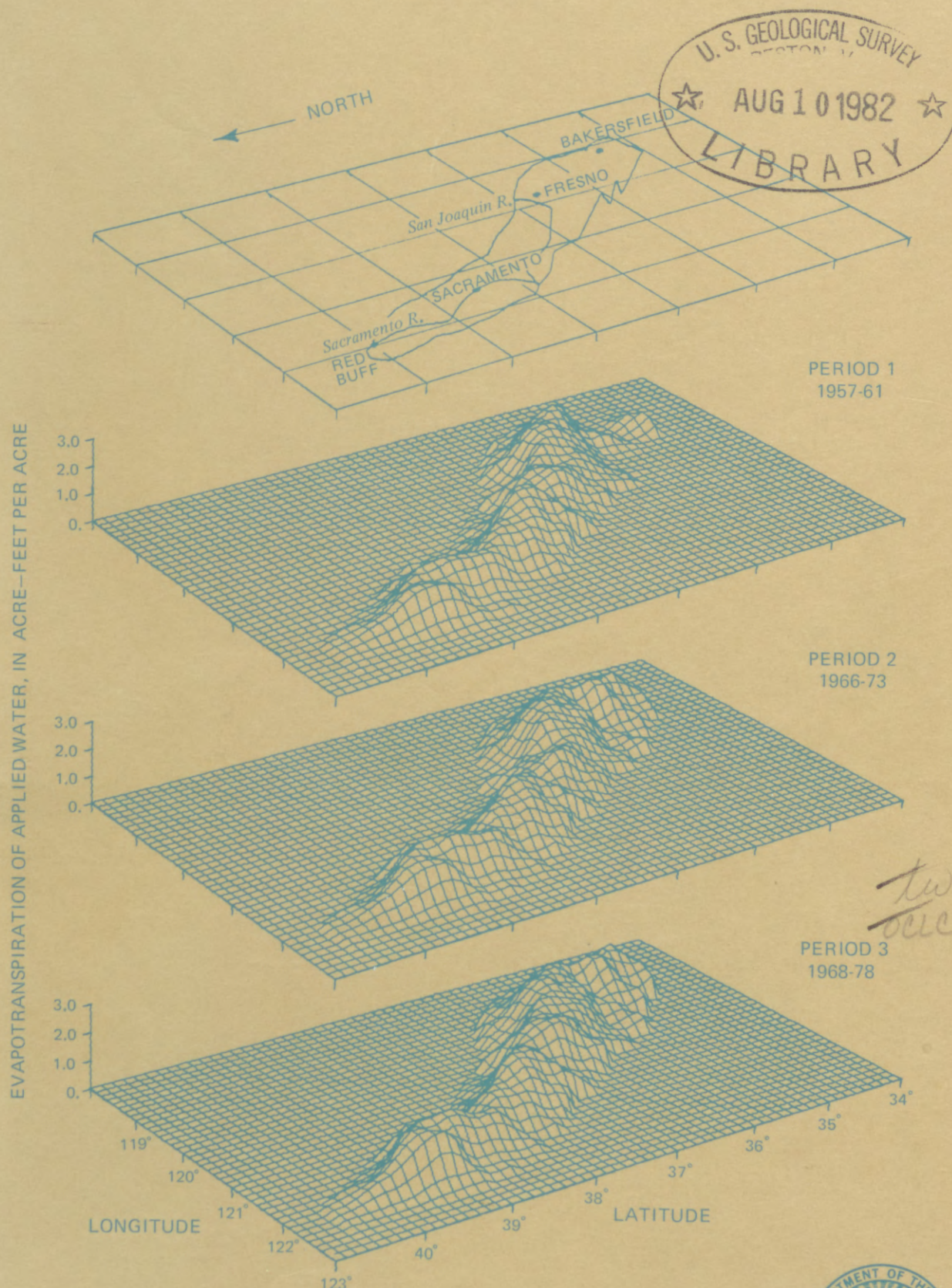


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EVAPOTRANSPIRATION OF APPLIED WATER CENTRAL VALLEY, CALIFORNIA 1957-78



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By Alex K. Williamson

U.S. GEOLOGICAL SURVEY

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San Joaquin Valley

Future

or study

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CONVERSION FACTORS

For readers who may prefer to use metric units (International System of Units) rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
acres	0.004047	km ² (square kilometers)
acre-ft (acre-feet)	0.001233	hm ³ (cubic hectometers)
ft (feet)	0.3048	m (meters)
in (inches)	25.4	mm (millimeters)
mi (miles)	1.609	km (kilometers)
mi ² (square miles)	2.590	km ² (square kilometers)

The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

EVAPOTRANSPIRATION OF APPLIED WATER

CENTRAL VALLEY, CALIFORNIA, 1957-78

By Alex K. Williamson

ABSTRACT

In the Central Valley of California, 57 percent of the total area of 20,000 square miles is irrigated. Recharge from irrigation water applied to agricultural lands is an important component in modeling the ground-water regimen. After exploring several methods of estimating recharge, a simplified water-budget equation was chosen. This equation requires estimating evapotranspiration of applied water (ETAW) but eliminates the need to determine the pumpage from the water-table aquifer, provided the time lag for infiltration is not longer than the time intervals of interest for modeling. This equation applies to recharge from applied irrigation water only, which is the largest ground-water component in the hydrologic cycle of the Central Valley.

The estimation of evapotranspiration from natural vegetation is as yet subject to large error. In the simplified equation derived for this study, ETAW for irrigated vegetation is the value used for evapotranspiration. ETAW can be estimated with much more assurance because the plant environment of irrigated agriculture in the Central Valley is much more homogeneous than are the conditions of natural vegetation. In addition, many studies have been made of ETAW for various crops.

ETAW was calculated by summing the products of ETAW coefficients and respective crop areas for each $7\frac{1}{2}$ -minute quadrangle area in the valley for each of three land-use surveys between 1957 and 1978. Results are shown as three-dimensional surfaces, maps, and tables. In 1975, the total ETAW was 15.2 million acre-feet, which can be divided among the Sacramento, Delta, San Joaquin, and

Tulare basins as 3.0, 1.9, 3.2, and 7.1 million acre-feet, respectively. In proportion to total area, ETAW and irrigated area increase toward the south. From 1959 to 1975, total ETAW in the Central Valley increased 43 percent and irrigated area increased 32 percent. The largest increases were in the Tulare basin, especially Kern County, where a sixfold increase in both ETAW and irrigated area resulted from the import of surface water in the California Aqueduct. In the northern half of the valley, irrigated area increased much more than ETAW, indicating that additional areas were planted in crops that have relatively low ETAW coefficients.

INTRODUCTION

Many areas of the United States depend on ground water for a large part of their total water supply. National recognition of the importance of ground water was heightened in 1976 and 1977 when the western part of the United States experienced major drought. Consequently, the United States House of Representatives recommended a national program for the analysis of regional aquifer systems. In 1977, the Geological Survey started a new series of hydrologic investigations called the Regional Aquifer Systems Analysis (RASA) Program.

Because of its long history of ground-water development and the complexity and immensity of the economic ties related to ground-water development, the Central Valley of California was among the first areas in the United States selected for study under the RASA program. This report is the result of work done to support the Central Valley Aquifer Project (Bertoldi, 1979).

Purpose and Scope

The primary purpose of the Central Valley Aquifer Project is to provide ground-water information useful to those concerned with managing water on a regional scale. To do this, the ground-water system will be simulated by digital modeling techniques. An important input to such a model is ground-water recharge. The source of most ground-water recharge in the Central Valley is irrigation of agricultural lands. The usual method for calculating recharge from applied irrigation water is to assume an irrigation efficiency (for example, 60 percent) which implies that the remainder (for example, 40 percent) becomes recharge to the ground-water system. Estimates of irrigation efficiencies, commonly made with little supporting documentation, range from 30 to 100 percent. In this study recharge from irrigation was calculated using a water budget in which values for all terms can be estimated. This report describes the simplified water budget and evaluates one component of that budget, evapotranspiration of applied water. Future reports will address the other components of the water budget.

Evapotranspiration of applied water (ETAW) was calculated using ETAW coefficients for individual crops and land-use surveys¹. Values were computed as totals for each 7½-minute quadrangle area in the valley for each of three land-use surveys covering that area between 1957 and 1978. Although a similar method has been applied to large geographic units in the valley, such as counties, hydrologic study areas, and irrigation districts (California Department of Water Resources, 1976a), this study is the first to apply a consistent method of analysis to consistent, detailed geographic units over the entire valley. Because of this consistency, the results can be used to compare magnitudes, distribution, and trends of irrigated acreage and ETAW throughout the valley.

¹ETAW is also called consumptive use and ETAW coefficients are also called crop [use] coefficients in other publications.

The Area

The Central Valley of California is one of the more notable structural depressions in the world. Surrounded by mountains and filled with alluvium derived from those mountains, the valley extends about 400 miles from Red Bluff in the north to Bakersfield in the south (fig. 1). It ranges in width from about 30 to 70 miles and covers about 20,000 mi². The valley has only one natural outlet, Carquinez Strait, through which the combined discharge of the Sacramento and San Joaquin Rivers flows on its way to San Francisco Bay. For study purposes, the Central Valley is referred to in four parts--Sacramento, Delta, San Joaquin, and Tulare basins (fig. 1) (California Region Framework Study Committee, 1968).

Climate in the valley is of Mediterranean type (dry summers). About 85 percent of the annual precipitation occurs in the 6 months from November to April. Annual precipitation ranges from 13 to 26 inches in the Sacramento Valley and 5 to 16 inches in the San Joaquin Valley. Summers are hot; winters are moderate, allowing a long growing season.

Given the favorable climate and fertile soils, the Central Valley boasts one of the greatest agricultural economies in the world. Four of the Nation's top five agricultural counties (in terms of the value of crops sold, \$3.1 billion in 1976) lie in the San Joaquin Valley and Tulare Basin; and approximately 40 percent of the Nation's fruits, nuts, and vegetables (1976 value, about \$1.5 billion) are grown in the Central Valley (U.S. Agricultural Crop Reporting Service, written commun., 1976). Agricultural practice in the valley is advanced, and irrigation has a major role in this type of controlled farming. As early as 1966, approximately 95 percent of the tonnage of agricultural products being harvested in California received some supplemental irrigation water (California Department of Water Resources, 1966).

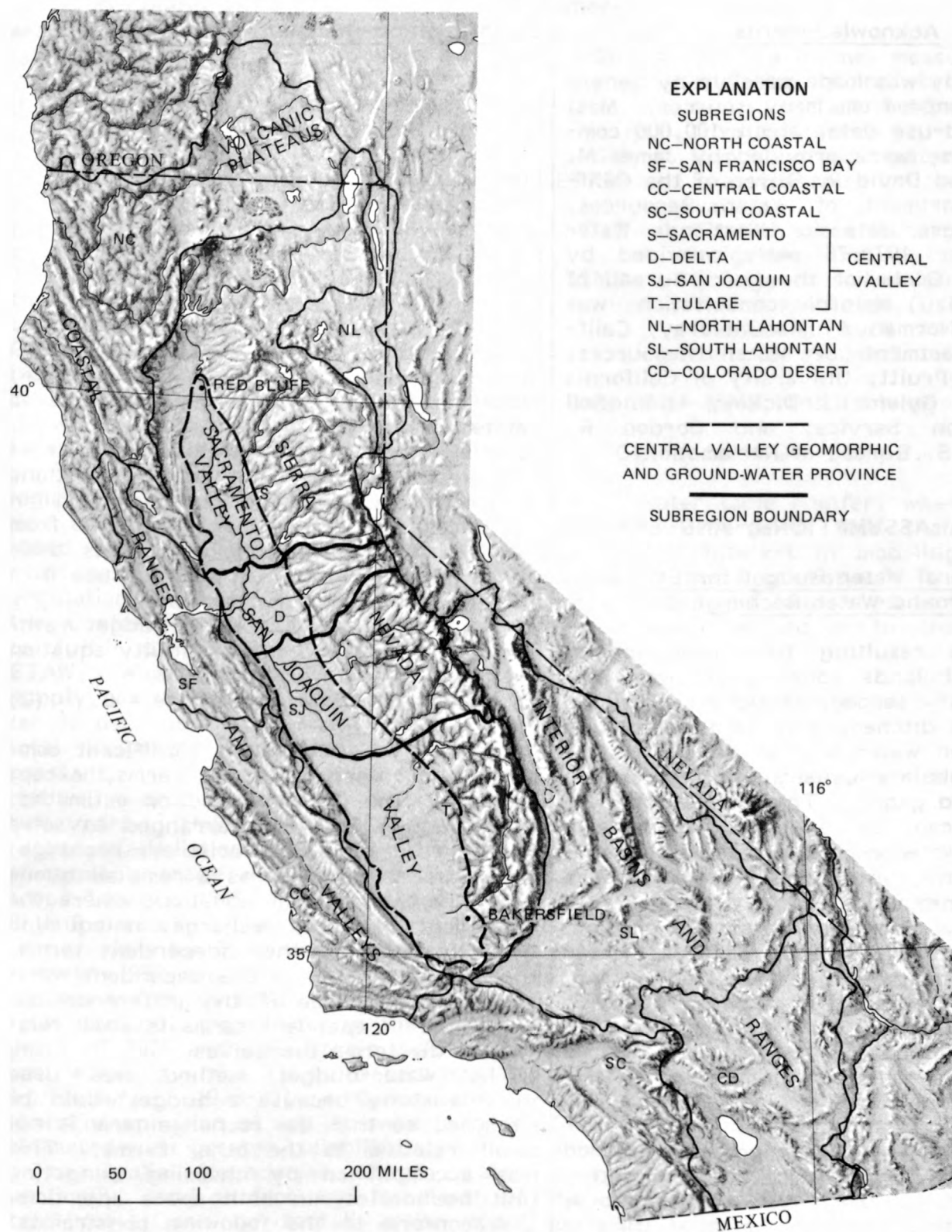


FIGURE 1.--Location of the Central Valley (modified from Thomas and Phoenix, 1976).

Acknowledgments

This study was made possible by generous assistance from many sources. Most of the land-use data, about 100,000 computer cards, were provided by James M. Wardlow and David P. Bilyeu of the California Department of Water Resources. The land-use data for Westlands Water District for 1975-76 were provided by William R. Cooke of the U.S. Bureau of Reclamation. Helpful consultation was given by Norman A. MacGillavray, California Department of Water Resources; William O. Pruitt, University of California at Davis; Gylan L. Dickey, U.S. Soil Conservation Service; and Gordon R. Lyford, U.S. Bureau of Reclamation.

METHODS, ASSUMPTIONS, AND ERRORS

Description of Water Budget for Estimating Ground-Water Recharge

Recharge resulting from irrigation of agricultural lands consists of two major components: seepage losses from unlined canals and ditches, and field percolation of irrigation water beyond the root zone. Major canals are usually lined to reduce seepage and gaged. Their contribution to recharge can be estimated separately.

Ground-water recharge cannot be measured directly, and indirect point measurement techniques, such as canal reach seepage by discharge difference or field percolation tests by soil-moisture measurements, cannot be extrapolated reliably owing to the large number of unknown factors affecting the recharge rate. Therefore, recharge for larger areas is commonly estimated by one of the following methods:

1. Proportional.--The proportional method assumes that a constant and determinable portion (often referred to as irrigation efficiency) of the inflow to an agricultural area is consumed and that the remainder becomes either surface outflow or ground-water recharge. The inflows are measured or estimated and the irrigation efficiency is estimated on the basis of experience and judgment.

2. Infiltration-Duration.--This method uses the equation:

$$Q_R = i \cdot W \cdot L \cdot T \quad (1)$$

where

Q_R = recharge volume,

i = infiltration rate,

L, W = dimensions of the infiltration area, and

T = time of duration of infiltration.

The problem with this method is in assigning a value to the infiltration rate, which is highly variable and difficult to estimate reliably.

3. Using results of other investigations.--

Results of many other investigations are available but the variation in methods used and assumptions from which they were derived limits their consistency and validity for use in a regional ground-water model.

4. Water Budget.--The water-budget method is based on the continuity equation

$$\Sigma \text{Inflows} - \Sigma \text{Outflows} \pm \Delta \text{Storage} = 0. \quad (2)$$

It is assumed that all the significant components of each of these terms, except recharge, can be measured or estimated. The equation is then rearranged to solve for the dependent variable, recharge, sometimes referred to as a residual quantity. In this type of equation, where the dependent variable, recharge, is equal to the difference of the independent terms, the random error in the dependent variable will be large if the difference between the independent terms is small relative to the terms themselves.

The water-budget method was used in this study because a budget could be designed so that the recharge term is not small relative to the other terms. This was accomplished by choosing budgeting unit boundaries, in both space and time, that conform to the following constraints:

- Data on flows across the boundaries available and of the highest accuracy possible.
- Minimum number of significant flow components.
- Boundaries compatible with other parts of the modeling and recharge

calculations so that flows are not missed or counted twice.

- d. Geographic units (for which average flow components were determined) of a similar size or smaller than the nodal spacing for the ground-water model.

For determining recharge from unlined canals and irrigated areas, a water budget that focuses on the artificial components of the hydrologic cycle was designed. The artificial components are larger than the natural components owing to the extensive agricultural development in the Central Valley. A major component in using a water-budget method to compute recharge is evapotranspiration. It is well known that estimating evapotranspiration is subject to large errors. By focusing on the artificial components of the hydrologic cycle, however, the evapotranspiration component desired is that from irrigated crops, where the environment is much more uniform than that of natural vegetation. Almost all irrigated fields in the Central Valley receive enough water to fulfill plant needs, which maximizes ETAW. When surface water is in short supply, as in drought years, ground water is used as a supplement, so that the total irrigation application is relatively constant. This is shown by the small variation in crop yields from dry years to wet years. The coefficient of variation (standard deviation divided by the mean) of annual average yield for 4 common field crops between 1965 and 1979 ranged from 2 to 6 percent. The coefficient of variation of yield for 3 common vegetable crops between 1972 and 1979 ranged from 3 to 6 percent. The variation was higher for 3 fruit and nut crops, but in the drought years of 1976 and 1977, their yields were well above average (U.S. Department of Agriculture, 1973-80). Consequently, evapotranspiration of applied water can be estimated with greater reliability.

The spatial boundaries chosen were: vertically, land surface and the depth of crop roots; and horizontally, the model node boundaries, or some similar-sized geographic units where the data could be transferred to nodal units by an areal proportion. The water budget is:

$$\overbrace{SW + GW}^{\text{inflow}} - \overbrace{ETAW - GWR}^{\text{outflow}} \pm \Delta SMS = 0. \quad (3)$$

where

- SW = Surface inflow, measured at the diversion point to an area, minus surface outflow, if any, from that area,
 GW = Pumped ground water,
 ETAW = Evapotranspiration of applied water,
 GWR = Ground-water recharge from irrigation, and
 ΔSMS = Change in soil moisture storage in the root zone (using a large time unit, such as one year, that is assumed to be zero).

Dropping ΔSMS and solving for GWR:

$$GWR = SW + GW - ETAW. \quad (4)$$

For a water table aquifer, where the time lag for recharge is less than the time periods of interest in modeling, the net recharge or flux between the ground-water body and land surface is the desired result according to the following equation:

$$FLUX = GWR - GW. \quad (5)$$

Subtracting GW from both sides of equation 4 gives

$$GWR - GW = SW - ETAW. \quad (6)$$

Substituting equation 5 into equation 6 gives

$$FLUX = SW - ETAW. \quad (7)$$

Equation 7 has the obvious advantage of having only one component, ETAW, that must be estimated, since net surface inflow (SW) is a measured item. ETAW and SW are calculated for areas within the same geographic boundary units. However, land-use data and surface-water data are not always collected or summarized for areas having coincidental boundaries. Therefore it was necessary to prorate the data values proportionally among similar boundary units. The calculation of ETAW, including assumptions and error analysis is the major purpose of this report, and as such is discussed in detail in the following sections.

Calculation of Evapotranspiration of Applied Water

Evapotranspiration of applied water (ETAW) is defined as the part of the plant-water requirement which is not supplied directly or indirectly by precipitation. In equation form, this gives:

$$ETAW_{crop} = ET_{crop} - \text{Effective Precipitation} \quad (8)$$

Total seasonal crop ET, measured at several sites, is extended to numerous other locations by a linear regression relating ET to pan evaporation. Effective precipitation, defined as that part of precipitation which contributes to ET_{crop} , is calculated by monthly soil-moisture budgets. Areas of each crop type are summed for each geographic area (7½-minute quadrangle) for use in equation 9, which follows.

$$ETAW_{QUAD} = \sum_{crop} (Area_{crop} \times ETAW_{crop}) \quad (9)$$

Crop Evapotranspiration of Applied Water Coefficients

Coefficients of evapotranspiration (ET) of applied water for a specific crop are determined by first measuring ET at a site. Then an evaporation index that can be measured at many locations is chosen. The relation of the index value to the measured ET is defined by a linear regression. ET in other areas is predicted by the regression equation using the evaporation index values in the areas of interest. Finally, the contribution to ET by precipitation is subtracted, leaving the ET of applied water (ETAW). These crop ETAW coefficients are shown in tables 1 and 2.

TABLE 1. - Estimated evapotranspiration of applied water for principal crops, Sacramento Valley

[Averages for entire valley floor. Differences in crop cultural practices may result in small variations from reported amounts. (Source, California Department of Water Resources, 1975, p. 37)]

Crop	Growing season evapotranspiration (acre-ft/acre)	Evapotranspiration of applied water (acre-ft/acre)							
		Rainfall zone, average annual precipitation (inches)							
		12-14	14-16	16-18	18-20	20-22	22-24	24-28	28-32
Alfalfa	3.5	2.8	2.7	2.6	2.4	2.3	-	-	-
Barley	1.0	0.1	0.0	0.0	0.0	0.0	0.0	-	-
Beans (dry)	1.4	1.2	1.1	1.1	1.1	1.1	1.1	-	-
Corn (field)	2.0	1.9	1.8	1.8	1.8	1.8	1.7	-	-
Deciduous orchard ¹	3.2	2.5	2.4	2.2	2.0	1.9	1.9	1.8	1.8
Almonds ²	2.4	-	1.7	1.6	1.4	1.3	-	-	-
Grain sorghum (Milo)	1.8	1.6	1.5	1.4	1.4	1.4	1.3	-	-
Pasture (improved)	3.6	3.0	3.0	2.9	2.9	2.8	2.8	2.7	2.6
Potatoes	1.6	1.5	1.4	-	-	-	-	-	-
Rice	3.5	3.3	3.3	3.3	3.3	-	-	-	-
Subtropical orchard ³	2.6	-	-	1.6	1.6	-	-	-	-
Sugar beets	2.5	2.0	1.9	1.7	1.6	1.5	1.5	-	-
Tomatoes ⁴	2.3	2.0	1.9	1.7	-	-	-	-	-
Vineyard ⁵	2.2	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.4

¹Except almonds.

²Not based on crop ET measurements. Almond ET estimated as $0.75 \times ET$ deciduous orchard.

³ET citrus estimated from: 60 percent of potential ET for active growing season, ET maximum = PET for rainy season (November-February). Twelve-month growing season.

⁴Machine-harvested canning tomatoes.

⁵Table grapes--use as maximum for vineyard; wine grapes may be lower.

TABLE 2. - Estimated evapotranspiration of applied water for principal crops, San Joaquin Valley

[Averages for entire valley floor. Differences in crop cultural practices may result in small variations from reported amounts. (Source, California Department of Water Resources, 1975, p. 38)]

Crop	Growing season evapotranspiration (acre-ft/acre)	Evapotranspiration of applied water (acre-ft/acre) Rainfall zone, average annual precipitation (inches)					
		4-6	6-8	8-10	10-12	12-14	14-16
Alfalfa (hay)	3.5	3.3	3.2	3.1	2.9	2.8	2.6
Barley	1.4	1.2	1.0	0.9	0.7	0.6	0.4
Beans (dry)	1.4	1.4	1.4	1.3	1.3	1.2	1.1
Cantaloupes	1.1	1.0	1.0	1.0	0.9	0.8	0.7
Corn (field)	2.0	2.0	2.0	2.0	2.0	1.9	1.8
Cotton ¹	2.6	2.5	2.5	2.5	2.4	2.3	2.2
Deciduous orchard ²	3.2	3.0	2.9	2.8	2.6	2.5	2.3
Almonds ³	32.2	2.1	2.0	1.9	1.7	1.6	1.5
Grain sorghum (Milo)	1.8	1.8	1.8	1.7	1.7	1.6	1.5
Pasture (improved)	3.7	3.5	3.4	3.3	3.1	3.0	3.0
Potatoes	1.6	1.5	1.4	1.2	1.1	1.0	1.0
Rice	3.8	3.7	3.6	3.5	3.4	3.4	3.1
Subtropical orchard ^{3, 4}	32.6	-	-	1.9	1.8	1.7	1.7
Sugar beets	2.9	2.7	2.6	2.5	2.4	2.3	2.2
Tomatoes ⁵	2.3	2.3	2.3	2.2	2.1	2.0	1.9
Vineyard ⁶	2.3	2.2	2.2	2.1	2.0	1.9	1.7

¹Assumed 1/3 solid plant, 1/3 skip row 2 x 1, 1/3 skip row 2 x 2.

²Except almonds.

³No observed ET data available. Growing season ET estimated from ground cover, irrigation practices, applied water, and other available data. Active growing season ET estimated as 60 percent of PET. Assume 12-month growing season. For rainy season (November-February) maximum ET = PET.

⁴Citrus and avocados.

⁵Machine-harvested canning tomatoes.

⁶Table grapes.

