Soil Analysis Driven Vineyard Design

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Goal of Winegrape Viticulture

- Provide the winery super-duper ultra-premium quality fruit.
- One of the major components of this goal is uniform ripeness of fruit within each **harvest** unit.
- A **block** is a field management zone.
- A **harvest unit** is the grapes that once harvested are mixed together to go to the winery.

Ripeness

- Somewhat subjective, but it is agreed that fruit should be uniformly ripe.
- All clusters 25 brix +/- 0.3; not an average of 21 to 27 brix.
- Great wine is not made by picking across a spectrum of ripeness.

Uniform Ripeness is achieved by:

- Uniform fruit maturation
- Uniform vine growth
- Uniform supply of water and nutrition
- Uniform soil
- Block design to compartmentalize similar soils and separate dis-similar soils.

Why a soil driven design and what will it provide?

- The Soil mass supplies all of the major components (water and nutrients) for plant growth - except light.
- Even minor variations in soil properties influence vine growth and performance.
- The **soil driven design** will provide a planting and management plan to minimize the influence in changes in soil properties across the landscape on vine growth and consequent fruit quality.

A Soil Driven Design should provide:

- Assessment of soil physical and chemical properties from the surface to a depth of the probable future rootzone (48” to 60”).
- Estimated soil total available water (TAW) with depth.
- Partition of soil blocks based on Total Available Water (TAW) and nutritional availability.
- Recommended tillage depth and implement type to reduce variability in TAW within each block.
- Matching of rootstocks to the soil properties.
- Matching of the planting density to the soil and rootstock properties.
- Recommended pre-plant and post plant amendments.

Who is a qualified soil scientist?

- University trained soil scientist (M.S. or Ph.D. is best). A soil science degree will require classes in introductory soils; soil fertility, soil chemistry, soil genesis and morphology; soil physics, soil microbiology.
- Advanced degrees will require these same classes at the graduate level to even greater depth.
- Most viticulturist do not have the depth of training to do competent soil analysis and interpretation. Most have only had one or two classes in soils. That does not make them an expert.
- Would you hire your dentist to do your heart surgery?
- Ask to see credentials of person claiming to be soil scientist !!!

Pre-Field Work Diagnostic Tools

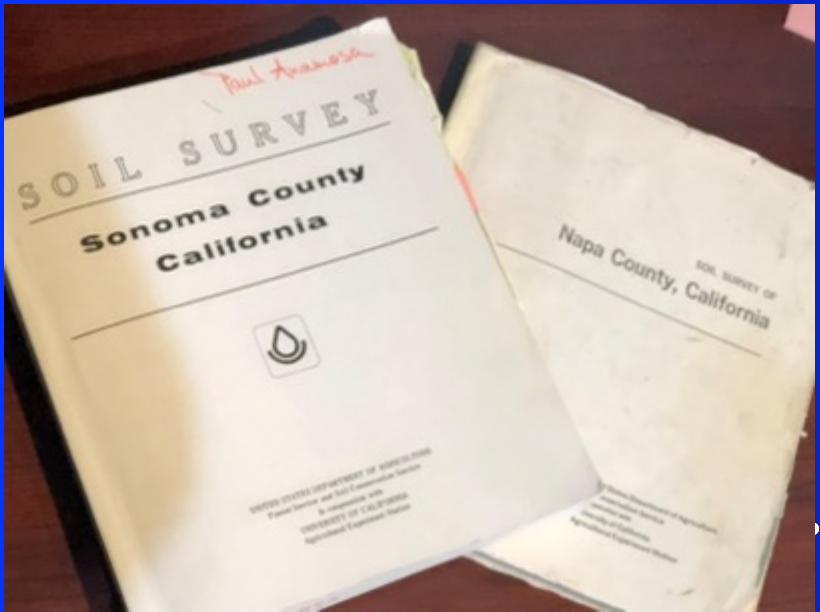
- **Soil Surveys** were conducted for most agricultural areas in the US in the 1970’s and 80’s that mapped the characteristics of soils across the landscape.
- There are several tools that use “remote sensing” to determine differences in soil and plant growth over the landscape.
- **Google Earth:** Historical photos to determine previous land use and weak and strong growth areas across the landscape.
- **Normalized Difference Vegetative Index (NDVI)** use data gathered by aerial cameras that measure wavelengths of light absorbed and reflected by green plants.
- **Enhanced Vegetation Index**, a ratio of how much sunlight is reflected off the plants in different color bands, including infrared. Less influenced by time of day or shade.
- **ElectroMagnetic Induction** uses an electromagnetic scanner that is pulled across the soil and sends down an electromagnetic pulse.

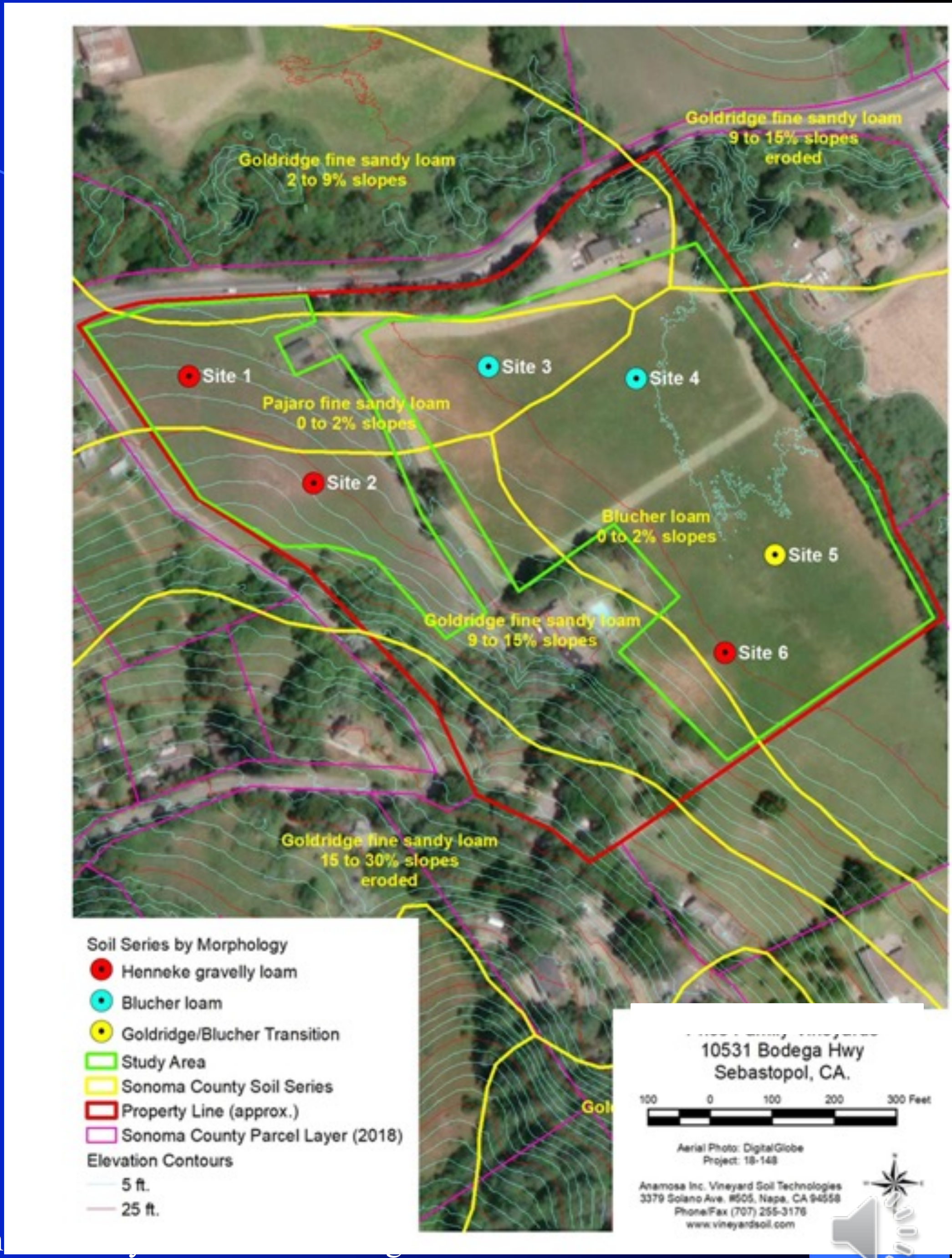
Soil Survey

Used field survey crews to map soil properties across the landscape.

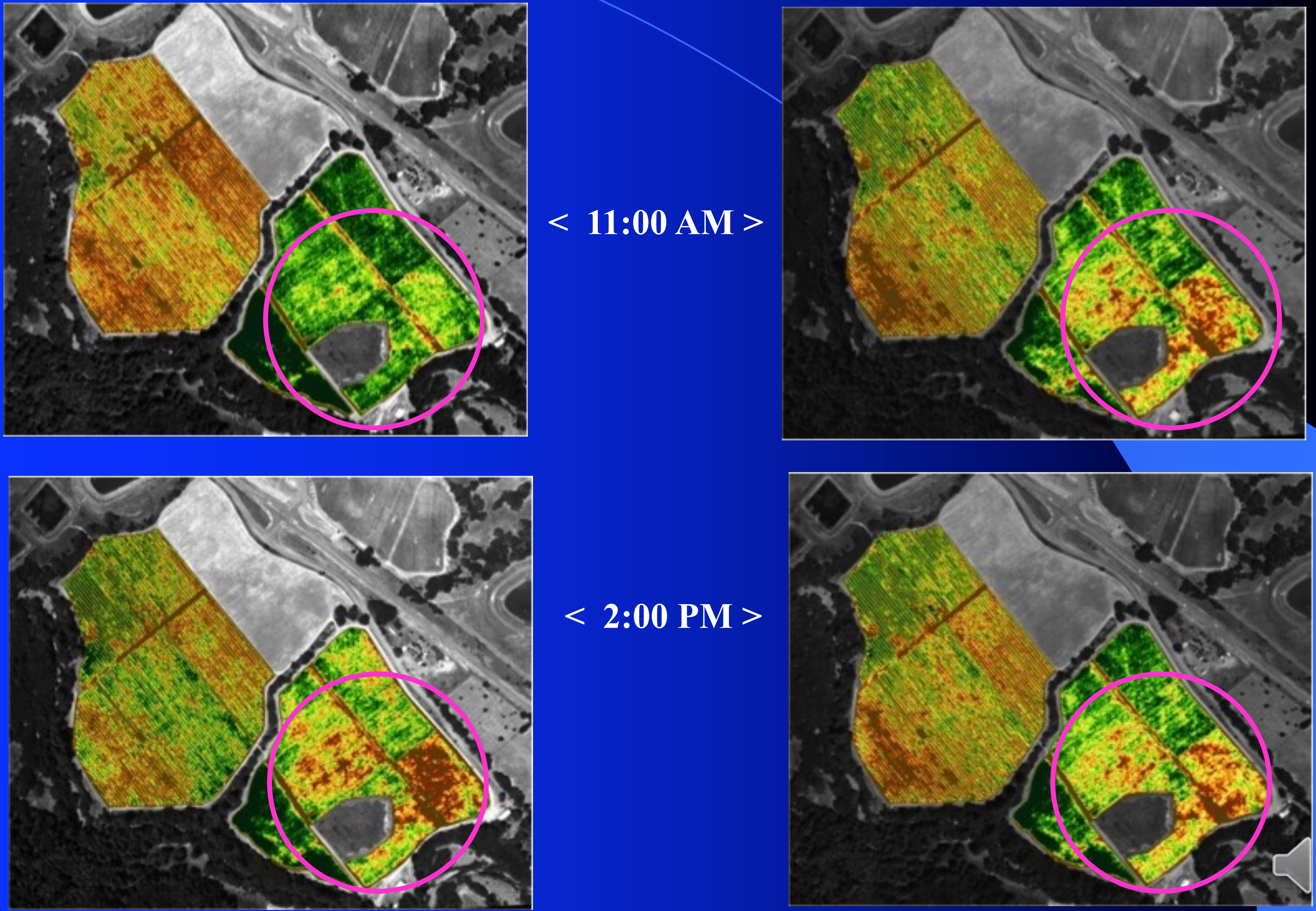
Allows for wide variations in soil chemical and physical data.

