IRRIGATION WATER QUALITY

ADVANCED VITICULTURE SHORTCOURSE

JUNE 4, 2018

COLLEGE STATION, TX

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WATER SOURCE

GROUND WATER

- RULE OF CAPTURE
- COSTS OF DRILLING AND PUMPING
- QUALITY CONCERNS

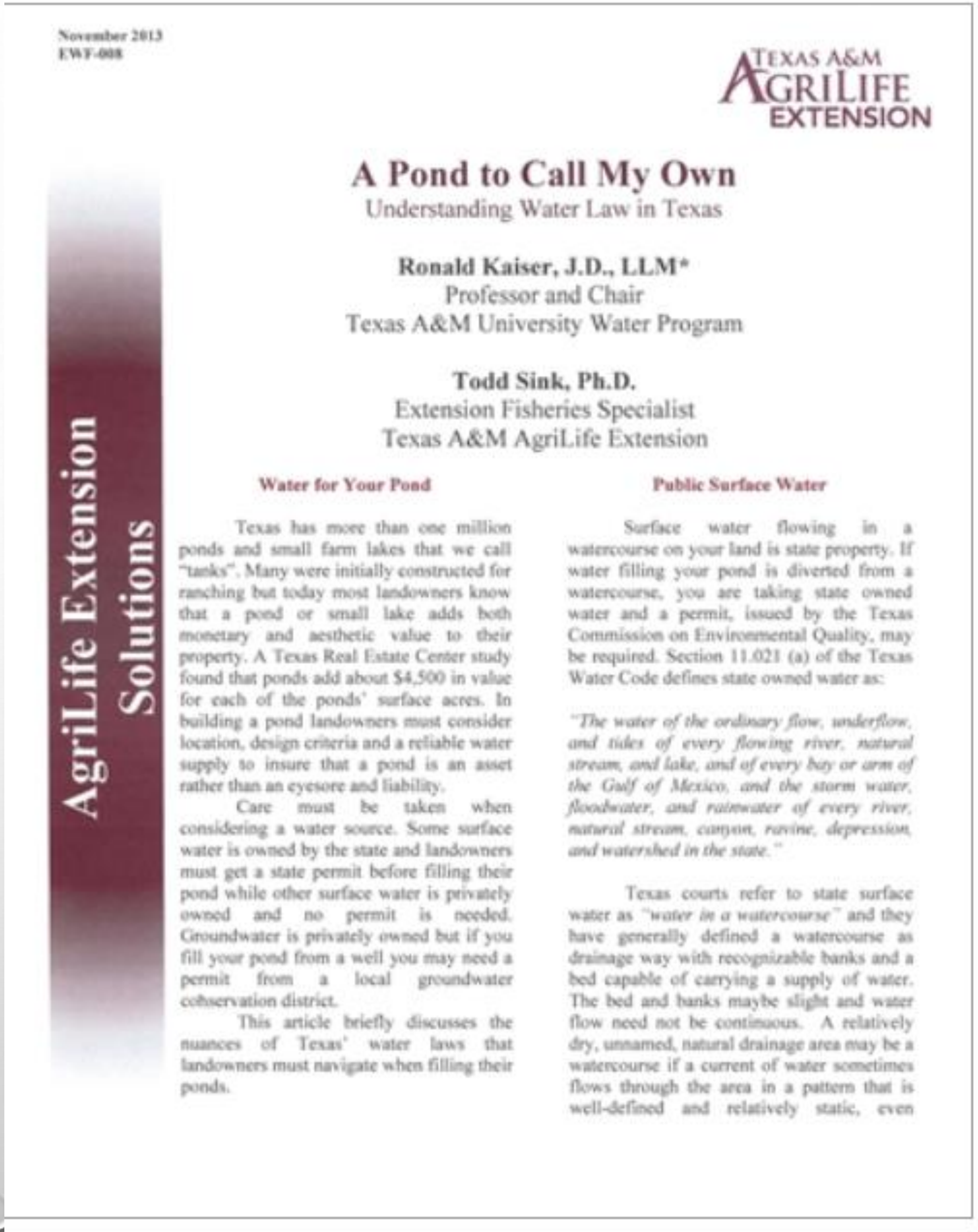
SURFACE WATER

- PUBLIC “WATER IN A WATERCOURSE”
- STOCK TANK EXEMPTION FOR NON-COMMERCIAL USE

HARVESTED WATER

- AVERAGE ANNUAL PRECIPITATION

Dr. Paul Kaiser, TAMU professor of water law & policy



November 2013
EWF-008

TEXAS A&M AGRILIFE EXTENSION

AgriLife Extension Solutions

A Pond to Call My Own
Understanding Water Law in Texas

Ronald Kaiser, J.D., LLM*
Professor and Chair
Texas A&M University Water Program

Todd Sink, Ph.D.
Extension Fisheries Specialist
Texas A&M AgriLife Extension

Water for Your Pond

Texas has more than one million ponds and small farm lakes that we call "tanks". Many were initially constructed for ranching but today most landowners know that a pond or small lake adds both monetary and aesthetic value to their property. A Texas Real Estate Center study found that ponds add about $4,500 in value for each of the ponds' surface acres. In building a pond landowners must consider location, design criteria and a reliable water supply to insure that a pond is an asset rather than an eyesore and liability.

Care must be taken when considering a water source. Some surface water is owned by the state and landowners must get a state permit before filling their pond while other surface water is privately owned and no permit is needed. Groundwater is privately owned but if you fill your pond from a well you may need a permit from a local groundwater conservation district.

