LOCAL AGENCIES OF THE NORTH DELTA

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Public Comment
2016 Bay-Delta Plan Amendment & SED
Deadline: 3/17/17 12:00 noon

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SWRCB Clerk

March 17, 2017

SENT VIA EMAIL (commentletters@waterboards.ca.gov)

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, California 95814

RE: Comment Letter – 2016 Bay Delta Plan Amendment & SED

Dear Ms. Townsend:

These comments on the Draft Revised Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the Bay-Delta: San Joaquin River Flows and Southern Delta Water Quality ("Plan and SED") are submitted on behalf of the Local Agencies of the North Delta ("LAND"). LAND is a coalition comprised of reclamation and water districts in the northern geographic area of the Delta.[1] Due to limited resources, and the necessity to direct those resources toward the most pressing threats to Delta water users, LAND is unable to provide detailed comments regarding every aspect of the Plan and SED to the State Water Resources Control Board ("Board") at this time. LAND does, however, have the following comments on the content of the Plan and SED.

A. The Plan Amendments Do Not Promote Reduced Reliance on the Delta

The proposed WQCP amendments do not appear to decrease reliance on the Delta. This is contrary to the 2009 Delta-Reform Act ("DRA"), Water Code sections 85000, et seq., which states that it is California policy to "reduce reliance on the Delta in meeting California's future water supply needs." (Wat. Code, § 85021; see also Ruling on Submitted Matter, JCCP No. 4758 (May 28, 2016), pp. 39-41 [affirming that policies that reduce Delta reliance are consistent with the DRA's mandate to increase water

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1 LAND member agencies cover an approximately 118,000 acre area of the Delta; current LAND participants include Reclamation Districts 3, 150, 307, 317, 349, 407, 501, 551, 554, 556, 744, 755, 813, 999, 1002, 2111, 2067, Maintenance Area 9 South, and the Brannan-Andrus Levee Maintenance District. Some of these agencies provide both water delivery and drainage services, while others only provide drainage services. These districts also assist in the maintenance of the levees that provide flood protection to homes and farms.

reliability].) In fact, as discussed below, relaxation of the southern Delta salinity objective could facilitate the approval and construction of the Delta Tunnels project, which would substantially increase Delta reliance, contravening the DRA.

B. The Plan Amendments' Proposed Relaxation of the South Delta Salinity Objective Would Be Detrimental to Water Users and Was Not Adequately Reviewed in the SED

Relaxing the South Delta Salinity Objective is likely to impair agricultural uses in the South Delta area and is contrary to the public interest. LAND is a Protestant in the Hearing Proceedings Regarding Petition Filed by the Department of Water Resources and U.S. Bureau of Reclamation Requesting Changes in Water Rights for the California WaterFix Project. As part of those proceedings LAND presented expert witness testimony in conjunction with other Delta water users explaining water rights injuries related to increased salinity levels. Attached herewith as Exhibit A are the testimony and presentations on salinity provided by each of those witnesses. These exhibits describe the mechanisms and effects on agriculture of applying water with increased salinity levels in the north Delta, which is also relevant to conditions in the South Delta.

LAND opposes the proposed relaxation of the South Delta Salinity Objective, which would impair agricultural productivity in the Delta. (SED, p. 18-2 [preferred alternative would increase the annual South Delta salinity objective to 1.0 dS/m].) We believe the SED: (1) provides an incomplete description of baseline salinity conditions, (2) lacks sufficient technical justification for this increase, (3) was not subject to adequate peer review on salinity impacts, and (4) inadequately describes indirect impacts.

1. The SED's Description of Baseline Salinity Conditions is Inadequate

The SED fails to accurately describe the baseline conditions in the Bay-Delta, rendering it inadequate as an informational document. Before a project's impacts can be assessed and mitigation measures considered, a CEQA review document must describe the existing environment. (Cal. Code. Regs., tit. 14 ("CEQA Guidelines"), § 15063, subd. (d)(2).) "This environmental setting will normally constitute the baseline physical conditions by which a lead agency determines whether an impact is significant." (CEQA Guidelines, § 15125, subd. (a).) Though the lead agency does have some discretion to omit an analysis of a project on the existing environmental conditions, "the agency must justify its decision by showing that an existing conditions analysis would be misleading or without informational value." (*Neighbors for Smart Rail v. Exposition Metro Line Construction Authority* (2013) 57 Cal. 4th 439, 457.) The SED fails to either use the existing environmental setting or justify the failure to do so.

The SED's environmental setting section for hydrology discusses the history of compliance with the South Delta salinity objective (SED, p. 5-46-49), but fails to disclose that the Board regularly relaxes the existing salinity objective, and does not treat salinity exceedances that occur afterward as violations.[2] Nor does the baseline discussion reveal that temporary salinity barriers are currently used to help avoid additional violations of the salinity objective.[3] Instead the SED includes these measures in Alternative 1, the No Project Alternative. (SED, p. 18-2.) These salinity conditions, and the physical barriers used to manage them, are part of the existing environmental setting; the failure to disclose these conditions renders the SED informationally deficient. (CEQA Guidelines, § 15125.) In addition, by conflating the baseline conditions with the No Project Alternative, the SED has unduly restrained the range of alternatives considered by the SED. (CEQA Guidelines, § 15126.6.)

2. The SED Does Not Provide Adequate Technical Justification for Relaxing the Salinity Objective

The primary motivation for increasing the salinity to 1.0 dS/m appears to reduce the number of violations that will occur. (SED, Table 18-4.) The SED notes that in the interior southern Delta, salinity values exceeded the current 0.7 dS/m standard that applies between April and August in up to 30 percent of recorded years. (SED, p. 5-46.) It also explains that relaxing the standard so that the standard is 1.0 dS/m year-round would reduce the number of violations in the interior southern Delta. (SED, p. 18-17.) The SED does not, however, provide a technical explanation for the decision to relax the salinity standard. Instead, the Board appears to be attempting to cure the deficiencies in properly managing water quality in the South Delta by simply lowering the standard against which compliance is measured. The more beneficial response would be for the Board to respond to this data by reassessing its practices so that water quality can be improved, or at least brought into compliance with the current, more protective standards.

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[2] See State Water Resources Control Board, Temporary Urgency Change Petitions – Orders, http://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/transfers_tu_orders/.

[3] See Department of Water Resources, Temporary Barrier Program Information, http://baydeltaoffice.water.ca.gov/sdb/tbp/web_pg/tempbar.cfm; Alexander, *State Building Rock Barrier to Protect Delta from Salt Water* (May 9, 2015), http://www.sfgate.com/drought/article/State-building-40M-emergency-rock-barrier-to-6252075.php ("This is one of the last tools we have available to manage salinity.").

3. The SED's Discussion of Impacts to Water Quality Due to Salinity Was Not Adequately Peer Reviewed

Though the SED purports to have undergone full peer review (SED, p. 4-23), a review of Appendix C reveals otherwise. Four of the five experts to whom the SED was submitted for review declined to review the sections addressing water quality degradation due to salinity changes, and related agricultural impacts analysis generated by Dr. Hoffman, because the topics were not within their area of expertise.[4] Thus, the peer review comments fail to provide an assessment of water quality degradation related to salinity change and the Hoffman report, and do not constitute an adequate peer review of Hoffman's work and are not best available science. (See, e.g., Cal. Code Regs., tit. 15, § 5001, subd. (f) & Appendix 1A [defining best available science].)

4. The SED's Discussion of Indirect Impacts Is Inadequate

CEQA requires that environmental review of a project's impacts include indirect and secondary impacts in addition to direct impacts. (CEQA Guidelines, § 15358, subd. (a).) SED Tables 18-6 and 18-7 summarize the significance of impacts due to indirect actions and non-flow measures, but neither these tables nor the SED actually describe any of these indirect impacts.

It also appears that the SED has not considered the reasonably foreseeable possibility that relaxing the salinity standard could facilitate the construction of the Delta Tunnels project by removing a standard that would otherwise limit the amount of water diverted from any new North Delta diversions. If DWR and the Bureau of Reclamation do not have to comply with a 0.7 dS/m salinity standard in the southern Delta, they have additional leeway to pump more water out of the Delta at the proposed Delta Tunnels northern pump sites. Construction of the Delta Tunnels project would cause immense indirect impacts, including impacts due to salinity changes. (See generally, <u>Exhibit A</u>.) The SED is therefore informationally deficient; a complete SED must contain descriptions of all direct and indirect impacts.

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[4] See generally, Appendix C Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives, Attachment 1 Peer Review Comments (John Dracup, Ph.D., P.E. ["Since the water quality and salinity is not my area of interest, I am not going to comment on or answer items 7, 8 and 9 of Appendix 2."]; Dr. Julian D. Oldern ["No response is provided because the topic is outside my realm of expertise."]; Dr. Thomas Quinn [Topics 7, 8, and 9 are "simply not within my ken."].) Dr. Henriette Jager's review omitted any reference to these topics whatsoever.

C. The Deficiencies of the Plan Amendments and the SED Are Part of a Pattern of Problems With ICF International's Work

LAND continues to be concerned about the role of ICF International in the preparation of both the WQCP and the SED, as well as the environmental documents for the Delta Tunnels project. ICF has recently taken a scientifically unsupported advocacy position on the salinity levels in the south Delta while simultaneously purporting to act as an objective evaluator of Delta salinity levels for the SED.[5] ICF not only suffers from a conflict of interest on this issue, it has generated an SED that does not satisfy CEQA's requirements. New consulting staff without any direct conflicts should be brought onto the project to provide credible analysis to provide an unbiased and complete analysis to fully inform the public.

* * *

The WQCP amendments and its SED are fundamentally defective and must be revised and recirculated in order to promote adequate water standards and comply with CEQA. Thank you for considering these comments.

Very truly yours,

SOLURI MESERVE
A Law Corporation

By: [signature]
Osha R. Meserve

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5 See January 20, 2017 Letter from South Delta Water Agency re: Water Quality Control Plan, available at:http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/docs/petitions/2017jan/20170120_sdwa_wqcp.pdf; see also January 28, 2104 Letter from South Delta Water Agency re: Resolution to Add Funds to Contract with ICF (discussing ICF's conflict of interest in preparing the EIR for the Bay-Delta Conservation Plan while also drafting Phase I of the SED, which proposed relaxation of the south Delta salinity objective).

Attachment: Exhibit A – Selected Islands Inc. et al.'s CWF Case in Chief Exhibits:

II-2-Revised	Stanley Grant Testimony - Revised 11/28/2016
II-3-Revised	Stanley Grant PowerPoint - Revised 11/28/2016
II-13	Michelle Leinfelder-Miles Testimony
II-14	Michelle Leinfelder-Miles PowerPoint
II-24-Revised	Erik Ringelberg Testimony - Revised 11/28/2016
II-25	Erik Ringelberg PowerPoint

EXHIBIT A

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Attorneys for Protestants
Local Agencies of the North Delta
Bogle Vineyards / Delta Watershed Landowner Coalition
Diablo Vineyards and Brad Lange / Delta Watershed Landowner Coalition
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

References

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DELTA CROPS & SALT WATER INTRUSION WITH TWIN TUNNEL OPERATION

Stan Grant
Certified Professional Soil Scientist & Horticulturist

Introduction

- Lower than normal Sacramento River flows allow deeper inland penetration of:
  - Tidal influences
  - Saltwater
- With *California Water Fix* tunnel operation, Sacramento River flows will continuously be below normal
- Thereafter, unceasing saltwater intrusion will affect the quality of riparian waters in the Delta

Introduction

- Seawater & brackish blends of sea & fresh water are rich in dissolved minerals, which are also known as salts
- High levels of sodium & chloride are among the minerals in seawater
- Seawater & brackish waters are, at the same time, saline, sodic, & high in chloride
- Saline, sodic, & high chloride waters harm crops in several ways

Introduction

- Woody perennial (tree & vine) crops are of particular concern with saline waters due to:
  - High initial capital costs for development
  - Long-term return investment expectations
  - Tree & vine sensitive to salinity
  - Long-term exposure over many years
  - Increasing orchard & vineyard acreage in the Delta

II_3_Revised

IRRIGATION WITH SALINE WATER

Soils & Irrigation

- The soil solution = the liquid in soils
- Soil solutions have little capacity to resist chemical changes
- Irrigation water passing through soils easily change soil solution chemistry
- Saline, sodic, & high chloride irrigation waters very rapidly make soil solutions similarly saline, sodic, & high in chloride

Saline Water & Plant Stress

- High salt concentrations in soil solutions create energy (osmotic) gradients
  - EC ≥ 1.5 to 2.5 dS/m
- Trees & vines have to work against energy gradients in soil solutions to take up water

Irrigation Water Salinity Effects on Grape Yields*

Irrigation Water Salinity (dS/m)	1.0	1.7	2.7	4.5
Estimated Grape Yield	100%	90%	75%	50%

Source: Gratton, SR. 2002.

*Pears & cherries, the most common tree crops in the north Delta, are more sensitive to salinity than grapevines.

II_3_Revised

SALINE-SODIC WATERS HARM SOILS PHYSICALLY

Saline Water & Soil Degradation

- Salts are electrically neutral associations of positively & negatively charged ions
  - Positively charged ions = cations
  - Negatively charged ions = anions
- Sodium is the most prevalent cation in river water-seawater mixtures
- Sodium markedly increases in soils receiving these waters for irrigations

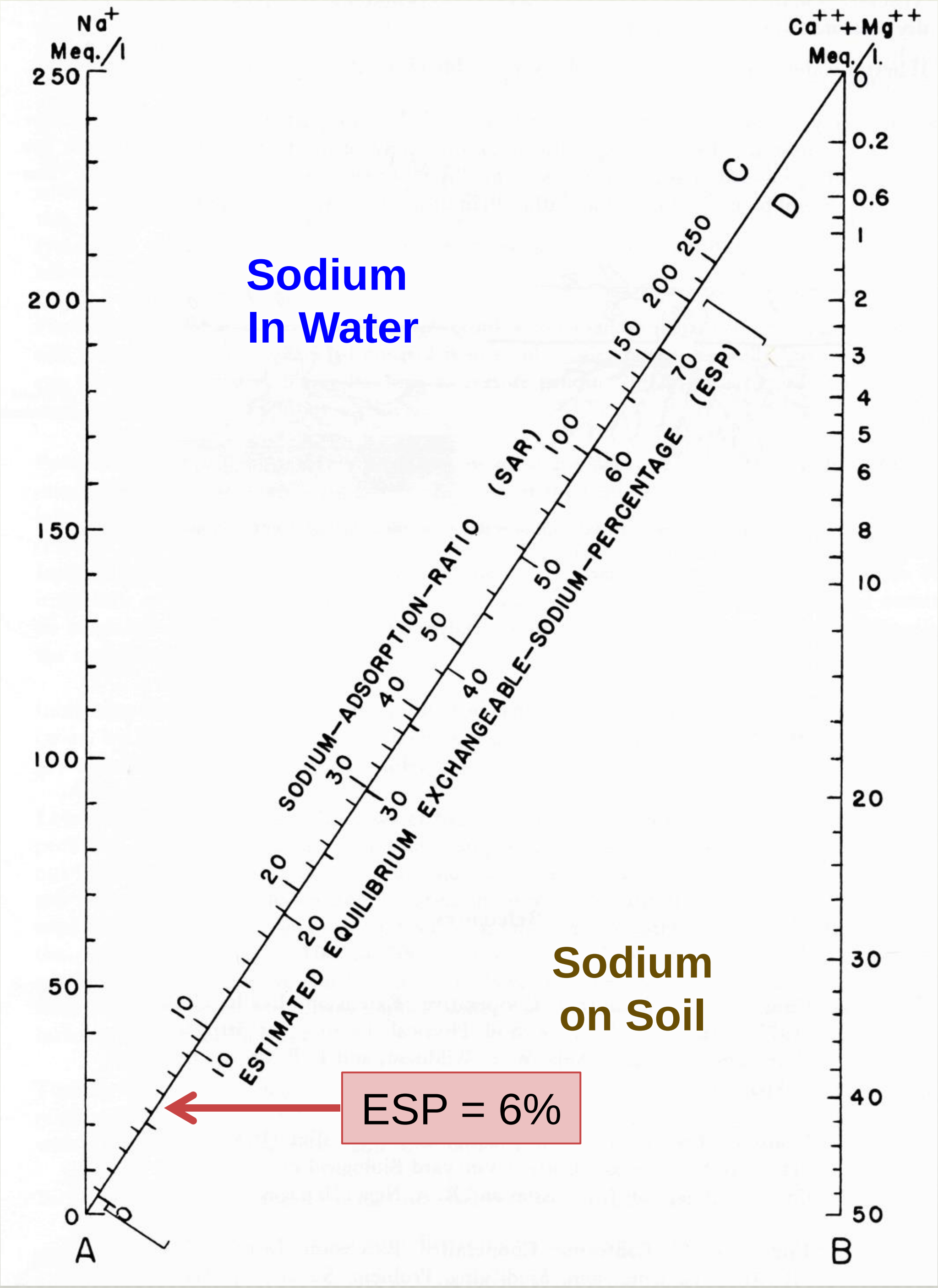
Saline Water & Soil Degradation

- Soils are negatively charged
  - Charge in soils resides mainly on the surfaces of clay & organic matter particles
  - Cations adhere to soil particle surfaces
- Sodium displaces other cations on soil particle surfaces after sodic water is applied
  - The exchangeable sodium percentage (ESP) increases

Saline Water & Soil Degradation

- As the ESP approaches 6%, soil particles disperse rather than aggregate
  - Soil porosity decreases
  - Soil permeability to air, water, & plant roots substantially declines
  - The root environment is prone to waterlogging & increased plant pathogens
  - Plant growth & productivity diminishes
  - Crop water use efficiency erodes

II_3_Revised



Source: Neja, RA; Ayers, RS, Kasimatis, AN. 1978.

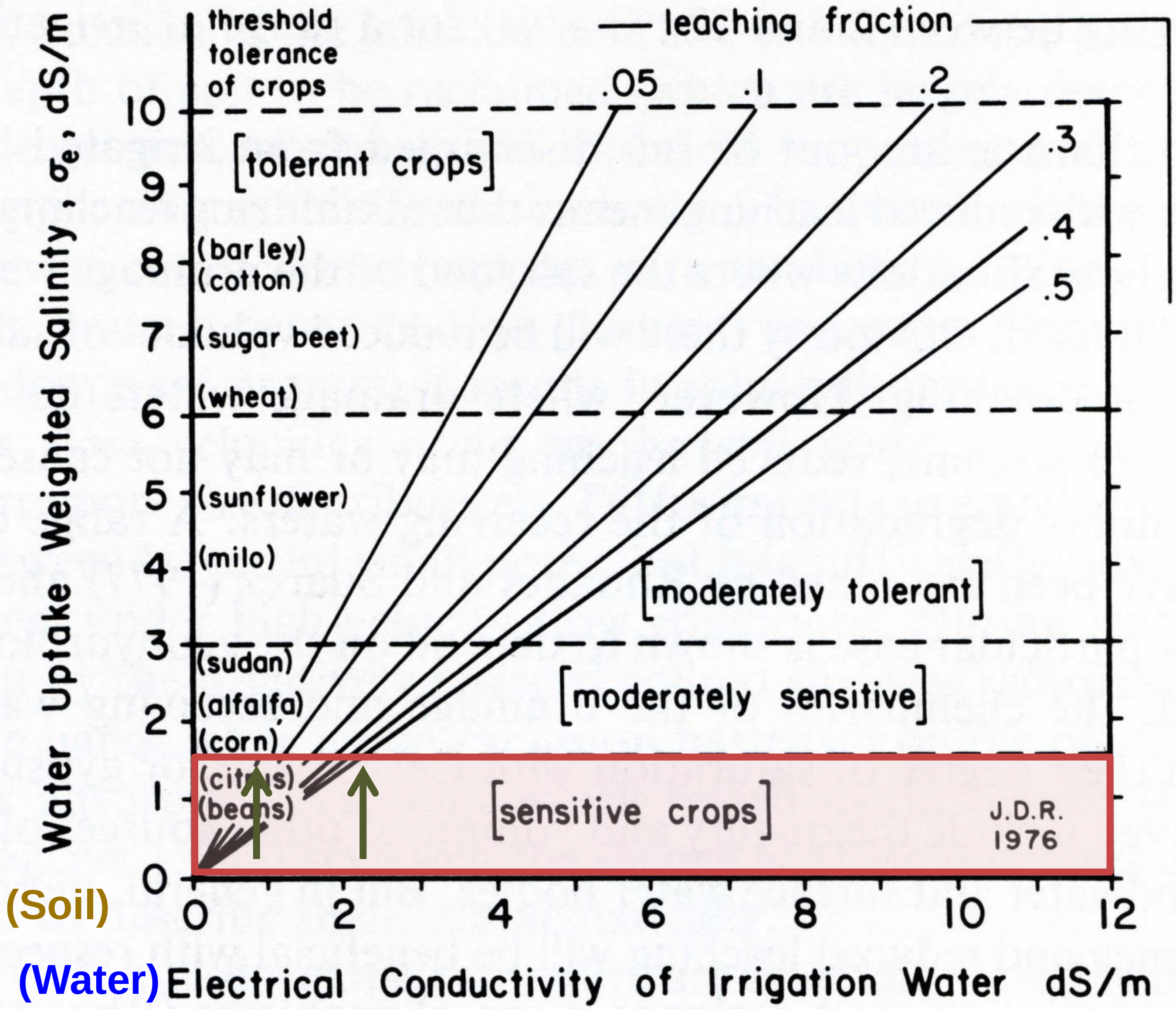
CROPS ON SALINE SOILS REQUIRE MORE WATER

Salinity Increases Water Needs

- To minimize water stress, crops irrigated with saline water need more water than when irrigated with Sacramento River water
  - To overcome salt induced water stress
  - To dilute & leach salts from root zones
- The extra water requirement = a leaching fraction (LF)

II_3_Revised

ASSESSING SALINITY HAZARDS
HIGH FREQUENCY IRRIGATION



Source: Rhoades, JD; Loveday, J. 1990.