Map Units are named after a soil series, but each map unit may contain up to 40% other soils. So accuracy is moderate.





NDVI versus EVI



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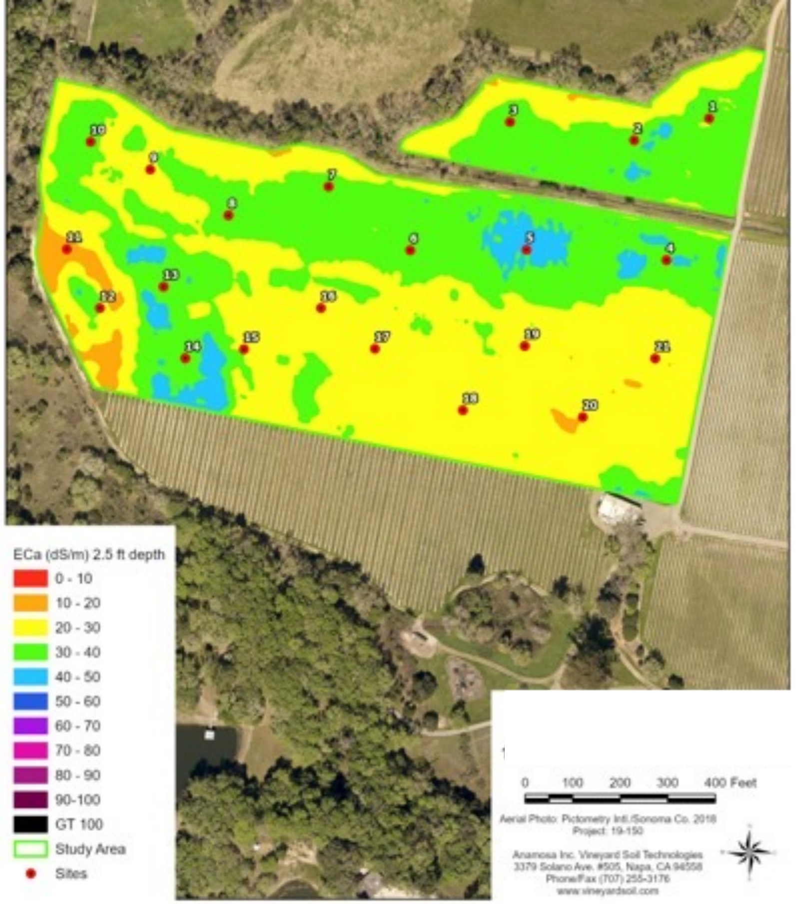
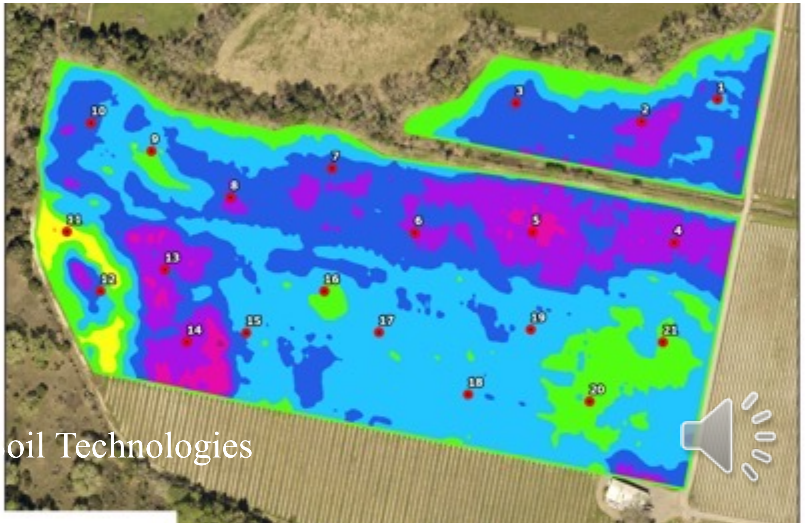
Electromagnetic Scanner

The transmission coil is working with an alternating current and generates a time-varying magnetic field in the soil. This magnetic field causes current to flow in the soil and generates a secondary magnetic field. The ratio of the secondary to the primary magnetic field is proportional to the ground conductivity of the soil.

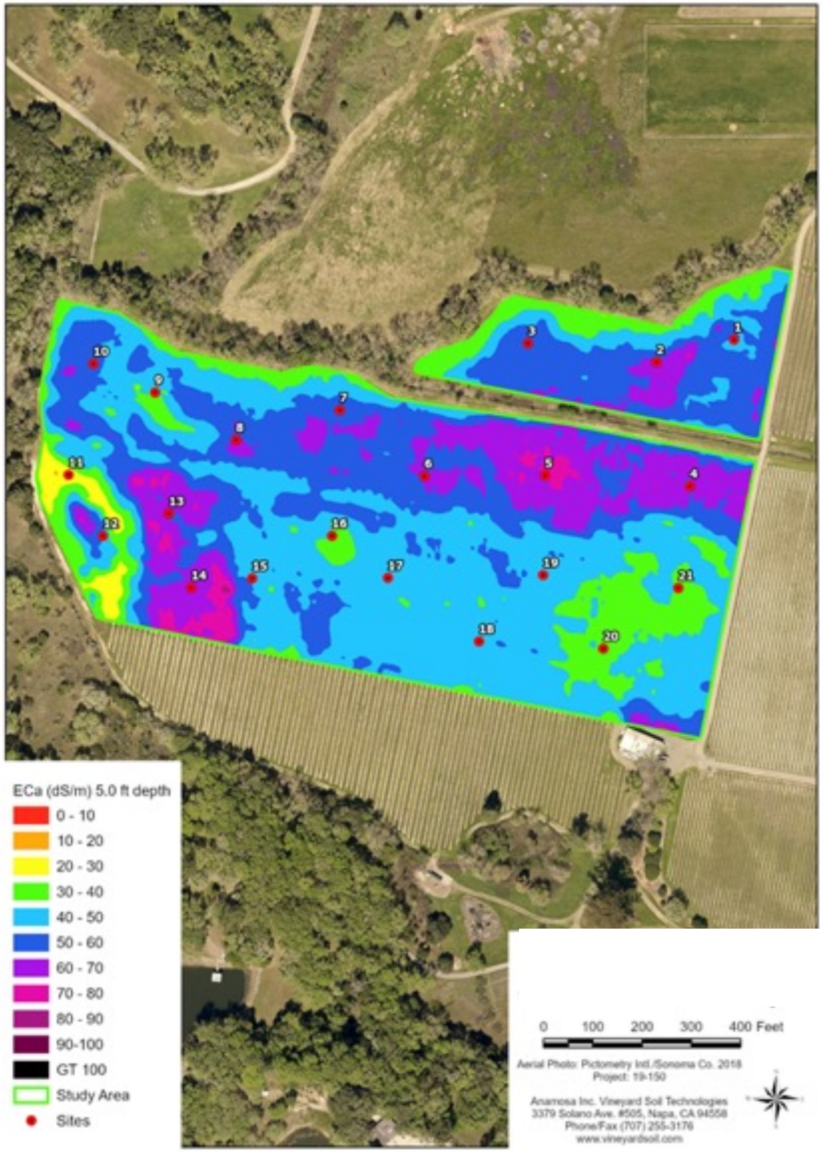
Soil Electrical Conductivity

- Only measures electrical conductivity and shows how that changes across the landscape.
- Does not have channels that measure anything else (Ca, Mg, pH, etc.)
- Does not differentiate between soil and rock well
- Measures only soil electrical conductivity, not plant vigor.
- Can display interference with trellis metals if less than 6-foot rows0





Electromagnetic Scanner: Allows for more precise and effective soil pit placement.



Aerial Photo: Pictometry Intl./Sonoma Co. 2018
Project: 19-150

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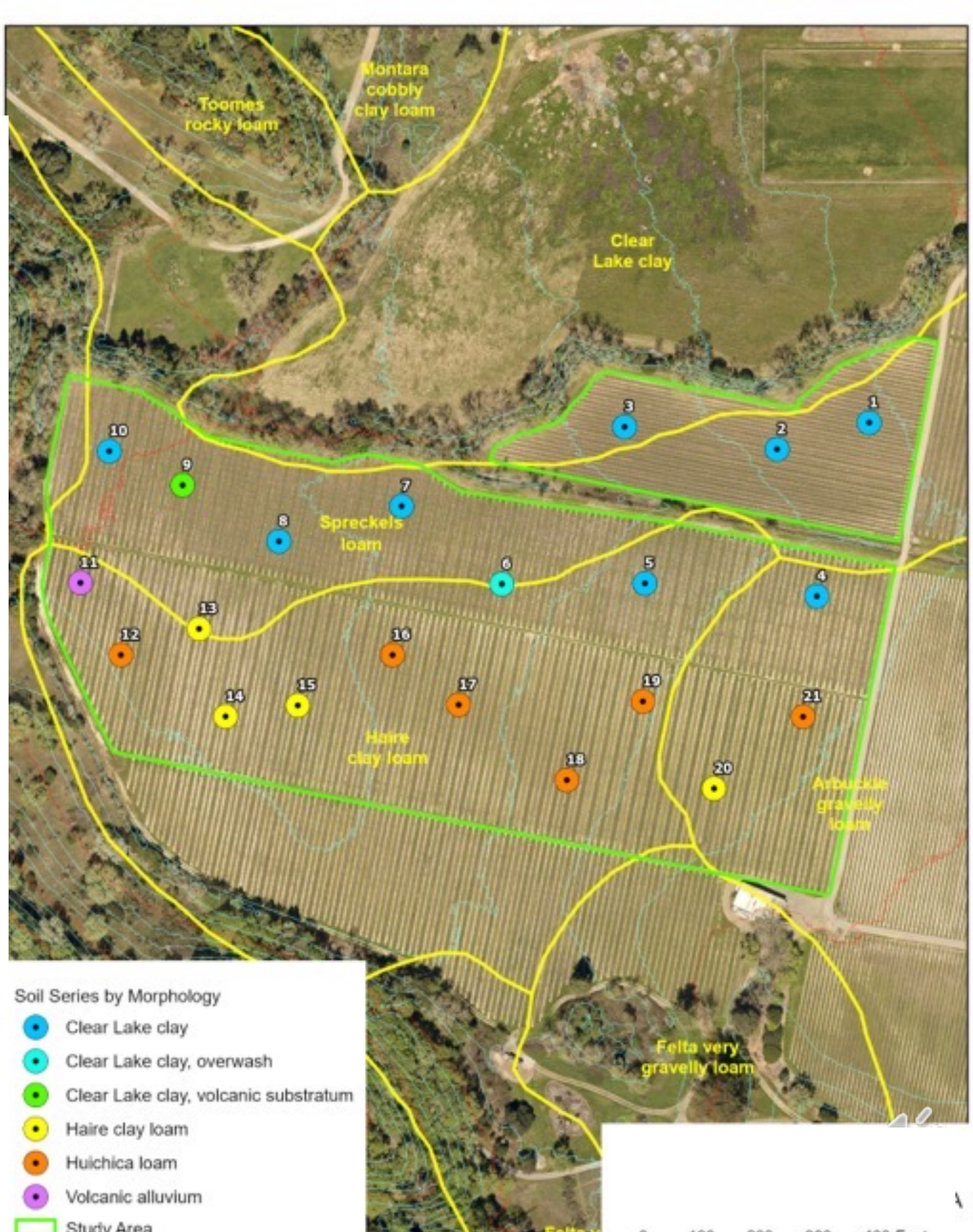
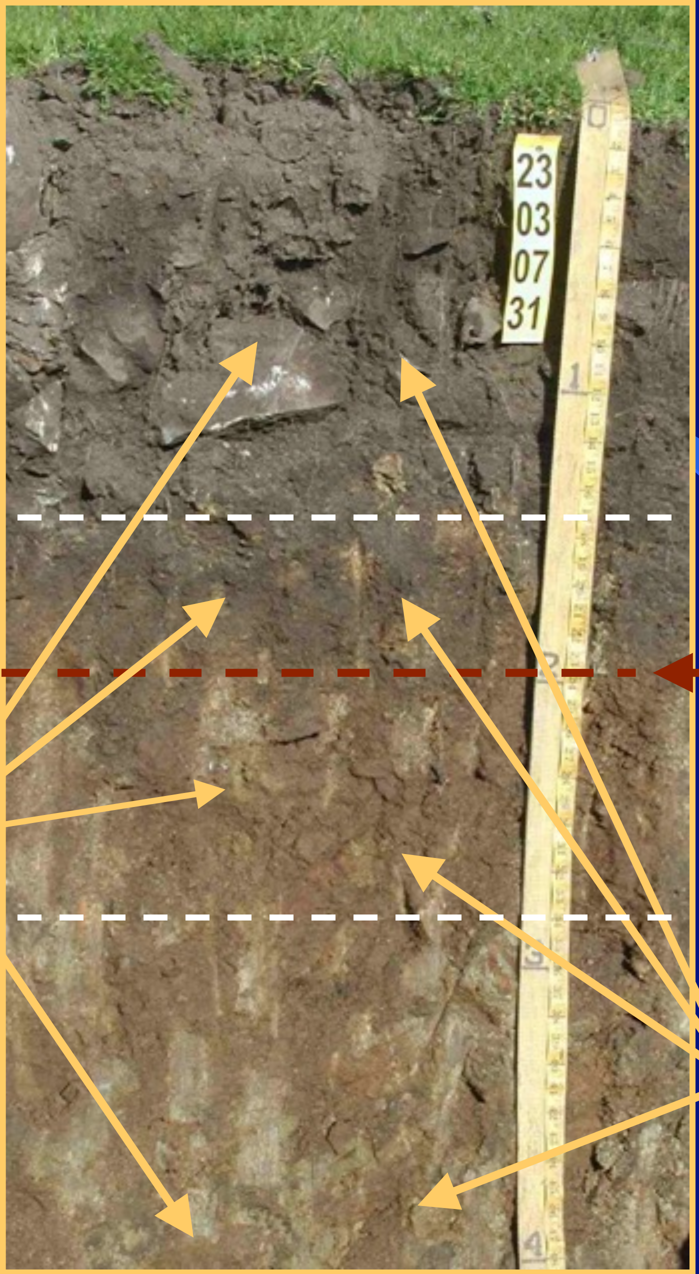


