From: Dante Nomellini, Jr. [mailto:dantejr@pacbell.net]
Sent: Tuesday, May 12, 2015 6:03 PM
To: 'Coats, Brian@Waterboards'; 'Evoy, Barbara@Waterboards'; 'Trgovcich, Caren@Waterboards'; 'Dadamo, Dorene@Waterboards'; 'Rizzardo, David@DWR'; 'Nemeth, Stephen@DWR'; 'O'Hagan, John@Waterboards'; 'Mrowka, Kathy@Waterboards'; 'JZOLEZZI@herumcrabtree.com'; 'Herrick, John @aol.com'; 'Jennifer Spaletta (jennifer@spalettalaw.com)'; 'George, Michael@Waterboards'; 'pminasian@minasianlaw.com'; 'jbuckman@friantwater.org'
Subject: RE: San Joaquin River Stakeholder Meeting - Senior Rights

Thank you SWRCB for hosting this morning's meeting. That was quite informative and a most appreciated opportunity for the stakeholders to be able to interact with the SWRCB, DWR and other stakeholders on this critical topic.

Nearly the entire meeting focused on natural flow and curtailment discussions upstream of the Delta, however, at the end of the meeting I was able to hand out and briefly discuss a couple of handouts that I prepared which pertain to natural flow and curtailments within the Delta.

Needless to say, I believe these handouts are a good read for everyone on this email list and highly pertinent to the matter of curtailments within the Delta, hence, I've attached them hereto for those that were not in attendance at the meeting.

I've also attached a copy of DWR's 1956 Report No. 4 which I reference in one of those attachments which contains a quite remarkable conclusion which, as I read it, states that water diversions to support agricultural operations in the Delta Lowlands (which comprise the vast majority of the Legal Delta) actually improve water quality during the summer months. If that is true, then such diversions would seemingly reduce the need for Storage Releases to maintain salinity control during those months, i.e., the months when storage supplies are the scarcest.

That is quite a profound conclusion that has obvious implications to curtailments within the Delta and the desired outcome of such curtailments.

Thanks again for the meeting and for taking the time to review these materials.

Sincerely,
Dan Jr.
Attorney for the Central Delta Water Agency

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_____

-----Original Appointment-----
From: Coats, Brian@Waterboards [mailto:Brian.Coats@waterboards.ca.gov]
Sent: Tuesday, May 05, 2015 8:40 AM
To: Evoy, Barbara@Waterboards; Trgovcich, Caren@Waterboards; Dadamo, Dorene@Waterboards; Rizzardo, David@DWR; Nemeth, Stephen@DWR; O'Hagan, John@Waterboards; Mrowka, Kathy@Waterboards; JZOLEZZI@herumcrabtree.com; Herrick, John @aol.com; Jennifer Spaletta (jennifer@spalettalaw.com); Dante Nomellini, Jr. (dantejr@pacbell.net); George, Michael@Waterboards; pminasian@minasianlaw.com; jbuckman@friantwater.org
Subject: San Joaquin River Stakeholder Meeting - Senior Rights
When: Tuesday, May 12, 2015 9:00 AM-11:00 AM (UTC-08:00) Pacific Time (US & Canada).
Where: Cal/EPA building, Conference Room 320

Meeting to discuss supply analysis and curtailments for senior rights in the San Joaquin River watershed.

DWR will present their full natural flow supply analysis for the first part of the meeting with a discussion on senior right curtailments afterwards.

For those that can't make the meeting and would like to participate on a conference call, the phone
number is 877-402-9753, participant code is 258306.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
GOODWIN J. KNIGHT, Governor
HARVEY O. BANKS, Director of Water Resources

INVESTIGATION OF THE SACRAMENTO-SAN JOAQUIN DELTA

Report No. 4

QUANTITY AND QUALITY OF WATERS APPLIED TO AND DRAINED FROM THE DELTA LOWLANDS

JULY 1956

TABLE OF CONTENTS

Table of Contents - Continued

TABLES

(Following Text)

Tables - Continued

PLATES

(Following Tables)

ACKNOWLEDGMENT

Valuable assistance and data used in this investigation were contributed by many individuals and by public and private agencies. Their cooperation is gratefully acknowledged; it greatly facilitated the collection and compilation of data contained in this report.

ORGANIZATION

Water Project Authority

of the

State of California

Frank B. Durkee, Director of Public Works
Chairman

Edmund G. Brown
Attorney General

Charles G. Johnson
State Treasurer

John M. Peirce
Director of Finance

Robert C. Kirkwood
State Controller

Harvey O. Banks, State Engineer
Executive Officer

Isabel C. Nessler
Acting Secretary

- - - - -

Effective July 5, 1956, the Water Project Authority was abolished and its functions, duties and responsibilities assigned to the Department of Water Resources by Chapter 52, Statutes of 1956.

Harvey O. Banks	Director of Water Resources
W. J. Shelton	Deputy Director of Water Resources
William L. Berry	Chief, Division of Water Resources Planning

Activities covered by this report were conducted by the staff of the Water Project Authority under the direction of

Irvin M. Ingerson — Principal Hydraulic Engineer

assisted by

Wayne MacRostie — Supervising Hydraulic Engineer

- - - -

The field and office work for this investigation were supervised by and this report was prepared by

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INVESTIGATION

of the

SACRAMENTO-SAN JOAQUIN DELTA

Report No. 4

QUANTITY AND QUALITY OF WATERS APPLIED TO AND DRAINED FROM THE DELTA LOWLANDS

* * *

PART I - INTRODUCTION

This series of five reports is designed to furnish new and additional factual data collected during the past three years, with analyses thereof, that are germane to those hydrologic problems in the State's water development programs which involve the use of Delta channels as conveyance conduits and as sources of diversion.

The Sacramento-San Joaquin Delta lies in the Central Valley of California and embraces the confluent channels and tributaries of the Sacramento River entering from the north, the Mokelumne and Calaveras Rivers entering from the east, and of the San Joaquin River entering from the south. The Delta is comprised of a block of nearly 400,000 acres of irrigated agricultural land interlaced by more than 600 miles of tidal channels which in turn surround more than 50 islands lying at or below sea-level and which are protected by levees.

The strategic geographic location of the Delta makes it the pivotal conveyance link across which the surplus water supplies of the northern portion of the State must be transported to the water-deficient areas of the central and southern portion to permit the continued agricultural, industrial, and municipal growth of those areas. The Central Valley Project has been designed, constructed, and put into operation to take advantage of the Delta channels to convey some 5,000 second-feet of the surplus Sacramento Valley waters to the south into the San Joaquin Valley. The plans of the Feather River Project call for the transfer and conveyance of an additional 11,000 second-feet through these same tidal Delta channels.

Despite the recognized importance of the pivotal position the Delta plays, or will play, in major programs of water development in California, there has been a dearth of geologic, hydraulic, hydrologic, and salinic information of the physical phenomena present. Such information is essential for intelligent planning of water transfer across the Delta area. On the other hand, the fruition of such water transfer plans must include solutions to problems of flood control, water utilization, and water disposal within the Delta area itself. The solutions will involve plans for optimum fresh-water distribution, saline-water drainage disposal, and degrees of channel salinity control to satisfy agricultural and industrial needs. The data and their analyses as presented in this series of reports are germane and essential to solutions of these Delta problems.

An investigation so comprehensive as to cover and report upon all of the facets of pertinent knowledge concerning the Delta area would be prohibitive in cost at this time. This series of reports perforce is limited to some of these facets, namely, ground water geology, water source and water utilization phenomena on two of the Delta islands, quantities and qualities of applied water and of drainage water in the Delta, and the extent of sea-water incursion in Delta channels.

This report is the fourth in this series and deals with some of the hydrographic and salinic aspects of water supply and water disposal in the Delta.

Purpose of This Investigation

One purpose of this investigation was to determine the monthly and seasonal quantities of water applied to the irrigated crops in the Delta Lowlands. This investigation was initiated in 1954 prior to, but in anticipation of, the "Sacramento River and Delta Trial Water Distribution Agreement for 1955" in which the State agreed to undertake "studies to ascertain the quantity of water required by water users diverting in and from the Delta".

Another purpose of this investigation was to determine the extent and sources of degradation in quality of the channel waters as they move from the Sacramento River to the Tracy Pumping Plant.

Area Under Investigation

For purposes of this report, the area under investigation, as delineated on Plate 1, will be called the "Delta Lowlands" and includes lands bordering the Sacramento and San Joaquin Rivers and their distributaries within the Delta area. The Delta Lowlands refer to those areas in the Sacramento-San Joaquin Delta consisting generally of the lands lying below an elevation of plus five, mean sea-level datum, and which, for the most part, consume water not susceptible to direct measurement since such water is largely derived from Delta channels by percolation or by numerous unratable siphons.

The Delta Lowlands comprise a land and water area of approximately 469,000 acres of which about 374,000 acres are developed for agricultural purposes and of which approximately 292,000 acres were irrigated in 1955.

The surface soils in the area embrace a large number of soil classes. The sedimentary mineral soil classes range from loamy sand to clay while the organic soil classes range from mucky loam to peat. Generally the organic soils are concentrated in the central part of the Delta. The purest organic soils (peats) vary in thickness from zero to over 30 feet and overlie mineral soils. Sedimentary soils generally lie along the Delta channels and cover the island areas lying above sea level.

Related Investigations and Reports

The following investigations and reports covering the Sacramento-San Joaquin Delta and adjacent areas were reviewed in connection with the current investigation:

California State Department of Public Works, Division of Water Resources. "Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay", Bulletin No. 27, 1931.

- - -"Putah Creek Cone Investigation", December 1955.

- - -"Sacramento River and Sacramento-San Joaquin Delta, Trial Water Distribution 1955, Summary Report of Data", January 1956.

- - -Water Quality Investigations, Report No. 7 "Quality of Ground Water in the Stockton Area, San Joaquin County", March 1955.

California State Water Resources Board. "San Joaquin County Investigation" Bulletin No. 11, June 1955.

United States Department of Agriculture, Bureau of Plant Industry. "Soil Survey, Dixon Area, California".

- - -"Soil Survey, Tracy Area, California".

- - -"Soil Survey, Sacramento-San Joaquin Delta Area California".

University of California, College of Agriculture. "Soils of Sacramento County". Weir, Walter W., April 1950.

Scope of This Investigation and Report

The period of field investigation covered by this report extended from May, 1954, through October, 1955.

Field observations covered the following activities: (1) determining the amount of water applied on sample fields for

the six major irrigated crops of the Delta Lowlands; (2) collecting surface water samples from drains and from Delta channels for mineral analyses; and (3) observing specific conductance of surface waters in drains and in Delta channels. Office studies included: (1) determining the quantity of waters applied to the Delta Lowlands; (2) determining from specific conductance observations the concentration of dissolved minerals in surface waters in drains and in Delta channels; and (4) the quantitative net degradation of water in Delta channels by saline drainage water from the Delta lands was determined from observed data giving both the quality and the quantity of water applied to and drained from those lands.

This report is divided into six parts: (1) Introduction, (2) Water Applied to Irrigated Crops of the Delta Lowlands, (3) Water Drained from the Delta Lowlands, (4) Water Supply and Disposal, (5) Quality of Water, and (6) Summary and Conclusions.

PART II - WATER APPLIED TO IRRIGATED CROPS OF THE DELTA LOWLANDS

This section deals with the determination of the amounts of water applied on the six major irrigated crops of the Delta Lowlands. The term "applied water" as used in this report refers only to that water which is diverted from channels by pumps or siphons and generally delivered for irrigation use in the immediate vicinity.

Irrigation Practices

Irrigation practices throughout the Delta Lowlands vary with the crop, soil type, depth to water table, quality of channel water available, and the irrigator's past experience and judgment.

In the areas of highly organic soil, subirrigation is used extensively. In this method temporary ditches, spaced about 30 feet apart and approximately 6 inches wide and 12 to 18 inches deep, are used to distribute the water through the fields. Raising the water level in the ditches by means of control structures causes horizontal movement of water through the soil resulting in subirrigation of the crops.

In the moderately organic and in the mineral soils, row crops are generally irrigated by the use of furrow-type irrigation. Alfalfa and pasture are generally irrigated by the use of strip-check irrigation. Sprinkler irrigation is used on many higher-elevation mineral and organic soil areas in the Delta both for its beneficial leaching effects as well as for the better control over the water than can be achieved in furrow irrigation.

Most irrigation takes place in the late Spring and Summer. However, some irrigators apply a large quantity of water in the early Spring before planting to increase the moisture content of the soil in the expectation of early seed germination.

The increase in salinity of the channel waters during the summer period causes some farm operators in the western portion of the Delta to cease irrigation during that period because of the deleterious effects of applying highly-saline water to crops. Waters are applied in the fall and winter seasons primarily to leach accumulated salts from the soils.

Some irrigators divert waters to their lands during the summer in excess of their requirements because ample water is available at practically no additional cost to them. Water conservation would be enhanced if more careful use of water were practiced.

Soil Types

A division of the Delta by soil types was estimated from data on soil maps embracing the Delta area compiled jointly by the United States Department of Agriculture and University of California. For purposes of this investigation the agricultural lands in the Delta area were divided, as shown on Plate 1, into three soil types: (1) north mineral, (2) middle organic, and (3) south mineral. These types cover approximately 121,000 acres, 192,000 acres, and 61,000 acres respectively. These acreages comprise,

respectively, about 33 per cent, 51 per cent, and 16 per cent of the total Delta Lowlands area developed for agricultural purposes.

Land Use

A comprehensive land-use survey was made in 1955 by the State Division of Water Resources, the results of which are detailed in that Division's report titled "Sacramento River and Sacramento-San Joaquin Delta, Trial Water Distribution 1955, Summary Report of Data". A summary from that report is shown in Table 1. For purposes of this investigation the areas of the exterior water surface and of the islands in the channels were excluded, leaving an area of 419,439 acres considered as the "Delta Lowlands".

Crops Investigated

As shown in Table 1 the seven major crops grown in 1955 on the Delta Lowlands were: (1) asparagus, (2) field corn, (3) alfalfa, (4) sugar beets, (5) tomatoes, (6) pasture, and (7) milo. Table 2 herein shows the irrigated acreages and the percentage of total irrigated area for each of the seven major crops and for all other crops as a single value.