Salinity Increases Water Needs

- Leaching fraction applications reduce:
  - The amount of applied water stored in root zones (application efficiency)
  - The amount of applied water beneficially used by crops (irrigation efficiency)
- Additional leaching fraction water also increases
  - Energy consumption for pumping
  - Labor, system maintenance, & other irrigation costs

II_3_Revised

SODIUM & CHLORIDE

Sodium & Chloride

- Sodium & chloride are the prominent ions in blends of intruded seawater & river water
- They readily associate due to their opposite charges (positive & negative, respectively)
  - However, they bond very weakly & sodium chloride salts are highly soluble
  - They readily dissociate
- Sodium & chloride readily move from soils into trees & vines as they take up water

Sodium & Chloride

- Sodium & chloride move with water as far as they can – the edges of leaves
- After accumulated sodium & chloride reach critical levels, tissues on leaf edges die
- In grapevines, critical concentrations are ≈ 0.25% sodium & 0.50% chloride

II_3_Revised

Late Season Chloride Toxicity in a Merritt Island Vineyard

Sample I. D.		MACRONUTRIENTS							MICRONUTRIENTS					POSSIBLE EXCESS	
Year	Block	Total N	NO3	P	S	K	Mg	Ca	Fe	Mn	Cu	Zn	B	Cl	Na
		%	ppm	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	%	%
10/26/10	P. Sirah weak	*NA*	581	0.15	0.15	0.3	1.06	3.6	470	137	3	151	145	1.2	0.02
10/26/10	P. Sirah good	*NA*	349	0.11	0.17	0.7	0.36	3.0	463	133	3	151	60	0.2	0.00
10/26/10	Cab Sauv weak	*NA*	242	0.19	0.16	0.6	0.79	3.3	519	38	3	150	264	1.6	0.03
10/26/10	Cab Sauv good	*NA*	230	0.10	0.22	0.9	0.41	3.4	526	45	3	130	64	0.2	0.00

1. Values highlighted in **light blue** are low and those highlighted in **light red** indicate high based on Progressive Viticulture guidelines. *NA* = not analyzed. ND = not detected.

II_3_Revised

Late Season Chloride Toxicity in a Merritt Island Vineyard

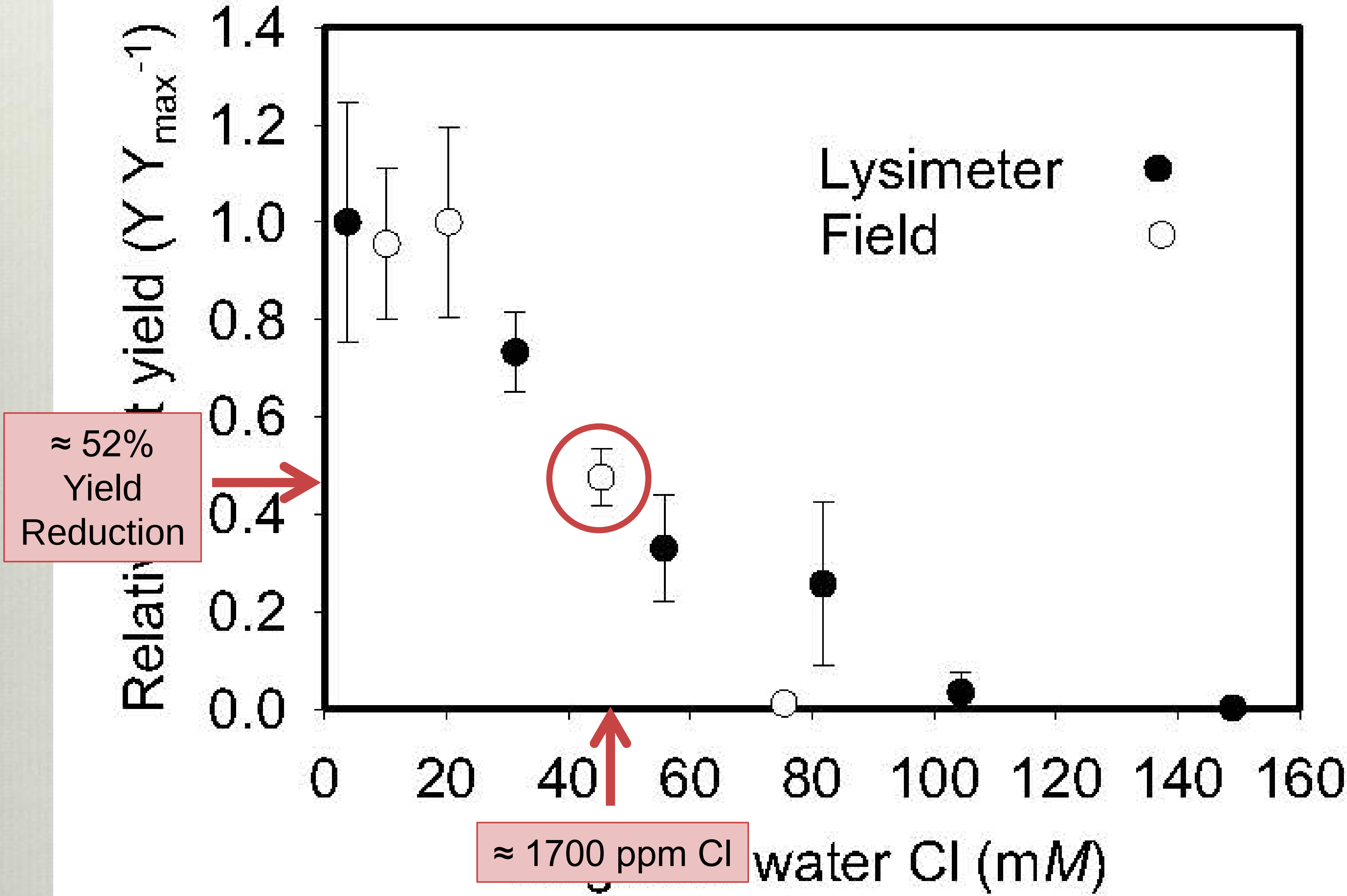
Sample I. D.	EC	CEC	O. M.	Exch. Na	ESP	Cl
	dS/m	meq/100 g	%	ppm	%	ppm
PS Weak 0"-15"	1.3	33	1.3	55	1	174
PS Weak 15"-39"	6.3	42	0.4	189	2	1802
PS Weak 39"-63"	6.9	30	0.3	316	5	2131
CS Weak 0"-15"	4.8	37	1.4	185	2	1308
CS Weak 15"-39"	5.7	29	0.3	268	4	1684
CS Weak 39"-63"	7.9	26	0.3	459	8	2444

1. Values highlighted in **light blue** are low and those highlighted in **light red** indicate high based on Progressive Viticulture guidelines. *NA* = not analyzed.

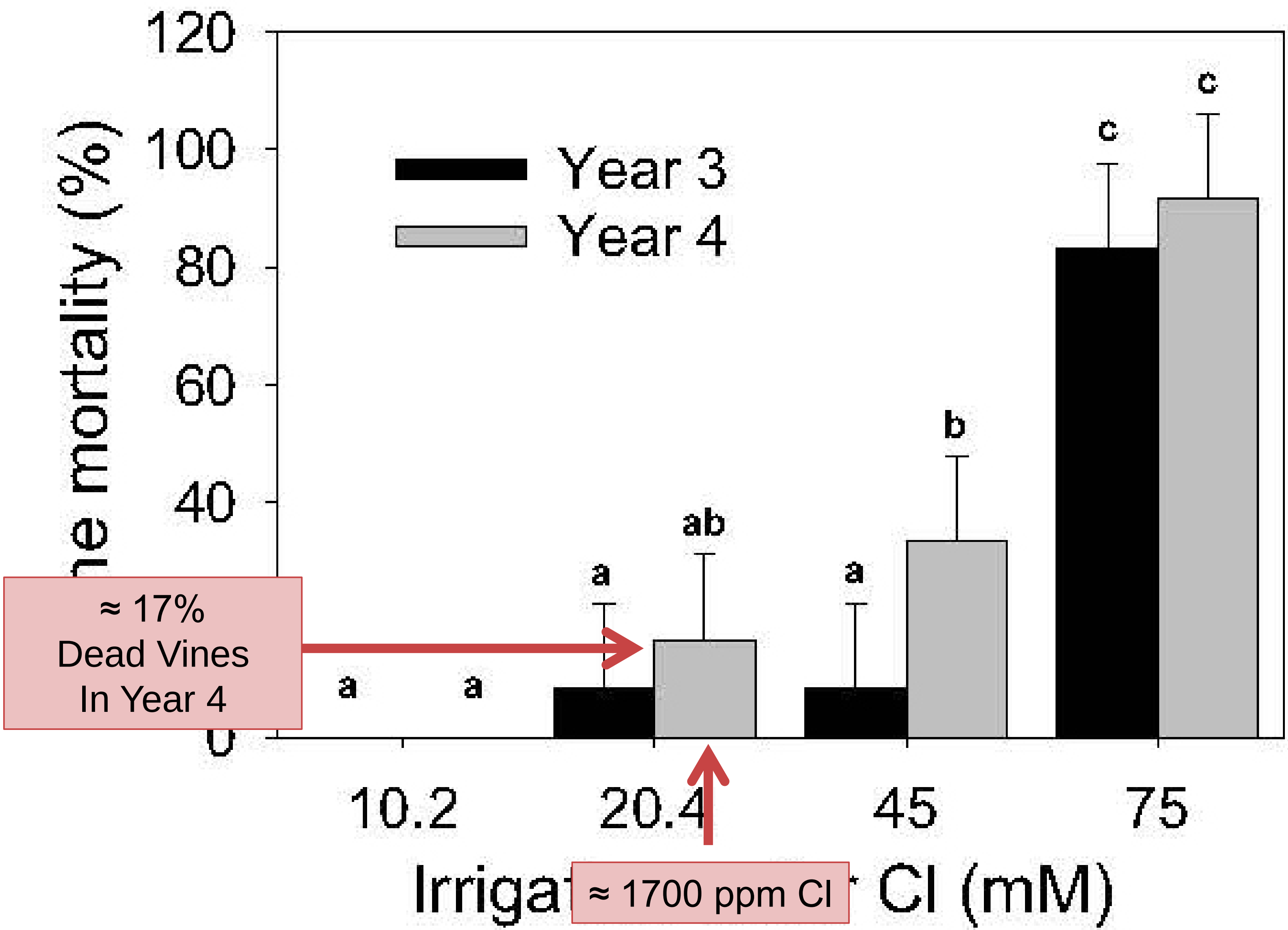
≥ 350 ppm

Sodium & Chloride

- Leaf tissue death due to toxicity limits a plants capacity to
  - Photosynthesize
  - Grow
  - Develop & ripen fruit
  - Ripen woody tissues
  - Survive



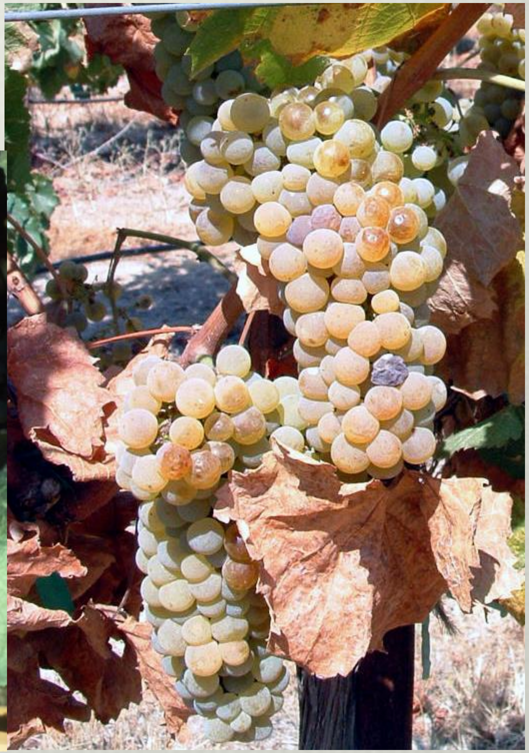
Source: Shani, U; Ben-Gal, A. 2005.



Source: Shani, U; Ben-Gal, A. 2005.

Sodium & Chloride

- Grape berries are also a final destination for sodium & chloride taken up from soils
- When berry concentrations are sufficiently high, sodium & chloride are sensible in wine as salty flavor
- Other descriptors: flat, dull, soapy, seawater-like, & brackish



Sodium & Chloride

- As with salinity, extra irrigation water is required to dilute & leach excess sodium & chloride
- Again, the extra water required for leaching decreases the efficiencies of applied water
- In soils, sodium negatively interacts with potassium & magnesium, while chloride negatively interacts with nitrate
- More fertilizer than normal may be needed for plants on sodic & high chloride soils

ONE MORE THING – DRAINAGE

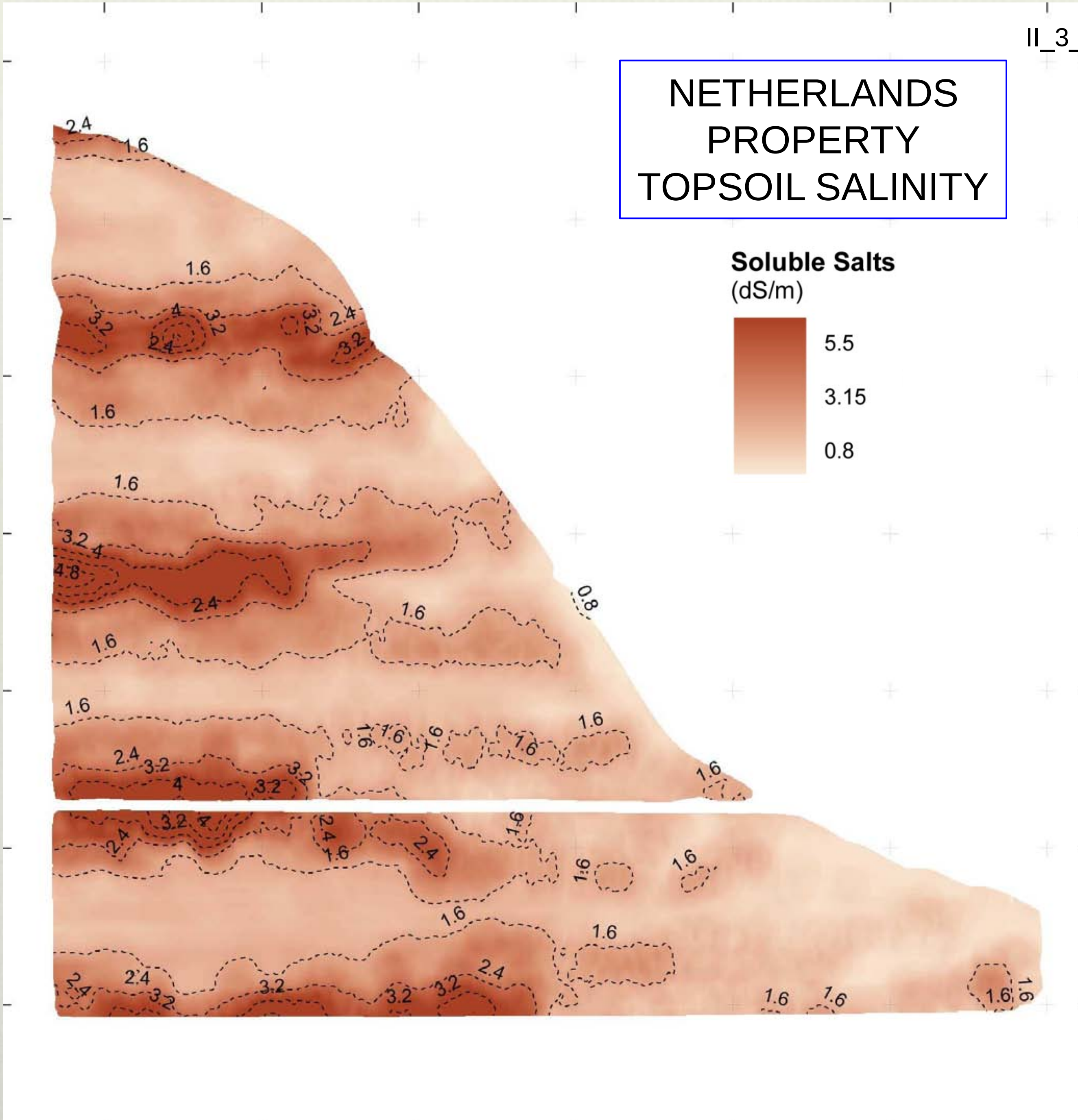
One More Thing - Drainage

- As we have seen, agricultural salt water intrusion problems require leaching
- However, leaching is effective only when salt laden water percolating below root zones has somewhere to go
- Therefore, adequate subsurface drainage is a second requirement for salt water intrusion induced problems on farm land