Evaluating Viticultural Potential

Layer depths
+
Texture
+
Rock %
+
Structure
+
. . .
=
TAW for each layer



Effective root depth

Salinity
Sodicity
Chloride
Alkalinity/Acidity
Aluminium
Boron
Ca:Mg
Heavy Metals

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Soil Physical Properties assessed by depth (horizons)

- Texture
- Structure & Porosity
- Hardness
- Rock type and volumetric content
- Presence of mottling or gleying
- Current rooting depth
- Combine them all into a Total Available Water with depth.

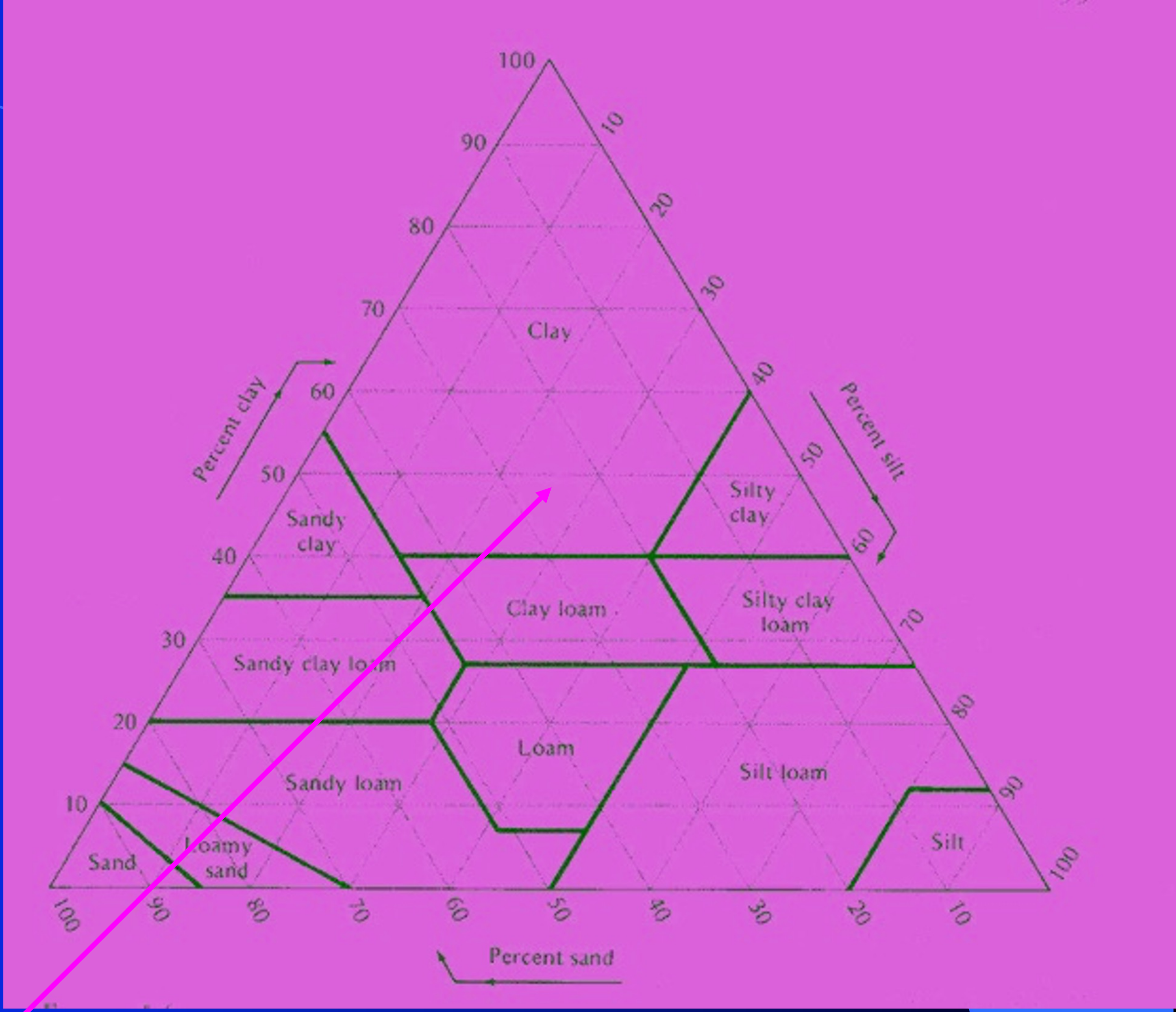
Texture

Soil is made up of air, organic matter and small mineral particles (LT 2mm) and rock (GT 2mm).

The less than 2mm is divided into size classes of sand, silt and clay.

The percentage of each of these particle sizes constitutes a soil’s texture.

Soil texture is a mix of different sized particles



A soil of this texture is called a Clay, but has only 50% clay, and 25% sand and 25% silt.

Soil Profile

Scale inches

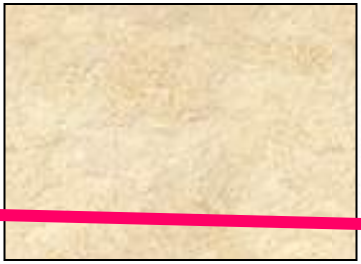
Soil Peds

Granular

Lenticular

Platy

Massive (no Peds)

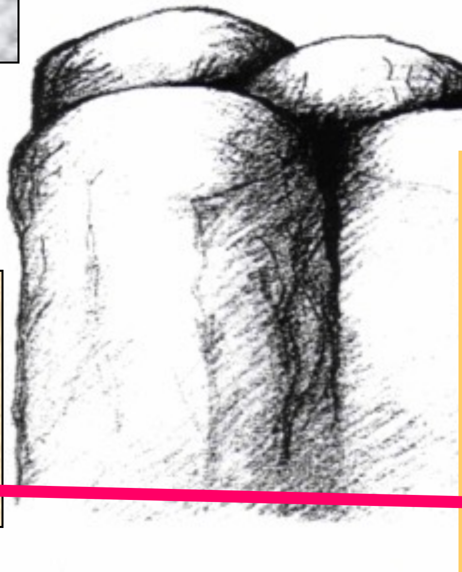


Sandy (no Peds)

Angular blocky

Subangular blocky

Polyhedral



Columnar

Prismatic

Hardness

- Is tillage needed?
- Will subsoil hardness stop roots to tillage depth?

Rock Content

- Amount of rock by volume
- Depth to non-tillable rock
- Rock type (shale, rhyolite, alluvial, etc.

Pa

What is Total Available Water?

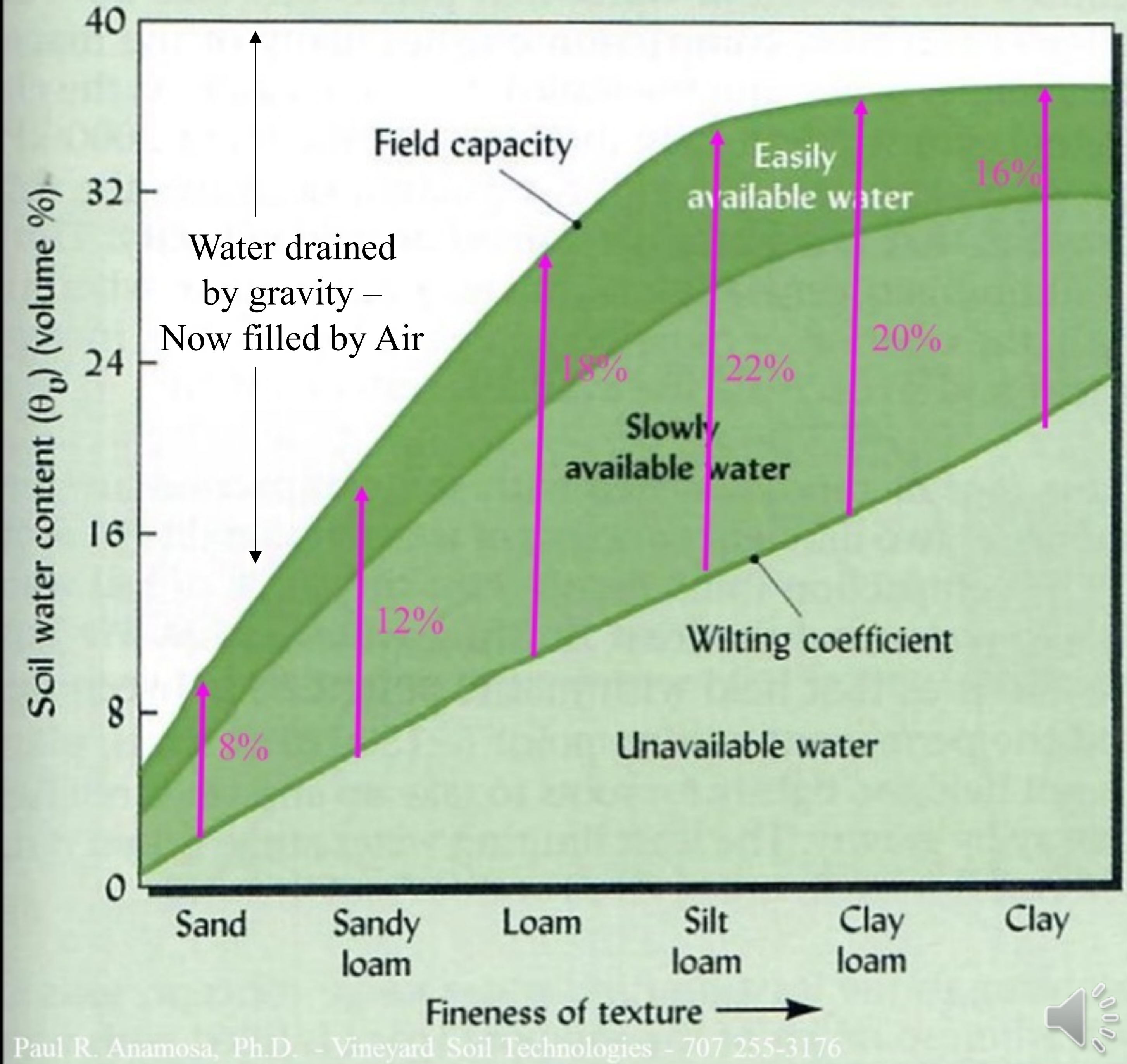
Soil:
Air / Water 48% volume
Minerals 52% volume