This article briefly discusses the nuances of Texas' water laws that landowners must navigate when filling their ponds.

Public Surface Water

Surface water flowing in a watercourse on your land is state property. If water filling your pond is diverted from a watercourse, you are taking state owned water and a permit, issued by the Texas Commission on Environmental Quality, may be required. Section 11.021 (a) of the Texas Water Code defines state owned water as:

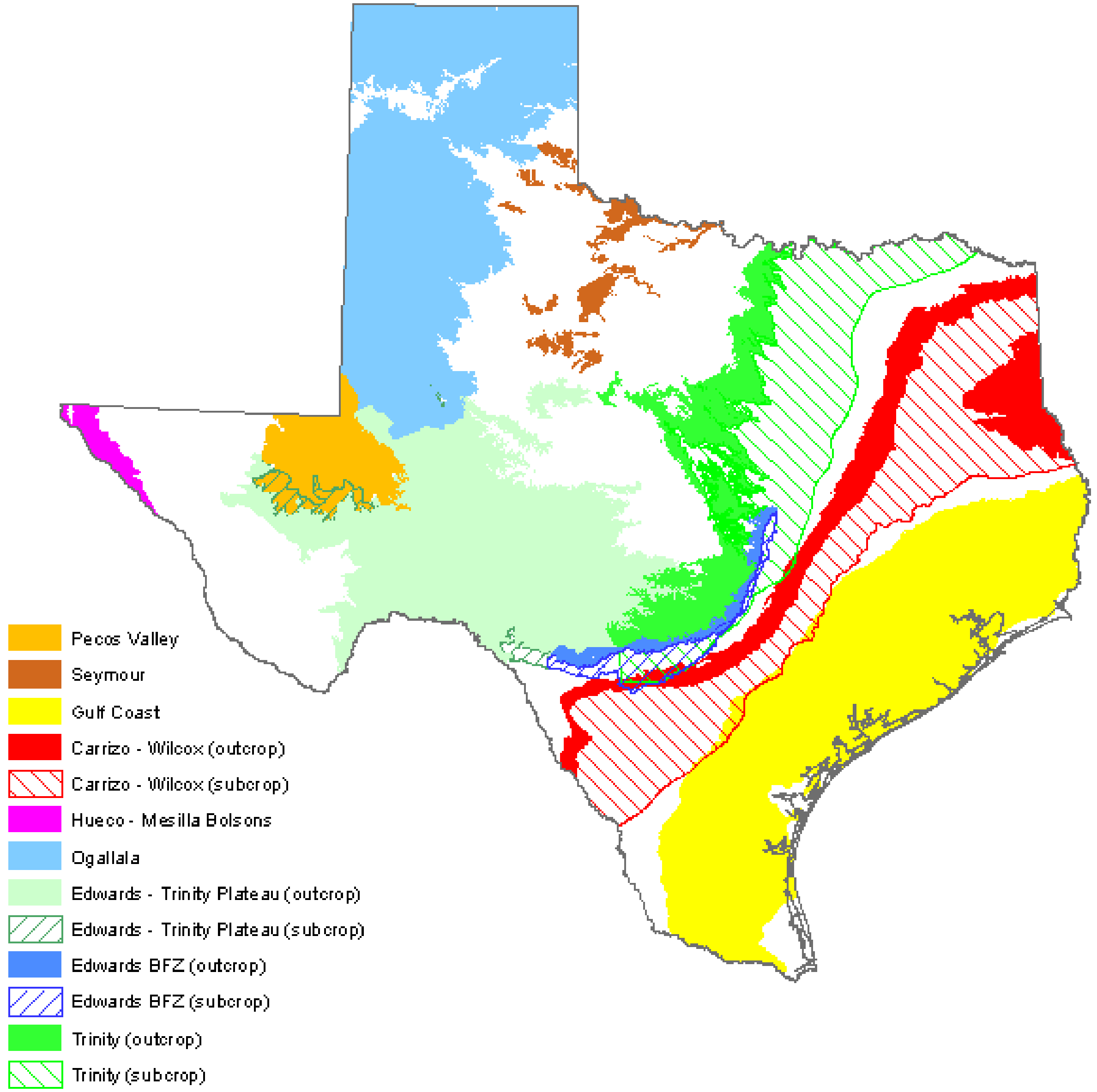
"The water of the ordinary flow, underflow, and tides of every flowing river, natural stream, and lake, and of every bay or arm of the Gulf of Mexico, and the storm water, floodwater, and rainwater of every river, natural stream, canyon, ravine, depression, and watershed in the state."