One More Thing - Drainage

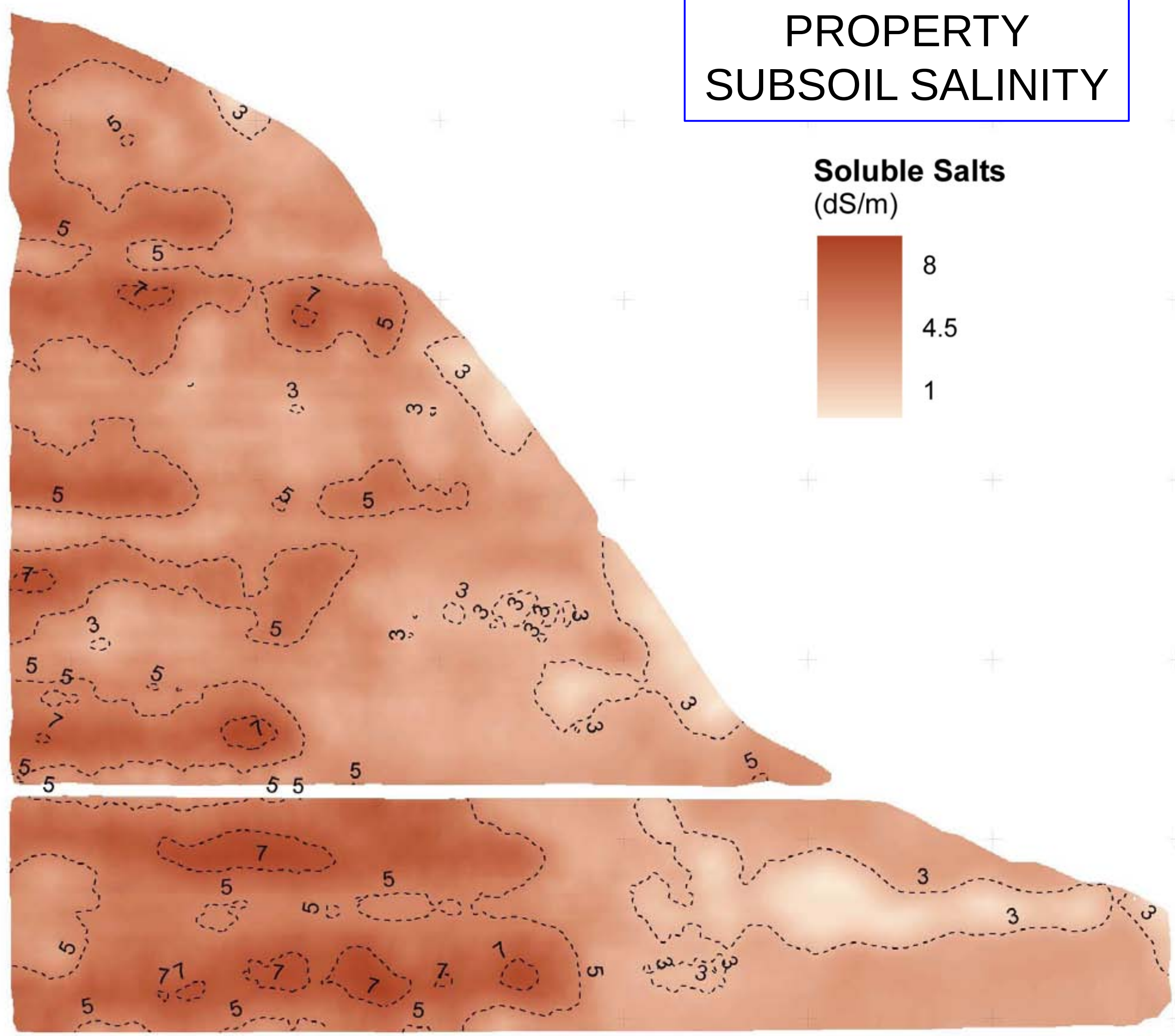
- Unfortunately, naturally well drained soils are somewhat uncommon in the Delta
- Rather, most Delta soils are subject to high water tables that restrict drainage
- Costly drainage systems will be required for managing salt water intrusion induced problems