Unit Application of Water

Quantities of water applied were estimated by measurements on six of the seven irrigated major crops in the Delta area in 38 sample fields totaling 3,369 acres. Locations of these

fields are shown on Plate 1. Each of these 38 sample fields was investigated separately and records of applied-water quantities were obtained. The fields were selected as typifying the soil, irrigation practices, and crops grown on each of the three soil types in the Delta Lowlands. As expected, irrigation practices, soil types in the Delta, and varying amounts of seepage, resulted in varying amounts of water applied to the irrigated crops. The length of the irrigation season also varied, for different crops, from one to eight months.

Although this investigation started in May, 1954, quantities of water applied to the sample fields earlier in the year were estimated from data on power consumption and/or from water users' records.

The unit applied-water factor for the seventh major crop, milo, was estimated from other available data. The estimated applied water during the irrigation season for milo, as determined from experiments by the University of California at Davis, is 1.0 acre-foot per acre. Data in the Division of Water Resources report "San Joaquin County Investigation" indicates that 0.7 acre-foot per acre was applied to an 80-acre test plot of milo. For purposes of this present report, 1.0 acre-foot per acre was used as the applied-water factor for milo for the entire Delta area. No measurements were made for certain major crops in each of the three soil-type areas because of (1) lack of cooperation by farmers in granting permission to make the measurements or in keeping the necessary records and (2) inability to

find an area encompassing only the one crop and containing a distribution system that would permit determination of the quantity of water applied to that crop. Therefore, values for such major crops were assumed to approximate the values for those crops in comparable areas for which actual applied water measurements were made.

The subdivision unit numbers referred to in tables described subsequently in this report designate subdivisions of the Sacramento-San Joaquin Delta of which the Delta Lowlands encompass all or part of all of the units except numbers 1, 4 and 5. The locations of the units are shown on Plate 2.

Major Crops on North Mineral Soils. Monthly and seasonal applications of water to crops of the north mineral soils area are shown in Table 3. The depths of applied-water during the irrigation season for five of the major crops were: field corn, 1.5 feet; alfalfa, 2.3 feet; sugar beets, 1.9 feet; tomatoes, 2.5 feet; and pasture, 2.2 feet.

The Division of Water Resources in its report "Putah Creek Cone Investigation, December 1955", determined certain applied-water factors on areas at the northern edge of the Delta. The weighted mean value of applied water for pasture reported therein was 3.9 acre-feet per acre, based upon a 430-acre area. This value was considered a reasonable applied-water factor for pasture and it was used in this report because the sample field for pasture in the present investigation, due to its small size of only five acres, was not considered representative of that crop.

A value of 0.7 acre-foot per acre for asparagus as determined for the south mineral soils area, was also used for the north mineral soils area.

Major Crops on Middle Organic Soils. Monthly and seasonal applications of water to crops of the middle organic soils area are shown in Table 4. The depths of applied-water during the irrigation season for four of the major crops were: asparagus, 1.4 feet; field corn, 3.6 feet; sugar beets, 3.3 feet; and tomatoes, 3.4 feet.

A value of 2.3 acre-feet per acre for alfalfa, as determined for the north mineral soils area, was assumed to approximate the unit quantity of water applied to alfalfa in the middle organic soils area.

A value of 3.9 acre-feet per acre for pasture, as determined for the north mineral soils area, was assumed as the unit quantity of water applied to pasture in the middle organic soils area.

Major Crops on South Mineral Soils. Monthly and seasonal applications of water to crops of the south mineral soils area are shown in Table 5. The depths of applied-water during the irrigation season for the six major crops were: asparagus, 0.7 foot; field corn, 1.5 feet; alfalfa, 4.2 feet; sugar beets, 3.7 feet; tomatoes, 2.6 feet; and pasture, 8.2 feet.

The applied-water values for two sample plots for pasture indicated an excessive annual use of water (over 10 acre-feet per acre) as compared to the other two plots. The Division of Water Resources in its report "San Joaquin County Investigation, June 1955", determined the weighted mean applied-water value for pasture on areas at the southeast edge of the Delta to be 4.5 acre-feet per acre as based upon a 240-acre area. However, for purposes of this report, the weighted average of 4.8 acre-feet per acre for the remaining two sample plots of pasture in Unit 27, as shown in Table 5, was used as the applied-water factor for pasture in the south mineral soils area.

Minor Crops. To determine the total quantity of irrigation water applied to the Delta Lowlands during the irrigation season, it was necessary to estimate unit applied-water values for the minor irrigated crops. This was done by calculating the weighted average unit depth of water applied to the major irrigated crops in each of the soil-type areas. These values for the north mineral, middle organic, and south mineral soils areas are 2.1, 2.3 and 2.4 acre-feet per acre, respectively. These weighted averages were multiplied by their respective soil-type areas; these quantities were then used as the estimated amount of water applied to the minor crops for inclusion in the evaluation of total water applied to the Lowlands.

Total Applied Water

The total seasonal amounts of applied water on irrigated crops of the Delta Lowlands were determined from the 1955 land-use survey data and the unit applied-water values described heretofore.

The total seasonal applications by soil type and by crop and the totals for the Delta Lowlands are shown in Table 6. The total irrigation seasonal use of applied water for the Delta Lowlands amounted to about 656,000 acre-feet or an average of 2.25 acre-feet per irrigated acre.

The monthly distribution of applied irrigation water was calculated for each of the aforesaid subdivisions from its crop pattern and applicable monthly applied-water values. Table 7 shows the monthly distribution of applied irrigation water by units, monthly percentages of seasonal totals, and monthly average unit applied-water values in acre-feet per acre. The monthly distribution of seasonal applied-water values varied from one per cent each in March and October to a maximum of 33 per cent (about 216,000 acre-feet) in July.

Waters Applied for Leaching Purposes

Water is applied to the Delta Lowlands for leaching excess salts from the soil, thereby lowering the salinity of the soil solution in the root zone. As will be shown hereinafter, evidence indicates that the concentration of salts in the soil increases during the summer season. These salts must subsequently be removed from the soils, otherwise the increasing saline concentration would accumulate and adversely affect plant growth.

Leaching waters are usually applied during the fall and winter months. No attempt was made during this investigation to determine the quantity of water applied for leaching purposes

because of the wide variations in leaching practices and because of the relative unimportance on channel demands of leaching water requirements since ample water of good quality is usually available during the late fall and winter seasons.

Precipitation

Precipitation, although not part of the "applied water" as considered in this report, does affect month by month the irrigation and leaching practices, and the quantities and qualities of drainage water as will be discussed later.

Data shown in Table 8 from the United States Weather Bureau Reports titled "Climatological Data, California" for the seven weather stations in and near the Delta, are considered representative of precipitation on the Delta. The average rainfall for the Delta Lowlands is assumed to be the arithmetic average of precipitation at those seven stations. Table 8 also shows the monthly rainfall at these stations for the period May, 1954, through October, 1955, and the monthly average for the Delta.

Monthly total quantities of precipitation on the Delta Lowlands, estimated by multiplying the aforesaid average depths of precipitation by the 419,439 acres of the Delta Lowlands are given in Table 9. The total precipitation for the March through October irrigation season in 1955 amounted to about 150,000 acre-feet.

PART III - WATERS DRAINED FROM THE DELTA LOWLANDS

Concurrent with the observations of water applied for irrigation in the Delta Lowlands, observations were made to determine the quantities of waters drained from those lands. Permission was secured from property owners to test and rate their drainage pumping plants and to secure their power consumption records. These data were used to calculate the water quantities pumped from the interior drain canals into the tidal channels.

Drainage Practices

In general, each island or tract in the Delta Lowlands has one or more drainage systems wherein the drainage waters first enter small drainage ditches leading to larger main drains and then terminate at the pumping plants. These plants, usually float-actuated between predetermined water levels in the main drains, pump water intermittently from the main drains into the contiguous channels.

Drainage pumps used in the Delta vary in combinations of the following types and sizes: 3- to 50-inch discharge pipe, 3- to 500-horsepower motor, horizontally or vertically mounted, double or single suction centrifugal type, mixed-flow or axial-flow propeller type, direct or belt connected to gasoline or diesel internal combustion engine or to an electric motor. The most common drainage-pump installation in the Delta area is a 30 to 75 horsepower, direct connected, electric-motor driven, axial-flow propeller-type pump.

Quantity of Drainage Water Pumped

The quantity of drainage water pumped from 82 per cent of the area in the Delta Lowlands for the period May, 1954, through October, 1955, by means of 162 pumping plants involving 255 pumps, was determined from pump test data and power consumption records. For the same period, drainage pumped by 64 pumps at 44 pumping plants servicing 16 per cent of the Delta Lowlands, was estimated by assuming that the plant rating factors were similar to comparable measured installations or by correlation with drainage-per-acre values in adjacent areas. The remaining 2 per cent of the area covers lands either drained by gravity or urbanized, and their drainage contributions were estimated by correlation with drainage-per-acre values in adjacent areas.

Table 10 shows the combined measured and estimated monthly total drainage from each subdivision unit within the Delta Lowlands and the monthly average unit drainage in acre-feet per acre. During the period of investigation the monthly total drainage varied from a low of about 30,000 acre-feet in October, 1955, to a maximum of approximately 96,000 acre-feet in January, 1955.

The average monthly unit drainage values in acre-feet per acre are shown graphically on Plates 3, 4 and 5 for three periods: May through October, 1954; November, 1954, through February, 1955; and March through October, 1955. A comparison of these three plates indicates that the average monthly drainage in

the Delta during the winter is greater than during the other seasons as indicated by the small area during the winter from which drainage was between zero and 0.10 acre-feet per acre per month. This increase is due to a combination of greater precipitation and lower consumptive use demands at that time. Also during the winter a noticeable increase occurred in the area from which drainage was between 0.31 and 0.60 acre-foot per acre per month. It may also be noted that certain areas in the northern and southern parts of the Delta show the results of high irrigation efficiency and minor seepage problems since the drainage from those areas remained in the zero to 0.10 acre-foot per acre per month category throughout the entire period of investigation. The higher elevation of those lands compared to lands in the central portion of the Delta probably accounts for the lesser seepage.

PART IV - WATER SUPPLY AND DISPOSAL

The water supply to islands of the Delta Lowlands consists of (1) applied irrigation water, (2) subsurface inflow, and (3) precipitation. Water disposal consists of (1) drainage water, and (2) consumptive use. Ground water storage changes account for any imbalance between supply and disposal. Of the foregoing items, applied irrigation water, precipitation, and drainage have been discussed and evaluated heretofore. This chapter presents an evaluation of consumptive use and a derivation of subsurface inflow under assumptions as to ground water storage changes.

Consumptive Use

The monthly total quantities of consumptive use of water were taken from the Division of Water Resources report titled "Sacramento River and Sacramento-San Joaquin Delta Trial Water Distribution 1955, Summary Report of Data". These quantities were derived by multiplying 1955 crop acreages by appropriate unit consumptive use values. Monthly consumptive use quantities within the Delta Lowlands are shown in Table 11 of this report. It will be noted that these values varied from about 22,000 acre-feet in January, 1955, to about 211,000 acre-feet in August, 1955. Of the annual consumptive use requirements of 1,160,000 acre-feet, about 1,036,000 acre-feet were consumed during the March through October irrigation season.

Subsurface Inflow

Subsurface inflow to islands of the Delta Lowlands was derived by means of the hydrologic equation. This equation provides that inflow to an area must equal disposal therefrom plus or minus changes in ground water storage. The measurable and estimable sources of water supply are the applied irrigation water and precipitation. The measurable and estimable water disposal consists of return drainage water and consumptive use. The unknown and practically unmeasurable terms in the hydrologic equations pertaining to Delta islands are (1) ground water storage changes, (2) contribution to the islands by seepage from contiguous channels, and/or (3) rising water from deep-seated and remote sources. Items 2 and 3 are discussed together herein as subsurface inflow.

The measurable and estimable values of water supply and disposal in the Delta Lowlands are presented in Table 12, which summarizes data presented heretofore. As shown, the partial water supply during the March through October, 1955, period consisted of about 805,000 acre-feet of applied irrigation water and of precipitation. During that period, water disposal consisted of approximately 1,453,000 acre-feet of drainage and of consumptive use. Therefore, during this period the excess of water disposal over the measurable water supply was approximately 648,000 acre-feet. Because of the irrigation and drainage practices in the Delta area, it properly may be assumed that the ground-water storage change during the March through October

period is comparatively insignificant. Therefore, it is concluded that the 648,000 acre-feet is indicative, during that period, of the magnitude of subsurface inflow.

The data presented in Table 12 are shown graphically on Plate 6. In this plate, for each month, the total measurable water supply is shown on the right side of the double column and the water disposal on the left side of the double column. It is to be noted that no applied irrigation water values were determined for the months of November, 1954, through February, 1955. In spite of this omission, an inspection of the plate shows that, except for the month of December, 1954, the water disposal exceeded the measurable and estimable water supply in every month during the 18-month period from May, 1954, through October, 1955, indicating subsurface inflow.

PART V - QUALITY OF WATER

An inspection of water analyses from the files of the Division of Water Resources shows that generally the quality of Delta channel water becomes progressively poorer as the water moves from the northern to the southern part of the Delta, that is, from the Sacramento River toward the Tracy Pumping Plant of the Central Valley Project. One possible cause of this degradation is the effect of sea-water intrusion, which effect is discussed in Report No. 5 in this series of reports on the Sacramento-San Joaquin Delta.

Another possible source of the degradation is the salt contributed to the channels by the drainage waters from the Delta islands. To evaluate this possibility the salt contribution to the Delta channels was determined from observations and computations involving the qualities and quantities of waters applied to and drained from the Delta Lowlands. The quantities of those waters have been discussed and presented heretofore.