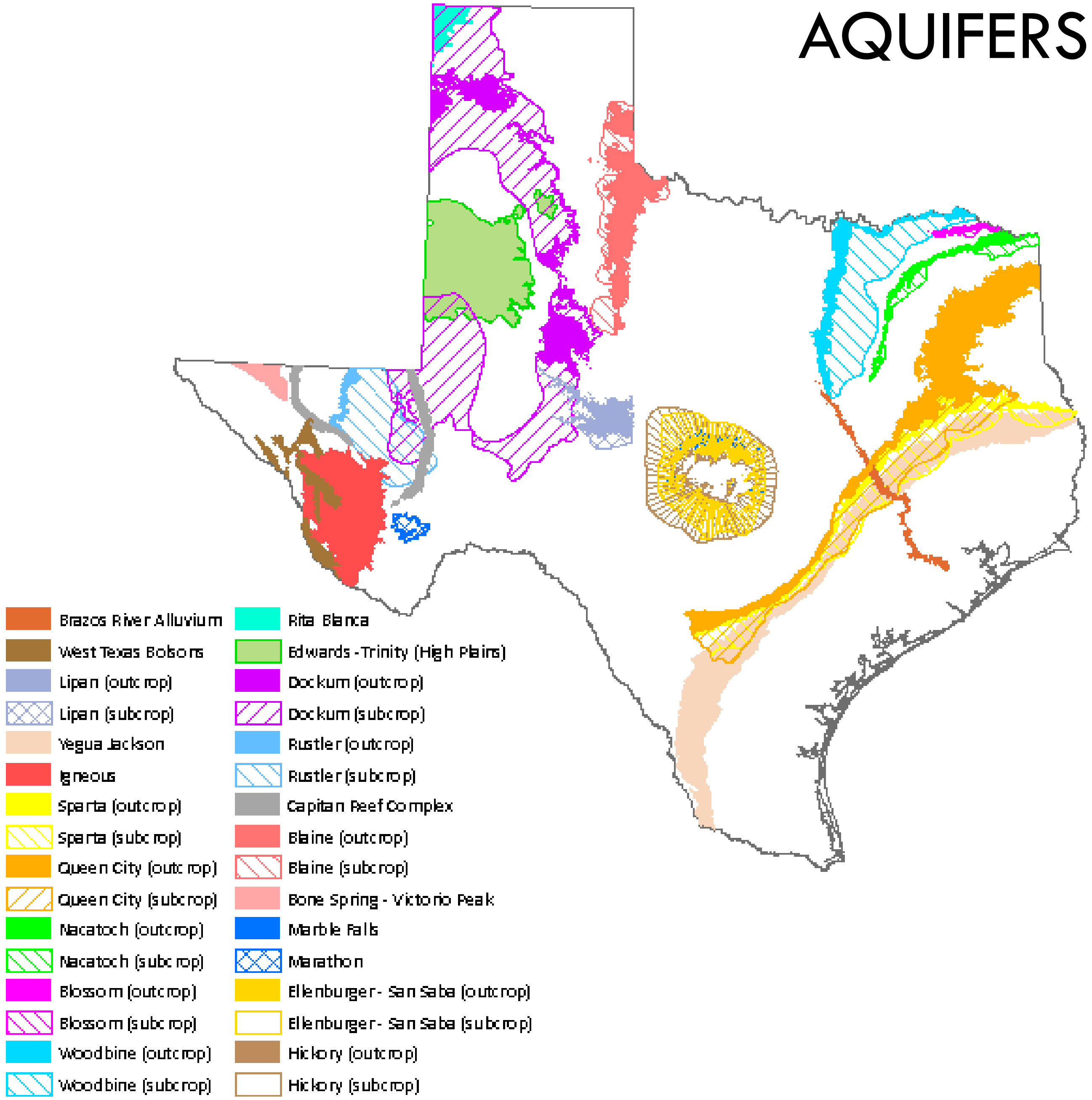
Texas courts refer to state surface water as *"water in a watercourse"* and they have generally defined a watercourse as drainage way with recognizable banks and a bed capable of carrying a supply of water. The bed and banks maybe slight and water flow need not be continuous. A relatively dry, unnamed, natural drainage area may be a watercourse if a current of water sometimes flows through the area in a pattern that is well-defined and relatively static, even