II_3_Revised


NETHERLANDS
PROPERTY
TOPSOIL SALINITY
Soluble Salts
(dS/m)
5.5
3.15
0.8

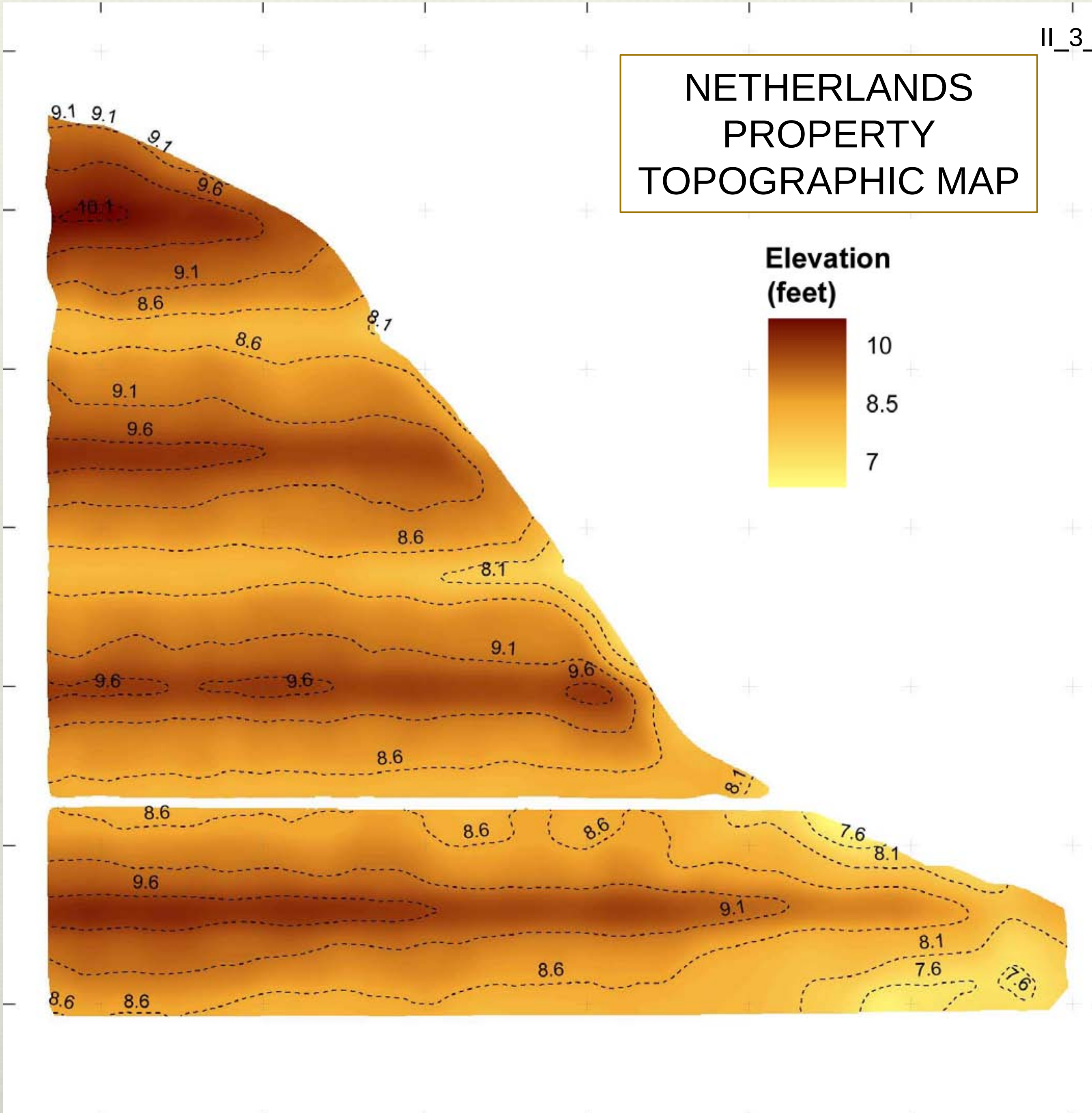
II_3_Revised

NETHERLANDS PROPERTY SUBSOIL SALINITY

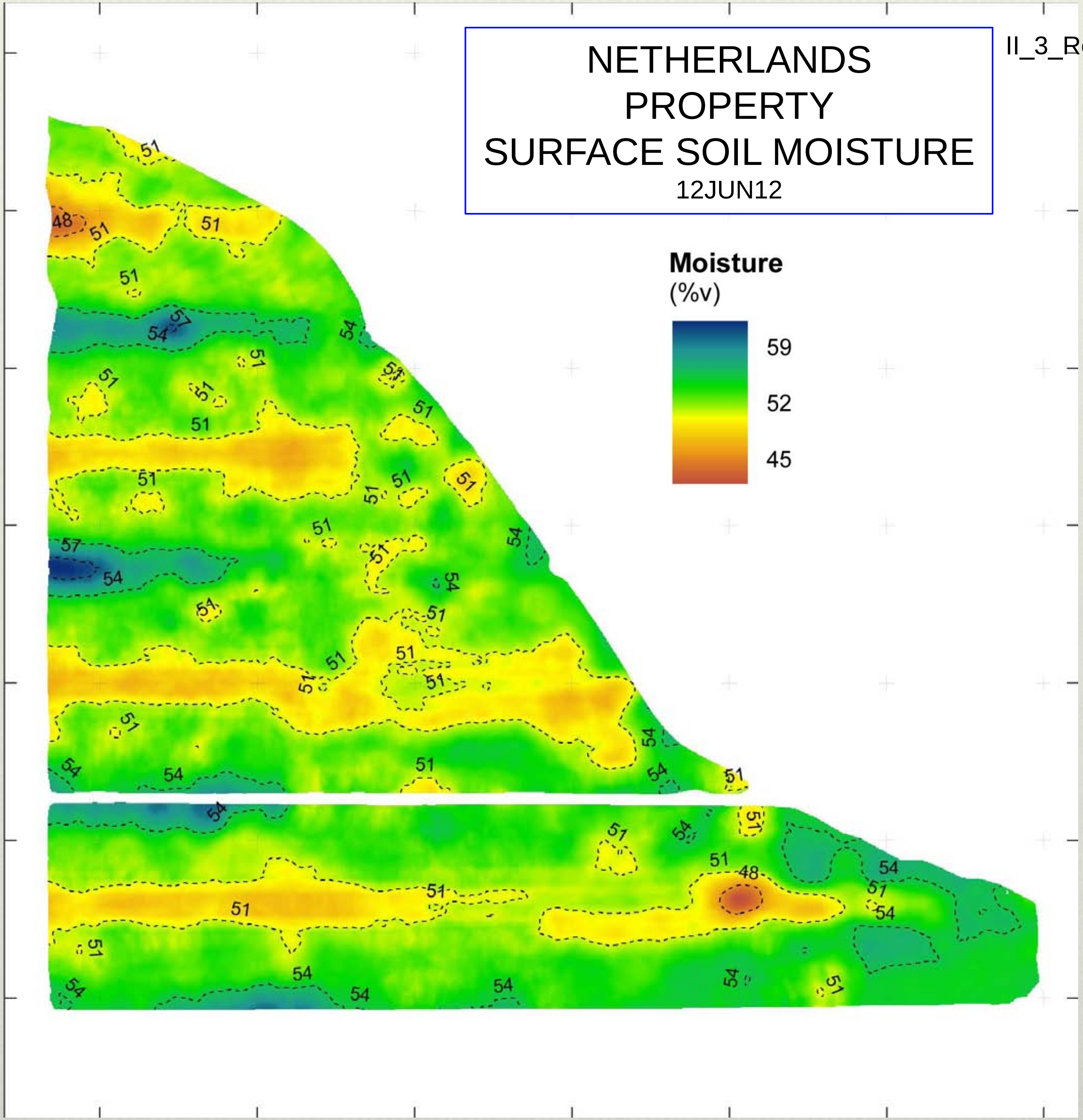


II_3_Revised

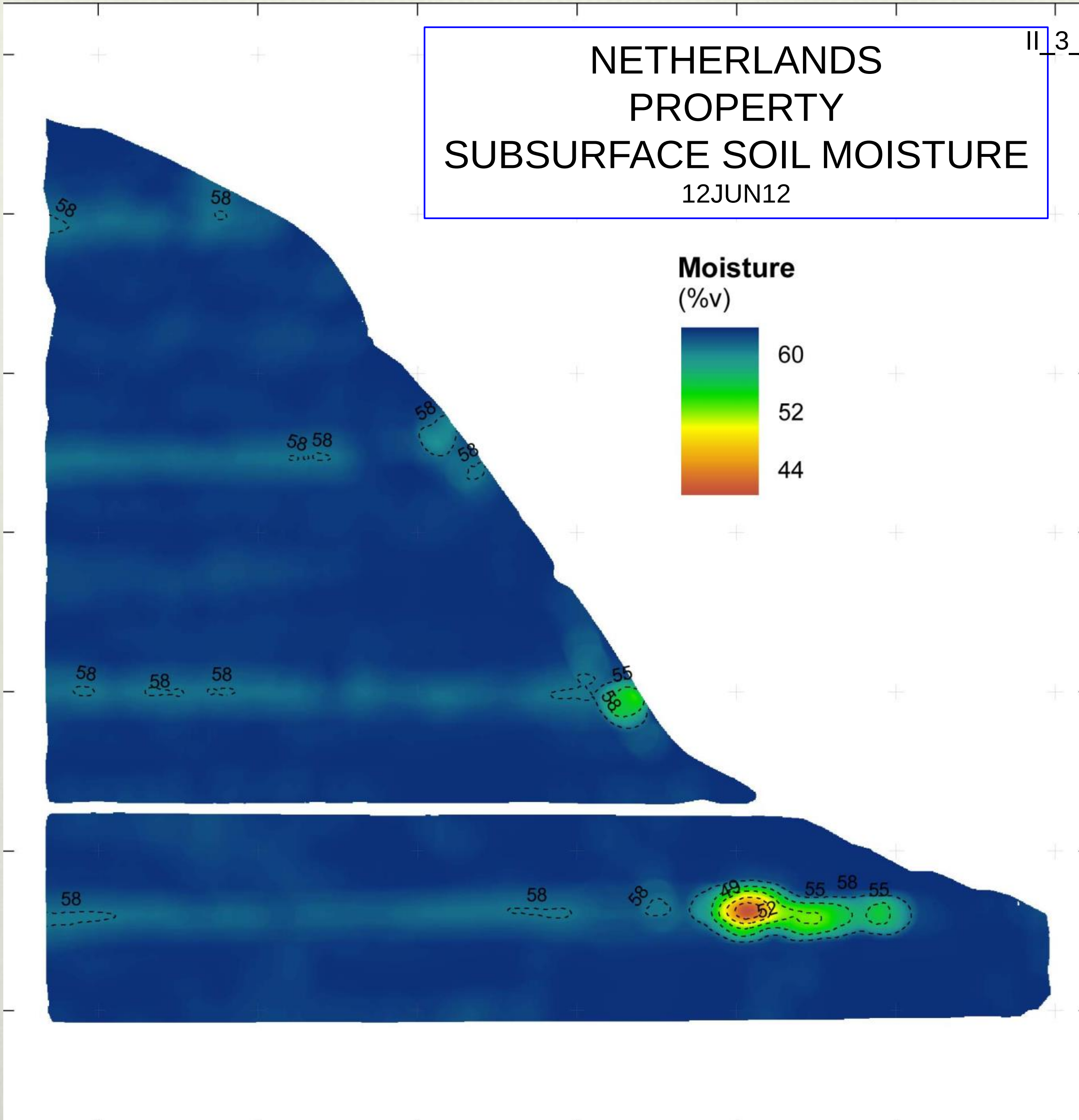
NETHERLANDS PROPERTY TOPOGRAPHIC MAP



II_3_Revised

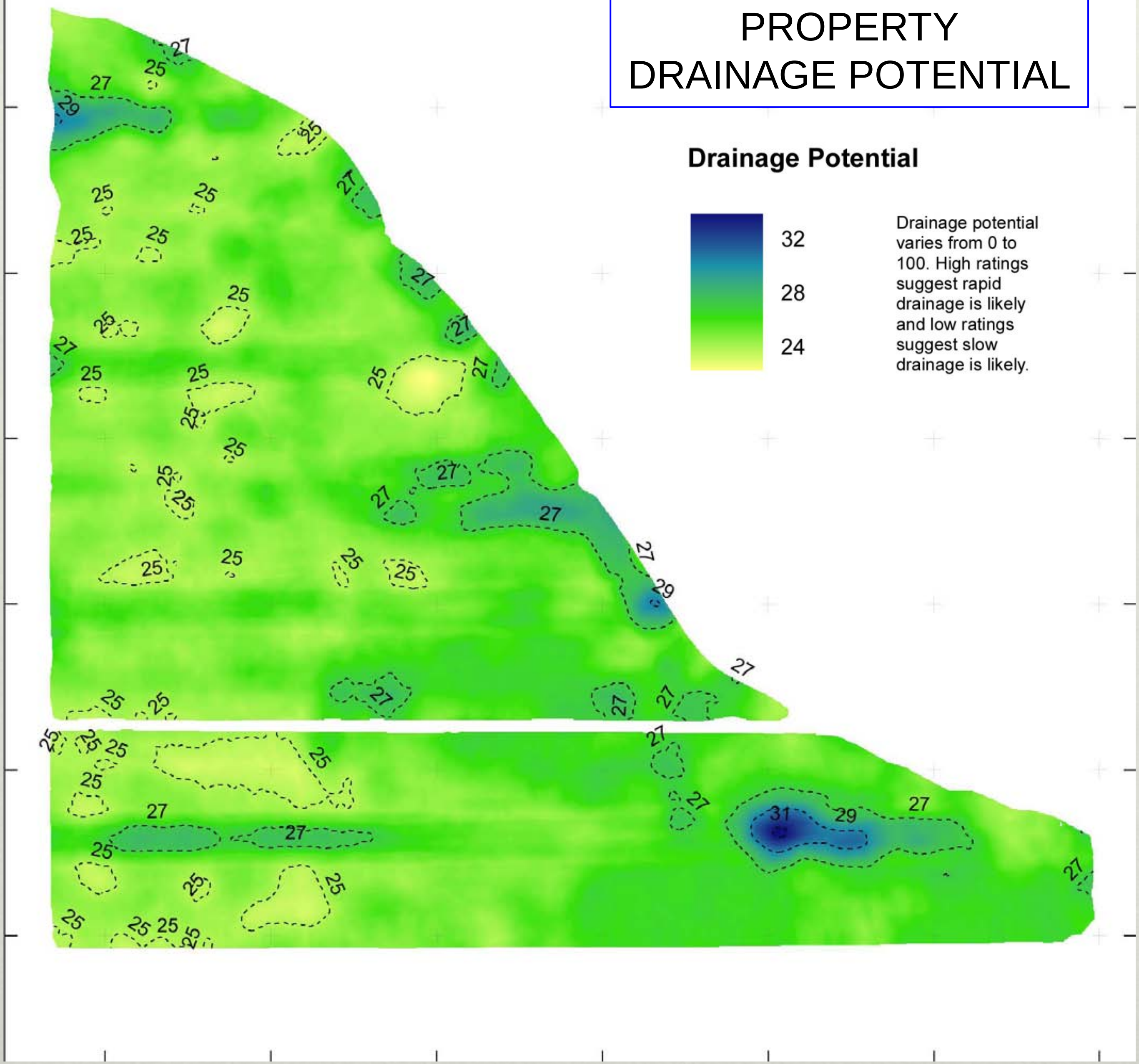

NETHERLANDS
PROPERTY
SURFACE SOIL MOISTURE
12JUN12
Moisture
(%v)
59
52
45

II_3_Revised


NETHERLANDS
PROPERTY
SUBSURFACE SOIL MOISTURE
12JUN12
Moisture
(%v)
60
52
44

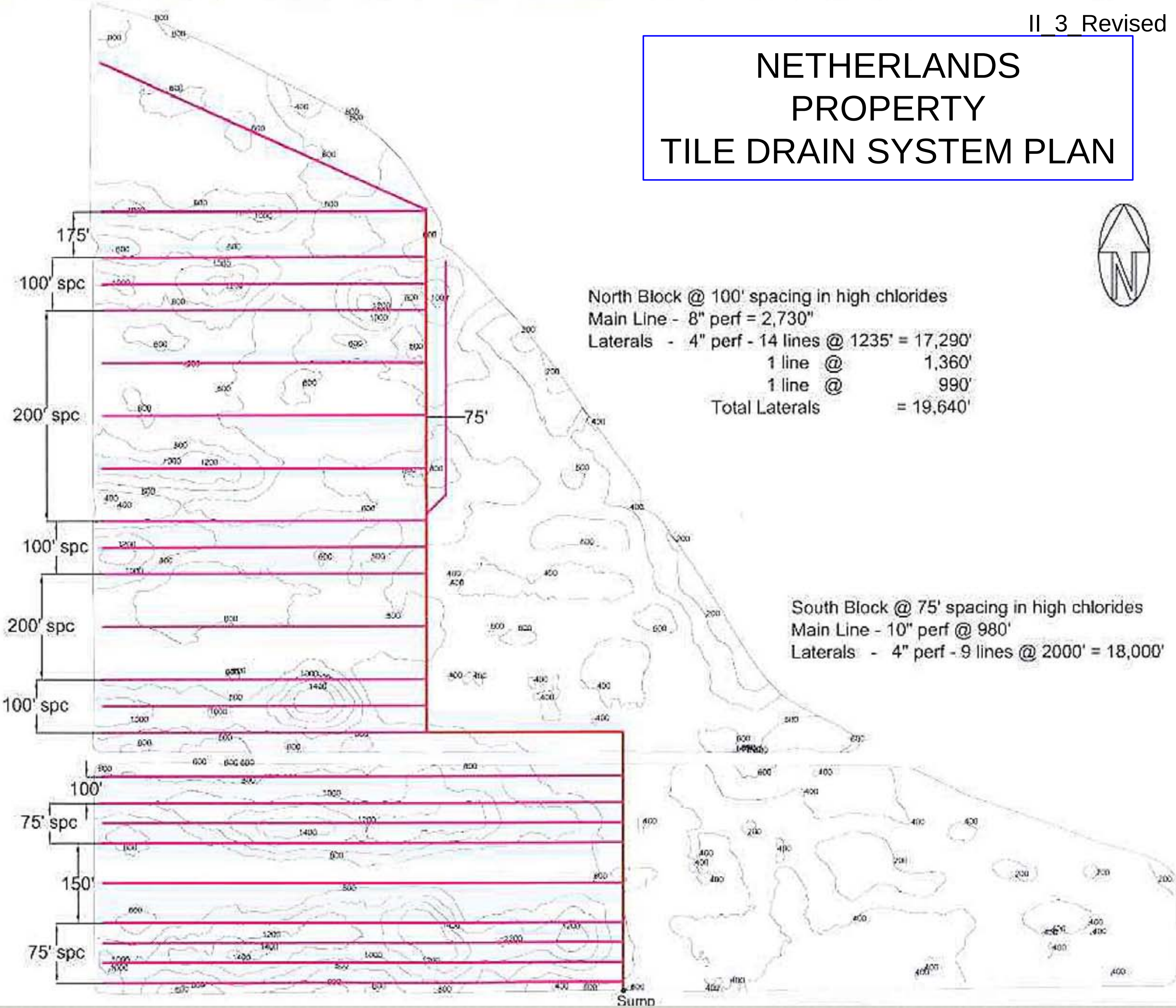
II_3_Revised

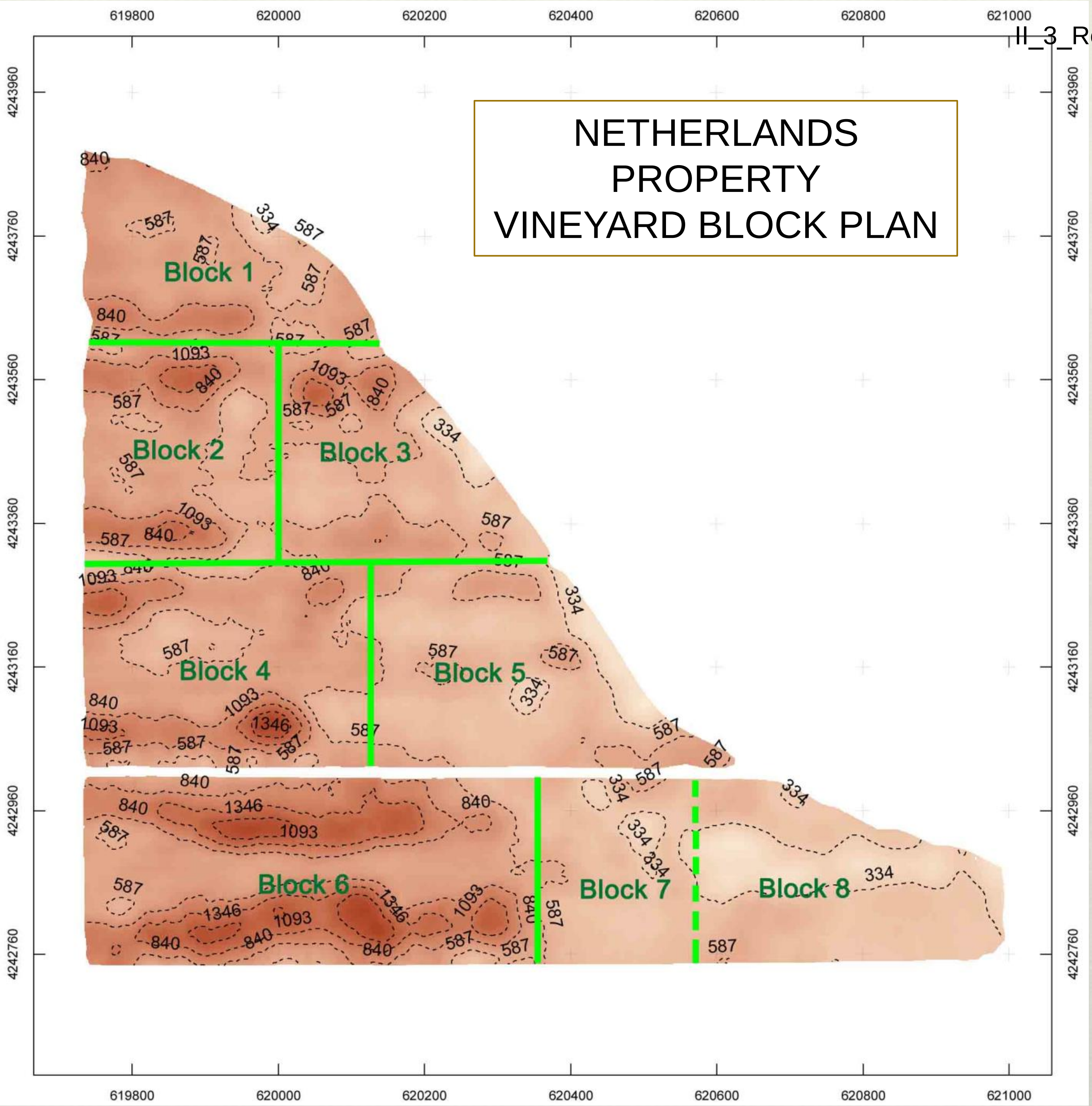
NETHERLANDS PROPERTY DRAINAGE POTENTIAL



II_3_Revised

NETHERLANDS PROPERTY TILE DRAIN SYSTEM PLAN




II_3_Revised
NETHERLANDS
PROPERTY
VINEYARD BLOCK PLAN
Block 1
Block 2
Block 3
Block 4
Block 5
Block 6
Block 7
Block 8
619800
620000
620200
620400
620600
620800
621000
4243960
4243760
4243560
4243360
4243160
4242960
4242760

II_3_Revised


NETHERLANDS
VINEYARD
JULY, 2015
Source: Google Earth
Ryer Ave
84
Rd 160

One More Thing - Drainage

- Drainage waters are returned to rivers & sloughs, compounding the negative impacts of salt water intrusion
- As a result, leaching fractions increase
- The ultimate solution: low salt, Sacramento River irrigation water

II_3_Revised

Low Salt River Water Used to Irrigate a Grand Island Vineyard

Sample I. D.	Date	SALINITY		PERMEABILITY		POSSIBLE TOXICITY		
		EC	TDS	SAR-Adj.	EC	SAR-Adj.	Na	Cl
		dS/m	ppm		dS/m		ppm	ppm
Vyd Irrigation	May, 2013	0.0	160	1	0.0	1	13	31
Vyd Pump	May, 2012	0.4	265	1	0.4	1	25	20
River	Dec, 2007	0.1	114	0	0.1	0	6	5
Canal	Dec, 2007	0.2	174	1	0.2	1	14	8
Irrigation	Sep, 2007	1.4	909	5	1.4	5	93	94

1. Values in black indicate no problems, those in **yellow** indicate increasing problems, and those in **red** indicate severe problems.

CONCLUSIONS

Conclusions

- Current conditions in the Delta are the most sustainable
  - Ample high quality, low salt irrigation water is readily available in Delta rivers & sloughs
  - Salt water induced water stress & sodium & chloride toxicities are uncommon
  - Little extra water is required for leaching
  - On-farm water use efficiency is high
  - The Delta vineyards & orchard produce high quality fruit & wine for the US & beyond

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Attorneys for Protestants
Local Agencies of the North Delta
Bogle Vineyards / Delta Watershed Landowner Coalition
Diablo Vineyards and Brad Lange / Delta Watershed Landowner Coalition
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 MICHELLE LEINFELDER-MILES** **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, Michelle Leinfelder-Miles, do hereby declare:

I. INTRODUCTION

I am the Delta Crops Resource Management Advisor with the University of California Cooperative Extension, based in San Joaquin County. I have 4.5 years of experience working in this capacity and fourteen years of research experience in agricultural cropping systems, which includes work in grains and forages, vegetable crops, and tree and vine fruit crops. I received my B.S. in Crop Science and Management from UC Davis (2001), my M.S. in Horticulture from Cornell University (2005), and my Ph.D. in Horticulture from Cornell University (2010). As the Delta Crops Resource Management Advisor, I conduct a multidisciplinary research and outreach program on agricultural production and resource stewardship. My research projects center on row crops and the management of water and soil resources in those agricultural systems. My outreach program is directed toward agricultural producers, allied industry representatives, and natural resource managers. I conduct instructional meetings and demonstration field meetings where I communicate research results from my own program and those of my UC colleagues to the agricultural community. A description of my research projects is included in my statement of qualifications. I have dedicated considerable time to assessing soil salinity conditions in the Delta because salinity has the potential to impact crop productivity and soil resource management.

II. INTRODUCTION TO SALINITY

Salt problems occur on approximately one-third of all irrigated land in the world. In the United States, salt problems occur near the coasts and in soils of the arid west. Some soils are salty because parent materials weather to form salts; while on croplands, salts may be carried in irrigation water, added as fertilizers or other soil amendments, or be present due to a shallow saline groundwater.

Measuring the salt load, or Total Dissolved Solids (TDS), in soil or water is not a practical way of deriving a salinity condition (II-16, Hanson et al., 2006). Rather, the salt load is typically estimated by measuring electrical conductivity (EC). Positively-charged cations (Ca^{2+},

Mg^{2+}, K^+, and Na^+) join with negatively-charged anions (Cl^-, SO_4^-, HCO_3^-) to form soluble salts ($NaCl$, $CaCl_2$, $MgCl_2$, $CaSO_4$, $CaCO_3$, and KCl). In a solution, the ions disassociate and will move toward an electrode of the opposite charge, creating a current that can be measured with an EC meter. When the solution comes from a soil saturated paste (methods described in Section IV), the abbreviation used is ECe, and when the solution is water, the abbreviation is ECw. A unit of measure for EC is decisiemens per meter (dS/m) or millimhos per centimeter (mmhos/cm), which are equivalent. Decisiemens per meter can be converted to microsiemens per centimeter (μS/cm) by multiplying by 1,000 (i.e. 1 dS/m equals 1,000 μS/cm).

III. EFFECTS OF SALINITY ON PLANT GROWTH

Salt impairs plant growth by exerting osmotic stress that results in decreased turgor pressure in plant cells, by causing specific ion toxicities that vary by plant species, or by degrading soil conditions that limit plant water availability. Osmotic stress is the most common means by which salt impairs plant growth (II-16, Hanson et al., 2006). Under a non/low-saline condition, the concentration of solutes (i.e. sugars and organic acids transported in the plant vascular system) is higher in plant roots than in the soil-water solution. This means that water moves freely into the plant roots because there is more force, called osmotic potential, pulling the water into the plant roots than there is force holding the water to the soil particles. Under conditions of higher soil salinity, plants must transport solutes within the plant to the roots in order to keep root solutes higher than soil-water solution solutes to avoid water stress. Remobilizing solutes requires energy, and that energy, then, is not used for plant growth. Thus, some plants will not show specific salt-induced symptoms as a result of saline soil conditions; rather, they may just exhibit lower growth or generic stunting which may or may not be realized by the farmer as being salt-induced (II-16, Hanson et al., 2006). Tables 2 through 5 in Hanson et al. (2006) present salt tolerance ratings (i.e. sensitive, moderately sensitive, moderately tolerant, tolerant) of various crops grown in California and in the Delta.

Plant growth may also be impaired by specific ions, like sodium (Na^+), chloride (Cl^-), or boron (B), which can accumulate in plant stems and leaves. This results in burning on the leaf tips or around the margins. Sodium is not an essential nutrient for plants, and in addition to specific toxicity, the presence of Na^+ in the soil may limit plant calcium, magnesium, or potassium uptake, and therefore, result in plant nutrient deficiencies. Chloride and B are essential plant nutrients, but they are micronutrients and are only needed in small amounts. When toxic concentrations of Cl^- or B occur in plant leaves, it appears as yellowing and progresses to burning along the leaf edges. When leaves yellow or burn, it reduces their photosynthetic capacity, thus reducing plant growth.

Plants may also be affected by salinity if soil conditions are degraded and water infiltration and drainage are impaired. Degraded soil conditions may exhibit white or black crusts on the soil surface or wet spots on the soil surface. The white crusting is the result of evapoconcentration of salts on the surface of the soil, and the black crusts form because humus is carried upward with water as water evaporates. Slick spots form because the soil particles are completely dispersed and soil structure is lost. To understand at the soil particle scale, consider that soil clay particles have a negative charge and cations like sodium, calcium, and magnesium are attracted to the clay particles. Sodium cations are not held closely to the clay particles, so if sodium dominates the other two cations in the soil, the clay particles will be more disperse. The soil swells, and water infiltration into the soil will decrease. Poor infiltration can result in standing water on the soil surface or poor aeration in the soil pores, neither of which promotes plant health and growth.

Since osmotic stress is the most common means by which salt impairs plant growth, it is important to address the relationship between applied water salinity and soil salinity. Irrigation water carries salts, and when irrigation water is applied to fields, salts are added to the soil. Thus, the applied water salinity influences the soil salinity. Salts accumulate in the soil at higher concentrations than they existed in the applied water because evaporation and plant uptake extract water from the soil leaving the salts behind. While salts may accumulate disproportionately in the soil profile depending on soil properties, leaching, irrigation systems, or other reasons, crops respond to the average soil salinity in the root zone (II-15, Ayers and Westcot, 1985). For these reasons, crop salinity tolerances are expressed as both seasonal average applied water salinity and average root zone soil salinity.

IV. DELTA RESEARCH PROJECT FINDINGS

I have led several field projects over the last few years where we have investigated soil salinity conditions in the south Delta under various cropping and irrigation regimes. In multi-year studies of a drip-irrigated processing tomato field (i.e. tomatoes made into paste or other products) and flood irrigated alfalfa fields, we found that salts were accumulating in the soil. In the tomato study, leaching occurred laterally away from the buried drip emitters. Salts concentrated in the top 10 cm (4 in) of soil and at about 90 cm (3 ft) below the surface, where fine-textured organic matter likely impeded downward water movement. Using surface irrigation water that ranged from 400-750 µS/cm (0.4-0.75 dS/m) across the three-year study, average root zone salinity increased over that time, from 0.79 dS/m at the start of the project to 1.31 dS/m at the end. In the alfalfa project, where seven fields were evaluated over three years, four out of seven sites had an ECe that met or exceeded 10 dS/m at 90 cm (3 ft) below the surface. This illustrates that salinity may build up in soil layers just below the depth which is typically sampled for soil nutrient and salinity status, approximately the top 60 cm (2 ft) for orchards (II-22, Brown and Niederholzer, 2007) and possibly shallower in annual crop systems. Thus over time, growers may not be aware of the degree to which soil salinity has increased in their fields.

In the aforementioned alfalfa study, average root zone salinity ranged from 0.71 dS/m to 7.18 dS/m across the seven south Delta sites and three years. At only two sites was an average root zone salinity below 2.0 dS/m maintained across the study period, the level at which 100 percent yield potential is expected for alfalfa. Some of the study sites likely accumulated salts because shallow groundwater impeded salts from leaching out of the root zone or low permeability soil impaired leaching. Seasonal average salinity of the irrigation water at these sites ranged from 360-1,930 µS/cm (0.36-1.93 dS/m) across the study period.

V. SOIL SAMPLES AT RYER ISLAND

In August 2016, I surveyed soil salinity conditions of two permanent crops, grapes and pears, on Ryer Island in the North Delta. Soil series information for these sites is available from the United States Department of Agriculture Natural Resources Conservation Service (NRCS, 2017). The soil series of the pear orchard is Valdez silt loam, which characterizes approximately 23,088 acres in California, most of which are in the Delta. This soil has low permeability. Soil maps provide the saturated hydraulic conductivity, or Ksat, of this soil as being approximately 32 mm/hr down to about 38 cm and 10 mm/hr from about 38-152cm. The Ksat of a soil is the ease with which water passes through a soil. The soil series of the vineyard is Egbert silty clay loam, which characterizes approximately 45,284 acres in California, most of which are located in the Delta. (The soil of the aforementioned processing tomato study was also an Egbert silty clay loam.) Soil maps of this soil provide a low Ksat of approximately 10 mm/hr in the top 15 cm, and a very low Ksat of approximately 5 mm/hr from 15-152 cm.

In the pear orchard, sampling procedures were as follows. Eight holes were augered (4.5-cm diameter) in-line with the tree row from random locations across a span of 20 rows. The orchard is sprinkler-irrigated with nozzle risers in the tree row. Four of the holes were sampled from between a nozzle and tree, and four were taken opposite the tree from the nozzle in a "shadow" of direct irrigation. The holes were augured in 30-cm increments to a depth of 150-cm. Samples from the same depth were composited into bulk samples, for a total of five representative samples from the orchard.

At the same time that bulk soil samples were taken, a soil moisture sample was also collected using a volumetric sampler (60-cm^3). The sample was collected from the center 7 cm of each 30-cm depth increment. After extracting the soil, it was sealed in a metal can to prevent moisture loss. The soil was weighed before and after oven-drying at 105 degrees C for 24 hours, and the soil moisture content (as a percent of the soil volume) was calculated.

A groundwater sample was collected by auguring until water was visually or audibly reached. The water was allowed to equilibrate in the hole before measuring the depth to groundwater and collecting a sample (200-mL). Water was stored in a cooler (37 degrees C) until analyzed.

Because the vineyard is drip irrigated, the wetting pattern from irrigation would be quite different and less uniform than the wetting pattern in the pear orchard. For this reason, we sampled two grid patterns in the vineyard, from vines that are approximately 20 rows apart. The grid pattern consisted of samples taken from 30 cm, 60 cm, 90 cm, and 120 cm from the vine row, in 30-cm increment depths, down to 150 cm, for a total of 20 samples from each of the two grids. The vine rows were spaced approximately 240 cm apart, so the 120-cm sample marked the mid-point between vines. Both grid samplings were taken from the Egbert soil series. Soil moisture samples were taken for each grid pattern at 30 cm from the vine row, following the aforementioned procedures. It was assumed that at this point in the season, since irrigation had ceased for the season, that soil moisture between 30 cm and 120 cm from the vine row would not be profoundly different. Groundwater was also sampled from both grid patterns following the aforementioned procedures.

The samples were processed for salinity by oven-drying at 38 degrees C and grinding to pass through a 2-mm sieve. Soil salinity was determined by measuring the electrical conductivity (EC) of the saturated paste extract, where higher EC indicates higher levels of dissolved salts in the soil. To conduct these procedures, a saturated paste extract was made by saturating a soil sample with deionized water until all pores were filled but before water pooled on the surface (II-41, Rhoades, 1996). When saturation was achieved, the liquid and dissolved salts were extracted from the sample under partial vacuum. The EC of the saturated paste extracts (ECe) was measured in the laboratory of UC Cooperative Extension in San Joaquin County using a conductivity meter (YSI 3200 Conductivity Instrument). The groundwater samples were vacuum-filtered for clarity and analyzed with the same conductivity meter.

The bulk samples from the pear orchard had ECe readings ranging from 0.25 to 1.18 dS/m down the soil profile. The groundwater was at a depth of 1.65 m and had an EC of 0.35 dS/m. Based on these data, the average root zone salinity at this orchard was 0.74 dS/m. Brown and Niederholzer (2007)(II-22) indicate that pear yields have been reduced when the average root zone salinity reached 2.5 dS/m; thus, the salinity at this site would not appear to be currently impacting yield.

In the vineyard, which is drip irrigated, the ECe pattern suggests that the wetting front is pushing salts to approximately 90 cm from the vine row and 90 cm deep. This region of both grids has some of the highest salinity of the profile, at or above 4.0 dS/m. The saturation percentage (SP) at the 90-cm depth exceeded 90 percent at both sampling grids. The SP of a soil correlates well with soil texture, and when the SP ranges from 65-135 percent, the soil is characterized as clay (II-19, Neya et al., 1978). Clays are fine textured soils that have low permeability; thus, the salts appear to be accumulating at the 90-cm depth where infiltration is inhibited by inherent soil characteristics.