Evapotranspiration measurement at a site.--One method of measuring ET of a crop at a site is to use a lysimeter (also called an ET tank) that has some means, usually by weighing, of measuring the amount of water removed from the tank to the atmosphere. Measurement errors of lysimeters are small--about 4 percent (W. O. Pruitt, oral commun., 1978). Only about 0.5 percent of this is actual measuring error; the remaining 3.5 percent results from the difficulty of duplicating field growth conditions in a tank. This method has been used for 11 years by the University of California at Davis to measure the ET of irrigated pasture. The coefficient of variation (standard deviation divided by the mean) is 5 percent, which

includes both the variation due to errors and the year-to-year variation due to weather and other factors (W. O. Pruitt, oral commun., 1978).

Another common method of measuring ET is to measure changes in soil moisture content. Neutron probes have been used since about 1960 to give accurate estimates of soil moisture content (California Department of Water Resources, 1975). Sites are carefully chosen so that there is little water lost to deep percolation. This has been checked with deep access tubes for the soil moisture meters and by keeping a plot water balance. "Such comparisons usually are in close agreement." (MacGillavray, 1978, p. 4).

In California, many ET measurements have been made, as follows (California Department of Water Resources, 1975, p. 19-22).

Area	Location	Type	Operator
Lower Sacramento Valley	Davis Woodland	Weighing ET tank Floating ET tank Bowen Ratio Energy Balance (used for rice paddies)	University of California, Davis
Delta Southern Tulare Basin	Thornton Arvin Wasco Buttonwillow	Floating ET tank Neutron probe Neutron probe Neutron probe	California Department of Water Resources
Other California locations		Six neutron probes Two ET tank sites	Science & Education Administration, formerly Agricultural Research Service
		Nine ET tank sites	California Department of Water Resources

Extrapolation to other locations.--To estimate ET values at other locations, an evaporation index which can be measured at many locations is chosen and correlated by linear regression with ET measurements at specific sites. ET in other areas is predicted by the regression equation using the index at the location of interest, resulting in the ET for a specified crop at a given site. The coefficient of determination (r^2) of the linear regression between monthly evapotranspiration and pan evaporation of 3 central valley stations was 96 percent (California Department of Water Resources, 1975, p. 98). This indicates that about 4 percent of the variation in ET is not explained by variation in pan evaporation.

There is a network of 29 agro/climatic stations in the Central Valley. Most of the stations are located in irrigated pasture environments and are equipped with Class "A" evaporation pans. The rest are equipped with Livingston black and white spherical atmometers. Some are equipped also with devices to measure incoming solar radiation.

In the Central Valley, the variation of these climatic indices is small in both time and space. For about 10 years of measurement at Davis, the coefficient of variation of March-October seasonal totals of pan evaporation was 6 percent; the coef-

ficient of variation for incoming solar radiation was 3 percent; the coefficient of variation from the Blaney-Criddle "f" factor was 2 percent (Blaney and Criddle, 1950); and the coefficient of variation for ET of grass was 4 percent (California Department of Water Resources, 1975, p. 89-90). The coefficient of variation of average March-October total pan evaporation of 10 stations with 4 or more years of record was 5 percent (California Department of Water Resources, 1975, p. 66-69). Owing to the small variation in ET and indicators of ET, the error added by the areal extension of the data is small.

Measurements of crop ET were obtained under conditions that characterized good management practices (California Department of Water Resources, 1975, p. 2). Poor management would result in less ET than reported here owing to stressing part of the crop with insufficient water. The amount of any such stress is assumed to be insignificant because agriculture in California tends to be oriented to maximum crop production rather than to minimum water consumption. In addition, this effect is partially balanced by higher than expected ET due to crops being located next to fallow fields, weed growth in orchards, etc. There is no appreciable variation in ET due to soil type (Jensen, 1973, p. 49).

Effective precipitation.--Effective precipitation was calculated by the California Department of Water Resources by using a monthly soil-moisture budget and assuming the following:

1. All precipitation during the growing season is effective (none is lost in direct evaporation).
2. Precipitation in the non-growing season in excess of potential ET can be stored in the soil.
3. Runoff of precipitation from graded agricultural land is negligible.
4. Maximum soil-moisture storage is 1.5 inches per foot of root zone depth.
5. As much as 0.75 inch per month evaporation from the soil may occur before the growing season.

Soil-moisture budgets were made for all major crops for each of 12 precipitation categories. Effective precipitation is affected mainly by the soil-moisture storage coefficient, depth of root zone, and monthly distribution of precipitation. Monthly distribution of precipitation is nearly uniform throughout the valley, though the annual amount is much greater in the north (about 20 inches) than in the south (about 5 inches). Effective precipitation is subtracted from evapotranspiration to obtain ETAW. The errors added to ETAW by this method are unknown but assumed to be small because the magnitude of effective precipitation is small relative to ET.

Land-Use Surveys

Land-use surveys in the Central Valley are made by the California Department of Water Resources, the U.S. Department of Agriculture, the U.S. Bureau of Reclamation, the State Department of Agriculture, individual counties and irrigation districts, and special-purpose agencies such as mosquito-abatement districts and crop producer associations. Surveys by the California Department of Water Resources were chosen for use in this study because they cover the whole valley using the same method. Since the late 1950's nearly

all of the valley has been surveyed at least three times. The method used is described in California Department of Water Resources Bulletin 176, 1971, and in Bulletin 160-66, Appendix A, 1967. Aerial photographs at a scale of 1:20,000, taken in mid-summer, and field canvasses are used to draw areas of respective crop types on 1:24,000-scale standard topographic maps. Data on the area of each crop type in each geographic unit are tabulated for computer processing according to the Department of Water Resources "standard land-use legend" (written commun., California Department of Water Resources, April 15, 1970).

The geographic units of interest chosen for this study were areas corresponding to standard 7½-minute topographic quadrangles. These units were chosen because they are the smallest (most detailed) unit for which data are consistent throughout the valley and are tabulated for computer analysis. This allows the calculation of water uses and areas by a computer program, saving many months of manual computations. The program compensates for the range in area of a quadrangle from 39,136 acres at the south end of the valley (lat 34°52'30") to 36,448 acres at the north end (lat 40°15').

For this study the period 1957-78 was divided into three parts: early, middle, and late. The early, middle, and late periods will be referred to as periods 1, 2, and 3 for the remainder of this report. Complete coverage by surveys of the whole valley was desirable for each period. Years of survey for the three periods are shown in figure 2. Although the time span of period 2 and period 3 overlap considerably, in most areas the three surveys are 5 to 10 years apart. Figure 3 shows the geographic features of the Central Valley.

All residential areas, and all agricultural areas designated as fallow, abandoned, idle, and reclaimed were ignored because this study deals with the ET of irrigation water, which confines it to actively irrigated land. Irrigated areas were assigned ETAW coefficients according to crop land-use categories shown in table 3.

There are some special problems in dealing with available land-use data. One problem concerns distribution of data in time and space.

TABLE 3. - Irrigated crop land-use categories

Crop category	Other crops assumed to have same ETAW coefficients
Barley	Grain, hay
Rice	
Cotton	Other field crops
Sugar beets	
Corn	
Sorghum	
Beans	Other truck crops
Cantaloupe	
Potatoes	
Tomatoes	
Alfalfa	Other pasture, lawns, parks, cemeteries
Mixed pasture	
Deciduous orchard	Deciduous fruits, nuts, except almonds
Almonds	
Citrus	All subtropical fruits
Vineyards	
	Table and wine grapes

The 1966 survey covered the entire valley part of Fresno, Kings, Tulare, and Kern Counties, but only areas newly irrigated since 1958 were surveyed and crops in those areas were not specified. It was assumed that the relative proportions of crops did not change from the 1958 survey. For Tulare, Kern, and parts of Kings Counties, a fourth survey was available, so the 1966 survey was not used. For the west side of Fresno County, a survey later than 1968 was not available from the Department of Water Resources. Fresno County was surveyed in 1979, but data are not yet tabulated. Such a survey was needed, because a change was anticipated due to the importation of surface water beginning in 1967 to the area served by the California Aqueduct. The Water and Power Resources Service provided land-use surveys of the area served by California Aqueduct water in Westlands Irrigation District, which covers western Fresno County, for each year, 1967-77. That survey showed crop acreages for each township (land net of

36 square-mile blocks), not for each quadrangle as did the rest of the surveys. To be consistent, the crop acreages were converted from township totals to quadrangle totals by relative proportions of land area of each quadrangle in each township.

For a few quadrangles in the northwest corner of Fresno County, only two complete surveys were available, 1958 and 1966. For these areas, the 1968 survey data were extrapolated to reflect the probable acreage increase since 1966 for the whole quadrangle. Only two surveys were available also for the northern part of Sutter County, 1961 and 1976. Intermediate values were interpolated for period 2.

Another problem encountered in using available land-use data is that of accurately identifying crop types from aerial photographs. To improve accuracy, field canvasses were made as a check. Land-area measurements by these land-use surveys are accurate to within 1 percent (California Department of Water Resources,

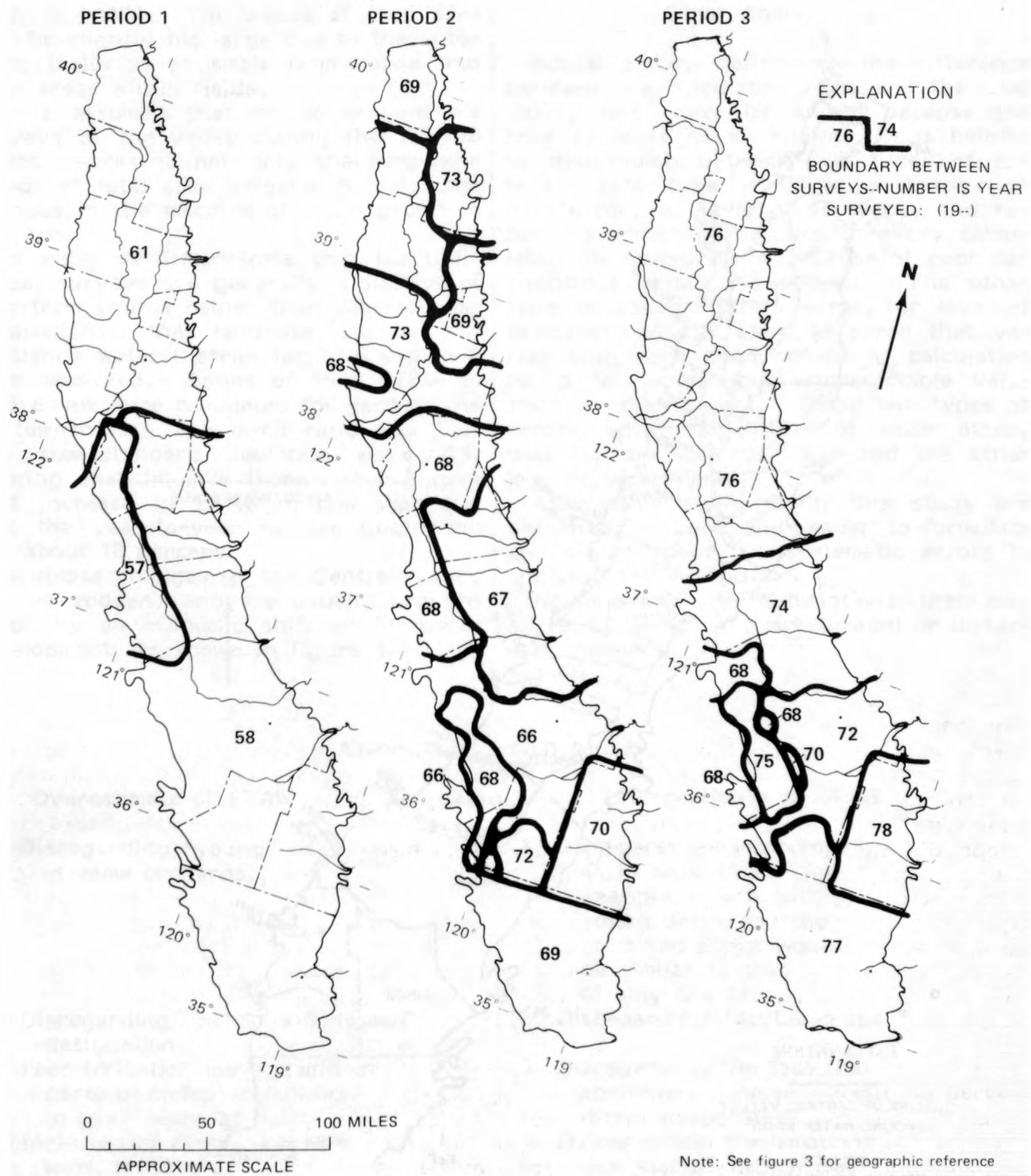


FIGURE 2.--Year of land-use surveys for each of three periods.

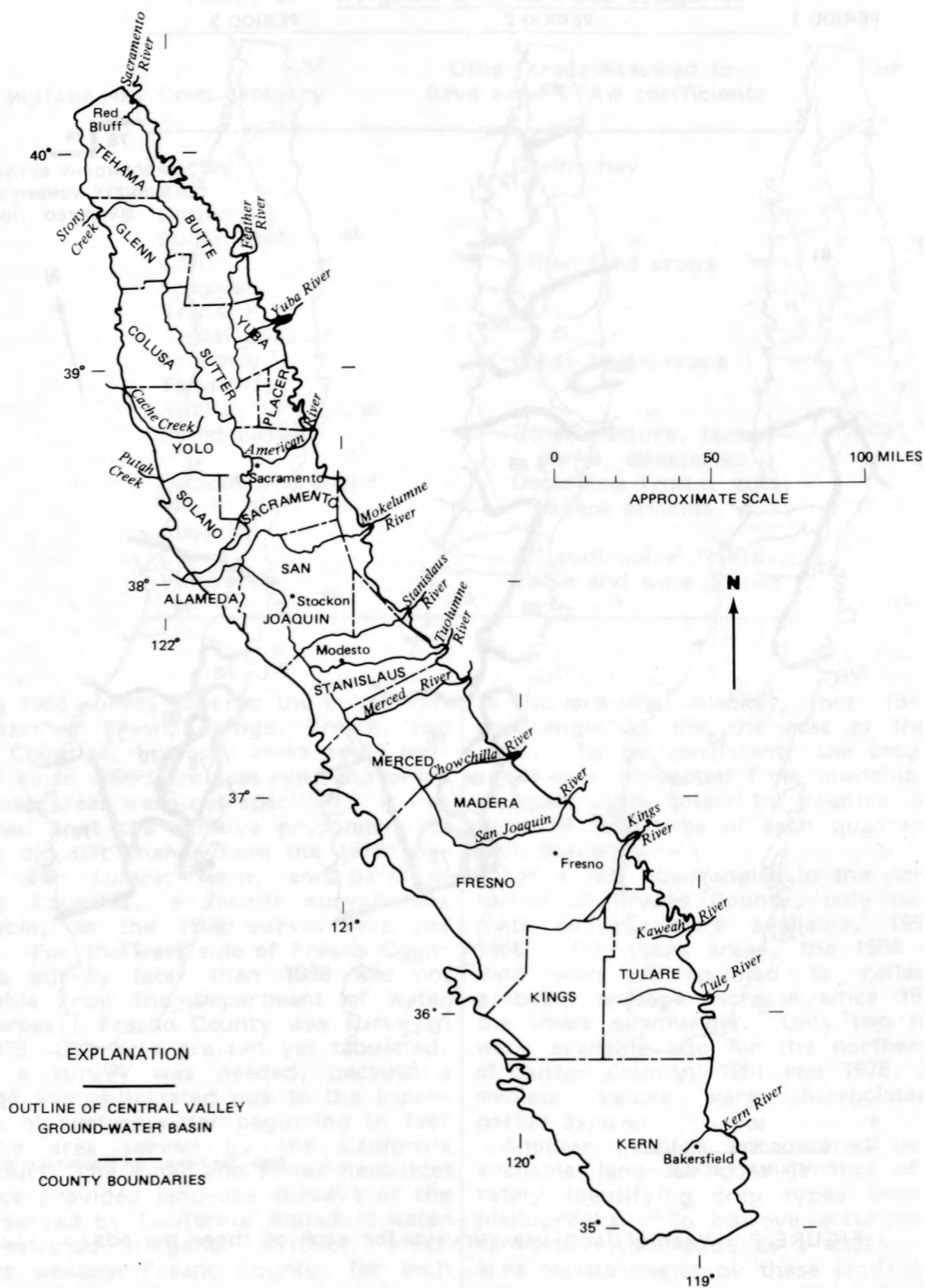


FIGURE 3.--Geographic features of the Central Valley.

1967, p. A11). The values of crop area may be slightly too large due to the automatic inclusion of small farm roads and work areas within fields.

It is assumed that the three land-use surveys of the valley during the 1957-78 period represent not only the long-term trends of total area irrigated but also the changes in the mixture of crops grown in any area.

In order to demonstrate that the individual surveys are generally indicative of long-term trends rather than year-to-year fluctuations, the land-use surveys of Westlands Water District for 1975 and 1976 were analyzed. Ratios of 1976 ETAW to 1975 ETAW were calculated for each of the 40 townships. The mean ratio was 1.05 and the standard deviation was 0.18, showing that in 1976 there was a 5 percent increase in ETAW in one year and that the year-to-year random fluctuation was about 18 percent.

Land-use changes in the Central Valley can be sudden, and are usually brought about by an economic shift or by water development, as shown in figure 4.

Error Analysis

Actual error, defined as the difference between the calculated value and the true value, can never be known because the true value is never known. It is helpful to distinguish between two types of errors. One type is called systematic or bias error, or level of accuracy, and refers to error that occurs in every calculation or measurement because of poor assumptions about the subject. The other type is called random error, or level of precision, which refers to error that varies with each measurement or calculation owing to natural but unpredictable variation in the subject. These two types of errors are independent of each other, that is, one can be high and the other low, or vice versa.

Assumptions followed in this study are presented to allow the reader to formulate an opinion about the systematic errors in applying the method.

The following are assumptions that may cause ETAW to be overestimated or underestimated.

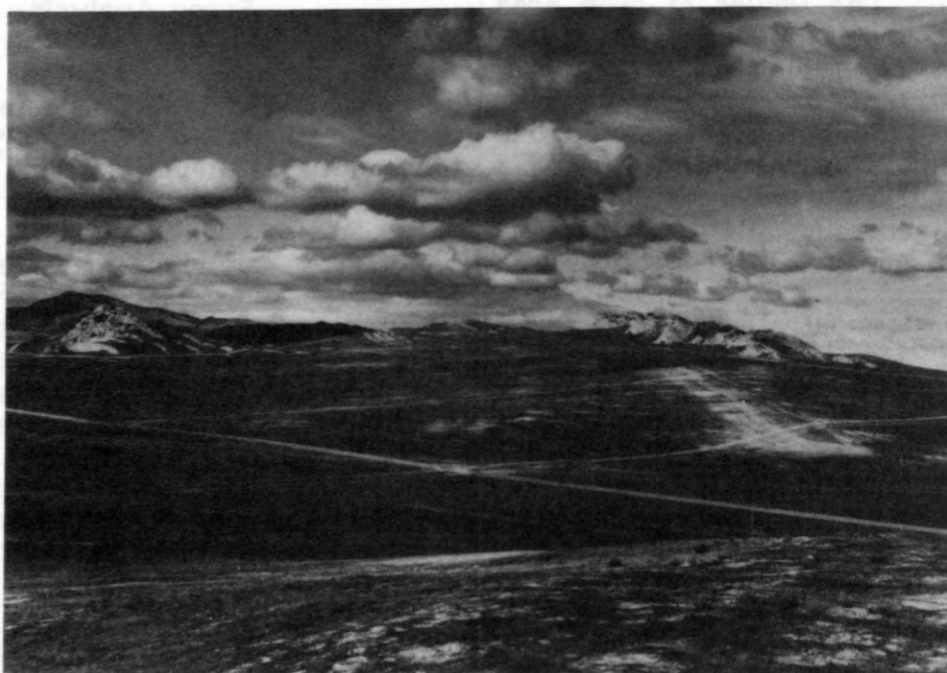
Assumptions which cause:

Overestimate of ETAW

1. Disregarding "young" designation of some orchards.
2. Disregarding "partially irrigated" designation.
3. Poor irrigation management in parts of fields, resulting in plant water deficits.
4. Inclusion of farm roads and work areas.

Underestimate of ETAW

1. Disregarding "intercrops", as in some cases (for example, beans with young orchards) the combined ETAW would be similar to that of only one crop.
2. Disregarding "double crops."
3. Disregarding the fact that sprinklers cause about 5 percent direct evaporation.
4. Disregarding "reclamation" designation, which may be fields that are being leached, so having some ETAW.



March 1968



October 1970

FIGURE 4.--Impact of water on agricultural development--State water project serving western Kern County. (From California Department of Water Resources, 1970, p. 50).

Values of the variability of the measured and calculated values used in this method will give the reader an idea of the random error of the method. Another way to estimate error is to use an independent method to check the method in question. The reader should note, however, that the difference in results between the two methods is not the value of the error, because neither method calculates the true value of the variable.

A check was made on the reliability of using ET/Epan ratios along with pan evaporation data at other locations (MacGillavray, 1978, p. 5-7). Using ratios developed in the Central Valley and pan evaporation at central coast locations, the ratio of calculated to measured seasonal ET had a mean of 1.02 and a standard deviation of 0.05, indicating that the ratios gave a good estimate of the ET relationship between two areas whose pan evaporation differed by 30 percent.

Another check was made on a regional ET value calculated using the same basic method used in this report (MacGillavray, 1978, p. 6-10). The regional, seasonal ET for the Colusa Basin was 6 percent different than the seasonal basin depletion determined by a hydrologic budget of surface flows developed by another scientist. This difference could indicate either validity of the regional ET value or an error in the ET value which corresponded to an error of similar magnitude in the hydrologic budget.

RESULTS

For each of three periods between 1957 and 1978, for each 7½-minute topographic quadrangle area in the Central Valley, the following were calculated:

1. Evapotranspiration of applied water (ETAW), in acre-feet per quadrangle.
2. Average unit ETAW, in acre-feet/ acre or feet (depth), defined as ETAW divided by irrigated area.
3. Total irrigated area, in acres, and proportion of total area irrigated, in percent.

The results are shown as follows:

1. Three-dimensional perspective views of ETAW, unit ETAW, and percentage of area irrigated for each of the three periods are shown in figures 5-7.
2. Maps showing ETAW, unit ETAW, and percentage of area irrigated for each of the three periods and for changes between periods are supplemental data A.
3. Tables showing ETAW, unit ETAW, percentage of area irrigated, irrigated area, and year of land-use survey for each of the three periods are supplemental data B.

The California Department of Water Resources has divided the Central Valley into 17 ground-water basins according to similar characteristics and political subdivisions for the purpose of managing the water resources (California Department of Water Resources, 1980). Those geographic units were used in this study to determine trends in specific areas of the valley. The largest of the 17 basins, the Sacramento Valley, was further divided for this study into eight smaller units on the basis of similar characteristics. All the smaller units will be called subbasins in this report, because they are grouped into four basins, as described in the introduction and shown in figure 1. The boundaries of these basins and subbasins are shown in figure 8 and are approximate because the divisions were made on quadrangle boundaries. Totals or averages of ETAW, unit ETAW, irrigated and total area, and year surveyed for the basins and subbasins are given in table 4. The same values for the four basins are plotted in figures 9-11.

Irrigated area in the Central Valley increased 43 percent between 1959 and 1975, from 5.08 to 7.24 million acres. This large increase occurred at the same time that large decreases occurred in the San Francisco Bay area and the southern California coastal counties because of urban expansion on agricultural land (California Department of Water Resources, 1967, p. A7). In the same period, ETAW in the Central Valley increased 32 percent, from

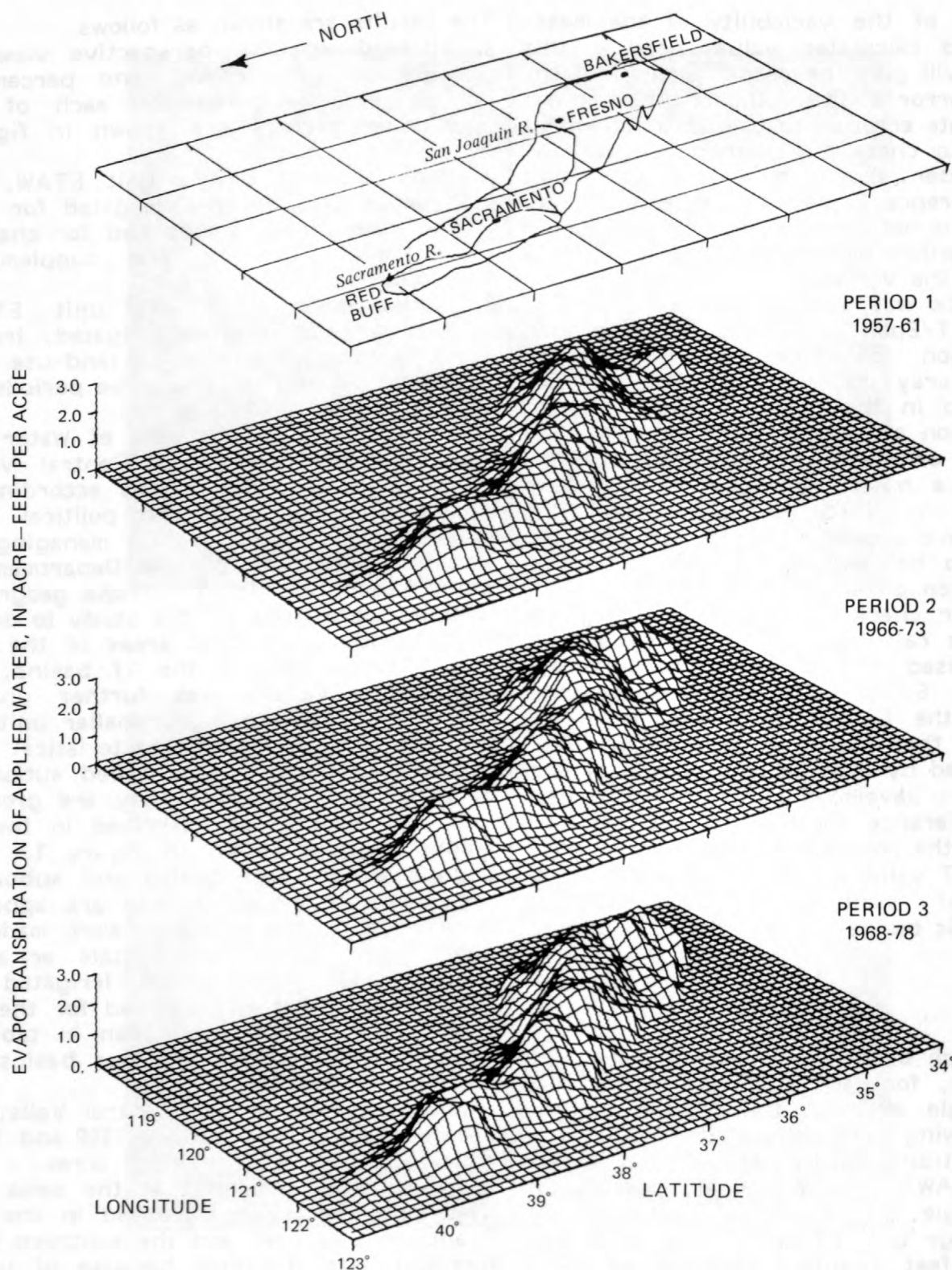


FIGURE 5.--Evapotranspiration of applied water (ETAW) for three time periods, represented by the apparent height of the surface of the three-dimensional views. The view is toward the southeast. The values, in acre-feet per acre, were determined by dividing the total ETAW for each 7.5-minute quadrangle area by the total area of the quadrangle. Notice the substantial change shown at the south end of the valley in the vicinity of Bakersfield, and the overall growth in ETAW in the valley.