PRINCIPAL AQUIFERS

Images from: Texas Water Development Board

MINOR AQUIFERS





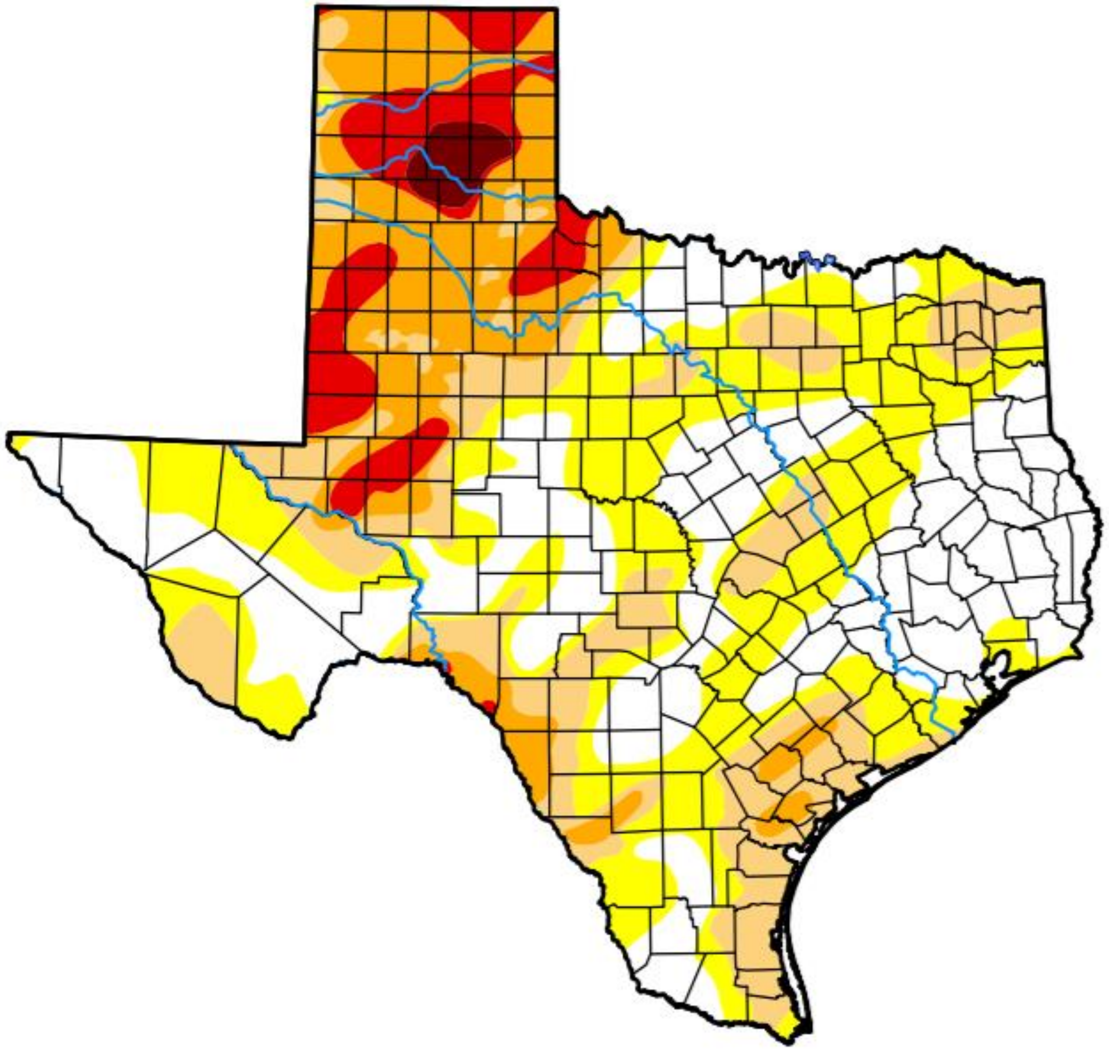
U.S. Drought Monitor

Texas

May 29, 2018

(Released Thursday, May. 31, 2018)

Valid 8 a.m. EDT



Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

Anthony Artusa
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/

MONITORING WELLS

- **Texas Water Development Board (TWDB)**
  Ground Water Database

http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp

- Consult neighbors and local well driller
- Test water during peak water usage
- Test water every 1-2 years, especially during or after a drought

MONITOR WATER LEVELS

- **US Geological Survey**

https://txpub.usgs.gov/txwaterdashboard/index.html

Surface water:

Lakes

Streams

Recent rainfall

- **Consult a Local Well Driller**

WELL OWNER DROUGHT RESPONSE

- MONITOR THE PUMP – SHUT DOWN AND ALLOW TO REST IF PUMP BEGINS SUCKING AIR
- LOWER THE PUMP –DEPENDS ON OVERALL WELL DEPTH
- ADD A PUMPED WATER STORAGE TANK TO ALLOW MORE TIME FOR THE WATER LEVEL TO RECHARGE.

The Texas Water Research Institute, Texas A&M Agrilife Extension Water Resources

AFFECTS ON VINEYARD MANAGEMENT

- FERTILIZERS:

  IRON, ZINC, MANGANESE, COPPER

  BECOME LESS AVAILABLE FOR SOIL UPTAKE

- IRRIGATION:

  CLOGGED, SCALED EMITTERS

  OSMOTIC STRESS IN VINES – FAULTY IRRIGATION DECISIONS

- DISEASE CONTROL:

  PREMATURE BREAKDOWN OF SPRAY SOLUTIONS

  (HYDROLYSIS)

VINEYARD RESPONSES

1. CAUSES STRESS IN WATER UPTAKE
2. POSSIBLE ION TOXICITY
3. ALTER THE SOIL'S STRUCTURE
4. IMPAIR NUTRIENT AVAILABILITY

TESTING OFFERS INSIGHT INTO THE POTENTIAL SEVERITY

TESTS WORK AS A GENERAL GUIDELINE AND WILL VARY BY:

- soil type
- rainfall
- irrigation frequency

GAME CHANGERS

SALINITY

- SODIUM – LIMITING AT SAR > 9
- CALCIUM (HARDNESS)
- TDS (TOTAL DISSOLVED SALTS)
  LIMITING AT > 1728PPM

TOXIC IONS

- BORON – LIMITING AT >3PPM
- CHLORINE – LIMITING AT >525PPM

SALINITY AND PH

PH

MEASURES THE H+ IONS IN THE WATER

ALKALINITY

MEASURES THE WATER'S ABILITY TO NEUTRALIZE ACIDITY

PPM CALCIUM CARBONATE (CACO3)

CARBONATES, BICARBONATES, HYDROXIDES

High alkaline water has high pH (basic pH)

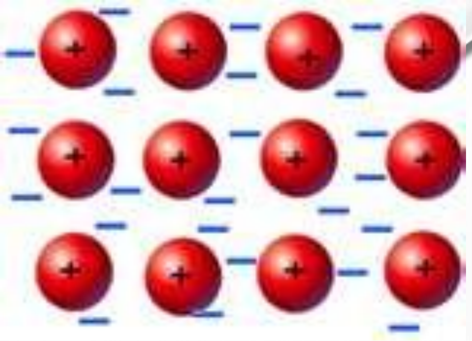
High pH water is not always alkaline

OTHER SALTS OF CONCERN

- **SULFATES—(SO4): NOT A SERIOUS LIMITATION**
  - ROTTEN EGG SMELL

  (AS BACTERIA CONVERT HYDROGEN SULFIDE GAS)