The average root zone salinity of the two grids is approximately 1.9 and 3.1 dS/m for the north and south grids, respectively. The groundwater was at a depth of 2.21 m and 2.84 m at the north and south grids, with corresponding ECs of 0.21 dS/m and 0.97 dS/m. (II-15, Ayers and Westcot (1985)) present salinity crop tolerances and yield potential for grapes. To attain 100 percent yield potential, the average root zone salinity should not exceed 1.5 dS/m. Likewise, for 90, 75, 50, and 0 percent yield potential, the average root zone salinity should not exceed 2.5, 4.1, 6.7, and 12 dS/m, respectively. While certain management practices, varietal differences, and environmental factors may impart a higher level of tolerance among certain vineyards, there is the potential for the salinity conditions at this site to impact yield, unless the soils are leached of the salts.

VI. SALINITY MANAGEMENT BY LEACHING

The primary management strategy for combating salinity is leaching, and leaching must be practiced when soil salinity has the potential to impact yield (II-15, Ayers and Westcot, 1985). Leaching occurs when water is applied in excess of soil moisture depletion due to evapotranspiration (ET) (II-16, Hanson et al., 2006), or the amount of water that is evaporated from the soil and transpired by the plant. Leaching may occur during the winter season when fields are fallow or crops are dormant, or leaching may occur whenever an irrigation event occurs.

The leaching fraction (Lf) is the fraction of the total applied water that passes below the root zone. This can be expressed as:

$$Lf = ECw/ECdw \qquad \text{(Equation 1)}$$

where ECw is the electrical conductivity of the applied water, and ECdw is the electrical conductivity of the drainage water at the bottom of the root zone, which is equal to 2ECe (II-15, Ayers and Westcot, 1985).

The leaching requirement (Lr) is the minimum amount of the total applied water that must pass through the root zone to prevent a reduction in crop yield from excess salts. Rhoades (1974) (II-21) proposed the following equation for the Lr:

$$Lr = ECw/(5ECet – ECw) \qquad \text{(Equation 2)}$$

where ECet is the average soil salinity, as measured by saturated paste extract, that a crop can tolerate. Thus, there are two factors necessary to estimate the Lr. One factor is the salt concentration of the applied water, which can vary substantially in the Delta based on time of year and location. The other factor establishing the Lr is the salt tolerance of the crop. Some crops are more tolerant of salinity than others. Alfalfa is a widely planted crop in the Delta and is considered moderately sensitive, so the following derivation uses salinity tolerance levels for alfalfa as an example. Beyond an average root zone soil salinity threshold (ECet) of 2.0 dS/m and a seasonal average applied water salinity threshold (ECw) of 1.3 dS/m, alfalfa yield reductions are expected (II-15, Ayers and Westcot, 1985). This relationship between ECe and ECw, where ECe = 1.5ECw, holds under the following assumptions: there is a 15-20 percent Lf and a 40-30-20-10 percent plant water uptake pattern from the upper quarter of the root zone to the lower quarter. Using these values in Equation 2, the Lr is calculated to be 15 percent. When ECet is given at 2.0 dS/m but ECw ranges from 0.5-2.0 dS/m, the Lr ranges from 5-25 percent.

The average ECw for this range of values is 1.3 dS/m, and the average Lr is 15 percent. The yield potential guidelines in Ayers and Westcot (II-15, 1985) assume a 15 percent Lf. Using these guidelines to predict crop response from a given applied water salinity requires an achievable Lf of 15 percent, and when ECw is higher than 1.3 dS/m, the Lf must be higher than 15 percent.

While a 15 percent Lf is a general rule of thumb in agricultural systems (II-19, Neya et al., 1978), given the Delta's unique circumstances and constraints, a 15 percent Lf may not always be possible. Soil permeability may be low, water tables are typically around 2 meters from the soil surface, and groundwater quality may be near the salinity thresholds for maintaining crop yield potential. Additionally, perennial crops such as alfalfa, pears and grapes have a high annual ET demand. It can be difficult to apply enough water to meet the ET and Lr of these crops, particularly on low permeability soils like the ones on Ryer Island.

Using soil salinity data gathered on Ryer Island and water salinity data from the California Data Exchange Center (II-42, CDEC, 2016) at Rio Vista – a water quality monitoring station near to the vineyard irrigation water intake on Ryer Island – a Lf can be calculated for the vineyard. Because the seasonal average salinity of the applied irrigation water was not tested as part of the Ryer Island project, hourly CDEC data for the period of April 1, 2016 to August 10, 2016 (ranging from 102-298 μS/cm or 0.102-0.298 dS/m) was averaged to derive an ECw for the vineyard, 142 μS/cm (0.142 dS/m). The bottom of the drip irrigation wetting front was assumed the bottom of the root zone, having average ECe values of 3.55 dS/m and 4.56 dS/m for the two grids (ECdw equal to 7.1 dS/m and 9.12 dS/m, respectively). Using Equation 1, the Lf at both vineyard locations was 2 percent. Using the same ECw, a grape ECet value of 1.5 dS/m, and Equation 2, the Lr for maintaining 100 percent yield potential for grapes is 2 percent. Thus, in 2016, the achieved Lf at the vineyard was equal to the Lr for maintaining yields. What this means is that we would not expect to see yield declines due to salinity in this situation because the achieved Lf met the Lr for maintaining yields. Had the Lf been lower than the Lr, yields may have been affected.

In 2015, using CDEC (II-42) data for the same time period that ranged from 148-3,627 µS/cm (0.148-3.627 dS/m), the average seasonal irrigation water salinity was an ECw of 509 µS/cm (0.509 dS/m). Again, using Equation 2 to calculate the Lr for this higher seasonal applied water salinity, we need a Lr of 7 percent to maintain 100 percent yield potential for grapes. This illustrates that as the seasonal average applied water salinity increases, a higher Lr will be required in order to maintain crop yields. If it is not possible to apply enough water to achieve a 7 percent Lf due to poor soil permeability, proximity of groundwater, or other agronomic considerations (such as crop disease susceptibility exacerbated by standing water), then this higher applied water salinity in 2015 compared to 2016 would suggest detrimental effects on crop yields, increases in the salt load of the soil, or both.

VII. CONCLUSIONS

Leaching is the primary means of managing salinity and must be practiced when there is the potential for salinity to impact yield. Soil sampling data from Ryer Island illustrate the inherent low permeability of certain Delta soils, the build-up of salts in the soil to levels that have the potential to affect crop yields, and a low achieved Lf. The Delta’s unique growing conditions, including low permeability soils and shallow groundwater, coupled with unpredictable winter rainfall, put constraints on growers’ ability to manage salts by leaching and achieve a Lf that meets the Lr to sustain crop yields. Higher surface water salinity would result in a higher Lr. Thus, salinity – a pervasive issue in the Delta – will continue to impact Delta agriculture, especially under conditions of higher surface water salinity.

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.

Michelle Leinfelder-Miles

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STATEMENT OF SERVICE

CALIFORNIA WATERFIX PETITION HEARING
Department of Water Resources and U.S. Bureau of Reclamation (Petitioners)

I hereby certify that I have this day submitted to the State Water Resources Control Board and caused a true and correct copy of the following document(s):

to be served **by Electronic Mail** (email) upon the parties listed in Table 1 of the **Current Service List** for the California WaterFix Petition Hearing, dated July 11, 2016, posted by the State Water Resources Control Board at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/service_list.shtml

I certify that the foregoing is true and correct and that this document was executed on July 12, 2016.

Signature: ______________________
Name: Mae Ryan Empleo
Title: Legal Assistant for Osha R. Meserve
Soluri Meserve, A Law Corporation

Party/Affiliation:
Local Agencies of the North Delta
Bogle Vineyards/DWLC
Diablo Vineyards and Brad Lange/DWLC
Stillwater Orchards/DWLC
Friends of Stone Lakes National Wildlife Refuge

Address:
Soluri Meserve, A Law Corporation
1010 F Street, Suite 100, Sacramento, CA 95814

The Effects of Water Quality on Soil Salinity and Leaching Fractions in the Delta

Michelle Leinfelder-Miles

Delta Crops Resource Management Advisor

UC Cooperative Extension, San Joaquin County

Presentation to the California State Water Resources Control Board

October 2016

UC CE | University of California
Agriculture and Natural Resources | Cooperative Extension

Introduction to Salinity

Salt problems occur on approximately one-third of all irrigated land in the world.

Why do salts exist in soil?

- Parent material weathers to form salts
- Salts are carried in irrigation water
- Soil amendments may contain salts
- Presence of shallow, saline groundwater

Introduction to Salinity

Examples of soluble salts are NaCl, $CaCl_2$, $MgCl_2$, $CaSO_4$, $CaCO_3$, and KCl

- Consist of positively-charged cations and negatively-charged anions
- Ions disassociate in solution and will move toward an electrode of opposite charge, creating a current
- Current is measured with Electrical Conductivity (EC) meter
- Soil saturated paste (ECe), water (ECw)
- Units 1 dS/m = 1 mmhos/cm = 1,000 µS/cm

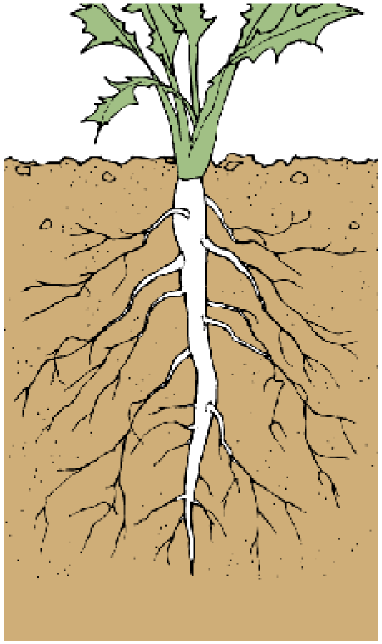
Effects of Salinity on Plant Growth

- Osmotic stress
  (*most common means by which salt impairs plant growth*)
- Specific ion toxicities
- Degraded soil conditions that limit plant water availability

Effects of Salinity on Plant Growth

Osmotic stress:

- Low soil salinity: concentration of solutes is higher in roots than in the soil-water solution, and water moves freely into roots
- Higher soil salinity: plants must transport solutes to the roots to keep root solutes higher than soil-water solution solutes and avoid water stress



Remobilizing solutes requires energy, which is then not used for plant growth.

Plants exhibit lower growth or generic stunting which farmers may not realize as being salt-induced.

Effects of Salinity on Plant Growth

Specific ion toxicity:

- Chloride and boron are micronutrients
- Sodium is not an essential nutrient and can limit plant uptake of other cations
- Burning on leaf tips and margins
- Symptoms limit photosynthetic capacity of the plant

Effects of Salinity on Plant Growth

Soil physical degradation:

- Impairs infiltration and drainage
- Visual indicators include white crusts on soil surface, black crusts, or slick spots
- Can result in standing water and poor soil aeration, neither of which promote plant health and growth

Applied water salinity vs. soil salinity

- Irrigation water carries salts, and when irrigation water is applied to fields, salts are added to the soil.
- Salts accumulate in the soil at higher concentrations than they existed in the applied water.
- Salts may accumulate disproportionately in the soil.
- Crop salinity tolerances are expressed as both seasonal average applied water salinity and average root zone soil salinity.

Delta Research Projects

1. Drip-irrigated tomato field

Electrical Conductivity, ECe (dS/m)

Spring 2013

Depth (cm)	Bed Center ↓			Furrow ↓
0 - 10	0.84	0.74	1.24	
10 - 20	0.93	0.84	0.75	0.72
20 - 30	0.81	0.84	0.92	0.74
30 - 40	0.94	0.84	0.73	0.76
40 - 50	0.67	0.92	0.74	0.79
50 - 60	0.64	0.76	0.74	0.79
60 - 70	0.68	0.79	0.75	0.71
70 - 80	0.82	0.77	0.79	0.71
80 - 90	0.83	0.77	0.74	0.73
90 - 100	0.81	0.80	0.78	0.66

Fall 2015

Depth (cm)	Bed Center ↓							Furrow ↓
0 - 10	2.50	2.51	2.97	2.34	2.67	2.27	2.76	2.69
10 - 20	1.37	1.17	1.12	1.02	1.05	0.96	2.51	4.49
20 - 30	0.85	0.85	0.85	0.86	0.90	1.08	0.81	1.04
30 - 40	0.87	0.94	0.99	0.92	0.95	0.87	0.74	0.76
40 - 50	1.12	0.89	1.26	1.15	0.99	0.86	0.85	0.71
50 - 60	1.06	1.05	1.37	1.08	0.89	0.84	0.61	0.71
60 - 70	0.94	0.96	1.52	1.16	1.09	0.88	0.71	0.87
70 - 80	0.83	0.94	1.32	1.49	1.21	1.11	1.01	0.87
80 - 90	1.15	1.17	1.46	1.51	1.58	1.56	1.43	1.21
90 - 100	1.47	1.75	1.66	1.68	1.67	1.68	1.68	1.51

Legend*				
2.5	3.5	5.0	7.6	13.0

* Ayers and Westcot, 1985

Delta Research Projects

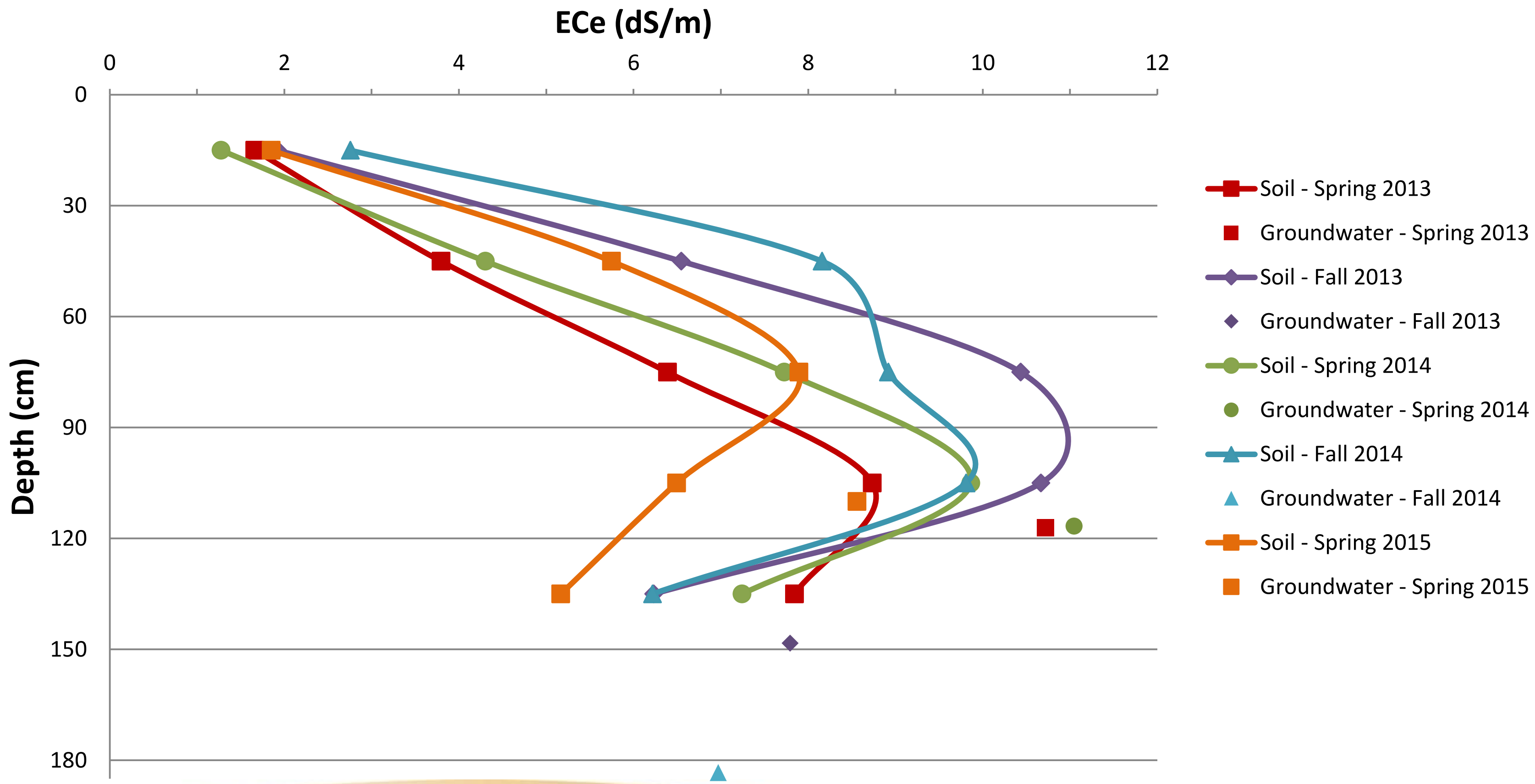
2. Flood-irrigated alfalfa fields

Four out of seven sites had an ECe that met or exceeded 10 dS/m at 90 cm (3 ft) below the surface.

- Typical soil sampling for nutrient and salinity status is 60 cm or less
- Over time, growers may not be aware of the degree to which soil salinity has increased in their fields.

Delta Research Projects

2. Flood-irrigated alfalfa fields



Delta Research Projects

3. Ryer Island

Sampling in August 2016

Delta Research Projects

3. Ryer Island

Field Methods: Pear orchard

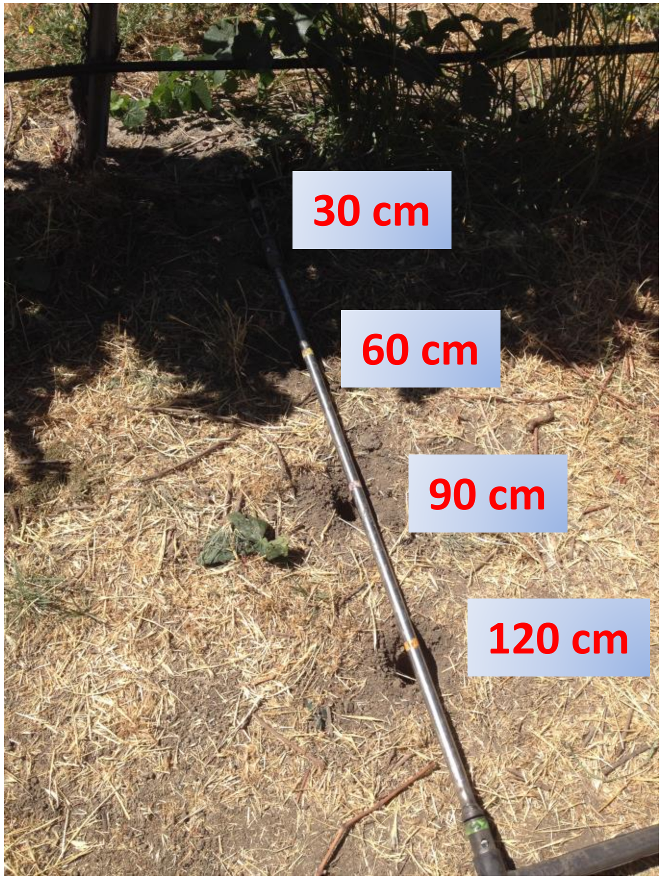
- 8 holes were augered in-line with tree rows across 20-row span
- 4 holes were augered between tree and sprinkler riser
- 4 holes were augered opposite the tree from the sprinkler in “shadow”
- Holes were augered in 30-cm increments to 150 cm
- Samples from same depth were composited, for 5 total samples
- Soil moisture, groundwater depth and salinity also sampled

Delta Research Projects

3. Ryer Island

Field Methods: Vineyard

- Grid pattern 30, 60, 90, and 120 cm from the vine row
- 30-cm increment depths, down to 150 cm
- Vine spacing was 240 cm
- Soil moisture, groundwater depth and salinity also sampled



Delta Research Projects

3. Ryer Island

Delta Research Projects

3. Ryer Island

Laboratory Methods:

- Oven-dry and grind soils
- Make soil saturated pastes
- Extract liquid and dissolved salts under partial vacuum
- Measure EC with conductivity meter

Delta Research Projects

3. Ryer Island

Pears - Electrical Conductivity

Depth (cm)	ECe (dS/m)
0 - 30	0.442
30 - 60	0.249
60 - 90	0.711
90 - 120	1.178
120 - 150	1.116

- Groundwater: 165 cm, 0.35 dS/m
- Average root zone salinity: 0.74 dS/m
- Yield declines expected when average root zone salinity is 2.5 dS/m
- We would not expect salinity at this site to be impacting yield.

