VACAVILLE

CITY OF VACAVILLE

650 MERCHANT STREET, VACAVILLE, CALIFORNIA 95688-6908
ESTABLISHED 1850

January 4, 2007

Ms. Gita Kapahi, Chief
Bay Delta/Special Projects Unit
P.O. Box 2000
Sacramento, California 95812-2000

SUBJECT: Consideration of the Southern Delta Water Quality Objectives for Salinity in the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

Dear Ms. Kapahi:

The City of Vacaville (City) has reviewed the State Water Resources Control Board's (State Water Board) Notice of Public Workshop regarding consideration of Southern Delta Water Quality Objectives for Salinity. The City operates the Easterly Wastewater Treatment Plant, which discharges treated effluent to waters tributary to the Delta. Although the south Delta standards do not directly apply to the City's discharge from its Easterly Wastewater Treatment Plan, the City is interested in how such standards relate to salinity standards in general. In addition, the City anticipates that salinity will be an issue in the City's next NPDES permit renewal.

In anticipation of salinity being a potential issue in its next permit, the City proactively prepared a *Draft Work Plan to Further Evaluate Electrical Conductivity in the City of Vacaville's Easterly Wastewater Treatment Plant Effluent and its Impact on Crops Grown in the Area*. The *Draft Work Plan* was submitted as part of the City's Report of Waste Discharge (ROWD), and the City intends to implement the Work Plan after its next permit is adopted by the Regional Board.

The State Water Board has requested interested parties recommend a scope of work for studies that may be appropriate regarding salinity in the southern Delta. In keeping with that request, the City submits the attached EC Study Work Plan that may be an appropriate study for determining appropriate salinity objectives for the South Delta to the extent that the South Delta Standards are derived from the United Nations Report titled *Water quality for agriculture* (Food and Agriculture Organization, Irrigation and Drainage paper 29, Rev.1, 1985). (See Attachment.) The *Draft Work Plan* submitted by the City is also consistent with the State Water Board's direction in its City of Woodland Order (WQO 2004-0010), which directed the Regional Board to consider site-specific considerations in assessing irrigation water suitability when applying salinity standards from the United Nations Report. In that Order, the State Board rescinded the electrical conductivity effluent limitation contained in the City of Woodland's NPDES permit and instead required the City to conduct a study "to evaluate soil chemistry, climate, rain and flood-induced leaching and background water quality for the affected area and their impact on irrigation salinity requirements." (Order, pages 7-8.)

Considering the State Board's decision in the City of Woodland Order and the similar study requirements that appear in Central Valley NPDES permits based on the State Board's Order, the City of Vacaville recommends that the State Board conduct a similar study of its own to determine the appropriate salinity objectives for the south Delta. Such a study would provide a substantial technical component for the adoption of appropriate water quality standards consistent with the Porter- Cologne Water Quality Control Act. The scope of the study should include the use of the model developed by Drs. Daniel Isidoro-Ramirez and Stephen R. Grattan from the University of California at Davis. Inputs to the model developed by Isidoro-Ramirez and Grattan include site-specific data for rainfall, crop type, soil type, evapotranspiration and irrigation water quality. The model also takes into account short and long-term rainfall scenarios for both average and dry periods and is able to tell if soil water salinity gets high enough to adversely affect crops of a given salt-sensitivity under given irrigation practices or whether there is a net salinization of the soil profile that will eventually affect crop yields. The results of such a study should provide the State Water Board with essential information regarding appropriate salinity standards for the southern Delta.

Although the City is familiar with the model and the work performed by Drs. Isidoro-Ramirez and Grattan, the City cannot speak to their availability and the time necessary to perform such a study. Thus, the City is unable to provide comments regarding potential study times and completion dates.

Thank you for the opportunity to comment. Please do not hesitate to call me at (707) 469-6412, or Jacque McCall at (707) 469-6416 if you have any questions.

Sincerely,

Dave Tompkins
Assistant Director of Public Works

Attachment: Draft EC Study Work Plan

SEPTEMBER 1, 2005

Draft Work Plan to Further Evaluate Electrical Conductivity in the City of Vacaville's Easterly Wastewater Treatment Plant Effluent and its Impact on Crops Grown in the Area

Prepared for:

City of Vacaville

Prepared by:

Larry Walker Associates

LARRY WALKER ASSOCIATES

ATTACHMENT

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Attachment 1: *An Approach to Develop Site-Specific Criteria for Electrical Conductivity, Boron and Flouride to Protect Agricultural Beneficial Uses*, Isidoro-Ramirez, Daniel Ph.D, and Stephen R. Grattan, Ph.D., Department of Land, Air and Water Resources, University of California, Davis, Davis, CA, July 2005.