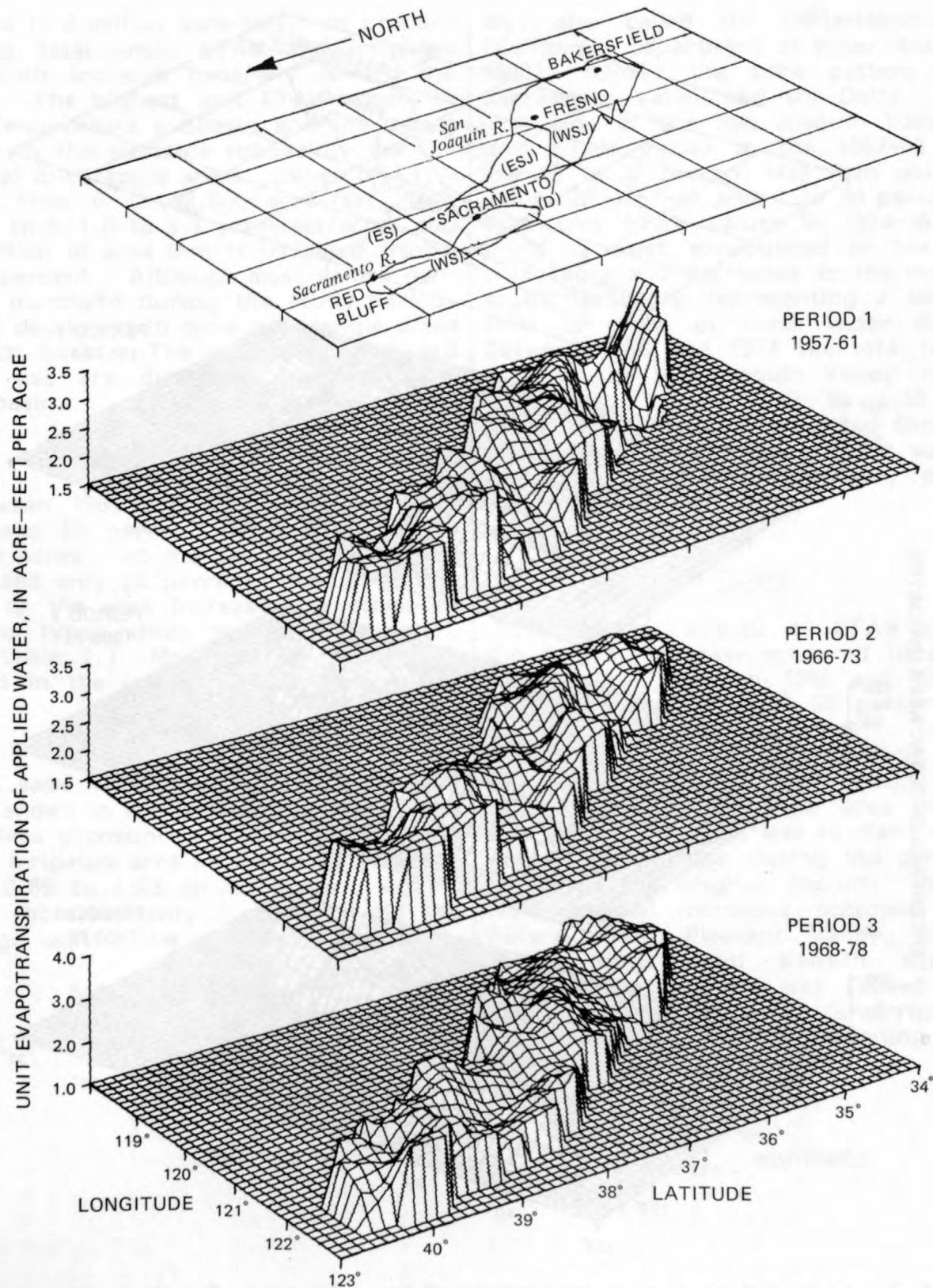


FIGURE 6.--Unit evapotranspiration of applied water (ETAW) for three time periods, represented by the apparent height of the surface of the three-dimensional views. The view is toward the southeast. The values, in acre-feet per acre, were determined by dividing the total ETAW for each 7.5-minute quadrangle area by the total irrigated area in that quadrangle. Unit ETAW is the weighted average crop ETAW. Notice that the lower Delta (D) and the west San Joaquin (WSJ) area have low unit ETAW for all three periods. Also, in all periods, the Sacramento Valley Westside (WS) has higher unit ETAW than the Eastside (ES), owing to the dominance of rice in the agriculture on the west side. In the east San Joaquin (ESJ) area, the unit ETAW is much lower in period 2 than in either periods 1 or 3. The high values south of Bakersfield in period 1 probably are not indicative of the area, because they represent a few quadrangles which had very little area surveyed.

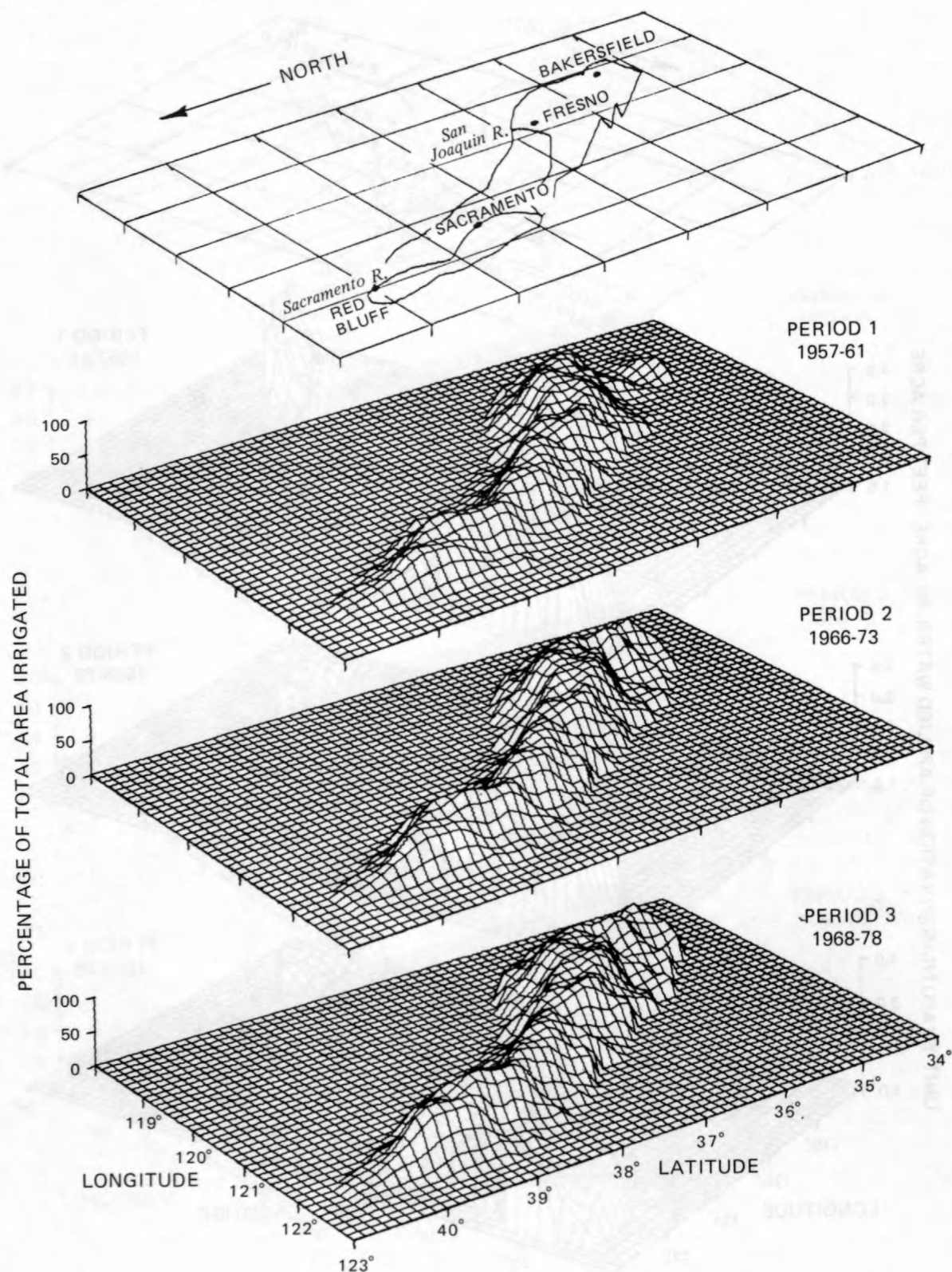


FIGURE 7.--Irrigated area as a percentage of the total area, for three time periods, represented by the apparent height of the surface of the three-dimensional views. The view is toward the southeast.

11.6 to 15.2 million acre-feet. In proportion to total area, ETAW and irrigated area both increase generally toward the south. The highest unit ETAW occurs in the Glenn-Colusa subbasin and the lowest occurs in the Westside subbasin. For individual quadrangle areas, values of ETAW range from 0 to 92,000 acre-feet, unit ETAW from 1.0 to 3.3 acre-feet/acre, and proportion of area that is irrigated from 0 to 97 percent. Although most values generally increased during the study period, values decreased in some quadrangle areas in each basin. The trends in land and water use are discussed separately for each basin.

Sacramento Valley

Between 1961 and 1976, irrigated area increased 55 percent, from 1.04 to 1.59 million acres. In the same period, ETAW increased only 22 percent, indicating that much of the area increase was composed of crop types which demand little water. (See table 1.) Most of the change occurred in the latter part of the period.

Delta

The same trend is shown in the Delta as is shown in the Sacramento Valley, but it is less pronounced. Between 1959 and 1976, irrigated area increased 21 percent, from 0.85 to 1.03 million acres. Again, ETAW increased only 2 percent, and the average unit ETAW declined 16 percent.

San Joaquin Valley

The west side of the San Joaquin Val-

ley, also called the Delta-Mendota area (California Department of Water Resources, 1980), follows the same pattern as the Sacramento Valley and the Delta. On the east side of the San Joaquin Valley, low unit ETAW values in the 1967-68 survey are 19 to 32 percent less than unit ETAW values in 1957-58 and 7 to 30 percent less than unit ETAW values in 1974-76. This trend is most pronounced in the Chowchilla area and decreases to the north and south, probably representing a temporary shift to crops of lower water demands. Between 1958 and 1974 the total irrigated area in the San Joaquin Valley increased 23 percent, from 1.10 to 1.36 million acres. This increase occurred throughout the basin except in the Modesto subbasin, where there was no increase, probably owing to urbanization.

Tulare

The largest amount of ETAW and also the largest increase occurred in the Tulare Basin. Between 1958 and 1975, the irrigated area increased 56 percent, from 2.09 to 3.26 million acres. The unit ETAW remained nearly constant during the period throughout the basin, so the ETAW increased with the area irrigated. The largest increase was in Kern County, where the increase during the period was six times the original amount. Progressively smaller increases occurred in the Tulare Lake, Pleasant Valley, Westside, Tule, Kings, and Kaweah subbasins. Most of the increase was caused by the delivery of surface water for irrigation by the California Aqueduct, beginning in 1967.

TABLE 4. - Summary of evapotranspiration of applied

[Numbers 1, 2, and 3 under column headings refer to periods
All values

Sub-basin No.	Name	Evapotranspiration of applied water (1,000 acre-ft)			Unit evapotranspiration of applied water (acre-ft/acre)		
		1	2	3	1	2	3
11	Tehama	330	350	360	2.4	2.2	1.8
12	Glenn-Colusa	370	380	470	3.0	2.9	2.5
13	Butte Basin	390	490	550	2.4	2.3	2.0
14	Colusa-Knights Ldg.	290	330	390	2.4	2.3	1.7
15	Sutter Basin	380	440	420	2.2	2.1	1.8
16	E. of Feather River	350	420	480	2.5	2.5	2.3
17	Cache-Putah	390	430	370	2.1	2.0	1.4
Total	Sacramento Valley	2,490	2,840	3,040	2.4	2.3	1.9
21	Sacramento County	420	430	430	2.3	2.1	1.8
22	Solano	190	220	230	2.1	2.0	1.6
23	E. San Joaquin County	790	830	800	2.2	2.2	2.0
24	Tracy	470	480	450	2.0	2.0	1.8
Total	Delta	1,860	1,960	1,910	2.2	2.1	1.8
31	Modesto	330	270	310	2.6	2.1	2.4
32	Delta-Mendota	890	930	980	2.4	2.3	2.3
33	Turlock	450	410	480	2.4	2.0	2.1
34	Merced	510	420	620	2.6	1.8	2.4
35	Chowchilla	260	190	290	2.6	1.8	2.6
36	Madera	320	270	480	2.5	1.8	2.3
Total	San Joaquin Valley	2,760	2,480	3,160	2.5	2.0	2.3
40	Pleasant Valley	60	70	90	1.6	1.6	1.6
41	Westside	700	850	990	1.7	1.7	1.8
42	Kings	1,600	1,800	1,800	2.3	2.3	2.3
43	Tulare Lake	550	760	790	1.9	2.1	2.1
44	Kaweah	640	640	660	2.4	2.2	2.3
45	Tule	590	660	750	2.3	2.3	2.2
46	Kern County	320	1,600	2,100	2.4	2.3	2.4
Total	Tulare	4,460	6,390	7,130	2.1	2.2	2.2
Grand total, Central Valley		11,570	13,670	15,240	2.3	2.1	2.1

water and area irrigated, by basin and subbasin

of land-use surveys: 1, 1957-61; 2, 1966-73; 3, 1968-78.
are rounded]

Irrigated area (1,000 acres)			Year surveyed			Number of 7½-minute quadrangles	Total area (1,000 acres)
1	2	3	1	2	3		
140	160	200	61	69	76	25	868
120	130	190	61	70	76	10	369
160	210	270	61	72	76	16	537
120	150	220	61	71	76	12	446
170	210	240	61	70	76	8	297
140	170	210	61	70	76	14	485
180	220	260	61	73	76	12	443
1,040	1,240	1,590	61	71	76	97	3,440
180	210	240	61	72	76	18	656
90	110	140	61	71	76	9	284
350	380	410	58	68	76	18	657
240	240	240	58	68	76	12	376
850	930	1,030	59	70	76	57	1,970
130	130	130	58	67	76	7	257
370	410	420	57	67	73	21	647
180	210	230	58	67	75	10	350
200	230	260	58	67	74	14	514
100	110	120	58	67	74	4	152
130	150	200	58	67	74	10	374
1,100	1,230	1,360	58	67	74	66	2,300
40	50	60	58	67	71	7	194
420	490	530	58	67	73	19	656
690	770	790	58	67	73	30	1,101
290	360	380	58	69	75	14	540
270	290	290	58	70	77	11	393
250	290	340	58	70	78	15	537
140	710	870	58	69	77	46	1,481
2,090	2,960	3,260	58	68	75	142	4,900
5,080	6,360	7,240	59	69	75	362	12,610

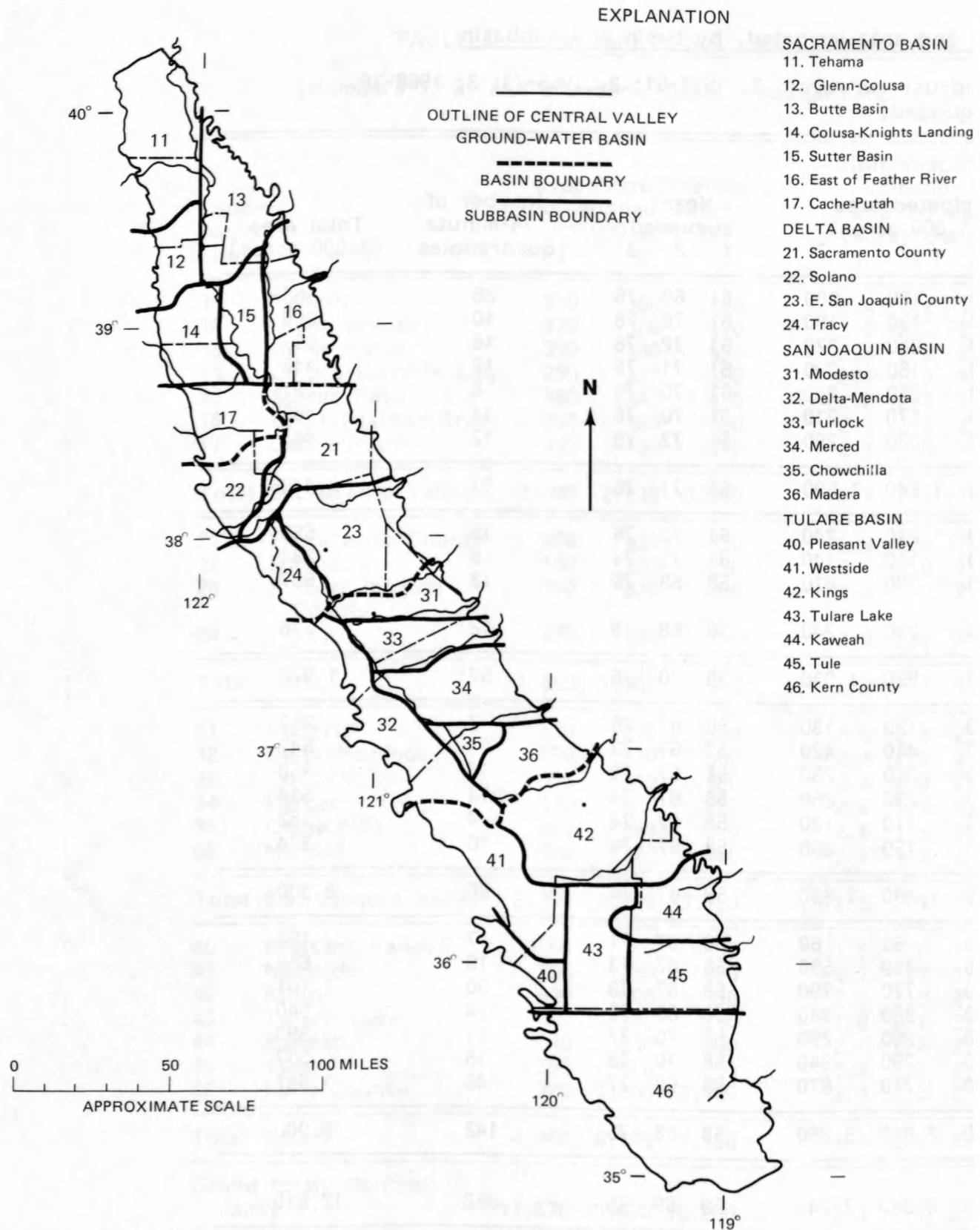


FIGURE 8.--Ground-water basins and subbasins of the Central Valley.

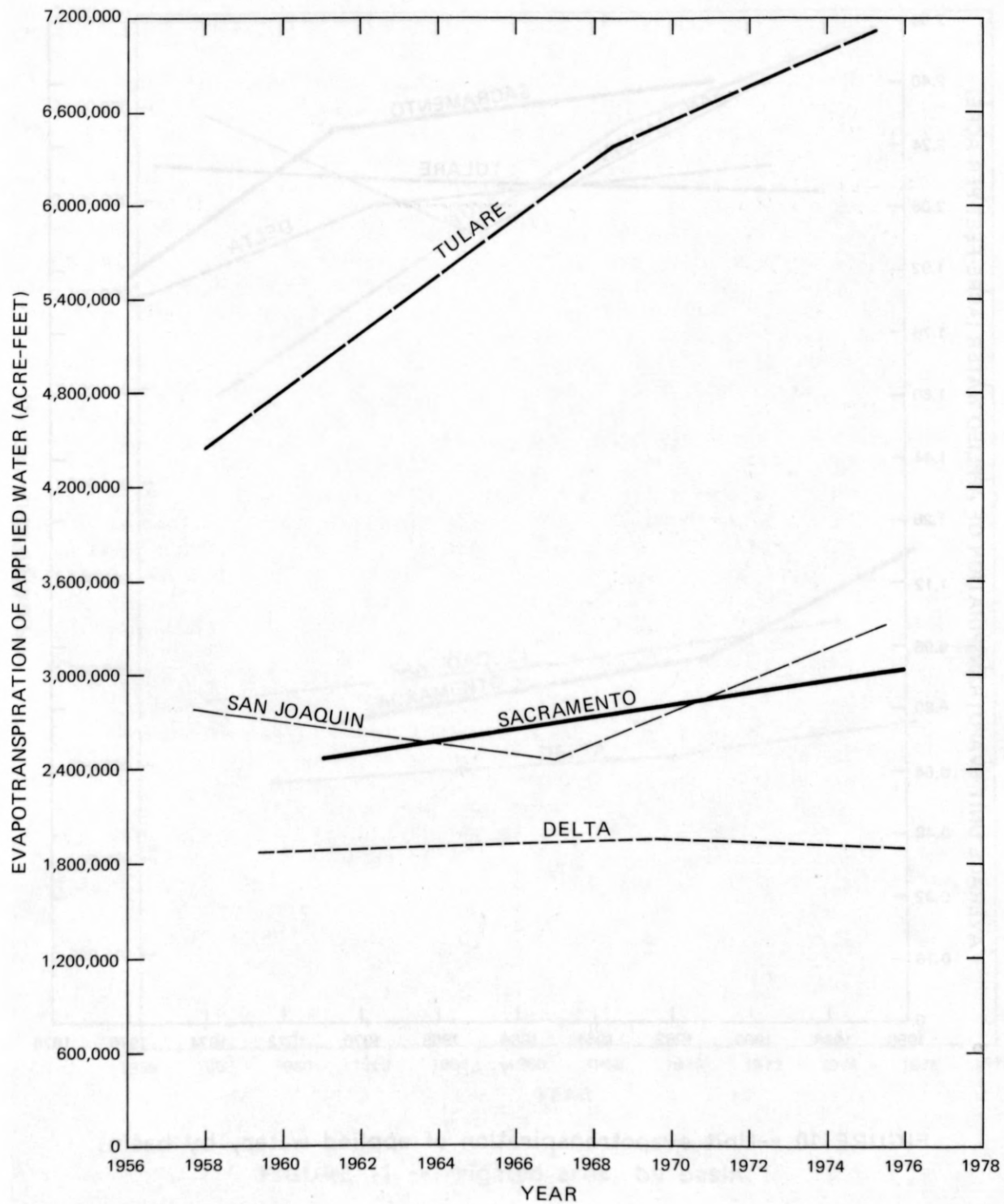


FIGURE 9.--Evapotranspiration of applied water, by basin.