Compress all soil in the effective root depth

Air remaining at Field Capacity

Inches of Total Available Water In the Effective Root Depth

Total Available Water influenced by Texture



Rock content limits TAW increase

5 % rock

TAW 6 inches
High vigor

40 % rock

TAW 4 inches
High vigor

75 % rock

TAW 1.8 inches
Low vigor

Rip to 48 inches

Total available water and ripping depth

5 % rock

TAW 1 inches
Very low vigor
Shallow

Natural root depth

5 % rock

TAW 2 inches
Low to Moderate vigor

Rip to 24 inches

5 % rock

TAW 6 inches
High vigor

Rip to 48inches

Soil profile information shown in a Profile Log

Legend: **Too high** ▨ Too Low ▦ Questionable ▥ Undesirable ▤

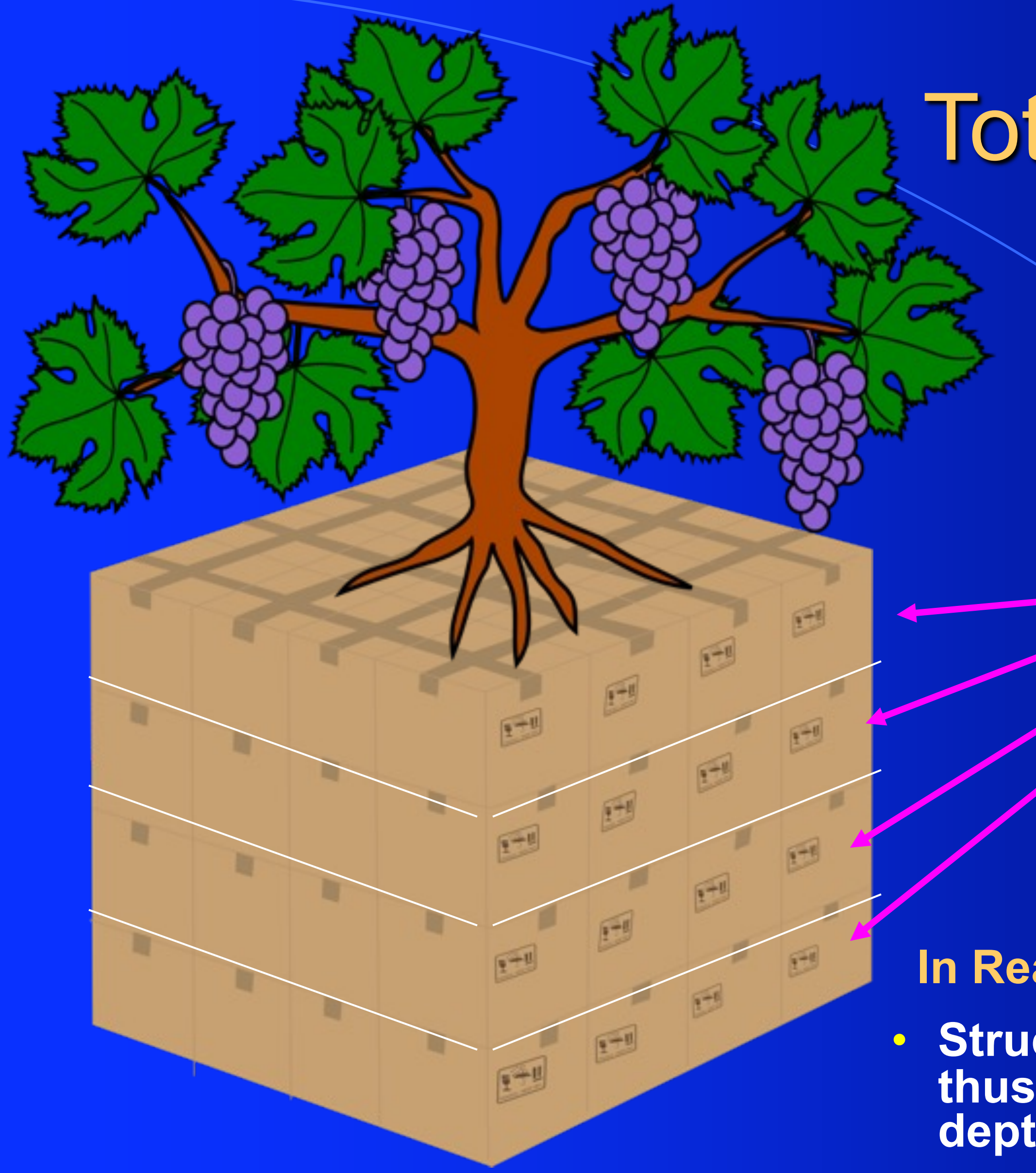
Depth	Scale in feet and inches. Second scale if present in cm.	Color	Texture	Rock	Soil Structure		Plasticity	Visible pores	Mottles	Free lime	Root density
					Hardness	Type					
in.	Profile No: 2	Rocky Brown Loamy over Brown Sandy Soil (Pk)							ERD (in.):		47
18		Dark Brown	Loam	40 % 1 to 2 inch Rounded alluvial	Firm	Fine Granular	Moderate	Many	No	No	Many
47		Dark Reddish Brown	Medium Sandy loam	70 % 2 to 4 inch Rounded alluvial	Firm	V.Fine Blocky	Low	Many	No	No	Many
60		Dark Reddish Brown	Medium Sandy loam	70 % 2 to 4 inch Rounded gravel and cobles	Firm	Massive	Low	Few	No	No	Few

Soil Rating Scheme based on Total Available Water (TAW) in the Effective Rooting depth (ERD)

TAW in the ERD (inches of water)	Soil Type Class	Rating	Management and Vine Performance Implications
< 1.5	I	Very low	Irrigation critical: Fruit quality often good
1.5 to 2.5	II	Low	Irrigation necessary: Fruit quality good
2.5 to 3.5	III	Moderately low	Irrigation desirable: Fruit quality optimal
3.5 to 4.5	IV	Moderately high	Irrigation desirable: Fruit quality optimal
4.5 to 6.0	V	High	Irrigation optional, Fruit quality questionable
6.0 to 8.0	VI	Very high	Irrigation unnecessary, Quality poor
> 8.0	VII	Excessive	Not suitable for premium wine production

(after Roberts & Cass, PWV 2007)

Total Available Water



TAW per vine in 7 ft row x 5 ft vine vineyard

Clay loam at Field Capacity, 20% water by volume

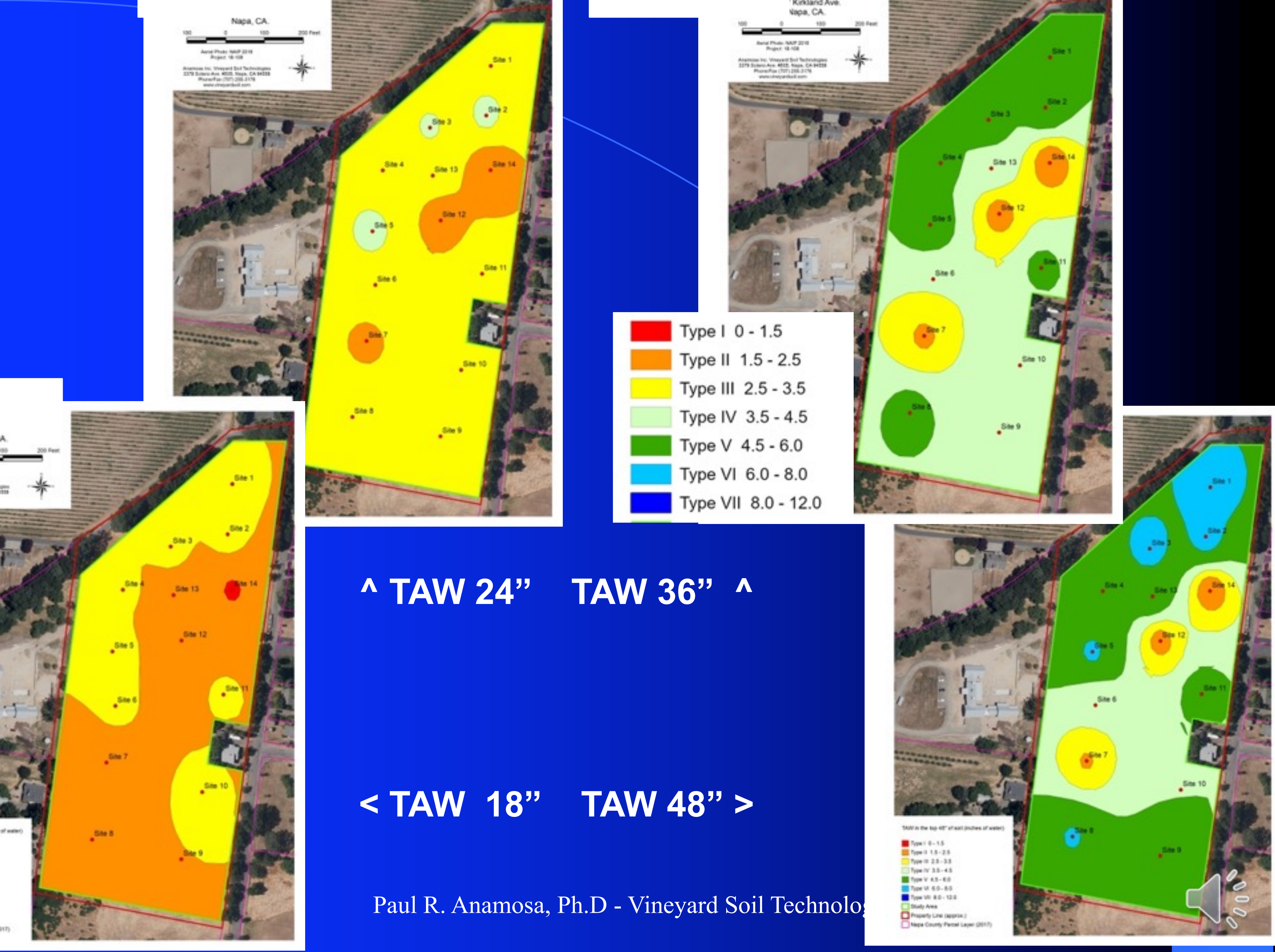
Depth *inches*	Water *inches*	Water *inches*^{3}	Water *gallons*
12	2.4	12096	52.36
24	4.8	24192	104.73
36	7.2	36288	157.09
48	9.6	48384	209.45

