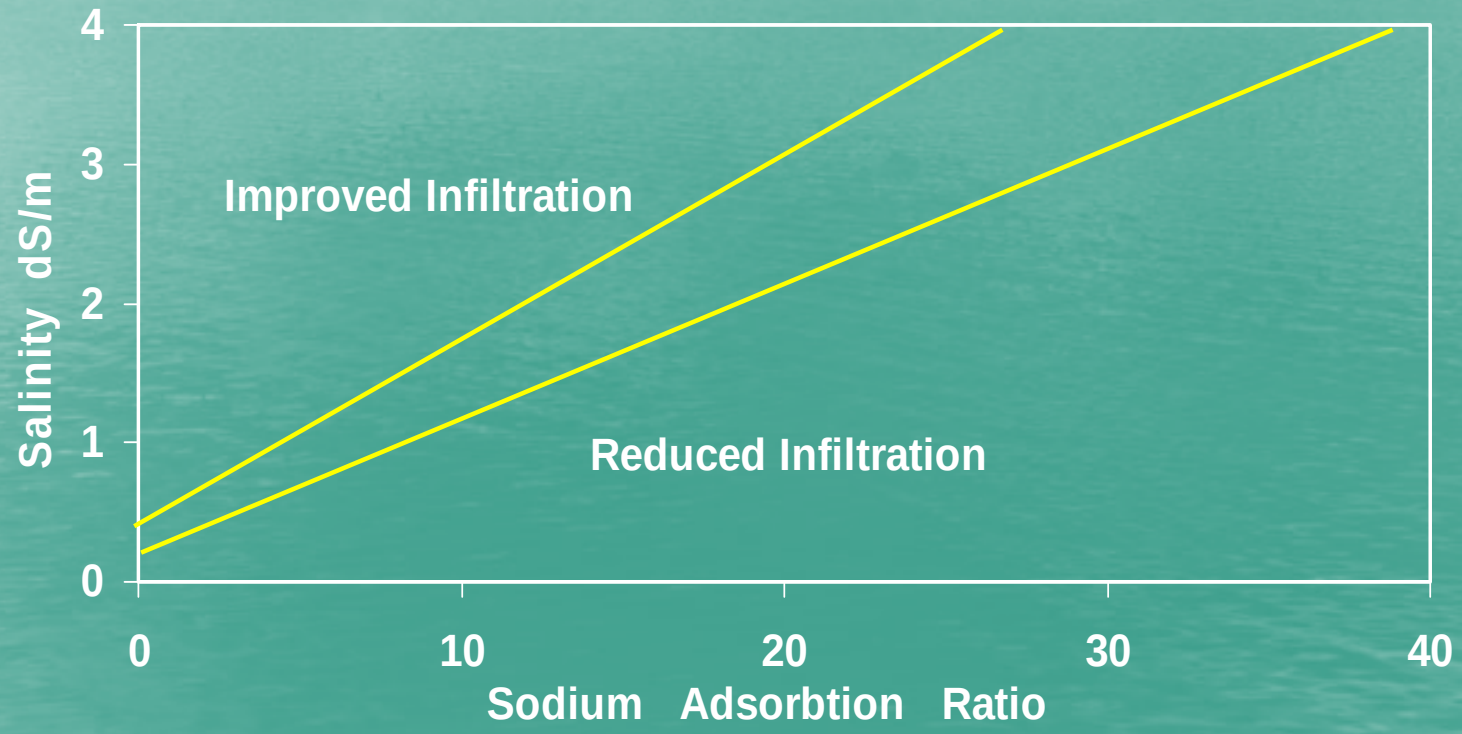
Water Quality Issues

1. Soil effects - Indirect
2. Impacts on Plants - Direct

Water Quality and Soils

- Impacts on soil structure
- Connection to water infiltration
- Combine to influence management including undesired consequences

Impact of Water Quality on Infiltration



Using Agricultural Analytical Labs

- Assist in sampling incl. handling/storage
- Identify key management concerns
- Lab results and interpretation
- Develop a management plan if needed

Water Sampling Approaches Differ

Soils

- Large sample #'s
- Grid or zone
- Composite?
- Depth (3-5')
- Composition- SP, ESP, lime %, Gypsum req.

