

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

EFFECTIVE PRECIPITATION

A Field Study to Assess Consumptive Use of Winter Rains by Spring and Summer Crops

February 1989

Department of Water Resources

Central District

Gordon K. Van Vleck
Secretary for Resources
The Resources Agency

George Deukmejian
Governor
State of California

San Joaquin District

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FOREWORD

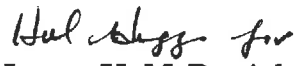
In parts of California, all of the water needed by some crops is supplied by rainfall. In other places, rain provides none of the water needed for production of some crops. On average, annual rainfall amounts to more than an acre-foot per acre on the floor of the Central Valley, but how much of that rain actually reduces irrigation requirements?

The amount of rain used by crops, called *effective precipitation*, is determined by crop and soil characteristics and by climate. A method of accurately estimating the effectiveness of rain falling during the growing season has been available for some time, but for most of California, rain falls during winter — the *non-growing* season for most crops. Winter rain can, however, help meet part of the evapotranspiration requirement of summer crops, because part of the rainwater can infiltrate the soil and be carried into the following growing season as *stored soil moisture*. This study was designed to determine amounts of winter rain water available for crop use, which reduces irrigation water needs in the following growing season.

Conducted as part of the Agricultural and Urban Water Use Program, this investigation was a joint effort of the Department of Water Resources Central District and San Joaquin District.



Louis A. Beck, Chief
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SUMMARY

Rainfall can be important for California's crops. In parts of the State, all of the water needed by some crops is supplied by rainfall. In other locations or for other crops, rain provides none of the water needed.

The amount of rain actually used by crops, called *effective precipitation*, is largely influenced by crop and soil characteristics and climate.

A method of accurately estimating the effectiveness of rain falling during the growing season has been available for some time, but for most of California, rain falls during winter — the *non*-growing season for most crops. Winter rain can, however, help meet part of the evapotranspiration requirement of summer crops, because part of the rainwater can infiltrate the soil and be carried into the following growing season as *stored soil moisture*.

Attempts have been made to account for this stored soil moisture when determining *crop ET of applied water* values, but a field measurement program has been needed to validate the estimates. This study was designed to determine broad relationships between monthly amounts of winter rain and the portion stored in the soil and available for crop use in the following growing season.

Total monthly rainfall and corresponding change in soil moisture content were measured during winter at about 10 sites in the Central Valley. The 4-year study, which began in 1983, showed:

- The relationship between total rainfall and change in soil moisture is remarkably similar for each of the four winter months: November, December, January, and February. The relationship is:

$$\text{Soil moisture change} = -0.54 + 0.940 (\text{rainfall amount}).$$

- Soil moisture content increases linearly with increased monthly rainfall for each of the four months. Surface evapotranspiration is relatively constant, at 0.6 to 0.8 inch per month.
- In October, when the soil is initially dry, both the amount of stored soil moisture and the amount of evaporation from the soil surface increase with increasing amounts of total monthly rain. Change in stored soil moisture is linearly related to October rainfall as:

$$\text{Soil moisture change} = -0.06 + 0.635 (\text{rainfall amount}).$$

- In March, when initial soil moisture content is generally high and evaporative demand is also high, surface evaporation rates are twice those for the four winter months, and the amount of rain going to soil moisture storage during March is correspondingly low. This is shown in the relationship:

Soil moisture change = $-1.07 + 0.837$ (rainfall amount).

The relationships shown above provide a rational basis for partitioning winter rain falling on fallow land (and excluding runoff) into:

- Stored soil moisture (*effective precipitation*),
- Evaporation from the soil surface, and
- Percolation to below the crop rooting depth.

Chapter 1. INTRODUCTION

The term *precipitation* includes all forms of water derived from atmospheric vapor and deposited on the Earth's surface: rain, sleet, hail, snow, mist (fog), and dew. For the major agricultural areas of California, rain is the principal form of precipitation. Snow, hail, and sleet are rare, and the amount of water derived from condensation of fog and dew is negligible. In this report, the terms *precipitation* and *rainfall* are used interchangeably, and have the same meaning.

Rain falling on agricultural land can be an important water supply for California's crops. For some crops and some parts of the State, all of the water needed may be supplied by rain. For example:

- Small grains grown during winter and spring (rainy season) in much of the State.
- Dry beans, a short-season summer crop, grown in central and south coastal areas with rain as the only water supply.
- Non-irrigated vineyards, common throughout the wine country of Northern California (although irrigated vineyards are found there as well).

For other crops or other locations, rain may contribute little or none of the water needed by crops. Examples include:

- Dry beans and other summer crops grown in the Central Valley after spring or early summer crops have been harvested.
- Essentially all crops in the southeastern desert, where rainfall is sparse and unpredictable.

The most common condition lies between those extremes — rainfall supplies only part of the crop water requirement.

The amount of rain used by crops, *effective precipitation*, is influenced by:

- Frequency, intensity, and total amount of rainfall;
- Percentage of ground cover, rate of evapotranspiration, and rooting depth of the crop;

- Infiltration rate, soil profile restrictions, capacity of soil to retain moisture, moisture deficiency of the soil, and timing of first irrigation; and
- Season of the rainfall in relation to growing period of the crop.

Rainfall is measured, usually by volunteer observers, at many locations throughout the major agricultural areas of California. Rainfall on cropland can amount to large volumes of water. For example, on the floor of the Central Valley, annual precipitation averages more than 1 acre-foot per acre. It amounts to about 7.6 million acre-feet over the 7.5 million irrigated acres in the valley.

The important question is: *How much of that rain is effective in reducing irrigation requirements?*

Chapter 2. PAST STUDIES OF EFFECTIVE PRECIPITATION

Hydrologists have long recognized the contribution of rainfall toward meeting crop water needs. Generally, rain falling during crop growing seasons has been separated from rain falling during the non-growing season.¹ Irrigation engineers traced the disposition of winter rain and identified the part stored in the soil as the "effective" component. Current work, including that reported here, follows that same course.

Winter soil moisture sampling in Southern California during the late 1920s indicated that the first half-inch of rainfall from each storm quickly evaporated, so the amount of rain in excess of a half-inch was considered to be *effective*. All of the rain falling during the crop growing season was considered effective.²

In the early 1950s, a comprehensive investigation was conducted to determine water demands statewide.³ To determine the effectiveness of precipitation in reducing irrigation requirements, total rain was divided into three groups:

- Precipitation occurring and evapotranspired during the *crop growing* season.
- Precipitation occurring during the *non-growing* season and evapotranspired by mature vegetation or evaporated from water and bare soil surfaces during that period.
- Precipitation occurring during the *non-growing* season and percolating to the root zone of the crop and retained for use by crops during the ensuing *growing* season.

To evaluate precipitation during the non-growing season, the following maximum amounts of monthly ET were assumed:

Annual crops or fallow land	1 inch per month
Orchards and vineyards	1 1/2 inches per month
Forage or cover crops	2 inches per month

¹ B. A. Etcheverry and S. T. Harding, *Irrigation Practice and Engineering*, Volume I, *Use of Irrigation Water and Irrigation Practice*. (New York: McGraw-Hill, 1933).

² California Department of Public Works, Division of Water Resources, *Ventura County Investigation*, Bulletin 46. (1933).

³ State Water Resources Board. *Water Utilization and Requirements of California*, Bulletin 2, Volume I. (1955).

Rain in excess of those amounts was assumed to be stored for use during the following growing season. The amount stored was further limited by available soil moisture storage capacity. In later years, when irrigation requirements estimated by that statewide study were compared to measured data, discrepancies were noted.

During the late 1950s and 1960s, an essential part of planning for the State Water Project was an effort to refine crop water use data and climatic data statewide. Because monthly evaporation was found to vary widely from region to region, the assumed single monthly consumptive use and effective precipitation values applied throughout the State were questioned.

Based on data collected more recently, a modified method for estimating effective precipitation was developed.⁴ For rainfall during the growing season, ET of rain was linked to crop ground cover development. In this method it is hypothesized that during the non-growing season, evaporation of rainfall from the soil surface is limited by potential ET (a value that varies from region to region throughout the State), and rain in excess of potential ET is available for soil moisture storage. This method for estimating effective precipitation for the non-growing season was based on limited soil moisture sampling in the southern San Joaquin Valley; it needed to be evaluated under a wider range of total rainfall.

⁴ Department of Water Resources. *Vegetative Water Use in California, 1974*, Bulletin 113-3. (1975).

Chapter 3. RAINFALL PATTERNS

Rainfall in California varies markedly from place to place in the same year, and from year to year in the same place. For instance:

- The average normal rainfall for the north coastal region (41.4 inches) is five times that for the southeast desert (7.4 inches). Specific locations in those areas have even greater variations. Long-term average rainfall at Crescent City, in the northwest corner of California, is 71 inches — some 30 times the 2.3 inches at El Centro, in the southeast corner of the State.
- Over the last 25 years, annual rainfall in the Central Valley has ranged from half of normal in 1976 to twice normal in 1983. This is a fourfold difference over that large area.

Table 1 lists monthly percentages of normal annual rainfall for five large regions of California. Although the **annual amounts** of precipitation vary greatly between the five regions, the **monthly percentage distribution** is remarkably similar for each of them. The table shows that two-thirds of

Table 1
MONTHLY PERCENTAGE DISTRIBUTION OF
NORMAL ANNUAL PRECIPITATION FOR
FIVE REGIONS IN CALIFORNIA

	% of ANNUAL PRECIPITATION*					
	North Coast	Sacramento Valley	San Joaquin Valley	Central Coast	South Coast	Average of 5 Regions**
January	20	20	19	21	20	20
February	17	18	18	20	21	19
March	13	14	16	15	15	15
April	8	8	11	8	8	8
May	4	4	4	2	2	3
June	1	1	1	1	0	1
July	0	0	0	0	0	0
August	0	0	0	0	1	0
September	1	1	1	1	1	1
October	6	5	4	4	4	5
November	11	9	8	8	8	9
December	19	20	18	20	20	19
Total, Nov to Feb	67	67	63	69	69	67
Total, Mar to Oct	33	33	37	31	31	33

* Averages for 7 to 9 sites in each region.

** The five regions include all of California west of the Cascade, Sierra Nevada, and Peninsular mountain ranges.

SOURCE: Table 7, DWR Bulletin 113-3, *Vegetative Water Use in California-1974*. (1975).

normal annual precipitation falls during November, December, January, and February.

Percentages shown are averages from about 7 to 9 sampling locations for each region. The five regions represent the portion of the State west of the Cascade, Sierra Nevada, and Peninsular mountain ranges. Although this is about half the total area of the State, it includes 90 percent of the irrigated land. Rainfall over this area is largely the result of winter storm systems sweeping in from the Northern Pacific. East of the mountain ranges, rainfall is sparse, and monthly distribution is strongly affected by summer convectional storms.

Annual precipitation generally decreases from north to south, and for the same latitude, amounts are greater near the coast and at higher elevations than in the inland valley.

The Central Valley is the most important agricultural area in California, comprising 75 percent of the State's irrigated land. Figure 1 shows average annual rainfall for cities along the 400-mile axis of the Central Valley. The rainfall gradient along the valley is remarkably uniform. During any given year, rainfall can vary markedly from these long-term averages.

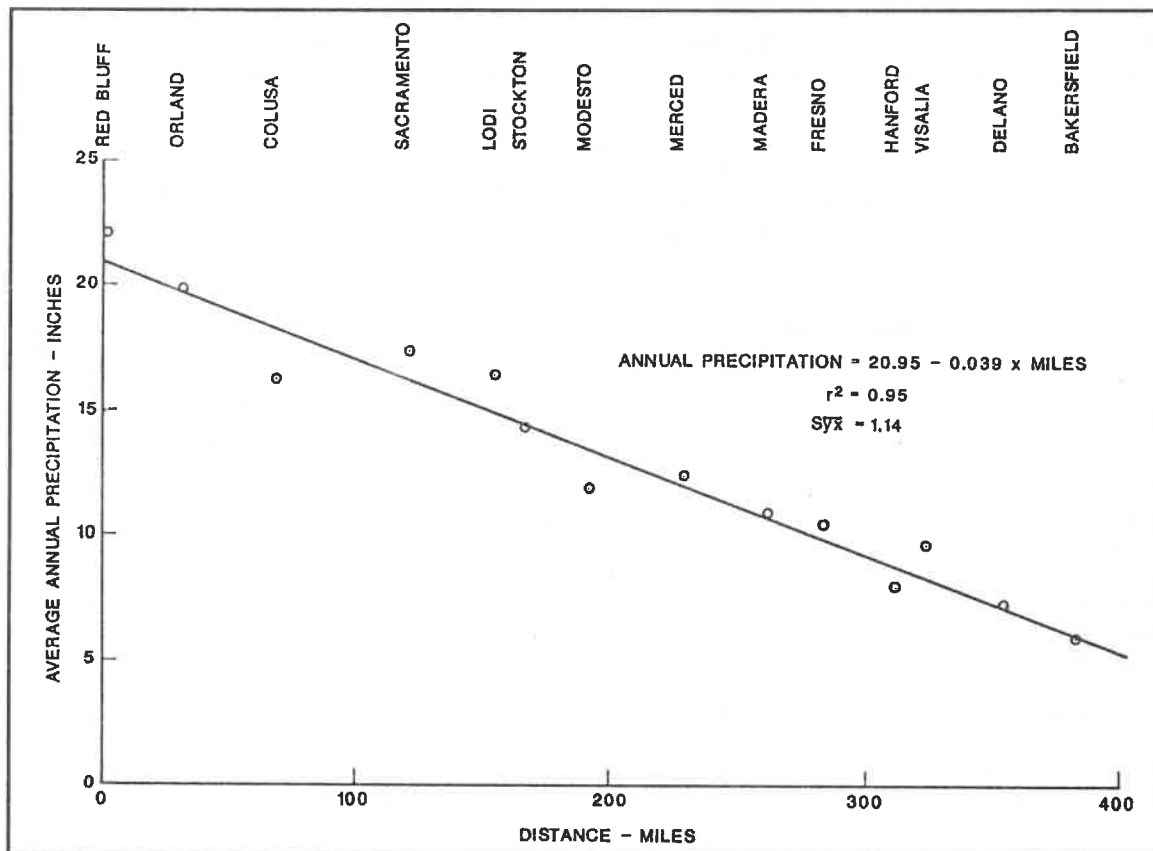


Figure 1
PRECIPITATION AMOUNTS ALONG A LONGITUDINAL TRANSECT OF THE
CENTRAL VALLEY IN CALIFORNIA

Chapter 4.EFFECTIVE PRECIPITATION

Geographic patterns of long-term average precipitation and month-to-month distribution of the precipitation provide a basis for estimating the beneficial use of that water supply. For a specific location or over a region, part of the measured rainfall usually cannot be used by crops. The amount that is used, *effective precipitation*, is discussed in this chapter.

Impact of Ground Cover on Effectiveness of Summer Rainfall

In arid climates, small to moderate amounts of rain are 100 percent effective when falling on a field in which a crop completely covers the ground. This means the rain offsets an equivalent amount of irrigation water needed to meet crop ET demand. Where crops do not cover the ground, such as shortly after emergence, rain can fall upon and evaporate from the bare soil between plants without contributing to crop water needs. Therefore, only part of the rainfall is effective, and that part depends on the percentage of crop ground cover.

Numerous soil moisture observations from evapotranspiration field plots indicate that crop ET rates reach maximum levels when ground cover is about 50 to 75 percent. Figure 2 presents a simple method to relate the effectiveness of rainfall to the percentage of ground covered by actively transpiring vegetation. The relationship shown is a reasonable estimate for general application to all crops.

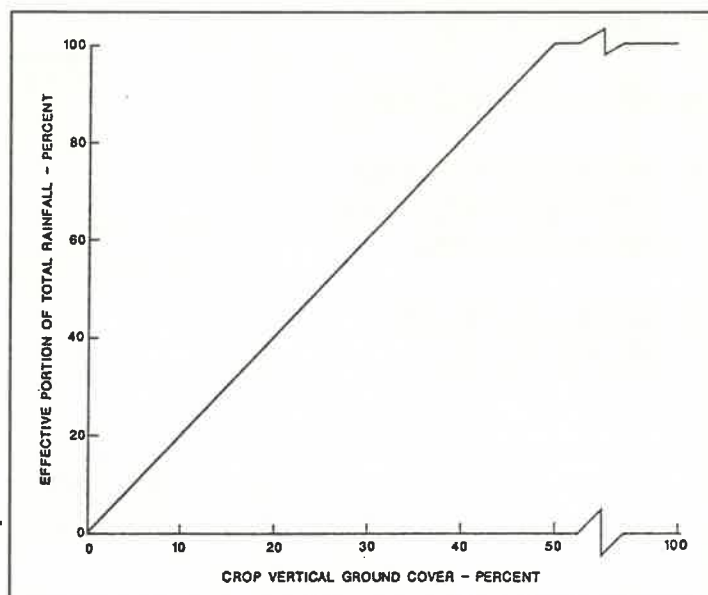


Figure 2
ASSUMED RELATIONSHIP BETWEEN
EFFECTIVENESS OF GROWING SEASON RAINFALL
AND
CROP GROUND COVER

Effectiveness of Winter Rainfall for Crop Production

About two-thirds of the rainfall in California is in winter, the non-growing season for most crops. Deciduous trees and vineyard are dormant during winter, and most field crops are not planted until spring or early summer. The active growing seasons for most crops are during March to October. Some crops, such as citrus trees, small grains, and some vegetables, are grown during winter.

Thus for most crops, the effective portion of the total rainfall is largely the amount of winter moisture stored in the soil and extracted in spring or summer. This effectiveness is influenced by infiltration and storage in the root zone, by runoff, and by evaporation.

Infiltration and Storage in the Root Zone

Some rain falling during winter may be stored in the soil and carried over for use by crops during the following growing season. Figure 3 is a diagram of the disposition of winter rain falling on a fallow (uncropped) field.

The maximum amount of moisture that can be stored in the soil for later use by crops is limited by:

- Soil texture and depth,
- Soil moisture content at the beginning of the winter rains, and
- Rooting depth of the subsequent crop.

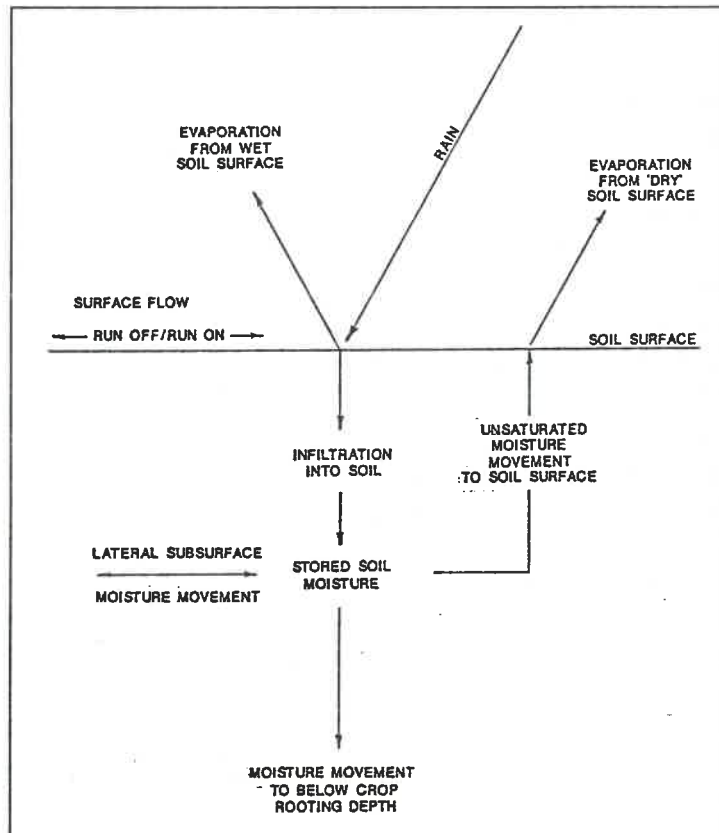


Figure 3
DISPOSITION OF RAIN FALLING ON A
FALLOW FIELD

Infiltrated water in excess of the maximum that can be stored moves downward in the soil and, while not immediately available to crops, may contribute to ground water storage. In areas of shallow (perched) ground water, moisture may move upward into the rooting zone, but downward movement below the root zone is far more common for agricultural land in the Central Valley.

The amount of stored moisture is further diminished by unsaturated flow from greater depths to the "dry" soil surface, from which it evaporates. This deep drying process may continue for several weeks following winter rains.