1.0 Background

The City of Vacaville (City) owns and operates the Easterly Wastewater Treatment Plant (EWWTP), which provides sewerage service to the city of Vacaville and the unincorporated area of Elmira. The EWWTP currently discharges treated effluent to Old Alamo Creek, a tributary of New Alamo Creek, Ulatis Creek and Cache Slough. Flows in Old Alamo Creek consist of stormwater runoff during the wet season, return flows from irrigated agriculture during the dry season and from a groundwater cleanup project operating at less than 100,000 gallons per day (a General Order NPDES facility). Old Alamo Creek joins with New Alamo Creek approximately three miles downstream of the plant. New Alamo Creek then joins with Ulatis Creek another three miles downstream near Highway 113. New Alamo Creek and Ulatis Creek are small natural creeks which serve as storm water channels in the winter months and as agricultural irrigation drainage channels for Solano Irrigation District and Maine Prairie Water District during the summer months. The irrigation deliveries are managed by the two irrigation districts. The improved channels are maintained by Solano County Water Agency.

During the summer months, the EWWTP's effluent mixes with the agricultural irrigation return flows and is used by others downstream for agricultural purposes. Because the EWWTP is used beneficially for agricultural purposes, it is anticipated that the Regional Water Quality Control Board may establish water quality based effluent limits in the City's upcoming permit renewal process to protect agricultural uses. The Regional Water Board has identified salts as one of the constituents of primary concern in effluent that may negatively impact the agricultural beneficial uses in areas where the EWWTP effluent is used indirectly for irrigation. Thus, the City of Vacaville intends to conduct a study in conjunction with the University of California, Davis (UCD) and utilize the model developed by UCD to determine the maximum level of electrical conductivity (EC) in the effluent that is still fully protective of crop production in the areas near the EWWTP discharge.

In addition, the City intends to use the results developed by the UCD model in conjunction with the results of the City's *Easterly Wastewater Treatment Plant Effluent Dilution Analysis*, June 2005, to determine the resulting E.C. levels after factoring in available dilution of the various water supplies, which represents the water quality available for irrigation purposes. The resulting EC levels will be compared to the maximum levels as established by the model created by UCD to determine if there is a negative impact to the agricultural beneficial uses in the area.

2.0 Problem Statement

The Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins contains a narrative chemical objective that states in part, "[w]aters shall not contain chemical constituents in concentrations that adversely affect beneficial uses." The Regional Water Quality Control Board for the Central Valley (Regional Water Board) has interpreted this statement in other similar discharge permits to mean that effluent can not contain levels of salinity that adversely affect the agricultural beneficial uses. To quantify this narrative objective, the Regional Water Board has routinely relied on a study developed for the United Nations titled, *Water quality for agriculture*, Food and Agriculture Organization, Irrigation and Drainage Paper 29, Rev. 1, 1985.

In relying on this study, the Regional Water Board has previously utilized EC as a conservative measure of water salinity and used the most conservative values for EC contained in the guidelines. However, the State Water Resources Control Board (State Water Board) recently opined in a precedential water quality order that to utilize the guidelines from the United Nations appropriately, the Regional Board must determine if site-specific conditions allow some relaxation in the most conservative value (700 µmhos/cm) in the matter of the Own Motion Review of *City of Woodland*, WQO 2004-0010, June 17, 2004, at page 7. Consequently, the State Water Board revised the City of Woodland's permit to require them to conduct a study to determine the appropriate salinity requirements for areas irrigated with water diverted downstream from the City's discharge point. The City of Woodland is responding to this new permit requirement by working cooperatively with UCD in the development of the model to determine the maximum level of EC in the discharge that is still protective of crops grown with the City's effluent.

The City of Vacaville anticipates that the Regional Water Board will evaluate the City's effluent and levels of EC in the effluent in the same manner as that for the City of Woodland. Thus, the City of Vacaville is responding proactively by preparing a Work Plan for the Evaluation of Electrical Conductivity in the City's EWWTP effluent and its potential impact to crops grown with the City's effluent. The study conducted by the City will take into consideration the site-specific factors as identified in the State Water Board's *City of Woodland* decision and the United Nations guidelines.