1 gal = 231 in^3

1 inch rain is 5040 inch^3 and 21.82 gallon

In Reality:

- **Structure is less porous with depth and thus less water holding capacity with depth.**
- **Rock does not hold available water**



^ TAW 24”   TAW 36”   ^

< TAW 18”   TAW 48” >

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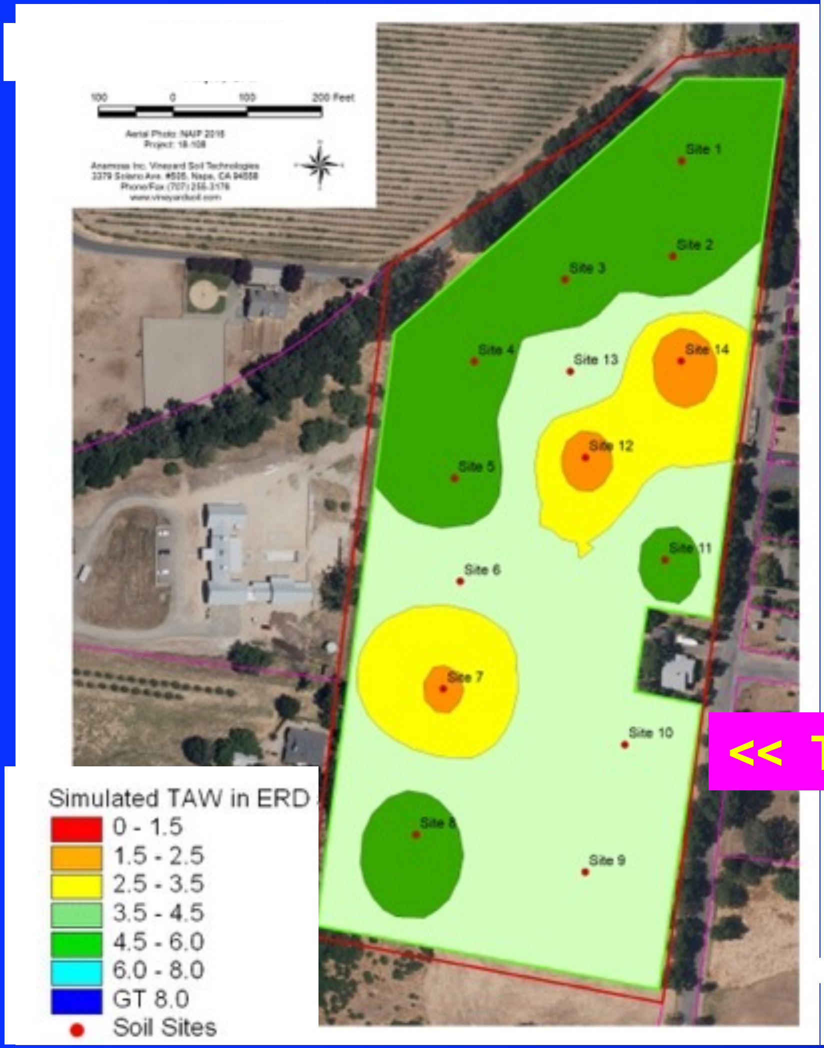
Rootstock Choices based on Total Available Water (TAW) in the Effective Rooting depth (ERD)

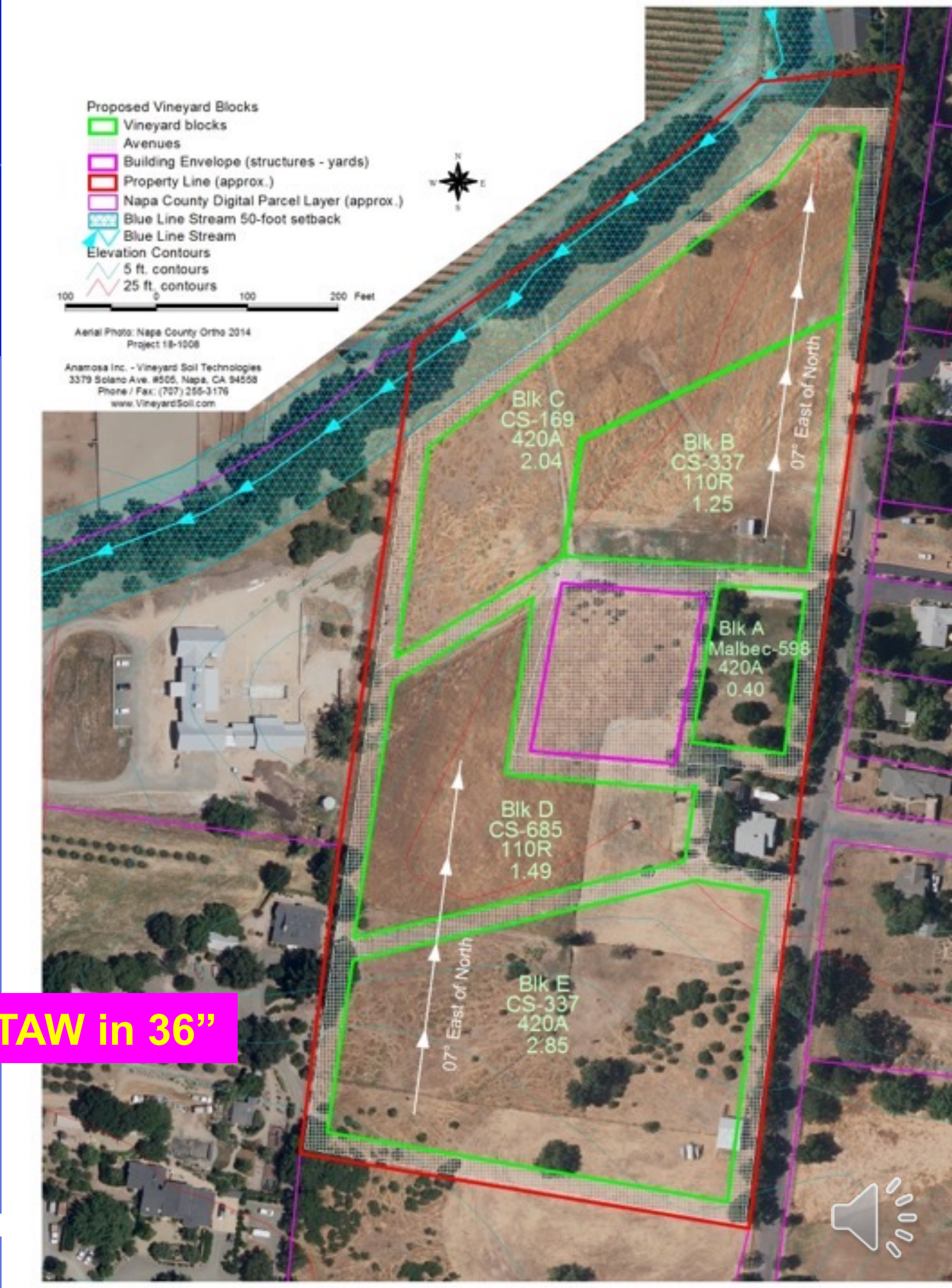
TAW in the ERD (inches of water)	Soil Type Class	Rating	Management and Vine Performance Implications
< 1.5	I	Very low	110R, 1103P, 140R
1.5 to 2.5	II	Low	3309C, Schwarzmann, 110R
2.5 to 3.5	III	Moderately low	3309C, 420A, 1616C
3.5 to 4.5	IV	Moderately high	420A, 1616C
4.5 to 6.0	V	High	420A, 1616C, Riparia Gloire
6.0 to 8.0	VI	Very high	Riparia Gloire
> 8.0	VII	Excessive	Not suitable for Premium Winegrapes

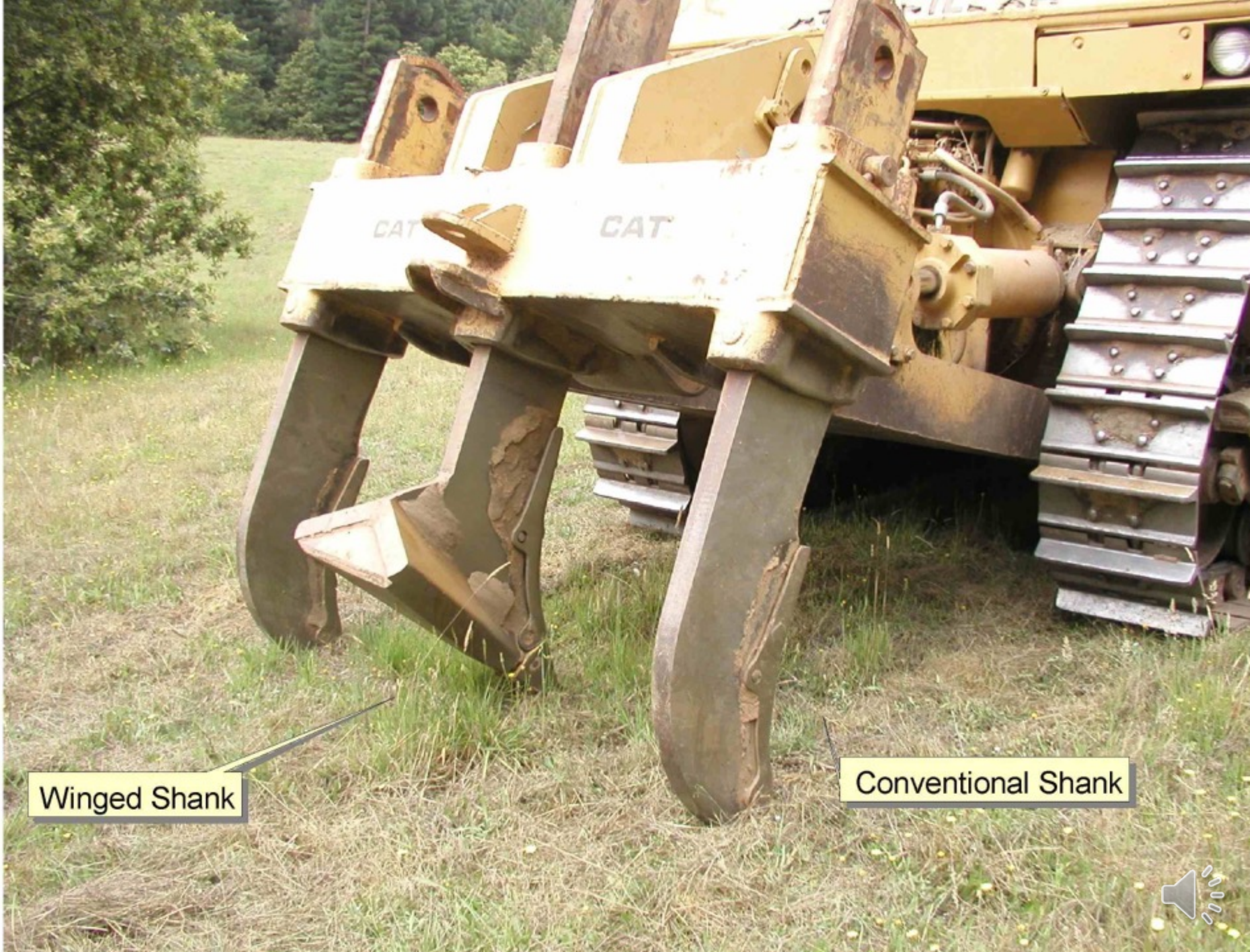
(after Roberts & Cass, PWV 2007)

Using total available water to determine deep tillage depth to establish rootzone depth.