- **NITRATES—(NO3): FREE PLANT GROWTH FERTILIZER**
  - MAY STIMULATE GROWTH AT WRONG TIME



ELECTRICALLY CHARGED IONS

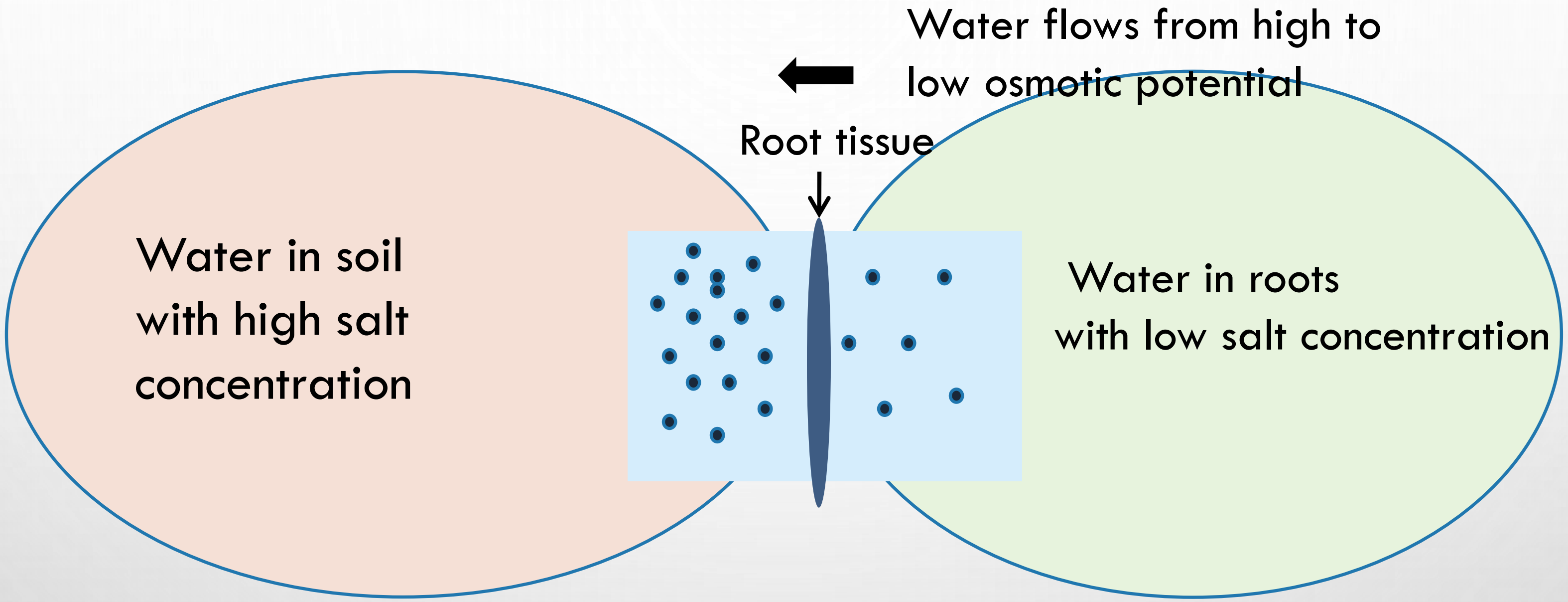
CATIONS +

- CALCIUM ($CA2^{+}$)
- MAGNESIUM $MG2^{+}$)
- SODIUM (NA^{+})
- IRON (FE^{2+} AND FE^{3+})
- AMMONIUM (NH^{4+})

ANIONS -

- BICARBONATE (HCO_3^{-})
- CABONATE (CO_3^{2-})
- CHLORIDE (CL^{-})
- SULFATE (SO_4^{2-})
- NITRATE (NO_3^{-})

OSMOTIC POTENTIAL



- WATER FLOWS FROM HIGH TO LOW WATER POTENTIAL
- PURE WATER HAS ZERO OSMOTIC POTENTIAL

BOTTOM LINE OF SALTS AND OSMOTIC POTENTIAL

- ALL IRRIGATION WATER CONTAINS DISSOLVED SALTS
- DISSOLVED SALTS INCREASE THE OSMOTIC POTENTIAL
- THE MORE DISSOLVED SALT IN SOIL WATER, THE MORE DIFFICULT IT IS FOR ROOTS TO EXTRACT IT (DROUGHT STRESS)

TERMS AND UNITS FOR INTERPRETING WATER ANALYSIS REPORTS.

Symbol	Meaning	Units
Total Salinity		
EC	electric conductivity	µmhos/cm
TDS	total dissolved solids	mg/L
Sodium Hazard		
SAR	sodium adsorption ratio	
ESP	exchangeable sodium percentage	

ALKALINITY MEASUREMENTS

ELECTRICAL CONDUCTIVITY (**EC**):

- PURE WATER WILL NOT CONDUCT ELECTRICITY, BUT IT WILL WITH THE ADDITION OF SALT
- EC IS A GOOD ESTIMATOR OF THE TOTAL DISSOLVED SALTS

TOTAL DISSOLVED SOLIDS (**TDS**) AND **TOTAL SOLUBLE SALTS** (**TSS**)

- EC CAN BE USED TO ESTIMATE TDS AND TSS USING

EC (dS/m) x 640 = TSS or TDS

GUIDELINES FOR IRRIGATION WATER IN VINEYARDS

Analysis (Salinity)	No Problem	Increasing Problem	Severe Problem
EC dS/m or mmho/cm	< 1	1.0 to 2.7	>2.7
TDS ppm or mg/L	<640	640 to 1728	>1728

Table 4. Permissible limits for classes of irrigation water.

Classes of water	Concentration, total dissolved solids	
	Electrical conductivity μmhos*	Gravimetric ppm
Class 1, Excellent	250	175
Class 2, Good	250-750	175-525
Class 3, Permissible[1]	750-2,000	525-1,400
Class 4, Doubtful[2]	2,000-3,000	1,400-2,100
Class 5, Unsuitable[2]	3,000	2,100

*Micromhos/cm at 25 degrees C.