Runoff

When rainfall is intense and/or infiltration rates are low, there may be some surface runoff from fields. This runoff is often offset by *run-on* from adjacent upslope fields. For the relatively flat fields that characterize most of California's farmlands, and with the typical low to moderate rainfall intensity, net surface runoff is usually negligible. Similarly, lateral movement of soil moisture is relatively small, and it can be neglected when estimating the effectiveness of winter rain.

Evaporation

The period of greatest rainfall coincides with the period of lowest evaporative demand. Figure 4 shows normal monthly rainfall and corresponding evaporation rates for two precipitation zones in the Central Valley. Although precipitation varies widely, evaporation rates are relatively constant throughout the valley. Therefore, rainfall in excess of evaporation varies with the total amount of precipitation.

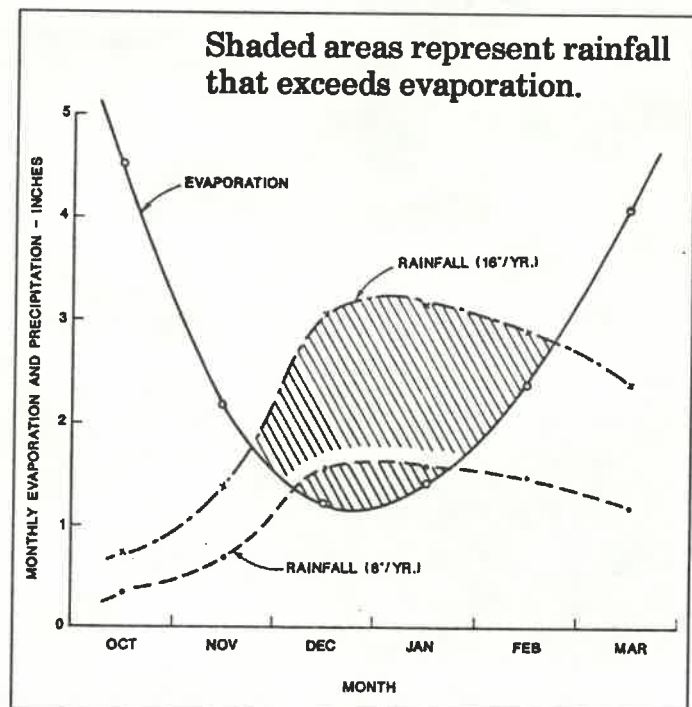
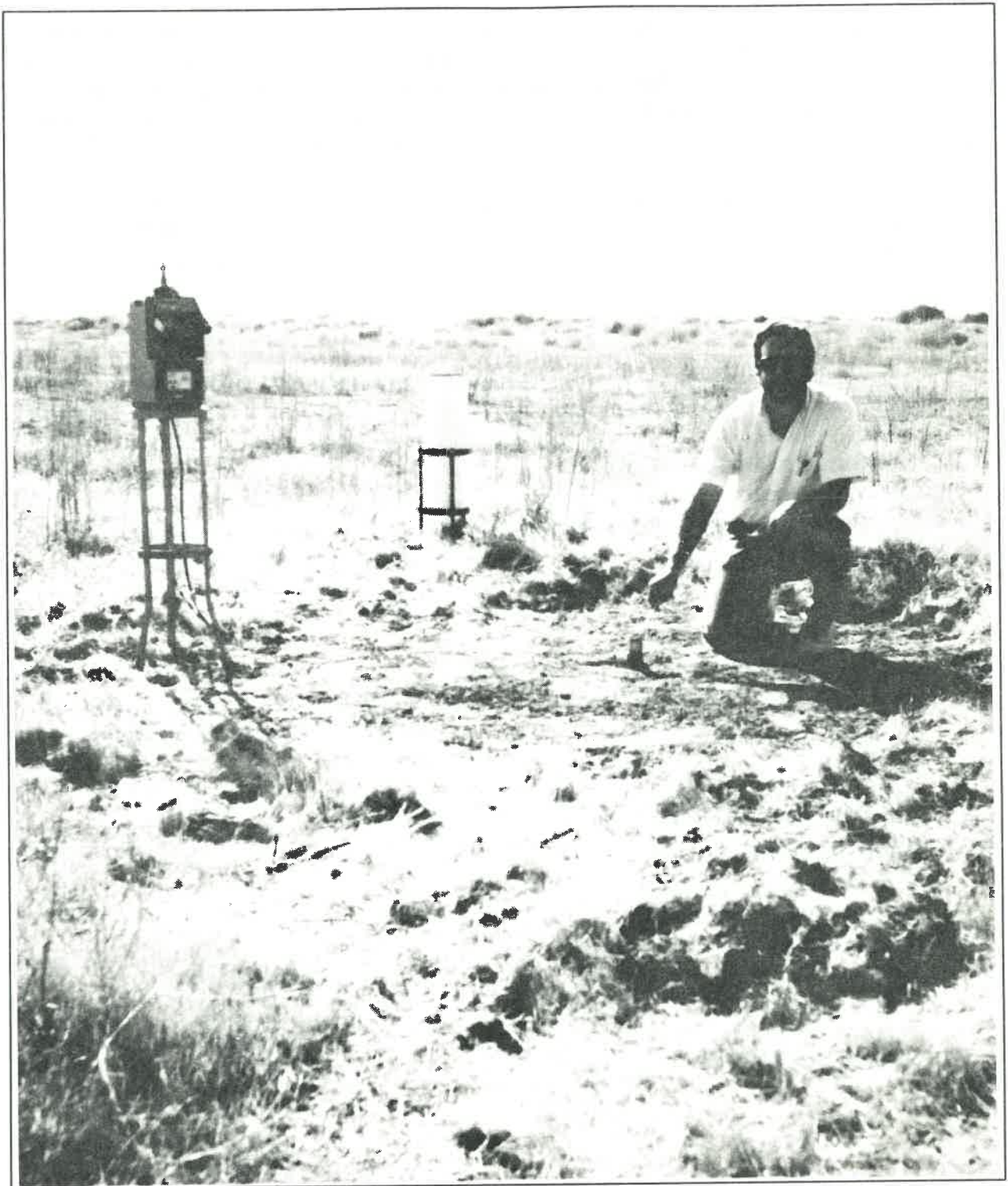


Figure 4
NORMAL MONTHLY EVAPORATION AND
RAINFALL FOR TWO PRECIPITATION ZONES
IN THE CENTRAL VALLEY



**View of typical field site. Access tube rain gauge (center foreground);
Standard rain gauge (background);
Neutron probe (on stand).**

Chapter 5. FIELD STUDY OF EFFECTIVE PRECIPITATION

The entire Central Valley is usually affected by the same winter storms, and the amount of rain from the storms generally decreases from north to south (see Figure 1 and Table 2). Therefore, field sites spaced along the valley axis are subjected to the same storm frequency but receive differing amounts of rainfall.

Table 2
LONG-TERM AVERAGE ANNUAL PRECIPITATION FOR SEVERAL LOCATIONS
IN THE CENTRAL VALLEY*
(in inches)

STATION	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTALS
Lodi	0.02	0.03	0.21	0.92	2.12	3.02	3.24	2.34	2.22	1.58	0.51	0.13	16.34
Stockton FS 4	0.01	0.02	0.17	0.68	1.86	2.71	2.96	2.29	2.00	1.45	0.47	0.11	14.73
Stockton AP	0.01	0.03	0.17	0.72	1.72	2.68	2.91	2.11	1.96	1.37	0.42	0.07	14.17
Modesto	0.02	0.04	0.16	0.62	1.52	2.10	2.15	1.81	1.64	1.36	0.38	0.07	11.87
Turlock	0.01	0.02	0.12	0.56	1.49	1.91	2.23	1.83	1.67	1.35	0.33	0.05	11.57
Merced AP	0.01	0.02	0.11	0.55	1.61	2.09	2.24	1.92	1.74	1.41	0.45	0.07	12.22
Madera	0.02	0.02	0.09	0.44	1.35	1.83	1.84	1.69	1.50	1.41	0.44	0.07	10.70
Fresno AP	0.00	0.02	0.07	0.42	1.22	1.71	1.84	1.72	1.62	1.24	0.32	0.06	10.24
Visalia	0.01	0.01	0.09	0.36	1.14	1.56	1.77	1.68	1.39	1.16	0.31	0.05	9.53
Hanford	0.01	0.01	0.08	0.30	0.96	1.28	1.43	1.38	1.23	0.87	0.25	0.04	7.84
Delano	0.00	0.01	0.11	0.21	0.93	0.93	1.29	1.19	1.09	1.03	0.22	0.09	7.10
Wasco	0.02	0.00	0.07	0.21	0.70	0.81	1.12	1.18	0.92	0.85	0.23	0.07	6.18
Bakersfield AP	0.02	0.01	0.08	0.26	0.69	0.74	0.96	1.03	0.83	0.85	0.19	0.06	5.72

* 30-year average, 1941-1970, from National Weather Service "Climatological Data".
Stations are listed from north to south.

Monthly evaporation rates are about the same throughout the valley floor, as shown in Table 3. Therefore, the potential for evaporation from wet soil following rainstorms is the same for all the field sites. By sampling along a longitudinal transect of the valley, changes in soil moisture content can be determined over a wide range of rainfall conditions during the same year. This concept was the basis for the reconnaissance-level field study described here.

Table 3
MONTHLY MEASURED EVAPORATION FROM CLASS "A" PANS
AT FOUR LOCATIONS IN THE CENTRAL VALLEY,
1983-1987
(in inches)

Year	Month	Location				Average
		NWS Lodi	Oakley INE	Fresno State/DWR	Bakersfield 10 NW	
1983/84	October	3.67	4.07	3.95	4.48	4.04
	November	1.79	1.74	1.83	2.06	1.85
	December	1.20	0.87*	1.06	1.15	1.07
	January	1.05	1.12	0.83	1.36	1.09
	February	1.71	2.01	2.14	2.74	2.15
	March	4.96	4.43	4.10	4.66	4.54
	April	6.55	6.34	5.90	6.13	6.23
	May	9.89	10.55	10.02	9.09	9.89
	June	9.68	10.06	9.72	9.85	9.83
	July	10.42	10.49	11.10	10.82	10.71
	August	9.06	8.89*	10.32	9.35	9.40
	September	7.68	7.52*	7.40	8.07	7.67
	Total	67.66	68.09*	68.37	69.76	68.47
1984/85	October	4.49	4.04	4.20	4.47	4.30
	November	2.00	1.82	2.50	2.53	2.21
	December	1.17	0.94	1.20	1.39	1.17
	January	0.63	0.69	0.83	0.96	0.78
	February	2.63	2.71	2.25	2.62	2.55
	March	4.38	3.78	3.61	4.09	3.96
	April	6.45	6.74	7.04	6.72	6.74
	May	8.40	8.83	9.23	8.68	8.78
	June	9.48	11.83	10.06	9.83	10.30
	July	8.97	N.R.	10.14	11.04	10.05
	August	8.01	9.52	9.68	9.75	9.24
	September	5.36	7.09	6.55	6.55	6.39
	Total	61.97	N.R.	67.29	68.63	66.47
1985/86	October	4.07	4.99	4.46	4.96	4.62
	November	1.71	2.18*	1.88	2.08	1.96
	December	0.76	0.98*	0.68	0.77	0.80
	January	0.93	1.29*	1.36	1.70	1.32
	February	2.09	1.92	1.92	2.20	2.03
	March	3.65	4.36	3.39	3.68	3.77
	April	5.34	5.91	5.99	6.30	5.88
	May	8.32	8.28	9.37	9.29	8.82
	June	9.53	9.80	10.72	10.63	10.17
	July	9.72	9.94	10.70	10.79	10.29
	August	8.35	8.76	10.45	9.69	9.31
	September	5.07	6.51	6.64	6.81	6.26
	Total	59.54	64.92*	67.56	68.90	65.23
1986/87	October	4.07	4.35	4.51	4.92	4.46
	November	2.64	3.04	2.15	2.69	2.63
	December	0.67	0.81	0.96	1.07	0.88
	January	N.R.	1.55	1.36	1.48	1.46
	February	2.51	2.30	2.49	2.37	2.42
	March	3.46	3.74	3.54	4.41	3.79
	April	6.26	6.58	7.09	7.34	6.82
	May	8.58	7.79	9.40	9.14	8.73
	June	9.39	9.45	10.26	10.26	9.84
	July	8.85	10.06	10.86	9.72	9.87
	August	8.53	9.32	9.59	9.70	9.28
	September	6.11	6.36	7.06	7.39	6.73
	Total	N.R.	65.35	69.27	70.49	66.91

* Partially Estimated
N.R. = No Record

Data Collection

In the fall of 1983, field sites were established at intervals of about 35 miles along a longitudinal transect of the San Joaquin Valley. Rainfall and soil moisture data were collected at about monthly intervals during each winter for 4 years. There were nine or ten field sites each year, but for various reasons some locations were changed from year to year. Field sites are shown in Figure 5 and described in Table 4.

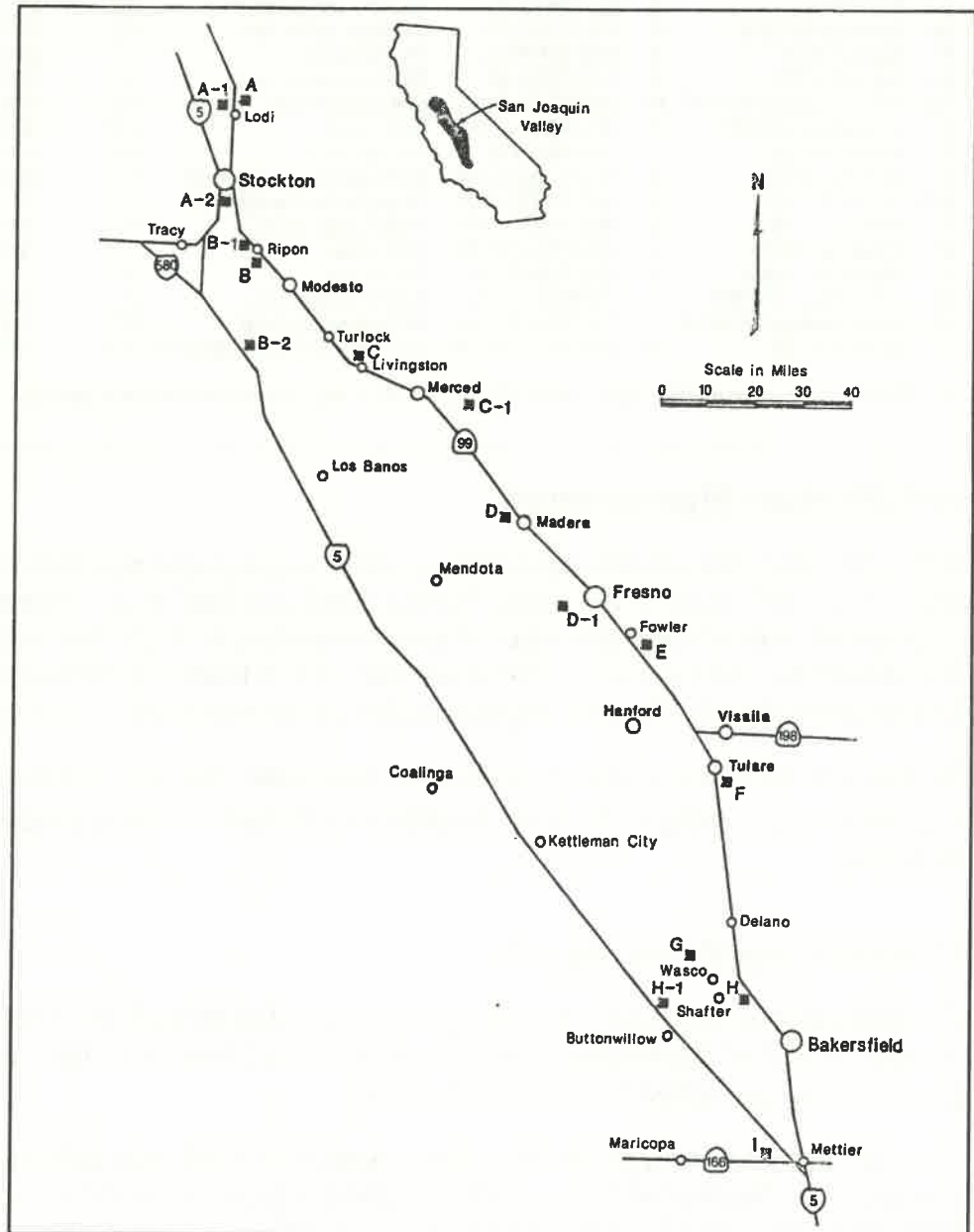


Figure 5
FIELD SITES, EFFECTIVE PRECIPITATION STUDY,
1983-1987

Table 4
DESCRIPTION OF FIELD SITES,
EFFECTIVE PRECIPITATION STUDY,
1983-1987

Miles and Direction Site from Nearest Town	Tract	Section/ Township/ Range*	Soil Type	Natural Land Slope (%)	Estimated Normal Rainfall (inches)	Dates Data Collected
A Lodi 0.5 NW	D	S6/T3N/R6E	Hanford sandy loam	0-2	14.5	1/84 to 6/85
A-1 Lodi 0.5 W	E	S6/T3N/R6E	Hanford sandy loam	0-2	14.5	10/85 to 4/87
A-2 Stockton 5.0 SSE	G	S31/T1N/R7E	Stockton adobe clay	0-1	13.0	9/86 to 4/87
B Ripon 0.5 SE	F	S29/T2S/R8E	Dinuba loam	0-3	13.0	11/83 to 8/84
B-1 Ripon 0.5 NW	K	S19/T2S/R8E	Hanford loamy sand	0-2	13.0	8/84 to 5/86
B-2 Crows Landing 3.0 NW	M	S9/T6S/R8E	Stomar clay loam	0-1	10.0	10/86 to 4/87
C Livingston 0.6 NW	P	S23/T6S/R11E	Delhi sand	0-3	12.5	11/83 to 4/87
C-1 Merced 5.0 SE	R	S1/T8S/R14E	Wyman loam	0-2	11.5	8/84 to 4/87
D Madera 1.5 NW	K	S14/T11S/R17E	Pachappa fine sandy loam	0-1	10.5	12/83 to 7/87
D-1 Fresno 8 WSW	E	S20/T14S/R19E	Hesperia fine sandy loam	0-3	9.0	10/86 to 7/87
E Fowler 1.8 SE	Q	S23/T15S/R21E	Delhi loamy sand	0-3	9.0	11/83 to 3/86
F Tulare 3.7 SSE	J	S26/T20S/R24E	Chino loam	0-2	8.0	11/83 to 7/87
G Wasco 10.0 NNW	R	S21/T25S/R24E	Pond loam	0-1	7.0	11/83 to 5/85
H Bakersfield 12.0 NW	L	S9/T28S/R26E	Exeter sandy loam	0-1	6.0	11/83 to 5/86
H-1 Buttonwillow 7.5 NNW	A	S18/T28S/R23E	Milham sandy loam	0-2	5.5	9/86 to 6/87
I Mettler 8.0 W	B	S10/T11N/R21W	San Emigdio fine sandy loam	0-3	8.5	12/83 to 6/87

* Mount Diablo Base and Meridian, except Site "I", which is San Bernardino Base and Meridian.

Soil Moisture Measurement

A 2-inch-diameter aluminum neutron probe access tube was installed vertically in the soil at each field site. In the southern half of the transect, where only small to moderate amounts of rain were expected, the tubes extended to 5-foot depths. Along the northern portion of the transect, where moderate to heavy amounts of rain were expected, the tubes extended to 10 feet.

Within a 6- to 8-foot circle around the access tube, the soil was kept free of vegetation by hoeing each time the site was visited – about monthly from fall to spring.

Precipitation Measurement

A standard non-recording rain gauge was installed at each field site, usually within 15 feet of the access tube, but more than 6 feet from the tube so the gauge would not affect rainfall at the tube.

A small-diameter rain gauge was also installed *in* each access tube. The small gauges were fabricated from short lengths of electrical metal tubing. An important feature of the gauge design is a vertical positioning sleeve made of a short length of rubber hose fitting tightly around the gauge. The bottom of the sleeve rests on the top of the access tube. The rubber sleeve is moveable so that for field, forage, and vegetable crops the top of the tube gauge can be maintained just above the vegetation surface. For the fallow field sites in this

study, the gauge tops were positioned at about 3 inches above the soil surface. Figure 6 shows the design of the access tube rain gauge.