<< TAW in 36”





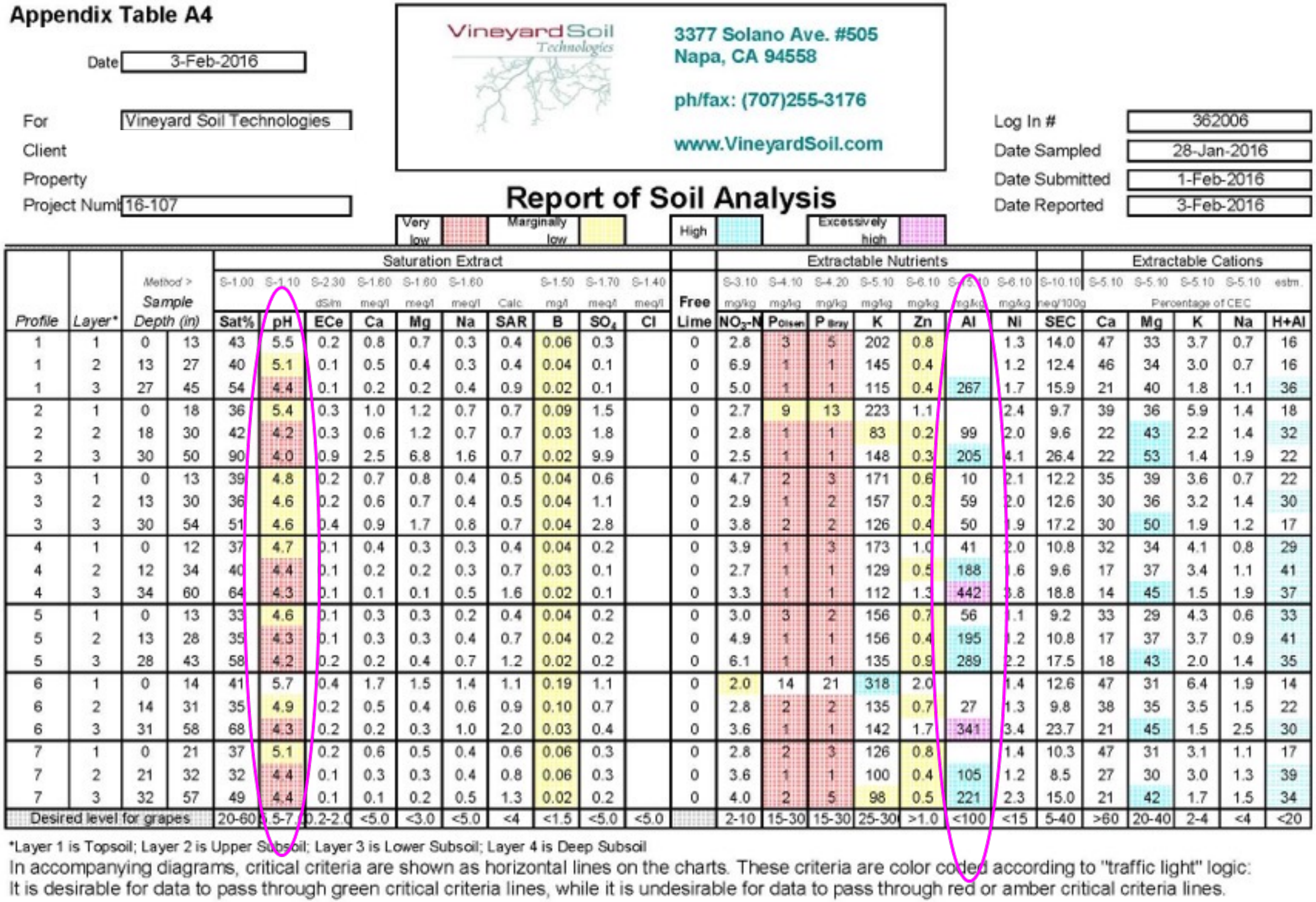
Winged Shank

Conventional Shank

Soil Chemistry & Fertility Status

1. **Determine soil pH and method of modification if needed.**
2. **Quantify nutrient concentrations with appropriate measure of bio-availability (i.e. Olsen vs. Bray analysis for phosphorus).**
3. **Determine if there are any elements within the Toxicity Range (boron, sodium, chloride, nickel, aluminum).**
4. **Determine most effective or efficient method for nutrient application (broadcast, tilled, banded, fertigation, foliar).**
5. **Extremely deficient nutrients should be added pre-plant or immediate post-plant to ensure high concentrations in rootzone.**
6. **Try to relieve all nutrient deficiencies except for possibly nitrogen.**

Appendix Table A4



Date 3-Feb-2016

For Vineyard Soil Technologies
Client
Property
Project Numb 16-107

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Log In # 362006
Date Sampled 28-Jan-2016
Date Submitted 1-Feb-2016
Date Reported 3-Feb-2016

Report of Soil Analysis

Very low 🟥 Marginally low 🟨 High 🟦 Excessively high 🟪

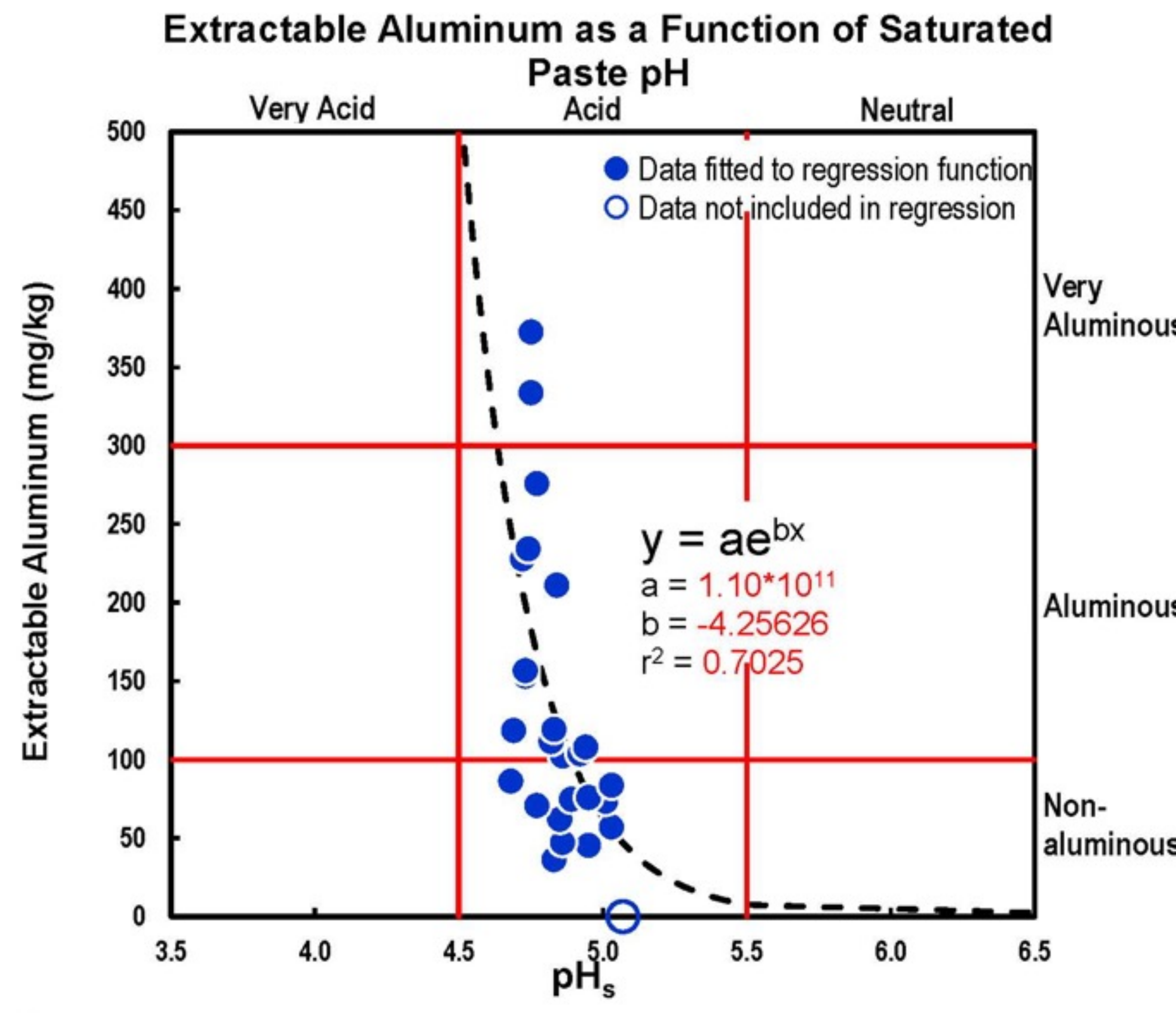
				Saturation Extract											Extractable Nutrients								Extractable Cations				
		Method >		S-1.00	S-1.10	S-2.30	S-1.60	S-1.60	S-1.60		S-1.50	S-1.70	S-1.40		S-3.10	S-4.10	S-4.20	S-5.10	S-6.10	S-5.10	S-6.10	S-10.10	S-5.10	S-5.10	S-5.10	S-5.10	estm.
		Sample				dS/m	meq/l	meq/l	meq/l	Calc.	mg/l	meq/l	meq/l	Free	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/100g	Percentage of CEC				
Profile	Layer*	Depth (in)		Sat%	pH	ECe	Ca	Mg	Na	SAR	B	SO_4	Cl	Lime	NO_3-N	P_{Olsen}	P_{Bray}	K	Zn	Al	Ni	SEC	Ca	Mg	K	Na	H+Al
1	1	0	13	43	5.5	0.2	0.8	0.7	0.3	0.4	0.06	0.3		0	2.8	3	5	202	0.8		1.3	14.0	47	33	3.7	0.7	16
1	2	13	27	40	5.1	0.1	0.5	0.4	0.3	0.4	0.04	0.1		0	6.9	1	1	145	0.4		1.2	12.4	46	34	3.0	0.7	16
1	3	27	45	54	4.4	0.1	0.2	0.2	0.4	0.9	0.02	0.1		0	5.0	1	1	115	0.4	267	1.7	15.9	21	40	1.8	1.1	36
2	1	0	18	36	5.4	0.3	1.0	1.2	0.7	0.7	0.09	1.5		0	2.7	9	13	223	1.1		2.4	9.7	39	36	5.9	1.4	18
2	2	18	30	42	4.2	0.3	0.6	1.2	0.7	0.7	0.03	1.8		0	2.8	1	1	83	0.2	99	2.0	9.6	22	43	2.2	1.4	32
2	3	30	50	90	4.0	0.9	2.5	6.8	1.6	0.7	0.02	9.9		0	2.5	1	1	148	0.3	205	4.1	26.4	22	53	1.4	1.9	22
3	1	0	13	39	4.8	0.2	0.7	0.8	0.4	0.5	0.04	0.6		0	4.7	2	3	171	0.6	10	2.1	12.2	35	39	3.6	0.7	22
3	2	13	30	36	4.6	0.2	0.6	0.7	0.4	0.5	0.04	1.1		0	2.9	1	2	157	0.3	59	2.0	12.6	30	36	3.2	1.4	30
3	3	30	54	51	4.6	0.4	0.9	1.7	0.8	0.7	0.04	2.8		0	3.8	2	2	126	0.4	50	.9	17.2	30	50	1.9	1.2	17
4	1	0	12	37	4.7	0.1	0.4	0.3	0.3	0.4	0.04	0.2		0	3.9	1	3	173	1.0	41	2.0	10.8	32	34	4.1	0.8	29
4	2	12	34	40	4.4	0.1	0.2	0.2	0.3	0.7	0.03	0.1		0	2.7	1	1	129	0.5	188	.6	9.6	17	37	3.4	1.1	41
4	3	34	60	64	4.3	0.1	0.1	0.1	0.5	1.6	0.02	0.1		0	3.3	1	1	112	1.3	442	3.8	18.8	14	45	1.5	1.9	37
5	1	0	13	33	4.6	0.1	0.3	0.3	0.2	0.4	0.04	0.2		0	3.0	3	2	156	0.7	56	.1	9.2	33	29	4.3	0.6	33
5	2	13	28	35	4.3	0.1	0.3	0.3	0.4	0.7	0.04	0.2		0	4.9	1	1	156	0.4	195	.2	10.8	17	37	3.7	0.9	41
5	3	28	43	58	4.2	0.2	0.2	0.4	0.7	1.2	0.02	0.2		0	6.1	1	1	135	0.9	289	2.2	17.5	18	43	2.0	1.4	35
6	1	0	14	41	5.7	0.4	1.7	1.5	1.4	1.1	0.19	1.1		0	2.0	14	21	318	2.0		1.4	12.6	47	31	6.4	1.9	14
6	2	14	31	35	4.9	0.2	0.5	0.4	0.6	0.9	0.10	0.7		0	2.8	2	2	135	0.7	27	1.3	9.8	38	35	3.5	1.5	22
6	3	31	58	68	4.3	0.2	0.2	0.3	1.0	2.0	0.03	0.4		0	3.6	1	1	142	1.7	341	3.4	23.7	21	45	1.5	2.5	30
7	1	0	21	37	5.1	0.2	0.6	0.5	0.4	0.6	0.06	0.3		0	2.8	2	3	126	0.8		1.4	10.3	47	31	3.1	1.1	17
7	2	21	32	32	4.4	0.1	0.3	0.3	0.4	0.8	0.06	0.3		0	3.6	1	1	100	0.4	105	1.2	8.5	27	30	3.0	1.3	39
7	3	32	57	49	4.4	0.1	0.1	0.2	0.5	1.3	0.02	0.2		0	4.0	2	5	98	0.5	221	2.3	15.0	21	42	1.7	1.5	34
Desired level for grapes				20-60	5.5-7.	0.2-2.	<5.0	<3.0	<5.0	<4	<1.5	<5.0	<5.0		2-10	15-30	15-30	25-30	>1.0	<100	<15	5-40	>60	20-40	2-4	<4	<20