3.0 Impact of Other Related Studies

UCD is currently developing the model for use by UCD in its permit for its wastewater treatment facility and the City of Woodland, as discussed above. For both of these permits, researchers from UCD are in communication with Regional Water Board staff on the model functions and inputs. The City of Vacaville will benefit from these discussions for the primary model functions should be fully vetted before the City of Vacaville undertakes its study as articulated in the Work Plan.

However, the maximum EC values identified in the UCD and City of Woodland versions of the study may or may not apply to the City of Vacaville. The model, as applied to the City of Vacaville, will consider timing and quantity of applied irrigation water, the quantity and distribution of rainfall, and realistic assumptions related to soil water principles based on soil types. While the city of Vacaville is located closely geographically to the city of Woodland and UCD, rainfall and soil characteristics may vary substantially. In addition, the crops that can be grown in the area of the City of Vacaville's discharge may also vary from those grown in proximity to UCD and the City of Woodland's discharge points.

4.0 Approach to Develop Site Specific Criteria

The study will be conducted using a model developed at UCD that is designed to determine the maximum EC of an irrigation water supply that is fully protective of crop production. Inputs to the model will be site-specific data for rainfall, crop type, soil type, evapotranspiration and irrigation water quality. The model allows numerous irrigation schedules to be tested under actual rainfall situations. Short and long-term rainfall scenarios will be evaluated representing both average and dry periods. The results will tell whether soil water salinity gets high enough to adversely affect crops of a given salt-sensitivity under given irrigation practices or whether there is a net salinization of the soil profile (that will eventually affect crop yields).

The lead investigator for this work will be Dr. Stephen Grattan, Department of Land, Air and Water Resources at the University of California, Davis. Dr. Grattan in cooperation with Dr. Daniel Isidoro-Ramiez developed the model to be used for similar studies for UCD and the City of Woodland. The workplan and schedule to conduct the study is presented below.

Attachment 1 contains a summary of the model titled, *An Approach to Develop Site-Specific Criteria for Electrical Conductivity, Boron and Fluoride to Protect Agricultural Beneficial Uses*, developed by Drs. Isidoro-Ramirez and Grattan, July 2005 for the City of Woodland.

TASK 1.0 GATHER EXISTING/RELEVANT INFORMATION

Inputs to the model include rainfall history, crop and soil types and characteristics, evaporation potential, and irrigation water quality. This information for Vacaville, New Alamo Creek and Ulatis Creek will be compiled. Sodium absorption ratios (SAR) of Vacaville's effluent will be evaluated to assess potential reductions in soil water infiltration potential for local soils.

TASK 2.0 EVALUATE MODEL ASSUMPTIONS

Key assumptions incorporated into the model include crop and soil types, irrigation practices used, evapotranspiration, rainfall patterns, water uptake and crop response. Input on these assumptions will be sought from local farmers, the Solano Irrigation District, Maine Prairie Water District and others. An advisory group of local farmers and other stakeholders as applicable will be convened and the assumption parameters and associated values will be established based on the advisory group's input. Input on how to set the threshold for impact (i.e., what is fully protective) will also be sought from this advisory group.

TASK 3.0 CALCULATE IMPACT OF EC ON CROP YIELDS

Using the data and assumptions obtained in Tasks 1 and 2, an EC that is fully protective will be calculated using the model based on site-specific conditions for the selected crops. Other levels of protection (e.g., 90% of yield, etc.) will be evaluated as appropriate.

As directed by the State Water Board's *City of Woodland* decision, the effects of rainfall, flood-induced leaching and ambient water quality including SAR will be evaluated for potential adverse effects on local soils and crop production. How these parameters impact EC requirements will also be addressed.

TASK 4.0 PREPARE REPORT

A report will be prepared describing the process, assumptions, and model as modified to investigate effects of salt levels in irrigation water drawn from New Alamo Creek and Ulatis Creek. The report will also present results of the site-specific investigation detailing the effects of ambient water quality, irrigation practices, precipitation, flooding, and local soils on crop production. The report will recommend site-specific numeric values for EC that fully protect New Alamo Creek and Ulatis Creek's AGR use designation.