[1] Leaching needed if used

[2] Good drainage needed and sensitive plants will have difficulty obtaining stands

Feagley, S. E., Texas AgriLife Extension State Soil Environmental Specialist

SODIUM ADSORPTION RATIO (SAR)

- RATIO OF ACTIVITY OF SODIUM TO CALCIUM AND MAGNESIUM
- CALCIUM AND MAGNESIUM COMPETE WITH SODIUM FOR EXCHANGE SITES

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

EXCHANGEABLE SODIUM PERCENTAGE (ESP)

- PERCENTAGE OF CEC IN SOIL OCCUPIED BY SODIUM

High levels of carbonate and bicarbonate increase sodium hazard of water

SODIUM ADSORPTION RATIO (SAR)

Table 5. The sodium hazard of water based on SAR Values.

SAR values	Sodium hazard of water	Comments
1-10	Low	Use on sodium sensitive crops such as avocados must be cautioned.
10 - 18	Medium	Amendments (such as Gypsum) and leaching needed.
18 - 26	High	Generally unsuitable for continuous use.
> 26	Very High	Generally unsuitable for use.

Feagley, S. E., Texas AgriLife Extension State Soil Environmental Specialist

LEAF SYMPTOMS OF HIGH SODIUM LEVELS IN WATER

HIGH SODIUM LEVEL AFFECTS ON SOIL

ESP (exchangeagle sodium percentage)
SAR (sodium adsorption ratio)

- HARD COMPACTED SOIL
- REDUCED WATER INFILTRATION
- REDUCED ROOT GROWTH

SODIUM IN WINE

Contribute "soapy" and "salty flavors

Detection threshold for sodium in wine

whites – 1.1 g/l

reds – 1.3 g/l

WATER OF TESTED VINEYARD

Water Source =Well Water Use =Irrigation

Parameter analyzed	Results	Units	Method	V. Limiting	Limiting	Acceptable
Calcium (Ca)	2	ppm	ICP			*****
Magnesium (Mg)	< 1	ppm	ICP			*****
Sodium (Na)	293	ppm	ICP		*****	
Potassium (K)	4	ppm	ICP			*****
Boron (B)	3.66	ppm	ICP		*****	
Carbonate (CO_3)	14	ppm	Titr.			*****
Bicarbonate (HCO_3)	492	ppm	Titr.			*****
Sulfate (SO_4-calculated from total S)	120	ppm	ICP			*****
Chloride (Cl-)	100	ppm	Titr.			*****
Nitrate-N (NO_3-N)	0.04	ppm	Cd-red.			*****
Phosphorus (P)	0.35	ppm	ICP			*****
pH	8.34		ISE			*****
Conductivity	1154	umhos/cm	Cond.		*****	
Hardness	1	grains CaCO3/gallon	Calc.			*****
Hardness	9	ppm CaC03	Calc.			*****
Alkalinity	427	ppm CaC03	Calc.		*****	
Total Dissolved Salts (TDS)	1029	ppm	Calc.		*****	
SAR	42.8		Calc.	*****		
Iron (Fe)	< 0.01	ppm	ICP			*****
Zinc (Zn)	0.01	ppm	ICP			*****
Copper (Cu)	< 0.01	ppm	ICP			*****
Manganese (Mn)	0.05	ppm	ICP			*****
Arsenic (As)						
Barium (Ba)						
Nickel (Ni)						
Cadmium (Cd)						
Lead (Pb)						
Chromium (Cr)						

Guidelines for Interpreting Soil Salinity Analysis for Grapevines

Analysis (units of measurement)	No Problem	Increasing Problems	Severe Problems
Salinity			
Electrical Conductivity = EC_e (umhos/cm or dS/m)	1.5 – 2.5	2.5 – 4	4 – 7
Total Dissolved Solids = TDS (ppm or mg/L)	960 – 1600	1600 – 2560	2560 - 5600
Permeability			
Exchangeable Sodium Percentage (ESP)	< 10%	10 – 15%	> 15%
Sodium Toxicity			
(Meq/L)	-	> 30	-
(ppm or mg/L)	-	> 690	-
Chloride Toxicity			
(Meq/L)	< 10	10 – 30	> 30
(ppm or mg/L)	< 350	350 - 1060	> 1060
Boron Toxicity			
(ppm or mg/L)	< 1	1 – 3	> 3

Guidelines for Interpreting Irrigation Water Quality for Grapevines

Analysis (units of measurement)	No Problem	Increasing Problems	Severe Problems
Salinity			
Electrical Conductivity = EC_w (umhos/cm or dS/m)	< 1.0	1.0 - 2.7	> 2.7
Total Dissolved Solids = TDS (ppm or mg/L)	< 640	640 - 1728	> 1728
Permeability			
Sodium Adsorption Ratio (SAR)	< 6	6 - 9	> 9
Sodium Toxicity*			
(Meq/L)	< 20	-	-
(ppm or mg/L)	< 460	-	-
Soluble Sodium Percent	< 60%		
Chloride Toxicity*			
(Meq/L)	< 4	4 – 15	> 15
(ppm or mg/L)	< 140	140 – 525	> 525
Boron Toxicity			
(ppm or mg/L)	< 1	1 – 3	> 3