Quality of Applied Water

The quality of applied water was determined in the field from specific-conductance data collected at random tide phases at 62 sampling points in the Delta channels at approximately six-week intervals during 18 continuous months of 1954 and 1955. At 22 of these sampling points, water samples were also collected at 3-month intervals, and subjected to complete mineral analyses. Correlations were determined between specific conductance of the

water and the sum of concentrations of mineral constituents in parts per million (ppm). By interpolation; a monthly average concentration was determined for the water at each sampling point. These monthly concentrations and the monthly applied-water quantities for each subdivision unit were used to determine the monthly tons of salt in the irrigation water applied to each unit of the Delta Lowlands. These monthly quantities, as well as values for tons-per-irrigated acre, are shown in Table 13. The monthly total salts in applied irrigation water varied from a minimum of about 2,100 tons in March, 1955, to a maximum of approximately 70,000 tons during August, 1954. Since no applied-water values were determined for the period November, 1954, through February, 1955, no salt tonnages are shown for those months. However, it is to be noted that water applied for leaching during this period of winter runoff from the Central Valley, would have been of generally good quality.

The monthly average quality of applied irrigation water within each subdivision unit was determined as an arithmetical average of the monthly water qualities at all of the sampling points within that unit. Table 14 shows that these values ranged from 70 ppm in Unit 27 during May, 1954, to about 1,800 ppm in Unit 14 during August, 1955. Also shown in this table are the weighted monthly averages for the entire Delta as computed from data in Table 13. These averages ranged from 86 ppm in May, 1954, to 300 ppm in August, 1954. Since applied-water values were not determined for the period November, 1954, through February, 1955, no weighted averages for that period could be calculated.

The data in Tables 13 and 14 involve only the salt content of applied surface water. They do not concern the salt in water entering the islands by seepage from channels or from other sources. Although the quality of such additional supplies is uncertain, it is indicated in Reports No. 2 and 3 that the ground water inflow to Medford and McDonald Islands was largely channel water. Available data are not sufficient at this time to indicate whether or not this is true for the Delta Lowlands as a whole. However, if for purposes of a rough approximation, it is hypothesized that the rate of ground water inflow to the islands of the Delta Lowlands is constant, and that the quality of such inflow equals the approximate Delta-wide average annual quality of channel waters of about 260 ppm, about 33,000 tons of salt per month in addition to those amounts shown in Table 13 would enter such islands.

An inspection of the average concentrations of applied water in Table 14 indicates that peak concentrations of salts in the channels occur in the late summer months. Evidence presented in Report No. 5 shows that this condition is due largely to sea-water incursion caused by a combination of high consumptive use, including high water-surface evaporation losses, and by the relatively low fresh-water inflow to the Delta at that time.

Quality of Drainage Waters

The quality of water drained from the Delta Lowlands was determined in a manner similar to that described in preceding section under the heading, "Quality of Applied Water". Specific

conductance field measurements at approximately six-week intervals were made of the drainage water at 196 sampling points. Water samples were also collected at 24 of these points at approximately three-month intervals and subjected to complete mineral analyses. The estimated quantities of drainage water, presented heretofore, and the drainage-water qualities were used to determine the amount of salt discharged at pumping plants in each unit. Table 15 shows the estimated monthly salt tonnage discharged to the channels within each unit and the monthly total discharge in tons-per-acre for the Delta Lowlands as a whole. The total salt tonnage discharged in the drainage water during the 18-month period varied from a minimum of about 19,000 tons in October, 1955, to a maximum of approximately 113,000 tons in January, 1955.

The data in Table 15 were converted to show, in Table 16, the weighted average concentration of drainage water in each subdivision unit and for the entire Delta Lowlands area. Total dissolved solids in drainage water varied from about 120 ppm in June, 1955, in Unit 3 to about 1,600 ppm in February, 1955, in Unit 17. The Delta average ranged between about 300 ppm in June, 1954, to 865 ppm in January, 1955. An inspection of Table 16 indicates that the average concentration of the drainage water remains comparatively constant between May and October. During this period in each year, the concentration increased from about 300 to approximately 475 ppm.

Values of average monthly salt discharge in tons-per-acre from the Delta Lowlands are shown graphically on Plates 7, 8,

and 9 for three periods: May through October, 1954; November, 1954, through February, 1955; and March through October, 1955. An inspection of these plates indicates that there was a larger area contributing high tonnages of salt per-acre-per-month during the winter than during other seasons. This is shown by the large areas in the categories of 0.21 to 0.50, and 0.51 to 0.80 tons-per-acre-per-month of salt removed during the winter months.

Channel-Water Degradation by Drainage Water. An inspection of the data shown in Tables 13 and 15 reveals that during summer months salt inflow to Delta Lowlands islands exceeds salt drainage therefrom. This is true even without taking into account the relatively large amounts of salt carried by subsurface inflow to the islands mentioned heretofore, and salts introduced by fertilization and other agricultural practices. In other months of the year, salt removal exceeds salt inflow. Thus the Delta lands act as a salt reservoir by first storing some of the salts that enter the islands during the summer and then by releasing those salts during the winter through leaching and/or drainage of precipitation. This indicates that agricultural practices within the Delta Lowlands during the summer, when the problem of water quality there is most critical, do not degrade good quality Sacramento River water as it moves through the Delta to the Tracy Pumping Plant but rather enhances its quality by removing a portion of its salt content. In the winter months, when the accumulated surplus salts are discharged to the channels, there is usually sufficient surplus flow through the Delta to dilute and to carry out to the ocean the leached salts. However, it should

be noted that the preceding statement applied to conditions as of 1954-55. Any additional upstream regulation or a "dry" year, such as 1924 or 1931, will decrease the winter flows through the Delta to the extent that leached salts may not be completely removed from the area. These findings are important and are the first available demonstrated conclusions relating to Delta channel water degradation by drainage waters.

PART VI - SUMMARY AND CONCLUSION

As a result of field investigation and analysis of other available data and on the basis of the estimates and assumptions discussed hereinbefore, the following summary and conclusion are presented:

Summary

1. The Delta Lowlands comprises the major portion of the Sacramento-San Joaquin Delta. The area, as shown on Plate 1, covers about 469,000 acres of which about 374,000 acres are developed for agricultural purposes and of which about 292,000 acres were irrigated in 1955.

2. Approximately 62 per cent of the Delta Lowlands was irrigated during the period of investigation, May, 1954, through October, 1955. The March through October seasonal demand for water applied to irrigated crops was approximately 656,000 acre-feet, with the maximum monthly demand of about 216,000 acre-feet occurring in July. These quantities were determined (a) from detailed investigations for the six irrigated major crops on 38 sample fields totalling 3,369 acres, and (b) from estimates for the other crops.

3. Monthly precipitation on the Delta Lowlands during the period of investigation varied from zero in summer months to about 128,000 acre-feet in December, 1954. The total precipitation during the period March through October, 1955, amounted to approximately 150,000 acre-feet.

4. Drainage water, returned monthly to the channels from the Delta Lowlands during the period of investigation, varied between approximately 30,000 acre-feet in October, 1955, and 96,000 acre-feet in January, 1955. During the irrigation season the maximum drainage pumping occurred during July, 1954, and amounted to about 81,000 acre-feet. During the period of March through October, 1955, the drainage amounted to approximately 417,000 acre-feet.

5. The estimated consumptive use in the Delta Lowlands during the period of investigation, based on the 1955 crop pattern, varied from approximately 22,000 acre-feet in January to about 211,000 acre-feet in August. On that basis the annual consumptive-use requirements are approximately 1,160,000 acre-feet, of which 1,036,000 acre-feet are consumed during the March through October irrigation season.

6. During the March through October, 1955, irrigation season, the difference between the approximately 805,000 acre-feet of water supply and the 1,453,000 acre-feet of water disposal, amounting to about 648,000 acre-feet of water must come from a combination of ground water storage changes (considered herein to be comparatively insignificant because of irrigation and drainage practices in the Delta) and from subsurface inflow comprising seepage from contiguous channels and/or rising water from deep-seated and remote sources.

7. The estimated quantity of salt in the irrigation water applied to the Delta Lowlands during the irrigation season

varied from approximately 2,100 tons in March, 1955, to about 70,000 tons in August, 1954, with a total of about 187,000 tons for the March-through-October season. The average concentration of total dissolved solids in applied irrigation water varied from about 100 to 300 ppm during that period.

8. Under the hypothesis that subsurface inflow to the Delta Lowlands is constant and that the quality of such inflow equals the average annual quality of channel waters, roughly 33,000 tons of salt per month would be introduced by subsurface inflow.

9. The estimated amount of salt discharged in the drainage waters from the Delta Lowlands during the period of investigation varied from approximately 19,000 tons in October to about 113,000 tons in January, 1955, with a total of about 248,000 tons for the March-through-October period. The average concentration of total dissolved solids in the drainage water varied from about 300 ppm in June, 1954, to 865 ppm in January,1955

Conclusion

The Delta Lowlands act as a salt reservoir, storing salts obtained largely from the channels during the summer, when water quality in such channels is most critical and returning such accumulated salts to the channels during the winter when water quality there is least important. Therefore agricultural practices in that area enhanced rather than degraded the good quality Sacramento River water enroute to the Tracy Pumping Plant.

TABLE 1

LAND USE - DELTA LOWLANDS - 1955

In acres

Crop		Crop	
Pasture			
Sudan	522	Fruit & Nuts	5,141
Miscellaneous	22,475	Grapes	110
Alfalfa	34,481	Native Vegetation	
Rice	2,103	Lush	897
Field Crops		Medium	7,891
Beans	420	Dry	3,116
Field Corn	47,557	Fallow & Bare	1,360
Milo	20,972	Idle Crop Land	1,103
Grain & Hay	79,709	Duck Ponds	203
Peas	97	Urban	6,914
Safflower	770	Tule & Swamp	4,581
Sunflower	2,204	Levee & Berm	16,616
Sugar Beets	30,181	Interior Water Surface	5,585
Truck Crops		Subtotal	419,439
Asparagus	80,325	Exterior Water Surface	42,168
Celery	1,083	Islands in Channels	7,027
Onions	1,193	Total	468,634
Potatoes	8,539		
Tomatoes	30,099		
Seed & Miscellaneous	3,192		

TABLE 2

IRRIGATED CROPS
DELTA LOWLANDS, 1955

Crop	Area in acres	Per cent of total irrigated area
Asparagus	80,325	28
Field Corn	47,557	16
Alfalfa	34,481	12
Sugar Beets	30,181	10
Tomatoes	30,099	10
Pasture	22,997	8
Milo	20,972	7
All others	25,055	9
Total	291,667	100

TABLE 3

WATER APPLIED TO CERTAIN IRRIGATED CROPS DURING 1954
DELTA LOWLANDS - NORTH MINERAL SOIL

Crop	Unit	Sample field acreage	Depth per month - in inches							
			April	May	June	July	August	September	October	Total
Field corn	19	14				11.8	5.8			17.6
					Weighted mean depth: 17.6" (1.5')					
Alfalfa	6	87	1.9	3.9	3.8	5.5	4.5	1.4	0.6	21.6
	6	55			8.4	8.0	6.5	9.4	10.0	42.3
	19	14		1.5	3.7	3.5	3.5	2.0		14.2
Total		156								
					Weighted mean depth: 28.2" (2.3')					
Sugar Beets	6	45		4.7	11.2	16.5				32.4
	6	44		2.7	7.5	7.0	2.2			19.4
	7	32			6.1	5.1	1.9			13.1
Total		121								
					Weighted mean depth: 22.6" (1.9')					
Tomatoes	6	45		19.0	8.1	15.5	5.0			47.6
	6	37		2.3	2.4	2.5	3.5			10.7
	7	20			10.7	8.8	3.4			22.9
Total		102								
					Weighted mean depth: 29.4" (2.5')					
Pasture	19	5	11.8		5.0	5.3	3.8			25.9
					Weighted mean depth: 25.9" (2.2')					

TABLE 4

WATER APPLIED TO CERTAIN IRRIGATED CROPS DURING 1954
DELTA LOWLANDS - MIDDLE ORGANIC SOIL

Crop	Unit	Sample field acreage	Depth per month - in inches					
			May	June	July	August	September	Total
Asparagus	25	774	4.7	4.7	5.8	6.4	2.7	24.3
	16	728		0.7	0.9	1.1	5.7	8.4
Total		1,502		Weighted mean depth: 16.6" (1.4')				
Field Corn	20	85			16.9			16.9
	24	75			30.9	30.9		61.8
	24	90			34.7	29.3		64.0
	16	78		10.5	6.2	7.6	6.0	30.3
Total		328		Weighted mean depth: 43.3" (3.6')				
Sugar Beets	20	115.5	5.2	10.2	12.6	8.7	3.9	40.6
	22	35.3			25.7	7.9		33.6
Total		150.8		Weighted mean depth: 39.0" (3.3')				
Tomatoes	20	54.5		1.2	4.1			5.3
	18	102.0		25.9	19.8	14.2		59.9
Total		156.5		Weighted mean depth: 40.9" (3.4')				

TABLE 5

WATER APPLIED TO CERTAIN IRRIGATED CROPS DURING 1954
DELTA LOWLANDS - SOUTH MINERAL SOIL

Crop	Unit	Sample field acreage	Depth per month - in inches										
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
Asparagus	24	68								7.9			7.9
			Weighted mean depth: 7.9" (0.7')										
Field Corn	24	75						4.2	7.0	4.6	1.8		17.6
			Weighted mean depth: 17.6" (1.5')										
Alfalfa	24	22.0				10.1		5.8	18.6	6.3	6.0		46.8
	24	53.0					11.0	9.7	14.5	6.1	6.4		47.7
	25	88.5					4.0	1.4	10.4	4.7	0.3		20.8
	26	32.0						28.9	34.1	26.2	33.0		122.2
	27	31.0				11.2		10.6	6.9	5.7	9.5	8.8	52.7
	27	31.0			5.0	5.1	5.8	9.0	5.2	10.2	5.3	6.3	51.9
	27	32.8				8.5	11.4	9.2	13.0	10.2	11.5	0.4	64.2
	27	32.5		1.0		7.1	5.6	8.0	13.3	12.3	2.5		49.8
Total		322.8											
			Weighted mean depth: 50.4" (4.2')										
Sugar Beets	24	76				4.4	4.4	7.7	10.6	13.2	4.7		45.0
			Weighted mean depth: 45.0" (3.7')										
Tomatoes	24	55						2.3	11.8	16.8	2.5		33.4
	24	68						6.4	4.3	7.2	11.1		29.0
Total		123											
			Weighted mean depth: 31.0" (2.6')										
Pasture	26	40.0						28.8	34.2	26.1	33.0		122.1
	27	62.3	5.6		5.1	18.4	21.2	17.0	26.7	12.6	16.5	4.3	127.4
	27	32.8				8.5	11.4	9.2	13.0	10.2	11.5	0.4	64.2
	27	32.5		1.0		7.1	5.6	8.0	13.3	12.3	2.5		49.8
Total		167.6											
			Weighted mean depth: 98.7" (8.2')										