5.0 Proposed Study Schedule

Task:	Completed by:
1.0 Gather existing/relevant information	6 months after Regional Board adopts a Revised NPDES permit for the City of Vacaville EWWTP
2.0 Evaluate model assumptions	12 months after Regional Board adopts a Revised NPDES permit for the City of Vacaville EWWTP
3.0 Calculate impact of EC on crop yields	18 months after Regional Board adopts a Revised NPDES permit for the City of Vacaville EWWTP
4.0 Prepare report Final report to Regional Board	24 months after Regional Board adopts a Revised NPDES permit for the City of Vacaville EWWTP

An Approach to Develop Site-Specific Criteria for Electrical Conductivity, Boron and Fluoride to Protect Agricultural Beneficial Uses

Daniel Isidoro-Ramirez, Ph.D.
Stephen R. Grattan, Ph.D.

Department of Land, Air and Water Resources
University of California, Davis
Davis, CA 95616

July 2005

General Background:

A model has been developed and revised to determine how the electrical conductivity of a given irrigation water supply affects crop production while taking annual rainfall into account. The model builds upon the principles and assumptions described by Ayers and Westcot (1985) for water uptake by roots and salinity response functions by crops. It calculates ET using a relationship described by Allen et al. (1998) and relates the electrical conductivity of the irrigation water (ECw) to the seasonal average rootzone salinity, expressed as the electrical conductivity of the saturated paste (ECe). The model considers the timing and quantity of applied irrigation water, the quantity and distribution of rainfall, and realistic assumptions related to soil water principles based on soil type.

The model can be used to either quantify the extent by which an irrigation water supply with a given EC would decrease the yield potential for a given crop under site-specific conditions or to determine the maximum EC of an irrigation water supply, that if used as the sole source of irrigation water over the long term, is fully protective of crop production. Moreover, the program could also be used to determine what additional agricultural practices might be necessary to restore full yield potential (e.g., applying additional irrigation to increase leaching).

This model is being used to evaluate site-specific conditions for the Davis-Woodland region (more specifically, the Yolo bypass) based on consistently conservative assumptions. Beans and melon are currently being chosen for this analysis since melon is sometimes grown in the bypass area (Jones and Stokes & Larry Walker Assoc., 2000) and beans may be grown in areas outside the bypass using the Tule Canal water. These crops are the most salt-senstive having the lowest soil salinity thresholds (i.e., ECe = 1.0 dS/m or 1,000 µmhos/cm). That is, the yield potential is not reduced provided the average rootzone salinity over the season does not exceed 1.0 dS/m. Protecting beans and melons would, in turn, protect all other crops commonly grown in the Yolo bypass and surrounding areas.

General Features:

This model takes into account many site-specific factors:

- Crop type
- Soil textural type (defines the limits for the available soil water content, soil water potential and soil-water movement characteristics).
- Rootzone depth (effective root depth)
- Crop evapotranspiration (estimates based on daily temperature minimum and maximum values using the Hargreaves method but adjusted by linear regression to conform with those estimates provided by Goldhamer and Snyder (1989).
- Irrigation schedules (very flexible)
- Root water extraction pattern [four-layer (40-30-20-10%) method adapted from Ayers and Westcot, 1985]
- Re-distribution of water among layers
- Leaching fraction
- Daily salt and water balance within each of the four layers

- Daily rainfall data for 53 yeas (National Climate Data Center (2004)
- Effective rainfall
  - Surface runoff (SCS method)
  - Off-season evaporation (FAO 56 method)
- Rainwater and irrigation water EC
- Predicted seasonal rootzone salinity (both arithmetic mean and ET-weighted mean)

Accounting for Rainfall and Irrigation Schedules

Among the entries to the model are the daily values of precipitation (rainfall) and irrigation. The main goal of this work is to establish how precipitation will affect crop yields when using irrigation water of a given constant quality (i.e., ECw). The historical rainfall record over the past 53 years for the Davis area was taken from the National Climate Data Center (2004) and was numerically sorted from the minimum (driest year) to the maximum (wettest year). If the rainfall of the m^{th} year in the ordered row is P_m, the probability that rainfall is lower than Pm is given by the order number (m) of a year divided by the total number of years (n) plus 1 [$Prob(P \leq P_m) = m/(n+1)$]. The actual rainfall distribution of the m^{th} can be used to determine the results of the simulation with a P_m probability in the conditions of the location. In order to get a more accurate estimate for a given probability value (say 20%) several years with P_m around 20% may be used and the mean results taken as the 20% probability is the outcome from performing such an irrigation schedule under such weather conditions.