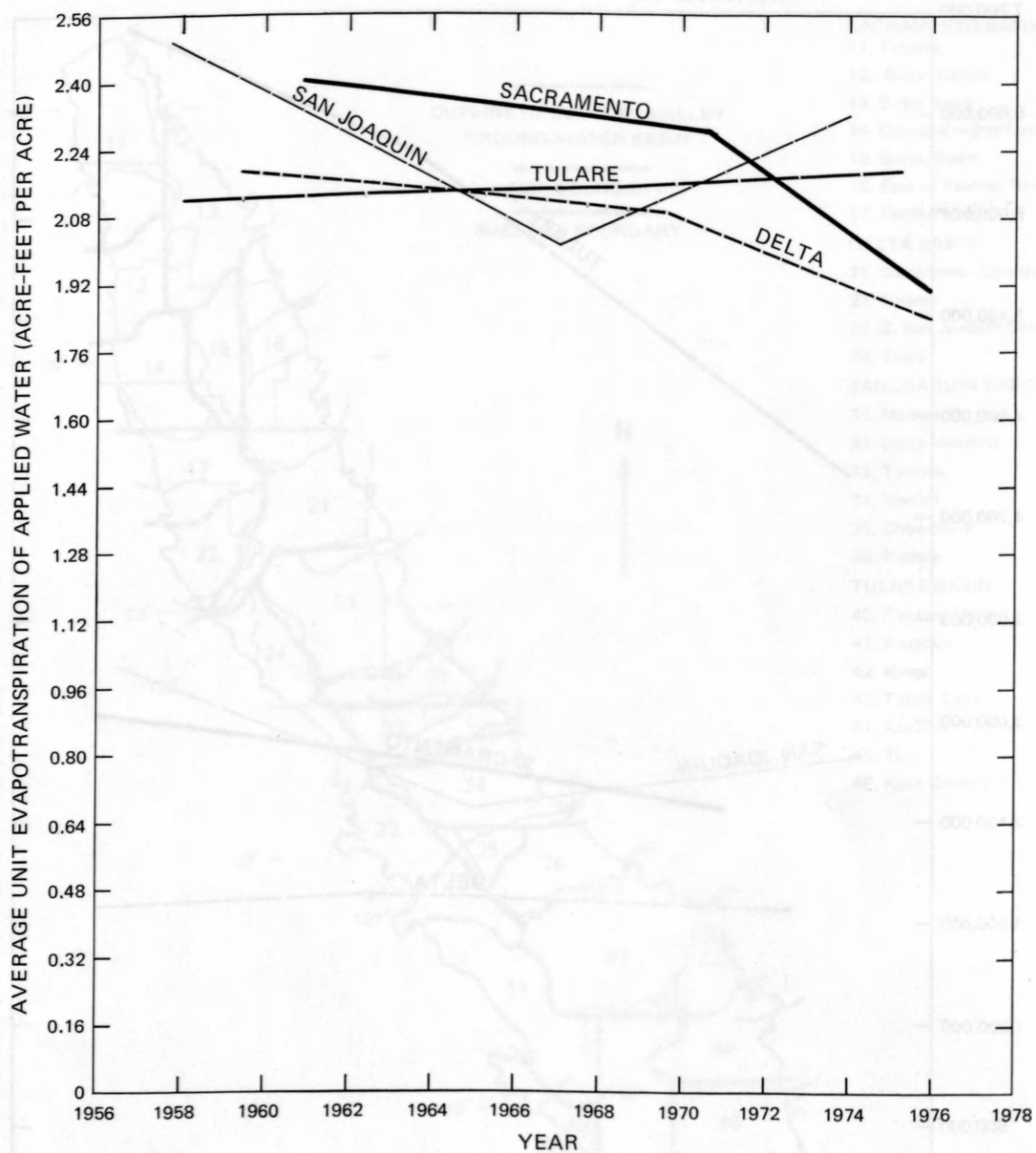


FIGURE 10.--Unit evapotranspiration of applied water, by basin.

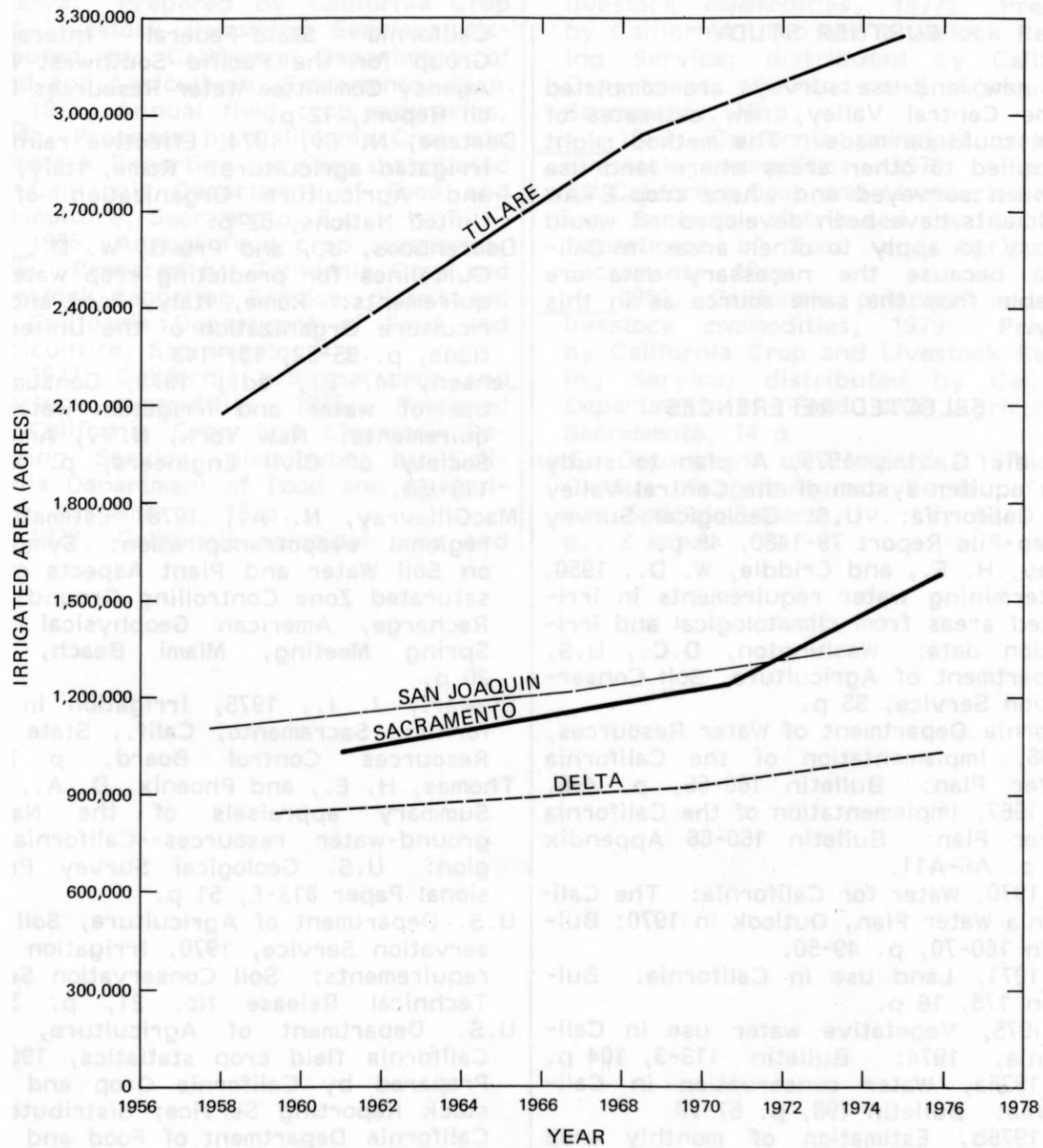


FIGURE 11.--Irrigated area, by basin.

FURTHER STUDY

As new land-use surveys are completed in the Central Valley, new estimates of ETAW could be made. The method might be applied to other areas where land use has been surveyed and where crop ETAW coefficients have been developed. It would be easy to apply to other areas in California because the necessary data are available from the same source as in this study.

SELECTED REFERENCES

- Bertoldi, G. L., 1979, A plan to study the aquifer system of the Central Valley of California: U.S. Geological Survey Open-File Report 79-1480, 48 p.
- Blaney, H. F., and Criddle, W. D., 1950, Determining water requirements in irrigated areas from climatological and irrigation data: Washington, D.C., U.S. Department of Agriculture, Soil Conservation Service, 35 p.
- California Department of Water Resources, 1966, Implementation of the California Water Plan: Bulletin 160-66, p. 4-6.
- _____, 1967, Implementation of the California Water Plan: Bulletin 160-66 Appendix A, p. A6-A11.
- _____, 1970, Water for California: The California Water Plan, Outlook in 1970: Bulletin 160-70, p. 49-50.
- _____, 1971, Land use in California: Bulletin 176, 16 p.
- _____, 1975, Vegetative water use in California, 1974: Bulletin 113-3, 104 p.
- _____, 1976a, Water conservation in California: Bulletin 198, p. 67-79.
- _____, 1976b, Estimation of monthly crop evapotranspiration for the Central Valley hydrology study: Memorandum report, 39 p.
- _____, 1977, Evapotranspiration of five irrigated crops in the southern San Joaquin Valley: 90 p.
- _____, 1980, Ground water basins in California: Bulletin 118-80, p. 34-44.
- California Region Framework Study Committee, 1968, California Region Framework Study, Water and related land resources, specifications and procedures: California State-Federal Interagency Group for the Pacific Southwest Inter-Agency Committee Water Resources Council Report, 12 p.
- Dastane, N. F., 1974, Effective rainfall in irrigated agriculture: Rome, Italy, Food and Agriculture Organization of the United Nations, 62 p.
- Doorenbos, J., and Pruitt, W. D., 1977, Guidelines for predicting crop water requirements: Rome, Italy, Food and Agriculture Organization of the United Nations, p. 35-82, 137-143.
- Jensen, M. E., ed., 1973, Consumptive use of water and irrigation water requirements: New York, N.Y., American Society of Civil Engineers, p. 49-65, 113-153.
- MacGillavray, N. A., 1978, Estimation of regional evapotranspiration: Symposium on Soil Water and Plant Aspects of Unsaturated Zone Controlling Ground Water Recharge, American Geophysical Union Spring Meeting, Miami Beach, Fla., 20 p.
- Stewart, J. I., 1975, Irrigation in California: Sacramento, Calif., State Water Resources Control Board, p. 15-40.
- Thomas, H. E., and Phoenix, D. A., 1976, Summary appraisals of the Nation's ground-water resources--California Region: U.S. Geological Survey Professional Paper 813-E, 51 p.
- U.S. Department of Agriculture, Soil Conservation Service, 1970, Irrigation water requirements: Soil Conservation Service Technical Release No. 21, p. 31-33.
- U.S. Department of Agriculture, 1973, California field crop statistics, 1965-72: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 20 p.
- _____, 1974a, California fruit and nut statistics, 1972-73: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 10 p.
- _____, 1974b, 1973 California fruit and nut acreage: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 24 p.
- _____, 1974c, California vegetable crops,

1972-73: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 26 p.

1975, Annual field crop summaries,

1974: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 8 p.

1976, Annual field crop summaries,

1975: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 4 p.

1977, California principal crop and livestock commodities, 1976: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 18 p.

1978, California principal crop and

livestock commodities, 1977: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 18 p.

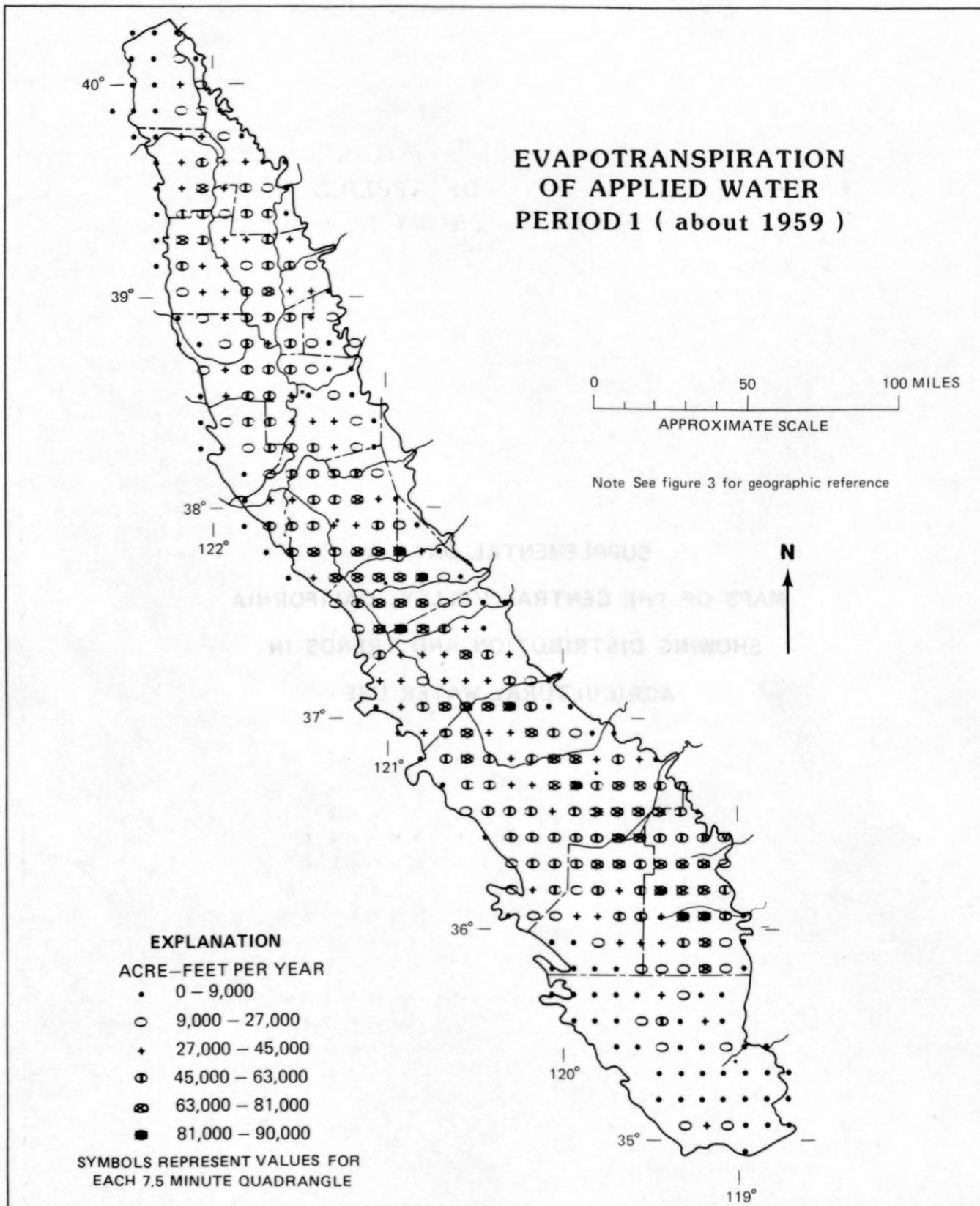
1979, California principal crop and livestock commodities, 1978: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 18 p.

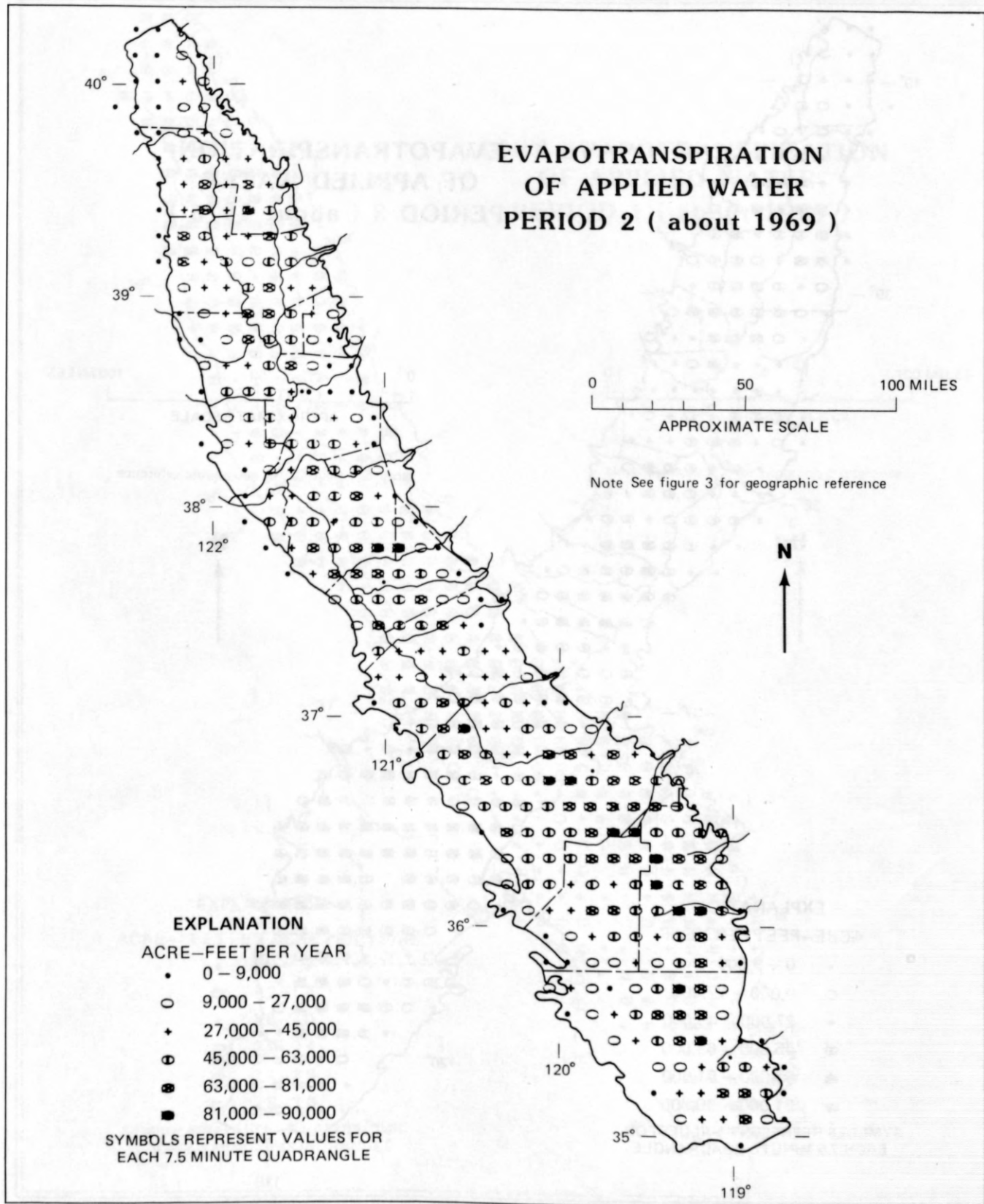
1980, California principal crop and livestock commodities, 1979: Prepared by California Crop and Livestock Reporting Service; distributed by California Department of Food and Agriculture, Sacramento, 14 p.

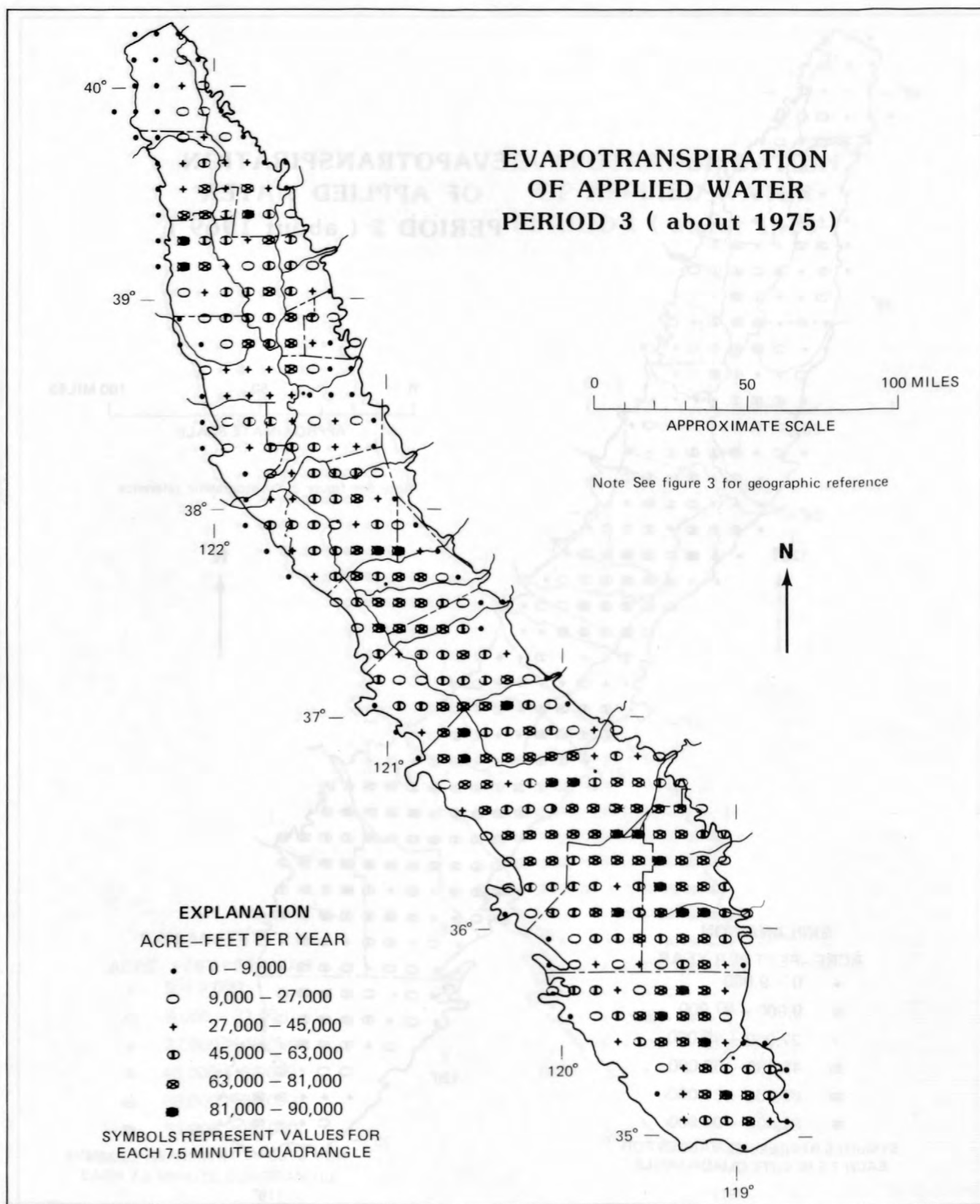
U.S. Department of Commerce, 1974, 1974 Census of agriculture: Bureau of Census Special Reports, v. IV, part 2, 99 p., 2 apps.

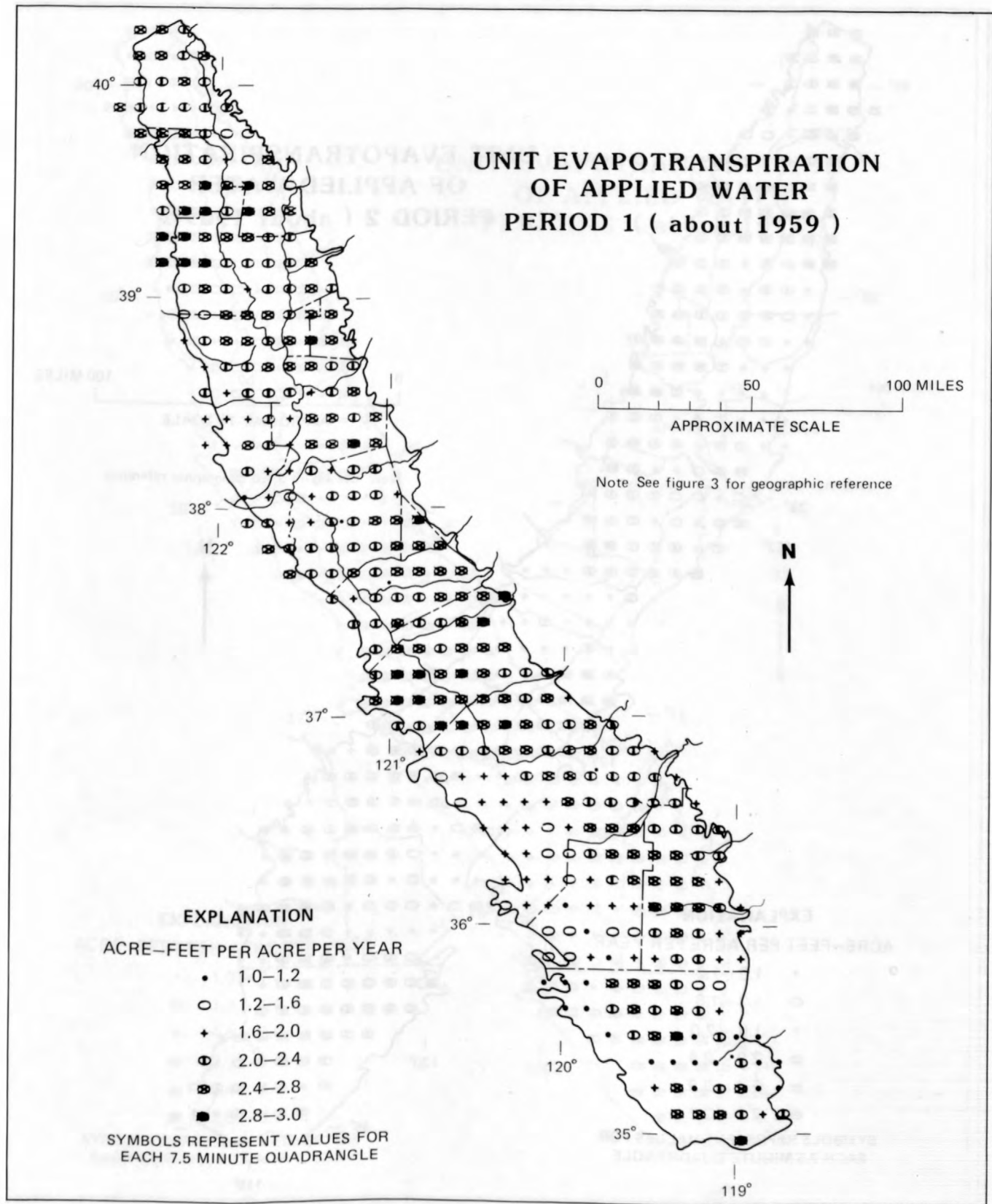
SUPPLEMENTAL DATA A
MAPS OF THE CENTRAL VALLEY, CALIFORNIA
SHOWING DISTRIBUTION AND TRENDS IN
AGRICULTURAL WATER USE