TABLE 6

IRRIGATION SEASONAL USE OF APPLIED WATER - DELTA LOWLANDS - 1954

Crop	Irrigated Area in Acres				Seasonal Applied Water Acre-feet/acre			Seasonal Applied Water Acre-feet			
	North Mineral Soils	Middle Organic Soils	South Mineral Soils	Total	North Mineral Soils	Middle Organic Soils	South Mineral Soils	North Mineral Soils	Middle Organic Soils	South Mineral Soils	Total for Delta Lowlands
Asparagus	6,878	53,096	20,351	80,325	0.7	1.4	0.7	4,820	74,330	14,250	93,400
Corn	13,681	30,342	3,534	47,557	1.5	3.6	1.5	20,520	109,230	5,300	135,050
Alfalfa	14,081	9,478	10,922	34,481	2.3	2.3	4.2	32,390	21,800	45.870	100,060
Sugar Beets	20,514	8,573	1,094	30,181	1.9	3.3	3.7	38,980	28,290	4,050	71,320
Tomatoes	13,284	9,899	6,916	30,099	2.5	3.4	2.6	33,210	33,660	17,980	84,850
Pasture	13,266	2,887	6,844	22,997	3.9	3.9	4.8	51,740	11,260	32,850	95,850
Milo	8,189	10,194	2,589	20,972	1.0	1.0	1.0	8,190	10,190	2,590	20,970
All other crops	17,403	5,041	2,611	25,055	2.1	2.3	2.4	36,550	11,590	6,270	54,410
Total	107,296	129,510	54,861	291,667				226,400	300,350	129,160	655,910
Weighted average acre-feet per acre								2.11	2.32	2.35	2.25

TABLE 7

MONTHLY DISTRIBUTION OF APPLIED WATER TO IRRIGATED CROPS
DELTA LOWLANDS
1954
In acre-feet

Unit	Irrigated acreage	March	April	May	June	July	Aug.	Sept.	Oct.	Seasonal Total
2	5394	110	460	790	2040	3730	2940	1130	110	11310
3	4074	80	320	560	1430	2630	2070	790	80	7960
6	24900	510	2040	3570	9180	16820	13250	5100	510	50980
7	6025	130	500	870	2240	4090	3230	1240	130	12430
8	16518	360	1450	2550	6540	11990	9450	3640	360	36340
9	7779	190	760	1330	3430	6290	4960	1910	190	19060
10	8447	150	600	1060	2710	4980	3920	1510	150	15080
11	11142	280	1110	1940	5000	9170	7220	2780	280	27780
12	12916	320	1290	2260	5810	10660	8400	3230	320	32290
13	10413	290	1150	2010	5160	9460	7450	2870	290	28680
14	4319	90	370	650	1670	3070	2420	930	90	9290
15	13445	400	1580	2770	7130	13070	10300	3960	400	39610
16	13598	330	1340	2330	6000	11000	8660	3330	330	33320
17	6130	110	430	760	1950	3580	2820	1080	110	10840
18	12792	350	1410	2480	6370	11680	9200	3540	350	35380
19	12943	330	1300	2280	5860	10740	8470	3250	330	32560
20	16534	400	1610	2810	7230	13260	10440	4020	400	40170
21	10666	210	820	1440	3690	6770	5340	2050	210	20530
22	14465	270	1080	1890	4860	8910	7020	2700	270	27000
23	19812	350	1410	2460	6330	11610	9150	3520	350	35180
24	24156	500	2010	3520	9060	16600	13080	5030	500	50300
25	25912	530	2120	3700	9530	17460	13760	5290	530	52920
26	651	20	90	150	400	730	570	220	20	2200
27	8636	250	990	1730	4440	8150	6420	2470	250	24700
Total	291667	6560	26240	45910	118060	216450	170540	65590	6560	655910
Per cent of seasonal total		1.0	4.0	7.0	18.0	33.0	26.0	10.0	1.0	100
Average acre-feet per acre		0.02	0.09	0.16	0.41	0.74	0.58	0.23	0.02	2.25

TABLE 8

AVERAGE PRECIPITATION IN SACRAMENTO-SAN JOAQUIN DELTA

In inches

Station	1954								1955									
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Antioch	0.39	0.05	0	0	0	0.02	1.53	3.44	2.59	1.26	0.92	1.40	0.74	0	0	0	0.03	0.15
Benson's Ferry	0.46	0.01	0	0.02	0	0.01	2.43	3.92	2.28	1.14	0.40	2.24	0.47	0	0	0	0.44	0.33
Davis	0.16	0.16	0	0.08	0	0	2.98	3.91	2.68	1.24	0.40	2.17	0.64	0	0	0	0.92	0.44
Lodi	0.26	0.08	0	0.04	0	0.01	2.34	4.32	3.40	1.39	0.17	3.09	0.51	0	0	0	1.10	0.13
Sacra-mento	0.21	0	0	0.35	0	0.02	3.35	4.93	3.14	1.33	0.37	2.75	0.67	0.01	0	0	0.95	0.57
Stock-ton	0.28	0.40	0	0	0	0	2.23	3.19	3.84	1.03	0.57	2.38	1.02	0	0	0	0.01	0.12
Tracy	0.37	0.42	0	0	0	0	1.45	1.85	2.94	0.77	1.91	1.12	0.83	0	0	0	0	0.03
AVERAGE	0.30	0.16	0	0.07	0	0.01	2.33	3.65	2.98	1.17	0.68	2.16	0.70	0	0	0	0.49	0.25

TABLE 9

PRECIPITATION ON DELTA LOWLANDS

In acre-feet

1954		1955	
May	10486	January	104161
June	5593	February	40895
July	0	March	23768
August	2447	April	75499
September	0	May	24467
October	350	June	0
November	81441	July	0
December	127579	August	0
		September	17127
		October	8738

TABLE 10

DRAINAGE FROM DELTA LOWLANDS

In acre-feet

Unit	Acreage	1954								1955									
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
2	11202	45	0	0	0	0	179	0	672	582	90	0	90	0	0	0	0	0	134
3	5465	639	552	662	526	234	147	225	387	594	558	475	403	541	401	667	573	299	43
6	33027	617	388	339	299	359	358	1480	2541	2944	2159	771	401	293	235	314	269	227	320
7	7510	510	117	104	60	64	44	183	379	669	367	221	229	259	189	214	120	122	59
8	22103	4126	2984	2227	2935	2997	3932	2867	1917	1046	1086	1752	2018	2354	3267	3817	2830	2411	1577
9	16085	1238	1628	2074	2081	1495	952	696	979	841	252	401	1057	742	1301	1408	1647	1067	710
10	11067	395	865	1057	975	350	261	313	486	637	352	245	443	535	757	874	860	624	450
11	14365	1620	1697	1337	1350	770	530	753	1383	1516	865	637	889	792	1349	1433	1411	591	417
12	16877	2408	3144	3559	2971	1450	1029	1481	2916	3105	1689	1690	2582	2171	3921	3927	3690	971	621
13	16641	886	1529	2022	1602	357	459	529	1288	1303	777	767	1081	964	1575	2356	2022	1049	435
14	14671	1730	2131	2053	926	648	1227	1483	2166	1961	1645	1983	2307	1614	1773	2264	846	545	891
15	26424	2583	2463	3005	2879	2055	2957	3425	4851	5721	2871	2782	2544	1801	2425	2805	3398	2079	2021
16	18343	2114	2434	2321	3181	2147	1521	1076	2804	4008	1470	1041	1854	1707	2457	2336	2044	1811	1511
17	10191	992	955	1379	1013	739	1159	1185	3597	3198	1039	1291	1823	1585	1613	2000	1499	1153	603
18	18504	4710	8676	11051	8210	6748	6994	4025	5759	4836	2425	1942	1439	3509	5603	10156	8081	3432	2884
19	17917	2507	3570	4636	4307	2688	1516	1268	2753	2454	1221	826	1301	2618	3160	3759	3282	1963	1275
20	21302	5456	9197	10223	10410	4627	4582	5639	10209	14637	3840	2016	3533	6521	10456	11726	11870	8521	3505
21	14846	3154	4000	5245	4705	2698	2691	3792	7388	7472	2765	1935	2350	3873	5340	5398	4576	3392	2175
22	19357	12368	15756	15252	12942	8629	9306	8637	10635	12773	7385	5127	3949	10734	16862	15557	12826	6142	5302
23	24493	2396	3032	3917	3259	1974	3790	3514	9308	11828	3229	2103	1843	2018	2481	2056	2818	1663	1981
24	32879	2125	2500	2964	2839	1849	2103	2795	8907	9189	3410	2053	2135	2355	2649	2862	2929	2285	1974
25	33212	2335	2197	3773	2289	1237	892	971	3812	3678	2188	1958	2540	2233	2553	3574	3217	2068	922
26	2810	96	131	144	149	99	88	140	399	412	150	92	95	107	133	155	153	113	93
27	10148	669	627	1231	949	343	100	60	195	264	127	311	722	487	584	948	1209	588	114
To-tal	419439	55719	70573	80575	70857	44557	46817	46537	85731	95668	41960	32419	37628	49813	71084	80606	72170	43116	30017
Acre-feet per acre		0.13	0.17	0.19	0.17	0.11	0.11	0.11	0.20	0.23	0.10	0.08	0.09	0.12	0.17	0.19	0.17	0.10	0.07

TABLE 11

CONSUMPTIVE USE REQUIREMENTS, DELTA LOWLANDS

1955

In acre-feet

January	22,371	July	191,744
February	26,108	August	211,339
March	35,001	September	156,805
April	84,015	October	91,609
May	129,609	November	42,593
June	136,679	December	32,915
		Total	1,160,323

WATER SUPPLY AND DISPOSAL
DELTA LOWLANDS
In acre-feet

	1954							
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Water Supply								
Applied Water	45910	118060	216450	170540	65590	6560	-	-
Precipitation	10486	5593	0	2447	0	350	81441	127579
Total Water Supply	56396	123653	216450	172987	65590	6910	-	-
Water Disposal								
Drainage	55719	70573	80575	70857	44557	46817	46537	85731
Consumptive Use	129609	136679	191744	211339	156805	91164	42573	32915
Total Water Disposal	185328	207252	272319	282196	201362	137981	89110	118646

	1955									
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Water Supply										
Applied Water	-	-	6560	26240	45910	118060	216450	170540	65590	6560
Precipitation	104161	40895	23768	75499	24467	0	0	0	17127	8738
Total Water Supply	-	-	30328	101739	70377	118060	216450	170540	82717	15298
Water Disposal										
Drainage	95668	41960	32419	37628	49813	71084	80606	72170	43116	30017
Consumptive Use	22371	26108	35001	84015	129609	136679	191744	211339	156805	91164
Total Water Disposal	118039	68068	67420	121643	179422	207763	272350	283509	199921	121181

TABLE 13

WEIGHT OF SALTS IN APPLIED IRRIGATION WATER
DELTA LOWLANDS

In tons

Unit	Irrigated acreage	1954						1955							
		May	June	July	Aug.	Sept.	Oct.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
2	5394	97	433	721	628	275	16	14	43	118	311	650	616	268	15
3	4074	64	292	501	456	184	12	10	33	81	214	440	394	176	12
66	24900	408	1824	3044	2956	1180	82	67	241	466	1324	2700	2380	985	94
7	6025	91	439	718	721	275	22	17	62	110	323	645	554	272	26
8	16518	250	1032	2219	1851	797	71	48	195	375	819	1860	1710	718	60
9	7779	166	957	1292	1134	499	39	57	185	284	443	1061	918	439	39
10	8447	133	553	840	896	427	34	49	158	212	391	820	725	333	33
11	11142	243	1041	1634	1611	707	46	42	148	230	721	1447	1248	609	59
12	12916	228	1130	1943	1840	760	52	42	156	283	814	1769	1463	725	58
13	10413	183	885	1725	1804	687	49	40	142	222	737	1647	1500	679	58
14	4319	74	643	6249	4880	553	24	19	150	96	868	3225	6137	1002	42
15	13445	290	1416	5050	7287	2031	121	126	374	471	1057	4143	5115	1864	142
16	13598	488	1069	3981	6527	1817	137	171	352	526	980	3068	4795	1767	141
17	6130	121	329	935	1558	523	61	66	150	249	366	818	1189	494	49
18	12792	256	1049	2320	2666	891	67	70	224	307	936	2225	2015	915	81
19	12943	236	733	2133	1809	641	59	52	168	236	726	1739	1694	690	61
20	16534	291	1426	3067	3096	1116	102	120	381	505	1279	2868	2500	1187	112
21	10666	172	763	1796	1925	742	80	88	300	460	884	1363	1482	725	81
22	14465	278	860	2170	2970	973	85	119	332	406	926	1915	2092	860	83
23	19812	328	1257	3001	3797	1480	152	180	574	870	1507	2827	2813	1178	119
24	24156	393	3143	6843	6068	2607	252	244	963	1710	3069	6098	4698	2190	263
25	25912	428	3306	8409	7844	3325	304	224	998	1782	3423	7459	6047	2893	293
26	651	15	184	339	287	131	12	7	37	74	132	298	250	117	14
27	8636	165	2767	6221	5031	2403	248	245	955	1368	3063	6709	4830	2302	251
Total		5398	27531	67151	69642	25024	2127	2117	7321	11441	25313	57794	57165	23388	2186
Tons/Ac		0.02	0.09	0.23	0.24	0.09	0.01	0.01	0.03	0.04	0.09	0.20	0.20	0.08	0.01