The model allows for the irrigation schedule to be rather flexible. First, we can define a leaching fraction (LF) and make $I = ETc/(1\text{-}LF)$ where I is the depth of applied (infiltrated) water. Furthermore "I" may be distributed in a given number of daily irrigations similar to actual farmers' irrigation practices or "I" may be applied at a frequency to prevent water stress. Any given schedule can be shifted a few days before or after so as to find which actual dates provide a better water schedule for the crop (such that actual ET is the closer to the achievable ETc).

Therefore, this model allows numerous irrigation schedules to be tested under a range of actual rainfall situations that could take place with a given probability. The results of the model will indicate whether soil salinity gets high enough to reduce yields of a particular crop under the given rainfall patterns and irrigation practices. When this occurs, the EC of the irrigation water must be decreased until such favorable soil salinity conditions (i.e., the ECe threshold, the maximum seasonal rootzone salinity of a particular crop above which yields decline) are achieved. There is also flexibility in determining maximum ECw values that will yield less than 100% yield potential which in many cases may be more economically viable.

The simulation can also be applied to multi-year historical rainfall series. If irrigation water quality were to remain constant over this same period, the resulting simulated series of ECe thresholds for various crops can be used to establish the probability of obtaining below/above the threshold values of ECe. The result is the distribution function of seasonal average rootzone salinity (ECe) for the entire period. This model can be used in other locations within the state given information on crop types, soil types and regional climatical data including historical rainfall records.

REFERENCES

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Ayers, R. S. and Westcot, D. W. (1985). Water quality for agriculture. FAO Irrigation and Drainage Paper 29. Rev.1. FAO, Rome, p. 173.

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NOAA National Climatic Data Center, Asheville, NC. 2004. Station number 042294. Davis 2 WSW Exp Farm. Asheville, NC available at http://www.ipm.ucdavis.edu/WEATHER/wxretrieve.html

SCS (2004). Soil Survey of Yolo County, California, available at http://www.ca.nrcs.usda.gov/mlra02/yolo/

Results of simulations performed on a mean year (1987 —48 percentile, 2002 —median, and the mean temperature year)

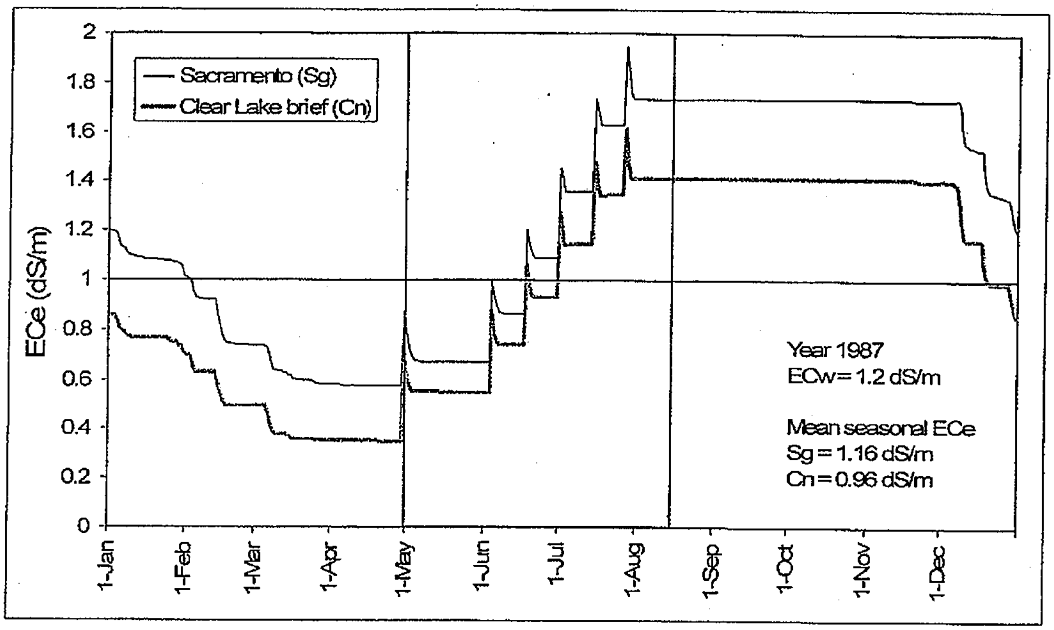

Figure 1. Daily electrical conductivity of the saturation extract (ECe) for the two main soils in the Yolo bypass (Sacramento flooded, Sg, and Clear Lake flooded, Cn) during the year 1987.