Water

- Fewer samples
- Delay after startup
- More frequent
- V. time and condition sensitive (bicarbonates)

Primary Constituents of Well Water

Cations

- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Sodium (Na^{+})

Anions

- Chloride (Cl)
- Carbonates
- Sulfate (SO_4^{2-})

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Cations

- Calcium (Ca^{2+})
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Anions

- Chloride (Cl)
- Carbonates (HCO_3^{-}, CO_3^{2-})
- Sulfate (SO_4^{2-})

Minor Constituents of Concern

- Iron (Fe)
- Manganese (Mn)
- Potassium (K+)
- Boron
- Nitrate
- Selenium

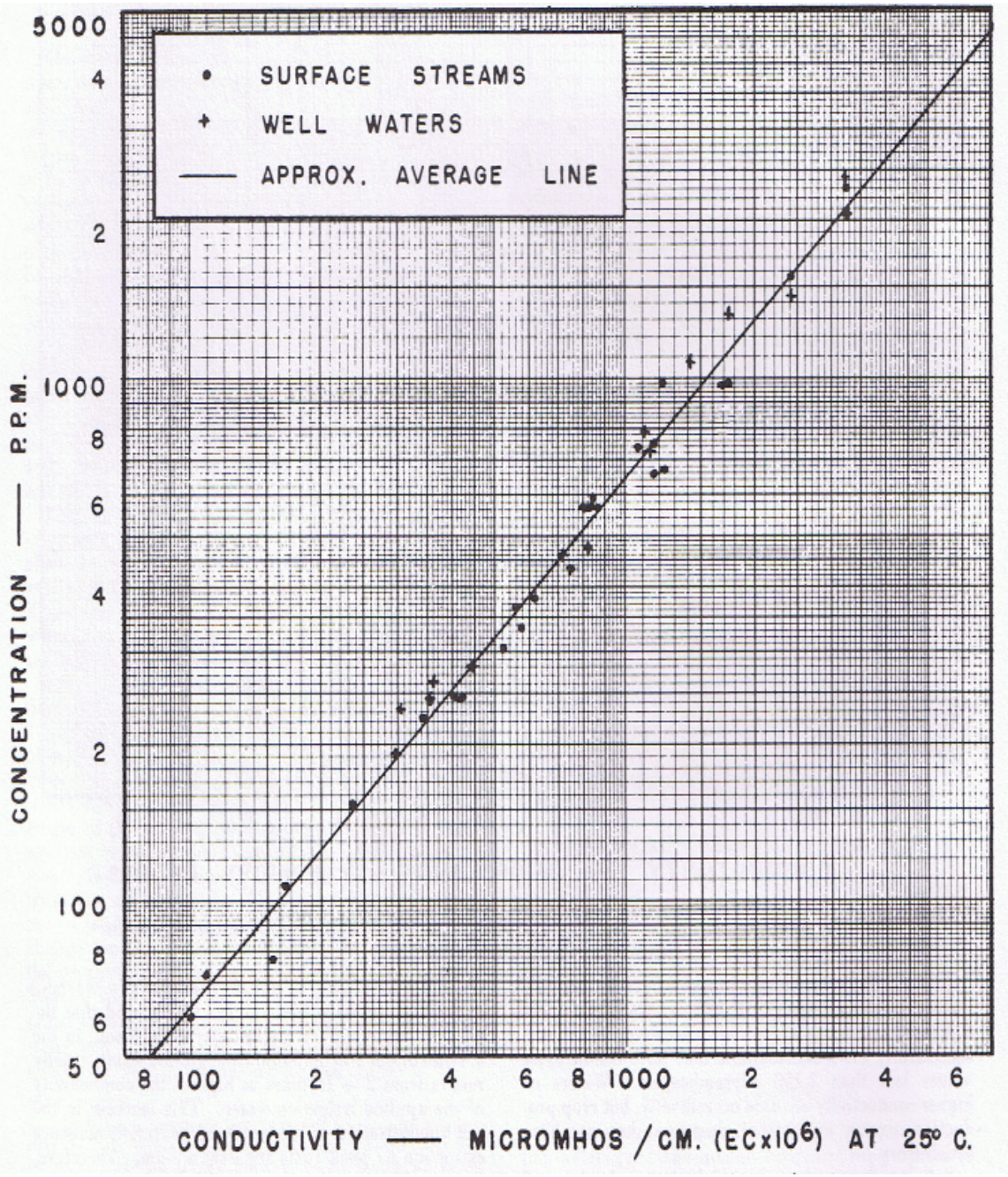
Terminology- Concentration Units

- Milligrams per liter (mg/l) = parts per million (ppm) = Total Dissolved Salts (TDS)
- Equivalence= units of charge
- Milliequivalents per liter = Meq/l
  - ppm/equivalent weight
- Pounds per acre foot

