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Stillwater Orchards / Delta Watershed Landowner Coalition

BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX	**TESTIMONY OF R. STANLEY GRANT IN SUPPORT OF SALINITY INJURY FOCUS PANEL** **Joint Case in Chief of: Islands, Inc., Delta Watershed Landowner Coalition, Bogle Vineyards, Diablo Vineyards, Stillwater Orchards and Local Agencies of the North Delta**

I, R. Stanley Grant, do hereby declare:

I. INTRODUCTION

I am a vineyard consultant and soil scientist. I am self-employed and my company is Progressive Viticulture, LLC. I received a Bachelor of Science in Geography from California State University, Hayward (1979) and a Master of Science in Soil Science from the University of California, Davis (1987). I am a certified professional horticulturist (CPH) through the American Society for Horticultural Science and a certified professional soil scientist (CPSS) through the Soil Science Society of America. I have nearly 29 years experience as a professional agriculturist. I first worked the Sacramento River Delta in 1987 as a student intern and was involved there to varying degrees during my employment at Gallo Vineyards and Duarte Nursery. The Delta has been one of my prime consulting markets since 2001. My Delta work has involved preplant vineyard site evaluations, vineyard designing, and post plant vineyard management consulting. In the next few weeks, I will begin work on a petition to expand the Clarksburg American Viticultural Area (AVA) to include Grand Island, Ryer Island, and other areas between those islands and the current AVA on the behalf of Delta winegrape growers.

II. OVERVIEW OF TESTIMONY

When the volume of water in the Sacramento River is below normal, tidal influences and saltwater intrusion extend deeper and further upstream into the Sacramento River Delta. Should the twin tunnels proposed under the *California Water Fix* project become operational, Sacramento River flows downstream of the tunnel diversions will be reduced. Under the North Delta Diversion Bypass Flows assumed in the modeling, as little as 5,000 cfs could be left in the river as bypass flows during the critical summer irrigation months. (DWR-515.) Especially in summer months, saltwater intrusion will diminish the quality of riparian waters used for irrigation of Delta farms, affecting both the quantity and quality of farm produce. These effects are due to the copious amounts of dissolved minerals, which are also known as salts, present in seawater and the brackish blend of seawater and fresh water that occurs where the Delta flows meet the San Francisco Bay. Among these salts are some mineral ions potentially toxic to plant tissues - sodium and chloride.

If the Tunnels are built and operated, a wide range of high value crops will be irrigated with saline waters. Given their high initial capital costs and corresponding long-term return on investment requirements, perennial vineyard and orchard crops in the Delta are the greatest concern for irrigation with saline, sodic, and high chloride waters. Moreover, among agricultural crops, the prominent tree crops in the Delta, pears and cherries, are sensitive to salinity, while grapevines are moderately sensitive (II-8, Grattan, 2002).

For vineyard and orchard crops, saline irrigation waters are those with total dissolved solids (TDS) greater than 640 and 1780 ppm (i.e. electrical conductivity or EC $\geq$ 1.0 to 2.7 dS/m). For these same crops, sodic and high chloride irrigation waters are those with sodium (Na) and chloride (Cl) concentrations greater than 69 to 207 ppm and 142 to 355 ppm, respectively. For comparison, typical seawater salinity contains about 35,000 ppm total dissolved solids (EC $\approx$ 69 dS/m) and sodium and chloride at about 10,500 ppm and 19,000 ppm, respectively. Given the magnitude of these concentrations, even small fractions of seawater can influence Delta water salinity due to seawater intrusion, this poses an obvious and very serious threat to irrigated vineyards and orchards in the Sacramento River Delta.

The seawater intrusion is moderated as it passes through the bays, and ends up at the Sacramento River so that it is lower in concentration, but still much higher than the typical river concentrations. With such saline irrigation waters there are both immediate and long-term concerns for tree and grapevine health and orchard and vineyard productivity and profitability. These include both direct effects on trees and vines and indirect affects through degraded orchard and vineyard soils. The long-term effects are especially troubling for Delta soils due to limited and costly options for remediation. Below are some points regarding saline water use on woody perennial crops in the Delta.

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III. SALINE WATER USE IN THE DELTA

1. IRRIGATED AGRICULTURAL SOILS REFLECT THE CHEMICAL CHARACTER OF THE IRRIGATION WATER APPLIED TO THEM, BECOMING SALINE, SODIC, AND HIGH IN CHLORIDE.

In general, soil is composed mainly of mineral matter (≈ 45%), water (≈ 25%), and air (≈ 25%), with much lesser amounts of partially decomposed and undistinguishable plant and animal remains (typically ≈ 5%, but often less in California soils). All components are chemically active to varying degrees.

The liquid component of soils, known as the soil solution, has little buffering capacity. Therefore, applied irrigation water passing through a soil readily affects it. Saline irrigation water will rapidly make a soil solution saline. Similarly, irrigation waters high in sodium and chloride will make soil solutions high in these elements. Consequently, soil salinity, sodium, and chloride levels are proportionate and often similar to levels in irrigation waters.