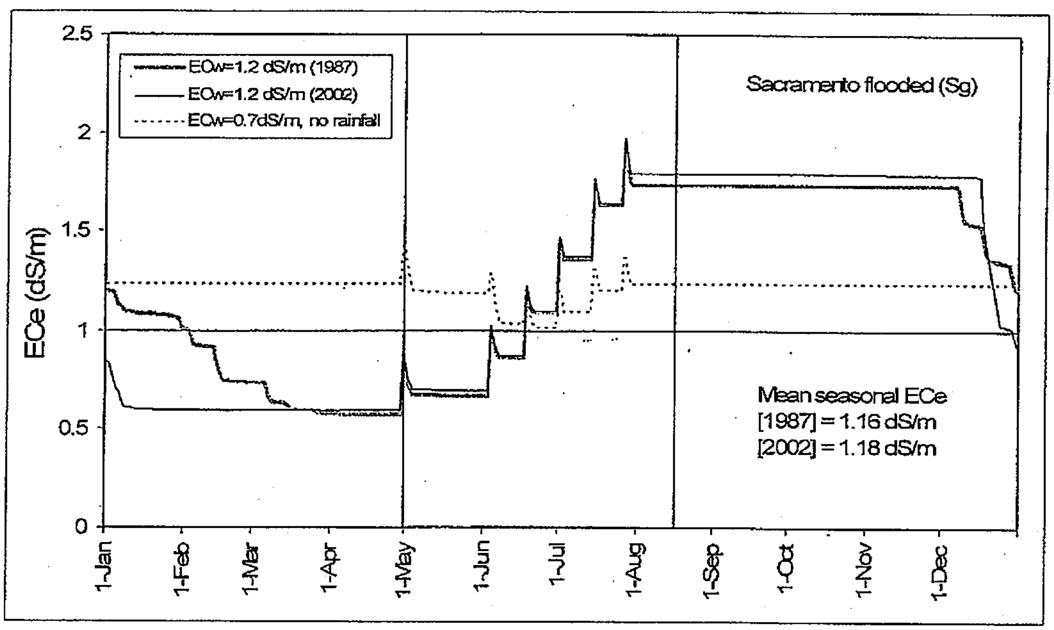

Figure 2. Daily electrical conductivity of the saturation extract (ECe) for the mean temperature year with no rainfall and an EC of the irrigation water ECw = 0.7 dS/m and for the years 1987 and 2002 with ECw = 1.2dS/m in the Sacramento flooded soil series (Sg).

Results for dry beans in the Sacramento flooded soil series (Sg)