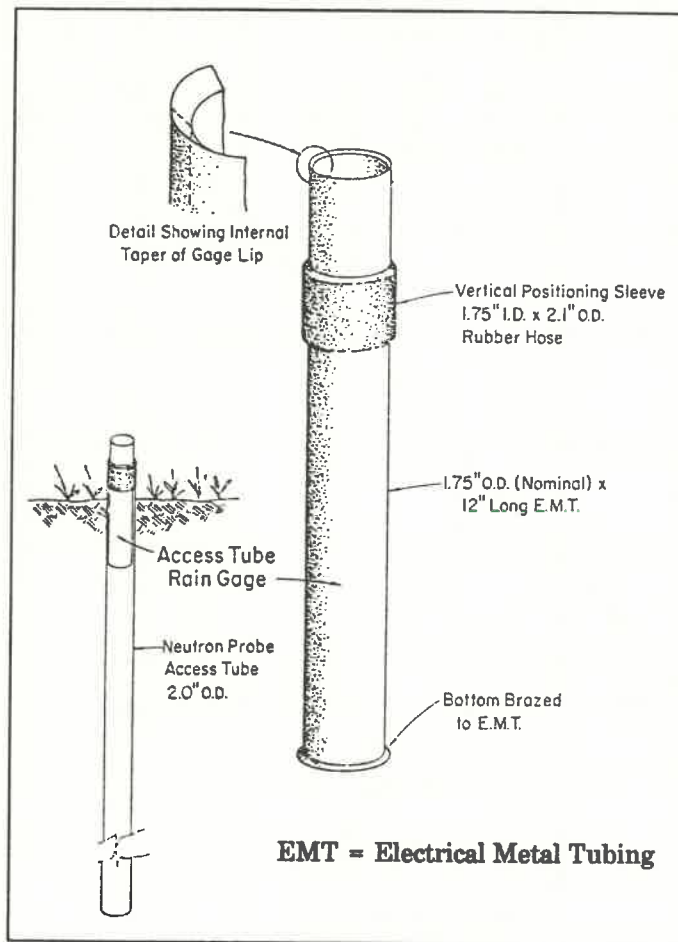


Figure 6
ACCESS TUBE RAIN GAUGE

Two methods were used to measure the amount of rain in the small gauges:

- Direct measurement of water depth in the gauge. Because of the difference between the inside and outside diameter of the gauge (EMT wall thickness), the measured depth was multiplied by 0.9 to get actual depth of rain.
- Determination of volume of water in gauge with a graduated cylinder. It was determined that 37 milliliters of water in the gauge is equivalent to about an inch depth of rain.

Figures 7 and 8 compare rainfall measured at the access tube gauges and that measured at the standard rain gauges for two winters. Because rain caught in the tube gauge was about 12 inches below the open tube top, evaporation was assumed to be minimal. In winter 1986-87, a few drops of lightweight oil were added to each tube gauge to further inhibit evaporation. Linear relationships between the tube gauges and the standard gauges for the two years are nearly the same. The small gauges provide good rainfall measurement at a minimum cost. The most important attribute of these gauges, however, is the improved reliability of field soil moisture measurements determined with a neutron probe.

As a check on rain measured at the field sites, precipitation records were gathered from nearby National Weather Service stations and from other locations where reliable records were available.

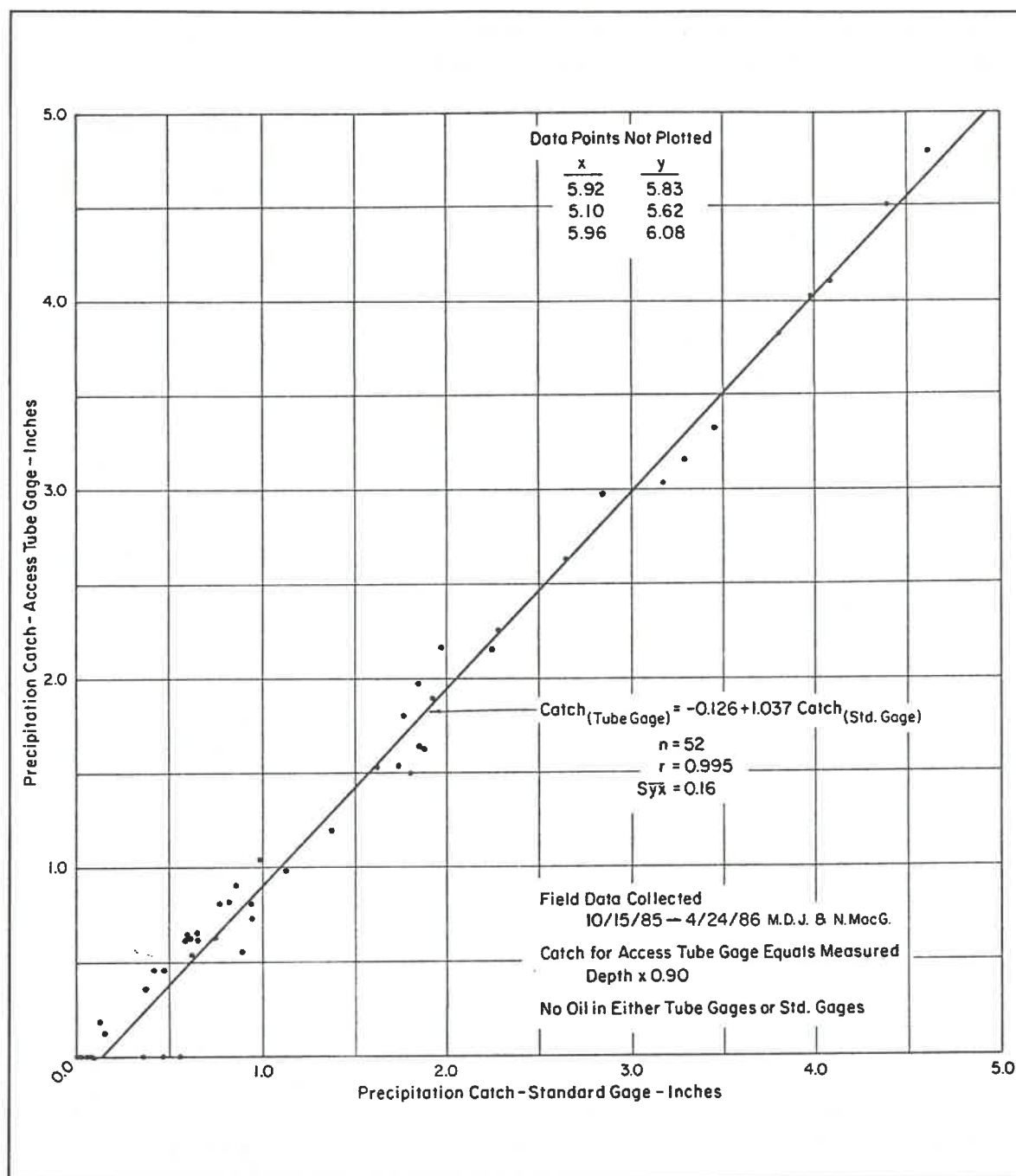


Figure 7
RELATIONSHIP BETWEEN MEASURED RAINFALL CATCH IN
ACCESS TUBE RAIN GAUGE (y) AND STANDARD RAIN GAUGE (x)
FOR WINTER OF 1985-86

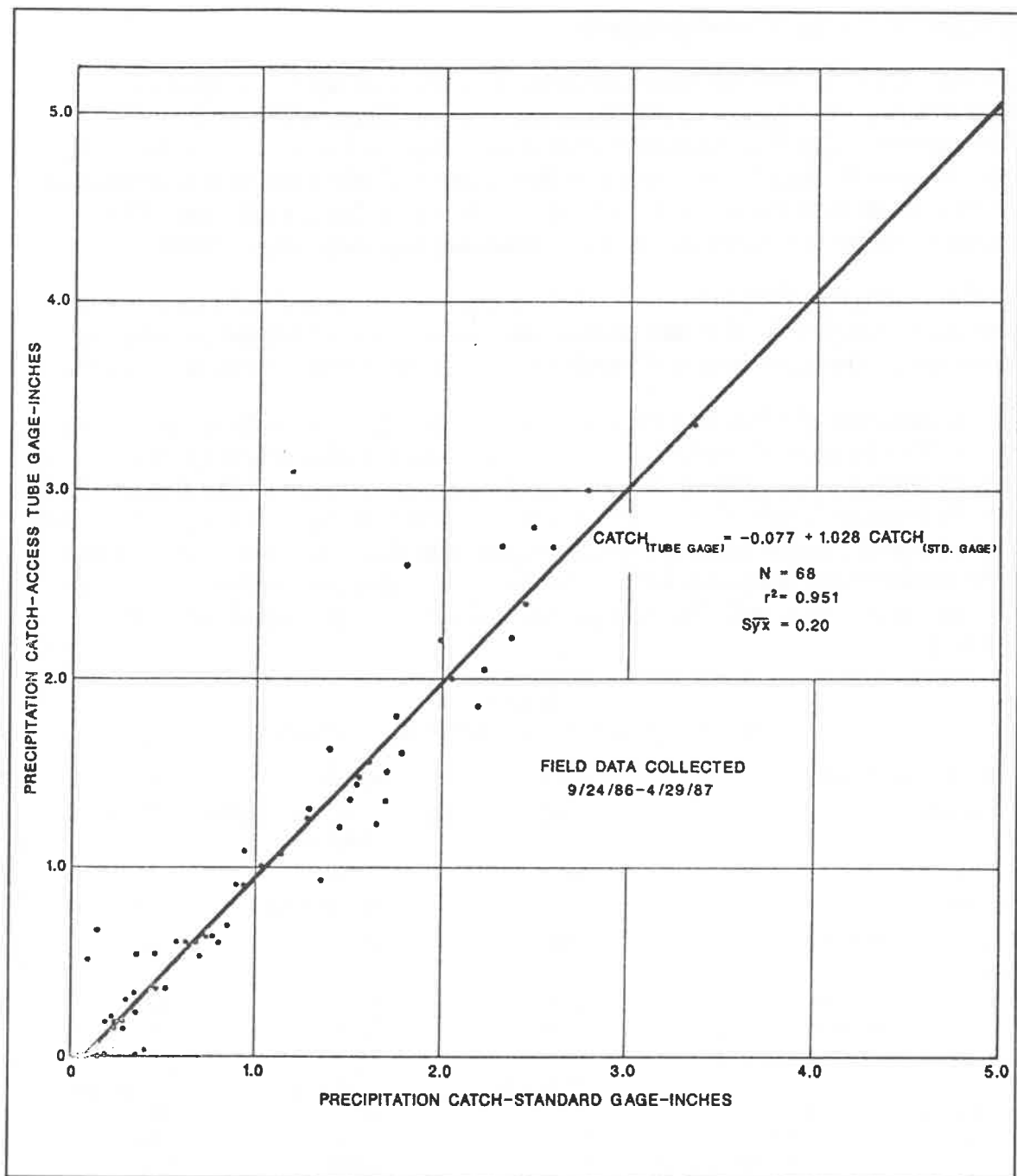


Figure 8
RELATIONSHIP BETWEEN MEASURED RAINFALL CATCH IN
ACCESS TUBE RAIN GAUGE (y) AND STANDARD RAIN GAUGE (x)
FOR WINTER OF 1986-87

Moisture Probe Standardization

To minimize the cost of collecting field data, the five northern sites were usually measured by personnel from the Central District office in Sacramento. The five southerly sites were measured by personnel from the San Joaquin District's field office in Bakersfield. Field work was coordinated so measurements were made on or about the same day for all sites. This required using two neutron probes to measure soil moisture content.

At the beginning of the study in 1983, to assure a comparable basis for determining soil moisture, the two probes then used were calibrated to common standards. Methods used and results obtained were reported in March 1984.⁵

In the summer of 1986, the 20-year-old Nuclear-Chicago neutron probe used by the San Joaquin District failed, and was replaced with a new CPN Model 503DR probe. The CPN instrument is the current version of the Campbell Pacific Nuclear Model 503 probe used by Central District. Although these two probes are of similar design, a quick comparison showed count ratios for the CPN probe were markedly higher for the same moisture content than those for the Campbell Pacific Nuclear probe. All three probes are described in Table 5.

Table 5
DESCRIPTION OF SOIL MOISTURE PROBES

Probe Identification	SJ-1	CD-1	SJ-3
Manufacturer	Nuclear-Chicago	Campbell-Pacific Nuclear	CPN Inc
Model No.	5806	503-A	503-DR
Serial No.	30	H30023121	H36076924
Year Manufactured	1966	1979	1986
Probe			
Length (inches)	14.0	12.0	12.7
Outside Diameter (inches)	1.500	1.865	1.865
Source			
Isotope	²⁴¹ AM-BE	²⁴¹ AM-BE	²⁴¹ AM-BE
Strength (millicurie)	80	50	50
Capsule Length (inches)	1.00	0.50	0.50
Capsule Outside Diameter (inches)	0.37	0.635	0.635
Geometry	Side-mounted	End-mounted	End-mounted
Detector			
Type	BF ₃	BF ₃	BF ₃
Length (inches)	8.0	4.0	4.0
Outside Diameter (inches)	1.00	1.25	1.25
Water Count			
Approximate Count per Minute ÷ 1,000 (in 2-inch aluminum tubing)	42.5	79.5	21.5

⁵ California Department of Water Resources, San Joaquin District, *Effective Precipitation Study – Calibration of Neutron Probes*. (1984).

With little time available for a detailed probe calibration, counting rates between probes were compared using soil counts taken in the 10 access tubes then in place at the various field sampling sites. Soil moisture counts were made with both probes on the same day for each access tube. This was done twice: once when the soil was "dry", and once at a later date when the soil was "wet". Those data provided a basis for relating soil moisture as measured with the two different probes. A calibration table was then developed for the new CPN probe. Methods and results were reported in a July 1987 progress report⁶.

Data Analysis

Data analysis was a straightforward comparison of measured monthly rainfall and the corresponding change in soil moisture content.

Rainfall measured with the standard gauges for the four winters is shown in Tables 6 through 9. Monthly rainfall measured at nearby National Weather Service stations and other locations with reliable records is shown in Tables 10 through 13. Soil moisture content for all field sites and all sampling dates is summarized in Tables 14 through 17.

Rainfall and soil moisture change data for all years were combined and sorted into monthly groups (October through March) for analysis. Data for each month were further sorted into groups based on amount of total rain. Increments of a half-inch of measured rain were used for all months except October and January. For those two months, increments of a quarter-inch were used because of the range and amounts of rainfall.

⁶ California Department of Water Resources, Central and San Joaquin Districts, *Progress Report – Effective Precipitation Study, 1986-87*. (1987).

Table 6
PRECIPITATION AT FIELD SAMPLING SITES,
1983-84
(in inches)

Period Ending (approx)	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H	Site I
11/23/83	--	--	--	--	--	--	--	--	--
11/29/83	0.69*	0.32*	0.36	0.54*	0.85*	0.96*	0.33*	0.60*	0.60*
12/28/83	5.01*	2.37*	2.48	1.56	1.63	1.24	1.48	1.39	1.15*
01/30/84	0.77*	0.39*	0.61	0.55	0.27	0.12	0.19	0.07	0.24
02/27/84	1.64	1.40	1.01	1.48	0.78	0.54	0.04	0.03	0.08
03/29/84	1.19	0.83*	0.63	0.45	0.24	0.37	0.15	0.12	0.99
05/03/84	0.65	0.33*	0.12	0.01	0.13	0.12	0.16	0.09	0.94
Total	9.95	5.64	5.21	4.59	3.90	3.35	2.35	2.30	4.00

Measured with standard non-recording rain gauges at sampling sites shown on Figure 5 and listed in Table 4.

* Rainfall measured at sampling site prorated to sample periods on basis of rainfall record at nearest National Weather Service station.

-- First measurement of season

Table 7
PRECIPITATION AT FIELD SAMPLING SITES,
1984-85
(in inches)

Period Ending (approx)	Site A	Site B-1	Site C	Site C-1	Site D	Site E	Site F	Site G	Site I
10/08/84	--	--	--	--	--	--	--	--	--
11/06/84	2.42	1.55	0.95	1.32	0.67	0.39	0.25	0.35	0.00
12/11/84	6.05	4.51	3.78	3.15	0.66	1.89	1.90	1.34	1.66
01/08/85	1.15	1.26	1.10	0.95	1.72	2.46	1.92	1.75*	2.31
02/07/85	0.68	0.22	0.77	0.96	0.36	0.31	0.19	0.24*	0.30
02/28/85	1.10	0.60	0.00	0.00	0.23*	0.30*	0.24*	0.35	0.53*
03/14/85	1.17	0.92	0.74	0.65	0.38*	0.51*	0.12*	0.18*	0.16*
04/05/85	1.82	1.02	0.78	1.07	1.34	1.47	0.37*	0.28*	0.47
05/07/85					0.09	0.00	0.03	0.00	0.00
Total	14.39	10.08	8.12	8.10	5.45	7.33	5.02	4.49	5.43

Measured with standard nonrecording rain gauges at locations shown on Figure 5 and listed in Table 4.

* Rainfall measured at sampling site prorated to sample periods on basis of rainfall record at nearest National Weather Service Station.

-- First measurement of season

Table 8
PRECIPITATION AT FIELD SAMPLING SITES,
1985-86
(in inches)

Period Ending (approx)	Site A-1	Site B-1	Site C	Site C-1	Site D	Site E	Site F	Site H	Site I
09/17/85	--	--	--	--	--	--	--	--	--
10/16/85	T	0.00	0.00	0.00	0.18	0.00	0.02	0.00	0.00
11/14/85	1.80	0.09	1.92	1.37	1.74	1.87	1.88	1.30	1.61
12/04/85	3.19	2.42	2.65	3.82	1.98	1.31	1.13	0.75	0.59
01/06/86	2.29	1.80	0.94	0.90	0.94	0.94	0.64	0.64	0.42
01/28/86	0.66	0.37	0.15	0.07	0.12	0.08	0.07	0.02	0.03
02/08/86	1.58*	1.58*	1.13*	0.58*	0.68	0.99	0.77	0.48	0.82
03/05/86	4.34*	3.64*	1.72*	2.72*	2.57*	2.54*	2.29*	0.86	0.38
03/20/86	4.41	3.96	3.47	4.10	2.53*	3.42*	2.34*	1.85	1.78
04/23/86	1.93	0.08	0.56	0.60	0.47	0.45	0.36	0.00	0.22
05/20/86	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.53	13.94	12.54	14.16	11.21	11.60	9.50	5.90	5.85

Measured with standard nonrecording rain gauges at locations shown on Figure 5 and listed in Table 4.

* Rainfall measured at sampling site prorated to sample periods on basis of rainfall record at nearest National Weather Service Station.

-- First measurement of season

Table 9
PRECIPITATION AT FIELD SAMPLING SITES,
1986-87
(in inches)

Period Ending (approx)	Site A-1	Site A-2	Site B-2	Site C	Site C-1	Site D	Site D-1	Site F	Site H-1	Site I
09/12/86	--	--	--	--	--	--	--	--	--	--
10/01/86	1.25*	0.80*	0.31*	0.43	0.14	0.41	0.38*	0.19	0.09	0.00
10/28/86	T	0.00	0.00*	0.00	0.00	0.00	T	0.00	0.00	0.00
12/04/86	0.04	0.03	0.00	0.04	0.05	0.02	0.06	0.40	0.58	0.63
01/06/87	1.74	1.42	1.28	1.66	2.33	2.23	2.21	1.71	2.75	2.49
02/05/87	2.80	2.06	0.90	1.27	0.93	0.51	0.76	0.81	0.28	0.37
02/20/87	2.78	2.50	2.34	1.81	1.99	1.66	1.61	1.54	0.68	0.47
03/11/87	2.60	1.75	2.00	3.34	2.45	1.41	1.55	0.62	0.37	0.43
03/31/87	0.94	1.35	0.53	0.46	0.36	0.98	1.13	0.76	0.09	0.00
04/29/87	T	T	0.00	0.00	0.18	0.05	0.00	0.00	0.00	0.00
Total	12.15	9.91	7.36	9.01	8.43	7.27	7.70	6.03	4.84	4.39

Measured with standard nonrecording rain gauges at locations shown on Figure 5 and listed in Table 4.

* Rainfall measured at sampling site prorated to sample periods on basis of rainfall record at nearest National Weather Service Station.