CONTRIBUTING FACTORS

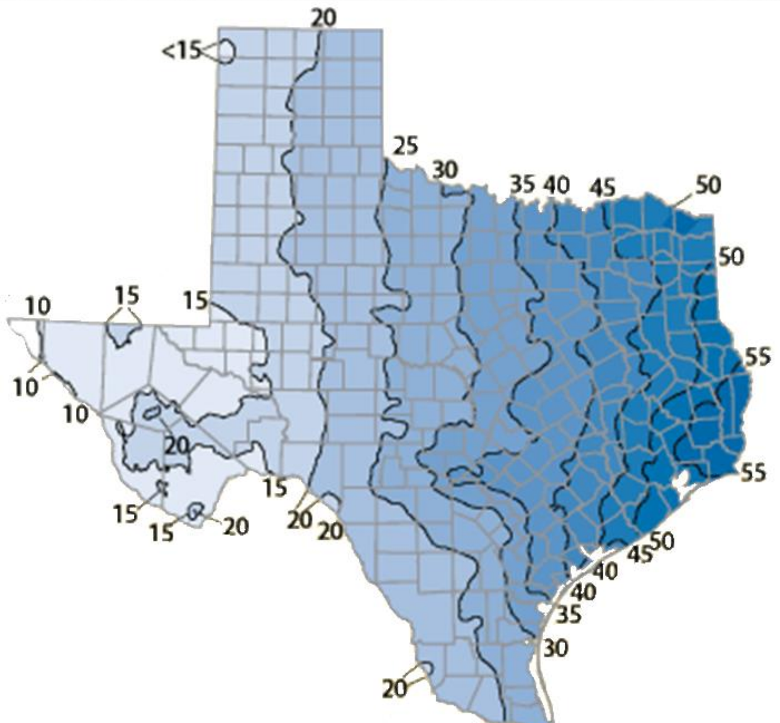
OFFENDING SALTS

SODIUM, CHLORIDE VS. SULFATES, CARBONATES

SOIL TYPE

COARSE TEXTURED SOILS LOWER RISK

RAINFALL/IRRIGATION DEPENDENCY



Texas Water Development Board

SOILS OF TESTED VINEYARD

Crop Grown: GRAPES

Analysis	Results	CL*	Units	ExLow VLow Low Mod High VHigh Excess.	Fertilizer Recommended
pH	4.5	(5.8)	-	Strongly Acid	
Conductivity	84	(-)	umho/cm	None	
Nitrate-N	14	(-)	ppm		0 lbs N/acre
Phosphorus	65	(50)	ppm		0 lbs P2O5/acre
Potassium	102	(150)	ppm		15 lbs K20/acre
Calcium	681	(180)	ppm		0 lbs Ca/acre
Magnesium	102	(50)	ppm		0 lbs Mg/acre
Sulfur	17	(13)	ppm		0 lbs S/acre
Sodium	63	(-)	ppm		
Iron	204.44	(4.25)	ppm		
Zinc	2.12	(0.27)	ppm		0 lbs Zn/acre
Manganese	19.54	(1.00)	ppm		0 lbs Mn/acre
Copper	0.27	(0.16)	ppm		0 lbs Cu/acre
Boron	0.21	(0.60)	ppm		1 lbs B/acre
Limestone Requirement					1.00 tons 100ECCE/acre
Limestone Requirement (Chemical Test)					1.2 tons 100ECCE/acre
Organic Matter	2.28		%		

Detailed Salinity Test (Saturated Paste Extract)			
pH	5.4		
Conductivity	0.39	mmhos/cm	
Sodium	50	ppm	2.160 meq/L
Potassium	18	ppm	0.448 meq/L
Calcium	29	ppm	1.455 meq/L
Magnesium	7	ppm	0.578 meq/L
SAR	2.14		
SSP	46.55		

*CL=Critical level is the point which no additional nutrient (excluding nitrate-N, sodium and conductivity) is recommended.

Limestone recommendations are based on 100 ECCE liming products. Limestone applications >3 tons/acre should be made >4 months prior to crop establishment to lessen micro-nutrient availability issues.

IRON DEFICIENCY IN ALKALINE SOIL

MAGNESIUM DEFICIENCY IN ALKALINE SOIL

Mitigating Saline Irrigation Water

- Mulch
- Store rainwater –
  pond or tanks
- Plant with rootstocks
- Leach the soil when irrigating
- Apply soil amendments –
  Gypsum most common
  Sulfur high alkaline soils