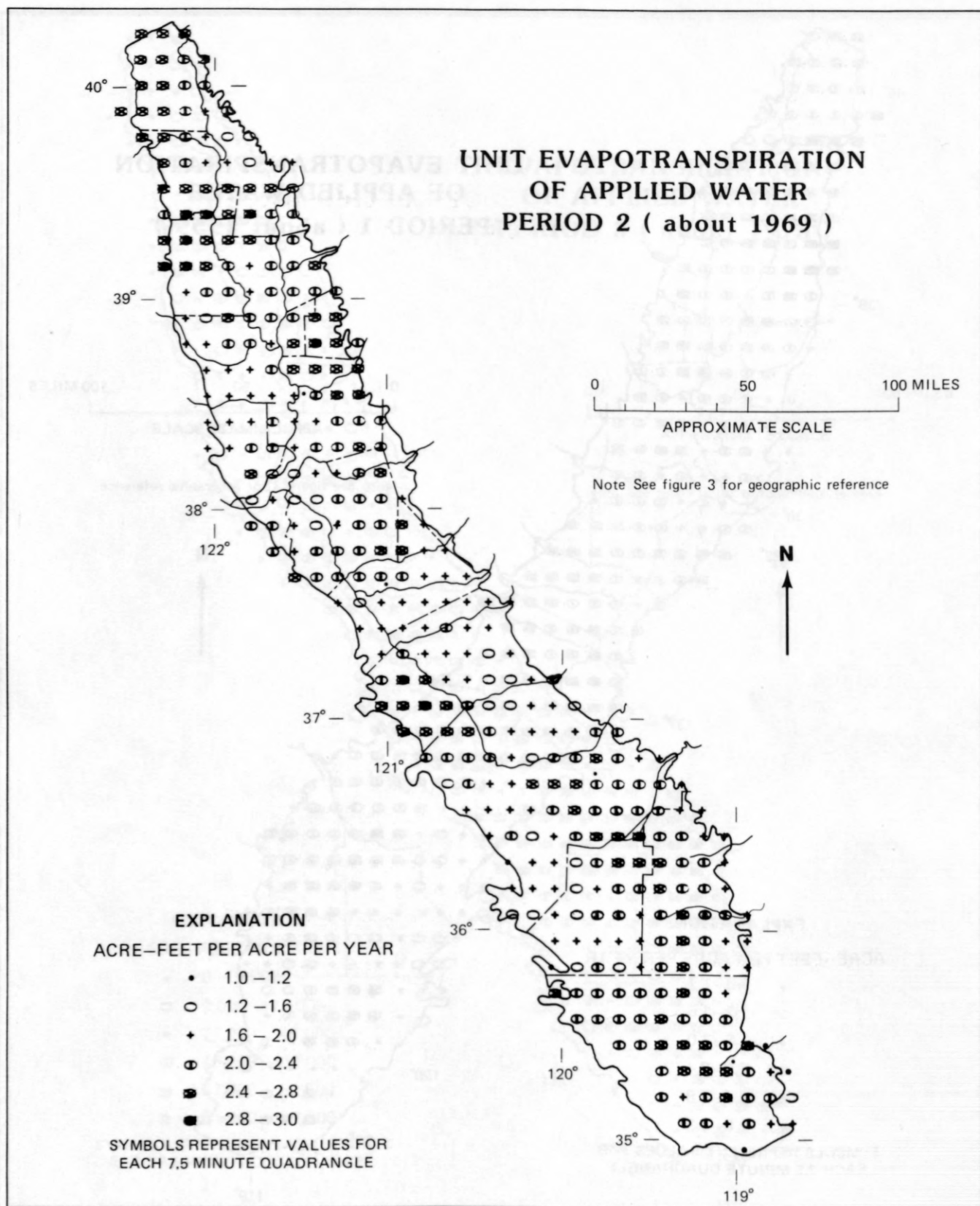




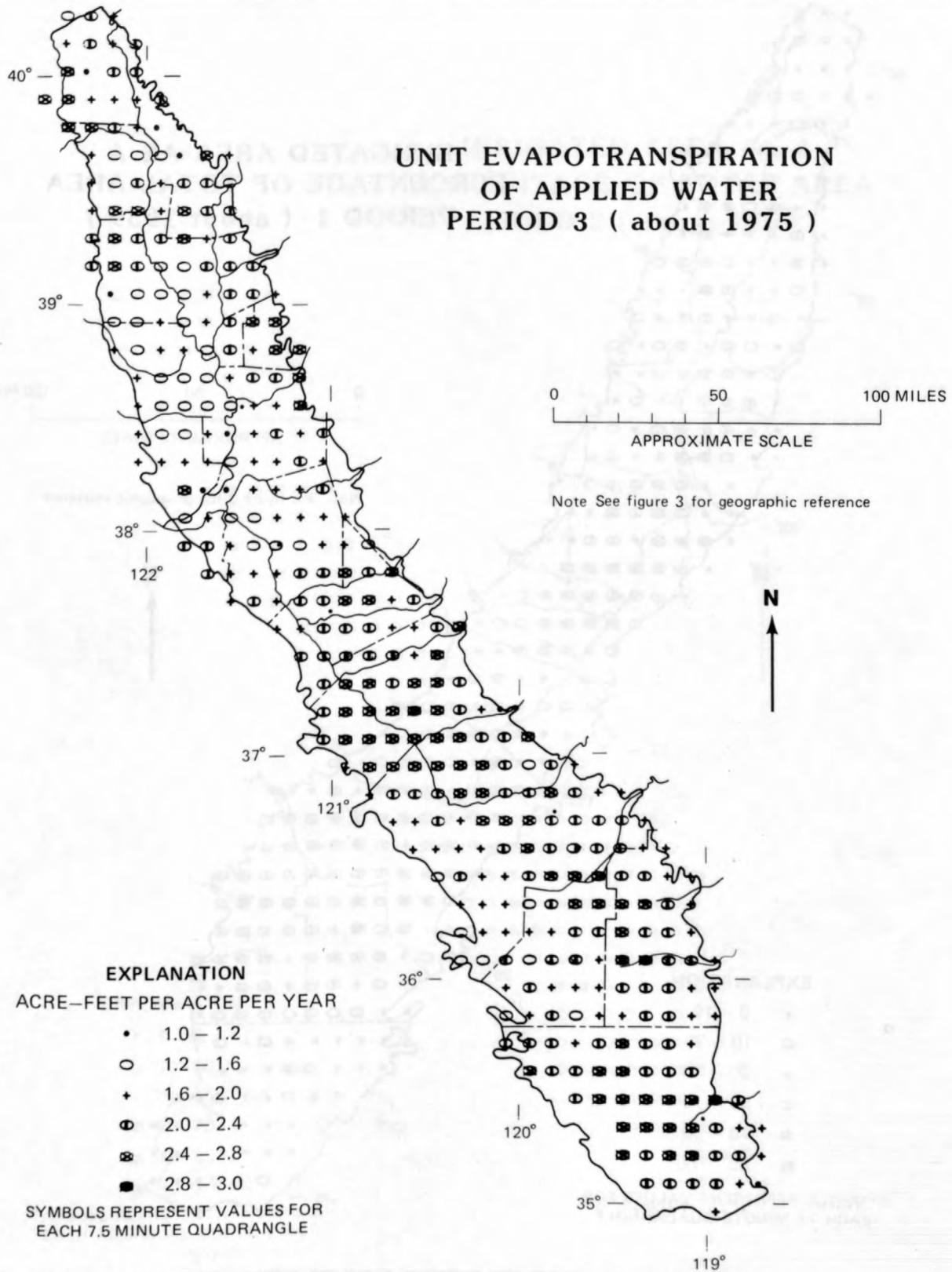


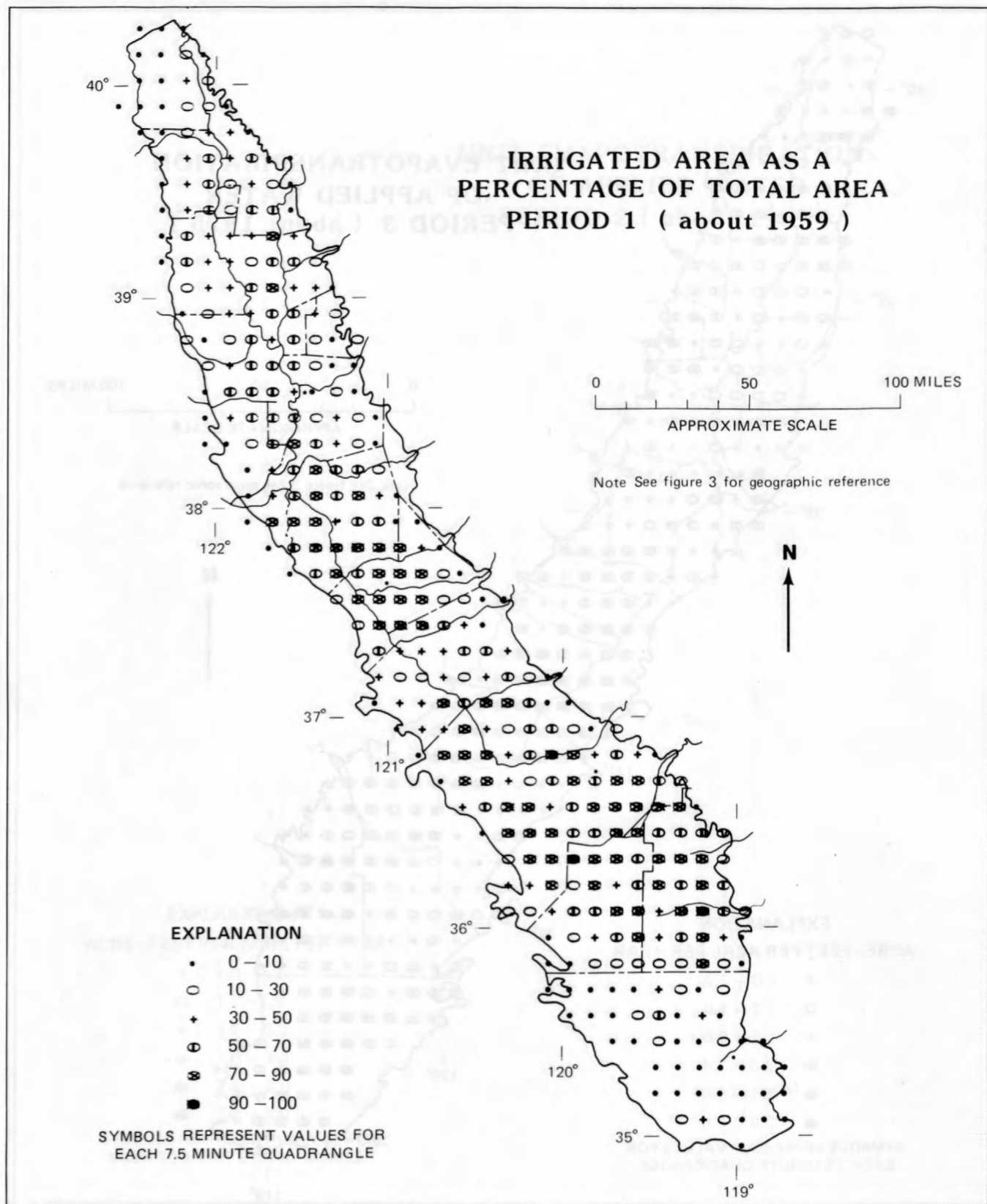




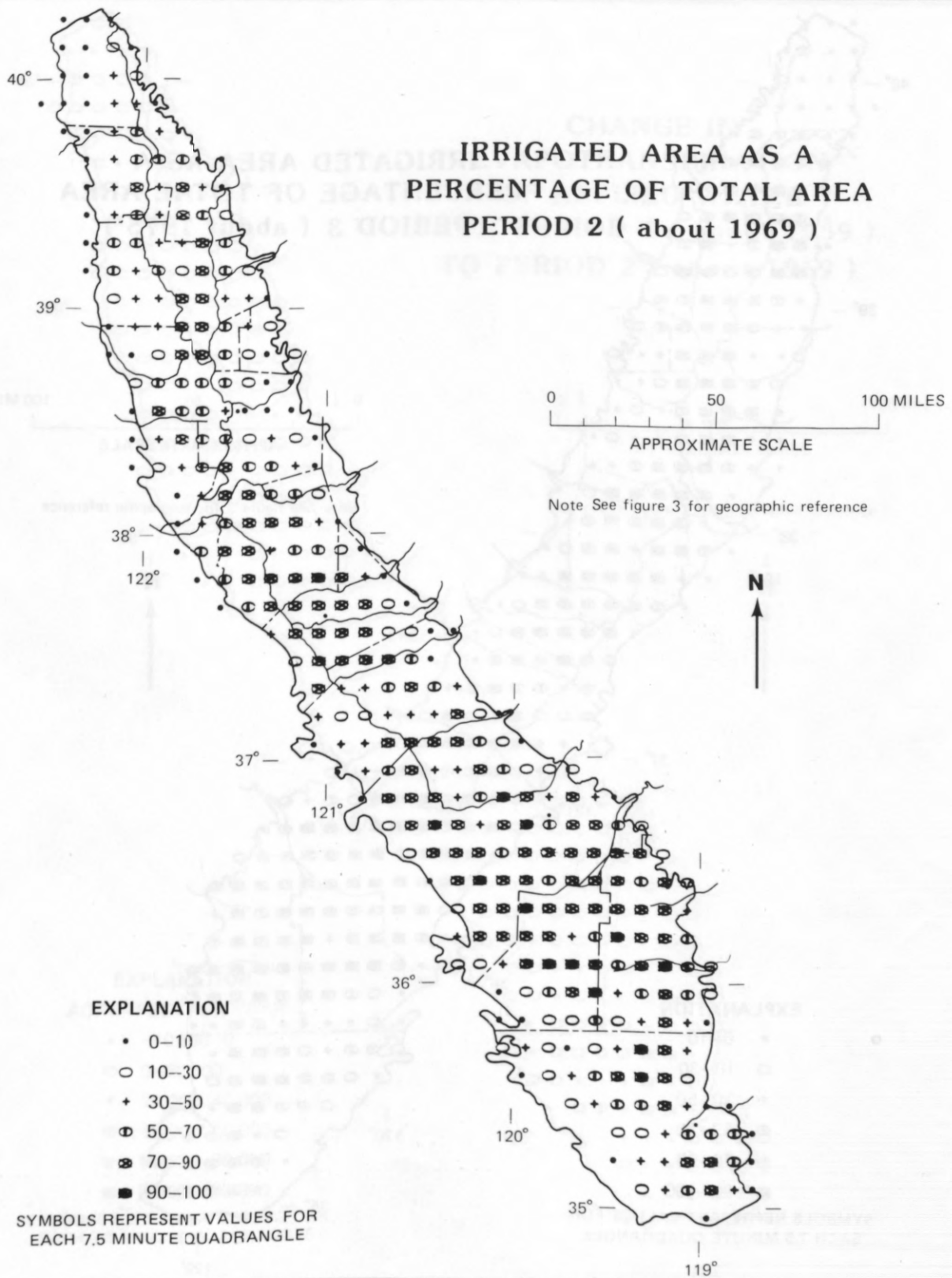


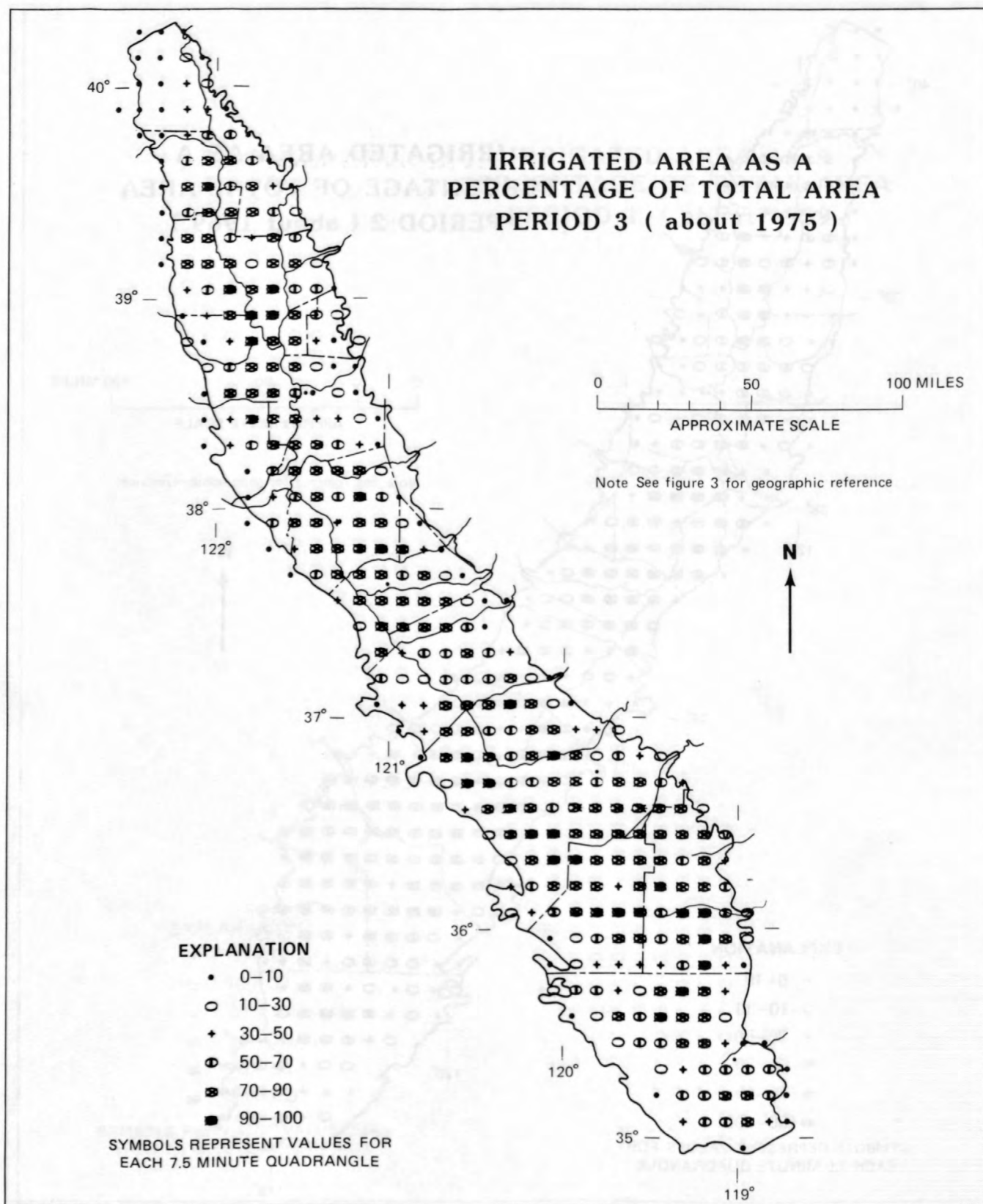
UNIT EVAPOTRANSPIRATION OF APPLIED WATER PERIOD 3 (about 1975)



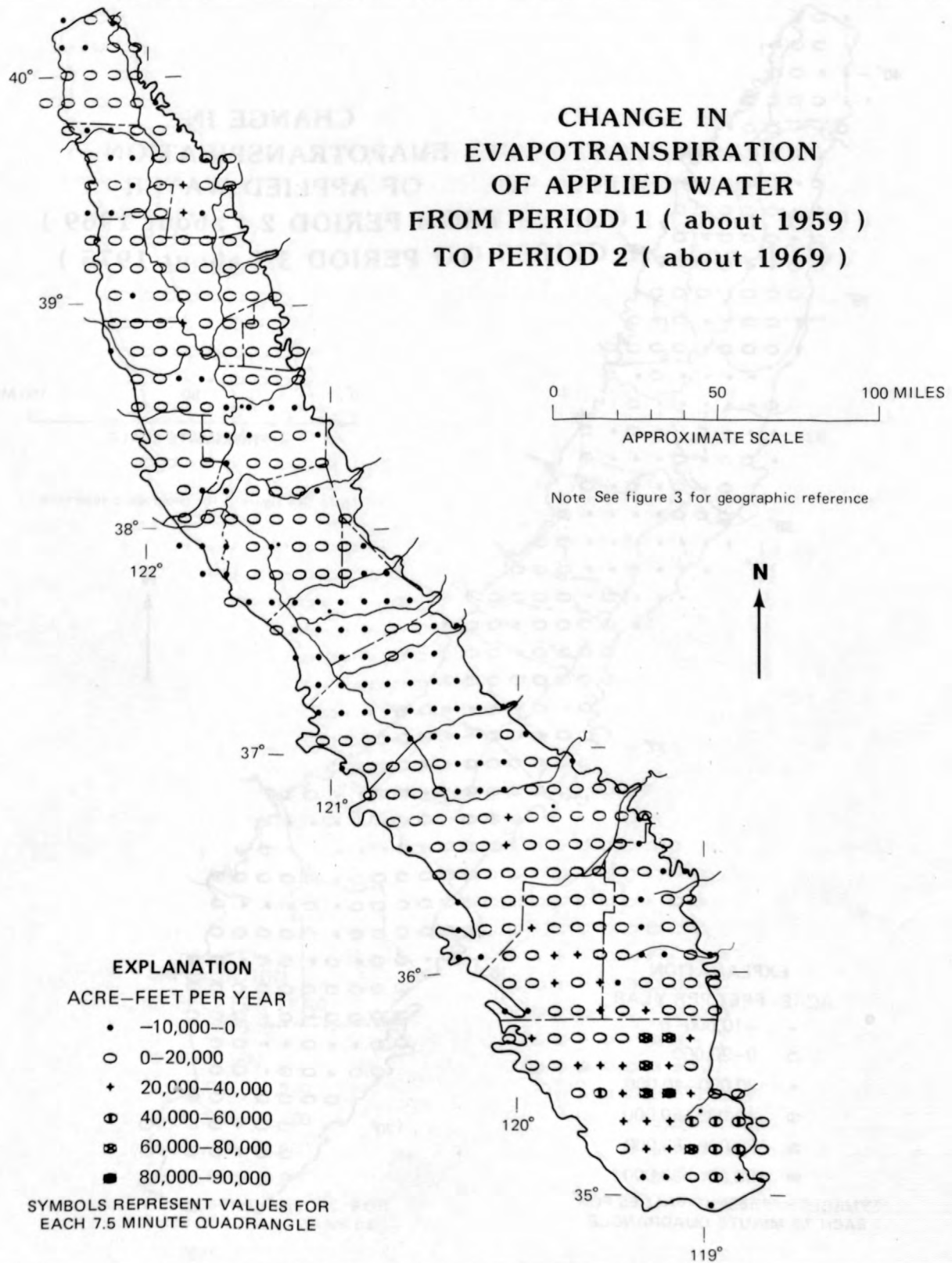


IRRIGATED AREA AS A
PERCENTAGE OF TOTAL AREA
PERIOD 2 (about 1969)