2. SOIL SALINITY FROM SALINE IRRIGATION WATER CREATES AN ENERGY GRADIENT PLANTS HAVE TO WORK AGAINST TO TAKE UP WATER, WHICH PREDISPOSES THEM TO WATER STRESS.

High *soil salinity* (EC ≥ 1. 5 to 2.5 dS/m) creates energy (osmotic) gradients that plants have to work against to take up water, predisposing them to water stress. High soil salinity is a predictable outcome of irrigation with water contaminated by seawater. For wine grapes, an increase in irrigation water salinity from 1.0 to 1.7 dS/m decreases fruit yields by 10%, while a similar increase to 2.7 dS/m will decrease yields by 25% (II-8, Gratton, 2002). At 4.5 dS/m, wine grape yields are 50% of their potential when irrigation water salinity was less than or equal to 1.0 dS/m.

3. VINEYARD AND ORCHARD SOILS IRRIGATED WITH SALINE-SODIC DEGRADE PHYSICALLY.

The salts in saline water consist of positively and negatively charge ions. Calcium, magnesium, potassium, and sodium are among the positively charged ions (cations) in saline waters. When used for irrigation, the relative concentrations of these cations in saline waters induce shifts the relative cation concentrations in soil solutions that mirror the irrigation water concentrations. The new cation composition in the soil solution, in turn, causes a similar shift in the relative quantities of cations adsorbed onto the surfaces of soil particles, which reside mainly on clay minerals and organic matter particles. In other words, saline waters interact with and change the solid soil components, as well as the soil solution.

As indicated above, intruded seawater is rich in sodium (sodium adsorption ratio or SAR > 6) and it will dramatically increase sodium in Delta irrigation waters. Cation exchange sites soil particles treated with these waters will correspondingly become rich in sodium (exchangeable sodium percentage or ESP ≥ 6%). Under these conditions, soil particles disperse rather than aggregate. Such dispersal decreases soil porosity and substantially diminishes soil permeability to air, water, and plant roots. As a result, root activity is restricted, overall plant growth and productivity is inhibited, and water use efficiency declines. At the same time, it will create a restrictive environment for most soil inhabitants, including beneficial microorganisms. This same environment is conducive for some plant pathogens.

4. VINEYARDS AND ORCHARDS ON SALINIZED SOILS WILL REQUIRE EXTRA IRRIGATION WATER TO AVOID OR MINIMIZE SEVERE WATER STRESS DUE TO SALINITY.

To minimize plant water stress, greater quantities of higher concentration saline water is required to meet irrigation demand than for low saline water, such as those typical of Sacramento River water. (Sacramento River water used for irrigation on Grand Island typically ranges from 0.0 to 0.5 ds/m during the summer irrigation season.) The amounts of additional saline water applied to agricultural lands to dilute and leach salts are crop specific (II-8, Grattan, 2002).

Additional water needed to manage salinity when crops are irrigated with saline waters reduces the percentage of applied water stored in root zones and the percentage of applied water beneficially used by crops (i.e. application efficiency and irrigation efficiency, respectively). Additional water demands also increase energy requirements for pumping and other irrigation costs such as labor and system maintenance. In the long term, such additional costs can affect the viability of farming operations.

5. SODIUM AND CHLORIDE ARE AMONG THE SALTS IN SALINE IRRIGATION WATERS.

Sodium and chloride are, by far, the two most prominent ions in seawater and correspondingly, they are present at very high concentrations in blends of seawater and Delta freshwater from the Sacramento River and other tributaries. Sodium is a positive ion (cation) and chloride is negative ion (anion). While the two readily associate in water due to their opposite charges, they bond very weakly. As such, sodium chloride salts are highly soluble and the two readily dissociate in soils.

Some of applied sodium, as described above, will react with charged soil particle surfaces. The remainder remains in the soil solution. Chloride, in contrast, does not interact with soils particles and it remains entirely in the soil solution. Both of these ions easily flow with soil water as plants take it up.

Chloride is considered excessive in waters at concentrations greater than 142 to 355 ppm (II-5, Ayers). The sodium hazard of irrigation water is more precisely represented as the sodium adsorption ratio (SAR) than as concentrations. The sodium adsorption ratio is the ratio of sodium to calcium and magnesium, which influence sodium activity in waters (SAR = [sodium] / ([calcium] + [magnesium])$^{**1/2}$). A sodium adsorption ratio > 3 is associated with increasing risk of sodium toxicity. As indicated above, the sodium adsorption of irrigation water influences the exchangeable sodium percentage of soils and the two are closely related.

6. SODIUM AND CHLORIDE TOXICITY LEADS TO FOLIAGE DAMAGE, INCOMPLETE RIPENING, AND FOR WINE GRAPES, DIMINISHED QUALITY. UNDER LONG-TERM EXPOSURE TO CHLORIDE TOXICITY, GRAPEVINES CAN DIE.