-- First measurement of season

Table 10
MONTHLY PRECIPITATION FOR SEVERAL LOCATIONS IN THE CENTRAL VALLEY,
1983-84
(in inches)

STATION	JUL 83	AUG 83	SEP 83	OCT 83	NOV 83	DEC 83	JAN 84	FEB 84	MAR 84	APR 84	MAY 84	JUN 84	TOTAL	% of NORMAL
Lodi	0.00	0.00	1.08	0.43	6.63	5.50	0.28	1.55	1.22	0.89	0.15	0.12	17.85	109
Stockton FS 4	0.00	0.00	1.11	0.43	6.06	4.54	0.33	1.35	1.09	0.43	0.00	0.00	15.34	104
Stockton AP	0.00	0.00	1.79	0.50	4.23	3.46	0.22	1.20	0.65	0.37	0.01	0.06	12.49	88
Ripon Farm Supply	0.00	0.00	2.45	1.19	4.79	3.28	0.15	1.66	0.83	0.35	0.00	0.10	14.70	*
Modesto	0.00	0.19	2.19	0.50	4.64	2.67	0.20	1.47	0.40	0.41	0.00	0.04	12.71	107
Turlock	0.00	0.00	2.68	0.53	4.03	3.48	0.18	1.12	0.65	0.23	0.00	0.04	12.94	112
Merced AP	0.00	0.23	0.58	0.66	3.80	2.67	0.41	1.57	0.36	0.28	0.00	0.17	10.73	88
Madera	0.00	0.00	0.22	0.66	2.58	2.45	0.35	1.48	0.59	0.18	0.00	0.00	8.51	80
Fresno AP	0.00	0.09	1.03	0.09	2.51	1.75	0.15	1.05	0.48	0.25	0.02	0.20	7.62	74
Visalia	0.00	0.08	0.34	0.22	2.02	2.30	0.03	0.50	0.46	0.27	0.00	0.00	6.22	65
Hanford	0.00	0.05	0.82	0.43	1.66	1.22	0.01	0.42	0.27	0.18	0.00	0.00	5.06	64
Delano	0.00	0.44	1.00	0.22	1.07	1.45	0.07	0.22	0.29	0.80	0.00	0.00	5.56	78
Wasco	0.00	0.47	0.10	0.27	0.57	1.18	0.05	0.06	0.27	0.23	0.00	0.00	3.20	52
Shafter Cot. Sta.	0.00	1.31	0.14	0.24	0.70	1.41	0.42	0.10	0.27	0.20	0.00	0.00	4.79	77
Bakersfield 10NW	0.00	0.58	0.16	0.15	1.27	1.40	0.06	0.14	0.44	0.27	0.00	0.00	4.47	*
Bakersfield AP	0.00	1.18	0.18	0.14	1.31	1.15	0.05	0.05	0.69	0.50	0.00	0.01	5.26	92
Wheeler Ridge- Maricopa HQ	0.00	0.80	0.81	0.33	1.90	0.90	0.24	0.08	0.99	0.94	0.05	0.04	7.08	*

*Record too short to determine normal.

T = Trace; N.R. = No Record

Table 11
MONTHLY PRECIPITATION FOR SEVERAL LOCATIONS IN THE CENTRAL VALLEY,
1984-85
(in inches)

STATION	JUL 84	AUG 84	SEPT 84	OCT 84	NOV 84	DEC 84	JAN 85	FEB 85	MAR 85	APR 85	MAY 85	JUN 85	TOTAL	% of NORMAL
Lodi	0.00	0.01	0.03	2.61	5.10	2.27	0.52	1.35	4.16	0.19	0.00	0.24	16.48	101
Stockton FS 4	0.00	0.00	0.00	1.48	4.24	1.80	0.84	1.35	2.60	0.27	0.00	0.21	12.79	87
Stockton AP	0.00	0.01	0.06	1.47	3.53	1.69	0.67	0.85	2.21	0.13	0.00	0.22	10.84	76
Ripon Farm Supply	0.00	0.00	0.00	2.18	2.30	2.47	0.50	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	--
Modesto	0.01	0.00	0.01	1.94	3.05	1.63	0.46	0.55	2.82	0.53	0.00	0.17	11.17	94
Turlock	0.00	0.00	0.00	1.13	2.78	1.71	0.42	0.54	1.54	0.19	0.00	0.14	8.45	78
Merced AP	0.00	0.00	0.11	1.15	2.71	1.72	0.54	0.97	1.07	0.06	0.00	0.46	8.79	72
Madera	0.00	0.00	0.00	0.87	2.37	2.12	0.59	0.71	1.65	0.52	0.00	0.34	9.17	86
Fresno AP	T	T	0.00	0.70	1.94	1.98	0.43	0.71	1.73	0.12	0.00	0.33	7.94	78
Visalia	0.02	0.11	0.00	0.78	2.48	1.95	0.92	1.19	1.10	0.12	0.00	0.05	8.72	92
Hanford	0.00	0.00	0.00	0.18	0.63	1.57	0.59	0.61	0.68	0.12	0.01	0.00	4.39	56
Delano	0.00	0.00	0.00	0.52	1.26	1.28	0.39	0.43	0.60	0.00	0.00	0.00	4.48	63
Wasco	0.04	0.16	0.04	0.33	1.02	1.23	0.66	0.42	0.61	0.00	0.00	0.80	5.31	86
Shafter Cot. Sta.	0.12	0.03	0.02	0.18	1.04	1.26	0.57	0.48	0.41	0.00	0.02	0.68	4.81	77
Bakersfield 10NW	0.00	0.03	0.00	0.21	1.10	1.26	0.60	0.62	0.54	0.03	0.12	0.81	5.32	*
Bakersfield AP	T	0.01	0.02	0.13	1.01	0.95	0.49	0.44	0.52	T	0.12	0.38	4.07	71
Wheeler Ridge- Maricopa Hq.	0.00	0.00	0.36	0.02	1.65	1.74	1.11	0.65	1.12	0.02	0.00	0.05	6.72	*

*Record too short to determine normal

T = Trace; N.R. = No Record

Table 12
MONTHLY PRECIPITATION FOR SEVERAL LOCATIONS IN THE CENTRAL VALLEY,
1985-86
(in inches)

STATION	JUL 85	AUG 85	SEP 85	OCT 85	NOV 85	DEC 85	JAN 86	FEB 86	MAR 86	APR 86	MAY 86	JUN 86	TOTAL	% of NORMAL
Lodi	0.00	0.00	0.75	0.95	3.62	2.72	3.15	7.51	4.41	2.47	0.31	0.00	25.89	158
Stockton FS 4	0.00	0.00	0.22	1.01	3.71	2.69	2.48	7.46	4.75	1.59	0.19	0.00	24.10	164
Stockton AP	0.05	0.01	0.07	1.25	2.49	1.72	1.69	5.82	3.64	0.93	0.15	0.00	17.82	126
Ripon Farm Supply	0.00	0.00	0.00	1.35	2.25	2.75	2.04	6.48	4.03	0.79	0.00	0.00	19.69	*
Modesto	0.00	0.00	0.07	0.87	2.65	1.70	2.65	4.30	4.63	0.74	0.28	0.00	17.89	151
Turlock	0.00	0.00	0.23	0.76	2.81	1.29	1.27	3.10	3.22	0.56	0.01	0.00	13.25	115
Merced AP	0.00	0.00	0.00	0.60	3.28	1.26	0.92	3.72	3.90	0.64	0.25	0.00	14.57	119
Madera	T	0.12	0.11	0.54	2.76	1.03	1.37	4.12	3.16	0.51	0.15	0.00	13.87	130
Fresno AP	0.04	0.02	0.43	0.85	3.02	0.72	2.12	3.66	3.42	0.36	0.16	0.00	14.80	145
Visalia	0.00	0.00	0.00	0.82	3.56	0.59	1.36	3.51	3.31	0.73	0.00	0.00	13.88	146
Hanford	0.05	0.00	0.00	0.54	2.11	0.66	1.46	2.60	3.43	0.45	0.00	0.00	11.30	144
Delano	0.00	0.00	1.05	0.30	2.20	0.13	1.38	1.58	2.29	0.81	0.00	0.00	9.74	137
Wasco	0.00	0.00	0.76	0.30	1.71	0.44	1.07	1.49	2.09	0.39	0.00	0.00	8.25	133
Shafter Cot.Sta.	0.00	0.00	0.74	0.30	1.61	0.44	1.08	1.23	2.02	0.31	0.00	0.00	7.73	124
Bakersfield 10NW	T	0.00	0.84	0.20	2.06	0.20	1.01	1.14	1.94	0.12	0.00	0.00	7.51	*
Bakersfield AP	T	0.00	0.24	0.18	1.65	0.27	1.12	0.80	2.89	0.25	0.00	0.00	7.40	129
Wheeler Ridge- Maricopa Hq.	0.00	0.00	0.49	0.56	1.77	0.47	0.75	1.01	1.93	0.65	0.08	0.00	7.71	*

*Record too short to determine normal.

T = Trace; N.R. = No Record

Table 13
MONTHLY PRECIPITATION FOR SEVERAL LOCATIONS IN THE CENTRAL VALLEY,
1986-87
(in inches)

STATION	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87	MAY 87	JUN 87	TOTAL	% of NORMAL
Lodi	0.02	0.00	1.25	0.00	0.04	0.75	2.82	4.08	4.52	0.15	0.00	0.00	3.63	83
Stockton FS4	0.04	0.00	0.92	0.00	0.07	0.98	2.67	4.13	4.33	0.14	0.00	0.00	13.28	90
Stockton AP	0.02	0.00	0.80	0.01	0.03	0.67	2.03	3.28	2.84	0.12	0.02	T	9.82	71
Ripon Farm Supply	0.00	0.00	0.36	0.00	0.00	0.67	1.86	4.42	0.71	0.00	0.00	0.00	8.02	*
Modesto	0.00	0.00	0.77	0.00	0.04	0.62	1.67	2.49	3.33	0.11	0.00	0.00	9.03	76
Newman	0.23	0.00	0.31	0.00	0.00	0.66	0.83	2.14	2.49	0.20	0.00	0.00	6.86	64
Turlock	0.00	0.00	1.02	0.01	0.03	0.68	1.68	2.07	3.71	0.10	0.00	0.00	9.30	82
Merced AP	0.00	0.00	0.30	0.00	0.06	0.71	1.70	2.96	3.92	0.08	0.00	T	9.74	80
Madera	0.00	0.00	0.43	0.00	T	0.97	1.60	2.26	2.91	0.36	0.06	0.00	8.59	80
Fresno AP	0.00	0.00	0.38	0.00	0.01	2.30	1.93	1.36	2.39	0.07	0.87	0.01	9.32	91
Visalia	0.00	0.00	0.34	0.00	0.32	1.30	1.62	3.00	1.59	0.21	0.10	0.02	8.50	89
Hanford	0.00	0.00	0.15	0.00	0.21	0.77	1.77	2.60	3.43	0.49	0.00	0.05	9.47	121
Delano	0.00	0.00	0.09	0.00	0.65	0.51	1.26	1.15	1.35	0.00	0.00	0.02	5.03	71
Wasco	0.10	0.00	0.13	0.00	0.79	0.81	2.21	1.07	1.25	0.02	0.00	0.08	6.46	105
Shafter Cot. Sta.	0.18	0.00	0.09	0.01	0.06	0.80	2.05	0.08	1.35	0.08	0.00	T	5.96	95
Bakersfield 10NW	0.00	0.00	0.04	0.00	0.67	1.13	1.99	0.86	1.33	0.33	0.06	0.14	6.55	*
Bakersfield AP	0.00	0.00	0.03	T	0.56	0.97	1.61	0.89	1.07	0.10	0.04	0.31	5.58	98
Wheeler Ridge- Maricopa HQ	0.52	0.00	0.05	0.00	0.76	0.87	1.80	0.80	0.91	0.15	0.00	0.26	6.12	*

*Record too short to determine normal.

T = Trace; N.R. = No Record

Table 14
MEASURED CHANGE IN SOIL MOISTURE AT FIELD SAMPLING SITES,
1983-84
(in inches)

Period Ending (approx.)	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H	Site I
11/29/83									
12/28/83		-.	-.	+2.33	+1.59	+0.76	+1.53	+1.27	-.
01/30/84	-.	+1.32	+2.81	-0.67	+0.54	-0.62	-0.69	-0.89	-0.13
02/27/84	+1.84	+0.83	+1.06	+0.26	+0.27	+0.62	-0.44	-0.11	-0.17
03/29/84	-0.57	+0.64	-0.25	-0.90	-0.06	-0.68	-0.36	-0.02	+0.09
05/01/84	-0.99	-0.47	-0.46	-1.28	-0.14	-0.04	+0.15	-0.01	-0.13
Total	+0.28	+2.32	+3.16	-0.26	+2.20	+0.12	+0.19	+0.24	-0.34

* Summarized from data in Appendix A. Sampling locations are shown on Figure 5 and listed in Table 4.

-. First measurement of season

Table 15
MEASURED CHANGE IN SOIL MOISTURE AT FIELD SAMPLING SITES,
1984-85
(in inches)

Period Ending (approx.)	Site A	Site B-1	Site C	Site C-1	Site D	Site E	Site F	Site G	Site I
10/08/84	-.	-.	-.	-.	-.	-.	-.	-.	-.
11/06/84	+0.80	+0.18	+0.15	+0.79	+0.04	+0.25	+0.87	+0.10	+0.65
12/11/84	+5.87	+4.13	+2.35	+2.60	+1.52	+0.68	-0.30	-0.02	-0.10
01/08/85	+0.59	-0.15	-0.17	+0.02	+0.50	+1.64	+0.97	+1.08	+1.20
02/07/85	+0.08	-1.12	-0.06	+0.49	-0.16	-0.12	-0.41	-0.07	-0.62
02/28/85	+0.05	-0.19	-0.11	-0.49	-0.46	-0.31	-0.22	-0.19	+0.06
04/05/85	+0.73	-0.56	-0.03	+0.11	+0.24	0.00		+0.02	+0.46
05/14/85	-2.16	-2.49	-0.91	-0.24	-0.97	-1.82	-0.30	-0.48	+0.16
Total	+5.96	-0.20	+1.22	+3.37	+0.71	+0.32	+0.61	+0.58	+1.81

* Summarized from data in Appendix B. Sampling locations are shown on Figure 5 and listed in Table 4.

-. First measurement of season

Table 16
MEASURED CHANGE IN SOIL MOISTURE AT FIELD SAMPLING SITES,
1985-86
(in inches)

Period Ending (approx.)	Site A-1	Site B-1	Site C	Site C-1	Site D	Site E	Site F	Site H	Site I
10/16/85	--	--	--	--	--	--	--	--	--
11/14/85	+0.98	+0.21	+1.26	+0.55	+2.21	+0.34	+1.48	+0.10	+0.86
12/04/85	+3.16	+2.25	+1.68	+5.05	+0.75	+1.14	+1.27	-0.02	-0.09
01/06/86	+2.46	-1.14	-0.64	-0.19	+0.12	+1.75	+0.85	+1.08	-0.16
01/28/86	+0.33	-0.47	-0.05	-1.22	-0.73	+0.36	-0.70	-0.07	-0.33
02/24/86	+10.84	+1.89	+2.61	+4.35	+1.77	+0.50	+2.47	-0.19	+0.18
03/20/86	+4.11	+0.20	+1.89	+1.51	+1.73	+3.19	+1.74	+0.02	+1.12
04/24/86	-4.72	-2.33	-1.36	-2.03	-1.48		-2.87	-0.48	
05/20/86	-1.34	-0.97	-0.96	-3.75	-0.77		-0.68		-1.09
Total	+15.82	+1.92	+4.43	+4.27	+3.36	+7.28	+1.68	+0.58	+0.67

* Summarized from data in Appendix C. Sampling locations are shown on Figure 5 and listed in Table 4.

-- First measurement of season

Table 17
MEASURED CHANGE IN SOIL MOISTURE AT FIELD SAMPLING SITES,
1986-87
(in inches)

Period Ending (approx.)	Site A-1	Site A-2	Site B-2	Site C	Site C-1	Site D	Site D-1	Site F	Site H-1	Site I
09/12/86	--	--			--	--		--	--	--
10/01/86	+0.39	+0.21		--	+0.26	-0.12	--	+0.09	+0.02	-0.22
10/20/86	-0.36	-0.06	--	-0.37	-0.18	-0.24	+0.04	-0.01	-0.04	-0.06
12/04/86						-0.24	-0.07	+0.05	+0.23	+0.86
01/08/87	+0.27	+0.73	+1.92	+1.19	+1.93	+3.49	+1.19	+0.32	+3.18	+1.49
02/07/87	+1.83	+1.33	+0.47	+0.66	0.00	-1.37	+0.24	+0.56	-0.40	-0.59
02/28/87	+3.57	+5.55	+4.63	+1.19	+1.81	+1.46	+1.32	+1.49	-0.04	+0.07
04/05/87	+0.90	+0.86	+1.83		+1.78	+0.54	+0.99	-0.71	+0.14	-0.14
05/14/87	-1.80	-1.04	-1.15	+1.02	-0.49	-0.93	+0.29	+0.01		
05/29/87	-2.37	-1.50	-0.51	-0.65	-3.84	-1.60	-3.24	-0.30	-1.49	
Total	+2.43	+6.08	+7.19	+3.04	+1.27	+0.99	+0.68	+1.50	+1.60	+1.41

* Summarized from data in Appendix D. Sampling locations are shown on Figure 5 and listed in Table 4.

-- First measurement of season

Annual averages of measured rain and corresponding change in soil moisture were calculated for each rainfall increment grouping. Figure 9 shows the calculated linear relationship between change in soil moisture content and total rainfall for each of the six months (October through March). Comparison of the graphs in Figure 9 shows that the relationship for the four winter months (November through February) is similar. Therefore, data for those four months were combined, and a single relationship was calculated. This is shown in Figure 10. Coefficients of determination (r^2) were high for individual monthly relationships, as well as for the single relationship for all four winter months.

For October, the slope of the line relating soil moisture change to rainfall is not as steep as for the winter months. This is because the initially dry soil in October limits surface evaporation under low rainfall conditions.

In March, evaporative demand is higher than in the winter months, resulting in greater evaporation of rain from the soil surface and a corresponding decrease in soil moisture storage.

Relationships determined in this field study represent averages over a fairly broad range of fallow field conditions. More detailed analysis of these and additional data is warranted to evaluate effects of varied field conditions (i.e., soil texture, rainfall patterns, weed growth, soil tillage).

Results of this study show that the procedures followed are sound. The relationships determined provide a rational basis for partitioning winter rain falling on a fallow field (and excluding runoff) as follows:

- Stored soil moisture (effective precipitation),
- Evaporation from the soil surface, and
- Percolation to below crop rooting depths.

Table 18 presents an estimate of disposition of rainfall for an average year in the Central Valley. Because optimum soil and crop conditions were assumed for calculating the amounts and percentages of effective precipitation, the estimates should be considered as a first approximation of the maximum consumptive use of annual rains by a crop planted in early spring and grown during summer months.