TABLE 14

AVERAGE QUALITY OF APPLIED WATER
DELTA LOWLANDS

Sum of the mineral constituents in parts per million

Unit	1954								1955										
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
2	90	156	142	157	179	105	65	109	99	111	91	68	110	112	128	154	174	100	119
3	84	150	140	162	171	106	82	87	89	113	88	75	106	110	123	140	164	109	106
6	84	146	133	164	170	118	96	91	85	100	96	87	96	106	118	132	142	136	130
7	77	144	129	164	163	122	103	86	80	96	95	91	93	106	116	126	161	146	134
8	72	116	136	144	161	144	94	80	85	113	98	99	108	92	114	133	145	123	113
9	92	205	151	168	192	149	152	185	202	219	220	179	157	95	124	136	169	152	160
10	92	150	124	168	208	169	176	183	190	216	242	194	147	106	121	136	162	163	165
11	92	153	131	164	187	122	108	102	95	102	109	98	87	106	116	127	161	155	148
12	74	143	134	161	173	119	98	83	79	111	96	89	92	103	122	128	165	133	122
13	67	126	134	178	176	124	99	114	132	126	102	91	81	105	128	148	174	148	129
14	84	283	1496	1482	437	200	212	124	150	171	156	298	108	382	772	1864	792	344	343
15	77	146	284	520	377	222	197	247	284	266	231	174	125	109	233	365	346	261	189
16	154	131	266	554	401	306	330	409	432	453	380	193	166	120	205	407	390	313	367
17	117	124	192	406	356	406	504	480	458	509	443	257	241	138	168	310	336	329	523
18	76	121	146	213	185	141	128	139	168	164	146	117	91	108	140	161	190	170	159
19	76	92	146	157	145	132	56	75	94	104	115	95	76	91	119	147	156	136	116
20	76	145	170	218	204	187	197	168	158	195	221	174	132	130	159	176	217	206	203
21	88	152	195	265	266	281	341	275	227	283	306	269	235	176	148	204	260	284	323
22	108	130	179	311	265	231	299	299	297	321	324	226	158	140	158	219	234	225	261
23	98	146	190	305	309	319	384	389	399	395	377	299	260	175	179	226	246	250	332
24	82	255	303	341	381	370	367	311	265	335	359	352	357	249	270	264	320	387	439
25	85	255	354	419	462	422	391	332	255	307	310	346	354	264	314	323	402	406	438
26	75	339	341	370	436	449	336	227	104	228	275	302	364	242	300	323	392	500	522
27	70	458	561	576	715	730	810	728	613	688	721	709	581	507	605	553	685	739	772
Wtd. Avg.	86	171	228	300	280	238					237	205	183	158	196	246	262	245	

TABLE 15

WEIGHT OF SALTS IN DRAINAGE WATER
DELTA LOWLANDS

In tons

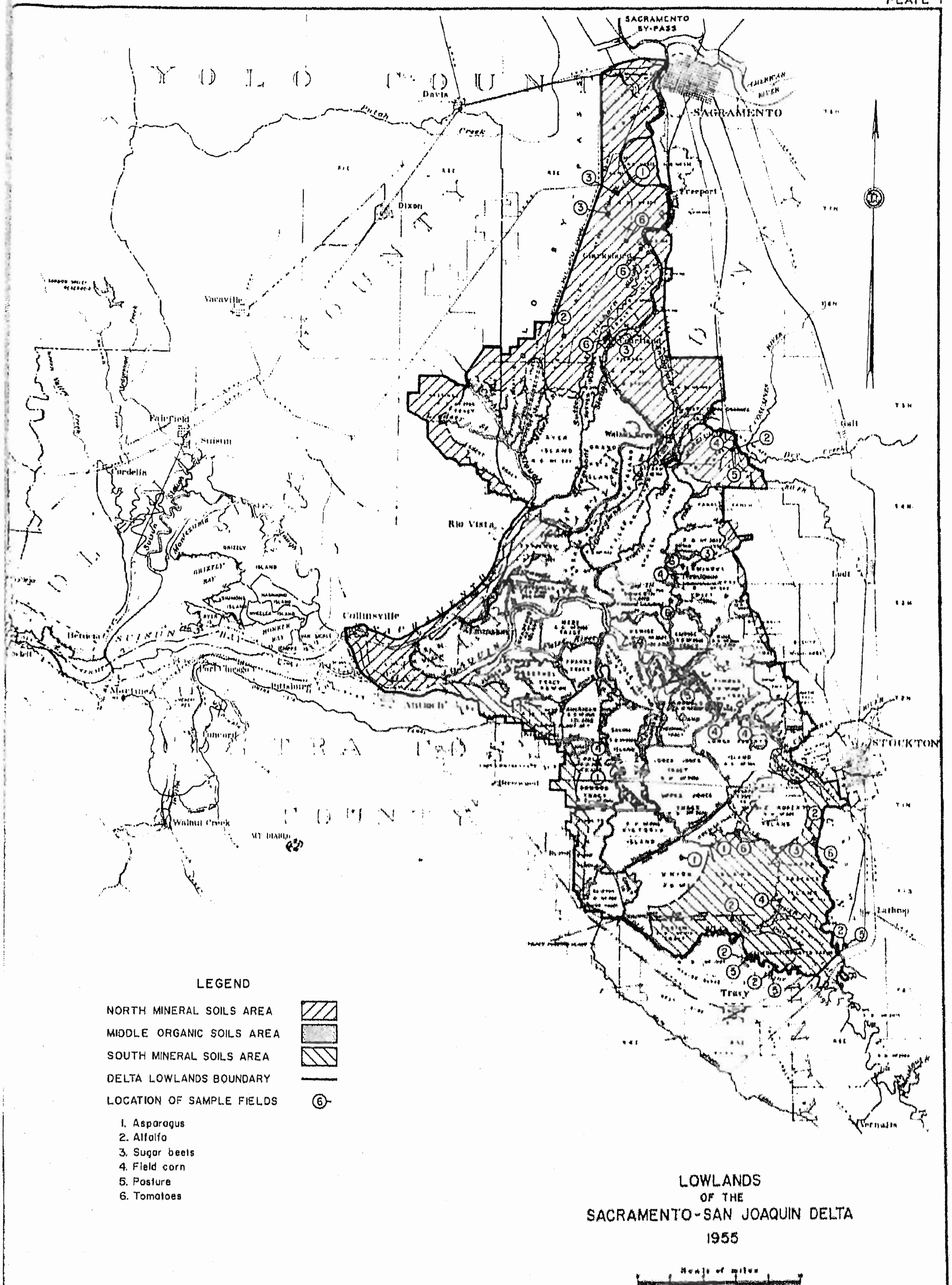
Unit	Acreage	1954								1955									
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
2	11202	47	0	0	0	0	195	0	782	677	96	0	82	0	0	0	0	0	112
3	5465	210	199	201	129	73	59	69	138	210	183	126	108	95	65	132	125	74	8
6	33027	194	108	60	67	99	143	794	2023	2286	2076	786	301	104	72	50	52	49	116
7	7510	157	52	37	24	26	20	102	248	439	263	170	160	147	83	85	42	46	30
8	22103	1074	842	640	936	921	1097	769	819	409	580	913	926	688	813	916	828	802	559
9	16085	556	731	772	1012	734	482	512	824	724	297	482	992	365	537	498	647	427	340
10	11067	192	411	397	271	110	92	115	241	399	237	170	299	286	410	236	208	153	135
11	14365	381	385	301	377	236	157	367	966	1067	578	404	497	269	460	286	357	167	129
12	16877	708	923	900	966	480	346	498	1540	2112	1045	906	1245	864	1565	1275	1135	314	235
13	16641	362	798	542	555	155	208	311	1106	1138	585	495	593	408	512	696	724	489	214
14	14671	1124	1656	2590	1435	798	1098	1582	2981	3188	2675	3029	2941	1514	1685	2634	1177	616	1190
15	26424	1645	1489	1748	2610	1999	2844	3737	6457	7708	4201	3741	3131	1294	1769	1731	2589	2089	1878
16	18343	1121	1343	1406	3112	2129	1452	1391	4408	5800	2510	1966	2026	1243	1574	1503	1555	1433	1203
17	10191	883	814	1162	960	781	1286	1572	6423	5662	2284	2159	3500	2293	1307	1436	1148	1014	615
18	18504	1347	2503	2946	3442	2621	2603	2557	4768	4086	2218	1710	1026	1217	2182	2676	2526	1362	1206
19	17917	940	1374	2410	2094	1169	979	1146	2774	3263	1515	862	1026	906	1198	1319	1314	852	646
20	21302	3264	4998	4823	6347	3491	3531	5150	12081	19485	5251	2751	4732	5523	8032	6505	7016	7544	3138
21	14846	1288	1596	2070	2233	1657	2028	2778	7489	9865	2750	1362	1651	2235	2343	2195	1801	1566	1320
22	19357	3025	3727	4708	6408	3815	3663	4251	7863	11986	6086	3447	2109	3753	5317	5385	4816	2304	2365
23	24493	1144	1192	1647	1730	907	1796	1865	6754	15843	3542	1647	1274	1153	1200	1175	1033	612	846
24	32879	1365	1548	1878	1852	1329	1591	2690	10325	11369	4393	2590	2569	2507	1907	1676	1765	1351	2128
25	33212	1501	1451	2337	1602	894	658	691	3789	4086	2234	1758	2295	2109	2288	2839	2525	1784	763
26	2810	63	80	96	98	66	73	121	456	513	192	118	120	119	95	83	86	66	91
27	10148	538	534	1253	1075	383	112	41	138	243	115	290	826	523	632	935	1342	709	131
To-tal	419439	23129	28754	34924	39335	24873	26513	33109	85393	112558	45906	31882	34429	29615	36046	36266	34811	25823	19398
Tons/Ac.		0.06	0.07	0.08	0.09	0.06	0.06	0.08	0.20	0.27	0.11	0.08	0.08	0.07	0.09	0.09	0.08	0.06	0.05

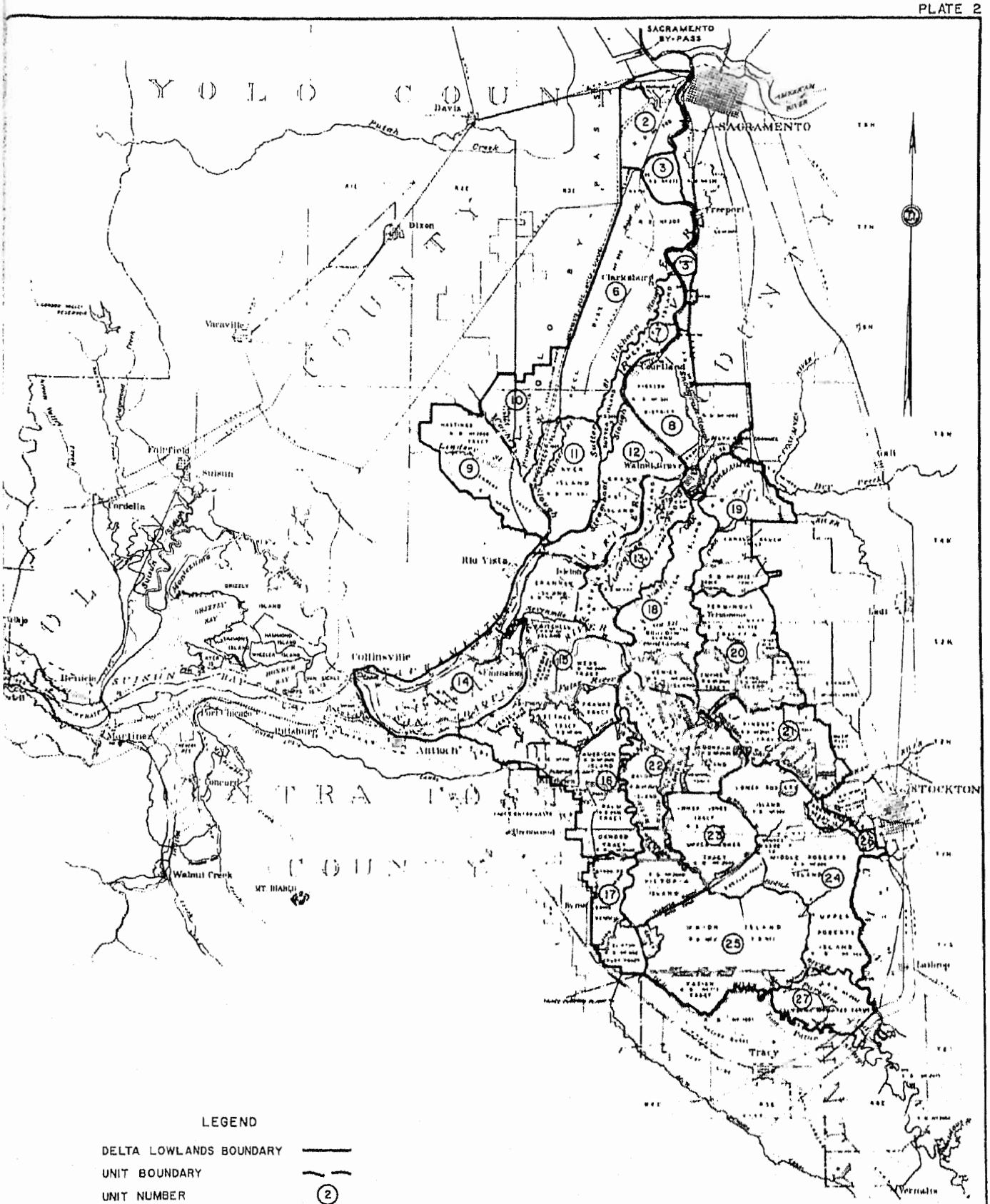
TABLE 16

AVERAGE QUALITY OF DRAINAGE WATER
DELTA LOWLANDS

Sum of mineral constituents in parts per million

Unit	1954								1955									
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
2	768	0	0	0	0	801	0	855	855	784	0	670	0	0	0	0	0	614
3	242	265	223	180	229	295	225	262	260	241	195	197	129	119	145	160	182	137
6	231	205	130	165	203	294	394	585	571	707	749	552	261	225	117	142	159	266
7	226	327	261	294	299	334	410	481	482	527	565	514	417	323	292	257	277	374
8	191	207	211	234	226	205	197	314	287	393	383	337	215	183	176	215	244	261
9	330	330	274	357	361	372	541	619	633	866	883	690	362	303	260	289	294	352
10	357	349	276	204	231	259	270	364	460	495	510	496	393	398	198	178	180	220
11	173	167	165	205	225	218	358	513	517	491	466	411	250	251	147	186	208	227
12	216	216	186	239	243	247	247	388	500	455	394	354	293	293	239	226	238	278
13	300	384	197	255	319	333	432	631	642	553	474	403	311	239	217	263	343	362
14	478	571	927	1139	905	658	784	1012	1195	1195	1123	937	689	699	855	1023	831	982
15	468	444	428	666	715	707	802	978	990	1075	988	905	528	536	454	560	739	683
16	390	406	445	719	729	702	950	1155	1064	1255	1388	803	535	471	473	559	582	585
17	654	626	619	697	777	816	975	1312	1301	1616	1229	1411	1063	596	528	563	646	750
18	210	212	196	308	285	274	467	609	621	672	647	524	255	286	194	230	292	307
19	276	283	382	357	320	475	664	741	977	912	767	580	254	279	258	294	319	372
20	440	399	347	448	555	566	671	870	978	1005	1003	984	623	565	408	434	651	658
21	300	293	290	349	451	554	538	745	970	731	517	516	424	322	299	289	339	446
22	180	174	227	364	325	289	362	543	690	606	494	393	257	232	254	276	276	328
23	351	289	309	390	338	348	390	533	984	806	576	508	420	356	420	269	270	314
24	472	455	466	479	528	556	707	852	909	947	927	884	782	529	430	443	435	792
25	472	485	455	514	531	542	523	731	817	750	660	664	694	659	584	577	634	608
26	482	449	490	483	490	610	635	840	915	941	943	928	817	525	394	413	429	719
27	591	626	748	833	821	823	502	520	677	666	685	841	789	795	725	816	886	845
Wtd. Avg.	305	299	319	408	410	416	523	732	865	804	723	673	437	373	331	355	440	475