GYPSUM REQUIREMENT

$$2NaX + CaSO_4 \rightleftharpoons CaX_2 + Na_2SO_4$$

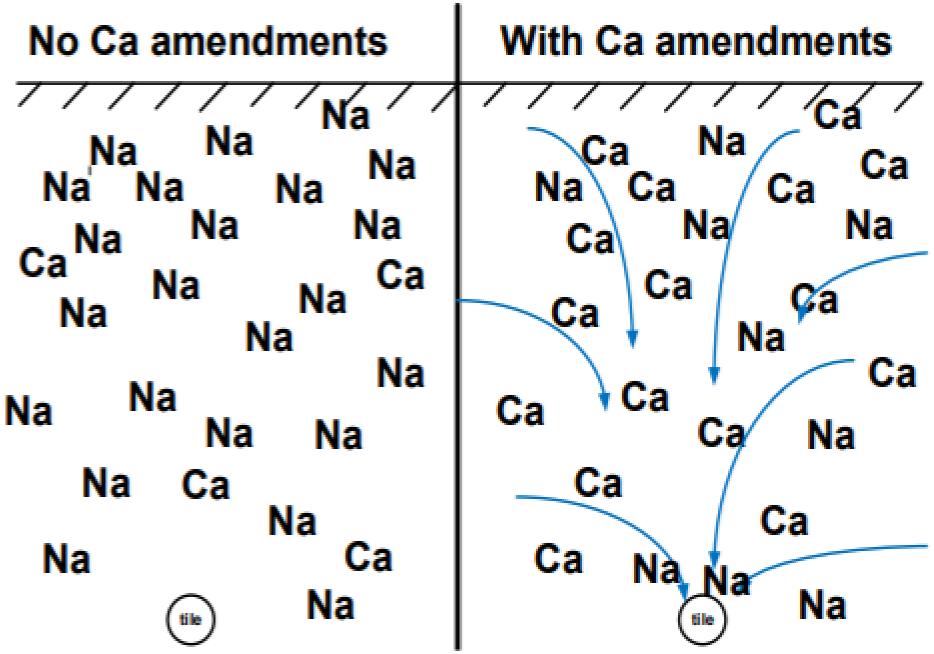


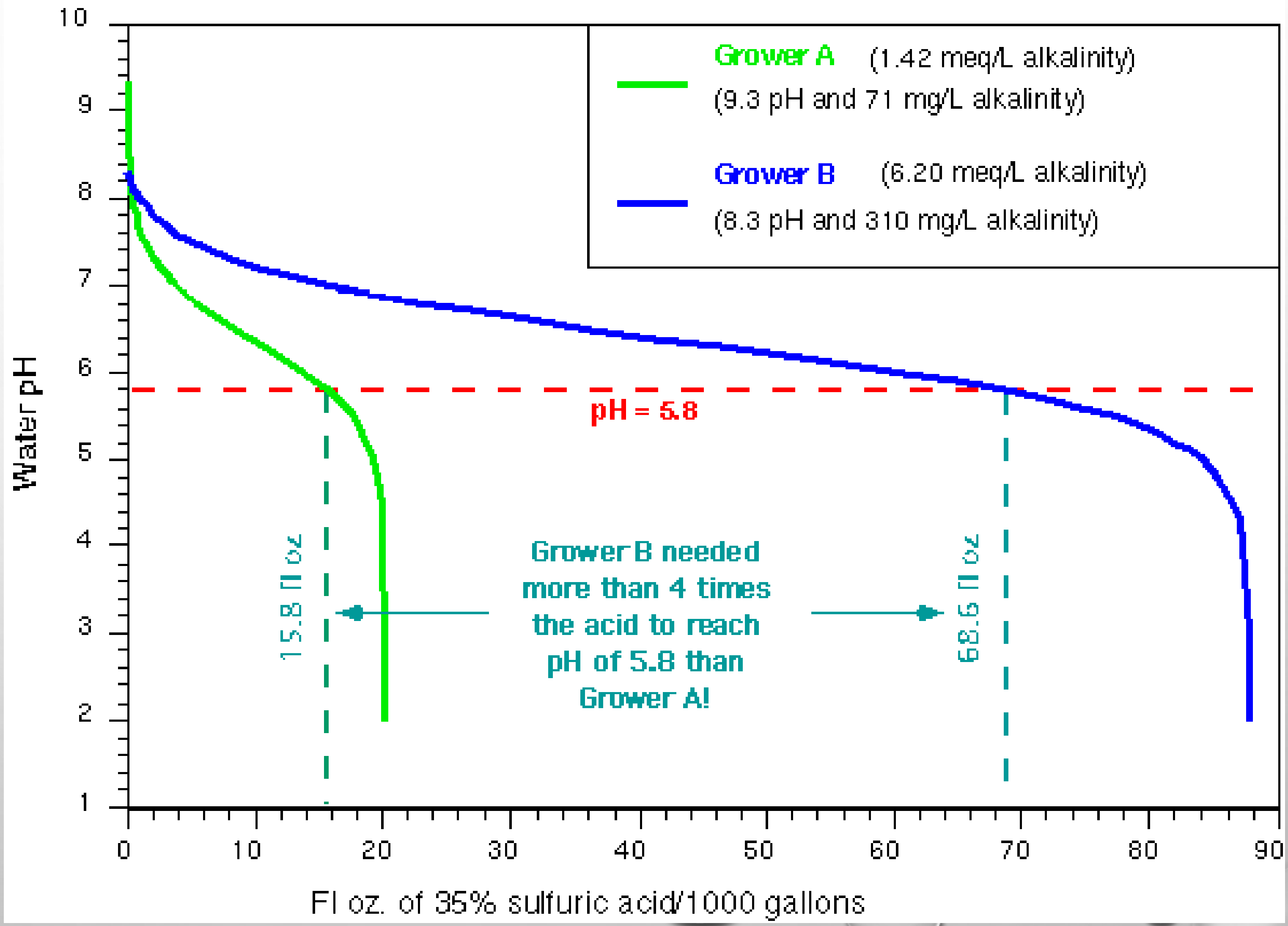
Figure by Thomas DeSutter and Maria Breker

ACID INJECTION REQUIREMENT

Determined by:

- total carbonates
- pH of water
- acid type

Figure from: Polydrip.com



RESOURCES

- SOILTESTINGLAB@TAMU.EDU TEXAS A&M SOIL, WATER, AND TISSUE TESTING LAB
- TEXASET.TAMU.EDU TEXAS A&M IRRIGATION TECHNOLOGY
- TWDB – TEXAS WATER DEVELOPMENT BOARD
- NRCS – NATURAL RESOURCE CONSERVATION SERVICE
- TEXAS DEPARTMENT OF AGRICULTURE
- USGS US GEOLOGICAL SURVEY
- TCEQ TEXAS COMMISSION ON ENVIRONMENTAL QUALITY (REGULATORY)