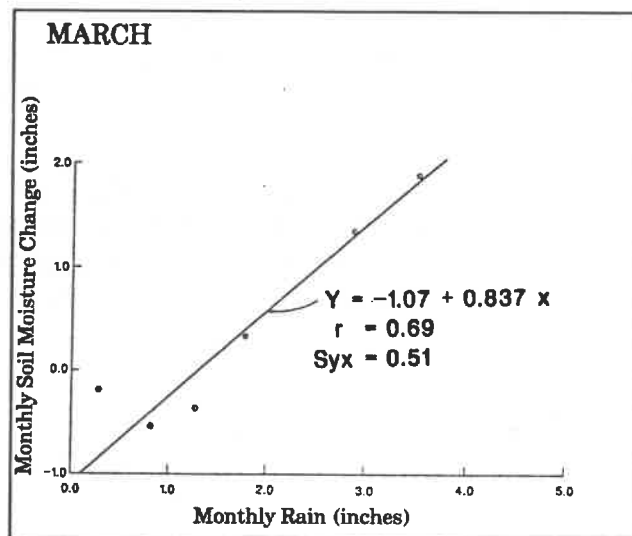
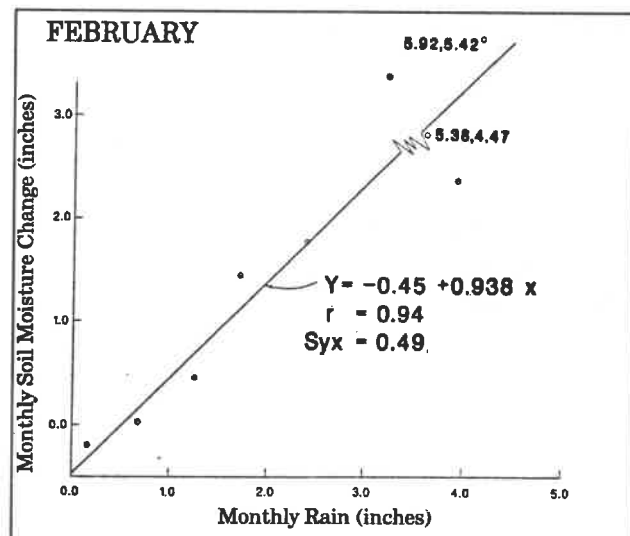
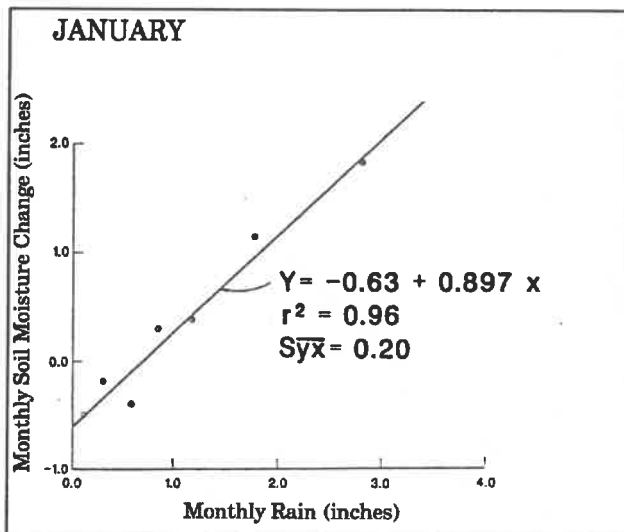
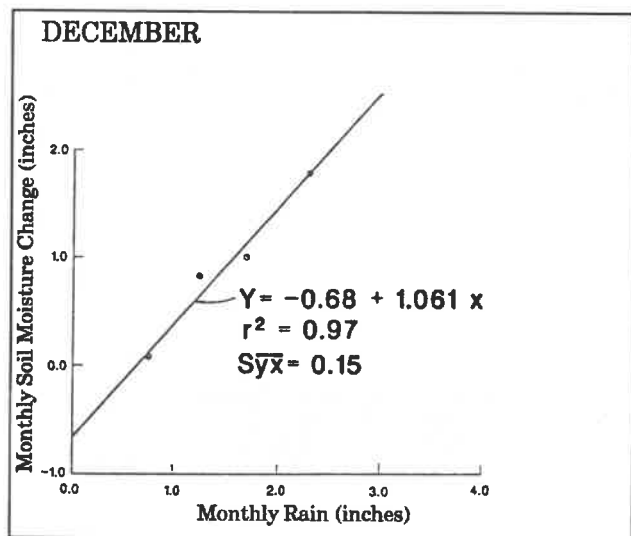
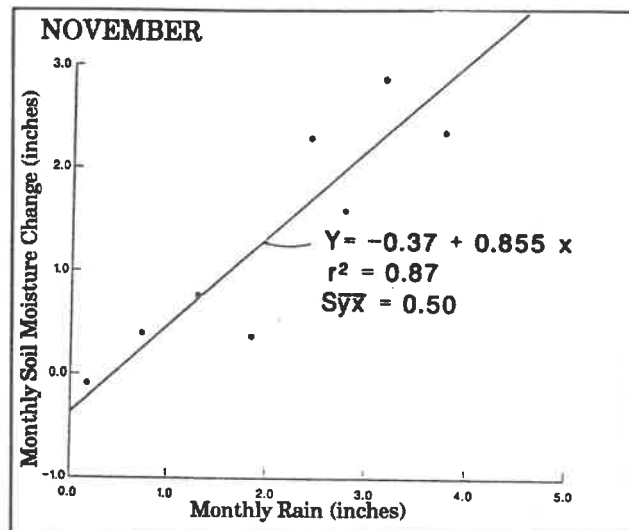
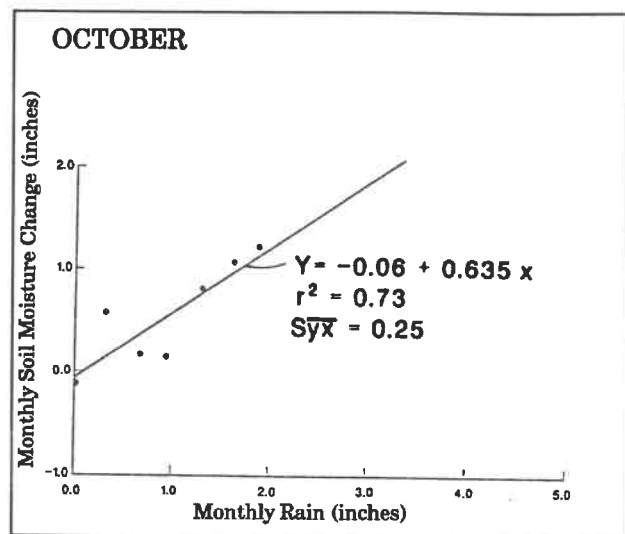


Figure 9
RELATIONSHIP BETWEEN MEASURED RAINFALL AND SOIL MOISTURE CHANGE,
1984-1987

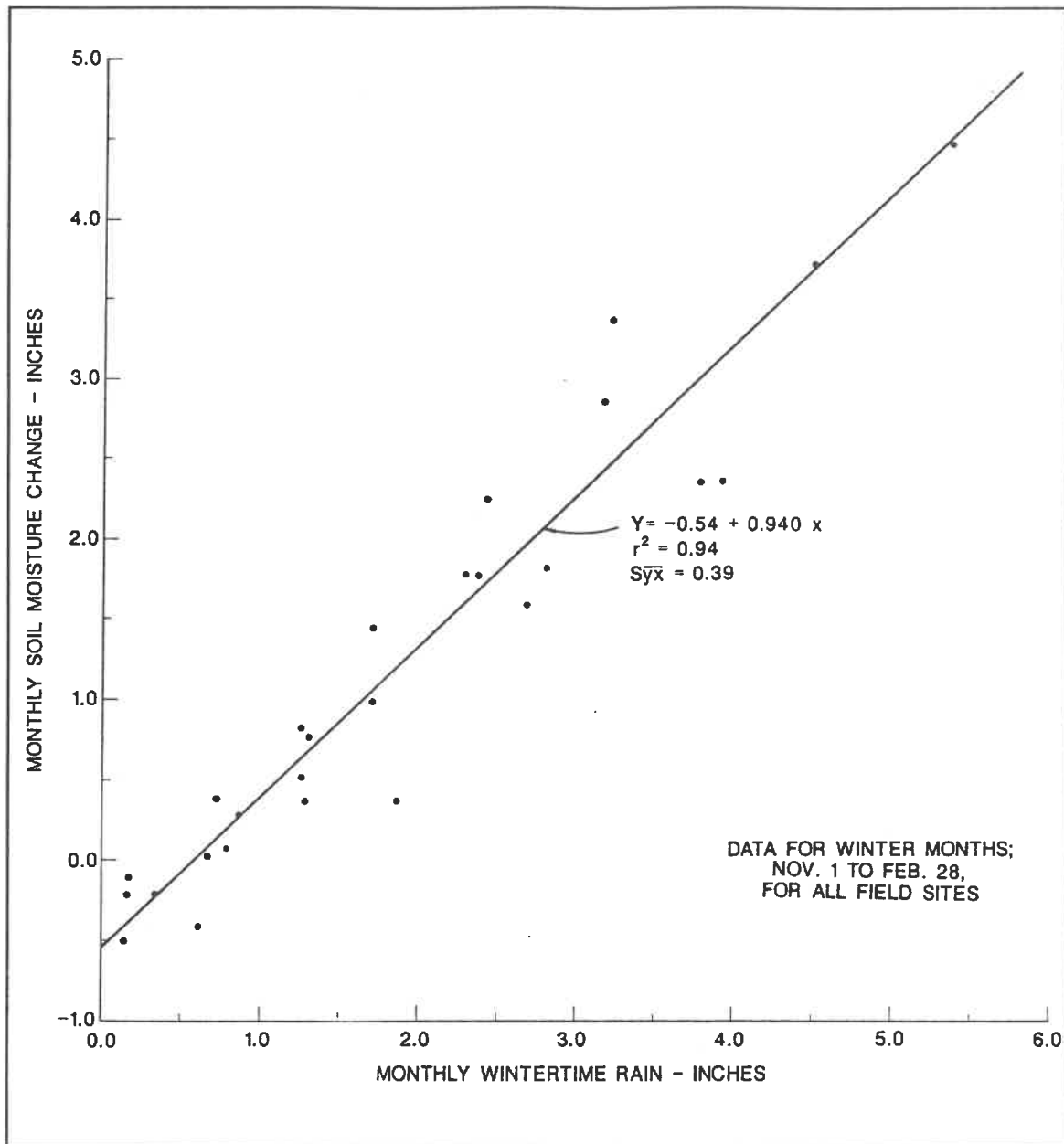


Figure 10
RELATIONSHIP BETWEEN MONTHLY RAINFALL AND
CHANGE IN SOIL MOISTURE CONTENT,
AVERAGE FOR WINTER MONTHS, 1984-1987

Table 18
Disposition of Average Annual Rainfall for Several Zones in the Central Valley

Zone	Distance South of Red Bluff (Miles)	Area (Acres ÷ 1000)	Average Annual Rain (Inches)	Effective Precipitation			Evap from Soil Surface	Deep Perco- lation	Effective Precipitation			Evap from Soil Surface	Deep Perco- lation
				Growing Season	Non-Growing Season	Total (Inches Depth)			Growing Season	Non-Growing Season	Total (Percent of Annual Rainfall)		
1	5	46	20.7	1.8	7.5	9.3	6.3	5.1	9	36	45	30	25
2	35	568	19.6	1.7	7.5	9.2	6.2	4.2	9	38	47	32	21
3	90	1,058	17.5	1.5	7.5	9.0	5.9	2.6	9	43	52	34	15
4	150	1,066	15.0	1.3	7.5	8.8	5.5	0.7	9	50	59	37	5
5	215	1,149	12.5	1.1	6.3	7.4	5.1	0.0	9	50	59	41	0
6	280	1,536	10.0	0.9	4.4	5.3	4.7	0.0	9	44	53	47	0
7	345	1,579	7.5	0.6	2.4	3.0	4.5	0.0	9	32	40	60	0
8	395	498	5.5	0.5	0.9	1.4	4.1	0.0	9	16	25	75	0
Weighted Average			12.1	1.0	5.2	6.2	5.1	0.8	9	42	51	42	7

ASSUMPTIONS: Average year rainfall amounts, frequency, and intensity.
No surface runoff.
Deep, medium-textured soil, with moisture storage capacity of 1.5 inch/foot.
Bare soil surface during winter months.
Crop planted in early April and harvested in late September.
5-foot rooting depth.

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GLOSSARY

- Available soil moisture storage capacity.** The difference in moisture content between field capacity and permanent wilting percentage.
- Deep percolation.** The drainage of soil water by gravity below the maximum depth of the rooting zone.
- Effective precipitation.** That portion of precipitation that is evapotranspired during a crop growing season, thus reducing the applied water requirement. It includes precipitation that (1) occurs during the growing season and (2) occurs before the growing season and is carried over into the growing season as stored soil moisture.
- Evapotranspiration (ET).** The amount of water transpired by vegetation and evaporated from adjacent soil surfaces.
- Field capacity.** The volume of water remaining in a well drained soil when the velocity of downward movement into unsaturated soil has become negligible.
- Ground cover percentage.** The percentage of a specified area covered or shaded by transpiring vegetation when viewed from directly overhead.
- Growing season.** The period during which crops grow and use water, normally considered to be planting to harvest for annual crops and leaf-out to leaf-drop for perennials.
- Irrigation efficiency.** The percentage of irrigation water applied to the field that is stored in the soil and is available for evapotranspiration by crops.
- Neutron probe.** An instrument for determining soil moisture content, based on the principle of fast-neutron moderation.
- Permanent wilting percentage (PWP).** The moisture content below which plants cannot readily obtain water. The soil moisture condition at which plants wilt and do not recover unless water is applied to the soil.
- Potential evapotranspiration (PET).** The amount of water transpired by a low-growing green crop of about the same color as grass that completely covers the ground and has an unlimited supply of water and an extensive fetch.
- Precipitation.** The deposition of water from the atmosphere upon the Earth's surface in the form of rain, snow, sleet, mist, or hail.
- Rooting depth.** The portion of the soil profile containing nearly all of the plant roots.
- Soil water.** Water present in the soil pores. Also called *soil moisture*, which includes water vapor.
- Transpiration.** The process by which water in plants is transferred as water vapor to the atmosphere.

Appendix A
MEASURED SOIL MOISTURE
AT FIELD SITES
1983-1984

Table A-1
MEASURED SOIL MOISTURE, 1983-84
SITE A, NEAR LODI
(inches per foot)

Depth (Feet)	01/31/84	02/29/84	03/01/84	03/29/84	05/01/84	08/23/84
0.5	2.38	2.52	2.51	1.87	1.55	0.34
1.0	2.65	2.80	2.80	2.30	1.97	0.66
1.5	2.70	2.95	2.88	2.58	2.14	0.79
2.0	2.79	3.06	3.00	2.73	2.37	0.85
2.5	2.71	2.99	2.97	2.73	2.52	0.90
3.0	2.69	2.88	2.87	2.65	2.46	0.84
3.5	2.79	2.92	2.92	2.74	2.56	0.87
4.0	2.83	2.91	2.91	2.86	2.73	0.88
4.5	2.70	2.79	2.76	2.74	2.61	0.87
5.0	2.69	2.73	2.69	2.66	2.51	0.86
5.5	2.80	2.84	2.84	2.81	2.69	0.87
6.0	2.40	2.56	2.56	2.57	2.52	0.95
6.5	1.49	2.30	2.26	2.42	2.34	0.95
7.0	1.06	1.77	1.75	2.15	2.17	1.01
7.5	1.28	1.47	1.48	2.02	2.20	1.20
8.0	1.28	1.33	1.34	1.57	1.81	1.20
8.5	1.34	1.37	1.40	1.41	1.62	1.42
9.0	1.02	1.04	1.04	1.04	1.09	1.10
9.5	0.76	0.80	0.78	0.77	0.78	0.80
Total	20.18	22.02	21.88	21.31	20.32	8.68
Soil type:	Hanford sandy loam					
Probe:	CD-1					

Table A-2
MEASURED SOIL MOISTURE, 1983-84
SITE B, NEAR RIPON
(inches per foot)

Depth (Feet)	11/23/83	01/31/84	02/29/84	03/01/84	03/29/84	05/01/84	08/22/84
0.5	2.75	2.26	2.47	2.46	2.08	1.58	0.72
1.0	2.56	2.40	2.62	2.54	2.45	2.18	1.33
1.5	1.71	1.85	2.05	2.05	1.93	1.81	1.32
2.0	1.14	1.67	1.81	1.92	1.79	1.69	1.31
2.5	0.82	1.63	1.75	1.83	1.75	1.70	1.36
3.0	0.76	1.61	1.74	1.79	1.78	1.74	1.40
3.5	0.66	1.43	1.58	1.63	1.64	1.63	1.33
4.0	0.64	1.27	1.40	1.47	1.47	1.48	1.25
4.5	0.64	1.10	1.28	1.31	1.37	1.36	1.18
5.0	0.58	0.88	1.06	1.10	1.15	1.15	1.01
5.5	0.47	0.63	0.83	0.86	0.91	0.93	0.79
6.0	0.33	0.35	0.59	0.60	0.68	0.74	0.56
6.5	0.36	0.26	0.37	0.41	0.47	0.51	0.45
7.0	0.42	0.37	0.39	0.43	0.45	0.50	0.50
7.5	0.75	0.57	0.61	0.63	0.64	0.66	0.63
8.0	1.41	1.19	1.27	1.31	1.28	1.29	1.24
8.5	1.87	1.55	1.60	1.65	1.72	1.70	1.61
9.0	2.86	2.57	2.70	2.77	2.80	2.78	2.63
9.5	2.94	2.72	2.86	2.91	2.90	2.88	2.81
Total	11.84	13.16	13.99	14.84	14.63	14.16	11.72
Soil type:	Dinuba loam						
Probe:	CD-1						

Table A-3
MEASURED SOIL MOISTURE, 1983-84
SITE C, NEAR LIVINGSTON
(inches per foot)

Depth (Feet)	11/22/83	01/31/84	03/01/84	03/29/84	05/02/84	08/22/84
0.5	0.53	0.66	0.93	0.81	0.64	0.30
1.0	1.56	1.28	1.43	1.20	0.98	0.57
1.5	1.58	1.27	1.34	1.14	0.95	0.64
2.0	0.98	1.00	1.06	0.96	0.87	0.62
2.5	0.53	0.93	0.98	0.90	0.78	0.59
3.0	0.20	0.93	0.94	0.87	0.79	0.53
3.5	0.22	0.96	0.94	0.88	0.83	0.50
4.0	0.22	0.96	0.94	0.91	0.83	0.52
4.5	0.27	0.97	0.94	0.90	0.87	0.59
5.0	0.32	1.03	1.05	1.05	1.00	0.78
5.5	0.46	1.15	1.21	1.20	1.23	0.93
6.0	0.53	1.11	1.25	1.23	1.24	0.95
6.5	0.89	1.34	1.72	1.81	1.73	1.37
7.0	0.89	1.15	1.64	1.77	1.73	1.42
7.5	0.74	0.77	0.97	1.12	1.13	1.02
8.0	0.64	0.66	0.77	0.87	0.92	0.83
8.5	0.65	0.68	0.76	0.77	0.88	0.83
9.0	0.72	0.72	0.77	0.75	0.80	0.79
9.5	0.83	0.80	0.86	0.85	0.87	0.86
Total	6.38	9.19	10.25	10.00	9.54	7.32
Soil type:	Delhi sand					
Probe:	CD-1					

Table A-4
MEASURED SOIL MOISTURE, 1983-84
SITE D, NEAR MADERA
(inches per foot)

Depth (feet)	12/06/83	12/27/83	01/31/84	02/28/84	03/28/84	05/15/84
0.5	1.49	3.69	1.89	1.84	0.80	0.43
1.0	1.34	3.48	2.54	2.59	1.86	1.10
1.5	0.88	1.24	2.18	2.14	2.01	1.23
2.0	0.86	0.87	1.31	1.64	1.72	1.12
2.5	0.83	0.81	0.88	0.98	1.07	0.97
3.0	0.85	0.85	0.82	0.85	0.88	0.92
3.5	0.97	0.94	0.94	0.98	0.93	0.97
4.0	1.06	1.06	1.05	1.05	1.04	1.02
4.5	1.09	1.06	1.06	1.05	1.06	1.04
5.0	1.04	1.06	1.06	1.13	1.07	1.08
5.5	1.17	1.16	1.15	1.19	1.14	1.17
6.0	1.27	1.27	1.28	1.27	1.26	1.29
6.5	1.32	1.37	1.34	1.33	1.34	1.38
7.0	1.58	1.37	1.40	1.43	1.43	1.41
7.5	1.70	1.87	1.78	1.84	1.86	1.94
8.0	2.32	2.42	2.34	2.51	2.45	2.45
Total	9.89	12.26	11.51	11.91	10.96	9.76
Soil type:	Pachappa fine sandy loam					
Probe:	SJ-1					

Table A-5
MEASURED SOIL MOISTURE, 1983-84
SITE E, NEAR FOWLER
(inches per foot)

Depth (feet)	11/30/83	12/27/83	01/30/84	02/28/84	03/28/84	05/03/84	08/21/84
0.5	0.45	1.12	0.44	0.37	0.20	0.26	0.15
1.0	0.76	1.23	0.72	0.64	0.49	0.42	0.18
1.5	0.57	1.05	0.72	0.64	0.53	0.49	0.32
2.0	0.28	0.91	0.77	0.70	0.59	0.53	0.46
2.5	0.21	0.54	0.87	0.78	0.73	0.62	0.49
3.0	0.19	0.25	0.84	0.78	0.73	0.67	0.48
3.5	0.35	0.45	0.88	0.91	0.88	0.86	0.79
4.0	0.91	1.05	1.82	2.14	2.29	2.28	2.23
4.5	0.58	0.69	0.92	1.19	1.32	1.31	1.24
5.0	0.38	0.45	0.65	0.85	0.98	1.01	0.91
5.5	0.72	0.83	1.02	1.19	1.34	1.34	1.15
Total	2.70	4.29	4.83	5.10	5.04	4.90	4.20
Soil type:	Delhi loamy sand						
Probe:	SJ-1						