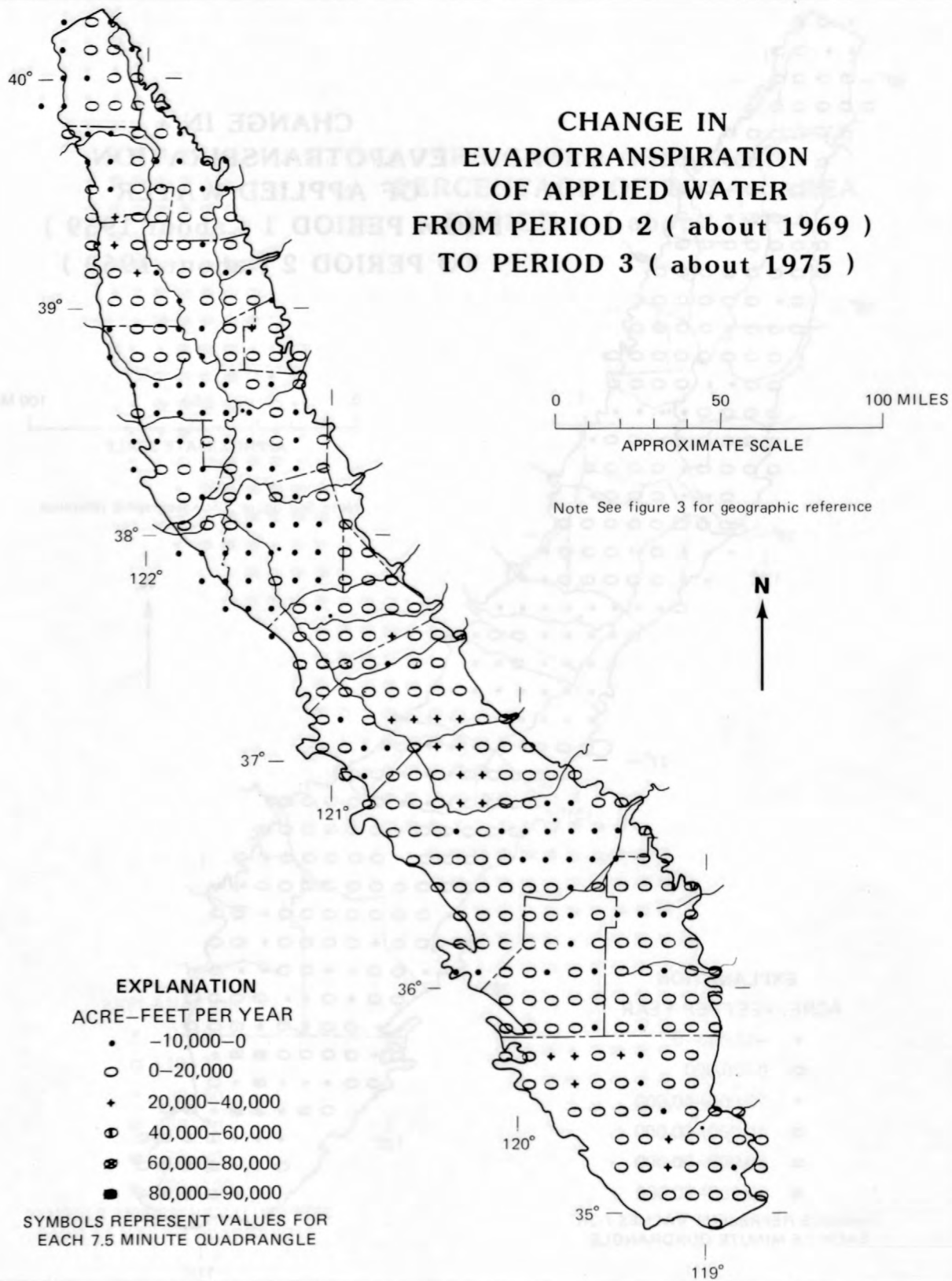




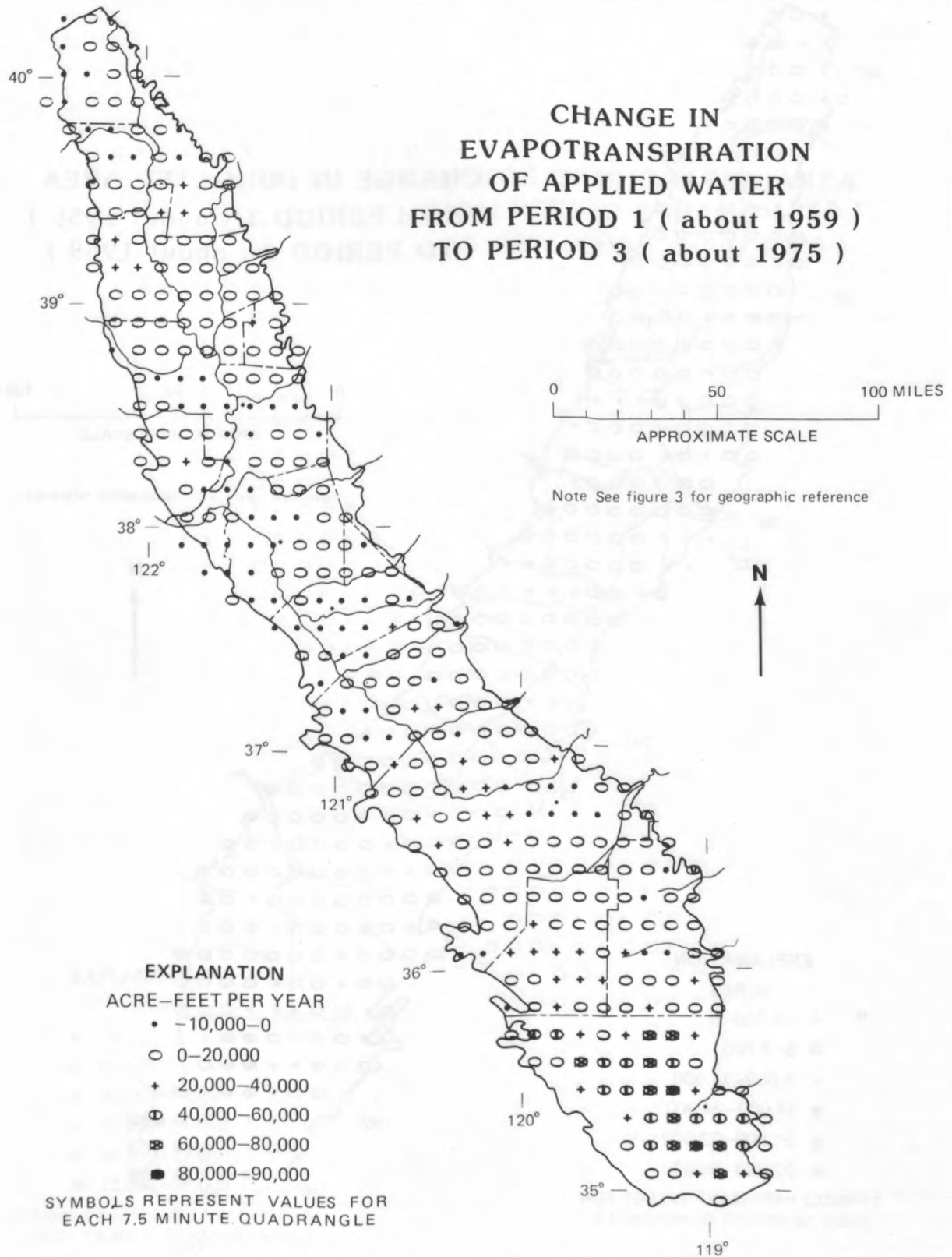
**CHANGE IN
EVAPOTRANSPIRATION
OF APPLIED WATER
FROM PERIOD 1 (about 1959)
TO PERIOD 2 (about 1969)**

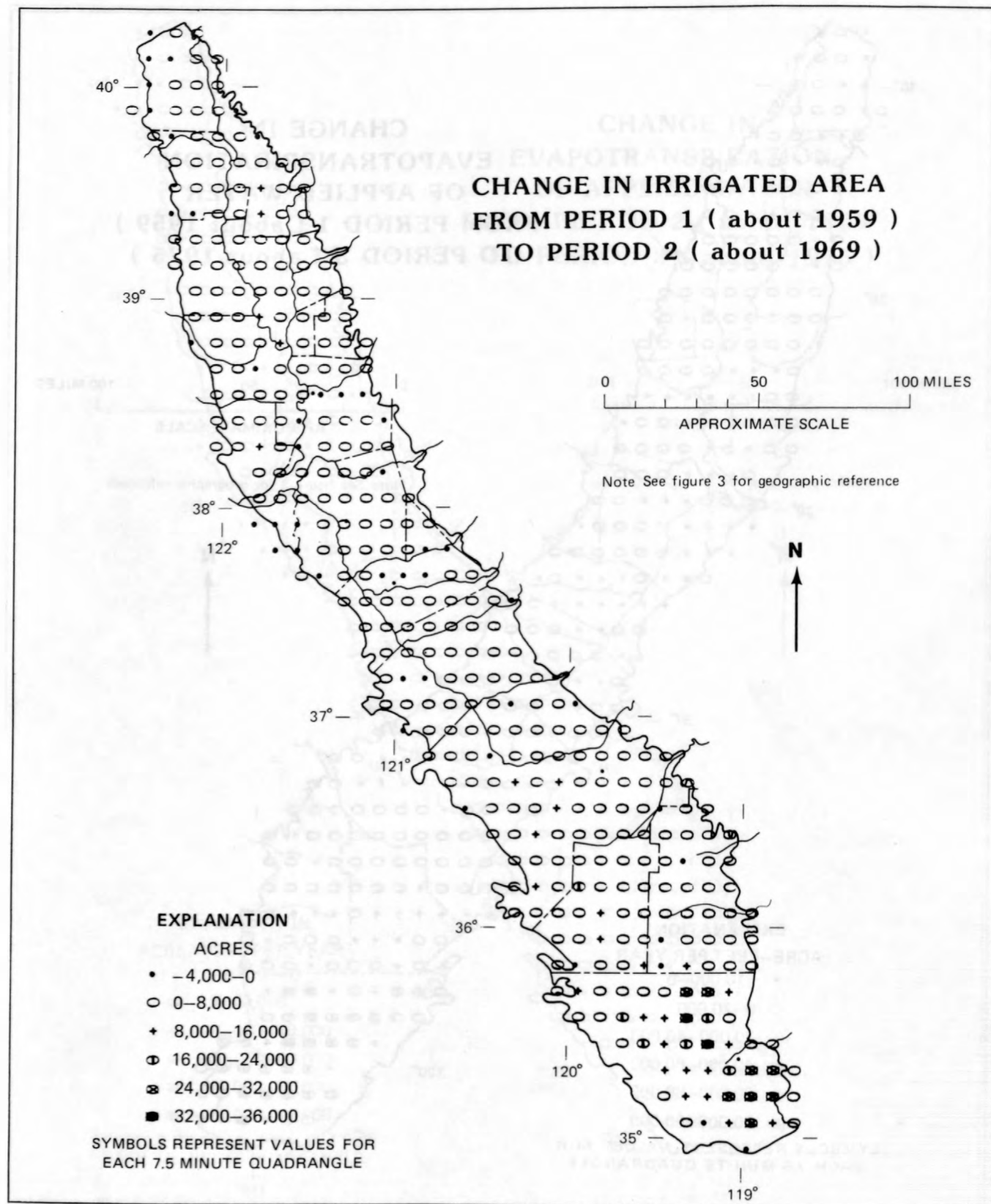


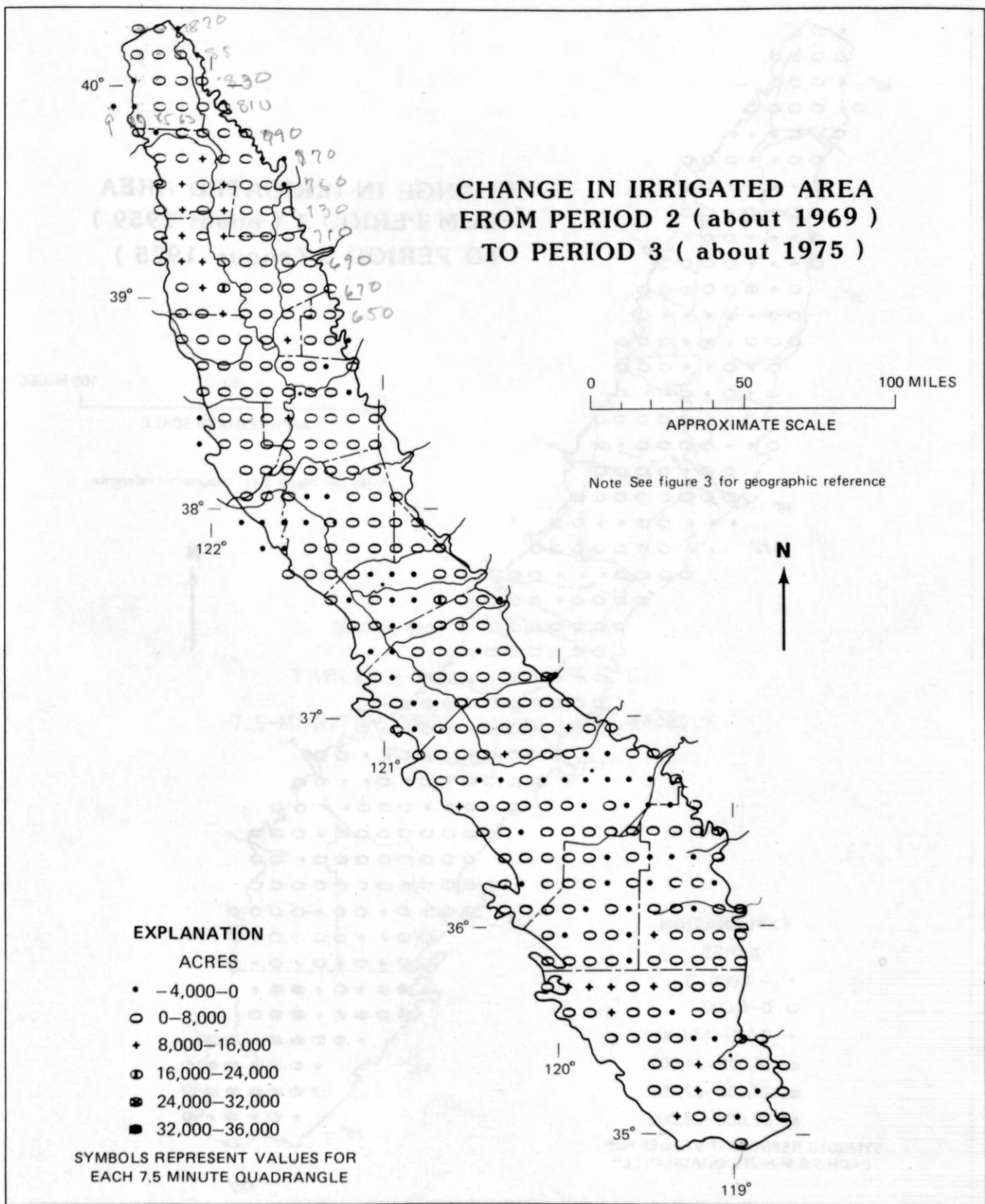
CHANGE IN EVAPOTRANSPIRATION OF APPLIED WATER FROM PERIOD 2 (about 1969) TO PERIOD 3 (about 1975)

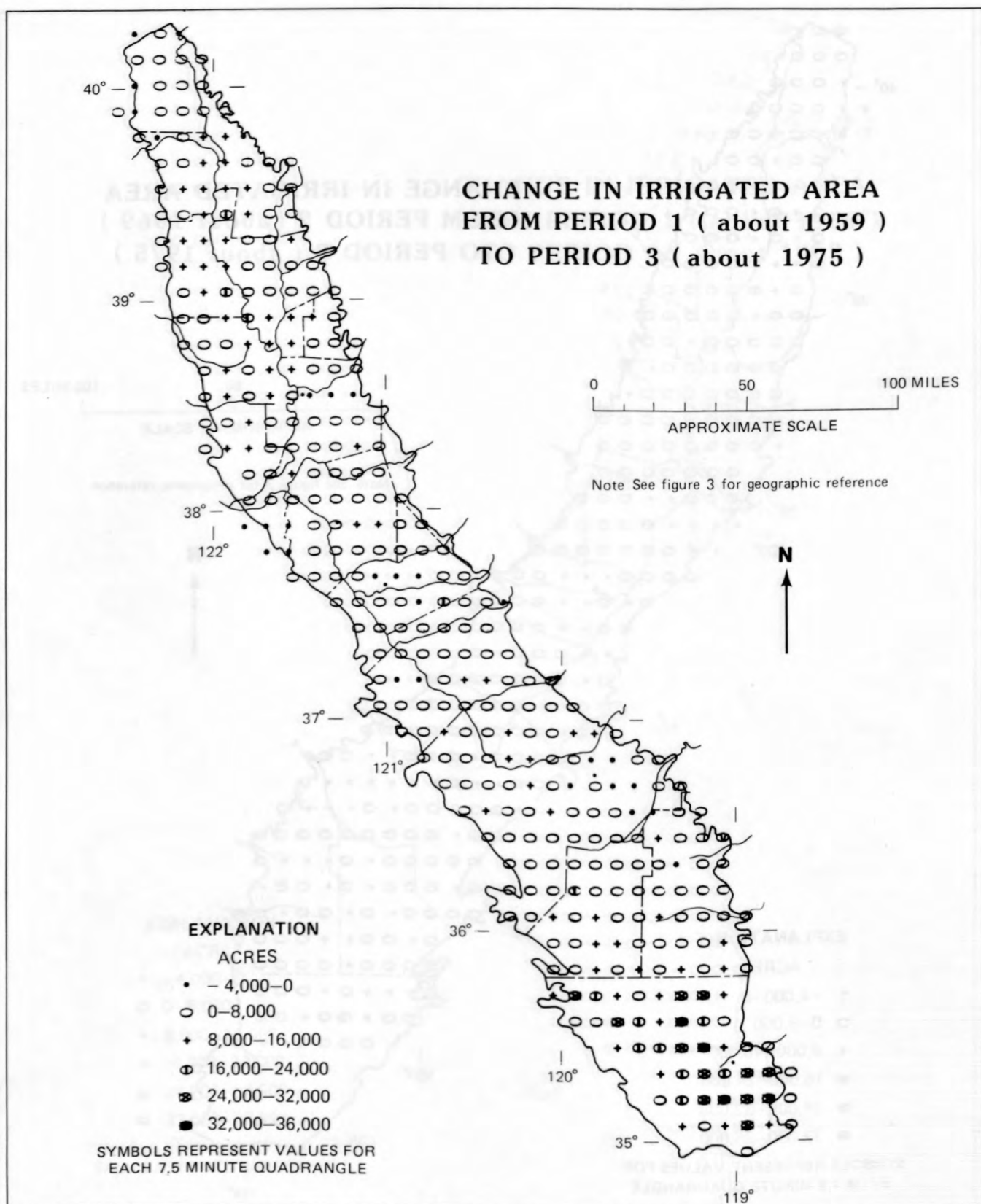


CHANGE IN EVAPOTRANSPIRATION OF APPLIED WATER FROM PERIOD 1 (about 1959) TO PERIOD 3 (about 1975)









SUPPLEMENTAL DATA B
TABLE OF RESULTS FOR EACH
7.5-MINUTE TOPOGRAPHIC QUADRANGLE

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TABLE OF RESULTS FOR EACH
7.5-MINUTE TOPOGRAPHIC QUADRANGLE

SUPPLEMENTAL DATA B. - EVAPOTRANSPIRATION OF APPLIED WATER AND AREA IRRIGATED

[Values shown are totals for the area in each 7.5-minute quadrangle for the year shown in each of three periods of land-use surveys. The total area of one quadrangle ranges from 39,100 acres at the south end of the valley to 36,500 acres at the north end. Abbreviations: Deg Min = degrees minutes; SPR(S) = Spring(s); BR = Bridge; PK = Peak]

Name of 7.5-minute quadrangle	Latitude (north) of southeast corner (Deg Min)	Longitude (west) (Deg Min)	Evapotranspiration of applied water (acre-ft)			Unit evapotranspiration of applied water (acre-ft/acre)			Area irrigated (percentage of total)			Irrigated area (acres)			Year surveyed		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
MITCHELL GULCH	4015.0	12222.5	1100	690	560	2.5	2.6	1.3	1.2	0.7	1.2	451	269	436	61	69	76
HOOKER	4015.0	12215.0	4700	5900	6700	2.7	2.7	2.4	4.9	6.1	7.6	1780	2240	2770	61	69	76
BEND	4015.0	12207.5	4900	6000	4000	2.2	2.6	1.9	6.1	6.3	5.8	2220	2300	2130	61	69	76
BLOSSOM	4007.5	12222.5	280	240	220	2.5	2.6	1.9	0.3	0.3	0.3	112	93	112	61	69	76
RED BLUFF W	4007.5	12215.0	1900	1900	2000	2.5	2.5	2.3	2.1	2.1	2.4	765	752	891	61	69	76
RED BLUFF E	4007.5	12207.5	14000	16000	17000	2.1	2.1	1.7	18.2	20.6	26.7	6640	7510	9750	61	69	76
TUSCAN SPRS	4007.5	12200.0	4800	4900	4400	2.6	2.5	2.3	5.1	5.4	5.2	1850	1970	1910	61	69	76
RED BANK	4000.0	12222.5	510	540	420	2.4	2.7	2.6	0.6	0.6	0.4	213	202	159	61	69	76
W OF GERBER	4000.0	12215.0	1300	1900	1000	2.4	2.6	1.2	1.5	2.0	2.2	548	747	800	61	69	76
GERBER	4000.0	12207.5	29000	35000	38000	2.5	2.4	2.1	31.4	40.0	48.9	11500	14600	17900	61	69	76
LOS MOLINOS	4000.0	12200.0	16000	18000	19000	2.2	2.2	2.2	19.4	22.1	23.6	7090	8090	8630	61	69	76
PASKENTA	3952.5	12230.0	140	180	170	2.7	2.7	2.7	0.1	0.2	0.2	51	65	64	61	69	76
FLOURNOY	3952.5	12222.5	1300	1400	1300	2.4	2.8	2.6	1.5	1.4	1.3	561	504	485	61	69	76
HENLEYVILLE	3952.5	12215.0	1800	2700	4500	2.4	2.7	1.9	2.1	2.7	6.6	753	991	2420	61	69	76
CORNING	3952.5	12207.5	18000	24000	25000	2.1	2.1	1.8	23.2	30.4	37.6	8520	11100	13800	61	69	76
VINA	3952.5	12200.0	22000	26000	27000	2.1	2.0	1.9	27.7	34.6	39.5	10200	12700	14500	61	69	76
RICHARDSON SPR NW	3952.5	12152.5	2100	1800	3800	2.4	2.1	2.2	2.4	2.3	4.6	879	855	1700	61	69	76
SEHORN CR	3945.0	12222.5	200	220	280	2.8	2.8	2.8	0.2	0.2	0.3	73	78	100	61	69	76
BLACK BUTTE DAM	3945.0	12215.0	5200	4800	4400	2.7	2.7	2.7	5.2	4.8	4.4	1900	1760	1630	61	69	76
KIRKWOOD	3945.0	12207.5	28000	27000	25000	2.6	2.4	2.2	29.2	30.5	31.1	10700	11200	11400	61	69	76
FOSTER ISLAND	3945.0	12200.0	33000	39000	41000	2.3	2.0	1.7	40.3	54.0	66.8	14800	19800	24500	61	69	76
NORD	3945.0	12152.5	18000	23000	26000	1.6	1.5	1.1	31.3	43.0	63.2	11500	15800	23200	61	73	76
RICHARDSON SPR	3945.0	12145.0	2500	1600	1400	1.6	1.4	1.1	4.1	3.1	3.4	1520	1120	1250	61	73	76

FRUTO NE	3937.5	12215.0	2200	2500	2500	2.8	2.7	1.9	2.2	2.5	3.6	814	930	1340	61	70	76
ORLAND	3937.5	12207.5	43000	40000	36000	2.5	2.3	1.5	47.2	47.7	63.7	17300	17500	23400	61	70	76
HAMILTON CITY	3937.5	12200.0	54000	48000	48000	2.4	2.0	1.5	61.1	63.8	87.9	22500	23500	32300	61	70	76
ORD FERRY	3937.5	12152.5	35000	43000	43000	1.9	1.8	1.5	49.0	66.5	78.0	18000	24500	28700	61	73	76
CHICO	3937.5	12145.0	28000	29000	28000	1.5	1.4	1.2	52.5	57.5	61.5	19300	21100	22600	61	73	76
HAMLIN CANYON	3937.5	12137.5	2800	2900	3700	2.7	1.9	2.7	2.8	4.2	3.7	1030	1530	1350	61	73	76
CHEROKEE	3937.5	12130.0	250	500	280	1.7	1.9	1.9	0.4	0.7	0.4	142	259	148	61	73	76
STONE VALLEY	3930.0	12215.0	740	1900	5800	2.7	2.5	1.7	0.8	2.1	9.0	278	778	3320	61	70	76
WILLOWS	3930.0	12207.5	38000	43000	42000	2.8	2.6	1.6	37.0	45.4	71.9	13600	16700	26500	61	70	76
GLENN	3930.0	12200.0	72000	71000	79000	2.9	2.7	2.4	68.5	70.6	91.0	25200	26000	33500	61	70	76
LLANO SECO	3930.0	12152.5	27000	37000	45000	2.7	2.5	1.8	26.9	39.6	65.7	9900	14600	24200	61	73	76
NELSON	3930.0	12145.0	45000	68000	71000	2.9	2.6	2.4	42.8	70.4	81.6	15800	25900	30100	61	73	76
SHIPPEE	3930.0	12137.5	24000	33000	31000	2.7	2.5	2.2	24.1	34.8	39.2	8870	12800	14400	61	73	76
OROVILLE	3930.0	12130.0	1500	1900	1700	1.4	1.5	1.5	2.9	3.4	3.2	1060	1260	1180	61	73	76
LOGAN RIDGE	3922.5	12215.0	1700	1200	4400	2.3	2.4	1.7	2.1	1.3	6.8	764	493	2520	61	70	76
LOGANDALE	3922.5	12207.5	52000	40000	64000	3.0	3.0	2.7	46.5	36.4	64.1	17100	13400	23700	61	70	76
PRINCETON	3922.5	12200.0	58000	67000	72000	3.0	2.9	2.6	52.1	61.5	75.9	19200	22700	28000	61	70	76
BUTTE CITY	3922.5	12152.5	25000	31000	50000	2.4	2.5	1.9	28.5	34.2	72.3	10500	12600	26700	61	70	76
W OF BIGGS	3922.5	12145.0	56000	83000	92000	3.0	3.1	2.8	50.1	72.8	87.7	18500	26900	32400	61	73	76
RIGGS	3922.5	12137.5	50000	50000	52000	2.5	2.4	2.3	54.3	57.5	60.8	20000	21200	22400	61	73	76
PALERMO	3922.5	12130.0	7500	13000	14000	2.5	2.2	2.2	8.2	15.8	16.6	3030	5820	6130	61	73	76
SITES	3915.0	12215.0	2100	3000	4700	3.1	2.6	2.2	1.8	3.1	5.8	672	1130	2140	61	70	76
MAXWELL	3915.0	12207.5	67000	70000	91000	3.0	3.0	2.8	59.8	62.3	86.5	22100	23000	32000	61	70	76
MOULTON WEIR	3915.0	12200.0	47000	51000	61000	2.8	2.6	2.2	45.7	52.5	74.1	16900	19400	27400	61	70	76
SANBORN SLOUGH	3915.0	12152.5	37000	40000	56000	2.6	2.5	2.2	38.2	42.8	67.4	14100	15800	24900	61	70	76
PENNINGTON	3915.0	12145.0	34000	43000	44000	2.6	2.7	2.6	34.8	43.5	46.5	12900	16100	17200	61	73	76
GRIDLEY	3915.0	12137.5	61000	67000	64000	2.3	2.1	2.0	73.4	84.7	84.8	27100	31300	31400	61	73	76
HONCUT	3915.0	12130.0	31000	47000	50000	2.3	2.3	2.2	36.4	54.7	61.0	13500	20200	22600	61	73	76
MANOR SLOUGH	3907.5	12215.0	3900	4900	6100	3.1	2.9	2.1	3.4	4.5	7.7	1270	1680	2850	61	70	76
MANOR SLOUGH	3907.5	12215.0	3900	4900	6100	3.1	2.9	2.1	3.4	4.5	7.7	1270	1680	2850	61	70	76
WILLIAMS	3907.5	12207.5	62000	65000	85000	3.1	2.9	2.7	54.4	60.0	84.5	20100	22200	31300	61	70	76
COLUSA	3907.5	12200.0	41000	43000	68000	3.0	2.7	2.4	37.4	42.6	74.8	13800	15800	27700	61	70	76
MERIDIAN	3907.5	12152.5	34000	48000	42000	2.2	2.1	1.6	41.2	61.9	71.3	15200	22900	26400	61	70	76
SUTTER BUTTES	3907.5	12145.0	13000	16000	16000	2.1	2.0	1.6	17.1	22.1	27.4	6320	8200	10200	61	70	76
SUTTER	3907.5	12137.5	54000	57000	60000	2.2	2.1	2.1	66.9	72.6	78.3	24800	26900	29000	61	70	76
YUBA CITY	3907.5	12130.0	51000	60000	59000	2.3	2.4	2.3	58.8	67.6	70.2	21800	25000	26000	61	69	76
BROWNS VALLEY	3907.5	12122.5	9900	12000	12000	2.5	2.5	2.1	10.5	13.0	15.4	3880	4820	5710	61	69	76