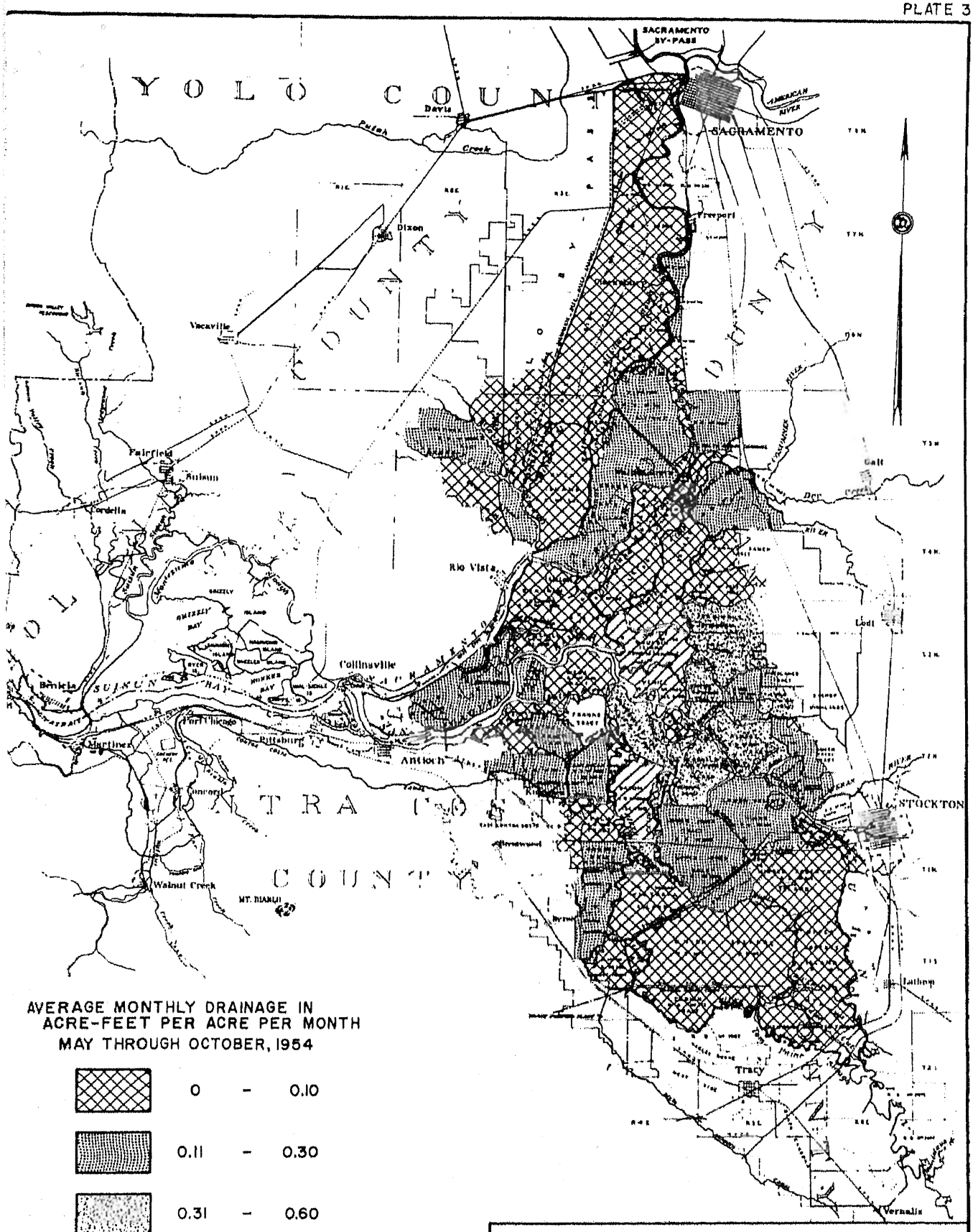

SACRAMENTO BY-PASS
SACRAMENTO
YOLO COUNTY
Davis
Putah Creek
Dixon
Vacaville
Freeport
Clarksburg
Courtland
Walnut Grove
Galt
Lodi
Rio Vista
Fairfield
Suisun
Cordelia
GRIZZLY BAY
Collinsville
Benicia
Martinez
Pittsburg
Antioch
Concord
Walnut Creek
CONTRA COSTA COUNTY
STOCKTON
Lathrop
Tracy
Vernalis
LEGEND
NORTH MINERAL SOILS AREA
MIDDLE ORGANIC SOILS AREA
SOUTH MINERAL SOILS AREA
DELTA LOWLANDS BOUNDARY
LOCATION OF SAMPLE FIELDS
1. Asparagus
2. Alfalfa
3. Sugar beets
4. Field corn
5. Pasture
6. Tomatoes
LOWLANDS
OF THE
SACRAMENTO-SAN JOAQUIN DELTA
1955
Scale of miles



SUBDIVISION UNITS
OF THE
SACRAMENTO - SAN JOAQUIN DELTA
1955

Scale of miles

PARTMENT OF WATER RESOURCES



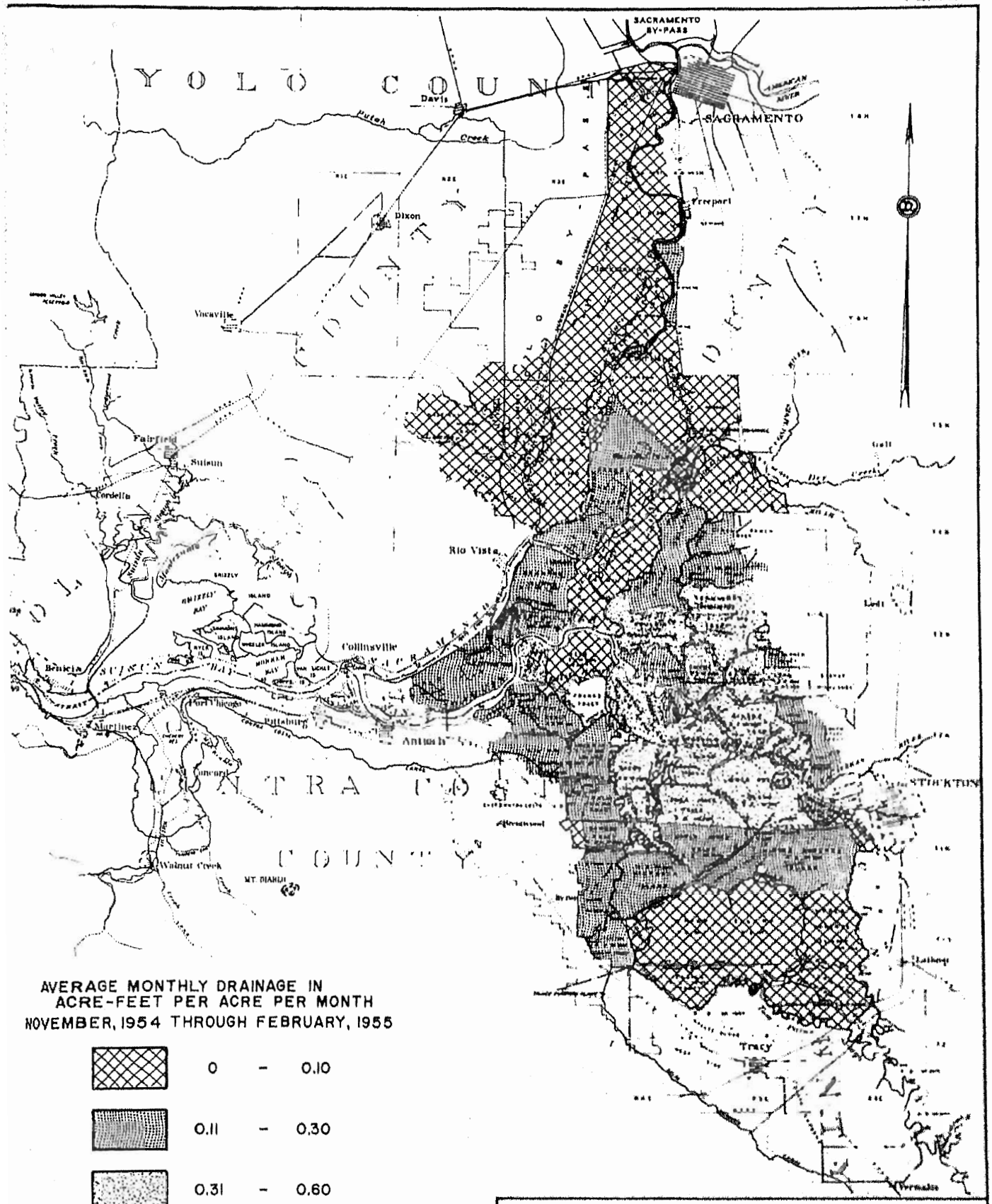
AVERAGE MONTHLY DRAINAGE IN ACRE-FEET PER ACRE PER MONTH MAY THROUGH OCTOBER, 1954