Table A-6
MEASURED SOIL MOISTURE, 1983-84
SITE F, NEAR TULARE
(inches per foot)

Depth (feet)	11/30/83	12/27/83	01/30/84	02/27/84	03/28/84	05/03/84	10/09/84
0.5	1.40	2.46	1.13	1.94	0.97	0.75	0.26
1.0	1.24	1.59	1.37	1.43	1.35	1.28	0.48
1.5	0.91	1.10	1.22	1.27	1.26	1.26	0.66
2.0	0.98	1.02	1.14	1.19	1.18	1.23	0.84
2.5	1.72	1.70	1.73	1.75	1.82	1.85	1.38
3.0	2.11	2.06	2.00	2.11	2.03	2.10	1.74
3.5	1.71	1.63	1.63	1.64	1.62	1.65	1.38
4.0	1.46	1.50	1.49	1.54	1.42	1.52	1.42
4.5	1.45	1.45	1.53	1.54	1.46	1.49	1.49
5.0	1.49	1.51	1.53	1.54	1.47	1.57	1.59
5.5	1.23	1.20	1.20	1.27	1.27	1.23	1.23
Total	7.85	8.61	7.99	8.61	7.93	7.97	6.24
Soil type:	Chino loam						
Probe:	SJ-1						

Table A-7
MEASURED SOIL MOISTURE, 1983-84
SITE G, NEAR WASCO
(inches per foot)

Depth (feet)	11/29/83	12/28/83	01/30/84	02/27/84	03/29/84	05/03/84	10/09/84
0.5	2.13	3.57	2.46	1.94	1.59	1.55	0.82
1.0	1.59	3.04	2.61	2.23	2.02	1.89	1.21
1.5	1.20	1.32	1.40	1.34	1.35	1.36	1.14
2.0	1.12	1.09	1.12	1.13	1.10	1.18	1.02
2.5	1.16	1.13	1.16	1.13	1.17	1.22	1.14
3.0	1.27	1.30	1.30	1.27	1.27	1.35	1.26
3.5	1.26	1.27	1.27	1.27	1.27	1.30	1.23
4.0	1.70	1.69	1.73	1.75	1.80	1.82	1.78
4.5	1.91	1.92	1.97	2.04	1.95	2.03	1.95
5.0	1.47	1.52	1.54	1.54	1.44	1.52	1.45
5.5	1.78	1.81	1.72	1.75	1.72	1.75	1.84
Total	8.30	9.83	9.14	8.70	8.34	8.49	7.42
Soil type:	Pond loam						
Probe:	SJ-1						

Table A-8
MEASURED SOIL MOISTURE, 1983-84
SITE H, NEAR BAKERSFIELD
(inches per foot)

Depth (feet)	11/28/83	12/28/83	01/30/84	02/27/84	03/29/84	05/03/84
0.5	0.67	1.95	0.67	0.37	0.32	0.34
1.0	0.54	1.45	0.94	0.78	0.74	0.67
1.5	0.47	0.74	0.82	0.78	0.74	0.70
2.0	0.47	0.48	0.61	0.70	0.67	0.65
2.5	0.53	0.49	0.49	0.63	0.60	0.64
3.0	0.58	0.61	0.58	0.54	0.64	0.65
3.5	0.66	0.67	0.65	0.70	0.68	0.68
4.0	0.69	0.69	0.66	0.70	0.68	0.69
4.5	0.68	0.72	0.67	0.70	0.72	0.72
5.0	0.75	0.73	0.72	0.70	0.73	0.75
5.5	0.79	0.84	0.79	0.78	0.81	0.83
Total	3.42	4.69	3.80	3.69	3.67	3.66
Soil type:	Exeter sandy loam					
Probe:	SJ-1					

Table A-9
MEASURED SOIL MOISTURE, 1983-84
SITE I, NEAR METTLER
(inches per foot)

Depth (feet)	12/20/83	01/30/84	02/27/84	03/29/84	05/03/84	10/10/84
0.5	1.69	1.58	1.13	1.07	0.91	0.25
1.0	1.02	1.09	1.19	1.20	1.15	0.49
1.5	0.77	0.76	0.78	0.84	0.85	0.61
2.0	0.67	0.67	0.63	0.74	0.68	0.64
2.5	0.69	0.63	0.63	0.63	0.64	0.65
3.0	0.60	0.57	0.55	0.58	0.57	0.55
3.5	0.61	0.57	0.55	0.58	0.59	0.52
4.0	0.59	0.53	0.55	0.58	0.53	0.52
4.5	0.65	0.64	0.63	0.63	0.63	0.57
5.0	0.77	0.75	0.78	0.76	0.79	0.77
5.5	0.74	0.74	0.78	0.77	0.77	0.79
Total	4.40	4.27	4.10	4.19	4.06	3.18

Soil type: San Emigdio fine sandy loam
Probe: SJ-1

Appendix B
MEASURED SOIL MOISTURE
AT FIELD SITES
1984-1985

Table B-1
MEASURED SOIL MOISTURE, 1984-85
SITE A, NEAR LODI
(inches per foot)

Depth (Feet)	08/23/84	10/08/84	11/06/84	12/11/84	01/08/85	02/07/85	02/28/85	03/14/85	04/05/85	05/14/85	06/21/85
0.5	0.34	0.30	1.23	2.84	2.76	1.63	1.64	2.09	1.96	1.02	0.70
1.0	0.66	0.53	1.11	2.93	2.72	2.18	2.19	2.40	2.51	1.50	1.14
1.5	0.79	0.69	0.85	3.00	2.64	2.43	2.43	2.40	2.65	1.79	1.33
2.0	0.85	0.80	0.80	3.02	2.74	2.62	2.63	2.53	2.77	2.10	1.66
2.5	0.90	0.82	0.82	2.90	2.70	2.70	2.70	2.52	2.70	2.14	1.67
3.0	0.84	0.80	0.74	2.26	2.51	2.62	2.62	2.45	2.57	2.09	1.76
3.5	0.87	0.84	0.83	1.12	2.36	2.66	2.68	2.54	2.52	2.29	1.89
4.0	0.88	0.85	0.84	0.87	1.48	2.51	2.51	2.42	2.36	2.26	1.95
4.5	0.87	0.83	0.83	0.83	0.89	1.60	1.62	1.86	1.98	1.99	1.76
5.0	0.86	0.83	0.80	0.82	0.83	0.92	0.93	1.04	1.21	1.55	1.48
5.5	0.87	0.88	0.85	0.84	0.86	0.87	0.87	0.88	0.93	1.09	1.18
6.0	0.95	0.86	0.86	0.89	0.87	0.87	0.87	0.88	0.90	0.93	0.95
6.5	0.95	0.86	0.86	0.83	0.87	0.85	0.85	0.87	0.90	0.87	0.85
7.0	1.01	0.87	0.91	0.89	0.90	0.87	0.87	0.93	0.90	0.90	0.90
7.5	1.20	1.02	1.05	1.06	1.05	1.05	1.06	1.06	1.06	1.05	1.05
8.0	1.20	1.00	1.00	1.01	1.02	1.00	1.00	1.02	1.00	1.02	0.98
8.5	1.42	1.00	1.00	1.02	1.03	1.02	1.02	1.02	1.02	1.04	1.02
9.0	1.10	0.74	0.74	0.74	0.76	0.76	0.77	0.78	0.78	0.78	0.74
9.5	0.80	0.59	0.60	0.59	0.65	0.63	0.63	0.63	0.63	0.63	0.60
Total	8.68	7.56	8.36	14.23	14.82	14.90	14.95	15.16	15.68	13.52	11.81
Soil type:	Hanford sandy loam										
Probe:	CD-1										

Table B-2
MEASURED SOIL MOISTURE, 1984-85
SITE B-1, NEAR RIPON
(inches per foot)

Depth (Feet)	08/24/84	10/10/84	11/06/84	12/11/84	01/10/85	02/07/85	02/28/85	03/14/85	04/05/85	05/14/85	06/21/85	09/17/85
0.5	0.23	0.22	0.42	2.14	2.08	1.50	1.42	1.60	1.39	0.30	0.24	0.22
1.0	0.36	0.31	0.44	2.04	1.96	1.45	1.37	1.40	1.38	0.45	0.42	0.32
1.5	0.38	0.36	0.40	1.74	1.62	1.27	1.28	1.23	1.23	0.51	0.44	0.44
2.0	0.46	0.44	0.42	1.74	1.62	1.30	1.28	1.23	1.20	0.52	0.50	0.48
2.5	0.61	0.65	0.59	1.77	1.62	1.41	1.34	1.30	1.27	0.67	0.65	0.66
3.0	0.74	0.78	0.74	1.37	1.34	1.21	1.27	1.18	1.12	0.78	0.77	0.78
3.5	0.73	0.83	0.74	1.07	1.16	1.07	1.07	1.05	1.00	0.80	0.78	0.83
4.0	0.80	0.87	0.80	0.95	1.13	1.07	1.07	1.01	1.00	0.85	0.87	0.87
4.5	0.95	1.03	0.97	1.04	1.18	1.18	1.18	1.14	1.12	1.00	1.06	1.05
5.0	1.19	1.35	1.23	1.33	1.52	1.55	1.46	1.48	1.47	1.33	1.46	1.33
5.5	2.43	2.81	2.57	2.77	2.94	2.90	2.90	2.84	2.88	2.82	3.03	2.77
6.0	3.35	3.51	3.28	3.45	3.56	3.51	3.50	3.46	3.44	3.47	3.50	3.40
6.5	3.40	3.62	3.40	3.53	3.68	3.65	3.62	3.58	3.60	3.55	3.65	3.53
7.0	3.55	3.61	3.32	3.47	3.62	3.55	3.52	3.45	3.48	3.50	3.35	3.40
7.5	2.38	2.42	2.22	2.40	2.68	2.62	2.63	2.53	2.52	2.36	2.40	2.36
8.0	2.00	2.00	1.81	1.96	2.30	2.33	2.31	2.20	2.16	1.96	1.93	1.98
8.5	1.64	1.70	1.60	1.70	2.12	2.14	2.12	2.06	1.96	1.77	1.80	1.66
Total	12.60	13.21	12.43	17.24	18.07	16.86	16.67	16.37	16.11	13.32	13.43	13.04
Soil type:	Dinuba loam											
Probe:	CD-1											

Table B-3
MEASURED SOIL MOISTURE, 1984-85
SITE C, NEAR LIVINGSTON
(inches per foot)

Depth (Feet)	08/22/84	10/08/84	11/06/84	12/11/84	01/09/85	02/15/85	02/28/85	03/15/85	04/04/85	05/14/85	06/20/85	09/17/85
0.5	0.30	0.25	0.44	1.35	1.08	0.96	0.80	0.97	0.88	0.51	0.28	0.15
1.0	0.57	0.48	0.85	2.03	1.47	1.34	1.23	1.19	1.16	0.90	0.48	0.25
1.5	0.64	0.59	0.80	1.68	1.31	1.22	1.10	1.10	1.04	0.79	0.42	0.30
2.0	0.62	0.56	0.65	1.15	1.05	0.97	0.97	0.93	0.88	0.66	0.35	0.30
2.5	0.59	0.52	0.52	0.97	0.97	0.90	0.90	0.87	0.86	0.62	0.35	0.30
3.0	0.53	0.51	0.48	0.83	0.93	0.88	0.88	0.85	0.83	0.63	0.40	0.30
3.5	0.50	0.51	0.47	0.59	0.95	0.88	0.87	0.87	0.83	0.71	0.42	0.30
4.0	0.52	0.48	0.48	0.50	0.88	0.87	0.86	0.85	0.83	0.74	0.45	0.30
4.5	0.59	0.51	0.51	0.52	0.79	0.83	0.83	0.83	0.82	0.74	0.47	0.35
5.0	0.78	0.63	0.59	0.63	0.71	0.84	0.88	0.90	0.87	0.84	0.56	0.42
5.5	0.93	0.78	0.74	0.80	0.75	0.91	0.93	0.95	0.96	0.95	0.72	0.51
6.0	0.95	0.83	0.78	0.78	0.78	0.88	0.87	0.91	0.96	0.94	0.80	0.58
6.5	1.37	1.20	1.18	1.20	1.18	1.23	1.29	1.30	1.32	1.32	1.25	1.00
7.0	1.42	1.31	1.22	1.25	1.22	1.23	1.27	1.30	1.32	1.32	1.27	1.08
7.5	1.02	0.96	0.88	0.88	0.90	0.90	0.91	0.93	0.93	0.96	0.96	0.83
8.0	0.83	0.82	0.76	0.80	0.78	0.77	0.79	0.80	0.80	0.83	0.84	0.71
8.5	0.83	0.79	0.76	0.78	0.76	0.77	0.77	0.78	0.78	0.80	0.80	0.71
9.0	0.79	0.80	0.74	0.78	0.70	0.70	0.72	0.74	0.74	0.72	0.78	0.68
9.5	0.86	0.86	0.84	0.87	0.85	0.85	0.85	0.84	0.84	0.85	0.85	0.84
Total	7.32	6.70	6.85	9.20	9.03	8.97	8.86	8.96	8.83	7.92	6.23	4.96
Soil type:	Delhi sand											
Probe:	CD-1											

Table B-4
MEASURED SOIL MOISTURE, 1984-85
SITE C-1, NEAR MERCED
(inches per foot)

Depth (Feet)	08/23/84	10/08/84	11/07/84	12/11/84	01/09/85	02/15/85	02/28/85	03/15/85	04/04/85	05/14/85	06/20/85	09/17/85
0.5	0.86	1.00	2.22	3.76	3.70	3.68	3.35	3.32	3.41	1.40	1.15	0.84
1.0	1.55	1.70	2.24	3.65	3.56	3.70	3.55	3.44	3.55	2.18	1.96	1.72
1.5	1.74	1.81	1.82	3.19	3.23	3.40	3.28	3.19	3.27	2.28	1.91	1.79
2.0	1.74	1.83	1.78	2.57	2.70	2.77	2.77	2.69	2.74	2.31	1.92	1.81
2.5	1.83	1.94	1.94	1.96	2.04	2.14	2.12	2.14	2.12	2.13	2.04	1.96
3.0	2.33	2.50	2.41	2.47	2.45	2.53	2.53	2.63	2.50	2.61	2.53	2.51
3.5	2.55	2.60	2.61	2.60	2.61	2.76	2.68	3.13	2.65	2.76	2.74	2.68
4.0	3.00	3.19	3.12	3.16	3.13	3.22	3.16	3.22	3.09	3.25	3.22	3.16
4.5	3.13	3.19	3.18	3.16	3.19	3.25	3.22	3.22	3.20	3.33	3.30	3.22
5.0	3.28	3.40	3.41	3.40	3.40	3.50	3.48	3.46	3.44	3.53	3.51	3.47
5.5	3.65	3.94	3.94	3.95	3.90	3.95	3.95	3.87	3.87	3.99	3.99	3.87
Total	12.83	13.55	14.34	16.94	16.96	17.45	17.05	17.16	16.92	14.89	14.14	13.52
Soil type:	Wyman loam											
Probe:	CD-1											

Table B-5
MEASURED SOIL MOISTURE, 1984-85
SITE D, NEAR MADERA
(inches per foot)

Depth (Feet)	08/22/84	10/08/84	11/06/84	12/12/84	01/09/85	02/07/85	03/05/85	04/04/85	05/07/85	09/17/85
0.5	0.40	0.30	0.45	2.15	2.42	1.88	0.90	0.94	0.45	0.25
1.0	0.69	0.77	0.91	2.15	2.59	2.51	2.19	2.18	1.49	0.82
1.5	0.99	1.02	1.03	1.35	1.65	1.81	1.96	1.90	1.65	1.08
2.0	1.29	1.28	1.33	1.35	1.42	1.64	1.74	1.69	1.57	1.28
2.5	1.44	1.44	1.38	1.41	1.42	1.38	1.56	1.61	1.49	1.38
3.0	1.54	1.54	1.52	1.46	1.49	1.49	1.54	1.54	1.52	1.42
3.5	1.68	1.71	1.63	1.61	1.55	1.55	1.55	1.69	1.63	1.49
4.0	1.71	1.75	1.74	1.65	1.63	1.55	1.62	1.69	1.68	1.59
4.5	1.88	1.84	1.84	1.78	1.71	1.74	1.69	1.72	1.68	1.63
5.0	1.97	2.03	1.94	1.90	1.91	1.94	1.81	2.07	1.94	1.84
5.5	1.99	2.03	2.12	2.08	1.96	1.93	1.93	1.90	2.07	2.00
6.0	1.83	1.90	1.90	1.90	1.88	1.84	1.81	1.85	1.85	1.81
6.5	1.82	1.90	1.90	1.90	1.88	1.83	1.78	2.05	1.85	1.88
7.0	1.99	2.14	2.09	2.10	2.05	2.00	1.93	1.90	1.95	2.04
Total	10.61	10.83	10.89	12.40	12.78	12.55	12.00	12.37	11.41	10.26

Soil type: Pachappa fine sandy loam
Probe: SJ-3

Table B-6
MEASURED SOIL MOISTURE, 1984-85
SITE E, NEAR FOWLER
(inches per foot)

Depth (Feet)	08/21/84	10/09/84	11/05/84	12/12/84	01/09/85	02/07/85	03/05/85	04/04/85	05/07/85	09/17/85
0.5	0.14	0.10	0.14	0.68	1.28	0.64	0.47	0.30	0.18	0.08
1.0	0.24	0.20	0.22	0.89	1.49	0.98	0.85	0.78	0.44	0.08
1.5	0.29	0.30	0.32	0.78	1.35	0.97	0.89	0.92	0.57	0.18
2.0	0.40	0.42	0.42	0.49	1.01	0.84	0.79	0.84	0.61	0.28
2.5	0.44	0.49	0.49	0.49	0.91	0.82	0.79	0.79	0.58	0.33
3.0	0.52	0.68	0.70	0.68	0.93	0.91	0.85	0.84	0.71	0.35
3.5	0.61	1.14	1.08	1.06	1.16	1.24	1.01	1.00	0.89	0.44
4.0	2.57	2.47	2.54	2.51	2.51	2.59	2.24	2.27	2.08	0.68
4.5	1.96	2.06	2.21	2.09	2.15	2.27	2.51	2.39	2.39	1.81
5.0	1.98	2.00	2.12	2.02	2.12	2.21	2.24	2.18	2.03	1.93
5.5	1.36	1.69	1.71	1.71	1.80	1.93	2.06	2.02	1.77	1.52
6.0	2.85	3.01	2.96	2.85	2.97	3.08	2.54	2.56	2.23	1.13
6.5	2.75	2.68	2.70	2.73	2.64	2.88	3.25	3.30	3.13	1.90
7.0	2.20	2.00	2.02	2.06	1.97	2.27	2.47	2.47	2.12	2.54
7.5	1.16	1.16	1.21	1.21	1.19	1.42	1.63	1.55	1.37	1.31
8.0	0.84	0.84	0.88	0.85	0.87	0.95	0.84	1.08	0.87	0.82
8.5	0.63	0.66	0.70	0.66	0.68	0.78	0.68	0.84	0.64	0.48
9.0	0.68	0.64	0.61	0.65	0.65	0.65	0.70	0.68	0.57	0.38
Total	10.81	11.27	11.52	12.20	13.84	13.72	13.41	13.41	11.59	8.12

Soil type: Delhi loamy sand
Probe: SJ-1

Table B-7
MEASURED SOIL MOISTURE, 1984-85
SITE F, NEAR TULARE
(inches per foot)

Depth (Feet)	08/21/84	10/09/84	11/05/84	12/11/84	01/10/85	02/07/85	03/05/85	05/07/85	09/18/85
0.5	0.26	0.26	0.71	1.19	2.42	1.26	0.94	0.34	0.25
1.0	0.46	0.42	0.93	0.77	1.42	1.33	1.21	0.94	0.52
1.5	0.66	0.66	0.99	0.70	1.00	1.08	1.06	1.08	0.84
2.0	0.82	0.84	1.01	0.87	0.89	1.00	0.97	1.05	0.91
2.5	1.40	1.38	1.52	1.33	1.33	1.38	1.35	1.32	1.28
3.0	1.78	1.74	1.84	1.74	1.69	1.71	1.78	1.79	1.74
3.5	1.36	1.38	1.46	1.38	1.38	1.38	1.42	1.54	1.52
4.0	1.45	1.42	1.43	1.38	1.33	1.42	1.35	1.38	1.33
4.5	1.48	1.49	1.50	1.45	1.38	1.42	1.42	1.42	1.33
5.0	1.58	1.59	1.52	1.52	1.45	1.49	1.52	1.55	1.49
5.5	1.21	1.23	1.24	1.23	1.21	1.21	1.21	1.23	1.26
Total	6.23	6.21	7.08	6.78	7.75	7.34	7.12	6.82	6.24
Soil type:	Chino loam								
Probe:	SJ-1								