Terminology- Concentration Units

- EC as a measure of salinity
- Conductivity (mho vs. ohm)
- dS/m = mmho/cm = 1000 umhos/cm
- SAR a ratio is unitless
- Alkalinity = Carbonate totals

Electrical Conductivity (EC) and TDS



Electrical Conductivity (EC) and TDS

- 1 dS/m = 640 ppm
- 5 dS/m = 800 ppm

Analytical Groundwater Tests

Location	pH	Ecw	Ca+Mg	Na	SAR	Adj. SAR	CL	CO3+HCO3	B	NO3-N
1	8.1	1.3	1.0	11.8	16.7	17.0	3.5	4.0	1.2	10.0
2	8.6	0.8	0.6	8.3	15.2	13.6	2.0	4.0	1.1	8.0
3	8.7	0.6	0.4	5.6	12.5	10.0	1.5	2.3	0.9	8.0
4	8.3	0.4	0.5	3.1	6.2	4.1	1.0	1.1	0.2	8.0
5	7.9	1.7	4.6	4.1	10.9	-	N/A	1.55	0.98	-
6	7.8	0.54	1.9	0.4	1.8	-	0.4	3.1	0.1	-
7	8.4	1.6	0.6	0.2	16.9	-	2.6	7.2	2.7	-

EC: 1 **dS/m** = 640 ppm 0.4 = 250 ppm 1.7= 1100 ppm

Sodium: SAR 1.8 to 17 Carbonates: 1.1 to 7.2 meq/l

Boron: 0.1 to 2.7 Chloride: 0.4 to 3.5 Nitrate: 2 to 10 ppm

Typical range in well water

- EC's 0.3 to 2.5 dS/m (200 to 1800)
- Calcium (0.2 to 15 meq/l)
- Magnesium (0.1 to 10 meq/l)
- Sodium (0.2 to 30 meq/l)
- Carbonate totals (0 to 10 meq/l)
- Chloride (0.2 to 25 meq/l)
- Sulfate (0.2 to 15 meq/l)

Typical range in well water

- Nitrates (0 to 10 mg/l)
- Boron (0 to 3 mg/l)
- Ammonium (0 to 4 mg/l)
- Potassium (0 to 2 mg/l) Sulfate (0.2 to 15 meq/l)

- pH (6.1 to 8.7)
- SAR (1 to 15)

Analytical Groundwater Tests

pH	Ecw	Ca+Mg	Na	SAR	Adj. SAR	CL	CO3+HCO3	B	NO3-N	
8.1	1.6	2.4	11.3	10.4		8.7	4.6	0.1	ND	
8.0	3.1	6.8	20.4	11.4		24.8	4.0	0.2	ND	
8.7	0.6	0.4	5.6	12.5		1.5	2.3	0.9	8.0	
8.3	0.4	0.5	3.1	6.2		1.0	1.1	0.2	8.0	