SUPPLEMENTAL DATA B. - EVAPOTRANSPIRATION OF APPLIED WATER AND AREA IRRIGATED--Continued

Name of 7.5-minute quadrangle	Latitude (north) of southeast corner (Deg Min)	Longitude (west) (Deg Min)	Evapotranspiration of applied water (acre-ft)			Unit evapotranspiration of applied water (acre-ft/acre)			Area irrigated (percentage of total)			Irrigated area (acres)			Year surveyed		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CORTINA CR	3900.0	12207.5	9600	11000	11000	2.3	1.8	1.0	11.2	15.8	30.6	4150	5880	11300	61	70	76
ARBUCKLE	3900.0	12200.0	32000	28000	40000	2.5	2.2	1.6	34.0	35.2	68.5	12600	13000	25400	61	70	76
GRIMES	3900.0	12152.5	34000	41000	49000	2.4	2.4	1.4	37.6	47.4	90.9	14000	17600	33700	61	70	76
TISDAL WEIR	3900.0	12145.0	47000	55000	51000	1.8	1.8	1.5	68.8	81.9	89.4	25500	30400	33200	61	70	76
GILSIZER SLOUGH	3900.0	12137.5	63000	64000	65000	2.3	2.1	1.9	74.8	82.5	90.4	27800	30600	33500	61	70	76
OLIVEHURST	3900.0	12130.0	40000	40000	47000	2.3	2.3	2.2	46.5	47.5	57.2	17200	17600	21200	61	69	76
WHEATLAND	3900.0	12122.5	34000	35000	41000	2.5	2.4	2.2	36.3	38.4	51.5	13500	14200	19100	61	69	76
CAMP FAR WEST	3900.0	12115.0	1100	3500	3200	2.3	2.3	1.8	1.3	4.1	4.8	475	1510	1770	61	69	76
RUMSEY	3852.5	12207.5	990	1400	1300	1.3	1.9	1.5	2.0	2.1	2.3	746	773	862	61	70	76
WILDWOOD SCHOOL	3852.5	12200.0	17000	21000	23000	1.6	1.6	1.4	28.3	33.8	43.1	10500	12500	16000	61	70	76
DUNNIGAN	3852.5	12152.5	39000	42000	55000	2.7	2.7	1.9	39.9	42.6	78.7	14800	15800	29200	61	70	76
KIRKVILLE	3852.5	12145.0	45000	70000	57000	2.5	2.4	1.6	47.8	79.1	93.5	17800	29400	34700	61	70	76
SUTTER CAUSEWAY	3852.5	12137.5	62000	63000	62000	2.6	2.2	1.8	63.5	78.4	93.3	23600	29100	34700	61	70	76
NICOLAUS	3852.5	12130.0	46000	54000	63000	2.4	2.3	2.3	51.5	62.9	74.2	19200	23400	27600	61	70	76
SHERIDAN	3852.5	12122.5	31000	41000	61000	2.6	2.7	2.8	32.2	40.4	59.4	12000	15000	22100	61	69	76
LINCOLN	3852.5	12115.0	12000	15000	18000	2.6	2.8	2.6	12.4	14.3	19.1	4600	5320	7090	61	69	76
GUINDA	3845.0	12207.5	7400	7400	6900	2.0	2.0	1.7	10.1	9.9	11.0	3760	3670	4090	61	73	76
BIRD VALLEY	3845.0	12200.0	2000	3500	3900	2.1	1.9	1.5	2.6	5.0	7.0	961	1850	2590	61	73	76
ZAMORA	3845.0	12152.5	16000	20000	21000	2.6	2.4	1.8	16.1	22.0	31.6	5980	8180	11800	61	73	76
ELDORADO BEND	3845.0	12145.0	56000	65000	65000	2.5	2.4	1.9	60.4	74.3	92.2	22500	27600	34300	61	73	76
KNIGHTS LANDING	3845.0	12137.5	38000	50000	48000	2.2	1.9	1.6	46.8	70.7	80.3	17400	26300	29900	61	73	76
VERONA	3845.0	12130.0	50000	55000	67000	2.7	2.7	2.2	50.1	53.8	83.3	18700	20000	31000	61	70	76
PLEASANT GROVE	3845.0	12122.5	21000	26000	28000	2.9	3.0	2.0	19.2	23.4	36.9	7150	8700	13700	61	69	76
ROSEVILLE	3845.0	12115.0	3400	5300	6100	2.7	2.8	2.5	3.5	5.0	6.7	1290	1880	2490	61	69	76
ROCKLIN	3845.0	12107.5	10000	13000	13000	2.0	2.3	2.5	13.4	14.8	14.1	5000	5500	5250	61	69	76
ESPARTO	3837.5	12200.0	12000	19000	17000	1.7	1.8	1.7	18.3	27.0	27.5	6810	10100	10200	61	73	76
MADISON	3837.5	12152.5	38000	44000	35000	2.3	1.9	1.4	43.9	61.0	67.4	16400	22800	25100	61	73	76
WOODLAND	3837.5	12145.0	45000	44000	34000	2.1	2.0	1.3	59.2	57.7	71.7	22100	21500	26700	61	73	76
GRAYS BEND	3837.5	12137.5	49000	48000	42000	2.5	2.1	1.5	53.4	62.0	75.4	19900	23100	28100	61	73	76
TAYLOR MONUMENT	3837.5	12130.0	58000	65000	63000	2.6	2.6	1.9	60.0	66.8	88.2	22400	24900	32900	61	69	76
RIO LINDA	3837.5	12122.5	11000	12000	14000	2.6	2.6	2.2	11.0	12.1	17.6	4090	4500	6550	61	69	76
CITRUS HEIGHTS	3837.5	12115.0	2000	4600	3000	2.1	2.5	2.1	2.5	4.8	3.9	935	1810	1450	61	69	76
FOLSOM	3837.5	12107.5	4800	5400	5900	2.4	2.5	2.6	5.4	5.7	6.1	2000	2120	2270	61	69	76

MONTICELLO DAM	3830.0	12200.0	2300	2500	2700	2.1	2.0	1.8	3.0	3.3	4.0	1120	1240	1510	61	73	76
WINTERS	3830.0	12152.5	41000	54000	45000	1.9	2.0	1.5	57.4	72.6	81.1	21400	27100	30300	61	73	76
MERRITT	3830.0	12145.0	47000	47000	38000	2.1	2.0	1.3	60.0	64.7	79.2	22400	24200	29600	61	73	76
DAVIS	3830.0	12137.5	46000	47000	43000	2.2	1.9	1.4	55.0	64.6	81.3	20500	24100	30300	61	73	76
SACRAMENTO W	3830.0	12130.0	34000	34000	32000	2.3	1.9	1.5	39.9	48.3	58.6	14900	18000	21900	61	73	76
SACRAMENTO E	3830.0	12122.5	4300	2300	1900	1.9	2.2	1.8	5.9	2.8	2.9	2200	1060	1070	61	69	76
CARMICHAEL	3830.0	12115.0	12000	8600	8700	2.4	2.5	1.9	13.3	9.2	12.3	4980	3450	4610	61	69	76
RUFFALO CR	3830.0	12107.5	2400	2300	1800	2.7	2.7	2.6	2.3	2.3	1.8	872	857	666	61	73	76
MT VACA	3822.5	12200.0	1300	3800	3600	1.8	1.8	1.8	1.9	5.6	5.4	713	2080	2020	61	73	76
ALLENDALE	3822.5	12152.5	22000	27000	26000	1.8	2.0	1.5	32.3	36.0	45.5	12100	13500	17000	61	73	76
DIXON	3822.5	12145.0	49000	60000	52000	2.0	2.0	1.5	65.4	81.4	91.0	24500	30500	34000	61	73	76
SAXON	3822.5	12137.5	52000	56000	56000	2.4	2.2	1.9	58.2	67.0	79.4	21800	25100	29700	61	73	76
CLARKSBURG	3822.5	12130.0	41000	36000	35000	2.0	1.9	1.2	56.7	51.6	76.7	21200	19300	28700	61	73	76
FLORIN	3822.5	12122.5	28000	20000	20000	2.7	1.9	1.7	27.6	27.7	31.9	10300	10400	11900	61	73	76
ELK GROVE	3822.5	12115.0	35000	36000	36000	2.7	2.4	2.2	34.8	40.0	44.5	13000	15000	16700	61	73	76
SLOUGH HOUSE	3822.5	12107.5	14000	17000	16000	2.4	2.3	2.0	16.1	19.7	21.4	6010	7360	8000	61	73	76
CARBONDALE	3822.5	12100.0	2500	2200	2200	2.7	2.4	2.1	2.5	2.4	2.8	950	889	1040	61	73	76
FAIRFIELD N	3815.0	12200.0	240	2800	1900	1.9	1.9	2.0	0.3	4.0	2.5	124	1480	937	61	68	76
ELMIRA	3815.0	12152.5	6500	17000	21000	2.0	1.8	1.7	8.8	24.9	34.2	3280	9320	12800	61	68	76
DOZIER	3815.0	12145.0	14000	32000	36000	2.6	2.1	1.9	14.0	39.7	50.3	5250	14900	18800	61	68	76
LIBERTY ISLAND	3815.0	12137.5	47000	51000	49000	2.2	2.3	1.7	57.1	60.0	75.2	21400	22500	28200	61	73	76
COURTLAND	3815.0	12130.0	53000	46000	48000	1.9	1.8	1.4	72.6	70.3	89.4	27200	26300	33500	61	73	76
BRUCEVILLE	3815.0	12122.5	55000	60000	59000	2.6	2.3	2.0	56.9	69.8	77.6	21300	26100	29100	61	73	76
GALT	3815.0	12115.0	38000	46000	40000	2.7	2.4	2.0	37.8	51.3	54.0	14200	19200	20200	61	73	76
CLAY	3815.0	12107.5	21000	34000	33000	2.9	2.5	2.1	19.3	35.7	41.9	7240	13400	15700	61	73	76
GOOSE CR	3815.0	12100.0	2500	4000	5000	2.5	2.2	1.7	2.7	4.9	7.7	1030	1840	2880	61	73	76
BIRDS LANDING	3807.5	12145.0	610	870	900	2.3	2.7	2.7	0.7	0.9	0.9	269	320	329	61	73	76
RIO VISTA	3807.5	12137.5	23000	21000	20000	1.8	1.6	1.1	33.1	36.0	50.0	12400	13500	18800	61	73	76
ISLETON	3807.5	12130.0	48000	37000	41000	1.9	1.3	1.2	66.6	75.9	89.0	25000	28500	33400	61	73	76
NEW HOPE	3807.5	12122.5	63000	65000	57000	2.3	2.0	1.7	73.0	88.5	89.7	27400	33200	33700	58	68	76
LODI N	3807.5	12115.0	49000	53000	53000	2.0	2.0	1.9	65.6	69.6	74.6	24600	26100	28000	58	68	76
LOCKEFORD	3807.5	12107.5	51000	55000	54000	2.1	2.1	1.9	65.7	68.9	75.5	24700	25900	28400	58	68	76
CLEMENTS	3807.5	12100.0	11000	11000	13000	2.4	2.5	2.2	12.7	12.0	15.5	4750	4490	5820	58	68	76

SUPPLEMENTAL DATA B. - EVAPOTRANSPIRATION OF APPLIED WATER AND AREA IRRIGATED--Continued

Name of 7.5-minute quadrangle	Latitude (north) of southeast corner (Deg Min)	Longitude (west) (Deg Min)	Evapotranspiration of applied water (acre-ft)			Unit evapotranspiration of applied water (acre-ft/acre)			Area irrigated (percentage of total)			Irrigated area (acres)			Year surveyed		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ANTIOCH N	3800.0	12145.0	2900	3800	4200	1.1	1.3	1.4	7.0	7.7	8.3	2650	2900	3110	61	73	76
JERSEY ISLAND	3800.0	12137.5	29000	30000	31000	1.8	1.7	1.7	43.2	46.1	48.7	16200	17300	18300	61	73	76
BOULDIN ISLAND	3800.0	12130.0	29000	30000	31000	1.5	1.5	1.5	51.7	54.0	56.1	19500	20300	21100	57	68	76
TERMINOUS	3800.0	12122.5	48000	48000	46000	1.8	1.5	1.5	72.0	82.9	80.1	27100	31200	30100	57	68	76
LODI S	3800.0	12115.0	58000	60000	48000	2.3	2.2	1.8	68.1	73.3	69.7	25600	27600	26200	58	68	76
WATERLOO	3800.0	12107.5	67000	70000	65000	2.2	2.2	1.9	81.1	84.6	90.8	30500	31800	34100	58	68	76
LINDEN	3800.0	12100.0	35000	38000	38000	2.2	2.2	2.0	41.7	45.7	50.4	15700	17200	19000	58	68	76
VALLEY SPRINGS SW	3800.0	12052.5	4200	4500	4900	1.9	2.0	2.0	5.8	6.1	6.4	2160	2300	2400	58	68	76
ANTIOCH S	3752.5	12145.0	1600	1300	930	2.1	2.3	2.4	2.0	1.5	1.0	742	560	381	61	68	76
BRENTWOOD	3752.5	12137.5	61000	59000	56000	2.3	2.3	2.3	71.1	68.0	64.8	26800	25600	24400	61	68	76
WOODWARD ISLAND	3752.5	12130.0	47000	46000	46000	1.7	1.7	1.7	74.1	73.6	72.8	27900	27700	27400	57	68	76
HOLT	3752.5	12122.5	52000	52000	51000	1.7	1.6	1.5	79.1	89.1	88.9	29800	33600	33500	57	68	76
STOCKTON W	3752.5	12115.0	30000	30000	24000	2.1	2.0	1.5	37.6	40.4	43.7	14100	15200	16500	58	68	76
STOCKTON E	3752.5	12107.5	43000	48000	44000	2.2	2.2	1.5	52.4	58.4	78.1	19700	22000	29400	58	68	76
PETERS	3752.5	12100.0	50000	60000	56000	2.5	2.3	1.8	53.2	67.9	83.5	20000	25600	31400	58	68	76
FARMINGTON	3752.5	12052.5	9900	13000	15000	2.8	2.6	1.9	9.3	13.1	21.1	3490	4940	7940	58	68	76
BACHELOR VALLEY	3752.5	12045.0	4300	2700	3900	2.9	1.8	1.4	4.0	4.0	7.3	1510	1510	2750	58	67	76
BYRON HOT SPRS	3745.0	12137.5	2500	2100	1700	2.6	2.4	2.1	2.6	2.3	2.1	967	886	804	61	68	76
BETHANY	3745.0	12130.0	47000	41000	35000	2.1	2.0	1.8	60.0	54.9	49.8	22600	20700	18800	57	68	76
UNION ISLAND	3745.0	12122.5	64000	73000	63000	2.2	2.2	1.9	78.1	87.2	87.3	29500	32900	32900	57	68	76
LATHROP	3745.0	12115.0	56000	60000	60000	2.1	2.2	2.0	70.1	73.5	79.2	26400	27700	29900	58	68	76
MANTECA	3745.0	12107.5	64000	73000	72000	2.1	2.3	2.2	79.7	82.0	86.3	30100	30900	32600	58	68	76
AVENA	3745.0	12100.0	81000	89000	88000	2.4	2.5	2.4	89.1	92.3	96.4	33600	34800	36400	58	68	76
ESCALON	3745.0	12052.5	86000	87000	89000	2.7	2.7	2.7	83.9	85.1	86.2	31700	32100	32500	58	68	76
OAKDALE	3745.0	12045.0	31000	21000	31000	2.7	1.8	2.4	30.5	30.4	33.7	11500	11400	12700	58	67	76
KNIGHTS FERRY	3745.0	12037.5	4900	3000	5000	2.7	1.8	2.7	4.8	4.5	4.9	1810	1700	1860	58	67	76
MIDWAY	3737.5	12130.0	4300	5000	4500	2.5	2.7	1.9	4.6	5.0	6.2	1740	1900	2330	57	68	76
TRACY	3737.5	12122.5	45000	44000	41000	2.3	2.3	2.1	51.2	50.7	51.6	19300	19200	19500	57	68	76
VERNALIS	3737.5	12115.0	64000	63000	63000	2.1	2.1	2.0	79.6	80.0	84.7	30100	30200	32000	57	68	76
RIPON	3737.5	12107.5	66000	63000	69000	2.6	2.1	2.3	67.9	79.6	79.8	25600	30100	30100	58	67	76
SALIDA	3737.5	12100.0	69000	66000	62000	2.2	2.2	2.1	81.3	80.2	76.8	30700	30300	29000	58	67	76
RIVERBANK	3737.5	12052.5	78000	60000	65000	2.7	2.2	2.5	77.3	73.3	67.6	29200	27700	25600	58	67	76
WATERFORD	3737.5	12045.0	85000	59000	78000	2.8	2.0	2.7	80.1	78.7	77.1	30300	29700	29100	58	67	76
PAULSELL	3737.5	12037.5	18000	14000	20000	2.7	1.9	2.0	17.7	19.8	26.2	6680	7460	9900	58	67	76
COOPERSTOWN	3737.5	12030.0	5900	4000	5600	2.8	1.8	2.4	5.6	6.0	6.3	2120	2260	2380	58	67	76

SOLYO	3730.0	12115.0	24000	25000	24000	2.1	2.0	1.8	29.4	32.5	34.1	11100	12300	12900	57	68	76
WESTLEY	3730.0	12107.5	62000	52000	61000	2.0	1.6	1.9	80.0	85.9	84.4	30300	32500	32000	57	68	76
BRUSH LAKE	3730.0	12100.0	70000	58000	68000	2.4	1.9	2.2	75.9	80.9	82.6	28700	30600	31300	58	67	76
CERES	3730.0	12052.5	72000	63000	67000	2.4	2.0	2.2	78.8	84.1	82.5	29800	31800	31200	58	67	76
DENAIR	3730.0	12045.0	78000	69000	71000	2.4	2.0	2.2	86.2	88.7	85.2	32600	33600	32200	58	67	76
MONTPELIER	3730.0	12037.5	12000	19000	47000	2.5	1.9	1.7	12.3	25.8	73.6	4670	9760	27900	58	67	76
TURLOCK LAKE	3730.0	12030.0	9700	11000	16000	2.6	2.0	1.8	10.1	14.9	23.0	3810	5620	8700	58	67	74
SNELLING	3730.0	12022.5	5800	4600	7900	2.8	1.8	2.3	5.4	6.9	9.2	2060	2620	3480	58	67	74
MERCED FALLS	3730.0	12015.0	1600	970	1100	2.9	1.8	2.8	1.4	1.4	1.1	541	538	404	58	67	74
PATTERSON	3722.5	12107.5	20000	19000	22000	2.1	2.0	2.1	25.0	25.3	28.1	9470	9570	10700	57	68	76
CROWS LANDING	3722.5	12100.0	69000	63000	71000	2.2	1.9	2.1	81.4	87.7	89.3	30900	33200	33800	57	68	76
HATCH	3722.5	12052.5	82000	57000	76000	2.7	1.7	2.3	79.2	87.7	85.7	30000	33300	32500	58	67	76
TURLOCK	3722.5	12045.0	66000	60000	65000	2.4	1.9	2.2	72.3	81.8	78.7	27400	31000	29800	58	67	74
CRESSEY	3722.5	12037.5	52000	67000	64000	2.2	2.2	2.1	62.4	79.0	81.7	23600	29900	31000	58	67	74
WINTON	3722.5	12030.0	40000	37000	45000	2.5	1.9	2.0	42.6	50.4	59.0	16100	19100	22400	58	67	74
YOSEMITE LAKE	3722.5	12022.5	5400	3800	6600	2.9	1.9	2.8	4.9	5.2	6.1	1840	1980	2330	58	67	74
NEWMAN	3715.0	12100.0	57000	55000	56000	2.2	2.0	2.1	67.7	71.4	71.0	25700	27100	27000	57	68	76
GUSTINE	3715.0	12052.5	38000	34000	40000	2.8	2.1	2.6	36.1	42.3	40.3	13700	16100	15300	57	68	74
STEVINSON	3715.0	12045.0	44000	32000	50000	2.7	1.9	2.5	43.1	45.0	52.2	16400	17100	19800	58	67	74
ARENA	3715.0	12037.5	45000	41000	58000	2.4	1.9	2.3	49.5	56.5	66.9	18800	21500	25400	58	67	74
ATWATER	3715.0	12030.0	64000	55000	72000	2.7	2.0	2.6	61.4	71.2	72.5	23300	27000	27500	58	67	74
MERCED	3715.0	12022.5	62000	39000	59000	2.7	1.6	2.5	60.3	62.7	62.6	22900	23800	23800	58	67	74
PLANADA	3715.0	12015.0	41000	33000	44000	2.6	1.9	2.4	42.3	45.4	47.7	16000	17200	18100	58	67	74
HOWARD RANCH	3707.5	12100.0	44000	42000	45000	2.4	2.3	2.4	47.9	48.7	50.8	18200	18500	19300	57	68	74
INGOMAR	3707.5	12052.5	30000	28000	25000	3.1	3.0	2.8	25.1	24.7	23.8	9560	9400	9040	57	68	74
SAN LUIS RANCH	3707.5	12045.0	18000	13000	16000	3.0	2.6	2.7	15.5	13.3	15.1	5910	5040	5730	57	68	74
TURNER RANCH	3707.5	12037.5	39000	27000	50000	2.7	1.7	2.5	37.5	41.4	52.5	14300	15700	20000	58	67	74
SANDY MUSH	3707.5	12030.0	34000	31000	59000	3.1	1.9	2.9	29.2	44.6	54.4	11100	16900	20700	58	67	74
EL NIDO	3707.5	12022.5	32000	27000	54000	2.7	1.5	2.5	30.3	49.3	57.2	11500	18700	21700	58	67	74
PLAINSBURG	3707.5	12015.0	55000	42000	65000	2.2	1.5	2.1	64.4	73.7	81.5	24500	28000	31000	58	67	74
LE GRAND	3707.5	12007.5	12000	12000	20000	2.2	1.8	2.0	14.9	17.0	26.3	5680	6460	10000	58	67	74
RAYNOR CR	3707.5	12000.0	1400	1200	1500	2.4	2.1	1.1	1.5	1.5	3.5	578	575	1320	58	67	74
SAN LUIS DAM	3700.0	12100.0	5600	6600	7100	2.5	2.5	2.1	5.8	6.9	8.8	2230	2640	3360	57	68	74
VOLTA	3700.0	12052.5	44000	47000	48000	2.9	2.8	2.6	39.8	43.3	48.1	15200	16500	18300	57	68	74
LOS BANOS	3700.0	12045.0	52000	56000	52000	3.0	3.0	2.8	46.4	48.5	48.0	17700	18500	18300	57	68	74
DELTA RANCH	3700.0	12037.5	79000	79000	79000	2.7	2.6	2.6	76.1	80.3	79.3	29000	30600	30200	57	68	74
SANTA RITA BR	3700.0	12030.0	67000	61000	77000	2.7	2.2	2.5	65.5	72.7	81.1	25000	27700	30900	58	68	74