Table B-8
MEASURED SOIL MOISTURE, 1984-85
SITE G, NEAR WASCO
(inches per foot)

Depth (Feet)	08/20/84	10/09/84	11/05/84	12/10/84	01/11/85	02/07/85	03/01/85	04/02/85	05/06/85
0.5	0.90	0.82	0.37	1.23	2.70	2.70	2.21	1.81	1.30
1.0	1.38	1.21	1.40	1.26	2.06	2.02	2.02	1.93	1.78
1.5	1.23	1.14	1.13	1.03	1.10	1.13	1.21	1.28	1.20
2.0	1.08	1.02	1.03	0.97	0.95	0.97	1.01	1.10	1.03
2.5	1.11	1.14	1.15	1.10	1.10	1.08	1.10	1.16	1.14
3.0	1.24	1.26	1.29	1.21	1.23	1.23	1.23	1.30	1.26
3.5	1.23	1.23	1.32	1.23	1.21	1.23	1.23	1.26	1.28
4.0	1.78	1.78	1.70	1.74	1.74	1.78	1.71	1.78	1.73
4.5	1.93	1.95	1.90	2.02	1.90	1.93	1.97	2.00	1.96
5.0	1.49	1.45	1.54	1.52	1.45	1.52	1.49	1.55	1.52
5.5	1.79	1.84	1.71	1.69	1.71	1.71	1.74	1.78	1.79
Total	7.58	7.42	7.52	7.50	8.58	8.65	8.46	8.48	8.00
Soil type:	Pond loam								
Probe:	SJ-1								

Table B-9
MEASURED SOIL MOISTURE, 1984-85
SITE I, NEAR METTLER
(inches per foot)

Depth (Feet)	08/20/84	10/10/84	11/02/84	12/10/84	01/11/85	02/06/85	03/06/85	04/02/85	05/06/85	05/15/85	09/19/85
0.5	0.26	0.25	0.49	1.01	2.42	1.35	1.10	1.13	0.78	0.50	0.00
1.0	0.55	0.49	0.91	0.72	1.81	1.72	1.69	2.09	1.52	1.29	0.49
1.5	0.66	0.61	0.89	0.61	0.74	0.77	0.89	1.02	1.20	1.07	0.77
2.0	0.64	0.64	0.79	0.66	0.62	0.61	0.64	0.77	0.94	0.82	0.77
2.5	0.67	0.65	0.70	0.66	0.62	0.61	0.64	0.68	0.85	0.77	0.68
3.0	0.55	0.55	0.57	0.52	0.51	0.51	0.52	0.57	0.77	0.64	0.57
3.5	0.52	0.52	0.55	0.55	0.51	0.51	0.52	0.61	0.77	0.63	0.51
4.0	0.52	0.52	0.55	0.55	0.55	0.52	0.57	0.61	0.70	0.64	0.55
4.5	0.57	0.57	0.64	0.62	0.61	0.61	0.61	0.61	0.73	0.68	0.57
5.0	0.76	0.77	0.78	0.78	0.73	0.70	0.79	0.77	0.88	0.80	0.70
5.5	0.76	0.79	0.79	0.78	0.73	0.70	0.77	0.79	0.84	0.81	0.78
Total	3.23	3.18	3.83	3.73	4.93	4.31	4.37	4.83	4.99	4.33	3.20

Soil type: San Emigdio fine sandy loam
Probe: SJ-1

Appendix C
MEASURED SOIL MOISTURE
AT FIELD SITES
1985-1986

Table C-1
MEASURED SOIL MOISTURE, 1985-86
SITE A-1, NEAR LODI
(inches per foot)

Depth (Feet)	10/03/85	10/17/85	11/14/85	12/04/85	01/13/86	01/28/86	02/24/86	03/20/86	04/24/86	05/20/86	09/12/86
0.5	0.32	0.32	1.80	3.34	2.92	2.57	3.00	2.61	1.78	1.40	0.68
1.0	0.52	0.52	0.80	3.00	2.78	2.63	2.95	2.88	2.36	2.08	1.23
1.5	0.50	0.52	0.56	2.58	2.51	2.46	2.63	2.64	2.21	1.96	1.20
2.0	0.44	0.46	0.48	1.55	2.33	2.22	2.45	2.47	1.96	1.77	1.17
2.5	0.46	0.45	0.46	0.58	2.26	2.20	2.52	2.52	2.03	1.81	1.23
3.0	*	0.48	0.48	0.46	2.11	2.14	2.68	2.68	2.14	1.98	1.33
3.5		0.50	0.50	0.47	1.33	1.96	2.79	2.78	2.30	2.13	1.43
4.0		0.52	0.52	0.51	0.65	1.31	3.06	3.09	2.56	2.43	1.74
4.5		0.56	0.59	0.55	0.59	0.71	3.35	3.30	2.85	2.76	2.09
5.0		0.59	0.59	0.54	0.63	0.58	3.37	3.44	3.00	2.90	2.19
5.5		0.55	0.56	0.52	0.54	0.54	3.40	3.51	2.94	2.81	2.00
6.0		0.56	0.53	0.52	0.56	0.56	3.69	3.81	3.13	2.90	1.96
6.5		0.74	0.72	0.71	0.74	0.72	3.80	4.04	3.27	3.16	2.36
7.0		0.92	0.93	0.88	0.92	0.93	3.02	3.62	3.01	2.93	2.41
7.5		0.67	0.78	0.74	0.78	0.80	1.32	2.89	2.38	2.33	1.78
8.0		0.56	0.59	0.54	0.59	0.56	0.63	2.16	1.73	1.70	1.17
8.5		0.56	0.59	0.52	0.54	0.56	0.54	1.93	1.58	1.50	1.05
9.0		0.78	0.79	0.71	0.74	0.73	0.71	2.20	1.98	1.93	1.22
9.5		1.62	1.57	1.44	1.55	1.56	1.50	3.06	2.99	3.03	2.37
Total	*	5.94	6.92	10.08	12.54	12.87	23.71	27.82	23.10	21.76	15.31
* Tube measured only to 2.5 feet.											
Soil type: Hanford sandy loam											
Probe: CD-1											

Table C-2
MEASURED SOIL MOISTURE, 1985-86
SITE B-1, NEAR RIPON
(inches per foot)

Depth (Feet)	09/17/85	10/17/85	11/14/85	12/04/85	01/13/86	01/28/86	02/24/86	03/20/86	04/24/86	05/20/86
0.5	0.19	0.19	0.52	1.93	1.77	1.60	1.85	1.93	1.42	0.93
1.0	0.28	0.28	0.40	1.77	1.66	1.40	1.66	1.79	1.25	0.95
1.5	0.42	0.40	0.42	1.57	1.48	1.33	1.57	1.67	1.21	0.95
2.0	0.52	0.51	0.51	1.17	1.52	1.33	1.64	1.78	1.16	0.97
2.5	0.71	0.75	0.74	0.83	1.72	1.57	1.96	2.12	1.24	1.02
3.0	0.83	0.80	0.78	0.75	1.31	1.22	1.55	1.67	1.06	0.94
3.5	0.87	0.86	0.81	0.81	1.13	1.13	1.34	1.46	1.03	0.93
4.0	0.92	0.90	0.91	0.86	1.10	1.07	1.45	1.39	1.10	1.05
4.5	1.10	1.06	1.07	1.02	1.18	1.20	1.83	1.67	1.38	1.23
5.0	1.42	1.46	1.50	1.42	1.55	1.62	2.40	2.17	2.14	2.08
5.5	2.90	3.01	2.94	2.92	2.97	3.06	3.55	3.45	3.50	3.37
6.0	3.53	3.47	3.45	3.41	3.44	3.47	3.84	3.78	3.65	3.58
6.5	3.66	3.65	3.60	3.53	3.55	3.65	4.02	3.90	3.86	3.75
7.0	3.54	3.44	3.40	3.28	3.40	3.36	3.70	3.65	3.30	3.16
7.5	2.49	2.36	2.32	2.26	2.43	2.44	3.16	3.09	2.82	2.57
8.0	2.10	1.93	1.89	1.83	1.93	1.99	2.98	2.88	2.48	2.22
8.5	1.77	1.74	1.66	1.62	1.74	1.85	3.19	3.02	2.70	2.47
9.0	2.81	2.88	2.70	2.70	2.77	2.90	4.14	4.04	3.55	3.35
Total	15.03	14.85	14.81	16.84	18.33	18.10	22.92	22.73	19.43	17.76
Soil type: Dinuba loam										
Probe: CD-1										

Table C-3
MEASURED SOIL MOISTURE, 1985-86
SITE C, NEAR LIVINGSTON
(inches per foot)

Depth (Feet)	09/17/85	10/17/85	11/14/85	12/05/85	01/13/86	01/28/86	02/24/86	03/20/86	04/23/86	05/20/86	10/01/86
0.5	0.16	0.16	0.67	1.39	0.93	0.78	1.23	1.47	0.81	0.56	0.28
1.0	0.28	0.26	1.02	2.08	1.32	1.21	1.89	2.09	1.08	0.90	0.54
1.5	0.35	0.32	1.02	1.86	1.27	1.13	1.66	1.72	1.03	0.87	0.57
2.0	0.35	0.32	0.71	1.20	1.02	1.00	1.18	1.20	0.90	0.80	0.50
2.5	0.32	0.32	0.40	0.88	0.90	0.91	1.15	1.15	0.85	0.74	0.45
3.0	0.34	0.32	0.32	0.46	0.78	0.80	1.15	1.14	0.85	0.74	0.44
3.5	0.33	0.34	0.35	0.32	0.54	0.68	1.18	1.22	0.88	0.79	0.47
4.0	0.34	0.34	0.36	0.32	0.35	0.47	1.20	1.23	0.92	0.80	0.47
4.5	0.38	0.36	0.36	0.34	0.35	0.40	1.16	1.23	0.93	0.83	0.48
5.0	0.44	0.44	0.44	0.44	0.44	0.45	1.05	1.40	1.16	1.03	0.57
5.5	0.52	0.52	0.52	0.51	0.52	0.51	0.72	1.50	1.40	1.20	0.69
6.0	0.59	0.59	0.58	0.56	0.59	0.59	0.63	1.44	1.44	1.27	0.74
6.5	1.02	0.97	1.00	0.97	0.97	0.96	0.96	1.84	2.06	1.93	1.17
7.0	1.11	1.07	1.07	1.02	1.05	1.04	1.02	1.30	1.91	1.77	1.20
7.5	0.85	0.83	0.83	0.80	0.83	0.83	0.80	0.84	1.26	1.18	0.89
8.0	0.74	0.74	0.74	0.71	0.71	0.71	0.70	0.72	1.02	1.00	0.79
8.5	0.74	0.75	0.74	0.71	0.68	0.72	0.73	0.72	0.90	0.93	0.80
9.0	0.71	0.68	0.74	0.66	0.71	0.68	0.68	0.68	0.75	0.84	0.76
9.5	0.86	0.85	0.83	0.82	0.82	0.80	0.80	0.79	0.80	0.86	0.86
Total	5.22	5.09	6.35	8.03	7.39	7.34	9.95	11.84	10.48	9.52	6.34
Soil type:	Delhi sand										
Probe:	CD-1										

Table C-4
MEASURED SOIL MOISTURE, 1985-86
SITE C-1, NEAR MERCED
(inches per foot)

Depth (Feet)	09/17/85	10/16/85	11/20/85	12/05/85	01/16/86	01/28/86	02/24/86	03/20/86	04/23/86	05/20/86	09/11/86
0.5	0.84	0.88	1.56	4.12	3.65	3.44	3.70	3.82	3.13	1.77	1.12
1.0	1.72	1.62	1.76	4.25	3.84	3.74	4.04	4.12	3.54	2.48	1.93
1.5	1.79	1.81	1.85	4.21	3.68	3.64	4.04	4.11	3.54	2.51	1.89
2.0	1.81	1.89	1.89	3.89	3.65	3.55	4.10	4.19	3.66	2.58	1.89
2.5	1.96	2.03	2.04	3.19	3.50	3.44	4.19	4.24	3.82	2.81	2.04
3.0	2.51	2.57	2.58	2.58	3.08	3.16	4.35	4.54	4.16	3.40	2.58
3.5	2.68	2.74	2.76	2.63	2.77	2.77	4.25	4.41	4.14	3.79	2.83
4.0	3.16	3.20	3.25	3.13	3.22	3.25	4.25	4.58	4.36	4.08	3.25
4.5	3.22	3.22	3.25	3.18	3.28	3.26	3.97	4.38	4.25	4.02	3.32
5.0	3.47	3.44	3.54	3.43	3.53	3.50	3.60	4.39	4.23	4.10	3.54
5.5	3.87	3.95	3.97	3.94	3.97	3.99	3.94	4.68	4.57	4.35	3.80
Total	13.52	13.68	14.23	19.28	19.09	17.87	22.22	23.73	21.70	17.95	14.10
Soil type:	Wyman loam										
Probe:	CD-1										

Table C-5
MEASURED SOIL MOISTURE, 1985-86
SITE D, NEAR MADERA
(inches per foot)

Depth (Feet)	09/17/85	10/16/85	11/13/85	12/04/85	01/06/86	01/28/86	02/08/86	03/24/86	04/23/86	05/20/86
0.5	0.25	0.25	1.23	2.02	2.12	1.16	1.06	1.03	0.50	0.35
1.0	0.82	0.79	2.40	3.17	2.97	2.44	2.57	3.05	2.27	1.91
1.5	1.08	1.13	2.20	2.27	2.19	2.12	2.10	3.35	2.46	2.11
2.0	1.28	1.28	1.90	1.71	1.80	1.83	1.88	3.07	2.42	2.21
2.5	1.38	1.33	1.51	1.49	1.50	1.46	1.55	2.81	2.34	2.13
3.0	1.42	1.42	1.38	1.45	1.40	1.44	1.41	2.52	2.27	2.20
3.5	1.49	1.45	1.46	1.49	1.45	1.52	1.49	2.32	2.27	2.22
4.0	1.59	1.52	1.49	1.49	1.49	1.49	1.50	2.10	2.14	2.03
4.5	1.63	1.55	1.63	1.58	1.56	1.59	1.55	1.78	2.12	2.10
5.0	1.84	1.90	1.83	1.87	1.82	1.78	1.80	1.82	2.08	2.08
5.5	2.00	2.00	1.96	1.94	1.98	2.00	2.00	1.96	2.12	2.24
6.0	1.81	1.81	1.80	1.78	1.85	1.80	1.74	1.79	1.80	1.85
6.5	1.88	1.84	1.75	1.84	1.80	1.77	1.80	1.78	1.78	1.77
Total	9.14	9.14	11.22	12.05	11.97	11.20	11.23	14.69	13.29	12.60

Soil type: Pachappa fine sandy loam
Probe: SJ-1

Table C-6
MEASURED SOIL MOISTURE, 1985-86
SITE E, NEAR FOWLER
(inches per foot)

Depth (Feet)	09/17/85	10/16/85	11/13/85	01/06/86	01/28/86	02/08/86	03/24/86
0.5	0.08	0.14	0.84	0.63	0.34	0.49	0.57
1.0	0.18	0.20	1.13	0.99	0.68	1.02	1.05
1.5	0.28	0.28	0.88	1.02	0.87	1.06	1.22
2.0	0.33	0.33	0.42	0.87	0.78	0.87	1.00
2.5	0.35	0.37	0.37	0.81	0.72	0.79	0.98
3.0	0.44	0.47	0.49	0.82	0.84	0.85	1.08
3.5	0.68	0.77	0.77	0.95	0.97	0.99	1.20
4.0	1.81	1.90	1.91	1.96	2.18	2.15	2.47
4.5	1.93	1.97	2.00	2.15	2.30	2.29	2.70
5.0	1.52	1.59	1.62	1.87	2.00	2.02	2.59
5.5	1.13	1.19	1.16	1.58	1.69	1.69	2.60
6.0	1.90	1.84	1.87	2.07	2.21	2.28	2.91
6.5	2.54	2.56	2.55	2.70	2.96	3.01	3.42
7.0	1.31	1.33	1.32	1.80	2.02	2.08	3.00
7.5	0.82	0.89	0.85	1.14	1.26	1.25	2.43
8.0	0.48	0.52	0.50	0.73	0.81	0.82	0.82
8.5	0.38	0.45	0.42	0.50	0.60	0.57	0.58
9.0	0.37	0.42	0.40	0.40	0.48	0.48	0.48
Total	8.27	8.61	9.75	11.50	11.86	12.36	15.55

Soil type: Delhi loamy sand
Probe: SJ-1

Table C-7
MEASURED SOIL MOISTURE, 1985-86
SITE F, NEAR TULARE
(inches per foot)

Depth (Feet)	09/18/85	10/16/85	11/14/85	12/04/85	01/06/86	01/28/86	02/08/86	03/17/86	04/24/86	05/20/86
0.5	0.25	0.25	2.34	2.77	1.79	0.95	1.54	2.73	0.49	0.35
1.0	0.52	0.52	1.31	2.45	1.81	1.38	1.85	3.68	1.71	1.16
1.5	0.84	0.82	0.92	1.55	1.52	1.42	1.63	3.53	2.18	1.55
2.0	0.91	0.91	0.89	1.10	1.20	1.17	1.24	2.79	1.98	1.63
2.5	1.28	1.31	1.29	1.28	1.32	1.31	1.38	1.92	2.10	2.12
3.0	1.74	1.78	1.78	1.81	1.72	1.75	1.74	1.82	2.06	2.18
3.5	1.52	1.59	1.58	1.55	1.53	1.54	1.61	1.49	1.65	1.71
4.0	1.33	1.33	1.34	1.42	1.38	1.35	1.34	1.35	1.33	1.40
4.5	1.33	1.38	1.37	1.38	1.38	1.38	1.35	1.36	1.38	1.35
5.0	1.49	1.52	1.56	1.61	1.56	1.56	1.59	1.55	1.60	1.66
Total	5.61	5.71	7.19	8.46	7.61	6.91	7.64	11.11	8.24	7.56
Soil type:	Chino loam									
Probe:	SJ-1									

Table C-8
MEASURED SOIL MOISTURE, 1985-86
SITE H, NEAR BAKERSFIELD
(inches per foot)

Depth (Feet)	09/19/85	10/15/85	11/14/85	12/05/85	01/07/86	01/29/86	02/08/86	03/05/86	03/17/86	05/19/86
0.5	0.25	0.25	1.31	1.52	1.37	0.82	1.01	0.92	2.02	0.38
1.0	0.38	0.38	0.95	1.23	1.23	1.04	1.08	1.13	1.83	0.64
1.5	0.45	0.45	0.47	0.66	1.14	0.91	0.93	1.00	1.43	0.73
2.0	0.48	0.48	0.46	0.51	0.87	0.79	0.81	0.86	1.14	0.73
2.5	0.49	0.51	0.49	0.52	0.71	0.64	0.65	0.79	0.88	0.77
3.0	0.55	0.54	0.58	0.55	0.56	0.57	0.62	0.68	0.70	0.84
3.5	0.57	0.61	0.58	0.57	0.61	0.55	0.58	0.63	0.67	0.84
4.0	0.61	0.64	0.60	0.62	0.58	0.62	0.60	0.66	0.64	0.85
4.5	0.66	0.64	0.66	0.64	0.66	0.67	0.69	0.66	0.71	0.84
5.0	1.08	1.02	1.12	1.05	1.09	1.03	1.02	1.12	1.12	1.26
Total	2.76	2.76	3.61	3.94	4.41	3.82	4.00	4.23	5.57	3.94
Soil type:	Exeter sandy loam									
Probe:	SJ-1									

Table C-9
MEASURED SOIL MOISTURE, 1985-86
SITE I, NEAR METTLER
(inches per foot)