	0	–	0.10
	0.11	–	0.30
	0.31	–	0.60
	0.60	–	1.00

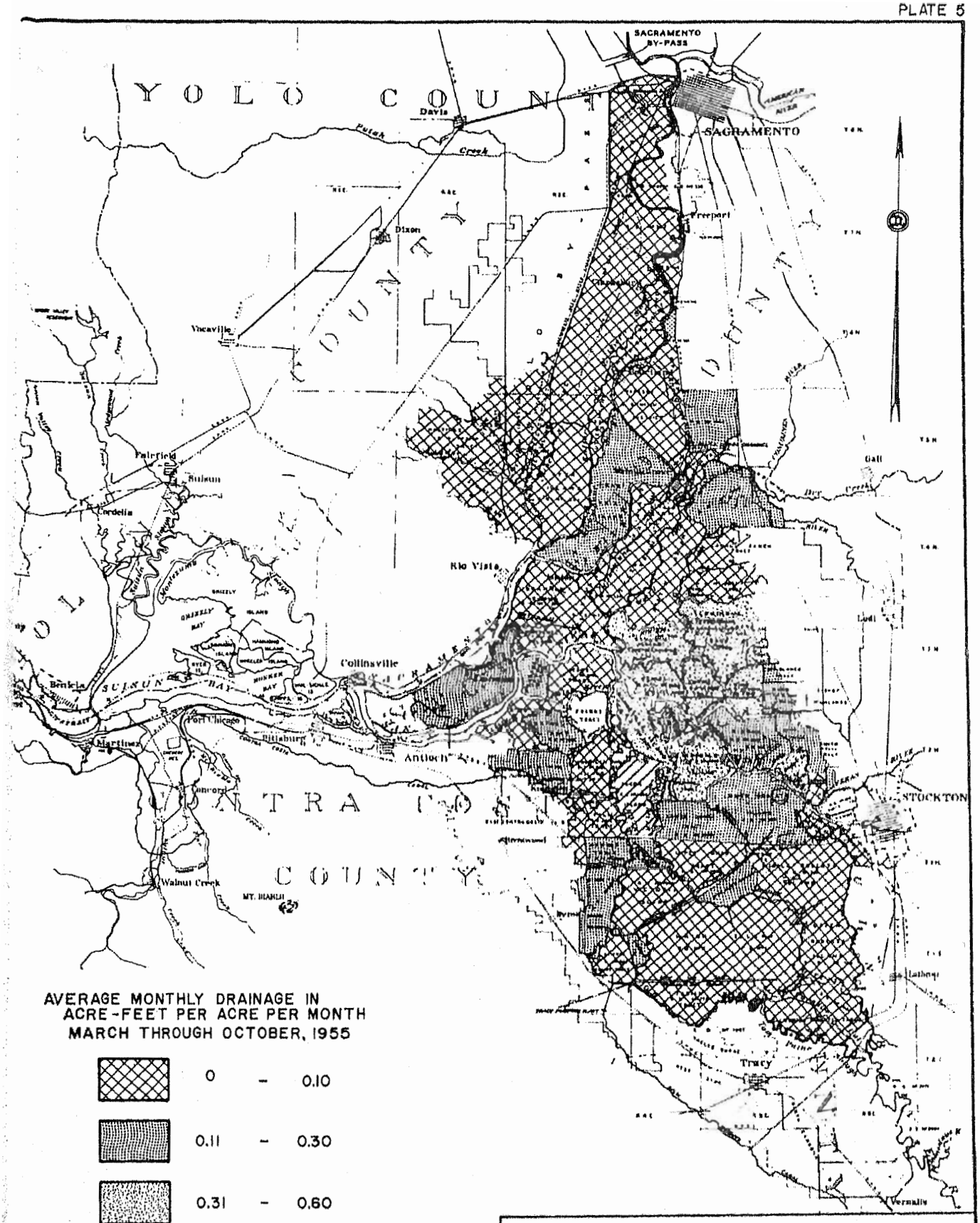
LOWLANDS DRAINAGE RATES

SACRAMENTO-SAN JOAQUIN DELTA

Scale of miles



RTMENT OF WATER RESOURCES



AVERAGE MONTHLY DRAINAGE IN ACRE-FEET PER ACRE PER MONTH MARCH THROUGH OCTOBER, 1955

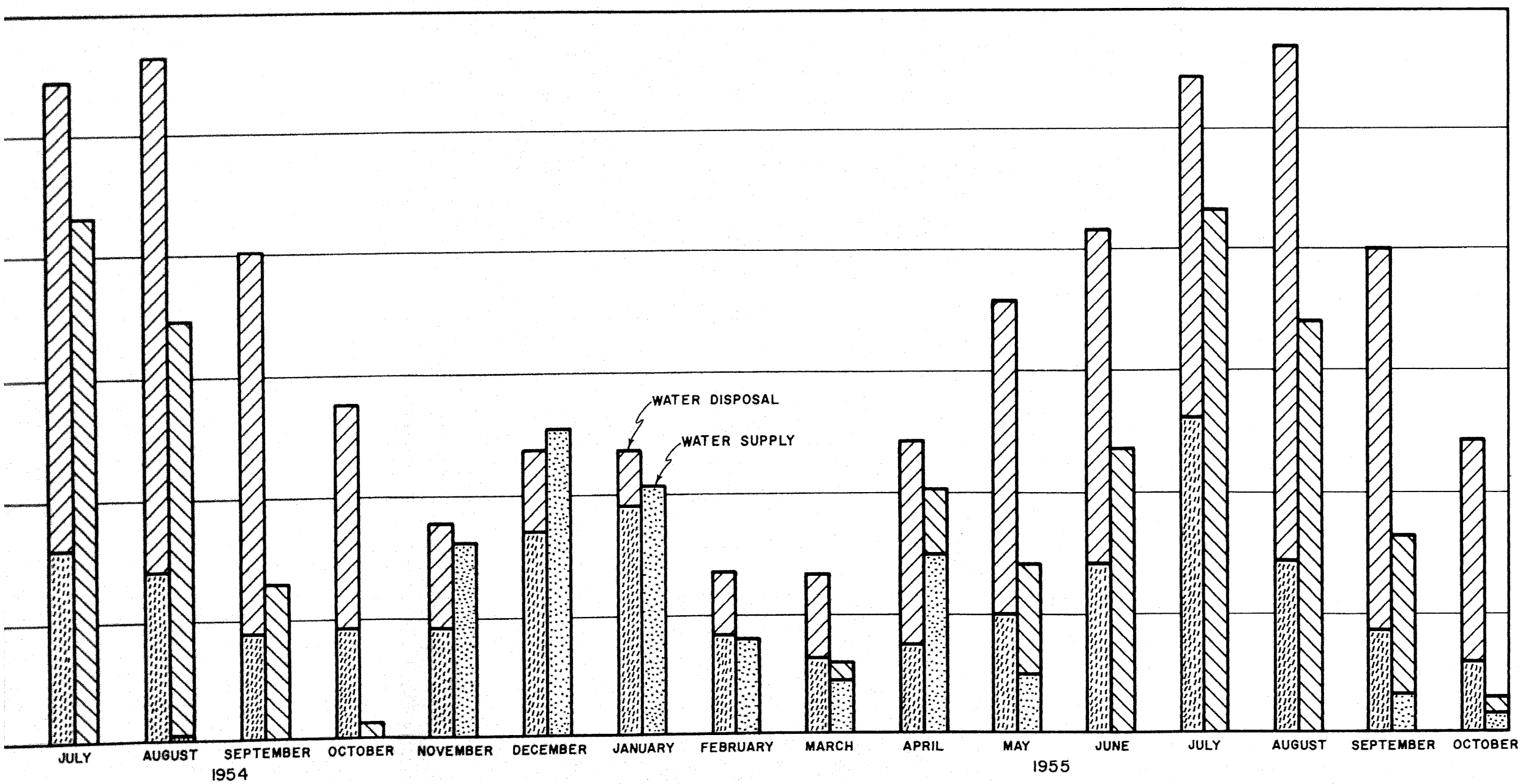
	0	–	0.10
	0.11	–	0.30
	0.31	–	0.60
	0.60	–	1.00