Delta Research Projects

3. Ryer Island

Grapes, North - Electrical Conductivity (ECe, dS/m)

Depth (cm)	Vine Row 0 ↓	30 cm	60 cm	90 cm	Alley Center 120 cm ↓
0 - 30		1.705	1.62	2.18	1.24
30 - 60		1.068	1.36	2.45	2.05
60 - 90		2.179	2.63	5.41	4.00
90 - 120		1.045	1.78	1.80	2.30
120 - 150		0.693	0.75	0.84	0.96

Legend*				
1.50	2.50	4.10	6.70	12.00

- Groundwater: 221 cm, 0.21 dS/m
- Average root zone salinity: 1.9 dS/m
- Wetting zone extends to about 90 cm deep and wide
- There is potential for salinity to impact yield

* Ayers and Westcot, 1985

Delta Research Projects

3. Ryer Island

Grapes, South - Electrical Conductivity (ECe, dS/m)

Depth	Vine Row 0 cm ↓	30 cm	60 cm	90 cm	Alley Center 120 cm ↓
0 - 30	1.20	2.19	3.57	2.18	
30 - 60	1.06	2.15	3.57	2.61	
60 - 90	3.03	2.94	4.44	5.18	
90 - 120	3.82	4.15	4.90	5.35	
120 - 150	2.30	1.88	2.79	2.49	

Legend*				
1.50	2.50	4.10	6.70	12.00

- Groundwater: 284 cm, 0.97 dS/m
- Average root zone salinity: 3.1 dS/m
- Wetting zone extends to about 120 cm deep and wide
- There is potential for salinity to impact yield

* Ayers and Westcot, 1985

Delta Research Projects

3. Ryer Island

Grapes, North - Electrical Conductivity (ECe, dS/m)

Depth (cm)	Vine Row 0 ↓	30 cm	60 cm	90 cm	Alley Center 120 cm ↓
0 - 30		1.705	1.62	2.18	1.24
30 - 60		1.068	1.36	2.45	2.05
60 - 90		2.179	2.63	5.41	4.00
90 - 120		1.045	1.78	1.80	2.30
120 - 150		0.693	0.75	0.84	0.96

Grapes, North - Saturation Percentage

Depth (cm)	Vine Row 0 ↓	30 cm	60 cm	90 cm	Alley Center 120 cm ↓
0 - 30		0.70	0.69	0.68	0.67
30 - 60		0.76	0.80	0.75	0.84
60 - 90		0.93	0.95	0.94	0.92
90 - 120		0.96	0.93	0.92	0.93
120 - 150		1.02	1.06	1.12	1.13

Delta Research Projects

3. Ryer Island

Grapes, South - Electrical Conductivity (ECe, dS/m)

Depth	Vine Row 0 cm ↓	30 cm	60 cm	90 cm	Alley Center 120 cm ↓
0 - 30		1.20	2.19	3.57	2.18
30 - 60		1.06	2.15	3.57	2.61
60 - 90		3.03	2.94	4.44	5.18
90 - 120		3.82	4.15	4.90	5.35
120 - 150		2.30	1.88	2.79	2.49

Grapes, South - Saturation Percentage

Depth (cm)	Vine Row 0 ↓	30 cm	60 cm	90 cm	Alley Center 120 cm ↓
0 - 30		0.66	0.69	0.66	0.67
30 - 60		0.84	0.82	0.83	0.79
60 - 90		0.91	0.98	0.96	0.94
90 - 120		0.89	1.00	0.95	0.90
120 - 150		1.02	1.08	0.98	1.00

Salinity Management by Leaching

- The primary management strategy for combating salinity is leaching, and leaching must be practiced when soil salinity has the potential to impact yield.
- Leaching occurs when water is applied in excess of soil moisture depletion due to evapotranspiration (ET).
- Leaching may occur during the rainy season or whenever an irrigation event occurs.

Salinity Management by Leaching

The leaching fraction (Lf) is the fraction of the total applied water that passes below the root zone:

$$Lf = ECw/Ecdw \quad \text{(Equation 1)}$$

where ECw is the electrical conductivity of the applied water, and ECdw is the electrical conductivity of the drainage water at the bottom of the root zone, which is equal to 2ECe.

Salinity Management by Leaching

The leaching requirement (Lr) is the minimum amount of the total applied water that must pass through the root zone to prevent a reduction in crop yield from excess salts:

$$Lr = ECw/(5ECet - ECw) \quad \text{(Equation 2)}$$

where ECet is the average soil salinity, as measured by saturated paste extract, that a crop can tolerate.

Salinity Management by Leaching

Alfalfa example:

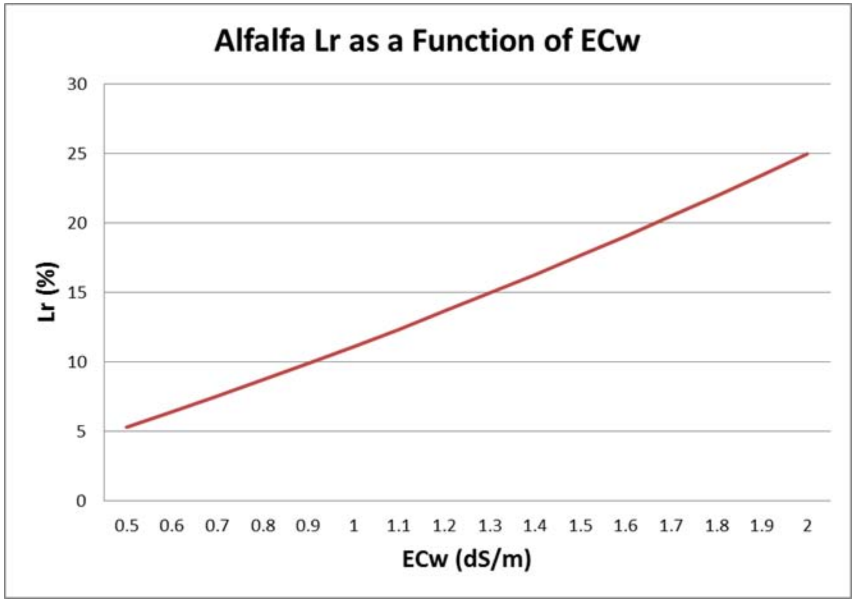
$$Lr = ECw/(5ECet - ECw) \quad \text{(Equation 2)}$$

- Thresholds Ecet = 2.0 dS/m, ECw = 1.3 dS/m)
- Lr = 15%

Salinity Management by Leaching

Alfalfa example (cont):

- When ECw ranges from 0.5-2.0 dS/m, the Lr is 5-25%
- A 15% Lr is a general “rule of thumb” in agriculture but may not always be possible due to low permeability soils, shallow/saline groundwater or other agronomic considerations



Salinity Management by Leaching

Ryer Island case study:

- Lf = ECw/ECdw (Equation 1)
- ECe at the base of the root zone is 3.55 dS/m
- ECdw = 2ECe = 7.1 dS/m
- Seasonal average ECw = 142 µS/cm (0.142 dS/m) (CDEC)
- Lf = 2%

Grapes, North - Electrical Conductivity (ECe, dS/m)

Depth (cm)	Vine Row 0 ↓	30 cm	60 cm	90 cm	Alley Center 120 cm ↓
0 - 30		1.705	1.62	2.18	1.24
30 - 60		1.068	1.36	2.45	2.05
60 - 90		2.179	2.63	5.41	4.00
90 - 120		1.045	1.78	1.80	2.30
120 - 150		0.693	0.75	0.84	0.96

Base of root zone

Salinity Management by Leaching

- Using the same ECw, a grape ECet value of 1.5 dS/m, and Equation 2, the Lr for maintaining 100 percent yield potential for grapes is 2 percent.
- Thus, in 2016, the achieved Lf at the vineyard was equal to the Lr for maintaining yields.

Salinity Management by Leaching

- We can calculate the Lr for 2015 using CDEC data (ECw = 504 µS/cm or 0.504 dS/m)
- Using Equation 2, the 2015 Lr was 7%.
- This illustrates that as ECw increases, a higher Lr will be required to maintain crop yields.
- If it is not possible to apply enough water to achieve a 7% Lf due to poor soil permeability, proximity of groundwater, or other agronomic considerations, then a higher ECw, as in 2015 compared to 2016, would suggest detrimental effects on crop yields, increases in the salt load of the soil, or both.

Conclusions

- Leaching is the primary means of managing salinity.
- Ryer Island data illustrate the inherent low permeability of certain Delta soils, the build-up of salts in the soil to levels that have the potential to affect crop yields, and a low achieved Lf.
- The Delta's unique growing conditions put constraints on growers' ability to manage salts by leaching and achieve a Lf that meets the Lr to sustain crop yields.
- Salinity will continue to impact Delta agriculture, especially under conditions of higher surface water salinity.

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Bogle Vineyards / Delta Watershed Landowner Coalition
Diablo Vineyards and Brad Lange / Delta Watershed Landowner Coalition
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 ERIK RINGELBERG** **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, Erik Ringelberg, do hereby declare:

I. INTRODUCTION

I am an environmental scientist with technical and managerial experience in developing, planning, and permitting large projects, assessing their environmental impacts, and, where necessary, developing mitigation measures. I have applied scientific experience in the assessment of water quality in both the field and in the laboratory, and have experience managing multi-disciplinary teams in the assessment of ecological baseline conditions and assessing the results of managed hydrologic regimes leading to water quality impacts.

As an environmental scientist, I have completed analyses of the Bay Delta Conservation Plan (BDCP) and its various permutations since 2008. Over those eight years, I have been asked to provide oral and written comments by the Local Agencies of the North Delta with particular emphasis on the technical considerations of project features that would impact water quality, terrestrial and aquatic ecology, and the rural agricultural community. Prior to those efforts, I provided support to the Pyramid Lake Pauite Tribe on its management of Pyramid Lake habitat and water quality. That work included managing sampling teams and a water quality laboratory that completed algal chlorophyll, nutrient, and other water quality analyses to assess the condition of the alkaline desert terminal lake.

My educational background and other qualifications are summarized in the Statement of Qualifications submitted concurrently herewith. Ex. II-22. My Powerpoint presentation Summary submitted concurrently herewith. Ex. II-24.

II. OVERVIEW OF TESTIMONY

My testimony is intended to provide scientific analysis and conclusions about the likely project impacts on water quantity and quality as it relates to the Sacramento River downstream of the proposed intakes within the Delta.

A. Project Salinity Influences--Summary

I was tasked to assess the proposed California Water Fix Petition for Change before the State Water Resources Control Board to identify from a scientific perspective if the project had potential to negatively affect beneficial uses from increased salinity in the Delta, and if so, what were those potential negative effects.

For most locations in the Delta, the beneficial uses relevant to project impacts to water quality related to salinity intrusion are identified in the Basin Plan as follows: Municipal and Domestic Supply; Recreation-Contact; Agriculture- Irrigation and Stock Watering, and also including, although not expanded upon in detail in this analysis, Freshwater Habitat- Warm and Cold, and Wildlife. (SWRCB-27, CVRWQCB, 2006) The following is an analysis of the Project's potential impacts on these beneficial uses related to salinity intrusion.

B. General Overview –Delta Salinity

1. Historic Delta Salinity

Contra Costa Water District (CCWD) has studied modern Delta salinity and its changes over time due to development at length. (See Exs. II-26 and II-27. CCWD 2009 and 2010 respectively) CCWD identifies in both summary form and in exhaustive detail how salinity patterns in the Delta have been altered over the modern development period and how physical changes to the system have both altered the geometry of the system, and the hydrology of the system. An important analysis created by the State identifies the sensitivity of the region to salinity intrusion and the commitments by the state to ensure that that does not happen. (II- 32, Bulletin 76.)

2. Current Delta Salinity

Salinity levels in the Delta are tidally controlled-twice a day tidal signal from the Pacific, through San Francisco Bay, Suisun, and up the rivers and sloughs. Relatively high energy tidal flow upriver can dominate Sacramento River outflow and allow salinity to migrate (advect) upriver. The salinity gradient is controlled by freshwater outflow, and changes constantly due to tides (and monthly and seasonal tidal differences). This gradient movement from the San Francisco Bay into the Delta is most obvious in droughts. We understand and track that salinity through Electrical Conductivity (EC).

Instead of looking at just chloride (Cl) or the sum of soluble salts, we use a simple and easy to measure surrogate of Cl. EC is correlated to salinity and allows for field measurements in real time (no lab work) that can go from the river or slough, to the diversion, to the field ditch, and to the soils of that field. Hundreds of years of study have identified how soils and plants respond to salinity, and modern research correlates those responses to EC.

Using averages to describe the salinity at a given location is a compromise of convenience. Since the tides changes daily, there are a range of salinity values expressed over a day. A mean is the average of that range and does not, and is not, intended to describe the ecological or agriculturally important salt concentration. For the ecology, the highest salt concentration (not the average) relates the exceedance of the physiological tolerance range at the organismal level or at the competitive success at the community level. For agriculture, the highest concentration (not the average) of the water diverted for crop use, salinity control and wildlife management can significantly impair productivity and lead to salt buildup. The average can influence the total load of the salt and effect leaching, but it is the absolute instantaneous concentration during irrigation that is critical, not the average.

For example, it is the timing of the salinity during the agricultural growing season, pre-irrigation and salinity flushing that are important. The important level in both these cases is the peak salinity, and for the season, the area under the curve that leads to the seasonal loading, which is the sum total of the salinity load (net).

C. Proposed Project Operations

Proposed operations are influenced by many factors, but it is physically controlled by one, two or three north Delta intakes. These intakes can be operated over a range of flows until that maximum can be reached, interoperation of the facilities North and South can occur, Delta Cross Channel (DCC) can be open or closed. The project design, at the engineering level however has a requirement for full 9,000 cfs diversion at low River flows (DWR-212, CER. 2014)

In addition to those general factors, the temporary barriers can be installed on sloughs, the Yolo Bypass can flow, and of course salinity standards and/or points of compliance can be modified. Each of these factors influence circulation of water within the Delta and have direct and indirect effects on salinity.

For example, flow routing through the DCC, and dam operations yield lower salinity in portions of the South Delta, while at times creating reverse flows that draw in greater flows from Suisun into the western Delta. Delta diversions and exports to the San Joaquin Valley can result in greater San Joaquin flows, which have a higher salinity concentration in their return flows. Agriculture, wetlands, stormwater runoff and simple evaporation can result in salinity within the Delta.

As explained in greater detail below, I have concluded that the proposed project diversion in the North Delta under certain project scenarios will establish essentially the equivalent of drought conditions, and their associated lower flows, in the Delta by removing significant flow of the Sacramento River during critical agricultural water use periods (for planting and maintenance during late spring and summer, and for salinity control and wetland management, fall) for salinity control.

From the limited summary flow data provided in the application, it appears that the flows immediately downstream of the intakes would be altered in the following manner (DWR-515 and DWR 5 errata, Pg 25-6):

- 6,000 cfs, 300 cfs would be diverted, leaving 5,700 cfs in the river.
- 15,000 cfs, 3,000 cfs would be diverted, leaving 12,000 cfs in the river.
- 22,000 cfs, 9,000 cfs would be diverted, leaving 13,000 cfs in the river.

These flow rules represent a flow reduction up to to 41%. Under these rules, the flow, for the vast majority of the time, would be constrained from 5,700 cfs to 13,000 cfs. These flows are directly equivalent to the range of flows at Freeport during critically dry year (mean 9,345 cfs 1922) to a dry year (mean 16,003 cfs 1989). (II-29, ICF 2016, Pg. 2-3). In plain language, the project rules create a drought-equivalent conditions on the Sacramento River. The project analysis in these same references essentially assert that these are simply operational rules and that the project would be managed dynamically. This is factually correct, but misleading. The operations are defined by the boundaries of the rules, that is why they exist. The operations themselves would be able to control the rate and timing of the new diversion. But the expressed project purposes are to use the new intakes as much as possible to improve water quality of the diverted water, and to minimize use of the existing pumps during periods with biological considerations. Operationally, then, there is every advantage from an export water quality and a delta smelt fisheries perspective to using the new point of diversion. Therefore, the operational rules described above are the only limitations on diversions at the new intakes.

As validation of my conclusions regarding diversion flow rules, the scenarios that were provided as illustration of the project modeling analysis ~~archive to~~ achieve the same diversion rates as the maximum diversion rules: 1978, which was also classified as a dry year is modeled with a flow in the river of 14,000 cfs, and a 6,000 cfs diversion, leaving 8,000 cfs in the river with a 43% flow reduction. The same modeling shows that even in an above normal year (1993), at a flow of 21,000 cfs, 9,000 cfs is diverted, leaving 12,000 cfs in the river, (DWR-5 errata, Pg 25-6).

These models are simply intended to demonstrate compliance and are not predictive, but the Petition treats them as if they were de facto predictions of how the project would meet standards under operational conditions in particular water year types. They are not predictive, and it appears that they even fail from a comparative sense, given their baseline assumptions and a lack of sensitivity during low flow conditions, such as what are being proposed by the Petition. (II-30, Smith, 2014)

These rules and their associated modeling illustrate that the project's new point of diversion will reduce flows in the Sacramento River to the same flows as occur in droughts, namely critically dry and dry years. This reduction of flow to essentially drought conditions has profound effects on the entire Delta. The Central and South Delta currently gets Sacramento River flows from both the DCC operations, as well as Georgianna Slough, and from the draw of the existing southern diversion pumps when San Joaquin River flows are low. By taking the flow from the north, less flow is available for salinity control from the point of diversion to the south, and less freshwater from the Sacramento is drawn into the Delta in general. This allows the brackish water to radiate inward into the Delta, but also provides less flushing within the Delta to remove accumulated salts from irrigation, wetlands and wildlife management. That accumulation works in concert with reduced outflow salinity control by the Sacramento River to increase salinity throughout the Delta.

These same conclusions have already been drawn by independent researchers:

> Withdrawing water from the system into an isolated water-conveyance facility, such as the currently proposed twin tunnels, would also alter transport throughout the delta. If built, net flows throughout the north and western Sacramento–San Joaquin River Delta would be proportionately reduced by the amount withdrawn into the conveyance facility, increasing the influence of the tides throughout the delta. …In the coming decades, the flow-station network can provide data that address uncertainty concerning the location of proposed water-conveyance facilities and that, after they are built, document the effects of these new water-conveyance facilities, management actions, and habitat-restoration efforts."
> (USGS Fact Sheet 2015-3061. 2016)

Therefore, to understand what those institutionalized drought conditions would look like, we need to look at the flows and EC's at the most hydrologically "open" point of the Delta during the drought, Rio Vista. Rio Vista has a USGS water quality station with a long period of record, and it is centrally located where both the north and central Delta are influenced by river and slough connection to ocean-associated salinity.

As shown in the provided exhibits, (Ringelberg Attachment A. to my testimony) flows at Rio Vista had numerous very high EC values over the past 3 years, but because of the 14-day running average under D-1641 (Figure 1.), and the TUCP, these were not considered to be exceedances in many cases. For illustration, EC is provided for that period at USGS Station 11455420, followed by the same time period for flow (Figures 2 and 3 respectively). To put this into perspective, each of the tributaries has a relative flow into the Delta, and the existing DCC and the south Delta pump operations also contribute to variations in the relative contribution. These contributions are "fingerprinted" which provides an understanding of the relative contribution over time (Figure 4.).

The salinity intrusion created massive spikes in EC. Those spikes are readily diverted onto agricultural fields for use for irrigation water, ironically salinity control, and for wetland and wildlife management. The difference in salinity concentrations are not visible and the operator cannot readily tell that this condition is happening while it is being applied to the field. Once salt loading occurs in the field, it takes expensive and complicated techniques to assess the degree of impacts and means of mitigating it, if possible.

D. Defects of Project Analysis

The project impacts on salinity are difficult to ascertain for a variety of reasons:

- Use of comparative rather than operational or predictive models to bound changes in EC.
- Use of model data for D-1641 compliance, not for operational impacts on agriculture.
- Use of averages, use of old data, and weak calibration, and known errors at low flows and without correlation to contemporary drought conditions.
- Use of 14-day rolling averages as compliance, instead of actually assessing AGR impairment, LF fraction.