Depth (Feet)	09/19/85	10/15/85	11/15/85	12/05/85	01/07/86	01/29/86	02/07/86	03/05/86	03/17/86	05/19/86	09/10/86
0.5	0.49	0.33	1.81	1.88	1.52	0.96	1.32	1.16	2.77	1.00	0.29
1.0	0.77	0.68	1.02	1.13	1.14	1.08	1.10	1.19	1.73	1.26	0.59
1.5	0.77	0.77	0.79	0.77	0.79	0.79	0.82	0.82	0.84	0.84	0.64
2.0	0.68	0.70	0.66	0.66	0.69	0.66	0.66	0.68	0.69	0.70	0.59
2.5	0.57	0.64	0.64	0.61	0.63	0.65	0.57	0.61	0.61	0.66	0.47
3.0	0.51	0.51	0.52	0.54	0.52	0.50	0.52	0.51	0.51	0.52	0.44
3.5	0.55	0.51	0.51	0.53	0.52	0.52	0.52	0.51	0.52	0.52	0.49
4.0	0.57	0.61	0.52	0.54	0.55	0.55	0.56	0.55	0.57	0.57	0.54
4.5	0.70	0.66	0.66	0.63	0.63	0.64	0.66	0.64	0.66	0.64	0.70
5.0	0.78	0.81	0.81	0.83	0.81	0.79	0.82	0.82	0.83	0.85	0.81
Total	3.20	3.11	3.97	4.06	3.90	3.57	3.78	3.75	4.87	3.78	2.78

Soil type: San Emigdio fine sandy loam
Probe: SJ-1

Appendix D
MEASURED SOIL MOISTURE
AT FIELD SITES
1986-1987

Table D-1
MEASURED SOIL MOISTURE, 1986-87
SITE A-1, NEAR LODI
(inches per foot)

Depth (feet)	09/12/86	10/01/86	10/28/86	01/06/87	02/05/87	02/20/87	03/11/87	03/31/87	04/29/87
0.5	0.68	1.17	0.90	2.09	2.61	2.29	2.79	1.95	1.26
1.0	1.23	1.32	1.29	1.39	2.65	2.68	2.76	2.47	1.92
1.5	1.20	1.23	1.25	1.15	2.34	2.50	2.54	2.37	1.79
2.0	1.17	1.19	1.16	1.10	1.77	2.36	2.42	2.13	1.64
2.5	1.23	1.22	1.18	1.14	1.31	2.46	2.51	2.14	1.68
3.0	1.33	1.32	1.31	1.22	1.23	2.60	2.65	2.30	1.80
3.5	1.43	1.49	1.37	1.32	1.29	2.63	2.70	2.34	1.86
4.0	1.74	1.77	1.70	1.55	1.55	2.79	2.99	2.58	2.19
4.5	2.09	2.12	2.00	1.91	1.80	2.79	3.09	2.79	2.46
5.0	2.19	2.18	2.13	1.96	1.95	2.53	2.98	2.77	2.50
5.5	2.00	1.96	1.85	1.77	1.66	2.03	2.75	2.61	2.37
6.0	1.96	1.96	1.86	1.70	1.66	1.77	2.76	2.66	2.35
6.5	2.36	2.37	2.31	2.14	2.12	2.16	2.89	2.89	2.63
7.0	2.41	2.40	2.33	2.30	2.25	2.23	2.49	2.60	2.51
7.5	1.78	1.81	1.70	1.62	1.58	1.52	1.72	1.90	1.85
8.0	1.17	1.16	1.11	1.05	1.02	1.04	1.10	1.24	1.22
8.5	1.05	1.04	0.99	0.95	0.93	0.92	0.95	1.04	1.06
9.0	1.22	1.20	1.15	1.09	1.06	1.07	1.09	1.14	1.20
9.5	2.37	2.48	2.35	2.14	2.43	2.16	2.17	2.22	2.28
Total	15.31	15.70	14.97	14.80	16.61	20.27	22.68	21.07	18.29

Soil type: Hanford sandy loam
Probe: CD-1

Table D-2
MEASURED SOIL MOISTURE, 1986-87
SITE A-2, NEAR STOCKTON
(inches per foot)

Depth (feet)	09/12/86	10/01/86	10/28/86	01/06/87	02/05/87	02/20/87	03/11/87	03/31/87	04/29/87
0.5	1.54	1.32	1.33	2.83	4.16	4.31	4.68	4.12	3.37
1.0	3.15	3.02	3.00	3.02	4.31	5.06	5.37	4.98	4.59
1.5	3.33	3.41	3.36	3.31	3.44	5.44	5.77	5.43	5.09
2.0	3.37	3.49	3.37	3.36	3.33	5.43	5.77	5.47	5.10
2.5	3.22	3.27	3.28	3.24	3.26	5.43	5.29	5.22	4.81
3.0	3.26	3.33	3.40	3.32	3.33	5.18	5.42	5.19	4.83
3.5	3.31	3.37	3.43	3.43	3.47	4.86	5.03	4.89	4.61
4.0	3.40	3.51	3.52	3.62	3.55	4.15	4.24	4.15	4.04
4.5	3.78	3.93	3.88	3.88	3.87	3.94	3.97	3.98	3.97
5.0	4.15	4.29	4.25	4.27	4.22	4.24	4.21	4.24	4.26
5.5	4.16	4.27	4.32	4.27	4.22	4.27	4.23	4.26	4.29
6.0	4.33	4.50	4.52	4.51	4.49	4.49	4.49	4.43	4.48
6.5	4.16	4.35	4.32	4.32	4.32	4.37	4.29	4.37	4.35
7.0	3.81	4.06	4.07	4.03	4.05	4.04	4.06	4.09	4.07
7.5	3.97	4.13	4.18	4.16	4.12	4.13	4.14	4.10	4.14
8.0	3.71	3.85	3.83	3.78	3.80	3.78	3.80	3.83	3.80
8.5	3.67	3.85	3.83	3.81	3.84	3.83	3.84	3.82	3.80
9.0	3.85	3.98	3.98	3.98	3.93	3.93	3.94	3.95	3.90
9.5	4.18	4.38	4.39	4.32	4.38	4.22	4.21	4.17	4.16
Total	34.18	35.16	35.13	35.13	37.05	42.55	43.38	42.35	40.83

Soil type: Stockton adobe clay
Probe: CD-1

Table D-3
MEASURED SOIL MOISTURE, 1986-87
SITE B-2, NEAR CROWS LANDING
(inches per foot)

Depth (feet)	10/28/86	01/07/87	02/05/87	02/20/87	03/12/87	04/01/87	04/29/87
0.5	1.27	3.47	3.49	4.23	4.66	3.85	3.48
1.0	1.29	2.62	3.19	4.63	4.98	4.43	4.23
1.5	2.22	2.16	2.30	4.73	4.92	4.60	4.36
2.0	2.24	2.13	2.16	4.35	4.73	4.42	4.21
2.5	2.20	2.19	2.30	4.02	4.49	4.19	4.11
3.0	2.48	2.44	2.43	2.98	4.20	3.95	3.96
3.5	2.60	2.59	2.66	2.76	3.38	3.44	3.44
4.0	2.30	2.32	2.34	2.40	2.38	2.51	2.51
4.5	2.50	2.59	2.57	2.62	2.67	2.68	2.69
5.0	3.19	3.36	3.35	3.36	3.34	3.36	3.40
5.5	3.49	3.75	3.76	3.74	3.73	3.74	3.77
Total	12.89	14.81	15.28	19.91	21.74	20.59	20.08
Soil type:	Stommar clay loam						
Probe:	CD-1						

Table D-4
MEASURED SOIL MOISTURE, 1986-87
SITE C, NEAR LIVINGSTON
(inches per foot)

Depth (feet)	10/01/86	10/28/86	01/06/87	02/05/87	02/19/87	04/01/87	04/29/87
0.5	0.28	0.12	0.80	0.91	0.83	0.80	0.47
1.0	0.54	0.43	1.10	1.50	1.69	1.30	0.99
1.5	0.57	0.48	1.08	1.32	1.50	1.15	0.93
2.0	0.50	0.46	0.94	1.09	1.16	0.99	0.85
2.5	0.45	0.43	0.70	0.91	1.11	0.94	0.83
3.0	0.44	0.42	0.45	0.59	1.08	0.94	0.82
3.5	0.47	0.42	0.41	0.43	1.02	0.95	0.86
4.0	0.47	0.44	0.41	0.42	0.90	0.97	0.84
4.5	0.48	0.46	0.42	0.43	0.63	1.01	0.93
5.0	0.57	0.57	0.52	0.55	0.55	1.15	1.06
5.5	0.69	0.65	0.66	0.64	0.65	1.30	1.22
6.0	0.74	0.72	0.70	0.72	0.71	1.30	1.20
6.5	1.17	1.14	1.10	1.12	1.13	1.82	1.81
7.0	1.20	1.18	1.16	1.16	1.15	1.49	1.57
7.5	0.89	0.87	0.86	0.84	0.84	0.94	1.31
8.0	0.79	0.80	0.73	0.76	0.76	0.77	0.83
8.5	0.80	0.78	0.73	0.71	0.76	0.73	0.74
9.0	0.76	0.71	0.72	0.70	0.70	0.70	0.69
9.5	0.86	0.83	0.82	0.83	0.84	0.81	0.80
Total	6.34	5.97	7.16	7.82	9.01	10.03	9.38
Soil type:	Delhi sand						
Probe:	CD-1						

Table D-5
MEASURED SOIL MOISTURE, 1986-87
SITE C-1, NEAR MERCED
(inches per foot)

Depth (feet)	09/11/86	10/02/86	10/28/86	01/07/87	02/05/87	02/19/87	03/12/87	04/01/87	04/30/87
0.5	1.12	1.15	1.16	3.52	3.46	3.67	3.71	3.44	1.88
1.0	1.93	1.91	1.87	3.03	2.90	3.81	3.91	3.65	2.22
1.5	1.89	1.93	1.88	2.18	2.12	3.49	3.78	3.61	2.22
2.0	1.89	1.95	1.92	1.89	1.95	2.93	3.74	3.57	2.25
2.5	2.04	2.10	2.09	2.10	2.10	2.32	3.55	3.57	2.42
3.0	2.58	2.69	2.62	2.69	2.68	2.66	3.55	3.46	2.87
3.5	2.83	2.85	2.83	2.81	2.83	2.83	2.90	2.94	2.89
4.0	3.25	3.31	3.27	3.26	3.28	3.28	3.33	3.32	3.36
4.5	3.32	3.37	3.35	3.30	3.34	3.32	3.36	3.34	3.33
5.0	3.54	3.58	3.57	3.53	3.56	3.54	3.58	3.56	3.52
5.5	3.81	3.87	3.79	3.91	4.00	3.98	3.53	3.95	3.78
Total	14.10	14.36	14.18	16.11	16.11	17.92	19.70	19.21	15.37
Soil type:	Wyman loam								
Probe:	CD-1								

Table D-6
MEASURED SOIL MOISTURE, 1986-87
SITE D, NEAR MADERA
(inches per foot)

Depth (feet)	09/10/86	09/24/86	10/02/86	10/28/86	12/04/86	01/07/87	02/05/87	02/19/87	03/10/87	03/18/87	04/06/87	04/29/87	07/06/87
0.5	0.44	0.50	0.58	0.52	0.60	3.49	1.95	2.76	2.90	2.89	2.06	1.26	0.64
1.0	1.30	1.26	1.30	1.25	1.22	3.53	2.53	3.24	3.35	3.29	2.80	2.04	1.37
1.5	1.60	1.55	1.55	1.53	1.47	2.68	2.24	2.98	3.17	3.06	2.63	2.04	1.57
2.0	1.90	1.77	1.86	1.77	1.71	2.18	2.14	2.60	2.80	2.75	2.50	2.14	1.79
2.5	1.89	1.80	1.78	1.77	1.68	1.87	1.93	2.09	2.30	2.27	2.23	1.98	1.70
3.0	1.96	1.90	1.90	1.82	1.81	1.81	1.87	1.90	2.01	2.10	2.05	1.96	1.77
3.5	2.00	1.95	1.94	1.88	1.79	1.81	1.85	1.80	1.90	1.95	2.07	1.92	1.80
4.0	2.05	1.97	2.02	1.97	1.89	1.86	1.91	1.91	1.93	1.93	2.06	1.97	1.89
4.5	2.12	2.07	2.10	2.08	2.00	1.93	1.98	2.04	2.03	2.01	2.09	2.00	2.03
5.0	2.26	2.19	2.25	2.20	2.16	2.14	2.15	2.15	2.18	2.18	2.21	2.19	2.19
5.5	2.14	2.12	2.14	2.10	2.04	2.09	2.04	2.04	2.04	2.04	2.08	2.09	2.12
6.0	2.01	1.99	1.99	1.97	1.96	1.92	1.97	1.96	1.95	1.91	1.95	1.91	1.94
6.5	2.01	2.03	2.05	2.01	2.02	1.95	2.02	2.01	2.01	2.01	2.02	2.00	2.01
7.0	2.63	2.63	2.64	2.63	2.60	2.60	2.65	2.61	2.07	2.73	2.76	2.75	2.84
Total	13.16	12.87	13.05	12.75	12.48	15.93	14.62	16.05	16.64	16.56	15.76	14.13	12.83
Soil type:	Pachappa fine sandy loam												
Probe:	SJ-3												

Table D-7
MEASURED SOIL MOISTURE, 1986-87
SITE D-1, NEAR FRESNO
(inches per foot)

Depth (feet)	10/02/86	10/28/86	12/04/86	01/06/87	02/05/87	02/19/87	03/10/87	04/06/87	04/29/87	07/06/87
0.5	0.64	0.60	0.58	2.40	2.33	3.07	3.22	2.59	0.94	0.65
1.0	1.24	1.20	1.21	1.76	2.09	3.21	3.43	3.12	1.49	1.42
1.5	1.49	1.46	1.43	1.50	1.58	2.38	3.19	3.06	1.68	1.66
2.0	1.28	1.30	1.27	1.24	1.29	1.34	2.05	2.69	1.44	1.46
2.5	1.15	1.14	1.15	1.11	1.13	1.15	1.19	1.97	1.36	1.33
3.0	1.11	1.10	1.08	1.10	1.09	1.07	1.09	1.27	1.24	1.27
3.5	1.13	1.14	1.10	1.11	1.12	1.12	1.10	1.14	1.16	1.22
4.0	1.16	1.15	1.16	1.15	1.17	1.14	1.17	1.16	1.16	1.20
4.5	1.17	1.17	1.16	1.16	1.18	1.17	1.16	1.16	1.21	1.20
5.0	1.13	1.15	1.14	1.13	1.15	1.13	1.15	1.17	1.17	1.18
Total	5.75	5.71	5.64	6.83	7.07	8.39	9.38	9.67	6.43	6.30
Soil type:	Hesperia fine sandy loam									
Probe:	SJ-3									

Table D-8
MEASURED SOIL MOISTURE, 1986-87
SITE F, NEAR TULARE
(inches per foot)

Depth (feet)	09/10/86	10/02/86	10/28/86	12/04/86	01/06/87	02/05/87	02/19/87	03/05/87	03/10/87	04/06/87	04/29/87	07/06/87
0.5	0.00	0.00	0.00	0.04	0.83	1.31	2.81	1.90	1.92	1.52	1.09	0.51
1.0	0.36	0.39	0.38	0.39	0.47	0.87	2.04	1.62	1.26	1.50	1.28	0.85
1.5	0.56	0.58	0.58	0.58	0.56	0.64	0.95	1.02	1.03	1.08	1.04	0.87
2.0	0.78	0.82	0.82	0.82	0.79	0.82	0.86	0.88	0.89	0.96	1.00	1.04
2.5	1.19	1.20	1.21	1.20	1.18	1.20	1.20	1.24	1.23	1.27	1.28	1.37
3.0	1.31	1.33	1.30	1.31	1.31	1.31	1.30	1.32	1.31	1.33	1.32	1.40
3.5	1.16	1.17	1.16	1.14	1.14	1.15	1.17	1.16	1.19	1.17	1.20	1.22
4.0	1.20	1.24	1.25	1.22	1.21	1.22	1.21	1.23	1.23	1.27	1.24	1.27
4.5	1.38	1.37	1.41	1.39	1.35	1.44	1.38	1.42	1.44	1.40	1.45	1.47
5.0	1.30	1.31	1.29	1.30	1.30	1.30	1.31	1.32	1.32	1.33	1.33	1.37
Total	4.62	4.71	4.70	4.75	5.07	5.63	7.12	6.56	6.41	6.42	6.12	5.68
Soil type:	Chino loam											
Probe:	SJ-3											

Table D-9
MEASURED SOIL MOISTURE, 1986-87
SITE H-1, NEAR BUTTONWILLOW
(inches per foot)

Depth (feet)	09/10/86	10/03/86	10/31/86	11/19/86	11/02/86	12/04/86	12/09/86	12/22/86	01/08/87	02/06/87	02/18/87	03/03/87	03/10/87	04/30/87	06/29/87
0.5	0.00	0.00	0.00	0.52	0.46	0.41	0.42	0.80	3.17	2.10	2.32	1.96	2.01	0.73	0.44
1.0	0.35	0.34	0.36	0.41	0.43	0.43	0.42	0.51	3.12	2.48	2.58	2.35	2.40	1.27	1.16
1.5	0.54	0.51	0.50	0.49	0.49	0.50	0.49	0.50	1.23	1.84	2.06	1.97	2.04	1.43	1.35
2.0	0.44	0.42	0.42	0.38	0.40	0.38	0.40	0.39	0.43	0.76	0.84	0.88	0.92	0.89	0.86
2.5	0.33	0.35	0.33	0.32	0.32	0.31	0.30	0.32	0.32	0.34	0.37	0.36	0.35	0.42	0.47
3.0	0.31	0.34	0.34	0.34	0.34	0.33	0.33	0.34	0.34	0.32	0.34	0.35	0.35	0.38	0.36
3.5	0.37	0.41	0.38	0.39	0.39	0.41	0.41	0.40	0.40	0.41	0.39	0.38	0.40	0.39	0.40
4.0	0.46	0.44	0.43	0.44	0.46	0.43	0.43	0.45	0.45	0.43	0.44	0.41	0.44	0.45	0.45
4.5	0.32	0.34	0.32	0.33	0.33	0.33	0.32	0.31	0.32	0.31	0.31	0.31	0.33	0.33	0.30
5.0	0.49	0.51	0.50	0.52	0.52	0.51	0.50	0.52	0.63	0.51	0.52	0.54	0.56	0.52	0.59
Total	1.81	1.83	1.79	2.07	2.07	2.02	2.01	2.27	5.20	4.80	5.09	4.76	4.90	3.41	3.19

Soil type: Milham sandy loam
Probe: SJ-3

Table D-10
MEASURED SOIL MOISTURE, 1986-87
SITE I, NEAR METTLER
(inches per foot)

Depth (feet)	09/10/86	10/03/86	10/31/86	11/19/86	11/26/86	12/09/86	12/22/86	01/08/87	02/06/87	02/18/87	03/05/87	03/11/87	06/29/87
0.5	0.29	0.12	0.12	0.51	0.40	1.64	1.21	2.90	1.61	1.74	1.48	1.53	0.19
1.0	0.59	0.50	0.45	0.51	0.51	0.77	0.85	2.09	2.00	1.97	2.00	1.92	0.79
1.5	0.64	0.64	0.58	0.58	0.58	0.57	0.58	0.70	0.93	0.95	0.99	0.98	0.80
2.0	0.59	0.59	0.58	0.58	0.57	0.54	0.55	0.56	0.58	0.57	0.57	0.58	0.66
2.5	0.47	0.55	0.53	0.54	0.52	0.52	0.54	0.52	0.52	0.52	0.53	0.51	0.58
3.0	0.44	0.39	0.40	0.42	0.38	0.40	0.40	0.39	0.38	0.41	0.39	0.39	0.42
3.5	0.49	0.42	0.43	0.40	0.43	0.41	0.42	0.43	0.41	0.41	0.42	0.41	0.43
4.0	0.54	0.51	0.48	0.48	0.49	0.49	0.49	0.46	0.48	0.47	0.48	0.47	0.48
4.5	0.70	0.60	0.60	0.62	0.58	0.56	0.57	0.59	0.58	0.58	0.57	0.59	0.61
5.0	0.81	0.80	0.82	0.82	0.78	0.82	0.81	0.86	0.83	0.83	0.81	0.79	0.83
Total	2.78	2.56	2.50	2.73	2.62	3.36	3.21	4.75	4.16	4.23	4.12	4.09	2.90

Soil Type: San Emigdio fine sandy loam
Probe: SJ-3