*Layer 1 is Topsoil; Layer 2 is Upper Subsoil; Layer 3 is Lower Subsoil; Layer 4 is Deep Subsoil

In accompanying diagrams, critical criteria are shown as horizontal lines on the charts. These criteria are color coded according to "traffic light" logic: It is desirable for data to pass through green critical criteria lines, while it is undesirable for data to pass through red or amber critical criteria lines.

Aluminum

- The concentration of Al increases exponentially with decreases in pH below 5.0
- Al is toxic at about 250 ppm
- Al complexes Phosphorus and reduces bioavailability
- Plants symptoms of Al toxicity is to show deficiencies in P and Ca.



Aluminum Toxicity Treatment

- Use lime to increase the pH of the surface horizon. The impact of lime does not leach, so it only works where it is put.
- Use gypsum (Calcium Sulfate – $CaSO_4$) to supply sulfate that will leach into the subsoil, bond with aluminum to form aluminum sulfate, and render it non-toxic.
- Typical rates of Gypsum to neutralize Aluminum are:
  - 1 ton/acre for each 100 mg/kg Al)
  - Since aluminum is not toxic until soil concentrations exceed 250 mg/kg, we only need to add gypsum to reduce the concentratons to below 100 mg/kg. So a aluminum concentration of 600 mg/kg will require about 5 tons/acre of gypsum
- Gypsum will leach – Lime will not leach.

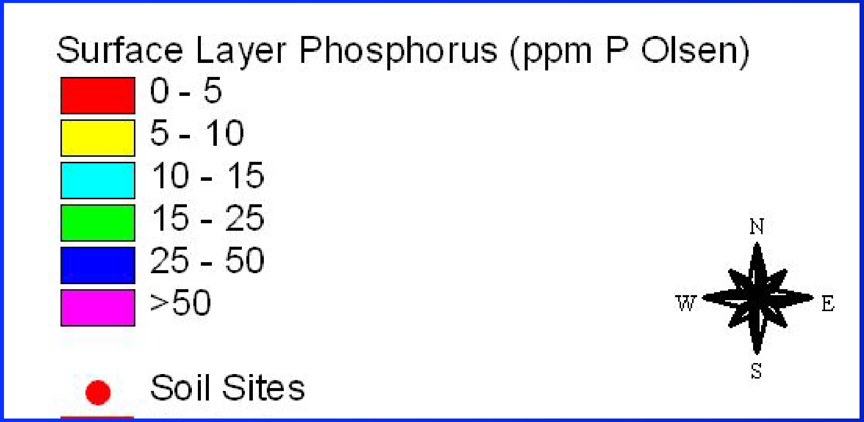
Lime will raise soil pH

What type of lime:

- Calcium carbonate ($CaCO_3$). This material is mined from the earth. It is also available as crushed oyster-shells (Oyster shell lime), and it is also a byproduct of the sugar beet refining process (sugar beet lime).
- Dolomite – Calcium magnesium carbonate ($CaMgCO_3$). Dolomitic lime is mined from the earth.
- Use dolomite if you need magnesium … use calcium carbonate if you need more calcium.
- Lime only works where it is placed. Nearly impossible to place lime in the subsoil below 18” depth.

Many soil-borne nutrient test are Bio-Availability indices

- Bio-availability indices are test that use specific extractants that try to exact the amount of nutrients that are available to plant roots for uptake.
- Examples: Phosphorus Olsen for pH above 6.5; Bray for pH values less than 6.5; Luckily these share same critical values
- Boron: Hot water versus cold water; use different critical values.



Critical Values for Boron extractants

Condition	Cold Water Saturated Paste	Hot Water Calcium chloride
Very Deficient	0 - 0.2	0 - 0.5
Marginally deficient	0.2 - 0.4	0.5 - 1.0
Adequate	0.4 - 1.0	1.0 - 2.0
Marginally toxic	1.0 - 1.2	2.0 - 2.5
Moderate to Severly toxic	> 1.2	> 2.5

Rootstock for Particular Soil Characteristics

- **High Water Availability – even with minimal rootzone (wet feet).**
  - **Good Match:** Riparia, 101-14*, 1616C, 5C
  - **Poor Match:** 420A, 110R, 1103P

- **Drought tolerance:**
  - **Good Match:** 3309C, 420A, 110R, 1103P,
  - **Poor Match:** Riparia, 101-14*, 1616C

* 101-14 reported to becoming susceptible to Phylloxera

Nematode
High Relative Resistance/Tolerance

- Xiphinema index - 039-16 obligatory; GRN-1
- Root Knot (Meloidogyne spp) - 101-14, 1613C, GRN, Dog Ridge, Freedom, Harmony
- Ring (M. or C. xenoplax) – GRN-1-3-4-5, O39-16
  - (moderate susceptible Schwarzmann, 420A

Lesion (P. vulnus) – GRN, 5C, Dog Ridge, Freedom, Harmony

** Need wine quality and production field data on new Walker GRN and USDA RS rootstocks **

TABLE 1. Resistance status of UCD GRN series rootstocks to plant-parasitic nematodes.

Rootstock	Parentage	Mi	MaA	MiC	Xi	Pv	Cx	Ts	Pah
UCD GRN1	*V. rupestris* cv A. de Serres, *M. rotundifolia* cv Cowart	R	R	R	R	MR	R	R	MR
UCD GRN2	*V. rufotomentosa*, *V. champinii* cv Dog Ridge, *V. riparia* cv Riparia Gloire	R	R	R	R	MR	MS	MS	MR
UCD GRN3	*V. rufotomentosa*, *V. champinii cv* Dog Ridge), *V. champinii* cv c9038, *V. riparia* cv Riparia Gloire	R	R	R	R	MR	MR	MR	MR
UCD GRN4	*V. rufotomentosa*, *V. champinii cv* Dog Ridge), *V. champinii* cv c9038, *V. riparia* cv Riparia Gloire	R	R	R	R	MR	MR	MR	MS
UCD GRN5	*V. champinii* cv Ramsey, *V. champinii* cv c9021), *V. riparia* cv Riparia Gloire	R	R	R	R	MR	R	MR	MR

Mi = root-knot nematode *Meloidogyne incognita* Race 3.
MaA = root-knot nematode *Meloidogyne arenaria* pathotype Harmony A, virulent on Harmony rootstock.
MiC = root-knot nematode *Meloidogyne incognita* pathotype Harmony C, virulent on Harmony rootstock.
Xi = dagger nematode *Xiphinema index*.
Pv = root lesion nematode *Pratylenchus vulnus*.
Cx = ring nematode *Mesocriconema xenoplax*.
Ts = citrus nematode *Tylenchulus semipenetrans*.
Pah = pin nematode *Paratylenchus hamatus*.
Resistance assessed relative to nematode reproduction on cv Colombard:
R <10% (resistant), MR 10-30% (moderately resistant), MS 30-50% (moderately susceptible), S >50% (susceptible).