The Project could complete the type of modeling that would demonstrate predictive impacts under operational scenarios that bound the project maximum salinity impacts to the North Delta, but despite repeated requests over several years to do so, DWR still has not provided the necessary information. A bounding scenario would be the months of July-November, king tide, dry and very dry water year, third and fourth years of drought, Winter Salmon Run temperature protection, 0/1/2 barriers installed. These are not hyperbolic bounds, but are exactly what occurred in the last two years in the Delta.

Despite those analytical defects, we can decipher some key elements from the overall analysis:

The project can thus take significant flows in above normal, normal, dry and critically dry years. The DCC can remain open for periods during that time, and that salinity would increase through advection as a result of those lower flows, and increase to similar levels as were seen in the last 3 years of the drought with Southern Delta operations. If operational constraints to protect Delta smelt remain, and are indeed on of the project purposes, the sustained operation of the North Delta diversions would institutionalize permanent drought-like flow conditions, and therefore high EC levels in the Delta.

III. Summary Conclusions

Under several of the project scenarios (essentially all water year conditions with less flows than above normal), the proposed project diversion in the North Delta will establish essentially permanent drought conditions in portions of the North Delta by removing up to half of the equivalent normal flow of the Sacramento River under certain project scenarios, and significant fractions of the flow at other times, resulting in salinity intrusion from downstream sources.

The project's impacts associated with lower flows from the withdrawal of water in the Freeport area, Delta Cross-channel operational impacts (lowering or influencing flows further in the Sacramento River sloughs and Cache Slough complex) will change the circulation and retention of salt, leading to complex interactions throughout the Delta. The project has failed to provide fine scale modeling for key agricultural intake locations within the Delta in support of its conclusions, and even the coarse scale modeling it did provide is insufficient to provide any predictive ability to show that it does not harm beneficial uses and in particular agricultural water users with sensitive crops.

It is my opinion that the petitioners have not adequately analyzed the project impacts as they relate to salinity intrusion and chronic salinity loading and the impacts that these conditions would create for legal users of water in this part of the Delta. That analysis is possible, but the Petitioners failed to do so. Furthermore it is clear that the petitioners have not substantively addressed the project operational impacts and the potential for individual and aggregate impacts to farms and municipal uses through their diversion of this water should the Waterfix be approved as described.

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 Rancho Cordova , California.

____

Erik Ringelberg

CITED REFERENCES

CVRWQCB [California Central Valley Regional Water Quality Control Board] 2006. The Water Quality Control Plan (Basin Plan) for the California Regional \ Water Quality Control Board Central Valley Region. Fourth Edition. Rev Apr. 2006. The Sacramento River.

Attachment A. Ringelberg Testimony- Additional Salinity References

Figure 1. 14-day Synthetic Running Average D-1641

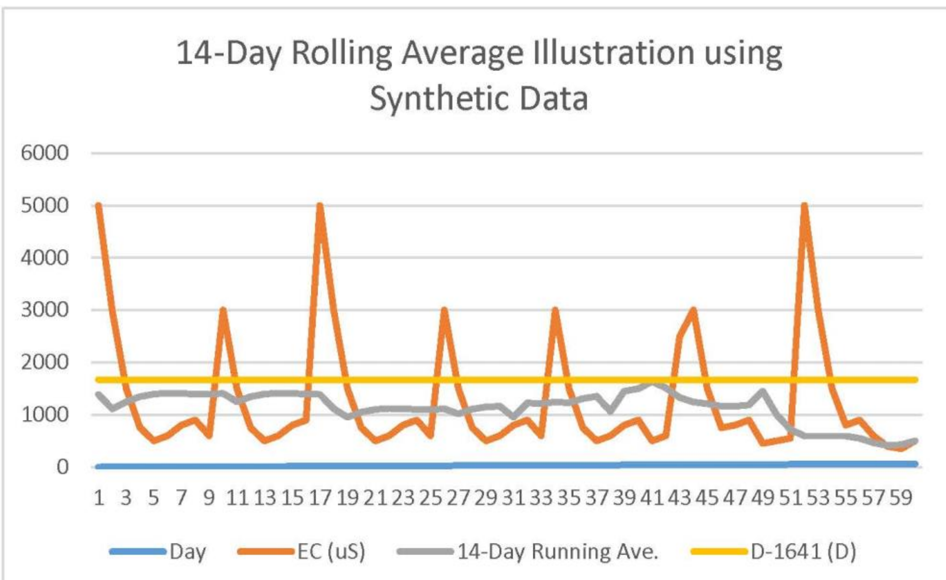


Figure 2. June 2013-2016 Conductivity (EC) at USGS 11455420

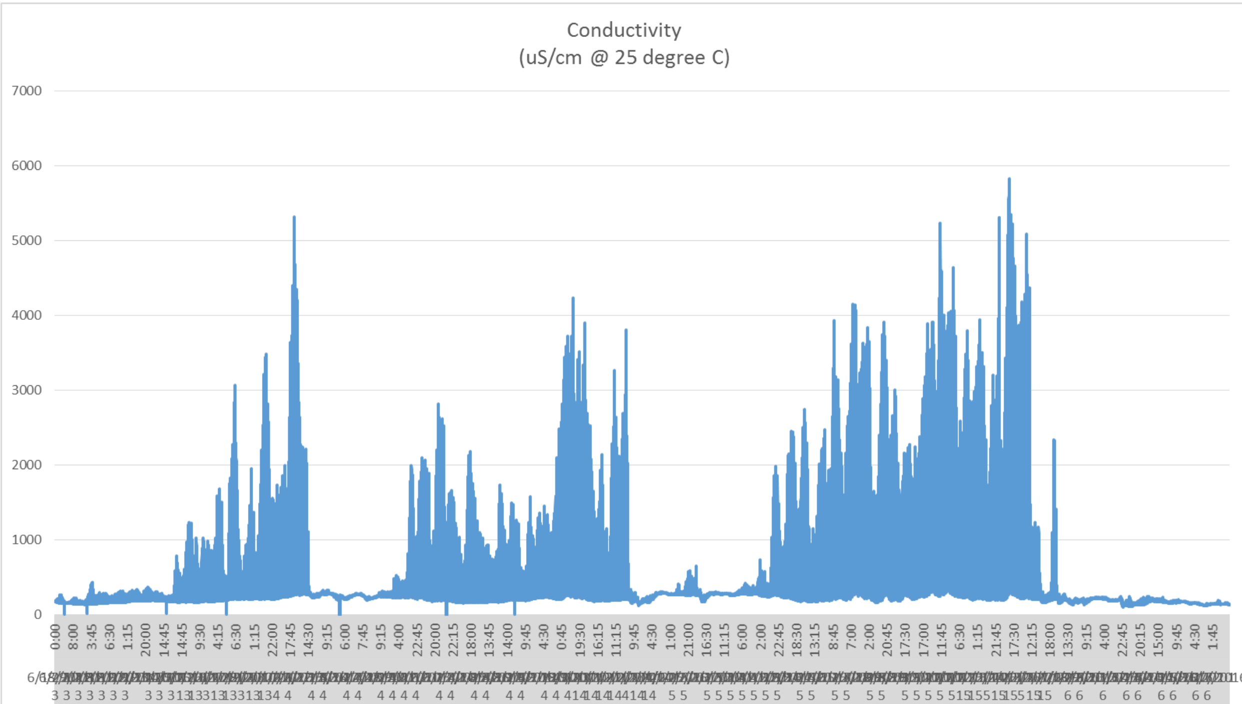
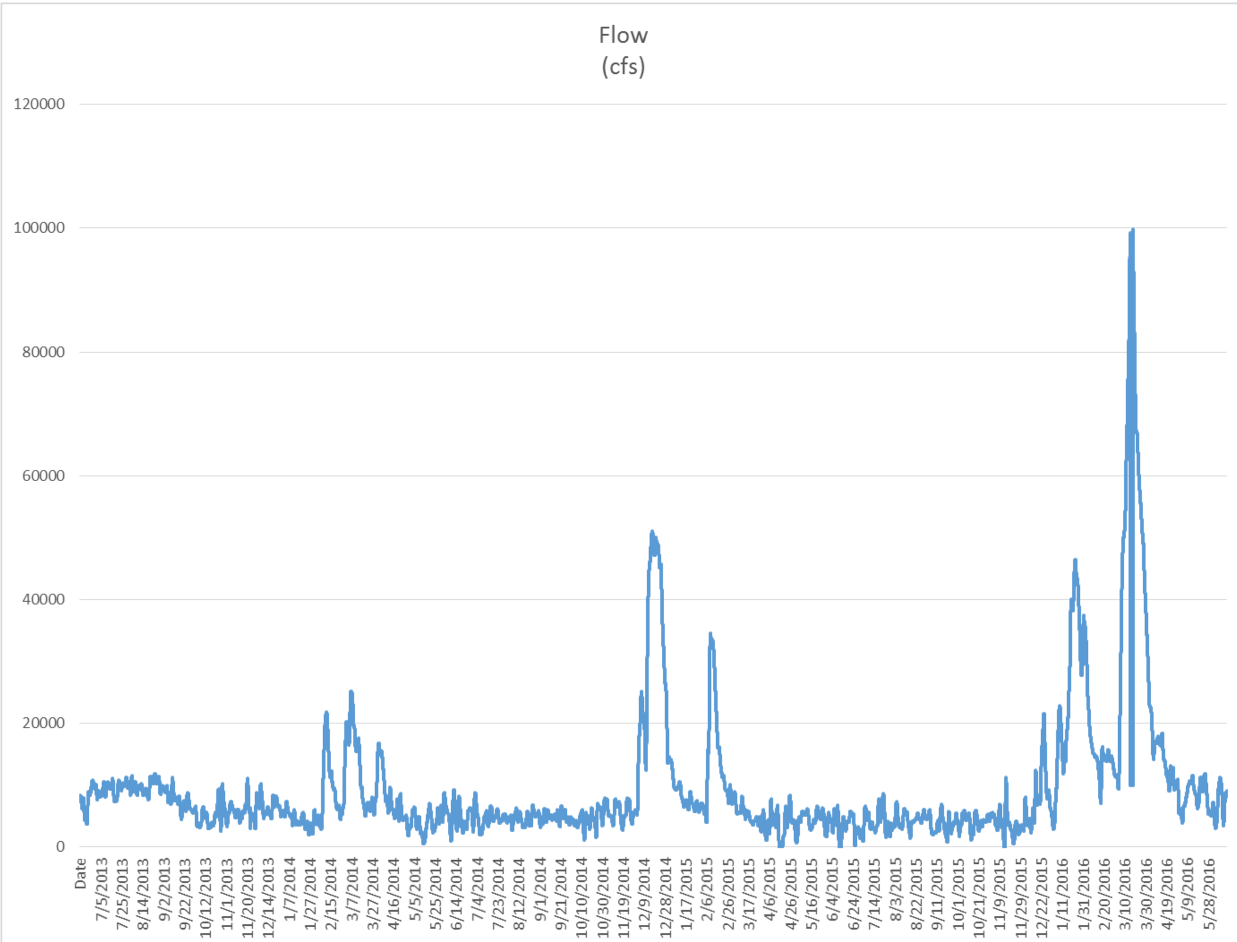
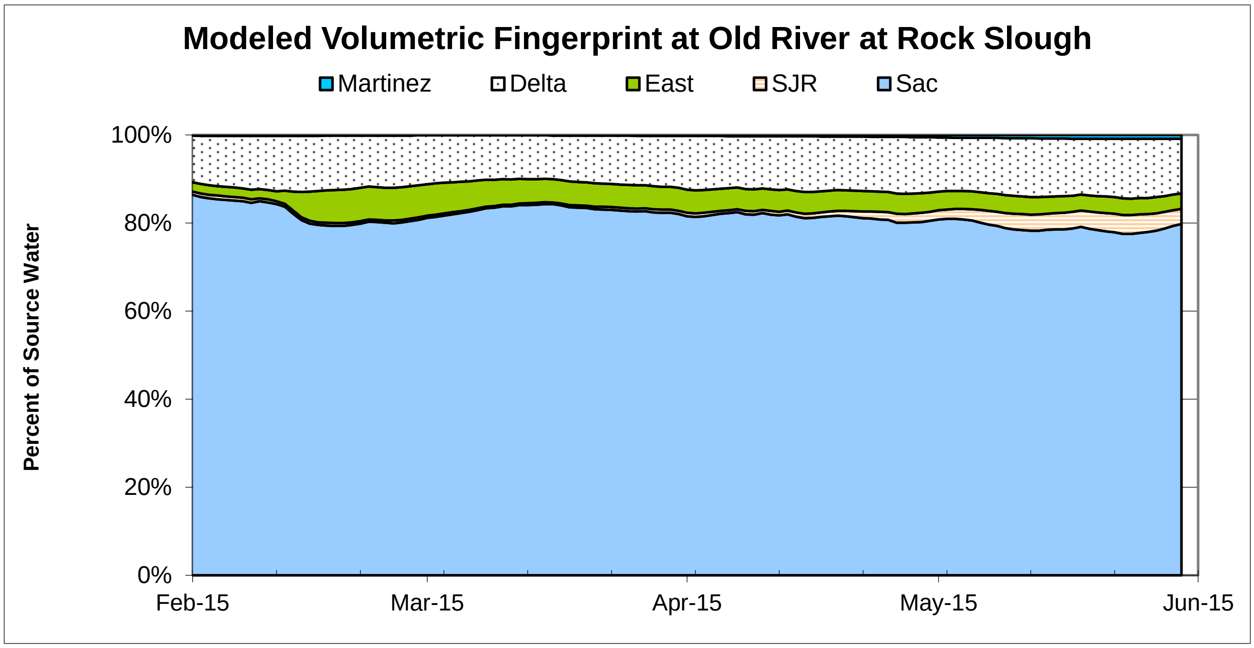


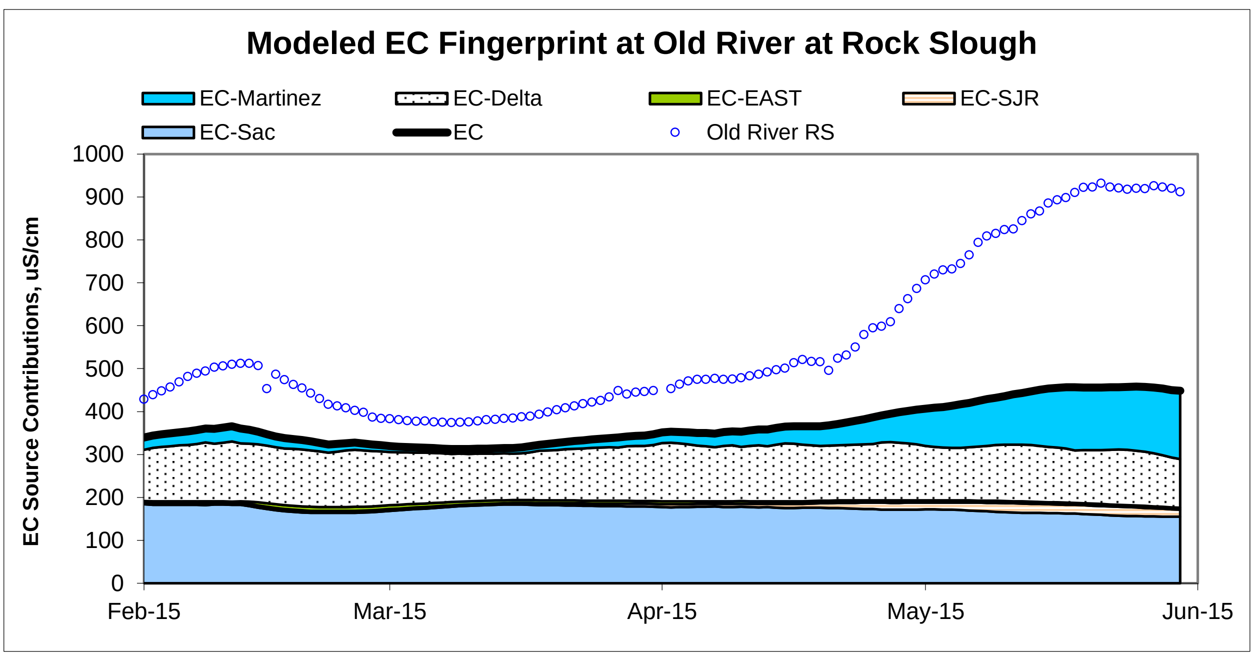
Figure 3. June 2013-2016 Flow (CFS) at USGS 11455420

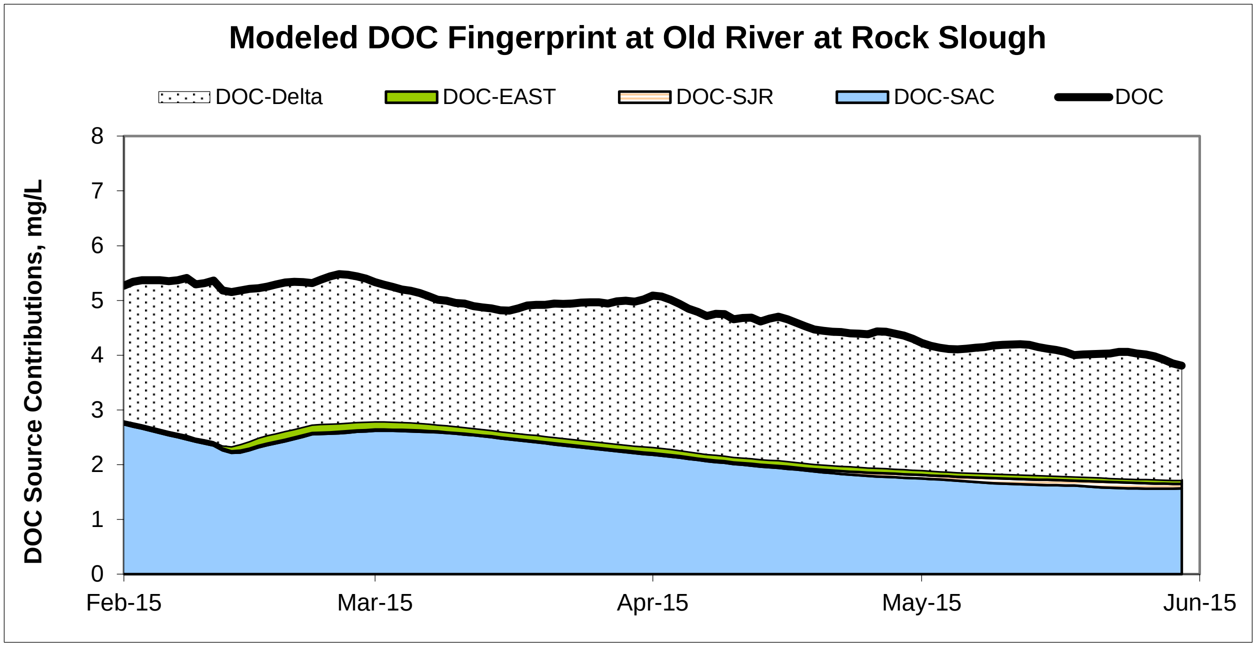


Figures 4--6 Modeled Volumetric, EC and DOC respectively

2015 DWR. 2014-2015 Rock Slough Fingerprint. Excel and Figures
http://www.water.ca.gov/waterquality/drinkingwater/public_docs/Archive%20Delta%20Fingerprints/






Modeled DOC Fingerprint at Old River at Rock Slough
DOC-Delta
DOC-EAST
DOC-SJR
DOC-SAC
DOC
DOC Source Contributions, mg/L
0
1
2
3
4
5
6
7
8
Feb-15
Mar-15
Apr-15
May-15
Jun-15

STATEMENT OF SERVICE

CALIFORNIA WATERFIX PETITION HEARING
Department of Water Resources and U.S. Bureau of Reclamation (Petitioners)

I hereby certify that I have this day submitted to the State Water Resources Control Board and caused a true and correct copy of the following document(s):

to be served **by Electronic Mail** (email) upon the parties listed in Table 1 of the **Current Service List** for the California WaterFix Petition Hearing, dated July 11, 2016, posted by the State Water Resources Control Board at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/service_list.shtml

I certify that the foregoing is true and correct and that this document was executed on July 12, 2016.