The dryness (influenced by solar radiation, heat transfer, and the vapor pressure deficit) of the aboveground atmosphere drives agricultural water use, drawing soil water into roots, through plants, and out of tiny pores on leaves. Sodium and chloride move readily with plant water. They travel as far as they can, which are the edges of leaves, and there they accumulate. When concentrations become sufficiently high, tissues on leaf edges die. For grapevines, these concentrations are 0.25% sodium and 0.50% chloride.

Plant leaves function as solar panels, capturing solar energy and converting it to chemical energy (carbohydrates) through photosynthesis. Leaf tissue death reduces a plants capacity for energy conversion and thereby, its capacity to grow, develop and ripen fruit, and ripen woody tissues, which is necessary for withstanding winter temperatures. In one study, irrigation water containing approximately ~~700~~ 1700 ppm Cl reduced grape yields by 52% (II-10, Shani & Ben-Gal, 2005).

Grape berries are also a final destination of sodium and chloride. When concentrations become sufficiently high (≈ 0.31 g NaCl/L), they become sensible in finished wine as a table salt flavor, which is displeasing to winemakers and wine drinkers. Wines high in sodium chloride have also been described as flat, dull, soapy, seawater like, and brackish.

Chloride usually becomes toxic before sodium, presumably because it has negligible interaction with the solid soil matrix due to its negative charge (Patrick Brown (UCD Plant Sci.), personal communication). Sodium, which has a positive charge, usually causes soil particle dispersal and soil structure degradation before becoming toxic in plant tissues. Before chloride toxicity, sodium induced soil structure degradation, or sodium toxicity develop, saline waters will have already induced water stress and yield losses in crop plants. During all of these processes, soil microbes are diminishing in number and in species diversity, as are the benefits they provide orchards and vineyards.

7. LIKE SALINITY INDUCED WATER STRESS, AVOIDANCE OR MINIMIZATION OF CHLORIDE AND SODIUM TOXICITY IN CROPS REQUIRES GREATER THAN NORMAL QUANTITIES OF IRRIGATION WATER. THEY MAY ALSO INCREASE FERTILIZER REQUIREMENTS.

Leaching fractions may be calculated for diluting and leaching sodium and chloride based on their concentrations. Again, the extra water required to minimize toxicity in crops irrigated with high chloride and sodic waters logically decreases water application and irrigation efficiencies.

Sodium and chloride compete with other mineral nutrient ions in the soil solution, including some mineral nutrients required by trees and vines. When sodium is present in excess, it restricts the uptake of potassium and magnesium (II-9, Keller, 2010). Similarly, when chloride is present in excess, it inhibits nitrate uptake (II-9, Keller, 2010). These effects may result in potassium, magnesium, and nitrogen deficiencies in trees and vines, effectively increasing the need for fertilizer inputs.

8. IN ADDITION TO GREATER THAN NORMAL VOLUMES OF WATER, MANAGEMENT OF SALINE, SODIC, AND HIGH CHLORIDE SOILS REQUIRES ADEQUATE SUBSURFACE DRAINAGE.

Leaching is effective only when salt laden water percolating below crop root zones has somewhere to go. Accordingly, ample subsurface drainage is an assumption implicit in leaching fraction calculations.

Unfortunately, naturally well drained agricultural soils are somewhat uncommon in Delta. Instead, most Delta soils are subject to high water tables that restrict drainage. Under these conditions, salts in Delta soils will accumulate and can quickly reach damaging levels.

To avoid salt accumulation in soils of Delta vineyards and orchards irrigated with high salt water, costly engineered tile drain systems are required. Drainage waters collected from such systems are returned to rivers and sloughs, compounding the salinity effects of saltwater intrusion. The obvious and ultimate solution is the maintenance of low-salt Sacramento River irrigation water.

IV. CONCLUSIONS

At this time, the prevailing situation for Delta agriculture is the most sustainable one, in that it requires few applied resources, make the best use of on-site resources, and has the least off site impacts. High quality, low-salt irrigation water is readily available from Delta rivers and sloughs. In well-designed and well-managed orchard and vineyard locations, these waters work in concert with subsurface drainage provided by open ditches currently operated by reclamation districts. Consequently, in Delta vineyards and orchards salt stress and sodium and chloride toxicities are limited in occurrence and extent at this time. Typically, they occur in parts of orchards and vineyards where shallow water tables persist throughout the year.

Further, there is limited need to apply extra water as leaching fractions to flush salts. In addition, no complex engineered drainage systems, additional fertilizers, and other mitigation measures are required under current conditions to offset salinity Perhaps most importantly, Delta vineyards and orchards, as they currently are, use water efficiency to produce an abundance of high quality fruit for people in the United States and beyond.

I declare under penalty of perjury under the laws of the State of California that the foregoing statements are true and correct.

Executed on the 1st Day of September at Stockton, California.

R. Stanley Grant

R. Stanley Grant

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