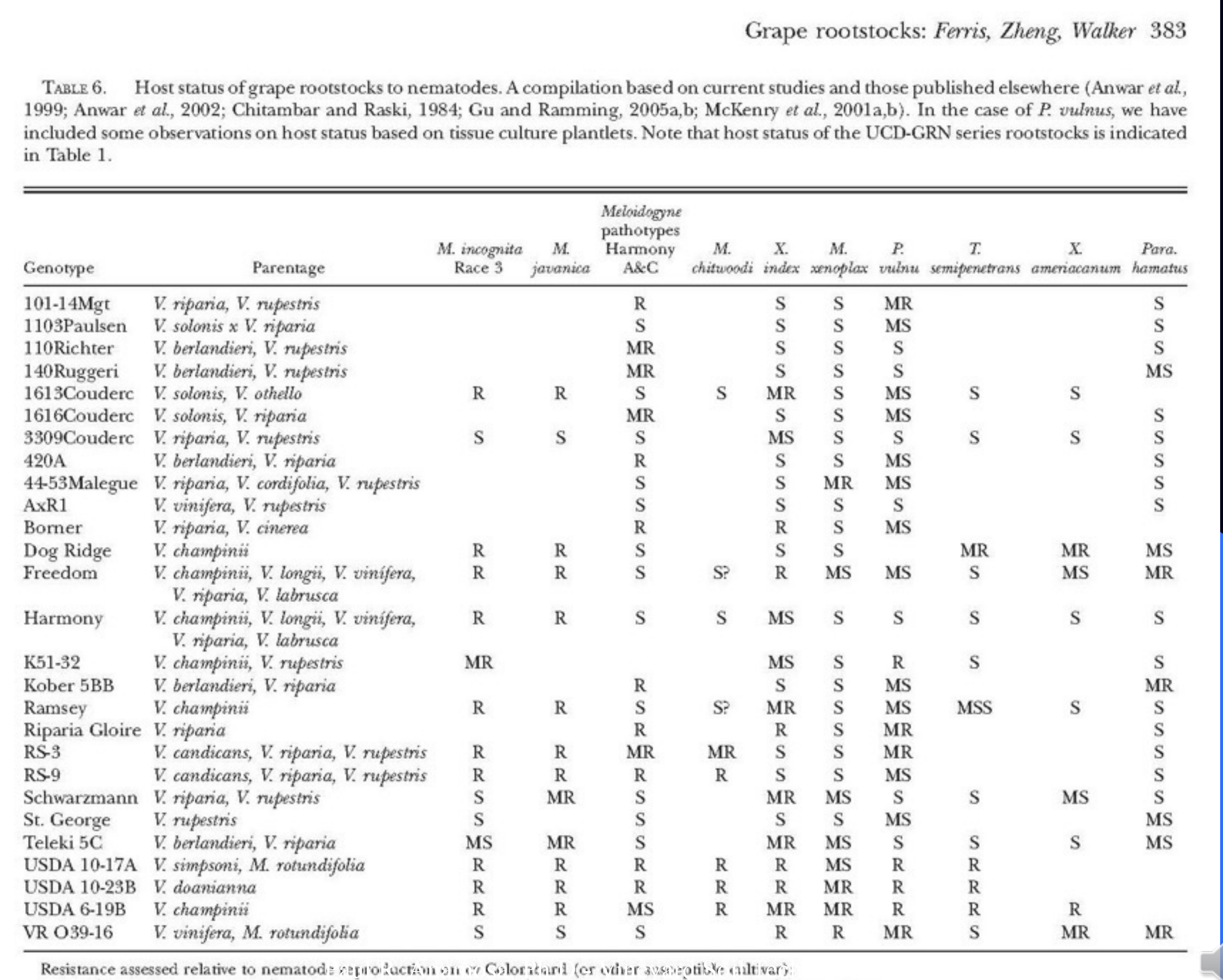


TABLE 6. Host status of grape rootstocks to nematodes. A compilation based on current studies and those published elsewhere (Anwar *et al.*, 1999; Anwar *et al.*, 2002; Chitambar and Raski, 1984; Gu and Ramming, 2005a,b; McKenry *et al.*, 2001a,b). In the case of *P. vulnus*, we have included some observations on host status based on tissue culture plantlets. Note that host status of the UCD-GRN series rootstocks is indicated in Table 1.

Genotype	Parentage	*M. incognita* Race 3	*M. javanica*	*Meloidogyne* pathotypes Harmony A&C	*M. chitwoodi*	*X. index*	*M. xenoplax*	*P. vulnu*	*T. semipenetrans*	*X. ameriacanum*	*Para. hamatus*
101-14Mgt	*V. riparia, V. rupestris*			R		S	S	MR			S
1103Paulsen	*V. solonis x V. riparia*			S		S	S	MS			S
110Richter	*V. berlandieri, V. rupestris*			MR		S	S	S			S
140Ruggeri	*V. berlandieri, V. rupestris*			MR		S	S	S			MS
1613Couderc	*V. solonis, V. othello*	R	R	S	S	MR	S	MS	S	S	
1616Couderc	*V. solonis, V. riparia*			MR		S	S	MS			S
3309Couderc	*V. riparia, V. rupestris*	S	S	S		MS	S	S	S	S	S
420A	*V. berlandieri, V. riparia*			R		S	S	MS			S
44-53Malegue	*V. riparia, V. cordifolia, V. rupestris*			S		S	MR	MS			S
AxR1	*V. vinifera, V. rupestris*			S		S	S	S			S
Borner	*V. riparia, V. cinerea*			R		R	S	MS			
Dog Ridge	*V. champinii*	R	R	S		S	S		MR	MR	MS
Freedom	*V. champinii, V. longii, V. vinifera, V. riparia, V. labrusca*	R	R	S	S?	R	MS	MS	S	MS	MR
Harmony	*V. champinii, V. longii, V. vinifera, V. riparia, V. labrusca*	R	R	S	S	MS	S	S	S	S	S
K51-32	*V. champinii, V. rupestris*	MR				MS	S	R	S		S
Kober 5BB	*V. berlandieri, V. riparia*			R		S	S	MS			MR
Ramsey	*V. champinii*	R	R	S	S?	MR	S	MS	MSS	S	S
Riparia Gloire	*V. riparia*			R		R	S	MR			S
RS-3	*V. candicans, V. riparia, V. rupestris*	R	R	MR	MR	S	S	MR			S
RS-9	*V. candicans, V. riparia, V. rupestris*	R	R	R	R	S	S	MS			S
Schwarzmann	*V. riparia, V. rupestris*	S	MR	S		MR	MS	S	S	MS	S
St. George	*V. rupestris*	S		S		S	S	MS			MS
Teleki 5C	*V. berlandieri, V. riparia*	MS	MR	S		MR	MS	S	S	S	MS
USDA 10-17A	*V. simpsoni, M. rotundifolia*	R	R	R	R	R	MS	R	R		
USDA 10-23B	*V. doanianna*	R	R	R	R	R	MR	R	R		
USDA 6-19B	*V. champinii*	R	R	MS	R	MR	MR	R	R	R	
VR O39-16	*V. vinifera, M. rotundifolia*	S	S	S		R	R	MR	S	MR	MR

Resistance assessed relative to nematode reproduction on cv Colombard (or other susceptible cultivar):
R <10% (resistant), MR 10-30% (moderately resistant), MS 30-50% (moderately susceptible), S >50% (susceptible).

How to put it together into vineyard design

- Create blocks to compartmentalize those properties that influence vine growth
- Prioritize by greatest influence:
  - Water holding capacity (texture, structure, rock)
  - Organic matter (nitrogen)
  - Hard pans & obstacles to root zone depth
  - Soil chemistry – pH, magnesium, phosphorus etc.

Vineyard Design Parameters

- Block outline
- Variety & clone
- Rootstock
- Deep tillage depth (TAW)
- Row orientation
- Amendments

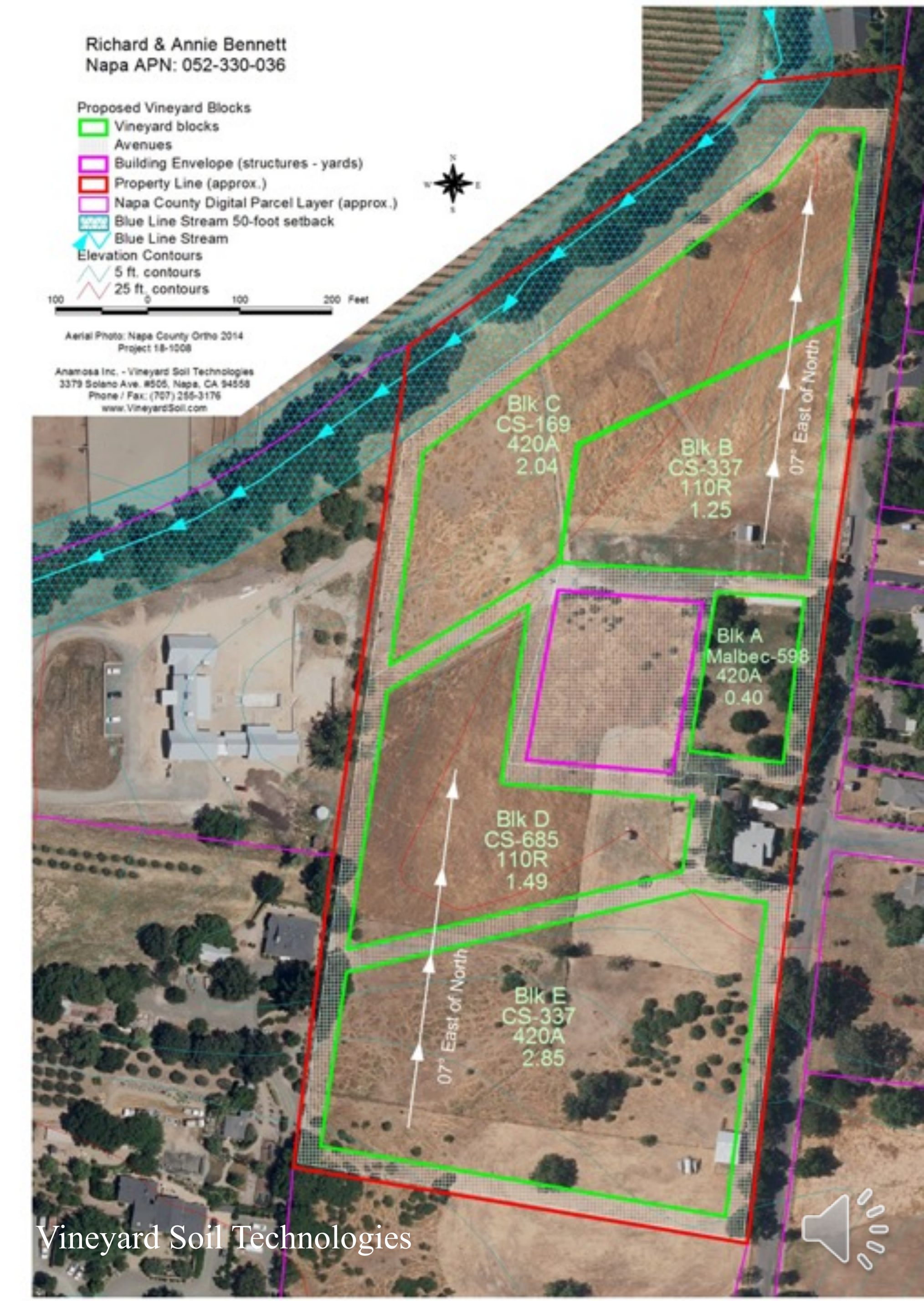


Table A5: Vineyard Design Parameters

Block	Acres	Variety	Rootstock	Tillage Depth inches	Vine Spacing Row x Vine, ft	Row Orientation degrees [2]
Blk A	0.40	Malbec 598	420A	30	6 x 4 bilat cane	07 East of North
Blk B	1.25	CS-337	110R	30	6 x 4 bilat cane	07 East of North
Blk C	2.04	CS-169	420A	30	6 x 4 bilat cane	07 East of North
Blk D	1.49	CS-685	110R	30	6 x 4 bilat cane	07 East of North
Blk E	2.85	CS-337	420A	30	6 x 4 bilat cane	07 East of North
Total	8.03					

[1] TBD - to be determined

[2] $N_t = N_m + 14.4$ where N_t is true north and N_m is magnetic north

Table A6 Amendment Chart

Block	Acres	Compost tons/acre[3]	Dolomite Lime tons/acre[3]	Gypsum tons/acre[3]	Compost lbs/vine [4]	Ammonium phosphate 11-52-0 oz/vine [4]	Magnesium sulfate oz/vine [4]
Blk A	0.40	5	3		1	2	2
Blk B	1.25	5	5	4	1	2	2
Blk C	2.04	5	3		1	2	2
Blk D	1.49	5	5	4	1	2	2
Blk E	2.85	5	3		1	2	2
Total	8.03						

[3] Broadcast the Compost, Dolomite Lime and Gypsum just prior to deep tillage.

[4] Thoroughly mix the pound of compost, 11-52-0, and magnesium sulfate into the soil of the planting hole

Magnesium sulfate can be tank mixed and injected post-planting if prefered.

Soil Driven Vineyard Design

- **Goal** to allow for compartmentalization of soil properties to improve the potential for uniform ripening of high quality fruit.
- Requires detailed analysis of the soil's physical and chemical properties of the surface as well as subsoil horizons.
- Requires a soil scientist to conduct and interpret results.

Soil Driven Design:

Is it worth it?

Typically, \$800 - \$1500 per acre for a \$40,000 to \$60,000 per acre vineyard (1% to 3% of establishment cost).

... and we can save 700 lira by not taking soil tests

Vin