Signature: ______________________
Name: Mae Ryan Empleo
Title: Legal Assistant for Osha R. Meserve
Soluri Meserve, A Law Corporation

Party/Affiliation:
Local Agencies of the North Delta
Bogle Vineyards/DWLC
Diablo Vineyards and Brad Lange/DWLC
Stillwater Orchards/DWLC
Friends of Stone Lakes National Wildlife Refuge

Address:
Soluri Meserve, A Law Corporation
1010 F Street, Suite 100, Sacramento, CA 95814

Delta Salinity Responses

Project Implications to Flows and Salinity

Erik Ringelberg

Current Conditions

Region dominated by Sacramento River Flows, existing project diversion can use both Sacramento River flows and San Joaquin.

Tidally controlled-twice a day tidal signal from the Pacific, through San Francisco Bay, Suisun, and up the rivers and sloughs.

Relatively high energy tidal flow upriver can dominate Sacramento River outflow and allow salinity to migrate (advect) upriver. We understand and track that salinity through Electrical Conductivity (EC).

Existing conditions allow ‘freshening’ of entire northern and central Delta parts of the system before export pumps.

Outflow Control

Tidally controlled-twice a day tidal signal from the Pacific, through San Francisco Bay, Suisun, and up the rivers and sloughs.

Relatively high energy tidal flow upriver can dominate Sacramento River outflow and allow salinity to migrate (advect) upriver. We understand and track that salinity through Electrical Conductivity (EC).

Salinity-EC

Instead of measuring chloride (Cl) or the sum of soluble salts, we use a simple and easy to measure surrogate of Cl. EC is correlated to salinity and allows for field measurements in real time (no lab work) that can go from the river or slough, to the diversion, to the field ditch, and to the soils of that field.

Hundreds of years of experience and study have identified how soils and plants respond to salinity, and research correlates those responses to EC.

Petition

New diversions intended to take off higher quality water (EC/TDS/Br/Cl) much further upstream.

Proposed project rules and likely operations mirror drought conditions on the Sacramento River.

- 6,000 cfs, 300 cfs would be diverted, leaving 5,700 cfs in the river.
- 15,000 cfs, 3,000 cfs would be diverted, leaving 12,000 cfs in the river.
- 22,000 cfs, 9,000 cfs would be diverted, leaving 13,000 cfs in the river.

These flows are directly equivalent to the range of flows at Freeport during critically dry year (mean 9,345 cfs 1922) to a dry year (mean 16,003 cfs 1989). (II-28, ICF 2016, Pg. 2-3).

Petition

Operations influenced by many factors, but one, two or three north Delta intakes can be operated over a range of flows until that maximum can be reached, essentially interoperation of the facilities North and South can occur, Delta Cross Channel (DCC) can be open or closed.

In addition to those general factors, the temporary barriers can be installed on sloughs, the Yolo Bypass can flow, and of course salinity standards and/or points of compliance can be modified. Each of these factors influence circulation of water within the Delta and have direct and indirect effects on salinity.

Project Salinity

Project impacts on salinity are difficult to ascertain for a variety of reasons:

- Use of comparative rather than operational or predictive models to bound changes in EC.
- Use of model data for D-1641 compliance, not for operational impacts on agriculture.
- Use of averages, use of old data, and weak calibration and correlation to contemporary drought conditions.
- Use of running averages as compliance.

Averages and Reality

Using averages to describe the salinity at a given location is a compromise of convenience.

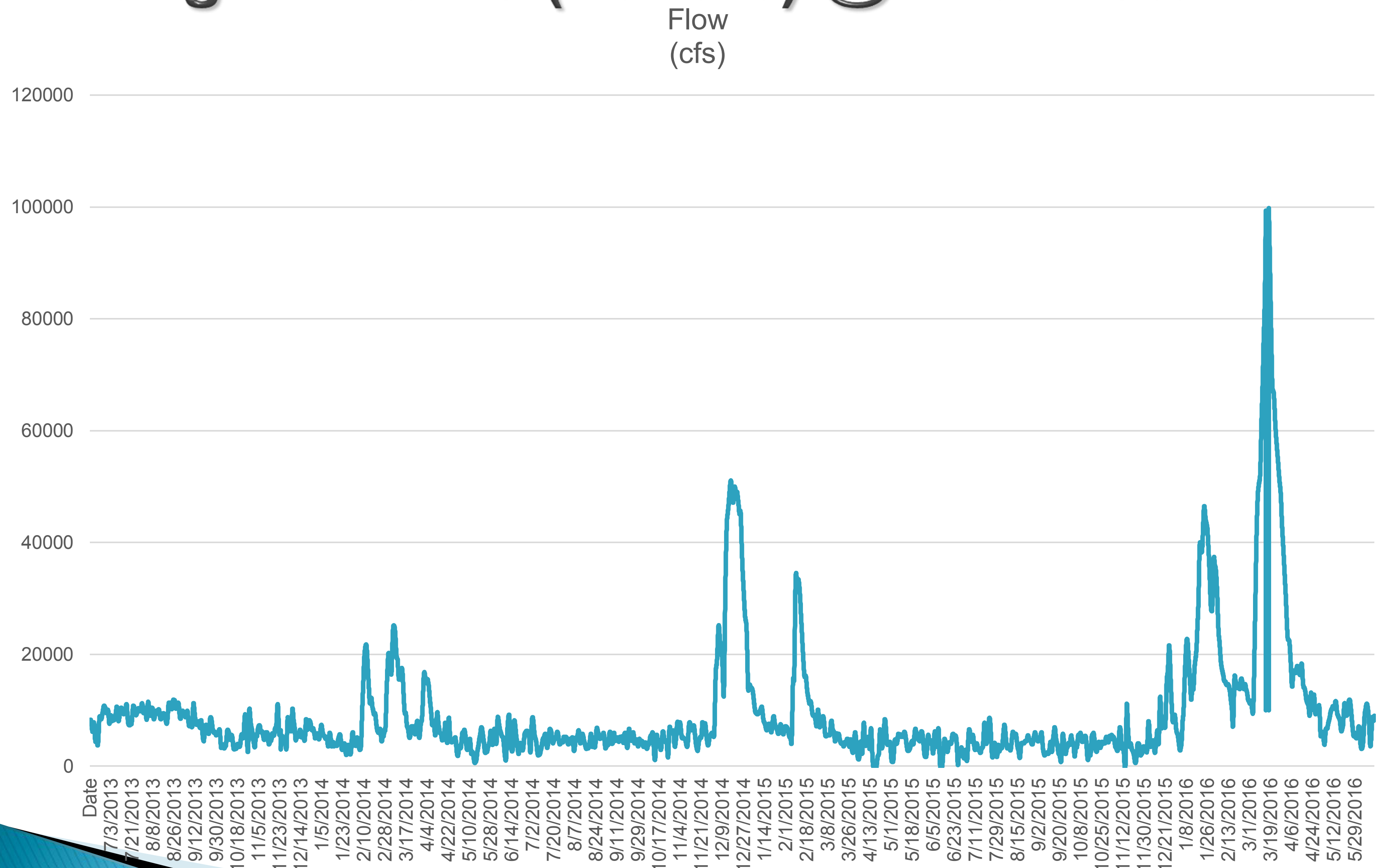
Since the tides changes daily, there are a range of salinity values expressed over a day. A mean is the average of that range and does not describe the ecological or agriculturally important salt concentration.

Averages and Reality

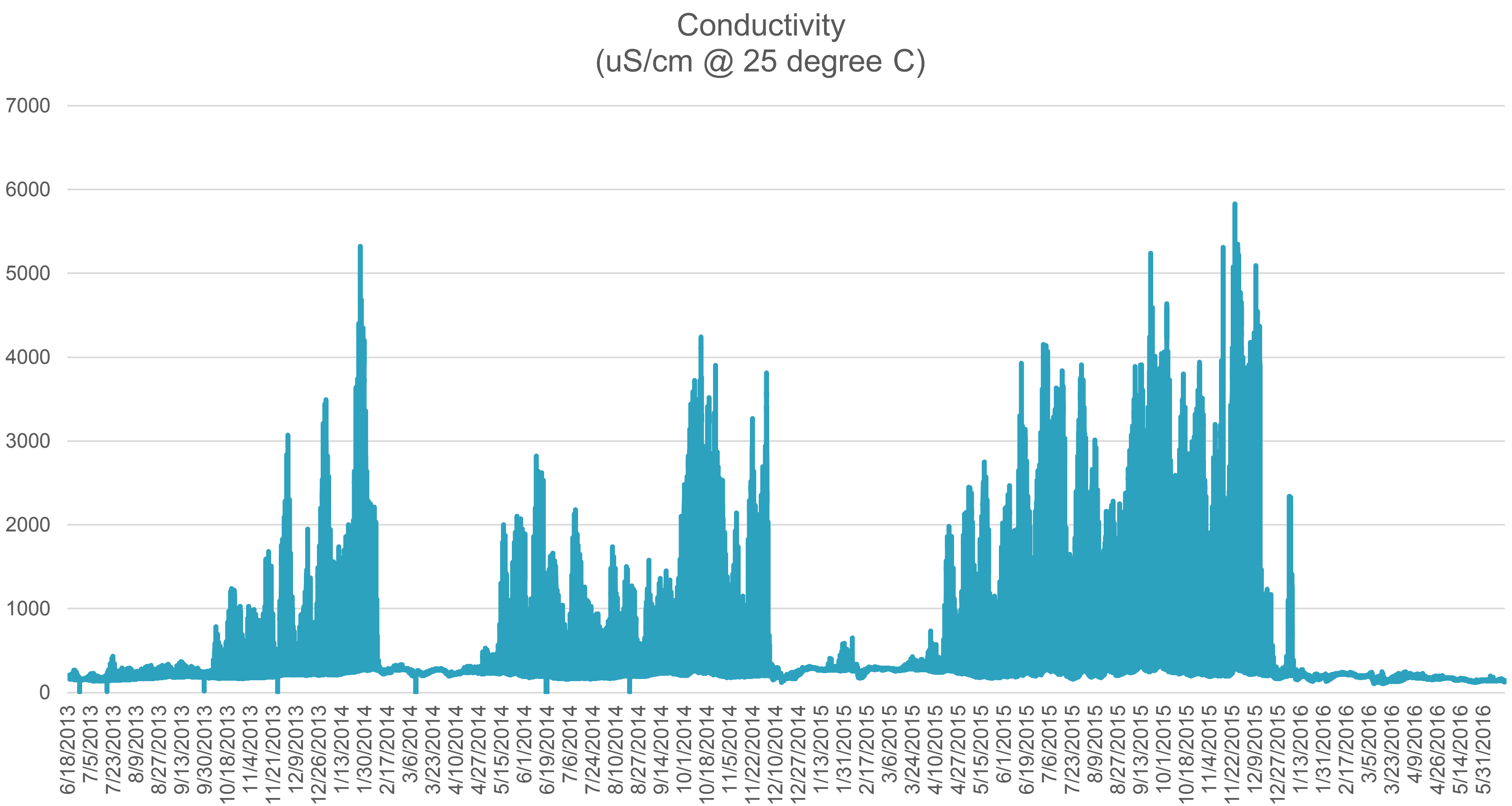
For agriculture, it is the timing of the salinity during the agricultural growing season, pre-irrigation and salinity flushing.

The important levels are both the peak salinity, and for the season, the area under the curve that leads to the seasonal loading, which is the sum total of the salinity load (net).

Drought Flows (2013-6) @ Rio Vista



Drought (2013-6) EC@ Rio Vista

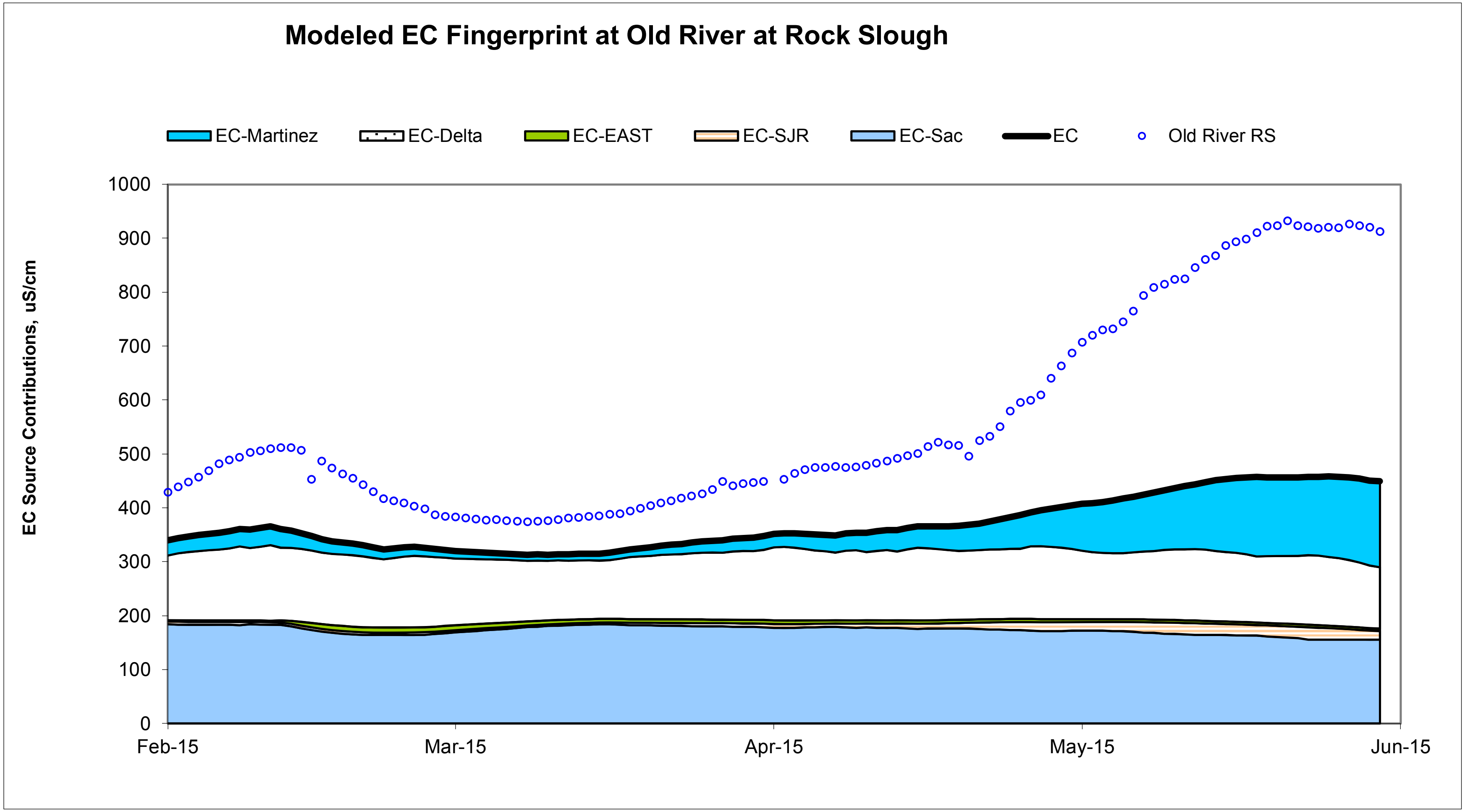


Outflow Control

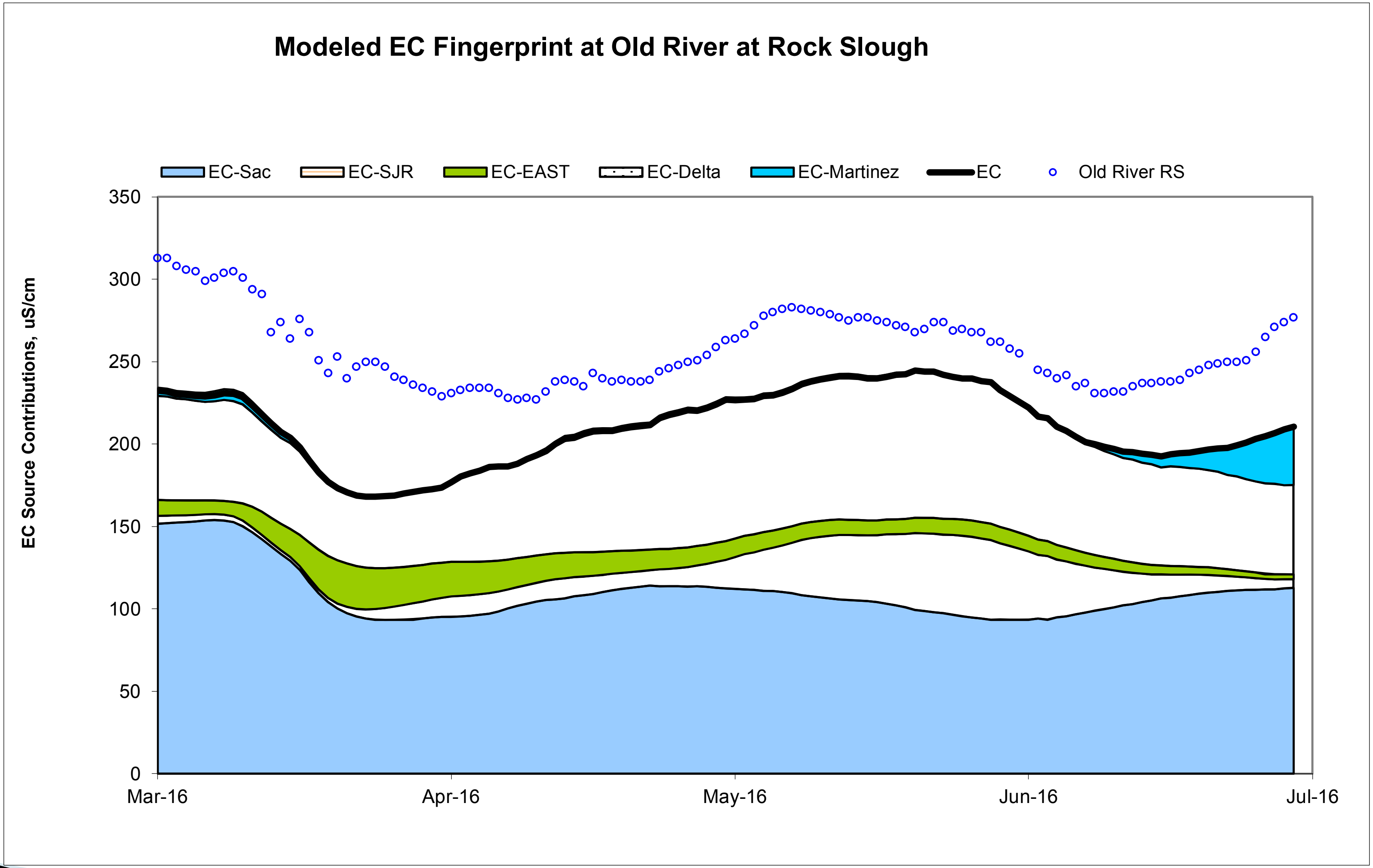
Salinity gradient is controlled by freshwater outflow, and changes constantly due to tides (and monthly and seasonal tidal differences). This is most obvious in droughts.

Outflow control is shown by EC levelling off even in droughts at flows above 12,000 cfs and salinity retreating from Rio Vista above 20,000 cfs. Flows below 12,00 cfs allow salinity to intrude, build, and ultimately spike.

2015 Fingerprint



2016 Fingerprint



Project Salinity

The Project could complete the type of modeling that would demonstrate predictive impacts under operational scenarios that bound the project maximum salinity impacts to the North Delta, but despite repeated requests overs several years to do so, still not provided.

A bounding scenario would be the months of July-November, king tide, dry and very dry water year, third and fourth years of drought, Winter Salmon Run temperature protection, 0/1/2 barriers installed. These are not hyperbolic bounds, but are exactly what occurred in the last two years in the Delta.

Salinity Conclusions

What can we infer from what was provided by the Petitioners?

The project can take, according to its operational bounds, typically 40% of the Sacramento River flow.

Salinity would increase through advection as a result of those lower flows, and increase to similar levels as were seen in the last 3 years of the drought with Southern Delta operations. If operational constraints to protect Central/South Delta fish remain, and are indeed on of the project purposes, the sustained operation of the North Delta diversions would institutionalize permanent drought-like flow conditions, and therefore increase EC and salinity in the Delta.

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