LOWLANDS DRAINAGE RATES

SACRAMENTO-SAN JOAQUIN DELTA

Scale of miles

ARTMENT OF WATER RESOURCES



LEGEND

WATER SUPPLY

PRECIPITATION

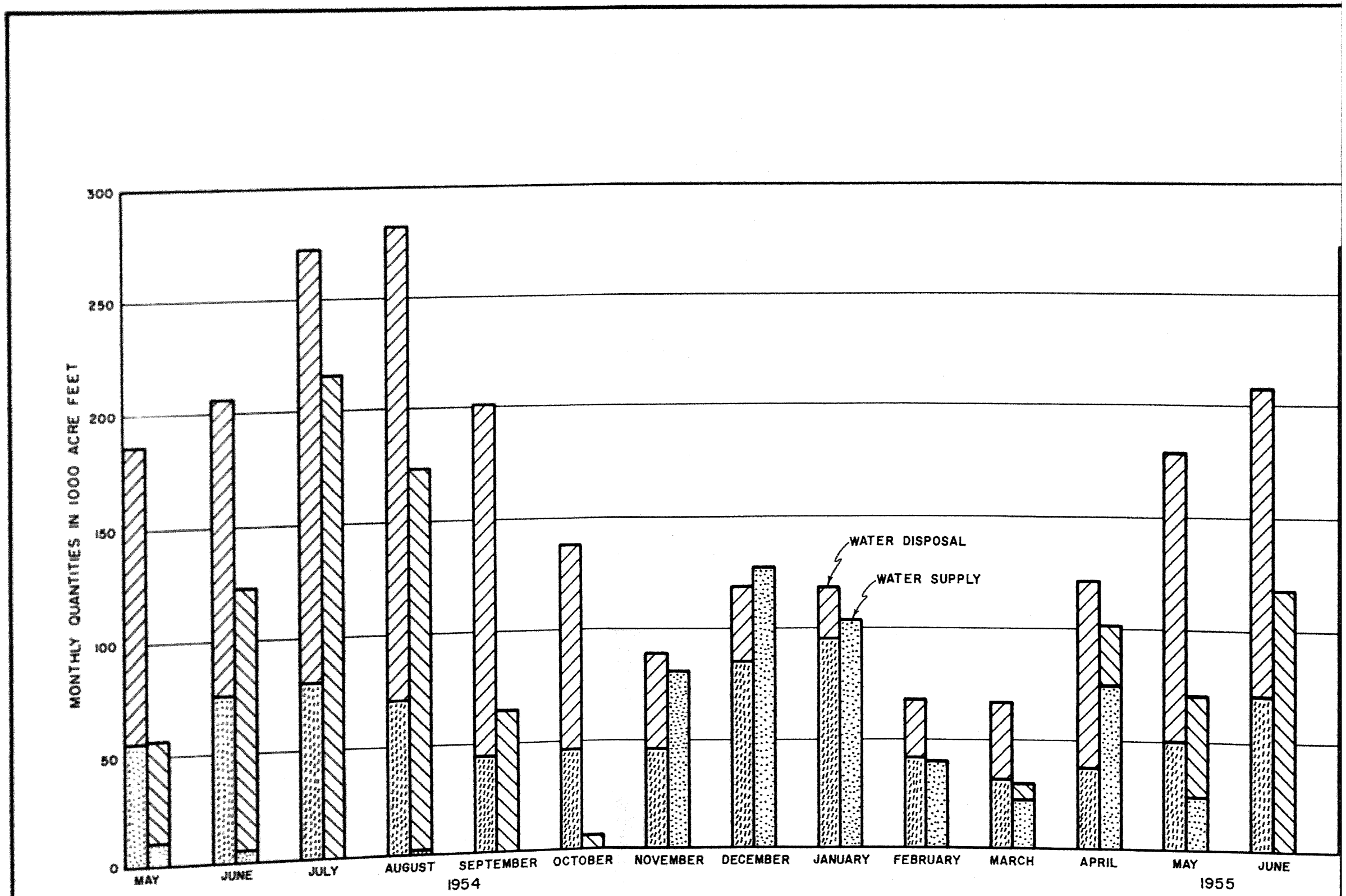
APPLIED WATER

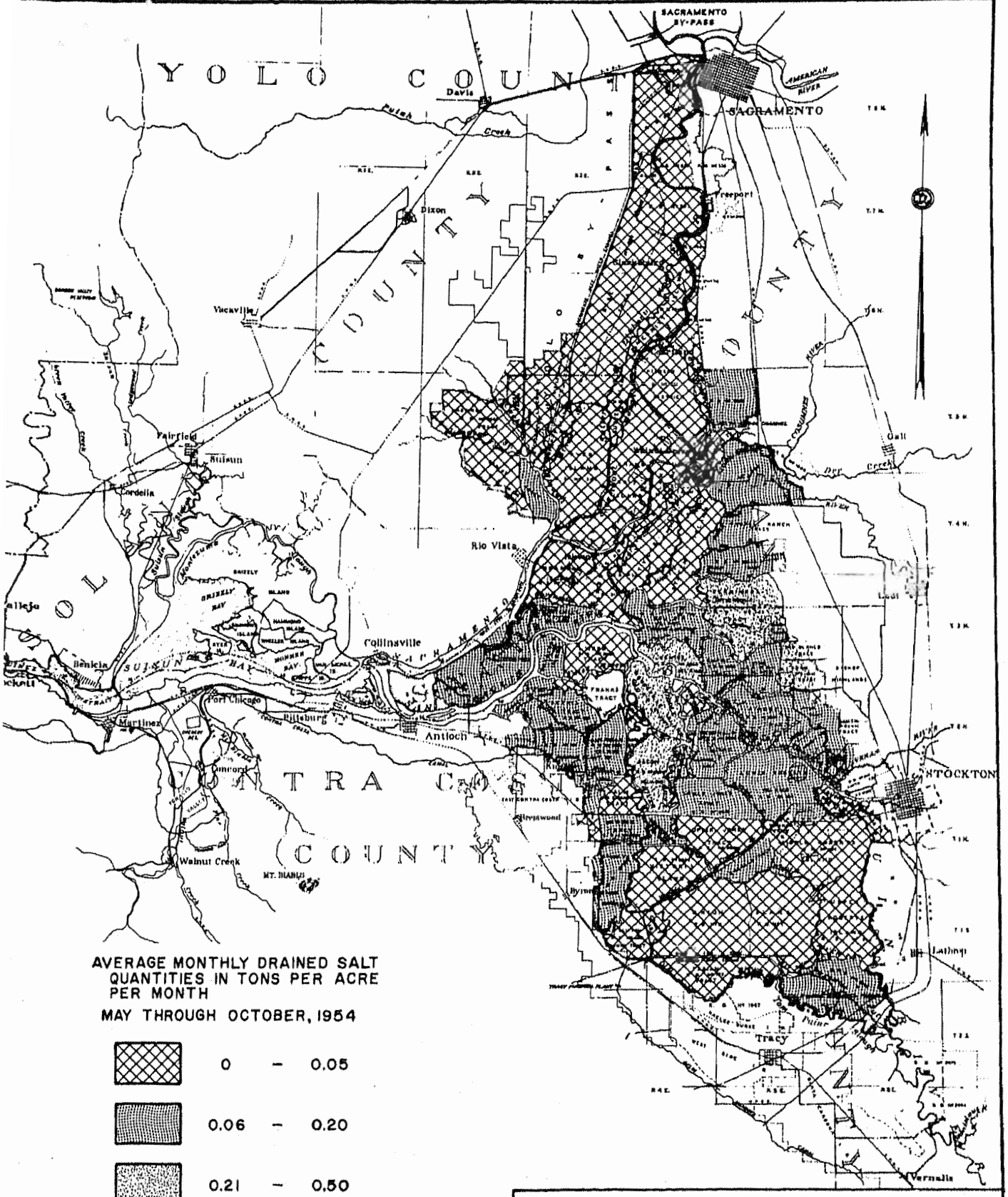
WATER DISPOSAL

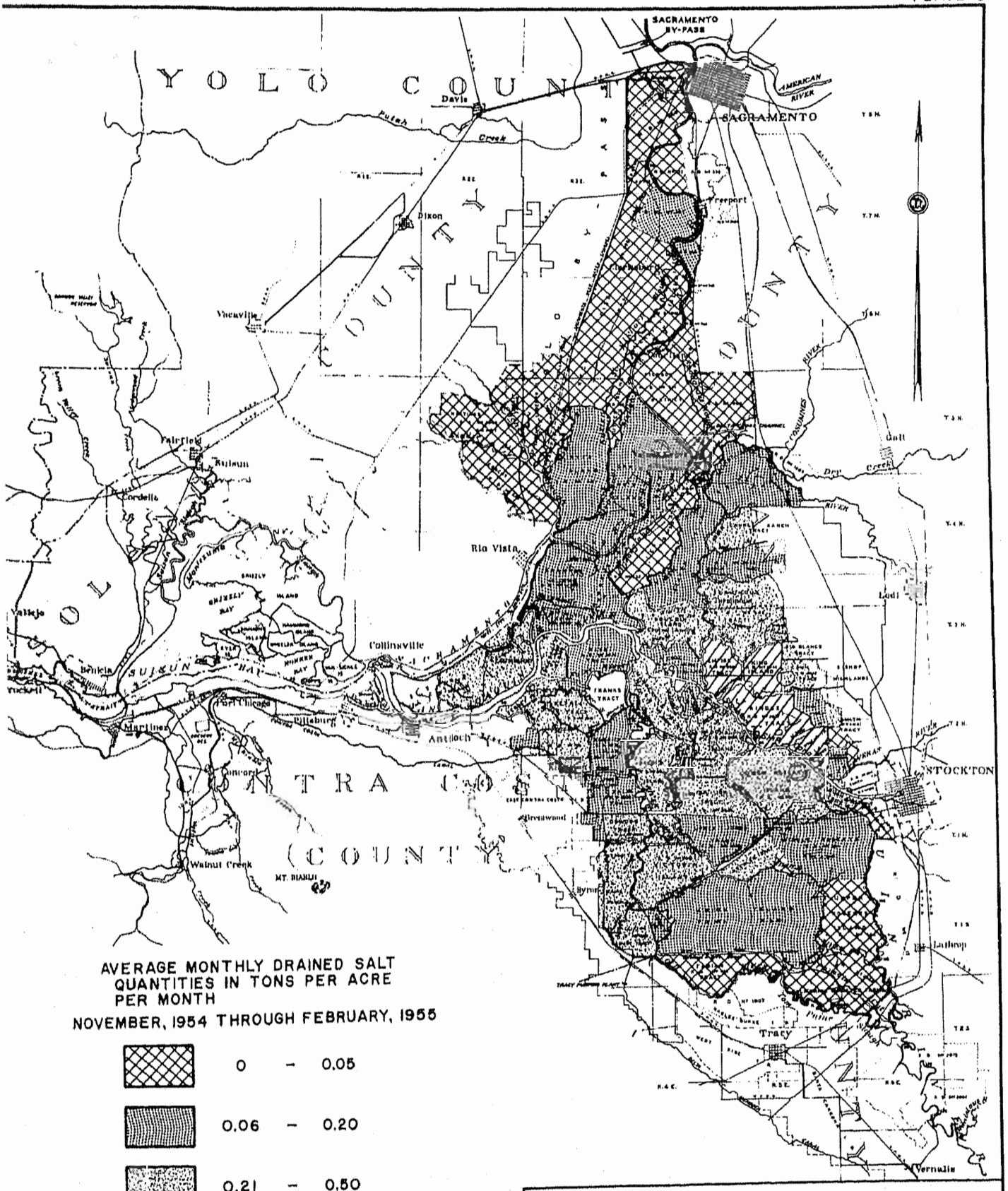
DRAINAGE

CONSUMPTIVE USE

COMPARISON OF WATER SUPPLY AND DISPOSAL
DELTA LOWLANDS
1954-55


MONTHLY QUANTITIES IN 1000 ACRE FEET
300
250
200
150
100
50
0
WATER DISPOSAL
WATER SUPPLY
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
1954
1955


SACRAMENTO BY-PASS
YOLO COUNTY
Davis
Putah Creek
SACRAMENTO
AMERICAN RIVER
Dixon
Freeport
SOLANO COUNTY
Vacaville
Fairfield
Suisun
Cordelia
Rio Vista
Dutch Slough
Benicia
SUISUN BAY
Collinsville
Port Chicago
Martinez
Pittsburg
Antioch
CONTRA COSTA COUNTY
Concord
Walnut Creek
MT. DIABLO
STOCKTON
Tracy
Lathrop
Vernalis
AVERAGE MONTHLY DRAINED SALT QUANTITIES IN TONS PER ACRE PER MONTH
MAY THROUGH OCTOBER, 1954
0 - 0.05
0.06 - 0.20
0.21 - 0.50
0.51 - 0.80
LOWLANDS DRAINED SALT RATES
SACRAMENTO-SAN JOAQUIN DELTA
Scale of miles

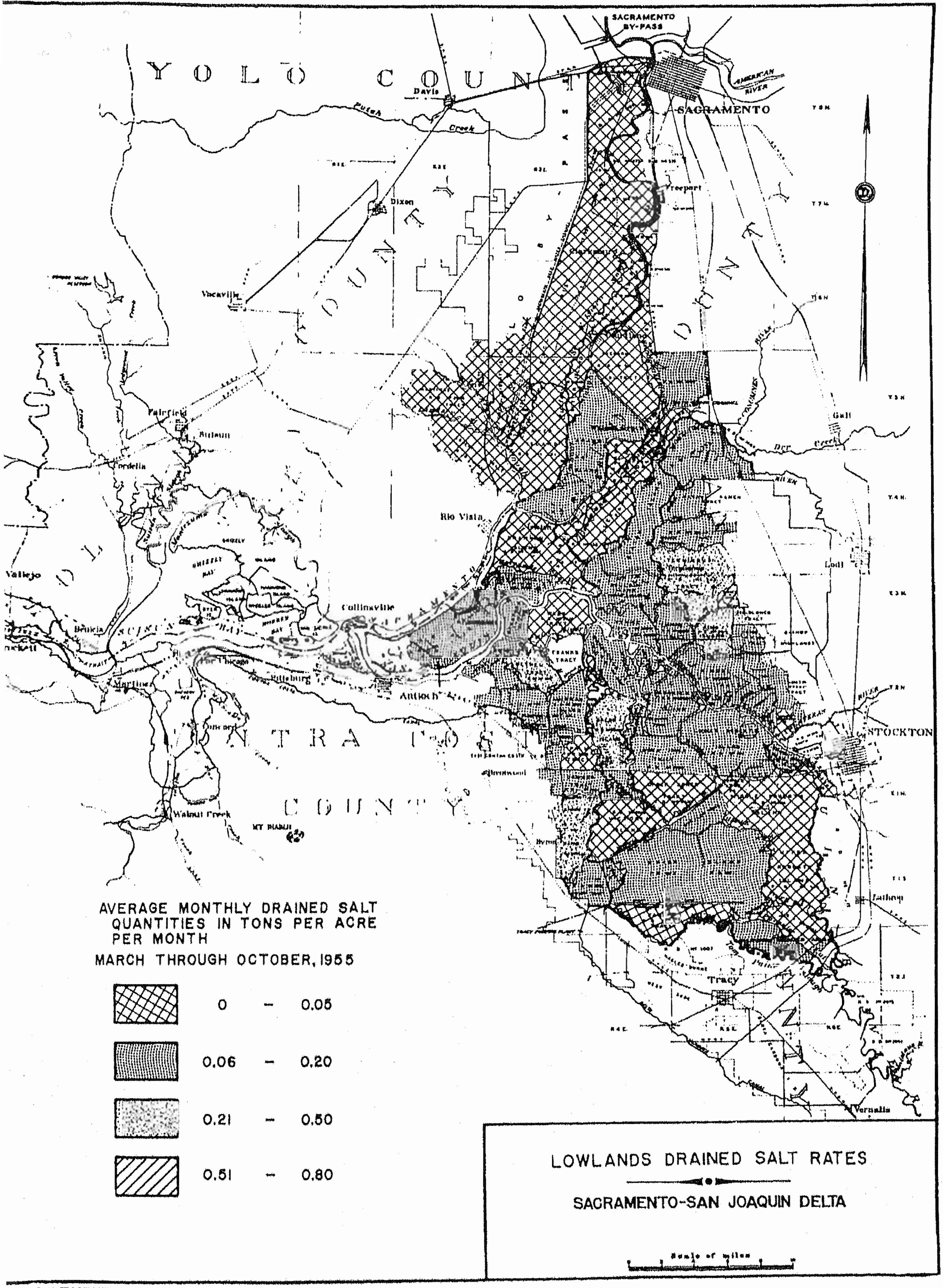


LOWLANDS DRAINED SALT RATES

SACRAMENTO-SAN JOAQUIN DELTA

Scale of miles

DEPARTMENT OF WATER RESOURCES


SACRAMENTO BY-PASS
YOLO COUNTY
Davis
Putah Creek
AMERICAN RIVER
SACRAMENTO
Freeport
Dixon
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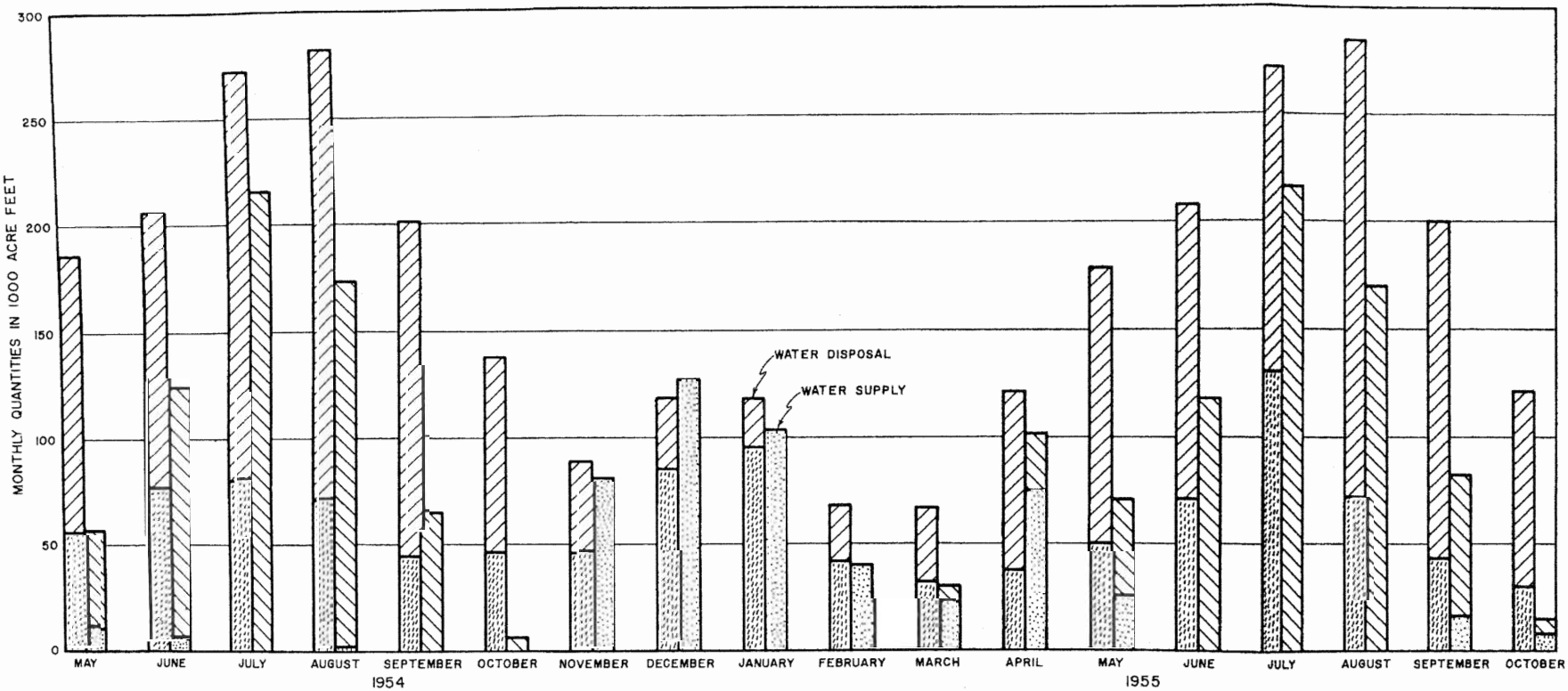
Suisun
Cordelia
Rio Vista
Galt
Dry Creek
Lodi
Vallejo
Benicia
Collinsville
Martinez
Port Chicago
Pittsburg
Antioch
STOCKTON
Concord
CONTRA COSTA COUNTY
Brentwood
Walnut Creek
MT DIABLO
Byron
Lathrop
Tracy
Vernalis
AVERAGE MONTHLY DRAINED SALT QUANTITIES IN TONS PER ACRE PER MONTH
MARCH THROUGH OCTOBER, 1955
0 - 0.05
0.06 - 0.20
0.21 - 0.50
0.51 - 0.80
LOWLANDS DRAINED SALT RATES
SACRAMENTO-SAN JOAQUIN DELTA
Scale of miles



WATER

PREC

APPL

WATER

DRAIN

CONS

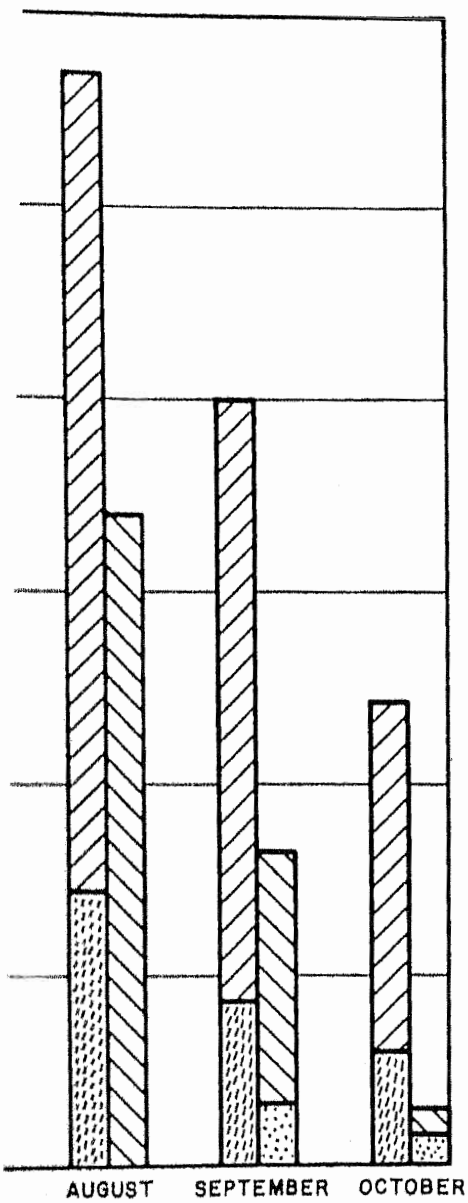
legend attached

COMPARISON OF WATER SUPP

DELTA LOWLAN

1954-55

DEPARTMENT OF WATER RESOURCES



To previous page

LEGEND

WATER SUPPLY

PRECIPITATION

APPLIED WATER

WATER DISPOSAL

DRAINAGE

CONSUMPTIVE USE