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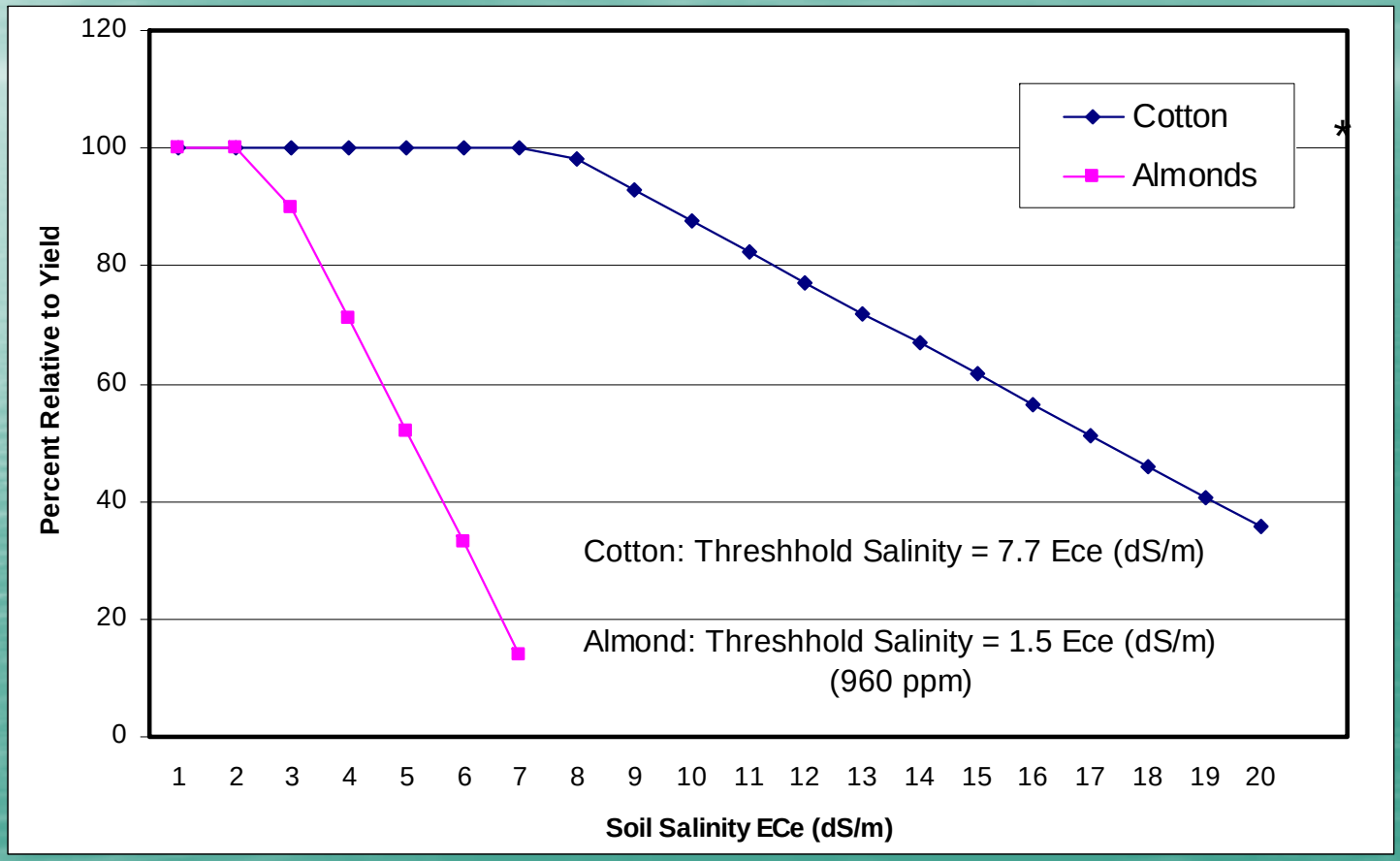
Evaluation Principles

- **Work with a reputable Lab**
- **The result is only as good as the sample**
- **Electroneutrality:** The anion charge is equivalent to cation charge (equivelence)

Water Quality and Plant Responses

- Plant Salinity Response
  - Osmotic effect (osmotic pressure)
  - Water Potential gradients

Relative Yield of Almonds and Cotton Affected by Soil Salinity



* Slope = 19

Water Quality and Plant Responses

- Plant Salinity Response
  - Osmotic effect (osmotic pressure)
  - Water Potential gradients
- Toxic Ion Effects
  - Na, Cl^-, B

Almond Leaf Symptoms

Sodium toxicity

Plant Responses and Risks to Toxic Ions

- Irrigation water concerns
- Soil considerations
- Leaf tissue indicators

Specific ions in irrigation waters – almond guidelines

	Degree of Restriction		
Specific Ion	None	Increasing	Severe
Sodium (ESP)	< 3.0	3 - 9	> 9.0
Chloride (meq/l)	< 4.0	4 - 10	> 10.0
Boron (mg/l)	< 0.5	0.5 - 3.0	> 3.0

Saturated Soil Extract

	Degree of Restriction		
Specific Ion	None	Increasing	Severe
Sodium (ESP)	< 5.0	5 - 15	> 15.0
Chloride (meq/l)	< 5.0	5 - 15	> 15.0
Boron (mg/l)	< 0.5	0.5 - 3.0	> 3.0

Leaf Tissue (Almonds)

	Degree of Restriction		
Specific Ion	None	Increasing	Severe
Sodium (ESP)	< .25	.25 - .40	> .40
Chloride (meq/l)	< .3	.3 - .5	> .5
Boron (mg/l)	< 30	30 - 85	> 85

Management Issues

Merging water, soil and plant observations

- Soil evaluation
- Soil volume
- % Lime
- ESP
- Gypsum Requirement

Management Issues

- EC Modification (soils)
  - Irrigation systems
  - Leaching fraction and timing of leaching
- Modification of SAR/ESP
  - Gypsum (lime)
  - Sulfur
  - Acids

Use your tools!

- Consider Routine Evaluation
- Sample key constituents
- Frequently monitor a changing system
- Periodically re-evaluate long term trends

Questions?