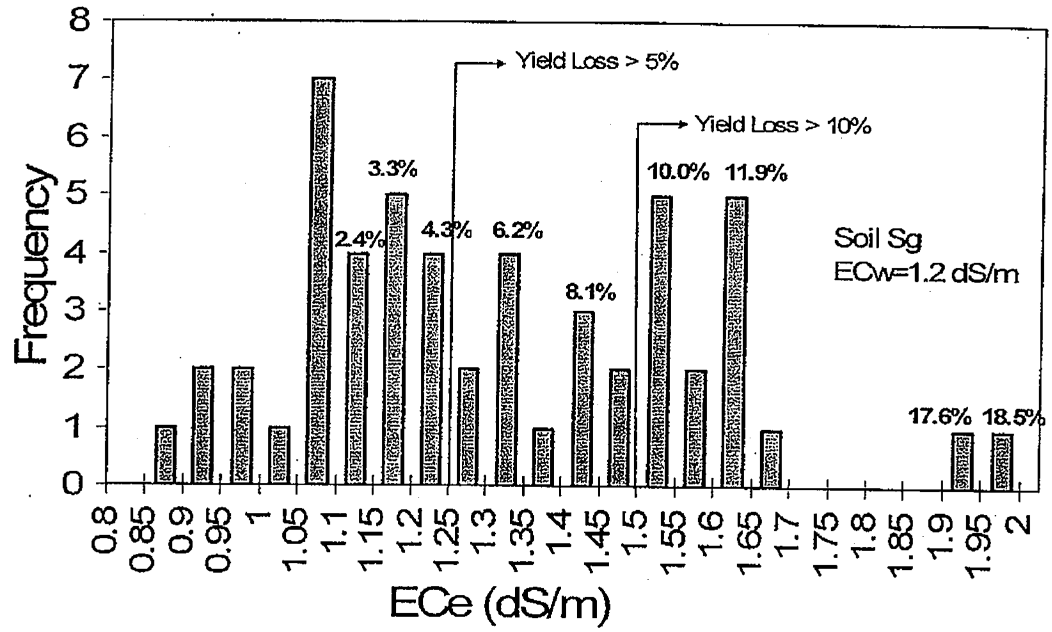

Figure 3. Frequency distribution of electrical conductivity of the saturation extract (ECe) for the 53 year series with ECw = 1.2 dS/m. Numbers on top of bars indicate the yield loss in % (loss >2%).

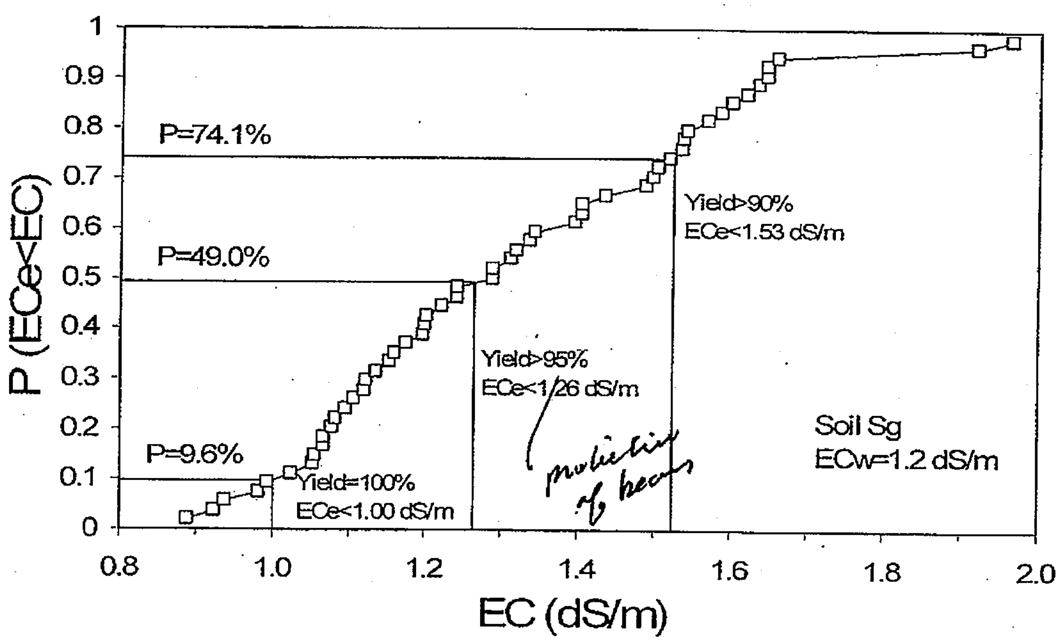

Figure 4. Probability distribution function of the resulting mean seasonal electrical conductivity of the saturation extract (ECe) with ECw = 1.2 dS/m.

Results for dry beans in the Clear Lake flooded (brief duration) soil series (Cn).