SUPPLEMENTAL DATA B. - EVAPOTRANSPIRATION OF APPLIED WATER AND AREA IRRIGATED--Continued

Name of 7.5-minute quadrangle	Latitude (north) of southeast corner (Deg Min)	Longitude (west) (Deg Min)	Evapotranspiration of applied water (acre-ft)			Unit evapotran-spiration of applied water (acre-ft/acre)			Area irrigated (percentage of total)			Irrigated area (acres)			Year surveyed		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
BLISS RANCH	3700.0	12022.5	71000	42000	76000	2.6	1.5	2.6	71.1	75.0	78.1	27100	28600	29800	58	67	74
CHOWCHILLA	3700.0	12015.0	91000	53000	88000	2.7	1.6	2.6	88.6	87.6	90.2	33700	33400	34400	58	67	74
BERENDA	3700.0	12007.5	50000	40000	60000	2.3	1.7	2.1	57.3	63.7	75.3	21800	24300	28700	58	67	74
KISMET	3700.0	12000.0	7300	7800	25000	2.6	1.9	2.4	7.4	10.9	27.6	2840	4140	10500	58	67	74
DAULTON	3700.0	11952.5	2900	2200	4400	2.0	1.6	2.7	3.8	3.7	4.2	1430	1410	1610	58	67	74
ORTIGALITA PK NW	3652.5	12052.5	3600	2800	5500	2.4	2.5	1.7	3.8	2.9	8.2	1470	1110	3130	57	68	74
CHARLESTON SCHOOL	3652.5	12045.0	38000	46000	42000	2.4	2.7	2.6	42.3	45.1	42.5	16100	17200	16200	57	68	74
DOS PALOS	3652.5	12037.5	48000	64000	76000	2.9	2.8	2.8	43.5	60.3	70.8	16600	23000	27000	57	68	74
OXALIS	3652.5	12030.0	81000	84000	85000	2.9	2.6	2.5	72.4	85.2	88.5	27600	32500	33800	58	66	68
POSO FARM	3652.5	12022.5	36000	38000	53000	2.6	2.1	2.7	36.0	48.5	51.6	13800	18500	19700	58	67	74
FIREBAUGH NE	3652.5	12015.0	28000	27000	57000	2.9	1.7	2.8	25.3	42.1	52.3	9660	16100	20000	58	67	74
BONITA RANCH	3652.5	12007.5	67000	47000	74000	2.6	1.7	2.5	68.7	70.9	78.2	26200	27100	29800	58	67	74
MADERA	3652.5	12000.0	59000	49000	60000	2.4	1.9	2.2	64.8	67.9	70.3	24700	25900	26800	58	67	74
GREGG	3652.5	11952.5	11000	17000	26000	2.3	2.0	1.6	11.9	22.0	43.5	4560	8390	16600	58	67	74
LANES BR	3652.5	11945.0	6800	11000	27000	2.5	2.1	2.1	7.1	13.9	34.4	2720	5310	13100	58	67	74
FRIANT	3652.5	11937.5	8900	8400	9400	2.3	2.1	1.9	10.0	10.5	13.0	3800	3990	4960	58	66	72
LAGUNA SECA RANCH	3645.0	12045.0	2000	6300	6800	2.0	2.2	1.9	2.5	7.7	9.5	960	2920	3610	58	66	68
HAMMONDS RANCH	3645.0	12037.5	58000	62000	68000	2.1	2.2	2.2	71.5	75.4	81.7	27300	28800	31200	58	66	68
BROADVIEW FARMS	3645.0	12030.0	64000	65000	83000	2.2	2.3	2.3	76.0	76.0	95.5	29000	29100	36500	58	66	68
FIREBAUGH	3645.0	12022.5	60000	62000	74000	2.2	2.3	2.3	72.7	72.1	85.8	27800	27600	32800	58	66	68
MENDOTA DAM	3645.0	12015.0	37000	29000	67000	2.5	1.9	2.6	38.7	40.4	67.6	14800	15400	25900	58	67	74
GRAVELLY FORD	3645.0	12007.5	53000	38000	74000	2.6	1.6	2.5	52.3	59.5	77.3	20000	22700	29500	58	67	74
BIOLA	3645.0	12000.0	80000	76000	79000	2.2	2.1	2.2	94.4	94.7	95.7	36100	36200	36600	58	66	72
HERNDON	3645.0	11952.5	70000	72000	75000	2.3	2.4	2.3	78.6	79.5	84.3	30000	30400	32200	58	66	72
FRESNO N	3645.0	11945.0	35000	36000	28000	2.5	2.5	2.5	36.8	37.6	28.5	14100	14400	10900	58	66	72
CLOVIS	3645.0	11937.5	62000	67000	54000	2.4	2.4	2.4	67.4	72.9	58.9	25800	27900	22500	58	66	72
ROUND MTN	3645.0	11930.0	29000	30000	36000	2.1	2.0	1.9	35.5	39.4	49.9	13600	15100	19100	58	66	72
PIEDRA	3645.0	11922.5	5600	6900	11000	2.0	2.0	2.0	7.2	9.0	14.5	2760	3440	5540	58	66	72
CHOUNET RANCH	3637.5	12037.5	4200	11000	14000	1.4	1.6	1.8	8.0	17.8	20.9	3050	6810	8000	58	66	68
CHANEY RANCH	3637.5	12030.0	51000	62000	72000	1.8	2.1	2.0	75.9	78.6	95.6	29100	30100	36600	58	68	75
COIT RANCH	3637.5	12022.5	57000	67000	75000	1.7	1.8	2.1	86.4	97.2	92.8	33100	37200	35500	58	68	75

TRANQUILLITY	3637.5	12015.0	33000	50000	36000	1.9	1.9	1.8	45.8	70.4	51.7	17500	27000	19800	58	66	72
JAMESAN	3637.5	12007.5	27000	47000	53000	2.4	2.5	2.5	29.2	49.3	54.9	11200	18900	21000	58	66	72
KERMAN	3637.5	12000.0	65000	87000	85000	2.7	2.7	2.7	62.3	83.9	82.7	23900	32100	31700	58	66	72
KEARNEY PARK	3637.5	11952.5	88000	91000	82000	2.6	2.6	2.5	89.2	91.6	86.2	34100	35000	33000	58	66	72
FRESNO S	3637.5	11945.0	59000	61000	54000	2.4	2.4	2.2	63.1	66.0	63.5	24100	25300	24300	58	66	72
MALAGA	3637.5	11937.5	68000	72000	67000	2.2	2.3	2.3	79.4	82.0	77.1	30400	31400	29500	58	66	72
SANGER	3637.5	11930.0	73000	75000	68000	2.2	2.2	2.1	87.5	88.8	83.4	33500	34000	31900	58	66	72
WAHTOKE	3637.5	11922.5	52000	53000	52000	2.2	2.2	2.2	60.9	63.1	62.9	23300	24200	24100	58	66	72
ORANGE COVE N	3637.5	11915.0	12000	15000	22000	1.9	1.9	1.8	16.1	21.2	32.4	6170	8100	12400	58	66	72
MONOCLINE RIDGE	3630.0	12030.0	16000	13000	28000	1.3	1.9	1.8	31.3	17.3	40.4	12000	6620	15500	58	68	75
LEVIS	3630.0	12022.5	46000	56000	67000	2.0	1.9	2.0	60.5	78.1	88.3	23200	29900	33800	58	68	75
CANTUA CR	3630.0	12015.0	53000	54000	61000	1.8	1.8	1.7	77.7	79.8	91.8	29800	30600	35200	58	66	68
SAN JOAQUIN	3630.0	12007.5	53000	58000	61000	1.8	1.9	1.9	75.9	79.7	83.0	29100	30600	31800	58	66	72
HELM	3630.0	12000.0	30000	50000	60000	1.9	2.1	2.3	40.8	62.7	68.4	15600	24100	26200	58	66	72
RAISIN	3630.0	11952.5	62000	80000	77000	2.7	2.7	2.5	60.6	76.9	81.5	23300	29500	31200	58	66	72
CARUTHERS	3630.0	11945.0	70000	76000	73000	2.2	2.3	2.2	81.2	86.4	85.4	31200	33100	32800	58	66	72
CONEJO	3630.0	11937.5	74000	78000	77000	2.3	2.3	2.2	85.3	88.4	89.5	32700	33900	34300	58	66	72
SELMA	3630.0	11930.0	75000	78000	76000	2.3	2.3	2.3	86.8	88.3	85.7	33300	33900	32900	58	66	72
REEDLEY	3630.0	11922.5	71000	74000	73000	2.1	2.2	2.2	87.0	86.2	85.5	33400	33100	32800	58	70	78
ORANGE COVE S	3630.0	11915.0	63000	62000	64000	2.1	2.0	2.0	78.2	81.9	81.9	30000	31400	31400	58	70	78
STOKES MTN	3630.0	11907.5	320	8500	9800	1.7	1.7	1.8	0.5	13.1	14.0	188	5040	5370	58	70	78
LILLIS RANCH	3622.5	12022.5	7500	7500	11000	2.0	2.0	1.5	9.8	9.8	19.7	3750	3750	7560	58	66	68
TRES PECOS FARMS	3622.5	12015.0	57000	64000	69000	1.9	2.1	2.1	78.1	80.6	85.5	30000	30900	32800	58	68	75
WESTSIDE	3622.5	12007.5	47000	58000	65000	1.7	1.6	1.9	72.3	94.2	90.7	27800	36200	34800	58	68	75
FIVE POINTS	3622.5	12000.0	51000	56000	63000	1.6	1.7	1.8	84.0	86.0	91.7	32300	33000	35200	58	66	70
BURREL	3622.5	11952.5	54000	62000	67000	2.0	2.1	2.1	69.8	77.0	82.1	26800	29600	31500	58	66	72
RIVERDALE	3622.5	11945.0	62000	71000	73000	2.8	2.8	2.6	58.9	66.3	72.2	22600	25500	27700	58	66	72
LATON	3622.5	11937.5	73000	86000	85000	2.6	2.6	2.5	72.7	85.9	87.1	27900	33000	33500	58	66	72
BURRIS PARK	3622.5	11930.0	73000	85000	87000	2.6	2.6	2.5	71.9	85.1	88.9	27600	32700	34200	58	66	72
TRAVER	3622.5	11922.5	52000	63000	70000	2.4	2.3	2.3	55.5	71.4	78.8	21300	27400	30300	58	70	78
MONSON	3622.5	11915.0	53000	55000	66000	2.3	2.1	2.2	59.6	67.3	77.5	22900	25800	29800	58	70	78
IVANHOE	3622.5	11907.5	54000	52000	54000	2.1	1.9	2.0	67.4	70.7	71.2	25900	27200	27300	58	70	78
WOODLAKE	3622.5	11900.0	18000	17000	18000	2.1	2.0	2.0	21.8	23.1	23.9	8380	8870	9190	58	70	78
DOMENGINE RANCH	3615.0	12015.0	13000	12000	19000	1.7	1.2	1.8	19.5	25.5	27.5	7510	9810	10600	58	68	75
HARRIS RANCH	3615.0	12007.5	51000	57000	64000	1.9	1.8	1.9	70.1	81.7	87.1	27000	31400	33500	58	68	75
CALFLAX	3615.0	12000.0	48000	61000	65000	1.6	1.8	1.9	78.8	89.0	91.4	30300	34200	35200	58	68	75
VANGUARD	3615.0	11952.5	49000	50000	52000	1.4	1.4	1.4	90.1	92.0	96.0	34700	35400	36900	58	68	70
LEMOORE	3615.0	11945.0	65000	71000	73000	2.3	2.3	2.4	73.4	78.3	78.7	28300	30100	30300	58	66	72

SUPPLEMENTAL DATA B. - EVAPOTRANSPIRATION OF APPLIED WATER AND AREA IRRIGATED--Continued

Name of 7.5-minute quadrangle	Latitude (north) of southeast corner (Deg Min)	Longitude (west) corner (Deg Min)	Evapotranspiration of applied water (acre-ft)			Unit evapotranspiration of applied water (acre-ft/acre)			Area irrigated (percentage of total)			Irrigated area (acres)			Year surveyed		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
HANFORD	3615.0	11937.5	75000	80000	78000	2.6	2.6	2.6	75.6	80.3	77.7	29100	30900	29900	58	66	72
REMNOY	3615.0	11930.0	60000	71000	73000	2.6	2.6	2.5	59.5	70.8	75.7	22900	27200	29100	58	66	72
GOSHEN	3615.0	11922.5	77000	83000	81000	2.6	2.5	2.5	77.9	85.7	85.1	30000	33000	32700	58	70	78
VISALIA	3615.0	11915.0	75000	68000	67000	2.6	2.4	2.5	76.4	72.3	68.8	29400	27800	26500	58	70	78
EXETER	3615.0	11907.5	69000	72000	71000	2.4	2.3	2.3	76.6	80.9	79.0	29500	31100	30400	58	70	78
ROCKY HILL	3615.0	11900.0	23000	24000	24000	2.1	2.0	1.9	28.2	31.2	32.6	10800	12000	12500	58	70	78
COALINGA	3607.5	12015.0	21000	20000	24000	1.8	1.7	1.5	30.9	31.4	41.6	11900	12100	16000	58	66	68
GUIJARRAL HILLS	3607.5	12007.5	34000	46000	48000	1.8	1.7	1.9	49.2	71.6	67.0	19000	27600	25800	58	68	75
HURON	3607.5	12000.0	46000	54000	63000	1.7	1.8	1.9	71.8	77.8	83.9	27700	30000	32300	58	68	75
WESTHAVEN	3607.5	11952.5	12000	42000	49000	1.4	1.5	1.7	21.3	72.2	76.0	8200	27800	29300	58	68	75
STRATFORD	3607.5	11945.0	49000	55000	61000	1.7	1.8	2.0	73.8	77.8	81.2	28500	30000	31300	58	66	72
GUERNSEY	3607.5	11937.5	33000	38000	34000	2.3	2.2	2.1	38.2	45.2	42.6	14700	17400	16400	58	66	72
WAUKENA	3607.5	11930.0	53000	58000	61000	2.5	2.4	2.2	55.8	62.4	72.7	21500	24000	28000	58	66	72
PAIGE	3607.5	11922.5	87000	89000	90000	2.6	2.5	2.5	87.0	94.1	93.1	33500	36300	35900	58	70	78
TULARE	3607.5	11915.0	68000	60000	69000	2.5	2.1	2.4	69.6	72.2	74.6	26800	27800	28700	58	70	78
CAIRNS CORNER	3607.5	11907.5	71000	72000	77000	2.5	2.2	2.3	75.1	83.9	85.5	29000	32300	32900	58	70	78
LINDSAY	3607.5	11900.0	48000	49000	49000	1.9	1.8	1.9	64.8	68.9	67.9	25000	26500	26200	58	70	78
KREYENHAGEN HILLS	3600.0	12015.0	7000	6800	6800	1.6	1.5	1.3	11.0	12.1	13.9	4240	4680	5380	58	66	68
AVENAL	3600.0	12007.5	18000	17000	15000	1.7	1.5	1.3	28.5	29.0	30.2	11000	11200	11700	58	66	68
LA CIMA	3600.0	12000.0	25000	32000	50000	1.7	1.8	2.1	38.3	46.5	61.0	14800	17900	23600	58	68	75
KETTLEMAN CITY	3600.0	11952.5	31000	42000	54000	1.2	1.4	1.6	66.6	77.4	86.2	25700	29900	33300	58	66	72
STRATFORD SE	3600.0	11945.0	43000	80000	75000	1.8	2.2	2.1	62.1	94.7	93.4	24000	36600	36000	58	72	77
EL RICO RANCH	3600.0	11937.5	53000	75000	81000	1.8	2.1	2.2	75.1	93.1	94.0	29000	35900	36300	58	72	77
CORCORAN	3600.0	11930.0	59000	61000	61000	1.9	1.9	1.9	79.0	83.3	81.3	30500	32200	31400	58	66	72
TAYLOR WEIR	3600.0	11922.5	41000	49000	67000	2.5	2.2	2.5	42.6	58.6	68.6	16400	22600	26500	58	70	78
TIPTON	3600.0	11915.0	91000	84000	87000	2.7	2.5	2.5	85.9	88.0	90.3	33200	34000	34900	58	70	78
WOODVILLE	3600.0	11907.5	90000	85000	85000	2.6	2.4	2.4	90.4	91.8	91.6	34900	35400	35400	58	70	78
PORTERVILLE	3600.0	11900.0	49000	55000	55000	2.4	2.2	2.1	54.0	64.8	67.7	20800	25000	26100	58	70	78
SUCCESS DAM	3600.0	11852.5	8900	8900	10000	1.9	1.8	1.8	12.1	13.0	14.7	4660	5020	5680	58	70	78
KETTLEMAN PLAIN	3552.5	12000.0	88	110	1500	1.5	1.7	2.0	0.2	0.2	1.9	59	65	744	58	68	72
LOS VIEJOS	3552.5	11952.5	7500	22000	22000	1.4	2.0	2.1	14.3	28.6	27.3	5540	11100	10600	58	72	77
DUDLEY RIDGE	3552.5	11945.0	14000	37000	47000	1.1	1.8	1.8	32.0	53.1	67.7	12400	20500	26200	58	72	77
HACIENDA RANCH NW	3552.5	11937.5	31000	50000	57000	1.3	1.7	1.7	60.4	75.3	87.7	23300	29100	33900	58	72	77
HACIENDA RANCH NE	3552.5	11930.0	37000	61000	64000	1.4	1.7	2.0	70.8	90.8	84.6	27400	35100	32700	58	72	77

ALPAUGH	3552.5	11922.5	33000	30000	50000	2.2	2.2	2.3	37.9	36.2	57.5	14600	14000	22200	58	70	78
PIXLEY	3552.5	11915.0	55000	62000	65000	2.5	2.5	2.3	57.3	64.4	73.7	22100	24900	28500	58	70	78
SAUSALITO SCHOOL	3552.5	11907.5	65000	71000	77000	2.2	2.2	2.2	76.9	83.6	92.5	29700	32300	35800	58	70	78
DUCOR	3552.5	11900.0	25000	39000	50000	2.0	2.0	1.8	33.4	50.6	70.5	12900	19600	27300	58	70	78
FOUNTAIN SPRKS	3552.5	11852.5	4100	11000	12000	1.7	1.8	1.9	6.4	15.4	16.0	2460	5970	6200	58	70	78
PYRAMID HILLS	3545.0	12000.0	5200	3700	4700	1.6	1.1	1.4	8.4	8.5	8.8	3260	3300	3420	58	68	72
AVENAL GAP	3545.0	11952.5	5300	4300	16000	1.4	1.4	1.9	9.8	7.9	21.7	3780	3050	8400	58	66	72
WEST CAMP	3545.0	11945.0	8500	24000	31000	1.8	2.2	2.2	12.2	28.0	35.9	4720	10800	13900	58	72	77
LONE TREE WELL	3545.0	11937.5	7600	11000	22000	1.0	1.3	1.6	19.6	21.7	36.5	7600	8390	14100	58	72	77
HACIENDA RANCH	3545.0	11930.0	10000	42000	29000	1.8	2.0	2.0	14.2	52.9	37.6	5480	20500	14500	58	72	77
ALLENSWORTH	3545.0	11922.5	15000	16000	27000	1.7	2.2	2.0	22.8	19.4	34.9	8820	7500	13500	58	70	78
DELANO W	3545.0	11915.0	21000	46000	46000	2.3	2.6	2.4	23.9	46.7	50.7	9240	18100	19600	58	70	78
DELANO E	3545.0	11907.5	70000	75000	80000	2.2	2.2	2.3	82.2	86.3	90.3	31800	33400	35000	58	70	78
RICHGROVE	3545.0	11900.0	17000	32000	36000	1.9	2.0	1.9	24.0	41.1	49.2	9290	15900	19000	58	70	78
QUINCY SCHOOL	3545.0	11852.5	98	1200	3500	1.7	2.0	1.9	0.1	1.5	4.8	58	586	1860	58	70	78
SAWTOOTH RIDGE	3537.5	12000.0	0	16000	19000	0.0	2.7	2.1	0.0	16.0	23.8	0	6190	9230	58	69	77
EMIGRANT HILL	3537.5	11952.5	0	36000	54000	0.0	2.3	2.1	0.0	40.4	65.6	0	15700	25400	58	69	77
ANTELOPE PLAIN	3537.5	11945.0	0	12000	46000	0.0	2.4	2.3	0.0	12.8	52.6	0	4980	20400	58	69	77
LOST HILLS NW	3537.5	11937.5	560	2700	29000	2.5	2.3	2.0	0.6	3.0	36.7	223	1170	14200	58	69	77
LOST HILLS NE	3537.5	11930.0	8800	9700	11000	2.7	2.3	2.1	8.2	10.6	13.3	3200	4120	5170	58	69	77
WASCO NW	3537.5	11922.5	34000	46000	70000	2.5	2.4	2.6	35.4	49.0	70.1	13700	19000	27200	58	69	77
POND	3537.5	11915.0	21000	89000	85000	2.4	2.5	2.4	22.7	92.5	92.5	8810	35900	35900	58	69	77
MCFARLAND	3537.5	11907.5	4300	77000	77000	1.5	2.3	2.3	7.6	87.8	88.2	2940	34100	34200	58	69	77
DEEPWELL RANCH	3537.5	11900.0	5200	26000	31000	1.3	1.9	2.0	10.3	34.7	40.7	3990	13500	15800	58	69	77
SHALE POINT	3530.0	11952.5	0	1400	5200	0.0	2.2	2.7	0.0	1.7	4.9	0	649	1900	58	69	77
BLACKWELLS CORNER	3530.0	11945.0	0	10000	14000	0.0	2.3	2.2	0.0	11.0	15.9	0	4280	6180	58	69	77
LOST HILLS	3530.0	11937.5	490	36000	63000	2.3	2.1	2.2	0.6	44.8	72.1	215	17400	28000	58	69	77
SEMITROPIC	3530.0	11930.0	25000	49000	66000	2.5	2.3	2.5	25.3	55.1	67.5	9820	21400	26200	58	69	77
WASCO SW	3530.0	11922.5	49000	75000	90000	2.4	2.5	2.6	52.5	78.5	90.0	20400	30500	35000	58	69	77
WASCO	3530.0	11915.0	1000	77000	75000	2.7	2.2	2.2	1.0	91.5	88.9	393	35600	34500	58	69	77
FAMOSO	3530.0	11907.5	32000	68000	77000	2.1	2.1	2.3	38.9	82.6	85.9	15100	32100	33400	58	69	77
N OF OILDALE	3530.0	11900.0	5600	12000	18000	1.7	2.2	2.2	8.7	14.3	21.2	3380	5560	8240	58	69	77
BELRIDGE	3522.5	11937.5	0	12000	28000	0.0	2.1	2.4	0.0	14.2	29.5	0	5520	11500	58	69	77
LOKERN	3522.5	11930.0	4600	45000	49000	2.4	2.4	2.5	4.9	47.4	50.1	1910	18400	19500	58	69	77
BUTTONWILLOW	3522.5	11922.5	21000	61000	71000	2.7	2.6	2.6	20.0	60.6	69.2	7760	23600	26900	58	69	77
RIO BRAVO	3522.5	11915.0	1300	64000	74000	3.0	2.6	2.6	1.1	62.6	72.2	435	24400	28100	58	69	77
ROSEDALE	3522.5	11907.5	0	86000	82000	0.0	2.6	2.5	0.0	85.9	84.3	0	33400	32800	58	69	77
OILDALE	3522.5	11900.0	11000	33000	33000	2.1	2.4	2.5	13.0	36.0	34.5	5070	14000	13400	58	69	77
OIL CENTER	3522.5	11852.5	0	1000	2700	0.0	2.6	3.3	0.0	1.0	2.1	0	387	818	58	69	77
RIO BRAVO RANCH	3522.5	11845.0	0	35	3200	0.0	1.0	2.3	0.0	0.1	3.5	0	35	1380	58	69	77

SUPPLEMENTAL DATA B. - EVAPOTRANSPIRATION OF APPLIED WATER AND AREA IRRIGATED--Continued

Name of 7.5-minute quadrangle	Latitude (north) (Deg Min)	Longitude (west) (Deg Min)	Evapotranspiration of applied water (acre-ft)			Unit evapotranspiration of applied water (acre-ft/acre)			Area irrigated (percentage of total)			Irrigated area (acres)			Year surveyed		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
E ELK HILLS	3515.0	11922.5	0	22000	25000	0.0	2.4	2.6	0.0	23.9	25.1	0	9300	9780	58	69	77
TUPMAN	3515.0	11915.0	0	27000	44000	0.0	2.5	2.6	0.0	27.2	43.5	0	10600	17000	58	69	77
STEVENS	3515.0	11907.5	0	37000	65000	0.0	2.7	2.6	0.0	35.9	64.3	0	14000	25100	58	69	77
GOSFORD	3515.0	11900.0	0	51000	57000	0.0	2.5	2.7	0.0	52.2	55.1	0	20400	21500	58	69	77
LAMONT	3515.0	11852.5	50	52000	59000	2.1	2.2	2.4	0.1	61.8	63.2	24	24100	24600	58	69	77
EDISON	3515.0	11845.0	0	43000	54000	0.0	1.8	1.9	0.0	63.1	69.8	0	24600	27200	58	69	77
BENA	3515.0	11837.5	0	350	1300	0.0	1.1	2.0	0.0	0.8	1.7	0	313	648	58	69	77
TAFT	3507.5	11922.5	210	2200	3200	1.8	2.2	2.5	0.3	2.5	3.3	118	979	1280	58	69	77
MOUTH OF KERN	3507.5	11915.0	1500	31000	44000	2.6	2.0	2.1	1.4	39.7	52.6	563	15500	20500	58	69	77
MILLUX	3507.5	11907.5	0	32000	67000	0.0	2.2	2.5	0.0	36.5	68.8	0	14300	26800	58	69	77
CONNER	3507.5	11900.0	500	78000	89000	2.2	2.5	2.6	0.6	79.5	89.7	223	31000	35000	58	69	77
WEED PATCH	3507.5	11852.5	3900	64000	72000	2.7	2.3	2.3	3.7	71.8	79.0	1450	28000	30800	58	69	77
ARVIN	3507.5	11845.0	0	55000	54000	0.0	2.1	2.1	0.0	66.8	65.1	0	26100	25400	58	69	77
BEAR MTN	3507.5	11837.5	0	1100	2700	0.0	1.5	2.0	0.0	1.9	3.4	0	725	1340	58	69	77
PENTLAND	3500.0	11915.0	14000	13000	30000	2.7	2.3	2.2	13.2	14.7	35.2	5160	5740	13800	58	69	77
CONNER SW	3500.0	11907.5	38000	33000	48000	2.7	2.4	2.4	35.6	35.5	50.7	13900	13900	19800	58	69	77
COAL OIL CANYON	3500.0	11900.0	24000	40000	53000	2.5	2.0	2.1	24.9	51.0	63.9	9740	20000	25000	58	69	77
METTLER	3500.0	11852.5	8300	68000	73000	2.4	2.1	2.3	9.0	83.3	83.2	3510	32600	32500	58	69	77
TEJON HILLS	3500.0	11845.0	5800	27000	35000	2.0	1.8	2.0	7.5	39.2	45.1	2940	15300	17600	58	69	77
TEJON RANCH	3500.0	11837.5	130	200	740	2.2	1.7	1.2	0.1	0.3	1.6	57	118	624	58	69	77
GRAPEVINE	3452.5	11852.5	250	0	4600	3.1	0.0	1.7	0.2	0.0	6.9	82	0	2690	58	69	77

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