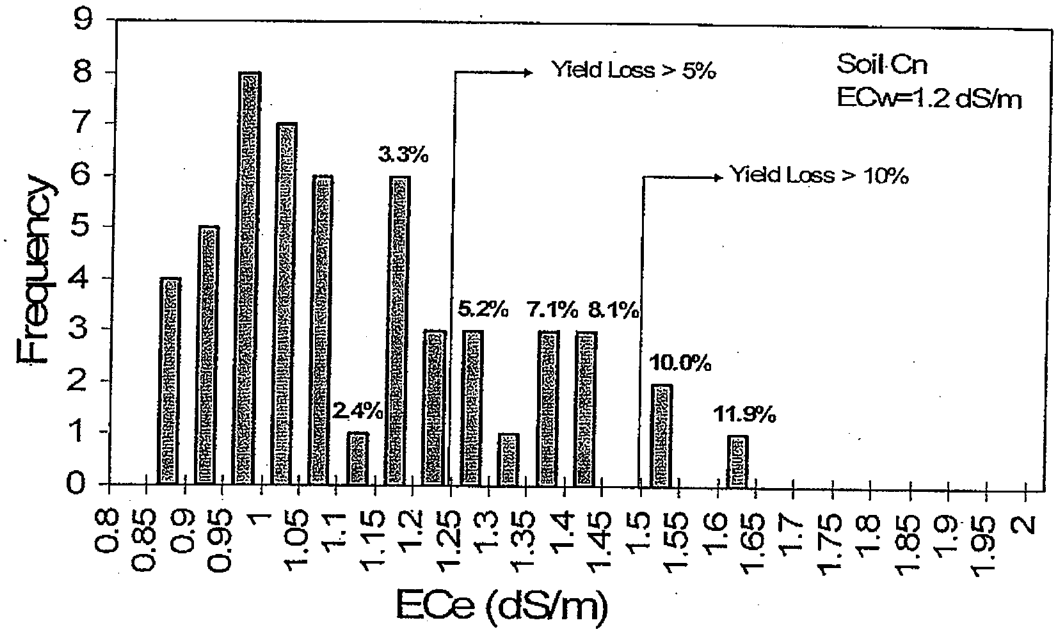

Figure 5. Frequency distribution of electrical conductivity of the saturation extract (ECe) for the 53 year series with ECw = 1.2 dS/m. Numbers on top of bars indicate the yield loss in % (loss >2%).

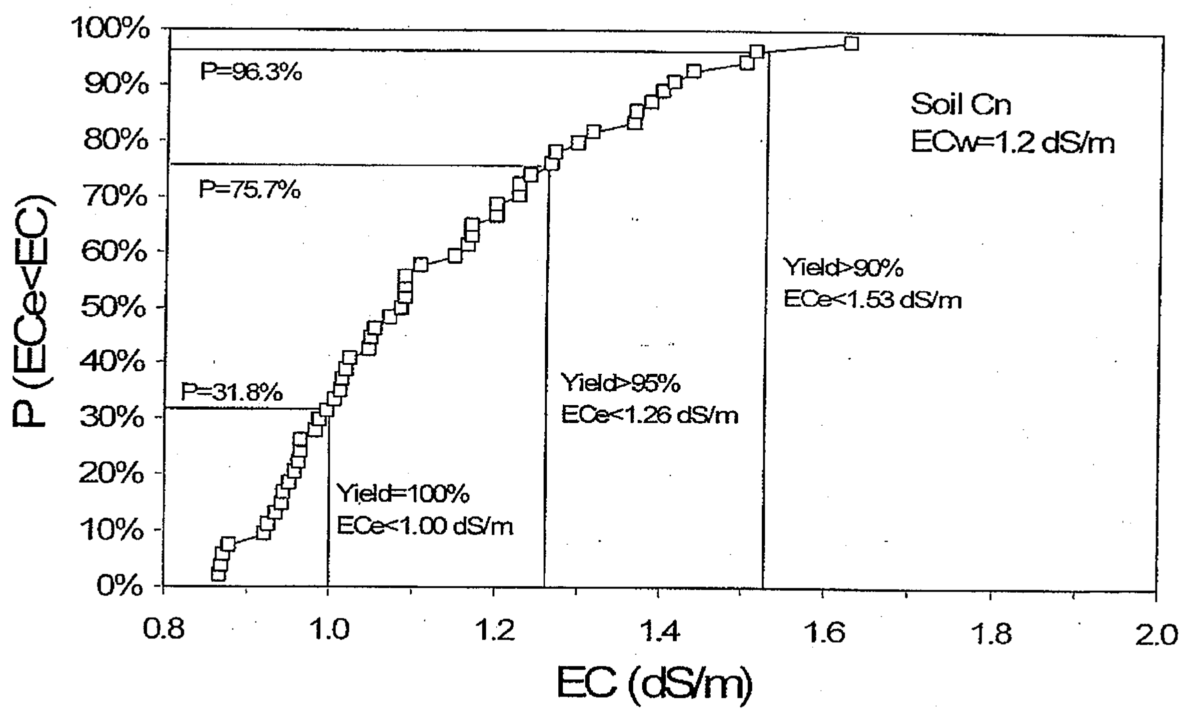

Figure 6. Probability distribution function of the resulting mean seasonal electrical conductivity of the saturation extract (ECe) with ECw = 1.2 dS/m.